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, RESOURCE REPLACEMENT FOR SAN JUAN GENERATING STATION PURSUANT TO THE ENERGY TRANSITION ACT Applicant	Case No. 19-00195-UT

Prepared Rebuttal Testimony of David A. Schlissel

On Behalf Of

Sierra Club

JANUARY 13, 2020

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I. Introduction.

Q. Please state your name and business address.

A. My name is David A. Schlissel. I am the President of Schlissel Technical Consulting, Inc. My business address is 45 Horace Road, Belmont, MA 02478.

Q. On whose behalf are you testifying?

A. I am testifying on behalf of Sierra Club.

Q. Please summarize your educational background and recent work experience.

A. I graduated from the Massachusetts Institute of Technology in 1968 with a Bachelor of Science Degree in Engineering. In 1969, I received a Master of Science Degree in Engineering from Stanford University. In 1973, I received a Law Degree from Stanford Law School. In addition, I studied nuclear engineering at the Massachusetts Institute of Technology during the years 1983-1986.

Since 1983 I have been retained by governmental bodies, publicly owned utilities, and private organizations in 38 states to prepare expert testimony and analyses on engineering, economic and financial issues related to electric utilities. My clients have included state utility commissions, attorneys general, and consumer advocates, publicly owned utilities, and local, national and international environmental and consumer organizations.

I have filed expert testimony before state regulatory commissions in Arizona, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oregon, Rhode Island, South Carolina, South

Dakota, Texas, Vermont, Virginia, West Virginia, and Wisconsin; before the U.S. Federal Energy Regulatory Commission and Atomic Energy Commission; and in state and federal court proceedings.

A copy of my resume was included as Attachment DAS-1 to my rebuttal testimony in Case No 19-00018-UT. Additional information about my work is available at www.schlissel-technical.com and www.ieefa.org.

Q. Have you previously testified before this Commission?

A. Yes. I testified before the New Mexico Public Regulation Commission in Case 2146, Part II. I also prepared a report in Case No. 05-00275-UT as a consultant to the Commission. Finally, I recently submitted testimony and testified in Case 19-00018-UT.

Q. What is the purpose of your testimony in this proceeding?

A. I have been asked to evaluate whether retrofitting San Juan Generating Station (SJGS) with a system to capture the plant's carbon dioxide emissions, compress the captured CO_2 and then sell it to oil companies for use in enhanced oil recovery activities is a feasible scenario as Public Regulation Commission Staff witness Dhiraj Solomon has testified. I have also been asked to address the recommendations concerning a power purchase agreement (PPA) made by Charles Griffey on behalf of Westmoreland and Roger Schiffman on behalf of the Board of County Commissioners for the County of San Juan and the City of Farmington.

Q. Please explain the status of carbon capture and storage or reuse (CCS or CCUS) in the electric utility industry.

A. Coal-fired electric generation facilities emit large quantities of CO_2 during operation. According to the Energy Information Administration, a unit of the Department of Energy, coal plants in the U.S. released 1,150 million metric tons of CO_2 in 2018, accounting for 65% of the electric generation sector's total CO_2 emissions nationwide.[1] At the same time, coal supplied only 28% of the electricity generated during 2018. This mismatch has become increasingly problematic for the industry as concerns about climate change have grown, and as cleaner alternatives, particularly zero-carbon renewable options such as wind and solar, have become commercially viable.

To address these concerns, some coal industry proponents have been pushing for the development of systems that can capture the fuel's carbon emissions, and either store that captured carbon underground or reuse it in other applications, particularly to increase the amount of oil recovered from older producing sites. Despite billions of dollars of federal research funds, only one such carbon capture project has been built at a coal-fired electric power facility in the U.S. – the Petra Nova project in Texas. A second, smaller carbon capture unit is also in operation in Canada at Boundary Dam Unit 3. Both of these projects, as I will show later, have failed to meet their promised performance goals, undercutting assertions by backers of the SJGS CCS retrofit that they will be using commercially proven technology.

[1] U.S. Energy Information Administration, "How much of U.S. carbon dioxide emissions are associated with electricity generation?", *available at* https://www.eia.gov/tools/faqs/faq.php?id=77&t=11.

Q. Please summarize your findings.

A. My main findings are as follows:

1. It would risky and unwise to delay approval of replacement resources, or give only conditional approval of replacement resources, in order to allow Enchant Energy (Enchant) and Farmington to submit a PPA bid. Mr. Griffey and Mr. Schiffman merely speculate on what a hypothetical PPA bid from Enchant would be, and have failed to provide any analysis of the economics or reliability of such a bid compared to other replacement resources. Moreover, even if Enchant submitted a bid that looks good on paper, there would be a significant risk that Enchant could not deliver on its bid, because carbon capture has never been used on a plant the size of San Juan, and a carbon capture project is likely to cost more and take longer to build than Enchant is promising.

2. Contrary to Mr. Solomon's testimony, continuing to operate SJGS after being retrofitted for CCS is not a feasible financial or economic scenario and is not a plausible scenario that PNM should have been required to evaluate in order to present a prima facie case on abandonment.

3. For the same reason, there is no reason for PNM to delay taking action to acquire cost-effective resources that may become unavailable or more expensive in the future due to diminishing tax credits, as has been recommended by Mr. Griffey and Mr. Schiffman. It is unlikely that the Farmington-Enchant proposal to retrofit SJGS will be able to offer

attractive power pricing terms to PNM without seriously undermining the financial viability of the SJGS retrofit project.

4. The *Preliminary Assessment of Post-combustion Capture of Carbon Dioxide at the San Juan Generating Station*, prepared by the Los Alamos National Laboratory (the *LANL Preliminary Assessment*) is not a truly independent assessment because it does not present any *independent* analysis by LANL. Instead, it mostly repeats what Sargent & Lundy already said in its pre-feasibility report; it uncritically accepts claims made by the owners and the builder of the Petra Nova carbon capture facility; and concludes that CO_2 demand for enhanced oil recovery (EOR) in the Permian Basin is essentially inexhaustible, meaning there should always be a market for the CO_2 captured at SJGS, without offering any analysis to support this conclusion.

5. The reports by Enchant and Sargent & Lundy (S&L) on which witnesses Solomon, Schiffman, and Griffey are relying are based on many overly optimistic or incorrect assumptions:

   a. That after operating at an average 70% capacity factor for almost the past decade, including an average 63% capacity factor since Units 2 and 3 were retired at the end of 2017, SJGS Units 1 and 4 will run for at least 12 years at an 85% to 100% capacity factor after being retrofitted for CO_2 capture. This assumption is, to say the least, overly optimistic given continuing low natural gas prices, growing competition from increasingly low-cost renewable

resources and energy storage, and the potential for declining performance due to plant aging.

b. That capturing CO_2 at a 90% rate at commercial-scale power plants for extended periods has been "proven" or "demonstrated" when, in fact, there is no evidence that either Petra Nova or Boundary Dam 3 has done so for any sustained period of time – in spite of unsupported industry claims that they have.

c. That a retrofitted SJGS will capture 6 million metric tonnes of CO_2 a year.

d. That SJGS can be retrofitted at a capital cost (measured on a per kilowatt basis) that would be 68% lower than the capital cost of the Petra Nova project.

e. That the SJGS retrofit could be designed, planned, built and tested in at least two years less time than Petra Nova and be online by mid-2023.

f. That the cost of capturing CO_2 at SJGS will fall between $39.15 and $43.49 per metric tonne.

6. The proposed retrofitting of SJGS for carbon capture would not be financially feasible even if it were able to capture 90% of the CO_2 the plant produces.

7. Mr. Solomon, Mr. Schiffman, Mr. Griffey, and Enchant and S&L have ignored entirely the substantial electricity market risks facing any SJGS

owner(s) and investors that seek to continue to operate SJGS with carbon capture:

a. SJGS has not been a low-cost generator and is extremely unlikely to become one after the carbon capture retrofit.

b. Subsequently, it is reasonable to expect that any plant owner(s) will suffer in excess of $300 millions in losses from the sale of electricity. This will be because the cost of generating power at the plant will be higher than the prices at which that electricity can be sold.

8. Mr. Solomon, Mr. Schiffman, Mr. Griffey, and Enchant and S&L also have ignored or dismissed, without analysis, significant CO_2/oil market risks facing any future SJGS owner(s) and investors:

a. The significant risk that the claimed market for all of the CO_2 captured at SJGS for use in EOR will not materialize for at least part, and perhaps a significant part, of the period between 2023 and 2035.

b. The risk that future oil prices will be too low to make the use of CO_2 captured at SJGS economic for oil producers and the plant's owner(s).

c. The significant risk that there will not be sufficient pipeline capacity to transport all of the CO_2 captured at SJGS to customers in the Permian Basin for the entire period 2023-2035.

9. In addition, Mr. Solomon, Mr. Griffey, Mr. Schiffman, and Enchant and S&L have ignored substantial costs that any prospective owner(s) or investors of SJGS would have to pay:

   a. The need to pay for maintenance that the current owners of the plant are deferring due to their proposal to abandon SJGS in 2022.

   b. The likely need to pay the plant's fixed costs for at least a year to eighteen months between the shutdown of SJGS in mid- to late-2022 and its restart following the retrofit, a period when the plant will not be producing any revenues from the sale of electricity or of captured CO_2.

10. Even if it were possible to capture 6 million metric tonnes of CO_2 from SJGS each year, the net emissions into the atmosphere would decline by only a fraction of this amount if the captured CO_2 were used for EOR activities.

Q. What materials did you review and what analyses did you prepare as part of the preparation of your testimony?

A. I have reviewed the Prepared Direct Testimony of Charles Griffey, Roger Schiffman, and Dhiraj Solomon, as well as the documents Mr. Griffey and Mr. Solomon included as exhibits to their testimony (including the *LANL Preliminary Assessment*). In addition, I have reviewed a number of presentations on the proposed carbon capture retrofit of SJGS from Enchant Energy, Inc. and Sargent & Lundy (S&L) and the publicly available information on the only two operating power plants in the world that have been retrofitted for CO_2 capture: the Petra

Nova project in Texas and Boundary Dam 3 in Saskatchewan, Canada. Finally, my recent work has included investigating natural gas and energy market prices in the Southwest and the development of renewable resources and energy storage in the Mountain and Pacific states.

II. The Commission Should Not Delay Approval of Replacement Resources in Order to Allow Enchant and Its Partners an Opportunity to Present a Power Purchase Agreement to PNM.

Q. Do you agree with witness Charles Griffey that the Commission should delay approval of replacement resources in order to give Enchant and its partners an opportunity to negotiate a power purchase agreement with PNM?[2]

A. No.

Q. Please explain.

A. As I explain in the rest of my testimony, the proposed project to retrofit SJGS with carbon capture is not financially viable. As I will show, the proposed retrofit is based on a number of key assumptions that go far beyond overly optimistic and into the realm of fantasy; that SJGS will operate at an 85% average annual capacity factor after the retrofit is completed (after having run at an average 70% capacity factor the past ten years); that the new carbon capture facility at SJGS would capture 90% of the CO_2 the plant would produce at an 85% capacity factor for a period of twelve years; that the retrofit could be completed for about one-third of the cost of the carbon capture facility at Petra Nova in Texas, the only existing carbon capture project at a power plant in the U.S. (and just one of two in

[2] Direct Testimony of Charles S. Griffey on behalf of Westmoreland Mining, LLC., at page 6, lines 10-14.

the world); and that Enchant and its partners would be able to raise enough funds to retrofit SJGS through 45Q tax financing. In fact, there is no evidence that the retrofit is likely to be undertaken, with or without a PNM PPA.

Q. Is there any evidence that the proposed SJGS retrofit will be in service by July 1, 2022, or even by mid-2023?

A. No. As Farmington has indicated in response to Data Request SC 1-15:

> The City and San Juan state that the continuation of SJGS as a CCUS facility is still in the planning stages and the City is not able to fully rely on the accomplishment of that effort. Although the July 8, 2019 Sargent & Lundy study and the December 12, 2019 Preliminary Assessment by LANL are encouraging, *the FEED study is still underway and its results are not yet known. There are many financial, economic and regulatory steps to be taken in addition to resolution of the technical issues addressed in these studies before the CCUS conversion and continued operation of SJGS can be realized.*" (Emphasis added).

In fact, it is most likely that the retrofit will never be realized because investors will be wary of putting their money into such a high-risk project when there are many opportunities to invest in lower-risk renewable resources, both in New Mexico and the rest of the United States.

Q. Do you agree with Mr. Griffey's claim that only the PPA price offered by Enchant is relevant, not an expert's forecast of the economics or the financial viability of the proposed SJGS carbon capture retrofit?

A. Absolutely not. Regardless of what hypothetical terms Enchant might offer in a theoretical PPA, I don't believe that the Commission should delay the acquisition of needed replacement resources when Enchant and its partners cannot demonstrate that the proposed carbon capture retrofit of SJGS is economically

and financially viable and will be available to serve PNM and its customers. Without any evidence that the project is economically and financially viable, how can PNM and the Commission have any confidence either that Enchant will be able to deliver on its promised energy and capacity and/or that it will be able to honor the PPA price(s) for the term of the proposed agreement?

Q. Has Mr. Griffey performed an economic analysis of retrofitting SJGS for carbon capture?

A. No.[3]

Q. Do you have any comment on Mr. Griffey's testimony on the relative CO2 emissions from PNM's proposed LM-6000 facility and a retrofitted SJGS?

A. Yes. When comparing the CO_2 emissions from generating alternatives, it is important to consider how much each alternative plant would be operated. For example, Enchant would be under substantial economic pressure to run SJGS and its carbon capture facility as much as possible in order to produce enough CO2 for use in EOR, and indeed claims that it will operate the plant at an average 85% capacity factor – in essence, SJGS will be a "must run" facility." This will affect how much CO_2 SJGS emits into the atmosphere, even if Enchant is able to achieve, or even get close to, its claimed 90% capture rate.

[3] Griffey Dir. at page 10, lines 14-15.

Q. Do you agree with Mr. Schiffman that there is "strong potential that the Farmington-Enchant Project can structure a PPA that has price and non-price terms that are favorable to PNM and other utility systems and their ratepayers."[4]

A. No. PNM will want a PPA with as low a price as possible because there will be no benefit for its ratepayers if it is paying more for power from SJGS than it could pay for the same electricity in the market or from merchant renewable resources. At the same time, Enchant and its partners will want as high a PPA price as possible in order to assure the financial viability of their proposed project, even when one accounts for Enchant's other potential revenue streams (*i.e.*, CO_2 sales and 45Q tax credits). As I have shown, the new owners of SJGS would suffer hundreds of millions of dollars in losses if they sold power to PNM, or any other utility, at recent forward market prices. Those losses would be even greater if they sold power from SJGS at below market prices.

Q. Isn't it reasonable to expect that revenues from CO_2 sales will make up some of the losses incurred in the sale of the electricity from SJGS?

A. No. Sargent & Lundy have estimated that the revenues from the sale of the CO_2 from SJGS might fall in the range of $15-$20/tonne.[5] However, Sargent & Lundy also estimate that the total fixed and variable O&M for the proposed SJGS carbon

[4] *Id*, at page 5, lines 12-15.
[5] Sargent & Lundy *Enchant Energy San Juan Generating Station – Units 1 & 4 CO2 Capture Pre-Feasibility Study*, dated July 8, 2019, at page 4-3.

capture facility would be slightly under $100 million a year,[6] which works out to $16.65/tonne of captured CO_2 if 6 million tonnes of CO_2 are captured each year. Thus, it is not even assumed that Enchant will be able to cover the cost of capturing CO_2 at SJGS with the revenues from the sale of that CO_2, let alone offset the more than hundreds of millions of losses incurred in the sale of the plant's electricity.

Q. Is it reasonable to expect that revenues from 45Q tax credits will offset any portion of the losses incurred in the sale of the electricity from SJGS?

A. No. As I indicate below in Table 3, there is a significant risk that Enchant and its partners won't even be able to rely on 45Q tax credits to raise all of the funding needed to pay for the construction of the proposed SJGS carbon capture facility. And that is likely to be true even if one believes Enchant and its partners' unrealistic assumptions about an 85% capacity factor, a 90% CO2 capture rate, and a construction cost two-thirds lower than Petra Nova's, on a $/kW basis.

Q. Is there any actual evidence to support Mr. Schiffman's claim that "the Enchant business model, and combined economic features of the project suggest a strong potential for the project to succeed…"[7]

A. No. Enchant has no experience operating power plants or carbon capture facilities. So there is no experience or evidence to support Mr. Schiffman's claims about the Enchant business model. Moreover, Mr. Schiffman acknowledges the

[6] *Id, Appendix E.*
[7] Direct Testimony of Roger Schiffman on behalf of Board of County Commissioners for the County of San Juan and the City of Farmington, at page 7, lines 15-18.

uncertainty around the viability and concreteness of the proposed SJGS carbon capture retrofit.[8]

III. No Party Has Presented Any Evidence that Retrofitting SJGS With Carbon Capture Would Be Financially Viable.

Q. What Does Mr. Solomon say about carbon capture in his testimony in this case?

A. Mr. Solomon reiterates the argument that he made in Case No 19-00018-UT, namely, that PNM should have analyzed a scenario in which San Juan is retrofit with carbon capture technology.[9]

Q. Does Mr. Solomon acknowledge the rebuttal testimony that you, Mr. Posner, Mr. Phillips, Mr. Graves, and other witnesses filed in Case No. 19-00018-UT showing that it would not be economically viable for PNM to retrofit San Juan with carbon capture?

A. No, Mr. Solomon has still not read the testimony filed in Case No. 19-00018-UT responding to his direct testimony. Staff Supplemental Response to SC 1-21, 1-22, 1-23, 1-24, 1-25. Mr. Solomon still appears unaware that PNM conducted the precise analysis of carbon capture that Mr. Solomon recommended.

Q. Did Mr. Solomon conduct his own analysis of either the technical or economic feasibility of carbon capture at SJGS?

A. No, he did not. In his testimony, Mr. Solomon relies entirely on claims made by Enchant Energy, the private company that has proposed the retrofit project at

[8] *Id*, at page 7, lines 14-15.
[9] Solomon Dir. at pages 10-11.

SJGS, as well as preliminary estimates from Sargent & Lundy, as well as the purportedly independent LANL assessment.

Q. Does Mr. Solomon have an opinion on whether it is economically feasible to install and operate carbon capture technology at SJGS?

A. No, apparently not. Mr. Solomon admitted in Case 19-00018-UT that he provided an opinion on only the technical feasibility of carbon capture and did not evaluate the economic feasibility of carbon capture at SJGS. Exhibit DAS-2 in Case 19-00018-UT, D. Solomon Depo. Tr. at 61: 8-16, 61:19 to 62:10.[10] Furthermore, Mr. Solomon admitted that he does not know if it would be cheaper to run SJGS with carbon capture than the alternatives that PNM has put forward to abandon and replace SJGS. *Id.* at 62:21 to 63:2. And Mr. Solomon had no evidence that it would be cost-effective to recover the capital costs of carbon capture technology at SJGS over 12 years, as Enchant has proposed to do. *Id.* at 96: 11-16.

Q. Has Mr. Schiffman or Mr. Griffey presented any evidence to show that the retrofitting of SJGS for carbon capture is economically or financially viable?

A. No, they have not.

Q. What is the relevance of the claims made by Enchant and S&L to the issue of whether it would be feasible for PNM to operate SJGS with carbon capture?

A. Mr. Solomon argues that PNM should have analyzed continuing to operate to SJGS with carbon capture, because that is allegedly a "feasible" scenario. Mr. Solomon's only support for his claim that carbon capture is feasible at SJGS are

[10] Mr. Solomon's deposition in Case No. 19-00018-UT was taken on November 13, 2019.

the statements made by Enchant, S&L and LANL. By showing that Enchant's and S&L's claims are inaccurate, I will show that there is no evidence that it is economically or financially feasible for anyone, including PNM, to continue to operate SJGS with carbon capture technology.

Moreover, LANL has acknowledged that it has not assessed the costs or financing of the proposed SJGS carbon capture project.[11]

Q. What are the key factors in assessing the economics of a carbon capture project at San Juan?

A. There are three potential revenue streams of a carbon capture project: sales of energy and capacity; sales of captured CO_2; and the 45Q tax credits for carbon capture.

The latter two revenue streams, from the sale of CO_2 and tax credits for CO_2, both depend on the volume of CO_2 that is captured from the plant, which in turn depends on how much the plant operates (and thus the amount of CO_2 it generates), and how much CO_2 is captured (i.e., the capture rate of the CCS equipment).

Q. What are the key assumptions in the Enchant and Sargent & Lundy claims about the economics of retrofitting San Juan with carbon capture?

[11] *LANL Preliminary Assessment*, at page 5.

A. Enchant and Sargent & Lundy assume that CCS equipment at San Juan could capture 6 million metric tonnes of CO_2 each year. For this to happen, they further assume that the plant would operate at a capacity factor of at least 85%, and the CCS equipment would capture at least 90% of the CO_2 for a period of twelve years. As I explain below, each of these assumptions is unrealistic, which is why the CCS project has little prospect of being economic for PNM or anyone else.

IV. It is Extremely Unrealistic to Assume that a Retrofitted SJGS Would Capture Six Million Metric Tonnes of CO_2 Per Year.

Q. What factors determine how much CO_2 a coal-fired generator like SJGS will capture in future years?

A. Quite simply, the amount of CO_2 captured is a function of how much CO_2 a coal-fired generator produces and the efficiency with which the carbon dioxide (CO_2 or carbon) capture system actually captures those emissions.

The first factor, how much CO_2 the plant generates is, in turn, largely dependent on how much it operates. The term capacity factor reflects how much power a plant produces in a given period, say a month or a year, versus how much it would have generated if it had operated at 100% power for all of the hours of the period. The higher the capacity factor, the more power is generated by the plant. Conversely, the lower the capacity factor, the lower the amount of power generated by the plant. Similarly, the amount of CO_2 produced by a coal plant goes up as its capacity factor increases.

In this case,[12] Mr. Solomon reiterates his recommendation from Case No. 19-00018-UT that PNM should have studied a scenario in which a retrofitted San Juan will capture 6 million tonnes of CO_2 annually.[13] Capturing 6 million tonnes annually of CO2 is contingent on two key assumptions: first, that San Juan Units 1 and 4 will operate at an average 85% to 100% capacity factor each year, thereby producing large amounts of CO_2, and second, that the plant's retrofitted CCS equipment will be able to capture 90% of the CO_2 produced. As I will demonstrate in this testimony, neither of these assumptions is reasonable.

A. A Retrofitted SJGS Cannot Be Expected to Operate at an 85% to 100% Annual Capacity Factor for An Extended Number of Years.

Q. Enchant and S&L evaluate the feasibility of their proposed retrofit of SJGS for CO_2 capture using a capacity factor range of 85% to 100%.[14] Is it reasonable to expect that SJGS would operate at a 100% capacity factor for a period of 12 years after being retrofitted for CO_2 capture?

A. No. It is simply fantasy to believe that any commercial scale power plant will operate at full power in every hour of the year for an extended period of time, let alone for twelve years. I have not seen any evidence that any coal-fired generator similar in size to SJGS Units 1 or 4 has operated at a 100% capacity factor for such a period of years.

[12] Prepared Direct Testimony of Dhiraj Solomon, at page 10, line 14 through page 11, line 13.
[13] Case No. 19-00018-UT, Prepared Direct Testimony of Dhiraj Solomon, at page 15, lines 10-11.
[14] *Enchant Energy San Juan Generating Station – Units 1 & 4 – CO_2 Capture Pre-Feasibility Study*, July 8, 2019, at pages 5-4 and Appendix E, . *available at* https://www.enchantenergy.com/wp-content/uploads/2019/07/Enchant-Energy_SJGS-CO2-Pre-feasibility-Study_FINAL-Rev-0-7-8.pdf.

Q. Did Enchant and/or S&L conduct any SJGS plant-specific analysis or modeling to evaluate at what capacity factor SJGS can be expected to operate in future years?

A. No, not that I've seen.

Q. What then do you believe is the basis for the 85% low-end of the capacity factor range at which Enchant and S&L claim SJGS will operate?

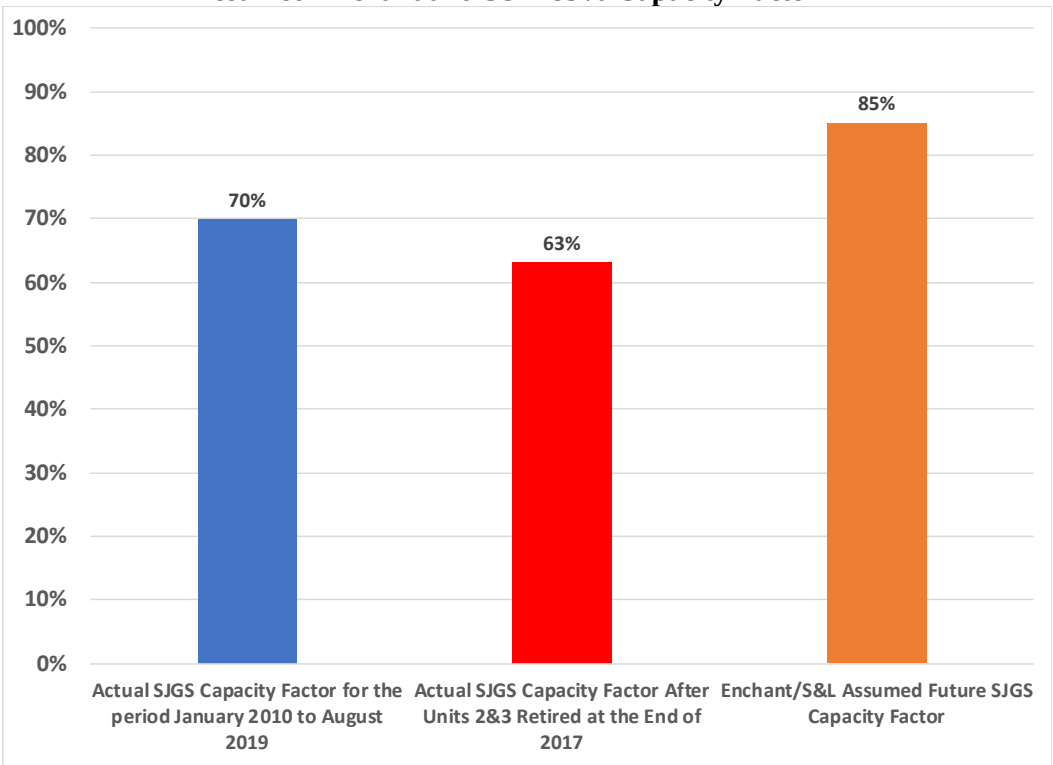
A. At best, they used the 85% coal plant capacity factor that has been used in some generic federal studies of carbon capture.[15] At worst, they chose an assumed capacity factor that gave them the result they needed to show that the project might be economically viable -- that is, that SJGS would capture on the order of 6 million metric tonnes of CO_2 per year. Either way, neither SJGS Unit 1 or Unit 4 have operated at an 85% capacity over the long-term or in recent years.

Q. At what capacity factors have SJGS Units 1 and 4 operated in recent years?

A. As shown in Figure 1, below, the two units achieved an average 70% capacity factor between January 1, 2010 and August 31, 2019, which clearly is far below the 85% average capacity factor that Enchant and S&L claim the plant will achieve starting in 2023, after being retrofitted for CO_2 capture.

[15] For example, see *Cost and Performance Baseline for Fossil Energy Plants Supplement: Sensitivity to CO_2 Capture Rate in Coal-Fired Power Plants*, U.S. DOE, National Energy Technology Laboratory (June 22, 2015), *available at* https://www.netl.doe.gov/projects/files/SupplementSensitivitytoCO2CaptureRateinCoalFiredPowerPlants_062215.pdf.

Figure 1: Average SJGS Unit 1 and 4 Capacity Factors Since 2010 vs. Assumed Enchant and S&L 85% Capacity Factor



Sources: SJGS data from EIA Form 923, downloaded from S&P Global Market Intelligence on January 2, 2020. Enchant and S&L assumed capacity factor is from Sargent & Lundy CO_2 Capture Pre-Feasibility included in Westmoreland Mining Witness Griffey's Exhibit CSG-2 .

Figure 1 also shows that the overall performance of SJGS Units 1 and 4 actually declined after Units 2 and 3 were retired at the end of 2017, achieving only a 63% capacity factor in the 22 months between January 2018 and October 2019.

Q. Have SJGS Units 1 and 4 achieved an 85% capacity factor in any year since 2010?

A. SJGS Units 1 and 4 did achieve 85% capacity factors in 2009 but have failed to reach that level in any subsequent year.

Only Unit 4 achieved a capacity factor above 80% after 2011, and that was an 81% capacity factor for only the single year of 2017.

Q. Why have you only considered the operating performance of SJGS Units 1 and 4 since the beginning of 2010 in Figure 1?

A. As shown in Figures 2 and 3, below, natural gas prices collapsed in 2009 and have remained very low since then. At the same time, the generation from renewable resources has increased dramatically, and is expected to continue to grow in coming years. Given these circumstances, the operating performance of SJGS Units 1 and 4 in the years through 2009 is simply not relevant to the question of what the likely performance of these units is going to be in future years starting in about 2023.

Q. Is there any evidence that the operating performance of Units 1 and 4 has improved in recent years?

A. No. As shown in Figure 1, the units have achieved only a combined 63% capacity factor since Units 2 and 3 were retired at the end of 2017. In addition, the units' recent operating performance under a number of measures typically used in the industry to assess power plant performance has been much poorer than one would expect from a plant with the potential to operate at an average 85% for an extended number of years.

Q. Please explain.

A. There are a number of measures typically used in the industry to assess power plant operating performance. For example, PNM typically uses the measures WEFOR, WAF and WEAF.

WEFOR stands for weighted equivalent forced outage rate. WEFOR measures how much of the time the plant is fully or partially required to reduce power as

the result of unplanned equipment problems with the result weighted by the size of the plant.

WAF stands for weighted availability factor. WAF measures the number of hours a plant is able to provide electricity to the grid, at any power level, during a certain period (e.g., monthly or yearly), divided by the total number of hours in that period. When calculating the WAF, an hour in which a large generating facility like SJGS is able to provide one MW of power is considered the same as an hour in which the facility is able to operate at full power. Most importantly, availability has nothing to say about the economics of a particular plant.

WEAF stands for weighted equivalent availability factor. A plant's equivalent availability reflects the power levels at which it actually operates. Therefore, unlike availability, equivalent availability reflects power derates -- that is reductions in the plant's power output even though it remains connected to the grid and capable of providing some power.[16]

Q. Do the WEFOR, WAF and WEAF figures posted by SJGS Units 1 and 4 in recent years support the assumption that the units will run at an average 85% annual capacity factor in future years?

A. No, as shown in Tables 1 and 2, below:

[16] NERC Generating Availability Data System (GADS) *Reporting Instructions*.

Table 1

SJGS Unit 1 Operating Performance 2018 & 2019[17][18]

	Average in 2018 & 2019	Industry Average in 2018 for Units 300-399 MW
Net Capacity Factor	57%	45%
WEFOR	31%	11%
WAF	66%	80%
WEAF	70%	77%

Table 2

SJGS Unit 4 Operating Performance 2018 & 2019[19][20]

	Average in 2018 & 2019	Industry Average in 2018 for Units 400-599 MW
Net Capacity Factor	67%	55%
WEFOR	13%	10%
WAF	83%	81%
WEAF	78%	77%

Given the recent performance of SJGS Units 1 and 4 shown in Tables 1 and 2, it is entirely unrealistic to expect that the Units' average capacity factor will jump from the 63% achieved in 2018 and 2019 to an average of 85% after the plant is retrofitted for carbon capture.

[17] Data developed from PNM response to Sierra Club Data Request 14-1.
[18] Unfortunately, NERC has not yet published the GADs data for 2019.
[19] *Id.*
[20] Unfortunately, NERC has not yet published the GADs data for 2019.

Q. What are PNM's projections for SJGS's future operating performance if Units 1 and 4 are not retired in 2022?

A. PNM's recent modeling of continued SJGS operation projects that Units 1 and 4 would achieve an average 70% capacity factor between 2023 and 2035 after being retrofitted for carbon capture.[21]

This would be consistent with the units' operating performance since 2010.

Q. Are there any other factors which suggest that SJGS's future annual capacity factors will be substantially lower than 85% if the plant continues to operate after 2022?

A. Yes. There are a number of factors that are likely to lead to a significant decline in SJGS operating performance if the new owner(s) attempt to continue to run the plant after retrofitting it for CO_2 capture. These include:

1. Continued low natural gas prices.
2. Growing competition from renewable resources, including energy storage.
3. Increasing integration of the Western power grid.
4. The impact of plant aging.
5. The impact of reduced spending on maintenance by the current owners.
6. The fact that SJGS will be a more complicated plant to operate.

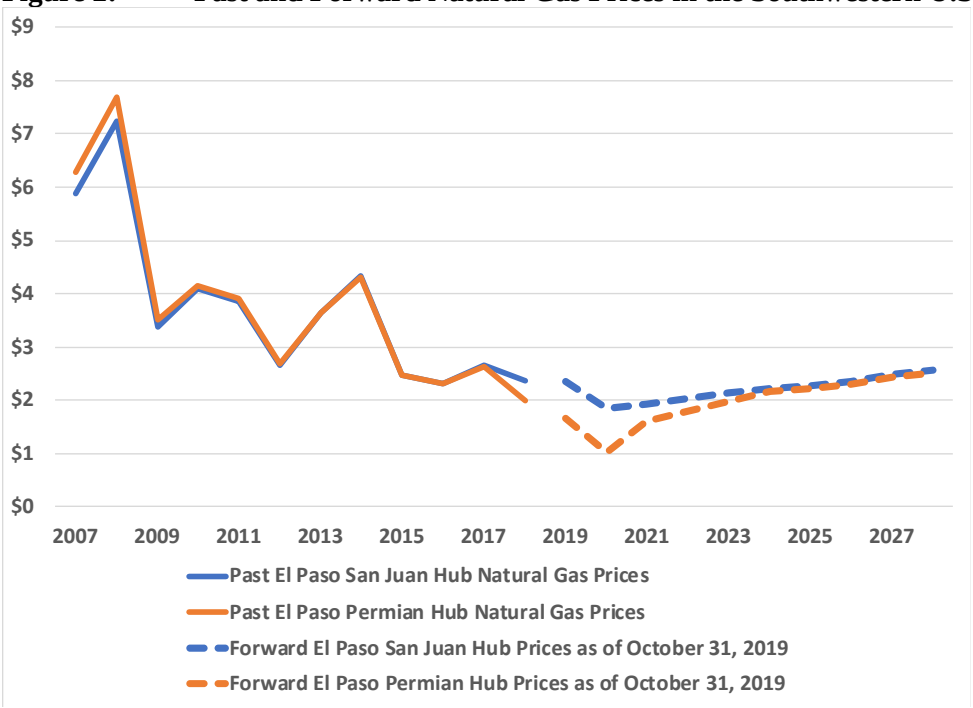
[21] San Juan Continues CCUS 1-2-3 Options Modeling Output Reports, provided by PNM in response to Sierra Club Data Request 1-14.

I will explain each of these factors in greater detail below.

Q. What are the market's expectations for future natural gas prices at trading hubs in the Southwest?

A. Similar to what has happened throughout the U.S., natural gas prices at trading hubs in the Southwest have declined significantly since 2008 and are expected to remain low for the foreseeable future, as can be seen in Figure 2, below.

Figure 2: Past and Forward Natural Gas Prices in the Southwestern U.S.



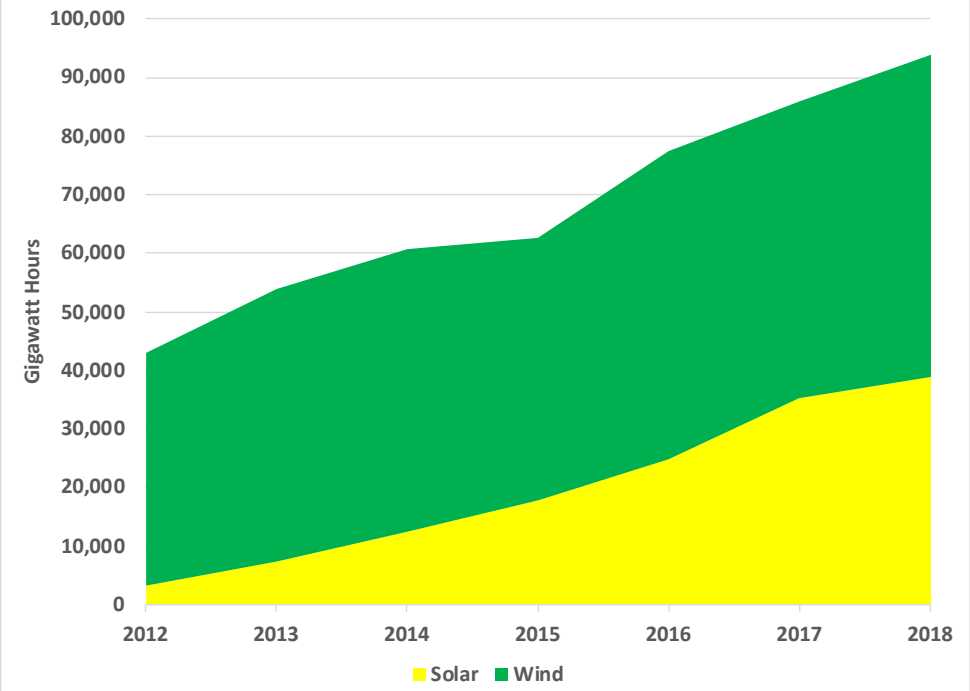
Sources: Past Natural Gas Prices downloaded from S&P Global Market Intelligence on October 31, 2019. Forward prices from OTC Global Holdings, also downloaded from S&P Global Market Intelligence on October 31, 2019.

Continued low gas prices will undermine the financial viability of projects like retrofitting San Juan with CCS by reducing fuel costs for the natural gas plants with which San Juan competes. This, in turn, will lead to (a) lower energy market prices and (b) increased generation at gas-fired plants, thereby displacing generation that otherwise would be produced at San Juan.

Q. Has generation from wind and solar resources grown significantly in the Western U.S. in recent years?

A. Yes. As prices have declined dramatically, the generation from solar more than doubled just between 2012 and 2018.

Figure 3: Rapid Growth in Wind and Solar Generation in the Western United States, 2012 to 2018



Source: EIA Electric Power Monthly.

And significantly more renewable resources are likely to be added in the Western U.S. in coming years. For example, California now mandates that 33% of electricity sales in 2020 and 60% of sales in 2030 be from renewable resources.[22] In addition, utilities in other states in the region also are planning to add substantial amounts of new wind and solar resources, as are independent power

[22] Stats. 2018, Ch. 312, Sec. 2. (SB 100) (effective Jan. 1, 2019); Cal. Pub. Util. Code § 399.11.

producers. Many of these resources will compete with San Juan and displace generation that the plant would otherwise produce.

Q. What has happened to wind and solar PPA prices in recent years?

A. Wind and utility-scale solar PPA prices have declined sharply in recent years. From 2009 to 2016, average levelized wind PPA prices fell from $70 per megawatt-hour (MWh) to about $20. Average levelized solar PPA prices declined by 75% from 2009 to 2016 and were about $35 per MWh for new projects in 2016.

Solar and wind PPA prices have dropped further in 2017 and 2018. In December 2017, Xcel Energy reported that a power-generation solicitation in Colorado drew bids for renewable power that were "incredible."[23] The median bid for 17,380 MW of wind projects received by Xcel Energy was $18.10 per MWh; for 5,097 MW of wind-plus-battery storage projects, the median bid was $21 per MWh; the median bid for 13,345 MW of solar projects was $29.50 per MWh; for 10,813 MW of solar-plus-storage, the median bid was $36 per MWh.[24] And Nevada Energy reported receiving "staggering" prices in more than 100 bids for biomass, geothermal, solar, wind and battery storage projects in response to a request for proposals, with battery-backed solar projects priced below $30 per MWh.[25]

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[23] https://www.utilitydive.com/news/xcel-solicitation-returns-incredible-renewable-energy-storage-bids/514287/.

[24] Public Service Company of Colorado, 2016 Electric Resource Plan 2017, All Source Solicitation 30-Day Report (Public Version), CPUC Proceeding No. 16A-0396E (Dec. 28, 2017) https://cdn.arstechnica.net/wp-content/uploads/2018/01/Proceeding-No.-16A-0396E_PUBLIC-30-Day-Report_FINAL_CORRECTED-REDACTION.pdf

[25] G. Hering, 'Staggering' prices drive NV Energy's 100% renewables bid amid ballot wrangle, S&P

Q. How will increasing regional integration of electricity markets hurt future SJGS operating performance?

A. Efforts have been under way in recent years to better integrate Western electric markets. For example, an Energy Imbalance Market (EIM) has been launched in the region. The EIM is "a real-time wholesale energy trading market that enables participants anywhere in the West to buy and sell energy when needed."[26] One of its goals is to find and deliver the lowest cost energy to consumers.[27] Another goal is that by optimizing resources from a larger and more diverse pool, it is able to better facilitate the integration of renewable energy that otherwise may be curtailed at certain times of the day. There are currently nine members in the EIM, including the California Independent System Operator (CAISO), and APS and NV Energy in the Southwest. Salt River Project, PNM, and Tucson Electric Power are scheduled to join by 2022, meaning that participants representing 77 percent of the Western Electricity Coordinating Council's total load will be active in the EIM.

The growth of the EIM amplifies the risk to San Juan from low-cost renewable resources in California and the rest of the West, as it will mean increased exposure to renewables prices that may be lower than San Juan's marginal costs.

Global Market Intel. (Apr. 13, 2018) https://www.spglobal.com/marketintelligence/en/news-insights/trending/xrl7pjatkohn-o95bsv1pq2

[26] https://www.westerneim.com/pages/default.aspx.

[27] CAISO, Press Release (Oct. 30, 2019), *available at* http://www.caiso.com/Documents/WesternEIMBenefitsReach801_07MillionSinceLaunchIn2014.pdf.

Q. What is the significance of plant aging on the expected future operating performance of SJGS Units 1 and 4?

A. San Juan Unit 1 is currently 43 years old. Unit 4 is 37. By 2023, the Units will be 47 and 41 years old, respectively. By 2030, they will be 54 and 48 years old. This is important because older plants, on average, tend to cost more to operate and maintain and are less reliable according to analyses by the U.S. Department of Energy's Argonne National Laboratory and the National Energy Technology Laboratory, which have found that coal plant heat rates increase with plant age, while plant availability declines.[28] Heat rate is a measure of a power plant's efficiency in generating electricity; a higher heat rate means that a plant is less efficient. And, in general power plants tend to become less efficient as they age. Plant availability measures the percentage of possible operating hours in which a plant was actually available to generate power, and plants tend to become less available to generate power as they age, in part because they tend to experience more unanticipated problems and unplanned outages.

At the same time, older plants tend to cost more to maintain, as equipment and components degrade or fail and must be repaired or replaced. These factors must be considered by potential plant owners and investors as they decide to participate in retrofit projects at aging coal plants such as SJGS.

[28] *See, e.g.*, U.S. Dep't of Energy,Staff Report to the Secretary on Electricity Markets and Reliability at 155 (Aug. 2017), *available at* https://www.energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf.

Q. Are there any other factors that could lead to lower SJGS capacity factors in the future after the plant is retrofitted for carbon capture?

A. Yes. For example, I understand that in Case No. 16-00276, PNM was pressed to avoid and defer capital spending for SJGS through 2022 that was not required for regulatory compliance or that were not needed for health and safety. In response to Sierra Club discovery in that case, PNM stated it was cancelling two projects it had previously planned: San Juan Common C&D Coal Reclaim System (ID# 76617317) and San Juan Common Auxiliary Boiler (ID# 76616917).[29] The actions of PNM and the other co-owners (except for Farmington) are consistent with common sense and what I have seen other utilities do: they stop spending money on major maintenance projects in the years leading up to an expected retirement date. For example, at the Navajo Generating Station, by May 2017, the Salt River Project (SRP) and the other Navajo Generating Station owners already had started to plan to reduce their maintenance spending to prepare for the plant's announced retirement in December 2019. SRP has said that the amount of deferred maintenance for all three units at NGS was about $132 million, or $44 million per unit.[30] Although the precise cost of such deferred maintenance at SJGS is unknown and would be specific to SJGS, this suggests that any owner(s) of SJGS who would try to continue to operate SJGS past 2022

[29] *See* PNM's Response to Discovery Request SC-5 in Docket No. 16-00276.
[30] Arizona Republic, "10 Obstacles to keeping the Navajo coal plant open," May 22, 2017, *available at* https://www.azcentral.com/story/money/business/energy/2017/05/22/arizona-10-challenges-keeping-navajo-generating-station-open/332911001/.

would have to pay a significant amount for maintenance work that previously would have been deferred by the current owners.

Q. What would be the risk if the owner(s) of SJGS tried to continue operating SJGS past 2022 but failed to pay for this deferred maintenance?

A. There would be a heightened risk of future equipment degradation and breakdowns, and more frequent and longer plant outages and deratings. This would both make it more expensive to operate and maintain the plant in the future and more difficult to achieve the higher capacity factors that will be needed to obtain the tax credits promised to investors.

Q. What is your conclusion about the likely operating performance of SJGS if the plant were retrofitted for carbon capture?

A. In their pre-feasibility analyses, Enchant and S&L assume that the operating performance of SJGS, which has averaged a 70% capacity factor over the past decade, will improve dramatically after being retrofit for carbon capture, and will average an 85% or higher annual capacity factor for an entire twelve year period. This assumption is extremely unrealistic. It is far more likely that SJGS's post-retrofit average annual capacity factors, at best, would fall somewhere around 70%, which would reflect the plant's long-term operating performance and the results of PNM's recent modeling analyses.

Q. Is it possible that the plant's operating performance could be even worse than this?

A. Yes. As a result of the factors I have discussed above, PNM (or Enchant's investors and the new SJGS owner(s)) would be exposed to the not-insignificant

risk that the plant's operating performance could be worse than an average 70% capacity factor. In fact, as demonstrated in Figure 1 and Tables 1 and 2, the SJGS's average capacity factor between January 2018 and October 2019 was only 63%.

Q. How many existing coal-fired generators actually have achieved 85% capacity factors in recent years?

A. It has been extremely rare in recent years that a coal-fired generator has achieved an 85% capacity factor in a single year, let alone over several years. In fact, only thirteen of the 390 coal-fired units in operation in 2018, or barely three percent, achieved 85% or higher capacity factors in 2018. Fifty seven units, or four times as many, failed to achieve even a 30% capacity factor in the same year.[31] Similarly, only four of the 390 coal-fired generators operating in 2018, or just one percent, achieved 85% or higher average capacity factors during the four-year period 2015 to 2018. Only 10 units had average capacity factors of 80% or higher. At the same time, 36 units had average capacity factors of 30% or lower during the same period.

[31] Source: EIA Form 923 data downloaded from S&P Global Market Intelligence on November 5, 2019.

B. 90% CO_2 Capture Has Not Been Proven.

Q. What assumptions regarding carbon capture do Enchant Energy and S&L make in their efforts to promote the retrofit and continued operation of SJGS?

A. Enchant and S&L claim that for an extended number of years, SJGS will: (1) capture 90% of the CO_2 it produces; and (2) that the carbon capture facility will operate at an 85% annual capacity factor, the same as the overall plant.

Q. Is there any publicly available evidence that this capture rate and capacity factor have been achieved by the carbon capture facilities at either Petra Nova or Boundary Dam on a consistent basis?

A. No. Despite claims that Petra Nova has captured 90% of the CO_2 it produces, there has been extremely little data provided to support these assertions and, at most, it appears that the carbon capture facility has only achieved this goal on a sporadic or intermittent basis. There is no evidence that Petra Nova has consistently achieved a 90% capture rate while operating at an 85% capacity factor over an extended period of time, contrary to claims by Enchant and S&L that these plants have demonstrated or proven 90% capture.[32]

Q. Has Petra Nova captured as much CO_2 as the owners projected when the carbon capture facility entered service at the end of December 2016?

A. No. Petra Nova was designed to capture "at least" 90% of the CO_2 from a 240 MW equivalent slip stream from the flue gas emitted by the 654 MW coal-fired

[32] Enchant Energy Corporation, Response to Institute for Energy Economics and Financial Analysis Report dated July 2019, at page 2.

W.A. Parish Unit 8. This has been variously translated into an expectation that Petra Nova would capture somewhere 1.6 million tons of CO_2 (that is, approximately 1.4 million metric tonnes) or about 33% of the total emissions from Unit 8, each year.[33]

Unfortunately, NRG and JX Nippon, the co-owners of the plant, have not regularly issued detailed reports on the amounts of CO_2 captured at Petra Nova. However, representatives from the company and from the U.S. DOE (which supplied $190 million of the $1 billion cost of the project) have made various public presentations in which they made claims about how much CO_2 had been captured. For example, the owners have claimed that Petra Nova captured (1) 1.0 million tons of CO_2 between its start of operations in January 2017 and October 2017[34]; (2) 2.4 million tons by December 2018; and (3) 3.9 million tons by December 2019.[35]

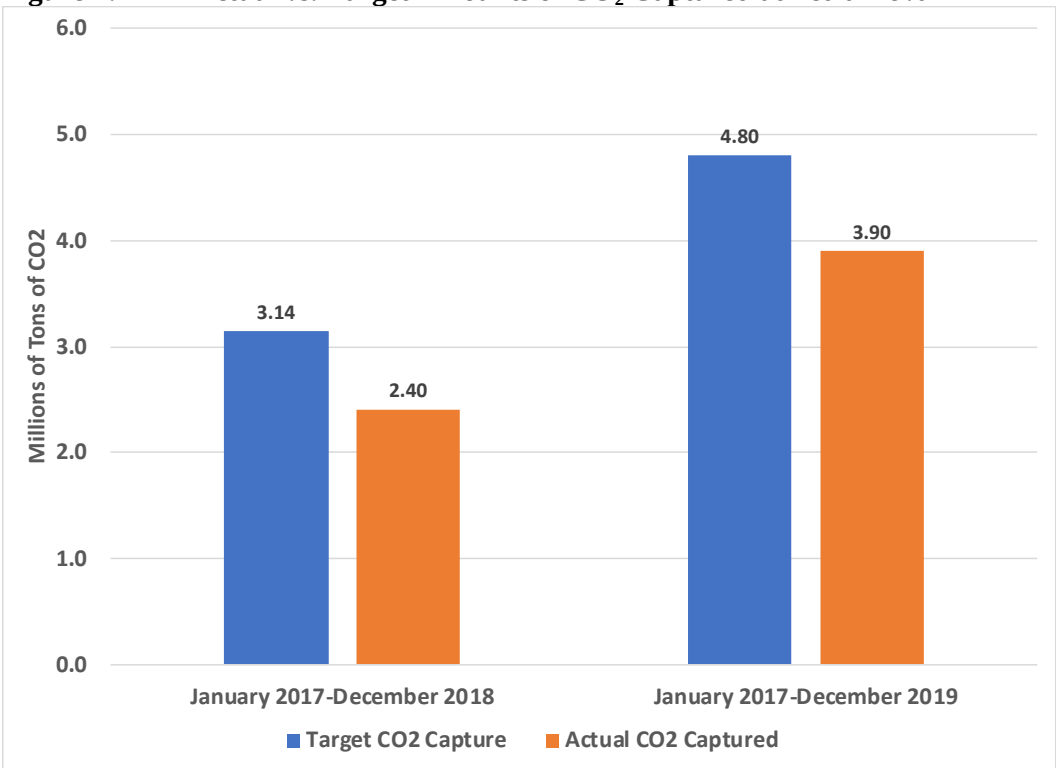
As shown in Figure 4, below, these amounts of captured CO_2 are significantly below what the owners originally projected for the carbon capture facility when it went into service:

[33] W.A. Parish Post-Combustion CO_2 Capture and Sequestration Project, Topical Report at 3, *available at* https://www.osti.gov/biblio/1344080-parish-post-combustion-co2-capture-sequestration-project-final-public-design-report; EIA, Today in Energy, Petra Nova is one of two carbon capture and sequestration power plants in the world, (Oct. 31, 2017), *available at* https://www.eia.gov/todayinenergy/detail.php?id=33552; National Energy Technology Laboratory, W.A. Parish Post-Combustion CO_2 Capture and Sequestration Project (Sept. 2012), available at https://www.netl.doe.gov/sites/default/files/environmental-policy/deis-sept/EIS-0473D_Summary.pdf.

[34] *DOE-Supported Petra Nova Captures More Than 1 Million Tons of CO_2*.

[35] Testimony of Greg Kennedy, NRG, before the U.S. House of Representatives Committee on Science, Space, and Technology, November 22, 2019 and *Happy Third Operating Anniversary, Petra Nova*, January 10, 2020, U.S. Department of Energy, Office of Fossil Energy.

Figure 4: Actual vs. Target Amounts of CO_2 Captured at Petra Nova



Source: STC analysis.

Thus, Petra Nova captured 900,000 tons less CO_2 during its first three years of operation despite the fact that Parish Unit 8 actually generated more power and, almost certainly, produced more CO_2, than it had in previous years.[36]

Q. Do the amounts of CO_2 that the owners claimed to have captured at Petra Nova reflect all of the CO_2 produced at the carbon capture facility?

A. No. Unlike the proposed retrofit of SJGS, the power to run the CO_2 capture equipment at Petra Nova is provided by a dedicated natural gas-fired combustion turbine. If the more than 1 million tons of CO_2 emitted by the CT between

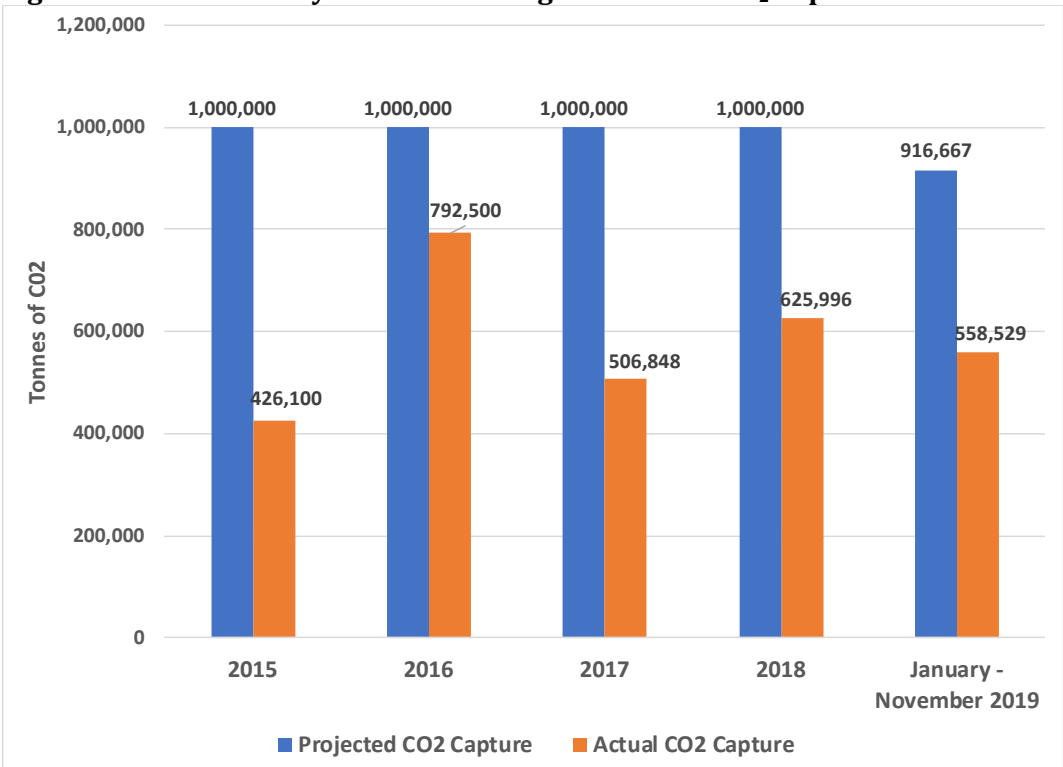
[36] *See* Figure 6, below.

January 2017 and November 2019 were included, the net amount of CO_2 captured at Petra Nova would be only 2.5 to 2.6 million tons.

Q. Has Boundary Dam 3 captured as much CO_2 as the owner SaskPower projected it would?

A. No. The carbon capture system at the 110 MW Boundary Dam Unit 3 in Saskatchewan, Canada, began operating in October 2014. Although the system was designed to capture 1 million tonnes a year reflecting a 90% capture rate, it has consistently captured far less CO_2 than projected.

Figure 5 Boundary Dam Unit 3 Target vs. Actual CO_2 Capture



Source: SaskPower, BD3 Status Updates.[37]

In fact, the plant's carbon capture system only operated at its design capacity of 3200 tonnes per day on 3 days through early 2018.[38]

Consequently, Boundary Dam Unit 3 actually did not capture 3 million metric tonnes of CO_2 until November 4, 2019 even though it was originally anticipated that it would capture that much by October or November 2017, two years earlier.

[37] The most recent update is available at https://www.saskpower.com/about-us/our-company/blog/bd3-status-update-November-2019. Previous updates containing information on CO_2 captured in prior years are available at SaskPower's blog.

[38] *Boundary Dam 3: Upgrades, updates and performance optimization of the world's first fully integrated CCS plant on coal*, presented by Corwin Bruce from the International CCS Knowledge Centre at the 2019 Clean Coal Technologies Conference on June 5, 2019. The International CCS Knowledge Centre is 50% owned by SaskPower, the owner of Boundary Dam Unit 3.

Q. LANL has said that there are several possible explanations for why Petra Nova and Boundary Dam 3 have captured less CO_2 than originally projected.[39] Do you agree?

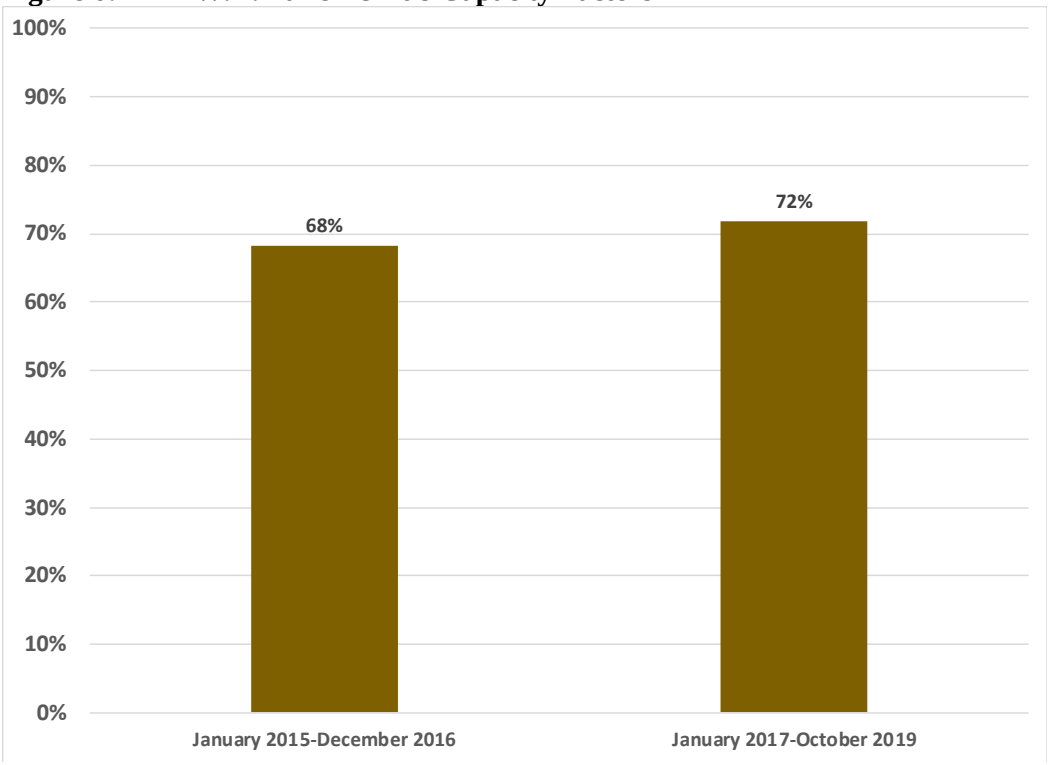
A. Yes. The shortfall between the projected and actual amounts of CO_2 captured at either Petra Nova and Boundary Dam 3 could have been due to (1) each plant actually produced less CO_2 than expected (i.e., had lower capacity factors) or (2) less CO_2 was processed by the carbon capture systems at each plant which, in turn could have been the result of either (a) operating problems with the carbon capture equipment or (b) conscious decisions by ownership to capture less CO_2 by not running the carbon capture equipment during all times that the plant is operating.

Q. Is there any evidence that W.A. Parish Unit 8 has been producing less CO_2 after January 2017 because the unit has been operating less?

A. No. Figure 6, below, shows that Parish Unit 8 actually has had a higher capacity factor since January 2017 than it did in the previous two years. Thus, it is reasonable to expect it actually produced more CO_2 after Petra Nova went into service than before.

[39] *LANL Preliminary Assessment*, at pages 11 and 12.

Figure 6: W.A. Parish Unit 8 Capacity Factors



Sources: EIA Form 923 data, downloaded from S&P Global Market Intelligence.

Q. Have you seen any evidence as to how much of the shortfall in CO_2 capture at Petra Nova is due to problems with the carbon capture facility versus a conscious decision by the plant's owners to capture less CO_2?

A. No. That would require the detailed operational data which Petra Nova's owners have failed to make public.

Q. Are you nevertheless able to estimate what CO_2 capture rate has been achieved at Petra Nova?

A. Yes.

Q. Please explain how you have made this calculation.

A. As I noted earlier, the power to run the Petra Nova carbon capture facility is provided by a dedicated combustion turbine. It is possible to estimate Petra

Nova's CO_2 capture rate by comparing Parish Unit 8's CO_2 intensity in those hours during which the combustion turbine was generating electricity beginning with the start of operations of the carbon capture facility in January 2017 with the Unit 8's CO_2 intensity in the years prior to 2017. After all, Petra Nova could not have been capturing CO_2 when the combustion turbine was not providing power.

Q. What is the data source you used in making this calculation?

A. Both Parish Unit 8 and the dedicated carbon capture combustion turbine are required to have Continuous Emissions Monitoring (CEM) systems that record their hourly gross generation and CO_2 emissions. This CEM data is available to the public on the EPA's Air Markets Program database.[40]

Q. Isn't it possible that the combustion turbine generated power in hours when Petra Nova was not operating?

A. That is possible. However, it appears from the CEM data that Unit 8 was generating electricity in almost every single hour between January 1, 2017 and September 30, 2019 during which the combustion turbine also was running and that there were very few hours during which the combustion turbine ran without Unit 8 also being in operation. Consequently, without any data from the plant owners to the contrary, it is reasonable to use those hours when the combustion turbine was in operation as a proxy for when Petra Nova was in operation.

[40] https://ampd.epa.gov/ampd/

Q. What are the results of your analysis of the CEMs data for Parish Unit 8?

A. The CEM data suggests that Petra Nova achieved an average capture rate of about 80-82% between January 1, 2017 and September 30, 2019 during times when the carbon capture equipment was in operation.

Q. Does this reflect the CO_2 emissions from the dedicated combustion turbine used to power Petra Nova?

A. No. If the approximately one million tons of CO_2 emitted from the combustion turbine are included, the net capture rate for Petra Nova for the period would have been below 60%.

Q. During how many hours in the period January 1, 2017 through September 30, 2019 did the combustion turbine generate power?

A. The combustion turbine and, it is reasonable to assume, the carbon capture Petra Nova facility, were in operation 17,510, or 73% of the 24,072 hours in this period. This is 6,365 hours per year, on average. Parish Unit 8 generated power in 21,398 hours in the period, of which 17,510 hours coincided with the combustion turbine.

Q. How does the average 6,365 hours that Petra Nova has been in operation per year compare with the number of hours that Enchant and S&L are assuming that the SJGS carbon capture facility would be running?

A. Enchant and S&L are assuming that the SJGS carbon capture facility will operate at the same 85% annual capacity factor as the balance of the plant. This means it would be running for somewhere between 7,446 hours (assuming it is at full load for those hours) and all 8,760 hours of the year (at an average of 85% load).

Either way, that would be longer than the average yearly operation of Petra Nova, to date.

Q. Have you seen any evidence as to the gross generation at Boundary Dam 3 before and after it was retrofitted for carbon capture?

A. No.

Q. Is it possible that some of the shortfall in the amount of CO_2 captured at Boundary Dam 3 is due to operating issues unrelated to the CO_2 capture facility?

A. Yes. Boundary Dam 3 has had significant issues with the CO_2 capture facility that have adversely impacted its ability to capture emissions and led to increased maintenance costs and plant downtime. For example, the carbon capture facility of the plant worked only about 40% of the time in much of 2014 and 2015 with the facility being shut down for a nearly two-month maintenance outage in the fall of 2015.[41] And the facility was shut down for 96 days in 2017 to complete projects designed to improve its operational performance and reliability.[42] SaskPower has said that the cost of fixing Boundary Dam 3's carbon capture flaws cost CAN$32 million in the years 2015 and 2016 and estimated that it was going to cost another CAN$15 million in 2017.[43]

[41] *Carbon Capture and Sequestration @ MIT* and *SaskPower's 2015-2016 Annual Report* at 59.
[42] *SaskPower's 2017-2018 Annual Report* at 36.
[43] CBC News, "SaskPower looking for help to fix 'high cost' Boundary Dam carbon capture flaw," May 28, 2018, *available at* https://www.cbc.ca/news/canada/saskatchewan/saskpower-looking-for-help-to-fix-high-cost-boundary-dam-carbon-capture-flaw-1.4680993.

Boundary Dam 3 also has experienced plant outages that were unrelated to its CO_2 capture system. However, these outages account for only part of the plant's failure to capture one million tonnes of CO_2 each year.

For example, SaskPower has claimed that 2018 was a strong year for carbon capture and storage at the Boundary Dam 3 Station, saying that the plant would have captured more than 625,996 tonnes of CO_2 in the year if it had not be shut down for 84 days due to a strong storm and massive power outage.[44] However, in the unlikely event that Boundary Dam had actually captured CO_2 at its maximum daily rate of 3,200 tonnes (a goal it achieved for just 3 days in its first 40 months after being retrofitted) for all of the 84 days of this outage, the plant's CO_2 capture rate still would have been only 80%, not 90%.

Q. Is there evidence that another reason for the shortfall in CO_2 capture at Boundary Dam was that capturing more CO_2 was not economic?

A. Yes. A 2019 presentation, *Derate Analysis for SaskPower's Boundary Dam Unit 3 During the First Four Years of Operation*, noted that:

> The capture facility at SaskPower's Boundary Dam Unit 3 (BD3), commenced operations in October of 2014 and continues to operate today. During this approximately four and a half year operating period, the capture facility has experienced increasingly improvement reliability and increased ability to theoretical maximum capture rate as shown in Figure 1. *There exists a disconnect between the installed capacity (design capacity) and achieved capacity of the capture plant. The disconnect is partly the*

[44] SaskPower, Press Release, "Strong Year for Carbon Capture and Storage at Boundary Dam Power Station," January 22, 2019, *available at* https://www.saskpower.com/about-us/media-information/news-releases/Strong-year-for-carbon-capture-and-storage-at-Boundary-Dam-Power-Station.

result of the limited economic incentives to capture beyond the delivery demand of the CO_2 off-taker. (Emphasis added)[45]

Q. Have you seen any evidence that Mr. Solomon, Mr. Griffey, Mr. Schiffman, or Enchant and S&L have analyzed the impact that post-retrofit plant outages, needed upgrades, or higher CO_2 capture O&M costs would have on the financial viability of the retrofit they are proposing for SJGS?

A. No.

Q. Based on your testimony so far, should a retrofitted SJGS be expected to capture substantially less than six million tonnes of CO_2 per year, on average?

A. Yes. This conclusion is based on (1) the fact that no commercial-scale power plant has achieved 90% CO_2 capture over any significant period of time and (2) SJGS' actual operating performance and the results of PNM's recent computer modelling showing annual capacity factors for SJGS of approximately 70% after the proposed carbon capture retrofit.

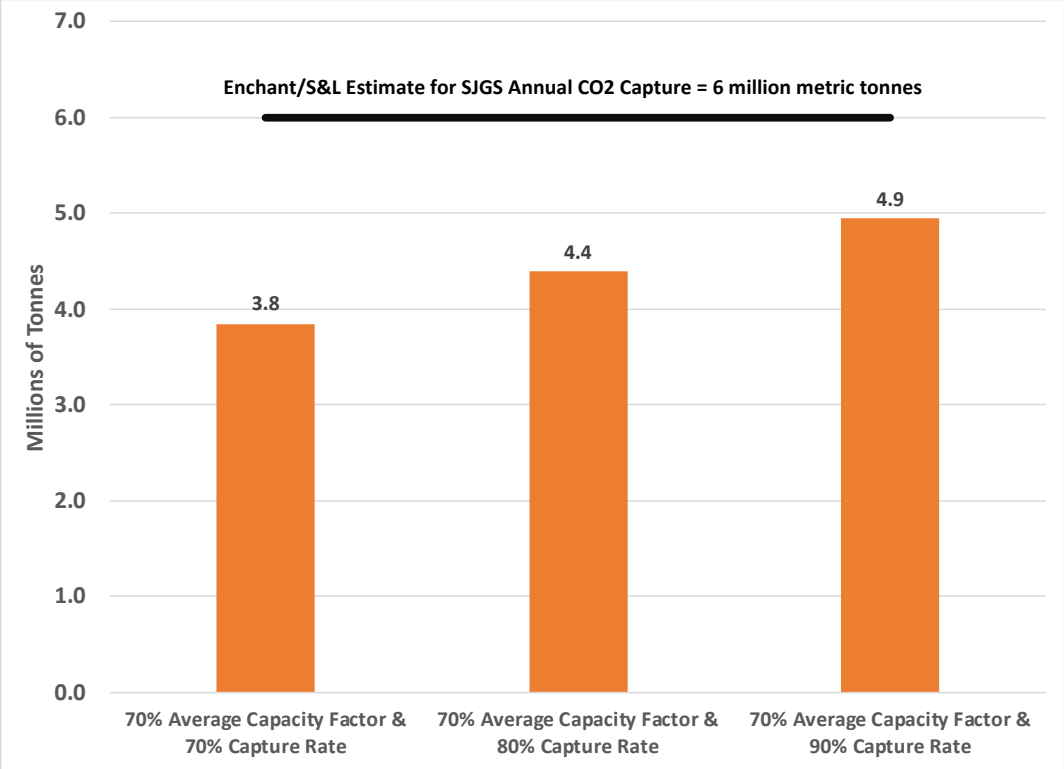
Q. Realistically, how much CO_2 do you think the carbon capture system at SJGS would capture each year, on average?

A. Based on the evidence I have reviewed, and the analyses I have discussed earlier, a retrofitted SJGS should be expected to capture no more than 3.8 to 4.9 million tonnes of CO_2 per year. And even that assumes that there are no significant issues

[45] *Derate Analysis for SaskPower's Boundary Dam Unit 3 During the First Four Years of Operation*, presented at the IEAGHG 5th Post Combustion Capture Conference, 17-19th September 2019.

encountered in scaling up the capture technology from the 240 MW-equivalent Petra Nova project to the proposed 914 MW SJGS project.

Figure 7: Tonnes of Captured Carbon that Can Be Expected from a Retrofitted SJGS



Source: STC Analysis based on methodology from Appendix E in S&L July 8, 2019 Pre-Feasibility Study.

Q. Why does the amount of CO_2 captured by SJGS matter to the financial feasibility of the proposed carbon capture project?

A. The amount of CO_2 that is captured is critical to the project's financial feasibility because it affects both the tax credits for which the project would be eligible and the revenue that would be generated from selling the captured CO_2.

Q. What is the significance of projecting that SJGS would only be able to capture 3.8 to 4.9 million metric tonnes a year instead of the 6.0 million tonnes that Enchant claims?

A. Capturing less CO_2 will mean that SJGS will generate less revenue from the sale of the CO_2 for enhanced oil recovery. Similarly, capturing less CO_2 will mean that the project will be eligible for far fewer 45Q tax credits. This, in turn, will mean that additional funds will have to be borrowed to pay for the retrofitting of SJGS. This will raise both the total capital cost of the retrofit and the cost per metric tonne of capturing CO_2, as I will describe in detail later in this testimony.

Q. Have you evaluated how much additional funding would be required?

A. Yes. Because of the significant uncertainty associated with the future performance of SJGS and the cost of retrofitting CO_2 capture, I have looked at nine scenarios (plus Enchant's Base Case) that reflect:

- A 70% annual capacity factor.
- CO_2 capture rates of 90%, 80% and 70%.
- Capital costs in 2023 dollars that range from a low capital cost of $1.40 billion (representing the 2019 S&L estimated cost); a mid-capital cost of $2.21 billion (representing 50% of the cost of building Petra Nova); and a high capital cost of $3.31 billion (representing 75% of the actual Petra Nova cost.

Q. What discount rate have you used in this analysis to calculate the present value of the 45Q tax credits that investors in the SJGS retrofit could expect to receive?

A. Based on the recommendation of David Posner's testimony in Case No. 19-00018-UT, I have used a 15% discount rate.

Q. What is the 45Q tax credit?

A. As witness David Posner describes in greater detail in his testimony in Case No. 19-00018-UT, the 45Q tax credit refers to federal tax credits available to certain carbon capture and sequestration projects.

Q. What capital costs do Enchant and S&L estimate for the CO_2 capture retrofit project at SJGS?

A. S&L estimates a capital cost of approximate $1.295 billion, in 2019 dollars, to retrofit SJGS with CO_2 capture technology.[46] This is $1,417 per kW.

Q. What are the results of your analysis?

A. Table 3, below, shows the percentages of the capital cost of retrofitting SJGS that can be expected to be obtained through tax equity financing from 45Q credits and the percentage of the estimated capital costs that would have to be funded from other sources in each of the scenarios I have examined.

[46] *Appendix E in S&L's July 8, 2019* CO_2 *Capture Pre-Feasibility Study, available at* https://www.enchantenergy.com/wp-content/uploads/2019/07/Enchant-Energy_SJGS-CO2-Pre-feasibility-Study_FINAL-Rev-0-7-8.pdf.

Table 3
SJGS Retrofit Financing

Scenario Assumptions		Percentage of Estimated Capital Cost that Could Be Funded through 45Q Credits	Percentage of Estimated Capital Cost that Would Have to Obtained Through Non-45Q Funding
Corrected Enchant & S&L Proposal	$1.40 Billion Capital Cost, 85% CF & 90% CO_2 Capture Rate	81%	19%
Scenario 1	$1.40 Billion Capital Cost, 70% CF & 90% CO_2 Capture Rate	67%	33%
Scenario 2	$1.40 Billion Capital Cost, 70% CF & 80% CO_2 Capture Rate	59%	41%
Scenario 3	$1.40 Billion Capital Cost, 70% CF & 70% CO_2 Capture Rate	52%	48%
Scenario 4	$2.21 Billion Capital Cost, 70% CF & 90% CO_2 Capture Rate	43%	57%
Scenario 5	$2.21 Billion Capital Cost, 70% CF & 80% CO_2 Capture Rate	38%	62%
Scenario 6	$2.21Billion Capital Cost, 70% CF & 70% CO_2 Capture Rate	33%	67%
Scenario 7	$3.31 Billion Capital Cost, 70% CF & 90% CO_2 Capture Rate	28%	72%
Scenario 8	$3.31 Billion Capital Cost, 70% CF & 80% CO_2 Capture Rate	25%	75%
Scenario 9	$3.31 Billion Capital Cost, 70% CF & 70% CO_2 Capture Rate	22%	78%

Q. Why is the first row of Table 3 described as the "Corrected Enchant & S&L Proposal?"

A. Appendix E in S&L's July 8, 2019 *CO_2 Capture Pre-Feasibility Study* lists the Total Project Cost as $1.295 billion.[47] On page 5-3 of the same document, this cost is clearly presented as being in 2019 dollars. However, the earliest date Enchant offers for the restart of SJGS after the retrofit is mid-2023.[48] Therefore, I have corrected the S&L analysis by converting the estimated S&L total project cost to $1.40 billion in 2023 dollars.

Q. What do you conclude from Table 3?

A. The S&L Base Case is completely unrealistic because the project is extremely unlikely to achieve either an 85% average annual capacity factor or a 90% CO_2 rate. In addition, as I will explain in the next section, the project's capital cost will

[47] https://www.enchantenergy.com/wp-content/uploads/2019/07/Enchant-Energy_SJGS-CO2-Pre-feasibility-Study_FINAL-Rev-0-7-8.pdf.
[48] Enchant Energy, Carbon Capture Retrofit of San Juan Generating Station Presentation to San Juan County Community at Slide No. 12 (July 16, 2019), , *available at* https://www.enchantenergy.com/wp-content/uploads/2019/07/Enchant-SJGS-Presentation-to-San-Juan-Community-July-2019.pdf.

very likely exceed S&L's $1.295 billion estimate (in 2019 dollars). But even with these unrealistic assumptions, tax equity financing would likely be able to provide only about 81% of the funds needed to retrofit SJGS with carbon capture. The remaining funding would have to come from other sources and place additional demands on the revenue streams from plant operation that have not been considered in the prefeasibility S&L study..

In scenarios with more realistic assumptions, at least 41% of the cost of retrofitting SJGS for carbon capture would have to be raised from what likely would be even more expensive sources.

IV. Retrofitting SJGS for CO_2 Capture is Likely to be Much More Expensive than Enchant and S&L Have Claimed.

Q. What is your response to Mr. Solomon's reference to a December 3, 2019 Memorandum of Understanding (MOU) between several companies, Enchant, and Farmington regarding a potential CCS project at San Juan?

A. I do not see how that MOU is relevant. The MOU merely indicates that various companies will work on developing a price for a potential carbon capture project at San Juan. The MOU does not say what that price will be. Most importantly, the MOU does not indicate if the price will make it economic for Enchant, PNM, or anyone else to actually go through with a carbon capture project at San Juan.

Q. Is there any evidence that the actual costs for carbon capture have declined?

A. No. In 2019, Sargent and Lundy provided capital cost *estimates* for carbon capture that are lower than the estimates it provided in 2010. However, the mere fact that the more recent 2019 S&L report estimates a lower capital cost for

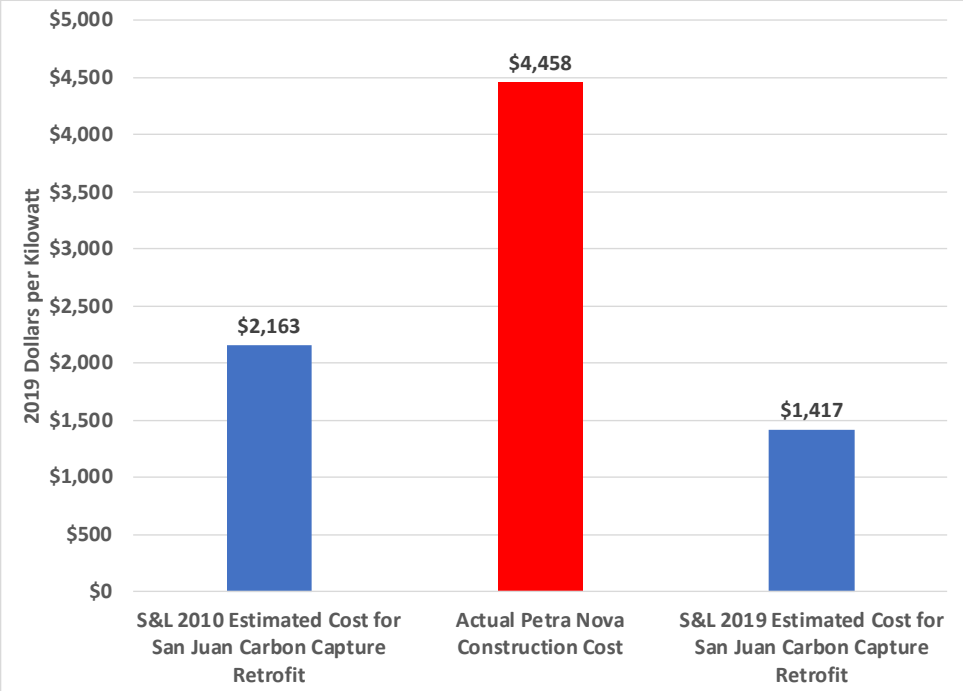
retrofitting SJGS for CO_2 capture does not offer any proof that the actual cost of retrofitting the plant will be any lower than S&L estimated in 2010. At the same time, the lower 2019 S&L capital cost estimate also provides no guarantee that the actual cost of retrofitting SJGS, in fact, will not be higher than S&L estimated back in 2010.

Q. How do S&L's 2010 and 2019 estimated capital costs for retrofitting SJGS with CO_2 capture compare with the actual capital cost of the Petra Nova project, which was built in the years 2014 to 2016?

A. The actual cost of building Petra Nova was $1 billion, or $4,200 per kW for a 240 MW facility.[49] Figure 8 below shows that this was substantially more expensive than S&L estimated in both 2010 and 2019 for the cost of retrofitting SJGS.[50] This is approximately three times the cost estimate from S&L that Mr. Solomon relies upon.

[49] EIA, Today in Energy, "Petra Nova is one of two carbon capture and sequestration power plants in the world," (Oct. 31, 2017), available at https://www.eia.gov/todayinenergy/detail.php?id=33552.
[50] Note that the actual $4,200 per kW cost of Petra Nova and both the 2010 S&L estimate in Figure 13 have been converted to 2019 dollars to be on a comparable basis as the 2019 S&L estimate.

Figure 8: Actual Petra Nova Cost vs. S&L Estimates for Retrofitting SJGS with CO_2 Capture



Source: Analysis based on costs from EIA Today in Energy for October 31, 2017 and Exhibits DS-1 and DS-2 to the Prepared Direct Testimony of Dhiraj Solomon in Case No. 19-00018-UT.

Figure 8 shows that the actual cost of designing and building the only existing commercial-scale CO_2 capture project in the U.S. was significantly higher, on a per kW basis, than S&L estimated for retrofitting SJGS in both 2010 and 2019.

Q. What does the comparison shown in Figure 8 say about the reasonableness of the S&L 2019 cost estimate for retrofitting SJGS?

A. The theory underlying the development of new technologies, such as carbon capture at commercial scale power plants, is that, over time, lessons learned from the construction and operation of new plants will drive down the prices for building and running each successive unit.

For example, the cost of installing new utility-scale solar capacity declined by 2/3 between 2007-2009 and 2017, as a result of the lessons learned in the building

and installation of 24.7 GW of new solar capacity.[51] Similarly, the prices of installing new wind capacity fell by 40% between 2009/2010 and 2018, as a result of the lessons learned during the installation of 56 GW of new wind capacity.[52] However, carbon capture technology today is not like solar and wind technology. Solar and wind prices declined because of many factors, including significant research and development, robust competition among suppliers, and an extremely large number of commercial projects around the world. By contrast, there are only two carbon capture projects at power plants in the entire world. Unlike the situation for solar and wind technologies, there are not a large number of projects either operating, under construction, or in the pipeline that could be expected to drive down costs before the retrofit of SJGS is under way.

Moreover, instead of assuming that the cost of retrofitting new carbon capture technology to existing coal-fired generators would decline over time, Enchant and S&L assumed that the cost of retrofitting SJGS with CO_2 capture, the very next commercial-scale power plant in the U.S. to be retrofitted with carbon capture technology, would immediately be 68% lower (on a dollar per kW basis) than the cost of building the Petra Nova plant in Texas.

[51] Lawrence Berkeley National Laboratory, Utility-Scale Solar – Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States – 2018 Edition, (Sept. 2018), *available at* https://www.researchgate.net/publication/327607147_Utility-Scale_Solar_Empirical_Trends_in_Project_Technology_Cost_Performance_and_PPA_Pricing_in_the_United_States_-_2018_Edition.

[52] U.S. Department of Energy, 2018 Wind Technologies Market Report, (Aug. 2019), *available at* https://www.energy.gov/sites/prod/files/2019/08/f65/2018%20Wind%20Technologies%20Market%20Report%20FINAL.pdf.

It is possible that the cost of retrofitting SJGS with CO_2 capture will achieve some cost savings from (1) the experience gained at Petra Nova, (2) the reuse of facilities at SJGS and (3) economies of scale. However, it also is quite possible that unanticipated problems will be experienced in scaling up the CO_2 capture technology from the 110 MW Boundary Dam and the 240 MW Petra Nova projects to the much larger 914 MW SJGS.

Q. Are there any other CO_2 capture projects currently being built at commercial-scale power plants in the U.S. or that can otherwise be expected to come online before the proposed retrofit of SJGS?

A. No, I have not seen evidence of any such projects.

Q. Did Petra Nova gain any cost-related benefits that would not be available to a company such as Enchant or PNM that tried to retrofit SJGS with carbon capture?

A. Yes. The U.S. Department of Energy provided $190 million of the $1 billion cost of building Petra Nova. In addition, approximately 30% of the financing for the project was insured by Nippon Export and Investment Insurance.[53] Both of these factors reduced the total cost of the project. There is no evidence in any witness' direct testimony that similar funding would be available to retrofit SJGS with carbon capture.

[53] Noriaki Shimokata, JX Nippon Oil & Gas Exploration Corporation, "Petra Nova CCUS Project in USA," (June 8, 2018), *available at* https://d2oc0ihd6a5bt.cloudfront.net/wp-content/uploads/sites/837/2018/06/Noriaki-Shimokata-Petra-Nova-CCUS-Project-in-USA.pdf.

Q. Did the 2019 S&L cost estimate for SJGS exclude any significant costs?

A. Yes. S&L's 2019 $1.295 billion capital cost for retrofitting SJGS excluded escalation, AFUDC, right of way and land purchase costs, and site security.[54]

Q. Have you seen any CO_2 retrofit cost estimates that would suggest a higher capital cost for the SJGS retrofit?

A. Yes. For example, the International Energy Agency, an active advocate for carbon capture, has estimated that the next generation of power plant CCS projects (that is, those after Petra Nova) will achieve 25 to 30 percent reductions in both capital and operating costs.[55] NARUC has noted that the IEA's projected reductions in the next generation of power plant CCS reductions, "…support the idea that costs will come down with more facilities."[56]

Similarly, the Clean Air Task Force (CATF), also an active advocate of CCS, believes that the capital cost of retrofitting existing coal plants for CCS will come down over time as later retrofits "benefit from the prior experience of the earlier projects."[57] CATF estimated that the capital cost for retrofits would decline to a range of $1,501 to $1,724 per kW by the sixth new project undertaken. However, the SJGS project, would be only the third carbon capture project at a power plant, not the sixth project, as CATF was discussing. And even CATF's cost estimate

[54] Exhibit DS-1 to the Prepared Direct Testimony of Dhiraj Solomon in Case No. 19-00018-UT, Appendix D.
[55] NARUC, Carbon Capture, Utilization, and Storage: Technology and Policy Status and Opportunities at 47 (Nov. 2018), *available at* https://pubs.naruc.org/pub/03689F64-B1EB-A550-497A-E0FC4794DB4C.
[56] *Id.*
[57] CATF, Carbon Capture & Storage in the United States Power Sector: The Impact of 45Q Federal Tax Credits at 24-25 (Feb. 2019), *available at* https://www.catf.us/wp-content/uploads/2019/02/CATF_CCS_United_States_Power_Sector.pdf.

for the sixth carbon capture project is higher than the $1,417 per kW that S&L assumes for SJGS, which as I've noted, would be just the third CO_2 retrofit undertaken at a commercial-scale power plant.

Q. Is there currently a fixed price contract for the retrofitting of SJGS?

A. No. A Memorandum of Understanding has been disclosed, but all this means is that the parties have agreed to talk about a fixed price contract. Based on the information I have seen, there does not appear to be an agreement about the "fixed price" for the retrofit, or what costs would be included in the fixed price or what costs would be outside of the contract, or any of the contract terms and details.

Q. What capital cost would be prudent to use to evaluate a proposed retrofit of SJGS with CO_2 capture?

A. Given the great uncertainty regarding the likely capital cost of retrofitting SJGS, it would be prudent to look at a fairly wide range of capital costs. For example, I would recommend looking at a range from a low cost of $1.40 billion (S&L's 2019 estimate in 2023 dollars) to a high cost of $3.31 billion (25% lower than Petra Nova) with a middle cost of $2.21 billion (50% of Petra Nova), all in 2023 dollars.

The low end of these costs represents S&L's 2019 estimate, on a per kW basis, escalated to 2023 dollars. The high end represents a 25% reduction in the actual capital cost of the Petra Nova project, again in 2023 dollars – this reflects the savings that the International Energy Administration has estimated can be

expected in the next generation of power plant CCS projects. [58] Finally, the middle cost reflects a reduction of 50% of the actual Petra Nova capital cost. It is important to emphasize that these costs are conservative and do not represent in any sense a "worst case" scenario in which significant unanticipated difficulties are encountered in scaling-up CO_2 capture technology to the much larger 914 MW SJGS project, which could lead to an even higher cost than Petra Nova.

V. It is Unlikely that a Retrofit of SJGS Could be Completed and Come Online before 2024.

Q. What in-service date has Enchant claimed it will be able to achieve for a retrofitted SJGS?

A. Enchant claims that the retrofit of San Juan with CCS could be financed, designed, the carbon capture system competitively bid, constructed, and pre-operationally tested in less than four years, with an online date in June 2023, if the project can be financed by mid-2020.[59]

Q. Do you agree that this schedule is reasonable?

A. No. Enchant's claim about a mid-2023 in-service date is unreasonably optimistic. There simply is too much to do to be able to have the project online so quickly.

[58] NARUC, Carbon Capture, Utilization, and Storage: Technology and Policy Status and Opportunities at 47 (Nov. 2018), *available at* https://pubs.naruc.org/pub/03689F64-B1EB-A550-497A-E0FC4794DB4C.
[59] Enchant Energy, *Carbon Capture Retrofit of San Juan Generating Station Presentation to San Juan County Community* at Slide No. 12 (July 16, 2019).

Q. Please explain the basis for your conclusion that it is unrealistic to assume the carbon capture retrofit can be completed and online at SJGS by mid-2023.

A. The FEED (Front End Engineering and Design) study for the retrofit of San Juan with carbon capture is still underway. Enchant's Project Management Plan for what it terms the "Large-Scale Commercial Carbon Capture Retrofit of the San Juan Generating Station" assumes that the final report for this study will not be submitted to the DOE until mid-April 2021.[60] Even if enough engineering were completed by mid-April 2021 to start some construction, that would leave only slightly more than two years to competitively bid the CO_2 capture system, order, fabricate and deliver system components, then construct and test the CO_2 capture retrofit before it went into service.

Q. How long did it take to design and build the Petra Nova CO_2 capture project?

A. The application for DOE funding for the 240 MW Petra Nova project was submitted in 2009, with the DOE grant awarded in 2011. This suggests that design for the project began at least three years before construction. S&L confirms this when it cites its experience working on the Petra Nova project from 2011 to 2017.[61]

[60] *Project Management Plan Large-Scale Commercial Carbon Capture Retrofit of the San Juan Generating Station, Enchant Energy* at 7 (May 9, 2019), *available at* http://ieefa.org/wp-ontent/uploads/2019/07/PMP-1.pdf.

[61] Sargent & Lundy, Enchant Energy, San Juan Generating Station – Units 1 & 4 CO_2 Capture Pre Feasibility Study at 1-2 (July 8, 2019), *available at* https://www.enchantenergy.com/wp-content/uploads/2019/07/Enchant-Energy_SJGS-CO2-Pre-feasibility-Study_FINAL-Rev-0-7-8.pdf.

The 240 MW Petra Nova project then began construction in the middle of 2014, and had an online date at the end of 2016, a construction schedule of approximately 2½ years.[62] Thus Petra Nova had a total project length of about six years, from the awarding of the DOE funding in 2011 to the online date in January 2017.

Q. Do you think it is realistic to assume that a carbon capture project at the 914 MW SJGS site can be completed in significantly less time than the smaller, 240 MW project at Petra Nova?

A. No. Enchant is claiming that it could design and build a much larger project (914 MW at SJGS versus 240 MW at Petra Nova) in less time, that is, under four years, than it took to design and build Petra Nova, which took six years.[63] However, it is extremely doubtful that Enchant and S&L's very aggressive June 2023 online date would allow adequate time for the successful completion of what would be a much larger CO_2 capture retrofit project.

PNM would be in a similar situation as Enchant if it were to try to retrofit SJGS with carbon capture, meaning that it is extremely unlikely PNM could bring carbon capture online at SJGS before 2024. Mr. Solomon provides no evidence that PNM (or anyone else) could complete a carbon capture project prior to 2024.

[62] Presentation by Petra Nova Parish Holdings on Petra Nova Carbon Capture at the June 2019 IEA Clean Coal Conference, at slide no. 3.
[63] Sargent & Lundy, Enchant Energy, San Juan Generating Station – Units 1 & 4 CO_2 Capture Pre-Feasibility Study at 3 (July 8, 2019), *available at* https://www.enchantenergy.com/wp-content/uploads/2019/07/Enchant-Energy_SJGS-CO2-Pre-feasibility-Study_FINAL-Rev-0-7-8.pdf.

Q. Does Enchant acknowledge that SJGS could return to service later than mid-2023?

A. Yes. Enchant has included some wiggle room in the projected online date by saying that the "plant could experience a 6-12 month shut-down before restart with [carbon capture]."[64] This appears to be based on a 30 to 36 month construction schedule and an additional 14-20 months to complete the Front End Engineering Design study.[65] This would mean an online date for the retrofitted San Juan plan in 2024, which, while still very aggressive, is more realistic than June 2023. This would mean an 18-24 month, or longer, shutdown between the end of 2022 and its restart with carbon capture in 2024 or later.[66]

Q. Is there any evidence in this case that carbon capture can be installed and operational prior to January 1, 2023, the deadline by which SJGS must meet a CO_2 emissions standard?

A. No, not that I have seen.

Q. Does Mr. Solomon recognize that SJGS must be shut down on January 1, 2023 if a carbon capture system is not operational on that date?

A. Yes, he does. Mr. Solomon admits that unless carbon capture technology is installed and operational at SJGS, the plant cannot meet the CO_2 emission

[64] *Id.*
[65] Enchant Energy Corporation, Response to Institute for Energy Economics and Financial Analysis report at 3, *available at* https://www.enchantenergy.com/wp-content/uploads/2019/07/Enchant-Energy-Corporation-response-to-Institute-for-Energy-Economics-and-Financial-Analysis-IEEFA-report-dated-July-2019.pdf.
[66] My understanding is that the Energy Transition Act requires SJGS to meet a CO_2 emission standard by January 1, 2023. If the carbon capture project does not come online by that date, and no variance or extension of the deadline is granted, then the plant would have to shut down until the carbon capture system is operational and the CO_2 performance standard can be met.

standard in the ETA that goes into effect on January 1, 2023 and must therefore shut down. Case 19-00018-UT, Exhibit DAS-2, D. Solomon Depo. Tr. at 35: 14-18, 39: 19 to 40: 20.

Q. By when does Enchant claim that it will have the funding in place for the SJGS retrofit?

A. Enchant makes contradictory assumptions about the schedule for developing the financing of the San Juan retrofit as it ties the achievement of a June 2023 online date to acquiring all of the needed financing of the project by June 2020.[67] However, Enchant apparently believes that it will be able to acquire all of the financing needed for the retrofit without demonstrating the financial viability of the project to potential investors as its project plan assumes that the "Feasibility of Coal Plant with CCUS" analysis won't be completed until April 2021, or nearly ten months after investors are expected to commit well over a billion dollars to the project.[68] This feasibility study "will determine if the project will move forward into final design and implementation" and would seem to be an important analysis that investors would want to evaluate before they commit to the project.[69]

[67] Enchant Energy, Carbon Capture Retrofit of San Juan Generating Station, Presentation to San Juan County Community at Slide 12 (July 16, 2019), *available at* https://www.powermag.com/wp-content/uploads/2019/08/final-enchant-sjgs-presentation-to-san-juan-community-july-2019.pdf.
[68] *Project Management Plan Large-Scale Commercial Carbon Capture Retrofit of the San Juan Generating Station, Enchant Energy* at PDF page 16 (May 9, 2019), *available at* http://ieefa.org/wp-content/uploads/2019/07/PMP-1.pdf.
[69] *Id*. at PDF page 10.

Q. Why is the date by which carbon capture at SJGS could come online so important?

A. The online date for any potential carbon capture project is important for several reasons. First, the longer it takes to build a plant, the greater the impact that escalation and financing costs will have on the total project cost. Second, the plant owner(s) and/or investors in any San Juan CO_2 capture retrofit would have to pay the plant's fixed costs during any shutdown of San Juan Units 1 and 4 between 2022 and its restart with carbon capture, whether in 2023, 2024 or even later. These fixed costs could total as much as $180 to $200 million if the retrofitted SJGS units did not restart until mid-2024 and would have to be borne by plant owner(s) and/or investors during a period when the plant would have no incoming revenues as it would not be generating any electricity that could be sold or capturing any CO_2 for sale for EOR.

Q. Have Mr. Solomon, Mr. Griffey, Mr. Schiffman, Enchant, and/or S&L accounted for the costs of having to shut down SJGS for an extended period before the carbon capture system could become operational?

A. No. I have not seen any serious acknowledgement of the increased costs that any owner(s) would have to bear due to having to shut down SJGS either in 2022 when the current non-Farmington owners want to exit the project or on January 1, 2023 to meet the requirements of the Energy Transition Act. As mentioned above, during any such shutdown, the plant owner(s) would still need to spend money to maintain the plant in good operating condition. In addition, the owner(s) might

need to pay for a coal supply, as coal contracts often have "take or pay" clauses that require the buyer to pay for coal even if it is not needed.

Mr. Solomon does not acknowledge these costs, nor does he explain why he thinks it would be reasonable for PNM to analyze a scenario in which ratepayers would have to pay potentially tens or hundreds of millions of dollars in fixed costs for SJSG to sit idle and not generate any electricity while a CCS system is built.

Mr. Griffey and Mr. Schiffman allude to the potential need for "bridge" purchases of energy and capacity to cover the time period when San Juan might have to shut down, but they do not account for the cost of such bridge purchases in any quantitative way. *See* Westmoreland Response to PNM 1-6; Farmington Response to SC 1-7(c).

VI. The Cost of Capturing CO_2 at SJGS Can Be Expected to be Much Higher Than the Enchant and S&L Cost Estimates.

Q. Enchant and S&L claim that the cost of capturing CO_2 at SJGS would be between $39.15 and $43.49 per metric tonne.[70] Do you agree that this is a reasonable range of possible capture costs for a retrofitted SJGS?

A. No.

Q. Please explain.

A. There are several reasons why the range of future CO_2 capacity costs forecast by Enchant and S&L are not realistic.

[70] *See* Appendix E to Exhibit DS-1 to the Prepared Direct Testimony of Dhiraj Solomon in Case No. 19 00018-UT.

First, the $39.15 per tonne low end of the range is based on the completely unrealistic assumption that SJGS would operate at a 100% capacity factor, as was discussed earlier in this testimony.

Second, and most importantly, the CO_2 capture costs claimed by Enchant and S&L are based on three unreasonable assumptions: (1) that after running at an average 70% capacity factor between 2010 and 2019, SJGS Units 1 and 4 will operate at an average 85% annual capacity factor after being retrofitted; (2) that SJGS will achieve on a sustained basis an unproven 90% CO_2 capture efficiency; and (3) that the cost of retrofitting SJGS will be 68% lower than the cost of designing and building the Petra Nova project.

Q. Have you recalculated what the cost per-tonne of capturing CO_2 would be if more reasonable capacity factors, CO_2 capture rates, and capital costs were used?

A. Yes.

Q. What methodology have you used to recalculate the per-tonne SJGS CO_2 capture costs?

A, I used the same methodology as is presented in Appendix E of the S&L July 2019 Pre-Feasibility Study. I only modified the analysis to include the 18 scenarios, reflecting reasonable ranges of capacity factors, capture rates and capital costs, that I used in the analysis presented in Table 1, above.

Q. What were the results of your analysis?

A. The results of my analysis are presented in Table 4, below. As can be seen, the per-tonne capture costs can be expected to be significantly higher than Enchant and S&L are claiming.

Table 4
Projected SJGS CO_2 Capture Costs

	Scenario Assumptions	CO_2 Capture Cost (Dollars per Metric Tonne)
Corrected Enchant & S&L Proposal	$1.40 Billion Capital Cost, 85% CF & 90% CO_2 Capture Rate	$45.69
Scenario 1	$1.40 Billion Capital Cost, 70% CF & 90% CO_2 Capture Rate	$52.36
Scenario 2	$1.40 Billion Capital Cost, 70% CF & 80% CO_2 Capture Rate	$58.90
Scenario 3	$1.40 Billion Capital Cost, 70% CF & 70% CO_2 Capture Rate	$67.31
Scenario 4	$2.21 Billion Capital Cost, 70% CF & 90% CO_2 Capture Rate	$72.56
Scenario 5	$2.21 Billion Capital Cost, 70% CF & 80% CO_2 Capture Rate	$81.63
Scenario 6	$2.21Billion Capital Cost, 70% CF & 70% CO_2 Capture Rate	$93.29
Scenario 7	$3.31 Billion Capital Cost, 70% CF & 90% CO_2 Capture Rate	$100.31
Scenario 8	$3.31 Billion Capital Cost, 70% CF & 80% CO_2 Capture Rate	$112.84
Scenario 9	$3.31 Billion Capital Cost, 70% CF & 70% CO_2 Capture Rate	$128.97

Q. Why is the Base Case capture cost in Table 4 ($45.69 per metric tonne) higher than the $43.49 cost in Appendix E of S&L's July 2019 Pre-Feasibility Study?

A. The Total Project Cost that S&L used in its analysis to calculate the cost of CO_2 capture is in 2019 dollars. I escalated this cost to 2023 dollars as that is what Enchant is claiming could be the online date for the retrofitted SJGS.

Q. Why are the CO_2 capture costs in Table 4, above, so much higher than the costs claimed by Enchant and S&L even in the scenarios which use the S&L estimated capital cost?

A. Assuming more realistic plant capacity factors and CO_2 capture rates means that the plant will capture millions fewer tonnes of CO_2 so the capital cost of the

retrofit and the fixed CO_2 capture O&M costs would be spread over fewer tonnes of CO_2 – see Figure 12, above. This means a higher cost of capture per tonne.

VII. Any Owner(s) and Investors in SJGS Would Be Exposed to Significant Electricity Market Risks.

Q. Has any witness examined the full range of risks to which SJGS's owner(s) and investors would be exposed?

A. No. Mr. Solomon, Mr. Griffey, and Mr. Schiffman have not discussed or presented any evidence on the electricity and the CO_2/oil market risks to which the new owner(s) and investors in SJGS would be exposed.

Q. Have Enchant & S&L or LANL addressed those risks?

A. Not really. Enchant has claimed that SJGS would be a "low-cost generator" but hasn't provided any analysis to support that claim. LANL has identified some risks associated with the CO_2/oil markets but then appears to have quickly dismissed those risks, also without any analysis.

Q. What are the significant electricity market risks that must be considered when evaluating whether retrofitting SJGS is feasible?

A. Any assessment of the financial feasibility of retrofitting SJGS for carbon capture must consider whether the electricity generated at the plant will be sold at prices at least equal to the costs of producing that electricity. If not, the plant's new owner(s) and/or investors should expect to suffer substantial economic losses.

Q. Is it reasonable to expect that any owner(s) of SJGS will be able to sell the electricity it produces at a profit?

A. No. It is far more likely that SJGS's owner(s) would incur substantial losses in the sale of the plant's electricity.

Q. What is the basis for this conclusion?

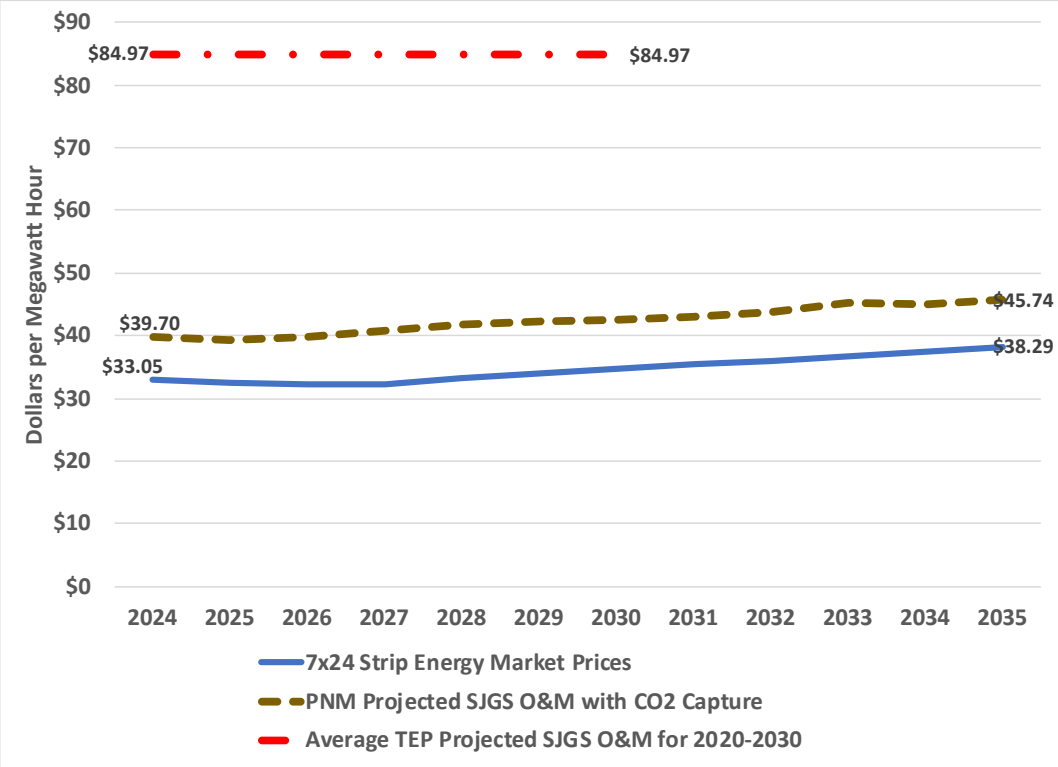
A. SJGS has not been a low-cost generator and SJGS Units 1 and 4 cannot be expected to be low cost-generators after being retrofitted for CO_2 capture, contrary to Enchant's claim.[71]

Q. What do the current owners of SJGS project for the future costs of generating electricity at SJGS if the plant is not retired in 2022?

A. PNM and TEP have both forecasted that SJGS will continue to be a high-cost generator if the plant is not retired in 2022, as shown in Figure 9, below:

[71] Enchant Energy, *The Economic Case for Power Plant Carbon Capture Retrofits: A Case Study on the San Juan Generating Station* – New Mexico, (Sept. 12, 2019)

Figure 9: PNM and TEP Projected SJGS Operating and Maintenance Costs vs. Market Prices



Sources: Forward Energy Market Prices downloaded from S&P Global Market Intelligence on November 1, 2019; Tucson Electric Power's projected SJGS costs of energy are from the company's April 28, 2018 response to the Notice of Inquiry in Arizona Corporation Commission Docket No. E-00000Q-16-0289; and PNM's projected costs are from the San Juan Continues CCUS 1-2-3 Options modeling output reports provided in response to Data Request Sierra Club 1-14.

Q. Do the other SJGS owners agree that the plant is not a low-cost generator and will not become one in the future?

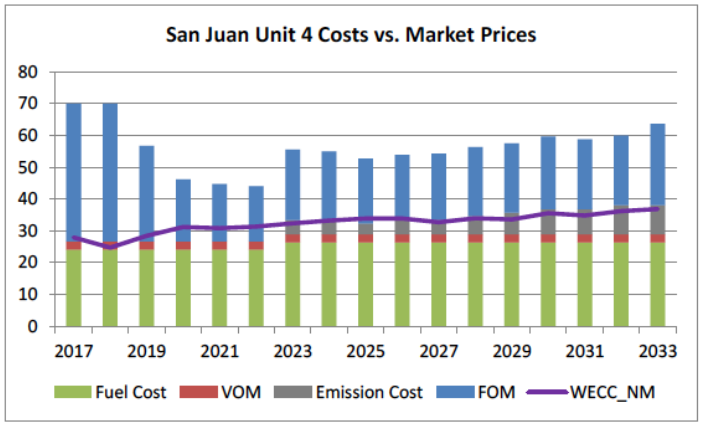
A. The City of Farmington doesn't, and I was unable to find any information about the expectations of the Utah Associated Municipal Power Systems. However, Los Alamos County does not consider SJGS to be a low-cost generator and expects the plant's cost of electricity to remain expensive if it is not retired in 2022, as was noted in a 2017 Integrated Resource Plan Report (IRP) prepared for the

County: "SJGS 4 incurs high fixed costs and is not economic to dispatch under current market conditions."[72]

The Los Alamos County IRP also included an exhibit that illustrated the plant's high costs.

Figure 10: Los Alamos County Projected SJGS Operating & Maintenance Costs

Exhibit 37: SJGS 4 Costs and Market Prices Comparison



Note: SJGS 4 runs at minimum level during 2017-2033.
Source: Pace Global.

Source: 2017 Integrated Resource Plan prepare for Los Alamos Country, August 1, 2017, at page 46.[73]

Q. Do the O&M projections in Figures 9 and 10 reflect a retrofit of SJGS to capture CO_2?

A. No.

[72] Pace Global, 2017 Integrated Resource Plan Report prepared for Los Alamos County at 46 (June 30, 2017), *available at* https://losalamosnm.us/common/pages/DisplayFile.aspx?itemId=14454077.
[73] *Available at* https://losalamosnm.us/common/pages/DisplayFile.aspx?itemId=14454077.

Q. What impact could such a retrofit be expected to have on the plant's non-CO_2 capture costs?

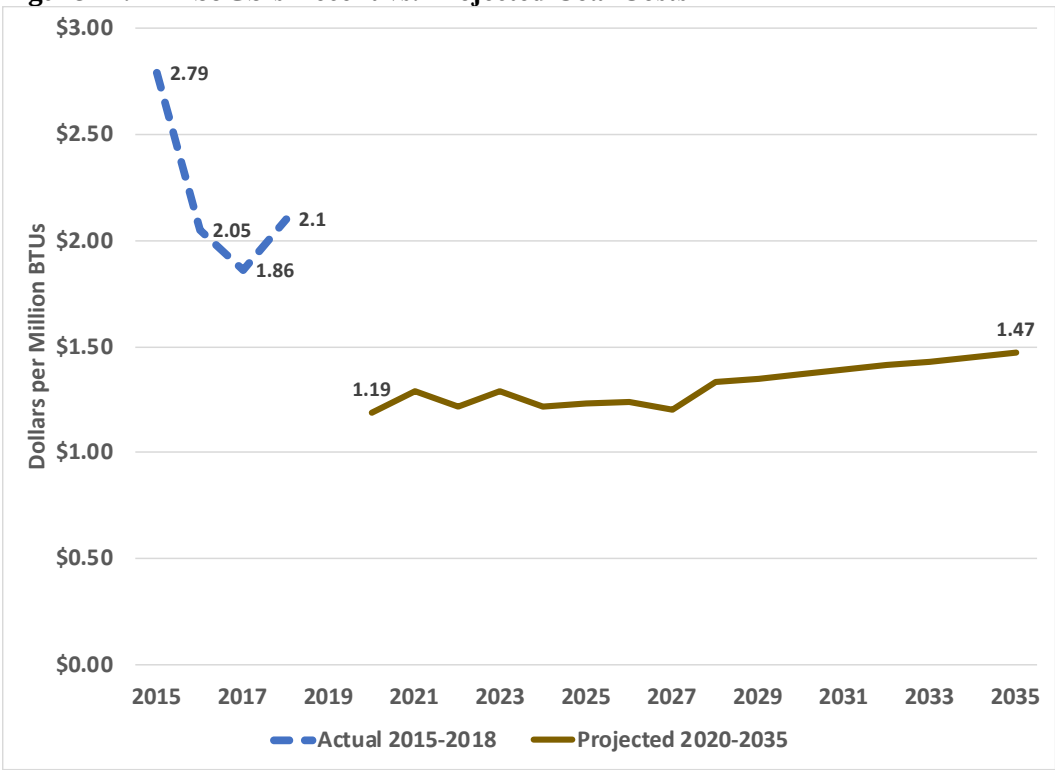
A. With a carbon capture retrofit, SJGS's average costs per MWh (separate from its CO_2 capture costs) would be higher than is shown in Figures 9 and 10. This is due to the very high parasitic loads due to the internal plant power that would be used to run the CO_2 capture equipment. This high parasitic load would decrease the plant's net capacity from 847 MW pre-retrofit to just 601 MW post-retrofit. This means that the plant's non-CO_2 capture-related fixed O&M costs must be spread over fewer MWh of output, and this raises the cost of each MWh that the owner(s) would be seeking to sell. As a result, electricity from SJGS would be even more expensive and less competitive than Figures 9 and 10 suggest.

Q. But doesn't Enchant claim that there will be cost savings from an improved coal contract?

A. Yes, Enchant does make that claim.[74] However, PNM's projected O&M costs presented in Figure 9 and included in my analysis already reflect that SJGS' future coal prices are expected to be much lower than they have been in recent years, as shown in Figure 11, below:

[74] *Carbon Capture Retrofit of San Juan Generating Station, Presentation to San Juan County Community*, July 16, 2019, at Slide 4, *available at* https://www.powermag.com/wp-content/uploads/2019/08/final-enchant-sjgs-presentation-to-san-juan-community-july-2019.pdf.

Figure 11: SJGS's Recent vs. Projected Coal Costs



Sources: PNM FERC Form 1 Filings and the Output Reports provided in PNM's Response to Data Request SC-14.

Q. What is the range of potential losses that you have calculated that the owner(s) of SJGS can reasonably be expected to suffer from the sale of electricity in the years 2024-2035, if SJS were retrofit with carbon capture technology?

A. The owner(s) of SJGS can expect to experience losses of approximately $340 million from the sale of high-cost electricity produced at SJGS during the years 2024-2035.

Q. Do these losses include the cost impact of any capital expenditures that owner(s) would have to spend on CO_2 capture or balance-of-plant maintenance or repairs?

A. No. In my experience coal plant owner(s) typically spend on maintenance-related capex projects until the plants are near retirement. However, the amounts they spend are plant specific. I have not included in this analysis any estimate of what those costs might be for SJGS for CO_2 capture or balance-of-plant maintenance or repairs. My estimated range of potential losses is, then, conservative or low.

VIII. Any Owner(s) and Investors in SJGS Also Would Be Exposed to Significant CO_2/Oil Market Risks.

Q. What are the main CO_2 and oil market risks to which the owner(s) or investors in SJGS would be exposed if the plant were retrofitted with carbon capture technology?

A. There are a number major risks to which SJGS owner(s) and investors would be exposed:

(1) That the market for CO_2 that the proponents now claim will exist for the captured CO_2 from SJGS will not materialize because of some combination of the following circumstances (a) the demand for oil from the Permian Basin is not as substantial as they currently anticipate; (b) producers in the Permian Basin are satisfied with the amounts of oil they are producing without using the captured CO_2 from SJGS in EOR; and/or (c) the price of oil from the Permian is too low to make using EOR economic.

(2) That the economics of the CO_2 market are worse than the proponents hope. Among the factors that could affect proponents' market expectations include: the costs of capturing CO_2 are higher than projected; the prices at which the captured CO_2 can be sold are lower than expected; and other, lower-cost CO_2 suppliers may enter the market, taking sales away from SJGS

(3) That there isn't enough pipeline capacity available to bring all of the CO_2 captured at SJGS to producers in the Permian Basin for all of the period 2023-2035.

(4) That the new owner(s) of SJGS won't be able to make contracted-for supply requirements because (a) the power plant is not operating as much as proponents now claim and, therefore, is not producing as much CO_2 and/or the carbon capture facility is not operating as well as proponents now claim it will.

Q. Has any party provided any analysis to show that there will be demand in the Permian Basin for all twelve years from 2023-2035 for the captured CO_2 from SJGS for use in EOR?

A. No. Neither Enchant nor S&L, nor any of the witnesses in this case, have presented any evidence that there actually is a significant demand for the CO_2 that would be captured at SJGS. Although LANL has discussed the question in its Preliminary Assessment, it merely cited the substantial oil reserves in the Permian

Basin,[75] implying that CO_2 demand for enhanced oil recovery (EOR) in the Permian Basin is essentially inexhaustible, meaning there should always be a market for the CO_2 captured at SJGS, without offering any economic or market analysis to support this conclusion.

Q. Have you seen any analysis that shows that the projected demand for CO_2 for EOR may not materialize?

A. Yes. In a November 2018 document entitled *Whatever happened to enhanced oil recovery?*, analysts with the International Energy Agency (IEA) described an 18 percent decline in oil production from North American EOR between 2014 and 2018. The IEA identified a range of obstacles that have hindered EOR, including: declining concerns over oil scarcity; an oil industry preference for lower-capital projects with faster returns than EOR can offer; the limited availability of technical expertise in EOR; and the fact that competing forms of oil extraction, particularly fracking, have seen dramatic cost declines that have rendered EOR less economically attractive.

Q. What factors would influence the demand for the captured CO_2 from SJGS?

A. It is reasonable to expect that the demand for the captured CO_2 from SJGS will be affected by a combination of (a) oil prices, (b) the economics of EOR in specific reservoirs and at specific sites, (c) the cost of capturing the CO_2 and piping it to the Permian Basin and (d) whether EOR is actually cost-competitive with alternate sources of oil from the Permian basin. Thus, contrary to what LANL's

[75] *LANL Preliminary Assessment*, at page 19.

Preliminary Assessment would suggest, the demand for captured CO_2 is not merely based on how much recoverable oil there is. To be credible, any claims about future demand for CO_2 in Permian Basin EOR projects must rely on a thorough analysis of the economics of both oil and CO_2 markets.

Q. If Enchant were to announce that it has a customer for CO_2, would that guarantee that there would be a market for the CO_2 from SJGS for the entire twelve year period from 2023 to 2035?

A. No. For example, oil prices are very volatile, so it's likely that both the demand and price for captured CO_2 for use in EOR will fluctuate significantly over time.

Q. Are there any examples where the demand for the captured CO_2 from Petra Nova and/or Boundary Dam 3 has declined substantially from that assumed by the plant owners when they were retrofitting their coal plants?

A. Yes. It is clear that the demand for the captured CO_2 from both Petra Nova and Boundary Dam 3 for use in EOR has declined significantly. In fact, *the LANL Preliminary Assessment* notes specifically that the owners of these facilities made conscious decisions to reduce the amounts of CO_2 processed in their carbon capture facilities.[76]

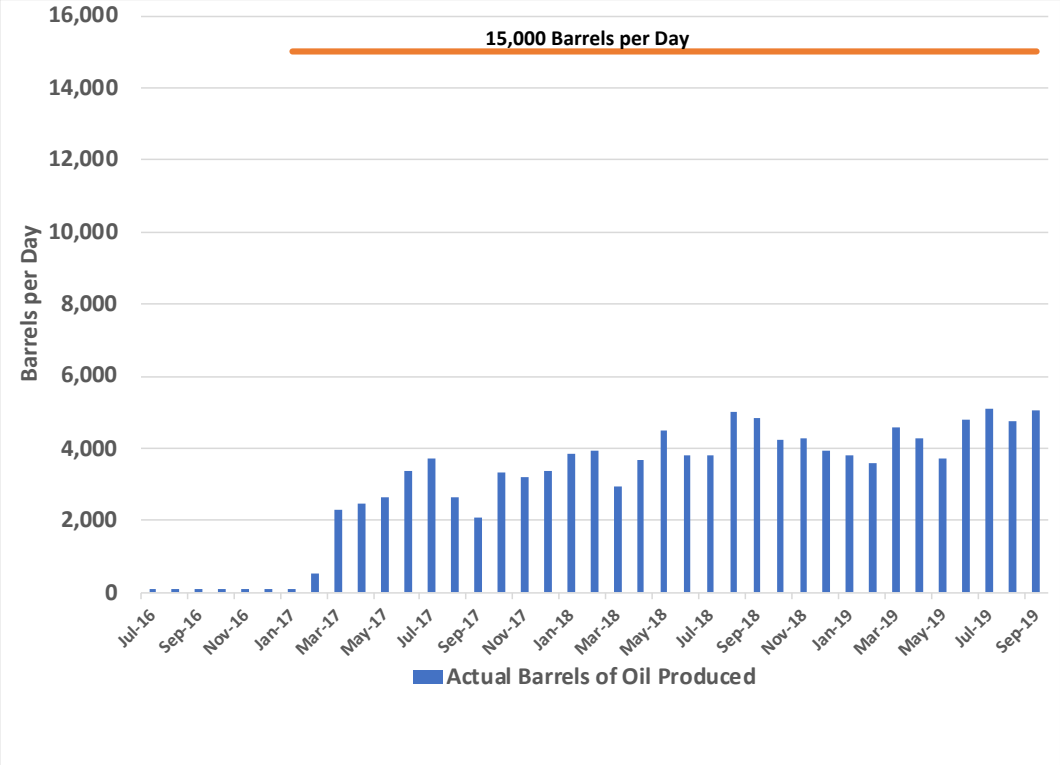
Q. Please explain.

A. NRG originally said that the CO_2 captured at Petra Nova would be used to increase the production of oil in its West Valley field to 15,000 barrels/day.

[76] *LANL Preliminary Assessment*, at pages 10-12.

However, as shown in Figure 12, below, the amount of oil produced at West Valley has only increased to about 4,200 barrels/day.

Figure 12: Actual vs. Estimated Daily Production at NRG's West Ranch Oil Field



Source: TexasDrilling.com.

Thus, it appears that the project has not been nearly as profitable as NRG expected. In fact, NRG took an impairment of $140 million on its $300 million investment in its subsidiary Petra Nova Parish Holdings in 2016 due to what it cited as the continued decline in oil prices.[77] NRG then took another impairment

[77] NRG Energy, Inc., NRG 10-K for the Year Ended December 31, 2016 at 170, *available at* https://investors.nrg.com/node/25486/html.

of $69 million in its investment in Petra Nova in 2017 based on a revised view of oil production expectations.[78]

Q. Is there any evidence that SaskPower is receiving less revenue from selling the CO_2 captured at Boundary Dam 3 than it anticipated?

A. Yes. It has been reported that in June 2016, the contract for supplying CO_2 from Boundary Dam Unit 3 was renegotiated, reducing the expected annual revenues over the life of the plant by about a third.[79]

Q. Should these Petra Nova and Boundary Dam 3 experiences serve as a warning to the owners of SJGS and potential investors in retrofitting the plant with carbon capture?

A. Yes.

Q. Are the market values for CO_2 claimed by Enchant prices that any owner(s) of SJGS would be guaranteed to receive for the sale of the CO_2 captured at the plant?

A. No. They are simply estimated values based on one of the oil price forecasts included in the EIA's 2018 Annual Energy Outlook. There is no guarantee that actual CO_2 prices will be anywhere near these values, or even as high as the $17.50 per tonne price assumed by Enchant and S&L in their marketing materials for the SJGS retrofit.

[78] NRG Energy, Inc., NRG 10-K for the Year Ended December 31, 2017 at 164, available at https://investors.nrg.com/static-files/7f12dcd9-bc0b-40c7-87aa-78f8616d663e .
[79] The Global Warming Policy Foundation, The Bottomless Pit: The Economics of Carbon Capture and Storage at 55 (2017), *available at* https://www.thegwpf.org/content/uploads/2017/06/CCS-Report.pdf.

Q. What factors are likely to determine future CO_2 prices?

A. It is reasonable to expect that future CO_2 prices most likely will be affected by actual and expected oil prices and by the competition between different CO_2 sources. Thus, they could be substantially lower than Enchant's estimates.

Q. What evidence have you seen that leads you to conclude that the availability of adequate pipeline capacity could be a major financial risk for investors in the carbon capture retrofit of SJGS?

A. This conclusion is based on the following information presented in the *LANL Preliminary Assessment* and in the November 2018 *Colorado* CO_2 *Resource Study* prepared by Leonardo Technologies, Inc., which is cited at length in the LANL report.

- The single accessible pipeline between SJGS and the Permian Basin is Kinder Morgan's ~500 mile long Cortez Pipeline, which currently carries the natural CO_2 produced at Kinder Morgan reservoirs in southwestern Colorado.
- LANL notes, based on the analysis by LTI, that Kinder Morgan's CO_2 reservoirs in Colorado produce between 22.7 and 24.6 million metric tonnes of CO_2 per year.[80] LANL also notes that the two main CO_2 reservoirs in Colorado owned by Kinder Morgan in total have 286 million metric tonnes of recoverable CO_2 remaining, citing the Kinder Morgan

[80] *LANL Preliminary Assessment*, at page 19.

website as the source.[81] This suggests a remaining production life for the Kinder Morgan reservoirs of ten years, if not longer.[82]

- LTI notes in its report that there is approximately 4 million metric tonnes per year of available capacity on the Cortez Pipeline which is just two-thirds of what Enchant will need to transport all of the CO_2 it says will be captured at SJGS each year to the Permian Basin.[83]
- On the basis of this data, LANL observes that the captured CO_2 from SJGS would have to compete with the naturally produced CO_2 from Kinder Morgan's McElmo and Doe-Canyon domes in Colorado.[84]

However, LANL quickly dismisses this potential competition for pipeline capacity without any analysis of how much of the CO_2captured at SJGS might be prevented from reaching potential purchasers in the Permian Basin and for how long. Instead, LANL simply concludes that "CO_2 demand for EOR in the Permian is not likely to pose a significant risk for CO_2 disposition associated with capture at SJGS."[85]

[81] *Id*.
[82] LTI cites current CO_2 production at Kinder Morgan's Colorado reservoirs is about 27 million metric tonnes a year. *Colorado CO_2 Resource Study*, at page 4. Even at this level of production, it appears that the reservoirs still would have a remaining production life of about ten years.
[83] *Colorado CO_2 Resource Study*, at page 4.
[84] *LANL Preliminary Assessment*, at page 19.
[85] *Id*.

Q. What would be the impact if Enchant were not able to obtain enough capacity on the Cortez Pipeline to carry all of the CO_2 captured at SJGS to the Permian Basin, even for a limited number of years?

A. Quite simply, the 45Q federal tax credits on which Enchant is depending to finance the retrofit of SJGS depend directly on how much CO_2 is used for EOR or is placed into permanent geological storage. If less than the full amount of CO_2 that is capturable at SJGS can be transported to the Permian Basin for use in EOR, the fewer 45Q tax credits will be available to investors unless, somehow, Enchant is able to permanently store some of the CO_2 through some means other than EOR. Thus, the prospect that part, perhaps a significant portion, of the CO_2 capturable at SJGS could not be used for EOR substantially raises the financial risk for investors in the project.

Q. Have the owners of Petra Nova or Boundary Dam had to pay any contract penalties because they have been unable to provide the amounts of CO_2 they have committed to providing to buyers?

A. It is unlikely that NRG has paid any contract penalties, because it uses the CO_2 captured at Petra Nova in its own oil field. However, SaskPower has reported that in 2014, it paid $12 million in penalties to Cenovus Energy for failing to deliver sufficient quantities of carbon dioxide from Boundary Dam 3.[86] In 2015,

[86] The Energy Mix, "Saskatchewan Pays $12 Million Penalty for Slow Production at CCS Plant," Nov. 4, 2015, *available at* https://theenergymix.com/2015/11/04/saskatchewan-pays-12-million-penalty-for-slow-production-at-ccs-plant/.

SaskPower paid $7.3 million to Cenovus for failing to deliver the volume of CO_2 it had contractually committed to provide.[87]

Q. Have the owners of either Petra Nova or Boundary Dam 3 indicated whether they intend to undertake any other coal plant carbon capture retrofits?

A. Yes. Even though Petra Nova was completed on schedule and on budget, in December 2016, even before the project began operations, NRG said that the project would be its last carbon capture plant due to a drop in oil prices.[88] Fortune Magazine noted that NRG Energy's Petra Nova project "may be completed, but it's unlikely to set a precedent for profitability."[89]

Similarly, SaskPower, the owner of Boundary Dam 3 announced that "After careful evaluation, [it had] made the decision to not retrofit Boundary Dam Power Station Units #4 and #5 with CCS technology."[90]

IX. The LANL Preliminary Assessment Is Not an Independent Assessment of the Feasibility and Viability of the Proposed SJGS Carbon Capture Project.

Q. Why have you concluded that the LANL Preliminary Assessment is not an independent assessment of the proposed SJGS carbon capture project?

A. There are several reasons for this conclusion.

[87] CBC News, "SaskPower CEO says $20M worth of carbon capture penalties are in the past," July 14, 2016, *available at* https://www.cbc.ca/news/canada/saskatchewan/saskpower-carbon-capture-penalties-20m-in-past-1.3679405.
[88] Fortune Magazine, "What Donald Trump Didn't Mention About Clean Coal," October 10, 2016, *available at* https://fortune.com/2016/10/10/donald-trump-clean-coal/.
[89] *Id.*
[90] SaskPower Annual Report 2018-2019 at 39, *available at* https://www.saskpower.com/about-us/Our-Company/Current-Reports.

First, LANL admits that its report is not a detailed engineering assessment nor is it based on a detailed engineering plan. Instead, the LANL Preliminary Assessment is "based largely on a pre-feasibility assessment by Sargent & Lundy, which was in turn based on detailed technical information from suppliers and Sargent & Lundy's extensive experience in these types of systems."[91] In fact, much of the LANL Preliminary Assessment merely repeats what Sargent & Lundy claimed in its pre-feasibility assessment without any evaluation of Sargent & Lundy's claims.

Second, without any supporting facts or data about the actual operating performance of the Petra Nova carbon capture facility, LANL accepts that a 90% capture rate has been achieved simply on the basis of discussions with representatives from MHI, the company that supplied the carbon capture equipment to Petra Nova and a company that is seeking to profit from the proposed SJGS carbon capture retrofit. For example, LANL says:

> Petra Nova has stated publicly that the facility achieves 90% capture of the processed flue gas.[92]
> Although MHI could not provide detailed statistics on the project (which are proprietary to Petra Nova), they noted that the amine performance met or exceeded MHI design expectations.[93]
> As with regeneration data, extensive capture efficiency data are typically not readily available for long-term performance, so our assessment included discussions with MHI experts relative to the experience at Petra Nova (Thomas et al, personal communication). Although they could not provide detailed statistics on the capture efficiency observed at Petra Nova (which are proprietary to Petra

[91] *LANL Preliminary Assessment*, at page 5.
[92] *Id*., at page 9.
[93] *Id*., at page 10.

Nova), they noted that the facility is performing as designed and readily capturing 90% of CO_2 from the flue gas that it processes.[94]

Consequently, no one outside of Petra Nova's owners knows (a) how much CO_2 the plant actually is capturing, (b) how much of the time Petra Nova is not processing (i.e., capturing) CO_2 due to market conditions, (c) how many equipment problems, outages and deratings have been experienced at Petra Nova and how much CO_2 that was potentially capturable was not, and (d) what it is actually costing to capture CO_2 at the plant.

Third, although acknowledging that the proposed use of the Cortez pipeline to bring captured CO_2 to the Permian Basin would require the displacement of natural CO_2 from reservoirs owned by Kinder Morgan, the owner of the pipeline, LANL offers no assessment of how or when SJGS' owner(s) would be able to ship the plant's captured carbon to Texas. Nor is there any assessment of what that transportation would cost, or of any potential incentive payments that SJGS might have to pay to entice Kinder Morgan to substitute CO_2 captured at SJGS for its own supplies of CO2.[95]

Finally, after presenting a few statistics about the potentially recoverable oil reserves in the Permian Basin, LANL simply concludes that "the significant difference between potential demand and total available natural CO_2 supply could be met by anthropogenic sources of CO_2 like SJGS."[96] However, LANL does not present any analysis or assessment of the future demand for CO_2 in the Permian

[94] *Id.*, at page 11.
[95] *Id.*, at page 4.
[96] *Id.*, at page 19.

Basin nor any evidence that there is a pent-up or potential demand for using captured CO_2 for EOR in the Permian. Notwithstanding this lack of analysis, LANL concludes: "In other words, CO_2 demand for EOR in the Permian is not likely to pose a significant risk for CO_2 disposition associated with capture at SJGS."

Q. But doesn't LANL say that "Several public presentations present databases on capture efficiency for both Petra Nova and Boundary Dam showing that both facilities have achieved 90% capture (e.g., MHI Group, 2017; Bruce 2019; Feng; Feng 2019a; Feng 2019b)?"[97]

A. Yes. LANL makes that claim, but it is not true with regard to the single Petra Nova-related presentation that LANL cited (MHI Group, 2017). In addition, none of the three Boundary Dam-related presentations actually includes a database on capture efficiency, although they do present information and data on the operating performance and deficiencies of the plant's capture facility.

Q. Did the 2017 MHI Group presentation present a database on the carbon capture efficiency at Petra Nova?

A. No. That presentation is attached as Exhibit DAS-2. As can be seen from that presentation, the only performance data on Petra Nova is included in Slide 15, which only presents data on the CO_2 capture rate for a period of 72 hours, not even 0.5% of the total hours which Petra Nova has operated since it went into service in late December 2016. Moreover, it is unclear whether this is actual

[97] *Id*., at page 10.

operational data or just illustrative, or was merely the result of a very short pre-operational test. In any event, it is completely incorrect and misleading for LANL to categorize this as a database on carbon capture at Petra Nova.

Q. Do the other three presentations cited by LANL show that 90% carbon capture has been achieved at Boundary Dam 3?

A. No. Although the three presentations show that the operating performance of Boundary Dam 3's capture facility has improved in recent years due to capital investments and at least one extended maintenance overhaul, none present any evidence that the plant has achieved a 90% CO_2 capture rate. In fact, the data in the presentations shows that the best capture rate achieved by the plant was 2,585 tonnes per day, significantly below the 3,200 tonnes per day that was expected if the plant had a 90% CO_2 capture rate.[98]

It is possible that Boundary Dam has captured 90% of the CO2 it has processed on a sporadic or intermittent basis over the years. However, the plant's operating performance does not demonstrate that 90% capture can be achieved over an extended period of years, or that it will be economical or profitable for a plant owner to do so.

[98] *Reliability Improvements of SaskPower's BD3 Capture Facility Through Operational and Process Design Changes: Experiencing the First Four Years of Operations,* September 18, 2019, at Slide No. 29. Attached as Exhibit DAS-3

Q. Does LANL present any assessment of the economic or financial feasibility or viability of the proposed SJGS carbon capture retrofit?

A. No. LANL does not present any assessment of the economic and financial viability of the SJGS carbon capture proposal. Further, LANL acknowledges that it did not look at non-technical aspects of the proposed project such as costs, financing and regulatory position.[99]

X. Conclusions.

Q. Please summarize your testimony.

A. The Commission should reject the recommendations of Mr. Griffey and Mr. Schiffman to delay approval of replacement resources to allow Enchant and Farmington to submit a PPA bid. There is simply no evidence that a PPA from Enchant and Farmington would be economically competitive. In addition, I have explained at length the significant hurdles for Enchant to retrofit San Juan with carbon capture: the project is unlikely to be financially feasible; the project is unlikely to be built and come online before 2024; and the project will likely cost more, and take longer to build, than Enchant is forecasting. Thus, even if Enchant submitted a bid that looked good on paper, there is a significant risk that Enchant will not be able to meet the pricing and/or the delivery date in any PPA bid it would submit.

There also is absolutely no basis for the Commission to accept Mr. Solomon's recommendation and order PNM to amend its application to include more detailed

[99] *Id*, at page 5.

studies of carbon capture. In Case No. 19-00018-UT, PNM submitted two analyses of the economics of retrofitting San Juan with carbon capture: a spreadsheet analysis from Mr. Graves; and Encompass modeling from Mr. Phillips. Both studies concluded that retrofitting San Juan with carbon capture would be significantly more expensive than abandoning and replacing the plant, and would be more expensive than operating San Juan without carbon capture. These results are consistent with the analysis I presented in my testimony in Case No. 19-00018-UT.

In reiterating his argument that PNM should have conducted a new analysis of continuing to operate SJGS with carbon capture, Mr. Solomon continues to ignore the rebuttal testimony submitted in Case No. 19-00018-UT from myself, David Posner, Nicholas Phillips, Frank Graves, and other witnesses, showing that it is not economically or financially feasible for PNM to operate San Juan with carbon capture. Moreover, Mr. Solomon has still not produced his own analysis of the engineering, economic, or financial feasibility of carbon capture at the plant. Instead, Mr. Solomon continues to rely on claims made by Enchant and S&L. But the SJGS retrofit proposal submitted by Enchant Energy relies on a series of assumptions that are little more than wishful thinking. In particular, Enchant's proposal hinges on the assumption that the retrofitted facility would be able to capture 6 million metric tonnes of carbon annually—a number that is unlikely to be achieved. To capture that much carbon each year would require the facility to capture 90% of the CO_2 it produces and operate at an annual capacity factor of at least 85% for twelve years, both of which are unrealistic.

As my testimony has shown, the only two existing power plants in the world that capture CO_2 have not captured 90% of their CO_2 emissions for any extended period of time, and it is unrealistic to expect that carbon capture at SJGS could do so either. Equally important, it is totally unrealistic to assume that the retrofitted SJGS facility would be able to achieve an annual capacity factor of at least 85% for the first 12 years of its operation when neither of the two units at the plant have hit that level since 2011. Age-related reliability issues and competition from renewable energy resources are almost certain to prevent the plant from operating anywhere near the 85% level assumed by Enchant.

Beyond these two problems, the Enchant proposal significantly understates the project's probable capital cost, assuming reductions from the of the Petra Nova carbon capture facility that are not tenable. Moreover, Enchant's claims as to when carbon capture could come online at SJGS are unlikely to be met. As this testimony has shown, more realistic assumptions about the construction costs and commercial completion date would substantially increase the project's cost, making it financially unviable from the outset.

Q. Consequently, do you agree with Mr. Solomon that carbon capture and sequestration is an economically and financially feasible option at SJGS that should have been analyzed in PNM's abandonment application?

A. No. Based on the evidence I have reviewed and the analyses I presented above, I do not believe that carbon capture and sequestration is financially feasible at SJGS. For the same reasons, I disagree with Mr. Solomon that a scenario involving carbon capture should have been modeled by PNM.

Q. Do you agree with Mr. Schiffman that including a retrofitted SJGS would represent flexibility in PNM's replacement resource plan?[100]

A. I don't see any way in which a baseload coal plant like SJGS could be considered a flexible resource. A retrofitted SJGS basically would be a must-run unit as the new owner(s) would feel pressure to run the units as much as they could in order to produce as much CO_2 as possible.

On the other hand, the renewable resources being proposed by PNM and other parties in this case do represent flexible resources.

Q. Have you seen any evidence that a retrofitted SJGS would ensure that PNM meets its reliability criteria?

A. No, I have not. In addition, as I have shown earlier in this testimony, SJGS Units 1 and 4 have not operated at high capacity factors in recent years. There is absolutely no evidence to support the idea that adding carbon capture technology to SJGS will enable the plant to operate at higher capacity factors. In fact, merging the two technologies, that is, the existing facilities for the generation of power at SJGS and the new carbon capture facility, are likely to cause currently unanticipated problems and lead to currently unexpected operating issues and costs.

Q. Westmoreland Mining witness Griffey claims that "If the Commission is concerned about global CO_2 emissions, then it should encourage

[100] Direct Testimony of Roger Schiffman, at page 8, lines 1-13.

consideration of CCUS at SJGS as a replacement resource."[101] Do you agree?

A. No. What Mr. Griffey and Enchant choose to ignore is that when captured CO_2 is used for EOR, additional oil is produced and that oil, in turn, emits CO_2 into the atmosphere when burned or used as a chemical feedstock.

For example, the *LANL Preliminary Assessment* cites that the use of captured CO_2 for EOR produces 435 kilograms (.435 tonne) of lifetime CO_2 equivalent emissions (CO_2e) per barrel of oil produced.[102] Even with the conservative assumption that using captured CO_2 for EOR produces only 2.08 barrels of additional oil per metric tonne,[103] this means that one tonne of the CO_2 captured at SJGS would lead to 0.90 tonnes of new CO_2e emissions into the atmosphere. In addition, even under Enchant's extremely optimistic assumptions, at least 10% of the CO_2 that would be produced at SJGS would not be captured and instead be emitted directly into the atmosphere. As a result, using the CO_2 captured at SJGS for EOR is unlikely to bring about any meaningful reduction in net CO_2 emissions into the atmosphere. If the Commission is concerned about global CO_2 emissions, it should approve PNM's proposal to abandon SJGS and require the Company to implement a 100% carbon-free replacement resource plan.

Q. Does this complete your testimony?

A. Yes.

[101] Direct Testimony of Charles S. Griffey on behalf of Westmoreland Mining, LLC, at page 12, lines 3-4.
[102] *LANL Preliminary Assessment*, at page 21.
[103] NETL *Carbon Dioxide Enhanced Oil Recovery*, 2010.

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	)	**Case No. 19-00195-UT**

VERIFICATION

STATE OF MASSACHUSETTS }
}
COUNTY OF MIDDLESEX }

David A. Schlissel, first being sworn on his oath, states:

I am the witness identified in the preceding Rebuttal testimony. I am the author of the Rebuttal testimony and am familiar with the contents. Based upon my personal knowledge, the facts stated in the Rebuttal testimony are true. In addition, in my judgment and based upon my professional experience, the opinions and conclusions stated in the Rebuttal testimony are true, valid, and accurate.

David A. Schlissel

David A. Schlissel

SUBSCRIBED AND SWORN TO before me on this 2nd day of January 2020 by David A. Schlissel.

Debbie D. Shay

Notary Public

My commission expires: 11/14/2025

DEBBIE D. SHAY
Notary Public
Commonwealth of Massachusetts
My Commission Expires
November 14, 2025

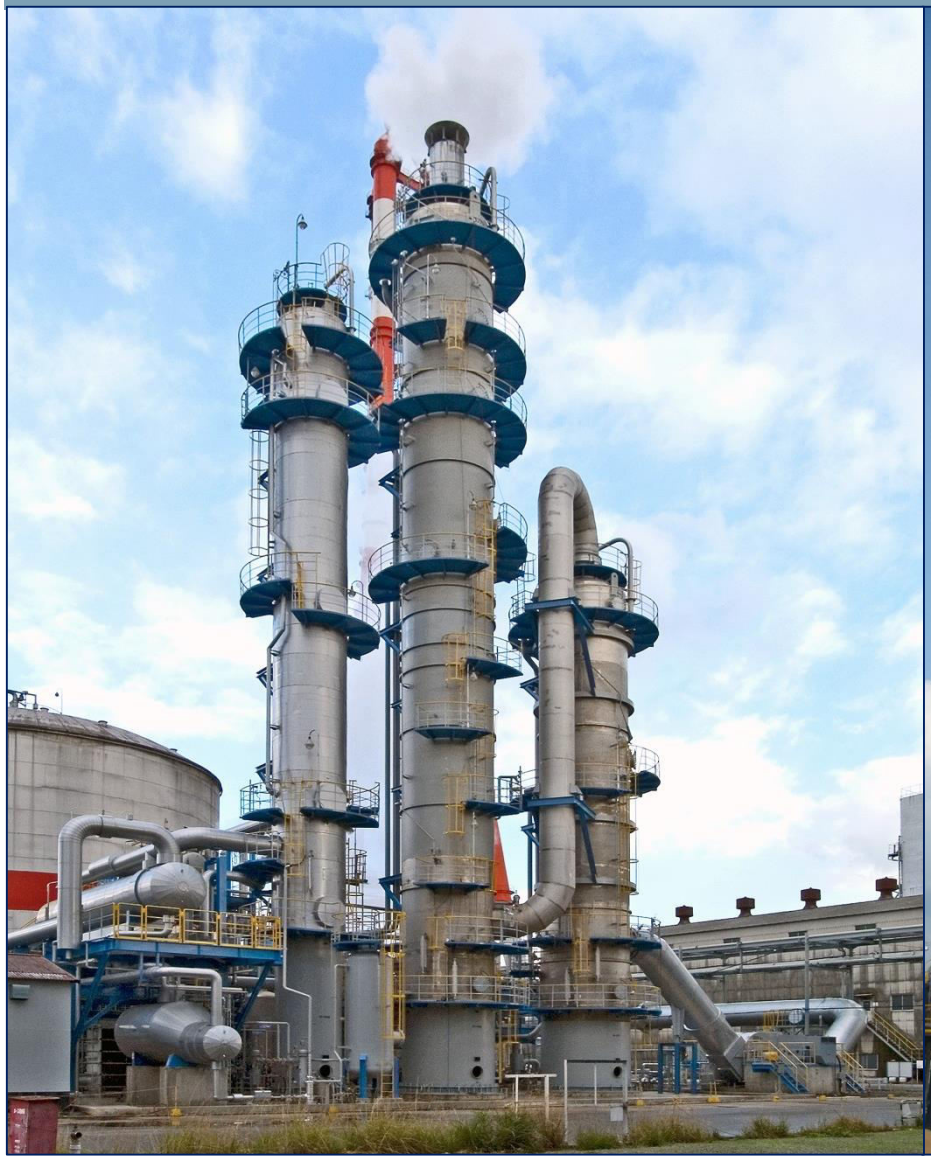
MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP

MHI's Carbon Capture Technology

2017 CO_2 & ROZ Conference
Carbon Management Workshop
Midland, Texas

December 4

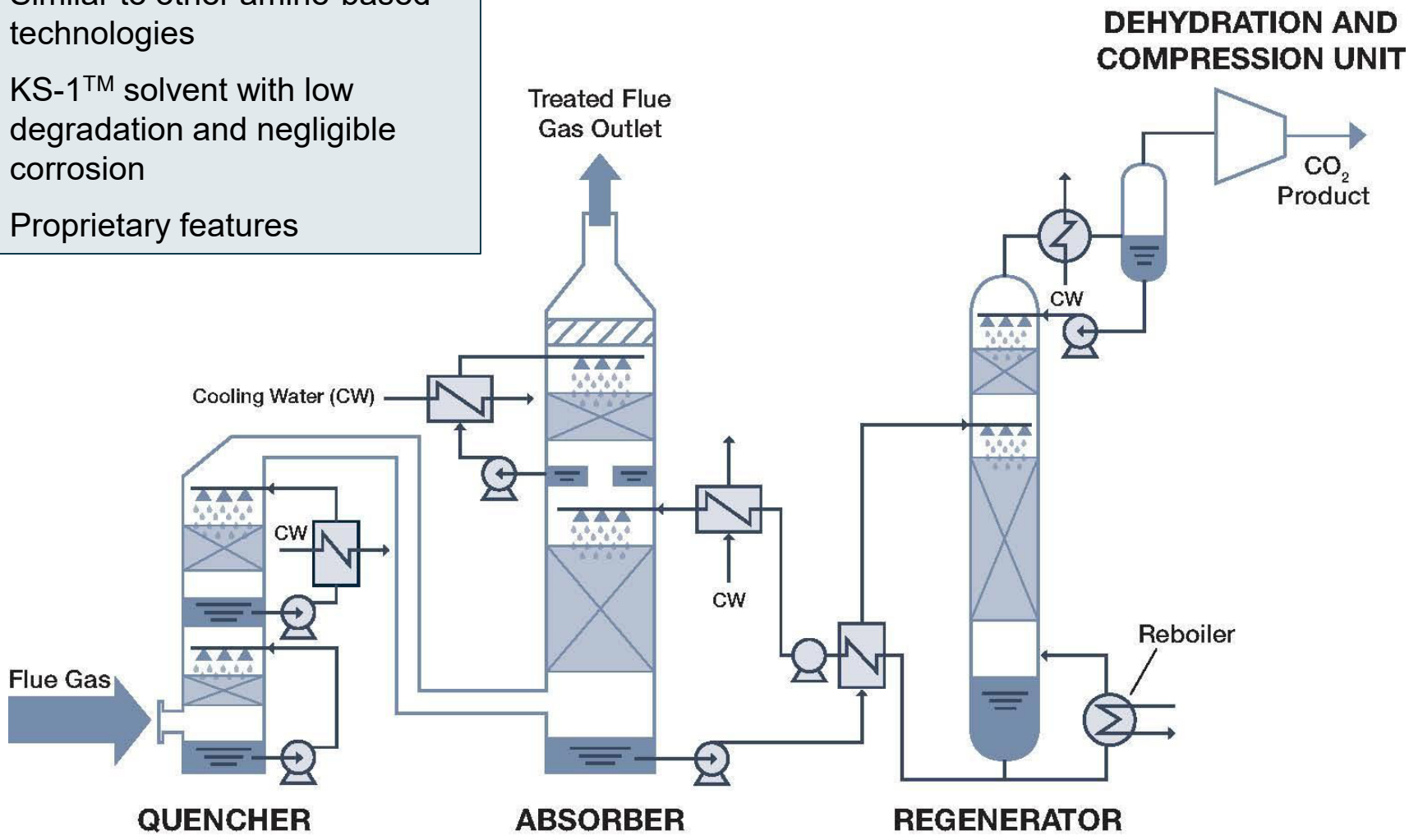
MITSUBISHI HEAVY INDUSTRIES AMERICA, INC.



Background

KM CDR – Kansai Mitsubishi Carbon Dioxide Removal – Process®

- Similar to other amine-based technologies
- KS-1™ solvent with low degradation and negligible corrosion
- Proprietary features



KM CDR Process is a registered trademark of Mitsubishi Heavy Industries, Ltd., in Japan, the United States of America, European Union (CTM), Norway, Australia, and China.

KM CDR Process® Development History

From 1991 –
2 TPD Nanko Pilot Plant on Natural Gas Exhaust (Kansai Electric Power Co.)

Engineering HQ (Yokohama)

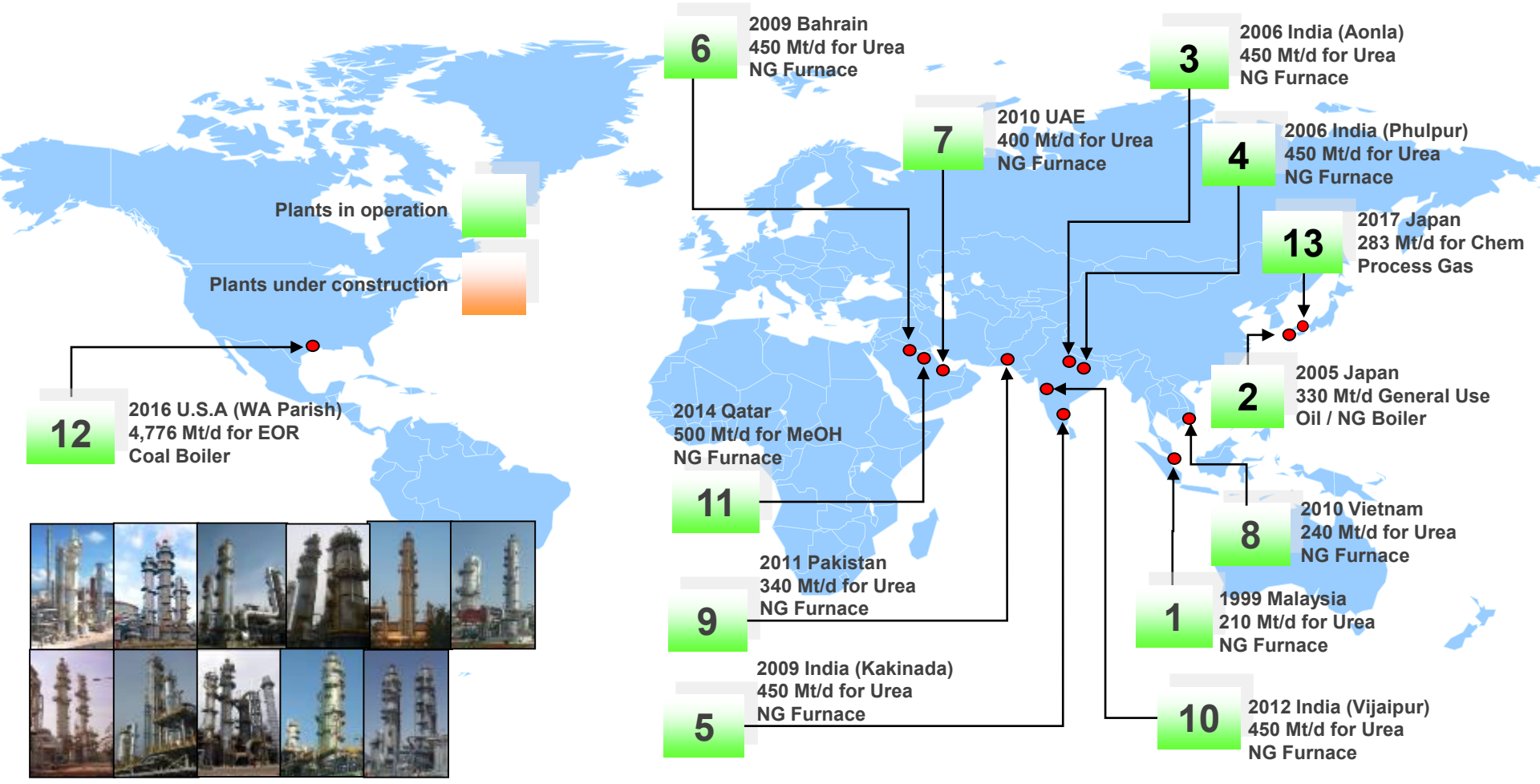
From 2002 -
1 TPD Hiroshima Pilot Plant on Coal Exhaust (MHI R&D Center)

From 2008 -
400MWeq Absorber Flow Tests (MHI Mihara)

From 2006 –
10 TPD Matsushima Pilot Plant on Coal Exhaust (J-Power)

KM CDR Process® Commercial Experience

MHI is the world's leading large scale post-combustion CO_2 capture technology licensor.



Testing and Scale-up for Coal-fired Flue Gas

2002 – Hiroshima R&D Facility (1 tpd)

2006 – Matsushima Pilot Plant (10 tpd)

MHI performed extensive testing to understand the impact of **flue gas impurities** and develop countermeasure technologies.

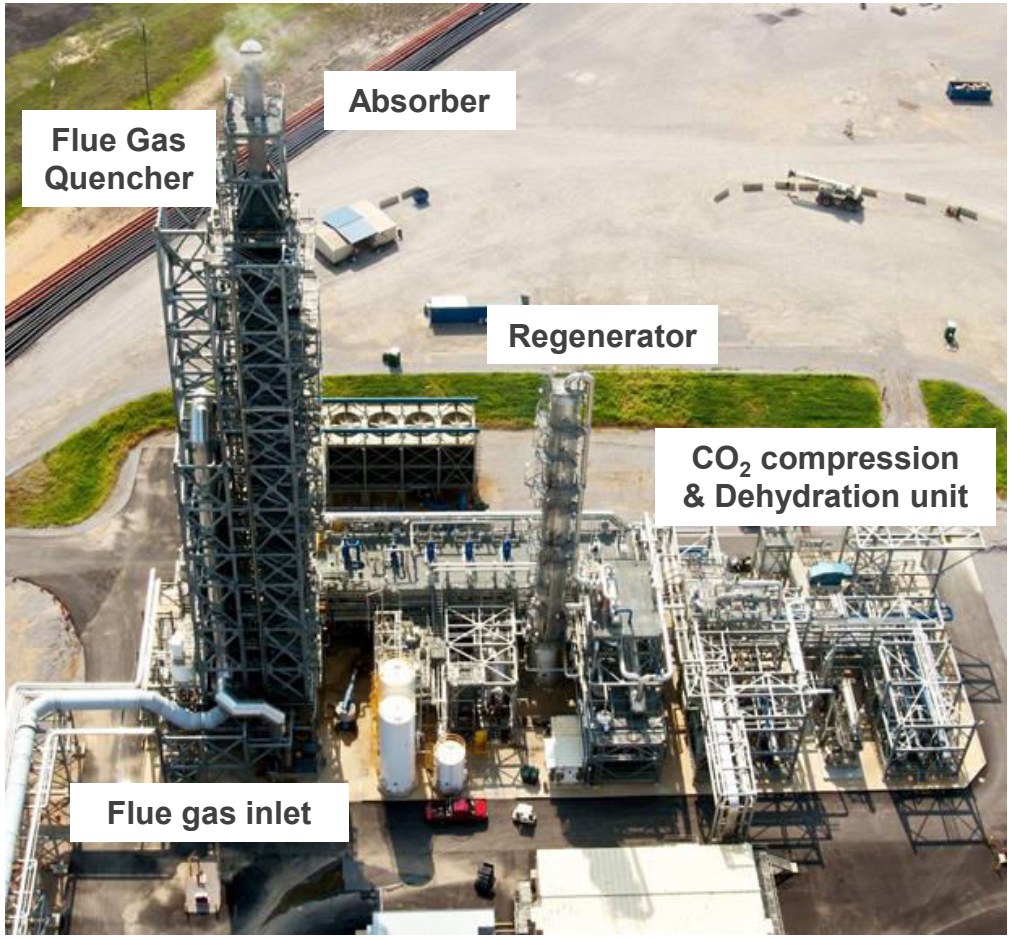
MHI performed liquid distribution tests for rectangular towers which **simplify scale-up and modularization efforts**.

(Scaling technique is similar to that used on more than 200 commercial FGD systems.)

2008 – Mihara Works (~35 ft x ~15 ft)

25MW$_{eq}$ CCS Demonstration Project at Plant Barry

Plant Barry CO_2 Demo Plant – helped prove commercial viability of carbon capture on coal fired flue gas



- Funding for capture facility from Southern Company, MHI, and others.
- Designed to capture 500 metric tons per day of CO_2 at 90% capture efficiency.
- From 2011-14: over 12,000 hours, over 250,000 tons captured, over 125,000 tons injected as part of SECARB sequestration demonstration.
- Tested multiple technology improvements.

MOVE THE WORLD FORWARD

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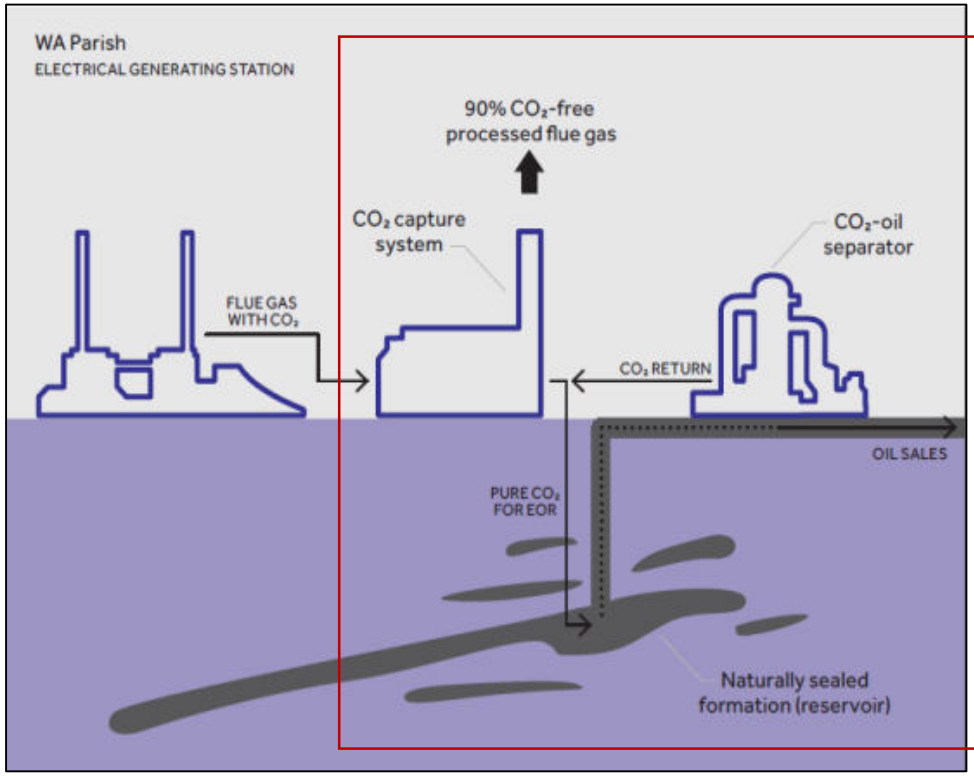
Petra Nova Project

Complete Petra Nova Project Overview

Oil revenues from CO_2 enhanced oil recovery can recover costs for the entire project without significant impact to the existing power plant.



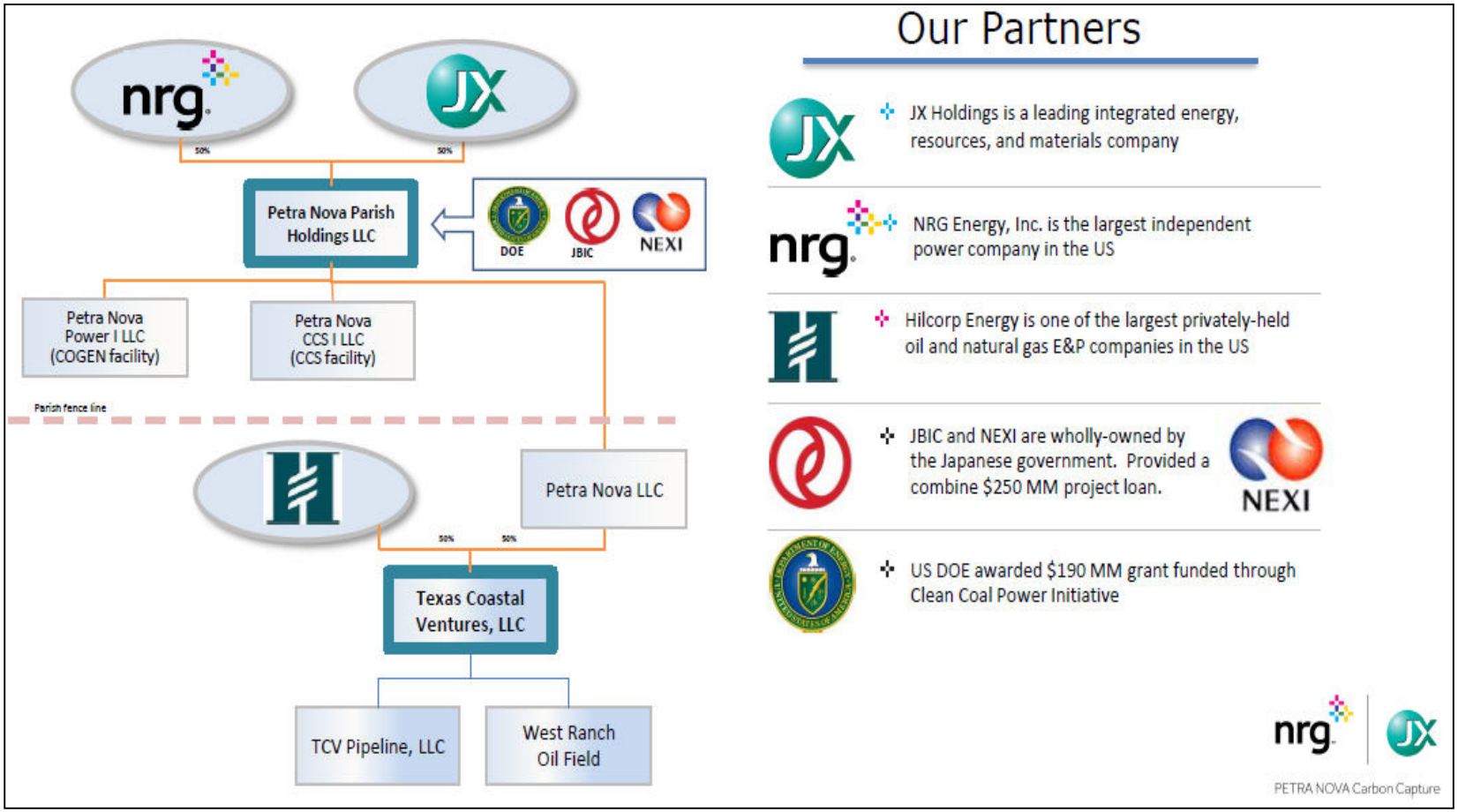
Four Key Components:

- **CO_2 Capture System** *(MHI technology)*
- **Cogeneration Plant**
- **CO_2 Transport / Pipeline**
- **Oil Field & Processing Facilities**

NRG Fact Sheet: Carbon capture and enhanced oil recovery: http://www.nrg.com/documents/business/generation/581409-factsheet-petra-nova-carbon-capture-final.pdf

Petra Nova Commercial Structure

NRG Energy and JX Oil and Gas formed the Joint Venture, Petra Nova Parish Holdings. They own the CCS facility and 50% of the CO_2 pipeline and oil field.



Reference: Petra Nova Parish Holdings

Petra Nova Carbon Capture Facility Project Overview

"NRG Energy, JX Nippon complete world's largest post-combustion carbon capture facility on-budget and on-schedule[1]"

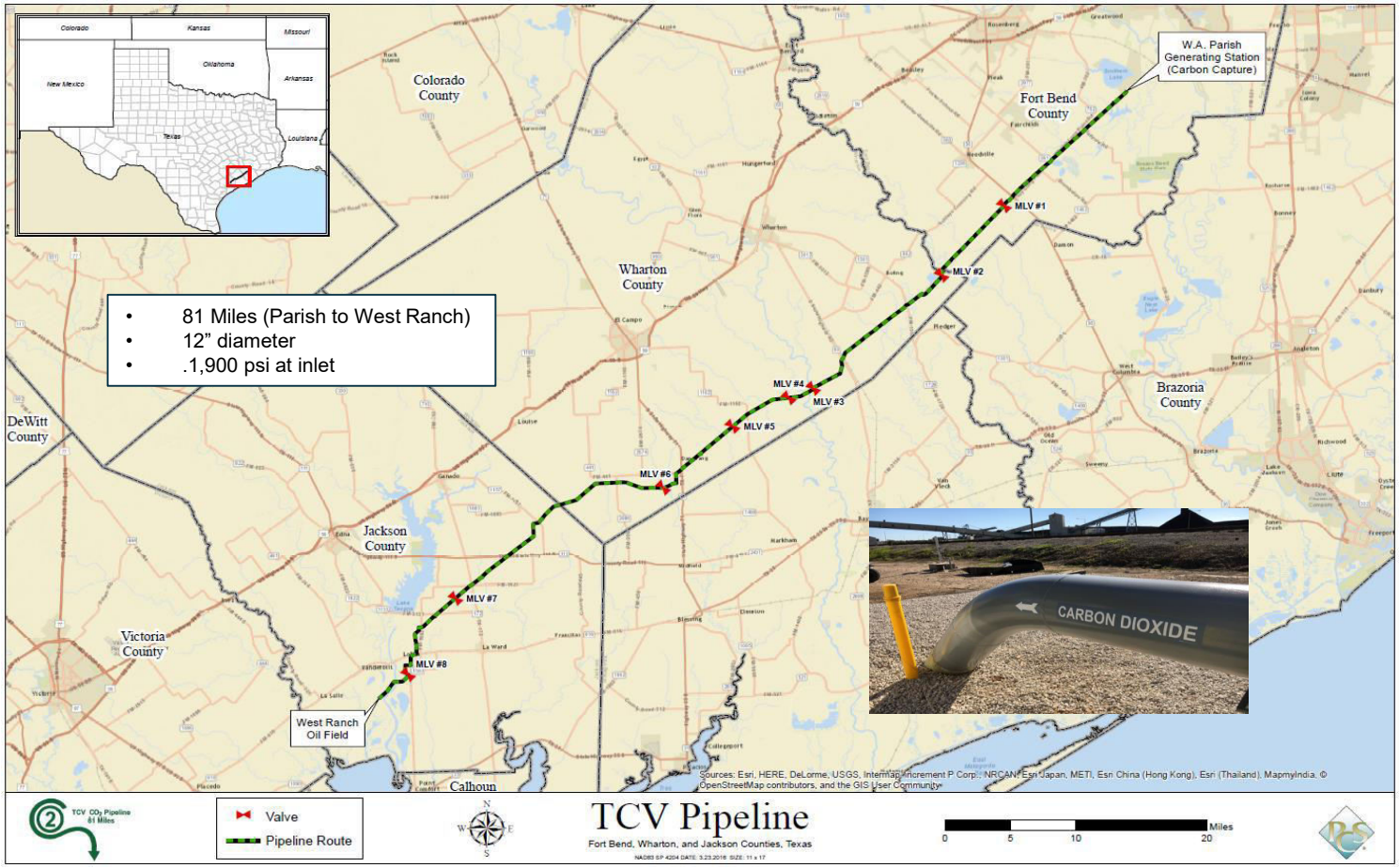
- Takes a partial "slip" stream from host unit - NRG's Parish Plant Unit 8
- Captures 5,200 tons of CO_2/day
- Achieved COD on Dec 29, 2016
- 2017 – Power Magazine "***Plant of the Year***"
- October 2017 – 1M tons of CO_2 captured

[1]NRG press release: http://investors.nrg.com/phoenix.zhtml?c=121544&p=irol-newsArticle&ID=2236424

Petra Nova Project CCS Facility Layout

Petra Nova Pipeline

Captured CO_2 is compressed by Mitsubishi's compressor and transported 81 miles by pipeline to the West Ranch Oil field for EOR.



Reference: Petra Nova Parish Holdings

Petra Nova Oilfield Facilities – EOR Operation

CO_2 captured from Parish Unit 8 is expected to boost oil production from 300 bbls/day to up to 15,000 bbls/day.

West Ranch Field Central Facilities

- 200 new wells to be drilled (over 100 now complete)
- 2 central processing facilities to separate oil-CO_2-water
- All produced CO_2 and water is reinjected into the formation

nrg | JX

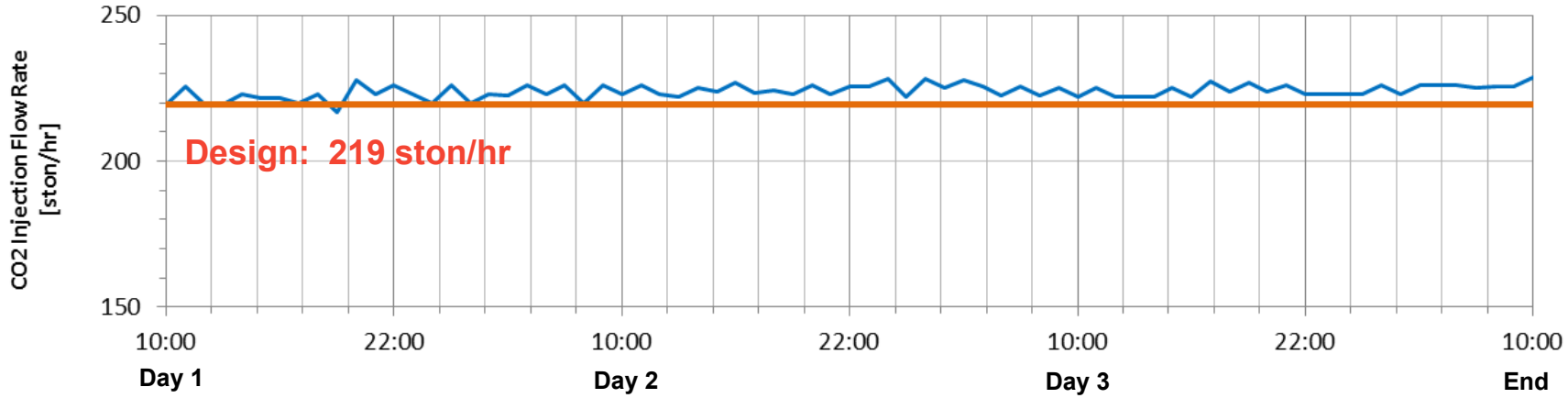
PETRA NOVA Carbon Capture

Reference: Petra Nova Parish Holdings

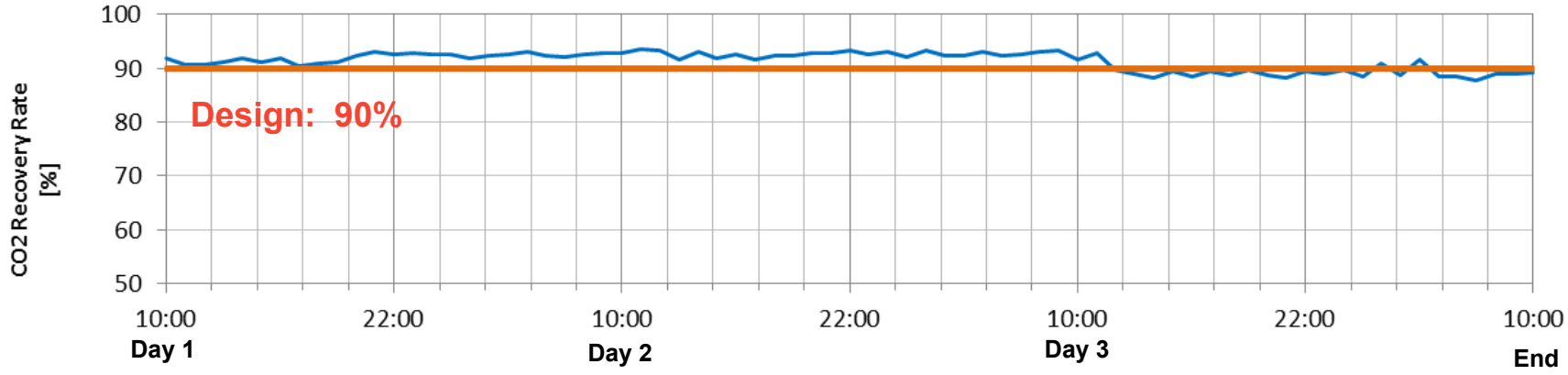
Petra Nova Project – Operation

MHI's proprietary control system (ALAC) successfully maintained stable operation.

CO_2 Production Flow Rate Trend (72hrs)



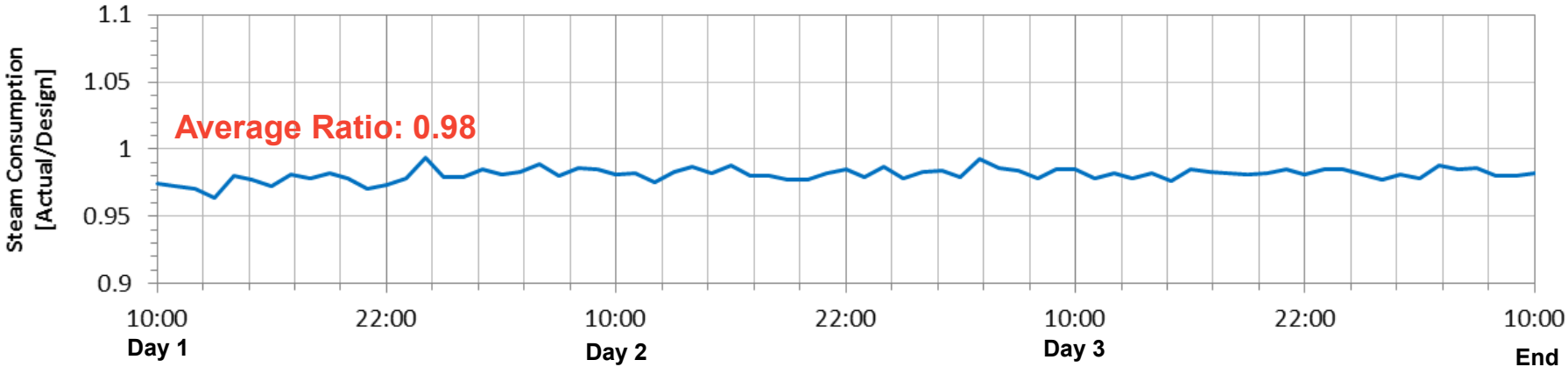
CO_2 Recovery Rate Trend (72hrs)



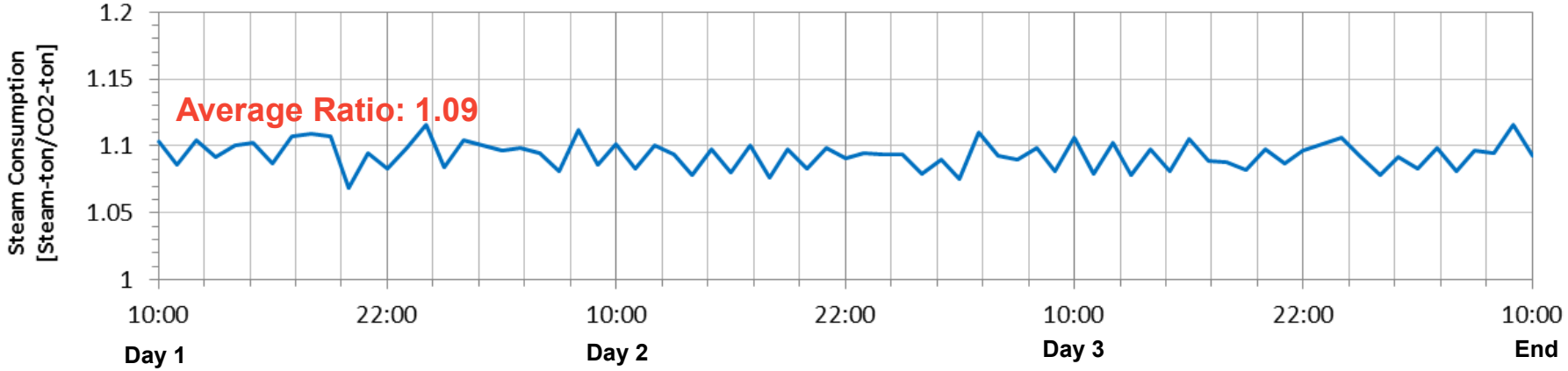
Petra Nova Project – Operation

Steam consumption exceeded expectations and has been consistently below design.

Steam Consumption Trend (Actual / Design) (72hrs)



Steam Consumption Trend (steam-ton/CO_2-ton) (72hrs)

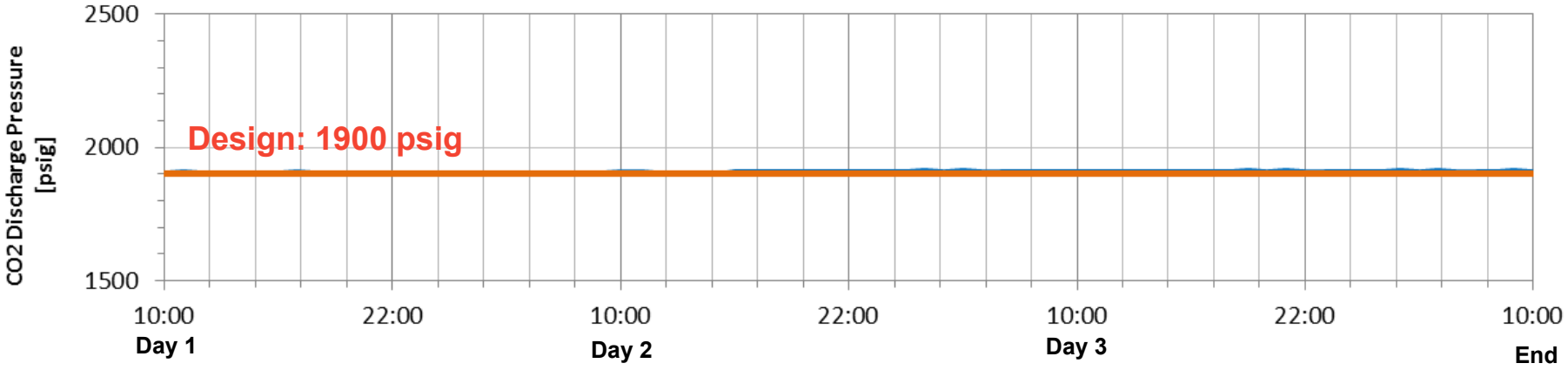


Petra Nova Project – Operation

World's largest integrally geared CO_2 compressor delivered by Mitsubishi Compressor.

- **8 stages**
- **28,700 hp**

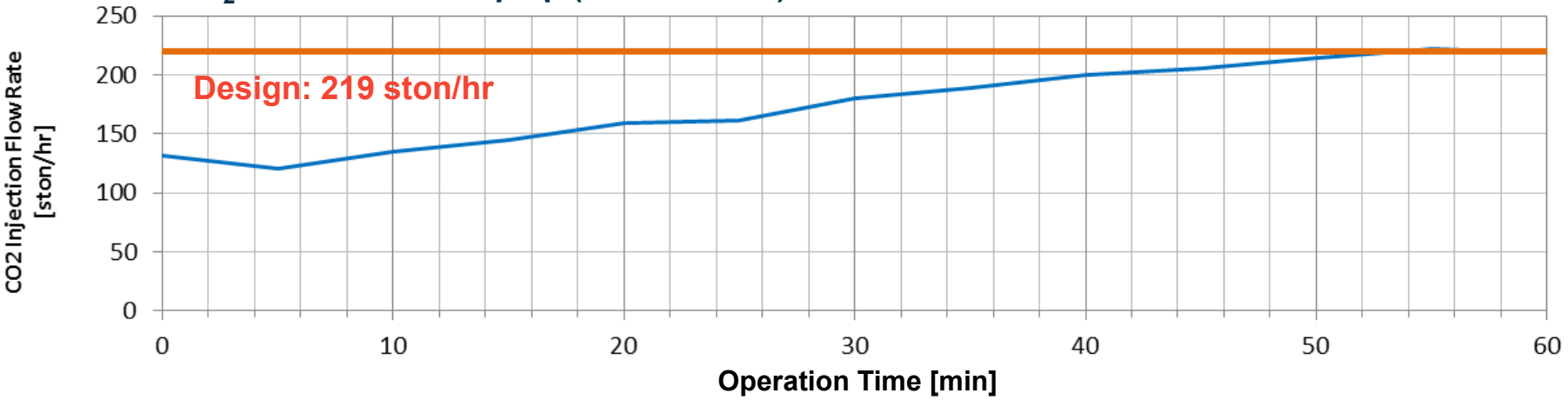
CO_2 Production Pressure Trend (72hrs)



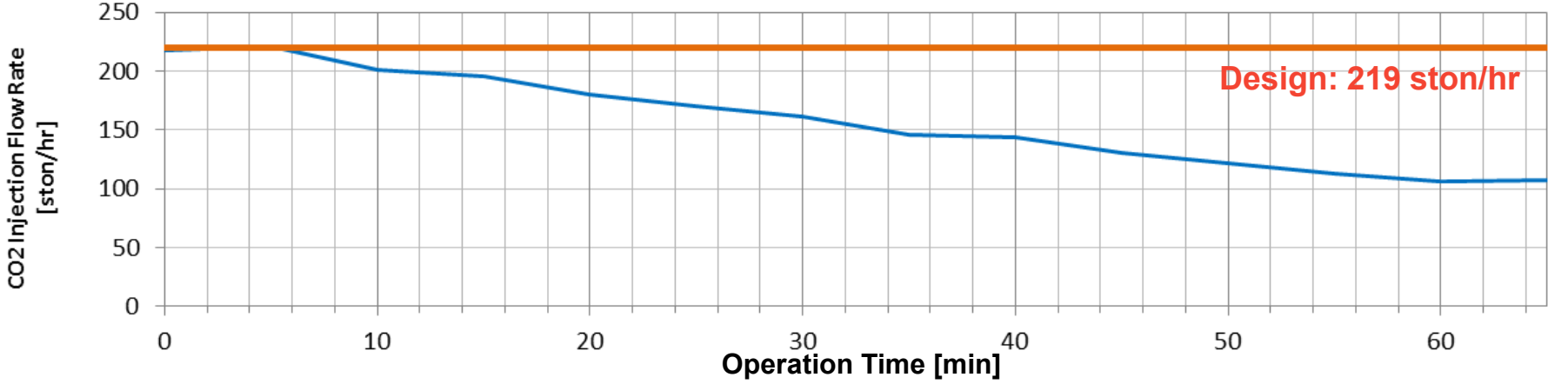
Petra Nova Project – Operation

MHI's proprietary control system (ALAC) smoothly ramps CO_2 production from 50% to 100% in less than 1 hour.

Automatic CO_2 Production Ramp up (50% -> 100%)



Automatic CO_2 Production Ramp down (100% -> 50%)



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New Solvent Testing

MHI has been investigating new solvents to further reduce the cost of CO_2 capture.

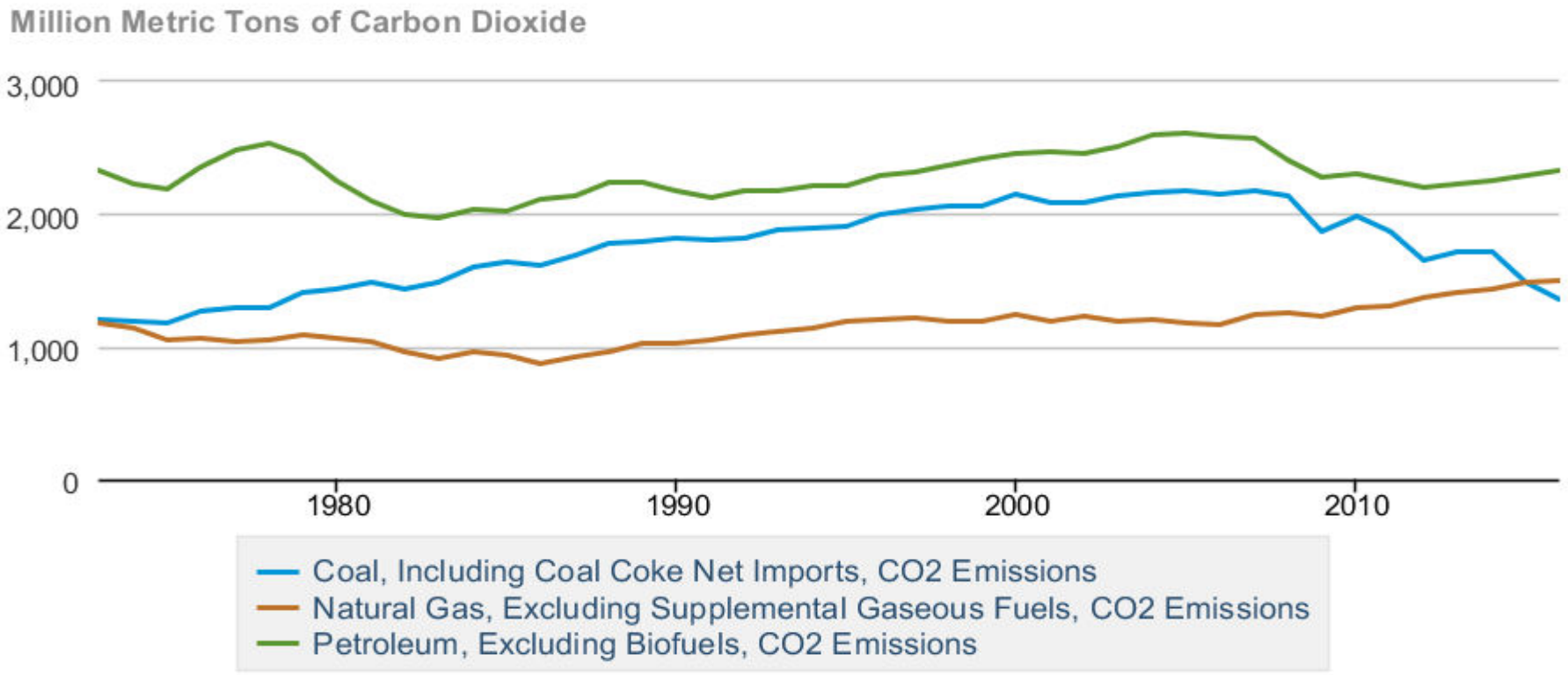
New Solvent Testing – Lab Results

	KS-1™	New Solvent
Steam Consumption	1	0.92
Solvent Degradation	1	0.53
Solvent Emission	1	0.40

- MHI conducted solvent screening in the laboratory and the Nanko pilot plant.
- New solvent has achieved lower steam consumption, solvent degradation, and solvent emissions than KS-1™.
- New solvent may require a higher solvent circulation flow rate which increases electricity consumption.
- Benefits appear to outweigh the higher flow rate.

Natural Gas Application

Table 12.1 Carbon Dioxide Emissions From Energy Consumption by Source



eia Source: U.S. Energy Information Administration

NGCC CO_2 Capture Application

MHI's KM CDR Process® can be successfully applied to NGCC power plants.

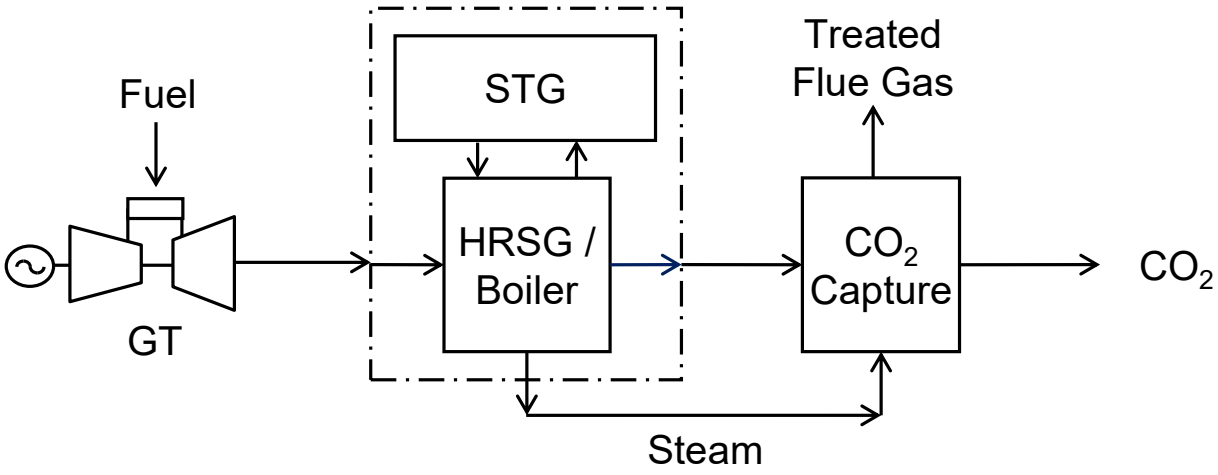
Typical Flue Gas Conditions

	Unit	Coal fired Boiler	NG fired GT
CO_2	Vol.%	10 - 14	3 - 4
O_2	Vol.%	4 - 6	10 - 15
SOx	ppm(dry)	1 - 50	<0.3
PM (Dust)	mg/Nm^3	3 - 10	NA

- KS-1™ has proved resistant to O_2 degradation despite higher concentration.
- MHI can provide large absorbers to account for lower CO_2 concentration.
- KM CDR Process® requires fewer treatment systems as a result of the minimal SOx and dust in flue gas.

NGCC CO_2 Capture Application

MHI has the capability to investigate advanced NGCC-CO_2 capture configurations to consider existing and new assets.



Fully optimized integration between NGCC and CO_2 capture can:

- Take advantage of high efficiency gas turbines
- Reduce parasitic load of CO_2 capture
- Reduce capital cost of CO_2 capture

MHI's Past, Present, and Future

Past

- Tested — MHI proved viability at multiple R&D facilities.
- Delivered — MHI delivered **eleven (11) operating commercial CO_2 capture plants** prior to the Petra Nova Project.
- Scaled-up — MHI successfully scaled-up and demonstrated long-term operation at Alabama Power's Plant Barry.

Present

- Petra Nova — **December 2016** – the world's largest post-combustion CO_2 capture project on coal-fired flue gas (4,776 mtpd) – completes performance testing.

Future

- New Solvents — MHI is developing new solvents to reduce utility consumption and emissions.
- NGCC — MHI is ready to optimize CO_2 capture for **NGCC applications.**

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IEAGHG 5th Post Combustion Capture Conference

17th -19th September 2019, Kyoto, Japan

Reliability Improvements of SaskPower's BD3 Capture Facility Through Operational and Process Design Changes: Experiencing the First Four Years of Operations

Stavroula Giannaris[a], Brent Jacobs[a], Dominika Janowczyk[a], Corwyn Bruce[a], Wayuta Srisang[a], Yuewu Feng[a]

[a]*The International CCS Knowledge Centre, 198 – 10 Research Drive, Regina, Saskatchewan, S4S 7J7, Canada*

Abstract

Carbon capture and storage technology is a proven CO2 abatement method that has been successfully implemented on various process globally including the retrofit of two coal fired power plants: SaskPower's Integrated Carbon Capture Storage Project on Boundary Dam's Unit 3 (Saskatchewan, Canada) and NRG's Petra Nova Project implemented on W.A. Parish's Unit 8 (Texas, USA). Although demonstrated on the industrial scale, global deployment is not proceeding at the desire pace. This stall in deployment has also stalled technological refinement, which is often a result of implementing multiple generations of a technology over a period of time. However, operating experiences gained in the first four years of operating the BD3 capture facility have yielded both operational and design refinements that can and should be applied to future installations of industrial scale CCS facilities at the benefit of decreases operating and maintenance costs and improve performance and reliability.

As the world's first industrial scale post combustion CO2 capture facility on a coal fired power plant, many lessons were learned through the design, construction and operations of the carbon capture facility at BD3. These lessons have resulted in novel optimizations, operating methods and overall learnings for the facility and its role as a power generator in the power utility. Through this process the original design decisions and intents were challenged, both validating and dis-proving what was at the time the best information available. This paper discusses the design and operational changes that were made as a result of evaluating the performance of the capture facility in the initial years of operation. These changes included: upgrades to instrumentation, installation of redundancy and isolations for key pieces of equipment, isolation upgrades for various other pieces of equipment, installation of flyash mitigation equipment, as well as process modifications for controlling amine degradation. Future upgrades and modifications are also presented in this paper which are supported by extending the capture facility's performance evaluation up to current day operations.

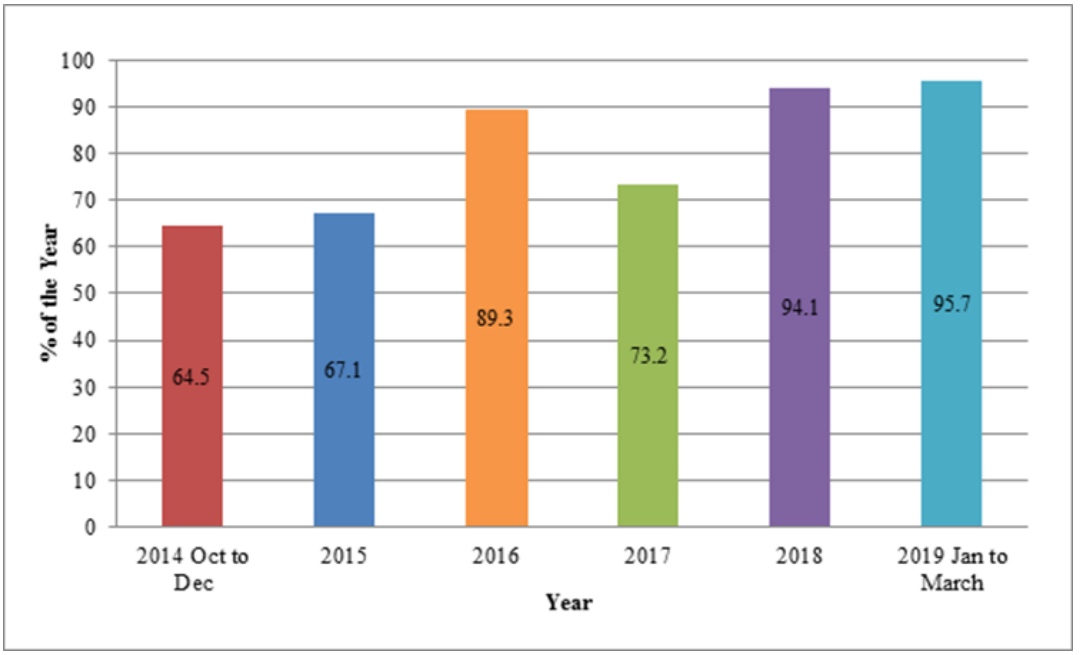

Figure 1. Summary of capture plant availability (October 2014 – March 2019)

Keywords: Post combustion carbon capture and storage, Boundary Dam Unit 3, Coal fired power plants, Capture facility reliability,

SC 1-7: Please refer to the direct testimony of Roger Schiffman at page 7, lines 18-21.

a. What exactly does Mr. Schiffman recommend that the Commission order to "build sufficient flexibility into PNM's procurement plan"?

b. By what date does Mr. Schiffman anticipate that Enchant could offer firm PPA pricing to PNM?

c. If the FEED study indicates that the Enchant project is not viable, and Enchant could not offer a PPA to PNM, how does Mr. Schiffman recommend that PNM ensure it has replacement energy and capacity available by mid-2022?

d. Please explain why PNM and its ratepayers should risk not having adequate replacement energy and capacity available based on a speculative PPA.

RESPONSE:

The City and San Juan object to this request on the grounds that it calls for speculation. Rule 1-026(B)(1) NMRA; 1.2.2.25 NMAC.

The City and San Juan further object to this request to the extent it seeks a legal conclusion because they are not calculated to lead to discovery of admissible evidence. *Mikeska v. Las Cruces Reg'I Med. Ctr*., 2016-NMCA-068, 388 P.3d 266, *cert, denied*, No. S-l-SC-35903 (July 20, 2016). (Standing for the proposition that opinion testimony seeking to set forth a legal conclusion is inadmissible); Rule 1-026 (B)(1) and (2) NMRA; 1.2.2.25 NMAC.

The City and San Juan further object to this request on the grounds that it is vague and ambiguous and requires them to engage in conjecture. Rule 1-026(B) NMRA; 1.2.2.25 NMAC. In re PNM Gas Servs., 2000-NMSC-012, 66, 129 N.M 1 (invalidating agency decision based on mere conjecture.)

The City and San Juan object to this request for information on the grounds that it is overly broad and ambiguous and seeks information which is not relevant to the subject matter involved in the pending cases and is not reasonably calculated to lead to the discovery of admissible evidence. *See generally* Rule 1-026(B)(1) NMRA; 1.2.2.25 NMAC; *see also Archuleta v. Santa Fe Police Dep't*, 2005-NMSC-006, ¶¶ 23-25, 29, 137 N.M. 161 (holding that no abuse of discretion occurred when the request was denied because the request, which did not relate to the specific incident or defendant, was overbroad and sought information that had little or no relevance); *Ruiz v. S. Pac. Transp. Co*., 1981-NMCA-094, ¶¶ 39-41, 97 N.M. 194 (affirming the court's determination that the discovery requests were objectionable because they were exceedingly broad or irrelevant); 1.2.2.25(C) NMAC ("Discovery in commission proceedings shall be governed by the New Mexico rules of civil procedure for the district courts applicable to discovery, except where such rules are inconsistent with this rule.").

The City and San Juan further object to this request to the extent that it seeks information protected from disclosure by the attorney-client privilege or the work product doctrine and/or seeks other confidential and proprietary information, including confidential and proprietary information belonging to third-parties, not subject to public disclosure. Rules 1-026(B)(2) and

11-508 NMRA; *Pincheira v. Allstate Ins. Co*., 2008-NMSC-049, 144 N.M. 601, 190 P.3d 322, *aff'g* 2007-NMCA-094, 142 N.M. 283,164 P.3d 982; 1.2.2.25 NMAC.

The City and San Juan additionally object to this request in that it would require them to provide information not in existence or not within their possession or control. 1.2.2.25(F) NMAC; Rule 1-034(A)(1) (establishing that a party may serve on another party a request to produce information that is within the scope of Rule 1-026 NMRA and in the "possession, custody or control of the party upon whom the request is served").

Without waiving the foregoing objections, the City and San Juan respond as follows:
a. Mr. Schiffman recommends that the Commission order that PNM review any PPA offered by Enchant prior to September 1, 2020, and complete an assessment of whether the PPA terms being offered represent cost reductions for PNM and its ratepayers, and comparable levels of reliability, relative to the resource plan approved by the Commission in this proceeding.
b. September 2, 2020, or earlier, assuming that a purchase contract is agreed to between Enchant, the City of Farmington, and other current owners of SJGS, including PNM.
c. A sufficient portion of the FEED study will be completed prior to June 1, 2020, to enable PNM to evaluate if the CCUS retrofit will be viable. In addition, as discussed in Mr. Schiffman's testimony, PNM could also consider short-term bridge transactions from currently uncontracted natural gas combined cycle resources in the region.
d. The City and San Juan further object on the grounds that this interrogatory mischaracterizes Mr. Schiffman's testimony. NMAC; Rule 1-034(A)(1) NMRA (establishing that a party may serve on another party a request to produce information that is within the scope of Rule 1-026 NMRA and in the "possession, custody or control of the party upon whom the request is served"). Mr. Schiffman's testimony does not suggest that PNM and its ratepayers should risk not having adequate replacement energy and capacity.

SC 1-15: Please refer to the direct testimony of Warren Unsicker, which states on page 9 that "The purpose of the up to 450 MW requirement in the ETA is to help mitigate against the economic impacts that will result from the SJGS and SJC Mine closing." Please explain why it would be consistent with this purpose of the ETA to locate 450 MW of replacement resources in the school district in light of the City of Farmington's plan to continue to operate SJGS.

RESPONSE: The City and San Juan object to this request because it fails to refer to the entire statement of Mr. Unsicker and is therefore out of context and misleading. Without waiving the foregoing objections, the City and San Juan state that the continuation of SJGS as a CCUS facility is still in the planning stages and the City is not able to fully rely on the accomplishment of that effort. Although the July 8, 2019 Sargent & Lundy study and the December 12, 2019 Preliminary Assessment by LANL are encouraging, the FEED study is still underway and its results are not yet known. There are many financial, economic and regulatory steps to be taken in addition to resolution of the technical issues addressed in these studies before the CCUS conversion and continued operation of SJGS can be realized. Consequently, the City and San Juan insist that the requirement of the ETA that up to 450 MW of replacement resources be located in the CCSD be applied so that if the continuation of SJGS as a CCUS facility is not accomplished the resulting economic impact of the shutdown of SJGS and the San Juan Coal Company mine will be partially offset. The City itself will not operate the plant and is in ongoing negotiations with a third party operator. As such, the City only has so much control over the final decision to keep the plant operational. Thus, the City must plan as if there is still the potential for the plant to no longer be operational and ensure the future of the economy and the tax base of the area.

SC 1-20.

Please refer to the direct testimony of Dhiraj Solomon, page 11, lines 4-6. Please confirm that the authors of the Los Alamos National Laboratory study referenced on these lines were not able to independently review data on the CO2 emissions capture rate of Petra Nova and Boundary Dam.

Staff Response SC 1-20:

Staff will supplement this response with information from Mr. Solomon when it becomes available.

Staff Supplemental Response SC 1-20:

See response to SC 1-19 above.

Preparer: Dhiraj Solomon, PE
Sponsor: Dhiraj Solomon, PE

SC 1-21.

Please refer to the direct testimony of Dhiraj Solomon, page 11, lines 1-13, concerning Case No. 19-00018-UT.

a. Has Mr. Solomon read the rebuttal testimony of Mr. Nicholas Phillips concerning carbon capture?
    i. If yes, does Mr. Solomon have any basis for disagreeing with any of Mr. Phillips' conclusions. If so, please explain the basis for Mr. Solomon's disagreement with Mr. Phillips' conclusions.
b. Has Mr. Solomon read the rebuttal testimony of Mr. Frank Graves concerning carbon capture?
    i. If yes, does Mr. Solomon have any basis for disagreeing with any of Mr. Graves' conclusions. If so, please explain the basis for Mr. Solomon's disagreement with Mr. Graves' conclusions.
c. Has Mr. Solomon read the rebuttal testimony of Mr. David Schlissel concerning carbon capture?
d. Has Mr. Solomon read the rebuttal testimony of Mr. David Posner concerning carbon capture?

Staff Response SC 1-21:

Staff will supplement this response with information from Mr. Solomon when it becomes available.

Staff Supplemental Response SC 1-21:

Mr. Solomon has not read the rebuttal testimonies of Messrs. Phillips, Graves, Schlissel and Posner referenced in a through s above because they were submitted in Case No. 19-00018-UT and the hearing in that case has concluded.

Preparer: Dhiraj Solomon, PE
Sponsor: Dhiraj Solomon, PE

SC 1-22.

Please refer to the direct testimony of Dhiraj Solomon, page 11, lines 11-13. Does Mr. Solomon agree that the rebuttal testimony of Mr. Nicholas Phillips in 19-00018-UT analyzes a scenario in which PNM operates San Juan with CCUS technology with 45Q tax credits and CO2 for EOR? If no, please explain.

Staff Response SC 1-22:

Staff will supplement this response with information from Mr. Solomon when it becomes available.

Staff Supplemental Response SC 1-22:

Mr. Solomon has not read the rebuttal testimony of Mr. Phillips in Case No. 19-00018-UT because the hearing in that case has concluded.

Preparer: Dhiraj Solomon, PE
Sponsor: Dhiraj Solomon, PE

SC 1-23.

Please refer to the direct testimony of Dhiraj Solomon, page 11, lines 11-13. Does Mr. Solomon agree that the rebuttal testimony of Mr. Frank Graves in 19-00018-UT analyzes a scenario in which PNM operates San Juan with CCUS technology with 45Q tax credits and CO2 for EOR? If no, please explain.

Staff Response SC 1-23:

Staff will supplement this response with information from Mr. Solomon when it becomes available.

Staff Supplemental Response SC 1-23:

Mr. Solomon has not read the rebuttal testimony of Mr. Graves in Case No. 19-00018-UT because the hearing in that case has concluded.

Preparer: Dhiraj Solomon, PE
Sponsor: Dhiraj Solomon, PE

SC 1-24.

Please refer to the direct testimony of Dhiraj Solomon, page 11, lines 11-13. Does Mr. Solomon agree that the rebuttal testimony of Mr. David Schlissel in 19-00018-UT explains why it is not economically feasible for PNM to operate San Juan with CCUS technology with 45Q tax credits and CO2 for EOR? If no, please explain.

Staff Response SC 1-24:

Staff will supplement this response with information from Mr. Solomon when it becomes available.

Staff Supplemental Response SC 1-24:

Mr. Solomon has not read the rebuttal testimony of Mr. Schlissel in Case No. 19-00018-UT because the hearing in that case has concluded.

Preparer: Dhiraj Solomon, PE

Sponsor: Dhiraj Solomon, PE

SC 1-25.

Please refer to the direct testimony of Dhiraj Solomon, page 11, lines 11-13. Does Mr. Solomon agree that the rebuttal testimony of Mr. David Posner in 19-00018-UT explains why it is not economically feasible for PNM to operate San Juan with CCUS technology with 45Q tax credits and CO2 for EOR? If no, please explain.

Staff Response SC 1-25:

Staff will supplement this response with information from Mr. Solomon when it becomes available.

Staff Supplemental Response SC 1-25:

Mr. Solomon has not read the rebuttal testimony of Mr. Posner in Case No. 19-00018-UT because the hearing in that case has concluded.

Preparer: Dhiraj Solomon, PE
Sponsor: Dhiraj Solomon, PE

SC 1-26.

Please refer to the direct testimony of Dhiraj Solomon, page 11, lines 3-4.

a. Why did Mr. Solomon wait until December 13, 2019 to ask the Commission to order PNM to make a supplemental filing to address "the ramifications if the Enchant Energy CCUS project were to proceed and be successful."
b. Please confirm that Mr. Solomon was aware of the Enchant CCUS project on July 1, when PNM filed its application to abandon and replace San Juan Generating Station Units 1 and 4.
c. Has Staff filed, or does Staff intend to file, a motion asking the Commission to order PNM to make a "supplemental filing" to address "the ramifications if the Enchant Energy CCUS project were to proceed and be successful."
d. What ramifications is Mr. Solomon referring to?
e. What ramifications does Mr. Solomon believe Enchant Energy's CCUS project has on the application from PNM for replacement resources?

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	**)**	**CASE NO. 19-00195-UT**

WESTMORELAND MINING, LLC'S RESPONSE TO PNM'S FIRST SET OF INTERROGATORIES AND REQUESTS FOR PRODUCTION

PNM INTERROGATORY 1-6: In the City of Farmington's response to the October 25th, 2019 Bench Request they indicate that commissioning of the CCUS may not be complete until June 2023, and they also cannot predict issues that may arise that will cause this estimated timeline to be delayed in a significant manner. Assuming this timeline, what resources will PNM rely on to meet customer needs in July 2022 through May 2023?

RESPONSE:

PNM could rely on purchased power to meet its capacity need for Summer 2022. Among other things, Mr. Griffey understands that PNM will join the Western Energy Imbalance Market (EIM) starting in 2021, which would make spot purchases available. Other short-term PPAs may also be available, as well as purchases from SJGS before the retrofit is completed. This could potentially be addressed in a PPA brought forth by Enchant/Farmington.

Prepared by: Counsel / Charles S. Griffey
Sponsored by: Charles S. Griffey