ECONOMIC IMPACT ASSESSMENT OF CCS RETROFIT OF THE COMANCHE GENERATING STATION

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For
The U.S. Department of Energy
Office of Fossil Energy

June 2019

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EXECUTIVE SUMMARY

This report is a summary of analysis accomplished in Phase 2 of a techno-economic analysis of integrating carbon capture, utilization, and storage (CCUS) technologies into a coal-fired power plant. Phase 1 investigated potential areas where there would be a market for carbon dioxide (CO_2) to support the application of CCUS. This preliminary analysis identified Colorado as an ideal location because it currently has existing natural CO_2 resources as well as pipeline infrastructure that is used to transport CO_2 to the Permian Basin for use in enhance oil recovery (EOR). The study also noted that the Comanche Generating Station would be an ideal case study since it is the coal-fired power plant that is closest to a major CO_2 pipeline, the Sheep Mountain Pipeline, which originates at the Sheep Mountain natural CO_2 source field in Colorado.

This report presents a techno-economic case study of adding CCUS to the Comanche Generating Station as a representative coal plant. Xcel Energy owns and operates the Comanche Generating Station but was not consulted or directly involved in this study. It is important to acknowledge at the outset of this study that Xcel had previously announced that two of the units at the Comanche Generating Station would be retired early.

Xcel Energy has developed the "Colorado Energy Plan" (CEP) portfolio, which is an electricity generating portfolio as part of the company's 2016 Electric Resource Plan. Among the major components of the CEP are the proposed early retirement of 660 MW of two coal-fired generation units at the Comanche Generating Station: Unit 1 by the end of 2022, and Unit 2 no later than the end of 2025. Under the proposal, Unit 3 would remain in service. Xcel's CEP portfolio was approved by the Colorado Public Utility Commission (CPUC) in 2018.

This report was developed based on publicly available information, to identify whether there was a business case for adding CCUS to existing coal plants in Colorado, using the Comanche Generating Station as a representative plant, and what the costs and benefits under the best business case scenario would be. This report examines the hypothetical scenario where all three of the Comanche Generating Station coal units would continue to operate after being retrofitted with carbon capture. In this scenario, the CO_2 captured from these units would be used for EOR in the Permian Basin.

Additionally, the work performed in this report compares the likely economic and job impacts of CCUS retrofits of the three units of the Comanche Generating Station, compared to the CEP, and a business as usual (BAU) scenario.

Table EX 1: Summary of the Three Electricity Options for Colorado

	BAU	CEP	CCUS
Coal Retirements	2033/2035	2022/2025	Not Retired
Resource Acquisition Period (RAP) Resource Need (MW) (by 2023)	450	775	450
Wind Additions (MW)	789 MW	1,131 MW	0
Solar Additions (MW)	322 MW	707 MW	0
Battery Storage (MW)	50 MW	275 MW	0
Generation Investment ($M)	$1,460	$2,550	$3,738
Transmission Investment ($M)	$175	$204	-
Total Investment ($M, nominal)	$1,636	$2,754	$3,738
Reduction in CO_2 Emissions in 23 Years (2020-2042) relative to Fleet-Wide 2005 Emissions	45%	52%	65%

Three scenarios were evaluated for this study:

Business as Usual (BAU): This scenario retains all coal-fired units at the Comanche Generating Station till their original retirement dates and adds new wind and solar power generation, existing gas generation, and some battery storage,

CEP: This scenario mandates early retirement of Comanche Units 1 and 2 and adds more wind, solar, existing gas generation, and significantly more battery storage,

Carbon Capture Retrofit Option (CCUS): All three units at the Comanche Generating Station continue operation after CO_2 capture retrofits, there is no new wind, solar generation, or battery storage. Management Information Services Inc. (MISI) conducted simulations of the impacts of the CCUS Retrofit Option and examined the results of the analysis of the CEP and BAU impacts conducted for Xcel by the University of Colorado (UOC).

Table EX 1 provides an overview of the total investment and CO_2 reductions in the three options. The techno-economic analysis of retrofitting units 1 to 3 with carbon capture demonstrates that the project can be funded with the revenues generated by the sale of CO_2 and monetization of the 45Q tax credit. The impact of the 45Q tax credit on the price of CO_2 is demonstrated by the increase of the CO_2 sales price for the period of 12-years.

MISI compared the estimated impacts of the CCUS Retrofit Option to those estimated for the CEP. A summary of some of the major differences in impacts estimated for the CCUS Retrofit Option compared to estimates for the CEP are given in Figure EX 1.

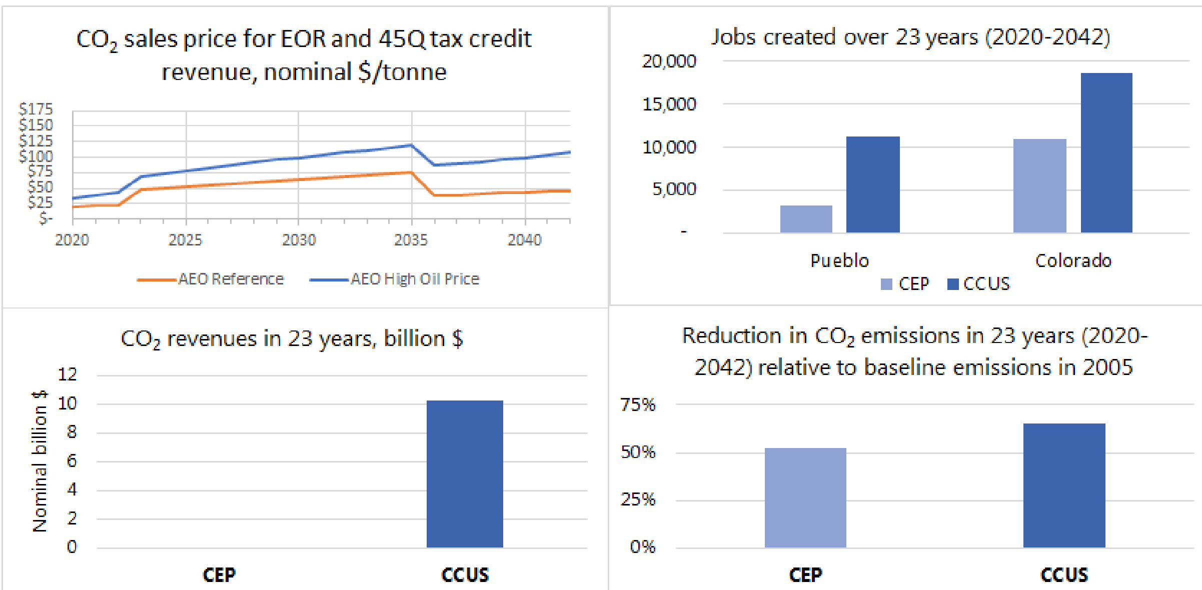

Figure EX 1: Summary of the Impacts of the CCUS Retrofit Option compared to the CEP

Source: Management Information Services, Inc., Xcel Energy, University of Colorado, and Leonardo Technologies, Inc.

The techno-economic analysis also shows that the two units slated for retirement can achieve a combined cost of electricity of $17.4/MWh (2017$). The combined cost of electricity is lower than the $18.3/MWh (2017$) estimated cost of electricity for the wind + storage combination option. When considering the retrofit of all three units the estimated cost of electricity rises to $19.7/MWh (2017$). The higher cost for all three units is largely due to the consideration of replacement makeup power to counteract carbon capture parasitic losses in Unit 3. The estimated cost of electricity for all three units is higher than the CEP wind + storage option but still lower than other CEP alternatives. This paper contains further discussion of the economic theory behind the replacement power cost.

The impacts of the CCUS retrofit option and the CEP option were evaluated over 23 years, from 2020 to 2042[1]. Compared to the CEP, the CCUS option:

- Reduces CO_2 emissions by 460 million metric tonnes [MMT], relative to baseline 2005 emission levels (65% reduction over 23 years). The CEP reduces CO_2 emissions by 369 MMT (52% reduction over 23 years),
- Generates $10.21 billion in CO_2 revenues,
- Creates 11,200, in Pueblo, the CEP creates 3,100 jobs in Pueblo,
- Creates 18,600 jobs in Colorado; the CEP creates 13,300 job in Colorado.

In addition, from 2020 to 2042, the CCUS retrofit option:

- Increases Pueblo wage and salary earnings by over $500 million,
- Increases Colorado wage and salary earnings by more than $900 million,
- Increases Colorado income tax revenues by over $40 million,
- Increases Pueblo real estate tax revenues by nearly 60% -- by more than $800 million,
- Transforms the Pueblo School District from a relatively poor one to one of Colorado's wealthiest.

The analysis demonstrates the CCUS retrofit option:

- Delivers lower-cost power for Xcel customers,
- Takes advantage of 45Q tax incentives,
- Accelerates the transformation to a low-carbon economy,
- Generates significant economic development in Pueblo and Colorado,
- Provides significant CO_2 reductions, and,
- Continues progress Colorado has made on cleaner air and reduces its carbon footprint.

The CCUS Retrofit Option would benefit Pueblo, the State of Colorado, and Colorado ratepayers. This report demonstrates a highly favorable business opportunity that supports further investigation of the potential for integration of CCUS technology.

1 Introduction

This report is a summary of analysis accomplished in Phase 2 of a techno-economic analysis of integrating CCUS technologies into a coal-fired power plant. Phase 1 investigated potential areas within the United States where there would be a market for carbon dioxide (CO_2) to support the application of CCUS. This preliminary analysis identified Colorado as an ideal location as it currently has existing natural CO_2 resources as well as pipeline infrastructure that transports CO_2 to the Permian Basin for use in enhance oil recovery (EOR). The study also noted that the Comanche Generating Station would be an ideal case study as it is the coal fired power plant that is closest to a trunk line, the Sheep Mountain Pipeline in Colorado. This report presents a techno-economic case study of adding CCUS to the Comanche Generating Station as a representative coal plant.

Xcel Energy is the major electricity provider in Colorado and its Comanche Generating Station in Pueblo, Colorado is a coal plant that is the largest power plant in the State. It is located near the EVRAZ Steel Mill, which is the single largest commercial account for Xcel in Colorado.[2] The Comanche Generating Station has steam-driven turbine-generators and utilizes low-sulfur coal from the Powder River Basin. The Station has a power production capability of 1,410 MW and consists of:[3]

- Unit 1: 325 MW, which initiated commercial operation in 1973.
- Unit 2: 335 MW, which initiated commercial operation in 1975.
- Unit 3: 750 MW, which initiated commercial operation in 2010.

The Comanche Generating Station controls air emissions with multiple technologies. Baghouses on all three units remove more than 99% of particulate emissions from the flue gas. All units have low-nitrogen oxides (NO_X) burners to control NO_X, and lime-spray dryers to control sulfur dioxide (SO_2) emissions. Activated carbon injection is used to control mercury emissions on all three units, and Comanche Generating Station is the first plant in Colorado to control mercury emissions.[4]

In August 2017, Xcel Energy filed a stipulation with a coalition of 14 groups requesting the CPUC to approve a process that could lead to $2.5 billion in clean energy investments in rural Colorado.[5] The "CEP" portfolio proposed an electricity generating portfolio to augment the company's 2016 Electric Resource Plan. Among the major components of the CEP are the proposed early retirement of 660 MW of two coal-fired generation units at the Comanche Generating Station: Unit 1 by the end of 2022 and Unit 2 no later than the end of 2025. Under the proposal, Unit 3 would remain in service.[6]

More recently, Xcel has emphasized the potential role of CCUS for the Comanche Generating Station and stated that it is reluctant to retire any of its assets prematurely.[7] Xcel emphasized that it is committed to explore technology such as fossil-fuel power with carbon sequestration, which offers the benefits of fossil fuel-based energy without the emissions.[8] Studies have assessed the economic and technological viability of CCUS technology and have confirmed that there is sufficient capacity to sequester carbon emissions.[9] When Comanche 3 went online in 2010, it had been designed to be adaptable to CCUS.[10]

Xcel has invested $200 million in emissions control equipment to reduce sulfur, mercury, and NO_x emissions from Comanche Units 1 and 2.[11] Notably, Xcel has justified the expense by asserting that the investment would provide clean air for several decades. Comanche Units 1 and 2 have recently been upgraded with sophisticated pollution-control equipment that has resulted in their emissions rates being below those of the remaining coal fleet. SO_2 emissions are 12% lower at Unit 1 and 15% lower at Unit 2 compared to the remaining coal fleet. Similarly, NO_x emissions are 33% lower at Unit 1 and 7% lower at Unit 2 when compared to the remaining coal fleet.[12]

The retirement of Comanche Units 1 & 2 will cause significant impacts on the local community. The retirement of Units 1 and 2, as contemplated by the CEP, would result in the loss of about 80 jobs, slightly less than half of the plant's current employment of about 170. Comanche employees can earn up to $100,000 a year, whereas the average Pueblo-area salary is about $44,000[13], about $10,000 less than the average salary in Colorado.[14]

This report presents a financial case study for Colorado which utilizes the Comanche Generating Station as a representative coal plant and models the scenario where all three power generating units are retrofitted with CCUS and continue to operate. The report also assessed the likely net economic and job impacts of CCUS retrofit of the three units of the Comanche Generating Station compared to the CEP and to a BAU scenario.

1 Scenario Description

Three scenarios have been identified as potential options which are mutually exclusive of the CCUS retrofit at the Comanche Power Station. These three scenarios represent potential pathways for the retirement or further development of Comanche. Relative financial, economic, and job impacts in this report have been prepared on the basis of comparison between these scenarios.

Business as Usual (BAU): This scenario retains all coal-fired units at the Comanche Generating Station till their original retirement dates and adds new wind and solar power generation, existing gas generation, and some battery storage,[15]

Colorado Energy Plan (CEP): This scenario mandates early retirement of Comanche Units 1 and 2 and adds more wind, solar, existing gas generation, and significantly more battery storage,[16]

CCUS Retrofit Option (CCUS): This scenario retains all three Comanche units and includes no new wind or solar generation or battery storage.

The CEP is Xcel Energy's roadmap to develop a significantly cleaner energy mix and reduce CO_2 emissions in Colorado. It is designed to achieve nearly 55% renewable energy on the power grid by 2026 and to reduce CO_2 emissions by 59% from 2005 levels.[17] Overall, the CEP will invest $2.55 billion in eight counties to add more than 1,100 MW of wind generation, more than 700 MW of solar generation, and 275 MW of large-scale battery storage.[18] Xcel will retire Units 1 and 2 at the Comanche Generating Station in Pueblo and will invest about $1 billion to acquire 500 MW of new wind generation and 383 MW of existing natural gas generation. The remaining investment, more than half of the total, will be made by independent power producers whose wind, solar, and storage projects will sell electricity to Xcel.

Xcel's forecast models are based on a portfolio of assets chosen from the historic low bids it received for new clean-energy resources in late 2017.[19] The utility stated, "The Colorado Energy Plan is Xcel Energy's latest contribution to the State's transition to a clean energy future."[20]. Xcel contends that the CEP will provide substantial consumer benefits, including:[21]

- Takes advantage of historically low clean energy prices and available tax incentives for renewable power
- Secures low-cost power for customers
- Saves customers money over time
- Accelerates the transformation of our energy resources at no net cost to consumers
- Spurs economic development opportunities in rural Colorado communities and across the State
- Delivers carbon dioxide emissions reductions

- Continues progress the State has made on cleaner air, reducing regional haze and shrinking its carbon footprint

Thus, Xcel notes that "The CEP is a proactive strategy that builds upon Xcel Energy's Our Energy Future plan focused on powering technology, customer choice and the economy. It outlines clear steps to take control of the State's energy future and modernize the grid, while we continually work to keep your bill as low as possible."[22]

2 Techno-Economic Analysis

The impacts of the CCUS Retrofit Scenario were estimated by MISI and LTI using results from the National Energy Modeling System (NEMS) 2018, the NETL pulverized coal carbon capture retrofit database (PC CCRD) spreadsheet model, and the NETL CO_2 transportation cost model. NEMS 2018 was used as the main projection for the macroeconomic and oil price data. The NETL PC CCRD was used to estimate the capital and operating costs of retrofitting Units 1 to 3 to separate 90% CO_2 with an amine-based CO_2 capture technology.[23] Heat rates from the U.S. Environmental Protection Agency (EPA)'s Air Markets Program Data (AMPD) tool were used to update those used in CCRD. Cost calculations assumed a 3-year construction period and a 30-year operation period. Coal fuel costs were assumed to be those presented in Xcel's electricity resource plan (ERP) modeling assumptions update.[24] Finally, the CO_2 transportation cost model was used to estimate the costs to build and operate the CO_2 pipeline from the Comanche Generating Station to the Sheep Mountain Pipeline.

2.1 CCUS Retrofit Cost and Revenue Methodology

Table 2-1: CCUS Retrofit Plant Construction Schedule

Year 1	Year 2	Year 3
0.25	0.40	0.35

Source: Management Information Services, Inc. and U.S. National Energy Technology Laboratory

Table 2-2:. CCUS Retrofit Plant Construction Expenditures (2017 dollars)

Year 1	Year 2	Year 3
$748M	$1,149M	$964M

It was assumed that CCUS retrofit construction would begin in 2020 and be completed by 2022, and that operations would begin in 2023. The construction schedule was developed from the NETL CCUS retrofit plant construction schedule and was estimated to be as shown in Table 2-1.[25] The retrofit capital cost of the three units was estimated to total $2.861 billion (2017 dollars): Unit 1 -- $727 million, Unit 2 -- $779 million, and Unit 3 -- $1,355 million. The total construction cost by year in 2017 dollars is given in Table 2-2.

A pre-retrofit capture capacity factor of 85% and post-retrofit capacity factor of 75% were used to estimate the costs. The total owner's cost was estimated by multiplying the total plant cost by 1.21 to obtain the total plant cost.[26] The CCRD calculations provided capital and O&M costs in 2011$ which were escalated by using NEMS-2018 GDP chain price index and used as inputs for a discounted-cash flow (DCF) analysis.

The financial assumptions used to calculate the costs were the ones used by Xcel in their 120 Day Report to the CPUC.[27] These included a 24.66% tax rate, project financed with 44% debt and 56% equity over a 30-year period, with interest charged during construction. Similarly, 3.75% nominal cost of debt and 9.83% return on equity were used for the DCF calculations. There are two sources of revenue for the DCF calculations – sale of CO_2 for EOR, and the 45Q tax credits from the use of CO_2 for EOR. These are described in detail in Section 2.3.

The DCF calculations were based on no makeup power costs for Units 1 and 2 and a makeup power cost of $15/MWh for Unit 3[28]. The use of makeup power cost is based on the economic concept of opportunity cost. The term "opportunity cost" is generally defined as the cost associated with a forgone revenue generation opportunity which cannot be pursued due to the selection of a mutually exclusive option. An often-quoted example is the loss of potential wages due to the pursuit of college education. It is generally considered that the real cost of attending college should be considered as the cost of attendance plus the loss of wages during the pursuit of the activity; when making a decision one generally considers the forgone wages and the cost of attendance against a higher level of lifetime earnings.

In the case of a coal plant CCUS retrofit, it is often considered that the reduction of electricity sales revenues caused by the drop in net generation due to CCUS parasitic losses is a case of an "opportunity cost". Even though this is the general case, one must consider different externalities associated with power markets to decide if the loss of generation needs to be considered as an opportunity loss. One situation in which opportunity cost does not apply is the use of the carbon capture retrofit as a life-extension project. The two mutually exclusive options in such a scenario is either keep running a retrofitted plant, or retire, which leads to the loss of all future revenues. For the purposes of this study, the options for Comanche Units 1 and 2 are CCUS retrofit or retirement, and therefore, no makeup power cost was considered in the techno-economic analysis for these units. On the other hand, Comanche Unit 3 is not slated for retirement, and makeup power cost was considered as part of its analysis.

The DCF calculations showed that the project is net-cash flow positive for all units, and therefore there is available revenues for lowering the cost of electricity (COE) ascribed to the units. The level of COE reduction was calculated by reducing the net-present value for each unit to zero and using the excess cashflow through the life of the retrofit to lower the COE. In other words, the income from the CO_2 capture retrofit can be used to offset the COE of the base plant without CO_2 capture adjusted for inflation. The AEO 2018 reference case was used to establish the long-term projection of West Texas Intermediate (WTI) oil price. The reduction in the cost of electricity (COE) was calculated by utilizing the project's positive cash flow in future years to fund the electricity cost reduction for the life of the project.

The levelized COE (LCOE) for each Unit (without CO_2 capture retrofit) was calculated by using the data on revenue requirement for Comanche Generating Station provided by Xcel.[29] This included capital revenue requirements, fixed operations and maintenance costs, and property taxes. Coal costs from Xcel's Electric Resource Plan modeling update and unit heat rates from EPA AMPD were used to calculate the annual fuel costs for each Unit. Variable O&M costs estimated for previous years from Xcel's FERC Form-1 data were used to calculate the annual variable O&M costs. The input data provided for the BAU portfolio were used for the LCOE calculation. The capital revenue requirement, (fixed) O&M costs and taxes provided by Xcel was distributed equally across both Units 1 and 2 (Xcel's data had combined the costs for Units 1 and 2). For years 2039 to 2052, the capital revenue requirement, (fixed) O&M costs and property taxes for Unit 3 were assumed to be the same as that for the year 2038. Similarly, the (fixed) O&M costs and property taxes for Units 1 and 2 for the years 2036 to 2052 were assumed to be the same as that for the year 2035. A present-value revenue requirement calculation was performed to calculate the LCOE, based on constant 2017 dollars, with and without the offsetting revenues from the CO_2 capture retrofit project at each Unit.

Finally, this study did not consider the use of RESA funds within its analysis. The renewable energy service adjustment (RESA) is a 2% maximum charge applied to the retail sales of electricity used for the development of renewable resources in Colorado. RESA funds are used by utilities to fund their implementation of programs used to achieve the renewable energy goals of Colorado's Renewable Energy Standard (RES). RESA is a ratepayer-funding mechanism collected at the retail-bill level and it is used by the utilities at the corporate level.

2.2 Utilization of CO_2 in the Permian Basin

It was assumed that CO_2 captured at Comanche Generating Station will be used for CO_2-EOR operations in the Permian Basin (i.e., not stored in saline formations). It was also assumed that the captured CO_2 will displace CO_2 from current natural sources, with no additional economic impact from EOR. The price assumptions related to EOR were derived from *AEO 2018*.[30]

The Permian Basin represents a large fraction of the current U.S. CO_2-EOR market (Figure 2-1). The potential future demand for CO_2 from oilfields in the southwest region of the U.S. is also very high.[31] The Comanche Generating Station is located close to existing oil and gas fields and CO_2 transportation infrastructure in southern Colorado, which is ideal for additional CO_2-EOR production.

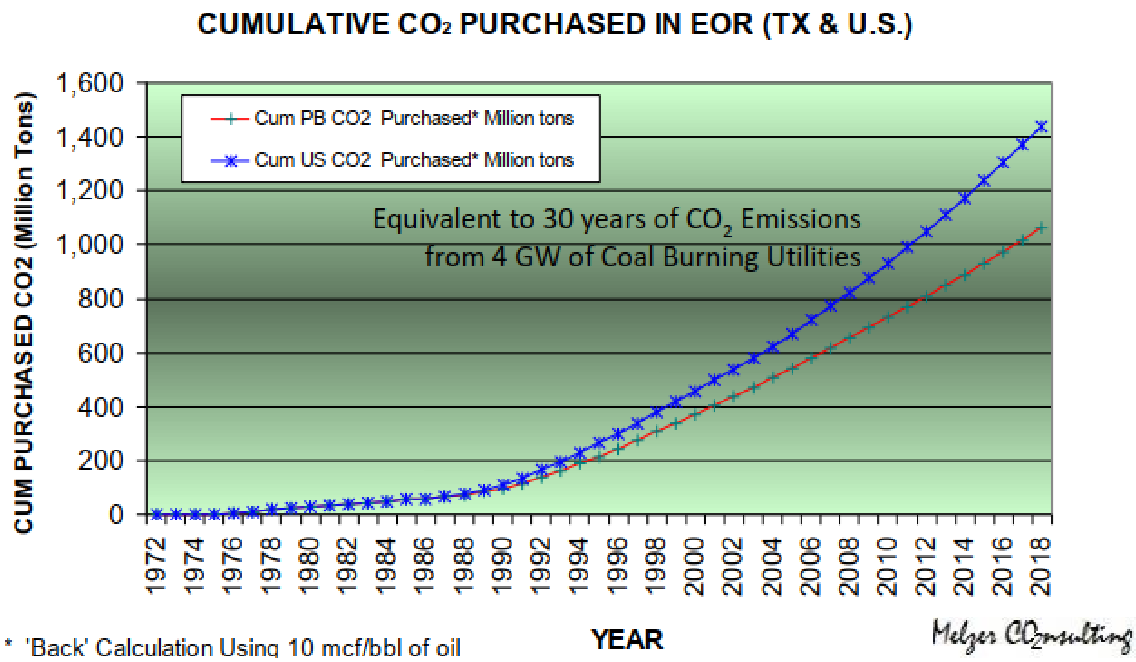

Figure 2-1: Cumulative CO_2 purchases for EOR in the Permian Basin (PB) compared to quantity for the entire United States

Source: Melzer Consulting[32]

A previous study was conducted to examine the potential to supply the market in the Permian Basin with anthropogenic CO_2 from the Comanche Generating Station.[33] The plant's three units produce a combined summer capacity power generation of 1,410 MW net. Comanche Generating Station has one of the lowest costs of generating electricity in Colorado, at $23/MWh, of which fuel costs are $15/MWh and the plant provides low-cost, base-load power.[34] Comanche Generating Station also has several air pollution control technologies that would enable the installation of CO_2 capture technologies. For example, the plant's older two sub-critical units (Units 1 and 2, 660 MW summer capacity) have baghouses to control particulate matter, lime spray dryers for SO_2 control, low-NO_x burners with overfire air for NO_x control, and activated carbon injection for mercury control. The plant's newer supercritical unit (Unit 3, 750 MW) has a selective catalytic reduction (SCR) system for additional NO_x control along with other features.[35]

Another positive attribute is the Comanche Generating Station's location with respect to CO_2 infrastructure, specifically the Sheep Mountain pipeline (SMPL) (Figure 2-2). If 90% of the CO_2 is captured, it would provide over 9 MMT/y to the Permian Basin, which is well within the 11 MMT/y spare capacity in the SMPL. Transporting CO_2 from the Comanche Generating Station to the oilfields in the Permian Basin would only require a feeder pipeline (over relatively favorable terrain) to transport CO_2 to the trunk line (SMPL). If CO_2 capture technology is installed at Comanche, and if the CO_2 is used for EOR in the Permian Basin, the average CO_2 revenue including the 45Q EOR tax credits and the sales price of CO_2 from (the start of CCUS operations in) 2023 to 2042 would be $36/tonne (T) (2017$)[36], and this will offset the cost of capturing CO_2. The added benefits of this scenario are that the overall CO_2 emission into the atmosphere would be decreased, and that the State could receive additional royalties from the production of the crude oil.[37]

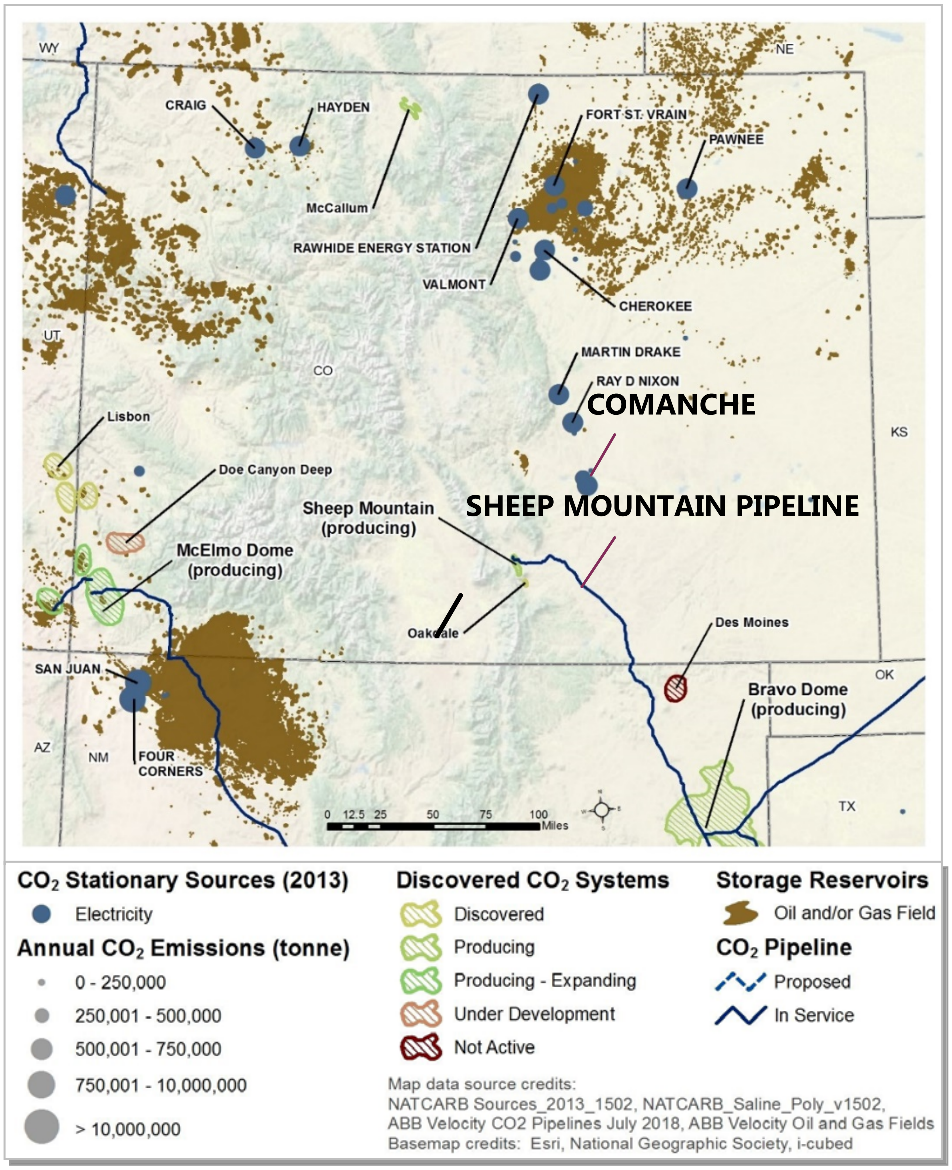

Figure 2-2: Natural CO_2 sources, power plants, and CO_2 trunk lines in Colorado and vicinity.

Source: U.S. National Energy Technology Laboratory.

Utilizing appropriate capture technologies, industrial and power generation sources of CO_2 could fill the need in the Permian Basin and with appropriate pipeline infrastructure investment could serve as a source for EOR in the oil fields in northeast Colorado bringing oil production revenue to the State.[38] Thus, of all the Colorado coal plants, the Comanche Generating Station is in a unique position of being one of the lowest cost electricity producers in Colorado, being located close to the existing CO_2 infrastructure, and has the capability of benefiting from the newly available 45Q Tax credits.

2.3 CO_2 Pipeline

The SMPL pipeline has sufficient spare capacity to carry anthropogenic CO_2 from the Comanche Generating Station.[39] The overall spare capacity in the CO_2 pipelines from Colorado to oilfields in the Permian Basin is 13 MMT/year -- for SMPL and Bravo pipelines. Up to 11 MMT/yr. of additional CO_2 can be transported to the Permian Basin using the excess capacity in the SMPL.

Both the SMPL and Bravo pipelines are considered common carriers, and SMPL currently transports anthropogenic CO_2 from the La Veta gas processing plant, along with natural CO_2 from Sheep Mountain.[40] In comparison, annual CO_2 emission from all power plants in Colorado was 36 MMT in the year 2017,[41] indicating that a significant fraction of the power plant CO_2 emissions could be captured and used for EOR in the Permian Basin depending on pipeline infrastructure and plant location.

It was assumed that 85 percent of the value of the 45Q tax credit would be available to offset the cost of CO_2 capture as a result of its monetization. The 45Q tax credit is available for a period of 12-years starting on the year 2023 and ending on the year 2035. The other source of revenue for the project would be the sale of CO_2 for EOR in the Permian Basin through the SMPL. The local market price of CO_2 was estimated by implementing regression analysis on CO_2 price sales data as reported by the Colorado Oil and Gas Conservation Commission (COGCC)[42]. The quarterly West Texas Intermediate (WTI) crude oil price was used as the independent variable to estimate future local CO_2 prices. This correlation was used to estimate CO_2 sales prices based on crude oil prices projected by EIA in its 2018 Annual Energy Outlook (AEO)[43] publication. CO_2 revenues are the sum of the monetized value of the 45Q tax credit and the projected sale price of CO_2 using the 2018 AEO WTI reference-oil price. [44]

It was estimated that only one 20" pipeline will be needed to transport the CO_2 produced from all three Comanche units. The CO_2 pipeline would be 37 miles in length connecting the Comanche Generating Station to the Sheep Mountain trunk pipeline -- 37 miles represents the shortest distance between the two points. Due to the short pipeline length, it was assumed that pipeline construction could be completed in 1 year and will not require the addition of compression stations.[45]

Pipeline cost calculations were performed using the Fossil Energy (FE)/NETL CO_2 Transport Cost Model.[46] The financial assumptions were consistent with estimates for oil and gas industry[47] (~30% debt, 70% equity, 8.8% cost of equity, 6.91% cost of debt). The tax rate within the model was modified to take into consideration the tax reduction implemented by the Tax Cuts and Jobs Act of 2017. All costs are assumed to be in EIA's Central region. The levelized cost of building and operating the 37-mile long pipeline was estimated to be \$0.60/T (2017\$). Pipeline O&M costs are dependent on the length of pipeline and were estimated on a per mile basis.

The impact of pipeline construction on jobs was estimated based on relevant published estimates of the economic and jobs impacts of pipeline construction and pipeline O&M and the economic and jobs profile of the oil and gas pipeline and related structures construction industry (NAICS 23712). The total CAPEX and job creation for pipeline construction in any given year is determined by the pipelines under construction and the relevant CAPEX for the pipelines. The jobs created by the pipeline deployment are the sum of the jobs created during the construction of the pipelines and the O&M jobs as the pipelines becomes operational.

2.4 Results: Main CCUS Scenario

The following is a summary of key results from the CCUS techno economic analysis and comparisons with the BAU and CEP scenarios. Overall it was found that the CCUS scenario achieved a higher level of CO_2 reductions when compared to BAU and CEP scenarios. It was also found that retrofitting Comanche Units 1 and 2 results in a lower levelized cost of electricity when compared to bid prices for new power plant construction as contemplated under CEP.

2.4.1 Impacts on Electricity Rates

Table 2-3: Comanche Plant CO_2 Retrofit Estimates for Units 1 to 3

	CO_2 Captured (MMT/year)	**Investment (million nominal $) [million 2017$]**	**Pre-retrofit capacity, MW**	**Post-retrofit capacity, MW**	**First-year cost of capture, 2017$/T**
Unit 1	2.24	$950 [$727]	383	274	$39.70
Unit 2	2.51	$1,018 [$779]	396	274	$37.98
Unit 3	4.57	$1,771 [$1,355]	851	635	$36.42

Source: Leonardo Technologies, Inc.

Table 2-3 shows the major CCUS metrics for the three Comanche units. It demonstrates that all units have the potential to capture 9.32 MMT/yr. of CO_2.[48] Total investment in nominal dollars is $3.74 billion ($2.86 billion in 2017$). The units have first-year costs of capture costs between $36/T and $40/T.

The cost estimates for renewables under the CEP are based on reported median levelized energy prices in Colorado for renewable energy technologies (see Table 2-4).[49] Additionally, Xcel reported that "*The Preferred CEPP includes unprecedented low pricing across a range of generation technologies including wind at levelized pricing between $11-18/MWh, solar between $23-$27/MWh, solar with storage between $30-$32/MWh and gas between $1.50 - $2.50/kW-mo.*" In 2017, generation-weighted average PPA prices in Colorado for wind were about $43/MWh and for solar PV were about $70/MWh.[33] It is notable that the CPUC Staff recommended that the company use the median bid prices provided in Table 2-4 for the resource acquisition (RAP) period from 2016 to 2024. They also recommended that the appropriate levelized costs for wind and PV solar for portfolio analyses for years outside the RAP (i.e., from 2025) would be $33/MWh and $46/MWh respectively.[50]

Table 2-4: Bid Prices Received by Xcel Energy to Replace Comanche Units 1 and 2

Technology	# of bids	Bid MW	# of projects	Project MW	Median bid price	Pricing unit
CT/IC engines	29	6365	19	4436	5.08	$/kW-mo
CT w/ battery storage	7	804	3	476	6.21	$/kW-mo
Stand-alone battery storage	28	2144	24	1945	10.53	$/kW-mo
Wind	96	41,915	42	16,949	19.3	$/MWh
Wind + solar	5	2601	4	2,151	19.96	$/MWh
Wind + battery storage	11	5,700	5	2,700	20.63	$/MWh
Solar PV	148	28,382	78	14,085	30.96	$/MWh
Wind + solar PV + battery storage	7	4,048	7	4,048	30.96	$/MWh
Solar PV + battery storage	79	14,980	57	10,098	38.3	$/MWh

Source: Xcel Energy[51]

Using the revenues from the CCUS retrofit, the Units 1-2 at Comanche Generation Station can produce electricity at a levelized cost lower than the cost of renewables under the CEP.

Table 2-5 compares the CEP and CCUS cost metrics for the three Comanche units. The LCOE in the table is calculated compared to the median bid price for renewables in the CEP.[52] The weighted LCOE from all three Units is $19.72/MWh, which is slightly higher69/ than the LCOE from wind + storage but lower than solar PV and solar PV + storage in Xcel's CEP. The combined LCOE for Units 1 and 2 is $17.37/MWh, which is lower than all of Xcel's CEP options.

Table 2-5: Levelized costs of electricity in the CCUS scenario compared to the CEP

Scenario	**CO_2 captured, MMT CO_2/y**	**Capex, (nom.$)**	**Levelized cost of electricity, 2020-2052, 2017$/MWh‡**	
90% capture on Units 1-3, $15/MWh make-up power for Unit 3	9.32	$ 3.74 billion	Unit 1	17.31
			Unit 2	17.44
			Unit 3	21.69
			Units 1-3	19.72
CEP	0	$ 2.75 billion	Wind + storage	18.3
			Solar PV	27.5
			Solar PV + storage	34

Source: Leonardo Technologies, Inc., Xcel. CEP levelized costs are based on the median bid prices reported in Table 2-4. These were assumed to be in 2022 dollars and were deflated to constant 2017 dollars using CPI deflators. The list of technologies listed under the CEP is not an exhaustive one. LCOE for coal retrofits includes the offsetting revenues from CCUS operations.

The CCUS Retrofit Option offers strong economic advantages, including:

- Under the CCUS Retrofit Option, the investment for the CCUS scenario is covered by the revenue from the CO_2 sales and the 45Q tax credits,
- The proximity of the SMPL to the Comanche Generating Station enables CO_2 use for EOR, more than offsetting the costs of capture,

With CCUS retrofits, plant operators will have an incentive to operate at a higher capacity factor because of the revenues from the sale of CO_2 and electricity, thereby making coal-fired generation competitive against renewables and against natural gas peaker and CC plants.

2.4.2 Impacts on CO_2 Emission Reductions and Revenues

Up to 11 MMT/yr. of CO_2 captured via the Comanche CCUS retrofits can be transported to the Permian Basin using the excess capacity in the Sheep Mountain Pipeline. CCUS retrofits on Units 1 to 3 can achieve CO_2 emissions reduction significantly higher than that achieved by retiring Units 1 to 3 early. The CCUS Retrofit Option can thus achieve substantial CO_2 emissions reductions, totaling over nine MMT annually.

The CCUS Retrofit Option can achieve significantly higher CO_2 emissions reductions compared to the early coal plant retirements under the BAU or the CEP scenarios. Data provided by Xcel indicates that by 2026 (i.e., after the early retirement of Units 1 and 2 in the CEP scenario), the reduction in Xcel fleet-wide CO_2 emissions in the BAU scenario is 47%, and 59% for the CEP scenario.[53] On the other hand, in the CCUS Retrofit scenario the CO_2 emissions are reduced by 78% in the year 2026. All emission reduction comparisons are compared to year 2005 base emission levels.[54]

During the time period from 2020 to 2042, the reduction in CO_2 emissions under the BAU and CEP, relative to the level of 2005 emissions is 45% and 52% respectively. With the CCUS retrofit, CO_2 emissions from 2020 to 2042 are reduced by 65% when compared to 2005 base emission levels.

From 2020 to 2042, the CCUS Retrofit Option generates $10.21 billion (nominal dollars) in CO_2 revenues. In comparison, such revenues do not accrue under the BAU or the CEP options.

2.4.3 Comparison Between Scenarios

Table 2-6 shows a side-by-side comparison of the techno economic analysis for the BAU, CEP, and CCUS scenarios. It is important to note that the CCUS scenario does require a higher level of investment when compared to the other scenarios. Even though the CCUS scenario has a higher capital cost, it is important to recognize that it also provides a significantly higher level of CO_2 emission reductions.

Table 2-6: Summary of Scenario Comparison

	BAU	**CEP**	**CCUS**
Coal Retirements	2033/2035	2022/2025	Not Retired
Resource Acquisition Period (RAP)	450	775	450

Resource Need (MW) (by 2023)			
Wind Additions (MW)	789 MW	1,131 MW	0
Solar Additions (MW)	322 MW	707 MW	0
Battery Storage (MW)	50 MW	275 MW	0
Generation Investment ($M)	$1,460	$2,550	$3,738
Transmission Investment ($M)	$175	$204	-
Total Investment ($M, nominal)	$1,636	$2,754	$3,738
Reduction in CO_2 Emissions in 23 Years (2020-2042) relative to Fleet-Wide 2005 Emissions	45%	52%	65%

2.5 Alternate Scenario Results

Two alternate scenarios were developed to test potential future developments in the area of CCUS. The first scenario is the extension of the 45Q tax credit from twelve years to the life of the retrofit (thirty years). The extension of the 45Q tax credit for the life of the retrofit could ensure the continuous operation of the carbon capture equipment and increase the returns from such an undertaking. The second scenario explores the achievement of DOE Office of Fossil Energy transformational goals ahead of schedule. Under such a scenario the capital and O&M costs for the deployment of CCUS retrofits would be substantially reduced.

2.5.1 Extension of 45Q from Twelve Years to Lifetime of Retrofit

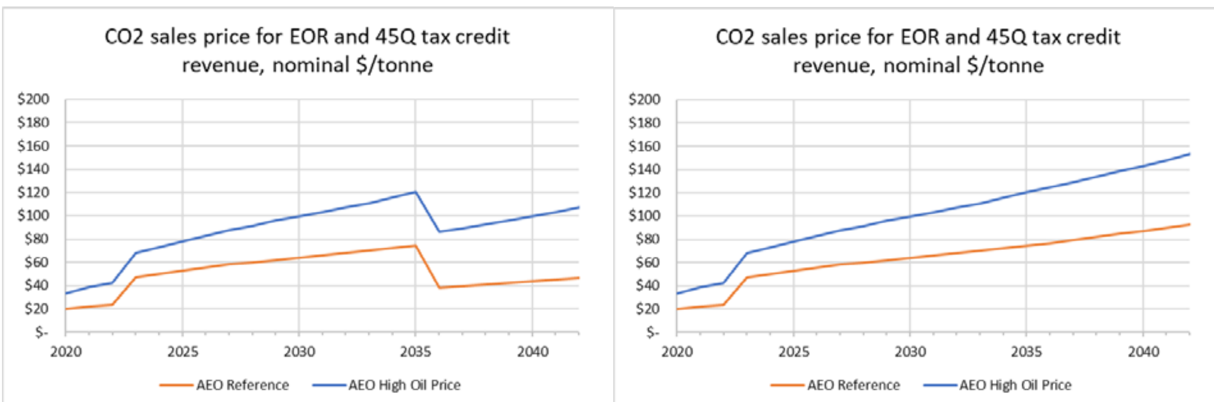

Figure 2-3: Comparison of CO_2 Revenues for the Lifetime 45Q Tax Credit Extension

Table 2-7: Comparison of Key Metrics for Alternate Scenario 1

Scenario	**CO_2 captured, MMT CO_2/y**	**Capex, (nom.$)**	**Levelized cost of electricity, 2020-2052, 2017$/MWh‡**	
Baseline Scenario with Twelve-Year 45Q Tax Credit	9.32	$ 3.74 billion	Unit 1	17.31
			Unit 2	17.44
			Unit 3	21.69
			Units 1-3	19.72
Alternate Scenario 1 with Lifetime 45Q Tax Credit	9.32	$ 3.74 billion	Unit 1	12.08 (-30%)
			Unit 2	11.64 (-33%)
			Unit 3	17.08 (-21%)
			Units 1-3	14.70 (-25%)

The extension of the 45Q tax credit to the life of the retrofit significantly improves the economic viability of the CCUS retrofit for all the Comanche units. Figure 2-3 shows a significant difference on the realized price of CO_2 after the year 2035 due to the extension of the tax credit. The left pane contains the price with the twelve-year credit, while the right pane shows the life of project extension.

The application of the extension to the 45Q tax credit results in a net increase in the amount of revenues for the sale of CO_2. This increases the total CO_2 revenue from $10.2B to $20.7B in nominal dollars.

2.5.2 Acceleration of DOE Office of Fossil Energy R&D Transformational Goals (Alternate Scenario 2)

The second alternate scenario explored was the implementation of DOE-FE R&D transformational goals on an advance schedule. This would mean that by the year 2023 the CAPEX reduction over the CCRD baseline would translate to a 30% reduction with a 5% reduction in the O&M costs. It is important to note that the goal reductions are applied with relation to the first-year of operation and not the start of the construction period. That is, the technology which enables the CAPEX and O&M reductions must be available for integration by the year 2020. For this alternate scenario the 45Q tax credit was left with its original twelve-year period.

Table 2-8: Comparison of Key Metrics for Alternate Scenario 2

Scenario	CO_2 captured, MMT CO_2/y	Capex, (nom.$)	Levelized cost of electricity, 2020-2052, 2017$/MWh‡	
Baseline Scenario with Twelve-Year 45Q Tax Credit	9.32	$ 3.74 billion	Unit 1	17.31
			Unit 2	17.44
			Unit 3	21.69
			Units 1-3	19.72
Alternate Scenario 2 with Early Achievement of Transformational Goals	9.32	$ 3.19 billion (-15%)	Unit 1	15.38 (-11%)
			Unit 2	15.40 (-12%)
			Unit 3	20.14 (-7%)
			Units 1-3	17.97 (-9%)

3 Jobs and Economic Impact Analysis

MISI has conducted numerous analyses using assumptions and methodology similar to those implied in the current study.[55]

3.1 The Colorado Energy Plan and the BAU Scenario

MISI used the results of the analysis of the CEP and BAU impacts conducted for Xcel by the UOC. The economic impacts of the Colorado Energy Plan were estimated for the Public Service Company of Colorado (PSCo), (a subsidiary of Xcel) by the Business Research Division of the Leeds School of Business at the University of Colorado at Boulder.[56] The UOC research team used the REMI model version 2.1.6, build 4817 for the analysis.[57] The REMI model is a dynamic forecasting and policy analysis model that incorporates econometric, input-output, and computable general equilibrium techniques. The model was created by REMI specifically for the State of Colorado and Pueblo County using national and local economic and demographic data.[58]

PSCo defined the scenario that UOC assessed. The Preferred Electric Resource Plan (here denoted as BAU) and the CEP were provided by PSCo. UOC developed economic scenarios that included portfolios of spending and rate changes brought about by the two different scenarios (i.e., BAU and CEP). The result was a simulated forecast of the economy under scenarios where utility rates and spending on operating and capital expenditures change. UOC compared the CEP to the BAU to quantify the economic impacts on the Colorado economy and the Pueblo economy.

UOC collected data on PSCo estimates related to ongoing operating and maintenance expenditures, capital expenditures, and revenue requirements. PSCo provided estimates of the percentage of expenditures directly in Colorado compared to activity that occurs in other States (i.e., leakage). The timing of operating and capital expenditures is specific to each scenario.

Data were provided in nominal dollars, quantified in the year of expected impact. The impacts were presented in fixed, 2018 dollars and discounted by the model using industry price deflators.[59] UOC entered costs into the REMI model based on total activity expenditures. For expenditures, a positive (negative) number reflects an increase (decrease) in spending under the CEP compared to the BAU. For revenue requirements, a positive (negative) number reflects higher (lower) electricity costs to residential, industrial, commercial, and government customers. UOC deferred to the model for the industry intermediate inputs and local purchasing coefficients for intermediate inputs, and for the proportion of spending devoted to capital and labor. The local purchasing coefficients within REMI change over time based on changing demand.

PSCo provided UOC with capital expenditures, operating expenditures, and revenue requirements for the BAU and the CEP. The timing of operating and capital expenditures was specific to each scenario, and UOC estimates where provided by PSCo for each scenario. For modeling purposes, cost assumptions were provided in nominal dollars.

UOC entered nominal costs into the REMI model based on total activity expenditures in Colorado and in Pueblo County. UOC deferred to the model for the local purchasing coefficients for intermediate inputs, and for the proportion of direct spending attributable to labor and capital. The local purchasing coefficients within REMI change over time based on changing demand.

3.2 The CCUS Retrofit Scenario

One methodology of developing an estimate of the CCUS retrofit jobs would be a comprehensive modeling approach of the type previously conducted for NETL.[60] A final demand vector for CCUS retrofits would be constructed, and this vector could then be used with economic input-output analysis to estimate the total (direct and indirect) employment generated by the CCUS retrofit program. This would provide an estimate of the overall jobs impact. However, due to time and resource constraints, this type of detailed analysis was not possible for this project.

The number of jobs that would be created by the CCUS retrofit program was calculated using proxy data. Two sources of data were used - national industry jobs estimates available from the Federal government, and estimates of jobs impacts available from analytical studies of the employment effects of power plant expenditures.

The jobs impacts of the CCUS retrofit construction were estimated based on previous MISI research and from analysis of CCUS data and projects.[61] It was also difficult to estimate the jobs that would be created by the ongoing O&M of the retrofitted units, since there are few data on the number of permanent O&M jobs that would be created by such a retrofit program.[62] One estimate of the O&M jobs that would be required by the retrofit program is that of the average O&M jobs in existing and planned coal power plants, and was used to estimate the O&M jobs that would be required using the normalized average of O&M jobs in existing coal power plants. A "micro" approach was used to examine the actual O&M permanent employees at a number of coal plants and a "macro" approach was used to estimate the overall national average of O&M employees at U.S. coal power plants. Using an estimate of annual plant O&M expenditures and average salaries in NAICS code 2211121, fossil fuel electric power generation, estimates of O&M employees for the retrofitted plant were derived.

The major economic and job impacts resulting from the coal plant CCUS retrofit program result from the capital cost expenditures for the plants and from the ongoing O&M of the plants.

3.3 Data Sources

MISI estimated the likely economic and direct and indirect job impacts in Colorado of the Comanche Generating Station CCUS retrofits, including the impacts on:

- The Pueblo and Colorado economies,
- Comanche Generating Station retrofit jobs,
- Pipeline-related jobs resulting from the coal CCUS retrofits,
- Potential implications for the occupational jobs and skill requirements resulting from the coal plant CCUS retrofits.

In conducting the impact assessment, MISI utilized data provided by DOE, NETL, LTI and data obtained from Xcel Energy, the University of Colorado, the State of Colorado, the Colorado Public Utilities Commission, Pueblo County, the Pueblo School District, and related sources, including:

- Cost estimates and project schedules for retrofitting each of the three Comanche units with CCUS technology,
- Cost estimates and project schedules for the CO_2 pipeline that will be required,
- Estimates of the length and location of the CO_2 pipeline that will be required,
- Estimates of CO_2 revenues from sales for EOR,
- Capital expenditure (CAPEX) and fixed and variable operations and maintenance (O&M) cost data for the coal CCUS retrofits,
- Pipeline assumptions (distance, CAPEX, fixed and variable O&M cost data, and expenditure schedules),
- Assumptions regarding the oilfields in which the captured CO_2 will be eventually stored after use for EOR,
- As available, other necessary parameters identified through discussions with DOE and NETL staff.

3.4 Constant-Dollar Data

In this study, historical and forecast economic data over a long period are assessed using constant dollar data. Aside from the general distortions, use of current dollar data in the analysis would, for example, undercount expenditures early in the forecast period relative to those later in the forecast period. Therefore, throughout this report, the constant dollar estimates given are stated in constant 2017 dollars. Estimates stated in nominal dollars or in other base year dollars were converted, where necessary, to 2017 constant dollars using the BEA Implicit GDP deflator series.[63]

Constant 2017 dollar data (2017=1.00) were derived using the GDP deflators to convert dollar values into 2017 base year estimates. Implicit price deflators (IPD) were used in the economic impacts part of the study.[64] The techno-economic analysis developed as part of this report used GDP chain-type deflators to determine the change in prices for equipment and labor required for the implementation of the carbon capture retrofit.[65]

3.5 The Jobs Concept

Job creation and loss is a key focus of this report. This analysis considers employment as a full-time equivalent (FTE) job in the U.S.[66] An FTE job is defined as 2,080 hours worked in a year's time, and adjusts for part time and seasonal employment and for labor turnover. The use of FTEs normalizes job creation among full time, part time, and seasonal employment.[67] For example, two workers each working 6 months of the year would be counted as one FTE job. An FTE job assessment allows meaningful comparisons over time and across jurisdictions as it consistently measures the input of labor in the production process.

A "job" created is defined as an FTE job created for one person for one year, and 50,000 jobs created will refer to 50,000 persons employed for one year. It is correct to state that "over a ten year period 500,000 cumulative jobs are created" as long as it is specified that this refers to 50,000 persons, each employed annually for 10 years.

MISI estimated the total (direct, indirect, and induced) jobs created by the CCUS retrofits and related expenditures: [68]

- Direct jobs are those created directly in the specific activity or process,
- Indirect jobs are those created throughout the required interindustry supply chain,
- Induced jobs are those created in supporting or peripheral activities,
- Total jobs are the sum or all of the jobs created.

For simplicity, MISI includes 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.

In the analysis and forecasting, MISI followed the conventions in the U.S. Energy Information Administration's (EIA) *Annual Energy Outlook 2018* (*AEO 2018*) and *Annual Energy Outlook 2017* (*AEO 2017*), and dollar estimates are expressed in terms of constant 2017 dollars.[69] The other standard conventions of the EIA AEO reports were also adhered to. In addition, the conventions of the required U.S. Bureau of Labor Statistics, U.S. Bureau of Economic Analysis, and U.S. Census Bureau databases were followed.[70]

3.6 Job Impacts

CO_2 emissions reductions in the CCUS Retrofit Option are significantly higher than those achieved by retiring the Comanche Units early, and this also avoids estimated job losses to Pueblo, creating large numbers of jobs in the process. Figure 3-1 shows that the CCUS Retrofit Option is estimated to create significantly more jobs both in Pueblo and in Colorado than the CEP. In Pueblo, compared to the CEP:

- The CCUS Retrofit Option creates nearly four times as many construction jobs,
- The CCUS Retrofit Option creates more than twice as many O&M jobs.

In Colorado, compared to the CEP:

- The CCUS Retrofit Option creates 70% more construction jobs,
- The CCUS Retrofit Option nearly as many O&M jobs.

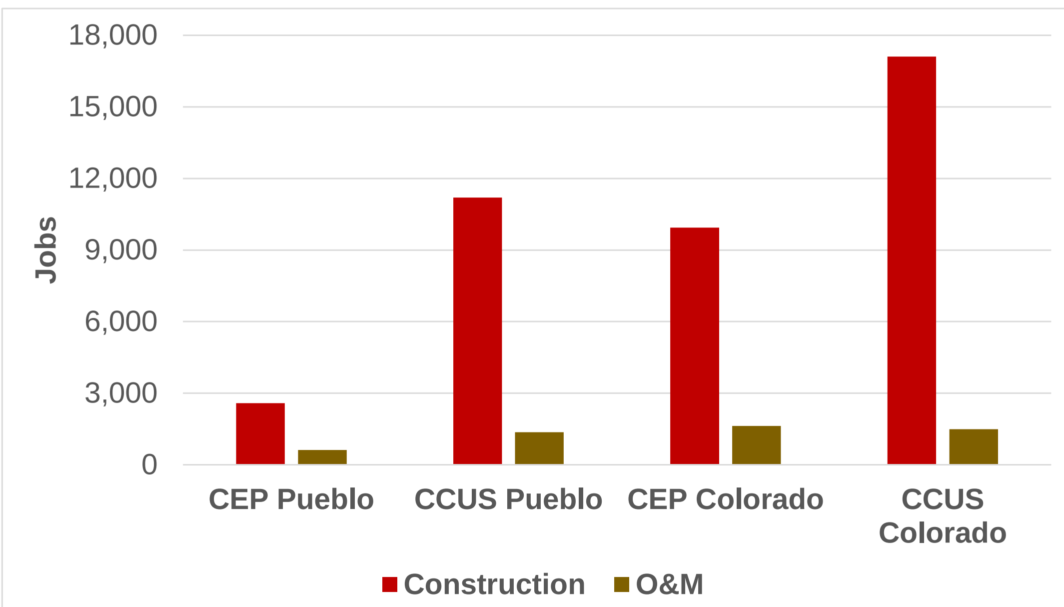

Figure 3-1: Total Jobs Created by the CEP and the CCUS Retrofit Option Over 23 Years

Source: Management Information Services, Inc. and University of Colorado.

Figure 3-2 shows the time periods over which the jobs are created by the CEP and the CCUS Retrofit Option. It demonstrates that the CCUS Retrofit Option creates more than four times as many jobs in Pueblo than the CEP, but, due to the 3-year construction schedule, most of the jobs are created in those 3 years.

Specifically, in Pueblo:

- In years 1-3, the CCUS Retrofit Option creates, on average, 25 times as many jobs as the CEP,
- In years 1-5, the CCUS Retrofit Option creates, on average, 35 times as many jobs as the CEP,
- In years 1-23, the CCUS Retrofit Option creates, on average, four times as many jobs as the CEP.

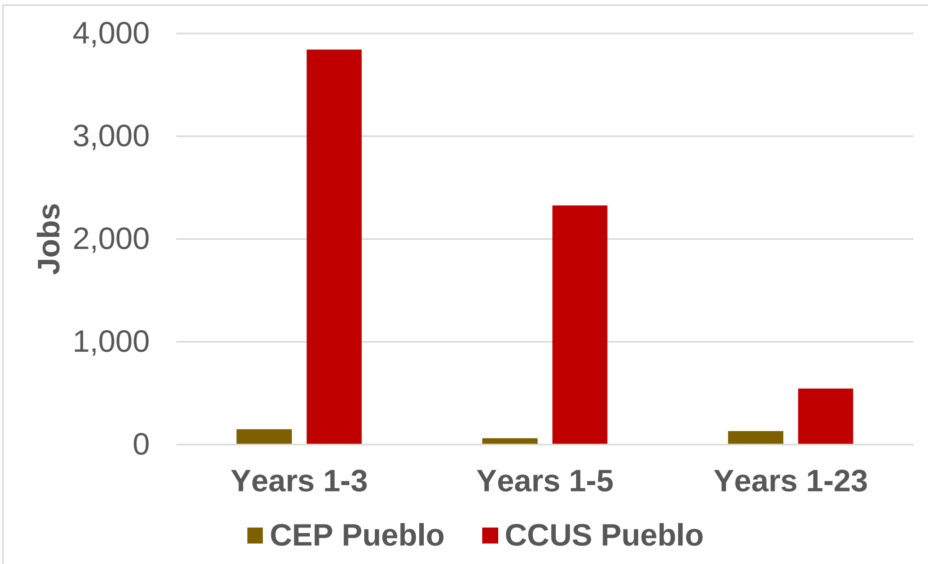

Figure 3-2: Average Number of Jobs Created in Pueblo

Source: Management Information Services, Inc. and University of Colorado.

Figure 3-3 compares the annual job creation in Pueblo of the CEP and the CCUS Retrofit Option. The years are listed as 1 through 23 because the UOC study assumed that CEP construction would begin in 2018, whereas MISI assumed that the CCUS retrofit construction would begin in 2020. Listing the years as 1 through 23 gives a meaningful comparison of the annual jobs created over time in the CEP and CCUS Retrofit Option.

Over the 23-year forecast period, the CCUS option creates nearly four times as many jobs in Pueblo as the CEP. In Pueblo, the CCUS Retrofit Option creates a maximum of nearly 4,000 jobs in year three, and as construction phases down creates over 50 jobs annually. Specifically, in Pueblo, the CEP:

- Creates a maximum of 1,100 jobs in year five and then phases down creating 20 jobs in year nine,
- In years 10 through 16 job creation is negative, and about 10 to 30 jobs are lost every year,
- In years 17 through 23 job creation is positive, and about 10 to 50 jobs are created every year.

Total employment in the Pueblo Metropolitan Statistical Area (MSA) in 2018 was about 72,000.[71] Assuming 2% annual growth, total employment in Pueblo in 2022 will be about 78,000. Thus, in 2022, the nearly 4,000 jobs created by the CCUS retrofits will increase total Pueblo employment by more than five percent. In addition, as noted, the CCUS Retrofit Option will also avoid the 80 jobs lost that would result from the early retirement of Comanche Units 1 and 2.[72] Thus, after the CCUS retrofit construction is completed, permanent Pueblo employment would increase by about 130 to 140 jobs – jobs that pay well above the Pueblo average.[73] Further, assuming an unemployment rate of 4% indicates Pueblo unemployment in 2022 will total about 2,900. Thus, the number of jobs created in Pueblo in 2022 will be 40% more than the total number of unemployed that year in the MSA.

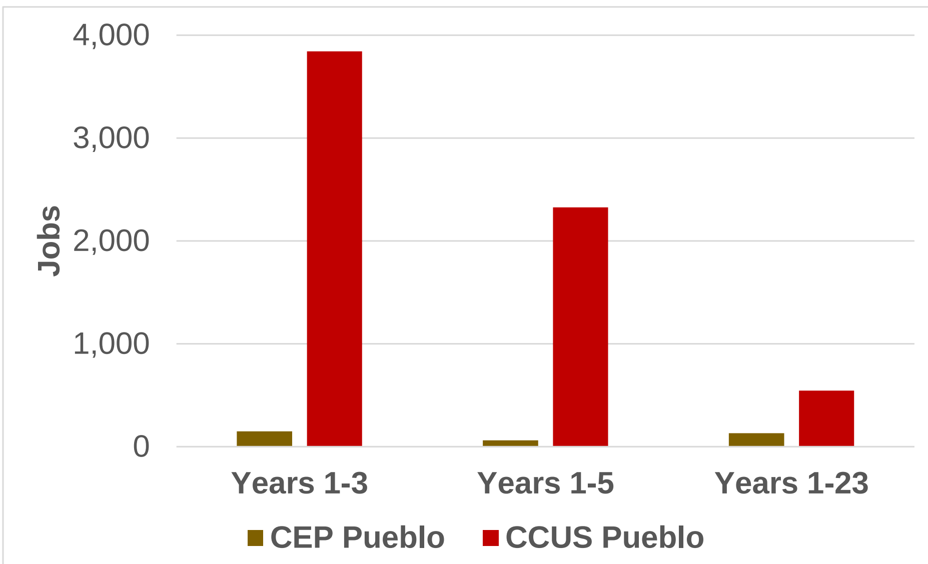

Figure 3-3 Annual Job Creation in Pueblo

Source: Management Information Services, Inc. and University of Colorado.

The CCUS retrofit option creates 40% more jobs in Colorado than the CEP. Specifically, in Colorado, as shown in Figure 3-4:

- In years 1-3, the CCUS Retrofit Option creates, on average, nearly three times as many jobs as the CEP,
- In years 1-5, the CCUS Retrofit Option creates, on average, nearly twice as many jobs as the CEP,
- In years 1-23, the CCUS Retrofit Option creates, on average, about 50% more jobs than the CEP.

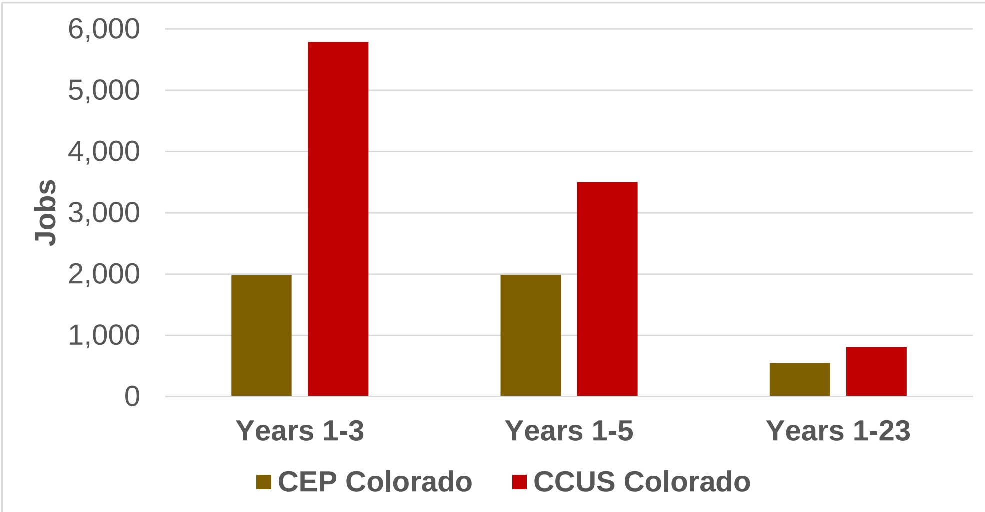

Figure 3-4: Average Number of Jobs Created in Colorado

Source: Management Information Services, Inc. and University of Colorado.

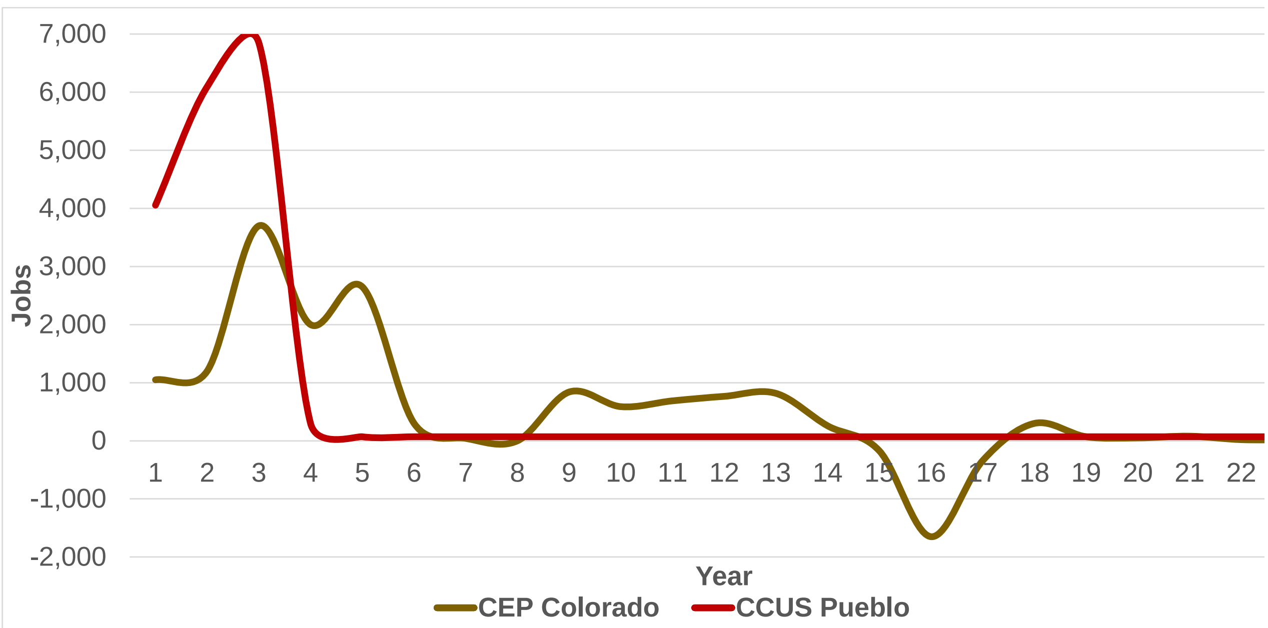

Figure 3-5: Annual Job Creation in Colorado

Source: Management Information Services, Inc. and University of Colorado.

Figure 3-5 compares the annual job creation in Colorado of the CEP and the CCUS Retrofit Option. The CCUS Retrofit Option creates about 40% more jobs in Colorado than the CEP. In Colorado, the CCUS Retrofit Option creates a maximum of nearly 7,000 jobs in year 3, and as construction phases down, about 70 jobs are created annually. In Colorado, the CEP:

- Creates a maximum of 3,700 jobs in year three,

- It then phases down and in year eight creates no jobs,
- In years nine through 14, job creation is positive with between 260 and 800 jobs being created each year,
- In years 15 through 17, job creation is negative with between 170 and 1,700 jobs lost each year,
- In years 18 through 23, job creation is positive with between 20 and 300 jobs being created each year.

3.7 Impacts on Earnings and Tax Revenues

The increased economic activity and jobs in Pueblo and Colorado will create increased earnings and tax revenues. Figure 3-6 shows that over 23 years, the CCUS Retrofit Option creates more than $500 million in earnings in Pueblo and more than $900 million in Colorado. The additional earnings in Pueblo will significantly increase total Pueblo earnings. The additional earnings in Colorado will increase State income tax revenues by more than $40 million.[74]

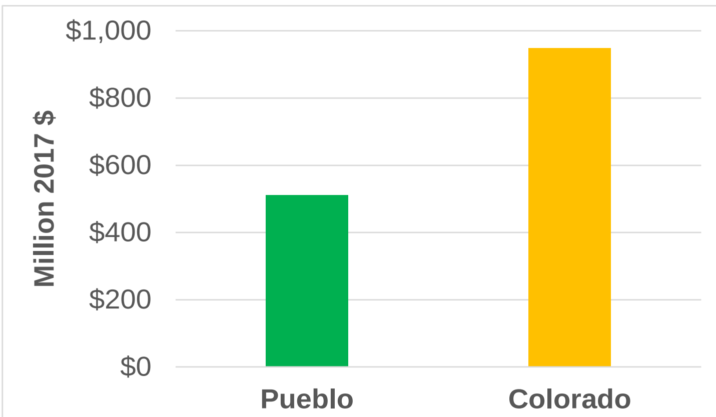

Figure 3-6: Increased Wage and Salary Earnings in 2022 from CCUS Retrofit Option

Source: U.S. Bureau of Labor Statistics and Management Information Services, Inc.

The CCUS Retrofit Option will greatly improve Pueblo's fiscal situation. Because Units 1 and 2 will not be prematurely retired, they will continue to generate real estate tax revenues for Pueblo. Under the CEP this would not be the case, and, under the CEP, Pueblo would experience substantial tax revenue reductions beginning in 2022 and 2025 when the units are retired.

However, more importantly, the CCUS Retrofit Option will greatly increase Pueblo tax revenues starting in 2023 when construction is complete. Therefore, not only will all three the Comanche coal units continue to be in operation and maintain the plant's assessed valuation, but the assessed valuation – and thereby the real estate taxes – will increase substantially. It is difficult to determine precisely the increased tax revenues that would accrue to Pueblo from the CCUS retrofits. However, based on the current assessed valuation of the Comanche Generating Station, the real estate taxes it currently pays, the estimated cost of the CCUS retrofits, and estimated tax and insurance payments, MISI estimates that the increased real estate taxes accruing to Pueblo beginning in 2023 would total about $40 million annually. These tax revenues would accrue every year for the life of the systems and would be an enormous beneficial windfall for Pueblo. If taxes are assessed as construction work in progress (CWIP), the tax revenue increase to Pueblo could begin as early as 2020.[75]

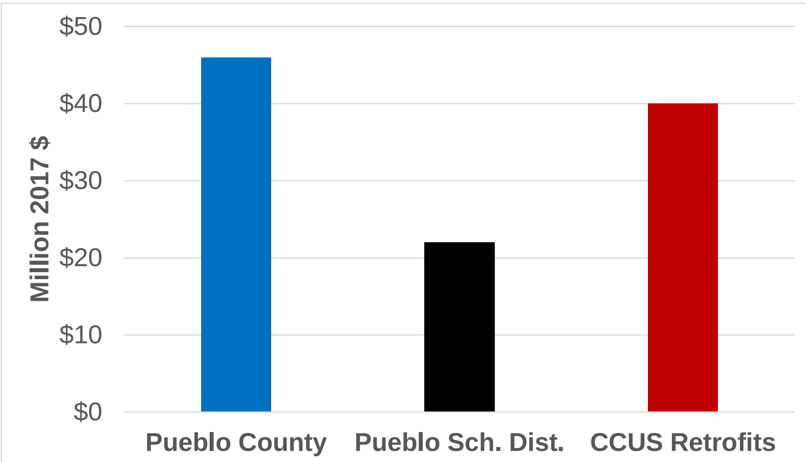

Figure 3-7: Pueblo Real Estate Tax Revenues, 2023

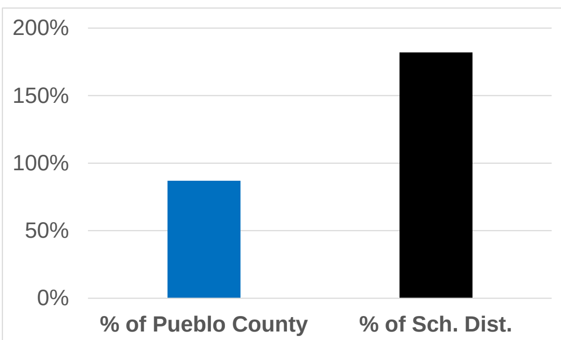

Figure 3-8: CCUS Retrofit Tax Revenues, 2023, as a Percent of County and School District Tax Revenues

Source: Management Information Services, Inc., Pueblo County Office of Budget and Finance, and Pueblo County School District 70, Department of Business Services.

Figure 3-7, Figure 3-8, Figure 3-9 and Figure 3-10 place the increased Pueblo tax revenues in perspective:[76] Figure 3-7 shows the estimated Pueblo real estate tax revenues in 2023 – the first year that the full tax assessment of the CCUS retrofits would occur. It shows that:

- The total real estate tax revenues for Pueblo County, exclusive of the CCUS retrofit taxes, would total about $46 million,
- The total real estate tax revenues for the Pueblo School District, exclusive of the CCUS retrofit taxes, would total about $22 million,
- The increased real estate tax revenues from the CCUS retrofit taxes would total about $40 million.

Figure 3-8, Figure 3-9, and Figure 3-10 show total CCUS retrofit tax revenues in 2023 and as a percent of Pueblo County and Pueblo School District tax revenues. It shows that the increased tax revenues from the CCUS retrofits:

- Are nearly equal to all other Pueblo County tax revenues.
- Are nearly twice those of the Pueblo School District tax revenues.
- Equal about 60% of the combined County and School District tax revenues.
- Comprise nearly 40% of the total tax revenues – including the CCUS retrofit tax revenues.

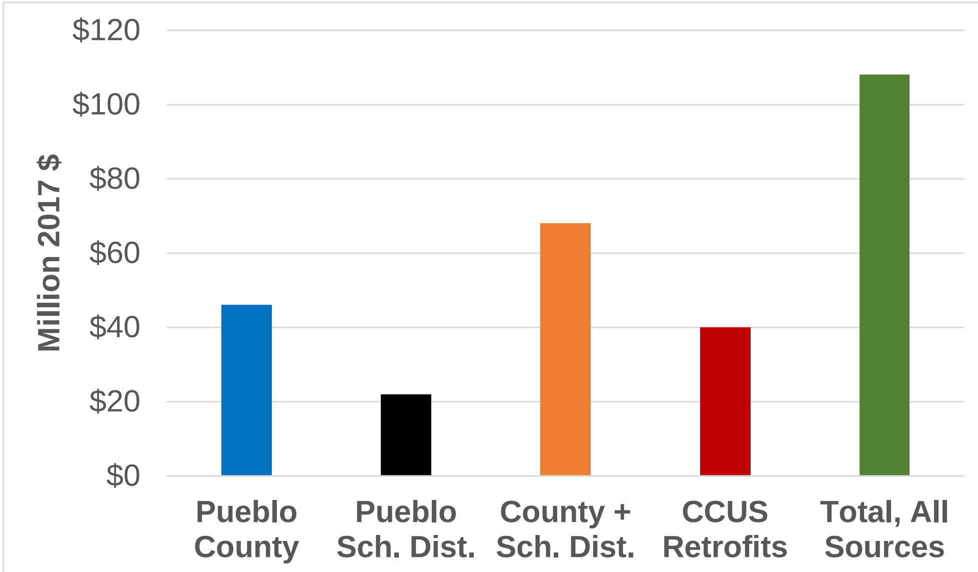

Figure 3-9: Comparative Tax Revenues, 2023

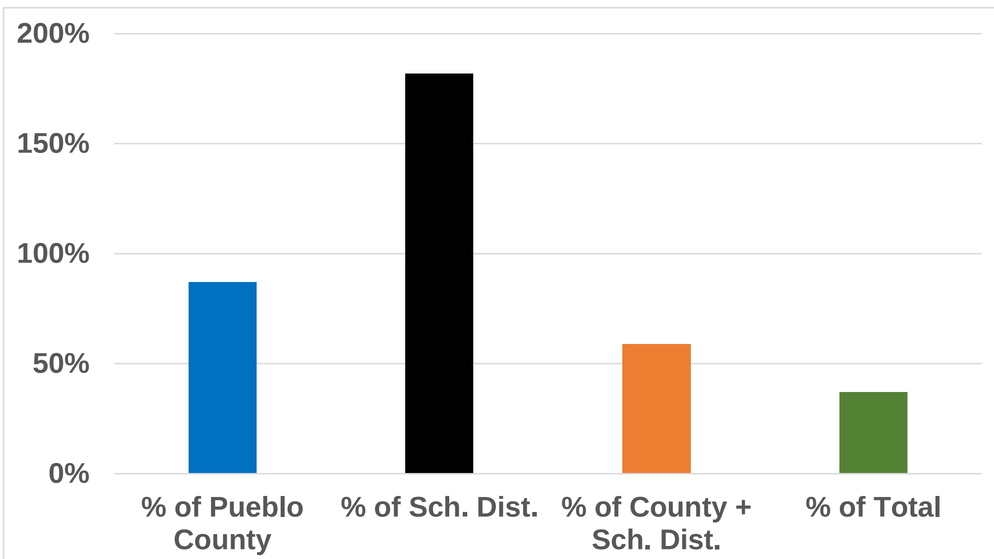

Figure 3-10: CCUS Retrofit Tax Revenues, 2023, as a Percent of County and School District Tax Revenues

Source: Management Information Services, Inc., Pueblo County Office of Budget and Finance, and Pueblo County School District 70, Department of Business Services.

Significantly, these figures illustrate that a major benefit of the CCUS Retrofit Option is that it would transform the Pueblo School District from a relatively poor school district to one of Colorado's wealthiest.[77]

4 COMANCHE UNIT 3 ANALYSIS

The analysis in the preceding sections has been focused on the complete retrofit of all the units in the Comanche Generating Station. Since there is a high likelihood of early retirement for Units 1 and 2; this section focuses on explaining the techno-economic analysis which was done for Unit 3. All the quoted costs in this section are in constant 2017-dollar value unless otherwise noted.

As previously discussed, the costs associated with the retrofit of the units at the Comanche Generating Station are based on NETL's Carbon Capture Retrofit Database (CCRD) for pulverized coal plants. The NETL CCRD uses representative cases for carbon capture retrofits and scales the different associated costs to match the target power plant characteristics. In the case of Unit 3, and contrary to Units 1 and 2, no expenditures are required for the installation of additional NO_x selective catalytic reduction (SCR) equipment, which is already installed in Unit 3. The capital costs associated with the retrofit of Unit 3 are shown in Table 4-1.

Table 4-1: Unit 3 Capital Cost Components, 2017

CO_2 Removal System	\$875 M
CO_2 Compression System	\$158 M
Letdown Turbine	\$15 M
Cooling Water System	\$84 M
Balance of Plant	\$195 M
Total Overnight Cost	\$1,605 M

The total overnight cost (TOC) in Table 4-1 is composed of the sum of the specified capital costs times a multiplier to convert from total plant cost (TPC) to TOC. For purposes of Unit 3 analysis, the total overnight cost represented above is the incremental cost associated with the carbon capture retrofit.

Similarly, the incremental operating expenditures were calculated by considering the characteristics of Unit 3. The additional operating costs were calculated to be approximately \$42M for increased annual fixed O&M costs, and \$12M for increased annual variable O&M costs.

Installation of carbon capture equipment also requires the use of electricity from the power plant to operate the additional capture, compression, and cooling equipment. The electrical parasitic load from this equipment was calculated to be around 82 MW. Additionally, heat from the boiler is required for regeneration of the capture solvent. The de-rate, or loss of power generation capacity, due to the use of steam for absorbent regeneration instead of power generation is estimated to be 139 MW. The total estimated unit de-rate is 221 MW as a result of the implementation of the carbon capture retrofit. The analysis presented here also takes into consideration the shortfall which will be created by the reduction in power capacity due to the carbon capture retrofit, this has commonly been called "replacement power". An estimate of $15/MWh (2017$) was used as the proxy cost for the implementation of replacement power[28].

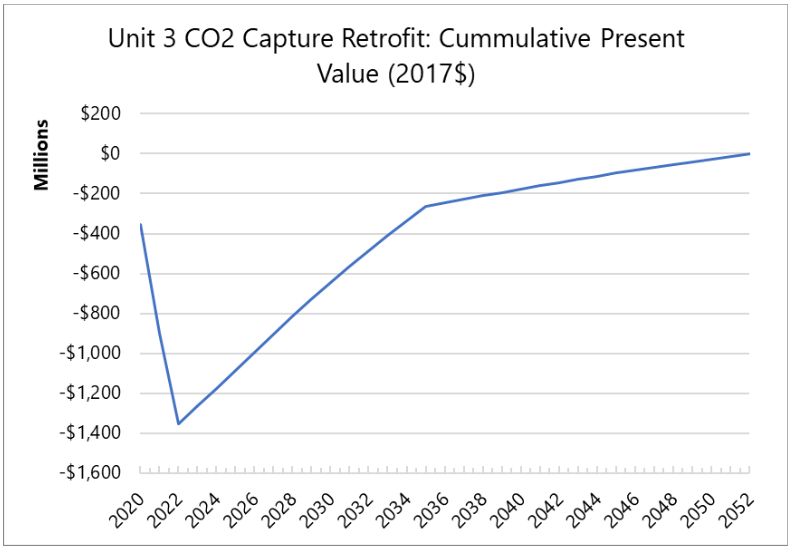

Figure 4-1: Cumulative Present Value for Unit 3 in 2017$

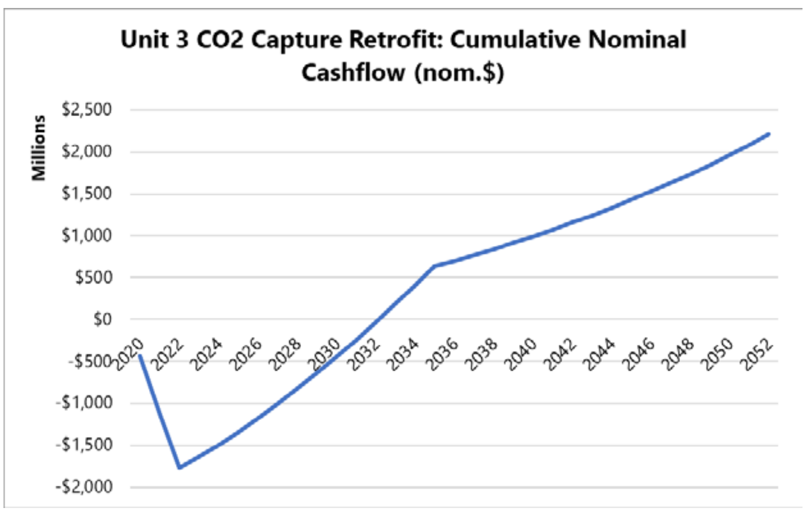

Figure 4-2 Cumulative Nominal Cashflow for Unit 3

A discounted cash flow (DCF) analysis was undertaken to understand how the costs to install the carbon capture retrofit in Unit 3 compares to the revenues that would be generated from the sale of CO_2 and the utilization of the tax incentives under section 45Q. Descriptions of the methodology for assessing the value of the CO_2 and 45Q tax credits were discussed earlier in this report. It is estimated that the monetization of the 45Q along with the sale of CO_2 will account for $5 billion in nominal revenues for Unit 3 from 2020 to 2042. The net-present value of this revenue stream during the years 2020 to 2042 is expected to be around $1.98 billion in constant 2017 dollars.

This project is envisioned to be undertaken under the rules for regulated utilities, and under such rules any windfall from the implementation of a CO_2 capture project will need to be returned to the ratepayers. A mechanism for calculating a reduction on the electricity rate for the power plant was implemented as a potential compliance path. This mechanism works by adding a COE modifier which is used to reduce the final cost of generating electricity by the unit. The use of this mechanism results in a net-zero present value for the CO_2 capture retrofit project by the end of its economic life. Figure 4-1 indicates the cumulative present value for the project by year. Figure 4-2 shows the expected nominal cumulative cashflows for the project.

The results of the DCF analysis points to a feasible scenario in which a carbon capture retrofit project on Comanche's Unit 3 is economically feasible and will lead to excess revenues which can be used for reducing the unit's COE. The excess revenues will be enough to reduce the COE for the power plant by $0.56/MWh (2017$) escalated with inflation each year.

5 CONCLUSIONS

The overall major conclusion is that the CCUS Retrofit Option provides many advantages when compared to the CEP. Mainly, it presents an economically-feasible business opportunity that creates more jobs and results in higher reduction in CO_2 emissions over the CEP.

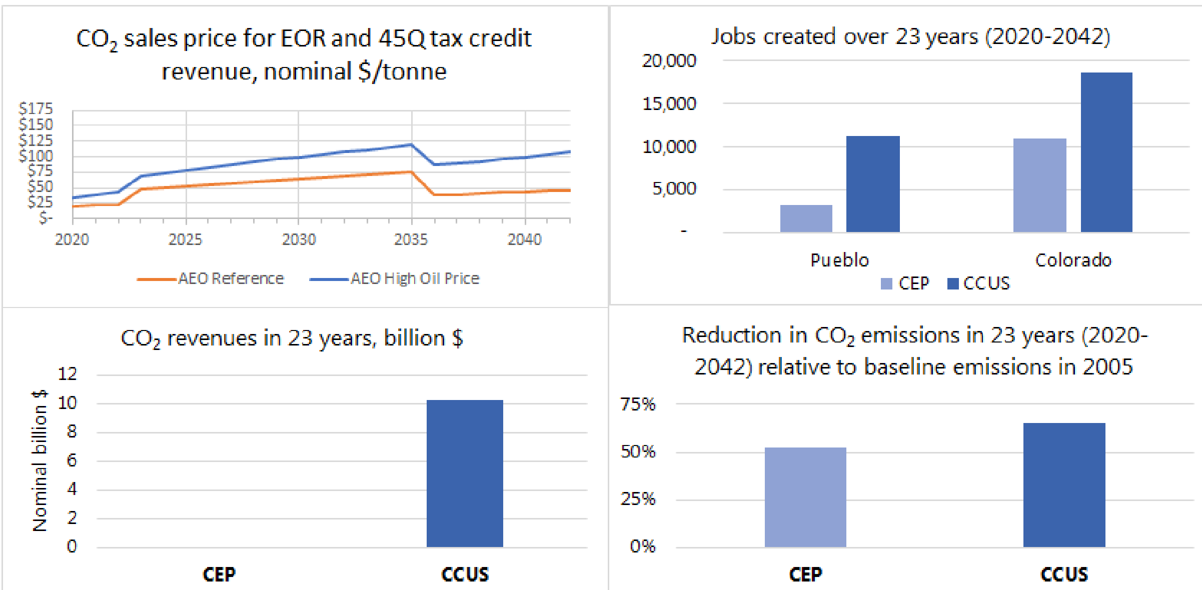

Figure 5-1: Summary of the Major Impacts of the CCUS Retrofit Option compared to the CEP

Source: Management Information Services, Inc., Xcel Energy, University of Colorado, and Leonardo Technologies, Inc.

The CCUS retrofit option, compared to the CEP:

- Reduces CO_2 emissions by 460 MMT (65%) from 2020 to 2042 relative to 2005 emissions. The CEP reduces CO_2 emissions by 369 MMT (52%),
- Generates $10.21 billion in CO_2 revenues
- Creates 11,200 jobs in Pueblo versus 3,100 jobs from CEP,
- Creates 18,600 jobs in Colorado; the CEP creates 13,300 job in Colorado.

In addition, the CCUS retrofit option:

- Increases Pueblo wage and salary earnings by over $500 million,
- Increases Colorado wage and salary earnings by more than $900 million,
- Increases Colorado income tax revenues by over $40 million,

- Increases Pueblo real estate tax revenues nearly 60% -- more than $800 million (the CEP will reduce Pueblo real estate tax revenues),
- Transforms the Pueblo School District from a relatively poor one to one of Colorado's wealthiest.

A summary of some of the major differences in expected impacts of the CCUS Retrofit Option compared to the expected impacts of the CEP is given in Figure 5-1.

The analysis results demonstrate the CCUS Retrofit Option:

1. Delivers lower-cost power for Xcel customers,
2. Takes advantage of 45Q tax incentives,
3. Accelerates the transformation to a low-CO_2 economy,
4. Generates significant economic development in Pueblo and Colorado,
5. Provides significant CO_2 reductions, and,
6. Continues progress Colorado has made on cleaner air and reduces its carbon footprint.

The benefits of CCUS Retrofit Option appear to support further investigation. A more detailed engineering analysis would need to be accomplished to better understand the specific plant details. Because Units 1 and 2 are slated for early retirement, it may be beneficial to accomplish a more detailed analysis of the retrofit focusing exclusively on Unit 3.

6 ACKNOWLEDGMENTS

This report was prepared by LTI and MISI for the Office of Advanced Fossil Technology Systems, Office of Energy for the United States Department of Energy (DOE). This work was completed under DOE Contract Number GS-23F-0231R, order number DE-FE0022594; DE-BP0005230.

The authors also wish to acknowledge and express sincere gratitude to all those who assisted and supported the efforts and preparation of this report including:
National Energy Technology Laboratory, DOE Office of Fossil Energy, Management Information Services Inc. (MISI), Leonardo Technologies, Inc., Deloitte Consulting, LLP

APPENDIX

LEONARDO TECHNOLOGIES, INC.

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[1] The University of Colorado's study used a 23 year time period to assess the economic impacts of the CEP. The impacts of the CCUS retrofits were also estimated using a similar time period.

[2]"EVRAZ Rocky Mountain Steel," Pueblo, Colorado, https://www.evrazna.com/LocationsFacilities/RockyMountainSteelMills/tabid/71/Default.asp.
[3]"Comanche Generating Station," Xcel Energy, https://www.xcelenergy.com/energy_ portfolio/ electricity/ power_plants/Comanche. Capacity in this section refers to the unit's summer generation capacity
[4]Ibid.
[5]"Xcel Energy, Other Groups Unveil Colorado Energy Plan," press release, Excel Media Relations, Denver, Colorado, August 29, 2017.
[6]Xcel Energy, "Colorado Energy Plan, Fall 2018 Update," Information Sheet, 2018.
[7]Allen Best, "How Will Xcel Achieve Carbon-Free Emissions by 2050?" *Colorado Independent*, December 8, 2018; Allen Best, "Xcel Energy Wants to Deliver Carbon-Free Electricity by 2050. Can Capturing Power Plant Emissions Help it Get There?" *Colorado Independent*, December 7, 2018.
[8]Deepan Dutta, "Xcel Energy, Colorado's Largest Utility, Committed to Going 100 Percent Carbon-Free by 2050, *Summit Daily*, December 6, 2018, https://www.summitdaily.com/news/xcel -energy-colorados-largest-utility-committed-to-going-100-percent-carbon-free-by-2050/.
[9]See, for example, Leonardo Technologies, Inc., "Colorado CO_2 Resource Study," prepared for the U.S. Department of Energy, November 2018; Peter Folger, "Carbon Capture and Sequestration (CCS) in the United States," Congressional Research Service, August 9, 2018; U.S. Geological Survey, "Carbon Sequestration to Mitigate Climate Change," https://pubs.usgs.gov/fs/2008/3097/pdf/CarbonFS.pdf; Gokhan Aydin, Izzet Karakurt, and Kerim Aydiner, "Evaluation of Geologic Storage Options of CO_2: Applicability, Cost, Storage Capacity and Safety," *Energy Policy*, Special Section on Carbon Emissions and Carbon Management in Cities with Regular Papers. Vol. 38, No. 9 (2010) pp.5072–5080.
[10]"Comanche Generating Station, https://energynews.us/2018/12/04/west/xcel-energy-has-an-ambitious-climate-plan-will-carbon-capture-be-part-of-the-solution/

[11] https://colorado.gov/pacific/sites/default/files/AP_PO_Comanche-1-2-Power-Plant_0.pdf
[12]Isaac Orr, "Colorado Must Keep the Comanche Power Plant Running at Full Steam," Heartland Institute, April 9, 2018.
[13]Grace Hood, "Coal-Fired Past or Green-Powered Future? Pueblo Looks For a New Economic Leg Up," Colorado Public Radio, July 30, 2018.
[14]https://www.payscale.com/research/US/Location=Pueblo-CO/Salary. The 2017 average mean wage for all occupations in Pueblo was $44,030; the 2017 average mean wage for all occupations in Colorado was $54,050. Sources: U.S. Bureau of Labor Statistics, Occupational Employment Statistics, May 2017 Metropolitan and Nonmetropolitan Area Occupational Employment and Wages Estimates, March 30, 2018, https://www.bls.gov/oes/2017/may/oes_39380.htm#00-0000; U.S. Bureau of Labor Statistics, Occupational Employment Statistics, May 2017 State Occupational Employment and Wage Estimates – Colorado, https://www.bls.gov/oes/2017/may/oes_co.htm

[15]Xcel refers to the BAU scenario as the Preferred Electric Resource Plan (ERP 450 MW).
[16]Xcel refers to the CEP scenario as the Preferred Colorado Energy Plan (CEP 1110MW – Preferred #6)
[17]Xcel Energy, "Xcel Energy, other groups unveil Colorado Energy Plan," Denver, Colorado, August 29, 2017; Xcel Energy, "Colorado Energy Plan, Fall 2018 Update," Information Sheet, 2018.
[18]"Colorado Energy Plan, Fall 2018 Update," op. cit.
[19]Ibid. and Xcel Energy, "2017 All Source Solicitation 30-Day Report," https://www.xcelenergy.com/company/rates_ and_regulations/resource_plans/psco_2017_all_source_solicitation.
[20]Ibid.
[21]"Colorado Energy Plan, Fall 2018 Update," op. cit.

[22]Ibid.

[23] Mission Execution and Strategic Analysis (MESA), CO_2 Capture Technology – Cost of Retrofit for Power Generation and Industrial Sources, August 2018.

[24] Appendix G: 2016 Electric Resource Plan Modeling Assumptions Update, CPUC Proceeding No. 16A-0396E, August 2017

[25]See Management Information Services, Inc., "Employment Impact Analysis of Coal Carbon Capture and Sequestration Retrofits," prepared for NETL, August 2015.

[26] The value of 1.21 was derived from NETL's Power Systems Financial Model (PSFM)

[27] See, for example, Proceeding 16A-0396E – Staff Comments on PSCo's 2018 120-Day Report, Public Version, July 23, 2018

[28] No makeup power cost was assigned to Units 1 and 2 because of their stated retirement; there would be no opportunity cost of missed generation arising from the use of power for CO_2 capture and compression. Makeup cost of $15/MWh is based on Xcel's 2016 and 2017 avoided cost data (average hourly incremental cost of electricity, AHIC) of $13.55/MWh -see 2017 Renewable Energy Standard Compliance Report, Public Service Company of Colorado, June 2018, Proceeding No. 16A-0139E

[29] Appendix L, Proceeding No. 16A-0396E.

[30]U.S. Energy Information Administration, *Annual Energy Outlook 2018*, op. cit.

[31]Another market for CO_2 in Colorado could be the oilfields in the northeastern part of the State.

[32] Melzer, S., New Business Intersections: How 45Q Interplays with ROZs, 45Q and CO_2 EOR's Vital Role in Carbon Management, and ROZ CO_2 EOR Seminar, 2018 CO_2 & ROZ Conference Week, Midland, Texas, December 2018.

[33]Leonardo Technologies, Inc., "Colorado CO_2 Resource Study," report for the Office of Advanced Fossil Technology Systems, Office of Energy, U.S. Department of Energy, November 2018.

[34]Ibid., costs here refer to operational and fuel expenses

[35]Ibid.

[36] This assumes 85% 45Q credit monetization, and 12-years of tax credit.

[37]Here, it is assumed that all of the CO_2 is transported out of the state of Colorado. However, if a CO_2 pipeline was constructed to the oil fields in northeastern Colorado, then Colorado would receive the revenues from the CO_2 sales.

[38]Leonardo Technologies, Inc., op. cit.

[39]CO_2 production from Sheep Mountain peaked at 35 Bscf/y in 1988 and has been declining subsequently. Leonardo Technologies, Inc., op. cit.

[40]Colorado Oil and Gas Commission, http://cogcc.state.co.us/COGCCReports/production.Aspx?id= MonthlyCO2SalesByCounty.

[41]U.S. Environmental Protection Agency, "EPA Envirofacts," 2017, https://www3.epa.gov/enviro/facts/ghg/search.html

[42] https://cogcc.state.co.us/data.html#/cogis

[43] *https://www.eia.gov/outlooks/aeo/*

[44]Simulations were conducted using the EIA Reference and High Oil Price scenarios.

[45]For interstate pipelines a 3 year construction period would be assumed.

[46] FE/NETL CO_2 Transport Cost Model (2018), DOE/NETL-2018/1876, https://www.netl.doe.gov/energy-analysis/details?id=543

[47] http://pages.stern.nyu.edu/~adamodar/

[48]Metric tonnes.

[49] The median price represents a price where half of the bids received for that technology are priced lower and the other half are priced higher, and may not represent the average bid price.

[50] Decision No. C18-0191, Before The Public Utilities Commission Of The State Of Colorado, Proceeding No. 16A-0396E, *In The Matter Of The Application Of Public Service Company Of Colorado For Approval Of Its 2016 Electric Resource Plan: Decision Allowing For Presentation Of The Clean Energy Plan Portfolio In Phase II, Requiring Presentation Of Additional Resource Portfolios, Specifying Additional Modeling Requirements, And Establishing Other Requirements*, March 2018

[51] Public Service Company of Colorado, 2016 Electric Resource Plan: 2017 All Source Solicitation 30-Day Report (Public Version), CPUC Proceeding No. 16A-0396E

[52]Ibid.

[53] Appendix O: Portfolio Emissions Results, Proceeding No. 16A-0396E

[54] The baseline, Xcel fleet-wide CO_2 emission value for 2005 is ~33.9 MMst. The BAU (Preferred ERP) has emissions reductions of 47% in 2026 (i.e., when both Units 1 and 2 are operating as usual, with higher gas generation and more renewables). CO_2 emissions in the BAU scenario are 33.9*(1-0.47) MMst or ~18 MMst = 16.3 MM metric tonnes (MMT).

To estimate the fleet-wide CO_2 emissions in the CCUS scenario on Units 1 to 3, the CO_2 captured from Units 1 and 3 are deducted from the above number (9.31 MMT, assuming that the 2026 capacity factors for Units 1 and 2 used by Xcel are similar to the ones used in the analysis - 75% for units with CCUS). The fleet-wide CO_2 emissions in the Units 1 to 3 CCUS retrofit scenario is: 16.31 - 9.31 = 6.99 MMT. The 2026 CO_2 reductions in the CCUS retrofit scenario over the 2005 fleet-wide baseline is 79%

[55]These related studies include the following: Management Information Services, Inc., "Estimates of the Jobs Likely to be Generated by the 2018 Enacted 45Q Legislation Compared to Those Likely From the 2017 Proposed CCUS Tax Credits," prepared for the National Energy Technology Laboratory, November 2018; Roger H. Bezdek, "The Economic and Job Benefits of U.S. Coal," presented at the American Coal Council 2018 Spring Coal Forum Clearwater Beach, Florida, March 8, 2018; Management Information Services, Inc., "Analyzing the Economic and Job Impacts of the DOE R&D Program and CCS Tax Credits," prepared for the National Energy Technology Laboratory (NETL), DOE contract DE-FE 0025912, January 2018; Management Information Services, Inc., "Analyzing and Estimating the Economic and Job Benefits of U.S. Coal," prepared for the U.S. Department of Energy, September 2017; Management Information Services, Inc., "Employment Impact Analysis of Coal Carbon Capture and Sequestration Retrofits," prepared for National Energy Technology Laboratory, August 2015; Roger H. Bezdek and Robert M. Wendling, "The Return on Investment of the Clean Coal Technology Program in the USA," *Energy Policy*, March 2013, Vol. 54, pp. 104-112; Management Information Services, Inc., "Estimates of The Jobs and Economic Benefits Resulting From the Capacity Build-Out and Oil Production Associated With the FE Technologies/EOR Market Snapshot, 2020-2100," prepared for the National Energy Technology Laboratory, September 2012; Roger H. Bezdek "Economic, Employment, and Energy Stimulus From Clean Coal Technology Deployment," chapter 2 in *Harnessing Coal's Carbon Content to Advance the Economy, Environment, and Energy Security*, National Coal Council, Washington, D.C., June 2012; Roger H. Bezdek and Robert M. Wendling, "Economic, Environmental, and Job Impacts of Increased Efficiency in Existing Coal-Fired Power Plants," *Journal of Fusion Energy*, 2012; Roger H. Bezdek and Robert M. Wendling, "Costs and Benefits of U.S. Government Investments in Clean Coal Technology: Implications For Europe," presented at GeoDarmstadt 2010 – 8th European Coal Conference, Darmstadt, Germany, October 2010. Also, see http://misi-net.com/.

[56]"Economic Impacts of the Preferred Colorado Energy Plan," a consulting research study conducted for Xcel Energy by the Business Research Division, Leeds School of Business, University of Colorado Boulder, June 20, 2018.

[57]Regional Economic Models, Inc. (REMI). Amherst, Massachusetts, https://www.remi.com/.

[58]The REMI model used for this analysis is the Policy Insight (PI+) model 2.1.6 two-region model for Pueblo County and the Rest of Colorado, with 2015 data as the last historical year within the model. RIMS II Multipliers (2010/2010), Table 2.5 Total Multipliers for Output, Earnings, Employment, and Value Added by Industry Aggregation PSEG Economic Impact Area (Type II), https://www.nrc.gov/docs/ML1326/ML13262 A071.pdf.

[59]The UOC study was published in June 2018, but the final price deflators necessary to derive 2018 dollars are not expected to be available until 2019. Thus, we are assuming that UOC used an alternate methodology to estimate the expected 2018 deflators.

[60]Management Information Services, Inc., *Economic and Employment Impacts of Increased Efficiency in Existing Coal-Fired Power Plants*, report prepared for the U.S. Department of Energy, National Energy Technology Laboratory, DOE/NETL-41817M4462, June 2009; Management Information Services, Inc., *Development of Economic and Job Impacts Analysis Tool and Technology Deployment Scenario Analysis*, op. cit.; and Management Information Services, Inc., "Employment Impact Analysis of Coal Carbon Capture and Sequestration Retrofits," prepared for National Energy Technology Laboratory, op. cit.

[61]See Ernst & Young, "Estimated Economic and Fiscal Impacts of the Kemper County IGCC Project," report prepared for the Mississippi Development Authority, March 2009; "Petition of Mississippi Power Company For a Certificate of Public Convenience and Necessity Authorizing the Acquisition, Construction, and Operation of an Electric Generating Plant, Associated Transmission Facilities, Associated Gas Pipeline Facilities, Associated Rights-Of-Way, and Related Facilities In Kemper, Lauderdale, Clarke, and Jasper Counties, Mississippi," Final Order on Remand Granting a Certificate of Public Convenience and Necessity, Authorizing Application of Baseload Act, and Approving Prudent Pre-Construction Costs, Before The Mississippi Public Service Commission Mississippi Power Company Docket No. 2009-Ua-014 Ec-120-0097-00; Jeff Byrd, "Kemper Co. Looks to Implement Portera Plan," *The Meridian Star*, February 22, 2015; Jeff Byrd, "Mississippi Power Officials Tout Benefits of Kemper Plant," *The Meridian Star*, April 5, 2015; SaskPower, "SaskPower Boundary Dam Carbon Capture Project," https://www.saskpower.com/our-power-future/infrastructure-projects/carbon-capture-and-storage/boundary-dam-carbon-capture-project;
Suzanne Goldenberg, "Canada Switches on World's First Carbon Capture Power Plant Boundary Dam Held up as First Commercial-Scale CCS Plant and Proof That Coal-Burning is Compatible With Cutting Emissions," *The Guardian*, October 1, 2014; Jesse Jenkins, "Financing Mega-Scale Energy Projects: A Case Study of the Petra Nova Carbon Capture Project," prepared for the CEO Council for Sustainable Urbanization, October 2015; Sonal Patel, "Capturing Carbon and Seizing Innovation: Petra Nova is Power's Plant of the Year," *Power*, August 2017; "Public Direct Testimony of Ralph C. Smith on Behalf of Citizens Action Coalition of Indiana, Inc., Hoosier Chapter of the Sierra Club, Save the Valley, Inc., and Valley Watch, Inc.," in Verified Petition of Duke Energy Indiana, Inc. Seeking (1) Approval of an Ongoing Review Progress Report: Pursuant to Ind. Code 8-1-8.5 and 8-1-8.7 and (2) Authority to Reflect Costs: Incurred for the Edwardsport Integrated Gasification Combined Cycle Generating Facility ("IGCC Project") Cause No.43114-IGCC-12/13 Property Under Construction in its Rates and Authority to Recover Applicable Related Costs and Credits Through its Integrated Coal Gasification Combined Cycle Generating Facility Cost Recovery Adjustment, Standard Contract Rider No. 61 Pursuant to Ind. Code §§ 8-18-.8-11, December 15, 2014; "Petition of Mississippi Power Company For Finding of Prudence In Connection With the Kemper County Integrated Gasification Combined Cycle Generating Facility, Response to Surrebuttal Filing in Support of Prudence," Before the Mississippi Public Service Commission, Mississippi Power Company Docket No. 2013-Ua-189 Ec-120-0097-00; David Schlissel and Dennis Wamsted, "Holy Grail of Carbon Capture Continues to Elude Coal Industry," Institute for Energy Economics and Financial Analysis, November 2018; Roger H. Bezdek, "Economic, Employment, and Energy Stimulus From Clean Coal

Technology Deployment," chapter 2 in *Harnessing Coal's Carbon Content to Advance the Economy, Environment, and Energy Security*, National Coal Council, Washington, D.C., June 2012; Management Information Services, Inc., "Analyzing the Economic and Job Impacts of the DOE R&D Program and CCS Tax Credits," prepared for the NETL, DOE contract DE-FE 0025912, January 2018; Management Information Services, Inc., "Estimating the Economic and Job Benefits of NETL Coal R&D Programs," prepared for the NETL, August 2017; Management Information Services, Inc., "Employment Impact Analysis of Coal Carbon Capture and Sequestration Retrofits," prepared for the N, August 2015; Management Information Services, Inc., *Literature Review of Employment Impact Studies of Power Generation Technologies*, report prepared for the U.S. DOE, NETL, DOE/NETL-41817M4462, April 2009; Management Information Services, Inc., "Analyzing and Estimating the Economic and Job Benefits of U.S. Coal," prepared for the U.S. DOE, September 2017.

[62]Ibid.

[63]U.S. Bureau of Economic Analysis, "GDP Price Deflator," https://www.bea.gov/data/prices-inflation/gdp-price-deflator.

[64]The IPD, compiled by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce, is a by-product of the deflation of GDP, and is derived as the ratio of current-to-constant-dollar GDP (multiplied by 100). It is the weighted average of the detailed price indices used in the deflation of GDP, but they are combined using weights that reflect the composition of GDP in each period.

[65]
https://www.eia.gov/opendata/qb.php?category=2641425&sdid=AEO.2018.REF2018.ECI_INDX_NA_NA_GDP_NA_NA_Y09EQ1D3Z.A

[66]
https://web.archive.org/web/20120928112059/http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Full-time_equivalent.

[67] Ibid.

[68]The basic MISI methodology and model are documented in Management Information Services, Inc., *Development of Economic and Job Impacts Analysis Tool and Technology Deployment Scenario Analysis*, report prepared for the U.S. Department of Energy, National Energy Technology Laboratory, DOE/NETL-402/092509, September 2009. For applications, see Management Information Services, Inc., "Two Thirds of a Century and $1Trillion+ U.S. Energy Incentives: Analysis of U.S. Expenditures for Energy Development, 1950-2016," prepared for the Nuclear Energy Institute, May 2107; Roger Bezdek and Robert Wendling, "Economic, Environmental, and Job Impacts of Increased Efficiency in Existing Coal-Fired Power Plants," *Journal of Fusion Energy*, Volume 32, Number 2 (April 2013), pp. 215-220; Roger Bezdek, "Maximum Burden: The Electricity Price Increases From the Proposed EPA Utility MACT Will Act as a Regressive Tax on the Elderly," *Public Utilities Fortnightly*, December 2012.

[69]U.S. Energy Information Administration, *Annual Energy Outlook 2018*, February 2018; U.S. Energy Information Administration, *Annual Energy Outlook 2017*, January 2017.

[70]See also U.S. Department of Commerce, Bureau of Economic Analysis, "Regional Economic Accounts, Gross Domestic Product," http://www.bea.gov/regional/index.htm; Melissa Thevenin and Jonathan Elliott, "Economic Impacts of the Construction Industry on the State of Colorado," Department of Construction Management, Colorado State University, January 2015; U.S. Energy Information Administration, "Colorado State Profile and Energy Estimates," http://www.eia.gov/state/?sid=CO.

[71]https://www.bls.gov/eag/eag.co_pueblo_msa.htm.

[72]Grace Hood, "Coal-Fired Past or Green-Powered Future? Pueblo Looks For a New Economic Leg Up," op. cit.

[73]Ibid. and https://www.payscale.com/research/US/Location=Pueblo-CO/Salary.

[74]Based on current Colorado State tax rates. See https://leg.colorado.gov/agencies/legislative-council-staff/individual-income-tax%C2%A0; Colorado Legislative Council Staff, "Economic & Revenue Forecast," December 2018, http://leg.colorado.gov/EconomicForecasts.

[75]This is potentially a significant factor. For example, the Shoreham Nuclear Power Station in New York State was under construction during the 1970s and 1980s. Even though it never even opened, the taxes Shoreham paid for nearly two decades made the local school district one of the wealthiest in the U.S., and the Shoreham case was a landmark in litigation concerning property tax assessments of power facilities. MISI staff were deeply involved for years in the extensive litigation that resulted from the property tax assessment of the Shoreham plant. See Long Island Lighting Co. v. Assessor and Bd. of Assessment Review for Town of Brookhaven," 246 A.D.2d 156 (2d Dep't 1998).

[76]See Pueblo County Office of Budget and Finance, "Pueblo County Comprehensive Annual Financial Report For The Year Ending December 31, 2017," June 22, 2018; Pueblo County School District 70, Department of Business Services, "Adopted Budget, Fiscal Years 2018-19," 2018; Colorado Legislative Council Staff, "Economic & Revenue Forecast," op. cit..

[77]As noted, the taxes paid by the Shoreham Power Station in New York made the local school district one of the wealthiest in the U.S.