

Scenario Development and Fuel Forecast Documentation – Budget 2023

November 18, 2022

Prepared by Southern Company Services – Resource Planning

Introduction

This report describes the development of the company's planning scenarios and key inputs for budget year 2023 (B2023). This report was developed by the company. In several prior years similar reports were developed by the company's modeling consultant, Charles River Associates.

Scenario Development Overview

Many factors affecting planning are uncertain. As part of its integrated planning activities, the company creates scenarios to aid in understanding some forms of uncertainty. Key uncertainties affecting planning include future environmental pressure—especially regarding carbon-dioxide; cost and performance of future generating technologies; future load growth; and the evolution of natural gas prices. To construct its scenarios, the company identifies different plausible viewpoints in each of these four areas. These viewpoints are combined to create several scenarios. The viewpoints and scenarios are refreshed annually. For B2023 (the analyses done during calendar year 2022 for use during calendar year 2023), the company created 6 scenarios. Any particular analysis might be based on only a subset of those scenarios.

B2023 Scenarios

The company considers multiple views of future pressure on the company's CO_2 emissions, multiple views of future cost and performance of generating technologies, multiple views of future electricity consumption, and multiple views of the future price of natural gas. For budget year 2023, the company assembled these multiple views in those four areas into 6 scenarios and two additional cases as summarized in Table A. The table indicates, for example, that Scenario 1 is defined by no additional pressure on CO_2 emission (relative to today), for the Tech Portfolio view of future cost and performance of technologies, the standard load forecast and moderate future natural gas prices. This scenario's abbreviated name is MG0.

Table A: B2023 Scenario Design

Scenario	GHG pressure view	Tech view	Load view	Gas view	Label
1	Lower ($0)	Tech Portfolio	Standard	Moderate	MG0
2	Mod. ($20+)	Tech Portfolio	Alt. 1	Moderate	$20
3	Higher ($50+)	Tech Portfolio	Alt. 2	Moderate	$50
4	Emissions Limit	Tech Portfolio	Alt. 2	Moderate	EL
5	$0	Tech Portfolio	Standard	Lower	LG0
6	$0	Tech Portfolio	Standard+HG0 delta	Higher	HG0
	Mod. ($20+)	Tech Portfolio	Alt. 1	Lower	LG20
	Mod. ($20+)	Tech Portfolio	Alt. 2	Higher	HG20

Scenario Design Views

As indicated in the table of scenarios, the company considers multiple views in four areas: the future degree of greenhouse gas pressure, the future cost and performance of generating and storage technologies, future load growth, and future price of natural gas. Certain details regarding these views are discussed in the following sections.

Greenhouse Gas Pressure

The degree of pressure on greenhouse gas emissions in the future is uncertain. The company has considered four different views of how that pressure could evolve. One of those views is that the degree of pressure remains largely unchanged from where it is today ("$0" view). Two of those views involve a fee imposed on each ton of carbon dioxide that the company emits ("$20+" and "$50+" views). A fourth view involves annual limits on the amount of carbon dioxide that the company could emit ("Emission Limit"). These views have been chosen to span a range of current plausible outcomes.

- The company's $0 view is the lightest plausible touch the company considers under the existing Clean Air Act. It involves no price on CO_2 emissions but does

require carbon capture (90%) at all new gas combined cycle units built beginning in 2040. This date is uncertain but is consistent with a more delayed sequence of reviews than required under the Clean Air Act.

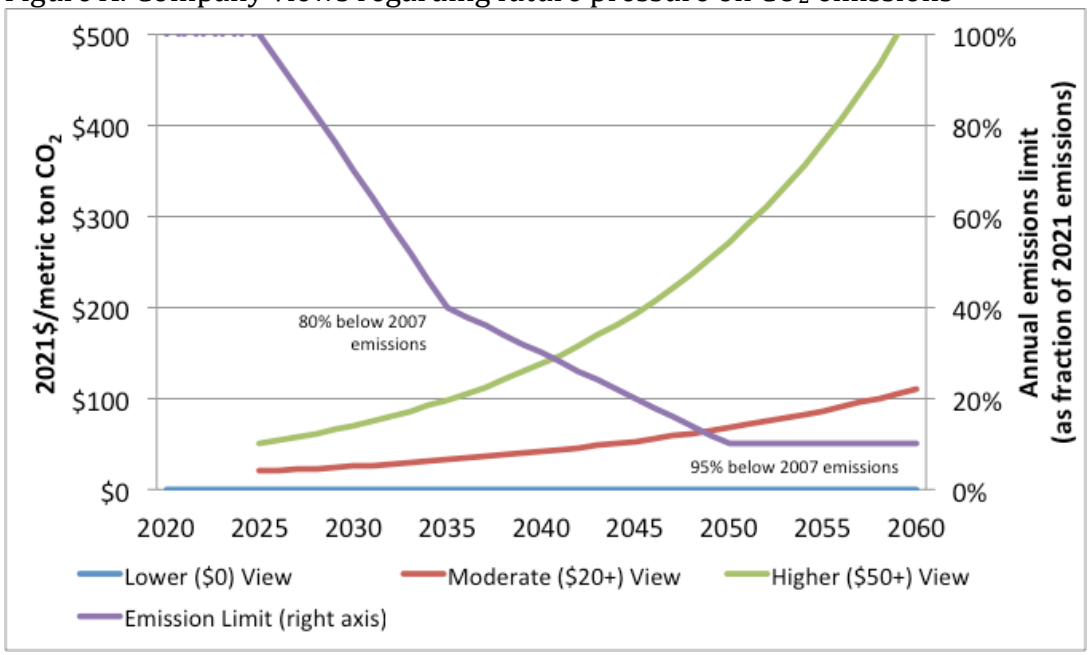
- The company's $20+ view adds a price on CO_2 emissions that begins in 2025 at $20 (2021$) per metric tonne of CO_2 and grows at 5% above inflation through the modeling horizon. The start year of this price, 2025, is consistent with current policy proposals. Carbon capture (90%) is required at all new gas combined cycle units beginning in 2035. This date is uncertain but is consistent with the sequence of reviews required under the Clean Air Act.

- The company's $50+ view adds a price on CO_2 emissions that begins in 2025 at $50 (2021$) per metric tonne of CO_2 and grows at 7% above inflation through the modeling horizon. Carbon capture (90%) is required at all new gas combined cycle units beginning in 2035. This view represents market-based pressure on CO_2 emissions consistent with targeting net zero emissions by 2050.

- The company's CO_2 Emissions Limit view imposes a requirement that the company's annual CO_2 emissions fall to 40% of current levels by 2035 and to 10% of current levels by 2050. (This is about 80% below 2007 emissions by 2035 and about 95% below 2007 emissions by 2050.) This view represents mass-based pressure on CO_2 emissions consistent with targeting net zero emissions by 2050.

These four views are illustrated in Figure A. (Note that the CO_2 Emissions Limit view refers to the right vertical axis; the other views refer to the left vertical axis.)

Figure A: Company views regarding future pressure on CO_2 emissions



Technology Cost and Performance

Electricity generating technology is always evolving and there are dozens of ways to satisfy the demand for electricity. The pace and direction of the evolution of each of these ways is uncertain. The company maintains a technology screening process that evaluates a wide portfolio of technologies at varying levels of development for inclusion in planning scenarios. This screening process identifies technologies that are commercial as well as pre-commercial to consider for inclusion in scenario analyses discussed in this report.

Commercial technologies that are included are deployed, tested, and monitored to such a degree as to be considered generic and repeatable. Pre-commercial technologies that are included are at various stages of their developmental process. The company bases this assessment of the technology on engagement with a variety of manufacturers, labs, and other organizations. The company develops representative cost and performance information for technologies that are expected to become commercially available during the planning horizon. As the pre-commercial technology portfolio represents estimates of cost and performance for technologies in development, the company is less confident about their cost and performance than the commercial portfolio. The company is, however, comfortable including them in these analyses even though they are not commercially available today.

Most of the pre-commercial technologies are ones whose adoption is consistent with higher pressure on CO_2 emissions. Thus, these technologies are adopted earlier and to a greater extent in scenarios that assume greater pressure on CO_2 emissions.

For Budget 2023 analyses, the technologies that screened as potentially cost-effective included natural gas combined cycle (with and without carbon capture), natural gas combustion turbine (with and without selective catalytic reduction, SCR), solar photovoltaic, wind, energy storage, nuclear, and super-critical CO_2.

- NGCC. The company's current assumption for planning purposes is that natural gas combined cycle plants without carbon capture are available for fleet expansion only through 2039 ($0 CO_2 view) or 2034 (all other CO_2 views). Another planning assumption is that beginning in 2035 or 2040, depending on the CO_2 view, new NGCC plants must capture 90% of their carbon dioxide emissions. The timing of this requirement is based on the company's understanding of the existing Clean Air Act and its statutory schedule for review of abatement technologies and requirements (New Source Performance Standards and Best Available Control Technology). With the capture facility, the plant is referred to as natural gas combined cycle with carbon capture and storage, NGCC-CCS. The net cost of NGCC reflects the company's understanding of the tax credits available under the Inflation Reduction Act (IRA).

- NGCT. The company's current assumption for planning purposes is that natural gas combustion turbines are available for fleet expansion through 2034. Beginning in 2035, new CTs must significantly reduce their NO_x emissions by being installed with a selective catalytic reduction (SCR) device. The timing of this requirement comes from the company's understanding of the existing Clean Air Act and its statutory schedule for review of abatement technologies and requirements.

- Solar PV. Solar photovoltaic with single-axis tracking is available as an expansion resource beginning in 2027. The company's view is that its cost will continue to decline, meaning it will become increasingly cost-effective throughout the study timeframe. The net cost of PV reflects the company's understanding of the tax credits available under the Inflation Reduction Act (IRA).

- Wind. Wind turbine is available as an expansion resource all years of the analysis. The company's view is that its cost will continue to decline, meaning that it will become increasingly cost-effective throughout the study timeframe. The net cost of wind reflects the company's understanding of the tax credits available under the Inflation Reduction Act (IRA).

- Energy Storage. Lithium-ion battery storage is available as an expansion resource beginning in the year of capacity need, 2029. Beginning in 2033 a less expensive storage medium that is slower charging and discharging ("medium duration storage") is assumed available, too. The company's view is that the cost of storage will continue to decline, meaning that it will become increasingly cost-effective throughout the study timeframe. The net cost of battery storage reflects

the company's understanding of the tax credits available under the Inflation Reduction Act (IRA).

- Nuclear. Advanced nuclear technology is available in the analyses beginning in 2040. This is a stylized technology in the pre-commercial portfolio representing the company's views of both a Small Modular Reactor (SMR) approach and a Molten Chloride Fast Reactor (MCFR) approach.

- Advanced gas with CCS. Super-critical CO_2 is a technology that separates oxygen from air to use in the combustion of methane. It uses some of the resulting CO_2 as the working fluid for the steam cycle and the rest is stored permanently underground. This technology is available as part of the pre-commercial portfolio in analyses beginning in 2040. This is a stylized technology representing the company's views of this technology.

Load Growth

Future electricity consumption is uncertain. The company has three different views of future load growth. In addition, the company appreciates that the future price of natural gas can impact the demand for electricity.

- Standard forecast. The company annually updates its forecast of electricity consumption throughout the planning horizon. The forecast is done separately for each of the three types of customers—residential, commercial and industrial. This forecast is one view of future load growth.

- Alternative forecast 1 (Alt. 1). This view of future load growth reflects the company's view of how a moderate amount of CO_2 pressure would affect load growth. The company considered that CO2 pressure would have two generally opposing effects on load growth. First, CO_2 pressure would be consistent with increased electrification of transportation, thus increasing load growth. Second, CO_2 pressure would be consistent with increased efficiency of electricity end-use either because of improved energy efficiency of devices or because of income and substitution effects associated with more expensive electricity.

- Alternative forecast 2 (Alt. 2). This load growth forecast is similar to Alternative 1, except that it reflects the effects of a large degree of CO_2 pressure, rather than a moderate degree.

Elasticity adjustments to load growth

The future consumption of electricity and the future price of natural gas are interrelated. And this interrelationship is not straightforward. This is because

natural gas is both an input to electricity production and a substitute for electricity in some end uses. Thus, the company has developed a load growth adjustment used in the scenario with higher future prices of natural gas. This load growth adjustment is derived from AEO analyses. Such analyses yielded a different electricity consumption path associated with a view that future natural gas price would be higher, reflecting the important feedbacks in the relationship between future natural gas price and future load growth.

For the B2023 planning process, the company compared southeast US electricity load growth in the AEO case with a higher future price of natural gas to southeast US electricity load growth in the AEO's Reference case. This difference was smoothed and then used to adjust the company's Standard load growth forecast for use in the company's scenario that assumes higher future prices for natural gas.

These four different views of future load growth are illustrated in the following diagrams. They show forecasts of annual winter peak capacity, annual summer peak and annual total energy.

Figure B: Winter Peak Capacity

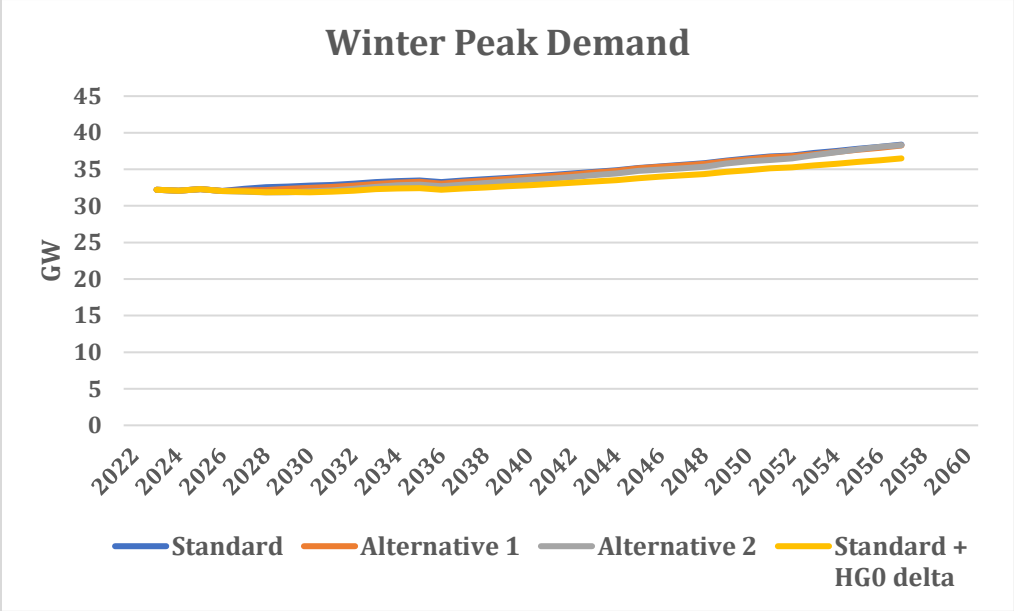


Figure C: Summer Peak Capacity

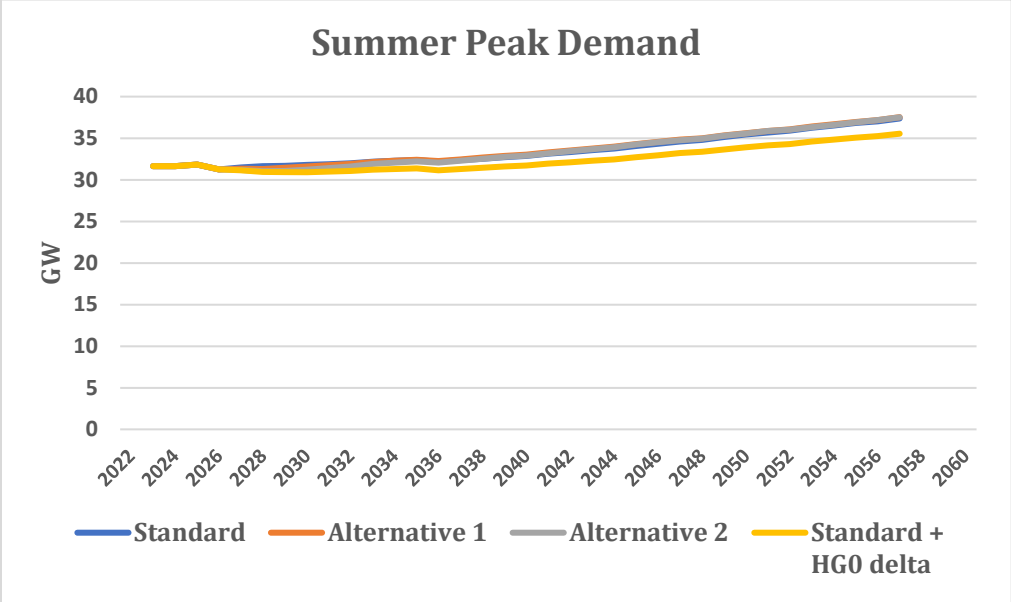
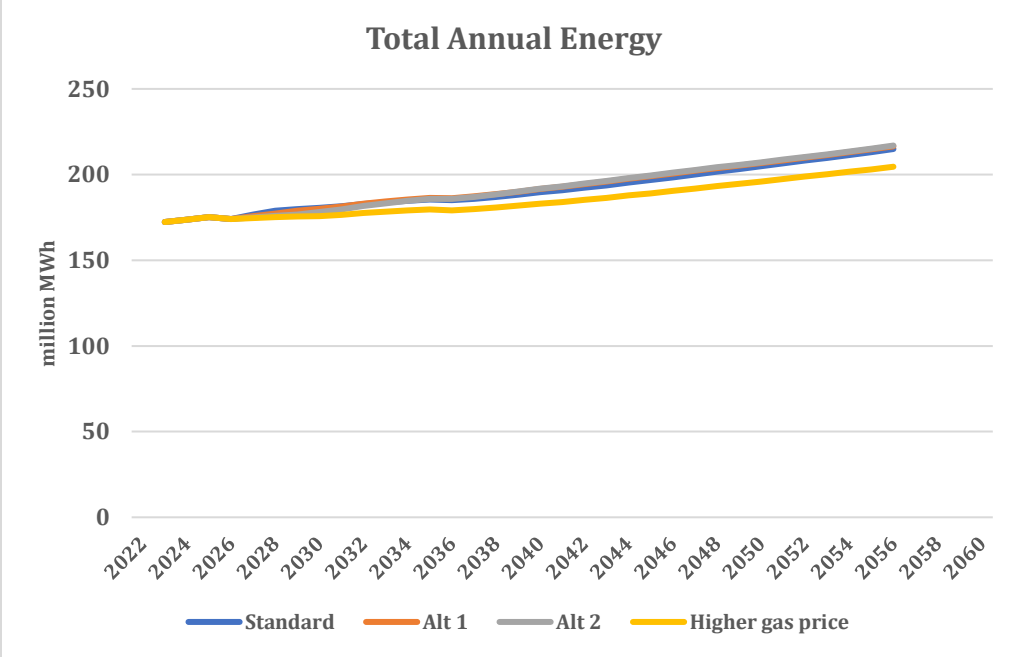


Figure D: Total Annual Energy



Fuel Prices

The price of fuels in the future is unknown. For the B2023 planning process, the company considered three different views of how the price of fuels could evolve: a lower path, a moderate path and a higher path. The company identifies a reputable source for the particular paths. For B2023, the company adopted paths produced by the US Energy Information Administration (EIA) for its 2022 Annual Energy Outlook (AEO) as its source for future prices of natural gas, coal, and oil.

The AEO is a major annual product of the EIA. It is available on the EIA's website (https://www.eia.gov). The analysis supporting the AEO uses the National Energy Modeling System (NEMS), EIA's main modeling system of the US energy economy. NEMS is detailed and comprehensive; full documentation is available at https://www.eia.gov/outlooks/aeo/nems/documentation. In addition to producing the AEO, EIA uses NEMS to analyze the energy content of policy proposals that Congress or the Administration asks about.

EIA constructs several scenarios each year. For each scenario, NEMS is used to identify price paths for natural gas, coal, oil, gasoline, etc. that are consistent with market conditions across the US energy economy in that scenario. All key assumptions and results from the NEMS analysis for the AEO are available for public viewing and downloading for no charge on EIA's website. Because the AEO is highly regarded and so readily available, it is often used as a reference in conversations about the future of energy in the US.

In addition to providing thorough documentation, EIA also invites the company's participation in workshops at which EIA personnel discuss model issues and assumptions and solicit input for changes. The company participates in these workshops as well as interacts with EIA personnel as part of the Stanford Energy Modeling Forum and other venues. Through the years, the company has developed a solid relationship with key data, analyses, and analytical personnel at EIA, facilitating its understanding of what has gone into the price forecasts that the company adopts.

The company also maintains familiarity with other sources of future fuel price estimates and the key assumptions behind those estimates. These other sources of information are used to help the company understand the views of others and how they compare to the views adopted by EIA in producing the AEO.

Future natural gas prices

For B2023 the three different views of future natural gas prices that the company adopted are:

- Lower price view: AEO's High Oil and Gas Supply case
- Moderate price view: AEO's Reference case
- Higher price view: AEO's Low Oil and Gas Supply case

Estimates of technically recoverable tight/shale oil and natural gas resources are particularly uncertain and change over time as new information is gained through drilling, production, and technology development. The "High Oil and Gas Supply" and "Low Oil and Gas Supply" views reflect this uncertainty.

In AEO's Low Oil and Gas Supply case the estimated ultimate recovery per well is assumed to be 50% lower than in the Reference case for tight oil, tight gas, shale gas in the United States, undiscovered resources in Alaska and offshore Lower 48 states. Rates of technological improvement that reduce costs and increase productivity in the United States are also 50% lower than in the Reference case. These assumptions increase the per-unit cost of crude oil and natural gas development in the United States.

In AEO's High Oil and Gas Supply case the estimated ultimate recovery per well is assumed to be 50% higher than in the Reference case for tight oil, tight gas, shale gas in the United States, undiscovered resources in Alaska and offshore Lower 48 states. Rates of technological improvement that reduce costs and increase productivity in the United States are also 50% higher than in the Reference case. These assumptions decrease the per-unit cost of crude oil and natural gas development in the United States. In addition, tight oil and shale gas resources are added to reflect new prospects or the expansion of known prospects. Rates of technological improvement that reduce costs and increase productivity in the United States are also 50% higher than in the Reference case.

The company relied on AEO 2021 for its B2022 analyses and has relied on AEO 2022 for its B2023 analyses. The following table gives some of the key assumption changes from AEO 2021 (B2022) to AEO 2022 (B2023).

Table B: Key Values for B2023 for Moderate Gas View

Driver	Key Values for B2023 Moderate Gas View
Resource Size	• 465.4 Tcf in proved shale reserves for B2023 (9.4 Tcf decrease from B2022) • 2,926 Tcf in total technically recoverable (TTR) U.S dry natural gas resources • (2% growth from AEO 2021 to AEO 2022)
Technology Improvements	• Drilling costs fall by 1%/yr • Equipment costs fall by 0.5%/yr • Well productivity increase 1-3%/ yr

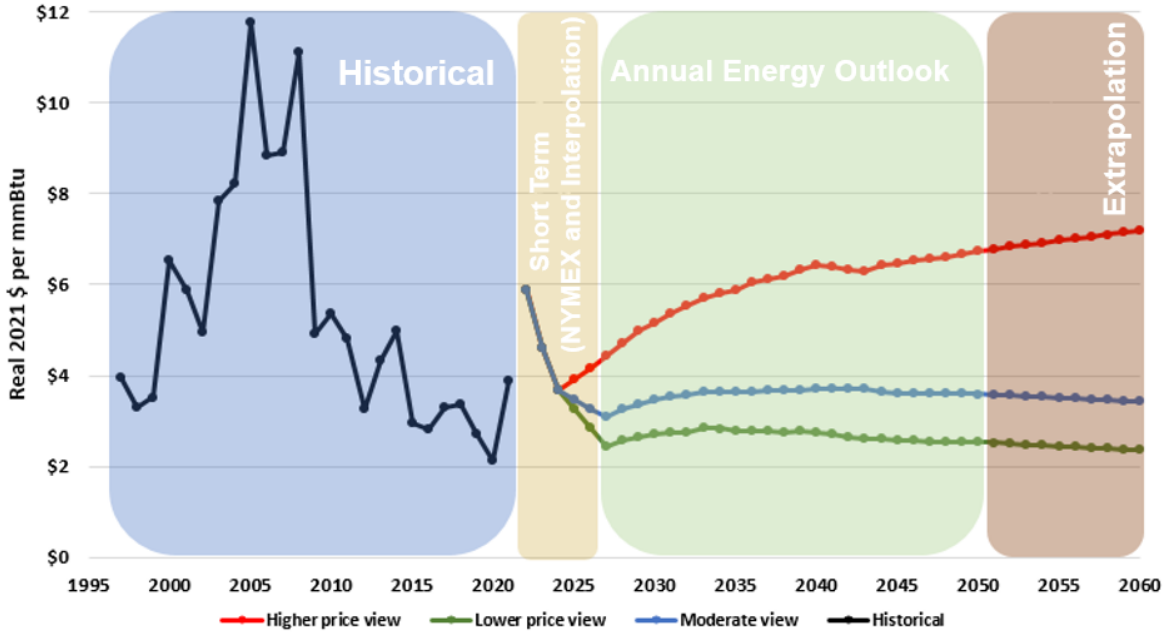
Future coal and oil prices

The price of coal and oil in the future is also uncertain. For budget year 2023, the company has adopted three different views of future coal prices and three different views of oil prices. These views are the coal and oil price paths from the AEO 2022 Reference, High Oil and Gas Supply and Low Oil and Gas Supply cases.

Future fuel price illustrations

The following illustrations show the fuel price paths that the company has used in the B2023 scenario analyses.

Figure E: Views of future price of Natural Gas at Henry Hub



The annual energy outlook is the company's source for long term future fuel prices. As shown in figure A, there are three parts to this forecast. The short-term forecast comes from closing prices on the NYMEX futures contract market. Some analyses also require future prices beyond the 2050 end of the AEO projections. The company constructs additional years by extrapolating the AEO projections.

Figure F: Views of future price of coal at mine, by scenario, Central Appalachia: Medium Sulfur Bituminous

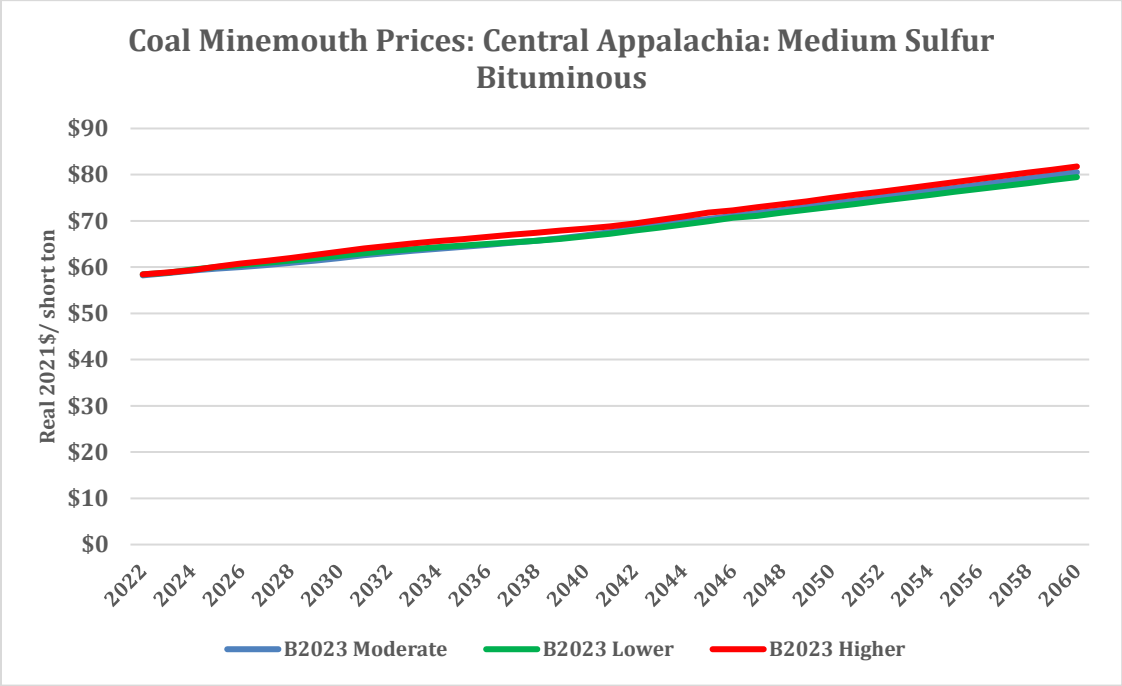


Figure G: Views of future price of coal at mine, by scenario, Illinois Basin

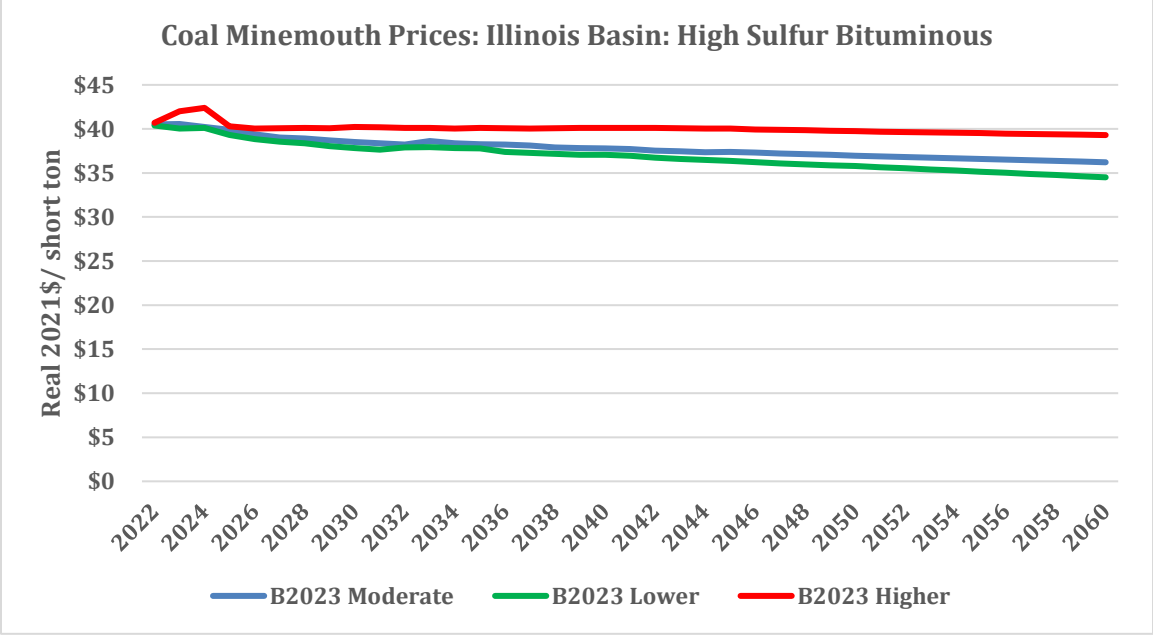


Figure H: Views of future price of coal at mine, by scenario, Powder River Basin

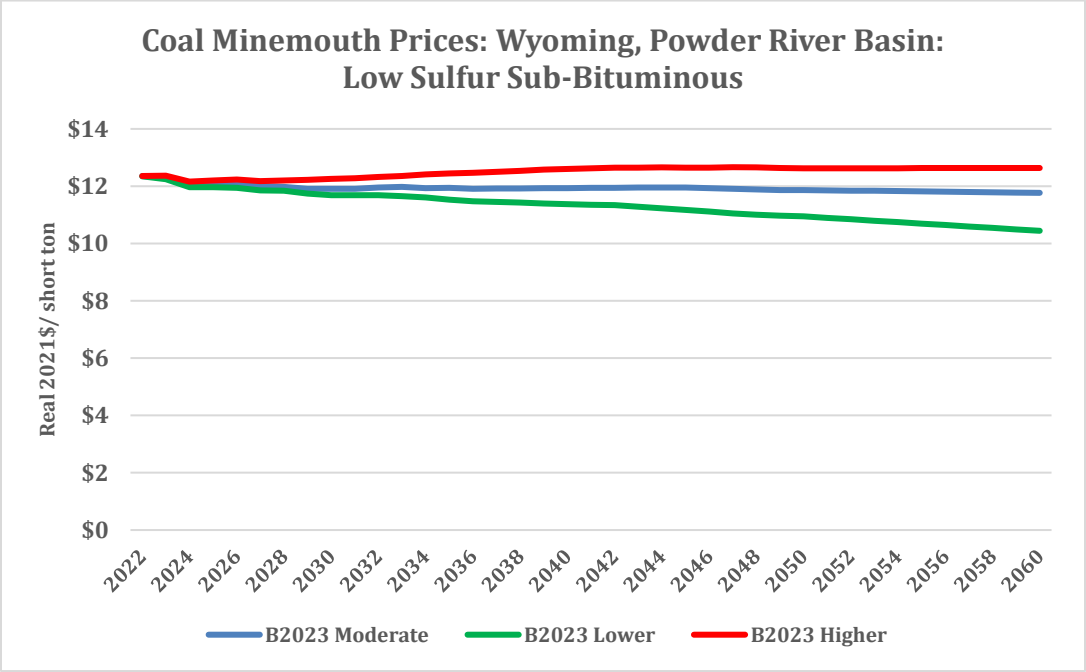
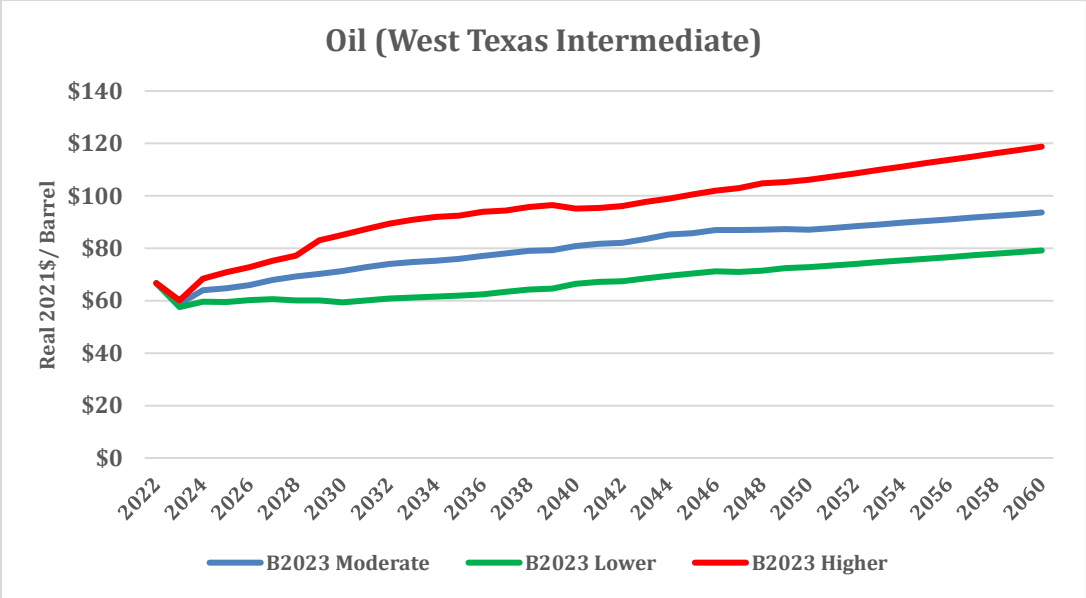


Figure I: Views of future price of oil, West Texas Intermediate



Conclusion

The scenario planning process provides a framework for understanding and considering the impact of some key uncertainties in resource planning. Such analyses provide information that is useful for making appropriate resource planning decisions when faced with future uncertainties.