Operation of Comanche 3 and Pawnee

Alternatives to PSCo's Electric Resource Plan Modeling

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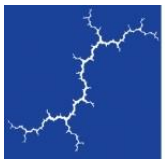
AUTHORS

Divita Bhandari
Jason Frost
Rachel Wilson



Synapse
Energy Economics, Inc.

485 Massachusetts Avenue, Suite 3
Cambridge, Massachusetts 02139

617.661.3248 | www.synapse-energy.com

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1. INTRODUCTION

Public Service Company of Colorado (PSCo) submitted its 2021 Electric Resource Plan (ERP) and Clean Energy Plan (CEP) on March 31, 2021, docketed as Colorado Public Utilities Commission (PUC) Proceeding No. 21A-0141E. To develop its preferred resource portfolio, PSCo used an electric system model called EnCompass to examine different scenarios. EnCompass is a capacity expansion and production cost model licensed from Anchor Power Solutions. The Colorado Energy Office (CEO) retained Synapse Energy Economics, Inc. (Synapse) to model additional alternative scenarios using the EnCompass model. At CEO's direction, Synapse modeling focused on baselining our work against Xcel's current modeling approach and then evaluating alternatives consistent with the goals of the state's *Greenhouse Gas Pollution Reduction Roadmap.*[1] These alternatives would achieve earlier emissions reduction, deeper reductions by 2030, or both. The baseline used for this analysis is PSCo's CEP Preferred Plan (SCC 7) as outlined in the utility's Electric Resource Plan. PSCo provided the EnCompass input files for the analysis as part of its supplemental filing on July 16, 2021.

The Preferred Plan assumed the following:

- Retirement of the Comanche 3 coal unit (Comanche 3) by end of year 2039;
- Reduced operation of Comanche 3 starting in 2030 with a 10 percent minimum and 33 percent cap on annual energy generation;
- Conversion of the Pawnee coal unit to gas by end of year 2027; and
- A social cost of carbon (SCC) calculated using a discount rate of 3 percent, included in the capacity expansion run only

At CEO's direction, the Synapse modeling evaluated the impact of the following changes to inputs and parameters, both individually and in different combinations:

- Removal of the "must run" requirement[2] at Comanche 3 starting January 1, 2025 with no annual dispatch minimum or dispatch cap;
- Alternative Comanche 3 retirement dates of end of year 2029 and end of year 2035;
- Retirement of the Pawnee unit at the end of 2028 rather than a conversion to gas; and

[1] *Greenhouse Gas Pollution Reduction Roadmap, See https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap*

[2] Application of a must-run requirement forces a unit to run at the economic minimum (in megawatts) set by the modeler. Removal of this must-run requirement allows a unit to dispatch economically in all hours, subject to unit commitment constraints.

- A higher social cost of carbon (SCC) value, discounted at 2.5 percent as opposed to 3 percent, included in the capacity expansion run and production cost modeling steps.

This report describes the overall modeling process, summarizes the scenarios evaluated, and details the results from the analysis—including system-wide greenhouse gas (GHG) emissions and revenue requirements.

2. OPTIMIZATION PARAMETERS

The optimization parameters within EnCompass determine the level of detail and associated complexity with which the model attempts to solve the problem. In its capacity expansion runs, PSCo optimizes for all years in its analysis period of 2024–2050 in a single run. This means that the model makes resource decisions in earlier years with perfect foresight, considering changes to input values that do not occur until later years. In its production cost runs, PSCo modeled all 365 calendar days in each year, rather than using one or more "representative" days and extrapolating those results to the rest of the days in the year.

In the Synapse analysis, we had to adjust certain of these optimization parameters to allow for faster model run times. The primary adjustments involved two EnCompass settings: optimization period and unit commitment. To properly account for the changes to the optimization parameters and allow for an "apples-to-apples" comparison between scenarios, Synapse modeled PSCo's Preferred Plan with the updated parameters and then tested alternative scenarios against the results of that plan. As a result of this, the effects of specific changes to input assumptions should not be evaluated in relation to PSCo's modeled scenarios, but to the Synapse scenarios. However, the results of the Synapse modeling and PSCo modeling can be compared in terms of the direction and magnitude of the emissions reductions and the net present value of revenue requirements (NPVRR) of the various portfolios.

2.1. Optimization Period

The EnCompass "optimization period" determines the period over which the model attempts to solve the problem. Evaluating the optimal build-out and dispatch of generation resources is substantially more calculation intensive for longer (e.g., 30 years versus 10 years) and more granular (e.g., hourly versus on/off peak) time horizons.

Capacity Expansion Runs

As mentioned above, PSCo optimizes for all years in its analysis period from 2024 to 2050 in a single model run, thus using a 26-year optimization period. Though optimal with sufficient time and computational resources, this longer optimization period was not feasible for our analysis due to time constraints. We broke the problem down into periods of six years with three-year extension periods,

which means that the model solved the problem based on a total of nine years of data at a time (six years of the current optimization period plus three years of the following optimization period). Including three years from the following period in each optimization is helpful because it gives the model more foresight to make better decisions about resource builds and retirements during the six-year optimization period.

Production Cost Runs

In the production cost runs, PSCo modeled all 365 calendar days in the year, one year at a time. To accelerate the runs, we instead modeled 30-day segments with 14-day extension periods. This adjustment significantly increased the speed of the runs while sacrificing little optimization accuracy (variables more than 14 days in the future rarely have a large effect on daily dispatch patterns). However, by not running the model over a year or more at a time, it was no longer possible to enforce annual constraints such as annual generation constraints or annual environmental limits (note that this does not apply to build and retirement constraints, which are enforced in the capacity expansion run). Despite not being enforced in the model, the environmental limits are still met in the production cost runs because the limits were enforced in the prior capacity expansion (in which the model added new resources to ensure compliance with these types of constraints). The primary annual constraint that needed to be removed was the 10 percent minimum dispatch limit on Comanche 3, which forces the unit to generate at more than 10 percent of its capacity each year. The result of this adjustment is that the model can select to run the Comanche 3 unit less and therefore it may produce less energy in the CEO scenarios than is allowed in the PSCo modeling.

2.2. Unit Commitment

Generation resources often have operational constraints that can be incorporated into capacity expansion and production cost models, but including these constraints increases the complexity of the optimization problem. These limits include minimum generation capacity, ramp rates, minimum run time, and minimum down time. In EnCompass, these can be entirely modeled (Full Commitment), partially modeled (Partial Commitment), or entirely excluded (No Commitment). Partial Commitment respects minimum run time, down time, and ramp rates. However, it allows for fractions of a generation unit to be turned on, which can result in generators producing electricity below their minimum capacity.

Capacity expansion runs are more computationally intensive because they determine both resource builds and dispatch simultaneously. As a result, these runs sometimes use less detailed commitment settings, particularly if they are being accompanied by more detailed production cost runs as they are here. PSCo's modeling runs used the Partial Commitment setting in its capacity expansion runs, which we adjusted to No Commitment in our analysis. We used this setting because the goal of the capacity expansion runs is to determine resource addition and retirement decisions. Unit commitment settings tend to have the greatest impact on more granular results, such as hourly energy prices, which we derive from the production cost runs. Relaxing the unit commitment settings in the capacity expansion, as we did, may make fossil units appear more flexible (and valuable) than they are. We mitigated this impact by keeping PSCo's must-run settings in place for Comanche 3 through 2030 in all capacity

expansion runs, even though this setting was lifted in most production cost runs. We maintained PSCo's Partial Commitment setting in our production cost runs, however, to more accurately determine how the selected generation fleet would operate and to model the associated costs.

3. INPUT ASSUMPTIONS AND SCENARIOS

As requested by CEO, the Synapse modeling largely examined the effects of changed input assumptions on the operation of PSCo's Comanche 3 and Pawnee units, evaluating the impact of the following changes through scenario analysis:

- Removal of the must-run requirement at Comanche 3 coal unit starting January 1, 2025;
- Alternative Comanche 3 retirement dates of end of year 2029 and 2035;
- Retirement of the Pawnee unit at the end of 2028 in lieu of gas conversion; and
- A higher social cost of carbon value, discounted at 2.5 percent as opposed to 3 percent, included in the capacity expansion and production cost modeling runs.

3.1. PSCo Baseline

The baseline used for CEO's analysis of the operation of Comanche 3 is PSCo's Preferred Plan (SCC 7), as it is described in the Company's Supplemental Direct Filing. The EnCompass input files for the analysis were provided as part of the Supplemental Direct Filing on July 16, 2021.

In relation to Comanche 3 and Pawnee, PSCo's SCC 7 baseline scenario includes:

- Retirement of Comanche 3 at the end of 2039;
- Reduced operation of Comanche 3 starting in 2030 with a 10 percent minimum and 33 percent cap on annual energy generation;
- Conversion of the Pawnee coal unit to gas at the end of 2027; and
- A social cost of carbon calculated using a discount rate of 3 percent applied to the capacity expansion modeling step only

In addition, the modifications from the Supplemental Direct Filing included the following:

- Updates to the Comanche 3 operations and maintenance (O&M) costs based on the Staff Report in Proceeding No. 20I-0437E
- Updates to the Comanche 3 Availability Factor based on the Staff Report in Proceeding No. 20I-0437E

Synapse tested a number of scenarios that vary the four specific input assumptions described above, both individually and in combination. Below is a comparison of the scenarios tested and key scenarios from PSCo's modeling.

Table 1. Matrix of modeled scenarios and underlying input assumptions

	SCC 7	PSCo Baseline	CEO Baseline	CEO 1	CEO 2	CEO 3	CEO 4	CEO 5	CEO 6	CEO 7	CEO 8
SCC Discount Rate	3%	3%	3%	3%	3%	3%	2.5%	2.5%	2.5%	2.5%	2.5%
SCC Application	Capacity expansion		Capacity expansion and production cost modeling								
Comanche 3 Retirement	EOY 2039	EOY 2039	EOY 2039	EOY 2039	EOY 2029	EOY 2035	EOY 2039	EOY 2029	EOY 2035	EOY 2039	EOY 2028
Comanche 3 Dispatch	Must run to 2030, 33% reduce operations 2030 onwards		Must run to 2030, economic dispatch 2030 onwards	Economic dispatch starting January 1, 2025							
Comanche 3 O&M and Availability Factor	As it appears in Direct Filing	Updated to Reflect Staff Report									
Pawnee Retirement	EOY 2041									EOY 2028	
Pawnee Gas Conversion	EOY 2027									No Gas Conversion	
Optimization Parameters	Same as Direct Filing		Updated Optimization Period and Unit Commitment								

3.2. CEO Baseline

Synapse created the CEO Baseline, which is like PSCo's Preferred Plan (SCC 7) in the Supplemental Direct Filing but includes specific modifications made to the optimization parameters as described in the Optimization Parameters section above**.**

In comparison with PSCo's baseline, the following inputs were changed for CEO's baseline:

- Revised optimization parameters (discussed above)
- Removal of the 10 percent minimum and 33 percent cap for Comanche 3 annual energy generation
- Application of the SCC in both the capacity expansion and production cost modeling steps.

The resulting GHG emissions are presented below in Figure 1.[3] The drop in emissions between 2025 and 2028 is driven by coal retirements on the system, including Craig 1, Craig 2, Hayden 1, and Hayden 2. The results also reflect the conversion of the Pawnee coal unit to gas at the end of 2027. Comanche 3 is

[3] Note that all emissions are presented in short tons.

the only coal unit that remains on the system beyond 2028 and runs with the 10 percent minimum and 33 percent cap through the end of 2039.

Due to the modifications made to the optimization parameter settings for purposes of modeling within required time constraints, the CEO Baseline is not identical to PSCo Baseline. For illustration, we have presented a comparison of the results of the two baselines in Figure 1 below.[4] In comparison with the PSCo Baseline, the emissions from the CEO Baseline are lower. This is likely driven by the modifications in the optimization parameter settings, which includes removal of the 10 percent minimum annual energy generation from Comanche 3 and in the application of the social cost of carbon in the production cost modeling run.

Figure 1. CO_2 emissions, CEO Baseline compared to PSCo Baseline

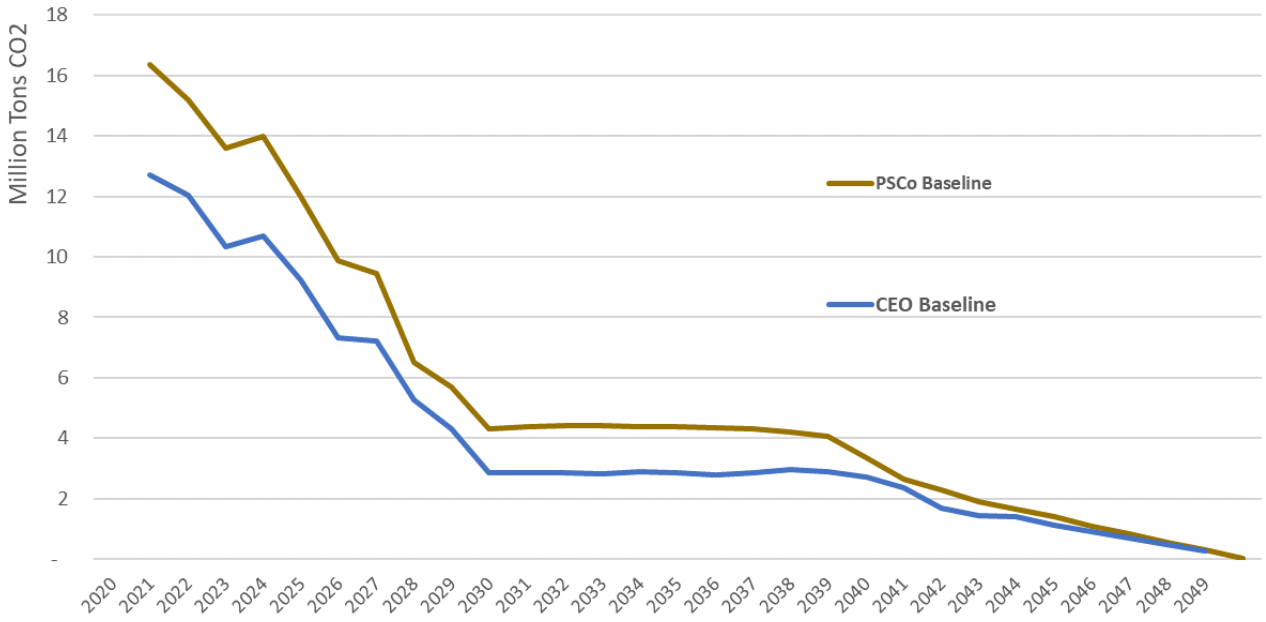


Figure 2 shows the capacity factor for Comanche 3 in the CEO Baseline. [redacted]

[4]All results from the PSCo Baseline were taken from attachment 21A-0141E _Landrum Suppl_Highly Confidential Workpaper_03_EO - SCC Com 3 Cost update_071621, Scenario C3 Staff_P3C3_Paw Gas-C3 39 Red_SCC_PC_No CO2

[redacted]

[redacted]

[redacted]

4. COMANCHE 3 EVALUATION

Synapse ran seven different alternative modeling scenarios, including the CEO Baseline and CEO 1 through CEO 6, that examine either removal of the must-run designation at Comanche 3, early retirement of that unit, or both as described below:

- Removal of the must-run requirement at Comanche 3 coal unit starting in 2025 with no annual dispatch minimum or dispatch cap;
- Alternative Comanche 3 retirement dates of end of year 2029 and end of year 2035;
- A higher social cost of carbon value, discounted at 2.5 percent as opposed to 3 percent.

Table 2, below, shows each of the scenarios relating to Comanche 3 and their specific input assumptions.

Table 2. Comparison of modeled scenarios that change inputs related to Comanche 3

	CEO Baseline	CEO 1	CEO 2	CEO 3	CEO 4	CEO 5	CEO 6
Comanche 3 Retirement	EOY 2039	EOY 2039	EOY 2029	EOY 2035	EOY 2039	EOY 2029	EOY 2035
Comanche 3 Dispatch	Economic dispatch starting in 2025						
Pawnee Retirement	EOY 2041						
Pawnee Gas Conversion	EOY 2027						
SCC Discount Rate	3%	3%	3%	3%	2.5%	2.5%	2.5%

4.1. CEO 1: Economic Dispatch, Comanche 3 Retirement at the end of 2039

CEO 1 is consistent with the CEO Baseline, except that it allows for economic dispatch of Comanche 3 starting in 2025 rather than in 2030. In order to allow for economic dispatch of Comanche 3, Synapse removed the must-run designations that applied to Comanche 3 prior to 2030. Similar to the CEO Baseline, we did not establish any annual dispatch caps or minimum generating requirements for Comanche 3. As in the CEO and PSCo Baseline scenarios, retirement of Comanche 3 occurs at the end of 2039.

Figure 3, below, compares the CO_2 emissions on the PSCo system in the CEO Baseline and CEO 1. The difference in emissions between 2025 and 2029 is driven by the economic dispatch of Comanche 3 through a removal of the must-run designations starting in 2025. In the CEO Baseline, the system-wide emissions in 2029 are 4.3 million tons. In CEO 1, the system-wide emissions in 2029 are 3.1 million tons. The emission reduction attributable to economic dispatch of Comanche 3 in 2029 is 1.2 million tons. This difference in emissions in 2029 that are attributable to economic dispatch of Comanche 3 accounts for almost 28 percent of the total system-wide emissions in the CEO Baseline in 2029. The total emissions in the CEO baseline are 120.7 million tons while total emissions in CEO 1 are 115.8 million tons. This results in an emissions difference of 4.9 million tons across the study period ending in 2050.

Figure 3. CO_2 emissions, CEO Baseline compared to CEO 1

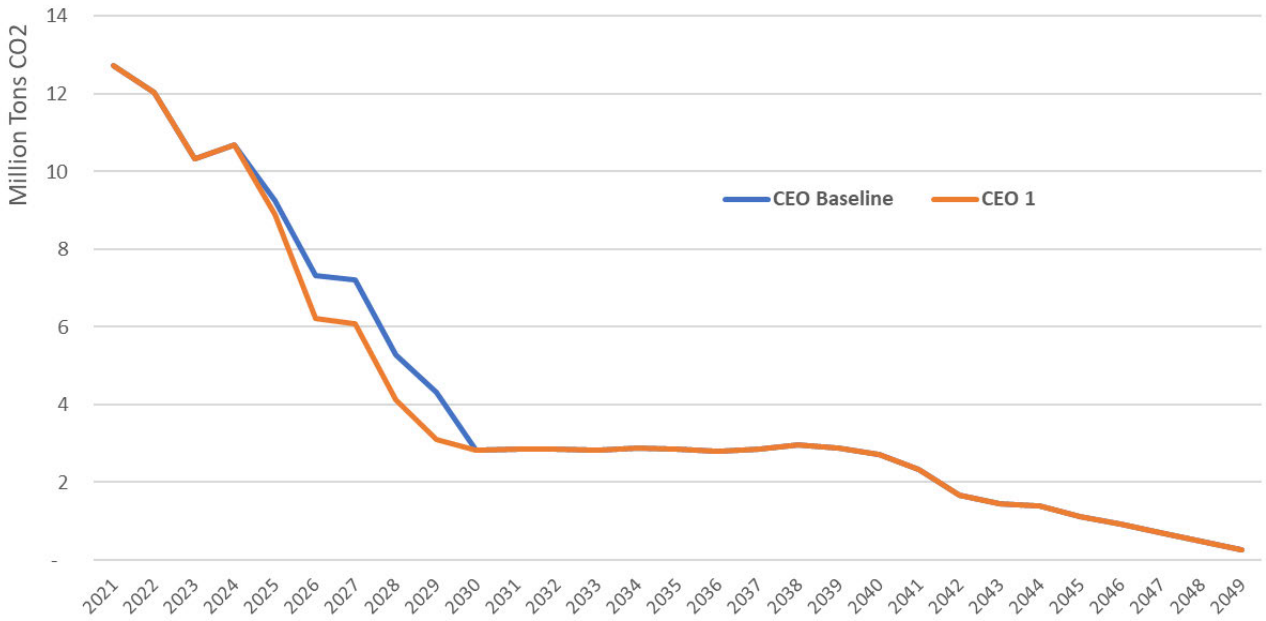


Figure 4 below compares the capacity factor of Comanche 3 in the CEO Baseline versus CEO 1. [redacted]

[redacted]

The only difference between the CEO Baseline and CEO 1 is the removal of the must-run designations of Comanche 3 in CEO 1. There are no other changes to new or existing resources, and the difference in emissions and operation of Comanche between the CEO Baseline and CEO 1 is solely attributable to the change to this must-run designation.

4.2. CEO 2: Economic Dispatch, Comanche 3 Retirement at the end of year 2029

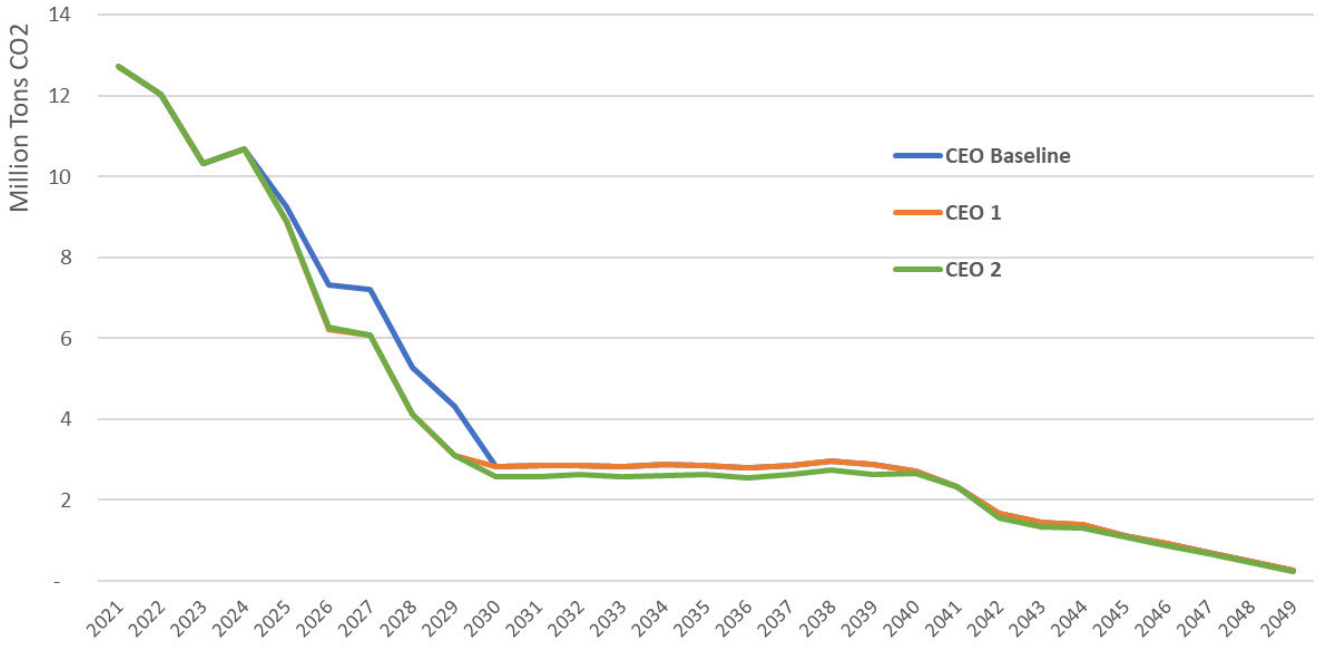
CEO 2 is consistent with the CEO Baseline, except for the following changes:

- Comanche 3 allowed to economically dispatch starting in 2025; and
- Comanche 3 is retired end of year 2029.

The inputs used for modeling of the end of year 2029 retirement of Comanche came from the model runs conducted for SCC 2 and SCC 5 in PSCo's Electric Resource and Clean Energy Plan.

In CEO 2, the overall system-wide emissions are further reduced in comparison with CEO 1 after the retirement of Comanche 3. Since both CEO 1 and CEO 2 include economic dispatch of Comanche 3 starting in 2025, the emissions difference is not as drastic in comparison with the CEO Baseline, [redacted]. In comparison with CEO 1, the total emissions reduction from CEO 2 across the study period ending in 2050 are 2.98 million tons. This is the difference between early retirement of Comanche 3 at the end of 2029 compared to the emissions from the economic dispatch of Comanche 3 in CEO 1. These emissions are shown in Figure 5.

Figure 5. CO_2 emissions, CEO Baseline compared to CEO 1 and CEO 2



As seen in Figure 6, [redacted]

[redacted]

[redacted]

In Table 3 below we see the comparison in the capacity build-out for CEO Baseline and CEO 2 in megawatts, by resource type. A positive difference indicates a higher build-out of the relevant resource in CEO 2 compared with the CEO Baseline. A negative value indicates a lower build-out of the relevant resource in CEO 2 compared with the CEO Baseline. The early retirement of Comanche 3 leads to changes in the resource build-out over the duration of the analysis period. We see that there are gas builds in both the scenarios irrespective of an end of year 2029 or a 2039 retirement. However, in the earlier retirement scenario there is an overall lower cumulative gas build towards the end of the study period. In CEO 2, the early retirement of Comanche 3 causes the EnCompass model to build more storage earlier in the analysis period, thus avoiding increased gas builds in the future.

Table 3. Resource buildout in MW for CEO 2 and CEO Baseline. The difference is the capacity of each resource in CEO 2 minus the capacity of each resource in the CEO Baseline.

Gas/Oil:Combustion Turbine	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 2	1,791	2,615	2,957	3,741	4,334	4,604
CEO Baseline	1,791	2,223	2,565	3,937	5,118	5,192
Difference	0	392	392	(196)	(784)	(588)
Gas/Oil:Internal Combustion	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 2	229	0	0	0	0	0
CEO Baseline	229	0	0	0	0	0
Difference	0	0	0	0	0	0
Solar	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 2	2,476	4,841	5,508	6,178	6,742	7,115
CEO Baseline	2,476	4,791	5,410	6,132	6,916	7,366
Difference	0	50	98	46	(174)	(252)
Wind	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 2	5,097	6,038	6,285	6,808	7,458	8,021
CEO Baseline	5,097	5,988	6,285	6,828	7,483	7,882
Difference	0	50	0	(20)	(26)	138
Battery	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 2	350	850	1,450	1,450	2,845	2,845
CEO Baseline	350	700	1,300	1,300	2,413	2,413
Difference	0	150	150	150	432	432

4.3. CEO 3: Economic Dispatch, Comanche 3 Retirement at the end of 2035

CEO 3 is consistent with the CEO Baseline, except for the following changes:

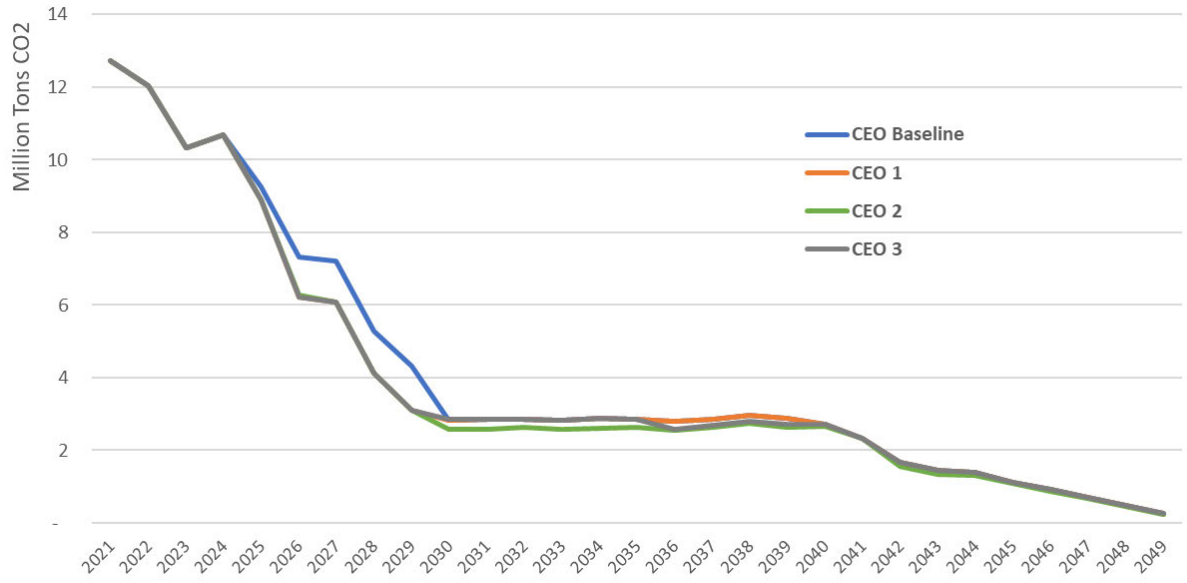
- Comanche 3 is allowed to economically dispatch starting in 2025 and
- Comanche 3 is retired end of year 2035.

The inputs used for modeling of the end of year 2035 retirement of Comanche came from the PSCo's response to Discovery Request CEO5-3.

In CEO 3, the overall system-wide emissions are reduced in comparison with CEO 1 after the retirement of Comanche 3 end of year 2035. Similar to the above results, the deeper emissions differences between CEO 3 and the CEO Baseline are primarily attributable to economic dispatch of Comanche 3. However, since CEO 1, CEO 2, and CEO 3 all include economic dispatch of Comanche 3 starting in 2025, the emissions difference between these scenarios is not as drastic in comparison with the CEO Baseline. [redacted]

[redacted] The incremental emissions reduction from CEO 3 when compared with CEO 1 across the study period ending in 2050 is 0.7 million tons. This is the difference between early retirement of Comanche 3 end of year 2035 compared to retirement end of year 2039 in CEO 1. These emissions are shown in Figure 7.

Figure 7. CO_2 Emissions, CEO Baseline compared to CEO 1 through CEO 3



As seen in Figure 8, [redacted]

[redacted]

[redacted]

In Table 4 below we see the comparison in the capacity build-out for CEO Baseline and CEO 3 in megawatts, by resource type. A positive difference indicates a higher build-out of the relevant resource in the CEO 3 scenario compared with the CEO Baseline and a negative value indicates a lower build-out of the relevant resource in the CEO 3 scenario compared with the CEO Baseline. CEO 3's early retirement of Comanche 3 at the end of 2035 leads to changes in the resource build-out over the duration of the analysis period. We see that there are gas builds in both the scenarios irrespective of an end of year 2035 or 2039 retirement. However, in the end of year 2035 retirement scenario there is an overall lower cumulative gas build by the end of the study period. In CEO 3, the early retirement of Comanche 3 causes the EnCompass model to build more renewables earlier in the analysis period, thus avoiding increased gas builds in the future.

Table 4. Resource buildout in MW for CEO 3 and CEO Baseline. The difference is the capacity of each resource in CEO 3 minus the capacity of each resource in the CEO Baseline.

Gas/Oil: Combustion Turbine	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 3	1,791	2,223	2,565	3,545	4,334	4,996
CEO Baseline	1,791	2,223	2,565	3,937	5,118	5,192
Difference	0	0	0	(392)	(784)	(196)
Gas/Oil: Internal Combustion	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 3	229	0	0	0	0	0
CEO Baseline	229	0	0	0	0	0
Difference	0	0	0	0	0	0
Solar	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 3	2,476	4,791	5,410	6,131	6,924	7,365
CEO Baseline	2,476	4,791	5,410	6,132	6,916	7,366
Difference	0	0	0	(1)	8	(1)
Wind	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 3	5,097	5,988	6,285	6,828	7,480	7,883
CEO Baseline	5,097	5,988	6,285	6,828	7,483	7,882
Difference	0	0	0	1	(3)	0
Battery	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 3	350	700	1,300	1,300	2,408	2,408
CEO Baseline	350	700	1,300	1,300	2,413	2,413
Difference	0	0	0	0	(6)	(6)

In Table 5, below we see the comparison in the capacity build-out for CEO 2 and CEO 3 in megawatts, by resource type. A positive difference indicates a higher build-out of the relevant resource in the CEO 3 scenario compared with CEO 2 and a negative value indicates a lower build-out of the relevant resource in the CEO 3 scenario compared with the CEO 2. CEO 2's early retirement of Comanche 3 at the end of 2029 leads to changes in the resource build-out over the duration of the analysis period. We see that in CEO 3's end of year 2035 retirement scenario there is an overall higher cumulative gas build towards the end of the study period. In CEO 2, the end of year 2029 retirement of Comanche 3 causes the EnCompass model to build more storage earlier in the analysis period, thus avoiding increased gas builds in the future.

Table 5. Resource buildout in MW for CEO 3 and CEO 2. The difference is the capacity of each resource in CEO 3 minus the capacity of each resource in CEO 2.

Gas/Oil: Combustion Turbine	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 3	1,791	2,223	2,565	3,545	4,334	4,996
CEO 2	1,791	2,615	2,957	3,741	4,334	4,604
Difference	0	(392)	(392)	(196)	0	392
Gas/Oil: Internal Combustion	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 3	229	0	0	0	0	0
CEO 2	229	0	0	0	0	0
Difference	0	0	0	0	0	0
Solar	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 3	2,476	4,791	5,410	6,131	6,924	7,365
CEO 2	2,476	4,841	5,508	6,178	6,742	7,115
Difference	0	(50)	(98)	(47)	182	251
Wind	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 3	5,097	5,988	6,285	6,828	7,480	7,883
CEO 2	5,097	6,038	6,285	6,808	7,458	8,021
Difference	0	(50)	0	20	22	(138)
Battery	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 3	350	700	1,300	1,300	2,408	2,408
CEO 2	350	850	1,450	1,450	2,845	2,845
Difference	0	(150)	(150)	(150)	(437)	(437)

4.4. CEO 4: Economic Dispatch, Comanche 3 Retirement at the end of 2039, SCC Discounted at 2.5 Percent

CEO 4 is consistent with the CEO 1, except for the inclusion of a higher social cost of carbon that has been discounted at 2.5 percent rather at 3 percent. As in CEO 1, Comanche 3 continues to dispatch economically beyond 2025. Comanche 3 retirement occurs end of year 2039.

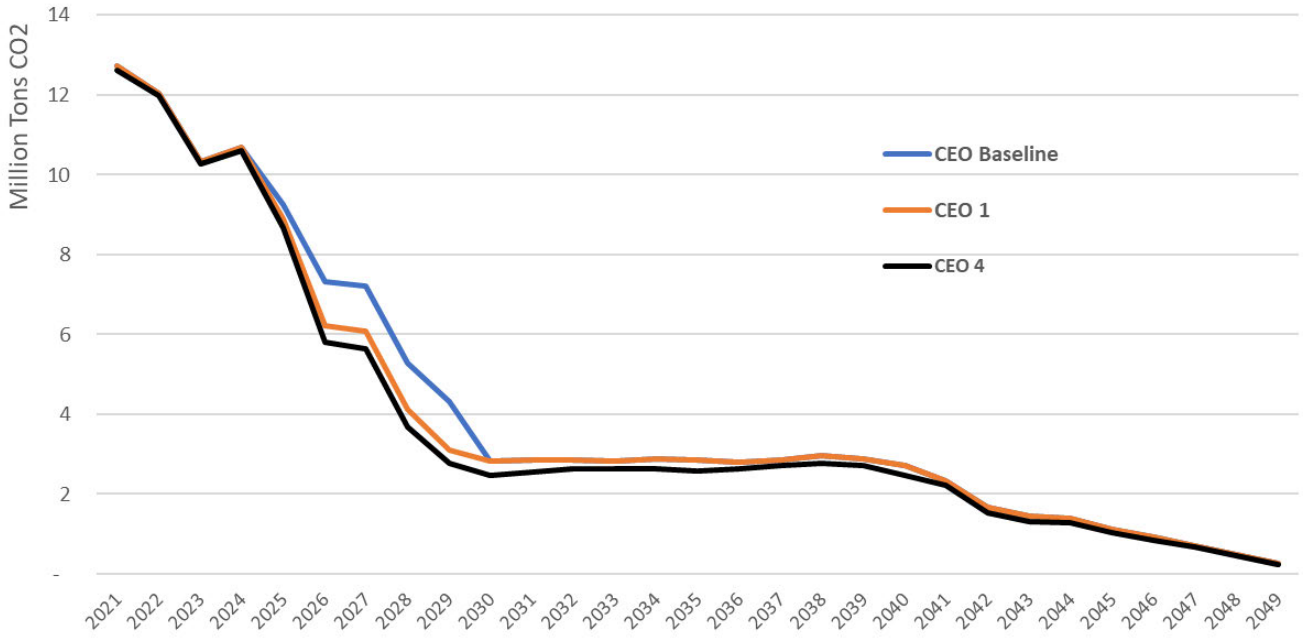
In comparison with the CEO Baseline, CEO 4 includes the following:

- Comanche 3 allowed to economically dispatch starting in 2025; and
- Social cost of carbon discounted at 2.5 percent.

As seen below in Figure 9, in comparing CEO 1 and CEO 4, the inclusion of a higher social cost of carbon results in a larger emissions reduction. In 2025, the difference in emissions is 0.2 million tons. In 2027, the emissions difference between the scenarios is approximately 0.44 million tons. Beyond 2041, CEO 4

continues to have slightly lower emissions than CEO 1. The higher social cost of carbon increases the cost of operations at PSCo's fossil fueled units which decreases their generation and, prompts the addition of more renewable resources. All this reduces emissions between scenarios.

Figure 9. CO_2 emissions, CEO Baseline compared to CEO 1 and CEO 4



As seen below in Figure 10, [redacted]

[redacted]

[redacted]

As seen below in Table 6, when comparing CEO 1 (similar resource build-out as CEO Baseline) and CEO 4, the higher social cost of carbon results in the selection of more renewables in the shorter term. We also see a higher adoption of battery storage over the analysis period. CEO 4 also results in fewer new gas resources overall by the end of the study period in 2050. This indicates that a higher social cost of carbon leads to the selection of a greater amount of renewable and storage resources and fewer new gas resources.

Table 6. Resource buildout in MW for CEO 4 and CEO 1. The difference is the capacity of each resource in CEO 4 minus the capacity of each resource in the CEO 1.

Gas/Oil:Combustion Turbine	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 4	1,791	2,027	2,565	3,741	4,726	4,800
CEO 1	1,791	2,223	2,565	3,937	5,118	5,192
Difference	0	(196)	0	(196)	(392)	(392)
Gas/Oil:Internal Combustion	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 4	229	0	0	0	0	0
CEO 1	229	0	0	0	0	0
Difference	0	0	0	0	0	0
Solar	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 4	2,476	4,938	5,554	6,273	6,895	7,178
CEO 1	2,476	4,791	5,410	6,132	6,916	7,366
Difference	0	148	144	141	(21)	(188)
Wind	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 4	5,097	6,288	6,635	7,142	7,583	8,045
CEO 1	5,097	5,988	6,285	6,828	7,483	7,882
Difference	0	300	350	314	100	163
Battery	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 4	600	950	1,300	1,350	2,783	2,783
CEO 1	350	700	1,300	1,300	2,413	2,413
Difference	250	250	0	50	369	369

4.5. CEO 5: Economic Dispatch, Comanche 3 Retirement at the end of year 2029, SCC Discounted at 2.5 Percent

In CEO 5, we modeled CEO 2, except for the inclusion of a higher social cost of carbon that has been discounted at 2.5 percent. Like CEO 1 and 2, Comanche 3 continues to dispatch economically starting in 2025. Comanche 3 retirement occurs at the end of 2029.

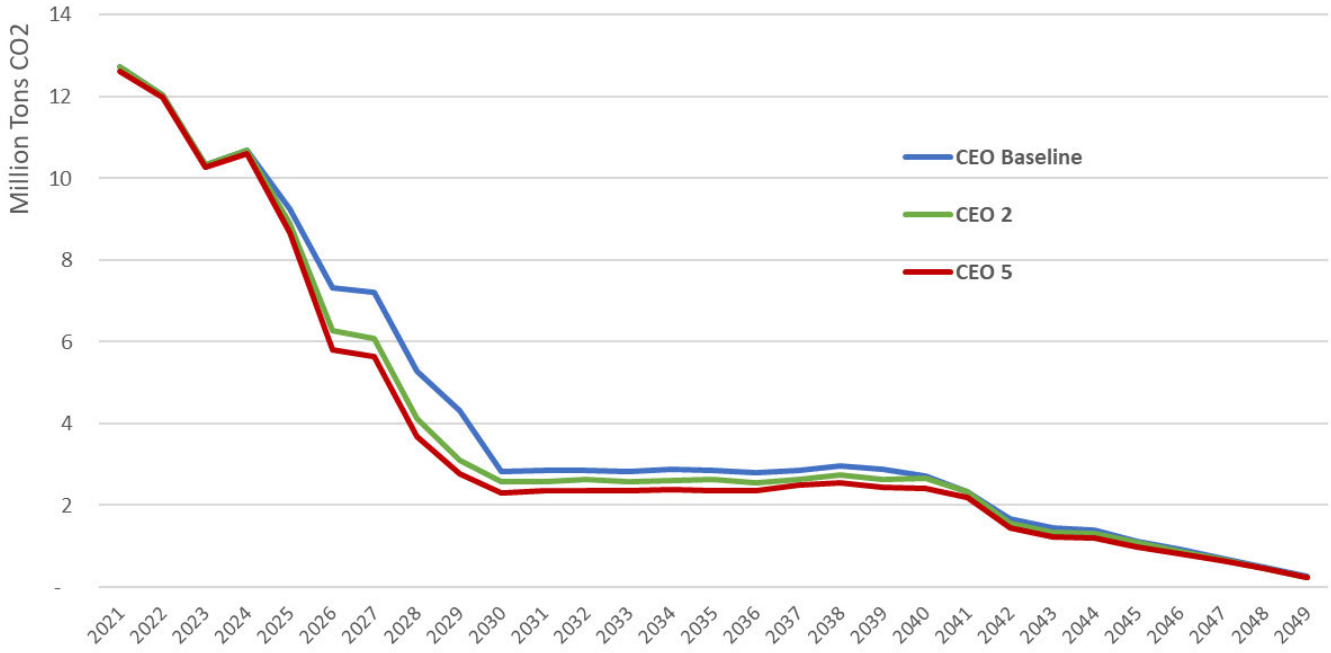
In comparison with the CEO Baseline, CEO 4 includes the following:

- Comanche 3 is allowed to economically dispatch starting in 2025;
- Social cost of carbon is discounted at 2.5 percent; and
- Comanche 3 is retired at the end of 2029

As seen in Figure 11 below, in comparing CEO 2 and CEO 5, the inclusion of a higher social cost of carbon results in a greater emissions reduction. In 2025, the difference in emissions is 0.2 million tons. In 2026, the emissions difference between the scenarios is at its highest, approximately 0.46 million tons. Beyond

2041, CEO 5 continues to have slightly lower system-wide emissions than CEO 2. The total difference in emissions between the scenarios CEO 2 and CEO 5 over the study period is 5.3 million tons.

Figure 11. CO_2 emissions, CEO Baseline compared to CEO 2 and CEO 5



As seen below in Figure 12, [redacted]

[redacted]

[redacted]

As seen below in Table 7, in comparing the resource build-out between CEO 2 and CEO 5, the higher social cost of carbon in CEO 5 results in the selection of more renewables in the shorter term. We also see a higher adoption of battery storage through the timeframe. Due to the accelerated build-out of renewables and battery storage, CEO 5 scenario also results in fewer new gas builds overall by the end of the study period.

Table 7. Resource buildout in MW for CEO 5 and CEO 2. The difference is the capacity of each resource in CEO 5 minus the capacity of each resource in the CEO 2.

Gas/Oil: Combustion Turbine	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 5	1,791	2,419	2,957	3,545	3,942	4,016
CEO 2	1,791	2,615	2,957	3,741	4,334	4,604
Difference	0	(196)	0	(196)	(392)	(588)
Gas/Oil: Internal Combustion	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 5	229	0	0	0	0	0
CEO 2	229	0	0	0	0	0
Difference	0	0	0	0	0	0
Solar	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 5	2,476	4,988	5,652	6,368	6,787	7,651
CEO 2	2,476	4,841	5,508	6,178	6,742	7,115
Difference	0	148	144	190	45	536
Wind	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 5	5,097	6,338	6,685	7,135	7,668	8,193
CEO 2	5,097	6,038	6,285	6,808	7,458	8,021
Difference	0	300	400	327	211	173
Battery	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 5	600	1,000	1,500	1,500	3,232	3,357
CEO 2	350	850	1,450	1,450	2,845	2,845
Difference	250	150	50	50	387	512

As seen in Table 8 below, in comparing the resource build-out between the CEO Baseline and CEO 5, we see that the incorporation of a higher social cost of carbon and early retirement of Comanche 3 in CEO 5 results in a reduced amount of gas on the system. The results indicate that wind and storage are a preferred replacement resource and show increased adoption of these resources by the end of the timeframe. In the shorter term, there is an increased build-out in renewables, storage and gas due to early retirement of Comanche 3. Despite the increase in gas on the system in the short term, the overall impact of the early build-out of the diverse set of resources results in lower gas build-out overall by the end of the analysis period.

Table 8. Resource buildout in MW for CEO 5 and Baseline. The difference is the capacity of each resource in CEO 5 minus the capacity of each resource in the CEO Baseline.

Gas/Oil: Combustion Turbine	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 5	1,791	2,419	2,957	3,545	3,942	4,016
CEO Baseline	1,791	2,223	2,565	3,937	5,118	5,192
Difference	0	196	392	(392)	(1,176)	(1,176)
Gas/Oil: Internal Combustion	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 5	229	0	0	0	0	0
CEO Baseline	229	0	0	0	0	0
Difference	0	0	0	0	0	0
Solar	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 5	2,476	4,988	5,652	6,368	6,787	7,651
CEO Baseline	2,476	4,791	5,410	6,132	6,916	7,366
Difference	0	198	242	236	(129)	285
Wind	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 5	5,097	6,338	6,685	7,135	7,668	8,193
CEO Baseline	5,097	5,988	6,285	6,828	7,483	7,882
Difference	0	350	400	307	185	311
Battery	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 5	600	1,000	1,500	1,500	3,232	3,357
CEO Baseline	350	700	1,300	1,300	2,413	2,413
Difference	250	300	200	200	818	944

4.6. CEO 6: Economic Dispatch, Comanche 3 Retirement end of year 2035, SCC Discounted at 2.5 Percent

CEO 6 is consistent with CEO 3, except for the inclusion of a higher social cost of carbon that has been discounted at 2.5 percent. Like CEO 1 and 2, Comanche 3 continues to dispatch economically starting in 2025. Comanche 3 retirement occurs at the end of 2035.

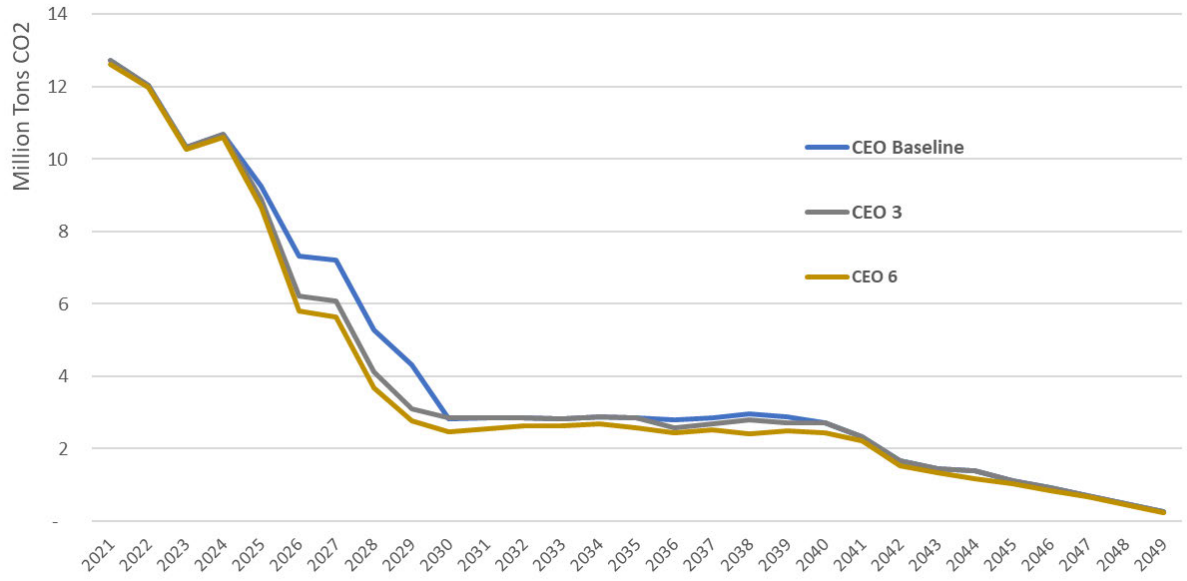
In comparison with the CEO Baseline, CEO 4 includes the following:

- Comanche 3 is allowed to economically dispatch starting in 2025;
- Social cost of carbon is discounted at 2.5 percent; and
- Comanche 3 is retired at the end of 2035

As seen in Figure 13 below, in comparing CEO 3 and CEO 6, the inclusion of a higher social cost of carbon results in a greater emissions reduction. In 2025, the difference in emissions is 0.2 million tons. In 2027,

the emissions difference between the scenarios is at its highest, approximately 0.44 million tons. Over the entire timeframe out until 2040, CEO 6 continues to have slightly lower system-wide emissions than CEO 3. The total difference in emissions between the scenarios over the study period is 5.7 million tons.

Figure 13. CO_2 emissions, CEO Baseline compared to CEO 3 and CEO 6



As seen below in Figure 14, [redacted]

[redacted]

[redacted]

As shown in Table 9 below, in comparing the resource buildout between CEO 3 with lower social cost of carbon and CEO 6 with higher social cost of carbon, the early retirement by end of year EOY 2029 compared to 2035 results in less gas overall on the system. We also see a higher adoption of battery storage through the time frame. As discussed above, retirement of Comanche 3 at the end of 2029 likely results in an early buildout of storage which results in a reduced gas build in later years.

Table 9. Resource buildout in MW for CEO 6 and CEO 3. The difference is the capacity of each resource in CEO 6 minus the capacity of each resource in CEO 3

Gas/Oil:Combined Cycle	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	2,241	2,184	2,184	2,905	2,745	2,769
CEO 3	2,241	2,184	2,184	2,905	2,745	2,048
Difference	0	0	0	0	0	721
Gas/Oil:Combustion Turbine	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	1,791	2,027	2,369	3,349	3,942	4,212
CEO 3	1,791	2,223	2,565	3,545	4,334	4,996
Difference	0	(196)	(196)	(196)	(392)	(784)
Gas/Oil:Internal Combustion	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	229	0	0	0	0	0
CEO 3	229	0	0	0	0	0
Difference	0	0	0	0	0	0
Solar	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	2,476	4,791	5,411	6,181	6,645	6,981
CEO 3	2,476	4,791	5,410	6,131	6,924	7,365
Difference	0	1	1	50	(279)	(384)
Wind	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	5,097	6,038	6,335	6,868	7,364	7,700
CEO 3	5,097	5,988	6,285	6,828	7,480	7,883
Difference	0	50	50	39	(115)	(183)
Battery	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	550	800	1,200	1,200	2,604	2,604
CEO 3	350	700	1,300	1,300	2,408	2,408
Difference	200	100	(100)	(100)	196	196

As shown in Table 10 below, in comparing the resource buildout between CEO 5 (Comanche 3 retirement at the end of 2029) and CEO 6 (Comanche 3 retirement at the end of 2035), the early retirement by end of year EOY 2029 compared to 2035 results in less gas overall on the system. We also see a higher adoption of battery storage and renewables through the time frame. As discussed above, retirement of Comanche 3 at the end of 2029 likely results in an early buildout of renewables and storage which results in a reduced gas build in later years.

Table 10. Resource buildout in MW for CEO 6 and CEO 5. The difference is the capacity of each resource in CEO 6 minus the capacity of each resource in the CEO 5

Gas/Oil:Combined Cycle	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	2,241	2,184	2,184	2,905	2,745	2,769
CEO 5	2,241	2,184	2,184	2,905	2,745	2,048
Difference	0	0	0	0	0	721
Gas/Oil:Combustion Turbine	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	1,791	2,027	2,369	3,349	3,942	4,212
CEO 5	1,791	2,419	2,957	3,545	3,942	4,016
Difference	0	(392)	(588)	(196)	0	196
Gas/Oil:Internal Combustion	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	229	0	0	0	0	0
CEO 5	229	0	0	0	0	0
Difference	0	0	0	0	0	0
Solar	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	2,476	4,791	5,411	6,181	6,645	6,981
CEO 5	2,476	4,988	5,652	6,368	6,787	7,651
Difference	0	(197)	(241)	(187)	(142)	(670)
Wind	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	5,097	6,038	6,335	6,868	7,364	7,700
CEO 5	5,097	6,338	6,685	7,135	7,668	8,193
Difference	0	(300)	(350)	(267)	(304)	(493)
Battery	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 6	550	800	1,200	1,200	2,604	2,604
CEO 5	600	1,000	1,500	1,500	3,232	3,357
Difference	(50)	(200)	(300)	(300)	(628)	(754)

5. PAWNEE EVALUATION

5.1. Pawnee Scenario Comparisons

To evaluate the option of Pawnee retiring at EOY 2028 or converting to gas by EOY 2027, two new scenarios were run and compared with CEO Baseline, CEO 1, CEO 4, CEO 2, and CEO 5. Those scenarios and their underlying input assumptions are shown as CEO 7 and CEO 8 in Table 11, below.

Table 11. Matrix of modeled scenarios and underlying input assumptions to evaluate Pawnee early retirement and gas conversion

	CEO Baseline	CEO 1	CEO 4	CEO 7	CEO 2	CEO 5	CEO 8
Comanche 3 Retirement	EOY 2039	EOY 2039	EOY 2039	EOY 2039	EOY 2029	EOY 2029	EOY 2029
Comanche 3 Dispatch	Economic dispatch starting in 2025						
Pawnee Retirement	EOY 2041	EOY 2041	EOY 2041	EOY 2028	EOY 2041	EOY 2041	EOY 2028
Pawnee Gas Conversion	EOY 2027	EOY 2027	EOY 2027	None	EOY 2027	EOY 2027	None
SCC Discount Rate	3%	3%	2.5%	2.5%	3%	2.5%	2.5%

5.2. CEO 7, Pawnee Retirement at the end of 2028, SCC Discounted at 2.5 Percent, Economic Dispatch of Comanche 3, and at the end of 2039

CEO 7 is consistent with CEO 4 (Comanche retiring at the end of 2039 and a 2.5 percent SCC discount rate), except that in CEO 7, Pawnee retires at the end of 2028 rather than conversion to gas at the end of 2027. Like CEO 1 and 2, in both CEO 4 and CEO 7, Comanche 3 dispatches economically starting in 2025.

As seen in Figure 15 below, in comparing CEO 1 (which is the same as CEO 4, except CEO 1 has a 3 percent SCC discount rate) and CEO 4 with CEO 7, the retirement of Pawnee at the end of 2028 and the conversion to gas at the end of 2027 result in similar long term emission reductions. [redacted] Since this generation is so low the difference in emissions between CEO 4 (gas conversion) and CEO 7 (early Pawnee retirement) is not substantially different. The only exception to this is in 2028. Because the Pawnee conversion to gas occurs at the end of 2027 in scenario CEO 4, and the early retirement in scenario CEO 7 does not happen until the end of 2028, the coal-fired Pawnee unit is emitting at a higher rate for an additional year (2028) under scenario CEO 7, resulting in increased emissions in that year.

Figure 15. CO_2 Emissions, CEO Baseline compared with CEO 1, 4, and 7

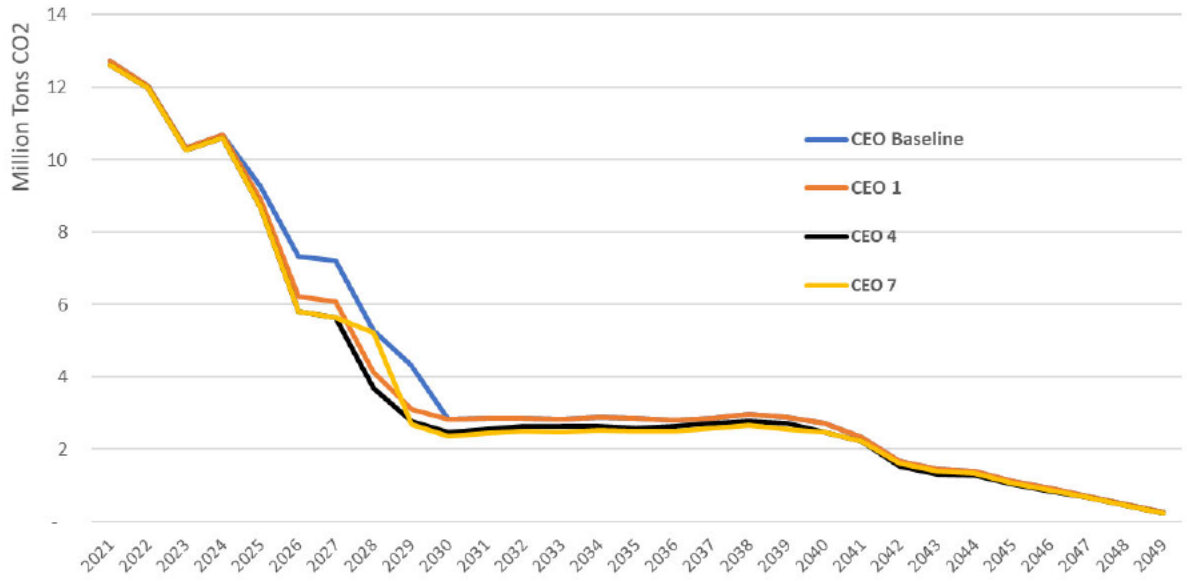


Figure 16 below shows the comparison of the Pawnee coal unit capacity factor in CEO 7 with the Pawnee gas unit in CEO Baseline, CEO 1 and CEO 4. [redacted]

[redacted]

[redacted]

In Table 12 below we see the comparison in the capacity build-out for CEO 7 and CEO 4 in megawatts, by resource type. A positive difference indicates a higher build-out of the relevant resource in the CEO 7 scenario compared with CEO 4 and a negative value indicates a lower build-out of the relevant resource in CEO 7 compared with CEO 4. The EnCompass model builds more replacement resources in the short term in CEO 7 when Pawnee retirement occurs end of year 2028 while in CEO 4 there are comparatively more resource builds in the future years after Pawnee retires end of year 2041. The earlier build of resources in CEO 7 due to early retirement results in slightly less gas and more solar in CEO 7 overall when compared with CEO 4.

Table 12. Resource buildout in MW for CEO 7 and CEO 4. The difference is the capacity of each resource in CEO 7 minus the capacity of each resource in CEO 4

Pawnee (Coal/Gas)	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 7	1,655	500	500	0	0	0
CEO 4	1,655	1,005	1,005	505	0	0
Difference	0	(505)	(505)	(505)	0	0
Gas/Oil: Combustion Turbine	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 7	1,791	2,419	2,957	3,741	4,334	4,408
CEO 4	1,791	2,027	2,565	3,741	4,726	4,800
Difference	0	392	392	0	(392)	(392)
Gas/Oil: Internal Combustion	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 7	229	100	100	100	100	100
CEO 4	229	0	0	0	0	0
Difference	0	100	100	100	100	100
Solar	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 7	2,476	5,039	5,652	6,369	6,848	7,403
CEO 4	2,476	4,938	5,554	6,273	6,895	7,178
Difference	0	100	98	95	(47)	225
Wind	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 7	5,097	6,338	6,635	7,098	7,582	8,064
CEO 4	5,097	6,288	6,635	7,142	7,583	8,045
Difference	0	50	0	(44)	(0)	19
Battery	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 7	600	1,000	1,350	1,350	2,576	2,732
CEO 4	600	950	1,300	1,350	2,783	2,783
Difference	0	50	50	0	(206)	(51)

5.3. CEO 8: Pawnee Retirement at the end of 2028, SCC Discounted at 2.5 Percent, Economic Dispatch of Comanche 3, and Retirement at the end of 2029

CEO 8 is consistent with CEO 5 (Comanche 3 retiring at the end of 2029 and a 2.5 percent SCC discount rate), except that in CEO 8, Pawnee retires at the end of 2028 as opposed to converting to gas at the end of 2027. Similar to CEO 1 and 2, in both CEO 5 and CEO 8, Comanche 3 continues to dispatch economically starting in 2025.

As seen in Figure 17 below, in comparing CEO 2 (which is the same as CEO 5, except CEO 2 has a 3 percent SCC discount rate) and CEO 5 with CEO 8, the retirement of Pawnee in EOY 2028 and the conversion to gas at the end of 2027 results in similar long term emission reductions. [redacted] Since this generation is so low the difference in emissions between CEO 5 (gas conversion) and CEO 8 (early retirement) is not significantly different. The exception to this is the year 2028, for reasons stated above.

Figure 17. CO_2 emissions, CEO Baseline compared with CEO 2, 5, and 8

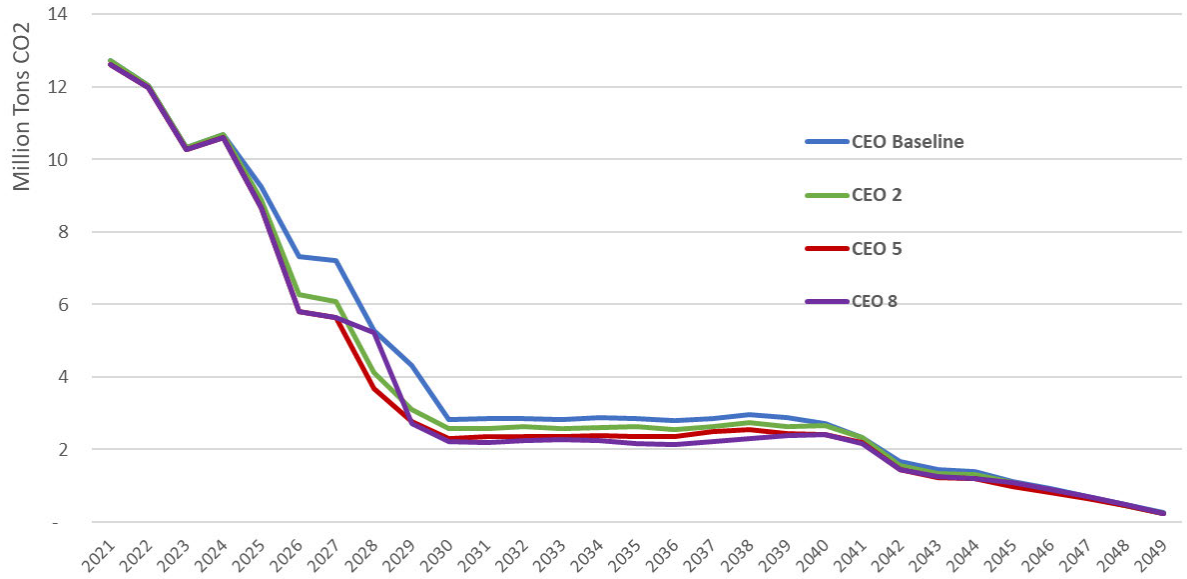


Figure 18 below shows the comparison of the Pawnee coal unit capacity factor in CEO 8 with the Pawnee gas unit in CEO Baseline, CEO 2 and CEO 5. [redacted]

[redacted]

[redacted]

As seen in Table 13 below, we see the comparison in the capacity build-out for CEO 8 and CEO 5 in megawatts, by resource type. A positive difference indicates a higher build-out of the relevant resource in the CEO 8 scenario compared with CEO 5 and a negative value indicates a lower build-out of the relevant resource in CEO 8 compared with CEO 5. The EnCompass model builds less gas and more battery storage in CEO 8 overall when compared with CEO 5.

Table 13. Resource buildout in MW for CEO 8 and CEO 5. The difference is the capacity of each resource in CEO 8 minus the capacity of each resource in the CEO 5

Pawnee (Coal/Gas)	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 8	1,655	0	0	0	0	0
CEO 5	1,655	505	505	505	0	0
Difference	0	(505)	(505)	(505)	0	0
Gas/Oil:Combined Cycle	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 8	2,241	2,184	2,905	2,905	2,024	1,327
CEO 5	2,241	2,184	2,184	2,905	2,745	2,048
Difference	0	0	721	0	(721)	(721)
Gas/Oil:Combustion Turbine	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 8	1,791	3,007	2,761	3,741	4,334	4,604
CEO 5	1,791	2,419	2,957	3,545	3,942	4,016
Difference	0	588	(196)	196	392	588
Gas/Oil:Internal Combustion	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 8	229	0	0	0	0	0
CEO 5	229	0	0	0	0	0
Difference	0	0	0	0	0	0
Solar	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 8	2,476	4,989	5,753	6,367	6,784	7,672
CEO 5	2,476	4,988	5,652	6,368	6,787	7,651
Difference	0	1	101	(1)	(3)	21
Wind	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 8	5,097	6,388	6,635	7,144	7,671	8,211
CEO 5	5,097	6,338	6,685	7,135	7,668	8,193
Difference	0	50	(50)	10	3	18
Battery	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CEO 8	600	1,000	1,400	1,450	3,243	3,701
CEO 5	600	1,000	1,500	1,500	3,232	3,357
Difference	0	0	(100)	(50)	11	344

6. SUMMARY OF RUNS WITH THE SCC APPLIED TO THE CAPACITY EXPANSION AND PRODUCTION COST MODELING

This section describes the results for the runs in which the SCC was applied to both the capacity expansion and the production cost modeling.[5] The results of these scenario runs include both the revenue requirement, on a net present value basis, as well as the cost of carbon emissions. As seen below in Table 14, the net present value (NPV) with the SCC applied to the production cost modeling for CEO 1 is incrementally lower than it is for the CEO Baseline due to the economic dispatch of Comanche 3 starting in 2025. When the SCC is applied to the production cost modeling for CEO 2 (the end of year 2029 Comanche 3 retirement) the NPV is incrementally lower than both the CEO Baseline and CEO 1. Incorporating a higher social cost of carbon results in a higher overall NPV as can be seen when comparing CEO 4 and CEO 5 to CEO 1 and CEO 2, respectively. The NPV with the SCC applied to the production cost modeling for CEO 5 (early Comanche 3 retirement in EOY 2029) continues to be slightly lower than for CEO 4 (EOY 2039 Comanche 3 retirement) even when both scenarios include the higher SCC (comparing CEO 4 to CEO 5).

Table 14. Revenue requirement with the SCC applied to capacity expansion and production cost modeling, 2021-2055

Scenario	NPV (billion $)	NPV Diff compared with CEO Baseline (billion $)	NPV % Diff compared with CEO Baseline
CEO Baseline, C3 Must Run, EOY 2039 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$45.8		
CEO 1, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$45.6	($0.16)	-0.35%
CEO 2, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$45.4	($0.38)	-0.83%
CEO 3, Economic Dispatch and EOY 2035 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$45.5	($0.29)	-0.64%
CEO 4, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	$47.7	$1.93	4.20%
CEO 5, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	$47.5	$1.75	3.81%
CEO 6, Economic Dispatch and EOY 2035 C3 Retirement, SCC discounted @2.5%, EOY 2027 Pawnee Gas Conversion	$47.6	$1.78	3.88%
CEO 7, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 2.5%, EOY 2028 Pawnee Retirement	$47.8	$1.99	4.34%
CEO 8, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2028 Pawnee Retirement	$47.8	$1.97	4.30%

[5] These are also referred to as SCC Production Cost runs within PSCo Encompass output files.

Table 14, above, includes the carbon cost at a discount rate of 3 percent for CEO Baseline through CEO 3 and a carbon cost at a discount rate of 2.5 percent for CEO 4 through CEO 8. Table 15, below, shows the results after removing the associated carbon cost and shows that the differences in the NPV for the higher SCC runs (CEO 4 through CEO 8) are driven primarily by this increased cost of carbon and (2) the revenue requirements are relatively similar where the carbon externality cost is removed.

Table 15. Revenue requirement without cost of CO_2 included, 2021-2055

Scenario	NPV (billion $)	NPV Diff compared with CEO Baseline (billion $)	NPV % Diff compared with CEO Baseline
PSCo Baseline	$38.9[6]		
CEO Baseline, C3 Must Run, EOY 2039 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$40.9		
CEO 1, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$40.9	$0.04	0.11%
CEO 2, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$40.8	($0.07)	-0.18%
CEO 3, Economic Dispatch and EOY 2035 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$40.8	($0.07)	-0.16%
CEO 4, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	$41.2	$0.27	0.67%
CEO 5, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	$41.1	$0.23	0.57%
CEO 6, Economic Dispatch and EOY 2035 C3 Retirement, SCC discounted @2.5%, EOY 2027 Pawnee Gas Conversion	$41.1	$0.18	0.43%
CEO 7, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 2.5%, EOY 2028 Pawnee Retirement	$41.2	$0.31	0.75%
CEO 8, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2028 Pawnee Retirement	$41.3	$0.43	1.06%

In order to accurately compare the cost of carbon, and consequently the revenue requirement inclusive of the SCC, between all of CEO's scenarios, CEO asked Synapse to recalculate the NPV of the CO_2 emissions cost for scenarios CEO Baseline through CEO 3 using social cost of carbon values discounted at 2.5 percent instead of 3 percent. This calculation was performed as a post-processing step, so no changes were made to any of the scenarios previously described. Table 16 below shows the comparison of the carbon externality cost for all scenarios when a common social cost of carbon discount rate of 2.5 percent is assumed.

[6] $38.9 billion obtained from 21A-0141E_Landrum Suppl_Public Workpaper_WithLinks_07_Ownership Template_Com 3 Cost update_071621.xlsx. Note that Hrg. Ex. 119, Supplemental Direct Testimony of Jon T. Landrum, at 31 lists the PVRR utility cost at $39.4 billion instead of $38.9 billion.

Table 16. Cost of carbon externality at a 2.5 percent discount rate, 2021-2055

Scenario	NPV (billion $)	NPV Diff compared with CEO Baseline (billion $)	NPV % Diff compared with CEO Baseline
PSCo Baseline	$9.5		
CEO Baseline, C3 Must Run, EOY 2039 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$7.1		
CEO 1, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$6.8	($0.30)	-4.17%
CEO 2, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$6.7	($0.44)	-6.13%
CEO 3, Economic Dispatch and EOY 2035 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$6.8	($0.33)	-4.61%
CEO 4, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	$6.6	($0.58)	-8.13%
CEO 5, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	$6.4	($0.72)	-10.06%
CEO 6, Economic Dispatch and EOY 2035 C3 Retirement, SCC discounted @2.5%, EOY 2027 Pawnee Gas Conversion	$6.5	($0.63)	-8.79%
CEO 7, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 2.5%, EOY 2028 Pawnee Retirement	$6.6	($0.55)	-7.68%
CEO 8, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2028 Pawnee Retirement	$6.4	($0.70)	-9.75%

7. SUMMARY OF EMISSIONS

As shown in Figure 19, the scenario with the lowest system wide emissions is CEO 5 which includes: 1) economic dispatch of Comanche 3 beginning in 2025; 2) retirement of Comanche 3 at the end of 2029; 3) higher social cost of carbon discounted at 2.5 percent; and 4) Pawnee converting to gas at the end of 2027. The system wide emissions in CEO 5 are incrementally lower than CEO 4 emissions, which includes the above factors but retires Comanche 3 in end of year 2039 instead of 2029. In the Figures and Tables that follow, it may be helpful to refer to Table 1 for a description of scenarios and to understand what the differences are between each CEO scenario and PSCo Baseline. Additionally, recall that PSCo Baseline applies SCC in the capacity expansion runs only and enforces the Company's 10 percent minimum dispatch constraint on Comanche 3. The CEO scenarios, as mentioned before, apply SCC in the capacity expansion runs *and* production cost modeling runs and because of changes to the optimization period, remove the 10 percent minimum dispatch constraint on Comanche 3.

Figure 19. CO_2 emissions, six scenarios

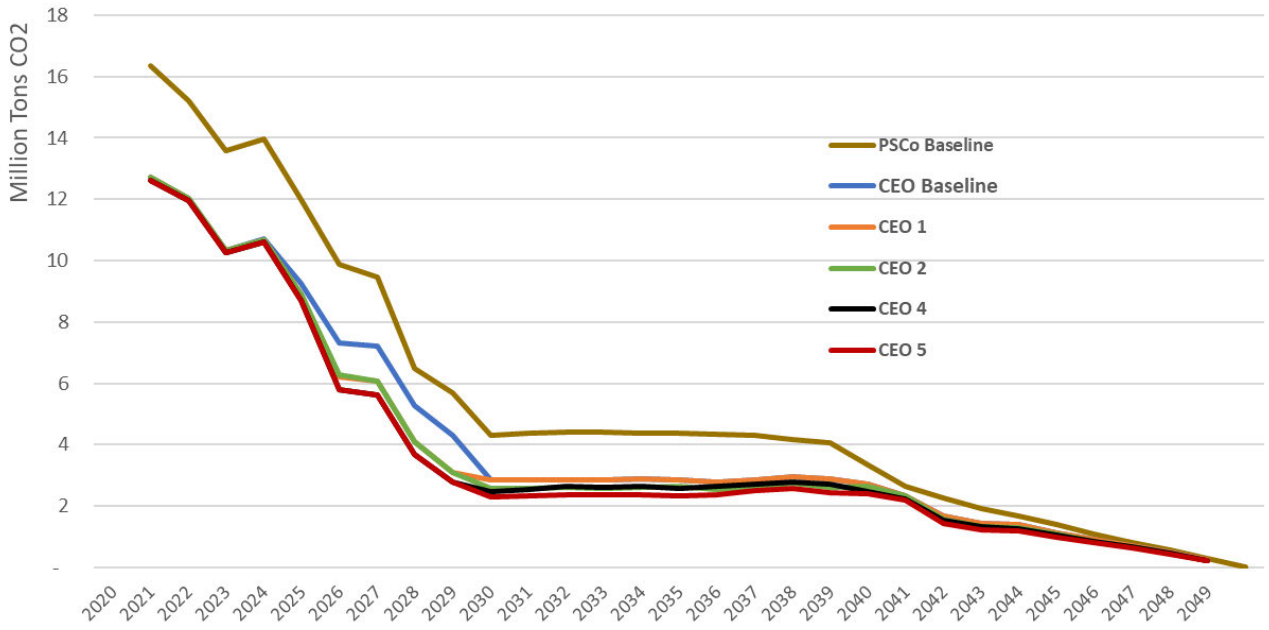
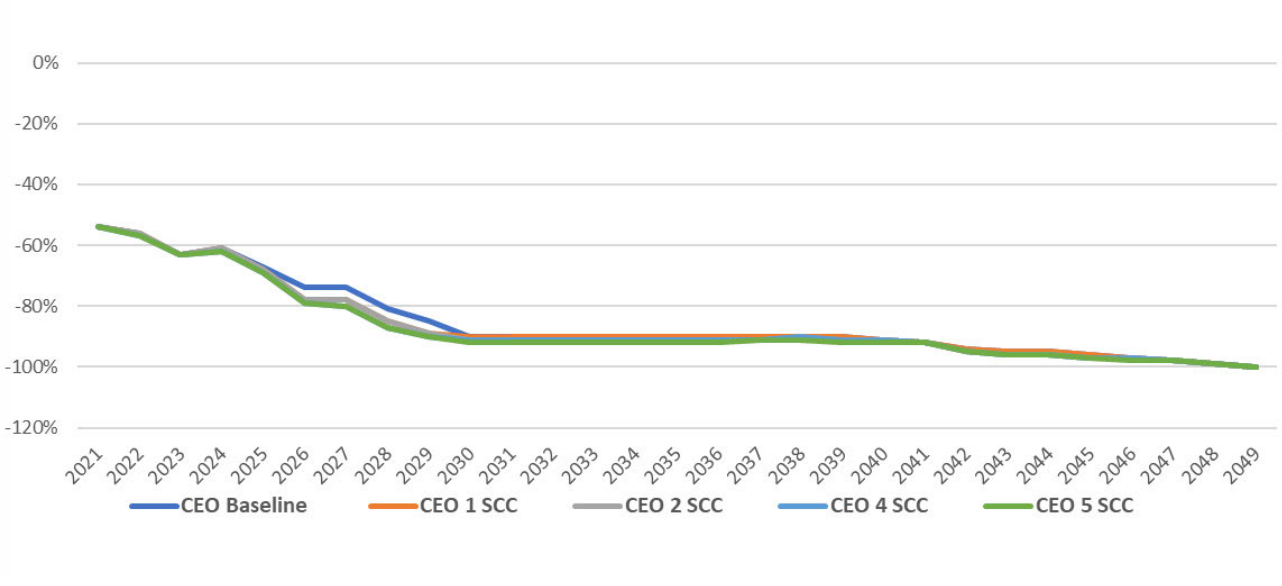


Figure 20 below shows the emissions reductions for the following modeled scenarios compared with the 2005 baseline emissions levels: CEO Baseline, CEO 1, CEO 2, CEO, 4, and CEO 5. These are all the modeled scenarios with Pawnee converting to gas at the end of 2027, with the exception of the scenarios that model Comanche retiring at the end of 2035. As can be seen, in 2030 all scenarios begin to result in emissions reductions on a similar order of magnitude.

Figure 20. Emissions reductions for five scenarios compared with 2005 baseline emissions levels



As shown in Table 17 below, CEO 5 is the scenario that is most changed from the CEO Baseline. The CEO Baseline reached 74 percent emissions reduction by 2026, 81 percent emission reduction by 2028, and 90 percent emission reduction by 2030. Similarly, the CEO 5 scenario reached 79 percent emissions reduction by 2026, 87 percent emission reduction by 2028, and 92 percent emission reduction by 2030. The scenarios with economic dispatch of Comanche 3 and the same 3 percent SCC discount rate as the CEO Baseline (CEO 1 through 3) reached emission reductions at a faster rate than the CEO Baseline. The scenarios inclusive of the 2.5 percent SCC discount rate and resulting higher cost of carbon (CEO 4 through 6) resulted in faster emissions reductions than the scenarios with the lower SCC.

Table 17. Percentage CO_2 reduction from 2005 emission levels

Scenario	2024	2026	2028	2030
PSCo Baseline	-49%	-64%	-76%	-84%
CEO Baseline, C3 Must Run, EOY 2039 C3 Retirement, SCC discounted @ 3%, 2028 Pawnee Gas Conversion	-61%	-74%	-81%	-90%
CEO 1, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	-61%	-78%	-85%	-90%
CEO 2, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	-61%	-78%	-85%	-91%
CEO 3, Economic Dispatch and EOY 2035 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	-61%	-78%	-85%	-90%
CEO 4, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	-62%	-79%	-87%	-91%
CEO 5, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	-62%	-79%	-87%	-92%
CEO 6, Economic Dispatch and EOY 2035 C3 Retirement, SCC discounted @2.5%, EOY 2027 Pawnee Gas Conversion	-62%	-79%	-87%	-91%
CEO 7, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 2.5%, EOY 2028 Pawnee Retirement	-62%	-79%	-81%	-92%
CEO 8, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2028 Pawnee Retirement	-62%	-79%	-81%	-92%

Table 18 below shows the cumulative emissions for 2030, 2040 and 2050. As we can see, by the end of the study period in 2050, the scenarios with the higher SCC have lower cumulative emissions. CEO 5 which includes early retirement of Comanche 3 in 2029 has the lowest cumulative emissions.

Table 18. Cumulative CO_2 emissions (million tons)

Scenario	2030	2040	2050
PSCo Baseline	107.0	149.1	161.8
CEO Baseline, C3 Must Run, EOY 2039 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	81.9	110.4	120.7
CEO 1, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	77.0	105.5	115.8
CEO 2, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	76.8	103.0	112.8
CEO 3, Economic Dispatch and EOY 2035 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	77.0	104.8	115.1
CEO 4, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	74.5	100.9	110.5
CEO 5, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	74.3	98.4	107.6
CEO 6, Economic Dispatch and EOY 2035 C3 Retirement, SCC discounted @2.5%, EOY 2027 Pawnee Gas Conversion	74.5	99.9	109.4
CEO 7, Economic Dispatch and EOY 2039 C3 Retirement, SCC discounted @ 2.5%, EOY 2028 Pawnee Retirement	75.8	101.0	110.9
CEO 8, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2028 Pawnee Retirement	75.7	98.3	107.8

8. EVALUATION OF THE SOCIAL COST OF CARBON APPLIED IN CAPACITY EXPANSION ONLY

At CEO's request, Synapse ran three additional scenarios where the SCC was included only in capacity expansion, rather than in capacity expansion and production cost modeling steps.[7] These scenarios were run to understand the effect of excluding the societal carbon cost from dispatch decision making. For the scenarios where NPV was included in the capacity expansion only, we reapplied the same discount rate as was applied in the production cost modeling step. A negative difference indicates that the dispatch with a SCC in both the capacity expansion and the production cost modeling results in a lower cost of carbon externality. Based on the results below in Table 19, we see that the carbon externality cost is higher when the SCC is only applied to the capacity expansion model.

[7] Scenarios including SCC in the capacity expansion only are termed as "PVRR" runs in PSCo's EnCompass output files.

Table 19. Cost of carbon externality for CEO Baseline, CEO 2 and CEO 5

Cost of Carbon Externality @	NPV with SCC in both Production Cost and Capacity Expansion (billion $)	NPV with SCC in Capacity Expansion only (billion $)	NPV Difference (billion $)
CEO Baseline, C3 Must Run, EOY 2039 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$4.9	$6.2	($1.3)
CEO 2, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$4.6	$5.8	($1.2)
CEO 5, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	$6.4	$8.2	($1.8)

In Table 20 below, we have included the results for the No CO_2 production cost runs i.e., including the SCC cost in the capacity expansion but removing the SCC cost in the production cost modeling to obtain the revenue requirement not inclusive of the carbon cost. The difference between all scenarios is negligible.

Table 20. Revenue requirement with the SCC applied to capacity expansion only for CEO Baseline, CEO 2 and CEO 5

Scenario	NPV (billion $)	NPV Diff compared with Baseline (billion $)	NPV % Diff compared with Baseline (billion $)
CEO Baseline, C3 Must Run, EOY 2039 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$40.4		
CEO 2, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	$40.4	($0.04)	-0.10%
CEO 5, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	$40.6	$0.19	0.47%

As shown in Table 21 below showing the emissions reduction compared with the 2005 emissions with and without SCC applied to the production cost modeling. When SCC is applied to the capacity expansion only, the emissions reduction occurs at a slower pace than when the SCC is applied to the capacity expansion and production cost modeling step.

Table 21. Percentage CO_2 reduction from 2005 emission levels for CEO Baseline, CEO 2 and CEO 5, comparing production cost modeling with and without SCC applied

		2024	2026	2028	2030
PSCo Baseline	SCC applied to capacity expansion and production cost modeling	-49%	-64%	-76%	-84%
CEO Baseline, C3 Must Run, EOY 2039 C3 Retirement, SCC discounted @ 3%, 2028 Pawnee Gas Conversion	SCC applied to capacity expansion and production cost modeling	-61%	-74%	-81%	-90%
	SCC applied to capacity expansion only	-49%	-66%	-77%	-86%
CEO 2, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	SCC applied to capacity expansion and production cost modeling	-61%	-78%	-85%	-91%
	SCC applied to capacity expansion only	-49%	-67%	-79%	-89%
CEO 5, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	SCC applied to capacity expansion and production cost modeling	-62%	-79%	-87%	-92%
	SCC applied to capacity expansion only	-49%	-68%	-80%	-90%

Table 22 below shows the cumulative emissions for 2030, 2040 and 2050. As we can see, by the end of the study period in 2050, the scenarios with SCC included in the production cost modeling have lower cumulative emissions. CEO 5 which includes early retirement of Comanche 3 in 2029 has the lowest cumulative emissions irrespective of whether the SCC is applied in the production cost modeling or not.

Table 22.Cumulative CO_2 emissions in (million tons), comparing production cost modeling with and without SCC applied

Cumulative Emissions		2030	2040	2050
CEO Baseline, C3 Must Run, EOY 2039 C3 Retirement, SCC discounted @ 3%, 2028 Pawnee Gas Conversion	SCC applied to capacity expansion and production cost modeling	81.9	110.4	120.7
	SCC applied to capacity expansion only	104.7	142.1	152.6
CEO 2, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 3%, EOY 2027 Pawnee Gas Conversion	SCC applied to capacity expansion and production cost modeling	76.8	103.0	112.8
	SCC applied to capacity expansion only	102.1	131.1	141.1
CEO 5, Economic Dispatch and EOY 2029 C3 Retirement, SCC discounted @ 2.5%, EOY 2027 Pawnee Gas Conversion	SCC applied to capacity expansion and production cost modeling	74.3	98.4	107.6
	SCC applied to capacity expansion only	100.0	126.8	136.2

Appendix - Files Referenced for Modeling and Analysis

EnCompass Input Files

Public Service Response to Discovery Request OCC 21-1

OCC21-1_Attachments, HIGHLY CONFIDENTIAL_EnCompass Input Files, EO Input Files_Updated

- 2027 Retirement - Blue Spruce.xlsx
- 2027 Retirement - Cherokee CC.xlsx
- 2027 Retirement - Craig 2.xlsx
- 2027 Retirement - FSV CC.xlsx
- 2027 Retirement - FSV56.xlsx
- 2027 Retirement - Hayden 1.xlsx
- 2027 Retirement - Hayden 2.xlsx
- 2027 Retirement - Manchief.xlsx
- 2027 Retirement - Pawnee 1.xlsx
- 2027 Retirement - RMEC.xlsx
- 2027 Retirement - Valmont 78.xlsx
- C3 Econ Dispatch.xlsx
- C3 Seasonal Ops.xlsx
- C3 Staff Data.xlsx
- CEP CO2 Cap 100x50 85pct.xlsx
- CEP CO2 Cap 100x50 95pct.xlsx
- CO2 $0 Cost.xlsx
- CO2 Cost SCC.xlsx
- Com3 Retire 2040 Dispatch Cap.xlsx
- Com3 Retire 2040 Dispatch Cap_No Sec.xlsx
- EMG Market and Fixed Cost Updates.xlsx
- ERP CO2 Cap 100x50 85pct.xlsx
- ERP CO2 Cap 100x50 95pct.xlsx
- Flex Reserve_Ramp Up_0 CO2 CEP_2021-01-22.xlsx
- Flex Reserve_Ramp Up_0 CO2 ERP_2021-01-22.xlsx
- Flex Reserve_Ramp Up_SCC CEP_2021-01-22.xlsx
- Flex Reserve_Ramp Up_SCC ERP_2021-01-22.xlsx
- Index_072121.xlsx
- Input_Benchmark RRs_2021-03-02.xlsx
- IREA_HC Constraint_BAU.xlsx
- IREA_HC Constraint_Gas.xlsx
- IREA_HC Constraint_Retire 2040.xlsx

- IREA_HC Constraint_Retire.xlsx
- July 2030.xlsx
- Limited Life Generics.xlsx
- Lock Comanche 3 BAU.xlsx
- Lock Comanche 3 Early Retire.xlsx
- Lock Comanche 3 Gas.xlsx
- Lock Comanche 3 Retire 2040.xlsx
- Lock Craig 2 BAU.xlsx
- Lock Craig 2 Early Retire.xlsx
- Lock Hayden 1 BAU.xlsx
- Lock Hayden 1 Early Retire.xlsx
- Lock Hayden 2 BAU.xlsx
- Lock Hayden 2 Early Retire_2027.xlsx
- Lock Pawnee BAU.xlsx
- Lock Pawnee Early Retire.xlsx
- Lock Pawnee Gas.xlsx
- Lock RMEC BAU.xlsx
- No TRX Generics.xlsx
- Pawnee Early Gas Convert.xlsx
- Peak Shift Backward 2 Hours.xlsx
- Peak Shift Forward 2 Hours.xlsx
- PSCO Consolidation Dataset_071621.xlsx
- Regulating Reserve_Ramp Up_0 CO2 CEP_2021-01-22.xlsx
- Regulating Reserve_Ramp Up_0 CO2 ERP_2021-01-22.xlsx
- Regulating Reserve_Ramp Up_SCC CEP_2021-01-22.xlsx
- Regulating Reserve_Ramp Up_SCC ERP_2021-01-22.xlsx
- RRs Assigned to Projects.xlsx
- SENS_ExpandedMKT.xlsx
- SENS_HighGas.xlsx
- Sens_HighLoad.xlsx
- SENS_Hydrogen10.xlsx
- SENS_LowGas.xlsx
- Sens_LowLoad.xlsx
- SENS_NoNewGas.xlsx
- SENS_SunkTxCost.xlsx
- SENS_SUPP High Gas.xlsx
- Shape_July2030.xlsx
- Supp_Add 200 MW CSG.xlsx
- Supp_Add 200MW DR.xlsx
- Supp_HighEV.xlsx
- Supp_LowPRM_400MWPurch.xlsx
- Supp_PurchasesTo200MW.xlsx

- Supp_V2G.xlsx

OCC21-1_Supplemental Attachments, Suppl Direct Database Files

- C3 Econ Dispatch.xlsx
- C3 Seasonal Ops.xlsx
- C3 Staff Data.xlsx
- CEP CO2 Cap 100x50 85pct.xlsx
- CEP CO2 Cap 100x50 95pct.xlsx
- CO2 $0 Cost.xlsx
- CO2 Cost SCC.xlsx
- Com3 Retire 2040 Dispatch Cap.xlsx
- Com3 Retire 2040 Dispatch Cap_No Sec.xlsx
- EMG Market and Fixed Cost Updates.xlsx
- ERP CO2 Cap 100x50 85pct.xlsx
- ERP CO2 Cap 100x50 95pct.xlsx
- Flex Reserve_Ramp Up_0 CO2 CEP_2021-01-22.xlsx
- Flex Reserve_Ramp Up_0 CO2 ERP_2021-01-22.xlsx
- Flex Reserve_Ramp Up_SCC CEP_2021-01-22.xlsx
- Flex Reserve_Ramp Up_SCC ERP_2021-01-22.xlsx
- Index_081721.xlsx
- IREA_HC Constraint_BAU.xlsx
- IREA_HC Constraint_Gas.xlsx
- IREA_HC Constraint_Retire 2040.xlsx
- IREA_HC Constraint_Retire.xlsx
- July 2030.xlsx
- Limited Life Generics.xlsx
- Lock Comanche 3 BAU.xlsx
- Lock Comanche 3 Early Retire.xlsx
- Lock Comanche 3 Gas.xlsx
- Lock Comanche 3 Retire 2040.xlsx
- Lock Craig 2 Early Retire.xlsx
- Lock Hayden 1 Early Retire.xlsx
- Lock Hayden 2 Early Retire_2027.xlsx
- Lock Pawnee BAU.xlsx
- Lock Pawnee Early Retire.xlsx
- Lock Pawnee Gas.xlsx
- Lock RMEC BAU.xlsx
- Pawnee Early Gas Convert.xlsx
- Peak Shift Backward 2 Hours.xlsx
- Peak Shift Forward 2 Hours.xlsx
- PSCO Consolidation Dataset_071621.xlsx
- Regulating Reserve_Ramp Up_0 CO2 CEP_2021-01-22.xlsx

- Regulating Reserve_Ramp Up_0 CO2 ERP_2021-01-22.xlsx
- Regulating Reserve_Ramp Up_SCC CEP_2021-01-22.xlsx
- Regulating Reserve_Ramp Up_SCC ERP_2021-01-22.xlsx
- SENS_SUPP High Gas.xlsx
- Shape_July2030.xlsx
- Supp_Add 200 MW CSG.xlsx
- Supp_Add 200MW DR.xlsx
- Supp_HighEV.xlsx
- Supp_LowPRM_400MWPurch.xlsx
- Supp_PurchasesTo200MW.xlsx
- Supp_V2G.xlsx

OCC21-1_Supplemental Attachments, Suppl Direct Database_Locked Plans

- Project Plans--C3 Staff_P1C1_Reference.xlsx
- Project Plans--C3 Staff_P1C1_Reference_SCC.xlsx
- Project Plans--C3 Staff_P2C3_Paw E Gas-C3 39 Red.xlsx
- Project Plans--C3 Staff_P2C3_Paw E Gas-C3 39 Red_SCC.xlsx
- Project Plans--C3 Staff_P3C3_Paw Gas-C3 39 Red.xlsx
- Project Plans--C3 Staff_P3C3_Paw Gas-C3 39 Red_SCC.xlsx
- Project Plans--C3 Staff_P3C3_SCC_C3 Econ.xlsx
- Project Plans--C3 Staff_P3C3_SCC_Seasonal Ops.xlsx
- Project Plans--C3 Staff_P3C4_Paw Gas-C3 Gas.xlsx
- Project Plans--C3 Staff_P3C4_Paw Gas-C3 Gas_SCC.xlsx
- Project Plans--C3 Staff_P3C6_Paw Gas-C3 39.xlsx
- Project Plans--C3 Staff_P3C6_Paw Gas-C3 39_SCC.xlsx
- Project Plans--C3 Staff_P3C7_Paw Gas-C3 29.xlsx
- Project Plans--C3 Staff_P3C7_Paw Gas-C3 29_SCC.xlsx
- Project Plans--C3 Staff_P4C6_Paw 28-C3 39 Red.xlsx
- Project Plans--C3 Staff_P4C6_Paw 28-C3 39 Red_SCC.xlsx
- Project Plans--C3 Staff_P4C7_Paw 28-C3 29.xlsx
- Project Plans--C3 Staff_P4C7_Paw 28-C3 29_SCC.xlsx
- Project Plans--C3 Staff_P4C7_SCC_C3 Econ.xlsx
- Project Plans--C3 Staff_P4C7_SCC_Seasonal Ops.xlsx
- Project Plans--P3C3_SCC_SUPP_Sens Limited Life Gas.xlsx
- Project Plans--P3C3_SCC_SUPP_Sens_HighGas.xlsx
- Project Plans--P3C3_Supp _High EV_V2G_SCC.xlsx
- Project Plans--P3C3_Supp_Add 200MW CSG_SCC.xlsx
- Project Plans--P3C3_Supp_Add 200MW DR_SCC.xlsx
- Project Plans--P3C3_Supp_LowPRM_SCC.xlsx
- Project Plans--Shift Peak + 2HR.xlsx
- Project Plans--Shift Peak - 2HR.xlsx
- Project Plans_Definitions.xlsx

Public Service Response to Discovery Request CEO 1-5

- 21A-0141E Confidential Attachment_CEO5-3(a)(iii).A1_Com3 Retire 2035 Data.xlsx

EnCompass Output Files and Post-Processing Workpapers

Public Service Response to Discovery Request OCC 1-2

Highly Confidential Workpapers, Volume 2, Encompass Output Files

- 21A-0141E_Highly Confidential Workpaper_Volume 2_09_EO - SCC Step 1 and 2 Base Final_030821.xlsb

Highly Confidential Workpapers, Volume 2, Corrected Encompass Output Files

- 21A-0141E_CORRECTED_Highly Confidential Workpaper_Volume 2_09_EO - SCC Base_071621.xlsb
- 21A-0141E_CORRECTED_Public Workpaper_Volume 2_01_Ownership Template_Base Runs_071621.xlsx
- 21A-0141E_CORRECTED_Public Workpaper_WithLinks_Volume 2_36_Ownership Template_Base Runs_071621.xlsx

Highly Confidential Workpapers, Landrum Supplemental

- 21A-0141E _Landrum Suppl_Highly Confidential Workpaper_02_EO - SCC Com 3 Cost update__Econ_Seas_071621.xlsb
- 21A-0141E _Landrum Suppl_Highly Confidential Workpaper_03_EO - SCC Com 3 Cost update_071621.xlsb
- 21A-0141E_Landrum Suppl_Public Workpaper_WithLinks_07_Ownership Template_Com 3 Cost update_071621.xlsx