An Updated Look at the Economics of the J.K. Spruce Power Plant

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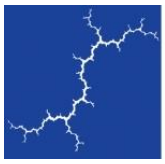
AUTHORS

Avi Allison
Jamie Hall
Thomas Vitolo, PhD



Synapse
Energy Economics, Inc.

485 Massachusetts Avenue, Suite 2
Cambridge, Massachusetts 02139

617.661.3248 | www.synapse-energy.com

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EXECUTIVE SUMMARY

The J.K. Spruce power plant consists of two coal-fired generating units operated by CPS Energy outside of San Antonio, Texas. This report builds from a previous Synapse Energy Economics, Inc. (Synapse) study to evaluate the current economic status of the Spruce units. We used publicly available data to evaluate the recent and projected performance of each Spruce unit relative to potential replacement options. We also reviewed CPS's resource planning process and assessed the reasonableness of concerns regarding the potential impact of retiring one or both Spruce units on CPS's credit rating and borrowing costs.

Overall, we find that the Spruce units are marginal resources that are likely uneconomic relative to cleaner alternatives such as wind and solar. Our detailed findings include the following:

- **Both Spruce units have lost money relative to the market over the past six years**. Synapse estimates that from 2013 through 2018, Spruce 1 cost $37 million more than market alternatives and Spruce 2 lost $84 million relative to the market. Though tight market conditions and high summer loads caused the Spruce units to earn positive net revenues in 2018, those revenues were outweighed by losses incurred from 2015 through 2017.

- **Both Spruce units are likely to lose money relative to the market for the next four years**. From 2019 through 2022, we project that each Spruce unit will lose money each year and will lose more than $30 million total relative to the market.

- **Under a specific set of future circumstances that would be favorable to continued operation, the Spruce units could become profitable relative to the market in the mid-2020s (although not relative to renewable energy resources).** The future profitability of the Spruce plant would likely require some combination of rapidly increasing gas prices, stagnant or declining coal prices, and an absence of any new environmental costs. Under those conditions and an assumption of optimal dispatch, we estimate that Spruce 1 and Spruce 2 would produce average annual net revenues of $20 million and $36 million, respectively, from 2023 through 2040.

- **If gas prices increase slowly, Spruce 1 will likely remain uneconomic indefinitely.** Under a lower gas price scenario in which gas prices rise gradually, in a manner more consistent with gas price futures markets, Spruce 1 incurs net present value (NPV) net losses of $53 million between 2019 and 2040. Spruce 2 earns NPV net revenues of $1 million.

- **Installing selective catalytic reduction (SCR) technology at Spruce 1 would be a risky investment.** If CPS were required to install SCR at Spruce 1—consistent with standard practice for addressing ozone pollution concerns—it would barely break even under favorable commodity price assumptions. If faced with rapidly increasing gas prices and no other environmental costs, Spruce Unit 1 would earn NPV net revenues of $34 million relative to the market from 2019 through 2040. If gas prices were to increase

only gradually, we estimate that Spruce 1 would incur NPV net losses of $230 million over this period.

- **Replacing Spruce with renewable generation would likely reduce CPS costs.** Under current power purchase agreement (PPA) prices and market dynamics, investing in solar and wind would generate levelized net revenues more than three times greater than the benefits offered by either Spruce unit, even in the absence of new environmental regulations. These increased net revenues could be used to lower electricity bills and/or lower taxes.

- **Replacing Spruce with a portfolio of non-emitting resources would likely save money for CPS ratepayers.** CPS has identified a potential replacement portfolio consisting of 1,000 megawatts (MW) of wind, 800 MW of solar, and 450 MW of energy storage. We estimate that retiring the Spruce units in 2025 and replacing them with this portfolio would result in average savings of approximately $85 million per year from 2026 through 2040.

- **The Spruce units face substantial environmental compliance risks.** In addition to likely having to install SCR at Spruce 1, CPS will face growing financial risks related to carbon pricing, coal ash pollution, and wastewater discharges if it continues to operate the Spruce units beyond the mid-2020s.

- **If the Spruce units are uneconomic, retiring them early would be unlikely to harm CPS's credit rating.** If the units are uneconomic, their retirement would be unlikely to negatively affect most key CPS financial metrics. CPS' debt-to-capitalization ratio would most likely suffer, but that metric appears to be of less concern to credit rating agencies than the continued operation of economically challenged coal units.

- **CPS's resource planning process is inadequate and lags behind those of its peers.** While other large municipal and investor-owned utilities throughout the country engage in rigorous, transparent resource planning processes, the basis for CPS's resource plans remains opaque.

We conclude that the available public evidence regarding the economics of the Spruce units is such that CPS should rigorously evaluate the potential near-term retirement of those units. CPS should use its proprietary data and electric-sector optimization models to assess alternative retirement dates as part of a transparent, thorough resource planning process. If CPS analysis confirms that one or both of the Spruce units are uneconomic relative to alternative resource options, CPS should pursue options for the orderly, near-term retirement of those units.

1. BACKGROUND AND INTRODUCTION

This report provides an updated economic assessment of the J.K. Spruce power plant. The Spruce plant is owned and operated by CPS Energy, a municipal utility that provides electric and natural gas services to the Greater San Antonio region. The plant is located in Bexar County, Texas and consists of two units. Spruce Unit 1 became operational in 1992 and has a nameplate capacity of 566 megawatts (MW). Spruce Unit 2 entered service in 2010 and has a capacity of 878 MW.[1] Both Spruce units were constructed with flue gas desulfurization (FGD) systems to limit emissions of sulfur dioxide (SO_2) and baghouses to control emissions of particulate matter.[2] Spruce 2 was constructed with a selective catalytic reduction (SCR) system to limit emissions of oxides of nitrogen (NO_X). Spruce 1 uses a low-NO_X burner (LNB) to achieve some NO_X reductions, but nevertheless has an emissions rate about three times higher than Spruce 2.[3]

In 2017, Synapse Energy Economics, Inc. (Synapse) conducted a preliminary economic assessment of the Spruce plant.[4] That evaluation found that the Spruce units had lost money relative to the Electric Reliability Council of Texas (ERCOT) market in recent years and would likely be uneconomic relative to renewable resource options on a forward-going basis. Since that report was published, CPS has released and promoted a new "Flexible Generation Path" resource plan. Under this plan, CPS is revising its previous plans to install SCR at Spruce 1 and is considering moving up the retirement date of Spruce 1 from 2047 to 2030.[5] However, CPS is evidently planning to continue operating Spruce 2 through at least the 2040s. To our knowledge, CPS has not publicly presented any rigorous analyses justifying its proposed plan, including its proposed Spruce unit retirement dates.

This report relies on the latest publicly available data to provide an updated assessment of the recent and projected financial performance of the Spruce plant.[6] Section 2 reviews the recent performance of the Spruce units relative to the ERCOT market. Section 3 evaluates the likely future performance of the Spruce units relative to the market. Section 4 compares the projected performance of the Spruce units to alternative generation resources including solar, wind, and battery storage. Section 5 identifies

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[1] U.S. EIA. Form EIA-860 data for 2017. Available at https://www.eia.gov/electricity/data/eia860/.

[2] U.S. Environmental Protection Agency. Air Markets Program Data. Available at: https://ampd.epa.gov/ampd/.

[3] *Ibid.*

[4] Allison, A., T. Vitolo, and J. Fisher. 2017. The Shaky Economics of the J.K. Spruce Power Plant: Weighing the Costs of a Coal Plant Against Renewable Energy Options. Synapse Energy Economics for Sierra Club. Available at https://www.synapse-energy.com/sites/default/files/Shaky-Economics-JKSpruce-17-032.pdf.

[5] Gold-Williams, P. 2018. CPS Energy Strategic Update, March 6, 2018. p. 8.

[6] Because CPS declined to provide its detailed data and assumptions regarding its system, we relied entirely on publicly available data.

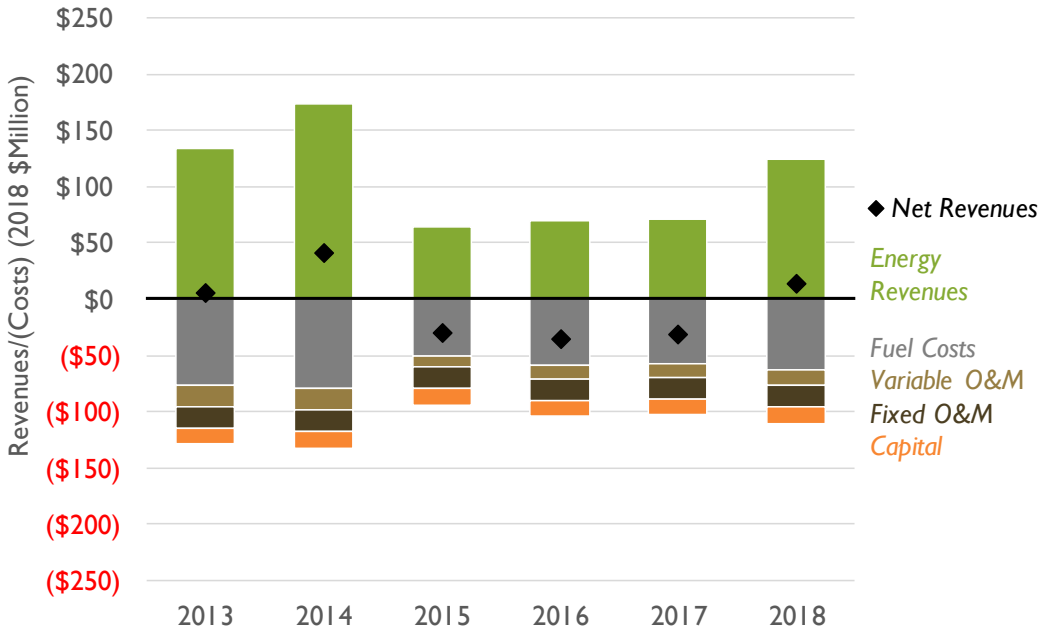
certain environmental compliance risks facing the Spruce units. Section 6 discusses the potential impacts of retiring the Spruce units on CPS's financial metrics and credit rating. Section 7 highlights the importance of robust and transparent resource planning processes in coal unit retirement decisions. Finally, Section 8 offers conclusions and recommendations.

2. RECENT PERFORMANCE

Our analysis finds that both Spruce units lost money relative to the market over the past six years. Between 2015 and 2017, both units lost more than $30 million per year.[7] Both units experienced positive net revenues in 2018, as unusually high summer temperatures led to high market prices that improved the value of the Spruce units. However, on balance these units have not been providing economic value in recent years.

Figure 1 shows Spruce 1's revenue and cost streams, along with its net revenues, for each full year from 2013 through 2018. We estimate that Spruce 1 lost a total of $37 million over that six-year period.

Figure 1. Spruce Unit 1 historical revenues and costs

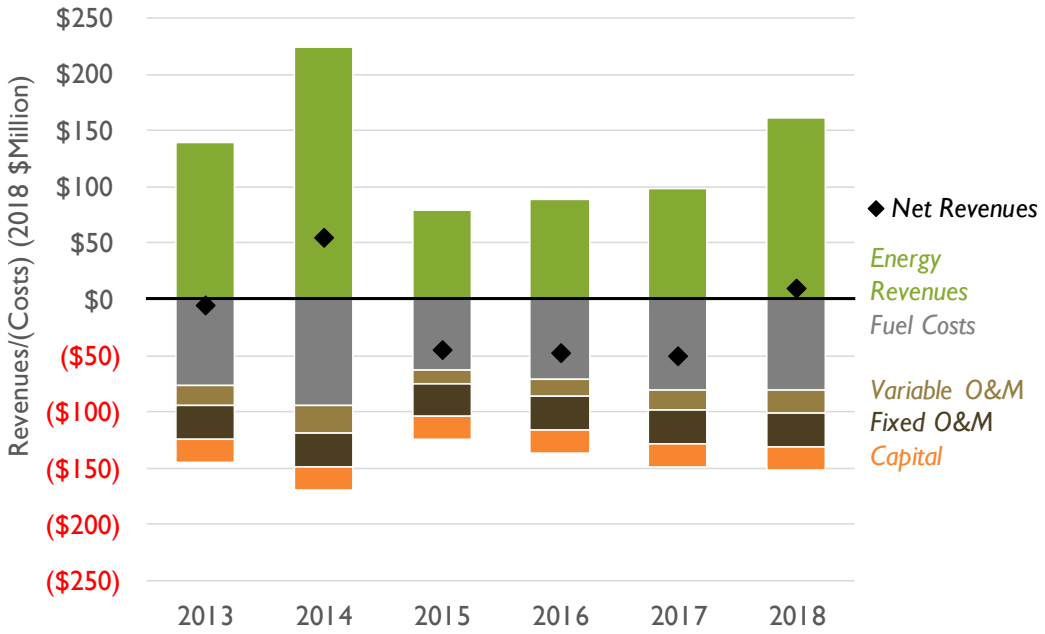


[7] It is possible that CPS did not actually experience the losses presented here, possibly due to the presence of hedging mechanisms such as a bilateral contract that locks in the price paid for Spruce's generation. Nonetheless, the performance of Spruce relative to the market as shown in this report provides the clearest indication of the economic viability of the Spruce plant over the longer term.

Source: Synapse calculations.

In recent years, Spruce 2 has fared similarly to Spruce 1, as shown in Figure 2. We estimate that Spruce 2 lost about $84 million between 2013 and 2018.

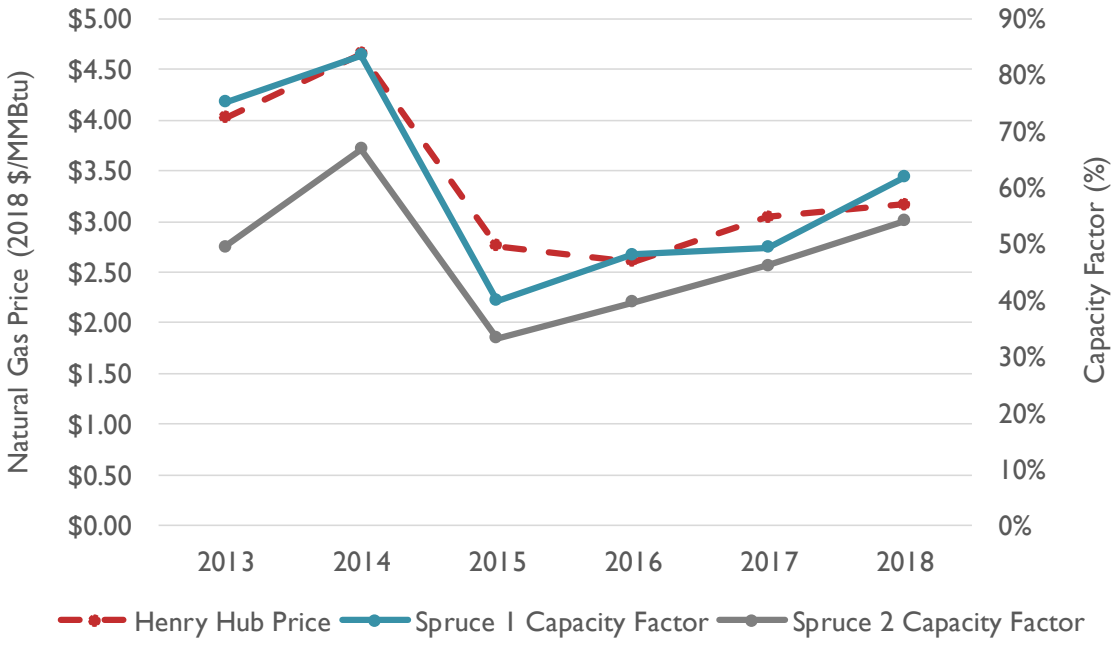
Figure 2. Spruce Unit 2 historical revenues and costs



Source: Synapse calculations.

The recent unprofitability of the Spruce units is largely a result of gas price trends. Figure 3 presents the historical relationship between Henry Hub natural gas prices and the capacity factors of the Spruce units. When gas prices dropped in 2015, both Spruce units operated less than half the time and earned less revenue when they did operate. As gas prices have gradually ticked up since 2016, the capacity factors of the Spruce units have recovered somewhat. But with 2018 gas prices still less than $3.20 per million British thermal units (MMBtu), Spruce unit capacity factors have remained well below the levels experienced earlier in the decade, when gas prices were greater than $4.00 per MMBtu.

Figure 3. Historical relationship between delivered natural gas price and Spruce capacity factors



Source: Form EIA-923; EIA historical Henry Hub prices; Synapse calculations.

3. PROJECTED FUTURE PERFORMANCE RELATIVE TO THE MARKET

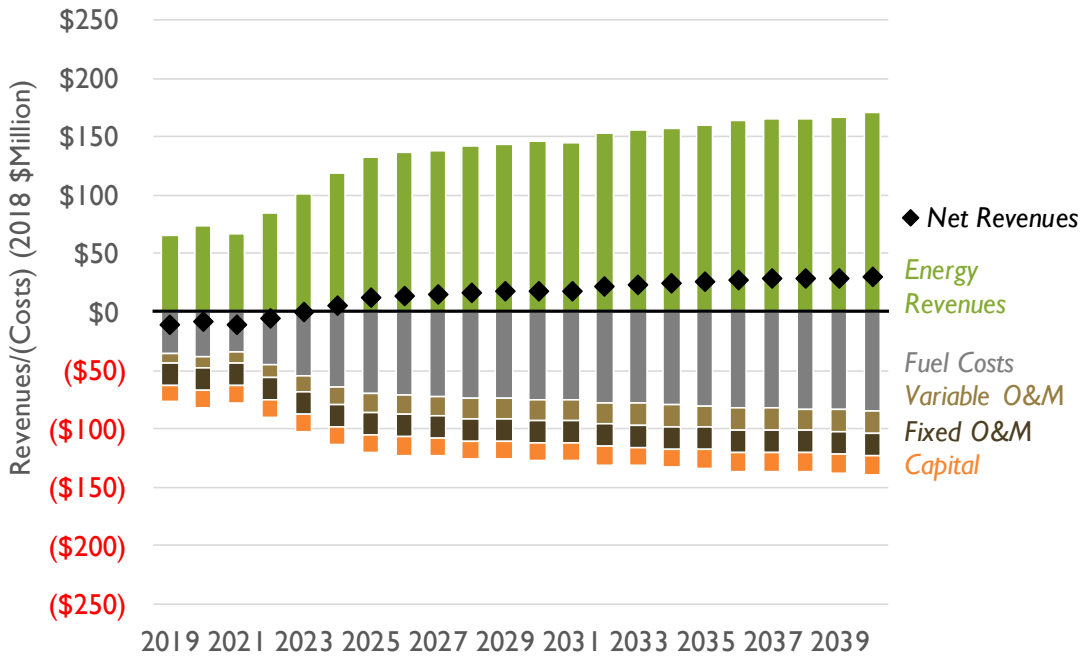
3.1. At best, Spruce may be somewhat profitable going forward

Using natural gas price assumptions from the U.S. Energy Information Agency's (EIA) Annual Energy Outlook (AEO) 2019 Reference Case, we project that the Spruce plant will be slightly profitable relative to the market over the long term. This is assuming no major environmental costs and minimal energy price suppression from renewables.

Figure 4 shows that under these assumptions Spruce 1 is likely to shift between being slightly unfavorable to slightly favorable relative to the market beginning in the mid-2020s. We project that from 2019 to 2040 Spruce 1 will provide net present value (NPV) net revenues of about $229 million under this scenario.[8]

[8] Although CPS is considering moving its planned Spruce 1 retirement date up to 2030, it has not committed to doing so. We therefore evaluated the economics of Spruce 1 over two full decades of future operation. Our results indicate that if CPS would save money by retiring Spruce 1 in 2030 rather than in 2040, it would almost certainly achieve further savings by retiring Spruce 1 in the 2020s rather than in 2030.

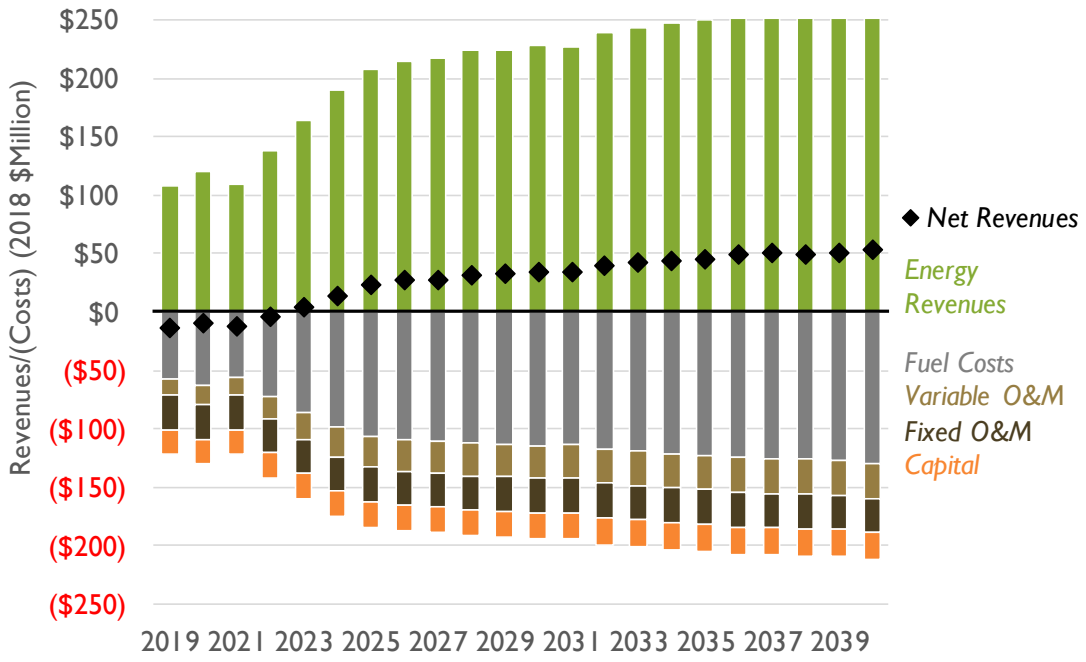
Figure 4. Spruce Unit 1 projected revenues and costs under AEO Reference gas price assumptions, 2019-2040



Source: Synapse calculations.

Spruce 2 is likely to perform somewhat better than Spruce 1 over the long term, in large part due to its lower heat rate. Still, we calculate that Spruce 2 will likely lose more than $40 million between 2019 and 2022 and only become economic in the mid-2020s, as presented in Figure 5. Over the full 2019–2040 period, Spruce 2 is projected to generate NPV net revenues of $448 million.

Figure 5. Spruce Unit 2 projected revenues and costs under AEO Reference gas price assumptions, 2019-2040



Source: Synapse calculations.

It is important to recognize that these results are based on the alignment of several assumptions that are favorable to the Spruce units, including:

- **Steadily increasing natural gas prices.** The AEO 2019 Reference case projects that natural gas prices at the Henry Hub will increase by 15 percent in real terms between 2018 and 2025, an increase of more than 2 percent per year. Under our modeling, these increased gas prices drive up energy prices, leading to increased energy revenues for coal units. We note that futures markets currently indicate that gas prices are likely to decline in the near term.

- **Slow growth of coal prices.** In contrast with increasing natural gas prices, the AEO Reference case projects that coal prices in Wyoming's Powder River Basin (from which Spruce gets its coal) will *decrease* in real terms between 2018 and 2025. This divergence of coal and gas prices is likely necessary for Spruce to be economically viable over the long term.

- **Optimal dispatch of the Spruce units.** We assume that the Spruce units operate at full capacity in all hours in which their production costs are below prevailing energy prices, and that they do not run at all during unprofitable hours. In practice, coal plants are not capable of ramping up and down quickly enough to operate at full capacity in one hour and turn off the very next hour. Instead, coal units end up either operating at a loss in some hours or failing to fully take advantage of hours with high energy prices. In addition, all coal plants are out of commission for certain stretches of the year, due to both planned maintenance and unplanned failures.

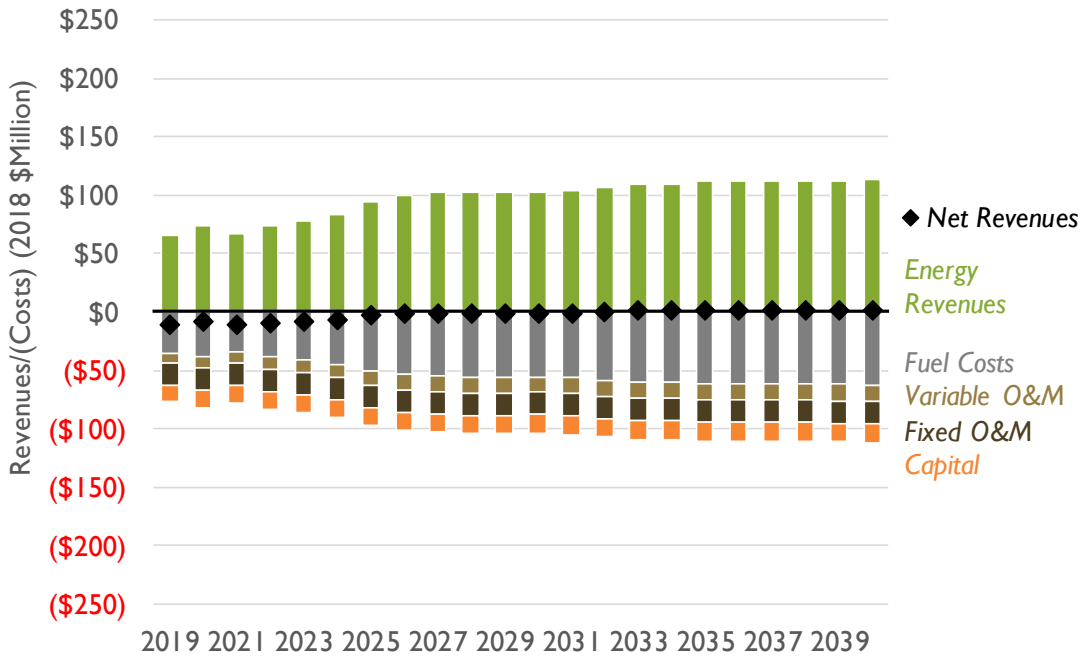
- **No new environmental costs.** Under this analysis, we do not assume any incremental costs associated with proposed or potential future environmental regulations. Over the next 20 years, there is a strong chance that the Spruce units will face new costs associated with regulations addressing carbon dioxide (CO_2), criteria air pollutants, and other forms of pollution. Any such regulations would put Spruce at a disadvantage relative to natural gas and renewable generation in the ERCOT market.

- **Minimal price suppression by renewables.** We assume that natural gas prices will continue to be the primary determinant of energy market clearing prices. However, as renewables with minimal operational costs continue their rapid growth within the ERCOT system, they may set the market price in an increasing number of hours. This could weaken the link between higher gas prices and higher energy prices and increase the number of hours during which the Spruce units cannot operate profitably. Even if renewables continue to rarely set market clearing prices, their increased prevalence will suppress prices by reducing the need for the highest-cost generation resources. In addition, increased penetration of solar and wind energy will present operational and economic challenges for coal units that struggle to ramp up and down in response to variable output from renewable resources.

3.2. If gas prices grow less rapidly than projected by AEO, Spruce 1 may remain uneconomic indefinitely

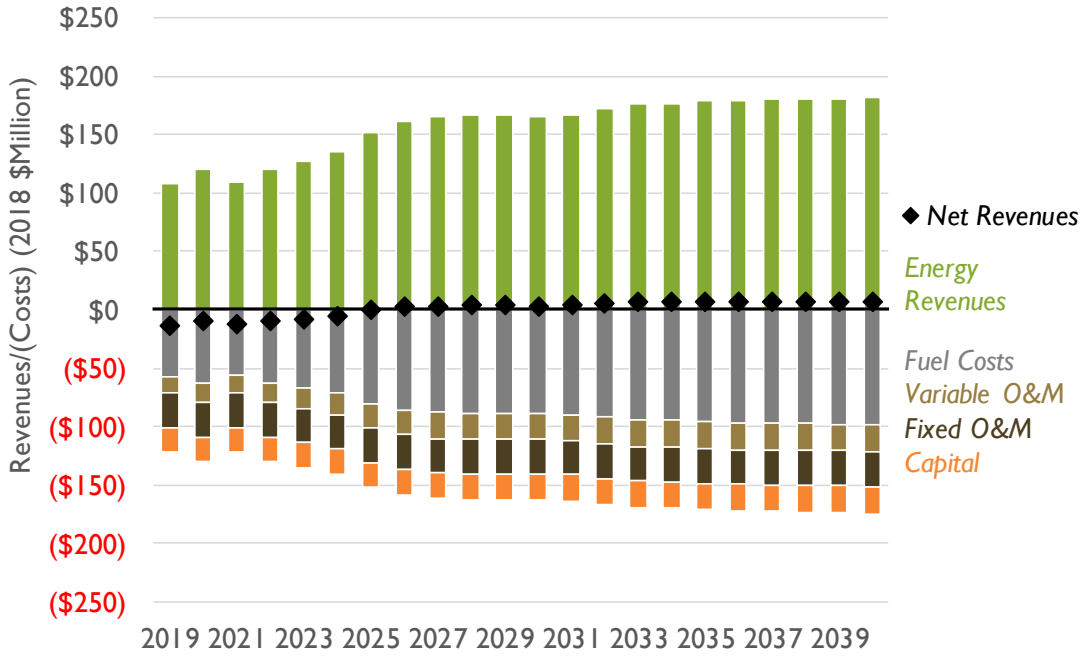
Because the economic performance of Spruce is strongly tied to natural gas prices, we examined a scenario in which future gas prices are lower than those projected in AEO 2019's base case. In this scenario, we rely on AEO 2019's "High oil and gas resource and technology" gas price projection. This projection shows lower gas prices that are more consistent with the NYMEX futures market than the AEO Reference case projection. Under this scenario, Spruce 1 does not earn positive net revenues until 2032, and even then it makes less than $2 million in net revenues per year through 2040 (see Figure 6). Spruce 2 does not earn more than $8 million in any year (see Figure 7). Under this scenario, Spruce 1 generates NPV net losses of $53 million between 2019 and 2040 and Spruce 2 generates NPV net revenues of $1 million between 2019 and 2040.

Figure 6. Spruce Unit 1 projected revenues and costs under AEO low gas price assumptions, 2019-2040



Source: Synapse calculations.

Figure 7. Spruce Unit 2 projected revenues and costs under AEO low gas price assumptions, 2019-2040



Source: Synapse calculations.

We note that this scenario maintains assumptions related to coal prices, environmental costs, operational constraints, and renewable price suppression that are favorable to the Spruce units. The negative impact of a lower gas price assumption on the economics of Spruce likely approximates the effect of assuming higher coal prices, a positive carbon price, or greater renewables-driven energy price suppression. If a lower gas price future were to be combined with other less favorable assumptions, the economic outlook for both Spruce units would worsen.

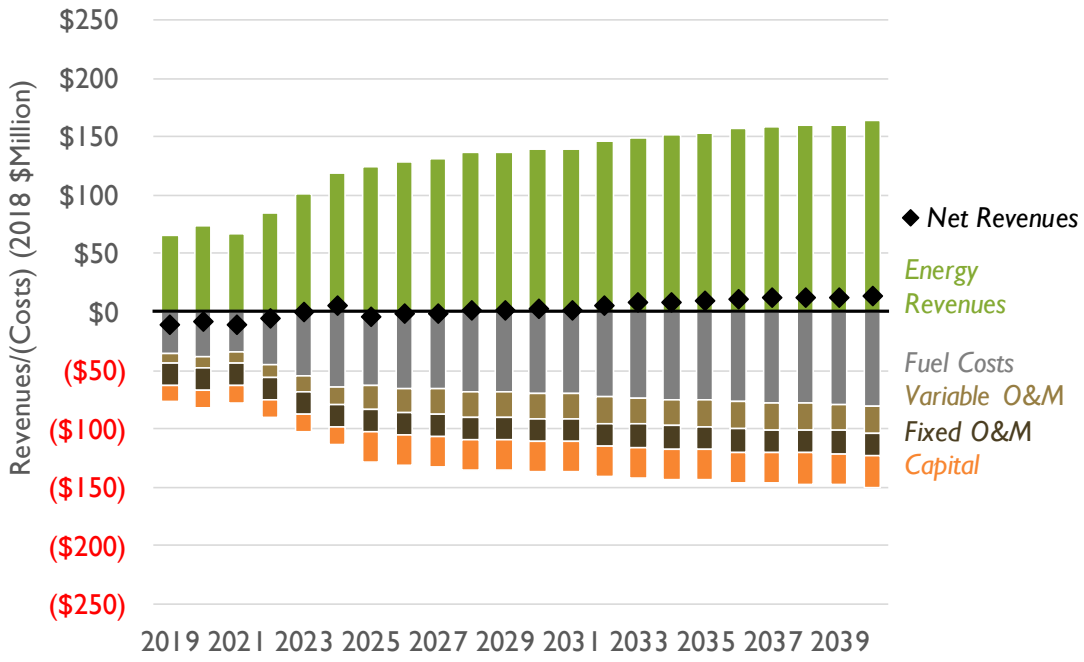
3.3. Spruce 1 may never recover the costs of an SCR

In 2018, the U.S. Environmental Protection Agency (EPA) designated air quality in Bexar County as in nonattainment with National Ambient Air Quality Standard (NAAQS) for ozone.[9] While CPS has removed plans to install an SCR at Spruce 1 from its budget and business plan, the Clean Air Act's Reasonably Available Control Technology standard would likely require that CPS eventually install SCR at Spruce 1 if Bexar County continues to exceed the ozone NAAQS. Therefore, Synapse evaluated the impact of installing SCR in 2025 on the economics of Spruce 1.

Under AEO 2019 Reference case gas price assumptions, the incremental costs associated with a new SCR system are sufficient to turn Spruce 1 from slightly economic to an economic wash. Figure 8 shows the projected annual revenues and costs faced by Spruce 1 assuming that CPS installs an SCR in 2025. The SCR carrying costs mostly offset the impact of increased gas prices in the 2020s. Therefore, under this scenario, Spruce 1 earns NPV net revenues of only $34 million between 2019 and 2040. We consider this to be within the margin of error for this analysis.

[9] U.S. EPA. July 2018. News Releases: EPA Finalizes Last 2015 Ozone Designations for 8 Counties in Texas. https://www.epa.gov/newsreleases/epa-finalizes-last-2015-ozone-designations-8-counties-texas.

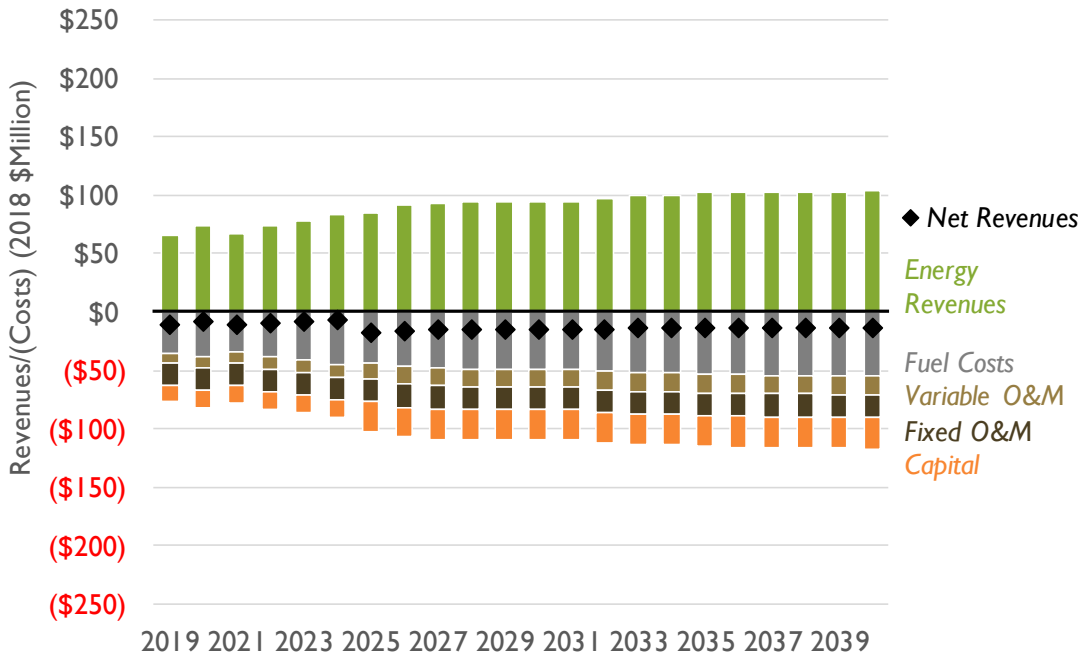
Figure 8. Spruce Unit 1 projected revenues and costs with SCR, AEO Reference gas prices, 2019-2040



Source: Synapse calculations.

If future gas prices follow the trajectory of the AEO 2019 low gas price projections, Spruce 1 would likely never recover the costs of an SCR. Instead, we project that Spruce 1 would lose money relative to the market in every year from 2019 through 2040, incurring NPV net losses of approximately $230 million (see Figure 9).

Figure 9. Spruce Unit 1 projected revenues and costs with SCR, AEO low gas price assumptions, 2019-2040



Source: Synapse calculations.

4. Performance of Spruce Relative to Replacement Generation Resources

Were CPS to retire one or both Spruce units, it would not have to rely on its own generating capacity for replacement. By participating in the ERCOT market, CPS can replace uneconomic internal resources with external market purchases. Especially since CPS currently has excess capacity well beyond its planning target,[10] it could easily retire the Spruce units without fully replacing their capacity.

However, there are several good reasons why CPS may want to replace the Spruce units with its own generating capacity. First, CPS may not trust ERCOT to ensure reliable electricity supply, particularly since ERCOT is forecasting that it will continue to fall below its desired planning reserve margins for the next several years.[11] Second, CPS likely wishes to minimize exposure to market volatility, as reflected in last summer's high energy prices. Finally, CPS may want to invest in particular types of generating resources (such as renewables).

[10] Eugster, C. 2019. CPS Generation Update, March 25, 2019. p. 6.

[11] Potomac Economics. 2019. *2018 State of the Market Report for the ERCOT Electricity Markets*. p. 124.

Fortunately, CPS operates in a region containing a plentiful amount of economically and environmentally beneficial alternatives to existing coal units. And while comparing the Spruce units to a market proxy provides a good sense of the current economic value of the units, comparing Spruce to alternative generation resources likely provides a more realistic sense of the nature and costs of replacing the coal plant. In this section we evaluate the economics of the Spruce units relative to power purchase agreements (PPA) for individual renewable resource alternatives and to a potential portfolio of replacement generation resources previously identified by CPS.

4.1. CPS has access to cost-effective clean energy alternatives

CPS's service territory lies entirely within the ERCOT interconnect, a region where renewable resources are very cost-effective. Recent PPAs in Texas have come in below $25 per megawatt-hour (MWh) for solar and below $17 per MWh for onshore wind.[12] These values are both well below average ERCOT energy prices. Texas municipal utilities have been among those benefitting from low-cost renewable resources. New Braunfels Utilities and Austin Energy have both reportedly signed PPAs for hundreds of megawatts of solar at a cost of around $25 per MWh.[13]

CPS itself has already begun to take advantage of low-cost renewable resources. CPS has signed PPAs for more than 1,000 MW of wind and more than 500 MW of solar, thereby already exceeding its goal of 1,500 MW of renewables by 2020.[14] CPS is also currently developing a paired solar-and-storage facility.[15] It will therefore soon have experience with a wide range of clean energy resources that could partially or fully replace the Spruce units.

However, CPS remains behind some of its fellow Texas municipal utilities in terms of renewable resource penetration. As of 2018, renewables represented 22 percent of CPS's nameplate capacity and provided less than 20 percent of its generation.[16] Under CPS's new Flexible Generation Plan, renewables would reach 50 percent of nameplate capacity in 2040.[17] In contrast, Austin Energy generated more than 37 percent of its energy using renewable resources in 2018 and is aiming for 55 percent renewable energy

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[12] Foehringer Merchant, E. 2018. "Texas Municipal Utility Signs New Super-Low Solar PPA," Green Tech Media. December 14, 2018. https://www.greentechmedia.com/articles/read/utility-signs-new-low-solar-ppa-in-texas#gs.bywz2i; Krulewitz, S. 2019. "Corporates May Be Leaving Millions on the Table by Procuring Wind Over Solar in ERCOT," Greentech Media. February 27, 2019. https://www.greentechmedia.com/articles/read/corporates-millions-on-table-by-procuring-wind-over-solar-ercot#gs.byucjp.

[13] Foehringer Merchant, E. 2018. "Texas Municipal Utility Signs New Super-Low Solar PPA," Greentech Media. December 14, 2018. https://www.greentechmedia.com/articles/read/utility-signs-new-low-solar-ppa-in-texas#gs.bywz2i.

[14] CPS Budget Plan Fiscal Year (FY) 2020. p. 5.

[15] *Ibid.*

[16] Gold-Williams, P. 2018. CPS Energy Strategic Update, March 6, 2018. pp. 9-10.

[17] Gold-Williams, P. 2018. CPS Energy Strategic Update, March 6, 2018. pp. 9-10.

by 2025 and 65 percent renewable energy by the end of 2027.[18] Meanwhile, the City of Denton is planning to serve 100 percent of its load with renewable energy contracts by 2020.[19]

4.2. Replacing Spruce with renewables would likely save money

We used publicly available data to estimate the economic impact of retiring the Spruce units and replacing them with PPAs for solar and wind resources. In this analysis, we assumed PPA costs consistent with the aforementioned recent PPAs in Texas (that is, $25 per MWh for solar and $17 per MWh for onshore wind).[20] We then applied historical utility-scale solar and wind hourly generation profiles provided by ERCOT for planning purposes to project the hourly revenues earned by the solar and wind resources.[21] Although CPS would not directly earn these revenues, it would experience them as avoided costs from its reduced need to procure energy to serve its customers.

We find that, if the current relationships between natural gas prices and energy prices hold, Texas solar and wind are more cost-effective resources than either Spruce unit. Figure 10 provides a comparison of the projected levelized benefits and costs, relative to the market, of Spruce 1 (with and without an SCR), Spruce 2, solar PPA replacement, and wind PPAs. While Spruce 1 and Spruce 2 provide marginal net benefits relative to the market under our favorable set of base assumptions, the solar and wind resource replacements are much more cost-effective under those same assumptions. Investing in a solar PPA today would provide net benefits of over $18 per MWh while investing in a wind PPA today would provide net benefits of over $15 per MWh.[22] These net benefit values are over three times greater than the net benefits offered by both Spruce units, even under the favorable AEO 2019 base case gas price assumptions and assuming no new SCR investment at Spruce 1.

[18] Austin Energy. Performance Report. https://data.austintexas.gov/stories/s/82cz-8hvk; Austin Energy. Renewable Energy. https://austinenergy.com/ae/green-power/renewable-energy.

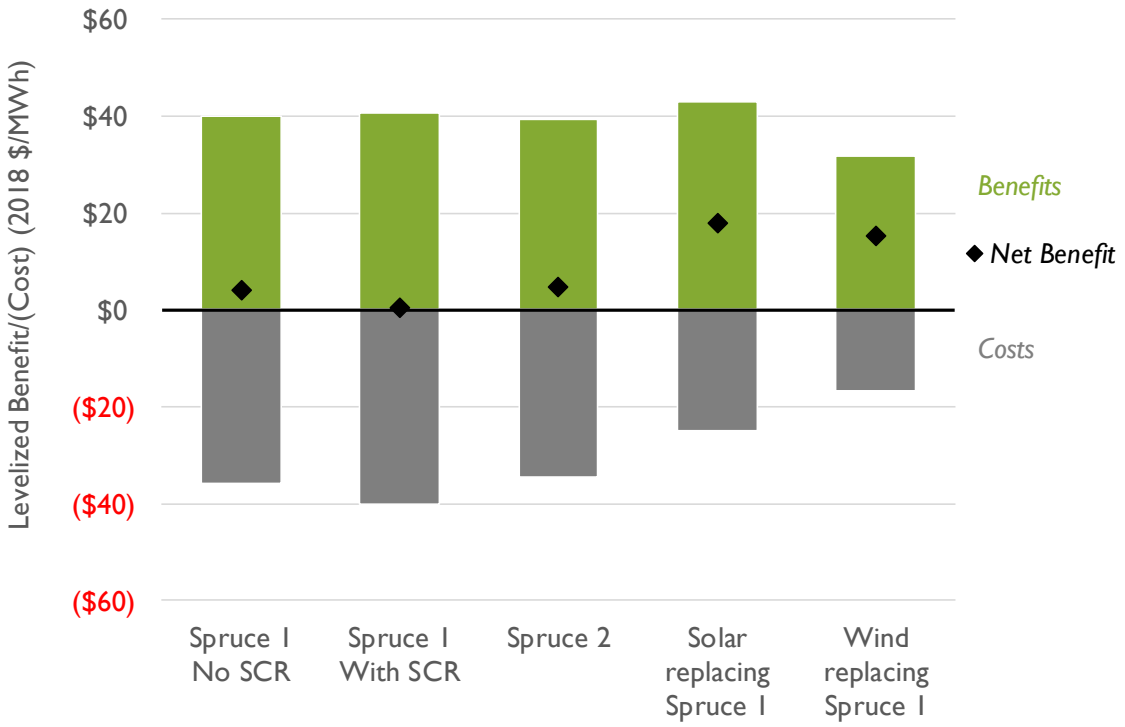
[19] City of Denton. Denton Renewable Resource Plan. https://www.cityofdenton.com/en-us/government/departments/denton-municipal-electric/renewable-energy.

[20] Future renewable energy prices will likely be affected by the off-setting forces of declining tax credit availability and declining costs.

[21] ERCOT. See: http://www.ercot.com/gridinfo/resource/. For solar, we used the profile of the Roserock plant because it was built recently (it started operations in 2016), it is relatively large (160 MW), and its output is contracted through a PPA to a nearby municipal utility (Austin Energy). For wind, we used the profile for "Site 139" (112.5 MW).

[22] While wind energy is currently less expensive than solar in ERCOT, we find that solar provides greater value because it produces more energy during periods of higher load and higher market prices.

Figure 10. Levelized benefits and costs of alternative resources relative to market, AEO Reference gas prices, 2019-2040



Source: Synapse calculations.

This assessment may overstate the benefits of renewables relative to the market. This is largely because increased renewable development will ultimately drive down prices during the hours when renewable resources generate most, thus decreasing their value. But given the magnitude of the benefit of new renewables relative to existing coal units and the propensity of Texas solar and coastal wind resources to generate during high-price hours,[23] the economic benefit of renewables relative to the Spruce units appears likely to hold.

4.3. Replacing both Spruce units with a portfolio of renewable and energy storage resources would likely save money

While a series of PPAs for a single renewable resource type could replace the energy and peaking capacity provided by the Spruce units, CPS may prefer to replace Spruce with a portfolio of diverse resources, including resources capable of efficiently providing ramping and ancillary services. In fact, CPS has already identified just such a potential replacement portfolio. Under this alternative, CPS would

[23] Recent ERCOT planning documents assume a 74 percent capacity credit for solar resources and a 58 percent capacity credit for coastal wind resources, indicating that both resource types perform well during peak, high-price hours. ERCOT. May 8, 2019. *Report on the Capacity, Demand and Reserves (CDR) in the ERCOT Region, 2020–2029*.

replace both Spruce units by 2025 with a mix of 1,000 MW of wind, 850 MW of solar, and 450 MW of battery storage.[24] We analyzed the cost of CPS developing this portfolio rather than continuing to operate the Spruce units. For the sake of simplicity, we assumed that the new resources all come online at the start of 2026—just after the Spruce units retire at the end of 2025—and fully replace the services provided by the Spruce units.[25] We calculated the O&M and ongoing capital costs associated with the resources included in this portfolio and compared these costs with those associated with the continued operation of the Spruce units.

We estimate that the replacement portfolio would save CPS an average of over $85 million per year between 2026 and 2040 relative to continuing to operate the Spruce units. We calculate the NPV savings of the replacement portfolio relative to the Spruce units to be approximately $947 million. This level of savings would likely overwhelm any incremental transmission upgrades required to access the associated level of new renewables. The savings would ultimately get passed on to San Antonio residents in the form of lower electricity bills, lower taxes, or both.

4.4. Replacing Spruce 1 with renewables would reduce emissions

Replacing Spruce 1 with renewable resources would result in significant reductions of harmful emissions in the Greater San Antonio region. Table 1 lists the 2019 average emission rates of SO_2, NO_X, and CO_2 for each Spruce unit.

Table 1. Emission rates of Spruce Unit 1 and Spruce Unit 2, 2019

Unit	SO_2 (lbs/MWh)	NO_X (lbs/MWh)	CO_2 (tons/MWh)
Spruce 1	0.48	1.51	1.07
Spruce 2	0.10	0.44	1.02

Source: EPA Air Markets Program Database.

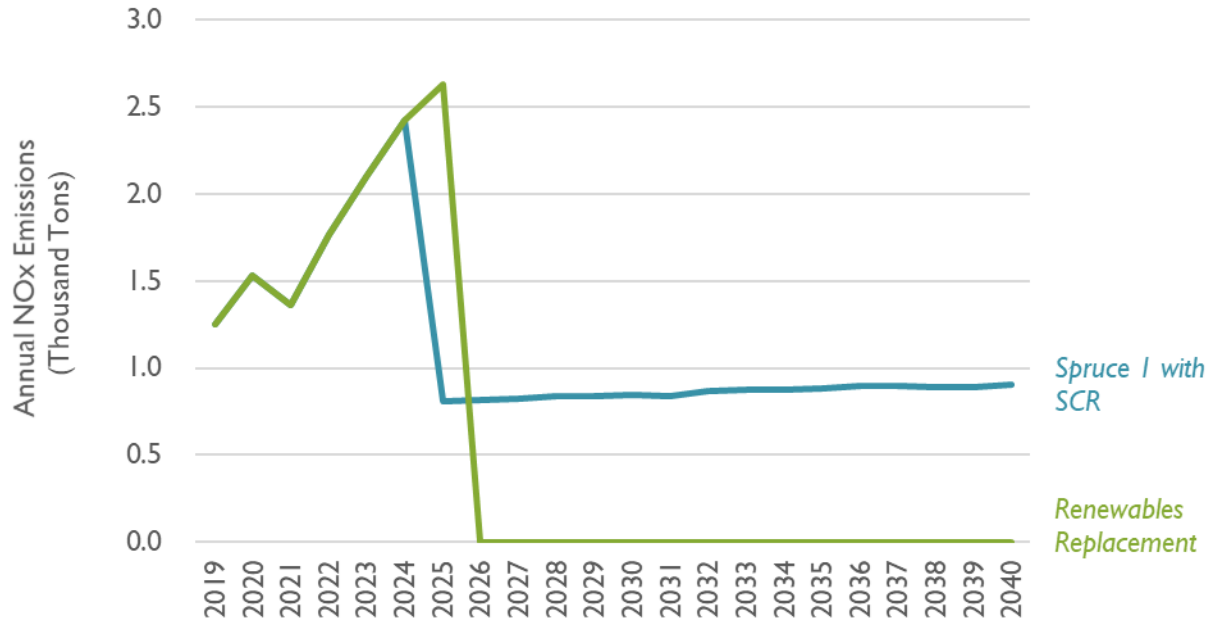
While installing SCR at Spruce 1 would reduce NO_X emissions considerably, replacing Spruce 1 with renewables would eliminate those emissions entirely (see Figure 11). We estimate that, over the period from 2025 through 2040, renewable replacement would reduce aggregate NO_x emissions by more than 11,000 tons relative to retrofitting Spruce 1 with SCR.[26]

[24] CPS presentation to local Environmental Stakeholders group. July 17, 2018.

[25] In reality, the development of these new resources would likely be staggered, with any resources coming online in earlier years causing both earlier costs and earlier benefits.

[26] This comparison assumes that Spruce 1 would have the same NO_X emissions rate as Spruce 2 (0.44 pounds per MWh) following the installation of SCR.

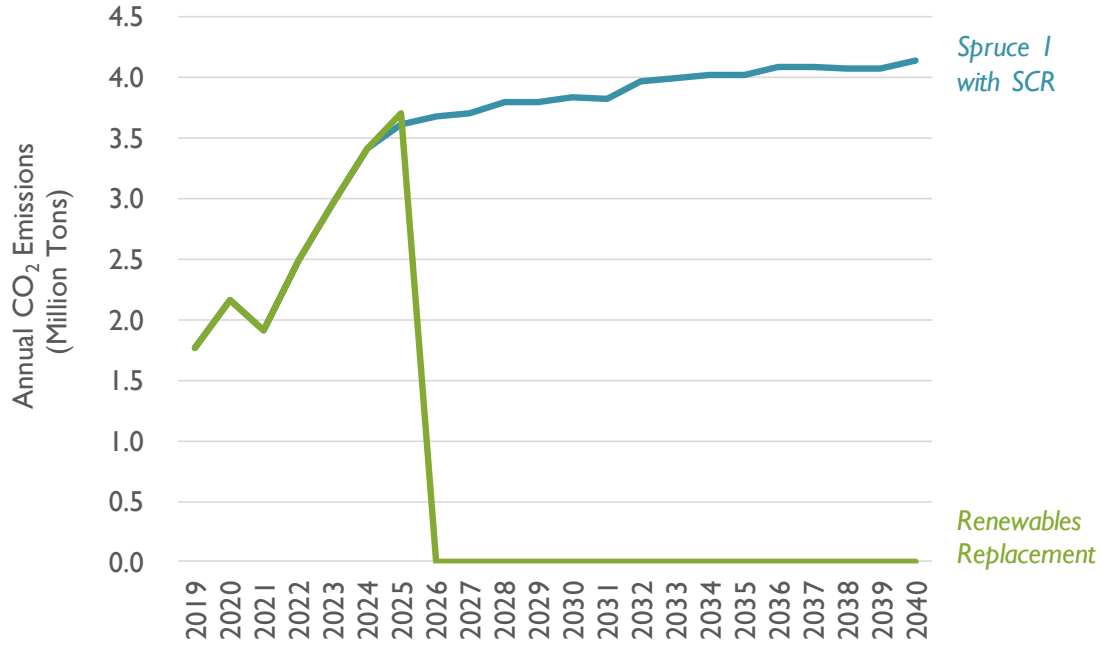
Figure 11. Annual Spruce Unit 1 NO_X emissions under 2025 SCR retrofit vs. 2026 renewable replacement



Source: EPA Air Markets Program Database, available at: https://ampd.epa.gov/ampd/.

Renewable replacement would also eliminate CO_2 emissions entirely (see Figure 12). We estimate that over the same period (2025 through 2040), renewable replacement would reduce aggregate CO_2 emissions by more than 59 million tons relative to continuing to operate Spruce 1 with SCR.

Figure 12. Annual Spruce Unit 1 CO_2 emissions under 2025 SCR retrofit vs. 2026 renewable replacement



Source: EPA Air Markets Program Database.

In addition to reducing NO_X and CO_2 emissions, replacing Spruce 1 with wind and solar resources would have substantial impacts on SO_2 emissions. We calculate that renewable replacement of Spruce 1 would result in average annual emission reductions of 842 tons of SO_2.

5. ENVIRONMENTAL RISKS AT SPRUCE

The relatively high emission rates of the Spruce units have associated regulatory and financial risks. The previously discussed cost of an SCR is one such risk. Here we discuss three other risks: those related to CO_2 emissions, coal ash, and wastewater discharges.

5.1. Carbon price risk

There are currently no laws or regulations that impose a CO_2 emission cost on CPS or its coal units. Given the current federal and statewide political landscape, it is unlikely that CPS would face a carbon price in the near term. However, federal carbon regulation remains a distinct future possibility. In fact, most large U.S. electric utility integrated resource plans (IRP) assume a positive carbon price starting prior to

2030.[27] To take one local example, the 2018 IRP of Southwestern Electric Power Company (SWEPCO)—an AEP affiliate with operations in Texas as well as Arkansas and Louisiana—assumed a base case carbon price starting at around $14 per ton in 2028 and increasing to $20 per ton by 2036.[28]

A carbon price such as that forecasted by SWEPCO would result in a major increase in costs for the Spruce units. Since both Spruce units emit more than one ton of CO_2 per MWh, a carbon price of $14 per MWh would result in increased production costs of nearly $15 per MWh. We estimate that this would amount to an increase in Spruce production costs of approximately 50 percent in 2028.

While a carbon price would also result in increased energy market prices—a favorable development for the Spruce units' economics—the increase in energy prices would almost certainly be much less than the increase in coal unit production costs. This is because gas units, which typically set market prices in ERCOT, typically only emit about half as much CO_2 per MWh as coal units. Thus, about half of the total new carbon costs faced by Spruce would represent increased net costs relative to the market. And all carbon costs would represent increased net costs relative to zero-emitting resources such as wind and solar. A carbon price such as that forecasted by SWEPCO would therefore likely render the Spruce units uneconomic relative to the market over the long term and would certainly worsen the economics of Spruce relative to renewables.

5.2. Coal ash risk

Recently enacted federal regulations impose a variety of requirements related to the disposal of coal combustion residuals, also known as coal ash.[29] These requirements include groundwater monitoring standards for coal ash storage and disposal sites, which are generally co-located with coal plants. Pollution concerns have emerged as CPS and other utilities have begun releasing the required groundwater monitoring data. For example, a recent assessment of CPS-reported data concluded that the groundwater near the Spruce units exceeds health thresholds for pollutants such as cadmium, selenium, lithium, and sulfate.[30]

As CPS continues to operate the Spruce units and generate additional coal ash, the risk of further groundwater pollution will only increase. This pollution could ultimately lead to additional required

[27] See, e.g., Entergy Arkansas. 2018 Integrated Resource Plan. October 31, 2018. P. 47; PacifiCorp 2019 Integrated Resource Plan Public Input Meeting. October 9, 2018. P. 15; Duke Energy Carolinas North Carolina. Integrated Resource Plan: 2018 Biennial Report. September 5, 2018. P. 87.

[28] SWEPCO. 2018. Integrated Resource Planning Report to the Arkansas Public Service Commission.

[29] U.S. EPA. Disposal of Coal Combustion Residuals from Electric Utilities. https://www.epa.gov/coalash/coal-ash-rule.

[30] Environmental Integrity Project. 2019. Groundwater Contamination from Texas Coal Ash Dumps. Available at https://www.environmentalintegrity.org/news/records-show-100-percent-of-texas-coal-power-plants-contaminating-groundwater/.

investments in environmental control technologies and/or financial penalties that would lower the value of the Spruce units.

5.3. Wastewater discharge risk

In 2015, EPA finalized updated Effluent Limitation Guidelines (ELGs) for coal plants.[31] These updated ELGs impose stringent limitations on discharges of several common coal plant wastewater streams. The ELG regulations require power plants to comply with the updated effluent limitations by the end of 2023.

The updated ELGs apply to two waste streams produced by the Spruce units: ash transport water and FGD wastewater.[32] For bottom and fly ash transport water, the ELGs require coal plants like Spruce to eliminate discharges.[33] For FGD wastewater, the ELGs require coal units to meet specific numerical limits for four contaminants: arsenic, mercury, selenium, and nitrate/nitrite. Like coal ash regulations, the ELGs could require additional investments in environmental control technologies at the Spruce units in the early- to mid-2020, which would further reduce the value of the units.

6. CREDIT RATING IMPACTS FROM SPRUCE RETIREMENT

CPS has raised concerns that the near-term retirement of one or both Spruce units could harm key CPS financial metrics in way that would lead to a credit downgrade.[34] If this were to happen, CPS would likely face higher borrowing costs, resulting in upward pressure on electricity rates for San Antonio residents. Here we briefly discuss the key financial metrics tracked by CPS and the validity of concerns regarding the impact of Spruce's retirement on those metrics and CPS's credit rating.

CPS financial plans and reports[35] focus on the following three key financial metrics:

- **Adjusted Debt-Service-Coverage Ratio (DSCR):** Adjusted DSCR measures the availability of revenues to cover current debt obligations, including annual interest and principal

[31] U.S. EPA. November 3, 2015. Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category, 80 Fed. Reg. 67,837.

[32] National Pollution Discharge Elimination System Permit No. WQ0001514000. Issued to CPS Energy by Texas Commission on Environmental Quality.

[33] U.S. EPA. November 3, 2015. Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category, 80 Fed. Reg. 67,837.

[34] CPS presentation to local Environmental Stakeholders group. July 17, 2018.

[35] CPS FY 2019 Financial Performance Report. March 25, 2019. pp. 6-8; CPS Financial Plan Preview: Fiscal Year 2020. January 28, 2019. p. 22.

payments. DSCR is equal to net operating income divided by debt obligations. Under CPS's "adjusted" version of DSCR, CPS transfers to San Antonio's General Fund are treated as an operating expense that detracts from net operating income.[36] CPS sets a target of 1.5 or greater for its Adjusted DSCR.

- **Days Cash on Hand:** This metric reflects the number of days of operating expenses that a company could pay with the cash it currently has available. It is calculated by dividing the amount of cash on hand by daily operating expenses. CPS's target for this metric is 150 days or greater.

- **Debt-to-Capitalization Ratio**: The debt-to-capitalization ratio reflects a company's debt as a percentage of its total capitalization. For a typical company, this is calculated by dividing total debt by the sum of total debt and shareholder equity. For CPS, the shareholder equity is replaced by financing with cash and Contributions in Aid of Construction. A higher debt-to-capitalization ratio implies a more highly leveraged company, which indicates a higher risk of bankruptcy. CPS sets a target debt-to-capitalization ratio of 60 percent or lower.

The debt-to-capitalization ratio appears to be the metric of greatest concern to CPS. It is the only key metric for which CPS has failed to meet its target in recent years. From fiscal years 2015 through 2019, CPS's debt-to-capitalization ratio ranged between 60 percent and 64 percent, consistently above its 60 percent target.[37] In addition, CPS has specifically identified impacts to the debt-to-capitalization ratio and related credit rating impacts as an issue of concern with respect to retiring the Spruce units. However, it is not clear that the retirement of the Spruce units would substantially impact this metric, nor is it clear that this metric is a concern for the major credit rating entities.

To our knowledge, CPS has not advanced a clear analysis as to whether retiring the Spruce units would harm its debt-to-capitalization ratio in a way that would impact its credit rating. Retiring a coal unit need not affect the percentage of new capital assets being funded with debt. The retirement of the Spruce units could be paired with major capital expenditures on replacement resources that would need to be funded primarily with debt. But retiring the Spruce units would also both reduce operating expenses and avoid major capital expenses, including the potential cost of an SCR. And the Spruce units could be replaced through a mix of PPAs and bilateral contracts that do not require major up-front expenditures.

CPS's debt-to-capitalization ratio concerns are most likely related to the fact that retiring the Spruce units would reduce its capital asset base without immediately affecting its debt burden. The magnitude of this effect would depend on the remaining book value of the Spruce units at the time of their retirement as well as the book value of the remainder of the CPS system. Any impact of near-term retirement on CPS's debt-to-capitalization ratio would likely be much greater for the relatively young

[36] These expenses typically amount to 14 percent of gross revenues and are projected to exceed $340 million in FY 2020 (CPS Budget Plan FY 2020).

[37] CPS FY 2019 Financial Performance Report. March 25, 2019. p. 6.

Spruce 2 than for the older Spruce 1. Thus, this consideration may weigh in favor of retiring Spruce 1 earlier than Spruce 2. However, if the Spruce units are uneconomic, a shift in the ratio of debt to capital assets resulting from their retirement would merely be a correction to reflect the true market value of CPS's generating fleet rather than a material change in the financial status of CPS. Also, it is worth noting that in FY 2019 CPS appears to have seen a slight *improvement* in its debt-to-capitalization ratio despite taking an impairment associated with the retirement of its J.T. Deely coal plant.[38]

Importantly, CPS's debt-to-capitalization ratio does not appear to be an issue of concern to the major credit rating entities. A recent Moody's assessment of CPS identified five factors that could lead to a credit rating downgrade but made no mention of a debt-to-capitalization ratio.[39] One issue that Moody's did flag was the concern that "lower energy prices caused by low natural gas prices and abundant wind energy" have made CPS's "coal fleet less competitive." This suggests that rating agencies are more concerned about the actual value provided by existing CPS coal units than they are about the ratio between CPS debt and total capitalization.

On its other two main financial metrics, CPS is over-performing relative to its targets and there is little reason to believe that the retirement of one or both Spruce units would change this. DSCR appears to be the metric of greatest interest to credit raters, as Moody's recently stated that an adjusted DSCR below 1.5 for a three-year period could result in a CPS credit downgrade.[40] Fortunately, CPS's adjusted DSCR has been greater than 1.7 in each of the past five years and reached a recent high water mark of 2.0 in 2019.[41] CPS's FY 2020 financial plan preview projected that this value would drop steadily over the next two years but still remain above 1.5.[42] And CPS's projections of this metric have been rather conservative in the past: CPS projected that its adjusted DSCR would drop from 1.76 to 1.64 in 2019.[43] Instead, it rose to 2.0.

More relevant to this analysis is whether retiring the Spruce units would result in a noticeably lower adjusted DSCR. For that to happen, retiring the Spruce units would have to lead to decreased net operating income, increased debt, or both. If the Spruce units are uneconomic relative to alternative resources, retiring them should increase net operating income. And while increased debt is a conceivable result of retiring the Spruce units, it is not a necessary one. If the Spruce units are replaced

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[38] Gold, G. 2019. CPS FY 2019 Financial Performance Report (Preliminary and Unaudited). March 25, 2019. p. 8.

[39] Moody's Investors Service. November 21, 2018. Rating Action: Moody's assigns Aa1 to San Antonio (CPS), Texas Electric and Gas Senior Lien Revenue Bonds and Aa2 to Subordinate Bonds; stable outlook. https://www.moodys.com/research/Moodys-assigns-Aa1-to-San-Antonio-CPS-Texas-Electric-and--PR_905608858.

[40] Moody's Investors Service. November 21, 2018. Rating Action: Moody's assigns Aa1 to San Antonio (CPS), Texas Electric and Gas Senior Lien Revenue Bonds and Aa2 to Subordinate Bonds; stable outlook. https://www.moodys.com/research/Moodys-assigns-Aa1-to-San-Antonio-CPS-Texas-Electric-and--PR_905608858.

[41] CPS FY 2019 Financial Performance Report. March 25, 2019. p. 6.

[42] CPS Financial Plan Preview: Fiscal Year 2020. January 28, 2019. p. 22.

[43] CPS Financial Plan Preview: Fiscal Year 2019. April 30, 2018.

in whole or in part with renewable PPAs, bilateral contracts, and/or market purchases, retiring them could reduce debt as compared to a scenario in which CPS continues to make capital investments in the Spruce plant.

CPS is also over-performing its cash-on-hand metric. The company has averaged more than 200 days of cash on hand over the past five years, including a recent high of 246 in 2019.[44] If the Spruce units are uneconomic, retiring them would likely improve this metric, as retirement would generally reduce operating expenses.

Fundamentally, if the Spruce units are uneconomic relative to alternative resource options and/or the market, the available evidence suggests that retiring them need not negatively impact CPS's credit rating or increase its borrowing costs. If CPS believes that there are sound financial reasons to continue operating the Spruce units even if they have negative market value, it should provide a clear case to support that belief and should evaluate options for mitigating such concerns.

7. CPS'S RESOURCE PLANNING PROCESS

CPS has not provided evidence that its decisions regarding its coal plants and other generation assets are based on robust analysis or a transparent planning process. Rigorous analysis and transparency are both critical to the development of sound long-term electric utility resource plans, including plans for coal unit retirements. Utilities should use rigorous modeling to identify low-cost, low-risk plans that are almost certain to be preferable to a plan grounded in inertia or heuristic comparisons. Transparent processes and stakeholder engagement allow affected residents to offer input regarding community priorities and provide an opportunity for outside experts to contribute useful technical and regulatory information.

Unfortunately, CPS has yet to demonstrate a rigorous and inclusive process as the basis for its planning. Although CPS recently developed a new Flexible Generation plan, that plan does not appear to be rooted in comprehensive analysis or stakeholder engagement.

CPS is an outlier in this regard. Throughout the country, most investor-owned utilities that operate power plants are required to undergo public, rigorous resource planning processes every two to three years. Many other large municipal electric utilities have also adopted sound resource planning practices. In 2017, the Los Angeles Department of Water and Power (LADWP)—the only municipal utility in the country that sells more electricity than CPS—released a 2017 long-term resource plan rooted in

[44] CPS FY 2019 Financial Performance Report. March 25, 2019. p. 6.

modeling of a variety of alternative scenarios and informed by stakeholder engagement.[45] Similarly, Austin Energy engages in a public resource planning process grounded in modeling and public input.[46]

Increasingly, utilities that own coal plants have used resource planning processes as opportunities to evaluate the economic case for retiring those plants in the near term. PacifiCorp, a large utility with operations in six western states, is evaluating the economics of 22 of its coal units as part of its ongoing 2019 IRP process.[47] Georgia Power Company's 2019 IRP included economic retirement assessments of each of its coal units.[48] The Northern Indiana Public Service Company's (NIPSCO) 2018 IRP evaluated alternative retirement dates for its five remaining coal units and found that retiring each of those units by 2023 would save NIPSCO ratepayers more than $4 billion.[49]

The NIPSCO IRP experience is particularly noteworthy because it involved the solicitation of generation resource options through an all-source request for proposals (RFP). The results of that RFP indicated the availability of plentiful, low-cost renewable resources with all-in costs lower than the forward-going costs of NIPSCO's existing coal units. Given the abundance of low-cost resource alternatives within Texas and the evolving costs of renewable and battery storage technologies, an all-source RFP would be a sound way for CPS to begin to determine its best options for replacing the Spruce units.

8. CONCLUSIONS

Our analysis indicates that the Spruce units are economically marginal resources that will only earn profits relative to the ERCOT market over the long term under a favorable array of commodity price, regulatory, and operational conditions. More importantly, we find that CPS would likely save its customers money and reduce its environmental impact by replacing the Spruce units with renewable and battery storage resources in the 2020s. In addition, we find that replacing the Spruce units with more economic resources would be unlikely to have negative repercussions for CPS's credit rating.

We note that this report is not intended to serve as a final word on the economic status of the Spruce units. Our analysis relies entirely on publicly available data rather than the more detailed unit-level data

[45] Los Angeles Department of Water & Power. December 2017. Power Strategic Long-Term Resource Plan. Available at https://www.ladwp.com/cs/idcplg?IdcService=GET_FILE&dDocName=OPLADWPCCB655007&RevisionSelectionMethod=LatestReleased

[46] Austin Energy. Electric Utility Commission Resource Planning Working Group. https://austinenergy.com/ae/about/reports-and-data-library/generation-resource-planning-update/euc-resource-planning-working-group

[47] PacifiCorp. 2019 IRP Public Input Meeting December 3-4, 2018.

[48] Georgia Power. January 31, 2019. 2019 Integrated Resource Plan. Technical Appendix Volume 2: Unit Retirement Study. Georgia Public Service Commission Docket No. 42310.

[49] Northern Indiana Public Service Company LLC. October 31, 2018. 2018 Integrated Resource Plan. Available at https://www.nipsco.com/about-us/integrated-resource-plan.

to which CPS has access. In addition, we rely on a simplistic generator dispatch tool rather than a full-scale electric-sector optimization model. However, this report highlights the need for CPS to conduct a thorough assessment of alternative retirement options for the Spruce units, using the most detailed data and models available to it.

CPS should conduct this modeling as part of a transparent resource planning process that is grounded in rigorous analysis and considers input from interested stakeholders. Such modeling should make use of the most up-to-date information regarding the costs of both Spruce units and possible replacement options. If CPS's analysis confirms that one or both of the Spruce units are uneconomic relative to alternative resource options, CPS should pursue options for the orderly, near-term retirement of those units.

Appendix A. Methodology and Assumptions

1. Historical Analysis Methods and Assumptions

We used publicly available data to evaluate Spruce 1 and 2 as merchant-equivalent generation. In doing so, we tested whether the units earn enough energy market revenues to offset fuel, operations and maintenance (O&M), and ongoing capital costs. Although CPS is not a merchant generator, it is in the best interest of the ratepayers for CPS to treat its generating units as separate from its load-serving operations. If CPS can procure energy from the ERCOT market more cheaply than it can provide energy through the continued operation of Spruce 1 and/or Spruce 2, then those units should be closed. The continued operation of units that are uneconomic relative to the ERCOT market is imprudent and incurs unnecessary expenses—expenses that are ultimately paid by the ratepayers in the CPS service territory.

Our retrospective analysis of the recent historical performance of the Spruce units included the estimation of Spruce 1 and 2's hourly energy revenues. We calculated historical hourly revenues using generation data reported by CPS to EPA's Air Markets Program Database[50] and day-ahead energy market settlement prices for the CPS load zone.[51] We calculated monthly fuel costs using EIA data on unit-specific fuel consumption and plant-specific delivered fuel prices.[52]

CPS does not publish unit-specific variable O&M, fixed O&M, or ongoing capital cost data. Therefore, we estimated those costs using generic assumptions from EIA's AEO.[53,54]

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[50] U.S. EPA. Air Markets Program Data. Available at: https://ampd.epa.gov/ampd/. EPA reports gross generation; that is, total generation produced by the generator, as opposed to net generation provided to the grid, which excludes internal plant electric consumption. Therefore, we used net generation as reported by U.S. EIA to calculate monthly net-to-gross factors for both units. We multiplied each unit's hourly gross generation by the relevant net-to-gross factor to determine hourly net generation for which CPS gets compensated through the ERCOT market. See Form EIA-923, available at: https://www.eia.gov/electricity/data/eia923/.

[51] ERCOT. Historical DAM Load Zone and Hut Prices. Available at: http://mis.ercot.com/misapp/GetReports.do?reportTypeId=13060&reportTitle=Historical%20DAM%20Load%20Zone%20and%20Hub%20Prices&showHTMLView=&mimicKey.

[52] U.S. EIA. Form EIA-923. Since delivered-coal prices were not available for Spruce, we used delivered-coal prices for the Deely coal plant, which is co-located with the Spruce plant. EIA data indicates that the Deely and Spruce plants both burn sub-bituminous coal imported from Wyoming. This evidence all suggests that the Deely and Spruce plants have historically shared a coal source and a delivered-coal price.

[53] U.S. EIA. February 2019. Assumptions to the Annual Energy Outlook 2019: Electricity Market Module, p. 14 (capital expenditures). Available at: https://www.eia.gov/outlooks/aeo/assumptions/pdf/electricity.pdf.

[54] U.S. EIA. September 2015. Assumptions to the Annual Energy Outlook 2015, p. 105 (O&M costs of new scrubbed coal plants). Available at: https://www.eia.gov/outlooks/aeo/assumptions/pdf/0554%282015%29.pdf. AEO 2015 was the last version of AEO that provided O&M cost assumptions for coal plants that do not included carbon capture and sequestration technology.

There are other potential of revenues and costs that we do not capture, but we would expect these cash flows to be negligible for the Spruce units. As an example, ERCOT runs an hourly market for ancillary services, through which units can earn incremental revenue.[55] However, most coal plants are unable or unwilling to depend heavily on the ancillary market, and past ERCOT market reports have assumed that coal plants do not earn any net ancillary revenues.[56] The Spruce units may also bear some additional cost, or at least an opportunity cost, associated with procuring emission permits through SO_2 and NO_x markets. Again, these costs are likely to be negligible for the Spruce units, as indicated by the low clearing prices of recent emission permit auctions.[57]

2. Forward-Going Modeling Assumptions

We used a custom-built cash flow model to evaluate the likely future economic performance of the Spruce units relative to the market from 2019 through 2040. This model treats all previously incurred capital expenses as irrelevant to the determination of whether to retire a unit or continue to operate it. Our forward-going cash flow model necessarily relied on several input assumptions. We describe these assumptions below.

Coal Prices and Fuel Costs

The Spruce plant was built to burn Powder River Basin coal.[58] Synapse relied upon EIA's AEO 2019 projection of Powder River Basin minemouth coal prices to forecast annual average delivered coal prices at the Spruce plant.[59] We assumed that Spruce delivered-coal prices would increase at the same rate as the minemouth prices.[60] Figure 13 shows the resulting delivered-coal price projection. Under this projection, coal prices increase at an average annual rate of 0.09 percent from 2019 through 2040.

[55] ERCOT. Zonal Energy and Ancillary Services Archives. Available at: http://www.ercot.com/mktinfo/services/.

[56] ERCOT. 2014 State of Market Report, p. 88. Available at: http://www.puc.texas.gov/industry/electric/reports/ERCOT_annual_reports/2014annualreport.pdf.

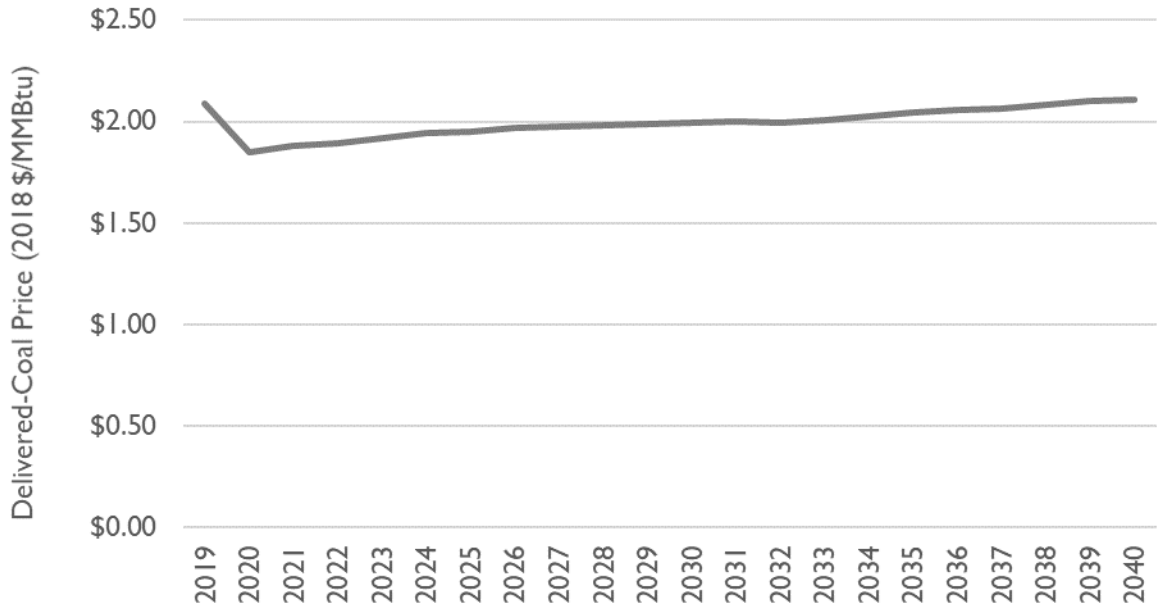
[57] U.S. EPA. SO_2 Allowance Auctions. Available at: https://www.epa.gov/airmarkets/so2-allowance-auctions#tab-2.

[58] Burns McDonnell. JK Spruce Unit 2. Available at: http://www.burnsmcd.com/projects/jk-spruce-unit-2.

[59] U.S. EIA. AEO 2019. Table 71. Coal Minemouth Prices by Region and Type. Available at: https://www.eia.gov/outlooks/aeo/supplement/excel/suptab_71.xlsx.

[60] Note that this implicitly assumes that coal transportation costs will increase at the same rate as the price of the coal commodity, a reasonable assumption given the modest, steady coal price growth projected by AEO.

Figure 13. Spruce delivered-coal price forecast



Sources: Form EIA-923, AEO 2019.

To arrive at dollar per MWh fuel costs, we multiplied the projected coal price by projected heat rates for each Spruce unit. We assumed that Spruce 1 and Spruce 2 would each maintain their 2018 net heat rate levels of 10.3 and 9.9 MMBtu per MWh, respectively.

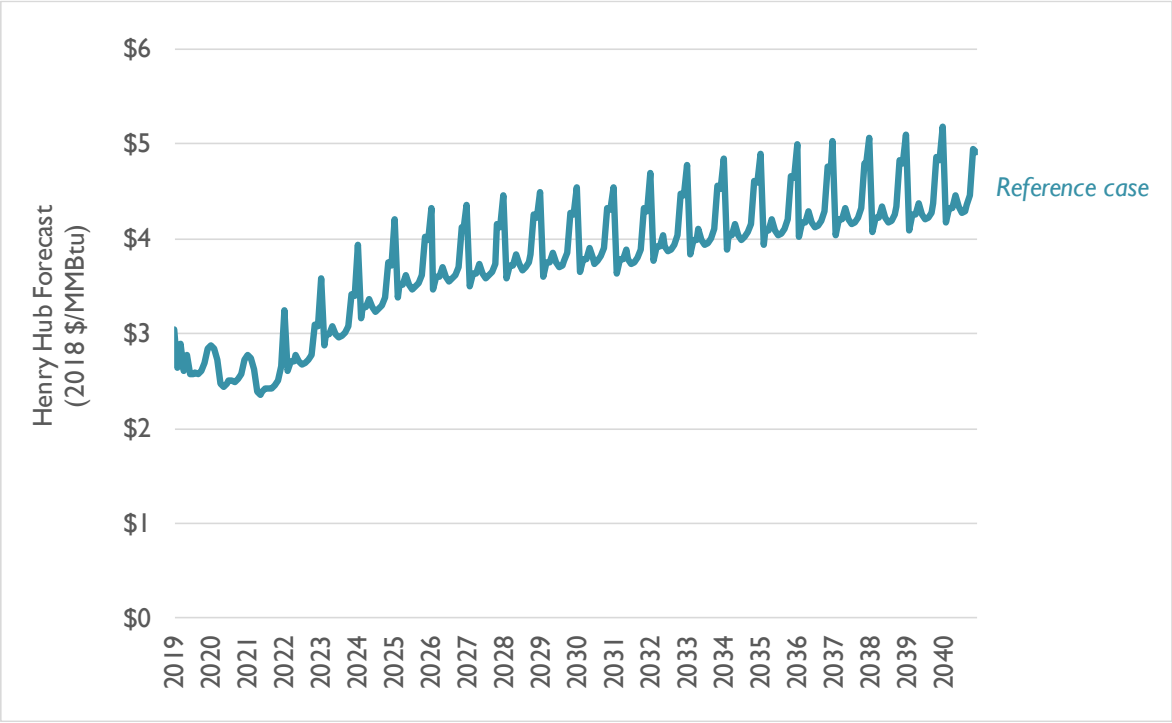
Natural Gas Prices

Synapse's analysis relied on multiple forecasts of monthly average Henry Hub natural gas prices. For each month between now and the end of 2021, we used current Henry Hub settlement prices in the NYMEX futures market.[61] After 2021, we increasingly relied on fundamentals-based, long-term forecasts. In our base projection, we used the AEO 2019 Reference case annual average Henry Hub forecast, adjusted to account for monthly fluctuations, to project gas prices from 2024 through 2040.[62] From 2022 through 2023, we used a blend of NYMEX futures and AEO 2019 projections. Figure 14 below shows our base Henry Hub forecast.

[61] NYMEX. Henry Hub Natural Gas Futures Settlements. Accessed May 29, 2019. Available at https://www.cmegroup.com/trading/energy/natural-gas/natural-gas_quotes_globex.html.

[62] EIA. AEO 2019. Table 13. Natural Gas Supply, Disposition, and Prices. Available at: https://www.eia.gov/outlooks/aeo/excel/aeotab_13.xlsx.

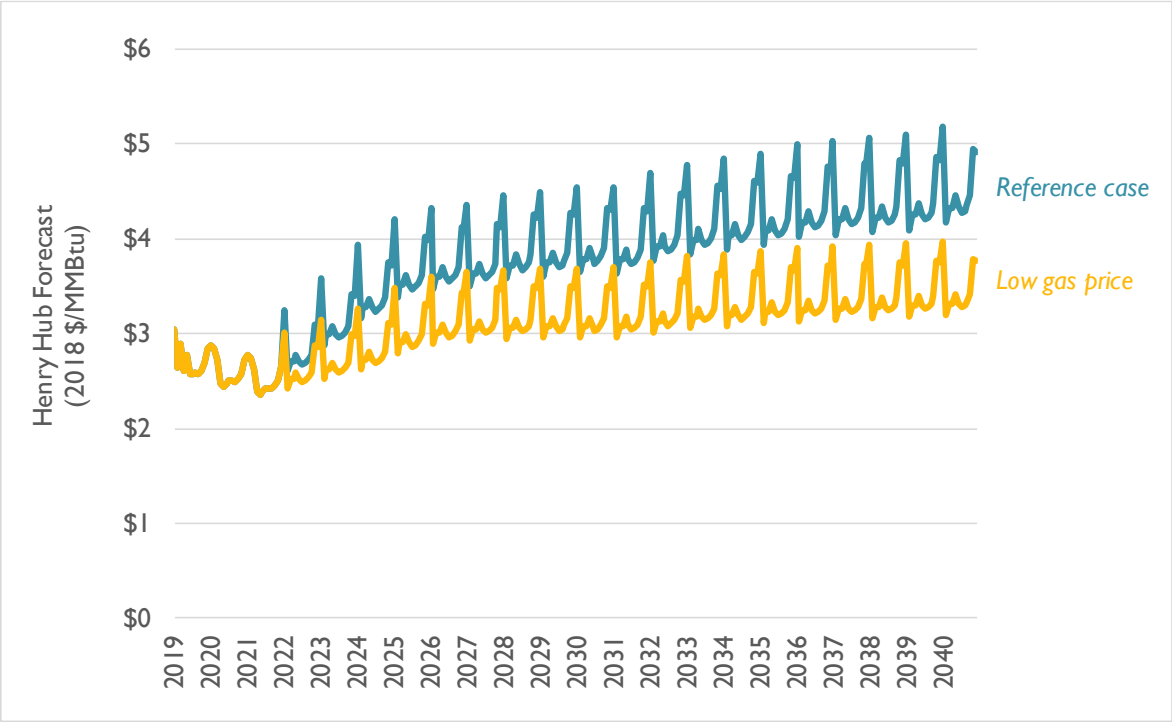
Figure 14. Henry Hub natural gas price base forecast



Sources: AEO 2019, NYMEX.

The most notable element of this forecast is the transition from low price projections in 2021 to higher projections in 2024. The shift is caused by EIA's assumption that Henry Hub prices will recover substantially in the middle of the decade. To account for the possibility that AEO may be projecting an unreasonably rapid increase in gas prices, we conducted a low gas price sensitivity using AEO's "High oil and gas resource and technology" price projection. Figure 15 below presents a comparison of our base case and low gas price projections.

Figure 15. Henry Hub natural gas price forecast comparison

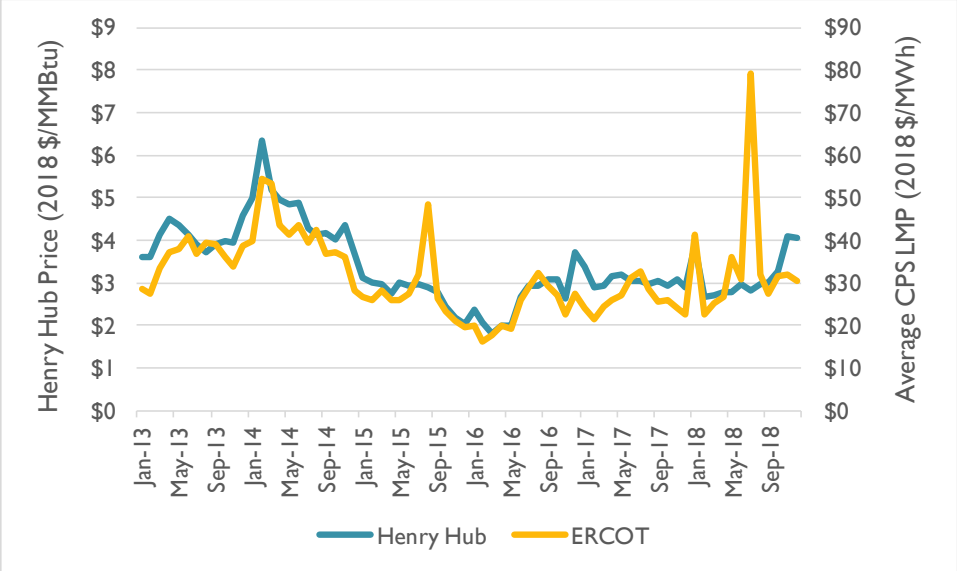


Sources: AEO 2019, NYMEX.

Market Energy Prices

Energy market prices at Spruce are strongly correlated with natural gas prices. This is demonstrated by Figure 16, which compares historical monthly Henry Hub prices with monthly average day-ahead energy prices for the CPS load zone. Since 2013, CPS load zone energy prices have moved very closely with Henry Hub prices in nearly all months, with only a few energy price spikes breaking the trend. Accordingly, we used forecasted monthly Henry Hub prices to projected future hourly energy prices faced by the Spruce plant.

Figure 16. Recent historical relationship between Henry Hub price and average CPS energy price



Our forecast of hourly Spruce energy prices relied on a regression analysis. The regression takes the following form: Energy Price ~ Henry Hub Price + Month + Henry Hub * Month. That is, the dependent variable is the energy price, and the independent variables are the Henry Hub price, the month, and the interaction term between the Henry Hub price and the month. We then used forecasted Henry Hub prices to project average monthly CPS energy prices for every month between now and 2040. Finally, we used historical data to scale the monthly projections to hourly projections.

Spruce Units Ongoing Capital and O&M Costs

We assumed variable and fixed O&M costs would remain constant in real terms over the lifetime of the Spruce plants, at the levels assumed by EIA for a "scrubbed" coal plant.[63] Ongoing capital costs are calculated using an equation provided in AEO 2019.[64]

[63] Assumptions to the Annual Energy Outlook 2015, p. 105.

[64] Assumptions to the Annual Energy Outlook 2019: Electricity Market Module, p. 14.

Renewable and Storage Capital and O&M Costs

In developing cost profiles for a Spruce replacement portfolio, we relied on solar and wind capital, fixed O&M, and variable O&M costs from NREL's 2018 Annual Technology Baseline.[65] We relied on levelized cost of storage values from Lazard's *Levelized Cost of Storage – Version 4.0*.[66]

SCR Costs

In evaluating the impact of an SCR investment on the economic viability of Spruce 1, we relied on SCR costs as estimated by EPA in regulatory modeling.[67] Those cost estimates, which include incremental O&M costs as well as capital costs, are reproduced in Table 2.

Table 2. SCR incremental cost estimates

Cost Type	Cost
Overnight Capital (2018 $/kW)	$299
Fixed O&M (2018 $/kW-year)	$0.78
Variable O&M (2018 $/kW-year)	$1.48

Source: U.S. Environmental Protection Agency.

Spruce Generation Patterns

For the purposes of this modeling exercise, we assumed that each Spruce unit will operate at full capacity in every future hour in which the CPS load zone energy price exceeds production costs and will stand idle in all hours in which its production costs exceed the local energy price. We defined production costs as the sum of fuel costs and variable O&M costs incurred by a unit. We calculated these costs as an annual average.

[65] Available at: https://atb.nrel.gov/. We used the mid-case Los Angeles assumptions for the solar costs and the mid-case TRG 6 assumptions for the land-based wind costs.

[66] Available at: https://www.lazard.com/media/450774/lazards-levelized-cost-of-storage-version-40-vfinal.pdf. We use the utility-scale (PV + Storage) assumptions for storage costs and deescalate the capital portion of levelized cost of storage using a -8 percent compound annual growth rate.

[67] U.S. EPA. November 2013. Documentation for EPA Base Case v.5.13 Using the Integrated Planning Model, pp. 5-7. Available at: https://www.epa.gov/sites/production/files/2015-07/documents/documentation_for_epa_base_case_v.5.13_using_the_integrated_planning_model.pdf.