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Comparative Environmental, Economic, and Jobs Impacts in the USA of Renewable Energy Compared to Carbon Capture, Utilization, and Storage

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ABSTRACT

This paper assesses the relative economic and jobs benefits of retrofitting an 847 MW USA coal power plant with carbon capture, utilization, and storage (CCUS) technology compared to replacing the plant with renewable (RE) energy and battery storage. The research had two major objectives: 1) Estimate the relative environmental, economic, and jobs impacts of CCUS retrofit of the coal plant compared to its replacement by the RE scenario; 2) develop metrics that can be used to compare the jobs impacts of coal fueled power plants to those of renewable energy. The hypotheses tested are: 1) The RE option will reduce CO_2 emissions more than the CCUS option. We reject this hypothesis: We found that the CCUS option will reduce CO_2 emissions more than the RE option. 2) The RE option will generate greater economic benefits than the CCUS option. We reject this hypothesis: We found that the CCUS option will create greater economic and jobs benefits than the RE option. 3) The RE option will create more jobs per MW than the CCUS option. We reject this hypothesis: We found that the CCUS option will create more jobs per MW more than the RE option. We discuss the implications of these findings.

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Introduction

In the USA, Public Service of New Mexico (PNM) plans to close the 847 MW coal-fired San Juan Generating Station (SJGS) and San Juan Mine (SJM) in 2022 -- one of the largest underground coal mines in the world. In place of the SJGS, PNM proposes to install 500 MW of photovoltaics (PV), 140 MW of wind, and 410 MW of batteries. However, the San Juan community and developer Enchant Energy plan to retrofit the SJGS with carbon capture, utilization, and storage (CCUS) and keep it and the SJM open [1]. At present, the issue of the continued operation of SJGS and SJM instead of replacement with renewable energy technologies is the subject of intense debate between environmentalists, renewable energy advocates, state and local government officials, and Native Americans – who operate the plant and the mine [2]. The debate centers on the relative merits of CCUS versus the renewable energy option with respect to the impact on carbon dioxide (CO_2) emissions, the economy, and jobs.

This research had two major objectives: 1) Estimate the relative environmental, economic, and jobs impacts of CCUS retrofit of the SJGS compared to its replacement by the PNM renewable energy (RE) scenario; 2) develop metrics that can be used to compare the jobs impacts of coal fueled power plants to those of renewable energy. The hypotheses tested are: 1) The RE option will reduce CO_2 emissions more than the CCUS option; 2) the RE option will generate greater economic benefits than the CCUS option; 3) the RE option will create more jobs per megawatt hour (MW) than the CCUS option.

Materials and Methods

If SJGS, or any other coal power plant, is to continue to operate in New Mexico decades into the future, we must assume that CCUS will necessarily be part of the solution.We thus compared the environmental, economic, and jobs effects of coal/CCUS with those from renewables. Specifically, we analyzed the scenario where SJGS is retrofit with CCUS and compared the impacts of this with those that would result from replacing SJGS with renewables. The renewables alternative adheres as closely as possible to the PNM Integrated Resource Plan (IRP) [3]. This allowed development of generic metrics capable of comparing the economic and job implications of replacing coal power generation utilizing CCUS with those resulting from renewables.

We conducted a case study which utilized the SJGS as a representative coal plant and which models the scenario where it continues to operate beyond 2022 – the date PNM proposes to close the plant. We assumed that all of the captured CO_2 is used for enhanced oil recovery (EOR), which is what Enchant Energy plans [4]. We estimated the likely economic and job impacts of CCUS retrofit of SJGS and compared these to the impacts of the PNM scenario that would close the SJGS and the SJM and provide replacement power with renewables and batteries. The major issue addressed here is the overall net environmental, economic, and job impacts in San Juan County and in New Mexico of installing

CCUS technology on SGJS, especially as they compare to those resulting from the PNM IRP and the renewables/battery storage option.

In conducting the impact assessment, we utilized data from various publicly available sources, including cost estimates for refitting SJGS with CCUS technology; the schedule for refitting SJGS; capital expenditure (CAPEX) and fixed and variable operations and maintenance (O&M) cost data for the coal CCUS retrofits; CO_2 pipeline parameters (distance, CAPEX, fixed and variable O&M cost data, and expenditure schedule); cost estimates for the PNM renewables and batteries proposed; O&M estimates for the PNM renewables and batteries proposed; estimate for the decommissioning of the SJGS; estimates of the severance payments, job training assistance, and San Juan community assistance proposed by PNM; as available, other necessary parameters identified through discussions with U.S. Department of Energy (DOE) staff.

We estimated the likely environmental, economic, and job impacts in San Juan County and in New Mexico of the SGJS CCUS retrofits and the PNM scenario, including: 1) Coal plant retrofits; 2) pipeline-related impacts resulting from the coal CCUS retrofits; 3) retention or closure of the SJGS and SJM; 4) renewable energy and battery impacts. We analyzed the impacts of the scenario where SJGS is retrofit with CCUS and compared the economic and jobs impacts of this with those that would result from replacing SJGS with renewables – as specified in the New Mexico Energy Transition Act (ETA) and the PNM IRP [5].

Results

Environmental Impacts

The New Mexico ETA requires electric generating facilities in the state with an originally installed capacity exceeding 300 MW, to comply with a CO_2 emissions standard requiring emission of under 1,100 lb./MWh by January 1, 2023 [6]. Installation of CCUS at SJGS will decrease CO_2 emissions by at least 90%, or approximately 6 million tons per year. Specifically, CCUS installation at SJGS would limit CO_2 emissions to 243 lb./MWh-gross and 254 lb./MWh-gross for Units 1 and 4 respectively, which is 77% below the emissions standard required by the ETA [7].

As a result of the environmental upgrade completed in 2017, the SJGS is at present fully compliant with all limits required under a 2013 settlement agreement with the New Mexico Environmental Department and the U.S. Environmental Protection Agency (EPA). SJGS had selective noncatalytic reduction (SNCR) technology installed for NOx control on Units 1 and 4. The SNCR was determined to be the Best Available Retrofit Technology (BART) at the time of the settlement agreement. The installation of SNCR on the SJGS brought the plant into compliance with Section 113(g) of the Clean Air Act [8].

The settlement agreement also resulted in a lower SO_2 permitted emission rate for Units 1 and 4 and the retirement of Units 2 and 3 by the end of 2017. With CCUS installed, SJGS will continue to be compliant with the terms of the 2013 settlement agreement. Installation of CCUS will not increase emissions of any controlled pollutants and, in addition to CO_2 reductions, will reduce facility emissions of particulate, SO_2, NOx, ammonia and mercury [9]. The estimated CO_2 emissions reductions from the PNM scenario were obtained from the PNM IRP [10].

Figure1 shows the estimated CO_2 emissions reductions under the CCUS scenario and the PNM scenario. It illustrates that: 1) Under the PNM scenario, CO_2 emissions will be reduced about 65%; 2) under the CCUS scenario, CO_2 emissions will be reduced nearly 89%. Thus, the CCUS scenario reduces CO_2 emissions by about 24% more than does the PNM scenario.

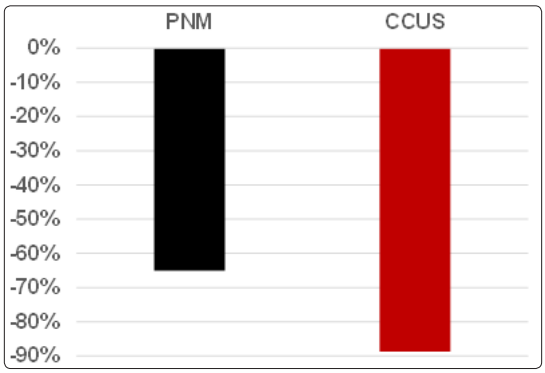

Figure 1: CO_2 Reductions under Each Scenario

Source: Sargent & Lundy and Public Service of New Mexico

Job Impacts

To compare the relative job impacts per MW in the San Juan area and in New Mexico, we utilized employment and demographic data as of January 2020 – prior to the COVID-19 pandemic and its economic consequences [11]. The January 2020 demographic and labor force information for New Mexico and San Juan County is summarized in Table 1 [12]. This table shows that in January 2020 for New Mexico: 1) The population was 2.2 million; 2) the labor force totaled 958,300; 3) employment totaled about 910,000; 4) unemployment totaled about 48,000; 5) The unemployment rate was 5.0%. It shows that in January 2020 for San Juan County: 1) The population was 124,000; 2) the labor force totaled 52,500; 3) employment totaled about 48,300; 4) unemployment totaled about 3,200; 5) The unemployment rate was 6.2%.

Table 1: Basic Demographic and Labor Force Estimates for San Juan County and New Mexico as of January 2020

	Population	Labor Force	Employed	Unemployed	Unemployment Rate
San Juan County	123,958	52,455	48,262	3,193	6.2%
New Mexico	New Mexico	958,293	910,393	47,900	5.0%

Source: New Mexico Department of Workforce Solutions

We estimated the total (direct, indirect, and induced) jobs created by the CCUS retrofits and related expenditures [13]: 1) Direct jobs are those created directly in the specific activity or process; 2) indirect jobs are those created throughout the required interindustry supply chain; 3) induced jobs are those created in supporting or peripheral activities; 4) total jobs are the sum or all of the jobs created; 5) For simplicity, we include induced jobs in the indirect category. The total (direct, indirect, and induced) jobs concept is the accepted methodology widely used in studies of this nature and in the peer-reviewed literature.

The job impacts under the CCUS scenario derive from: 1) CCUS Construction; 2) CCUS plant O&M; 3) pipeline construction; 4) pipeline O&M; 5) continued operation of the SJGS and the SJM [14]. The PNM scenario consists of: 1) 500 MW of solar; 2) 140 MW of wind; 3) 410 MW of batteries; 4) no natural gas or other fossil fuels; 5) Closure of the SJGS and the SJM in

2022; 6) The provision by PNM of approximately $41 million in payments for severance, job training, and community assistance. The job impacts from the PNM scenario derive from: 1) PV plant construction; 2) PV plant O&M; 3) Wind turbine plant construction; 4) Wind turbine plant O&M; 5) Battery storage construction; 6) Batter storage O&M; 7) continued operation of the SJGS and the SJM through 2022; 8) decommissioning of the SJGS [15].

We found that the CCUS scenario avoids economic harm and job losses to the San Juan area and New Mexico and creates large numbers of jobs. Figure 2 shows that the CCUS scenario creates significantly more jobs than the PNM scenario. In San Juan County: The CCUS Scenario creates 26 times as many construction jobs; the CCUS Scenario creates 92 times as many O&M jobs; the CCUS Scenario creates 17 times as SJGS and SJM jobs [16]. In New Mexico, compared to the PNM scenario: The CCUS Scenario creates about the same number of construction jobs; the CCUS Scenario creates four times as many O&M jobs; the CCUS Scenario creates more than 16 times as many SJGS & SJM jobs. Over the long term, the CCUS scenario would ensure full employment in San Juan County whereas the PNM scenario would result in over 12% unemployment in the county.

Figure 3 shows that similar results hold true for the impacts in New Mexico: In 2021-2023, the CCUS scenario creates annually in New Mexico, on average, 814 more jobs than the PNM scenario – more than 20% more jobs each year; in 2024 and 2025, the CCUS scenario creates on average, 3,500 more jobs as the PNM scenario – 10 times as many jobs each year; in years 2026 - 2055, the CCUS scenario creates annually in New Mexico, on average, 3,600 more jobs as the PNM scenario – 14 times as many jobs each year [17].

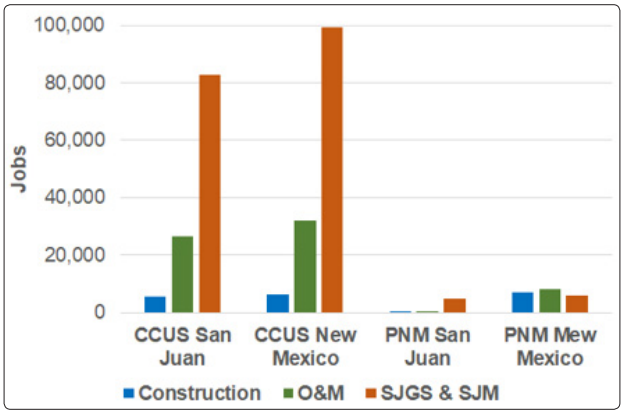

Figure 2: Total Jobs Created by the Two Scenarios, 2021-2055

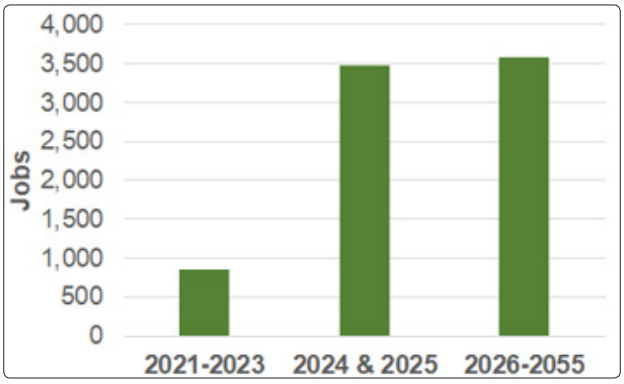

Figure 3: Net Difference in Jobs Created Annually in New Mexico by the CCUS Scenario Compared to the PNM Scenario
Source: Management Information Services, Inc.

Tax Revenue Impacts

The SJGS and the SJM are major tax generating facilities for the local San Juan area. The facilities provide substantial property taxes to local jurisdictions, including San Juan County, the Central Consolidated School District (CCSD), and the San Juan Community College (SJCC) – nearly $7 million annually to those three institutions alone. At least as significant, they provide thousands of well-paying direct and indirect jobs that generate substantial local tax revenues. Similarly, substantial local tax revenues will be generated by the CCUS retrofit construction and continuing O&M. Nevertheless, the most important contribution of the CCUS scenario to local tax revenues is the continued operation of the SJGS and the SJM.

The PNM scenario will also create local tax revenues via the construction and O&M of the renewables and batteries installed locally: 1) 14 MW of batteries; 2) 13 MW of wind; 3) 13 MW of central station PV [18]. As noted, we also assumed that all of approximately $41 million in payments for severance, job training, and community assistance under the PNM scenario would accrue to the local San Juan area. Nevertheless, the San Juan area local tax revenues would be much less under the PNM scenario than under the CCUS scenario, for three major reasons. First, the local installation of 40 MW of RE and batteries would represent only a small fraction of the assessed value of the CCUS retrofit facilities. Second, the number of local San Juan jobs under the PNM scenario would be only a small fraction of those generated under the CCUS scenario. Third, and most important, under the PNM scenario the SJGS and SJM would be closed, whereas under the CCUS scenario they would remain open – generating substantial direct and indirect local tax revenues.

The value of the new RE and CCUS facilities will be subject to property tax by San Juan County, the CCSD, and SJCC, and other local jurisdictions. Under New Mexico law, the taxable value of a property is equal to 33.33% of its assessed value [19]. In 2018, the San Juan County assessor estimated the taxable values of the SJGS and the SJM at $349.4 million and $25.2 million respectively, for a combined taxable value of $374.6 million [19]. San Juan County's total combined property tax rate is $24.28 per $1,000 taxable value -- 24.28 mils. MISI assumed that this tax rate would be applied to the new facilities constructed under the PNM scenario and the CCUS scenario [21].

Direct and indirect local tax impacts will accrue during construction of the facilities under each scenario and annually thereafter during O&M. Direct and indirect local tax revenue impacts will be generated, and these include gross receipts, personal income, and property taxes paid by supply chain businesses, construction workers, O&M workers, contractors, employees of supply chain businesses, and workers in local induced company operations.

The two scenarios will have very different impacts on local San Juan area tax revenues. The major differences result from: 1) The fate of the SJGS and the SJM and the tax revenues from these facilities; 2) the total tax revenues generated by the jobs created – and the tax revenues lost when jobs are lost; 3) the property tax revenues generated by the San Juan CCUS facilities and the San Juan renewable energy facilities; 4) the tax revenues and equivalent payments generated by the combined severance, job training, and community assistance funds provided under the PNM scenario -- $40.6 million.

During the construction phase for the CCUS and the RE facilities, 2021-2023, tax revenues are generated in the CCUS scenario

by the SJGS and SJM jobs, the CCUS construction jobs, and the tax revenues created by the operation of SJGS and SJM. During the construction phase for the RE facilities, 2021-2023, tax revenues are generated in the PNM scenario by the SJGS and SJM jobs through 2022, the RE and battery construction jobs, the decommissioning of SJGS beginning in 2023, and the tax revenues created by the continued operation of SJGS and SJM in 2021 and 2022.

In the years 2024 and 2025, the construction of all facilities has been completed. Tax revenues are generated in the CCUS scenario by the SJGS and SJM jobs, the CCUS O&M jobs, and the tax revenues created by the continued operation of SJGS, SJM, and CCUS retrofit facilities. In these two years, the tax revenues in the PNM scenario are generated by the tax revenues created by the operation of the RE and battery facilities, the RE and battery O&M jobs, the decommissioning of SJGS, and the tax revenues and equivalent payments created by the combined severance, job training, and community assistance funds provided under the PNM scenario.

In the years 2026 - 2055, tax revenues are generated in the CCUS scenario by the SJGS and SJM jobs, the CCUS O&M jobs, and the tax revenues created by the continued operation of the SJGS, the SJM, and the CCUS retrofit facilities. In these years, the tax revenues in the PNM scenario are generated by the tax revenues created by the operation of the RE and battery facilities.

The two scenarios have very different impacts on San Juan area tax revenues - Figure 4. 1) Over 2021-2055, the CCUS scenario generates $1.33 billion in total local tax revenues compared to $160 million under the PNM scenario; 2) Over 2021-2055, the CCUS scenario generates $1.17 billion more in local tax revenues than the PNM scenario-more than eight times as much.

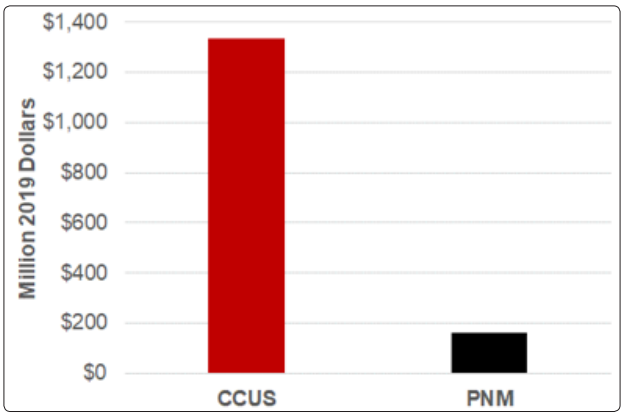

Figure 4: Total San Juan Tax Revenues, 2021-2055, Generated by Each Scenario
Source: Management Information Services, Inc.

The CCUS scenario will greatly improve the local San Juan fiscal situation. Since the SJGS and the SJM will not be prematurely retired, they will continue to generate real estate tax revenues and the jobs at the facilities will continue to generate local tax revenues. Under the PNM scenario this would not be the case. Further, the CCUS scenario will also increase San Juan tax revenues: 1) The SJGS and SJM jobs will be maintained and additional CCUS O&M jobs will be created; 2) not only will the SJGS continue in operation, but its assessed valuation will increase substantially.

The CCUS scenario will greatly benefit local schools – Figure 5 and 6. The differing impacts of the two scenarios on the tax revenues for San Juan County, the Central Consolidated School District (CCSD), and the San Juan Community College (SJCC) are shown in these figures [22]. 1) During years 2021-2023 of facilities' construction, the CCUS scenario contributes 28% of all tax revenues to the three jurisdictions and the PNM scenario contributes 13%; 2) In 2024 and 2025, when under the PNM scenario SJGS decommissioning is still occurring and severance, job training, and community assistance payments are being made, the PNM scenario contributes 5% of all tax revenues to the three jurisdictions and the CCUS scenario contributes 14%; 3) During years 2026-2055, the CCUS scenario contributes 14% of all tax revenues and the PNM scenario contributes less than 0.5%; 4) long term, the CCUS scenario would annually generate a substantial portion of the tax revenues of San Juan County, the CCSD, and the SJCC, whereas the PNM scenario would generate only a trivial share of the tax revenues; 5) long term, under the PNM scenario the three jurisdictions would have to raise, each year, an additional $35 - $40 million in tax revenues from other sources; 6) long term, under the PNM scenario, jurisdictions would have to raise a total of an additional $1.1 billion - $1.2 billion in tax revenues.

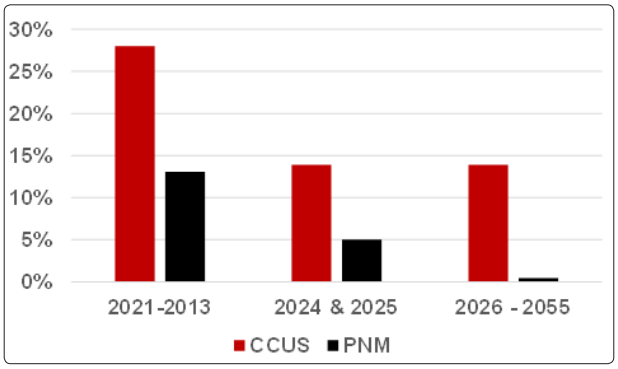

Figure 5: Impacts of the CCUS Scenario and the PNM Scenario on the Total Tax Revenues from All Sources of San Juan County, the CCSD, and the SJCC
Source: Management Information Services, Inc.

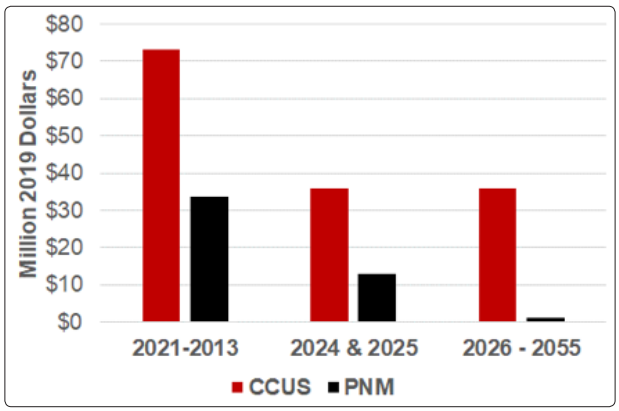

Figure 6: Average Annual San Juan Area Tax Revenue Impacts
Source: Management Information Services, Inc

The increased economic activity and jobs in the San Juan local community under the CCUS scenario will create increased earnings and tax revenues: 1) During the construction phase for the CCUS and the RE facilities, 2021-2023, the CCUS scenario generates over $73 million/yr. in local tax revenues and the PNM scenario generates less than $34 million/yr. Thus, in 2021-2023, the CCUS scenario generates each year more than twice the local tax revenues as does the PNM scenario. 2) In 2024 and 2025, the CCUS scenario generates $36 million/yr. in local tax revenues and the PNM scenario generates $13 million/yr. Thus, in 2024 and

2025, the CCUS scenario generates each year triple the local tax revenues as does the PNM scenario. 3) In 2026- 2055, the CCUS scenario generates $36 million/yr. in local tax revenues and the PNM scenario generates $1.1 million/yr. Thus, in 2026-2055, the CCUS scenario generates each year 33 times more in local tax revenues as does the PNM scenario.

Jobs Metrics

The CCUS scenario results in substantially more jobs/MW than the PNM scenario. Figure 7 summarizes the differences in jobs created/MW over 2021-2055 by the two scenarios. In terms of total jobs/MW over this period: 1) in San Juan, the CCUS scenario generates over 135 jobs/MW whereas the PNM scenario generates 5.2 jobs/MW – a 26-fold difference; 2) in New Mexico, the CCUS scenario generates over 162 jobs/MW whereas the PNM scenario generates 20 jobs/MW – an 8-fold difference. In terms of total jobs per MW over this period, excluding jobs from the SJGS and SJM: 1) In San Juan, the CCUS scenario generates 38 jobs/MW whereas the PNM scenario generates 0.48 jobs/MW – a 79X difference; 2) in New Mexico, the CCUS scenario generates 70.6 jobs/MW whereas the PNM scenario generates 10 jobs/MW – a 7-fold difference.

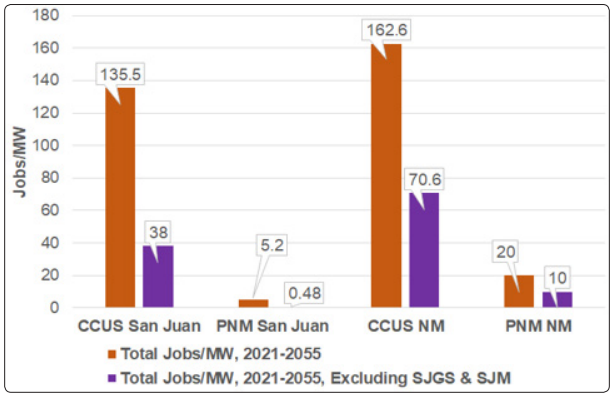

Figure 7: Comparison of Total Jobs per MW, 2021-2055
Source: Management Information Services, Inc.

Figure 8 shows the differences in jobs/MW over 2021-2055 under the CCUS scenario and the PV portion of the PNM scenario: 1) In San Juan, the CCUS scenario generates over 135 jobs/MW whereas the PV portion of the PNM scenario generates 11.1 jobs/MW – a more than 12-fold difference; 2) in New Mexico, the CCUS scenario generates over 162 jobs/MW whereas the PV portion of the PNM scenario generates 18.4 jobs/MW – a 9-fold difference.

Figure 9 shows the differences in jobs/MW over 2021-2055 under the CCUS scenario and the wind portion of the PNM scenario: 1) In San Juan, the CCUS scenario generates over 135 jobs/MW whereas the wind portion of the PNM scenario generates 13.5 jobs/MW – a 10-fold difference; 2) in New Mexico, the CCUS scenario generates over 162 jobs/MW whereas the wind portion of the PNM scenario generates 16.5 jobs/MW – nearly a 10-fold difference.

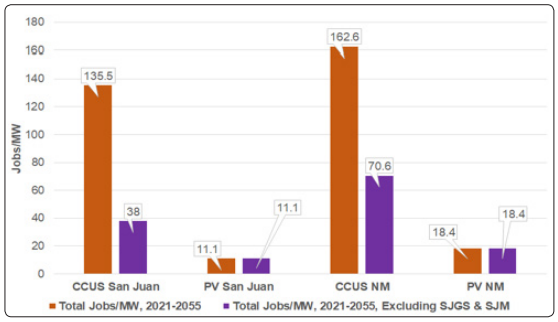

Figure 8: Comparison of Total Jobs per MW under the CCUS Scenario and the Photovoltaics Portion of the PNM Scenario, 2021-2055
Source: Management Information Services, Inc.

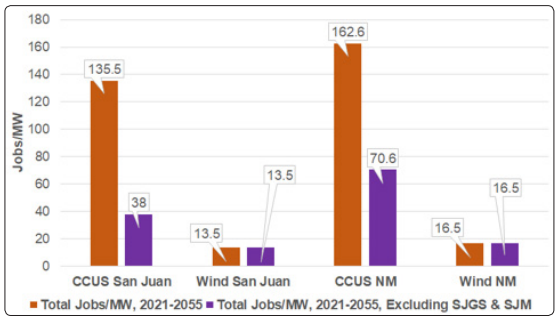

Figure 9: Comparison of Total Jobs per MW under the CCUS Scenario and the Wind Portion of the PNM Scenario, 2021-2055
Source: Management Information Services, Inc.

In terms of total jobs/MW over this period, excluding jobs from the SJGS and the SJM: 1) In San Juan, the CCUS scenario generates 38 jobs/MW whereas the wind portion of the PNM scenario generates 13.5 jobs/MW; in New Mexico, the CCUS scenario generates 70.6 jobs/MW whereas the wind portion of the PNM scenario generates 16.5 jobs/MW.

Figure 10 shows the differences in jobs/MW over 2021-2055 under the CCUS scenario and the batteries portion of the PNM scenario: 1) In San Juan, the CCUS scenario generates over 135 jobs/MW whereas the batteries portion of the PNM scenario generates 8.6 jobs/MW – a 16-fold difference; 2) in New Mexico, the CCUS scenario generates 162 jobs/MW whereas the batteries portion of the PNM scenario generates 8.9 jobs/MW – an 18-fold difference. In terms of total jobs/MW over this period, excluding jobs from the SJGS and the SJM: 1) In San Juan, the CCUS scenario generates 38 jobs/MW whereas the batteries portion of the PNM scenario generates 8.6 jobs/MW;2) in New Mexico, the CCUS scenario generates 70.6 jobs/MW whereas the batteries portion of the PNM scenario generates 8.9 jobs/MW – an 8-fold difference.

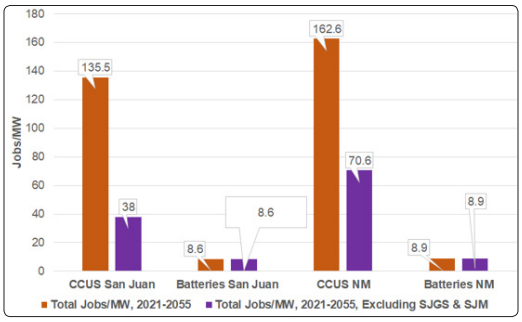

Figure 10: Comparison of Total Jobs per MW under the CCUS Scenario and the Batteries Portion of the PNM Scenario, 2021-2055
Source: Management Information Services, Inc.

Figure 11 presents a summary comparison of jobs/MW in New Mexico under the CCUS scenario and the wind, photovoltaic, and batteries portions of the PNM scenario. In terms of total jobs/MW in New Mexico, 2021-2055, the CCUS scenario generates: 1) Nearly nine times as many jobs/MW as the photovoltaics portion of the PNM scenario; 2) nearly 10 times as many jobs/MW as the wind portion of the PNM scenario; 3) more than 19 times as many jobs/MW as the batteries portion of the PNM scenario. Figure EX-11 shows that in terms of total jobs/MW, 2021-2055, excluding jobs from SJGS and SJM, the CCUS scenario generates: 1) Nearly four times as many jobs/MW as the photovoltaics portion of the PNM scenario; 2) more than four times as many jobs/MW as the wind portion of the PNM scenario; 3) more than eight times as many jobs/MW as the batteries portion of the PNM scenario. Figure EX-11 shows that in terms of total jobs/MW generated by construction in 2023 – the year of maximum construction, the CCUS scenario generates: 1) 7% more jobs/MW as the PV portion of the PNM scenario; 2) more than twice as many jobs/MW as the wind portion of the PNM scenario; 3) nearly twice as many jobs/MW as the batteries portion of the PNM scenario. Figure 11 shows that in terms of O&M jobs/MW over 2024-2055, the CCUS scenario generates: 1) four times as many jobs/MW as the PV portion of the PNM scenario; 2) more than three times as many jobs/MW as the wind portion of the PNM scenario; 3) more than 10 times as many jobs as/MW the batteries portion of the PNM scenario.

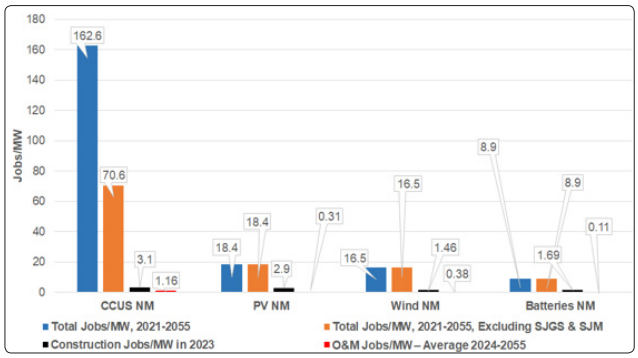

Figure 11: Comparison of Jobs per MW in New Mexico under the CCUS Scenario and the Wind, Photovoltaic, and Batteries Portions of the PNM Scenario

Source: Management Information Services, Inc.

Conclusions

The basic conclusion derived here is that the CCUS retrofit scenario is greatly preferable to the PNM RE scenario: 1) It provides much greater economic and jobs benefits for San Juan and for New Mexico; 2) it produces greater CO2 emissions reductions than the PNM scenario; 3) It preserves and expands San Juan tax revenues; 4) it represents the difference in San Juan between full employment and double-digit unemployment; 5) on the basis of every job metric, including total jobs/MW, construction jobs/MW, and O&M jobs/MW, the CCUS scenario generates many more jobs per MW than the PNM scenario -- in both San Juan and in New Mexico.

We thus conclude that, irrespective of the comparison, the CCUS scenario generates substantially more jobs/MW than does the PNM option or any of the RE components of the PNM option – both in San Juan and in New Mexico. There is no appropriate comparison in which the PNM scenario, or any of its RE components, generates more jobs/MW than does the CCUS scenario – in either San Juan or in New Mexico. This holds true whether we are measuring the jobs/MW created by each scenario, by each scenario excluding the jobs impacts of SJGS and SJM, the construction portions of the scenarios, or the O&M portions of the scenarios. Specifically, here we derived 68 individual comparisons. In two of these cases, the jobs/MW advantage of the CCUS option was between 4% and 7%. In all of the other 66 comparison cases the jobs/MW advantages of the CCUS option were huge – often orders of magnitude. Thus, the CCUS scenario will generate many more jobs/MW than the PNM scenario or the RE components of the PNM scenario – both in local San Juan and New Mexico.

The hypotheses tested are: 1) The RE option will reduce CO2 emissions more than the CCUS option. We reject this hypothesis: We found that the CCUS option will reduce CO2 emissions more than the RE option. 2) The RE option will generate greater economic benefits than the CCUS option. We reject this hypothesis: We found that the CCUS option will create greater economic and jobs benefits than the RE option. 3) The RE option will create more jobs per MW than the CCUS option. We reject this hypothesis: We found that the CCUS option will create more jobs per MW more than the RE option.

If the SJGS closes, the implications for the San Juan area are ominous: Its historically stable source of well-paying jobs and revenues will disappear. Thus, CCUS may be the key to San Juan's and New Mexico's future and can be a win-win [23]. This research has documented the immense long term economic and job benefits that CCUS retrofits of the SJGS will have for the state and for local communities. The SJGS CCUS retrofit will establish San Juan and New Mexico as a world leader in the technology. This will pay large and increasing dividends to the San Juan area and to the state as CCUS becomes established as one of the dominant energy technologies of the 21st century.

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Author's Contributions

The author is responsible for the preparation, development and publication of this manuscript.

Ethics

The author anticipates no ethical issues that may arise after the publication of this manuscript.

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14. We estimated the number of jobs that would be created by the CCUS retrofit program using national industry jobs estimates available from the federal government and other sources, and estimates of jobs impacts available from analytical studies of the employment effects of power plant expenditures. The methodology is detailed in Management Information Services, Inc., "Use of the San Juan Generating Station to Develop Metrics to Compare Coal Fueled Power Plant Jobs Impacts to Those of Renewables," prepared for the U.S. Department of Energy, September 2020; http://misi-net.com/publications.html.
15. The job impacts and jobs potential of renewable energy systems have been the subject of extensive research over the past two decades, and MISI relied on this body of research to develop the jobs estimates reported here. The methodology is detailed in Management Information Services, Inc., "Use of the San Juan Generating Station to Develop Metrics to Compare Coal Fueled Power Plant Jobs Impacts to Those of Renewables," prepared for the U.S. Department of Energy, September 2020; http://misi-net.com/publications.html.
16. SJGS decommissioning jobs were included in the PNM total.
17. We assumed that all of the RE jobs created at the state level would be in New Mexico.
18. https://www.pnmforwardtogether.com/irp.
19. https://www.nmlegis.gov/handouts/RSTP%20092619%20Item%203%20O'Neill%20Prop%20Tax%20Summary%20History.pdf.
20. San Juan County Assessor, https://www.sjcassessor.net
21. San Juan County also levies a county local option of 0.014375 on transactions occurring in unincorporated areas. See O'Donnell, op. cit.
22. Based on the total estimated 2018 tax revenues for the three jurisdictions.
23. The UN has concluded that ambitious GHG reduction goals are simply not feasible without massive CCUS initiatives. "If the world is to succeed in constraining CO2 emissions to levels consistent with a less than 2°C rise in global temperatures, then Carbon Capture and Storage (CCS) will need to contribute about one-sixth of needed CO2 emission reductions in 2050, and 14 percent of the cumulative emissions reductions between 2015 and 2050." United Nations Commission for Europe, "Carbon Capture and Storage: A Technological Challenge Already Solved," 2020. Even advocates of the USA Green New Deal have acknowledged the necessity for CCUS as a large part of the program: "When Representative Alexandria Ocasio-Cortez (D-NY) and Senator Ed Markey (D-MA) introduced a resolution for a Green New Deal in February this year, both lawmakers left nuclear energy and carbon capture on the table." https://www.theverge.com/2019/8/22/20828794/bernie-sanders-green-new-deal-2020-elections-climate-change. Further, CCUS enjoys strong bipartisan in the USA: For example, in the U.S. Congress, at the FY20 DOE Budget Hearing, Representative Greg Walden stated "I am encouraged by the work DOE is doing to support transformative breakthroughs in 'carbon free' fossil energy and carbon capture technologies." Opening Statement of Republican Leader Greg Walden, Subcommittee on Energy "The Fiscal Year 2020 DOE Budget," May 9, 2019. Further, President-elect Joe Biden is on record as supporting CCUS; see Adam Aton, "Climate Heresy in Wis. as Democrats Call For 'Clean Coal,'" E&E News, September 10, 2020.