Scenario Development and Fuel Forecast Documentation – Budget 2021

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Prepared by Southern Company Services – Resource Planning

Introduction

This report describes the development of the company's planning scenarios and fuel price forecasts for budget year 2021 (B2021). 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 the evolution of natural gas prices; future environmental pressure—especially regarding carbon-dioxide; cost and performance of future generating technologies; and future load growth. 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 B2021 (the analyses done during calendar year 2020 for use during calendar year 2021), the company created 10 scenarios. Any particular analysis might be based on only a subset of those scenarios.

B2021 Scenarios

The company considers multiple views of the future price of natural gas, multiple views of future pressure on the company's CO_2 emissions, multiple views of future cost and performance of generating technologies, and multiple views of future electricity consumption. For budget year 2021, the company assembled these multiple views in those four areas into 10 scenarios as summarized in Table A. The table indicates, for example, that Scenario 1 is defined by moderate future natural gas prices, no additional pressure on CO2 emission (relative to today), standard value for future cost and performance of technologies and the standard load forecast. This scenario's abbreviated name is MG0.

Table A: B2021 Scenario Design

Scenario	Natural Gas Price Path	Greenhouse Gas Pressure	Technology Cost & Performance	Load	Short Name
1	Moderate	$0 fee	Tech Application Stds[1]	Reference[2]	MG0
2	$50 CO_2	$50+ fee	Tech Application Stds	Reference + $50 delta	$50
3	Low	$0 fee	Tech Application Stds	Reference + LG0 delta	LG0
4	Low	$20+ fee	Tech Application Stds	Reference + LG20 delta	LG20
5	High	$0 fee	Tech Application Stds	Reference + HG0 delta	HG0
6	High	$20+ fee	Tech Application Stds	Reference + HG20 delta	HG20
7	Moderate	$0 fee	Tech Application Stds	High Electrification	HL[3]
8	Moderate	$0 fee	Tech Application Stds	High EE & DER adoption	LL[4]
9	Moderate	$0 fee	Low cost zero-CO_2 tech[5]	Reference	Tech
10	Moderate	CO_2 Intensity[6]	Tech Application Stds	Reference	CI

Notes:
1. Southern Company Technology Application Standards which contain assumptions on generating technology cost and performance benchmarks.
2. Standard load forecasts produced by each operating company that serve as the reference forecasts.
3. Higher load growth based on the EPRI electrification study.
4. Lower load growth based on aggressive adoption of energy efficiency improvements and distributed resources.
5. Lower costs for solar, wind, storage, and 4th generation nuclear technologies.
6. The CO_2 intensity view reflects current legislative ideas that have the effect of imposing a shrinking annual cap on emissions.

Scenario Design Views

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

Natural Gas Prices

The price of natural gas in the future is unknown. For the B2021 planning process, the company considered four different views of how the price of natural gas could evolve: a lower path, a moderate path, a higher path, and a path consistent with significant pressure on CO_2 emissions. The company identifies a reputable source for the particular paths. For B2021, the company adopted and adapted paths produced by the US Energy Information Administration (EIA) for its Annual Energy Outlook (AEO).

The company has adopted the Annual Energy Outlook produced annually by the US Energy Information Administration 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/outlooks/archive/aeo20/). 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 of the 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.

For B2021 the four different views of future natural gas prices that the company adopted are:

- Low price view: AEO's High Oil and Gas Supply case
- Moderate price view: AEO's Reference case
- High price view: AEO's Low Oil and Gas Supply case
- $50 CO2 price view: The company adapted the natural gas price path from AEO's Alternative Policies case using a $35 per ton fee on CO2 emissions

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 the 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 the 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. Crude oil pipeline and export capacity in the Liquid Fuels Markets Module (LFMM) is assumed to increase in the projection period to accommodate higher levels of domestic oil production.

As mentioned earlier, the B2020 version of this report used CRA's forecast of natural gas prices. Adopting the AEO natural gas prices for B2021 has made a year to year comparison of what has changed in the model assumptions less straightforward. The following table shows some of the key assumption changes from B2020 to B2021.

Table B: Key Changes from B2020 to B2021 for Moderate Gas

Driver	Key Changes for B2021 Moderate Gas
Resource Size	• 116 Tcf increase in proved shale reserves from B2020 • 15% growth in total technically recoverable (TTR) U.S. dry natural gas resources (Tcf) from AEO2019 to AEO2020 • PGC 2018 report showed a 20% increase in TTR from 2016
Production Rates	• IP rate assumptions increase to 40% above current levels by 2059 • A change from 30% above current levels by 2059 in B2020
Well Costs	• Fixed well cost down from current levels 40% by 2059 • B2020 assumed fixed well cost down from current levels 30% by 2059 • Variable well costs decrease to 80% of current levels by 2059 • B2020 assumed variable well cost down from current levels 85% by 2059
U.S. LNG Exports	• Exports grow to 14.0 Bcf/d by 2026, and peak at 15.9 Bcf/d in 2030 • A change from a peak of 12.7 Bcf/d by 2026 in B2020 • For B2021 LNG exports are now an input to the model instead of an output
Pipeline Exports to Mexico	• US exports grow to 7.8 Bcf/d by 2028, and levels off around 8.2 Bcf/d by 2042 • B2020 assumed US exports grew to 8.4 Bcf/d by 2023, and leveled off around 9.8 Bcf/d by 2032 • For B2021 pipeline exports are now an input to the model instead of an output

Future coal and oil prices

The price of coal and of oil in the future is also uncertain. For budget year 2021, 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 Reference, High Oil and Gas Supply and Low Oil and Gas Supply cases.

The following illustrations give the fuel price paths that the company has used in the B2021 scenario analyses.

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

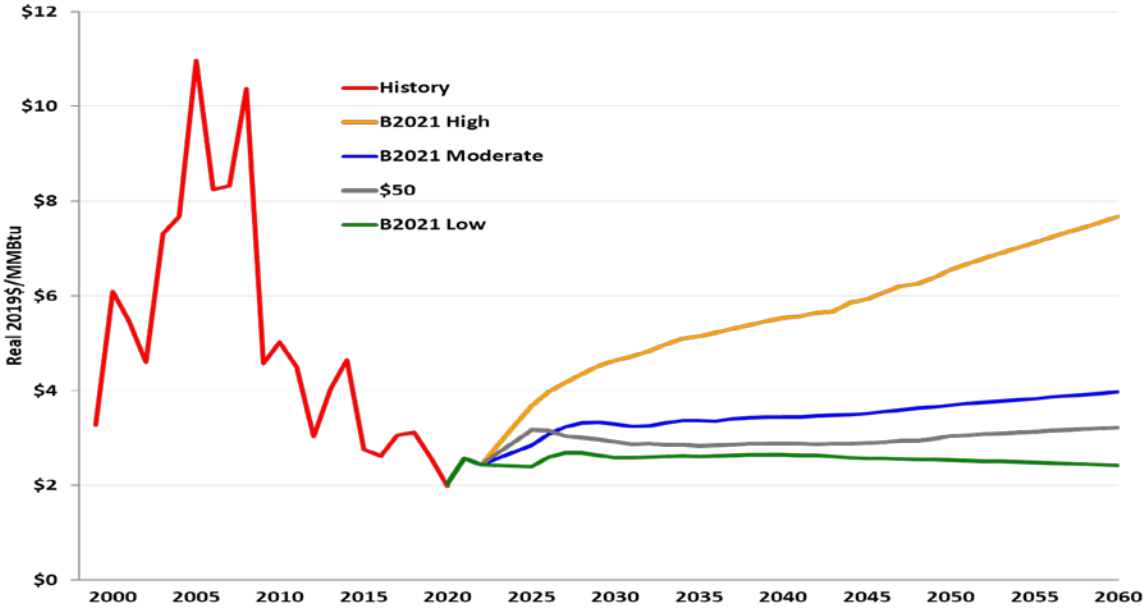


Figure B: Views of future price of coal at mine, by scenario, Central Appalachia

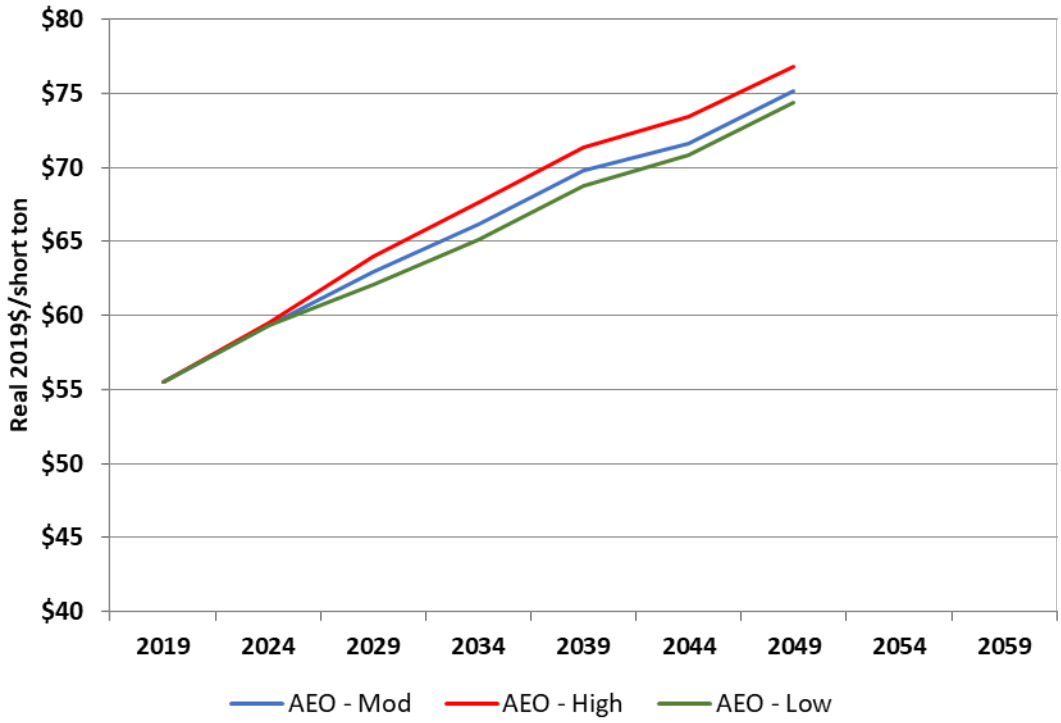


Figure C: Views of future price of coal at mine, by scenario, Illinois Basin

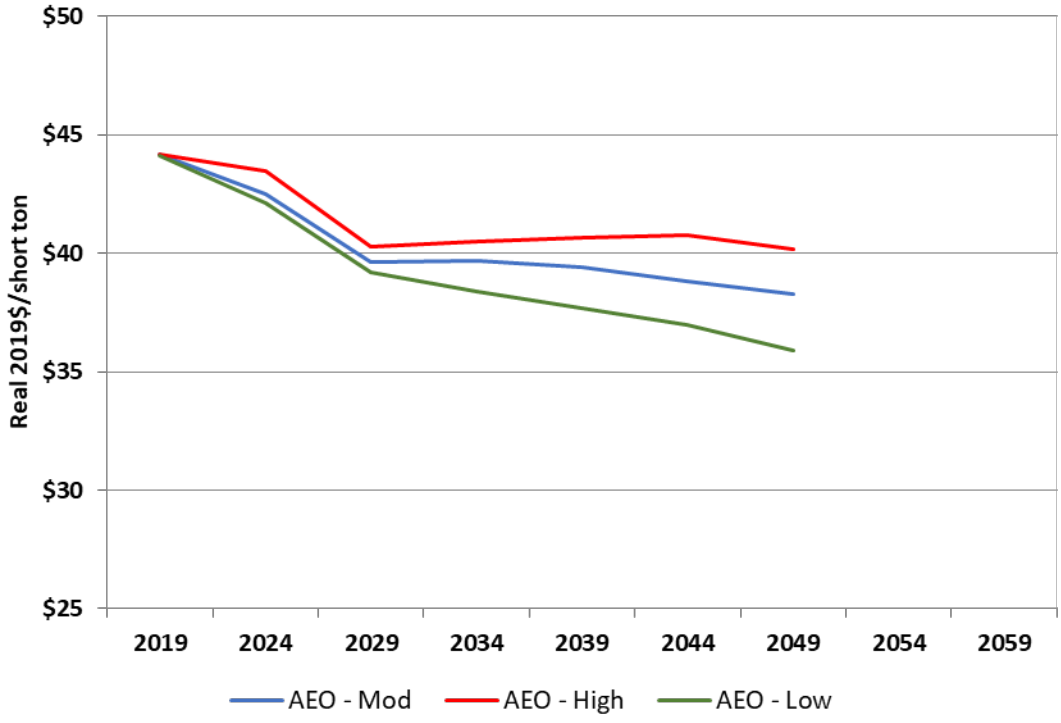


Figure D: Views of future price of coal at mine, by scenario, Powder River Basin

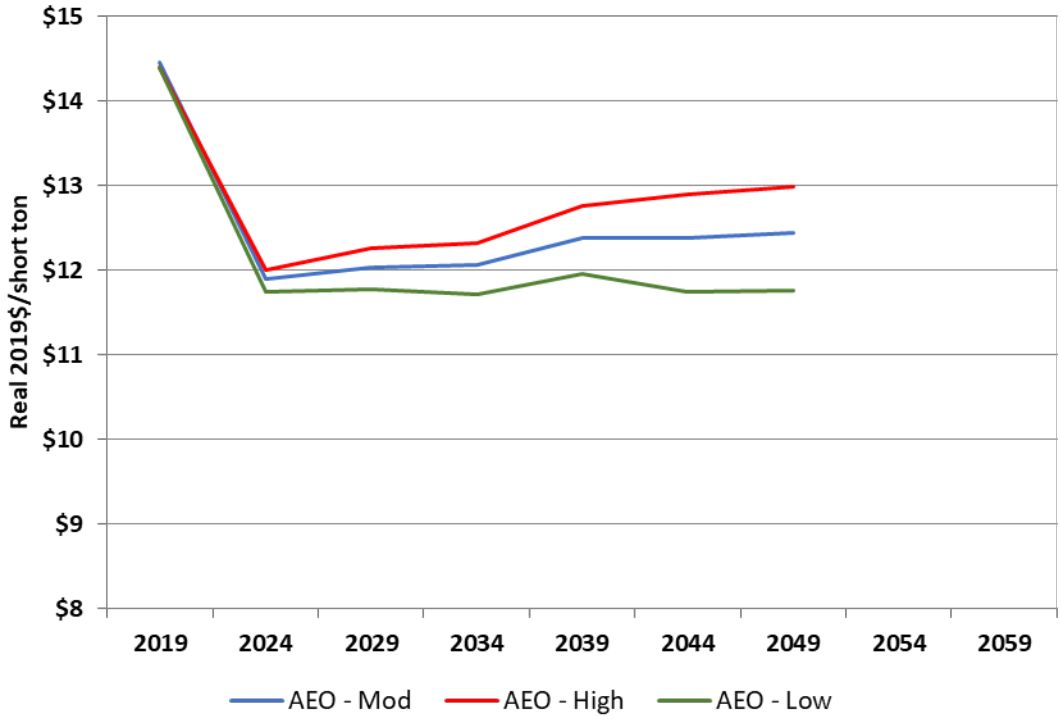
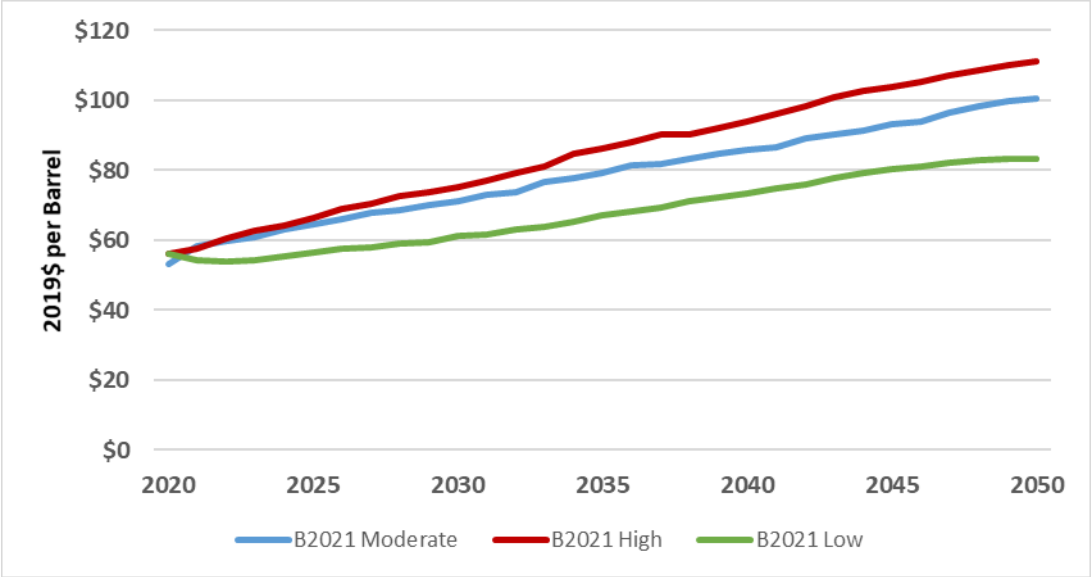


Figure E: Views of future price of oil, West Texas Intermediate



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 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 ("CO_2 Intensity"). 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 units built beginning in 2040. This date is uncertain, but is consistent with a more delayed sequence of reviews required under the Clean Air Act.

- The company's $20 view adds a price on CO_2 emissions that begins in 2025 at $20 (2019$) 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 a less delayed sequence of reviews required under the Clean Air Act.

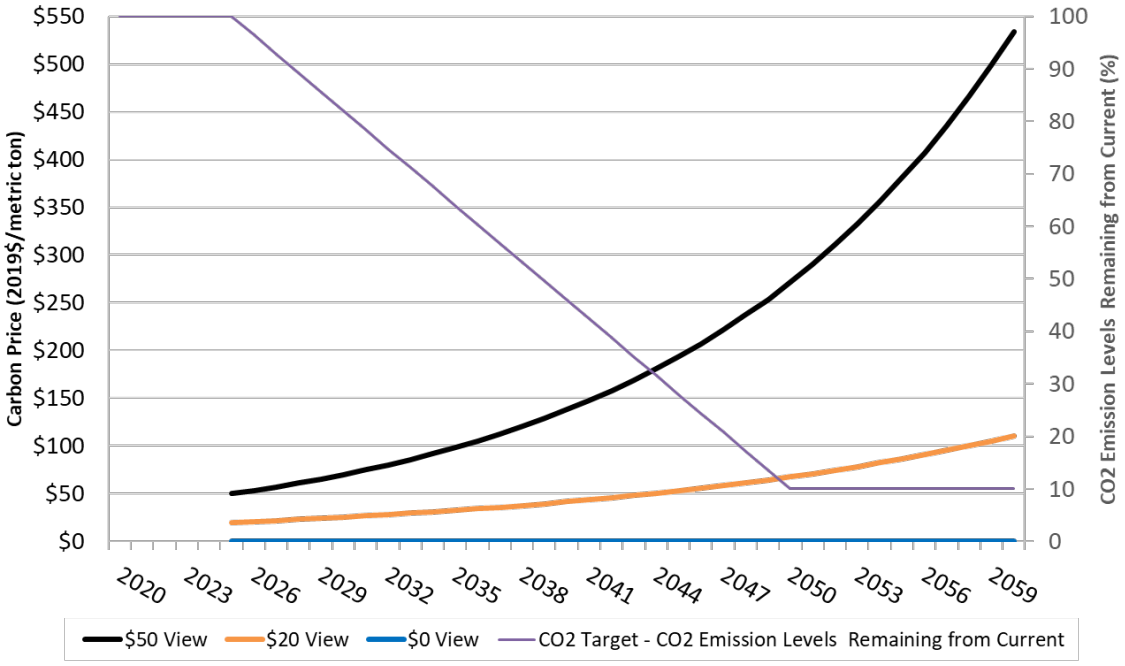
- The company's $50 view adds a price on CO_2 emissions that begins in 2025 at $50 (2019$) per metric tonne of CO_2 and grows at 7% above inflation through the modeling horizon. Carbon capture (90%) is required at all new gas combined

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 Intensity view adds, instead, 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 F. (Note that the CO_2 Intensity view refers to the right vertical axis; the other views refer to the left vertical axis.)

Figure F: Company views regarding future pressure on CO_2 emissions



Technology Cost and Performance

Electricity generating technology is always evolving. 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 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 Budget 2021 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)), nuclear, solar photovoltaic and battery storage.

- 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 utilization or storage, NGCC-CCUS.
- 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 all years of the analysis. The company's view is that its cost will continue to decline, meaning it will become increasingly cost-effective throughout the study timeframe. The company has two views of the future cost of solar PV. Both views adopt costs that decrease from today. The rate of that decline is lower in the standard view. The rate of cost decline is higher in the company's low-cost CO_2 abatement technology view.
- Battery storage. Battery storage 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 company has two views of the future cost of battery storage. Both views adopt costs that decrease from today. The rate of that decline is lower in the standard view. The rate of cost decline is higher in the company's low-cost CO_2 abatement technology view.
- Nuclear. A fourth-generation nuclear technology is available in some scenarios as an expansion resource beginning in a future year. The cost of this technology is uncertain. The company has two views of this cost. The cost is lower in the company's low-cost CO_2 abatement technology view.

Load Growth

Future electricity consumption is uncertain. The company has three different views on future load growth. In addition, the company appreciates 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 types of customers—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 customer-sited generation resources (e.g. rooftop solar). This view has smaller load growth than in the base forecast.

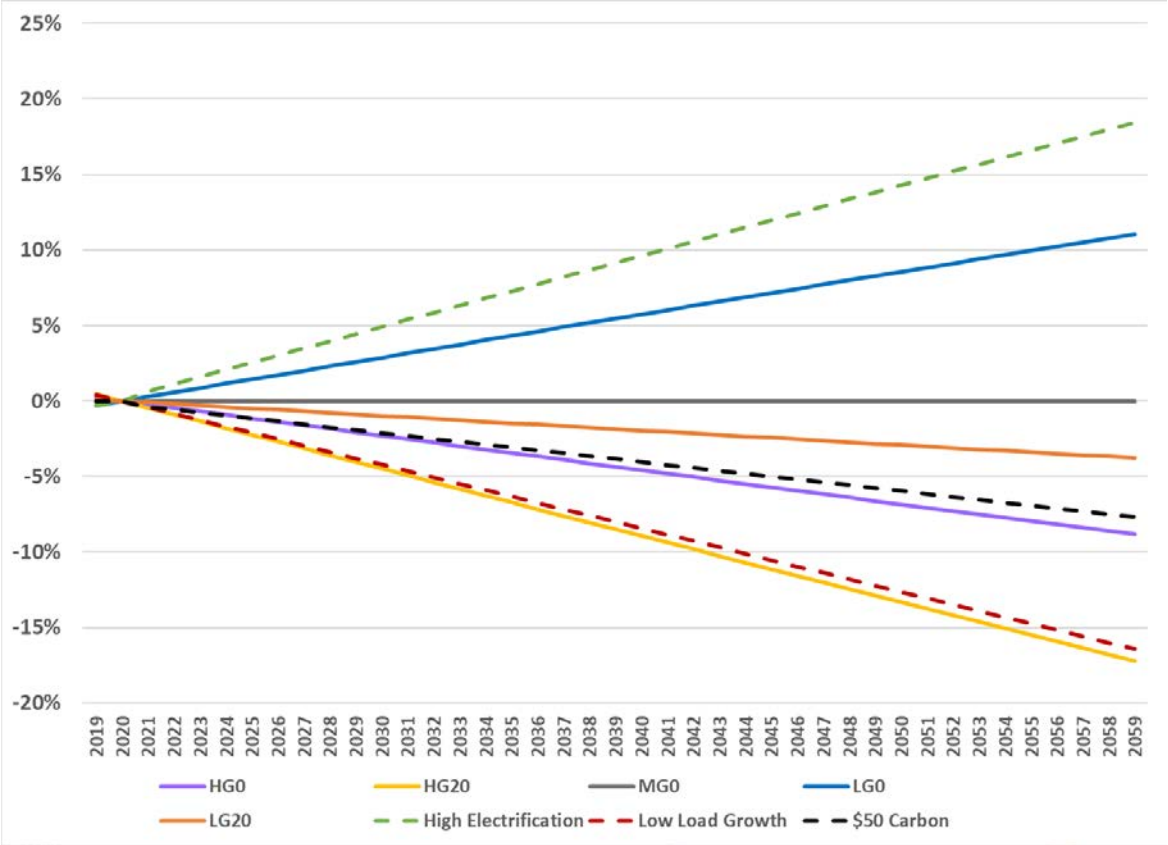
Elasticity adjustments to load growth

The consumption of electricity, the price of natural gas and the level of any fee on emitting CO_2 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. Also, 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 US energy economy. Such analyses yielded different electricity consumption paths associated with different views of future natural gas price and different views of future CO_2 pressure reflecting the important feedbacks in those relationships.

For the B2021 planning process, the company has utilized the work that 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.

The load growth adjustments to the base forecast are shown in Figure G.

Figure G: Load adjustments for scenario analyses



The purpose of the scenario planning process is to provide a framework for understanding and considering the impact of some key uncertainties in planning. Such analyses provide information that is useful for making decisions under considerable uncertainty.