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IEEFA.org

Carbon Capture's Methane Problem

Life Cycle Analysis of Proposed New Mexico Carbon Capture and Sequestration Project Shows 90% or Higher Capture Is a Myth

Executive Summary

The U.S. Department of Energy (DOE) has issued a notice of intent to fund six carbon capture demonstration projects. Two are to be located at new or existing coal-fired generators, two at new or existing gas-fired facilities, and two at new or existing industrial facilities not proposed for electric generation.[1]

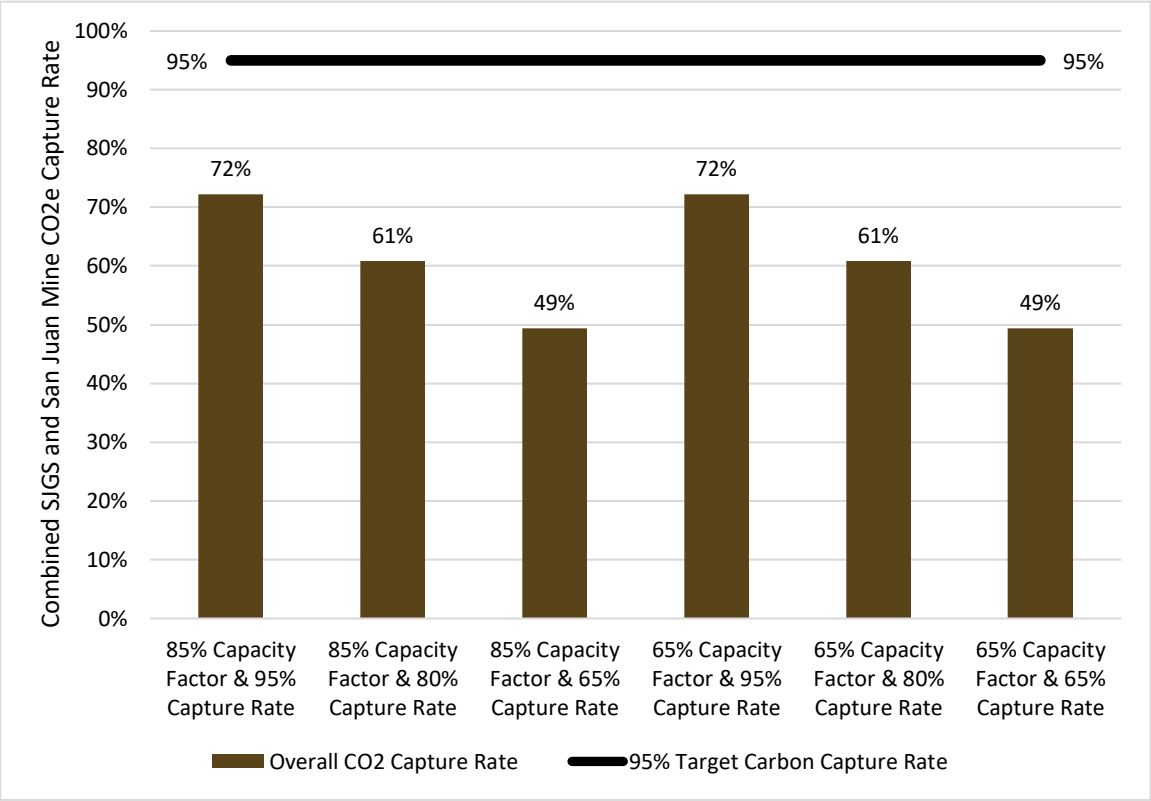
DOE says it intends to evaluate the full life cycle emissions for each funding application and "will give preference to applications that reduce GHG [greenhouse gas] emissions to the greatest extent across the full end-to-end project inclusive of upstream and downstream emissions." DOE also says projects must achieve a minimum unit-wide carbon dioxide (CO_2) capture rate of 95% "once stable operations are achieved."

Like other proponents of carbon capture and storage (CCS) seeking federal funding of their projects, Enchant Energy and its allies claim that retrofitting the San Juan Generating Station (SJGS) in New Mexico for carbon capture could capture 90% or more of the CO_2 emitted by the power plant. Real-world evidence suggests that this carbon capture rate is unrealistically high. Yet even if it were achievable, the total climate impact of SJGS would still be significant because of the substantial methane emissions from the San Juan coal mine that supplies fuel to the station.

Our analysis finds that the effective CO_2 capture rate at the plant after including the mine's methane emissions would be no more than 72%. The figure is likely too high, since it assumes Enchant will be able to consistently capture 95% of CO_2 generated at the plant. (See Figure ES-1.)

[1] U.S. Department of Energy. Office of Clean Energy Demonstration Funding Opportunity Announcements, DE-FOA-0002806 NOTICE OF INTENT TO ISSUE FUNDING OPPORTUNITY ANNOUNCEMENT NO. DE-FOA-0002738 TITLED BIL: CARBON CAPTURE DEMONSTRATION PROJECTS PROGRAM (SECTION 41004(B)). July 13, 2022.

Figure ES-1: The Combined SJGS and San Juan Mine CO_2e Capture Rate Would Be Significantly Lower than the 90% - 95% Rate Claimed by Enchant Energy and Other Proponents for the SJGS Capture Project



Source: IEEFA analysis.

IEEFA has chosen to focus on Enchant's proposed project for three reasons. First, there is publicly available data on the production and emissions at both the plant and the mine. Second, Enchant has acknowledged that there is very limited investor interest in its carbon capture project; consequently, it will be seeking almost $1 billion in funding from the federal government. Finally, all but one of San Juan's current owners have decided that the plant is no longer economical to operate and should be retired this year.

IEEFA's analysis concludes:

1. Even if Enchant captures 90% of the CO_2 produced by SJGS, the combined CO_2-equivalent (CO_2e) capture rate for both the mine and the plant would be only 68%. In this scenario, the project would continue to emit more than 3 million tons of CO_2-equivalents annually.

2. If Enchant were able to capture only 75% of the CO_2 produced by SJGS, the effective capture rate for both the mine and the plant would be 57%.

3. If Enchant were able to capture only 65% of the CO_2 produced by SJGS, the effective capture rate for both the mine and the plant would be 49%.

As disappointing as these findings may be to carbon capture advocates, they likely substantially understate the SJGS project's total climate effects. In addition to uncaptured CO_2 from the power plant and significant methane emissions from the San Juan coal mine, CO_2 can leak during transportation to a storage site, and may also leak from underground storage facilities. In addition, if SJGS carbon were used for enhanced oil recovery (EOR) projects, significant additional volumes of CO_2 would be released during the production process and through consumption (CO_2 leakage and the CO_2 emissions from EOR are not considered in this analysis).

The problem of associated methane emissions is endemic not only to SJGS, but also to other coal and natural gas plants where carbon capture is being proposed, as well as to "blue hydrogen," or natural gas-fired hydrogen projects that are seeking state and federal subsidies. For example, in the case of a gas-fired generator, even if a 90% capture rate is achieved over the long term, there are still likely to be significant methane leaks during production of the natural gas and its transportation to the generator, as well as from CO_2 pipelines and the underground storage facility.

Table of Contents

Introduction

The analysis that follows is focused on the San Juan Generating Station (SJGS) and the adjacent mine that supplies coal to the plant. However, these questions are relevant for any proposed carbon capture project:

1. How much methane (in carbon dioxide-equivalent, or CO_2e) has the San Juan mine emitted during the past decade and how much would it emit if SJGS is retrofitted for carbon capture?

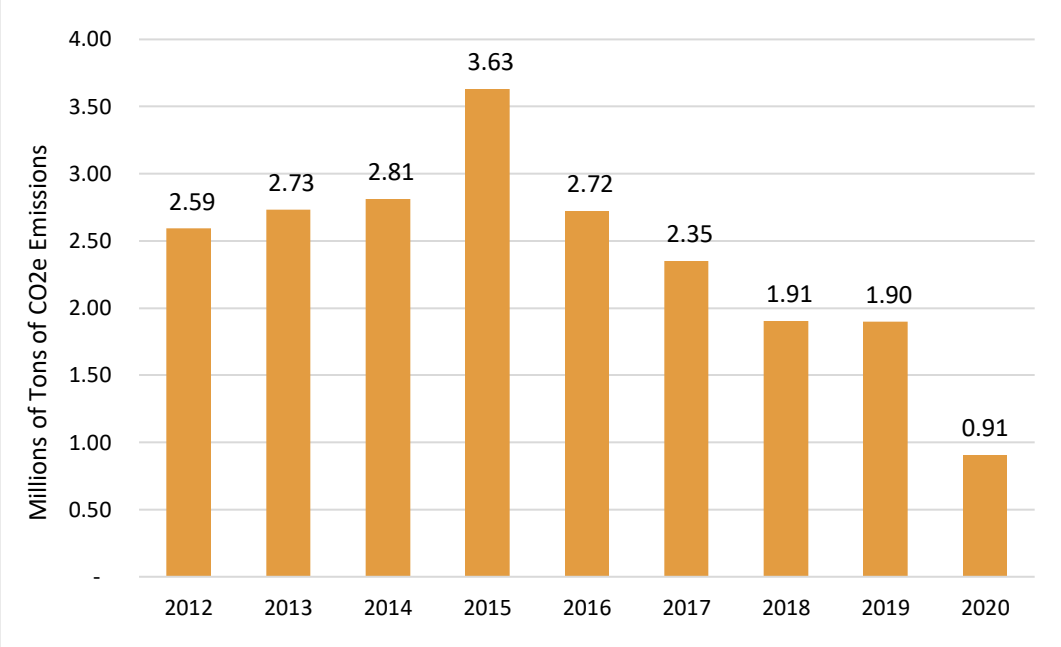
2. How much CO_2 would SJGS produce if it was retrofitted for carbon capture?

3. How much of the total CO_2e produced by the mine and the plant actually would be captured, assuming different CO_2 capture rates at the power plant?

How Much Methane Does the San Juan Mine Emit?

The San Juan mine emits significant amounts of methane, a powerful greenhouse gas, as the figure below illustrates.

Figure 1: Annual San Juan Mine Methane Emissions



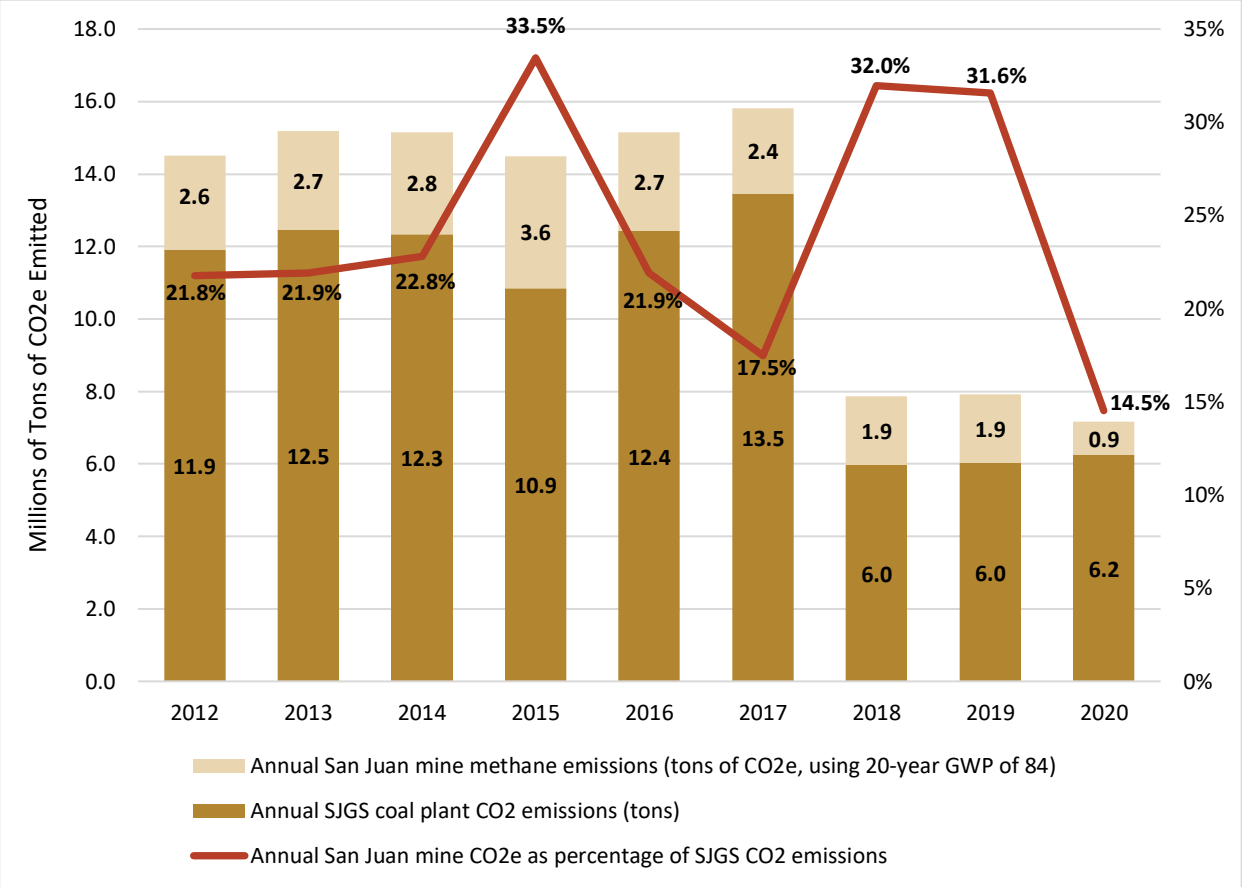
Source: U.S. EPA FLIGHT database with a 20-Year GWP of 84.

This figure shows the annual emissions of methane in terms of CO_2 equivalent, rather than tons, using a 20-year global warming potential (GWP) of 84. The 20-year GWP is more relevant than the lower 100-year GWP because climate tipping points that are not addressed in the shorter-term result in difficult-to-reverse

environmental damage that makes long-term problems worse.[2] For example, melting of Arctic ice within the next 20 years would accelerate planetary warming, and could be irreversible.[3]

It is important to emphasize, however, that the methane emissions from the mine reported to the EPA may seriously understate its actual emissions. For example, a recent study by the International Energy Agency (IEA) concluded that actual methane emissions from oil, gas and coal are 70% higher than reported in official data.[4]

Figure 2: The Combined CO_2e Emissions From Both the Mine and the Power Plant Have Been Substantially Higher Than Those From Just the Plant



Source: EIA Form 923 and EPA FLIGHT database.

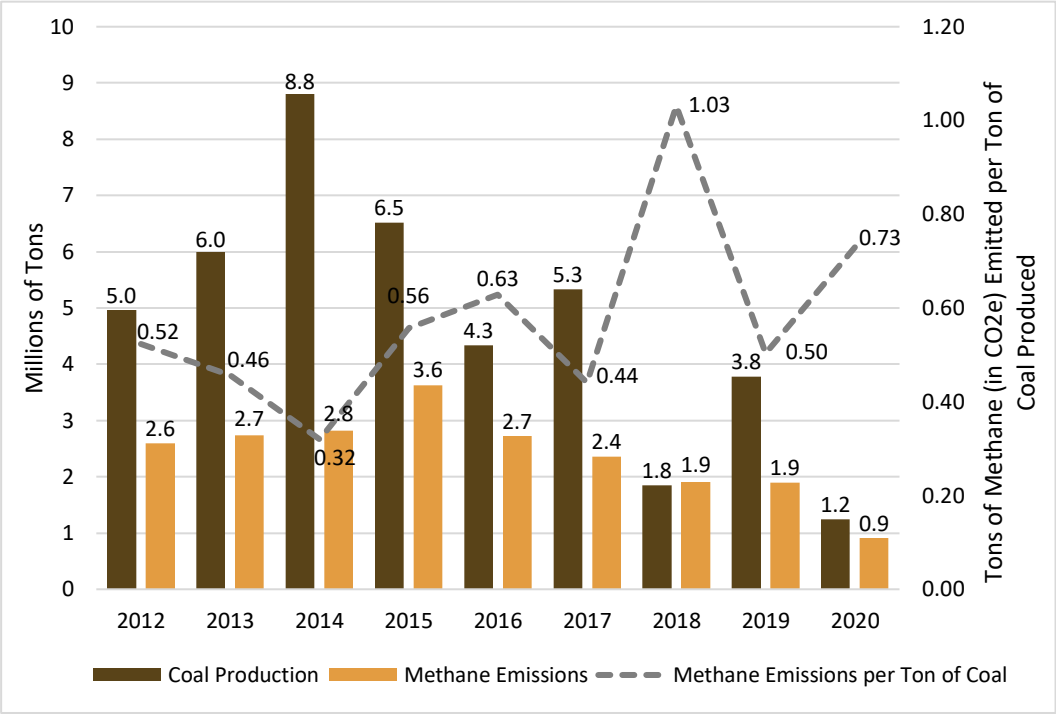
As shown in Figure 2, the CO_2e emissions from the mine have been significant—averaging roughly 25% of the CO_2 emissions from the plant between 2012 and

[2] Conversion with Professor Mark Jacobson from Stanford University.
[3] *Ibid.*
[4] IEA. Methane emissions from the energy sector are 70% higher than official figures. February 2022.

2020.[5] However, the methane emissions from the mine have been ignored in the public discussion about the amount and percentage of the CO_2 emissions from SJGS will be captured.

As will be explained below, Enchant claims that SJGS will run more after being retrofitted for carbon capture than it has in recent years. So to determine how much methane would be emitted by the mine, it is necessary to determine the average of CO_2e emitted by the mine for each ton of coal produced. The results of this analysis are presented in Figure 3.

Figure 3: Coal Production at the San Juan Mine Has Declined, but Methane Emissions per Ton of Coal Produced Have Increased



Sources: IEEFA analysis of data from EPA FLIGHT database using GWP of 84.

As this figure shows, methane emissions per ton of mined coal increased from 0.52 tons of CO_2e in 2012 to 0.73 tons in 2020, even though the amount of coal produced declined sharply due to reduced demand from the retirements of SJGS Units 2 and 3 at the end of 2017. (Data for 2021 are not yet available.)

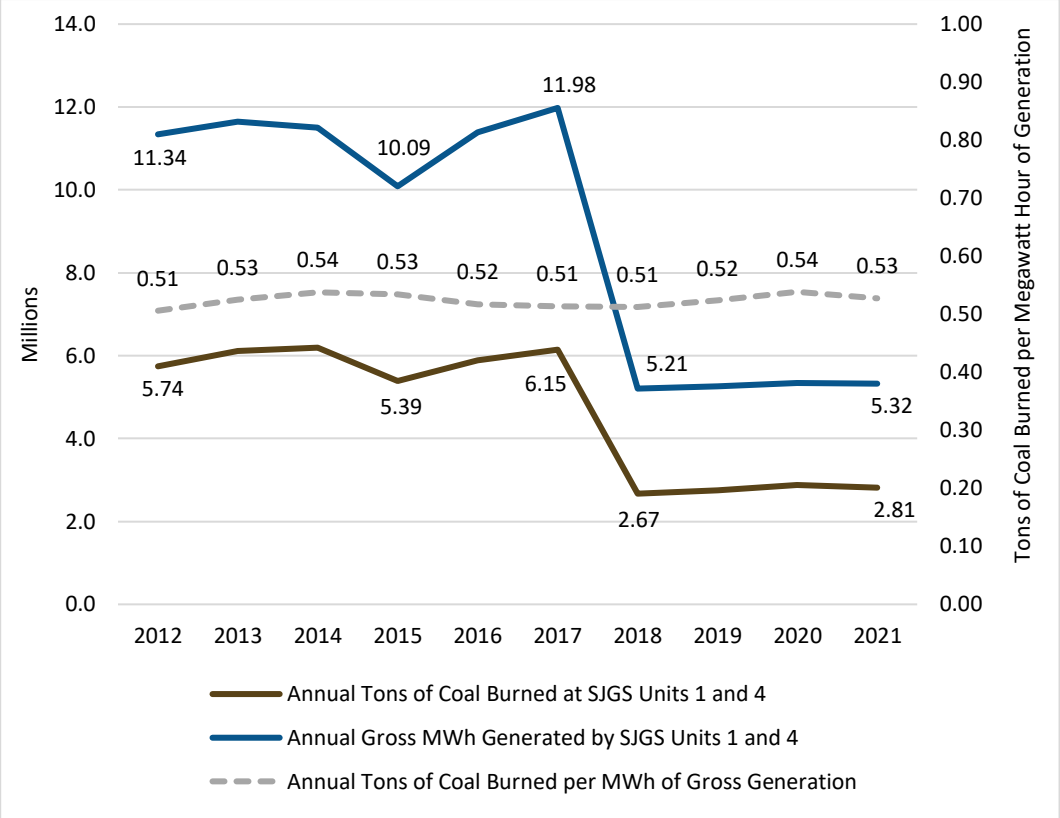
To be conservative, we have assumed that if SJGS were retrofitted for capture carbon, the mine would emit 0.69 tons of methane (in CO_2e) per ton of coal produced. The figure represents the average emission rate for 2018-20, the only years after output from the San Juan mine declined due to the retirements of SJGS Units 2 and 3 and for which data are publicly available.

[5] The sharp decline in overall emissions in 2018 reflects the closure of two of the plant's original four generating units, not any carbon capture efforts.

How Much Methane Would Be Emitted by the Mine if SJGS Is Retrofitted for Carbon Capture?

The amount of methane emitted by the mine if SJGS is retrofitted for carbon capture would depend heavily on how much coal is needed by the plant. That, in turn, would depend on how much power and energy the plant generates. Since 2012, slightly more than one-half of a ton of coal was consumed for each megawatt-hour (MWh) of electricity generated by the plant. (See Figure 4.)

Figure 4: On Average, SJGS Units 1 and 4 Burn Slightly More than One-Half of a Ton of Coal per MWh of Gross Generation



Source: IEEFA analysis of data from EIA Form 923.

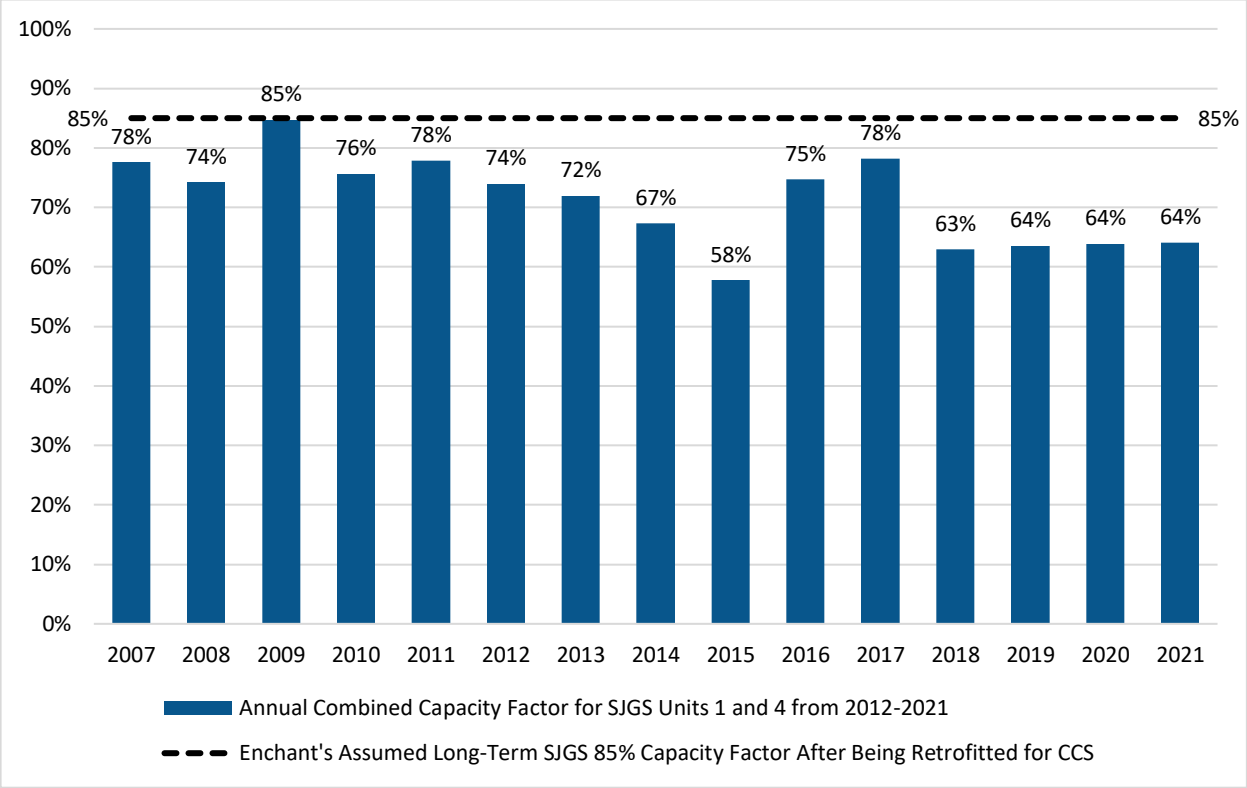
A power plant's capacity factor compares the energy (in MWh) the plant actually produces in a year to the amount generated if it had operated at full power at all hours throughout the year. The result, presented as a percentage, is its capacity factor. The higher a power plant's capacity factor, the more energy it generates.

Enchant claims that Units 1 and 4 at SJGS would achieve a combined average capacity factor of 85% each year after being retrofitted for carbon capture.[6] As

[6] A power plant's capacity factor measures the amount of energy (in MWh) it generates in a year as a percentage of how much energy it would have produced if it had operated at full power for all hours throughout the year. The higher the capacity factor, the better.

shown in Figure 5, this would represent a dramatic improvement from the plant's actual operating performance over the past 15 years.

Figure 5: Performance of SJGS Units 1 and 4 Has Been Significantly Worse Than Enchant's 85% Assumed Capacity Factor Would Have Suggested



Source: Data from EIA Form 923 downloaded from S&P Global.

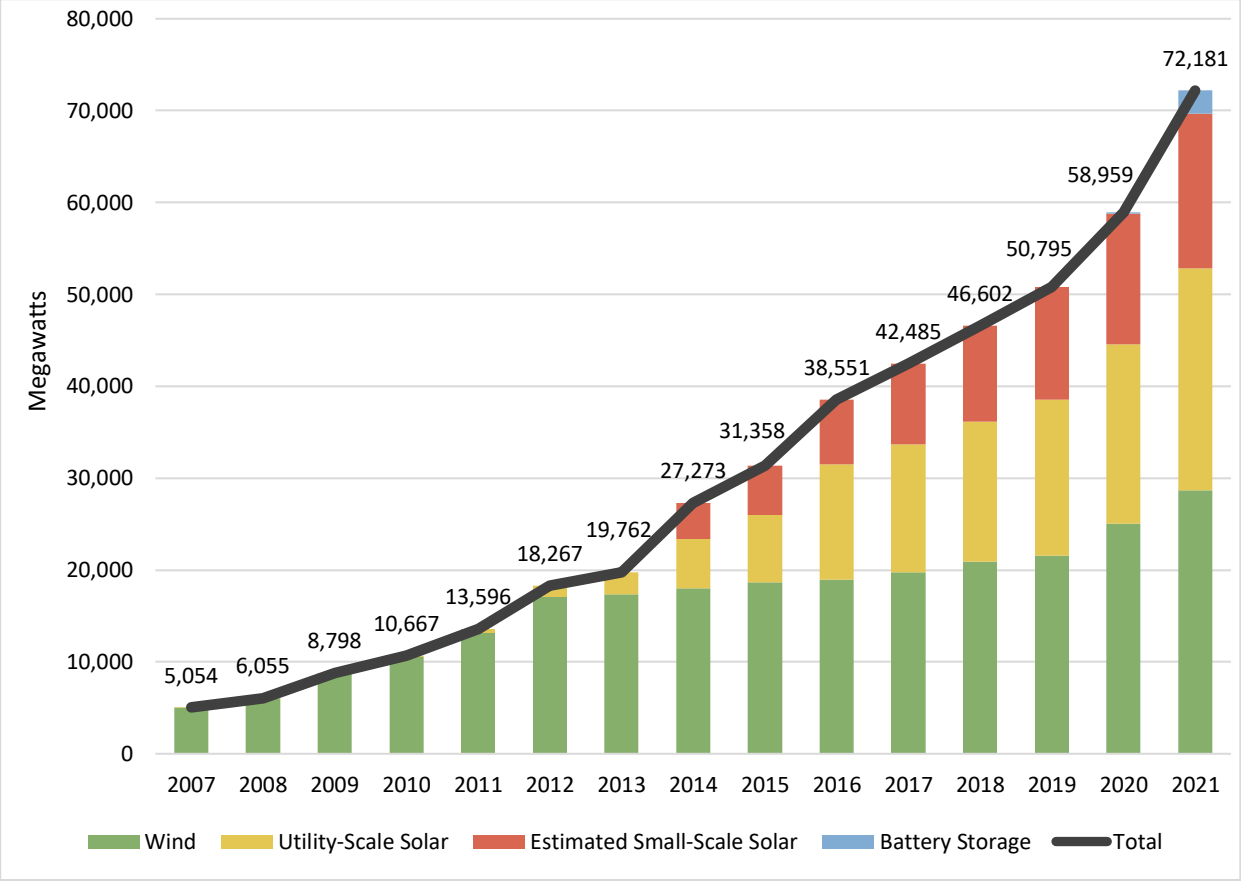
Enchant's claim that the units will achieve a combined 85% capacity factor on a sustained basis over a period of decades is very unrealistic, given that:

- The combined capacity factor for SJGS Units 1 and 4 has reached 85% only once in the 15 years since 2007, and never since 2009.
- The units' combined capacity factor has achieved 78% or higher only once since 2011.
- The units' combined capacity factor has been only 63% to 64% in each of the last four years.
- The capacity factors of SJGS Units 1 and 4 did not increase even after the close of the 2,250-megawatt (MW) Navajo Generating Station in late 2019.
- The performance of Units 1 and 4 actually declined after SJGS Units 2 and 3 were retired at the end of 2017.

Enchant further claims that achieving an 85% annual capacity factor is reasonable if you consider that the new carbon capture facilities would be an additional load. However, even if you consider the new carbon capture facilities as an additional load running 85% of the time, the plant's overall capacity factor would increase from 64% to just 70%. Even if you consider the new carbon capture facilities would run 100% of the time, the plant's overall capacity factor would be just 74%, which would still be substantially below the 85% claimed by Enchant. Consequently, if Enchant wants to achieve an 85% capacity factor, it still would have to find a substantial number of new customers for the expensive power from SJGS. This is extremely unlikely in light of the growing competition that fossil-fired generators in the Southwest face from lower-cost renewable resources and the adverse impact aging can be expected to have on the units' operating costs and performance.

Total installed renewable capacity in the western U.S. electricity grid has increased some 14-fold since 2007. The growth of installed solar capacity has been even more dramatic, climbing from barely any in 2011 to 41,000 MW just 10 years later. More than 2,500 MW of battery storage have been added since 2020.

Figure 6: The Amount of Renewable Capacity and Battery Storage in the Western U.S. Grid Has Skyrocketed in the Last 15 Years



Source: EIA Electric Power Monthly and data from Lawrence Berkeley Nation Laboratory reports.

Most importantly, much more is on the way. There are almost 390,000 MW of proposed renewable and storage capacity in the western region's interconnection queues, including:

- 37,727 MW of new stand-alone solar resources
- More than 53,000 MW of new standalone wind, including more than 6,300 MW of offshore wind resources
- 104,707 MW of new stand-alone storage capacity
- More than 181,000 MW of new storage paired with wind or solar resources
- Another 13,423 MW of other new hybrid resources (that is, those that include two or more generator and storage technologies) and new hydro and geothermal capacity.[7]

In addition, the capacity figures listed for the 181,000 MW of new storage paid with wind or solar resources only includes the generator capacity, not the storage capacity. If even 20% of this proposed capacity ends up being built in the next five years, the region's renewable and battery storage capacity will double.

Moreover, electricity provided by the new wind, solar and storage capacity can be expected to be increasingly less expensive than power generated at SJGS. The price of producing power at SJGS has generally remained above $40/MWh over the past decade and has remained high even though the current owners have not funded more than $150 million of maintenance expenditures in anticipation of retiring the units this coming summer.[8] At the same time, average solar power purchase agreement (PPA) prices in the California ISO and the non-ISO West declined by 89% and 87% respectively between 2009 and 2021. Average wind PPA prices declined by 69% during the same period.[9] Similarly, average battery storage costs fell by 72% between 2015 and 2019, according to a new analysis by the Energy Information Administration (EIA).[10] More declines are expected in coming years after current supply chain issues are resolved.[11]

San Juan Units 1 and 4 are already 45 and 40 years old, respectively. They would be at least five or six years older when the proposed retrofitting of SJGS for carbon capture actually would be completed.

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[7] U.S. Department of Energy Berkeley Lab Electric Markets & Policy Group. *U.S. Interconnection Queues 2021*. March 21, 2022.
[8] PNM FERC Form 1 Filings available at FERC.gov.
[9] U.S. Department of Energy Berkeley Lab Electric Markets & Policy Group. Utility-Scale Solar 2021 Edition and Land Based Wind Market Report. October 2021.
[10] Energy Information Administration. Battery Storage in the United States: An Update on Market Trends. August 16, 2021.
[11] Lawrence Berkeley National Laboratory. Levelized cost-based learning analysis of utility-scale wind and solar in the United States. May 2022. Also see: National Renewable Energy Laboratory. Cost Projections for Utility-Scale Battery Storage: 2021 Update. June 2021.

The problems for aging plants have been identified in analyses from the Department of Energy's Argonne National Laboratory and the National Energy Technology Laboratory.[12] They found older plants typically cost more to operate and maintain, and are less reliable. In particular, they found coal plant heat rates increase as the plants age and that their availability declines. Higher heat rates mean a plant requires more fuel to generate electricity, effectively raising the cost of production. Lower availability means a plant will be less able to generate electricity, missing sales and effectively raising plant costs by forcing the operator to spread fixed operation and maintenance (O&M) costs over a smaller amount of production.

Finally, as plants get older, maintenance costs tend to increase as equipment and components age and must be repaired or replaced. These have already been issues at SJGS, and they are certain to increase in severity as the units age.

For these reasons, we believe it is extremely unlikely that SJGS will achieve an 85% capacity factor in any single year, let alone on a consistent basis over a period of years or decades. The most likely scenario is that the plant's annual capacity factors will decline over the years from the current level of 64% if it is not retired this year, as planned.

The only scenario in which the plant's capacity factor is likely to increase over the long term, even in a minor way, is a completely wasteful one in which Enchant runs the plant simply to produce and capture more CO_2 and earn more 45Q tax credits or direct payments from the federal government. But even in this scenario, it is hard to see that Enchant and any investors would make substantial profits on a sustained basis if the power produced by SJGS were being sold at a significant discount from the cost of production, as can be expected given the declining prices of solar, wind and battery storage facilities.

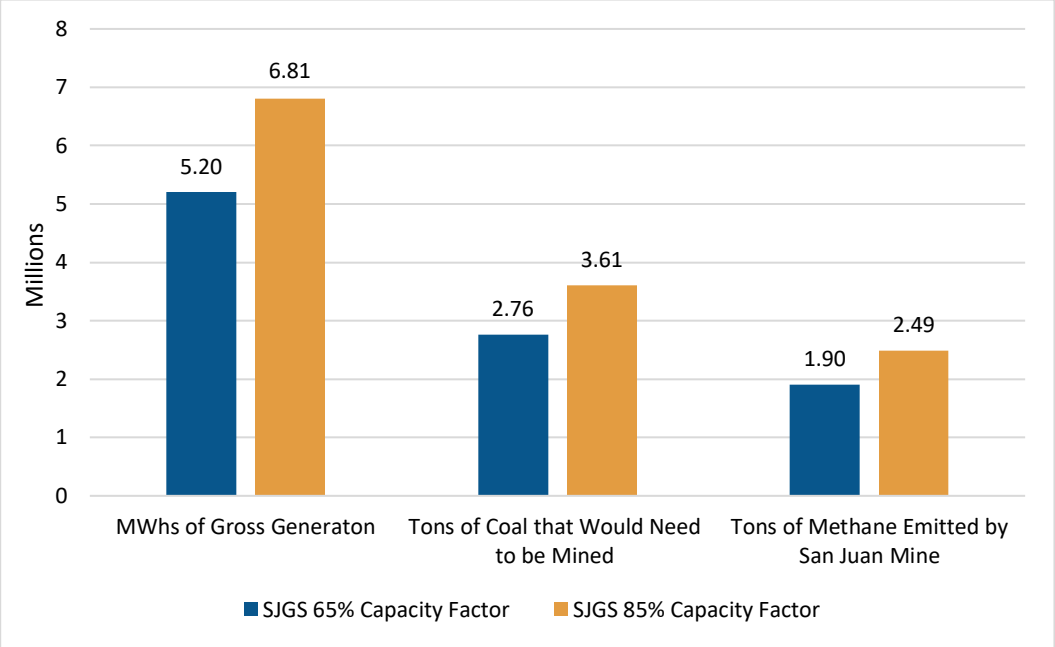
Nevertheless, we have looked at what the overall carbon capture rates will be for the facility (including both the mine and the plant) under a high capacity factor of 85% and a low one of 65% The high end of this range reflects Enchant's assumed 85% capacity factor. The low end of the range assumes that the plant's future performance would be same as its recent past.

At a 65% capacity factor, the annual gross generation of the 914-MW SJGS would be 5,204,316 MWh, which has roughly been its annual generation since 2017. At an 85% capacity factor, it would generate 6,805,644 MWh. We use gross generation because the plant must produce enough power not only to sell to customers (that is, its net generation) but also to run its internal equipment, including the carbon capture facilities after being retrofitted.

Figure 7 shows how much coal SJGS would need to burn to generate this many MWhs and the annual methane emissions from the San Juan mine if the mine produced that much coal.

[12] U.S. Department of Energy. Staff Report to the Secretary on Electricity Markets and Reliability. August 2017, p. 155.

Figure 7: San Juan Mine's Coal Production and Methane Emissions (in CO_2e) at 65% and 85% SJGS Capacity Factors



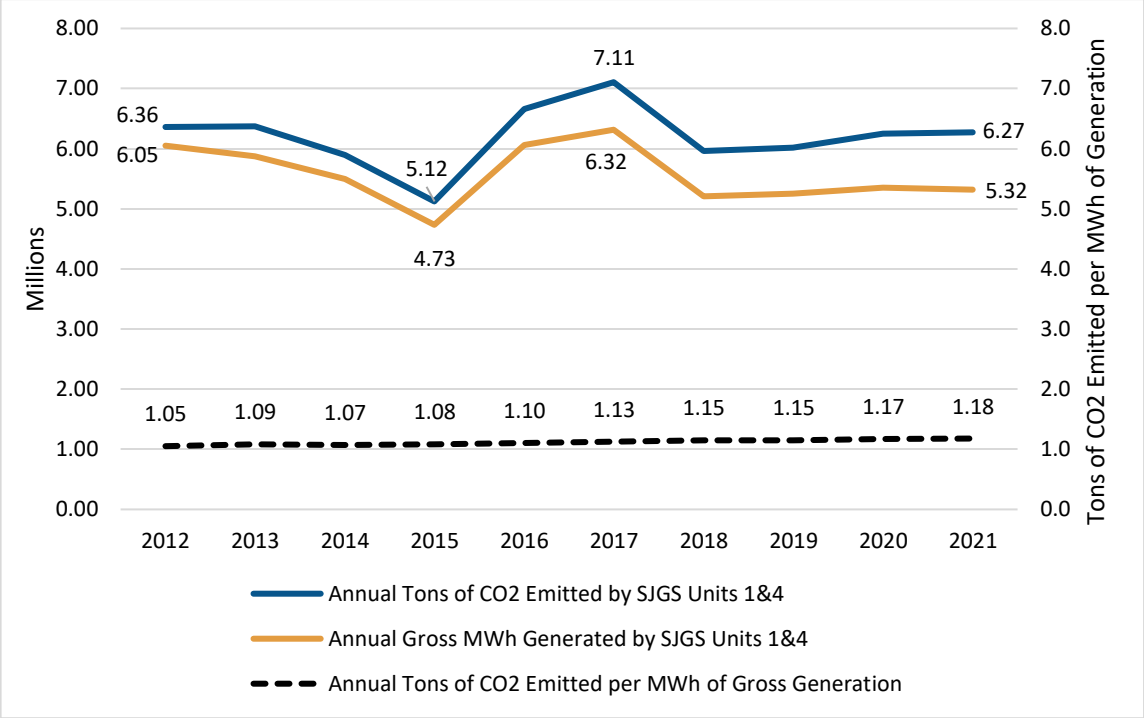
Source: IEEFA calculations based on DOE EIA Form 923 and EPA FLIGHT data.

Based on the recent history of the methane emissions from the San Juan mine, we are expecting its future CO_2e emissions would range between 1.90 and 2.49 million tons annually if SJGS operates within the range of 65% to 85% capacity factors.

How Much CO_2 Would SJGS Produce If Retrofitted for Carbon Capture?

As the dashed line in Figure 8 shows, the average amount of CO_2 emitted by SJGS Units 1 and 4 per MWh of gross generation has increased steadily over the past decade from 1.05 tons of CO_2 per gross MWh in 2012 to 1.18 tons of CO_2 in 2021.

Figure 8: Annual CO_2 Emissions and Gross Generation From SJGS Units 1 and 4



Source: EIA Form 923 and EPA data downloaded from S&P Global.

Using the average of 1.16 tons of CO_2 gross MWh generated between 2018 and 2021, and annual capacity factors ranging from 65% to 85%, we project that the plant would produce between 6.04 and 7.89 million tons of CO_2 annually after being retrofitted for carbon capture. Now the question turns to the appropriate range to assume for the carbon capture rates that the retrofitted SJGS could potentially achieve over the long term.

What Is an Appropriate Range of Carbon Capture Rates to Assume for a Retrofitted SJGS?

Previous IEEFA research demonstrates that despite the unsupported claims of carbon capture advocates, existing carbon capture technology has never demonstrated a sustained ability to capture 90% of the CO_2 produced by a commercial-sized coal plant. Indeed, we believe that based on the actual experience at the Boundary Dam 3 and Petra Nova carbon capture projects, it is more likely that SJGS will capture no more than 65% to 75% of the CO_2 produced by Units 1 and 4 after being retrofitted.[13] Nevertheless, our analysis assumes SJGS's future capture rate would range between 65% and 90%, with the high end of the range reflecting Enchant's claims about the future performance of the carbon capture facility after

[13] IEEFA. Where's the Beef? May 2021. Also see: IEEFA. Carbon capture coals miss the mark at Boundary Dam 3 coal plant. April 2021.

SJGS is retrofitted. Obviously, the effective capture rates that we show for both the plant and the mine would be even lower if we assumed that SJGS would capture less than 65% of the CO_2 it produces.

Are There Other Possible Circumstances That Could Lead to Even Lower Carbon Capture Rates?

This analysis does not include a worst-case scenario in which either SJGS's annual capacity factors or the average carbon capture rate for the plant drops below 65%—although there are certainly scenarios where the plant captures less CO_2, and the plant and mine together emit more CO_2 over a sustained period or in any year.

The analysis does not consider them, but there are a number of circumstances that would lower the effective carbon capture rates of the proposed Enchant project.

1. Leaks in the equipment used to compress captured CO_2 before it is piped to the geological storage site.
2. Leaks in the pipelines that transport the captured CO_2 from the plant to the storage site.
3. Leaks at the underground storage site.
4. Use of some or all of the captured CO_2 for enhanced oil recovery (EOR).

Summary of Assumptions

To summarize, this analysis reflects the following:

1. The San Juan Mine emits an average of 0.69 tons of CO_2e per ton of coal produced.
2. None of the methane emitted by the mine is captured.
3. SJGS achieves either a 65% or 85% annual capacity factor.
4. SJGS burns an average of 0.53 tons of coal to generate each MWh of electricity.
5. Each MWh of generation from SJGS produces 1.18 tons of CO_2.
6. Consequently:
    - At a 65% SJGS capacity factor, the total CO_2e produced by the San Juan Mine and SJGS would be 7.9 million tons.
    - At an 85% SJGS capacity factor, the total CO_2e produced by the mine and the plant would be 10.4 million tons.

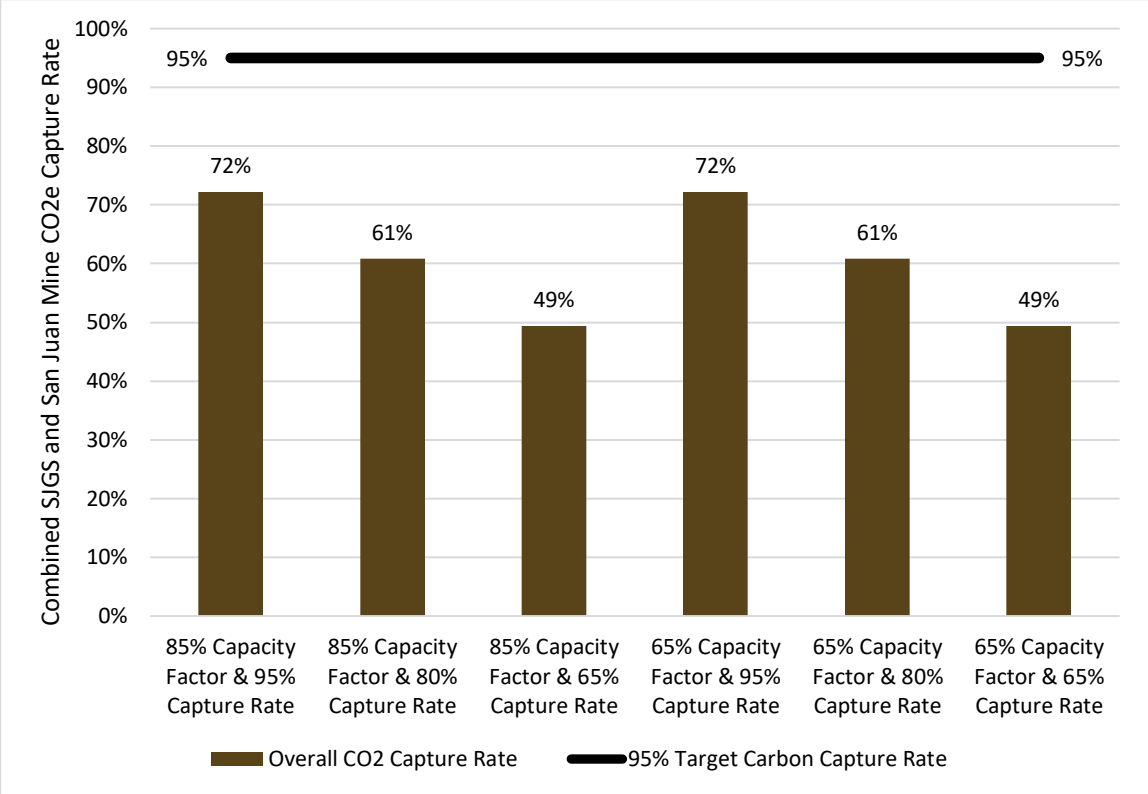
7. The carbon capture facility added to SJGS captures 65% to 95% of the CO_2 produced by the plant.

8. The analysis does not consider the potential for CO_2 to leak from pipelines or the underground storage facilities, and does not consider the emissions consequences of using captured CO_2 for EOR.

Results

The results of our analysis are presented in Figure 9.

Figure 9: The Combined SJGS and San Juan Mine CO_2e Capture Rate Would Be Significantly Lower than the 90% - 95% Rate Claimed by Enchant Energy and Other Proponents for the SJGS Capture Project



Source: IEEFA analysis.

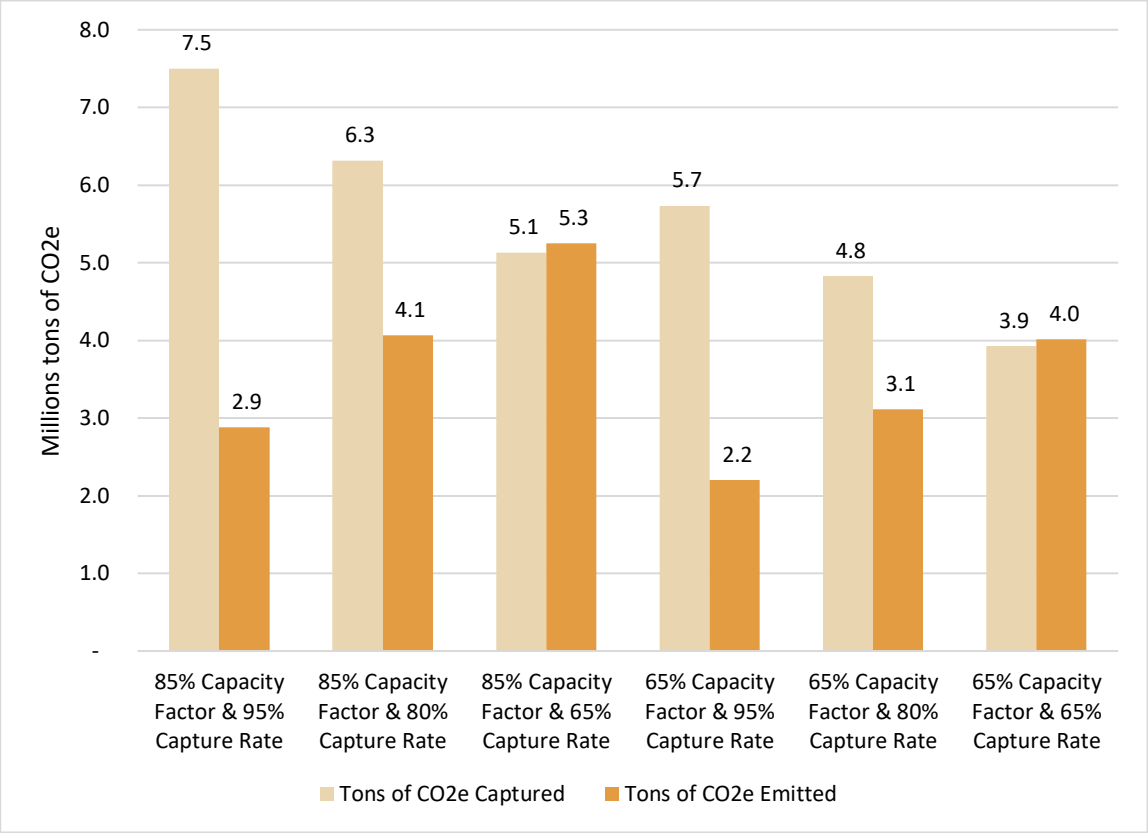
The most significant results shown in Figure 9 are that:

1. Even if Enchant does manage to capture 95% of the CO_2 produced by SJGS, the overall capture rate including both the mine and the plant's emissions would be only 72%. In this scenario, the project would continue to emit almost 3 million tons of CO_2 annually.

2. If Enchant were able to capture 80% of the CO_2 produced by SJGS, the overall capture rate for both the mine and the plant would be 61%.

If Enchant were able to capture only 65% of the CO_2 produced by SJGS, the overall capture rate for both the mine and the plant would be 49%. Figure 10 shows how much of the CO_2e produced by the plant and the mine would be emitted each year and how much would be captured in each of the six scenarios we have examined.

Figure 10: SJGS and the San Juan Mine Would Continue to Emit Significant CO_2e Emissions Even if the Plant Operated at an 85% Capacity Factor and Captured 95% of the CO_2 Produced by the Plant



Source: IEEFA analysis.

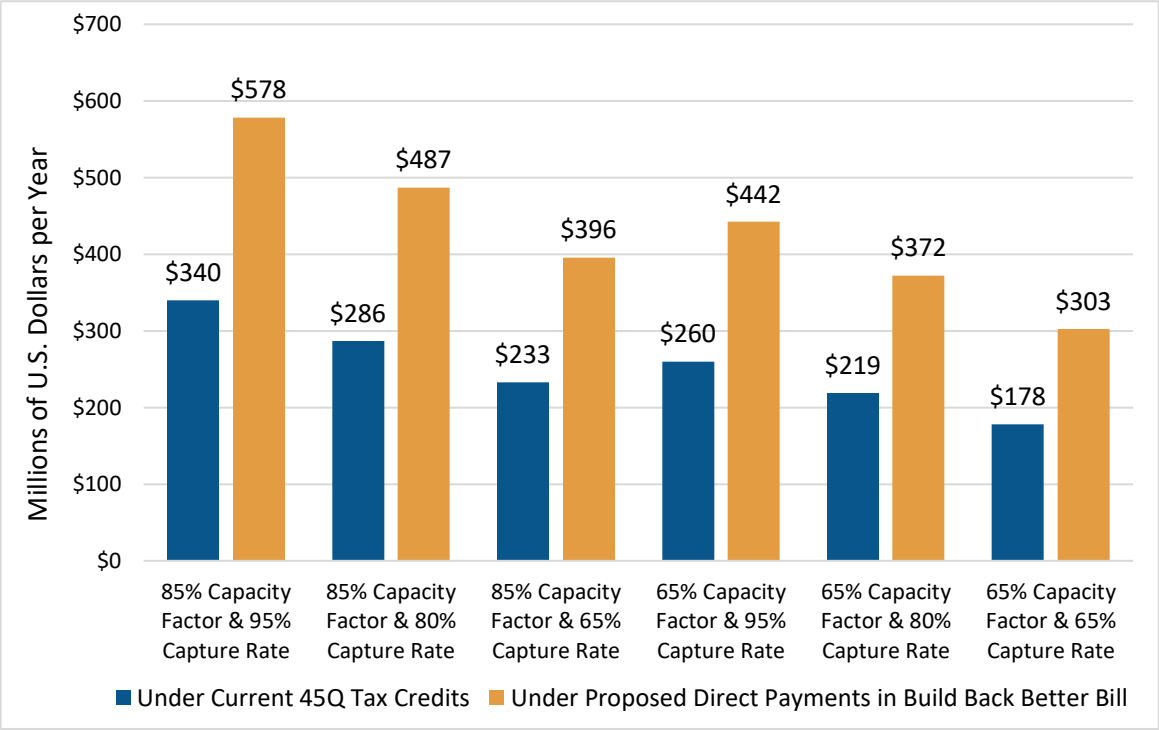
Most significantly, even if it were possible each year to both operate SJGS at an average 85% capacity factor and to capture 95% of the CO_2 produced by the plant, the project would continue to emit almost 3 million tons of CO_2e annually.

The amounts of CO_2e emitted each year would be even higher if the plant ran at an 85% average annual capacity factor, but only 80% or 65% of the CO_2 produced by the plant were captured.

How Much Will It Cost to Subsidize Enchant's Proposed Carbon Capture Project?

Under existing and proposed 45Q subsidies, federal taxpayers will bear a heavy burden subsidizing carbon capture projects like the one proposed by Enchant.

Figure 11: Potential Annual Costs for Federal Taxpayers Under Existing and Proposed Federal 45Q Carbon Capture Subsidies



Source: IEEFA analysis based on current 45Q tax credits and provisions of Build Back Better Bill.

As shown in Figure 11, if Enchant manages to operate SJGS at an 85% capacity factor and capture 95% of the CO_2 produced by the plant, federal taxpayers would be responsible for $340 million in tax credits each year under the existing 45Q program and could pay as much as $578 million in direct payments if the proposal in the Build Back Better bill or legislation with similar tax credits is enacted.[14] If the plant does not operate that well and/or Enchant's carbon capture project does not capture as much of SJGS's CO_2 as proponents claim it will, taxpayers still would pay hundreds of millions of dollars a year to Enchant and its investors, even though millions of tons of CO_2e emissions from the mine and plant continue to be emitted into the atmosphere.

[14] Figure 11 reflects the current 45Q tax credit of $50 per metric tonne ($45.36 per ton) of CO_2 sequestered in geological storage and the proposed $85 per metric tonne ($77.10 per ton) tax credit/direct payment in the Build Back Better bill.

However, the 45Q tax credits are not the only CCS subsidies federal taxpayers would underwrite to support the proposed SJGS carbon capture project. Enchant has said it plans to seek almost $1 billion in loans from the U.S. Department of Energy and the Rural Utilities Service.[15] The U.S. DOE has indicated it is willing to pay 50% of the cost of the initial six CCS development projects. [16]

Conclusion

Carbon capture and storage proponents have long used questionable assumptions about plant performance and long-term operational reliability to justify planned retrofit projects. IEEFA research has demonstrated the flaws in those assumptions.[17]

Now, another problem shows even greater flaws in the push for CCS: Methane emissions would significantly undercut the overall performance of any CCS retrofit or new coal or gas-fired power plant.

For example, our research in this report shows that factoring methane emissions into the proposed CCS retrofit at the San Juan Generating Station in New Mexico could reduce the overall capture to less than 50% while costing U.S. taxpayers hundreds of millions of dollars annually. That is not an environmentally or financially sensible solution.

[15] IEEFA. Where's the Beef? May 27, 2021.
[16] U.S. Department of Energy. Office of Clean Energy Demonstration Funding Opportunity Announcements, DE-FOA-0002806 NOTICE OF INTENT TO ISSUE FUNDING OPPORTUNITY ANNOUNCEMENT NO. DE-FOA-0002738 TITLED BIL: CARBON CAPTURE DEMONSTRATION PROJECTS PROGRAM (SECTION 41004(B)). July 13, 2022.
[17] IEEFA. 'Holy Grail' of carbon capture continues to elude coal industry; 'cautionary tale' applies to domestic and foreign projects alike. November 19, 2018. Also see: IEEFA. Mothballing of Petra Nova carbon capture project shows likely fate of other coal-fired CCS initiatives. August 3, 2020.

About IEEFA

The Institute for Energy Economics and Financial Analysis (IEEFA) examines issues related to energy markets, trends and policies. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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