

Scenario Development and Fuel Forecast Documentation – Budget 2022

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Prepared by Southern Company Services – Resource Planning

Many factors affecting resource planning are inherently uncertain because they involve the future. As part of its planning process, the Company develops scenarios to aid in understanding some forms of future uncertainty, thus allowing the Company to make appropriate planning decisions. Key uncertainties affecting planning include (i) the evolution of natural gas prices; (ii) future environmental pressures—especially regarding carbon-dioxide; (iii) cost and performance of future generating technologies; and (iv) future load growth. Therefore, in developing 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 Budget 2022[1] ("B2022") the Company created 11 scenarios.[2]

B2022 SCENARIOS

The Company considers multiple views of the future price of natural gas, the future pressure on the company's carbon dioxide ("CO_2") emissions, the future cost and performance of generating technologies, and future electricity consumption. For B2022, the Company assembled multiple views in those four areas into the 11 scenarios summarized in Table 1. By way of example, Scenario 1, which is abbreviated as MG0, is defined by moderate future natural gas prices, no additional pressure on CO_2 emission (relative to today), standard value for future cost and performance of technologies, and the standard load forecast.

[1] The analyses are conducted during calendar year 2021 for use during calendar year 2022.

[2] In several prior years, similar information and reports were developed by the Company's modeling consultant, Charles River Associates ("CRA").

Table 1: B2022 Scenario Design

Scenario	Natural Gas View	Greenhouse Gas Pressure View	Technology Cost & Performance View	Load View	Short Name
1	Moderate price path	$0 fee	SCS Gen-Tech App Stds[1]	SCS Forecasting[2]	MG0
2	Moderate price path	$20+ fee	SCS Gen-Tech App Stds	SCS Forecasting + MG20 delta	MG20
3	$50 CO_2 price path	$50+ fee	SCS Gen-Tech App Stds	SCS Forecasting + $50 delta	$50
4	Low price path	$0 fee	SCS Gen-Tech App Stds	SCS Forecasting + LG0 delta	LG0
5	Low price path	$20+ fee	SCS Gen-Tech App Stds	SCS Forecasting + LG20 delta	LG20
6	High price path	$0 fee	SCS Gen-Tech App Stds	SCS Forecasting + HG0 delta	HG0
7	High price path	$20+ fee	SCS Gen-Tech App Stds	SCS Forecasting + HG20 delta	HG20
8	Moderate price path	$0 fee	SCS Gen-Tech App Stds	Electrification-influenced load growth[3]	HL[3]
9	Moderate price path	$0 fee	SCS Gen-Tech App Stds	DER/EE-influenced load growth[4]	LL[4]
10	Moderate price path	$0 fee	Lower costs of zero-CO_2 technologies[5]	SCS Forecasting	Tech
11	Moderate price path	2050 CO_2 Intensity[6]	SCS Gen-Tech App Stds	SCS Forecasting	2050 CI

Notes:

1. Southern Company Services' Technology Application Standards, which contains company assumptions on technology cost and performance benchmarks
2. Standard forecasts produced by Operating Company Load Forecasting and SCS Load Forecasting
3. Higher load growth based on Electric Power Research Institute (“EPRI”) electrification study provided by SCS Forecasting
4. Lower load growth based on aggressive adoption of distributed resources and efficiency improvements provided by SCS Forecasting
5. Costs and performance of solar, wind, storage, and 4th gen nuclear provided by SCS Generation Planning & Development and SCS Research & Development
6. The CO_2 Intensity view is based on current legislative ideas

Additional details regarding the scenarios depicted in Table 1 are discussed below.

FUEL PRICE FORECAST

Natural Gas Prices

The future price of natural gas is unknown. For the B2022 planning process, the Company considered the following four different views of how natural gas prices could evolve over time: a lower path; a moderate path; a higher path; and a path consistent with significant pressure on CO_2 emissions. As part of its planning process, the Company bases its analysis on a reputable source for the paths. For B2022, the Company adopted and adapted paths produced by the U.S. Energy Information Administration ("EIA") for its 2021 Annual Energy Outlook[3] ("AEO"). Because the AEO is highly regarded and readily available, it is often used as a reference in conversations about the future of energy in the United States. EIA constructs several scenarios each year. For each scenario, the National Energy Modeling System ("NEMS") is used to identify price paths for fuel sources such as natural gas, coal, oil, and gasoline that are consistent with market conditions across the U.S. energy economy in that scenario. All key assumptions and results from the NEMS analysis for the AEO are publicly available without charge on EIA's website.

The Company also regularly reviews 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 other views and how they compare to the views adopted by EIA in producing the AEO.

For B2022, the Company adopted the following four different views of future natural gas prices:

- 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
- \$50 CO_2 price view: The Company adapted the natural gas price path from AEO's Alternative Policies case, which assumed a \$35 per ton fee on CO_2 emissions

[3] 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, EIA's main modeling system of the U.S. 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.

Estimates of technically recoverable tight/shale oil and natural gas resources are 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 the 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 in the 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 the 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 in the 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. Crude oil pipeline and export capacity in the Liquid Fuels Markets Module is assumed to increase in the projection period to accommodate higher levels of domestic oil production.

The Company relied on AEO 2020 for its B2021 analyses and has relied on AEO 2021 for its B2022 analyses. Table 2 gives some of the key assumptions for AEO 2021 (B2022).

Table 2: Key Values for B2022 for Moderate Gas View

	Key Values for B2022 Moderate Gas View
Resource Size	• 474.8 Tcf in proved shale reserves for B2022 (36 Tcf increase from B2021) • 2,867 Tcf in total technically recoverable (TTR) U.S. dry natural gas resources (1.4% growth from AEO 2020 to AEO 2021)
Production Rates	• IP rate assumptions increase to 40% above current levels by 2059 • These assumptions were the same in B2021
Well Costs	• Fixed well cost down from current levels 40% by 2059 • B2021 assumed this same fixed well cost pattern • Variable well costs decrease to 80% of current levels by 2059 • B2021 assumed this same variable well cost pattern

Future Coal and Oil Prices

The prices of coal and of oil in the future are also uncertain. For B2022, 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 2021 Reference, High Oil and Gas Supply, and Low Oil and Gas Supply cases.

Summary of Fuel Prices

The following illustrations give the fuel price paths that the Company has used in the B2022 scenario analyses.

Figure 1: Views of future price of Natural Gas at Henry Hub

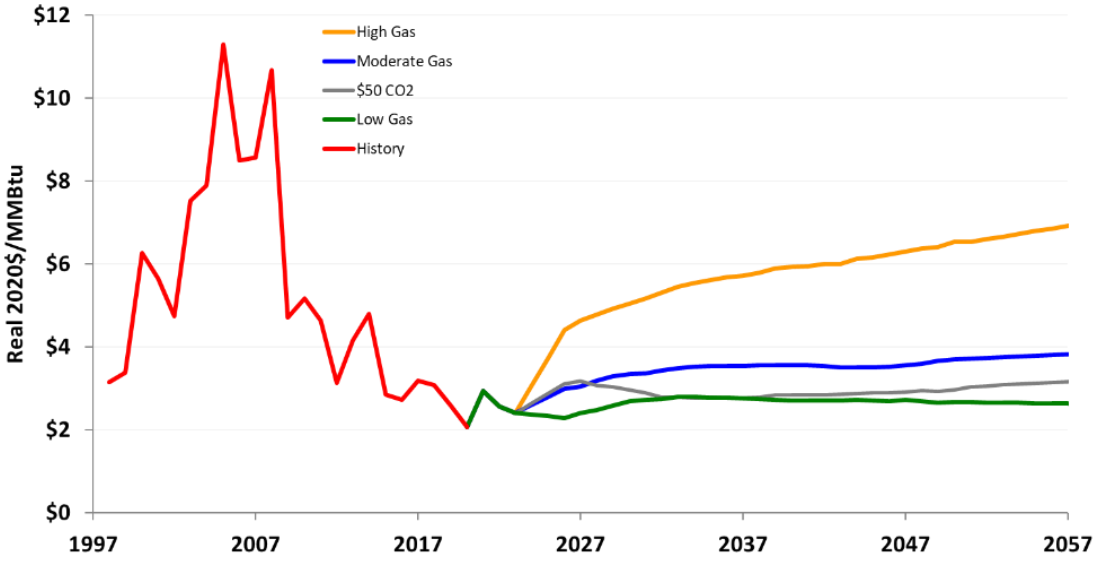


Figure 2: Views of future price of coal at mine, by scenario, Central Appalachia

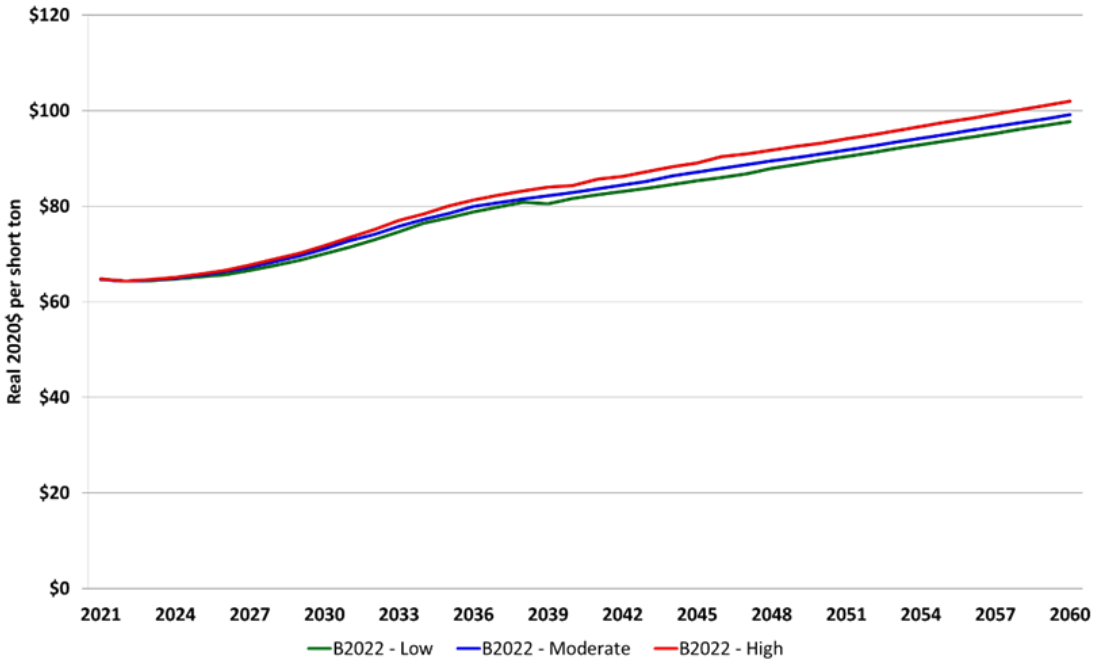


Figure 3: Views of future price of coal at mine, by scenario, Illinois Basin

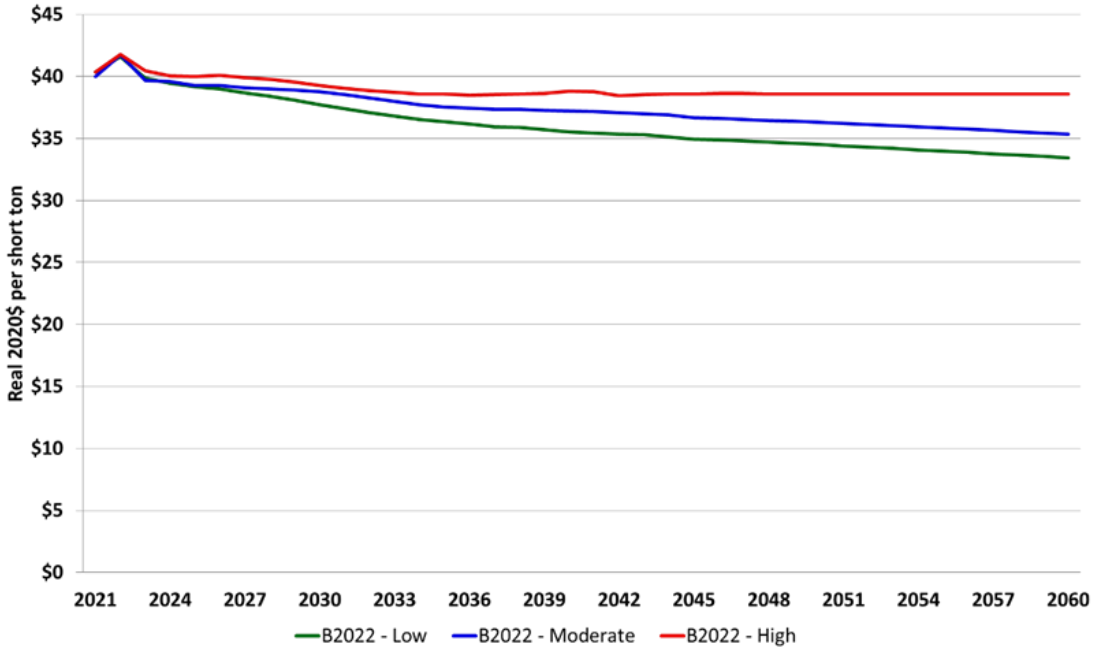


Figure 4: Views of future price of coal at mine, by scenario, Powder River Basin

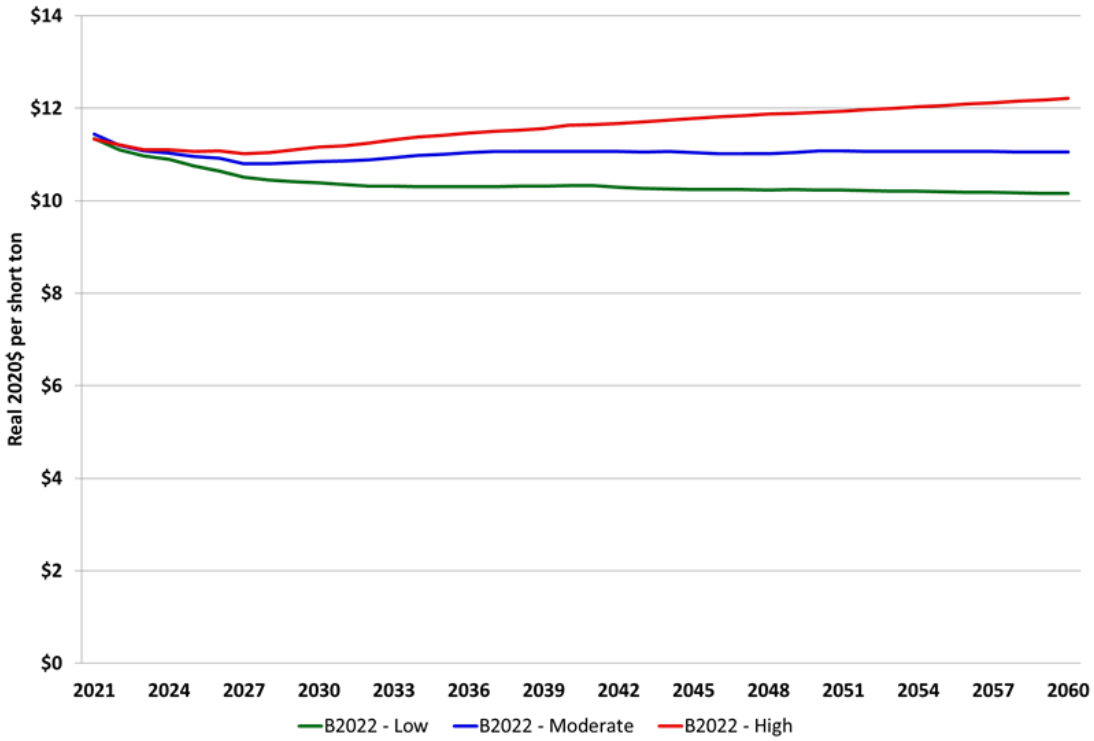
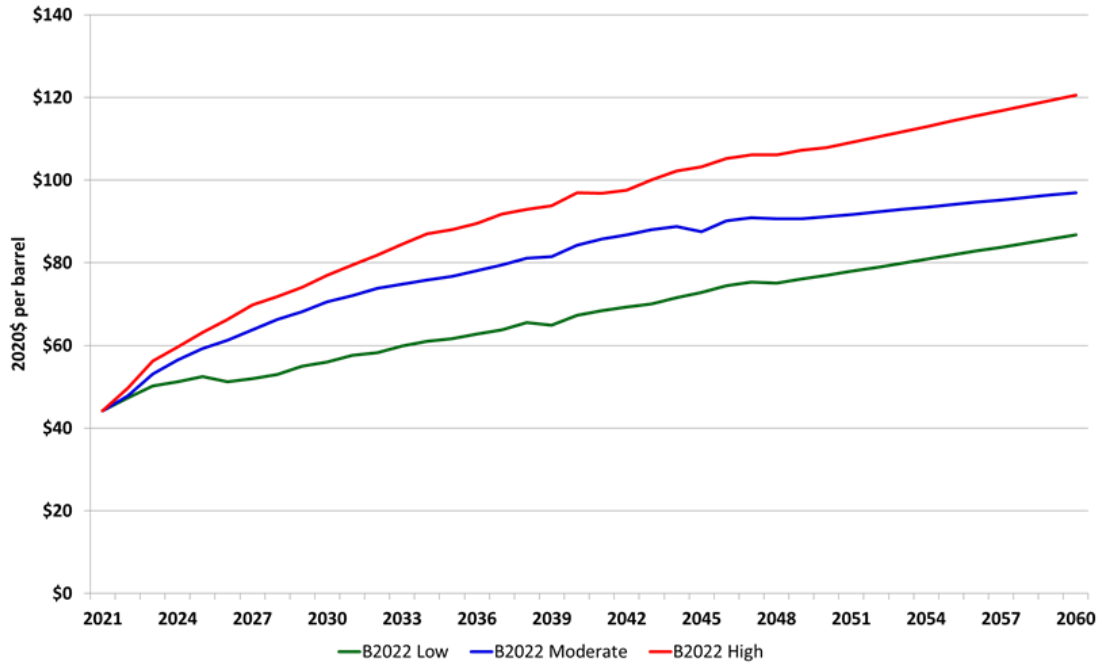


Figure 5: Views of future price of oil, West Texas Intermediate



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 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 ("CO_2 Intensity"). These views have been chosen to span a range of current plausible outcomes.

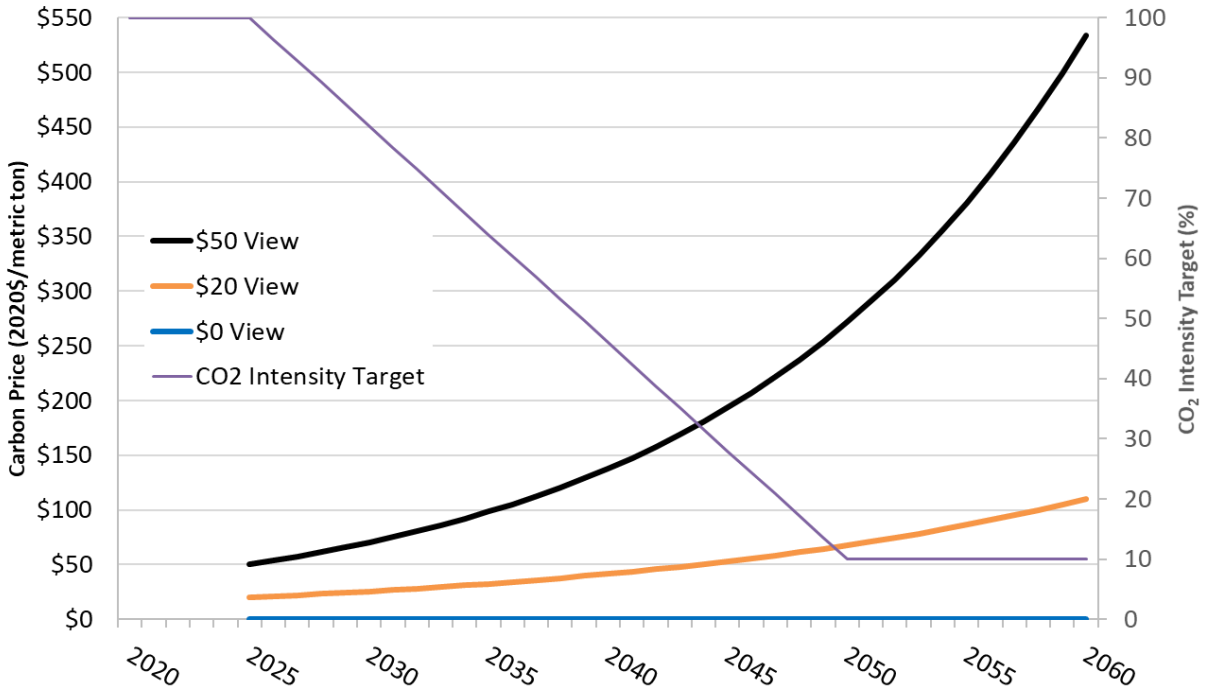
- The $0 view is the lightest plausible pressure the Company considered under the existing Clean Air Act. It involves no price on CO_2 emissions but does require carbon capture (90%) at all new gas combined cycle units beginning in 2040. This date is uncertain but is consistent with a more delayed sequence of reviews required under the Clean Air Act.
- The $20 view adds a price on CO_2 emissions that begins in 2025 at $20 (2020$) per metric ton of CO_2 and grows at 5% above inflation through the modeling horizon. The 2025 start year 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 a less delayed sequence of reviews required under the Clean Air Act.

- The $50 view adds a price on CO_2 emissions that begins in 2025 at $50 (2020$) per metric ton 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 CO_2 Intensity view adds a requirement that the Company's annual CO_2 emissions fall to 10% of current levels 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 6. (Note that the CO_2 Intensity view refers to the right vertical axis; the other views refer to the left vertical axis.)

Figure 6: Views regarding future pressure on CO_2 emissions



TECHNOLOGY COST AND PERFORMANCE

Electricity generating technology is always evolving. While there are dozens of ways to satisfy the demand for electricity, the pace and direction of the evolution of each option is uncertain. The Company screens these approaches and identifies technologies that have the possibility of playing a cost-effective role in the system during the modeling horizon. Among the technologies that might play a cost-effective role, there remains uncertainty about the cost of each technology relative to its expected productivity and relative to other technology options.

For B2022 analyses, the technologies that screened as potentially cost-effective included natural gas combined cycle ("NGCC") (with and without carbon capture), natural gas combustion turbine ("NGCT") (with and without selective catalytic reduction ("SCR")), reciprocating internal combustion engine ("RICE"), solar photovoltaic ("PV"), wind, and battery energy storage. For Scenario 10 ("Tech" case), the Company also considered nuclear and natural gas direct-fired supercritical CO_2 cycle[4] with carbon capture and sequestration ("CCS").

LOAD GROWTH

Future electricity consumption is uncertain. The Company has three different views on future load growth. In addition, the Company recognizes that the future price of natural gas and future pressure on CO_2 emissions can impact the demand for electricity.

- **Base load forecast**. The Company annually updates its forecast of electricity consumption throughout the planning horizon. The forecast is done separately for each of the three major customer classes—residential, commercial, and industrial. This forecast is one view of future load growth.
- **Electrification-influenced load growth**. A second view of future load growth considers significant electrification of energy uses that currently use other fuels including transportation and space and water heating. This view has larger load growth than in the base load forecast.
- **End-use efficiency and customer generation**. A third view of future load growth considers significant ongoing increases in end-use efficiency and an increasing role for

[4] Also referred to as a supercritical CO_2 cycle.

customer-sited generation resources, which decrease the net load served by the utility. This view has smaller load growth than in the base forecast.

The consumption of electricity, the price of natural gas and the level of any fee on CO_2 emissions are interrelated. This interrelationship is not straightforward because natural gas is both an input to electricity production and a substitute for electricity in some end uses. Moreover, pricing of CO_2 emissions affects natural gas and electricity differently. Thus, the Company has developed a set of load growth adjustments used in scenarios with CO_2 pricing and with higher or lower future prices of natural gas. These load growth adjustments are derived from analyses using an integrated model of the U. S. energy economy. Such analyses yielded different electricity consumption paths associated with different views of future natural gas prices and different views of future CO_2 pressure reflecting the important feedbacks in those relationships.

For the B2022 planning process, the Company has utilized the work that Charles River Associates ("CRA") did prior to B2020 to derive these series of load adjustments. Before B2020, the CRA modeling process produced a series of load adjustments used in scenarios with CO_2 pricing and with higher or lower future prices of natural gas. The Company analyzed the historical load adjustment data from three years of these analyses and averaged the observed adjustments to smooth out the year-to-year differences in the degree of adjustment. These adjustments were then applied to the base load forecast.

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.