SEPTEMBER 2018

Review of Platte River Power Authority's Zero Net Carbon Energy Study

September 2018

ENERGY VENTURES ANALYSIS

Prepared by:

ENERGY VENTURES ANALYSIS

1901 N. Moore Street
Suite 1200
Arlington, VA 22209-1706

703-276-8900
www.evainc.com

Executive Summary

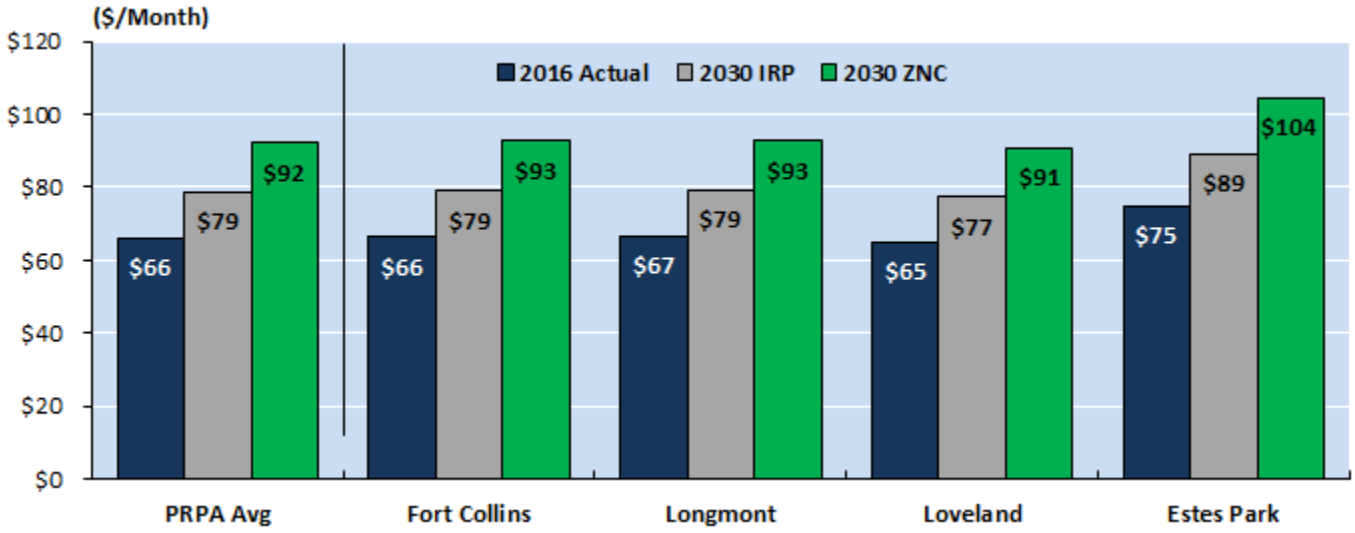
In July 2017, Platte River Power Authority (PRPA) - a political subdivision of the State of Colorado which provides electric power service to the Fort Collins, Loveland, Longmont and Estes Park municipalities - agreed to model a zero net carbon emission ("ZNC") electric generating resource scenario of its entire system. Platte River engaged Pace Global to analyze the system cost to convert to a portfolio that will yield ZNC for its generating system by 2030.

Energy Ventures Analysis ("EVA") evaluated the underlying modeling and data assumptions of the Zero Net Carbon Portfolio Analysis (ZNC study) and its financial impact on PRPA electric customers. EVA's review of the ZNC study resulted in the following key findings.

- **Zero Net Carbon is *not* Zero Carbon emissions.** The portfolio modeled in the ZNC study is based on a new gas-fired power plant prematurely replacing PRPA's coal-fired Rawhide plant in 2030, plus new renewable plants. The ZNC goal is met by assuming that PRPA will market the excess renewable power to displace fossil-fuel power generated by other utilities.
- **The ZNC study requires PRPA to overbuild renewable resources without a guarantee it will achieve "zero net carbon."** The ZNC accounting method utilized in the ZNC study is highly dependent on PRPA adding a significant amount of renewable resources (almost double its current generating capacity by 2030 and much more than would be needed to meet its load), while there is no guarantee that there will be a market for the excess amount of renewable energy that is needed to achieve "zero net carbon" nor that it will necessarily offset carbon-generating energy sources in those sales. PRPA customers would pay for this excess amount of electric generating capacity that is not needed for local demand.
- **The ZNC study underestimates the cost of the ZNC portfolio to PRPA customers by relying on outdated data.** The ZNC study uses an outdated CO_2 emission rate to estimate the CO_2 emission displacement from its surplus renewable energy sales. By utilizing an emission rate that is too high, the study underestimates the renewable power additions and capital costs needed to achieve "zero net carbon."
- **Under the ZNC portfolio, PRPA residential customers' electric bills will increase by 39% over 2016 actual rates versus a 19% rate increase under the IRP plan.** Although likely underestimated, the ZNC portfolio's cost is $51 million higher than the IRP portfolio cost in 2030, which translates into a 17% increase in electric bills for PRPA residential customers.
- **Replacing PRPA's existing coal plants with new natural gas generation will not reduce lifecycle GHG emissions.** Adding a new gas-fired combined cycle plant to PRPA's generation fleet will result in slightly ***higher*** lifecycle greenhouse gas emission than operating Rawhide until the end of its useful life.
- **If PRPA pursued the ZNC option in the Pace Global study, it would replace one of the most dependable, reliable and lowest-cost resources in the country with a less reliable and higher-cost option.** Rawhide Unit #1 is the lowest cost resource on the PRPA system and is one of the lowest-cost resources in Colorado and the entire United States, while also providing extraordinary generation reliability. By replacing Rawhide with a new gas-fired plant before the end of its useful life, PRPA would be sacrificing reliability and cost predictability to achieve a "zero net carbon" goal that is not guaranteed and probably won't be achieved.
- **100% renewable electricity supply for PRPA is not achievable, would jeopardize reliability, and would increase costs.** While many cities say they have a long-term goal of 100% renewable power supply, only a few small cities use 100% renewables, and they mostly rely on purchased power from other suppliers.

Many cities say they have 100% renewable goals, but like Denver, CO are supplied by utilities which do not promise anything close to 100% renewables, because of reliability concerns. Moving toward 100% renewables will require massive overbuilding of power capacity at a large increase in retail power costs.

EXHIBIT ES-1: AVERAGE MONTHLY RESIDENTIAL ELECTRIC BILL FOR PRPA RESIDENTIAL CUSTOMERS[1]

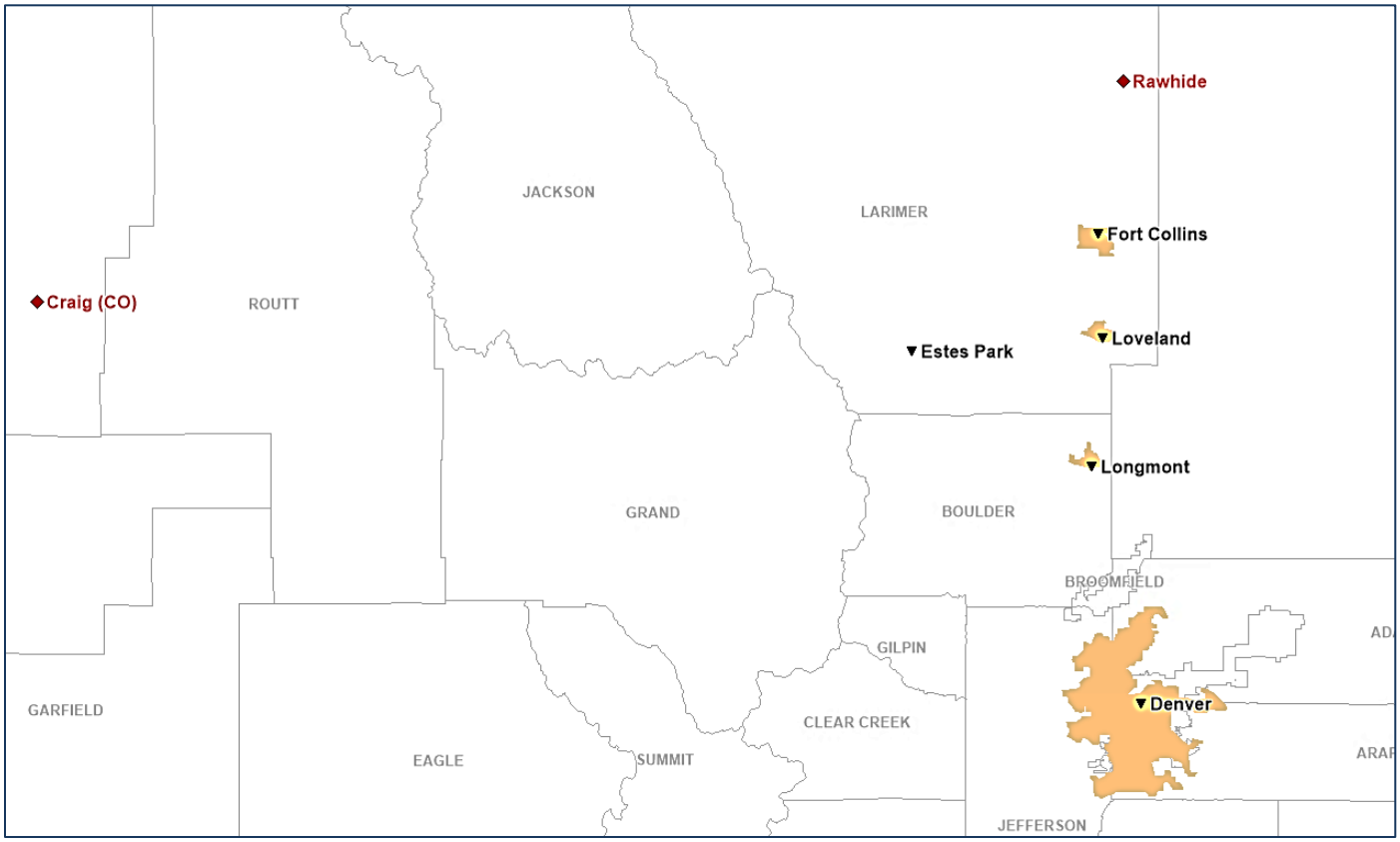


[1] 2016 actual data from EIA Form 861; 2030 IRP rates calculated from production cost forecast in IRP; ZNC rates calculated from Pace Global study of cost increases to achieve zero net carbon emissions.

Introduction

Platte River Power Authority (PRPA) is a political subdivision of the State of Colorado, providing electric power service to its four-member municipalities – Fort Collins, Loveland, Longmont, and Estes Park.

EXHIBIT 1: PRPA AND ITS FOUR MUNICIPAL CUSTOMERS



PRPA was formed in 1973 as part of Colorado House Bill 1666 as a political subdivision to provide electricity to the load-serving utilities of Fort Collins, Loveland, Longmont, and Estes Park. In 2017, PRPA sold 3,188 million kWh to its municipal customers, while selling 1,000 million kWh in the wholesale electric market.[2] Fort Collins accounts for almost half of PRPA's municipal electricity sales, while Longmont, Loveland, and Estes Park account for 25%, 23%, and 4%, respectively.

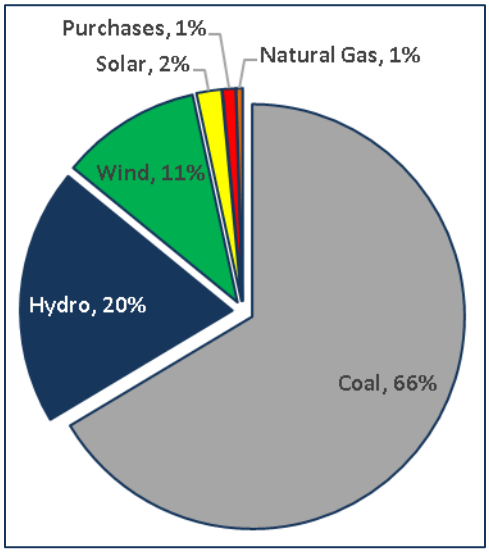
EXHIBIT 2: PRPA MUNICIPAL ELECTRICITY SALES BY CUSTOMER (MILLION KWH)

	2014	2015	2016	2017
Fort Collins	47%	47%	48%	48%
Longmont	25%	25%	25%	25%
Loveland	24%	24%	23%	23%
Estes Park	4%	4%	4%	4%
Total Municipal Sales	**3,154**	**3,201**	**3,216**	**3,189**

[2] PRPA 2017 Annual Report; https://www.prpa.org/annual-report-2017/PRPA_Annual-Report-2017.pdf

Through 2017, PRPA's power generation portfolio has grown to about 1,000 MW and includes coal, natural gas, water, wind, hydro, and solar resources. In 2017, one-third of PRPA's electricity generation came from renewable energy resources, while the remaining two-thirds came from low-cost coal generating resources.

EXHIBIT 3: PRPA 2017 GENERATION MIX



In July 2017, the Platte River Board of Directors agreed to model a zero net carbon (ZNC) electric generating resource scenario for all four communities and communicate the results of the study to stakeholders and the public. Platte River engaged Pace Global to analyze the system cost to convert to a portfolio that will yield ZNC for its generating system by 2030[3]. This report is a review of the Pace Global ZNC Study and the high-level economic impacts on PRPA customers.

The Fallacy of "Zero Net Carbon"

The objective of PRPA's ZNC Analysis was to assess the economic feasibility of Platte River transitioning to a generation portfolio that achieves zero net carbon dioxide emissions starting in 2030 by offsetting CO_2 emissions generated by its own generation fleet and market purchases with surplus renewable energy sales to neighboring utilities. It is important to note that "zero net carbon" is not "zero carbon"; under this scenario, PRPA would build a new gas-fired plant to replace its coal-fired Rawhide plant, which would reduce CO_2 emissions in 2030 but not eliminate them. The plan achieves zero "net" carbon emissions by constructing renewable power plants far in excess of PRPA's needs, selling the excess power to other utilities in the area, and taking "credit" for reducing the CO_2 emissions from these other power companies to offset PRPA's own emissions.

The ZNC study assumed that PRPA would sell any excess power from its renewable energy resources that are not needed to meet the electric load of its member municipalities into the regional wholesale power market and displace non-baseload fossil-fuel generation at the marginal emission rate of 1,803 lbs/MWh. Similarly, PRPA's future market purchases were assumed to have an emissions rate of 1,803 lbs/MWh. Therefore, to calculate the net CO_2 emissions for the PRPA system, the ZNC study calculated the emissions from PRPA's generation fleet, added the emissions from market purchases, and subtracted the displaced emissions from its

[3] PRPA ZNC Report; https://www.prpa.org/znc/znc-report/

excess renewable energy sales. The ZNC study utilized an old 2014 estimate of 1,803 lbs/MWh for the regional emission rate, derived by the U.S. Environmental Protection Agency (EPA) as part of its eGRID database.[4]

This method has several shortcomings. First, to achieve net zero carbon using this accounting method, PRPA needs to generate a significant amount of generation well above its own electric needs. The ZNC portfolio assumes that PRPA needs to sell almost 15% of its net generation into the wholesale energy market to offset its CO_2 emissions. To achieve the amount of excess carbon-free electric generation, PRPA will be required to almost double its current generating capacity of 1,020 MW to 1,805 MW by 2030. As the ZNC portfolio retires all PRPA's coal generating facilities, it will need to add more than 1,200 MW to its current portfolio. Accounting for the capacity credit of wind and solar, this excess amount of generating capacity would result in a reserve margin - the amount of available capacity of the expected system load at peak demand times - of 47% in 2030, compared to 22% in the 2030 IRP portfolio. PRPA customers would have to pay for this excess amount of electric generating capacity that is not needed for local demand.

Second, the ZNC study assumes that PRPA will continue to be able to sell significant amounts of its excess electricity to neighboring utilities. One of the largest buyers of PRPA's excess electricity is Xcel Energy's Public Service Company of Colorado ("Xcel"). However, as part of its recently approved "Colorado Energy Plan," Xcel aims to add up to 2,400 MW of wind, solar, and energy storage to its system[5], increasing the amount of renewable energy in its energy mix to 55%, while minimizing the amount of energy imports into Xcel's system.

Finally, because Xcel and other Colorado utilities are planning to add renewable energy resources to their mix over the next decade, Pace's assumption that all of PRPA's surplus energy sales are replacing marginal fossil fuel generation at an emission rate of 1,803 lbs/MWh is unreasonable. Since renewable energy generation is highly variable (during each day as well as seasonally) and relatively consistent among Colorado resources (wind and solar generation increase and decrease at the same time), it is more likely that PRPA's surplus renewable energy sales will displace other renewable energy if PRPA finds buyers for it at all. As more renewable resources are added to the Colorado energy system, the number of times when renewable energy will have to be curtailed, as its generation exceeds electric demand at the time, will increase. For example, each year, California, as it adds more renewable generation to its system, has to curtail higher and higher amounts of renewable energy generation as its demand for electricity is lower than supply.[6] Therefore, assuming that PRPA surplus renewable generation is only offsetting fossil fuel generation for the entire forecast period is overestimating the CO_2 offset potential of the ZNC portfolio and underestimating its cost.

Carbon Dioxide Emissions in Colorado are Declining; not Static

To estimate the amount of CO_2 emissions displaced by surplus renewable energy generation sold by PRPA into the wholesale market, Pace Global used the CO_2 emission rate for WECC Rockies (RMPA) for non-baseload fossil generation from EPA's 2014 Emissions & Generation Resource Integrated Database (eGRID)[7]. eGRID is a comprehensive source of data on the environmental characteristics of almost all electric power generated in the United States. In addition to emission rates for all plants, eGRID also reports emission rates for non-baseload

[4] EPA eGRID Database; https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid
[5] Xcel Colorado Clean Energy Plan; https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Resource%20Plans/CO-Energy-Plan-Fact-Sheet.pdf
[6] CAISO Curtailment Facts; https://www.caiso.com/documents/curtailmentfastfacts.pdf
[7] EPA 2014 eGRID Summary Tables; https://www.epa.gov/energy/egrid-2014-summary-tables

power plants. Although the non-baseload emission rates are sometimes used as an estimate to determine the emissions that could be avoided through projects that displace marginal fossil fuel generation, assuming the non-baseload emission rate to be static between 2014 and 2050 is unrealistic.

Since the release of the ZNC study, EPA released the results of the 2016 eGRID[8]. In just two years, the non-baseload emission rate for RMPA dropped by more than 6%, from 1,803 lbs/MWh to 1,688 lbs/MWh. The main reason for the decline was the retirement of additional coal units in the region. As shown in Exhibit 4, almost 2 GW of additional coal retirements has been announced in Colorado alone over the next seven years, rendering the 1,803 lbs/MWh emission rate assumption obsolete.

EXHIBIT 4: ANNOUNCED COAL UNIT RETIREMENTS IN COLORADO

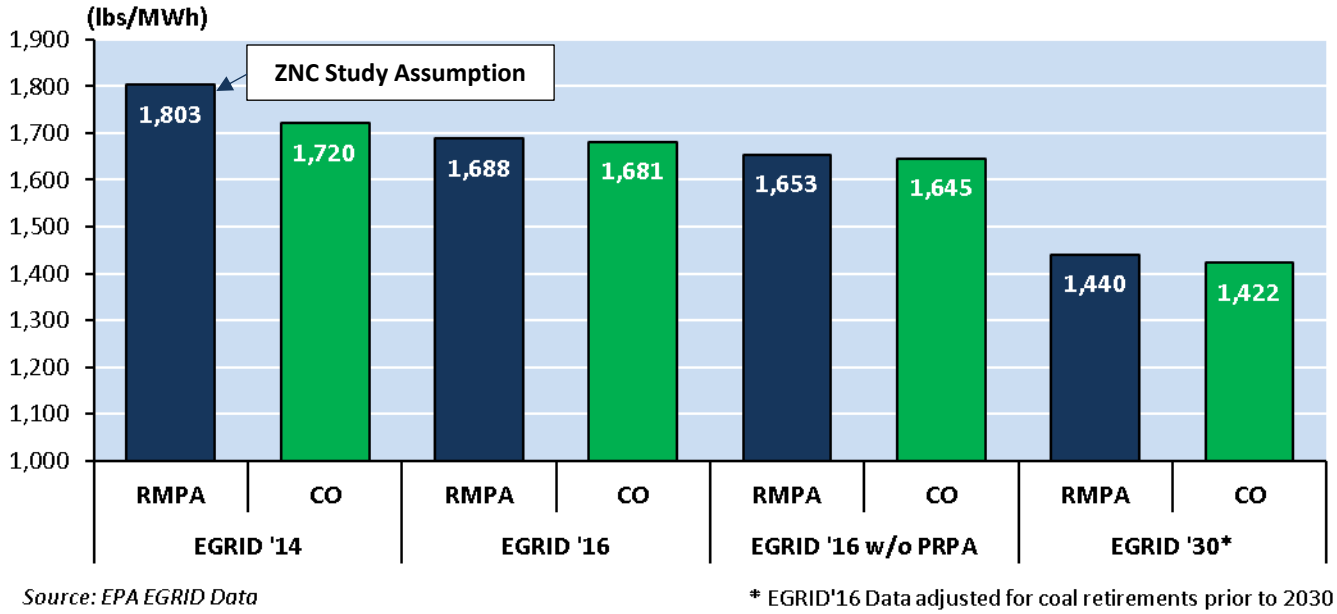
Plant	Unit(s)	Capacity (MW)	2016 Capacity Factor	Retire Year
Cherokee	4	380.8	58.7%	2017
Valmont	5	191.7	60.1%	2017
CO ENCo	1-4	35.4	64.5%	2017
Nucla	1-4	113.8	23.0%	2022
Comanche	1	382.5	63.8%	2022
Comanche	2	396.0	52.9%	2025
Craig	1	446.4	63.2%	2025
Total		**1,946.6**		

The 2014 eGRID emission rate used by Pace in the ZNC study also includes PRPA's Rawhide Energy station. Since PRPA's surplus renewable generation is not going to displace its own generation at Rawhide, the emission rate should have been adjusted to exclude Rawhide altogether. Excluding Rawhide from the 2016 eGRID, the non-baseload emission rate for the RMPA region drops further to 1,653 lbs/MWh, or more than 8% below the 2014 eGRID emission rate used in ZNC study.

As shown in Exhibit 4, more than 2 GW of coal-fired generating capacity is announced to retire between 2017 and 2030. Adjusting the 2016 eGRID data to exclude the units announced for retirement before 2030, the non-baseload emission rate for the RMPA region drops to 1,440 lbs/MWh, very close to the lower limit of 1,434 lbs/MWh Pace presented in the ZNC study, for which the presented ZNC portfolio is represented to be the lowest-cost solution. However, the 1,440 lbs/MWh adjusted emission rate is very likely too high. It is safe to assume not all the generation from the 2 GW of retiring coal-fired power plants will be replaced solely with non-CO_2 emitting resources. Any increase in natural gas-fired generation as a result of these coal retirements will result in a further reduction in the non-baseload emission rate. It is unlikely that PRPA's surplus renewable energy generation will replace exclusively marginal fossil fuel generation, but also some renewable generation in certain situations. According to the ZNC study, "New Renewables Cost" already accounts for 48% of the annual cost estimate of the ZNC portfolio in 2030. Any emission rate below the lower limit of 1,434 lbs/MWh will require additional renewable energy generating resources and further increase the capital expenditures under the ZNC portfolio.

[8] EPA 2016 eGRID Database; https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

EXHIBIT 5: NON-BASELOAD EMISSION RATE ESTIMATES USING EPA EGRID METHODOLOGY



As part of the ZNC study, Pace assumed a "carbon price trajectory that reflects a carbon regulatory future post-2024".[9] The CO_2 emission price, which was applied to all fossil fuel units, starts at approximately $4/ton in 2024 and increases to approximately $18/ton by 2050. Although the CO_2 price trajectory is relatively modest and well below the global social cost of carbon used under the previous federal Administration, it is highly speculative. Since the EPA recently proposed the Affordable Clean Energy (ACE) Rule,[10] which requires states to establish unit-specific emission rates for fossil steam electric generating units, it is unlikely a federal CO_2 regulation will be put in place before 2030 that would equal the assumed CO_2 price of the ZNC study. It is unusual in the integrated resource planning process to predict regulatory changes that go above and beyond federal regulations currently in place or in the rulemaking process. Excluding the proxy CO_2 emission price from the financial analysis would widen the gap between the already costlier ZNC portfolio and the 2016 IRP portfolio by an additional $16 million per year, or 8%.

Financial Impact of the ZNC Portfolio on PRPA Retail Customers

Platte River Power Authority provides electricity to four load-serving municipal utilities. As shown on Exhibit 14, the 2016 average electric retail rate for Fort Collins, Longmont and Loveland was among the lowest for any utility in the state of Colorado. The average monthly bill for residential customers was $67 per month, well below the rate charged by Xcel Colorado.

[9] Pace ZNC Study, page 5.

[10] EPA Affordable Clean Energy Rule; https://www.epa.gov/stationary-sources-air-pollution/proposal-affordable-clean-energy-ace-rule

EXHIBIT 6: 2016 RETAIL ELECTRIC RATES FOR PRPA'S MUNICIPAL CUSTOMERS (¢/KWH)[11]

	Residential	Commercial	Industrial	Total
Fort Collins	$ 10.10	$ 7.76	$ 6.51	$ 8.32
Longmont	$ 9.29	$ 9.27	$ 6.54	$ 8.18
Loveland	$ 9.73	$ 9.86	$ 6.95	$ 8.31
Estes Park	$ 12.32	$ 8.23	n/a	$ 11.03
PSCo	*$ 11.47*	*$ 9.20*	*$ 6.51*	*$ 9.34*

According to PRPA's public financials, 2016 electric production cost was $108.5 million.[12] As highlighted in the ZNC study, the net annual production cost for the 2016 IRP portfolio will increase to $174.8 million in 2030, while the 2030 annual production cost under the ZNC portfolio almost doubles over 2016 to $209.6 million, as shown in Exhibit 7.

EXHIBIT 7: NET PRODUCTION COST COMPARISON BETWEEN 2016 ACTUALS AND 2030 PORTFOLIOS[13]

	2016 Actuals	2030 IRP	2030 ZNC
Fuel Cost	$ 46,360	$ 38,918	$ 38,644
O&M Cost	$ 44,632	$ 40,838	$ 10,765
Emission Cost	$ -	$ 19,568	$ 3,512
Existing Renewables Cost	$ 29,404	$ 37,882	$ 37,882
New Thermal Cost	$ -	$ 7,062	$ 30,116
New Renewables Cost	$ -	$ 8,135	$ 99,967
Market Purchases	$ 3,867	$ 29,380	$ 3,191
Market Sales	$ (15,769)	$ (6,994)	$ (14,471)
Total Net Cost	$ 108,494	$ 174,789	$ 209,606
Difference to 2016	*$ -*	*$ 66,295*	*$ 101,112*

In 2030, a ZNC portfolio would cost PRPA customers $51 million more per year, 20% more than the portfolio presented in PRPA's 2016 IRP. The increased cost will be directly passed through to PRPA's retail customers; assuming all other expenses remain at 2016 levels, the difference between the two portfolios would result in an increase of approximately $164 per year for the average PRPA residential customer, or 17% higher than in the IRP portfolio. PRPA residential customers' electric bills would increase over 2016 actual rates by 39% versus 19% in the IRP plan. A 100% renewable portfolio would be substantially more expensive.[14]

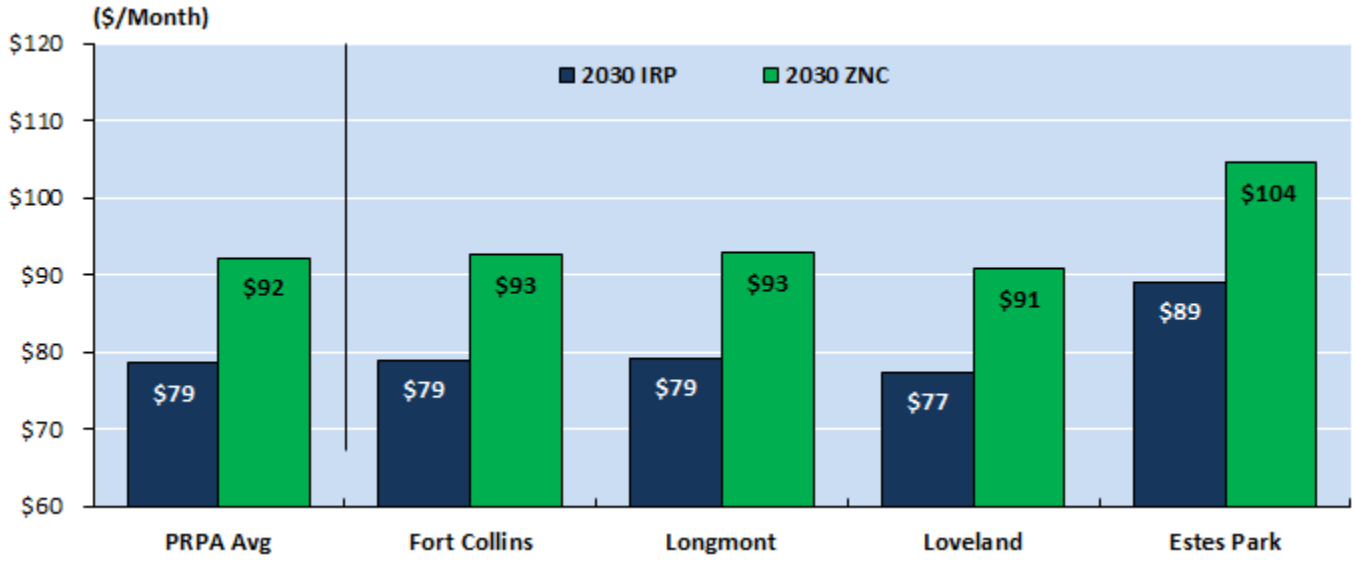
[11] EIA Form 861 data for 2016.

[12] PRPA 2018 Budget Report; https://www.prpa.org/wp-content/uploads/2017/12/PlatteRiver2018AnnualBudgetwebversion.pdf

[13] The 2030 projected production costs are from the Pace ZNC study, Exhibit 14; 2016 actual costs are from the PRPA budget.

[14] The total retail rates are based upon actual 2016 residential rates for Fort Collins plus the cost increase for power generation projected in the ZNC study for the 2030 IRP and ZNC cases.

EXHIBIT 8: AVERAGE MONTHLY RESIDENTIAL ELECTRIC BILL FOR PRPA RESIDENTIAL CUSTOMERS



For reasons described in the previous chapter, the cost of the ZNC portfolio is underestimated, as it assumes that other utilities will purchase the excess renewable power from PRPA rather than increase their own renewable energy portfolios.

Proposals for 100% Renewable Energy Supply from PRPA

The City of Fort Collins is considering a resolution to achieve 100% renewable electricity supply from PRPA by the year 2030. This approach is being promoted by the Sierra Club and the Northern Colorado Partners for Clean Energy, who submitted comments on the Pace ZNC study through a contractor, Energy Strategies. However, there are no specific proposals to develop the resources needed to achieve this goal, nor are there any studies of the impact on the cost and reliability of electric power for PRPA's members.

The primary options for renewable electricity supply are hydroelectric power, wind and solar. Hydro power has long been used as a major source of power in the United States, but there are no major developments planned because most of the available sites have been developed and remaining potential sites have encountered significant environmental opposition. The growing sources of renewable electricity generation are wind and solar power. The recent growth has been fueled in large part by massive federal subsidies through the 30% Investment Tax Credit and the federal Production Tax Credit (currently $24 per megawatt-hour), which are scheduled to be phased out by 2023.

There are major concerns which surround attempting to move to actual 100% renewable energy supply – reliability and cost. The generation of electricity from wind and solar sources is variable and not reliable; they only supply power when the wind blows or the sun shines. Utilities have traditionally used fossil-fuel power plants (coal and natural gas) to provide reliable power. These plants can be controlled by the utility to increase generation and decrease generation as needed to follow the varying demand for power. The flexibility of the fossil power fleet has made it possible for utilities to add renewable power sources and maintain reliability of power supply. Without fossil generation, the only other option is the development of electricity storage to bank excess power when demand is low and release it when demand is high. While pumped storage hydro has filled this role in some areas, no new pumped storage projects are under development (again, due to environmental

opposition). The new storage option under development is battery storage. This is a new technology which shows promise but has very limited commercial availability at the present time. Consequently, for the foreseeable future, battery storage is not an affordable, reliable, realistic option on the scale needed to power a community, or in this case, four communities.

Cost is also a concern with a shift to 100% renewable strategy. There has been little-to-no growth in demand for electricity for the last decade. As a result, new power plants are not needed to meet demand growth. The construction of new renewable plants to replace existing fossil plants (like Rawhide) will drive up retail power prices, as shown in the Pace ZNC study. To achieve a 100% renewable strategy, PRPA could not build a new gas-fired plant to replace Rawhide as assumed in the ZNC study but would have to rely on a massive over-build of excess renewables and/or unproven battery storage technology. In either case, PRPA would be incurring large costs to build new capacity to replace the Rawhide plant. These costs will be much higher than current market estimates if the federal subsidies are phased out as scheduled under current law.

While there have been many cities which have made "commitments" to 100% renewable energy recently, most of these are merely aspirational goals, with no plans to actually generate 100% of their power from renewable sources. The Sierra Club recently released a report called "Ready for 100% - 2018 Case Study" in which it produced a list of "more than 80 cities" which had made commitments to "repower their communities with 100% clean, renewable energy sources like wind and solar."[15]

The 10 "case studies" presented in this report included the city of Denver, CO. Denver does not generate any electricity; it is served by Xcel's Public Service of Colorado. As stated in the Sierra Club report, Xcel will not be supplying Denver with 100% renewable power, rather "Xcel plans for 55% of the energy they generate in Colorado to come from renewable sources."[16] Actually, Xcel's "Colorado Energy Plan" looks like the PRPA ZNC study:

- Prematurely retire 2 existing coal units by 2025 at Comanche – totaling 670 MW
- Spend $2.5 billion to construct new renewable power generation
    - 1,100 MW of wind
    - 700 MW of large-scale solar
    - 275 MW of large-scale battery storage
- In addition, "add 380 MW of natural gas generation to provide reliability support to the expanded renewables"[17]

Under this plan, Xcel will build 2,455 MW of renewables and natural gas (for reliability) generation to replace 670 MW of coal generation despite no increased demand for electricity. Xcel did not disclose how large the rate increase will be for their customers. Thus, Denver is hardly a "case study" for 100% renewable energy supply – it is an example of increasing renewables from 28% to 53% of electricity at a very large cost increase.

Of the cities listed as having made a commitment to 100% renewables in the Sierra Club "Ready for 100" report, many of them are in California. The cities in Colorado include: Aspen, Boulder, Pueblo, Nederland, Breckenridge, Lafayette, Longmont, and Denver. Only 7 of the cities listed in the Sierra Club's 'Ready for 100'

[15] Sierra Club https://www.sierraclub.org/sites/www.sierraclub.org/files/blog/1846%20RF100-CaseStudies2018_Report_06_web.pdf
[16] Id at 10.
[17] Xcel Energy, https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Resource%20Plans/CO-Energy-Plan-Fact-Sheet.pdf

report are represented to have achieved a 100% renewable standard; most of the rest have set aspirational goals for 2030, as Denver did.

One of the few cities which the Sierra Club asserts has achieved a 100% renewable energy supply is Aspen, CO. Aspen has a very small municipal utility which only serves half of the town's residents. As shown on Exhibit 14, the City of Aspen utility serves only 3,022 customers, less than 10% of Longmont and Loveland and less than 5% of Fort Collins. Aspen was able to take advantage of the fact that it had already built 2 hydroelectric plants in the 1980's so it was most of the way toward 100% renewable power already, but "Getting the last 25 percent was a huge challenge for us" according to Aspen Mayor Steve Skadron.[18] Aspen attempted to construct another hydropower plant and spent over $7 million before it canceled the project (about $2,300 per customer). Eventually, Aspen simply entered into power purchase agreements with other parties. The other half of Aspen gets its power from Holy Cross Energy, which has just 30% renewable power, similar to the average for Colorado.[19]

The 100% renewable energy goal has come at a high cost for the customers of the City of Aspen utility. Exhibit 14 shows the 2016 average cost of retail power sales for all the utilities in Colorado. Customers of the City of Aspen pay an average rate of 12.14 cents per kWh, 46% higher than the retail customers in Fort Collins and 22% higher than the customers of Holy Cross Electric, serving the other half of Aspen. Comparing just residential power rates, the City of Aspen is 32% more expensive than Fort Collins and 23% more than Holy Cross.

Lifecycle GHG Emission Impact of the ZNC Portfolio

The ZNC portfolio, as shown in the ZNC study results, requires the premature retirement of both PRPA's Rawhide and Craig coal-fired power plants and replaces them with a 286 MW natural gas-fired combined cycle plant in 2030. By replacing existing fossil fuel with new fossil fuel, PRPA would be committing itself to another CO_2 emitting resource for the long-term. The proper comparison of lifecycle greenhouse gas ("GHG") emission impacts is to compare the emissions from a new gas-fired plant over its expected 40-year life with the emissions from the existing Rawhide plant through the end of its useful life in 2047, followed by new renewable power with battery storage.

To estimate the true lifecycle GHG emission impact of the two scenarios, EVA is using its proprietary GHG Lifecycle Model (LCM). The LCM estimates the lifecycle GHG emissions from electric power generation using natural gas, coal, and wind power plus storage generation. The LCM includes GHG emission estimates for the extraction, transportation, combustion, and maintenance components of the electric power generation using the various fuels. The fuel extraction and transportation processes are mainly based on the U.S. National Energy Technology Laboratory's (NETL) 2014 Upstream Dashboard v2.8[20]. In the power generation section, the LCM estimates the GHG emissions from natural gas, coal, and wind power generating facilities emitted during the

[18] See http://www.cpr.org/news/story/aspen-charts-a-100-percent-renewable-course-can-other-cities-match-that

[19] On September 19, 2018 the board of Holy Cross Energy announced its goal of "70 by 30," a shift from 39% renewables today (mostly WAPA hydro) to 70% by 2030 through power purchases of wind and solar using PSCo transmission from eastern CO. Holy Cross owns 8% of Comanche unit #3 coal, which PSCo does not have firm plans to retire. This coal provides 50% of current power supply.

[20] https://netl.doe.gov/File%20Library/Research/Energy%20Analysis/Life%20Cycle%20Analysis/UpStreamDashboard_v2.8.xlsm

fuel consumption and operation of the plant using CO_2 equivalent emission factors from the EIA[21] and NETL's 2012 Wind Technology Assessment[22].

EXHIBIT 9: GHG LIFECYCLE EMISSION COMPARISON BETWEEN COAL + RENEWABLES AND NEW GAS CCGT

Category	Units	Coal	Wind + Storage	CCGT
Generation	*GWh*	2,000	2,000	2,000
Heat Rate	*MMBtu/MWh*	10.10		7.00
Fuel Region		PRB		Permian
Coal Heat Content	*lbs/Btu*	8,800		-
Mode of Transportation		Rail		Pipeline
Length of Transport*	*miles*	400		600
Remaining Life	*years*	17	23	40
Fuel Requirement	*tons/mcf*	1,147,727	-	13,500,482
GHG Emissions (CO2e)				
Extraction	*tons*	919,602	-	4,492,387
Transportation	*tons*	261,452	-	2,470,674
Power Generation	*tons*	36,795,310	12,170	32,760,000
Total	***tons***	**37,976,365**	**12,170**	**39,723,061**

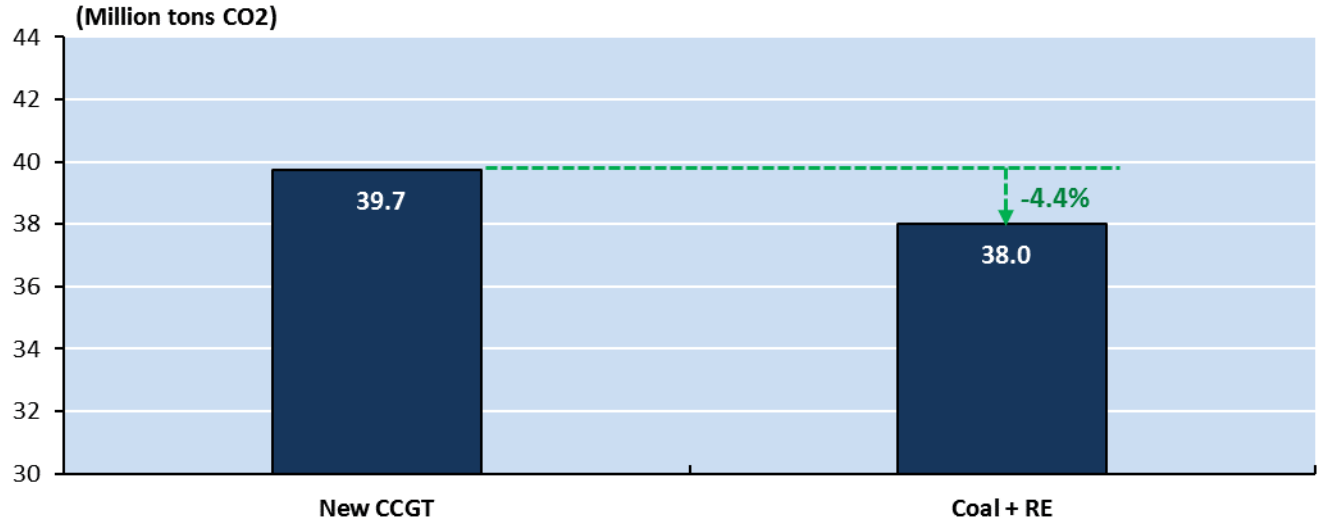
** Includes roundtrip for coal train*

According to the results of the LCM, operating the Rawhide coal plant until the end of 2047 would yield almost 2 million tons of CO_2e emissions **less** than replacing it with a new CCGT in 2030. In fact, Rawhide could operate well beyond its estimated retirement year of 2047 before the ZNC portfolio with the new CCGT results in actual lifecycle greenhouse gas emission reductions. ***Allowing more time for renewable energy plus storage to become more economically feasible to replace baseload or intermediate resources by continuing to operate the Rawhide Energy Station past 2030 will result in higher GHG emission reductions than replacing existing fossil fuel generation with new fossil fuel and CO_2-emitting generation.***

[21] https://www.eia.gov/environment/emissions/co2_vol_mass.php

[22] https://www.netl.doe.gov/energy-analyses/pubs/Wind-TAR-NETL-30AUG12.pdf Figure 4-5. Only lubricating oils and cable factors are used in the LCM.

EXHIBIT 10: LIFECYCLE GHG EMISSIONS FROM COAL + RENEWABLES VS. NEW COMBINED CYCLE PLANT



Source: EVA GHG Lifecycle Analysis

Rawhide Operations Compared to other Generating Resources

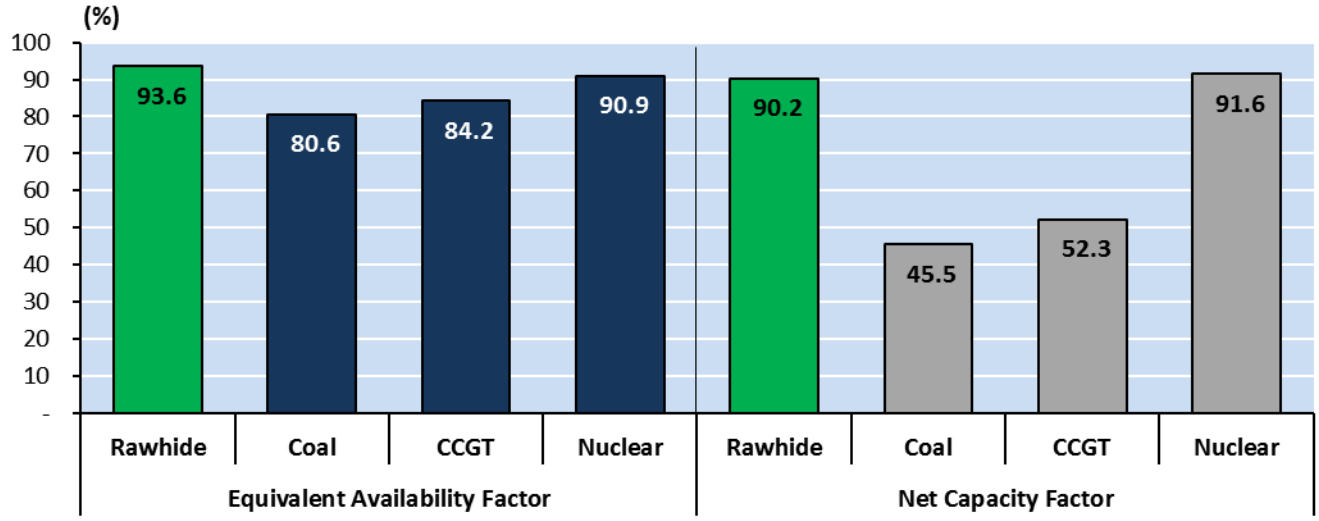
Platte River's Rawhide Energy Station is PRPA's largest single source of system capacity at 280 MW and is mainly used for PRPA's baseload energy needs. Rawhide began commercial operations in 1984. By 2018, PRPA will have retired the original debt of the plant. Besides having emissions well below average in Colorado and the surrounding area, Rawhide is also the lowest cost resource on the PRPA system and one of the most reliable generating resources in the country.

Two of the measures the North American Electric Reliability Corporation (NERC) - a not-for-profit regulatory authority who oversees the reliability and security of the North American electric grid - uses to assess the reliability and dependability of electric generating units (EGU) are the equivalent availability factor (EAF) and the capacity factor (CF)[23]. The EAF provides insight into the amount of time the EGU was available to produce electricity, while the CF measures the actual energy generated as a fraction of the maximum possible energy it could have generated at maximum operating capacity.

In 2016, Rawhide averaged a 93.6% equivalent availability factor (EAF) and a 90.2% capacity factor, which are both well above the national averages for fossil fuel units and similar to the EAF and CF of nuclear power plants, as shown in Exhibit 11. Therefore, Rawhide has the reliability characteristics of a nuclear power plant, while having the operating flexibility of fossil fuel plants.

[23] NERC 2017 Generating Availability Data System; https://www.nerc.com/pa/RAPA/gads/Pages/default.aspx

EXHIBIT 11: RAWHIDE RELIABILITY PERFORMANCE COMPARED TO THE NATIONAL AVERAGE



Source: North American Reliability Corporation 2017 GADS Survey

Besides its high dependability and reliability, Rawhide is also one of the lowest-cost generating resources in Colorado. Over the last two years, Rawhide's production cost averaged $24.90/MWh, making it the lowest cost source of power, including power purchases, on PRPA's system. According to the Federal Energy Regulatory Commission's (FERC) Form 1 database[24], Rawhide is also one of the lowest cost fossil-fuel power plants in the RMPA region, as shown in Exhibit 12.

EXHIBIT 12: PRODUCTION COST COMPARISON BETWEEN RAWHIDE AND OTHER FOSSIL-FUEL PLANTS[25]

Company	Plant	State	Type	Production Cost ($/MWh)		
				2016	2017	Average
Platte River	**Rawhide**	**CO**	**Coal**	**$ 24.3**	**$ 25.5**	**$ 24.9**
Xcel	Comanche	CO	Coal	$ 15.9	$ 23.3	$ 19.6
Xcel	Pawnee	AZ	Coal	$ 25.0	$ 21.2	$ 23.1
Xcel	Craig	CO	Coal	$ 33.8	$ 37.5	$ 35.7
Xcel	Hayden	CO	Coal	$ 37.8	$ 34.5	$ 36.2
PacifiCorp	Jim Bridger	WY	Coal	$ 39.2	$ 36.0	$ 37.6
PacifiCorp	Cholla	AZ	Coal	$ 40.8	$ 42.3	$ 41.6
PacifiCorp	Lake Side	UT	CCGT	$ 26.9	$ 33.1	$ 30.0
Xcel	Rocky Mountain	CO	CCGT	$ 34.0	$ 33.2	$ 33.6
Xcel	Fort St Vrain	CO	CCGT	$ 33.5	$ 36.0	$ 34.8

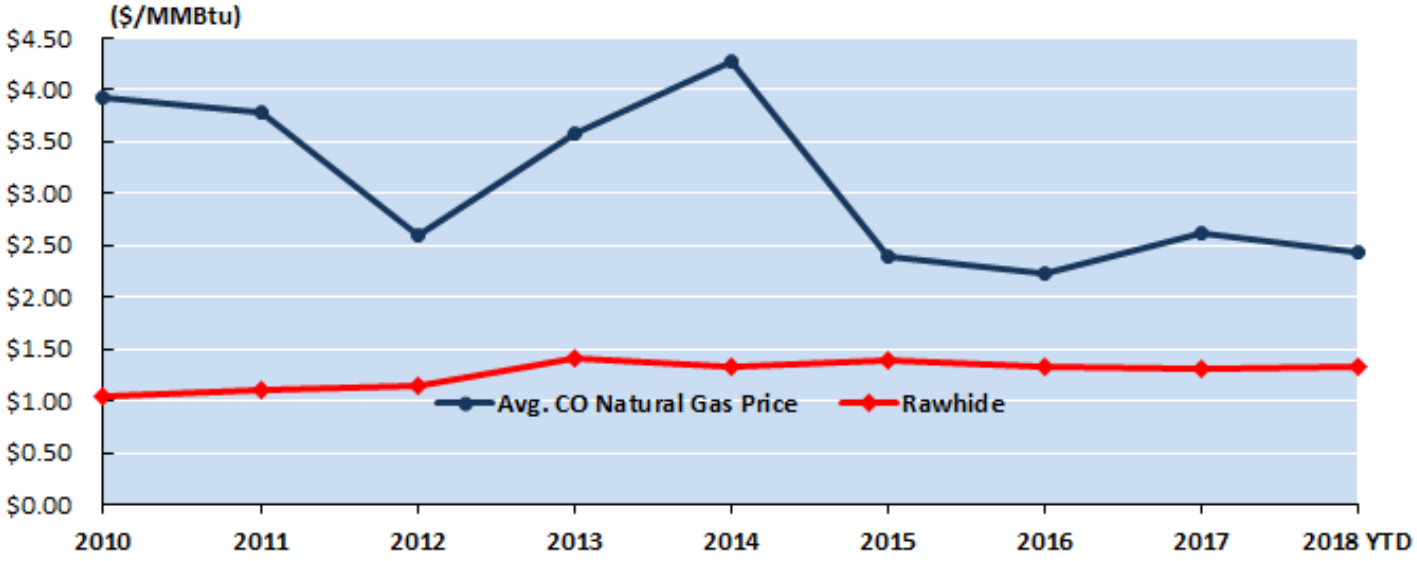
Not only is Rawhide's production cost lower than the cost for comparable coal-fired power plants, but it is also significantly lower cost than new, more efficient natural gas-fired combined cycle plants in the Colorado and RMPA region. For example, although being 25% more fuel efficient than Rawhide, PacifiCorp's 10-year old Lake Side CCGT is more than 10% more expensive to operate and maintain. With the future retirements of other low-cost generating resources in the region such as Xcel's Comanche power plant, Rawhide will be the lowest cost fossil fuel-fired generating resource in Colorado.

[24] FERC Form 1 Historical Data; https://www.ferc.gov/docs-filing/forms/form-1/data.asp?csrt=11896222881264291169
[25] PRPA annual budgets and FERC Form 1 data.

The main reason for Rawhide's low production cost is its close proximity to Powder River Basin coal reserves, the largest and lowest cost coal reserves in the country. Since PRPA procures fuel for Rawhide under long-term rail and fuel contracts, any fuel cost volatility is mitigated through the stability of existing contracts. Over the last eight years, the standard deviation for the delivered coal price to Rawhide was less than $0.14/MMBtu, according to EIA Form 923 data.[26] In contrast, delivered natural gas prices to Colorado power plants varied more than $0.78/MMBtu, or almost six times as volatile as Rawhide's fuel cost over the same period.

Since natural gas is a widely traded commodity, national weather or supply disruption events such as hurricanes or cold weather in the Northeast can have significant impacts on natural gas prices in Colorado. In contrast, PRB coal prices are relatively immune to weather and short-term demand fluctuations and are primarily driven by mine production costs. Rawhide's future fuel cost is more predictable than the fuel cost for a new CCGT plant.

EXHIBIT 13: ANNUAL DELIVERED FUEL COST OF RAWHIDE COAL AND NATURAL GAS IN COLORADO



Conclusion

EVA's review of PRPA's Zero Net Carbon study reveals no long-term GHG emission benefits from prematurely retiring the coal unit at Rawhide and replacing it with natural gas. However, this action would require significant capital investments that would cause large customer rate increases.

Attempting to replace Rawhide with a 100% renewable electricity supply would jeopardize reliability and significantly increase PRPA's cost, which would be reflected in customer electric rates. The massive overbuilding of power capacity would lead to a large increase in retail power costs.

[26] EIA Form 923; https://www.eia.gov/electricity/data/eia923/

EXHIBIT 14: 2016 UTILITY RETAIL POWER RATES IN COLORADO

Utility	Ownership	Customers	Megawatthours	Residential	Commercial	Industrial	Total
Moon Lake Electric Assn Inc	Cooperative	2,276	507,143	7.34	7.31	6.61	6.67
City of Gunnison - (CO)	Municipal	4,218	67,779	9.28	7.11	-	7.95
White River Electric Assn, Inc	Cooperative	3,323	737,542	11.83	11.49	7.61	8.05
City of Longmont	Municipal	38,509	781,817	9.29	7.76	6.54	8.18
City of Loveland - (CO)	Municipal	35,875	702,647	9.73	9.27	6.95	8.31
City of Fort Collins - (CO)	Municipal	71,016	1,503,720	10.10	8.34	6.51	8.32
Empire Electric Assn, Inc	Cooperative	14,765	747,967	14.88	7.74	7.86	8.73
City of Colorado Springs - (CO)	Municipal	225,406	4,566,389	12.03	7.70	7.15	8.89
City of Fort Morgan	Municipal	6,028	246,238	8.92	9.36	8.76	9.10
Public Service Co of Colorado	Investor Owned	1,441,981	28,800,915	11.47	9.20	6.51	9.34
City of Fountain	Municipal	18,687	218,337	10.08	8.55	-	9.55
Poudre Valley Associated Services	Cooperative	39,640	1,215,055	11.63	11.29	7.56	9.70
Holy Cross Electric Assn, Inc	Cooperative	56,024	1,190,409	10.84	9.00	9.16	9.96
United Power, Inc	Cooperative	79,966	2,150,653	12.18	10.79	7.99	10.16
Yampa Valley Electric Assn Inc	Cooperative	25,970	548,567	11.37	10.50	-	10.23
City of Glenwood Springs - (CO)	Municipal	6,183	127,200	10.81	10.24	-	10.40
La Plata Electric Assn, Inc	Cooperative	42,265	945,381	15.42	11.99	6.36	10.74
Town of Estes Park	Municipal	10,525	126,470	12.32	9.86	-	11.03
Wheatland Electric Coop, Inc	Cooperative	51	2,051	16.51	10.56	-	11.19
K C Electric Association	Cooperative	6,493	195,537	13.31	11.32	10.21	11.30
Highline Electric Assn	Cooperative	8,374	326,115	13.22	12.48	10.77	11.44
Morgan County Rural Elec Assn	Cooperative	8,030	311,144	13.87	10.90	10.96	11.49
Delta Montrose Electric Assn	Cooperative	32,757	523,600	13.56	12.34	8.75	11.68
High West Energy, Inc	Cooperative	992	96,249	13.48	10.90	11.82	11.89
Y-W Electric Assn Inc	Cooperative	8,817	332,183	14.27	9.51	12.62	12.13
City of Aspen- (CO)	Municipal	3,022	65,983	13.30	11.53	-	12.14
Intermountain Rural Elec Assn	Cooperative	151,215	2,299,987	13.05	11.44	8.64	12.34
San Isabel Electric Assn, Inc	Cooperative	23,789	439,342	16.46	16.23	7.41	12.48
Town of Frederick - (CO)	Municipal	2,236	27,683	12.48	11.92	13.20	12.53
Mountain View Elec Assn, Inc	Cooperative	50,663	817,845	14.02	11.76	8.23	12.67
Mountain Parks Electric, Inc	Cooperative	20,229	277,788	14.35	11.29	9.36	12.71
Black Hills/Colorado Elec.Util	Investor Owned	95,624	1,923,650	15.74	12.51	9.03	12.76
Grand Valley Power	Cooperative	17,223	242,869	14.05	12.12	8.77	13.03
Southeast Colorado Power Assn	Cooperative	10,277	184,521	16.98	14.17	12.66	14.61
San Miguel Power Assn, Inc	Cooperative	13,339	193,219	15.59	13.42	15.72	14.62
Gunnison County Elec Assn.	Cooperative	10,678	119,681	16.31	12.95	10.68	14.90
San Luis Valley R E C, Inc	Cooperative	12,428	205,887	16.91	13.66	15.48	15.54
Sangre De Cristo Elec Assn Inc	Cooperative	12,035	112,375	17.14	14.80	-	16.43
Tri-County Electric Coop, Inc	Cooperative	41	141	14.71	22.02	60.00	19.65
Southwestern Electric Coop Inc	Cooperative	5	59	20.45	18.67	-	20.00