

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE



March 14, 2025

DOE/NETL-2025/4923

Disclaimer

This project was funded by the United States Department of Energy, National Energy Technology Laboratory, in part, through a site support contract. Neither the United States Government nor any agency thereof, nor any of their employees, nor the support contractor, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

All images in this report were created by NETL, unless otherwise noted.

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL
GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Sarah Leptinsky¹: Methodology, Formal Analysis, Investigation, Writing – Original Draft, Visualization; **Marc Turner**¹: Methodology, Validation, Formal Analysis, Writing – Original Draft, Writing – Review and Editing, Visualization, Supervision; **Matthew Oakes**¹: Methodology, Formal Analysis, Writing – Original Draft, Supervision; **Danny Quinn**¹: Methodology, Formal Analysis, Writing – Original Draft; **James Gummo**¹: Methodology, Formal Analysis, Writing – Original Draft; **Sally Homsy**²: Writing – Review and Editing, Validation; **Troy Teel**¹: Writing – Review and Editing, Validation; **Patricia Cvetic**¹: Writing – Review and Editing; **Norma Kuehn**¹: Writing – Review and Editing, Validation; **Mark Woods**¹: Writing – Review and Editing, Supervision; **Travis Shultz**²: Conceptualization, Writing – Review and Editing, Supervision, Project Administration; **Hannah Hoffman**¹: Writing – Review and Editing

¹National Energy Technology Laboratory (NETL) support contractor

²NETL

Corresponding contact: Indrajit Bhattacharya, Indrajit.Bhattacharya@netl.doe.gov, 412-386-7389

Suggested Citation: S. Leptinsky et al. (2025). *Examination of Factors Affecting the Cost and Performance of a Natural Gas Combined Cycle Equipped with Carbon Dioxide Capture*. National Energy Technology Laboratory, Pittsburgh.

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL
GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

This page intentionally left blank.

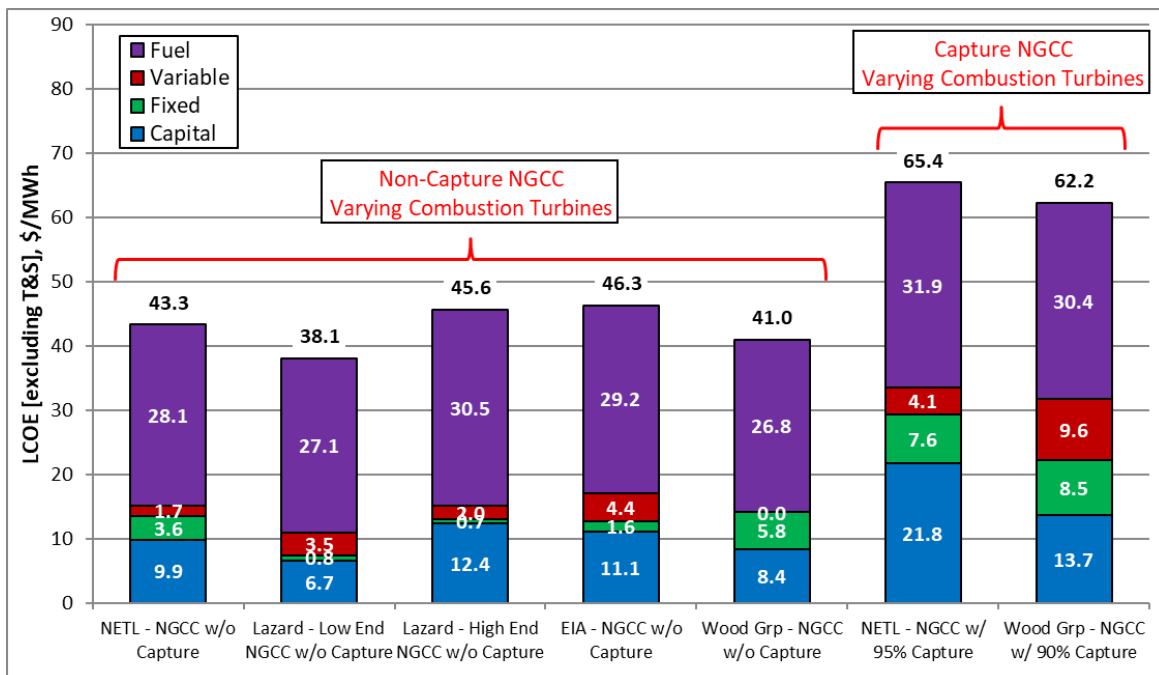


1 INTRODUCTION

Techno-economic analyses (TEAs) are performed to evaluate the cost and performance of a power-generation technology for a variety of purposes, including to establish a commercial benchmark; estimate the commercial potential of a technology; inform research and development priorities and business or policy decisions; compare—on a common basis—technologies for a given purpose; project the economic benefit of a technology; identify feasibility, performance, and cost issues; inform testing, modeling, or design priorities; and assess economic uncertainty and risk. TEA study data are routinely used as input for energy system modeling efforts (e.g., capacity expansion, production cost) engaged in planning, performing scenario analyses, or developing energy sector regulations. Others, while conducting research or performing a feasibility study, may seek to approximate the cost and performance of a plant’s technology and configuration to be constructed at a particular location and time. For all of these uses, it’s important to understand the impact of deviations from a study’s assumptions on the reported cost and performance.

TEAs of fossil fuel power plants incorporating CO₂ capture are published by multiple sources (e.g., National Energy Technology Laboratory [NETL], Wood Group, Energy Information Administration [EIA], Lazard). As demonstrated in Exhibit 1-1, cost and performance estimates for a particular technology and plant configuration will differ due to a host of factors embodied in the study’s assumptions. These differences may include technology selection, production scale, vintage of data, finance structure and assumptions, market assumptions (e.g., feedstock prices), operational assumptions (e.g., capacity factor), construction assumptions, and performance assumptions.

Exhibit 1-1. Published TEA comparison studies (NETL, 2022-a) (Lazard, 2018) (EIA, 2016) (Wood Group, 2018)



NGCC = natural gas combined cycle; T&S = transport and storage

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

While the variation in reported cost estimates due to the AACE International (AACE) uncertainty classification associated with a study may be acknowledged, potential deviations due to other factors are often not extensively reported. Details associated with the location, design, construction, operation, and finance of the subject plant, in actual practice, will entail multiple deviations from a reference study's assumptions, potentially resulting in substantial differences in cost and performance.

The purpose of this Technical Note is to report the findings of an examination of the effect of plausible deviations in select study assumptions on the reported cost and performance estimates for a power plant case drawn from NETL's "Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity" (known as the Fossil Energy Baseline [FEB]) (NETL, 2022-b). An F-Class NGCC power plant equipped with state-of-the-art, solvent-based, post-combustion carbon dioxide (CO₂) capture (95 percent carbon capture rate)—designated as Case B31B.95—was selected for this work. This sensitivity analysis provides insight into the effects of parameter variations within and across selected categories—ambient conditions, construction cost, natural gas (NG) price, capacity factor, and finance—on the plant performance and capital and operating and maintenance (O&M) costs, and the subsequent impact on common figures of merit.

The capital cost estimate of Case B31B.95 is intended to represent the next commercial offering, with an uncertainty range of -15 percent/+25 percent—consistent with AACE Class 4 cost estimates—based on the level of engineering design performed (NETL, 2019-b) (AACE, 2003) (AACE, 2005). The capital costs rely on vendor cost estimates for component technologies and apply process contingencies at the appropriate subsystem levels to account for expected but undefined costs, which can be a challenge for emerging technologies such as CO₂ capture.

As the cost estimate uses the same cost estimating methodology as mature plant designs, the unique cost premiums associated with the initial, complex integrations of emerging technologies such as CO₂ capture in a commercial application are not fully accounted for. Thus, it is anticipated that early deployments of NGCC plants with CO₂ capture may incur costs higher than those reflected within the FEB and this Technical Note. Continuing research, development, and demonstration is expected to result in designs that are more advanced than those assessed in the FEB, leading to cost reductions over time.

Actual reported project costs are also expected to deviate from the FEB and Technical Note cost estimates due to project- and site-specific considerations (e.g., contracting strategy, permitting, water quality, local environmental concerns, weather delays) that may make construction more costly. Such variations are not captured by the reported cost uncertainty.

2 METHODS

The FEB estimates the full-load, steady-state cost and performance of specific greenfield power plant configurations using a common set of assumptions to enable direct comparison of the evaluated cases. The levelized cost of electricity (LCOE) and cost of capture (COC) are derivative figures of merit.

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

To the extent possible, the plant design of each sensitivity in this Technical Note is maintained consistent with the B31B.95 base case to isolate the effects of each factor, modifying only the performance and cost parameters necessary to accurately assess the factor’s impact.^a

Some of the key assumptions supporting the base case cost estimates include the following:

- Basic design with average material specifications, limited redundancy and plant automation, and optimized plant layout to minimize cost
- Greenfield site, free from hazardous materials or archeological artifacts
- Ideal site conditions (flat and level site, no rock excavation, limited seismic or wind considerations, no piles, easily accessible, etc.)
- Competitive bidding environment
- Low-cost labor market with relatively high productivity
- Adequate supply of skilled craft labor available locally
- Optimized construction schedule

The parameter values for the ambient condition category sensitivities—selected to span plausible ranges for power plant locations in the United States—are listed in Exhibit 2-1. Base case values correspond to those of the B31B.95 reference case. Aspen Plus® was used to model plant performance at each set of ambient conditions. The capital costs were scaled from FEB costs using select process parameters extracted from the performance models using the methodology established by NETL (NETL, 2019-a).

Exhibit 2-1. Ambient condition sensitivity ranges

Parameter Value	Basis	Case Name
Site Elevation		
0 m	International Organization for Standardization (ISO) (NETL, 2022-a)	Base
1,609 m	Denver, CO (USGS, 2005)	High
Ambient Temperature		
5.3 °C	Annual Average – North Dakota (NCEI, n.d.-a)	Cold
15.0 °C	ISO (NETL, 2022-a)	Base
22.4 °C	Annual Average – Florida (NCEI, n.d.-a)	Hot
Ambient Relative Humidity		
20%	Annual Average (afternoon) – Las Vegas, Nevada (NCEI, n.d.-b)	Dry
60%	ISO (NETL, 2022-a)	Base

^a While the cases within this study include CO₂ capture, the effect of ambient conditions on the capture system could not be accounted for as the available vendor data were insufficient to determine the effect on cost or performance across the range of factors assessed.

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Parameter Value	Basis	Case Name
90%	Annual Average (morning) – Lake Charles, Louisiana (NCEI, n.d.-b)	Hum

USGS = U.S. Geological Survey; NCEI = National Centers for Environmental Information

The parameter sensitivity ranges for the construction cost category are shown in Exhibit 2-2. Base case values correspond to those of the B31B.95 reference case. In many of the accounts, the low range value represents the base case, meaning the base case is already at ideal conditions and cannot be reduced further.

Exhibit 2-2. Construction conditions sensitivity ranges

Parameter	Low	Base	High
Use of Piles	No	No	Yes
Cost of Concrete	1.00	1.00	1.25
Cost of Steel	0.90	1.00	1.30
Seismic – Equipment – Purchase	1.00	1.00	1.04
Seismic – Equipment – Install	1.00	1.00	1.01
Seismic – Foundations – Purchase	1.00	1.00	1.25
Seismic – Foundations – Install	1.00	1.00	1.15
Seismic – Steel – Purchase	1.00	1.00	1.50
Seismic – Steel – Install	1.00	1.00	1.30
Labor Productivity	0.95	1.00	1.25
Labor Rate (Merit: Low; Union: High)	0.85	1.00	1.29
Process Contingency	1.00	1.00	2.00
Project Contingency	1.00	1.00	1.50

For projects having identical scope, the labor cost is primarily driven by location, labor pool, and market conditions. These factors will determine wage rates and anticipated local productivity. The labor rate explores variations in cost resulting from the use of union versus merit shop (non-union) labor, whereas labor productivity explores the variations in cost resulting from either improved or reduced productivity relative to the expected regional labor productivity for the selected construction labor market. The labor productivity sensitivity is applied as a factor to labor cost—low productivity results in labor costs increasing by 25 percent, and high productivity results in labor costs decreasing by 5 percent.

The potential severity of seismic activity will have an impact on the project design requirements, and therefore costs. The base case estimates consider a project location with minimal seismic activity and no requirement for special design considerations. Therefore, the base case estimates also represent the low case sensitivity. For the high case sensitivity, a location in the area roughly between St. Louis and Memphis was selected. This is representative

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

of areas with potentially more severe seismic activity across the United States but does not encompass the more extreme conditions typically associated with the West Coast.

Site-specific soil conditions determine whether the project foundations require piles. For the purposes of this Technical Note, a case with piles was evaluated relative to the base case without piles.

For the cost-of-concrete sensitivity, only the cost associated with the purchase and delivery of concrete was evaluated.

The cost of steel explores variations in the supply and delivery cost of all products containing steel: building structural steel, miscellaneous steel, pipe and valves, concrete reinforcing steel, mechanical equipment, electrical equipment, and electrical bulks.

Sensitivities were performed to explore variations in cost related to adjusting levels of project and process contingencies, respectively. Contingencies account for anticipated but unspecified costs due to a lack of complete project definition and engineering. Project contingency was added as a percentage of the total plant cost (TPC). The process contingency is intended to compensate for uncertainty in cost estimates caused by performance uncertainties associated with the development status of a technology; as applied here, it is associated with the less mature CO₂ capture and associated instrumentation and control elements.

For the finance category, four parameters were assessed: effective tax rate, return on equity, interest on debt, and debt-to-equity ratio. The parameter sensitivity ranges for the finance category are shown in the Exhibit 2-3. Base case values correspond to those of the B31B.95 reference case.

Exhibit 2-3. Financial parameter sensitivity ranges

Parameter	Low	Base	High
Effective Tax Rate, %	15.0	25.7	36.3
Return on Equity, %	8.5	10	13.8
Interest on Debt, %	4.7	5.0	7.5
Debt-to-Equity Ratio	1.00	1.22	1.50

Additionally, sensitivities were performed on the capacity factor and the NG price, with the parameter sensitivity ranges for each shown in Exhibit 2-4.

Exhibit 2-4. Financial parameter sensitivity ranges

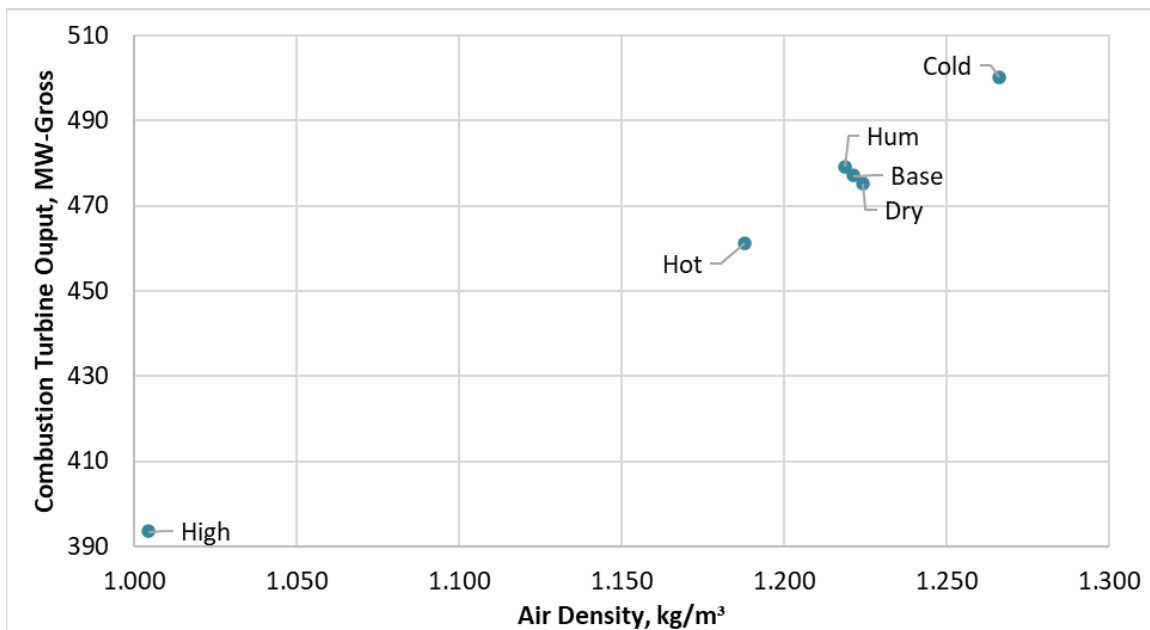
Parameter	Low	Base	High
Capacity Factor, %	30	85	90
NG Price, \$/GJ	1.90	4.19	7.54

The costs within this study are all reported on a December 2018-dollar basis, consistent with the FEB. There are many indices available to adjust costs to alternate dollar bases. Sensitivities were performed to explore the variations in cost resulting from the use of several indices, including the Consumer Price Index (CPI), Handy Whitman (HW), and Chemical Engineering Plant Cost Index (CEPCI)^b to adjust the year-dollar basis to 2022. The results of these sensitivities were then used to determine the impact on the TPC, LCOE, and COC.^c

3 COST AND PERFORMANCE RESULTS

The cost and performance results for the parameter sensitivities within each category are summarized in the following exhibits. Exhibit 3-1 and Exhibit 3-2 demonstrate the impact of air density (as a function of altitude, temperature, and humidity) on the combustion turbine and the bottoming cycle output, respectively. The net power and net plant efficiency for the ambient condition sensitivity cases are shown in Exhibit 3-3 and Exhibit 3-4. Exhibit 3-5 through Exhibit 3-7 demonstrate the ambient condition sensitivity impacts on TPC, LCOE, and COC.

Exhibit 3-1. Ambient condition (elevation, temperature, and humidity) impacts on combustion turbine output



^b As many indices provide reference data at a variety of granularities, the CEPCI sensitivity is completed at two levels: 1) using the final index values (CEPCI) and 2) using more granular index values for equipment, construction labor, buildings, and engineering (CEPCI Gran). While many indices, including CEPCI, allow for even further refinement, offering values for specific types of equipment (e.g., heat exchangers, pumps, electrical), this study does not include a sensitivity at this level of granularity.

^c The COC is calculated using the LCOE from the analogous non-capture case with the same sensitivities applied.

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-2. Ambient condition (elevation, temperature, and humidity) impacts on bottoming cycle output

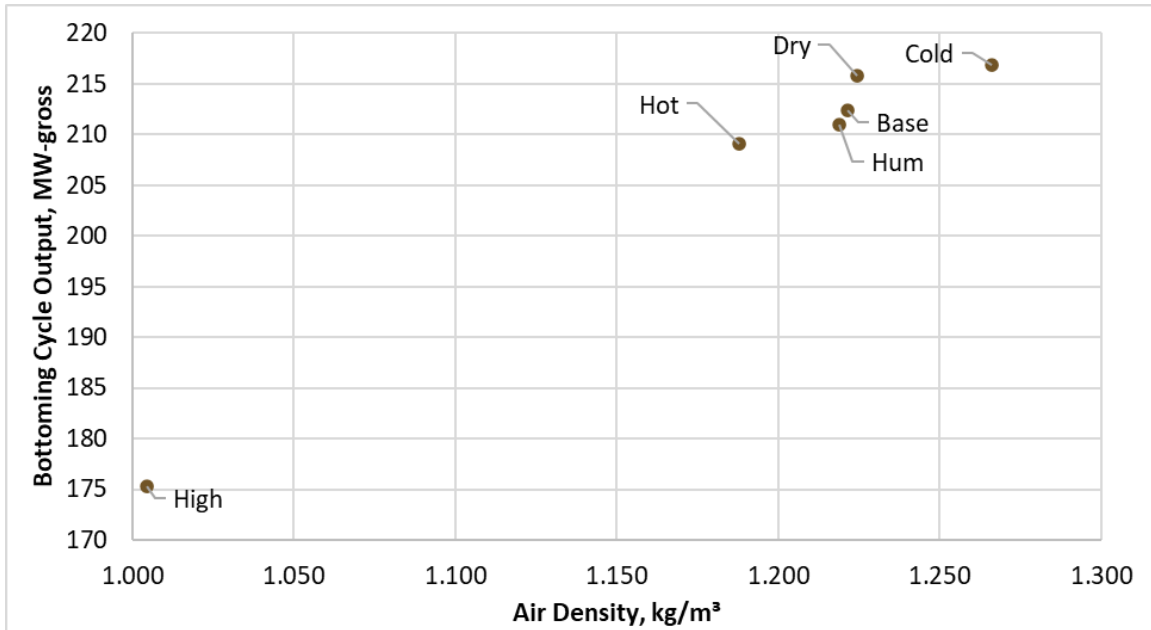
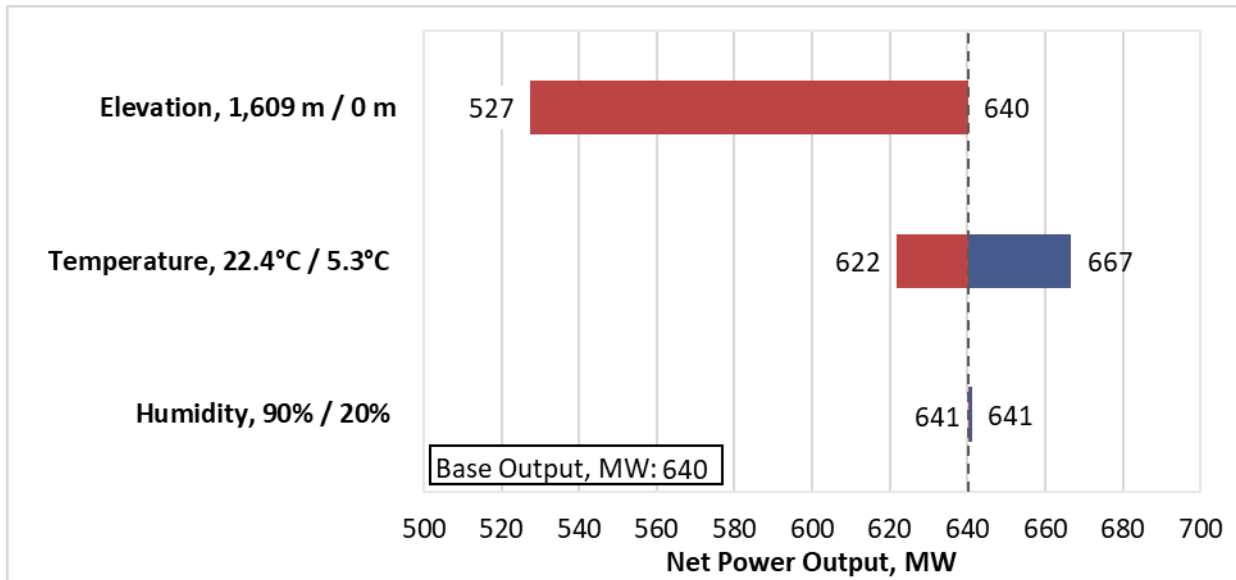


Exhibit 3-3. Ambient condition NGCC net plant output sensitivity



EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-4. Ambient condition NGCC net plant efficiency sensitivity

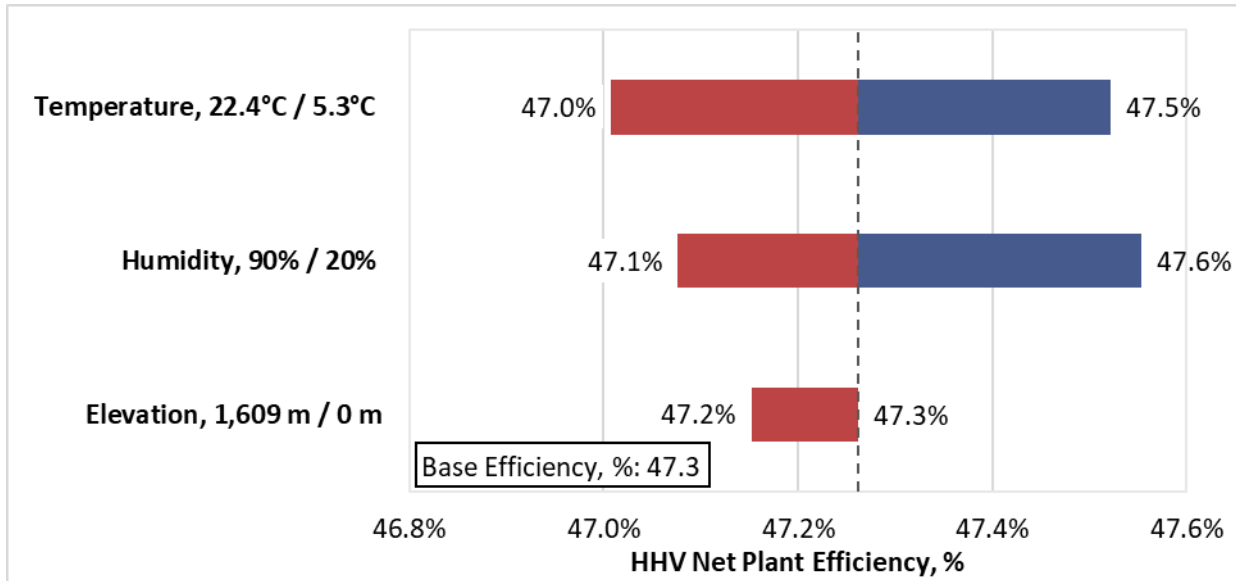
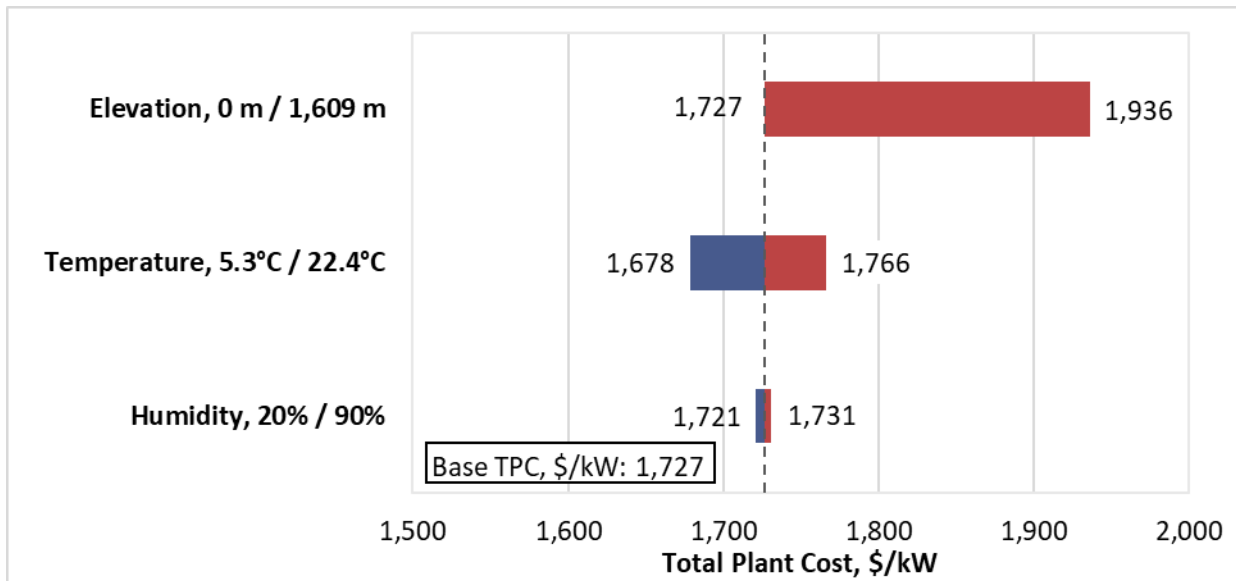


Exhibit 3-5. Ambient condition NGCC sensitivity impact on TPC



EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-6. Ambient condition NGCC sensitivity impact on LCOE

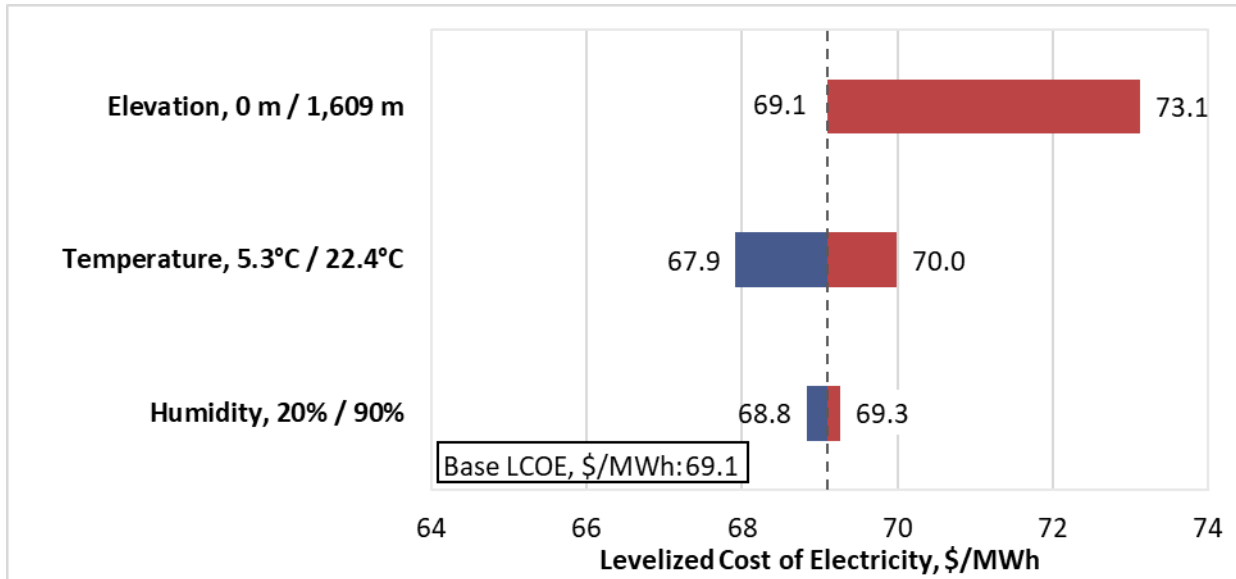
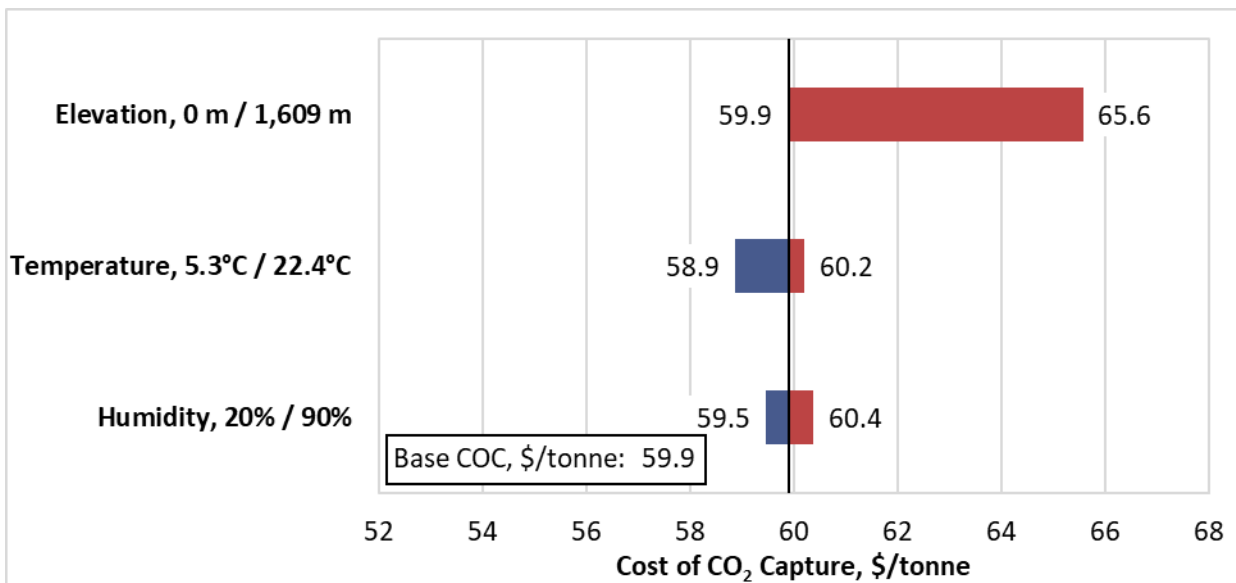


Exhibit 3-7. Ambient condition NGCC sensitivity impact on COC



The results of the impact of the natural gas price on the base case LCOE and COC are presented in Exhibit 3-8 and Exhibit 3-9, respectively.

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-8. NG price impact on LCOE

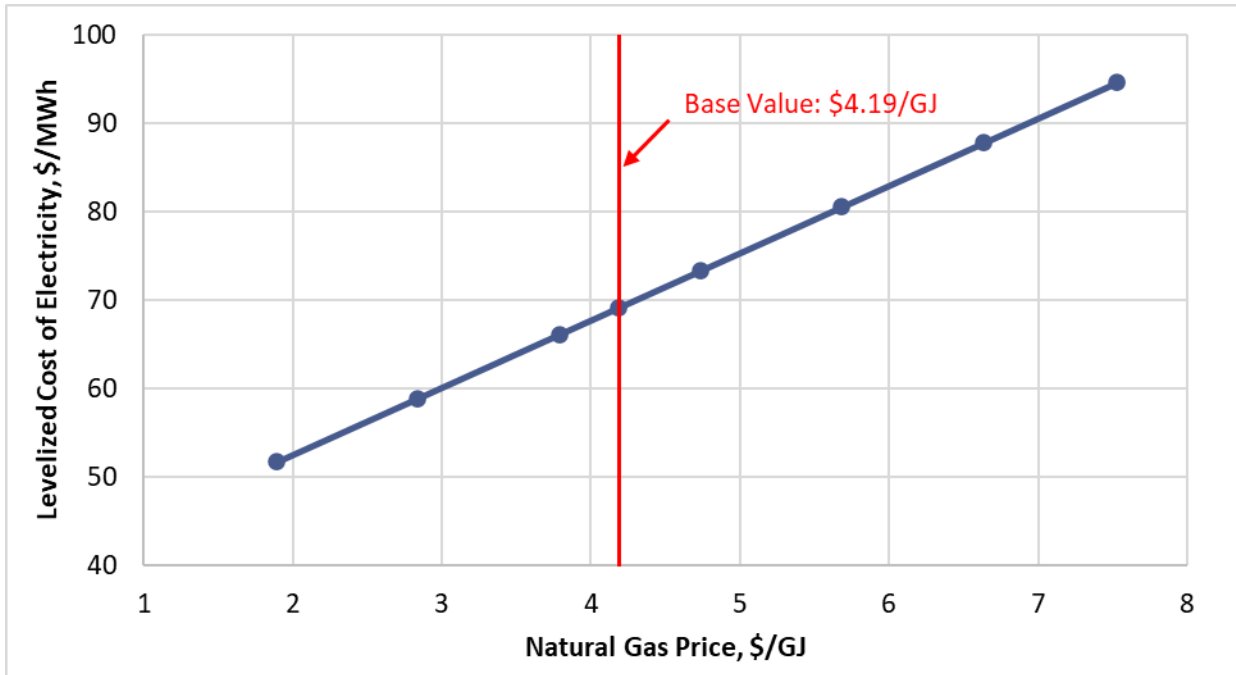
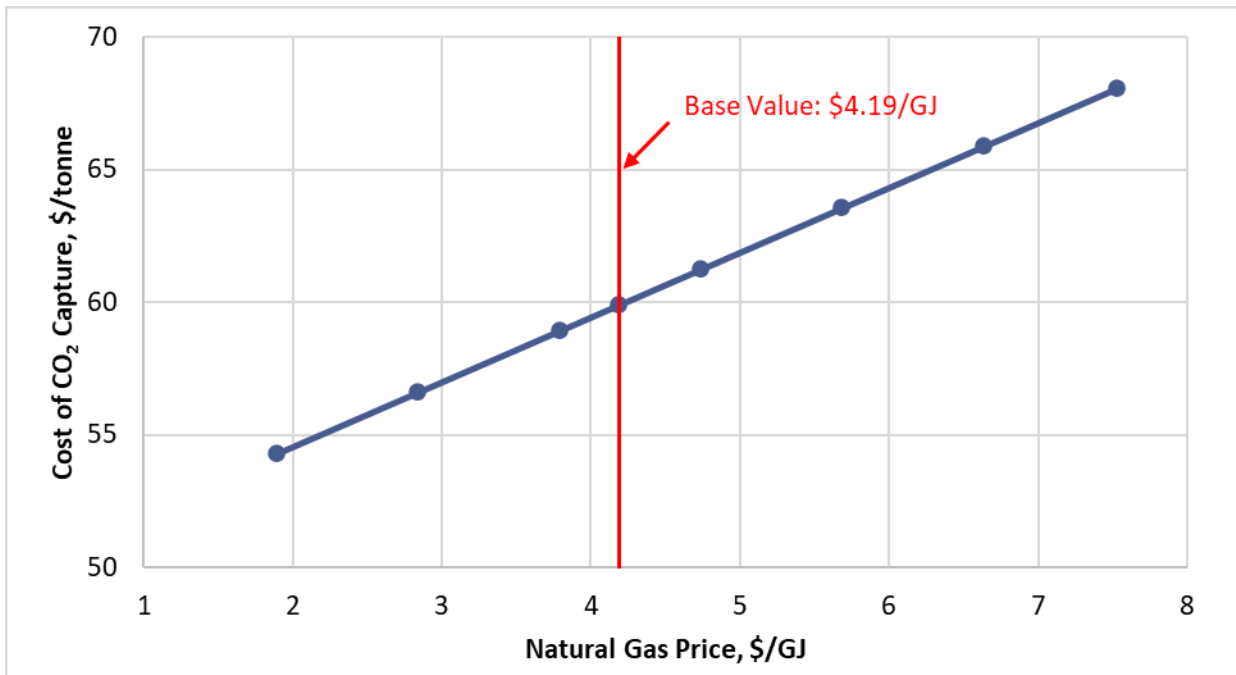


Exhibit 3-9. NG price impact on COC



The results of the impact of the capacity factor on the base case LCOE and COC are presented in Exhibit 3-10 and Exhibit 3-11, respectively.

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-10. Capacity factor impact on LCOE

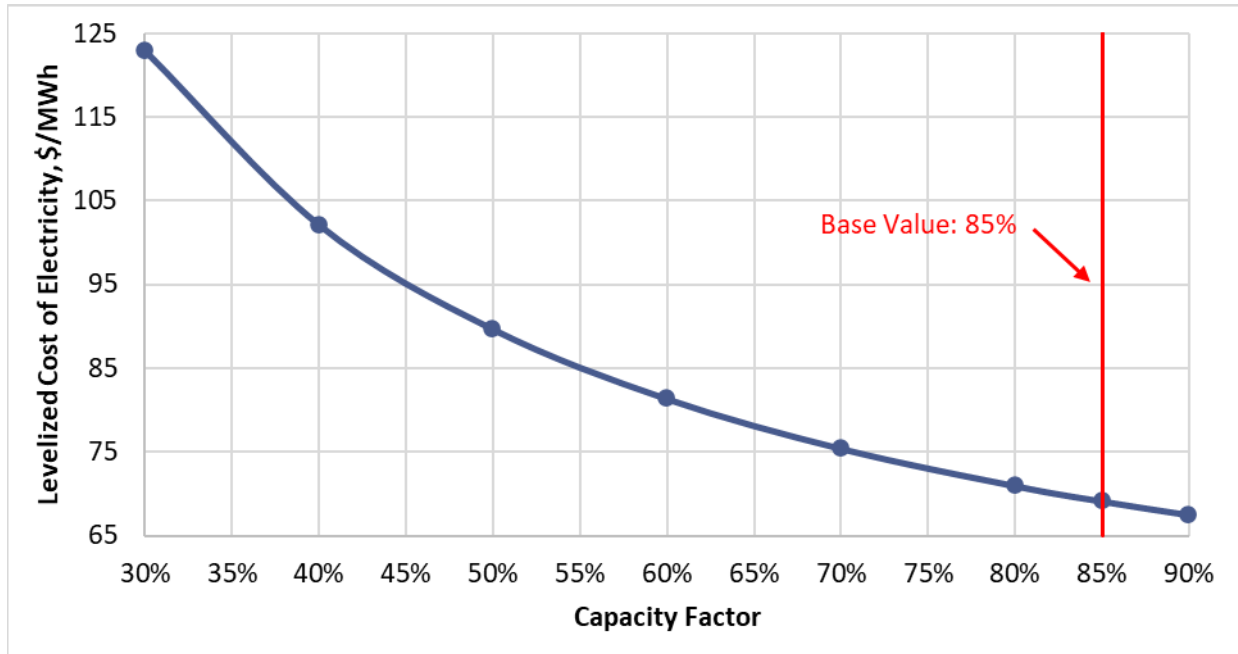
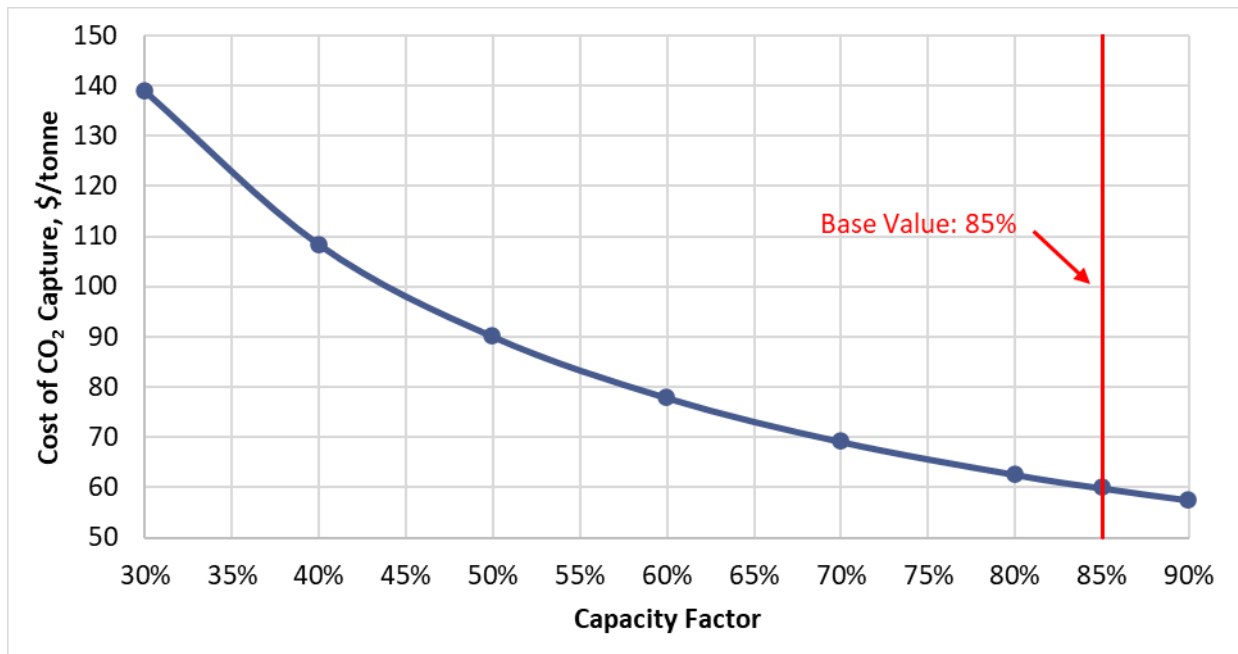


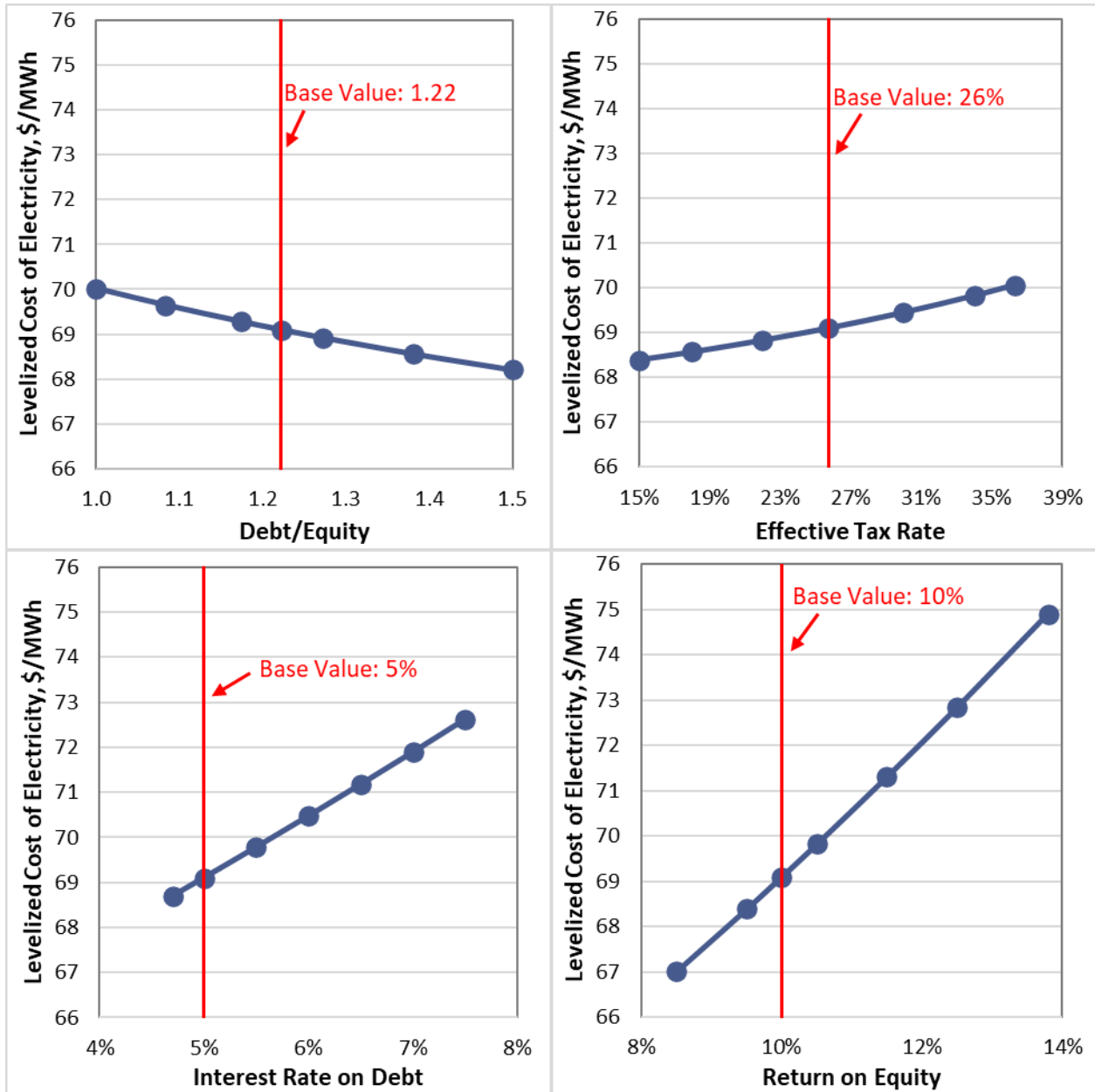
Exhibit 3-11. Capacity factor impact on COC



For the finance category, the impact of debt/equity, effective tax rate, interest rate on debt, and return on equity parameters on LCOE and COC can be found in Exhibit 3-12 and Exhibit 3-13, respectively.

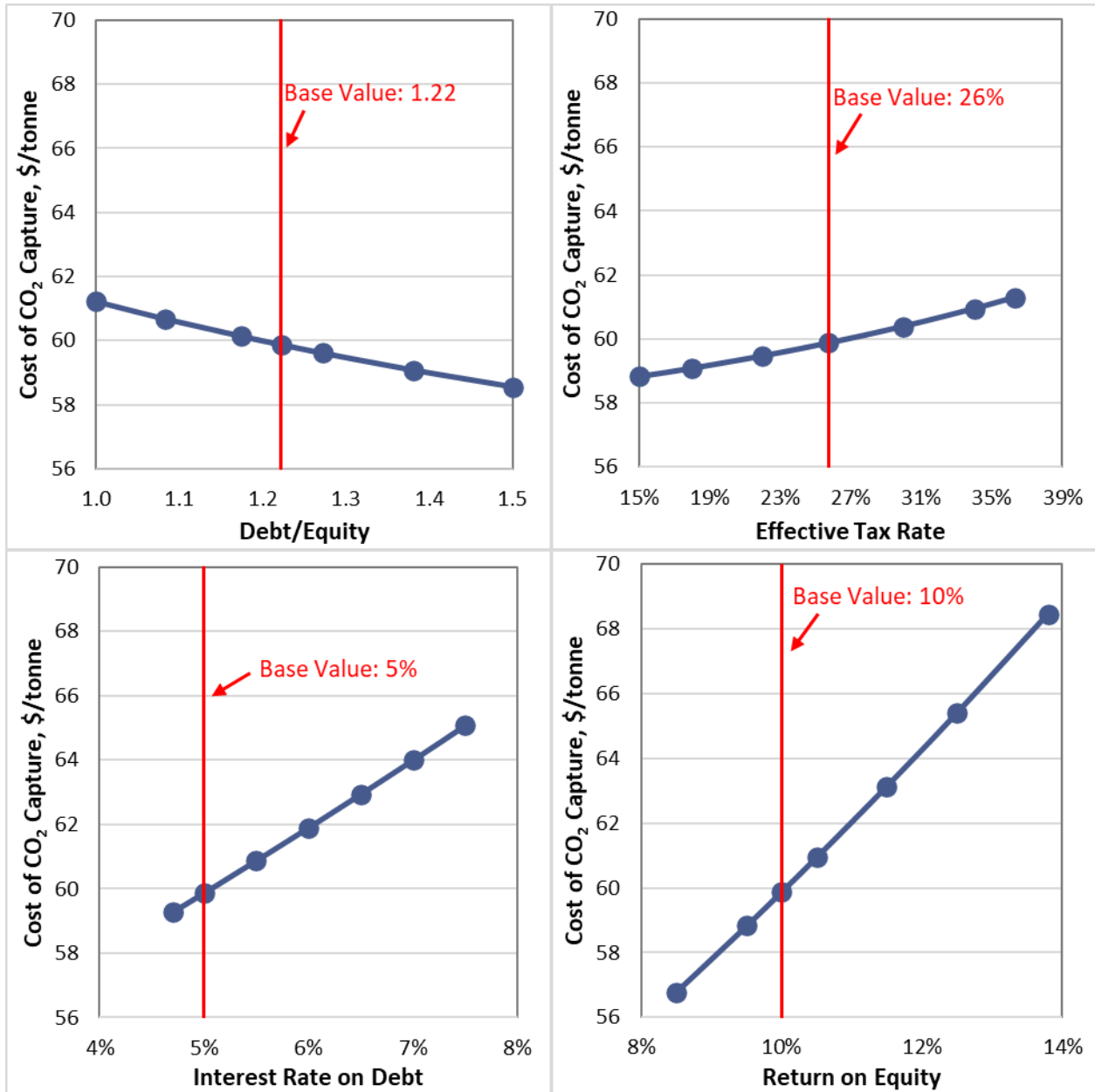
EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-12. LCOE sensitivity to debt/equity, effective tax rate, interest rate on debt, and return on equity



EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-13. COC sensitivity to debt/equity, effective tax rate, interest rate on debt, and return on equity



The impact of cost scaling on TPC, LCOE, and COC using several cost indices is provided in Exhibit 3-14, Exhibit 3-15, and Exhibit 3-16, respectively.

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-14. Cost index impact on TPC when adjusting for inflation

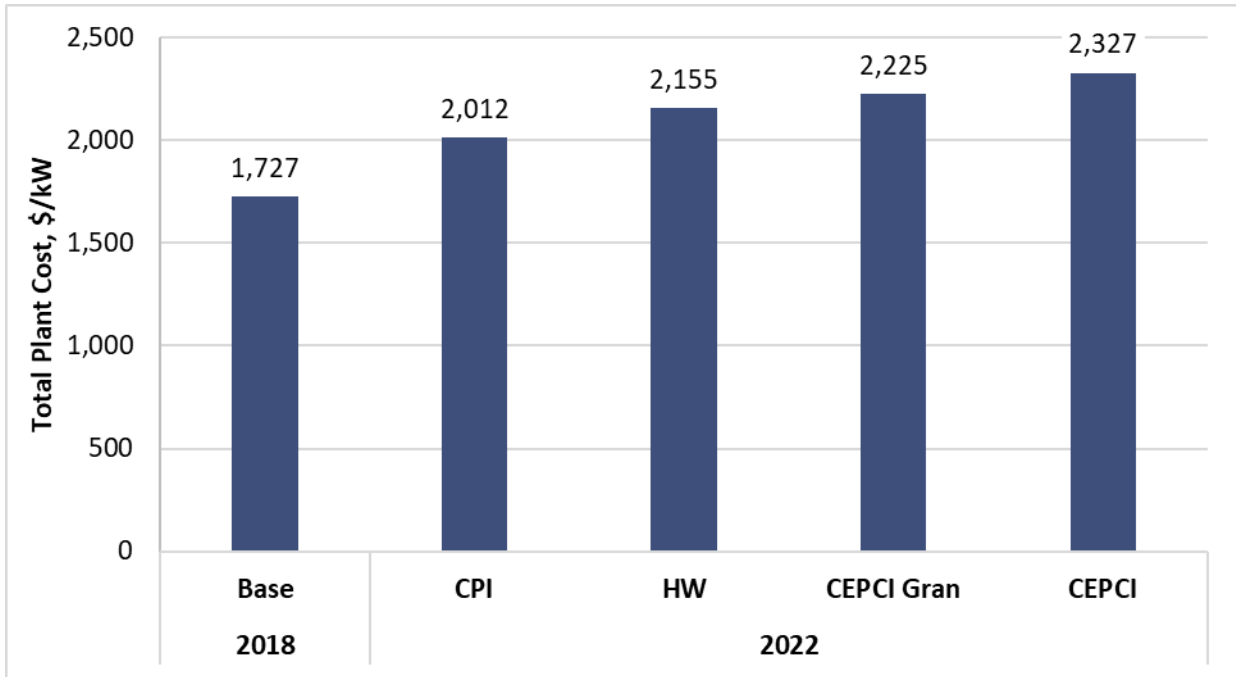
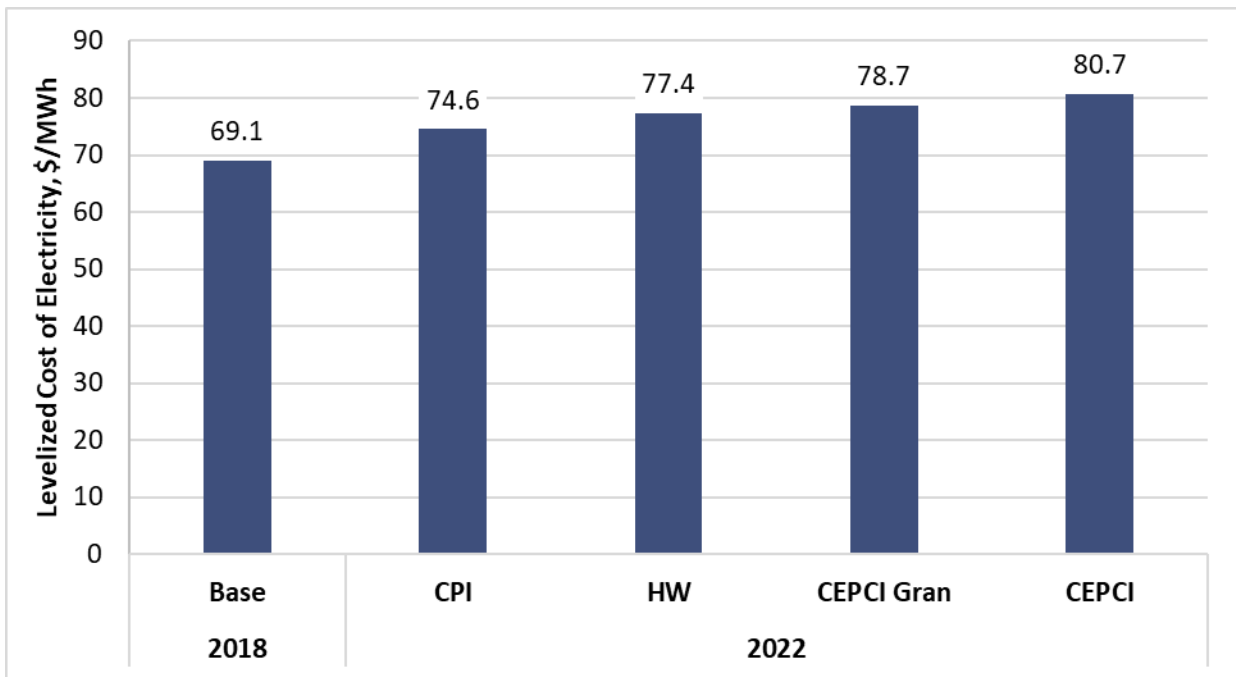
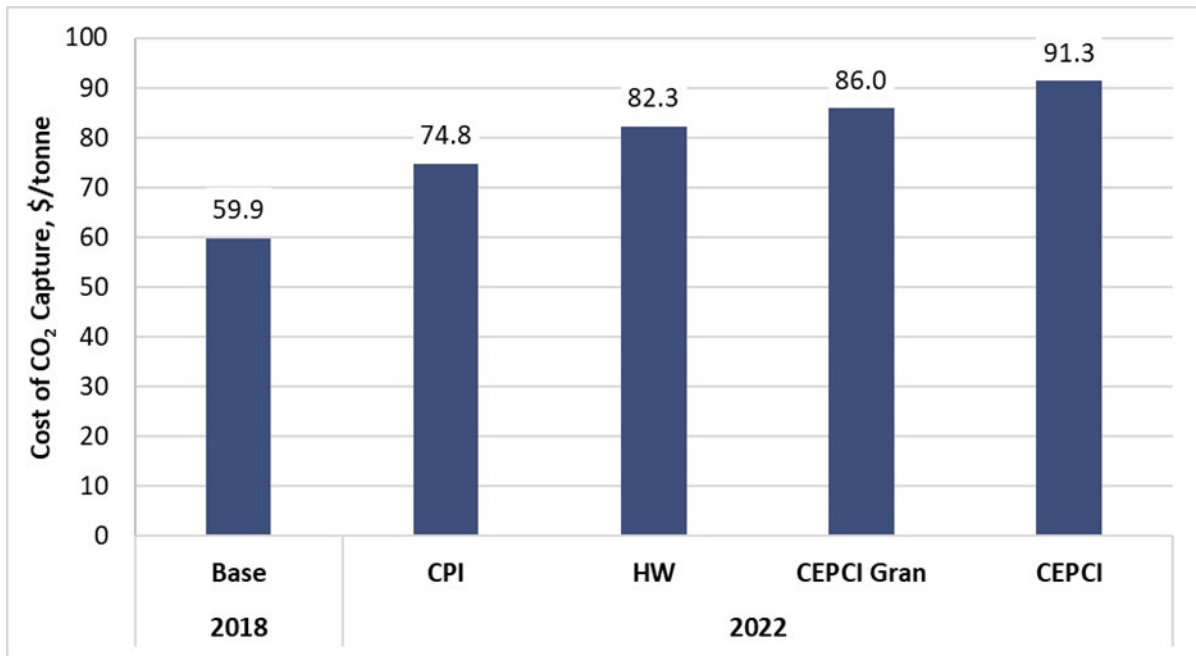


Exhibit 3-15. Cost index impact on LCOE when adjusting for inflation



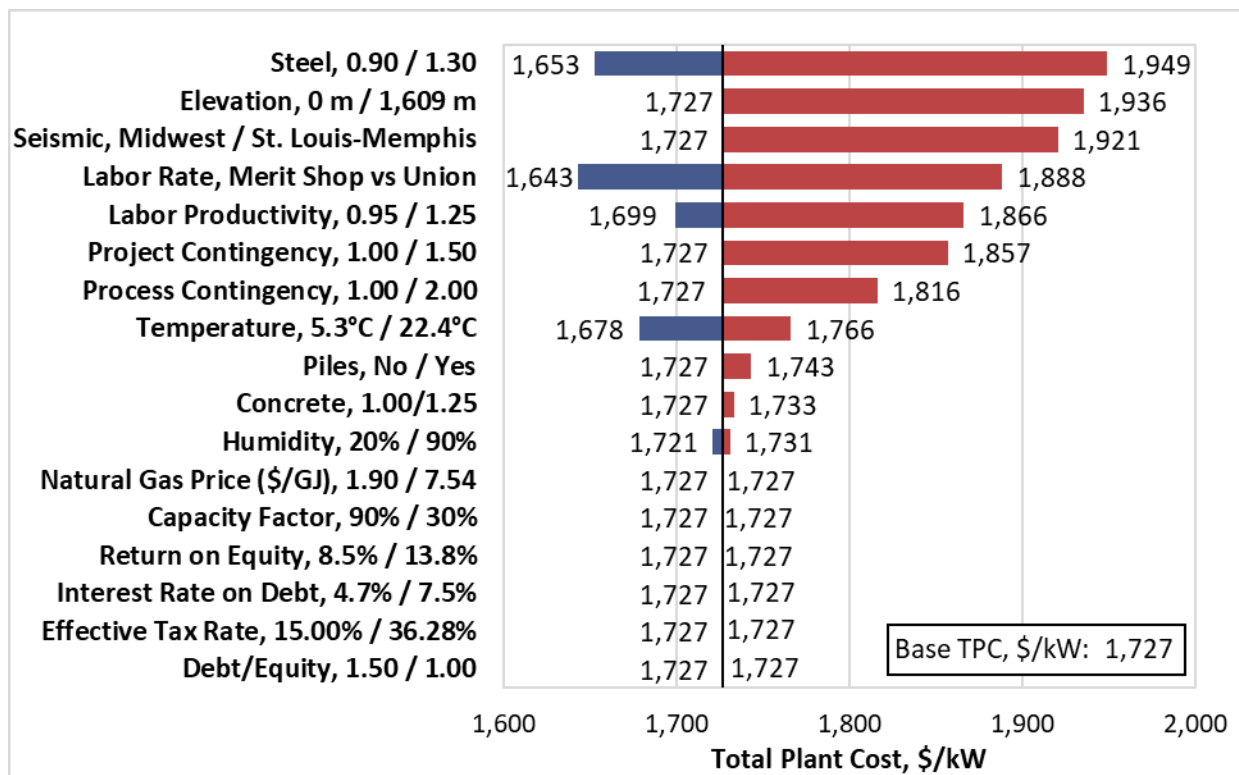
EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-16. Cost index impact on COC when adjusting for inflation



The collective results of the construction, ambient conditions, and finance sensitivities on the TPC, LCOE, and COC are shown in Exhibit 3-17, Exhibit 3-18, and Exhibit 3-19.

Exhibit 3-17. Collective construction, ambient conditions, and financial category sensitivities for TPC



EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-18. Collective construction, ambient conditions, and financial category sensitivities for LCOE

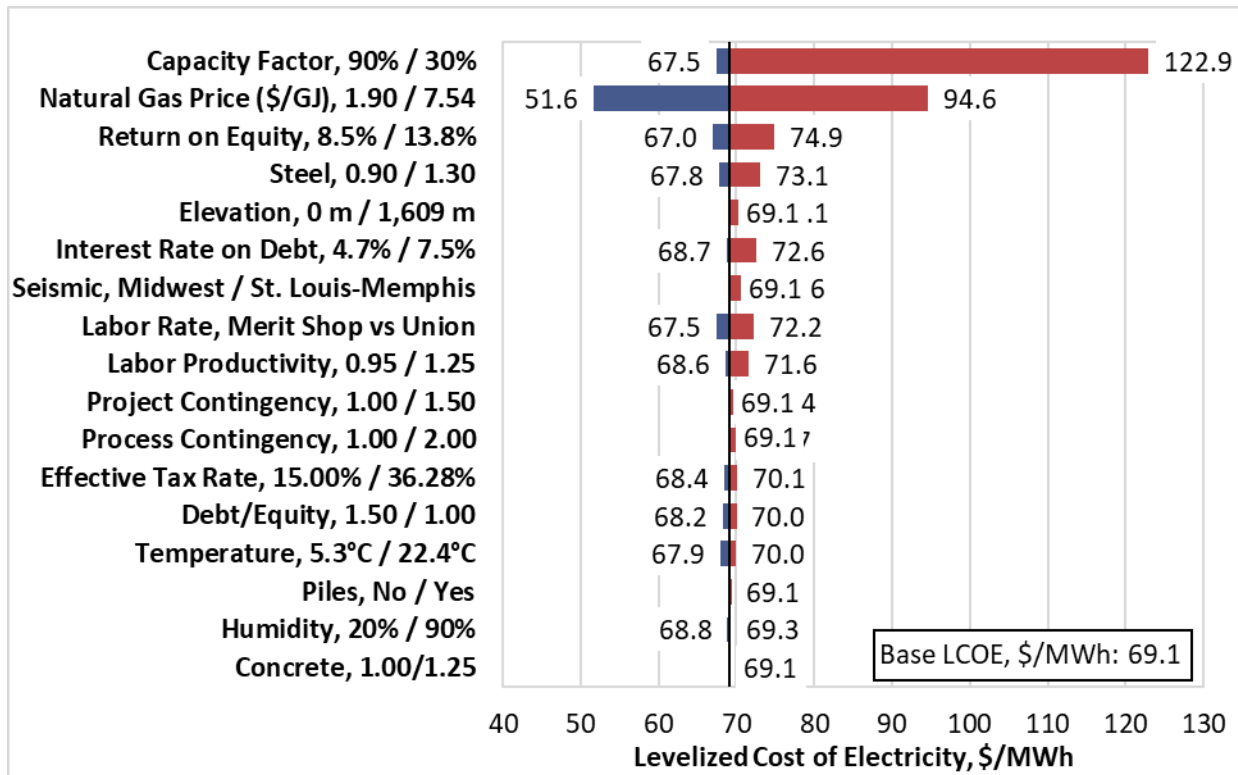
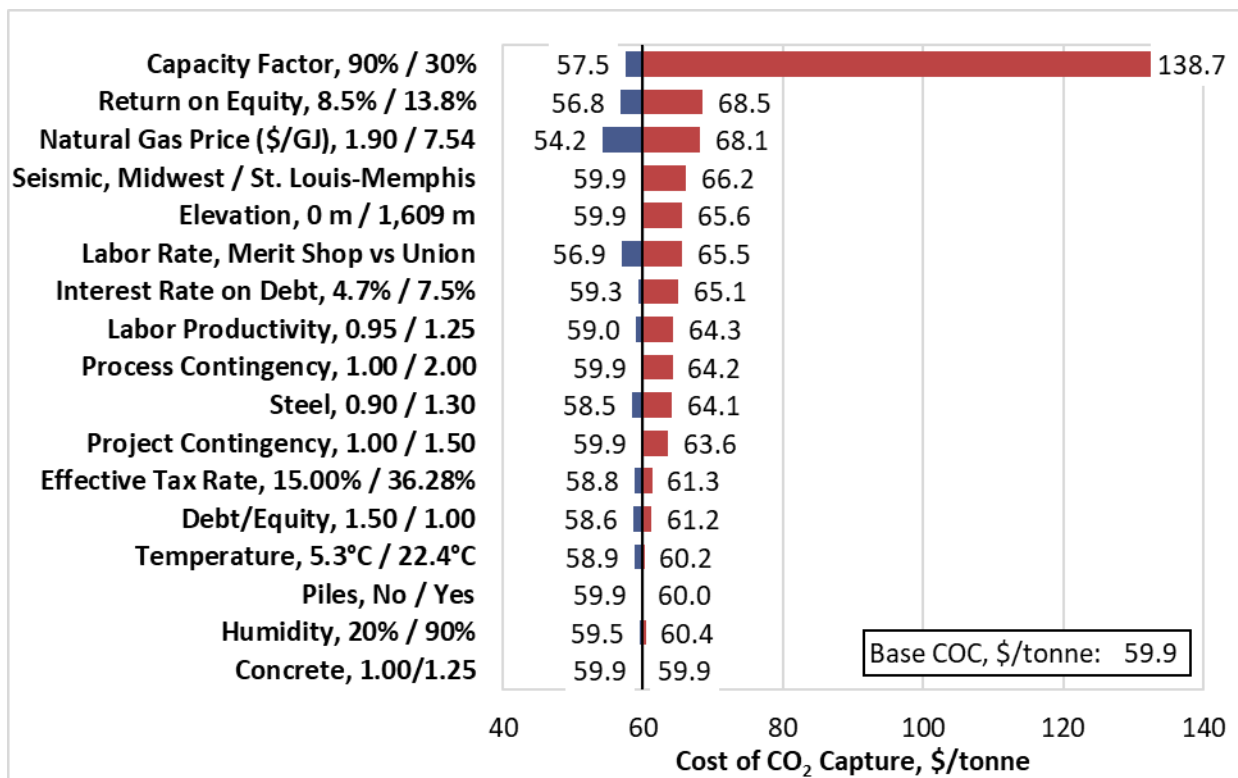


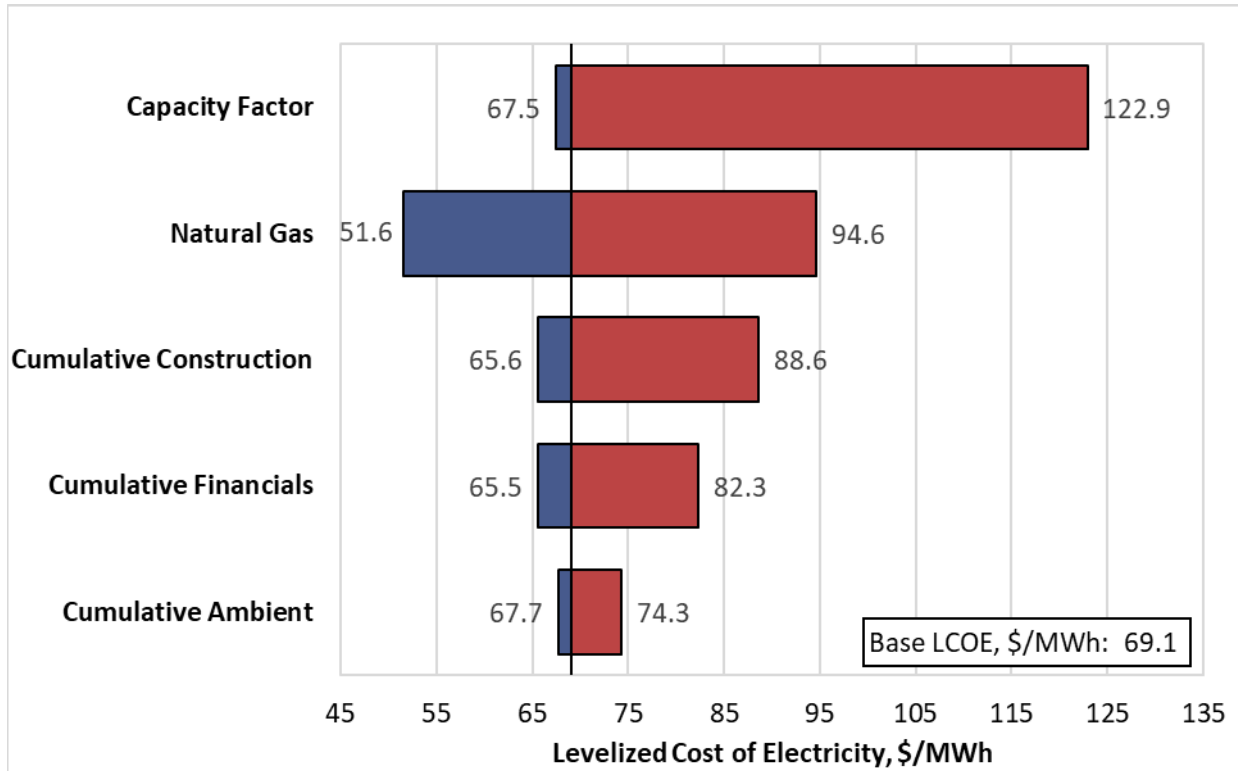
Exhibit 3-19. Collective construction, ambient conditions, and financial category sensitivities for COC



EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-20 and Exhibit 3-21 demonstrate the cumulative impact of the sensitivities within each category on the LCOE and COC.

Exhibit 3-20. Cumulative category sensitivities for LCOE



EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-21. Cumulative category sensitivities for COC

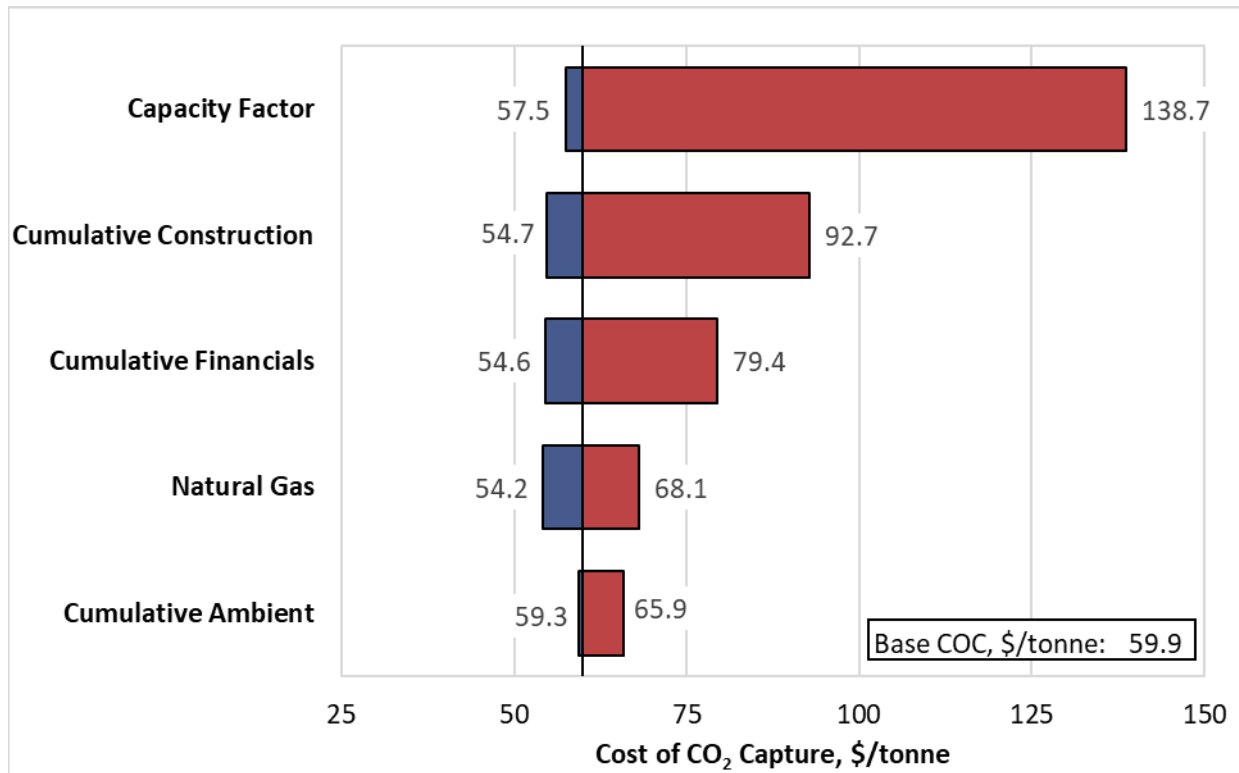


Exhibit 3-22, Exhibit 3-23, Exhibit 3-24, and Exhibit 3-25 show the compounding effect of the combined best- and worst-case ambient conditions, construction cost considerations, NG price, and financial assumptions on the LCOE and COC. The waterfalls illustrate the stepwise impact of modifying the base case using the cumulative sensitivity category extremes.

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-22. Best cumulative LCOE waterfall sensitivity

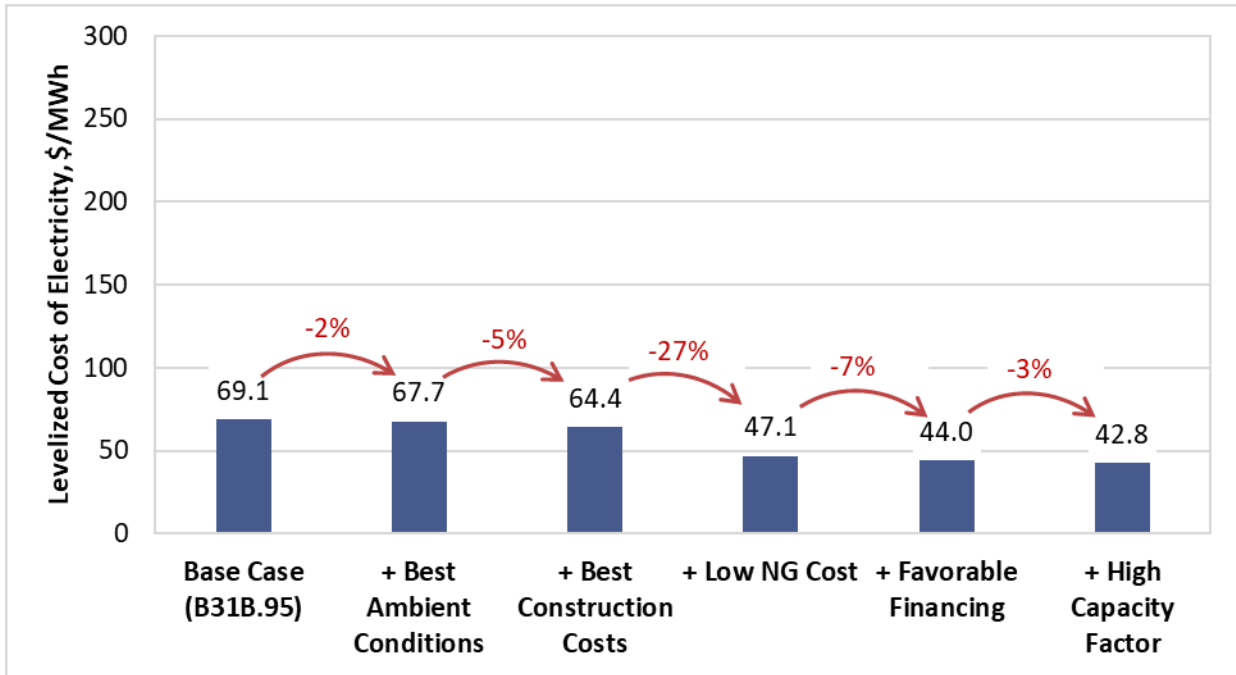
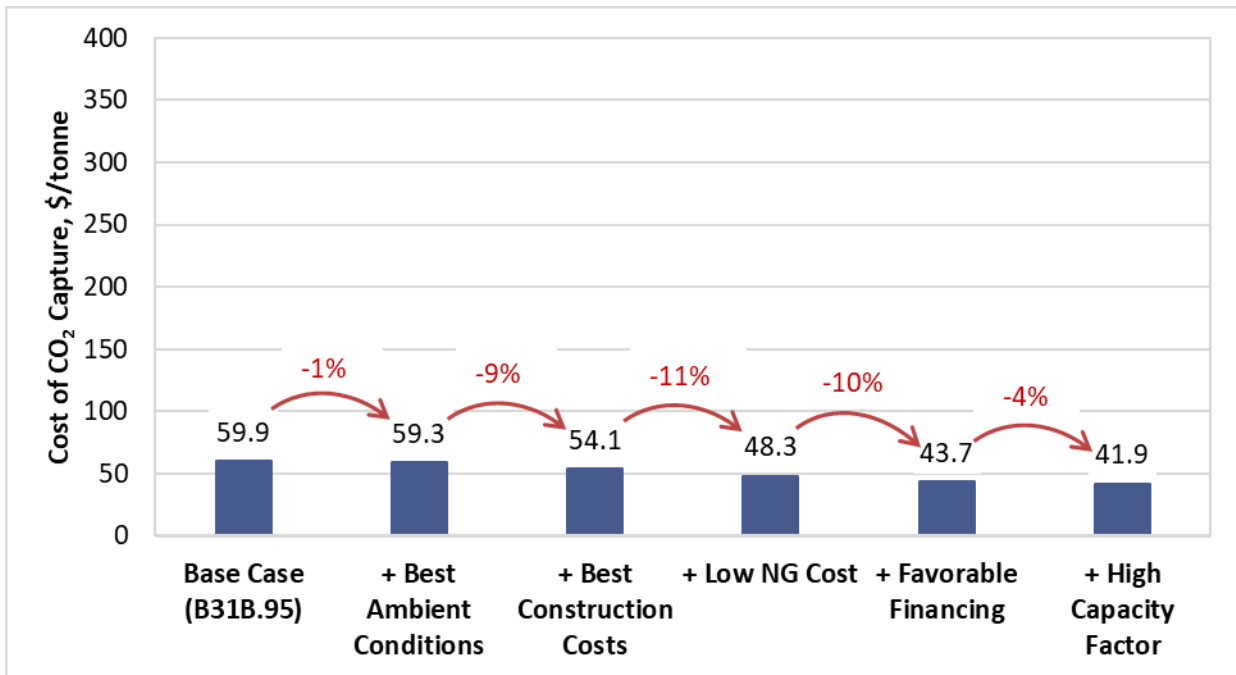


Exhibit 3-23. Best cumulative COC waterfall sensitivity



EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Exhibit 3-24. Worst cumulative LCOE waterfall sensitivity

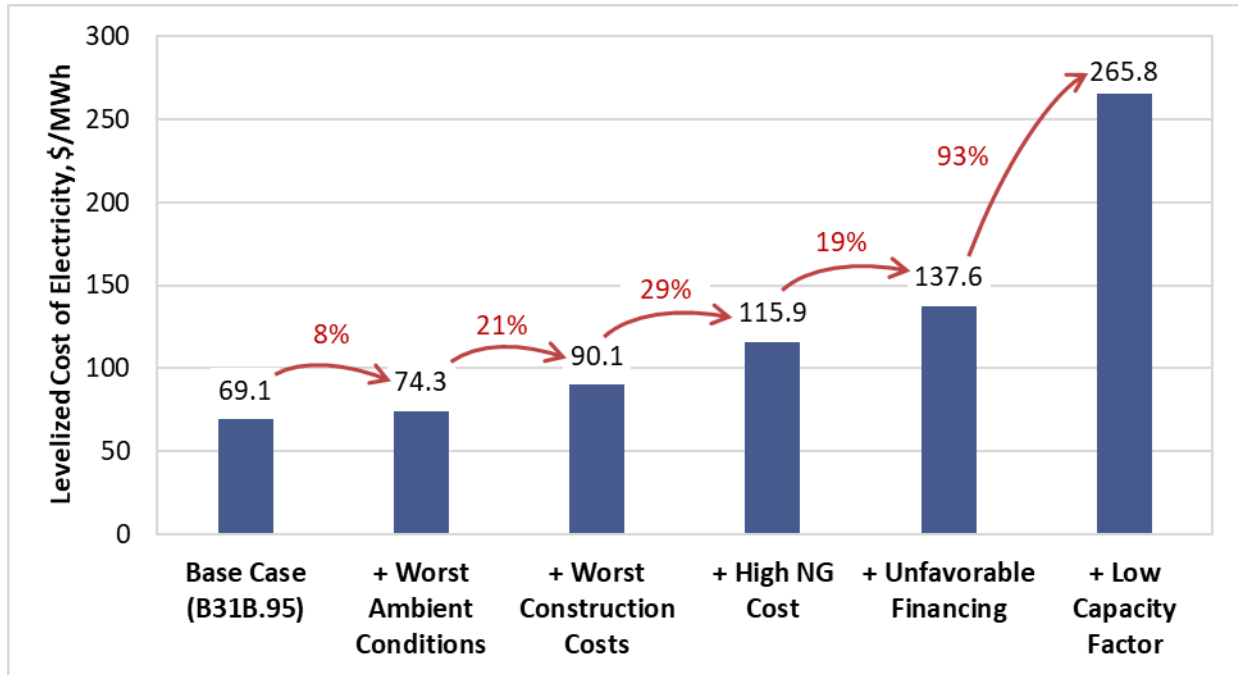
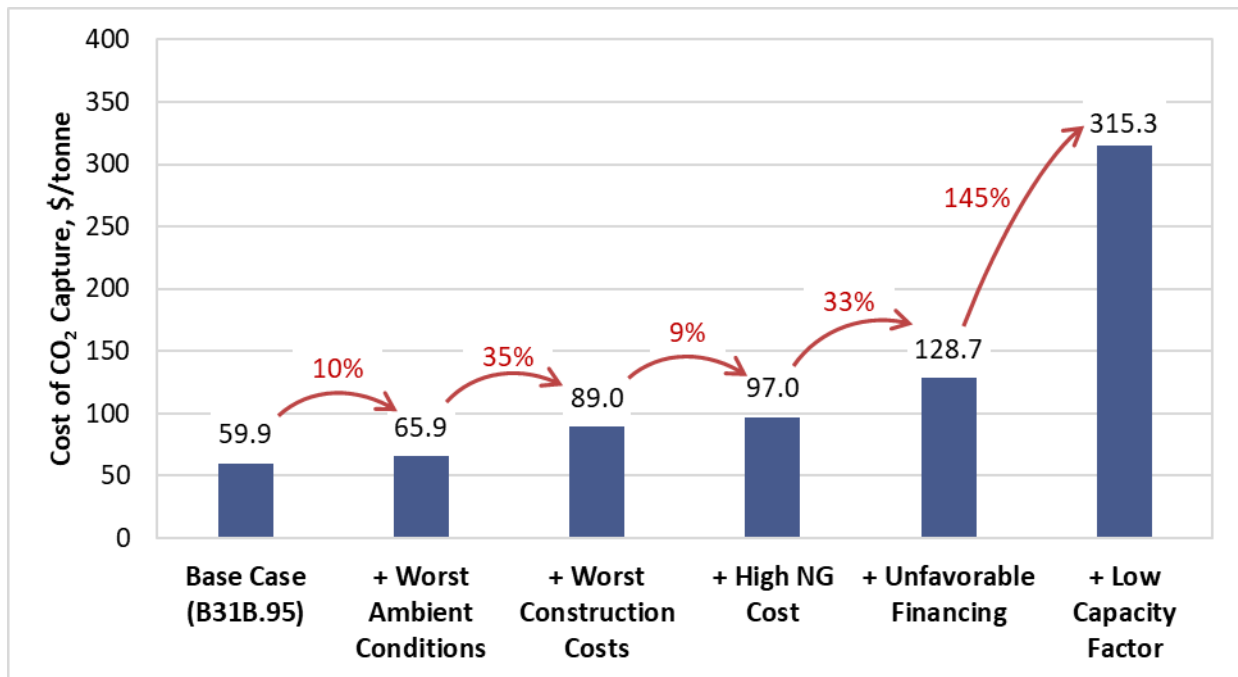


Exhibit 3-25. Worst cumulative COC waterfall sensitivity



4 SUMMARY

TEAs of fossil power plants incorporating CO₂ capture are published by multiple sources, including NETL’s FEB. Cost and performance estimates for a particular technology and plant configuration may differ across these studies—and from real-world projects—due to a host of factors. Many of those factors are embodied in the design basis assumptions. This Technical Note assesses the impact of several of the factor values that can impact a fossil energy plant’s cost and performance.

As shown in Exhibit 4-1, of the individual parameters assessed in this study, the capacity factor had the most significant impact on both LCOE and COC, followed by NG price and return on equity. While the cost of steel has the next most significant impact on LCOE (followed by labor rate, ambient pressure, and interest rate on debt), the labor rate has the next most significant impact on COC (followed by seismic zone, interest rate on debt, and ambient pressure).

Exhibit 4-1. Summary of parameters’ impacts on LCOE and COC

Parameter (Ranked by LCOE Impact)	LCOE, %	Parameter (Ranked by COC Impact)	COC, %
Capacity Factor	-2 to +78	Capacity Factor	-4 to +132
Natural Gas Price	-25 to +37	Natural Gas Price	-9 to +14
Return on Equity	-3 to +8	Return on Equity	-5 to +14
Cost of Steel	-2 to +6	Labor Rate	-5 to +9
Labor Rate	-2 to +5	Seismic Zone	0 to +10
Ambient Pressure	0 to +6	Interest Rate on Debt	-1 to +9
Interest Rate on Debt	-1 to +5	Ambient Pressure	0 to +10
Seismic Zone	0 to +5	Cost of Steel	-2 to +7

In terms of aggregate sensitivity categories, Exhibit 4-2 shows that the capacity factor and NG price sensitivities’ impact on LCOE exceeded the cumulative impact of each of construction costs, financial parameters, and ambient conditions. However, while the capacity factor sensitivity impact on COC also exceeded the cumulative impacts of each of construction costs, financial parameters, and ambient conditions, the NG price sensitivity impact on COC only exceeded the cumulative impact of ambient conditions.

Exhibit 4-2. Summary of aggregate sensitivity categories’ impacts on LCOE and COC

Parameter (Ranked by LCOE Impact)	LCOE, %	Parameter (Ranked by COC Impact)	COC, %
Capacity factor	-2 to +78	Capacity Factor	-4 to +132

EXAMINATION OF FACTORS AFFECTING THE COST AND PERFORMANCE OF A NATURAL GAS COMBINED CYCLE EQUIPPED WITH CARBON DIOXIDE CAPTURE

Parameter (Ranked by LCOE Impact)	LCOE, %	Parameter (Ranked by COC Impact)	COC, %
Natural Gas Price	-25 to +37	Cumulative Construction Costs	-9 to +55
Cumulative Construction Costs	-5 to +28	Cumulative Financial Parameters	-9 to +33
Cumulative Financial Parameters	-5 to +19	Natural Gas Price	-9 to +14
Cumulative Ambient Conditions	-2 to +8	Cumulative Ambient Conditions	-1 to +10

While plausible ranges were selected for each factor, it is unlikely that the extreme values—high or low—would coincide simultaneously. Nevertheless, a combination of the extremes illustrates the importance of careful, collective consideration of these parameters for a given application. When the cumulative impacts of all the factors are assessed together, LCOE ranges from -38 to 285 percent, and the impact to COC ranges from -30 to 427 percent relative to the base case. The low end of the cumulative sensitivity is designated as the best case, and the high end of the cumulative sensitivity is designated as the worst case. It is evident that the assumptions of the B31B.95 base case are collectively favorable to a low LCOE—within the uncertainly range (-15/+25 percent) for the majority of the sensitivities.^d

Certain market factors could incentivize plants in more adverse situations, such as financial structure, local fuel and electricity markets, geographic isolation, necessity for reliable power, or government incentives. There are additional factors that can affect the cost of a plant that are not quantitatively addressed in this study, such as construction delays or severe weather events, that can lead to further escalating costs.

The assumptions made in a TEA have a significant impact on cost and performance results, beyond the reported accuracy of the particular study. This work emphasizes the need to take study assumptions into account when comparing estimates from different sources and when using study results for research purposes, feasibility studies, energy system modeling, etc. This work also emphasizes the need to complete detailed, site-specific front-end engineering design studies to obtain accurate performance and cost estimates for real projects.

^d The only outlier being the cost of natural gas, where a cost of \$1.90/GJ can decrease the LCOE by -25 percent.

5 REFERENCES

- AACE. (2003). *Conducting Technical and Economic Evaluations – As Applied for the Process and Utility Industries; TCM Framework: 3.2 – Asset Planning, 3.3 Investment Decision Making*. AACE International. Retrieved November 20, 2013, from <http://www.aacei.org/non/rps/16R-90.pdf>
- AACE. (2005). *Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries; TCM Framework 7.3 – Cost Estimating and Budgeting*. AACE International. Retrieved November 20, 2013, from <http://www.aacei.org/non/rps/18R-97.pdf>
- EIA. (2016). *Capital Cost Estimated for Utility Scale Electricity Generating Plants*. U.S. Energy Information Administration.
- Lazard. (2018). *Lazard's Levelized Cost of Energy Analysis - Version 12.0*. Lazard.
- NCEI. (n.d.-a). *Climate-at-a-Glance: Statewide Mapping*. (National Centers Environmental Information) Retrieved July 18, 2022, from <https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/statewide/mapping>
- NCEI. (n.d.-b). *Comparative Climatic Data. Observed Data (CCD): Average Relative Humidity: Morning (M), Afternoon (A)*. (National Centers Environmental Information) Retrieved July 18, 2022, from <https://www.ncei.noaa.gov/products/land-based-station/comparative-climatic-data>
- NETL. (2019-a). *Quality Guidelines for Energy System Studies: Capital Cost Scaling Methodology: Revision 4 Report*. Pittsburgh: U.S. Department of Energy.
- NETL. (2019-b). *Quality Guidelines for Energy System Studies: Cost Estimation Methodology for NETL Assessments of Power Plant Performance*. Pittsburgh, PA: U.S. Department of Energy.
- NETL. (2022-a). *Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity, Revision 4a*. Pittsburgh, PA: U.S. Department of Energy.
- NETL. (2022-b). *Cost and Performance Baseline for Fossil Energy Plants Volume 1: Bituminous Coal and Natural Gas to Electricity*. Pittsburgh, PA: U.S. Department of Energy.
- USGS. (2005). *Elevation and Distances in the United States*. United States Geological Survey.
- Wood Group. (2018). *Assessing the Cost Reduction Potential and Competitiveness of Novel (Next Generation) UK Carbon Capture Technology*.

www.netl.doe.gov
Albany, OR • Houston, TX • Morgantown, WV • Pittsburgh, PA
(800) 553-7681

