

**The Economic Case for Power Plant Carbon Capture Retrofits:
A Case Study on the San Juan Generating Station – New Mexico**



ENCHANT ENERGY

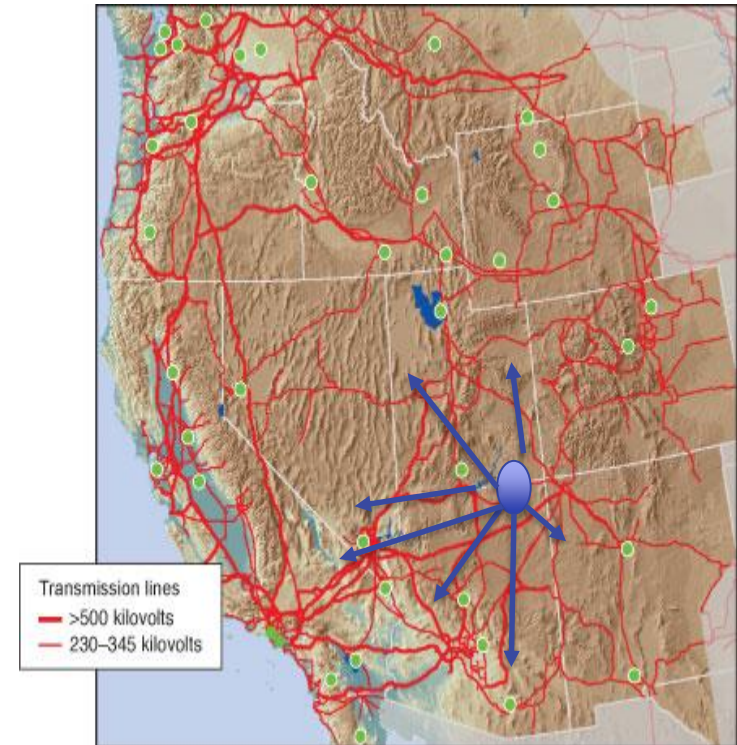
October 2019

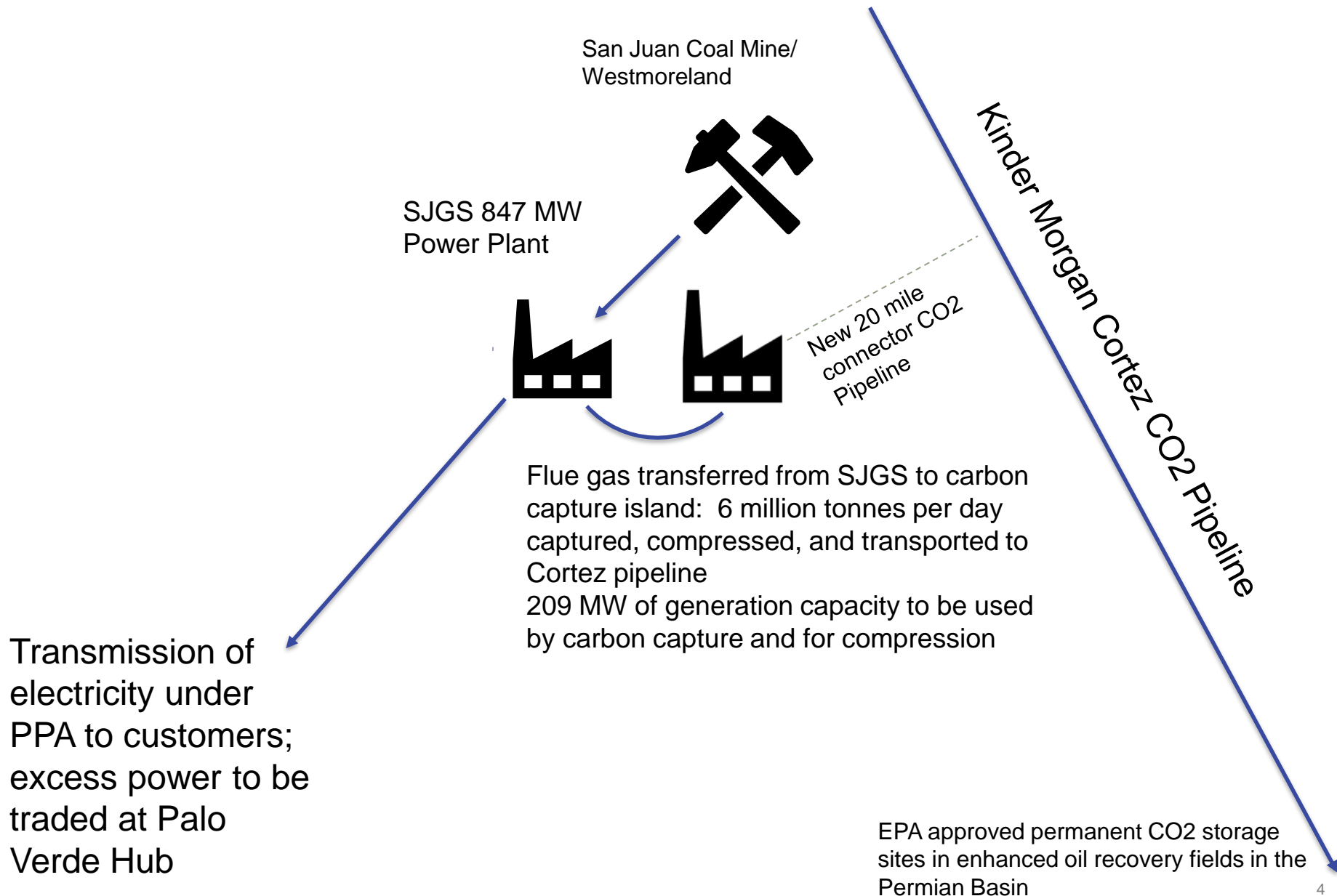
Summary

- San Juan Generating Station (“SJGS”) is perhaps the best site in the US for the next large-scale installation of Carbon Capture Utilization and Storage (“CCUS”) Technology
- Cost of Capture is estimated at \$39 to \$43 per metric ton: a 35-40% reduction from previous installations
- Proximity to a deep market for pipeline quality CO₂ in conjunction with revamped 45Q tax credit enables CCUS project installation without increasing the Levelized Cost of Electricity (“LCOE”) of the host generator
- Project is a Win, Win, Win for Climate, Ratepayers, and the Community

What is San Juan Generating Station ?

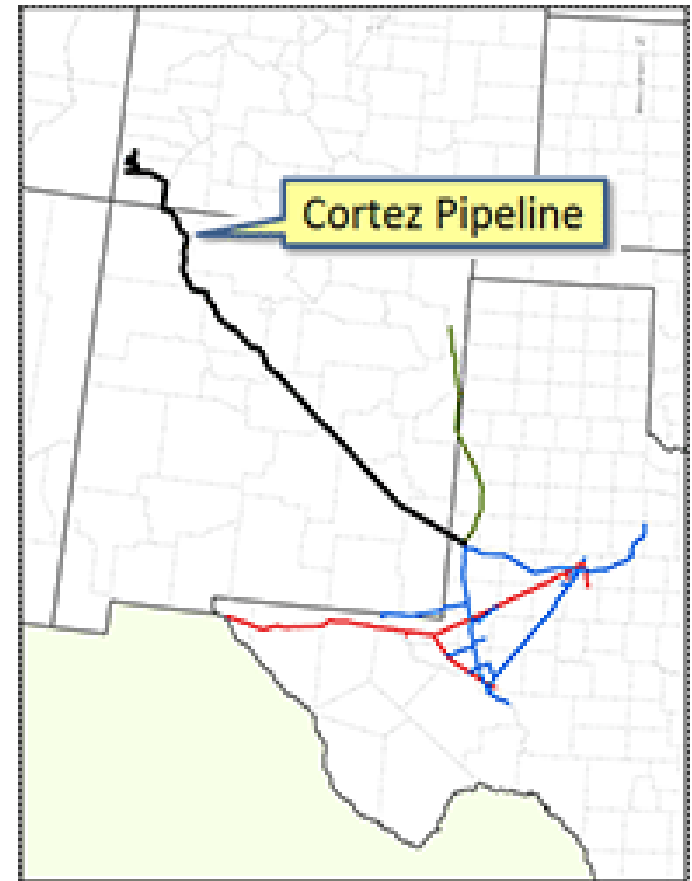
- 847 MW Coal-fired Electricity Generation Station in Northwest New Mexico originally built in the 1970s, expanded in the 1980s
- High BTU Coal is supplied by the adjacent San Juan coal mine, owned by Westmoreland Holdings
- SJGS is operated by PNM on behalf of PNM (66%), TEP (20%), Farmington (5%), Los Alamos (4%), & UAMPS (4%)
- Plant size decreased from 1,895 MW in 2017 from shutdown of Units 2 & 3 in conjunction with installation of Selective Non-Catalytic Reduction (“SNCR”) equipment and settlement with EPA
- Low cost generator with low NO_x/SO_x/Mercury emissions, but significant CO₂ emissions
- Located at the center of the Southwestern transmission grid, with connections to New Mexico, Arizona, Nevada, California, Utah, and Colorado





Cortez Pipeline and McElmo Creek Pipeline

The Cortez Pipeline and the McElmo Creek Pipeline serve the McElmo Dome and Doe Canyon CO₂ source fields in southwestern Colorado. Kinder Morgan operates the approximately 500 mile Cortez Pipeline which carries CO₂ from the McElmo Dome and Doe Canyon to the Denver City, Texas, hub. The Cortez pipeline system is capable of transporting 1.5 billion cubic feet of CO₂ per day. The McElmo Creek Pipeline is an approximately 40-mile pipeline that supplies the McElmo Creek unit in Utah and is operated by Resolute.



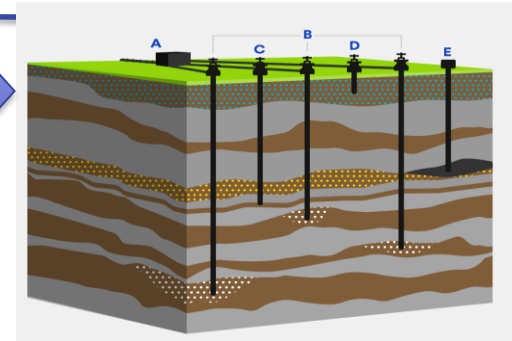
10% of CO2 emissions escape to the atmosphere

638 MW of low emissions power available to back up renewables in region



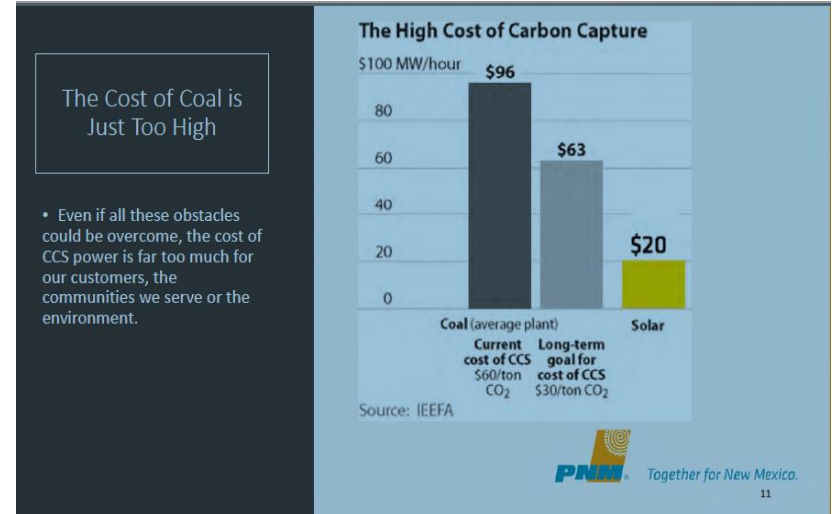
90% of CO2 emissions are captured, transported to depleted oil fields, and then permanently stored deep underground

San Juan Coal Mine



Depleted Oil Field

Misinformation on Carbon Capture Abounds



“They’re using the carbon to release carbon elsewhere” - Sierra Club

“According to many experts, the technology is largely theoretical and often an expensive alternative to cleaner renewable energies like solar and wind”

Amine-based CO₂ removal process has been used since the 1930's to treat natural gas streams. Thousands of Amine units are currently in operation in the US

Applying the Amine process to power plants was developed over ten year period with support from Obama DOE and Canadian Department of Energy

Los Alamos National Laboratory is working on technology evaluation report due December 2019

Track Record

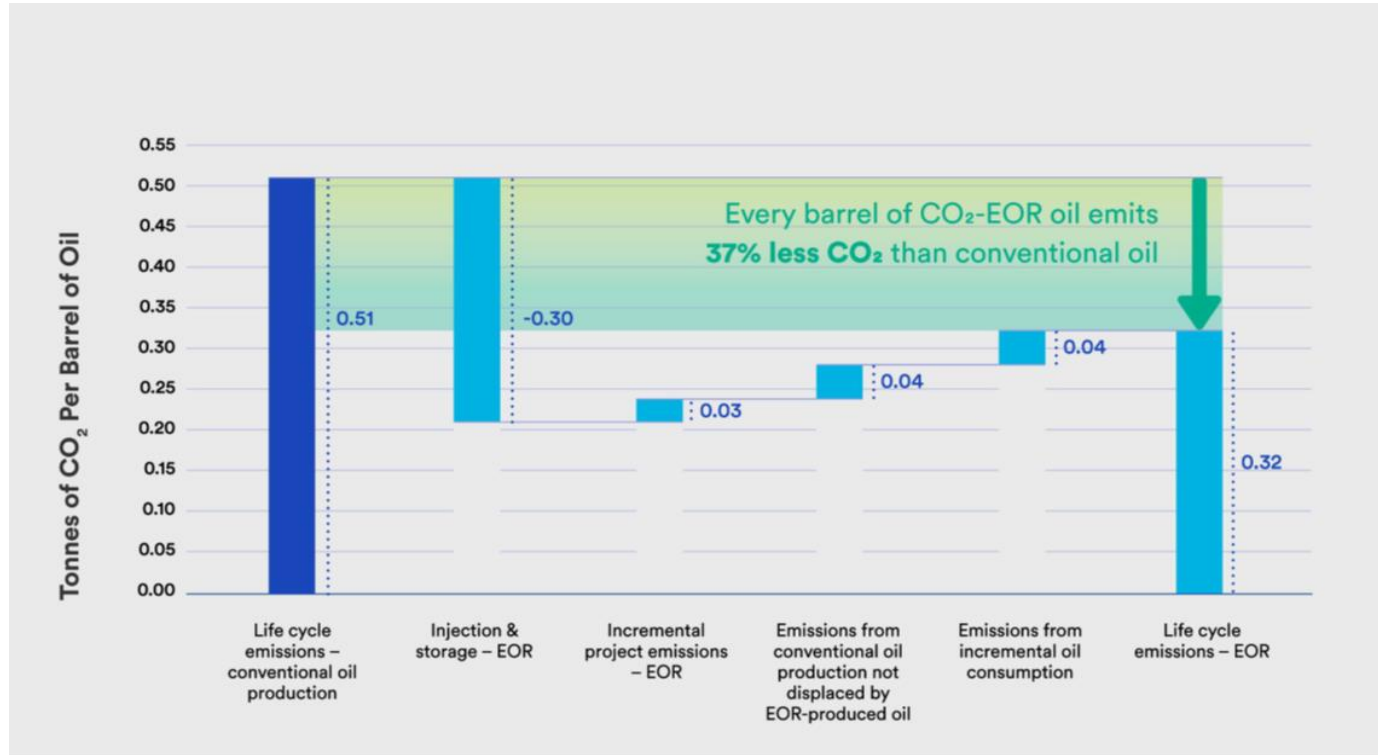
- Petra Nova
 - Retrofit of 240 MW unit in multi-unit coal-fired power plant near Houston
 - Completed December 2016 after 30 month construction period: on time and under budget
 - Capturing 1.4 million metric tons per year with 90% capture rate for over 2 years
 - Technology from Mitsubishi Heavy Industries
- Boundary Dam
 - Retrofit of 110 MW unit in multi-unit coal-fired power plant in Saskatchewan, Canada
 - Currently capturing 2,400 tons per day equivalent to 876,000 metric tons per year
 - Commissioned in October 2014
 - Technology from Cansolv division of Shell
- San Juan Generating Station
 - Retrofit 2 coal-fired units with combined 847 capacity with two 240 MW units and one 360 MW unit.
 - Will Capture 6 million metric tons per year starting in 2023.
 - Currently evaluating technologies



18 large-scale facilities in operation



Clean Air Task Force Study demonstrates EOR from Captured CO2 emits 37% less CO2 than conventional oil



Results of Sargent & Lundy Scoping Study

- S&L scoping study estimates that cost of capture at SJGS will range from \$39.15 to \$43.49 per tonne
- Carbon capture will decrease CO₂ emission intensity from 2,201 lbs/MWh to 249 lbs/MWh
- CO₂ captured will be 6 million tonnes per year which will provide 313 mmscfd of pipeline quality CO₂
- Annual O&M costs, including the allocated cost of 29% plant derating, are estimated at \$16.34 - \$16.65 per tonne

Table ES-1: Cost of CO₂ Capture

Description	Units	85% Capacity Factor	100% Capacity Factor
Total Project Cost	\$	1,295,280,000	1,295,280,000
CCF		0.1243	0.1243
Annualized Capital Cost	\$/yr	161,000,000	161,000,000
Annual O&M Cost	\$/yr	99,939,000	115,389,000
Total Annual Cost	\$/yr	260,939,000	276,389,000
CO ₂ Captured	mmscfd	313	368
Annual CO ₂ Captured	tonnes/yr	6,000,000	7,060,000
Cost of Capture	\$/tonne ¹	43.49	39.15

Note 1. Cost of capture reported as dollars per metric ton (equivalent to 2,240 lbs).

Table 3-3: CO₂ Rates for San Juan Generating Station

SJGS CO ₂ Rates		Unit 1	Unit 4	Total Plant
Baseline Plant CO ₂ Emissions Rate ¹	(lb/MWh _{gross})	2,165	2,236	2,201
Post-Project CO ₂ Emission Rate	(lb/MWh _{gross})	243	254	249
Max Full Load Post-Project CO ₂ Capture Rate	(lb/hr)	703,724	1,071,852	1,775,576
Post-Project CO ₂ Capture Rate ²	(mmscfd)	124	189	313
	(mmscfy)	45,200	68,845	114,045

Note 1. Data from EPA's Air Market Program Database (AMPD) - Annual average for 2014-2018 - Total plant is estimated based on the average of Units 1 and 4.

Note 2. Values calculated assuming an annual average facility capacity factor of 85%.

S&L Study demonstrates financial feasibility

- Project generates \$2.5 billion of 45Q Tax Credits over 12 years which covers estimated capex of \$1.3 billion by almost two times
- Sales of pipeline quality CO2 fully cover the annual operating costs of the CCUS including the cost of power and steam used in the CCUS
- At SJGS, the retrofit with CCUS will be self-financing and will not increase the cost of generation for the power plant
 - The CCUS will provide a captive customer using 29% of output and paying for 29% of generation costs
 - SJGS remains low-cost power generator in Southwest power market

	85% Capacity Utilization
Cost of Capture	\$ 43.39
45Q tax credit in 2026	\$ 35.00
Value of pipeline quality CO2	\$ 17.50
Total Revenue	\$ 52.50
Coverage of cost of capture by revenues	121%

Win, Win, Win

- Win for Climate:
 - Reduces New Mexico emissions by 6 million Metric Tons per year
 - SJGS with CCUS will generate 27% less CO2 Emissions if used as replacement power instead of Solar and Wind backed by a natural gas peaking unit
 - Carbon capture technology, which is generally agreed to be necessary to fight Climate Change, will be advanced through its largest deployment to date at SJGS
- Win for Ratepayers:
 - Removing SJGS from the rate base in conjunction with securitization will reduce the average monthly bills for New Mexico ratepayers
 - Including a 300 MW PPA from SJGS after the retrofit as part of the replacement power plan will increase the cost savings further
- Win for Community:
 - 458 direct jobs, 1,000 non-direct jobs, and about \$8 million in annual local tax revenues are preserved
 - New Mexico becomes a pioneer in Carbon Capture and develops workforce to apply Carbon Capture Technology in other high CO2 emitting regions such as Russia, Indonesia, China, and India

Palo Verde Average price is rising and so is volatility



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