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Enchant's Proposed CCS Project at the San Juan Generating Station: False Promises and Major Risks

Executive Summary

Enchant Energy and its partners tout the proposal to retrofit Units 1 and 4 at the San Juan Generating Station (San Juan or SJGS) in New Mexico with carbon capture equipment to prevent their closure in 2022 as a win-win-win proposition; one that will benefit ratepayers, the surrounding community and the environment. We believe nothing could be further from the truth: Enchant's proposal is based on little more than a series of very unlikely, almost fantastical, assumptions that impose major risks on plant owners and the local community, burn through investors' cash and stand to provide little to no benefit to anyone other than the promoters.

The Enchant plan, which first surfaced in 2019, calls for capturing the carbon dioxide (CO_2) from the two remaining units at the San Juan station, which currently have a summer operating capacity of 847 megawatts (MW). The Enchant proposal would make the project the largest power plant carbon capture and storage (CCS) facility in the world—by far. The next largest project (one of only two power plant CCS projects in the world) is the Petra Nova plant in Texas run by NRG Energy, which captures carbon from a 240MW slipstream from Unit 8 of the W.A. Parish plant.

The scale-up relative to Petra Nova in and of itself presents an enormous risk to the project's feasibility. But even greater risks are evident in three assumptions made by Enchant, assumptions that all must hold true for the project to have even a chance of being commercially viable. These three assumptions are:

- That the retrofitted units will operate at an average capacity factor of at least 85% for the first 12 years of the project's operation;
- That the retrofitted plant will capture 90% of the CO_2 produced at San Juan, and will do so for at least 85% of the hours every year for 12 years; and
- That the plant will be able, as a result, to sell six million metric tons[1] of CO_2 every year for use in enhanced oil recovery (EOR) activities in the Permian Basin in order to pay for the project.

None of these three assumptions is realistic, as we will demonstrate in the body of this report.

Both units, for example, have consistently failed over the past decade to post annual capacity factors of 85%, and both have generated less power and operated more

[1] A metric ton weighs 1,000 kilograms, or 2,204.6 pounds. The U.S. ton, 2,000 pounds, is equivalent to 908 kg. Figures throughout this report are in metric tons or simply tonnes.

unreliably as time has gone by. Looking ahead, plant aging and significant market changes—especially around soaring renewable generation and readily available low-cost gas—will cap the plant's performance well below the 85% level posited by Enchant.

Similarly, operating performance at Petra Nova and the second, smaller power plant carbon capture facility, at Boundary Dam 3 in Canada, have fallen short of capturing 90% of the CO_2 produced at each of these plants. There is no reason to believe that the much-larger San Juan project will be able to meet that performance level consistently for at least 85% of the hours for a period of 12 years, one of the prerequisites for Enchant's proposal.

These two circumstances alone—market forces and technological challenges—suggest that Enchant will never be able to capture the six million metric tons of CO_2 needed to make the project potentially feasible.

We also will show that Enchant has substantially understated the risks in the CO_2 and oil markets, risks that we believe call into question any power plant project that relies on sales into these markets to make a carbon capture proposal pencil out. Enchant also has publicly ignored the significant financial risks associated with selling the electricity produced at San Juan and instead has claimed, incorrectly, that San Juan will sell its electricity because it is a low-cost generator, which it is not.

Enchant is selling a fantasy, one that requires believers to ignore the serious risks associated with the proposal. This may work for Enchant, which can, in the end, always opt to walk away from the project (after pocketing federal grant money). Regulators, the city of Farmington, citizens, the state of New Mexico and investors won't have that option.

Sound resource and financial planning requires examining a range of possible outcomes, and here the Enchant proposal falls especially short, relying on a single overly optimistic set of assumptions that falsely makes the proposal seem financially feasible on its face.

The truth is that money put into the proposed San Juan project will very likely end up being money wasted. We believe the dream Enchant is selling, if it goes forward, will turn into something more closely resembling a nightmare for all concerned, and that investors and regulators should approach the project with the scepticism it deserves.

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It Is Extremely Unrealistic to Expect That San Juan Will Capture Six Million Metric Tons of CO_2 Each Year

Simply put, the amount of CO_2 captured is a function of how much CO_2 a coal-fired generator produces and the efficiency with which a capture system works.

The first variable, how much CO_2 the plant produces is, in turn, largely dependent on how much the plant operates. The term capacity factor indicates 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 the hours of the same 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 goes up.

Capturing 6 million metric tons of CO_2 annually, as Enchant claims it will do at San Juan, is contingent on two key assumptions: first, that San Juan Units 1 and 4 will operate at an average annual capacity factor of at least 85%, thereby producing large amounts of CO_2, and second, that the retrofitted plant's carbon capture equipment will be able to capture 90% of the CO_2 produced, and will do so for at least 85% of the hours each year in the 12-year period 2023-2034. As we will demonstrate in this report, neither of these assumptions is reasonable.

San Juan Cannot Be Expected to Operate at an Annual Capacity Factor of 85%

San Juan's Performance History

The key to the economics of Enchant's entire proposal is the company's assumption that the retrofit plant will operate at an average capacity factor of at least 85% for 12 years following the project's start-up. Only by running at this rate can the plant produce the six million metric tons of CO_2 emissions that can then be captured and sold and on which the project's financial feasibility depends.

The problem is that the San Juan plant is extremely unlikely to operate at this level over any extended period, which calls into question the entire business model on which Enchant's proposal is built.

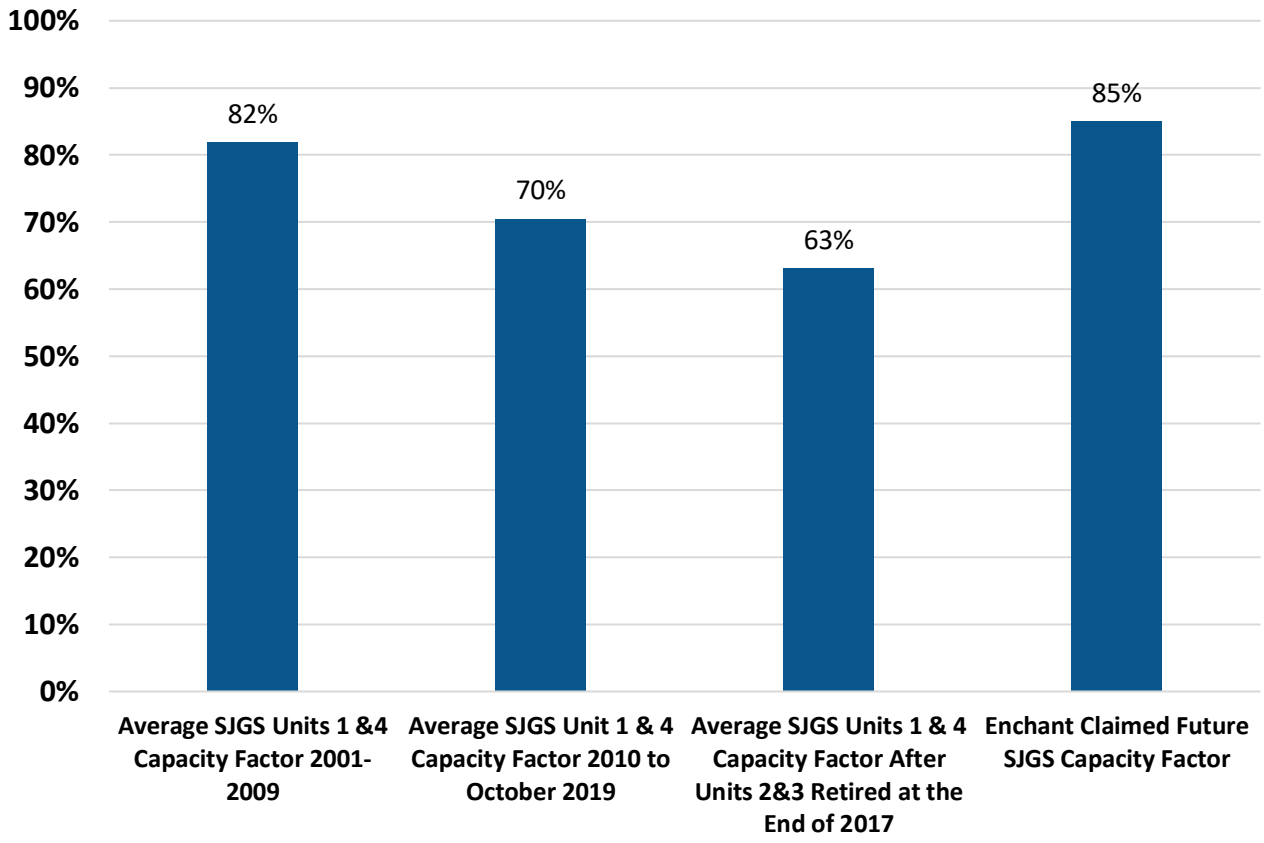
How Enchant arrived at the 85% capacity factor projection is unclear since neither unit has operated at that level for any length of time since 2001.

This projection underscores the unrealistic nature of Enchant's proposal. From 2001-2009, which was before both the fracking revolution that brought huge supplies of low-cost gas into the electricity sector and before the surge in wind and solar generation that is both low cost and emissions free, Unit 1 posted an average capacity factor of 80% and Unit 4 recorded an average of 83%, for an average of 82% for both units. Fairly close to 85%, but not 85%.

Since then, the performance at both units has dropped significantly. The collective capacity factor for the two units has averaged only 70% since January 2010.

And the closer to the present we look, the worse the two units have performed. For example, since the plant's other two units (2 and 3) were closed at the end of 2017, the average capacity factor of Units 1 and 4 has been just 63%. The plant's performance from January 2001-October 2019 can be seen in the following chart.

Figure 1 - Actual San Juan Annual Capacity Factors vs. Enchant's Claims of Future Plant Performance



Source: EIA, S&P Global Market Intelligence, Sargent & Lundy[2]

The capacity factor declines at San Juan are far from unique. Energy Information Administration statistics show that the average capacity factor for coal plants in the U.S. dropped from 64.2% in 2009 to 53.6% in 2018. Further, through the first 11 months of 2019, the average fell to 47.8%, an indicator of growing momentum around change across the U.S. electric sector.

[2] EIA Form 923 data downloaded from S&P Global Market Intelligence, Sargent & Lundy. Enchant Energy San Juan Generating Station – Units 1 & 4 CO_2 Capture Pre-Feasibility Study. July 8, 2019.

Enchant's claimed 85% capacity factor assumption also flies in the face of industry-wide experience.

In 2018, only 13 of the 390 operating coal-fired units in the U.S. operated with an 85% capacity rate—barely 3% of the entire fleet—while 57 units, or four times as many, failed to achieve even a 30% capacity factor in the same year.[3]

Just as important, only four of the 390 coal-fired generators operating in 2018—that is, just 1% of the total—posted an average capacity factor of 85% or higher during the four-year period from 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.

Enchant claims that by adding carbon capture equipment to San Juan, which will require 246MW of the plant's capacity to operate, the plant's overall capacity factor will rise. This may be true to a very limited extent, but the plant's overall capacity factor would remain—in the best-case scenario—in the range of 71% to 75%, far below Enchant's 85% required capacity factor for the entire plant.

Not only have San Juan's capacity factors declined over the past decade, as shown in Figure 1 above, Units 1 and 4 have operated unreliably, as shown in measures commonly used in the electric power industry.

One such indicator, WEFOR (which stands for weighted equivalent forced outage rate), measures how much of the time a power plant is fully or partially required to reduce power as the result of unplanned (also called forced) equipment problems, with the result weighted by the size of the plant. Put another way, WEFOR is a measure of a unit's unavailability due to unplanned events. The lower the WEFOR the more reliably the unit is operating.

A second commonly used measure is WEAF, which stands for weighted equivalent availability factor. A plant's equivalent availability reflects the power levels at which it operates. WEAF reflects both planned and unplanned full and partial unit outages and derates.[4] A higher WEAF means that the unit is available for a greater fraction of the year without any outages and equipment or seasonal deratings.

Thus, the lower the WEFOR and the higher the WEAF, the better.

Tables 1 & 2 show the average WEFOR and WEAF numbers achieved by Units 1 and 4 from 2014-2019 and compares that performance with comparable coal-fired generators around the U.S.

[3] EIA Form 923 data downloaded from S&P Global Market Intelligence on November 5, 2019.
[4] North American Electric Reliability Corporation (NERC). Generating Availability Data System (GADS) Reporting Instructions. January 1, 2020

Table 1 - San Juan Unit 1 Operating Performance 2014-2019[5,6]

	San Juan Unit 1 Average 2014-2019	Industry Average for Coal-Fired Units Sized 300-399 MW
WEFOR	23%	10%
WEAF	69%	79%

Table 2 - San Juan Unit 4 Operating Performance 2014-2019[7,8]

	San Juan Unit 4 Average 2014-2019	Industry Average for Coal-Fired Units Sized 400-599 MW
WEFOR	16%	9%
WEAF	78%	79%

The figures in Tables 1 and 2 show that:

- San Juan Unit 1 was shut down for unplanned full or partial outages 23% of the time in the years 2014-2019, and was only available to operate at full power 69% of the time.[9]
- San Juan Unit 4 was shut down for unplanned full or partial outages 16% of the time during this period and was only available to operate at full power 78% of the time.
- San Juan Units 1 and 4 are much less reliable than comparably sized coal-fired units.

Unreliable operating performance like this is one of the factors that will prevent San Juan from achieving the 85% annual capacity factor projected by Enchant.

Other than saying it will be adding the new carbon capture facility, Enchant hasn't provided any evidence as to what other steps it would take to reverse San Juan's history of declining and unreliable operating performance nor has Enchant said how much it would have to spend to do so.

[5] San Juan Unit 1 data is from PNM's response to Sierra Club Data Request 14-1 in New Mexico Public Regulation Commission Case No. 19-00195-UT.
[6] The industry average data is from the years 2014-2018. NERC has not yet published the GADs data for 2019.
[7] San Juan Unit 4 data is from PNM's response to Sierra Club Data Request 14-1 in New Mexico Public Regulation Commission Case No. 19-00195-UT.
[8] The industry average data is from the years 2014-2018. NERC has not yet published the GADs data for 2019.
[9] Unit 1's reliability was much worse in the years 2018 and 2019 when its WEFOR average 31% and its WEAF was just 63%.

A Rapidly Changing Market

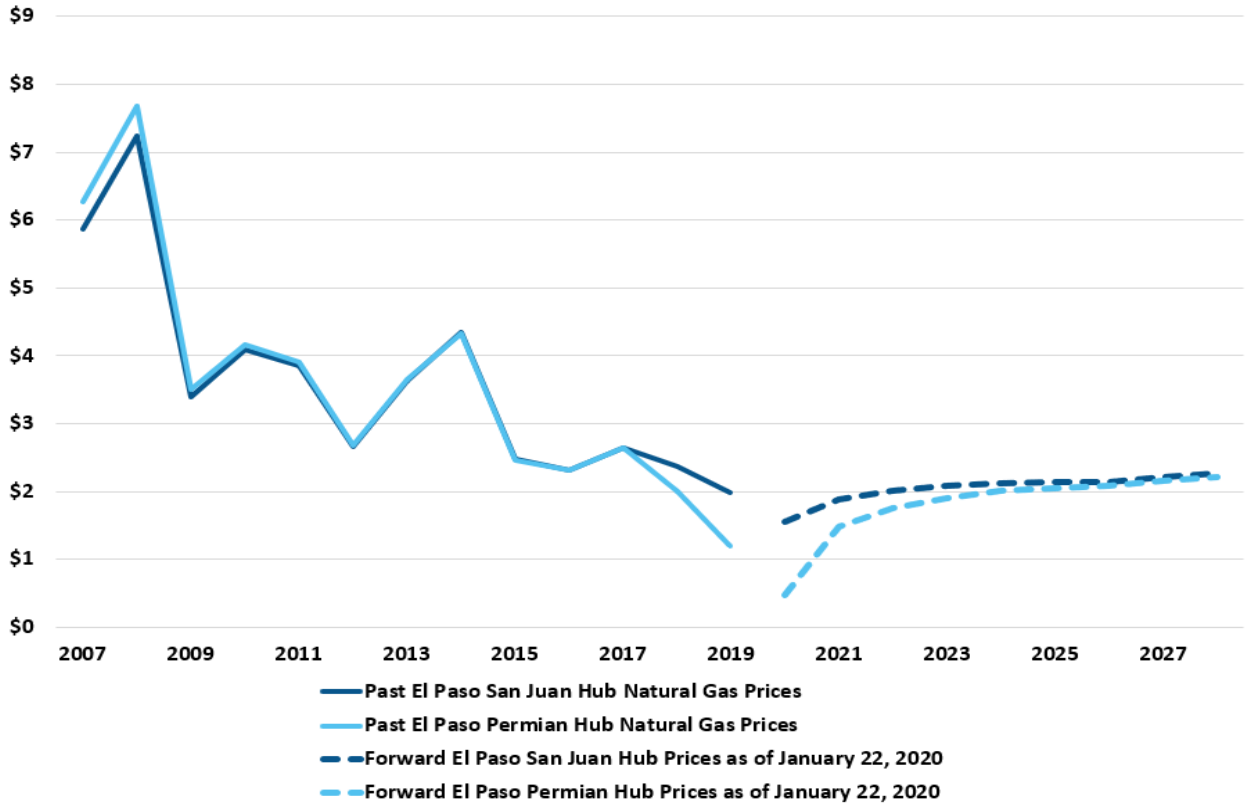
The capacity factor declines at San Juan are likely to continue, and probably accelerate, pushed down by a combination of forces roiling the electricity markets in general across the U.S. and a number of plant-specific issues. These factors include:

- The projected continued availability of low-cost gas.
- Growing competition from renewable resources and energy storage.
- Increased integration of the Western power grid.
- The impact of plant aging.
- The impact of reduced spending on maintenance by the current owners.
- The fact that San Juan will be a much more complicated plant to operate with carbon capture.

Natural Gas

Similar to what has happened elsewhere in the U.S., 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: S&P Global Market Intelligence, OTC Global Holdings[10]

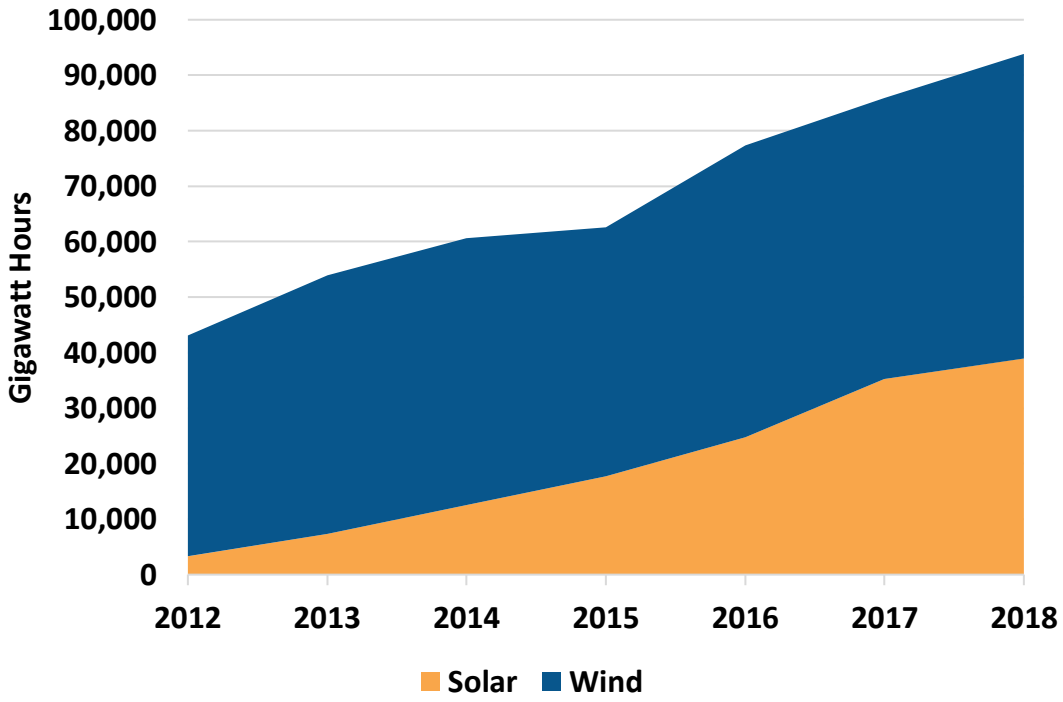
These persistently low prices will undermine the financial viability of the proposed retrofit of San Juan with carbon capture by reducing fuel costs for gas-fired plants with which San Juan would compete. This, in turn, would lead to (a) lower energy market prices and (b) increased generation at gas-fired plants, thereby displacing generation that otherwise would be produced at San Juan, lowering its capacity factor.

Renewable Competition From Wind and Solar Resources

Wind and solar generation have increased significantly in the Western U.S. in the past decade, with dramatic price declines resulting in a doubling in generation between 2012 and 2018, see figure 3 below.

[10] The forward prices in Figure 2 represent the markets view of what future gas prices will be. Past Natural Gas Prices downloaded from S&P Global Market Intelligence on January 24, 2020. Forward prices from OTC Global Holdings, also downloaded from S&P Global Market Intelligence on January 24, 2020.

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



Sources: U.S. Energy Information Administration[11]

More renewable generation is on the horizon regionally as states push utilities to boost their renewable generation. California, for example, now mandates that 33% of electricity sales in 2020 and 60% of sales in 2030 come from renewable resources.[12] Elsewhere, Colorado is pushing a "roadmap" to 100% renewable energy in the state by 2040 and Nevada passed legislation last year requiring the state's utilities to meet a 50% renewable energy standard by 2030. New Mexico last year enacted a law that requires utilities to get 50% of their power from renewables by 2030 and 80% by 2040.

As the amount of installed renewable generation has climbed, the prices of buying power from solar and wind resources have fallen.

Data from Lawrence Berkeley National Laboratory (LBNL) shows that the prices of solar power purchase agreements (PPAs) have fallen dramatically in all regions of the country, declining by more than 80%.[13] Current PPA prices are now commonly below $50/MWh and often significantly less than that. In a review of 38 PPAs signed since 2017, LBNL found that 27 were priced below $40/MWh, with 21 less than

[11] U.S. Energy Information Administration (EIA). Electric Power Monthly.
[12] State of California. Renewables Portfolio Standards Program. Stats. 2018, Ch. 312, Sec. 2. (SB 100) (effective January 1, 2019); Cal. Pub. Util. Code § 399.11.
[13] Lawrence Berkeley National Laboratory (LBNL). Utility-Scale Solar 2019 Edition. December 2019. Prices cited here are levelized in 2018 U.S. dollars and include any contract escalation clauses.

$30/MWh and 4 under $20/MWh (all levelized, in 2018 dollars).[14] Significantly, the LBNL survey also found that 23 of these PPAs included battery storage of 4-5 hours and that these projects were not much more expensive than the PPAs from the solar-only projects.[15] And solar PPA prices are expected to continue to decline over time.

For example, in June 2018—in a sign of things to come—NV Energy signed a PPA for power from a solar project with a price of $23.76/MWh, a price that, at the time, was believed to have possibly set a new record.[16] NV Energy subsequently signed a PPA for power from a project that includes 300MW of solar and 135MW of 4 hour storage with a price that averages about $35/MWh.[17]

The same trend of declining PPA prices is evident in the wind industry. Prices for the best wind resources in the Interior region were roughly $60/MWh in 2009-2010; today, PPAs in those same areas are often in the $15-$20/MWh range. Wind prices in the rest of the country have fallen sharply as well, dropping from an average of around $90/MWh in 2010 to less than $30/MWh today.[18]

Utilities in states across the region also are planning to add substantial amounts of new wind and solar resources, as are independent power producers. Many of these resources will compete with San Juan and displace generation that the plant would otherwise produce, pushing the plant's capacity factor ever lower.

Integrating the Western Market

As more and more renewable capacity comes online in the West, a major push is under way to better integrate the regional electricity market. This integration is being driven particularly by the Energy Imbalance Market (EIM) created by the California system operator in 2014 as "a real-time wholesale energy trading market that enables participants anywhere in the West to buy and sell energy when needed."[19] One of its goals is to find and deliver the lowest cost energy to consumers.[20] Another goal—by optimizing resources from a larger and more diverse pool—is to be able to better facilitate the integration of renewable energy that otherwise may be curtailed at certain times of day.

The EIM currently has nine members, including the California Independent System Operator (CAISO), and APS and NV Energy in the Southwest, but it is growing. Salt River Project, Public Service Company of New Mexico (PNM) and Tucson Electric Power are scheduled to join by 2022, meaning that participants representing 77

[14] Ibid.
[15] LBNL. Utility-Scale Solar 2019 Edition. December 2019.
[16] Utility Dive. NV Energy 2.3 cent solar contract could set new price record. June 13, 2018.
[17] Greentech Media. NV Energy Announces 'Hulkingly Big' Solar Plus Storage Procurement. June 25, 2019.
[18] U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy. 2018 Wind Technologies Market Report. August 8, 2019.
[19] CAISO Western Energy Imbalance Market.
[20] CAISO Press Release. Western EIM Benefits top $861 million since launching five years ago.

percent of the Western Electricity Coordinating Council's total load will be EIM members.

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 renewable energy prices that are likely to be lower than San Juan's marginal costs. In turn, as buyers have more opportunity to buy lower cost renewable energy, they are likely to buy less from San Juan, another factor that will drive its capacity factor down.

The Impact of Plant Aging

San Juan Unit 1 is 43 years old. Unit 4 is 37. By 2023, when the carbon capture retrofit is supposed to begin operating, the units will be 47 and 41 years old, respectively. By 2035, the end of Enchant's 12-year forecast horizon, the units will be 59 and 53 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.[21] 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 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 have more unanticipated problems and unplanned outages.

In other words, even if Enchant somehow managed to improve San Juan's operating performance over what it has been in recent years—an extremely unlikely possibility—it will be harder and harder, and increasingly more expensive, to maintain that higher level of performance.

90% Carbon Capture Has Not Been Proven Over an Extended Number of Years

On top of its claim that the retrofitted San Juan will run at an average 85% capacity factor, Enchant posits that the carbon capture plant will be able to capture 90% of the plant's CO_2 emissions day in and day out over a 12-year period—a prediction that bears no relationship to the performance to date at Petra Nova and Boundary Dam, the only two coal-fired carbon capture power plants in the world.

Moreover, both Petra Nova and Boundary Dam 3 are much smaller than the proposed San Juan project would be. Petra Nova captures CO_2 from a 240MW equivalent slipstream from the flue gas emitted by the 654MW coal-fired W.A.

[21] See, e.g., DOE, Staff Report to the Secretary on Electricity Markets and Reliability. August 2017, page 155.

Parish Unit 8 power plant and Boundary Dam 3 captures the CO_2 from a 110MW plant. The proposed San Juan carbon capture project would be 914MW, or almost four times the size of Petra Nova and almost seven times the size of Boundary Dam 3. As the industry has learned through painful experience, serious and expensive problems can occur when scaling up new technologies.

Petra Nova

Petra Nova was originally designed to capture "at least" 90% of the CO_2 from the flue gas in a 240MW slipstream from Parish Unit 8. Put another way, Petra Nova was expected to capture 1.4 million metric tons, or about 33% of the total emissions from Unit 8, each year.[22]

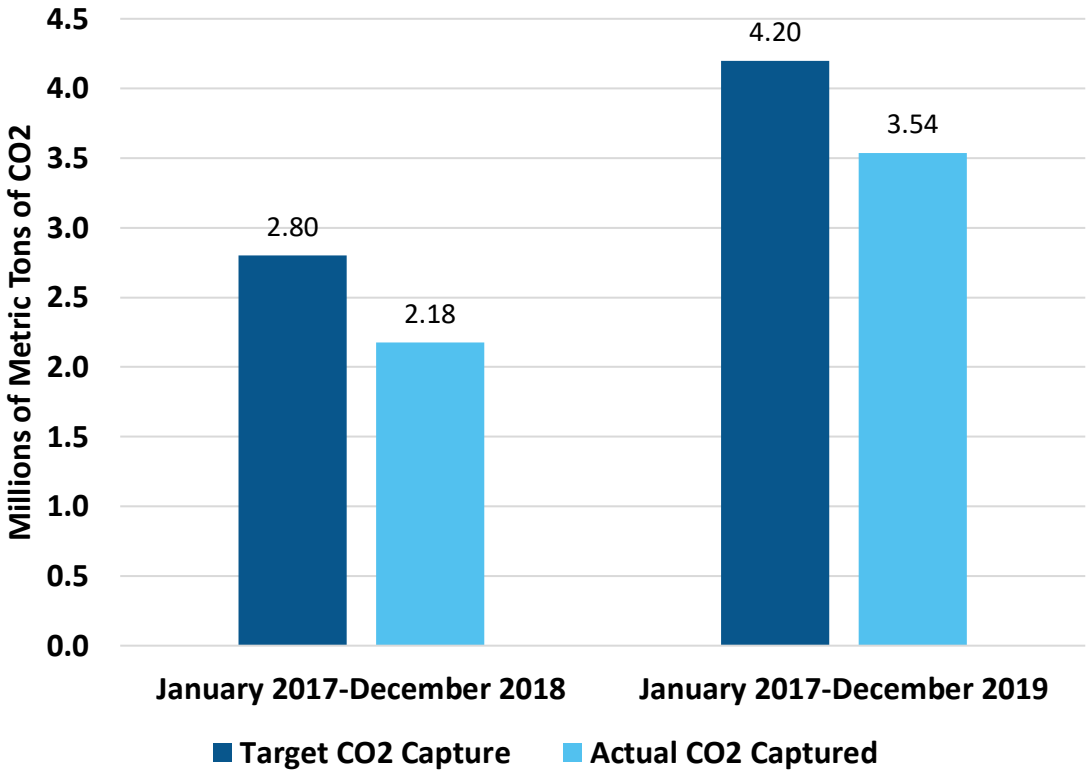
The plant's co-owners, NRG Energy and JX Nippon, have not publicly released any detailed information regarding Petra Nova's CO_2 capture performance. However, representatives from the companies and from the U.S. DOE (which supplied $190 million of the $1 billion cost of the project) have made various public presentations in which they made claims about how much CO_2 is captured. For example, the owners have claimed that Petra Nova captured:

- 907,185 metric tons of CO_2 between the start of operations in January 2017 and October 2017;[23]
- 2.18 million metric tons by December 2018; and
- 3.54 million metric tons by December 2019.[24]

As shown in the figure 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.

[22] DOE Office of Scientific and Technical Information (OSTI). W.A. Parish Post-Combustion CO2 Capture and Sequestration Project, Final Public Design Report. February 17, 2017.; EIA, Today in Energy. Petra Nova is one of two carbon capture and sequestration power plants in the world. October 31, 2017; DOE Office of Fossil Energy, National Energy Technology Laboratory. W.A. Parish Post-Combustion CO_2 Capture and Sequestration Project Summary. September 2012.
[23] DOE Office of Fossil Energy. DOE-Supported Petra Nova Captures More Than 1 Million Tons of CO_2. October 23, 2017
[24] NRG Energy. Testimony of Greg Kennedy, before the U.S. House of Representatives Committee on Science, Space, and Technology, November 22, 2019; and DOE Office of Fossil Energy. Happy Third Operating Anniversary, Petra Nova. January 10, 2020.

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



Sources: NRG, Inc., U.S. Department of Energy

Petra Nova captured 662,000 fewer metric tons of CO_2 during its first three years of operation than projected despite the fact that Parish Unit 8 actually generated more power and, almost certainly, produced more CO_2, than it had in previous years.[25]

Enchant has claimed that Petra Nova has captured 1.4 million metric tons of CO_2 per year for over two years, an assertion that is false.[26] As shown in Figure 4, Petra Nova captured an average of 1.18 million metric tons of CO_2 per year during its first three years of operation (2017-2019).

Enchant also claims that 90% capture of CO_2 has been proven or demonstrated, as, for example, in its most recent PowerPoint where it said that Petra Nova has had a 90% capture rate. Neither of Petra Nova's owners, or anyone from Enchant or any of its partners, has provided data showing that Petra Nova has achieved 90% capture. Enchant, like other CCS proponents, merely repeats what the owners of Petra Nova have claimed without providing any supporting evidence.[27]

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[25] Parish Unit 8's annual capacity factor rose from 68% in the two years prior to the start of operations at Petra Nova to 72% in the three years since Petra Nova began capturing CO_2.
[26] Enchant Energy. Carbon Capture Utilization & Storage, Project Summary. December 17, 2019, slide 8.
[27] For example, the Los Alamos National Laboratory's *Preliminary Assessment of Post-combustion Capture of Carbon Dioxide at the San Juan Generating Station* simply observed at pages 9, 10, and

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 (d) what it actually costs to capture CO_2 at the plant.

We acknowledge that determining what Petra Nova's actual CO_2 capture rate is difficult, again because of lack of data from the plant's owners. However, we believe a reasonable estimate can be derived from using the continuous emissions monitoring (CEM) data for both W.A. Parish Unit 8 and the dedicated gas-fired combustion turbine built to power the carbon capture equipment. Among other things, the CEM data tracks hourly gross generation and CO_2 emissions; it is publicly available through the EPA's Air Markets Program database.[28]

Using this information, it is possible to estimate Petra Nova's CO_2 capture rate by comparing 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 Unit 8's CO_2 intensity in the years prior to 2017.[29]

That analysis shows that Petra Nova achieved an average capture rate of 80% to 82% between January 1, 2017 and September 30, 2019 during times when the carbon capture equipment was in operation.

However, it is important to remember that the power to operate Petra Nova's carbon capture equipment is provided by a dedicated combustion turbine. When the CO_2 emissions from this combustion turbine are included, Petra Nova's net CO_2 capture rate drops to below 60%.

It also is vital to remember that Enchant not only assumes that San Juan could achieve a 90% capture rate, it assumes that the retrofitted plant would achieve this level of performance for at least 85% of the hours in a year, and would do so for the entire 12-year period from 2023-2034. Given that Petra Nova has captured CO_2 for at most an average of 73% of the hours in the three-year period from January 2017-October 2019, the project's operating history does not support Enchant's claim that the carbon capture facility at San Juan could capture CO_2 at a higher rate for a continuous 12-year period.

11, that Petra Nova has stated publicly that the facility achieves 90% capture of the processed fuel gas without seeing any actual operational data supporting this claim.

[28] U.S. Environmental Protection Agency Air Markets Program Data.

[29] It is possible that the combustion turbine was used to generate power (and not run the CO_2 capture equipment) during some hours of operation. However, the CEM data shows that Unit 8 was operating almost every hour from January 1, 2017-September 30, 2019 during which the turbine was operating and that there were only a few hours when the turbine was running and Unit 8 was not. As such, it is reasonable to use those hours when the combustion turbine was in operation as a proxy for when the carbon capture equipment was operating.

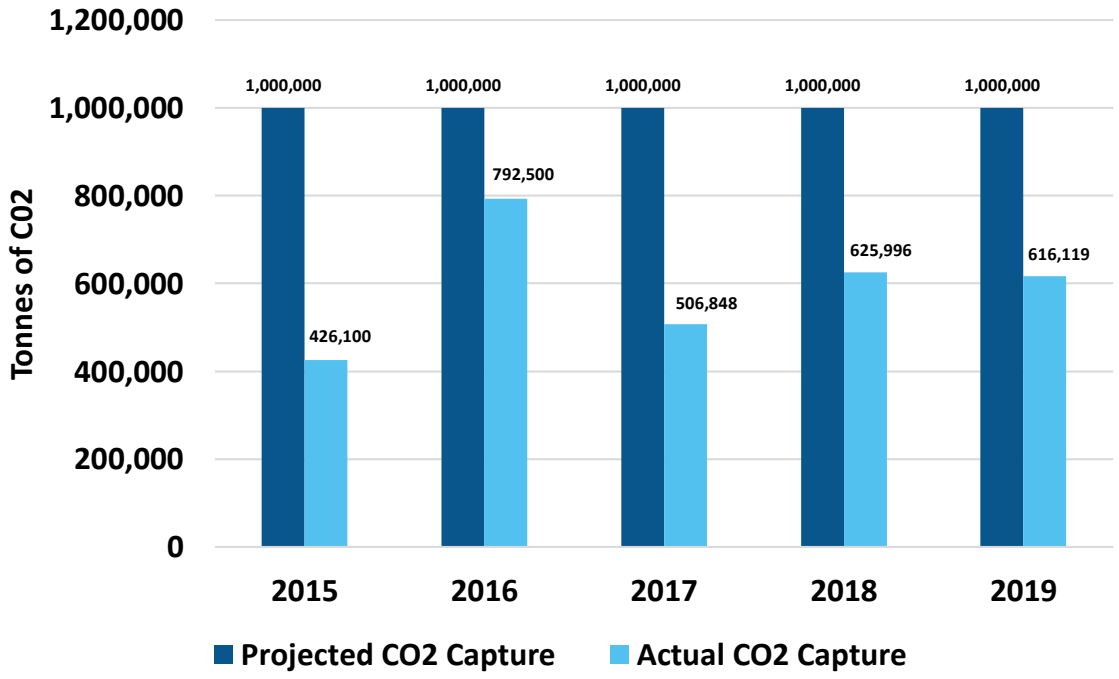
Failure to capture 90% of the emissions at San Juan would have a devastating impact on the proposal's already questionable economics.

Boundary Dam 3

The carbon capture system at the 110MW Boundary Dam Unit 3 in Saskatchewan, Canada, began operating in October 2014. It was designed to capture 1 million metric tons a year, a 90% capture rate, but data from the utility shows it has consistently captured far less CO_2 than projected (see figure 5).

The plant's carbon capture system only operated at its design capacity of 3,200 metric tons per day on three days through early 2018.[30] Consequently, while backers originally projected the facility would capture 3 million metric tons of CO_2 by November 2017, the plant did not hit that marker until November 4, 2019, two years later than projected.

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



Source: SaskPower, BD3 Status Updates[31]

[30] *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.

[31] SaskPower. BD3 Status Update: December 2019. January 9, 2020. Previous updates containing information on CO_2 captured in prior years are available at SaskPower's blog.

Enchant claims that Boundary Dam is "currently" capturing 2,400 metric tons per day, equivalent to 876,000 metric tons per year.[32] Data available on Saskatchewan Power's web site contradicts Enchant's numbers. On occasion, Boundary Dam 3 has averaged more than 2,400 metric tons per day over the course of a single month, but the plant has never approached that performance level for a full year. In 2019, for example, SaskPower says the plant captured an average of 2,093 metric tons per day when it was operational**.** For the year as a whole, the plant captured only 616,229 metric tons and, as shown in Figure 5, has never captured 876,000 metric tons in any calendar year.[33]

The results from Petra Nova and Boundary Dam 3 belie Enchant's assertions about the future performance of a carbon capture plant at the San Juan Generating Station. It is highly unlikely that the facility would be able to capture the 6 million metric tons of CO_2 annually that Enchant says is needed to pay for the project.

A more realistic expectation, reflecting the actual 70% average capacity factor of San Juan Units 1 and 4 over the last 10 years and carbon capture efficiencies ranging from 70%-90%, is that the plant would capture no more than 5.2 million metric tons of CO_2 a year, and perhaps as little as 4.1 million metric tons—far less than the 6 million metric tons projected by Enchant.[34] Even that assumes there are no significant issues encountered in scaling up the capture technology from the 240MW-equivalent Petra Nova project to the proposed 914MW San Juan project.

Here it is important to emphasize that San Juan might well capture less, perhaps much less, CO_2 than 4.1 million metric tons per year. The carbon capture system might have serious problems that would prevent achieving even a 70% capture rate and/or the plant might not run at an average 70% capacity factor. And conceivably, the market for the captured CO_2 from San Juan will not be anywhere near as robust as Enchant claims—and may not exist at all.

The amount of CO_2 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.

Capturing less than 6 million metric tons of CO_2 would mean that San Juan would generate less revenue from the sale of the CO_2 for enhanced oil recovery. Similarly, capturing less CO_2 would mean that the project would be eligible for far fewer 45Q tax credits. This, in turn, would mean that additional funds would have to be borrowed to pay for the retrofitting of San Juan. This would raise both the total capital cost of the retrofit and the cost per metric ton of capturing CO_2, as we will describe in detail later in this report.

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[32] Enchant Energy. Carbon Capture Utilization & Storage Project Summary. December 17, 2019, Slide 8.
[33] SaskPower. BD3 Status Update: December 2019. January 9, 2020.
[34] If we assume that Enchant's claim that the new carbon capture facility at San Juan will operate at only a 70% capacity factor, the plant would be expected to capture no more than 4.9 million metric tons of CO2 a year, and perhaps as little as 3.8 million metric tons.

Retrofitting San Juan for CO_2 Capture Is Likely to Be Much More Expensive Than Enchant Claims

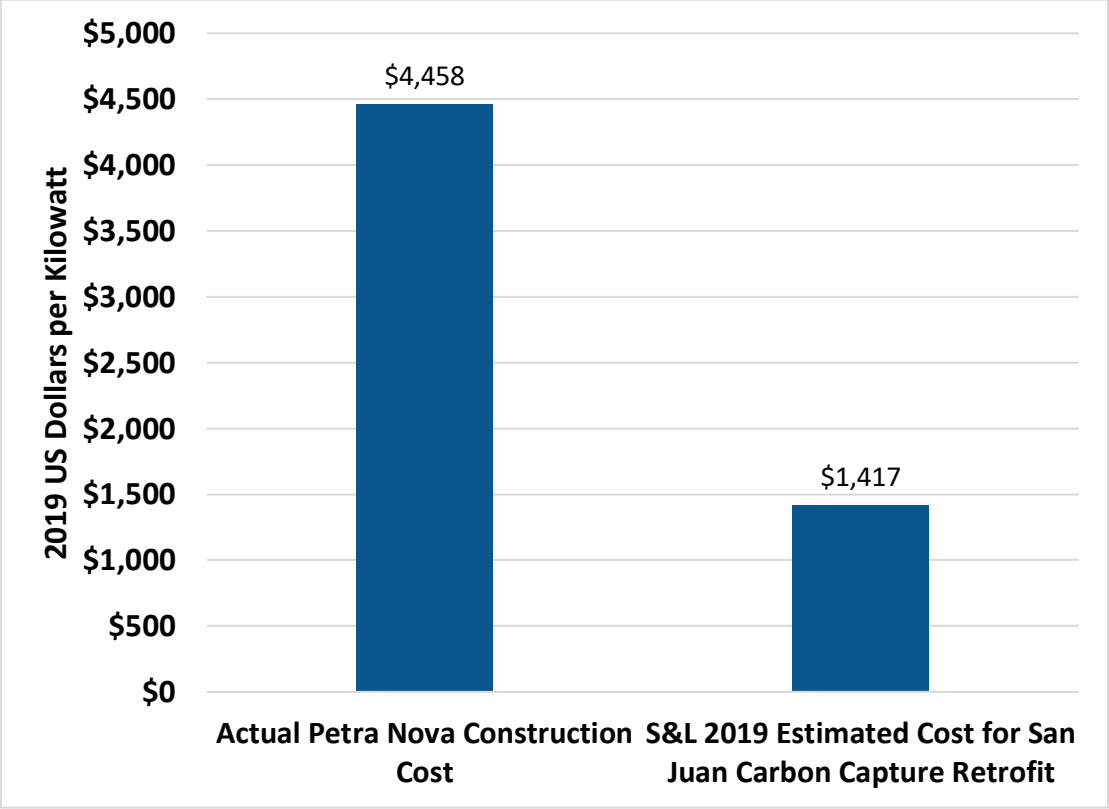
The economics of Enchant's proposal also hinge on the cost of building the carbon capture facility at San Juan, since Enchant is proposing to fund the construction through the sale of the tax credits available through the federal government's newly expanded 45Q program. The program offers a $35 per ton payment for CO_2 captured and sold for reuse in EOR activities.

Here, as with its earlier assumptions about the plant's future capacity factor and its CO_2 capture efficiency, Enchant strains credulity.

A preliminary construction assessment prepared by Sargent & Lundy estimates the project's cost at approximately $1.295 billion, in 2019 dollars or $1,417 per kW.[35] However, this estimate excludes escalation, AFUDC[36], rights of way and land purchase costs, and site security.[37] By comparison, the actual cost of building the 240MW Petra Nova facility was $1 billion, or $4,458 per kW, also in 2019 dollars.[38]

[35] Sargent & Lundy. CO_2 Capture Pre-Feasibility Study. July 8, 2019, Appendix E.
[36] AFUDC stands for allowance for funds used during construction and represents the costs of financing the construction of a new plant such as the proposed San Juan carbon capture facility.
[37] Sargent & Lundy. CO_2 Capture Pre-Feasibility Study. July 8, 2019, Appendix D.
[38] EIA, Today in Energy. Petra Nova is one of two carbon capture and sequestration power plants in the world. October 31, 2017.

Figure 6 - Actual Petra Nova Cost vs. S&L Estimate Cost for Retrofitting San Juan with CO_2 Capture



Source: EIA, Sargent *& Lundy*[39]

In other words, the actual cost of designing and building the only existing commercial-scale CO_2 capture project in the U.S. was more than three times as high, on a per kW basis, as Sargent & Lundy has estimated for the cost of retrofitting San Juan. In other words, Enchant and S&L contend San Juan can be retrofitted for 68% less, on a dollars per kW basis, than Petra Nova. This estimate is extremely optimistic, to say the least.

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 nearly 70% between 2010 and 2018, as a result of the lessons learned in the building and installation of 24.7GW of new solar capacity.[40] Similarly, the price of installing new

[39] Analysis based on costs from EIA Today in Energy, October 31, 2017 and Sargent & Lundy CO_2 Capture Pre-Feasibility Study. July 8, 2019.
[40] LBNL. Utility-Scale Solar - Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States, 2019 Edition. December 2019.

wind capacity fell by 40% between 2009-2010 and 2018, as a result of the lessons learned during the installation of 56GW of new wind capacity.[41]

However, carbon capture technology is not like solar and wind technology. The decline in solar and wind prices was driven by research and development, robust competition among suppliers, and thousands of new commercial projects. By contrast, there are only two operational carbon capture projects at power plants in the entire world. Unlike with solar and wind, few carbon capture initiatives are in play, and there aren't enough to affect costs before the proposed retrofit of San Juan 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 assume that the cost of retrofitting San Juan with CO_2 capture—making it 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.

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

However, it appears that by planning to start construction of San Juan's carbon capture facility at the end of the First Quarter of 2021, barely two years after the project was first being discussed,[42] Enchant has failed to learn from what NRG considered one of the key lessons from Petra Nova. That is, the importance of completing as much of the project's engineering and design work before construction began. As David Greeson, NRG's Vice President of Development and the head of the team that developed Petra Nova explained, NRG "probably spent at least twice as much as you would normally spend on engineering and design before we ever put a shovel in the ground."[43] In fact, it appears that NRG began the design and engineering work for Petra Nova in 2009, or about five years before construction began, and completed 90% of the project's conceptual design before it even broke ground.[44,45] As NRG explained to E&E News, this meant that it needed to make few changes after construction. Looking at Enchant's timeline for the San Juan retrofit, it is hard not to get the sense that the project is being rushed.

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[41] U.S. Department of Energy. 2018 Wind Technologies Market Report. August 2019.
[42] Enchant Energy. Presentation to Senate Committee, February 4, 2020. At Slide No. 18.
[43] E&E News. Carbon Capture Takes "Huge Step" With First U.S. Plant. January 10, 2017.
[44] Presentation on Petra Nova by Petra Nova Parish Holdings LLC, at the June 2019 IEA Clean Coal Conference. Slide No. 3.
[45] In fact, Sargent & Lundy touts its involvement in the development and implementation of Petra Nova starting in 2011, or three years before construction began, as part of its relevant experience for the San Juan project. Sargent & Lundy. CO_2 Capture Pre-Feasibility Study, at page 1-2. July 8, 2019.

Nevertheless, other estimates for CO_2 retrofits suggest that the cost of adding carbon capture to San Juan will be significantly higher than Sargent & Lundy has claimed. The International Energy Agency, an 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.[46] The National Association of Regulatory Utility Commissioners (NARUC) has noted that the International Energy Agency's (IEA's) projected reductions in the next generation of power plant CCS reductions, "…support the idea that costs will come down with more facilities."[47]

Similarly, the Clean Air Task Force (CATF), also an advocate of CCS, asserts 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."[48] CATF estimates that the capital cost for retrofits will decline to a range of $1,501 to $1,724 per kW by the time a sixth new project is undertaken.[49] However, the proposed San Juan project would be only the third carbon capture project at a power plant, not the sixth. And even CATF's cost estimate for the sixth carbon capture project is higher than the $1,417 per kW that S&L assumes for San Juan.

Enchant claims that it will soon have a fixed-price contract in place for retrofitting San Juan. However, while a memorandum of understanding (MOU) has been disclosed, all this means is that the parties have agreed to discuss a contract. There is no evidence of any fixed price agreed upon for the retrofit or what categories of costs would be included in the fixed price, what costs would fall outside of the contract, or any of the purported agreement's other terms.

Moreover, having a fixed-price contract does not guarantee that the carbon capture facility would be built for the contracted-for price or that the owners would not bear any of the risk of cost overruns. Some fixed-price contracts have clauses whereby the agreed-upon price can be exceeded if certain enumerated circumstances occur. Sometimes one or all parties to the contract can decide to void it if the estimated cost of finishing the project goes too high.

This is what happened in 2017 at Southern Company's Vogtle plant in Georgia. Southern Company had negotiated a fixed-price contract with Westinghouse to build two new nuclear reactors, which meant that Westinghouse was to bear most of the risk for schedule delays and cost overruns. However, when the estimated cost of building the new reactors doubled, Westinghouse went bankrupt and said it would no longer be involved in new nuclear construction. As a result, the owners of the planned new reactors, and their ratepayers, have had to bear much of the Vogtle cost overruns. Similar schedule delays and cost overruns led to the cancellation of

[46] National Association of Regulatory Utility Commissioners (NARUC). Carbon Capture, Utilization, and Storage: Technology and Policy Status and Opportunities. November 2018, page 47.
[47] Ibid.
[48] Clean Air Task Force (CATF). Carbon Capture & Storage in the United States Power Sector: The Impact of 45Q Federal Tax Credits. February 2019, pages 24-25.
[49] Ibid, pages 24-25.

two planned nuclear reactors in South Carolina even though the owners of that project also had fixed-price contracts with Westinghouse.[50]

While we are not saying that cost overruns at San Juan would be anywhere near the same magnitude as those at the reactors in Georgia and South Carolina, those examples show that fixed price contracts do not eliminate project risk—a point that potential investors and backers of the Enchant proposal would be wise to remember.

A More Realistic Capital Cost Analysis

Given the great uncertainty around the likely capital cost of retrofitting San Juan, prudent potential investors would be well advised to examine a range of capital costs and how those costs would affect the project's economic viability. For the following analysis, we use three cost estimates (all in 2023 dollars):

- $1.4 billion, the low-end cost, which represents Sargent & Lundy's 2019 estimate escalated to 2023 dollars (the plant, according to Enchant, would come online in 2023);
- $2.21 billion, the mid-range estimate, which reflects a conservative 50% reduction relative to the per kW cost of the Petra Nova project; and
- $3.31 billion, the high-end estimate, which reflects the theoretical savings expected by IEA from the next generation of power plant CCS projects[51] and which is 25% below the per kW cost of Petra Nova.

It is important to emphasize that all of these estimates 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 914MW San Juan project, which could lead to an even higher cost per kW than Petra Nova.

Using these three capital cost estimates, we have examined nine scenarios using an assumed capacity factor of 70% throughout, with estimated capture rates of 90%, 80%, and 70% to see how much of the plant's costs likely would be covered by the 45Q tax credits on which Enchant is relying. We also examined a base case using Enchant's assumptions about the plant' s capital costs, future capacity factor and capture efficiency.

In all the cases examined, the tax credits fall well short of funding the entire project, meaning that Enchant, already under-capitalized, or some other entity would have to come up with the additional money needed to complete and run the project. The results of our analysis are presented in Table 3.

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[50] For example, see Pittsburgh Post-Gazette. Pushing risk off a cliff: how Westinghouse ended up in bankruptcy. October 23, 2017 and CRS Insight, Westinghouse Bankruptcy Filing Could Put New U.S. Nuclear Projects at Risk. April 19, 2017.

[51] NARUC. Carbon Capture, Utilization, and Storage: Technology and Policy Status and Opportunities. November 2018, page 47.

Table 3 - San Juan Retrofit Financing[52,53]

	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	82%	18%
Scenario 1	$1.40 Billion Capital Cost, 75% CF & 90% CO_2 Capture Rate	73%	27%
Scenario 2	$1.40 Billion Capital Cost, 75% CF & 80% CO_2 Capture Rate	64%	36%
Scenario 3	$1.40 Billion Capital Cost, 75% CF & 70% CO_2 Capture Rate	56%	44%
Scenario 4	$2.21 Billion Capital Cost, 75% CF & 90% CO_2 Capture Rate	46%	54%
Scenario 5	$2.21 Billion Capital Cost, 75% CF & 80% CO_2 Capture Rate	41%	59%
Scenario 6	$2.21Billion Capital Cost, 75% CF & 70% CO_2 Capture Rate	36%	64%
Scenario 7	$3.31 Billion Capital Cost, 75% CF & 90% CO_2 Capture Rate	31%	69%
Scenario 8	$3.31 Billion Capital Cost, 75% CF & 80% CO_2 Capture Rate	27%	73%
Scenario 9	$3.31 Billion Capital Cost, 75% CF & 70% CO_2 Capture Rate	24%	76%

Even with Enchant's unrealistic assumptions about how much CO_2 San Juan would capture and how much it would cost to retrofit the plant, tax equity financing would likely be able to provide only about 82% of the necessary capital. The remaining 18% would have to come from other sources, which would place additional demands on the revenue streams from plant operations that have not been considered in Sargent & Lundy's pre-feasibility study.

[52] The 75% San Juan capacity factors used in Table 1 conservatively assume that the new carbon capture facility would operate at an 85% capacity factor while the remainder of the plant would operate at the same 70% net capacity factor the plant has achieved since 2010.
[53] See the Prepared Rebuttal Testimony of David B. Posner in New Mexico Public Regulation Commission Case No. 19-00018-UT.

In scenarios with more realistic assumptions, at least 27% of the cost of retrofitting San Juan for carbon capture would have to be raised from what likely would be even more expensive sources. This would raise the cost of the retrofit, further undermining the project's financial viability.

It Is Unlikely that the Proposed San Juan Retrofit—If It Occurs at All—Could Be Completed Before Late 2023 to Early 2024

Enchant has made numerous claims about when a retrofitted San Juan would be online, all of which revolve around a ground-breaking sometime in 2021 and operational commissioning sometime in 2023.[54] This schedule is extremely optimistic given that it would require the entire project to be financed, designed, competitively bid, constructed and pre-operationally tested in less than four years. It also flies in the face of the history at the much-smaller Petra Nova project, which took six years to design and build.[55]

And, in reality, the timeline is even shorter than four years, since the FEED (Front End Engineering and Design) study for the San Juan retrofit is not even scheduled for completion until mid-April 2021.[56] In conventional projects, final investment decisions are not made until that initial analysis is finished, meaning that investors committing to the Enchant project now would be risking their money without even having the benefit of a full overview of the potential risks and a good grasp of the project's likely costs. Even if enough engineering were completed by early 2021 to start construction at that time, that would leave less than three years to competitively bid the CO_2 capture system, order, fabricate and deliver system components, then construct and test the CO_2 capture retrofit to meet Enchant's mid-to-late 2023 deadline.[57]

The 2023 online assumption made by Enchant is key for two reasons. First, a new state CO_2 emissions standard takes effect that year that would require the plant to shut down if the carbon capture facility is not operational.[58] That, in turn, would require the plant owners and/or investors to pay for all of the plant's fixed costs until it could resume commercial operation once the carbon capture retrofit was completed. These fixed costs could total as much as $93 to $141 million[59] depending

[54] Enchant Energy. Carbon Capture Utilization & Storage: Project Summary. December 17, 2019, slide 8.
[55] Sargent & Lundy. Enchant Energy, San Juan Generating Station – Units 1 & 4 CO_2 Capture Pre-Feasibility Study. July 8, 2019, page 3.
[56] Enchant Energy. Project Management Plan Large-Scale Commercial Carbon Capture Retrofit of the San Juan Generating Station. May 9, 2019, page 7.
[57] Enchant Energy, Sargent & Lundy, Presentation to New Mexico Senate Finance Committee, San Juan Generating Station Carbon Capture Utilization & Storage Project. February 4, 2020, slide 18.
[58] This would mean that San Juan's CO_2 emissions exceeded the mandated standards in New Mexico's new Energy Transition Act and the plant would have to be shut down until it could meet the new standards.
[59] San Juan's fixed costs based on the results of PNM's modeling of continued operation of San Juan with carbon capture in New Mexico Public Regulation Commission Case No. 19-00018-UT.

on how long San Juan was closed—a costly additional charge to an already iffy commercial proposition.

In addition, generically speaking, the longer a project takes to build, the higher the financing costs. And, as we demonstrated in the table above, Enchant has no cushion in any of its estimates

Capturing CO_2 at San Juan Will Likely Be Much More Expensive Than Enchant Claims

Enchant and Sargent & Lundy claim that the cost of capturing CO_2 at San Juan would be between $39.15 and $43.49 per metric ton.[60] However, this is unrealistic in several respects.

First, the $39.15 per metric ton low end of the range is based on the unrealistic assumption that San Juan would operate at a 100% capacity factor.

Second, the CO_2 capture costs claimed by Enchant and S&L are based on the three unreasonable assumptions we examined earlier: (1) that after running at an average 70% capacity factor between 2010 and 2019, San Juan Units 1 and 4 will somehow operate at an average 85% annual capacity factor after being retrofitted for carbon capture; (2) that San Juan will capture 90% of the CO_2 it produces on a sustained basis; and (3) that the cost of retrofitting San Juan will be 68% lower than it cost to design and build the Petra Nova project.

We have recalculated the cost of capturing CO_2 at San Juan using the same methodology Sargent & Lundy used in Appendix E of its July 2019 pre-feasibility study. The only changes we made were to use a conservative 75% average annual capacity factor, 70% to 90% CO_2 capture rates, and the same range of retrofit costs we used in Table 3.

Our results are presented in Table 4. As can be seen, the per-metric ton capture costs will most likely be significantly higher than Enchant and Sargent & Lundy are claiming.

[60] For example, see the Sargent & Lundy CO2 Capture Pre-Feasibility Study and the Presentation to the New Mexico Senate Finance Committee.

Table 4 - Projected San Juan CO_2 Capture Costs

	Scenario Assumptions	First Year CO_2 Capture Cost (Dollars per Metric Ton)
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, 75% CF & 90% CO_2 Capture Rate	$51.78
Scenario 2	$1.40 Billion Capital Cost, 75% CF & 80% CO_2 Capture Rate	$58.26
Scenario 3	$1.40 Billion Capital Cost, 75% CF & 70% CO_2 Capture Rate	$66.58
Scenario 4	$2.21 Billion Capital Cost, 75% CF & 90% CO_2 Capture Rate	$70.64
Scenario 5	$2.21 Billion Capital Cost, 75% CF & 80% CO_2 Capture Rate	$79.47
Scenario 6	$2.21Billion Capital Cost, 75% CF & 70% CO_2 Capture Rate	$90.83
Scenario 7	$3.31 Billion Capital Cost, 75% CF & 90% CO_2 Capture Rate	$96.54
Scenario 8	$3.31 Billion Capital Cost, 75% CF & 80% CO_2 Capture Rate	$108.61
Scenario 9	$3.31 Billion Capital Cost, 75% CF & 70% CO_2 Capture Rate	$124.12

Interestingly, the average CO_2 capture costs are higher even when using Sargent & Lundy's unrealistically low carbon capture retrofit capital cost because we used more realistic plant capacity factors and CO_2 capture rates. This means the plant will capture substantially less CO_2, which in turn means the capital cost of the retrofit and the fixed CO_2 capture O&M costs would be spread over many fewer metric tons of CO_2. The end result is a higher cost of capture per metric ton.[61]

Enchant in its cost estimates has left out the cost of the spur pipeline that would be needed to transport the CO_2 captured at San Juan to the main Cortez pipeline. Nor has it included any of the costs it would have to pay to have the captured CO_2 transported to the Permian Basin through the Cortez pipeline. The non-profit Clean Air Task Force has estimated the cost of transporting CO_2 from New Mexico to the Permian Basin at $4.72 per tonne.[62]

The reality is that even Enchant and Sargent & Lundy's numbers show that selling the CO_2 captured at San Juan will not produce any significant profits for plant

[61] The Corrected Enchant Base Case CO_2 capture cost in Table 4 is $45.69 per metric ton. This is higher than the $43.49 per metric ton cost in S&L's study because S&L used 2019 dollars. We have escalated this cost to 2023 dollars, as that is when Enchant claims the carbon capture project will begin operations.

[62] Clean Air Task Force. Carbon Capture & Storage in the United States Power Sector. February 2019, page 33.

owners. Sargent & Lundy has estimated that just the O&M cost associated with capturing CO_2 at San Juan would average about $16.65 per metric ton while the price at which the captured CO_2 could be sold would be around $17.50 per tonne. This would mean the net revenue that could be expected from the sale of the captured CO_2 in the Permian Basin would be less than $1 per metric tonne. Adding any meaningful cost for transporting the captured CO_2 from San Juan to the Permian Basin would offset this small profit and, as a result, signify that selling the CO_2 from San Juan would produce annual losses, not profits, for plant owners and investors.

San Juan's Owners and Investors Would Be Exposed to Significant Electricity Market Risk

Another central—and centrally weak—component of Enchant's economic assessment is that the retrofitted San Juan plant would be a "low-cost electricity supplier" able to compete in the increasingly competitive Southwest power market.

The reality is, San Juan is not currently a low-cost generator, and adding complexity to the plant in the form of carbon capture equipment is not going to change that fact. Los Alamos County, one of the four San Juan owners in favor of retiring the plant, concluded as far back as 2017 that Unit 4, for example, "incurs high fixed costs and is not economic to dispatch under current market conditions."[63]

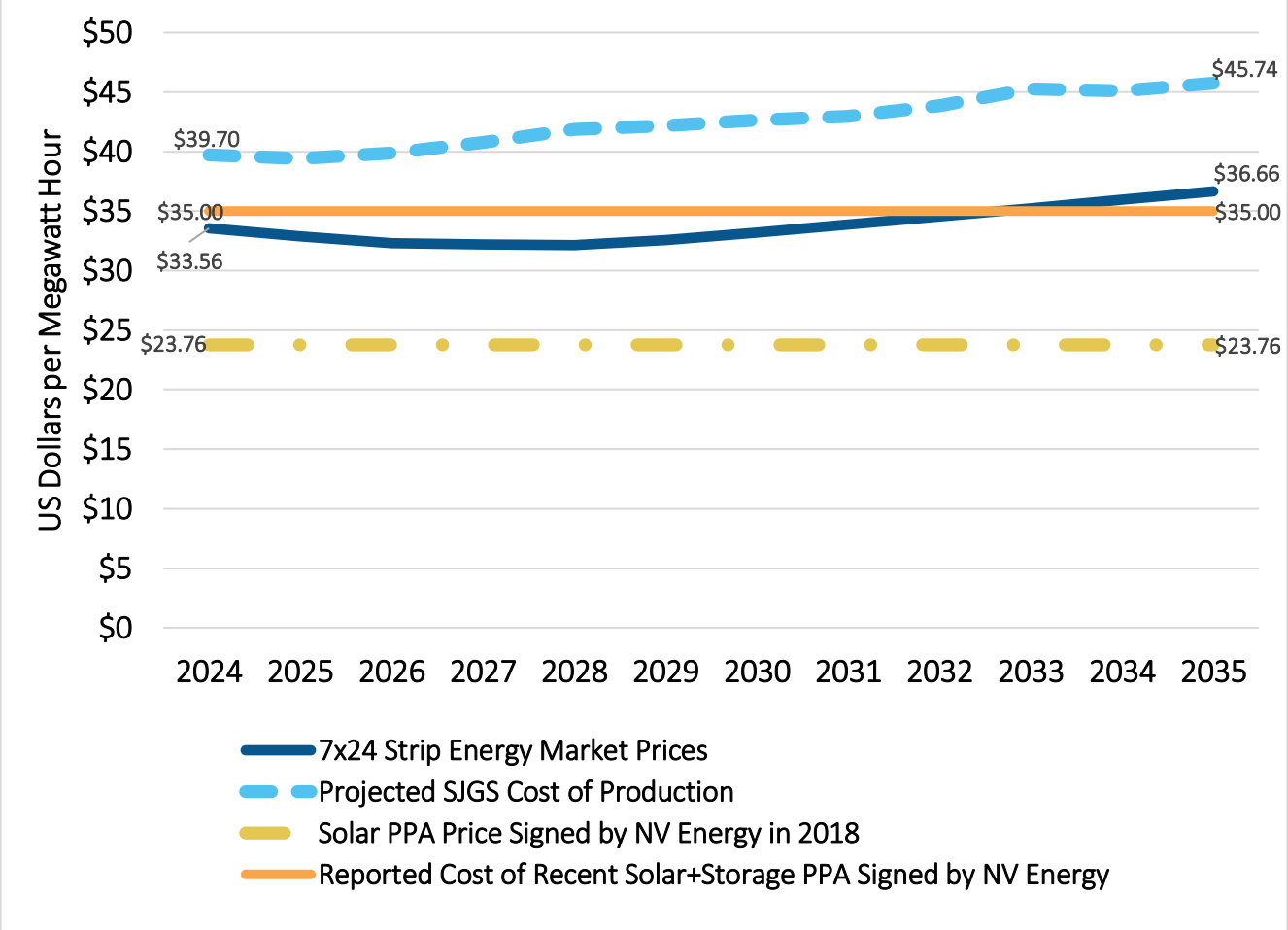
Indeed, by using a substantial amount of the plant's power, the CO_2 capture equipment will result in San Juan's non-carbon capture-related fixed and O&M costs being spread across a smaller number of saleable kilowatt-hours, thus raising costs across the board and putting the plant's owners and investors at serious risk.

Using projected operating & maintenance costs taken from recent modelling by PNM, the majority owner and plant operator, it appears that the cost of generating electricity at San Juan will be an average of $6 per MWh higher than expected market prices, and even more expensive than buying electricity through power purchase agreements (PPA) from utility-scale solar providers in every year through at least 2035.[64]

[63] Pace Global. 2017 Integrated Resource Plan Report prepared for Los Alamos County. June 30, 2017, page 46.

[64] The projected cost of operating San Juan after being retrofitted for carbon capture are drawn from the San Juan Continues CCUS 1-2-3 Options modelling output reports provided in response to Data Request Sierra Club 1-14 in New Mexico Public Regulation Commission Case No. 19-00195-UT.

Figure 7 - Projected Cost of Generating Electricity at San Juan vs. Expected Energy Market and Renewable PPA Prices



Sources: Energy market prices, PNM modelling, NV Energy65

Thus, electricity market forces in and of themselves stand to create huge losses for San Juan's owners and investors: We calculate that the plant's owners and investors could end up losing at least $300 million and perhaps as much as $450 million from the sale of electricity produced at San Juan through 2035 if they sell the plant's electricity at currently expected future market prices.

Compounding that challenge is that Enchant's projections don't include any estimate for the maintenance costs that are now being deferred by PNM and the other owners because they plan to shutter the plant in 2022. Should Enchant and its investors proceed with the carbon capture retrofit, they would have to fund these costs as well, or risk future operating derates and outages at the plant. We have not

[65] Based on Forward energy market prices for the Four Corners trading hub as of January 16, 2020; results of PNM's modelling of continued operation of San Juan with carbon capture in New Mexico Public Regulation Commission Case No. 19-00195-UT, NV Energy 2.3 Cents Solar Contract Could Set New Price Record, and NV Energy Announces 'Hulkingly Big' Solar-Plus-Storage Procurement.

included an estimate for these costs in this analysis, but it is safe to say that those costs would further undercut the plant's competitiveness in the Southwest market.

San Juan owners and investors in San Juan would be caught in a Catch 22. On the one hand, they would have to run the plant as much as possible in order to produce as much capturable CO_2 as possible and, thus, secure the largest number of 45Q federal tax credits for their investors. On the other hand, operating San Juan in this fashion likely would mean having to sell electricity from the plant at very low prices, perhaps at below market or renewable PPA prices, or even having to dump some of the electricity altogether (that is, not sell all of it). This would mean not being able to recover all of the more than $1 billion in San Juan's projected fixed O&M costs,[66] and is a significant reason why we believe that the owners and investors will suffer significant losses from selling electricity generated at San Juan.

San Juan's Owners and Investors Also Would Be Exposed to Significant CO_2/Oil Market Risks

Finally, Enchant's proposal assumes that it will be able to sell all the CO_2 it can capture into the enhanced oil recovery (EOR) market in the Permian Basin in southeast New Mexico and West Texas. A great deal of uncertainty surrounds this assumption, and it adds to the risk to investors in the San Juan carbon capture retrofit project.

These EOR risks include that:

1. The potential demand for CO_2 for use in EOR projected by the project's proponents will not materialize.[67]

2. The economics of the CO_2 market are worse than the proponents assume. For example, the costs of capturing CO_2 may be higher than projected; the prices at which the captured CO_2 can be sold may be lower than expected; and other, lower-cost CO_2 suppliers may enter the market, taking sales away from San Juan.

3. There won't be enough available pipeline capacity to bring all the CO_2 captured at San Juan to producers in the Permian Basin. The 45Q federal tax credits on which Enchant is depending to finance the retrofit depend directly on how much CO_2 is used for EOR or is placed into permanent geological storage. If Enchant can't get all the

[66] Power plant O&M costs fall into two general categories. Variable O&M, which are mainly fuel costs, change with the amount of power generated at the plant. Fixed O&M, on the other hand, represent costs that are incurred irrespective of how much power, if any, is generated. These fixed O&M costs include such expenditures as management salaries, labor costs, materials, preventive maintenance, and the costs of major planned overhauls. They must be incurred even if the plant doesn't produce any power during the period being examined.

[67] In fact, neither Enchant nor Sargent & Lundy, or any witnesses before the New Mexico Public Regulation Commission in Cases Nos. 19-00018-19 or 19-00195-19 have presented any evidence that there actually is a significant demand for the CO_2 that would be captured at SJGS.

captured CO_2 to the Permian Basin, it can't claim (or sell) the tax credits, which would significantly raise the financial risk to investors in the project.

4. The new owners of San Juan won't be able to fulfil their contracted CO_2 supply requirements because (a) the power plant is not operating as much as proponents claim it will and, therefore, is not producing as much CO_2 and/or (b) the carbon capture facility does not operate as well as proponents now claim it will.

In fact, it is quite reasonable to expect that the supposed demand for CO_2 from San Juan for use in EOR may not materialize at all. In a November 2018 report, analysts with the IEA described an 18 percent decline in oil production from North American EOR between 2014 and 2018.[68] 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 cost declines that have rendered EOR less economically attractive.

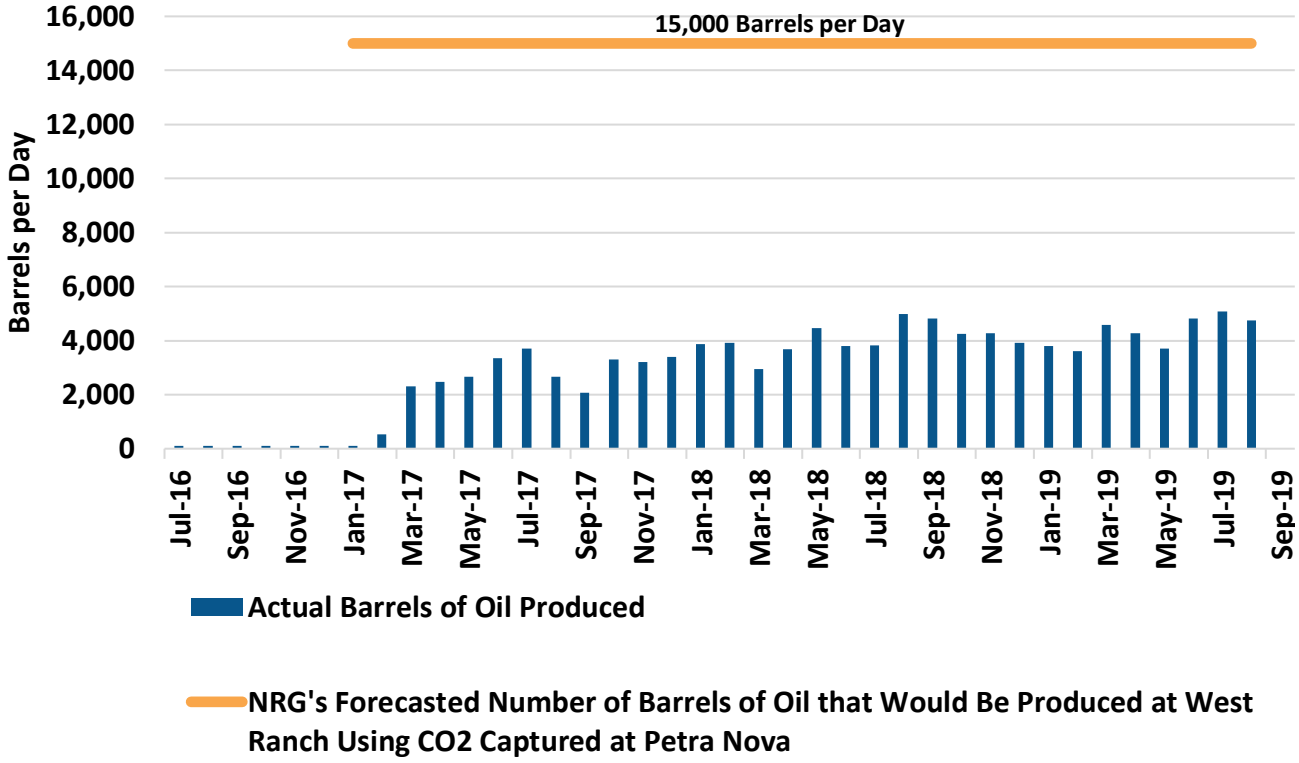
Even if Enchant were to announce that it has a customer for CO_2, that would not guarantee a market for the CO_2 from San Juan for the entire 12-year period that, according to Enchant, the project would run. Oil prices are extremely volatile, so it's likely that both the demand and the price for captured CO_2 for use in EOR will fluctuate significantly over time, introducing additional risk.

To this point, demand for captured CO_2 from both Petra Nova and Boundary Dam appears to be less than what had been assumed by the plant owners when they began retrofitting their coal plants for carbon capture.

NRG, for instance, originally said the CO_2 captured at Petra Nova would be used to increase production of oil in its West Valley field to 15,000 barrels/day. However, as shown in Figure 8, the amount of oil produced at West Valley has increased to only about 4,200 barrels/day.

[68] IEA. Whatever happened to enhanced oil recovery? November 28, 2018.

Figure 8 - Actual vs. Estimated Daily Production at NRG's West Ranch Oil Field



Source:TexasDrilling.com

Indeed, it appears that the Petra Nova project has not been nearly as profitable as NRG expected, as the company 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.[69] NRG then took a second impairment of $69 million in its investment in Petra Nova in 2017 based on a revised view of oil production expectations.[70]

It similarly 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.[71]

These Petra Nova and Boundary Dam 3 results should serve as a warning to San Juan owners and potential investors that betting on the oil market is a highly risky proposition and one that should be taken seriously.

[69] U.S. Securities and Exchange Commission (SEC). NRG 10-K, 170 for the Year Ended December 31, 2016.
[70] SEC. NRG 10-K-170 for the Year Ended December 31, 2017.
[71] The Global Warming Policy Foundation. The Bottomless Pit: The Economics of Carbon Capture and Storage at 55. Report 24. 2017.

It also must be emphasized that the market values for CO_2 claimed by Enchant are not prices that owners of San Juan would be guaranteed for the sale of the CO_2 captured at the plant. Instead, they are simply estimates based on one of the oil price forecasts included in the EIA's two-year-old 2018 Annual Energy Outlook. There is no guarantee that actual CO_2 prices will be anywhere near these values, or as high as the $17.50 per metric ton price assumed by Enchant and S&L in their marketing materials for the San Juan retrofit.[72]

Future CO_2 prices will be affected by actual and expected oil prices and by the competition among different CO_2 sources. Thus, they could very well be substantially lower than Enchant's estimates—another risk for investors to consider in deciding whether to back the San Juan project.

Retrofitting San Juan With Carbon Capture Would Bring No Net Environmental Benefit

When Enchant claims that retrofitting San Juan for CO_2 capture would be a win for the environment, it ignores the fact 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.

An assessment by Los Alamos National Laboratory (LANL) concludes that the use of captured CO_2 for EOR produces 435 kilograms (.435 metric ton) of lifetime CO_2 equivalent emissions (CO_2e) per barrel of oil produced.[73] Even with the conservative assumption that using captured CO_2 for EOR produces only 2.08 barrels of additional oil per metric ton,[74] this means that one metric ton of the CO_2 captured at San Juan would lead to 0.90 metric tons of new CO_2 equivalent 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 San Juan would not be captured and instead be emitted directly into the atmosphere. As a result, using the CO_2 captured at San Juan for EOR is unlikely to bring about any meaningful reduction in net CO_2 emissions.

The best way to address concerns about CO_2 emissions locally and regionally (and worldwide) is to retire San Juan Units 1 and 4 and require PNM to implement a 100% carbon-free replacement resource plan.

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[72] In addition, as noted earlier in this report, there's no evidence that Enchant or Sargent & Lundy have included any cost for transporting the CO_2 captured at San Juan to the Permian Basin.
[73] LANL. Preliminary Assessment of Post-combustion Capture of Carbon Dioxide at the San Juan Generating Station. December 12, 2019, page 21.
[74] DOE National Energy Technology Laboratory. Carbon Dioxide Enhanced Oil Recovery. 2010.

Conclusion

Enchant Energy attempts unsuccessfully to demonstrate the financial viability of its proposed carbon capture project at San Juan by relying on several unrealistic, if not outright false, assumptions.

These flawed assumptions include:

- That San Juan will operate at an 85% annual capacity factor for the entire period of the proposed project from 2023-2034;
- That the San Juan plant will achieve an average 90% carbon capture rate every year from 2023-2034;
- That San Juan's owners will be able to sell enough captured CO_2 to oil producers in the Permian Basin to pay for the project.

These core assumptions are further reinforced by additional flaws in Enchant's proposal, including that the retrofit will cost only $1.3 billion, when it will likely be much more, and that the plant would be able to sell its power at a profit—when it is far more likely to end up selling it at a loss or basically giving it away.

Rational investors and regulators will dismiss all these assumptions out of hand because the simple reality is that the proposed carbon capture retrofit at the San Juan Generating Station is not financially viable.

Investors would be better served by putting their money in projects that have a realistic chance of succeeding.

About IEEFA

The Institute for Energy Economics and Financial Analysis conducts research and analyses on financial and economic issues related to energy and the environment. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. https://ieefa.org

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