ENERGY STRATEGIES

PLATTE RIVER POWER AUTHORITY'S ZERO NET CARBON ANALYSIS

A Critique of the Pace Global Report and Recommendations for Future Analysis

Prepared for

Colorado Sierra Club
Northern Colorado Partners for Clean Energy

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Contents

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While many people provided support to Energy Strategies in the preparation of this report, the opinions, findings and recommendations expressed in this document are those of Energy Strategies, LLC.

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1. Executive Summary

Platte River Power Authority (Platte River) provides wholesale electric generation and transmission services to the municipal utilities of its owner communities—Estes Park, Fort Collins, Longmont, and Loveland. Its generation portfolio is heavily dependent on coal. Due to the interest of its owner municipalities and their customers for cleaner sources of power, Platte River undertook a study to explore the costs of transitioning to a resource generation portfolio that would achieve and maintain zero net carbon (ZNC) emissions. Platte River hired Pace Global, who used the Aurora economic planning model to evaluate the cost impacts to Platte River of transitioning to a generation portfolio that achieves zero net carbon dioxide emissions starting in 2030. The study, Zero Net Carbon Portfolio Analysis ("ZNC Analysis"), showed that Platte River could achieve a ZNC portfolio by retiring its Craig and Rawhide coal-fired power plants while adding 950 megawatts (MW) of solar and wind energy and a new 286 MW combined cycle natural gas fired plant to its generation portfolio in 2030. Compared to a more business-as-usual portfolio, developed through the last Integrated Resource Plan (IRP), the ZNC portfolio costs were shown to be only 8% higher than the IRP portfolio on a net present value basis, over the period of the analysis, 2018–2050.

Energy Strategies evaluated the modeling approach, the data inputs, and the assumptions underlying the ZNC Analysis. The purpose of the evaluation was to identify gaps in the analysis and provide recommendations on how the analysis could be improved to provide a more robust and complete assessment of the costs to Platte River of transitioning to a zero-net-carbon or 100% renewable zero-carbon resource portfolio. The Energy Strategies review of the ZNC Analysis resulted in the following key findings and recommendations.

ZNC Accounting

The ZNC accounting scheme adopted for the ZNC Analysis has limited value as a metric for use in resource planning and decision making. Its use in this analysis is problematic for three reasons. First, it is an unreliable measure of actual carbon dioxide (CO_2) emissions reductions and is not a standard that has been adopted by any existing or proposed regulatory framework to control emissions of CO_2. Second, it depends on an emissions rate to account for the emissions associated with sales and purchases in the wholesale market. The single proxy rate that was used inaccurately reflects regional emissions rates and resource transition occurring in the Colorado market and broader region. Lastly, in this analysis ZNC accounting is dependent on Platte River procuring resources and incurring costs in excess of what is needed to serve its load. There has been no assessment of whether there will be a market for the excess renewable energy Platte River is required to sell to achieve ZNC.

The ZNC accounting scheme is problematic and may undermine effective resource planning.

The emissions rate used in the ZNC analysis for wholesale market transactions is too high.

Energy Strategies recommends Platte River abandon the ZNC accounting scheme and instead work with its owner municipalities and stakeholders to develop a baseline CO_2 emissions forecast and then establish CO_2 reduction goals for the utility that would be achieved within a specified time period. If the ZNC portfolio approach is used in future resource modeling, Platte River should calculate a more accurate emissions rate and account for how the emissions rate will change over time. Aurora can be used to dynamically identify the emissions rate of the marginal dispatchable generation units in the region at the point in time that Platte River is selling excess energy or purchasing energy in the regional market.

Establishing a carbon dioxide reduction goal would be a better approach than ZNC accounting.

Modeling Approach

The ZNC Analysis conducted by Platte River was acknowledged to be a limited "proof-of-concept" study. The analysis only evaluated a single ZNC resource portfolio and did not include sensitivity analysis to account for the uncertainty of assumptions such as future load growth, fuel prices, capital and operating costs and performance of new supply technologies, and costs of environmental regulations. Future resource assessments of ZNC portfolios should evaluate more than one ZNC portfolio, including 100% renewable energy plus storage portfolios. To account for future uncertainty, each portfolio should be tested with high and low ranges of prices and other data assumptions to assess the sensitivity of the results to changes in input values.

Future resource planning should evaluate a number of portfolios that achieve ZNC or zero carbon goals and include sensitivity analysis.

Another limitation of the ZNC Analysis is the dependence on "least-cost" as the primary metric for portfolio selection. In the changing utility business environment, least-cost and reliability metrics alone are not sufficient for making resource decisions. Platte River's selection of a future resource portfolio must account for the performance of its resource portfolios against environmental costs and performance, fuel price risk, demand-side and new technology supply options, and impacts on customers' bills, in addition to least-cost and resource adequacy requirements.

"Least-cost" and reliability metrics alone are not a sufficient basis for selecting a resource portfolio.

Renewable Energy and Storage Modeling Assumptions

Platte River's modeling assumptions for renewable energy and energy storage were overly conservative. Reasonable assumptions

about costs, performance, and availability of each resource option based on the most current market information must be included in the evaluation of future portfolios.

Assumptions used in the ZNC Analysis to evaluate renewable energy and battery storage were overly conservative and did not reflect current market conditions

For renewable energy prices, assumptions should be developed by a thorough process of price discovery that takes into account published independent third-party costs estimates and the most current renewable energy power purchase agreements in the region. For battery energy storage, there have been dramatic decreases in the costs, and Platte River should use more recent and accurate capital and operating cost assumptions for battery energy storage. Battery storage was inappropriately eliminated early on, based on the high prices used. Given the uncertainty of future costs, sensitivities around the battery storage capital costs, especially, could allow an evaluation that would show the price point at which storage would be compelling as an alternative to more fossil-fueled generation.

Platte River should develop and use more accurate pricing, capacity factors, and capacity credit values for renewable resources and battery storage in future resource planning

For renewable energy capacity factors, assumptions that more accurately account for efficiency improvements should be used. Assuming future renewable energy supply options will have the same performance as resources in Platte River's current portfolio may be a conservative assumption, but it is not reasonable. If capacity factors are unknown, Platte River should evaluate renewable resources using two sensitivities that reflect low and high range of capacity factors that reflect resources available in the region.

Capacity credit values assigned to wind and solar resources, and battery storage, should be based on an Effective Load Carrying Capability (ELCC) study of the Platte River system. Battery storage in sizes of 4 megawatt-hours and above should receive capacity credit at 100% in future analysis. Alternatively, Platte River could include a capacity credit for battery storage lower than 100% for its baseline and use 100% in a sensitivity case.

Regional Transmission Organization Participation

Portfolios should be modeled with the assumption that Platte River will be part of a regional transmission organization, such as the Southwest Power Pool.

Platte River may be part of an RTO in the near future, such as the Southwest Power Pool. Despite the challenges of modeling Platte River's system as part of an RTO, every effort should be made to incorporate this into future modeling. It will have direct and immediate effects on transmission costs and the appropriate emissions rate to use for market sales and purchases.

Pricing Carbon Dioxide

To account for the likelihood of state or federal regulations and the economic and environmental impacts of climate change on broader society, Energy Strategies recommends that Platte River's future ZNC portfolio analysis and integrated resource planning modeling be run using at least two CO_2 price sensitivities.

Platte River should include a CO_2 price in its analysis that reflects the risk of carbon regulation over the study period.

The first set of CO_2 prices should reflect the regulatory costs Platte River's generation portfolio will be subject to under federal or state CO_2 regulation. A second CO_2 price sensitivity Platte River should include in all future ZNC and IRP portfolio analyses should account for the economic and environmental damages associated with climate change. The best measurement available for these costs is the Social Cost of Carbon (SCC).

A sensitivity case using the Social Cost of Carbon for a CO_2 price should also be run to reflect the economic and environmental damages of climate change.

Demand-Side Resources

Efficiency, demand response and distributed generation are resources that reduce load, contribute to capacity planning requirements, defer investments in transmission and distribution upgrades, and mitigate environmental regulatory and fuel price risks. Platter River should treat demand-side resources on a comparable and consistent basis to supply-side resources by developing levelized cost curves and allowing Aurora to choose the amount of demand-side and distributed resources that are cost effective.

Demand-side and distributed resources should be modeled and evaluated in the same manner as supply side resources are evaluated

Combined Cycle Capacity Additions

The ZNC portfolio includes a 286 MW combined cycle natural gas-fired plant to provide for the reserve margin needs of the system and to shape and firm the substantial amounts of new wind and solar resources added to the ZNC portfolio. The costs of this resource are substantial, approaching $350 million. Platte River should ensure that the Aurora model has the option to choose a smaller combined cycle GE Frame unit and is not limited to the 286 MW plant. Platte River should also allow the model the option to choose to convert one of the simple cycle units at the Rawhide CT plant to combined cycle production, specifically, the 7FA unit

Platte River should ensure Aurora has the option to choose smaller combined cycle options, to avoid adding an expensive, large combined cycle unit that is underutilized.

installed in 2008. Energy Strategies expects that this would allow significant installed cost reductions, making the ZNC portfolio's costs more competitive with the IRP reference portfolio.

Natural Gas Prices

The addition of the 286 MW natural gas-fired combined cycle plant to the ZNC portfolio in 2030 increases the relevance of natural gas prices in evaluating the overall cost of the ZNC portfolio. Natural gas markets have experienced episodes of extreme price volatility over the past decade. Projections of natural gas prices used to analyze supply-side options should account for the uncertainty of natural gas markets by including low and high natural gas price forecast sensitivities in addition to the base price assumptions.

Sensitivity cases with different gas price forecasts would help quantify the costs and risk of Platte River's ZNC portfolio relying on gas-fired generation.

Timing of Coal Unit Retirements

Early achievement of the ZNC goal by accelerating the procurement of renewable energy and moving up the retirement dates of Platte River's coal-fired generation may be a financial benefit to Platte River and the owner municipalities it serves. Modeling of future resource portfolios during the next planning process should include scenarios in which Platte River accelerates the retirement dates of its coal-fired generation fleet and evaluates the economic and environmental trade-offs of transitioning to a ZNC or 100% renewable energy portfolio before 2030.

Earlier retirement of Platte River's coal generation and accelerated procurement of renewable energy resources should be evaluated.

Stakeholder Involvement in ZNC and Zero Carbon Planning

A robust and meaningful stakeholder process is essential to ensure Platte River's resource decisions are aligned with municipal owners' and stakeholders' shared energy, public health, and environmental goals.

Energy Strategies acknowledges Platte River's substantial public outreach efforts to engage stakeholders after the release of the study through the public outreach meetings. There are a number of ways public outreach and stakeholder processes can be improved, however. The goal would be to increase the level of transparency and provide stakeholders with the opportunity to be more engaged and provide meaningful input during the development of future resource planning efforts.

Platte River should incorporate a more robust stakeholder process into future ZNC and resource planning assessments.

2. Introduction

Platte River Power Authority (Platte River) is exploring a future generation supply portfolio that seeks to achieve and maintain zero net carbon dioxide (ZNC) emissions beginning in 2030. Platte River provides wholesale electric generation and transmission to the municipal utilities of its owner communities—Estes Park, Fort Collins, Longmont, and Loveland. To evaluate the feasibility and costs of a ZNC portfolio, Platte River hired Pace Global, who used the Aurora economic planning model to evaluate the productions costs and create a least-cost ZNC resource portfolio. Pace Global also prepared a report that compares the costs of providing Platte River and its four owner municipalities with a ZNC resource portfolio to the preferred resource portfolio selected in its 2016 Integrated Resource Plan. The report that summarizes the modeling was released on December 5, 2017 ("ZNC Analysis"). A related study was also commissioned by Platte River: the HDR Battery Energy Storage Technology Assessment dated November 29, 2017 ("HDR Battery Assessment").

Platte River has taken an important first step to achieve lower carbon dioxide (CO_2) emissions through this planning analysis. The ZNC Analysis showed that Platte River could achieve a ZNC portfolio by retiring the 432 megawatts (MW) of generation capacity of its Craig and Rawhide coal-fired power plants while adding 950 MW of solar and wind energy and a new 286 MW combined cycle natural gas fired plant to its generation portfolio by 2030. In contrast, the business-as-usual portfolio, created through the 2016 Integrated Resource Plan (IRP) process, did not retire Rawhide until 2047. In 2030, the annual cost difference between the selected ZNC portfolio ($209.6 million) and the IRP-derived portfolio ($174.8 million) was $34.8 million. Over the entire period of the analysis, 2018–2050, the ZNC portfolio costs were shown to be only 8% higher than the IRP portfolio on a net present value basis. In a future that deployed the ZNC portfolio, 76% of the power generated by Platte River would be from wind, solar and hydro sources in 2030. The ZNC portfolio also achieves significant CO_2 reductions. The CO_2 emitted from Platte River's portfolio declines from about 3.2 million tons in 2018 to an average of 443,079 tons in the years 2030–2050.

Energy Strategies reviewed the ZNC Analysis, the HDR Battery Assessment, the Pace Global presentation from December 12, 2017, and Platte River's 2016 IRP. Energy Strategies also composed a list of data requests and questions for Platte River, and they responded with a spreadsheet and answers to the questions on January 26, 2018. Energy Strategies used this additional information and the original documents to then finish its independent assessment and develop this report. The purpose of the Energy Strategies critique and recommendations is to provide analytical support to Sierra Club and Northern Colorado Partners for Clean Energy (Colorado Partners) as they collaborate with Platte River and its owner municipalities to develop a zero-net-carbon or zero-carbon resource portfolio for the future. Energy Strategies found a number of issues that should be addressed more fully or differently as Platte River continues to model future resource portfolios. Broadly, the concerns fall into two categories: the ZNC accounting approach, and the modeling approach and assumptions.

3. ZNC Accounting

Platte River's generation portfolio is heavily dependent on coal-fired generation to serve the electricity needs of its owner municipalities. Platte River owns and operates the 278 MW Rawhide coal-fired generation station and has a 154 MW ownership interest in Units 1 and 2 of the Craig generation station.[1] It also has contracts for the delivery of renewable power from approximately 198 MW of wind, solar, and hydroelectric power resources.

Platter River's CO_2 emissions in 2014 were 3.6 million tons, 99.6% of which were associated with its coal-fired generation plants. The Rawhide plant was responsible for 2.4 million tons while Craig Units 1 and 2 contributed an additional 1.2 million tons to Platte River's CO_2 inventory. Less than 1% of its CO_2 emissions came from the operations of its Rawhide gas peaking plants.[2]

The objective of the 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. ZNC is a carbon dioxide emissions accounting scheme derived from the concept of carbon neutrality. The study attributes its adoption and use of the ZNC concept to the Carbon Neutral Cities Alliance.[3] For Platte River, carbon neutrality under ZNC accounting can be achieved by either generating more renewable energy than is needed to serve its load and counting the excess delivered into the grid as an offset against the CO_2 emissions from the utility's fossil generation, or by purchasing carbon offsets. A third alternative would be for Platte River to serve its load entirely with 100% renewables plus energy storage.

Adopting the ZNC accounting scheme for this study enables Platte River to continue to include CO_2-emitting fossil generation technologies in its generation portfolio to provide voltage support and ensure system reliability, while meeting a carbon-neutrality or ZNC objective.

ZNC Accounting: How It Works

The accounting mechanism used in the study to calculate ZNC had multiple steps. First, an average marginal emissions rate for the Western Electricity Coordinating Council (WECC)-Colorado power market was needed.[4] The study derived a marginal emissions rate of 1,803 lbs/MWh using reported emissions data from non-baseload generation data from the eGrid Rockies database. The study then assumed that

[1] Unit 1 of the Craig Generation Station is scheduled for retirement in 2025.
[2] While Platte River's hydro resources have been considered non-CO_2 emitting sources of power, there is a growing body of scientific literature that attributes emissions of greenhouse gases to dammed reservoirs created for hydroelectric projects. New guidance for measuring greenhouse gas emissions associated with flooded lands (reservoirs) has been drafted and proposed for inclusion in the 2019 refinements of the IPCC National Greenhouse Gas Inventory Guidelines. Countries will vote on IPCC acceptance of the proposed revisions to the flooded lands methodology in May 2019.
[3] The City of Fort Collins' Climate Action Plan has adopted a goal to reduce total greenhouse gas emissions by 80% by 2030 and achieve carbon neutrality by 2050.
[4] While there is not a defined "WECC-Colorado" power market, the AURORA modeling focused on this area and it was assumed that imports/exports into and out of Platte River were with surrounding utilities.

Platte River would sell any excess power above the amount needed to meet its owner-municipalities' electricity loads into the wholesale power market load, and by doing so, offset CO_2 emissions from non-baseload fossil generation units in the region at that rate of 1,803 lbs/MWh. Similarly, Platte River's market purchases were assumed to have an emissions rate of 1,803 lbs/MWh. This is particularly important when comparing the IRP portfolio to the ZNC portfolio because Platte River is a net importer for most years in the IRP portfolio.

The net CO_2 position of Platte River for any forecast year is therefore calculated by summing the CO_2 emissions from each generation resource in its ZNC portfolio and then adjusting the total emissions for the CO_2 associated with making market sales and purchases. Since market sales are assumed to offset non-baseload generation in the regional market at the rate of 1,803 lbs/MWh, those emissions are subtracted from Platte River's total CO_2 emissions. Conversely, the CO_2 emissions associated with Platte River's purchases of power are added to its inventory of CO_2 emissions. The end goal in this accounting scheme is for Platte River's total tons of CO_2 from its generation and market transactions to be zero or less than zero. Table 1 illustrates the accounting scheme for 2030.

Table 1: ZNC Accounting for Two Portfolios in 2030[5]

	(a) Emissions Rate (lb/MWh)	(b) 2030 Generation (MWh) in ZNC Portfolio	(a * b)/2000 Accounting Tons of CO_2 for ZNC Portfolio	Accounting Tons of CO_2 for IRP Portfolio
Coal	2,807	0	-	
CT	1,351	18,713	12,641	
CC	794	941,129	373,628	
Hydro	0	611,793	-	-
Solar	0	1,026,798	-	-
Wind	0	1,385,805	-	-
Total Plant Generation		**3,984,238**	**386,269**	**2,128,910**
Exports	(1,803)	586,287	(528,537)	
Imports	1,803	47,658	42,964	
Net CO_2 Emissions			**(99,305)**	**2,417,725**

CT = simple cycle combustion turbine. CC = Combined cycle combustion turbine.

The ZNC Analysis also provided information on the actual CO_2 emissions reductions—a point-source method—from the selected ZNC portfolio. The primary difference between ZNC emissions accounting and the more traditional point-source accounting method is that the ZNC scheme accounts for the CO_2 emissions embedded in Platte River's market transactions, where they sell (export) and purchase (import) power supplies.

[5] Pace Global, "Zero Net Carbon Portfolio Analysis," (hereafter: ZNC Analysis) Prepared for Platte River Power Authority, December 5, 2017, Exhibit 1, p. 8. Available at: https://www.prpa.org/znc/znc-report/ IRP emissions data was provided in response to the data request.

ZNC Accounting: Critique

While the ZNC Analysis demonstrates that a carbon-neutral resource portfolio can be achieved by Platte River in 2030 at a marginally higher cost to the reference IRP portfolio, Energy Strategies believes the ZNC accounting scheme adopted in this analysis has limited value as a metric for use in resource planning and decision-making going forward.

Regulatory Issues

The ZNC accounting scheme does not meet any existing or proposed federal or state regulatory standard for carbon dioxide. The business case for Platte River to reduce its CO_2 emissions is to minimize the regulatory and financial risk the utility faces from future CO_2 emissions regulations. From an air quality regulatory perspective, federal or state mandates to reduce CO_2 emissions will require Platte River to demonstrate that its CO_2 emission reductions are real, measurable, verifiable, and permanent. The ZNC accounting scheme adopted for this study was based on a simplifying assumption that only the generation and emissions of non-baseload fossil generation in the region would be impacted by Platte River's sales of excess renewable energy into the regional market. There is no demonstration that Platte River's excess power sales would actually result in CO_2 emission reductions that are measurable, verifiable, and real. As a voluntary accounting scheme, it is an interesting exercise, but the accounting of emissions reduced by Platte River's sales of renewable power into the wholesale market is not a reliable or accurate measure of actual CO_2 emissions reductions achieved by the ZNC portfolio.

The ZNC Analysis does not acknowledge that the ZNC accounting scheme does not comply with existing or proposed environmental regulation, which requires real, verifiable and measurable reductions.

Accounting Assumption Issues

All the accounting for sales and purchases requires problematic assumptions about the emissions rate of the regional grid in order to calculate Platte River's ZNC emissions position for any one year. ZNC accounting rests on three major assumptions:

- that sales made by Platte River will be renewable energy,
- that sales made by Platte River will displace energy that would have been made by CO_2-emitting resources, and
- that purchases made by Platte River are from CO_2-emitting resources.

Assuming all sales will be renewable energy sales is problematic. For example, if the portfolio includes a fossil-fueled resource in addition to all the renewable energy, there is no limit to how much that fossil-fueled resource runs, as long as the model includes sales to offset that generation. There is actually no way to "trace an electron" and determine that any sales made from the Platte River system are actually generated from renewable energy. The ZNC Analysis did not discuss Platte River sales being "bundled" with their clean energy attributes, i.e., sold with Renewable Energy Certificates. The accounting scheme as discussed in the ZNC Analysis simply deducts CO_2 emissions from Platte Rivers inventory ledger when there are sales, and adds CO_2 when there are purchases.

Assuming all displaced energy will be from carbon-emitting resources is equally problematic. The assumed emissions rate of 1,803 lbs/MWH only accounts for the emissions rate of non-baseload fossil generation plants in the eGrid Rocky Mountain Region. In fact, the region's generation portfolio consists of both fossil-fueled carbon-emitting and non-carbon generation sources. It is erroneous to assume that only the dispatch of non-baseload fossil generation plants will be offset by Platte River sales of excess power. Depending on the hour, Platte River's sales into the market could be offsetting other renewable energy or a gas-fired generation unit whose emissions are half the 1,803 lbs/MWh regional emissions rate assumed in the analysis. The experience in California shows that when a lot of renewable energy is added to a system, some renewable energy may displace other renewable energy. California frequently has to deal with an oversupply of renewable resources. [6] This situation occurs often in spring and early summer, when solar is in peak production, but it is not yet hot enough to see the demand of air conditioning. The California Independent System Operator (CAISO) then must "curtail" renewable resources, scaling back plant generation. CAISO says that it curtailed 187,000 MWh in 2015, and 308,000 MWh in 2016.[7] So it is certainly possible that Platte River's sales may simply displace other renewable energy, not a carbon-emitting resource.

The last assumption, that all purchases will be from emitting sources, is problematic for the same reason. If Platte River is short, Platte River may be purchasing other utilities' excess renewable energy, which has zero CO_2. But ZNC accounting requires market purchases be added to Platte River's CO_2 accounting at the 1,803 lbs/MWh rate.

Renewable Energy Penetration Issues

The ability of Platter River's generation portfolio to achieve ZNC hinges on the assumption that Platte River is the only utility in the region with aggressive CO_2 reduction and renewable energy goals and that it will be able to offset emissions from its 286 MW combined cycle unit through sales of zero-carbon renewable energy into the regional market. This modeling assumption is not indicative of expected changes to Colorado's future generation mix or those that are occurring in the larger WECC region. Xcel Energy's Colorado Energy Plan envisions retirement of two units of the Comanche coal-fired power plant, and adding up to 1,000 MW of wind, 700 MW of solar and 700 MW of natural gas and/or storage. By 2026, Xcel plans on reducing it CO_2 emissions by an estimated 4.6 million tons and increase the amount of renewable energy in its energy mix to 55%.[8] This includes over 40% wind penetration or nearly twice as much the current amount of wind in Xcel's Colorado footprint.[9]

As variable generation capacity increases throughout the state, the market is likely to experience over-generation conditions comparable to California. As already noted, CAISO is often forced in spring and

[6] California ISO, "Fast Facts: What the Duck Curve Tells Us About Managing a Green Grid," 2016, https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf
[7] California ISO, "Fast Facts: Impacts of Renewable Energy on Grid Operations," May 2017, https://www.caiso.com/Documents/CurtailmentFastFacts.pdf
[8] Xcel press release. August 29, 2017, http://investors.xcelenergy.com/file/Index?KeyFile=390093969
[9] Xcel fact sheet, 2017, at https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Resource%20Plans/CO-Energy-Plan-Fact-Sheet.pdf

summer to curtail renewable energy due to over-generation. The effect may not be as dramatic in Colorado, since Colorado would have more wind in the mix than California, which has a renewable energy mix heavily weighted to solar. If there are over-generation conditions in Colorado, this could have a significant impact to the cost and feasibility of a ZNC portfolio. As more renewables are added in the state, the excess supply of energy will exert downward pressure on the price that buyers are willing to pay for that generation. However, the ZNC Analysis sets up a framework that depends on sales of excess renewable energy to meet the ZNC goal. This will become harder to achieve as more renewables are brought on line.

The ZNC Analysis acknowledges some of these risks by noting that more renewables may lower the prices in the market, and lower the CO_2 offset value, which would require more renewables to be built. However, it does not also acknowledge the recent and proposed retirements of coal generation, and the fact that a CO_2 offset value (proxy emissions rate) closer to that of a gas unit might be appropriate even as early as 2030, the goal year.

4. Critique of the Modeling Approach and Data Assumptions

Utility economic modeling has limitations. The results are always dependent on the assumptions (e.g., the forecast for natural gas prices) and the setup of the model. This section critiques the modeling approach and methodology that was used to create the ZNC portfolio, as well as the data inputs and assumptions that were used.

Energy Strategies recognizes this was a first step, a "proof-of-concept" exercise for Platte River. It is logical that the next step is to test sensitivities and produce multiple portfolios, in order to be able to evaluate different strategies and compare the risks, costs, and emissions reductions of various portfolios. The critique that follows discusses the inputs and approaches used in the ZNC Analysis.

4.1. Renewable Energy

The Energy Strategies review of the modeling assumptions for renewable energy focused on three areas that would impact the cost and performance of the ZNC portfolio: capacity factor, costs, and capacity credit. The ZNC Analysis included new wind and new solar energy in the resulting portfolio. Many of the assumptions regarding renewable energy that were incorporated into the analysis affect the cost of the portfolio.

Capacity Factor

The capacity factors for wind and solar energy resources assumed by Platte River in the ZNC Analysis are very conservative and in Energy Strategies' opinion too low. The ZNC Analysis indicates that the capacity factors for solar and wind were modeled at 20% and 40%, respectively.[10] Capacity factors are an important influence on the cost of the ZNC portfolio important because they determine how many MWh

[10] ZNC Analysis, p. 20

are available from that resource in meeting the total demand. While the assumed capacity factors might be a reasonable starting point given that Platte River's existing projects have not exceeded these capacity factors, there is also good reason to believe that wind and solar capacity factors for newer systems are increasing and will continue to do so in the coming decades. Assuming higher capacity factors for wind and solar would lower their all-in cost.

For example, the recent power purchase agreement Platte River entered into with Enyo Renewable Energy was priced assuming the Roundhouse Wind Project would operate at a capacity factor between 44.0% and 45.7%.[11] As another point of comparison, in Public Service Company of Colorado's (PSCo) 2016 Electric Resource Plan (ERP), the reported capacity factors for solar and wind were in the high 20s and low 40s, respectively.[12] Higher capacity factors for wind and solar translates into to lower all-in costs.

Table 2: Renewables Capacity Factor Comparison

	ZNC Study	Xcel Energy/PSCo 2016 ERP
Solar capacity factor	20%	29.6%
Wind capacity factor	40%	41.5% - 43.6%

Power Purchase Agreement Prices

The ZNC Analysis noted that its renewable capital cost estimates reflected rapid declines in renewable costs.[13] However, the corresponding Power Purchase Agreement (PPA) costs presented in Figure 9 of the report and detailed by year in a subsequent data request, do not reflect such price declines.[14] To the contrary, the ZNC Analysis assumes that wind PPA costs will *increase* through 2020 and will then decline over the rest of the study time horizon at an average annual rate of only 0.4%, in nominal terms.

Similarly, for solar, the ZNC Analysis assumes that solar PPA costs will increase through 2022 and then decline slowly over the rest of the study time horizon, and not reach parity with the assumed 2018 price until 2026 in real terms. However, industry estimates project that solar costs are continuing to decline until at least the mid-2030s.[15] Additionally, the Production Tax Credit (PTC) and Investment Tax Credit are set to remain intact through the end of 2022. Therefore, it is reasonable to project that PPA costs will *decrease* rather than increase through 2022.

[11] Presentation to Platte River Board of Directors, December 2017
[12] Xcel 2016 ERP, Volume 1, Page 46 (Table 1.5-2): https://www.xcelenergy.com/staticfiles/xe/PDF/Attachment%20AKJ-1.pdf
[13] ZNC Analysis, p.5
[14] Platte River Data Request Response to Energy Strategies, #3
[15] See E3 study conducted for WECC, "E3_WECC_CapitalCosts_Final" published January 21, 2017, available at: https://www.wecc.biz/SystemAdequacyPlanning/Pages/Datasets.aspx#LongTermPlanningTool

In addition to not capturing long-term price declines adequately, Energy Strategies also believe the near-term renewable energy PPA prices used in the ZNC Analysis were too high. For example, the all-in PPA price for wind used in the ZNC analysis was $45.16/MWh in 2021. However, Platte River's 2017 Wind Request for Proposals (RFP) received nine bids for delivery of wind in 2021 (including transmissions and integration) that were under $40/MWh. One bid was well under $30 MWh.

As another point of comparison, Xcel received bids in response to its all-sources RFP covering the period 2018–2023 that resulted in median indicative prices for wind and solar being offered at $18.10 MWh and $29.50 MWh, respectively. The median wind PPA price bid into the Xcel RFP was nearly $8.00 per MWh lower than the average price assumed in the ZNC analysis over the same period and the bids for solar PV were about $7.00 lower. These cost differences are significant.

Capacity Credit

One of the objectives for the ZNC Analysis was to develop a least-cost portfolio while maintaining Platte River's planning reserve margin of at least 15%. Energy Strategies believes the capacity credit Platte River has assigned to wind and solar resources may be too low. The ZNC Analysis indicates that the capacity credit for solar and wind were modeled at 30% and 12.5%, respectively.[16] The capacity credit values used in this analysis seem overly conservative when compared to neighboring utilities. Table 3 compares the assumed capacity credits among various models.

Table 3: Renewable Energy Capacity Credit Comparison

	ZNC Study	Xcel Energy 2016 ERP[17]	Black Hills 2016 ERP[18]	Rocky Mountain Power (East) 2017 IRP[19]
Solar	30.0%	Existing utility-scale: 55.0% Incremental: 27.7% - 53.0%	37%	37.9%
Wind	12.5%	Existing: 16.0% Incremental: 8.4% - 18.8%	20%	15.8%

In response to Energy Strategies question regarding the source of the assigned capacity credit values, Platte River said their values were based on assumptions made during the development of Platte River's 2016 IRP. Platte River also indicated it will revisit these assumptions before its next IRP and will set

[16] ZNC Analysis, p. 28
[17] Xcel 2016 Electric Resource Plan, Volume 2, Table 2.7-4 and Table 2.7-5: https://www.xcelenergy.com/staticfiles/xe/PDF/Attachment%20AKJ-2.pdf
[18] Black Hills 2016 Electric Resource Plan, Table H-1, General Planning Assumptions: https://www.blackhillsenergy.com/sites/blackhillsenergy.com/files/coe_att-ls-1-2016-bhce-erp-6-3-16.pdf
[19] PacifiCorp 2017 Integrated Resource Plan, Vo. II Technical Appendices, Appendix N: Wind and Solar Capacity Contribution Study, p. 313, April 2017. https://www.rockymountainpower.net/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2017_IRP/2017_IRP_VolumeII_2017_IRP_Final.pdf

qualifying capacity values for wind and solar resources based on "the most recent studies and the expected effective load carrying capacity (ELCC) methodology supported by the SPP market."

Capacity credit is the amount of the resource's capacity that is counted towards meeting peak load in MW, and it is critical in determining whether the reserve margin requirements have been met in any given year. If resources need to be added to reach the reserve margin, this has a significant impact on the overall cost of the ZNC portfolio. If the results of future ELCC studies allowed Platte River to apply the average of the capacity credit values in the range used by PSCo, Black Hills, and Rocky Mountain Power, the ZNC portfolio would achieve a planning reserve margin of around 14.5% in 2030 without the addition of the 286 MW gas-fired combined cycle.[20]

4.2. Energy Storage

Energy Strategies recognizes that predicting the future for a developing technology is difficult. However, the ZNC Analysis appears to have ignored the recent dramatic decreases in cost for battery storage, and it used other assumptions that disadvantaged battery storage as a resource in the least-cost modeling analysis. The ZNC Analysis used four-hour duration battery storage (1 MW/4 MWh) as a long-term capacity option. Energy Strategies has the following concerns with the assumptions regarding energy storage.

Capital Cost ($/kW)

Energy Strategies believes that the costs assigned to battery storage in the ZNC analysis were too high. The capital cost in 2018$ used in the ZNC analysis for 1 MW/4 MWh Lithium-Ion (Li-Ion) batteries was $2,206 per kW.[21] The ZNC Analysis noted the source of this cost assumptions was the HDR Battery Assessment, which provided a 2017 capital cost for Li-Ion batteries in three different technologies, with the cheapest and most common (Lithium Nickel Manganese Cobalt Oxide) at a low installed cost of $2,280 per kW to a high installed cost of $3,110 per kW.[22] The ZNC Analysis says that "lithium-ion battery energy storage costs are expected to decline by approximately 20% over the next five years"[23] and attributes this forecast to the HDR Battery Assessment. The HDR Battery Assessment said that costs have fallen approximately 14% per year over the past five years (which would be a decline of 55% over five years), and that the downward trend will continue.[24] It does not provide a forecast for the decline over the next five years; the "20% over five years" assumption first appears in the ZNC Analysis. This assumption (20% decline over five years) is inappropriately conservative.

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[20] Estimate based on average of the capacity credit values used by PSCo for its "incremental" resources, and averaged with the values assigned Black Hills and Rocky Mountain Power.
[21] ZNC Analysis, p. 30
[22] HDR, "Battery Energy Storage Technology Assessment," (hereafter: HDR Battery Assessment) Prepared for Platte River Power Authority, November 29, 2017, Table 1, pages 8 - 9. Available at: https://www.prpa.org/znc/znc-report/
[23] ZNC Analysis, p. 17
[24] HDR Battery Assessment, p. 8

There are some publicly available forecasts for the continuing declines in Li-Ion batteries. Bloomberg New Energy Finance, in a July 2017 report,[25] shows that the price of Li-Ion batteries fell 73% between 2010 and 2016, and was at $273/kWh in 2016. They forecast that Li-Ion batteries will fall to "as little as $73/kWh" by 2030. This is a decline on average of 9% per year, continuing until 2030 (14 years), and resulting in a total decline from 2016 of 73%. Another publicly available forecast for the continuing decline comes from Lazard, in a November 2017 report entitled *Lazard's Levelized Cost of Storage Analysis—Version 3.0.*[26] This report forecasts the capital costs for Li-Ion batteries declining about 10% per year, or 36% over the next five years.[27] Table 4 compares the Bloomberg and Lazard forecast declines against the forecast used in the ZNC Analysis.

Table 4: Annual and Five-Year Declines in Battery Storage Costs

	ZNC Analysis	Bloomberg New Energy Finance	Lazard
Annual	About 5.5% decline	9% decline	10% decline
5-year	20% decline	About 31% decline	36% decline

Another way to gain insight into current and future energy storage costs is through a review of recent results of utility RFPs and signed PPAs. Of course, timing and location differences will mean these are not perfectly comparable to projects available to Platte River. Figure 10 in the ZNC Analysis shows the Levelized Cost of Energy (LCOE) for the options of Wind + Storage and Solar + Storage as two of the most expensive options at a LCOE of more than $67/MWh and $72/MWh respectively.[28] The firming cost for wind was $22/MWh and the firming cost for solar was $34/MWh.

As a source for comparison, Tucson Electric's 2017 PPA was for 100 MW solar plus 30 MW storage for less than $45/MWh.[29] In the responses to the all-source RFP issued by PSCo, renewables plus storage appear to be even lower cost than Tucson's very recent PPA. The December 2017 filing[30] by PSCo shows the company received non-binding "indicative" offers that were surprisingly low. "Firming" with storage adds very little to the PPA price—about 15% to 22% more than the cost for the stand-alone renewable. It is unknown how much of the wind and solar was firmed, however, making a comparison to the ZNC

[25] Claire Curry for Bloomberg New Energy Finance, "Lithium-ion Battery Costs and Market," July 5, 2017, available at https://data.bloomberglp.com/bnef/sites/14/2017/07/BNEF-Lithium-ion-battery-costs-and-market.pdf
[26] Lazard, "Lazard's Levelized Cost of Storage Analysis—Version 3.0," November 2017, available at https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf
[27] Lazard, slide 16
[28] ZNC Analysis, p. 18. Platte River provided the numbers for the table in response to a request.
[29] UtilityDive, "Updated: Tucson Electric Signs Solar + Storage PPA for 'less than 4.5¢/kWh'" May 23, 2017. https://www.utilitydive.com/news/updated-tucson-electric-signs-solar-storage-ppa-for-less-than-45kwh/443293/
[30] Public Service Company of Colorado, "2016 Electric Resource Plan: 2017 All Source Solicitation 30-Day Report (Public Version), CPUC Proceeding No. 16A-0396E)," December 28, 2017. Downloaded using proceeding number from http://www.dora.state.co.us/pls/efi/EFI_Search_UI.search.

Analysis assumptions problematic. The ZNC Analysis could have assumed 100% of the energy was firmed, and the PSCo bids might have assumed only a small percentage was firmed.

Table 5 compares the LCOE prices used in the ZNC Analysis with the Tucson Electric PPA and the median bid prices (meaning half the bids were higher, half were lower) that were sent in response to PSCo's RFP. A calculation of all-in LCOE is not the same as a PPA price, and the amount of renewable energy that was firmed is probably quite different. However, these are not small price differences.

Table 5: Comparison of Renewables Plus Storage Prices[31]

	ZNC Analysis LCOE	Tucson Electric RFP	PSCo RFP Indicative Median Non-Binding Bid
Wind, no storage	$45.00	N/A	$18.10
Wind with Battery Storage	$67.00	N/A	$21.00
Solar, no storage	$38.00	N/A	$29.50
Solar (PV) with Battery Storage	$72.00	$45.00	$36.00

The 286-MW CC in the ZNC portfolio would be considered an intermediate resource, not a peaking resource. Renewable energy plus storage is already displacing peaking resources on an economic basis, and this is a trend that is expected to continue.[32] It is possible that by 2030, renewable energy plus storage may begin displacing intermediate resources, as well. There are two recent examples of renewables plus storage replacing gas peakers on an economic basis. In 2014, Southern California Edison had selected NRG to build 262 MW of gas-fired generation to provide power on a limited, as-needed basis to ensure reliability in its Ventura County service territory (the Puente Power Plant in Oxnard, California). By 2017, as the plant was still in the regulatory process, the opposition to the project was so great (and the cost estimates for a battery storage alternative were so old and outdated) that NRG asked for a suspension of the filing. In December 2017, Southern California Edison filed a new plan that included a new transmission line and a plan to issue a new RFP in February 2018 for renewables plus storage.[33] The second example is Arizona Public Service's request for proposals for a peaking resource to serve load between 3 pm and 8 pm. On February 12, 2018, Arizona Public Service announced the

[31] Public Service Company of Colorado, "2016 Electric Resource Plan: 2017 All Source Solicitation 30-Day Report (Public Version), CPUC Proceeding No. 16A-0396E)," December 28, 2017. Downloaded using proceeding number from http://www.dora.state.co.us/pls/efi/EFI_Search_UI.search.

[32] See for example: University of Minnesota Energy Transition Lab: Institute on the Environment, "Modernizing Minnesota's Grid: An Economic Analysis of Energy Storage Opportunities," Minnesota Energy Storage Strategy Workshop Final Report, July 11, 2017, http://energytransition.umn.edu/wp-content/uploads/2017/07/Workshop-Report-Final.pdf

[33] Robert Watson for Utility Dive, "SoCal Edison's new alternative energy plan could be 'nail in coffin' for Puente gas plant," December 22, 2017, https://www.utilitydive.com/news/socal-edisons-new-alternative-energy-plan-could-be-nail-in-coffin-for-pu/513723/

selected technology was not a gas-fired peaker, but a 50 MW solar-fueled battery.[34] Battery energy storage is already becoming the preferred low-cost choice for future peaking resource needs. It may in time become much more economic even for intermediate resource needs.

Capacity Credit Assigned to Battery Storage

The peak credit for energy storage in the ZNC Analysis was assumed to be 75%.[35] Capacity credit is determined by the amount of energy available from the resource on average for the peak load period. All the fossil-fueled power plants in the ZNC Analysis were given a 100% capacity credit. In a response to an Energy Strategies question, Platte River indicated that their research, with support from HDR Engineering, indicated that 75% for battery storage was a "reasonable estimate." Their response also pointed to PSCo's recent assumption in its all-source RFP for a 75% capacity credit, and that the "value falls within the range of other findings as well." Energy Strategies was unable to find a publicly available document for the PSCo assumption but has no reason to doubt Platte River on this point.

The HDR Battery Assessment said that nearly 100% could be used, however, and provides no support for the reduction to 75%. In fact, the HDR Battery Assessment refers to an ICF report done for the Electric Reliability Council of Texas (ERCOT) that indicates that close to 100% is appropriate for a 4 MWh battery, even after acknowledging the ancillary services use of batteries.[36]

California, in the RESOLVE modeling used for the California Public Utilities Commission 2017 IRP, assumed 100% as the capacity credit for battery storage in sizes of 4 MWh and above.[37] (Utilities in California no longer develop their own IRPs; it's a system-wide integrated plan.)

As cited in the HDR Battery Assessment and as used by the California Public Utilities Commission, a battery storage capacity credit closer to 100% should be modeled as the base case or, at minimum, a sensitivity case, in future modeling runs.

Fixed and Variable O&M Values

The Fixed Operations and Maintenance (O&M) value in 2018 dollars for battery storage is listed in Figure 21 in the ZNC Analysis as $29 per kW-yr.[38] This is unreasonably high, and in fact is the highest

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[34] Arizona Public Service, "APS, First Solar Partner on Arizona's Largest Battery Storage Project," February 12, 2018. https://www.aps.com/en/ourcompany/news/latestnews/Pages/aps-first-solar-partner-on-arizonas-largest-battery-storage-project.aspx

[35] ZNC Analysis, p. 17.

[36] Johal, Tome, and Collison for ICF, "Unlocking the Hidden (Capacity) Value in Energy Storage," November 1, 2016, available at: https://www.icf.com/resources/white-papers/2016/unlocking-the-hidden-capacity-value-in-energy-storage

[37] Energy + Environmental Economics, "RESOLVE Documentation: CPUC 2017 IRP Inputs & Assumptions," September 2017, p. 76. Available at: http://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/irp/AttachmentB.RESOLVE_Inputs_Assumptions_2017-09-15.pdf

[38] ZNC Analysis, p. 30. While the column is labeled $/kW, Energy Strategies has confirmed the data in this column is $/kW-yr.

value across all the technologies listed in this table. The value listed for Li-Ion batteries per kW-yr in 2017 dollars in the HDR Battery Assessment is $6 to $14, across all three Li-Ion technologies.[39] Another resource, a PacifiCorp-commissioned study, finds Fixed O&M for Li-Ion batteries per kW-yr in 2016 dollars to be $6 to $11.[40]

Similarly, the Variable O&M value per MWh in 2018 dollars is listed in Figure 1 in the ZNC Analysis as $1.[41] The value in the HDR Battery Assessment report, while in 2017 dollars, is provided as $0.0003/kWh, which is equivalent to $0.30/MWh. The PacifiCorp-commissioned study on battery energy storage considers "energy storage Variable O&M to be "negligible."[42] Figure 1 in the ZNC Analysis may have rounded up rather than down for table presentation, but it may instead point to an inflation of the costs for battery storage that may have affected the model runs.

Ancillary Services Provided by Battery Storage

The ZNC Analysis notes that intra-hour modeling would be required to include the value of storage beyond capacity, that is, the value of fast-ramping, frequency regulation, and voltage control.[43] Energy Strategies recognizes that this early first step of modeling could not include all these sources of value. However, because of other identified issues (cost and capacity credit), Energy Strategies believes that battery storage was inappropriately eliminated at an early stage, precluding any analysis of these other sources of value. Energy Strategies strongly recommends battery storage be more fully considered in future modeling. If intra-hour ancillary services such as bridging services, spinning reserves, and peak shaving cannot be modelled for the IRP, these types of positive attributes should be noted in the qualitative discussion.

Another compelling use for battery storage is in *dispatchable demand.* If the amount of renewable energy being generated exceeds that which is sellable into the market for an acceptable price, battery storage can act as load or demand to "soak up" that excess energy, which then becomes dispatchable supply when needed.

4.3. Emissions Rate for Sales and Purchases

One of the more critical assumptions, the emissions rate applied to purchases and sales, was determined during the methodology process.[44] Platte River uses this emissions rate as part of the ZNC accounting: sales reduce the CO_2 in the balance sheet and purchases increase the CO_2.

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[39] HDR Battery Assessment, p. 9

[40] DNV GL for PacifiCorp, "Battery Energy Storage Study for the 2017 IRP," (hereafter: DNV GL Battery Storage Study), August 22, 2016, p 19. Available at: http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2017_IRP/10018304_R-01-D_PacifiCorp_Battery_Energy_Storage_Study.pdf

[41] ZNC Analysis, p. 30. While the column is labeled $/kW, Energy Strategies has confirmed the data in this column is $/kW-yr.

[42] DNV GL Battery Storage Study, p. 18

[43] ZNC Analysis, p. 17

[44] ZNC Analysis, p. 3-5.

Platte River decided upon 1,803 lbs/MWh based on non-baseload CO_2 emissions as reported in EPA eGrid data for the Rockies subregion.[45] In a response to a question, Platte River further elaborated that they were comfortable with the rate because it "falls between a gas and coal unit's emission rate, which seemed reasonable."[46] In other words, with the rate at 1,803 lbs/MWh, it implies that when Platte River sells excess renewable energy into the market, it is displacing, on average, half coal and half gas. While this assumption may seem reasonable in 2018, there is no analysis to show it actually is reasonable, and it will not be reasonable for sales made after 2030. Yet this one rate was used throughout the entire study period, to 2050.

The region's power generation portfolio is undergoing significant change. Since 2010 over 4,582 MW of coal-fired generation is the Western U.S. interconnection have been retired. At the same time, the region has been adding new and cleaner power generation resources. Over the same period 27,118 MW of zero-emitting wind and solar have been added to the region's generation portfolio. In addition, 5,397 MW of combined cycle power plants have been brought online. The CO_2 emissions rate of these units are half that of the coal-fired generation being replaced.

Looking forward between now and 2030, an additional 7,789 MW of coal-fired generation will be retired in the Western interconnect.[47] The regional grid is undergoing significant change and the assumed emissions rate used in the ZNC Analysis needs to more accurately reflect that change in order to provide a more accurate accounting of:

- CO_2 emissions reductions of Platte River's ZNC portfolio,
- MW capacity of new renewable resources needed to offset emissions of CO2 from gas-fired generation in the utility's resource portfolio, and
- Costs associated with adding new renewables to achieve the ZNC objective.

The mix of plants in operation in 2030, when Platte River becomes a net exporter, will be completely different than today—there may be very little coal left in the region, as either a baseload or intermediate resource. Given Xcel Energy's Colorado Energy Plan, Platte River may be selling excess renewable energy into a market that is already saturated with wind and solar, and renewables may be displacing gas peaking plants, effectively making the displaced-emissions rate much, much lower than 1,803 lbs/MWh.

Some of the risks of the changing generation portfolio in the region are acknowledged in the report.[48] The region's power plant emissions rate is and will continue to decline over time. And as noted in the section on ZNC Accounting, it is entirely possible—especially by 2050—that sales are actually curtailing

[45] ZNC Analysis, p. 5 and 7. The source showing the 1,803 lbs/MWh can be found in Table 3 of the eGRID2014v2 Summary Tables, created February 27, 2017, at https://www.epa.gov/sites/production/files/2017-02/documents/egrid2014_summarytables_v2.pdf

[46] Platte River Response to Questions from Energy Strategies, #1

[47] SNL Energy Regional Coal Unit Retirement Summary_v2

[48] ZNC Analysis, p. 24

other renewable energy sources, which would imply that the emissions rate that would be appropriate when accounting for sales would be close to zero lbs/MWh.

A single fixed proxy emissions rate for sales and purchases is too blunt a tool for a meaningful analysis of the feasibility and costs of achieving a zero-net-carbon portfolio. The Aurora model has the capability to identify the marginal dispatchable thermal unit and provide a more accurate estimate of the emissions rate of generation being displaced by Platte River's sales of renewable power in to the regional market. Future modeling of ZNC portfolios should use an emissions rate estimated dynamically by Aurora. The net effect of using a constant emission rate of 1,803 lbs/MWh in this study is to significantly understate the additional renewable energy capacity and costs needed to achieve Platte River's ZNC objective and overstate the CO_2 emission reductions achieved by the ZNC portfolio. With a different rate, or a less static rate, solutions such as battery energy storage may prove to be much more attractive as a least-cost resource option.

4.4. Natural Gas Prices

Given the increased role of natural gas-fired generation in the West, gas prices are an important determinant of Western electricity prices and the cost competitiveness of solar and wind resources. The addition of the 286 MW natural gas-fired combined cycle plant to the ZNC portfolio in 2030 increases the relevance of natural gas prices in evaluating the overall cost of the ZNC portfolio compared to the IRP reference case portfolio.

For the ZNC Analysis, Platte River used a single forecast of the annual delivered price of natural gas. This single forecast used Henry Hub forward prices over the period 2018–2050 as its base.

The first observation about Platte River's natural gas price assumptions is that the analysis only included a single price forecast. Natural gas markets have experienced episodes of extreme price volatility over the past decade. Projections of natural gas prices over the 32-year study period of this analysis should account for the uncertainty of natural gas markets in the future by including low and high natural gas price forecast sensitivities in addition to the base price assumptions.

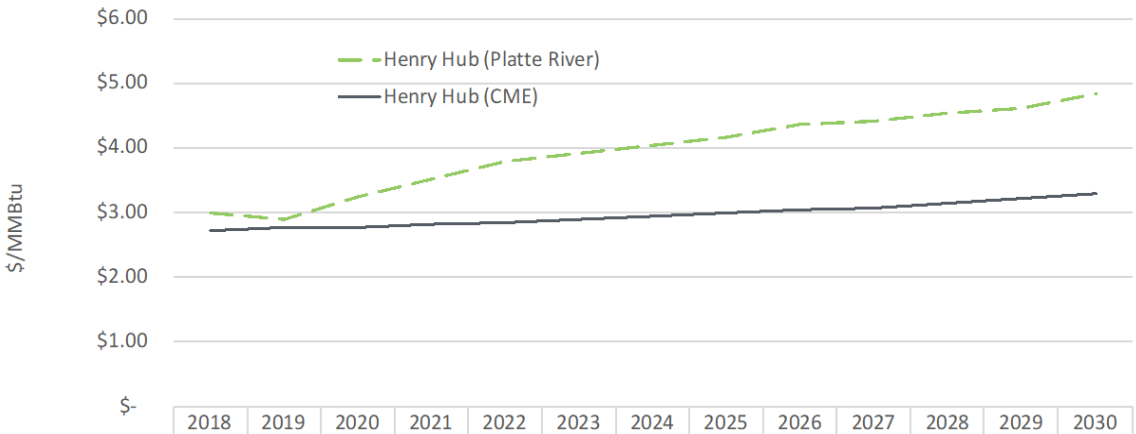
Second, the Henry Hub price forecast utilized in the ZNC Analysis appears to be quite high compared with recent price forecasts Energy Strategies has tracked in the wholesale gas markets. Figure 1 shows the Henry Hub price curve from the Platte River data (received in mid-January 2018) and the Henry Hub forward prices as of February 13, 2018 as published by CME.[49]

Although both price trends in the graph below are similar in the first two years, by 2030 the Henry Hub price assumptions used in the ZNC analysis are 47% higher than the CME price forecast of Henry Hub

[49] CME Group publishes the NYMEX Henry Hub futures prices from that traded forward market. As defined by CME Group in their website, "NYMEX, a Designated Contract Market offering products subject to NYMEX rules and regulations, became a part of CME Group in 2008."

prices for the same year. Forward prices do differ on a daily basis, however the reason for the difference between the two price forecasts cannot be explained from the information provided by Platte River.

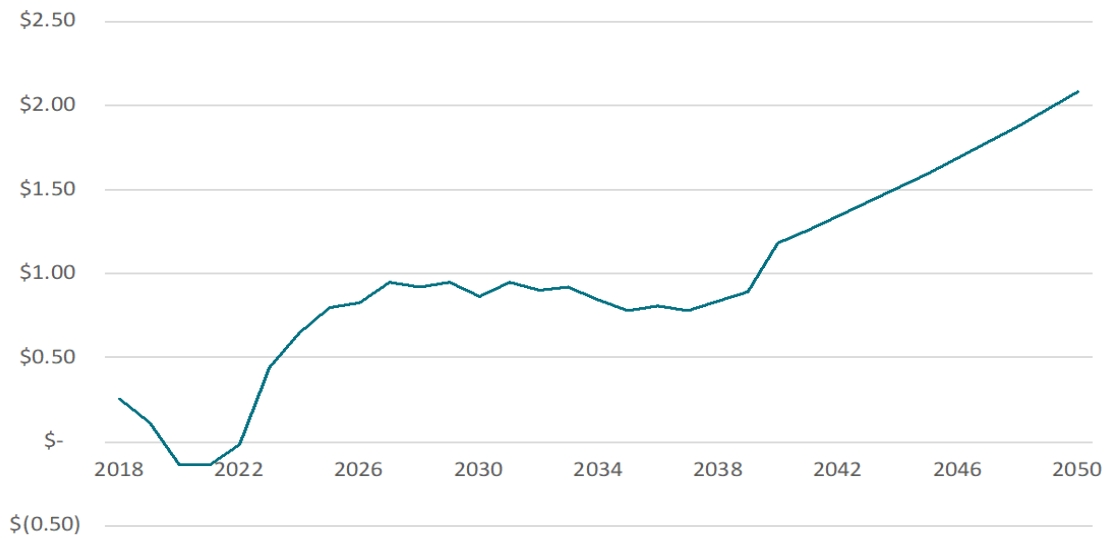
Figure 1: Henry Hub Forward Prices: Platte River Data and Current CME Data



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Henry Hub (Platte River)	$2.99	$2.89	$3.24	$3.51	$3.78	$3.91	$4.04	$4.16	$4.36	$4.40	$4.53	$4.61	$4.83
Henry Hub (CME)	$2.73	$2.78	$2.77	$2.81	$2.85	$2.89	$2.93	$2.98	$3.03	$3.08	$3.13	$3.21	$3.29

In addition to the Henry Hub natural gas commodity price forecast appearing to be high, the "delivered" price of natural gas to Platte River appears to be high, too. The "delivered" natural gas price is composed of the price paid for the natural gas commodity and the costs associated with delivery of the gas to a location, in this case, Platte River. The costs include the basis differential, pipeline transport costs, delivery costs charged by the local natural gas distribution company and other transaction-related costs. Platte River's forecasted gas prices show that the basis differential and non-commodity price components would contribute over 15% to Platte River's total delivered cost of gas. As previously discussed, the data received from Platte River combined all price components into a "Delivered Platte" price which does not separately define all non-commodity price components. Annual basis plus delivery can be calculated by subtracting the Platte River Henry Hub price for each year from the Delivered Platte price for each year. Figure 2 illustrates the calculated basis plus delivery price components for each year of the forecast.

Figure 2: Platte River Basis plus Delivery Costs



The large percentage variations in the early years of the forecast cannot be explained with the available data. Over the forecast period, basis plus delivery increases by 183%, averaging 5.4% each year. Generally, basis differential does not vary significantly over time and transportation and local distribution company rate regulation do not increase 5.4% every year. An average annual escalation rate nearer the rate of inflation, i.e. 2%, would be a more appropriate escalation rate for the basis plus delivery price components of the natural gas price assumption.

The ZNC portfolio's new 286 MW combined cycle plant is forecast to generate on average nearly one million MWhs of energy each year. As a result of increased natural gas consumption in the ZNC portfolio, higher forecasted Henry Hub prices combined with higher assumed escalation rates of basis and non-commodity delivery costs will impact the economic viability of the ZNC portfolio. If each of the suggested changes were made to the ZNC delivered gas forecast, Energy Strategies estimates the natural gas costs for the ZNC portfolio would be on average $18 million lower per year, equating to a $130 million reduction in the net present value of the ZNC portfolio.

4.5. Carbon Dioxide Prices

Platte River's 2016 IRP recognizes the importance of accounting for future CO_2 regulations in its resource planning decisions when it acknowledged ". . . It is likely that carbon regulations and the long-term goals of our communities will advance the need for portfolio changes."[50]

Pace Global's ZNC modeling includes a CO_2 price trajectory that reflected "a carbon regulatory future post 2024."[51] Including a price for CO_2 to model the ZNC portfolio is consistent with utility resource planning best practices and the 2016 IRP. However, Pace Global acknowledges the price trajectory used

[50] Platte River Power Authority IRP, p. 6
[51] ZNC Analysis, p. 5

in the ZNC analysis is "relatively low," doesn't start until 2024, and never rises above $10 in real terms (2018$).[52] The CO_2 price does not increase in real terms between 2035 and 2050.[53] Table 6 shows the CO_2 prices used in the analysis in nominal terms.

Table 6: ZNC CO_2 Nominal Prices

Year	$/ton CO_2
2020	$ -
2025	$ 3.96
2030	$ 8.73
2035	$13.10
2040	$14.46
2045	$15.96
2050	$17.63

Energy Strategies estimates that emissions costs are 11% of the IRP portfolio cost in 2030.[54] This is at the low nominal price of $8.73. If the CO_2 price were a little more than tripled, the 20% cost advantage in 2030 that the IRP portfolio has over the ZNC portfolio disappears. That is, the ZNC portfolio is actually cheaper in 2030 with just this one change in assumptions.

Energy Strategies acknowledges Platte River's commitment and Pace Global's efforts to account for the future regulatory risk and its inclusion of CO_2 prices in the ZNC Analysis. Still, Pace Global's "relatively low" CO_2 price assumptions and the use of a single set of CO_2 prices in the ZNC portfolio modeling falls short of what is required to adequately account for the real financial and environmental risks that CO_2 emissions may pose to Platte River, its owner municipalities, their ratepayers, and society at large.

Assigning a price to the emissions of CO_2 serves two important purposes in the resource planning and decision-making process. First, as Platte River acknowledges, CO_2 emissions are likely to be covered by federal or state regulation in the future. Its reliance on coal-fired generation exposes its owner municipalities and their rate payers to potentially significant costs to comply with those regulations. These regulatory risks and costs, to which Platte River and its owner municipalities are exposed, need to be accounted for in current and future resource planning decisions.

Second, carbon dioxide emissions impose negative economic and environmental externality costs on society and Colorado citizens in the form of climate change impacts. The costs associated with these types of negative economic and environmental externalities are captured in the Social Cost of Carbon (SCC). This measure is intended to capture all of the costs caused by climate change and tie those costs back to the effect that a single ton of carbon dioxide emissions has on society. The Interagency Working Group on Social Cost of Carbon defines the SCC as "an estimate of the monetized damages associated

[52] ZNC Analysis, p. 5
[53] Platte River Data Request Response to Energy Strategies, #9
[54] ZNC Analysis, Ex. 14, p. 21 ($19.6 million in emission costs, $174.8 million total cost for the IRP portfolio.)

with an incremental increase in CO_2 emissions in a given year" and notes that it is "intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change."[55]

Within the past year, the Colorado Public Utilities Commission has issued a decision requiring Public Service Company of Colorado to run a price sensitivity on resource portfolios to account for these economic and environmental externality damages using the SCC. The Commission directed the company to specifically use the SCC calculated at the 3% discount rate and listed in Table A1 of the Interagency Working Group on Social Cost of Carbon's Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis. These values range from $42 per metric ton of carbon dioxide in 2020 to $69 in 2050.[56]

Both CO_2 prices—an expected regulatory compliance cost and the social cost of carbon—are important assumptions for Platte River to include in the ZNC Analysis and future integrated resource planning analysis and resource decisions.

4.6. Regional Transmission Organization (RTO) Participation

The ZNC Analysis did not model Platte River as part of a Regional Transmission Organization (RTO), which would have significant implications on the results. Pace Global indicated there were uncertainties, including approval, participants, and market rules that made modeling Platte River's participation in an RTO difficult. It also acknowledged the significant risk and cost reduction that could be available to Platte River if it joins an RTO.[57] Pace Global further acknowledged that it has begun to analyze this option for Platte River.

Platte River is a member of the Mountain West Transmission Group (MWTG). In 2017, MWTG announced it would begin the process for becoming a member of the Southwest Power Pool (SPP) to take advantage of its wholesale electricity markets and to eliminate excessive transmission fees. MWTG is currently negotiating the terms and conditions of its membership into SPP. Given that Platte River could be a member of the SPP or another RTO in the near future, it would be appropriate to include a set of scenarios in the next modeling of the ZNC portfolio with Platte River as a member of SPP.

An RTO market should reduce transmission costs for resources, particularly for renewables. Under the RTO construct, transmission rate pancaking, whereby transmission customers incur multiple transmission charges for long-distance power deliveries, is removed and transmission costs are reduced. Because the ZNC Analysis assumed that two wheeling charges would be required for wind energy, it is reasonable to expect that remote wind from high-quality resource areas in SPP could be delivered at a

[55] Interagency Working Group on Social Cost of Carbon, U.S. Government, 2015. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 (May 2013, Revised July 2015).

[56] Interagency Working Group on Social Cost of Carbon, U.S. Government, 2015. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 (May 2013, Revised July 2015).

[57] Pace Global presentation, "Zero Net Carbon Portfolio Analysis," December 12, 2017, Slide 31

lower cost in a future in which Platte River is a member of SPP. In addition, an RTO provides a more liquid market for energy purchases and sales. As a member of SPP, Platte River will have a larger market to sell renewable energy as required by the zero-net-carbon strategy. However, a larger market also typically means lower prices for both purchases and sales. So while Platte River might find a home for its "excess" renewable energy in the SPP marketplace, it is likely to receive a lower price for that energy than if it were outside an RTO.

4.7. Goal Date of 2030

The ZNC Analysis did not attempt to assess the feasibility and costs of Platte River accelerating its transition to a ZNC portfolio. Both the target date of achieving a ZNC portfolio and the shutdown of the utility's coal-fired generation capacity were hardwired to occur in 2030. This hardwired input also dictated the timing for adding renewable energy resources.

There is an argument to be made for Platte River to evaluate the feasibility and costs of retiring its Craig coal-fired generation units earlier than the 2025 and 2030 dates assumed in the analysis. According to the 2016 IRP, much of the of generation from Platte River's 154 MW share of Craig Units 1 and 2 "is marketed to other utilities as surplus sales, and generally not required to meet the loads" of its owner municipalities. The IRP also says that the generation from Craig "lags behind Platte River's Rawhide plant in performance, costs and reliability."[58]

If Platte River could negotiate exiting both Craig units between now and 2025, retirement of these units from its portfolio could be accomplished while still maintaining a minimum 15% reserve margin. Moreover, it could allow Platte River to avoid some or all of the on-going variable and fixed operation and maintenance costs that have averaged an estimated $36.8 million over the last three years.[59]

Because of the hardwired 2030 date, the ZNC portfolio doesn't ramp up the procurement of renewable energy capacity until 2025.[60] There is a potential cost to Platte River of delaying purchases of wind and solar resources until 2025. The Federal PTC and the Investment Tax Credit for wind and solar renewable energy projects are scheduled to phase out over the next several years. A resource procurement strategy that takes advantage of the remaining time during which tax credits are available could allow Platte River to capture the benefits of lower cost resources. An analysis Energy Strategies prepared for the American Wind Energy Association (AWEA) California Caucus in the fall of 2017 found the LCOE from wind projects that were able to capture the full benefits of the PTC was 44–52% lower than the LCOE of energy from wind projects that come on line after the expiration of the PTC in 2026.[61]

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[58] Platte River 2016 Integrated Resource Plan, p. 37. https://www.prpa.org/wp-content/uploads/2016/08/06-01-IRP-final-report-2016.pdf

[59] Platte River Power Authority Annual Budget, 2015-2018.

[60] ZNC Analysis, p. 11

[61] Energy Strategies, "Relative Value of the Full Production Tax Credit for Wind Resources." Analysis prepared for AWEA California Caucus by Energy Strategies, October 2017, https://www.energystrat.com/new-insights-experience/

In response to its recent wind RFP, Platte River received proposals offering up to 1,430 MW of wind. Presumably the pricing on most, if not all of these projects, would be able to take full advantage of the PTC. Platte River has already taken a first step toward this objective by signing a PPA with Enyo Renewable Energy for 150 MW from its Roundhouse Project. The agreement also provides Platte River with the option of purchasing up to 75 MW of additional wind capacity by the end of 2018. Coupled with a solar RFP, the remaining projects represent a potential opportunity for Platte River to accelerate its procurement of renewable energy and capture the financial benefits of the tax credits before they expire.

Early achievement of the ZNC goal by accelerating the procurement of renewable energy and moving up the retirement dates of Platte River's coal-fired generation may be of financial benefit to Platte River and the owner municipalities it serves. However, there is also an important environmental and societal benefit that would result from Platte River taking earlier action on these resource decisions. The extent and effects of climate change depend on how much, and how quickly, CO_2 emissions are reduced. For purposes of stabilizing the effects of climate change and limiting temperature increases, it is better to reduce CO_2 emissions today than postponing action to a later date. Future emissions cause incrementally larger environmental damages. By taking action earlier and accelerating the reduction of CO_2 emissions from its generation portfolio, Platte River would be making a more valuable contribution to mitigating the environmental damages of climate change than if it postponed its efforts to reduce emissions to 2030 or later.

4.8. Demand-Side Resources

Demand-side resources (DSR) are often the lowest cost components of a utility's resource portfolio. In a recent briefing to the Platte River Board of Directors, the utility's 2017 demand-side programs were reported to have delivered 25,900 MWh of energy savings and 4.1 MW of avoided capacity at a LCOE of $38/MWh.[62] Unfortunately, DSR was treated differently in the ZNC Analysis than it is usually handled in the IRP process. Platte River provided Pace Global a load forecast to use that already included DSR. DSR includes energy efficiency and demand response tools, such as time-of-use rates. This single load forecast also included Platte River's assumptions about the penetration of customer-owned distributed generation and electric vehicles. By providing a load forecast to Pace Global that already included energy efficiency, it's impossible to tell if additional DSR would be cost-competitive with supply-side resources (such as the CC plant). Usually in an IRP process, DSR is available alongside supply-side resources, and the amount and cost of various levels of DSR is quantified. In the ZNC Analysis, there was little transparency provided regarding DSR. The load forecast used in the ZNC Analysis is lower than the load forecast used in the 2016 IRP. Platte River indicated they continually update their forecasts, and the main driver in recent updates was the penetration of distributed solar.

It is important for stakeholders to know the assumptions made regarding demand-side resources. Sensitivity testing around some of these assumptions could dramatically alter the required size of the

[62] Platte River, Energy Efficiency Program Year-End Results for 2017, Memorandum to the Board of Directors, February 14, 2018.

resource portfolio. Incorporating demand-side management tools may be a strategy for reducing capacity-driven resource additions. This would reduce the need to overbuild renewable resources, which have relatively low capacity credit. Increased demand reduction programs would result in a smaller build-out of renewables and gas-fired generation to meet the capacity needs of the system. It would also reduce the need to run Platte River's quick-start combustion turbines, which are used primarily for capacity purposes and represent the utility's most expensive resources.

Future analysis should evaluate the effects of including more demand-side measures, including distributed generation penetrations. The assumptions should be more transparent for stakeholder review. Platte River has baseline levels of energy efficiency, demand response, and distributed generation represented, but if it were to conduct a detailed study of the cost of enhancing these programs (especially energy efficiency and demand response), then perhaps there would be a net benefit with that expansion under a ZNC future. This is especially true given the fact that the resulting portfolio showed a capacity need in the form of a combined cycle unit in 2030. These technologies might cost-effectively avoid that need.

4.9. Combined Cycle Plant

In the ZNC portfolio, as the coal resources are retired, Platte River adds a 1x1 GE 7F.05 combined cycle plant in 2030. The ZNC Analysis says "The combined cycle resources are added primarily to meet the reserve margin needs of the system."[63] With the addition of this 286 MW resource, the reserve margin in 2030 reaches 47%.

Once this unit was selected as part of the low-cost model, Energy Strategies assumes the model dispatches this unit when it is needed to meet load, and/or when it is economic to make sales into the market. In 2030, when both Craig and Rawhide production is removed from the supply stack, the combined cycle unit would operate at a capacity factor of approximately 38%, based on modeled production volumes.

From 2030 to the end of the analysis period in 2050, the capacity factor of the combined cycle would increase yearly until hitting its highest point in 2040 at just over 46%. The effective capacity factors of the modeled combined cycle illustrate that a substantial portion of its capacity is not fully utilized. The capacity factors of the combined cycle unit for every five years starting in 2030 are illustrated in Table 7, along with the respective annual reserve margin percentages.

Table 7: Capacity Factors and Reserve Margin of the ZNC Portfolio

Year	2030	2035	2040	2045	2050
Capacity Factor	38%	43%	46%	40%	42%
Reserve Margin	47%	45%	42%	40%	36%

[63] ZNC Analysis, p. 18

The listing of key assumptions in the ZNC Analysis indicates that the cost modeling for the study was designed to maintain a reserve margin of 15%. It must be noted that Platte River's current reserve margin is already significantly above that level (it is 38%). The addition of the combined cycle in 2030 pushes the reserve margin even further above the required level. At 47% in 2030, the reserve margin is nearly 3.5 times higher than required. It is still about 2.5 times higher than required at the end of the analysis period, in 2050, when the reserve margin is 36%. A smaller combined cycle option or additional market purchases would appear to be reasonable alternatives.

Platte River indicates that the "size of the [combined cycle] added in the model is based on standard products offered by GE, with performance and cost estimates supplied by HDR Engineering."[64] Platte River also said that "substantially smaller" combined cycle units were included as inputs to the model but were not selected as part of the least-cost solution. Although smaller 1x1 combined cycle options were included in the model, all of them were higher cost aero-derivative gas turbines with significantly lower efficiency than the GE 7F.05 1x1 selected by the ZNC case. It would be helpful to understand why smaller GE frame units were not considered. GE offers two other 7F 1x1 units (i.e., 7F.04 and 7F.03), each of which have lower MW capacity and installed cost than the modeled 7F.05. The lower installed cost and relatively similar heat rates of the smaller GE frame options would help alleviate the large excess in reserve margin, and act to reduce the overall cost of the ZNC portfolio.

Platte River's ZNC analysis should also evaluate the costs of conversion of the Rawhide GE 7FA turbine to a 1x1 combined cycle facility as a strategy for managing intermittency of the ZNC portfolio's renewable resources and maintaining Platte River's reserve margin. In the 2016 IRP, Platte River evaluated the conversion of the simple cycle GE 7FA unit at their Rawhide CT plant to a 1x1 CC. The 7FA is a 128 MW unit (150 MW nameplate). According to the *Portfolio Options by Strategy* table in the 2016 IRP, conversion of the 7FA from simple to combined cycle would increase the unit's capacity by 86 MW, making the total capacity approximately 214 MW.[65] The conversion of the 7FA would capitalize on the existing investment of the combustion turbine already in place.

The ZNC Analysis shows a system that is already at relatively high levels of reserve margin adding large volumes of renewable resources and a 286 MW combined cycle plant. The result is to further expand Platte River's excess reserve margin and the ZNC portfolios costs. By including the smaller GE frame combined cycle options or the conversion of the simple cycle GE 7FA unit to a 1x1 combined cycle unit as resource options in the ZNC Analysis, Platte River could potentially provide the firming for the renewable energy resource additions and reduce the total cost of the ZNC portfolio cost.

[64] Platte River Data Request Response to Energy Strategies, #11
[65] Platte River Power Authority, "2016 Integrated Resource Plan," June 15, 2016, p. 40, https://www.prpa.org/wp-content/uploads/2016/08/06-01-IRP-final-report-2016.pdf

4.10. Discount Rate for Portfolio Net Present Values

In the Colorado Public Utilities Commission decision approving PSCo's 2016 Electric Resource Plan (Decision No. C17-0316), the Commission directed PSCo to use its after tax weighted average cost of capital in calculating net present values for its various modeled portfolios. In addition, it directed PSCo to present two sensitivity runs using two alternative discount rates, 0% and 3%.[66] Pace Global used 3% in the calculations of net present value (NPV) for the two portfolios in the ZNC Analysis.

Energy Strategies looked at the effect of the use of a 3% real discount rate in the ZNC Analysis. Generally, higher discount rates are an advantage to fossil-fuel portfolios, since they have long-term fuel costs, whereas renewable portfolios do not. In this case, renewable energy appears to be handled in a PPA-like fashion (costs spread equally over a long period of time, rather than an upfront investment), so the ZNC portfolio is not particularly affected by the discount rate against a more traditional portfolio. Energy Strategies found the 8% cost advantage favoring the IRP portfolio on a 2018 – 2030 NPV basis fell to 7% by using a 0% discount rate. This is not a meaningful difference. Energy Strategies finds the 3% real discount rate is appropriate.

4.11. Stakeholder Involvement

Stakeholder involvement in the ZNC Analysis was limited to Platte River Board of Directors responding to a request from stakeholders for the utility to evaluate the costs and operational impacts of a "100% net carbon-free resource" for the four owner municipalities. While the Board should be commended for agreeing to conduct the ZNC analysis, the development of the modeling approach and input assumptions was undertaken without any stakeholder involvement and lacked transparency. It was only after release of the study that Platte River agreed to consider inputs on the modeling and data assumptions that went into the analysis. The ZNC study is the foundation upon which hundreds of millions of dollars could be invested by Platte River on the part of its municipal owners and their customers. Transparency and public involvement is a necessary element of planning efforts such as the ZNC analysis.

5. Conclusions and Recommendations

With this study, Platte River has taken an important first step to account for the structural trends that are taking place in the electric utility industry and respond to the expressed interest of the owner municipalities and their customers to reduce CO_2 emissions and provide cleaner sources of power. The changes in the industry are being driven by:

- fundamental shifts in customer energy demand and expectations for cleaner energy,
- technology advancements and dramatically falling costs of alternative supply options,
- more stringent environmental regulations, and

[66] Colorado Public Utilities Commission Decision No. C17-0316, proceeding No. 16A-0396E, p. 31–33, available at http://www.dora.state.co.us/puc/PUCsearch.html

- pressure to maintain affordable rates.

Energy Strategies reviewed the Platte River ZNC Analysis' modeling approach, data inputs, and assumptions. The intent of our review was to identify gaps in the analysis, assess the accuracy and reasonableness of data inputs and assumptions and offer recommendations on how the analysis could be improved to provide a more robust and complete assessment of the costs to Platte River of transitioning to a zero-net-carbon or 100% renewable zero-carbon resource portfolio. We found a number of opportunities for improvement. We offer the following conclusions and recommendations for consideration by Platte River's management team, resource planners, municipal owners and stakeholders participating in future resource planning processes.

ZNC Accounting

Energy Strategies believes the ZNC accounting scheme adopted in this analysis has limited value as a metric for use in resource planning and decision-making. The ZNC accounting scheme is problematic because it lacks relevance to existing or proposed regulatory schemes to regulate emissions of carbon dioxide. It is also dependent on a single proxy emissions rate that inaccurately reflects regional emissions rates and resource transition occurring in the Colorado market and broader WECC region. Lastly, it requires Platte River to procure resources and incur costs in excess of what is needed to serve its load. Moreover, there is no assessment of whether there will be a market for the excess renewable energy Platte River is required to sell to achieve ZNC.

It is possible that CO_2 reductions can be achieved at lower cost if Platte River adopts a CO_2 emissions reduction goal that is based on actual tons of CO_2 reduced.

Recommendations

- Energy Strategies recommends Platte River abandon the ZNC accounting scheme and instead work with its owner municipalities and stakeholders to develop a baseline CO_2 emissions forecast and then establish CO_2 reduction goals for the utility that would be achieved within a specified time period (either total tons or tons per year).

- If the ZNC portfolio approach is used in future resource modeling, Platte River should apply a more accurate emissions rate that changes over time by employing the full capabilities of the Aurora model to dynamically identify the emissions rate of the marginal dispatchable generation units in the region at the point in time that Platte River is selling excess energy or purchasing energy in the regional market.

Modeling Approach

The ZNC Analysis conducted by Platte River was a limited "proof-of-concept" study. The analysis only evaluated a single ZNC resource portfolio and did not include sensitivity analysis of the results to account for the uncertainty of assumptions such as future load growth, fuel prices, capital and operating costs and performance of new supply technologies, and costs of environmental regulations. Evaluation of a number of portfolios using a range of sensitivities on assumptions would help Platte River and its

owner municipalities better understand the full range of costs and risks the utility would be exposed to under different resource portfolio scenarios and modeling assumptions.

Another limitation of the ZNC Analysis is the dependence on "least-cost" as the primary metric for portfolio selection. In the changing utility business environment, least-cost and reliability metrics alone are not a sufficient basis for decisions on the selection of a resource portfolio.

Recommendations

- Future resource planning and analysis should evaluate more than one zero-net-carbon and/or zero-carbon portfolio.
- Each portfolio should be tested with a high and low range of prices and other key data inputs to assess the sensitivity of the results to changes in assumptions such as future load growth, fuel prices, capital and operating costs, performance of new supply technologies, and costs of environmental regulations.
- Evaluation and selection of a preferred portfolio should be based on the performance of the portfolio against a range of metrics, including fuel price risk, environmental costs and impacts, supply diversity, reliability, and impacts on customers' bills; not just "least-cost."

Renewable Energy and Storage Modeling Assumptions

Platte River's modeling assumptions for renewable energy and energy storage were overly conservative. Reasonable assumptions about costs, performance, and availability of each resource option based on the most current market information should be used in the evaluation of future resource portfolios.

Recommendations

- Renewable energy price assumptions should be developed by a thorough process of price discovery that takes into account published independent third-party costs estimates and the most current renewable energy PPAs in the region.
- Renewable energy capacity factors that more accurately account for technology advancements and efficiency improvements should be used. Assuming future renewable energy supply options will have the same performance as resources in Platte River's current portfolio may be a conservative assumption, but it is not reasonable. If capacity factors are unknown, Platte River should evaluate renewable resources using two sensitivities that reflect low and high capacity factors.
- Capacity credit values assigned to wind and solar resources and battery storage should be based on an Effective Load Carrying Capability (ELCC) study of the Platte River system.
- Battery storage in sizes of 4 MWh and larger should receive capacity credit of 100%. Alternatively, Platte River could evaluate a capacity credit for battery storage at 75% in a base case, and a 100% capacity credit in a sensitivity case.

- Battery energy storage capital and operating cost assumptions used in the ZNC Analysis did not reflect the dramatic cost decreases currently seen in the market. More current capital and operating cost assumptions should be used in future resource assessments. Given the uncertainty of future costs, modeling sensitivities around a range of capital costs, especially, would allow Platte River to identify the price point at which battery storage would be compelling as an alternative to more fossil-fueled generation.

Regional Transmission Organization Participation

Platte River may be part of the SPP or another RTO in the near future. This will have an important impact on the costs and operations of Platte River's resources and system. Joining an RTO will reduce transmission costs and provide a more liquid market for energy purchases and sales. It will also affect the emissions rate used to calculate Platte River's zero net carbon position relative to its CO_2 emissions goal.

Recommendations

- Despite the expressed challenges of modeling Platte River's participation in an RTO like the SPP, every effort should be made to incorporate this into future modeling, due to the impact it will have on future resource decisions and the ZNC accounting approach.

Pricing Carbon Dioxide to Account for Regulatory and Environmental Risks

Assigning a price to CO_2 emissions in the resource-planning and decision-making process serves two important purposes. First, CO_2 emissions are likely to be covered by federal or state environmental regulations in the future. This regulatory risk and the associated cost needs to be accounted for in resource decisions. Second, CO_2 emissions impose negative economic and environmental externality costs on society and Colorado citizens in the form of climate change impacts. Both prices are important assumptions for Platte River to include in the ZNC analysis and future resource planning decisions.

Recommendations

- Energy Strategies recommends that Platte River's future ZNC portfolio analysis and integrated resource planning processes be run using at least two CO_2 price sensitivities:
    - The CO_2 prices representing regulatory costs should be based on modeling analyses of the Clean Power Plan (CPP) that are available in the public domain. PSCo's 2016 Electric Resource Plan proposed to use modeling and data from three such studies prepared by the Environmental Protection Agency, the North American Electric Reliability Corporation, and MJ Bradley Associates. These sources would provide Platte River with a solid foundation upon which to develop a set of CO_2 prices to run a sensitivity based on a regulatory future Platte River will likely face over the life of its generation resources.
    - A price sensitivity using the Social Cost of Carbon (SCC) should be included in future ZNC portfolio analysis and integrated resource planning modeling to account for the economic and environmental damages associated with climate change. Colorado Public Utilities Commission

issued a decision directing PSCo to run a price sensitivity on resource portfolios using the SCC calculated at the 3% discount rate and listed in Table A1 of the Interagency Working Group on Social Cost of Carbon's Technical Update.[67]

Demand-Side Resources

In the ZNC Analysis, Platte River incorporated energy efficiency, demand response, and distributed generation as an adjustment that reduced its load forecasts. These resource options offset energy consumption, can contribute to capacity planning requirements, defer investments in transmission and distribution upgrades, and mitigate environmental regulatory and fuel price risks. Moreover, they are typically lower cost than conventional supply-side resources. Platte River should treat demand-side resources in future ZNC or resource planning modeling consistent with the way it models supply-side resources.

Recommendations

- Platte River should develop levelized cost curves for demand-side resources and distributed generation and include these resources as energy supply options in the Aurora model in future ZNC analysis or integrated resource planning. Doing so would allow the Aurora model to choose the amount of demand-side and distributed generation resources that are cost effective relative to other conventional supply-side options.

Combined Cycle Capacity Additions

The ZNC portfolio includes a 286 MW combined cycle natural gas fired plant to maintain planning reserve margins and shape and firm the substantial amounts of new wind and solar resources added to the ZNC portfolio. The cost of this resource is substantial, approaching $350 million. There may be less expensive options for adding combined cycle generation capacity to Platte River's generation portfolio that would lower the cost of the ZNC portfolio.

Recommendations

- Platte River should include smaller combined cycle GE frame units as resource options in the Aurora model and evaluate the conversion of one or more simple cycle units at the Rawhide CT plant to combined cycle production, specifically, the 7FA unit installed in 2008.

Natural Gas Prices

The addition of the 286 MW natural gas fired combined cycle plant to the ZNC portfolio in 2030 increases the relevance of natural gas prices in evaluating the overall cost of the ZNC portfolio compared

[67] Interagency Working Group on Social Cost of Carbon, U.S. Government, 2015. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 (May 2013, Revised July 2015).

to the IRP reference case portfolio. Natural gas markets have experienced episodes of extreme price volatility over the past decade.

Recommendations

- Natural gas price projections should account for the uncertainty of natural gas markets. Platte River should include low and high natural gas price forecast sensitivities in addition to its base price assumptions in its resource planning assessments.

Timing of Coal Unit Retirements

Early achievement of the ZNC goal by accelerating the procurement of renewable energy and moving up the retirement dates of Platte River's coal-fired generation may be a financial benefit to Platte River and the owner municipalities it serves.

Recommendations

- Modeling of future resource portfolios during the next ZNC analysis or IRP process should include scenarios in which Platte River evaluates the economic and environmental trade-offs of retiring its coal-fired generation fleet prior to 2030 and accelerating its procurement of renewable energy resources and battery storage supply options.

Stakeholder Involvement in ZNC and Zero Carbon Planning

A robust and meaningful stakeholder process is essential to ensure Platte River's resource decisions are aligned with municipal owners' and stakeholders' shared energy, public health, and environmental goals. Energy Strategies acknowledges Platte River's substantial public outreach efforts to engage stakeholders after the release of the ZNC Analysis. However, the stakeholder process can be improved in order to increase the level of transparency and provide stakeholders with the opportunity to be more engaged and provide meaningful input during future resource planning efforts.

Recommendations

- Platte River should adopt a collaborative, transparent process for receiving input and recommendations from stakeholders for the next cycle of resource planning.

- Interested stakeholders should be given the chance to take an active role in the creation of the resource plan and allowed to provide input into the design of resource portfolios, verify modeling input assumptions, assess the validity of the results, and evaluate the results in the context of community and state policy goals and objectives.

- The process should include workshops where technical details of resource portfolios, modeling approaches, and assumptions can be provided and discussed.

Concluding Remarks

Energy Strategies believes that future resource decisions addressing the utility industry's transition to cleaner, affordable, and new resource options should be informed by comprehensive modeling, thorough analysis, the most current and best information on performance and cost of resource options, and the involvement of stakeholders.

The ZNC Analysis was an acknowledged "proof of concept" study whose value as a resource planning tool was severely limited. The analysis only evaluated a single ZNC portfolio and used a single set of overly conservative assumptions regarding the price, capital costs, and performance of renewable energy, energy storage, and demand side resource options. However, even with these constraints the study concluded that Platte River could transition to a resource portfolio that supplied 76% of Platte River's electricity load with renewable energy, reduced its CO_2 emissions by 86% and did so at a cost that was only $221 million (8%) more on a NPV basis than the 2016 preferred IRP portfolio. The use of more reasonable assumptions could easily have resulted in the ZNC portfolio actually being the least-cost portfolio.

The recommendations that Energy Strategies has provided, if adopted, will affect the process for how future resource portfolios will be defined, how the costs of those resource portfolios will be evaluated and will result in a more robust and meaningful assessment of resource options that would enable Platte River to transition to a zero-carbon portfolio.

Key recommendations that would primarily affect the process of defining future resource portfolios include: (1) the use of a more appropriate and accurate emissions rate for ZNC accounting or the replacement of the ZNC scheme with a CO_2 emissions reduction goals; (2) creating and evaluating several portfolios with different combinations of zero carbon resource options; (3) modeling demand side resources and distributed generation in a consistent and comparable manner as supply side resources; (4) evaluating the economic and environmental trade-offs of earlier coal unit retirement and accelerated renewable energy procurement; and (5) adoption of a more transparent community engagement process that would allow stakeholders an early and active role in the development of resource scenarios and input assumptions.

Those recommendations that would primarily impact the costs of resource portfolios include: (1) the use of more reasonable and current assumptions about costs and performance of renewable energy, energy storage, demand side resources and distributed generation; (2) running sensitivities on CO_2 prices and natural gas prices to account for regulatory and market risks and uncertainty; and (3) evaluating smaller combined cycle units and/or less expensive options for shaping and firming renewable electricity supplies, and (4) modeling Platte River's system as part of a RTO.

Energy Strategies encourages Platte River to continue the analysis and research it has begun into a zero-carbon future. By meeting the structural changes coming to the utility industry with a thorough assessment of resource options, thoughtful deliberation and stakeholder involvement, Platte River will be able to meet the environmental goals of its owner municipalities while still providing reliable, affordable energy.