



Salt Lake City

Communities Renewable Energy Study:

Analysis of impacts and benefits associated with transitioning to 100 percent renewable power

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Executive Summary

The municipalities of Salt Lake City, Park City, and Summit County ("Communities") are interested in expanding their efforts to develop renewable energy and reduce reliance on electricity generated from fossil fuels. This Community Renewable Energy Study ("Study"), which was prepared to fulfill Solicitation 2016-014, evaluates the cost and rate impacts associated with serving all of the electricity load of Residential, Commercial, and Industrial customers within the Communities with renewable energy. This Study also examines the environmental and economic co-benefits of a transition to 100% renewable energy.

This Study calculates and compares the differences in electricity expenditures and rates for the Communities' residents and businesses continuing to receive electricity supply from Rocky Mountain Power's standard resource portfolio or transitioning to 100% renewable energy. The renewable energy supply scenarios were selected on the basis of being least-cost and in-state, which resulted in all portfolios consisting of utility-scale photovoltaic (PV) solar. Each community set 2032 as the target year for 100% renewable energy, and Summit County requested additional analysis with 2040 as the target year. This Study analyzed scenarios that varied the timing of the acquisition of the renewable energy resources, with each community either acquiring resources on an accelerated basis (resulting in achievement of the goal early, in 2022), at a fixed annual amount between 2019 and the target year, or on a schedule in which most of the resources are obtained in the first three years, with the balance acquired by the target year. This Study also looked at two approaches to achieving 100% renewable energy: Community Renewable Energy Tariffs and Community Choice Aggregation. In addition to the cost impacts, this Study calculates the economic and environmental co-benefits of a change to 100% renewable energy.

If the Communities replace standard-offer service with 100% renewable energy, the costs for residents and businesses will be modestly higher. However, the benefits include dramatic reductions in greenhouse gas emissions and criteria pollutant emissions, water savings, and economic development benefits to Utah.

The results show that rates would be 9% to 14% higher in 2032 for the Communities, versus business-as-usual. Community Choice Aggregation would be more expensive than Community Renewable Energy Tariffs. Steady, incremental acquisition of renewable energy would reduce rate shock, with rates only slowly moving higher than business-as-usual. The accelerated acquisition schedules, which would allow the Communities to achieve the targets in 2022, could result in rate shock, with 2021 rates

12% to 16% higher than business-as-usual in 2021 for a Community Renewable Energy Tariff. The emissions savings were significant, with 0.9 million to 2.1 million tons of carbon dioxide (CO₂) emissions avoided in 2032, if all three Communities pursue 100% renewable energy on this timeline. The cumulative avoided GHG emissions over the 2019-2032 period would total between 7.0 to 18.0 million tons.

These results should be considered guidance as to direction and magnitude of the economic and environmental impacts of transitioning to 100% renewable power; they are based on one set of assumptions and forecast results 15–25 years into the future. Major assumptions include the continued deployment of significant new energy efficiency measures that reduce load growth, the growing adoption of customer-owned net metered solar PV on the system, the use of utility-scale PV solar in Utah that averages \$44 to \$48 per megawatt-hour (MWh), and Rocky Mountain Power standard-offer rates increasing at 2.13% per year on average.

This analysis did not attempt to quantify the long-term benefits that a 100% renewable electricity supply offers residents and businesses in maintaining affordable and stable electricity rates. Electricity generated from renewable energy sources is not subject to the same regulatory and price volatility risks as Rocky Mountain Power's fossil-based energy portfolio.

This Study was conducted by creating a model that uses each Community's unique electric energy use data, but with a single methodology and set of assumptions to analyze the costs and rate impacts of adopting a 100% renewable electric supply. This report is one of three that summarizes the results specific to each community.

Replacing Rocky Mountain Power's electricity supply with 100% renewable energy will result in electricity costs for residents and businesses that will be modestly higher than continuing to take standard offer electricity service from the utility. The benefits this report quantifies include dramatic reductions in greenhouse gas emissions (GHG) and criteria pollutant emissions, water savings, and substantial economic development benefits to Utah. Benefits that were not quantified—but are likely—are the advantages renewable electricity offers in maintaining stable rates in the future and the hedge it provides against volatile natural gas prices.

Introduction

Salt Lake City, Park City, and Summit County are committed to incorporating environmentally, socially, and economically sustainable practices in government operations and in the services and program opportunities they provide residents and businesses. All three Communities have adopted policies and programs to enhance economic resiliency, community vitality, and environmental quality through initiatives

promoting cleaner air, energy efficiency, mass transit, less-polluting transportation options, climate change mitigation, and renewable energy.

Central to the Communities' environmental sustainability initiatives are goals regarding renewable energy and GHG reductions. Transitioning to renewable energy reduces GHG emissions, as most traditional energy resources rely on GHG-emitting fossil fuels. All three Communities have adopted climate change goals to reduce GHG emissions in their government operations and communities. Both Salt Lake City and Park City have adopted aggressive goals to transition to 100% renewable energy for community-wide electricity supply by 2032. Salt Lake City, as part of its strategy to lead by example, also committed to procure 50% renewable energy for city government facilities by 2020 and 100% by 2032. Park City adopted a community-wide net-zero carbon goal by 2032, the most ambitious carbon goal in North America, and committed to 100% renewable electricity for all city operations by 2022.

The Communities are interested in expanding their efforts to develop renewable energy and reduce their reliance on electricity generated from fossil fuels. In light of dramatic reductions in the cost of renewable energy in the last five years, the Communities see an opportunity to provide long-term stability in the cost of cleaner electricity for their communities. In addition, the Communities recognize the significant GHG emissions reductions opportunities and other health, air, and water co-benefits that could be achieved by pursuing 100% renewable energy-electricity targets.

In light of dramatic reductions in the cost of renewable energy in the last five years, the Communities see an opportunity to provide long-term stability in the cost of cleaner electricity for their communities.

In recognition of the opportunity to procure more clean power, manage electricity price risk, and provide affordable renewable energy from more local sources, Summit County, on behalf of the Communities, issued a Request for Proposals (RFP) in May 2016 (Solicitation 2016-014). The Request required a consultant to prepare a Community Renewable Energy Study evaluating the costs, rate impacts, and the environmental and economic co-benefits associated with the Communities meeting 100% of their electricity loads with renewable energy.

Project Team

To support the Communities' efforts to change their community-wide electricity supply to 100% renewable energy and reduce their reliance on carbon-intensive fossil fuels, the Communities selected Energy Strategies, LLC to conduct the renewable energy feasibility assessment. Energy Strategies has extensive experience assisting private

companies, institutions of higher education, and government agencies evaluate the technical, economic, and regulatory feasibility of renewable energy and other clean energy technologies. The firm has conducted more than 100 technical, economic, and financial investment analyses and regulatory assessments of co-generation systems and renewable energy, both at utility scale and distributed generation levels, for both public and private sector clients. In 2015, a consulting team led by Energy Strategies completed a renewable energy plan for Salt Lake City's Department of Public Utilities.

The Steering Committee worked closely with Energy Strategies and provided data, policy guidance, input on modeling assumptions, and review of the work as it progressed.

In addition to selecting Energy Strategies to conduct the technical and economic analysis, a Steering Committee was formed to provide oversight of the project and work product of the consultant. Lisa Yoder, Sustainability Program Manager for Summit County; Tyler Poulson, Sustainability Program Manager for Salt Lake City; and Luke Cartin, Environmental Sustainability Manager for Park City served as members of the Steering Committee. The Steering Committee worked closely with Energy Strategies and provided data, policy guidance, input on modeling assumptions, and review of the work of the consultant as it progressed.

Overview of the Study Approach

The Communities requested Energy Strategies evaluate the renewable energy costs, rate impacts, benefits, and options for the Communities to displace the carbon-based electricity provided by Rocky Mountain Power with 100% renewable energy. For Park City and Salt Lake City, we evaluated 2032 as the target year for achieving the 100% renewable energy goal. For Summit County, we analyzed the impacts of achieving 100% renewable electric service for the target years of 2032 and 2040.

Base Case:

Three electricity supply service futures were analyzed for the Communities. The first electricity future assumed the residents and businesses in Park City, Salt Lake City, and Summit County would continue to receive traditional, fossil-based, standard-offer electricity service from Rocky Mountain Power. This future is referred to as the Base Case. The Base Case represents a forecasted future and was created from a specific set of assumptions about customer growth, electricity demand, and electricity rate increases for the period 2015-2032. Different assumptions would result in a different Base Case.

Community Renewable Energy Tariff (CRET):

The second supply future assumed that the Communities would continue to receive traditional utility service from Rocky Mountain Power and that discussions currently underway between the company and Park City and Salt Lake City would result in an approved tariff that would allow incorporated cities and county governments to request 100% renewable energy service on behalf of residents and businesses within their jurisdictions. Under this scenario, Rocky Mountain Power would procure and deliver renewable generated electricity at the request of the Communities while continuing to retain ownership and management of the generation source, and the transmission and distribution systems, and would continue to provide all other associated electric services, including line repair, billing, and customer service functions. This path is referred to in this analysis as Community Renewable Energy Tariff (CRET).

The Communities requested Energy Strategies evaluate the renewable energy costs, rate impacts, benefits, and options for the Communities to displace the fossil fuel-based electricity provided by Rocky Mountain Power with 100% renewable energy.

Community Choice Aggregation (CCA):

The third electricity supply service future analyzed by Energy Strategies assumed the Utah legislature passes Community Choice Aggregation (CCA) legislation. CCA is a policy that allows local government entities to aggregate electricity loads within their jurisdictions and procure alternative energy supplies while maintaining the role of the monopoly electric service provider for transmission, distribution, and other traditional electric services. States that have passed CCA laws include California (2002), Illinois (2009), Massachusetts (1997), New Jersey (2003), Ohio (1999), and Rhode Island (1997). CCA allows local governments to procure electricity supply independent of the local electric service provider and enter into power purchase agreements with renewable energy generators. The local electric service provider still provides traditional transmission, distribution, metering, and billing services but transmits the power from the independent power provider to the local government entity and its community.

Under either procurement approach, the Communities will have a number of renewable energy options to consider, including:

- the selection of preferred renewable technologies (e.g., geothermal, solar, wind);
- the location of the resource (e.g., local, in-state, or regional);
- the timing and procurement strategy (ownership of the power source or third-party ownership with a power purchase agreement); and

- scale of the resources to be acquired to meet each jurisdiction's renewable energy goal (mix of large utility-scale projects and/or small distributed generation projects).

The renewable energy procurement pathway (CRET or CCA) has no impact on the timing, technology, or quantity (energy or capacity) of the supply portfolio. The primary impact of the procurement pathway is the additional costs associated with the CCA pathway.

Energy Strategies worked with the Steering Committee to develop renewable energy procurement scenarios for each of the Communities. All the scenarios modeled assumed the initial renewable electricity purchases would be from new generation projects as a result of long-term power purchase agreements. Renewable resource portfolios under each supply scenario were constructed on the basis of lowest cost and assumed to be located in Utah. The various renewable energy supply scenarios for each community were then analyzed and compared to the business-as-usual Base Case as well as among each other on the basis of costs and rate impacts to each customer class, avoided GHG emissions, avoided criteria pollutants, and economic benefits.

The modeling and economic analysis employed by Energy Strategies provide the Communities with an analytical tool, framework, and results that will inform decision makers and allow them to begin assessing the economic and environmental trade-offs between various renewable energy procurement strategies and choices.

2015 Business-As-Usual Base Case

In 2015, Rocky Mountain Power provided regulated, cost-of-service electricity to 118,500 Residential, Commercial, and Industrial customer accounts within the jurisdictional boundaries of the three Communities: Park City, Salt Lake City, and Summit County. The analysis of Summit County included both incorporated and unincorporated areas of the county, but excluded Park City. The combined annual electricity consumption of the Communities—about 3.8 million MWh—is a significant portion of Rocky Mountain Power's electricity sales in Utah. The combined load represents about 16% of the total load served by Rocky Mountain Power in Utah in 2015.¹

The average rate of these customer classes served by Rocky Mountain Power in 2015 was \$0.09 per kWh and expenditures on electricity totaled \$340.2 million. The customer

¹ Data to create the Base Case was provided to Energy Strategies by Park City, Salt Lake City, and Summit County. The data was compiled from a monthly report Rocky Mountain Power provided to each Community entitled, "PacifiCorp Electric Operations: Operating Revenue, kWh, Customers, Sales Tax, Other Taxes by Operating District"

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class incurring the largest expenditures for power was Commercial, followed by Residential.

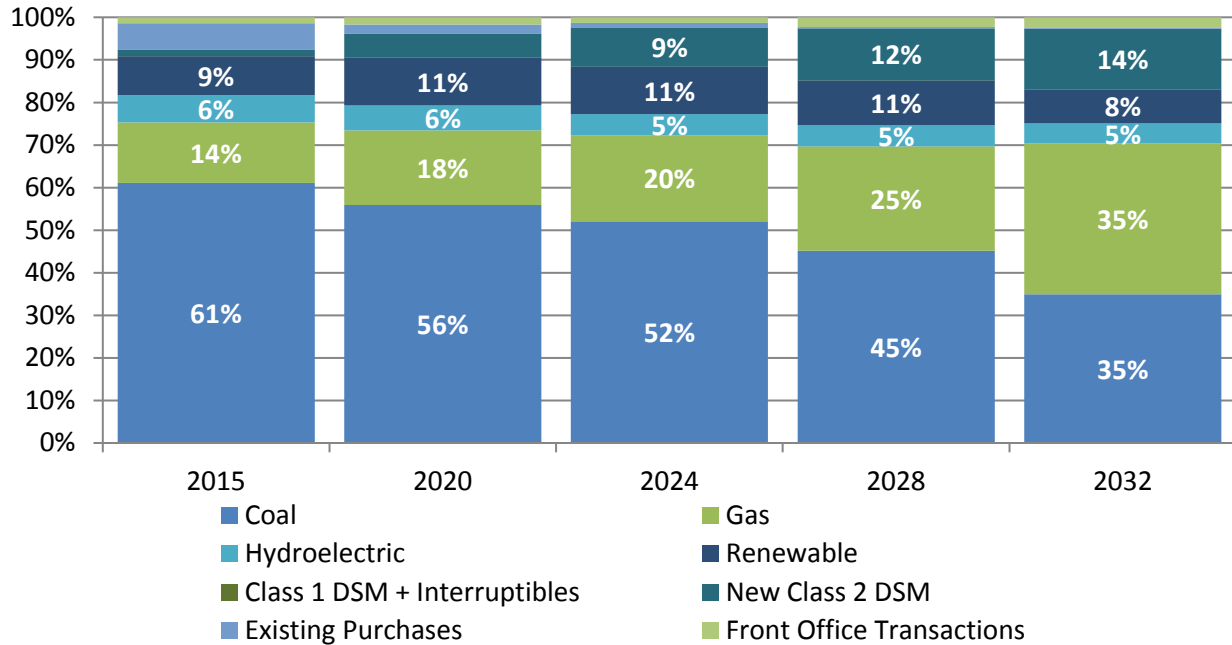
Table 1 shows how the electricity customers of Rocky Mountain Power are distributed between the three Communities by customer class, the amount of electricity consumed, and the total expenditures for 2015.

Table 1: Profile of the Communities Electricity Usage in 2015

Community	Customer Class	Number of Customers	Annual Energy MWh	Annual Expenditures 000 \$	Average Monthly Expenditures	Rates \$/kWh
Salt Lake City	Residential	79,568	539,291	\$61,358	\$64	\$0.114
	Commercial	9,846	2,115,157	\$174,388	\$1,476	\$0.082
	Industrial	693	526,608	\$42,812	\$5,148	\$0.081
	Total	90,107	3,181,056	\$278,559	–	\$0.088
Summit County (Excluding Park City)	Residential	16,059	164,780	\$18,788	\$97	\$0.114
	Commercial	2,187	165,822	\$17,078	\$651	\$0.103
	Industrial	195	30,726	\$2,710	\$1,158	\$0.088
	Total	18,441	361,328	\$38,576	–	\$0.107
Park City	Residential	8,653	108,401	\$11,892	\$115	\$0.110
	Commercial	1,272	125,034	\$10,768	\$705	\$0.086
	Industrial	27	3,951	\$367	\$1,132	\$0.093
	Total	9,952	237,386	\$23,027	–	\$0.097
Total	–	118,500	3,779,770	\$340,161	–	\$0.090

Rocky Mountain Power's current energy resource portfolio is heavily dependent on fossil fuels. In 2015, more than 75% of the electricity supplied to Utah customers was generated from coal and natural gas, with 61% of the electricity derived from coal-fired power plants. Wind, solar, and geothermal energy sources provided only 9% of the electricity power supplied to Utah customers in 2015, while hydroelectric resources from the company's hydroelectric dams in the Pacific Northwest contributed an additional 6% of the power.

**Figure 1: Rocky Mountain Power's Electricity Supply by Energy Source
Selected Years 2015–2032²**



The Communities' study of a transition to 100% renewable electricity is driven by a desire to reduce their carbon footprints and deliver other related co-benefits of clean energy for their Communities. The necessity of seeking an alternative, clean electric service supply is demonstrated by evaluating the forecast of the energy mix of Rocky Mountain Power's electricity supply over the Study period. Rocky Mountain Power's current electricity supply is heavily dependent on coal: 61% of the electricity supplied to Rocky Mountain Power customers in Park City, Salt Lake City, and Summit County is generated from coal. Less than 20% of the power supply comes for non-carbon emitting resources. While the energy mix of Rocky Mountain Power's resource portfolio is expected to change between 2015 and 2032, the primary change is a shift from one form of fossil energy, coal, to another less carbon-intensive energy source, natural gas. Figure 1 shows Rocky Mountain power's electricity supply by energy source for select years. The decline of coal and increase in the contribution from natural gas generation suggests that Rocky Mountain Power's GHG emissions rate and total emissions will decline over time, but more than 70% of Rocky Mountain Power's electricity supply will still be generated from GHG-emitting fossil resources.

² 2015 Integrated Resource Plan Volume 1, PacifiCorp, March 31, 2015, Figure 8.25, page 193.
pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2015IRP/PacifiCorp_2015IRP-Vol1-MainDocument.pdf

Rocky Mountain Power's GHG emissions decline over time, but the planned resource mix will continue to be dominated by coal and natural gas generation.

Increases in the cost of electricity are expected to occur regardless of the energy mix. The question this Study attempts to answer is the cost difference between business-as-usual and various 100% renewable energy scenarios.

Study Methodology

This Study primarily aims to compare the cost of future standard-offer electric service from Rocky Mountain Power to the cost of serving the Communities with 100% renewable energy. The approach utilized for the Study is a cash flow model that estimates customers' annual electricity expenditures under standard-offer service and under various 100% renewable energy supply and electric service delivery scenarios.

Energy Strategies first developed a business-as-usual Base Case for Rocky Mountain Power standard-offer electricity service over the Study period. This required a projection of electricity demand, rates, and expenditures for each community and for the primary customer classes of service: Residential, Commercial, and Industrial. A forecast of the annual electricity supply was also developed to estimate the amount of renewable energy that would be needed to meet the 2032 and 2040 renewable goals if adopted by the Communities. Three renewable energy procurement scenarios, which varied the rate at which the Communities' renewable energy targets were achieved, were then defined.

Estimates were made of the costs of delivered electricity and the impacts on customer electricity rates and expenditures for each supply scenario. These results were then used to evaluate and compare the differences in costs between the Communities continuing to receive standard-offer electric service or opting instead to supply residents and businesses with 100% renewable electricity.

For purposes of the analysis, we have assumed that the Communities would bear all the costs and benefits of transitioning to 100% renewable energy per Clean Energy Cooperation Statements that Park City and Salt Lake City currently have with Rocky Mountain Power. In addition, because of the continued involvement of the Utah Public Service Commission, we are assuming no cost shifting will occur between the Communities receiving 100% renewable energy and other Rocky Mountain Power customers.

Finally, the economic and environmental co-benefits of the renewable energy scenarios were calculated, such as the impact to GHG, criteria pollutants, water, and economic impacts.

While all three Communities requested a potential target year of 2032, Summit County requested an additional target year of 2040 to reach 100% renewable energy usage. Therefore, the overall Study period was 2016 to 2045. While many of the reported results isolate a single year for comparison (e.g., 2021 or 2032), some tables provide another metric for comparison: a sum that captures all 29 years of the Study period, discounted back to 2017 at 6%.

This analysis focuses on the usage by the three primary customer classes: Residential, Commercial, and Industrial. There are some customers and load associated with other classes (Irrigation, Lighting, and Other Sales), but in 2015, these other classes represented only about 1% of the total load for the Communities. Note that all results and data in tables for Summit County is for residents and businesses outside of Park City but still in the county; that is, Summit County results are not inclusive of Park City results.

Projected Customer Load

Energy Strategies' projections of future electricity demand for each Community were created using a 2015 base year and then calculating each year's future usage by applying growth rates that varied by customer class.

These growth rates were based upon statewide load growth rates PacifiCorp (Rocky Mountain Power's parent company) developed for Residential, Commercial, and Industrial customer classes for its 2015 Integrated Resource Plan (IRP). PacifiCorp's estimates of statewide growth rates covered the period between 2015 and 2024 and account for declining electricity use due to improved efficiency of lighting, appliances, and building practices. Energy Strategies made small adjustments to these statewide growth rates in order to provide a more granular forecast of future electricity load in each of the three Communities. These adjustments account for projected population growth rates specific to Park City, Salt Lake City, and Summit County. Table 2 shows the community-specific annual load growth rates used in this Study to create the forecasts of electricity demand by customer class for the period 2016 through 2045. The same growth rate was assumed to persist until the end of the forecast period.

**Table 2: Forecast Average Change in Annual Electricity Consumption
by Community, 2016–2045**

Community	Residential	Commercial	Industrial	Average for All Classes
Salt Lake City	-0.17%	0.64%	0.48%	0.48%
Summit County	-0.20%	0.75%	0.57%	0.33%
Park City	-0.19%	0.70%	0.53%	0.32%

The estimated load growth rates in Table 2 do not account for the impact of new energy efficiency programs and increased penetration of new customer-owned distributed generation. For this analysis, we have treated these measures as new resources that will be used to meet electricity demand over the forecast period. Adjustments for new energy efficiency and new distributed generation were made before we calculated the amount of renewable energy to be procured, as described in the section that follows.

Renewable Energy Portfolios: Size and Timing

The forecasts of electricity demand and the energy mix of the future electricity supply were used to estimate the amount of renewable energy necessary to meet the 2032 and 2040 renewable targets. The amount of renewable energy required to reach each Community’s goal was calculated by reducing the projected demand for electricity by the amount that was expected to be met by:

- new energy efficiency resources;
- new customer-owned distributed generation; and
- non-emitting renewable energy and hydroelectric resources already embedded in Rocky Mountain Power’s electricity supply.

For new energy efficiency, Energy Strategies used the amount projected by PacifiCorp in its 2015 IRP. The level of distributed generation was estimated based on a study from Navigant that was prepared for PacifiCorp.³ The number of megawatts (MW) needed to generate the required megawatt-hours (MWh) was then calculated. In this analysis, all MW are reported in MW of alternating current (AC).

³ *Private Generation Long-Term Resource Assessment (2017–2036)*, Navigant Consulting, Inc., July 29, 2016, Prepared for PacifiCorp. pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2017_IRP/PacifiCorp_IRP_DG_Resource_Assessment_Final.pdf

Another key consideration for the supply portfolio was timing: renewable energy could be acquired in large quantities early, or closer to the goal year, or multiple paths in between.

Energy Strategies and the Steering Committee chose to evaluate three supply scenarios that varied the timing of the procurement of the renewable resources. Any of these supply scenarios could be followed by a Community to acquire the renewable energy to meet a 100% renewable energy goal. The three scenarios evaluated were Front-End Loaded, Straight-Line, and Hybrid.

Energy Strategies and the Steering Committee chose to evaluate three supply scenarios that varied the timing of the procurement of the renewable resources. Any of these supply scenarios could be followed by a Community to acquire the renewable energy to meet a 100% renewable energy goal.

Front-End Loaded

Front-End Loaded refers to a scenario where all the necessary renewable energy is acquired before the expiration of the applicable federal Production Tax Credit.⁴ This scenario was modeled by assuming all the required renewable energy to achieve the 2032 100% renewable target was procured in even, annual increments in a three-year span of time, from 2019-2021. In this scenario, each community would meet a 2032 renewable energy goal approximately 11 years early.

Straight-Line

Straight-Line refers to a scenario where all necessary renewable energy to achieve 100% renewable energy in 2032 is assumed to be acquired every year between 2019 and 2032 in equal amounts. This scenario was modeled by calculating the number of installed MW that would be required to generate the MWh of electricity needed to meet the 2032 target, and then dividing those MW by the number of years between 2019 and 2032. In this scenario, each community would meet its renewable energy goal in 2032.

Hybrid

The Hybrid supply scenario is a blend of the Front-End Loaded and Straight-Line procurement strategies. This scenario assumed between 60% to 67% of the needed capacity to meet a Communities' renewable energy goal are acquired between 2019 to 2021 to take advantage of the federal renewable energy Production Tax Credit.

⁴ energy.gov/savings/renewable-electricity-production-tax-credit-ptc

Each year after, until the target year, additional resources were assumed to be added in equal amounts so that the 100% goal was met in 2032.

For each of the three supply scenarios, the Study made the same calculations to estimate costs to achieve 100% renewable energy supply for Summit County by 2040.

The model underlying this report allows significant flexibility for the Communities to analyze different technologies, portfolio costs, procurement timing, and goal years. This report, however, summarizes the results of one specific set of scenarios.

Renewable Energy Portfolios: Costs and Technologies

Energy Strategies based its estimates of future renewable energy costs on two sources. PacifiCorp's preliminary 2017 IRP Supply-Side Resource Table⁵ was the primary source, and publicly reported, market-based renewable energy contract prices were the other source. Costs are reported in Levelized Costs of Energy (LCOE) terms, which consider both the upfront capital and contract costs, plus ongoing operations and maintenance, to create a levelized financial cost figure (in \$/MWh) to generate electricity over a given timeframe. In most cases, the annual levelized costs reported in the contract price studies were lower than the costs indicated in the PacifiCorp preliminary 2017 IRP resource table. Even so, there was no consensus opinion among these studies with respect to pricing. In light of those findings, Energy Strategies ultimately utilized the PacifiCorp's assumed costs as the primary basis for our estimates of renewable energy costs in this report. The model underlying this work, however, was designed to enable the user to test the impact of higher or lower renewable energy costs.

PacifiCorp's preliminary 2017 IRP Supply-Side Resource Table provided capital and fixed operations and maintenance estimates for renewable energy generation as of 2016. The cost for these technologies is expected to change over time. Energy Strategies accounted for costs changes by adjusting PacifiCorp's renewable costs estimates by the percentage changes in the average annual contract prices for future solar PV and wind resources reported in published market reports. Based on these assumed capital cost adjustments, Energy Strategies estimates that utility-scale costs of solar PV will decline between 2016 and 2025, and then remain virtually flat for the remainder of the Study period. Wind energy prices were expected to remain relatively flat for the period 2016 to 2020, then increase modestly over the remainder of the Study, at rates between 0.4% and 1.2%. Table 3 provides the assumptions used in this analysis for the costs of Utah-based renewable energy by resource for selected years from 2015 to 2040.

⁵ *Supply-Side Resource Table*, PacifiCorp, September 8, 2016, http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2017_IRP/SSR_Database_2016.pdf

**Table 3: Costs of Utah Renewable Energy by Resource for Selected Years
2019–2040**

Renewable Technology	2019	2020	2021	2022	2025	2030	2032	2035	2040
Solar PV-Utah (MWh)	\$50.14	\$47.89	\$46.40	\$44.85	\$42.85	\$43.38	\$43.60	\$43.92	\$44.47
Wind-Utah (MWh)	\$56.23	\$56.33	\$56.56	\$56.81	\$57.67	\$58.39	\$58.68	\$59.11	\$59.85
Geothermal-Binary (MWh)	\$88.09	\$89.76	\$91.47	\$93.21	\$98.62	\$99.85	\$100.34	\$101.09	\$102.34

Our estimate of delivered renewable costs also assumed that all Rocky Mountain Power transmission and distribution services would continue, and the costs of these services were included in our estimate of the cost of renewable energy under each supply scenario.

The Communities requested that the Study focus on scenarios that would result in each community serving 100% of their customer load with renewable energy by the target year from the lowest-cost renewable energy projects that could be located in Utah. As can be seen in Table 3, utility-scale PV solar in Utah is lower cost than Utah wind or geothermal.⁶ Therefore, the results in this Study reflect the use of Utah PV solar even though Wyoming wind in 2015 was estimated to be 20% less expensive. As previously noted, the underlying model allows significant flexibility for the Communities to analyze different portfolio costs or technologies.

Appendix A includes more information on the sources and numbers used to estimate the costs for renewable energy supply portfolios.

Energy Expenditures and Rate Impacts

Once the costs for the renewable energy portfolios were estimated, the impact to expenditures and rates of replacing Rocky Mountain Power fossil-based electricity with renewable energy was calculated for each year and for each customer class.

Actual 2015 Rocky Mountain Power billing data provided by the Communities served as the foundation for estimates of expenditures and rates in the Base Case. Data included: number of customers, annual electricity sales, and electricity expenditures by customer class for each Community. From this data, Energy Strategies calculated the effective electricity rates (\$/kWh) by customer class and escalated the calculated rates by 2.13%

⁶ PacifiCorp's Supply-Side Resource Table from September 8, 2016, assumed a 32% capacity factor for Utah solar PV generation.

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annually over the 2016–2045 study period. That rate of change is the average annual percentage increase of forecasted electricity rates in the Mountain Region as reported by the U.S. Energy Information Administration's 2016 Annual Energy Outlook.⁷

We then calculated Base Case electricity expenditures for each year of the Study period by customer class by multiplying the annual forecast of electricity rates by our forecast of MWh of electricity load.

The impact of renewable energy costs on the Communities' annual electricity expenditures under each scenario was calculated by adding renewable energy cost to the Base Case expenditures. These costs included the assumed costs per MWh of the renewable energy technology, transmission costs of delivering the power to each Community, and the cost of integrating renewable energy into the Rocky Mountain Power system. The gross renewable energy cost was then adjusted to account for avoided costs. Avoided costs represents the credit we assumed Rocky Mountain Power would provide to residents and businesses for generation service they were no longer providing under each renewable energy scenario. This provided an estimate of the total incremental change in the costs and expenditures for the renewable energy cases projected out to 2045. This number was added to the annual Base Case expenditures to give a total estimated cost for the 100% renewable energy case.

The total projected annual costs (Base Case plus renewable energy costs) was then divided by the annual forecast of MWh for each customer class in each Community. This provided the new renewable energy electricity rate by customer class by year

It is important to point out that electricity rates reported in this analysis do not represent the actual tariffs Rocky Mountain Power charges or will charge Residential, Commercial and Industrial customers in Utah. For analytical purposes, electricity rates in this report are a function of the total dollar electricity sales divided by total MWh delivered for each community.

⁷ eia.gov/outlooks/aeo

Table 4: Estimated Costs for Renewable Portfolios for Selected Years 2019–2040

Estimated Costs per MWh	2019	2020	2021	2022	2025	2030	2035	2040
Renewable Resource Cost	\$50.14	\$47.89	\$46.40	\$44.85	\$42.85	\$43.38	\$43.92	\$44.47
Transmission Cost	\$3.26	\$3.33	\$3.40	\$3.48	\$3.70	\$4.12	\$4.57	\$5.08
Integration Cost	\$0.76	\$0.76	\$0.76	\$0.76	\$0.76	\$0.76	\$0.76	\$0.76
Gross Renewable Cost	\$54.17	\$51.99	\$50.57	\$49.09	\$47.32	\$48.26	\$49.26	\$50.31
Avoided Cost Adjustment Credit	\$29.78	\$29.48	\$29.19	\$28.89	\$28.04	\$26.66	\$25.36	\$24.11

Economic and Environmental Co-Benefits

The primary purpose of this Study is to examine costs and electricity rate impacts of the Communities if they choose to provide residents and businesses with an electricity supply generated from renewable energy. By choosing 100% renewable energy, however, there are impacts other than those related to electricity rates. These impacts are known as “co-benefits.” The co-benefits analyzed in this Study relate to:

- economic development benefits of developing community scale solar PV projects in Utah;
- GHG emissions that will be avoided by displacing electricity from coal-fired and gas-fired power plants;
- criteria pollutant emissions that will be avoided; and
- fresh water consumption at power plants that will be avoided.

This section describes the methodology for calculating these co-benefits.

GHG Emissions

Replacing traditional generation with renewable energy reduces or “avoids” emissions that would otherwise be released into the atmosphere. The methodology that Energy Strategies used to calculate avoided CO₂ emissions estimated the most potential avoided emissions (the high estimate) and the least potential avoided emissions (the low estimate). Energy Strategies believes the actual avoided emissions would fall within the range. Actual avoided emissions will depend on the specific power plant that is displaced by the addition of the renewable energy, and predicting that with any accuracy can mean relying on complex, often proprietary models with many inputs

such as a forecast for natural gas prices. The Energy Strategies range approach is transparent and straightforward and does not require accurately forecasting natural gas prices or the economic dispatch of power plants. The tradeoff, of course, is less certainty as to the actual environmental co-benefits.

Energy Strategies calculated a range of avoided emissions based on the type of generation that the renewable energy displaces.

In the high case, Energy Strategies assumed the additional renewable energy displaces generation proportionally from PacifiCorp's resource portfolio. In the low case, Energy Strategies assumed that the additional renewable energy changes the amount of energy that PacifiCorp purchases in the wholesale electricity market. Additional details on the methodology for calculating environmental co-benefits can be found in Appendix B.

The amount of avoided CO₂ emissions varies by year. For this analysis, avoided CO₂ emissions are the difference between business-as-usual emissions and the emissions associated with a specific scenario. For the renewable energy scenarios and the business-as-usual scenario, emissions were calculated using average emission rates for each fuel type, derived from historical data.⁸ The business-as-usual line changes over time.

CO₂ is the primary GHG pollutant, and the rise in GHG emissions is linked to climate change. Climate change will alter weather and precipitation patterns, cause a rise in sea levels, and change ecosystems around the world. The public health threat from climate change includes the effects of heat waves, drought, extreme weather events, and declining air quality.⁹

Energy Strategies also assigned a monetary value to the tons of avoided CO₂ emissions that would result from the Communities' switch to renewable energy. Federal agencies have been estimating the value of avoided CO₂ emissions in rulemaking for many years as part of the required cost-benefit analysis. The Interagency Working Group on the Social Cost of Carbon (IWG) developed a methodology for monetizing avoided CO₂ emissions. The Social Cost of Carbon (SCC) is a present value calculation of the

⁸ Five-year historical emissions data were downloaded for PacifiCorp plants and a weighted average was calculated by fuel type. Data source is EPA's Air Markets Program Data, accessed through an online data subscription service (SNL).

⁹ *Overview of Climate Change Impacts on the United States*, 2014 U.S. National Climate Assessment, U.S. Global Change Research Program, May 2014.

avoided future global economic damages, as estimated by three peer-reviewed climate economic-impact models (namely, DICE, FUND, and PAGE). The damage estimates are global, and include damages from changes in agricultural productivity, damage to human health, and property damage from increased flood risk. The damages are for the years 2020 through 2300 (280 years). In discounting the avoided economic damages to a present value, three different discount rates were used, 5%, 3%, and 2.5%. The higher the discount rate, the lower the present value of these future damages. The IWG recommends presenting all three discount rates when reporting monetary values of future damages.¹⁰ Energy Strategies used the SCC values from the August 2016 IWG update.¹¹

Criteria Pollutants

To calculate the avoided emissions of criteria pollutants, Energy Strategies used the same methodology that was used to calculate the avoided emissions of CO₂—a methodology built around a high-low range based on the type of displaced electricity generation. The criteria pollutants that were quantified are nitrogen oxides (NO_x) and sulfur dioxide (SO₂). As with CO₂, the avoided NO_x and SO₂ emissions are the difference between business-as-usual emissions and the emissions associated with a specific renewable energy scenario. Emissions were calculated using average emission rates for each fuel type (natural gas and coal) derived from historical data.¹²

SO₂ impacts human health through irritation of the respiratory system. SO₂ can also lead to the formation of other sulfur oxides, which are precursors to particulate matter (PM). Salt Lake County and Tooele County are currently designated by the Environmental Protection Agency (EPA) as a nonattainment area for SO₂, and multiple counties along the Wasatch Front are currently designated as “Serious” nonattainment areas for EPA’s standard for particulate matter.

NO_x emissions are also precursors to the formation of particulate matter and are harmful to the human respiratory system. Both SO₂ and NO_x emissions create haze and

¹⁰ Washington State Department of Ecology adopted a 2.5% social discount rate to monetize the global societal benefits of avoiding CO₂ emissions in its cost-benefit analysis of Washington’s Clean Air Rule, a regulation establishing a state-wide emissions cap and mandatory reductions of CO₂ emissions. Justification for using a 2.5% discount rate was recommended in a Washington State interagency memo entitled, *The Social Cost of Carbon: Washington State Energy Office Recommendation for Standardizing the Social Cost of Carbon When Used for Public Decision-Making Processes*, November 4, 2014.

¹¹ *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis, Under Executive Order 12866*, Interagency Working Group, August 2016, obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf

¹² Five-year historical emissions data were downloaded for PacifiCorp plants and a weighted average was calculated by fuel type. Data source is EPA’s Air Markets Program Data, accessed through an online data subscription service (SNL).

affect visibility. Ozone, another criteria pollutant, is not released directly into the air, but is created through the interaction of NO_x and volatile organic compounds.

Unlike CO₂, there is no federal or standard process for monetizing avoided SO₂ and NO_x emissions. The monetization of CO₂ emissions is a result of economic-impact models analyzing climate change, but the primary damages from criteria pollutants are impacts to human health and premature mortality. It is naturally more difficult to place a dollar value on these impacts. There have been efforts to develop a standard methodology, but, in addition to the problems valuing human life, there is a proximity issue. Unlike the global impact of CO₂, the impact of SO₂ and NO_x emissions can be very localized. The proximity of a power plant to a population center is a critical input to determining the impact on human health and premature mortality. Since this report does not model the change in generation for specific power plants, an estimate of the dollar value of the benefit from reduced emissions of these criteria pollutants is very difficult to calculate.

One regulatory jurisdiction, Minnesota Public Utilities Commissions, does have its utilities calculate a value for avoided NO_x emissions using high and low values. For power plants located in rural areas, the 2015 values are \$26.54 per ton and \$150.39 per ton. Energy Strategies used these values as an example monetization for NO_x emissions.

Water

Replacing traditional generation with renewable energy reduces or “avoids” freshwater consumption as well as airborne emissions. Water use in the West by thermoelectric plants is small compared to the major uses—agriculture and municipal supplies—but reduced water use can still be an important co-benefit. Energy Strategies only calculated a high-end amount of avoided water use, based on proportional reduction of PacifiCorp's energy mix. The actual avoided water use will be some amount below this high-end amount. The different methodology for water use is mostly due to data availability issues, which leads to a more uncertain estimate for any scenario. Unlike emissions, there is no standardized reporting by power plant for water use. Water use varies by season, temperature, and many different power plant characteristics, such as the type of pollution control equipment.

Water pollutants are another concern associated with fossil-fueled generation. In some power plant designs, water is withdrawn from a nearby source, used to cool the plant, and then returned to the water source. This process is called “once-through cooling.” Power plants may have other wastewater streams from controls intended to reduce airborne emissions, coal ash management, and equipment cleaning. A 2015 EPA rule updated the effluent limit guidelines to address dissolved pollution, such as toxic metals. While many power plants in other parts of the country will be affected by the rule, few in the West will be. Most plants in the West do not use once-through cooling, but instead

withdraw water for closed-cycle systems. Water is not returned to the source, but instead is released as water vapor into the air through cooling towers. Other wastewater streams are also carefully managed by power plants in the West. Both Colstrip (Montana) and Jim Bridger (Wyoming), for example, are zero-liquid-discharge facilities (evaporation only). Moving to 100% renewable energy may reduce water pollutants, but quantification was not attempted for this project.

Economic Impacts

The economic co-benefits from building renewable energy projects to meet Summit County's, Salt Lake City's, and Park City's renewable energy targets were estimated using National Renewable Energy Laboratory's (NREL) Jobs and Economic Development Impact (JEDI) model. The JEDI model is an input-output economic model developed by NREL to estimate the economic impact of constructing and operating power plants, fuel production facilities, and other projects at the state level.

Energy Strategies used JEDI to calculate the economic benefits to the Utah economy of Summit County, Salt Lake City, and Park City achieving a 2032 renewable energy target using the Front-End Loaded procurement strategy.

The JEDI model requires the user to enter basic information about a project, including installed costs (\$/kW); maintenance and operating costs (\$/kW); state, location, year of construction; and facility size (MW). Based on these inputs, the model estimates the project's total installed costs and its economic impacts in terms of jobs, wages and salary, and economic output (value of production) on the local economy.

Energy Strategies used JEDI to calculate the economic benefits to the Utah economy of Summit County, Salt Lake City, and Park City achieving a 2032 renewable energy target using the Front-End Loaded procurement strategy. The benefits are related to the construction and operation of renewable energy facilities.

Energy Expenditures and Rate Impacts

Summary

The incremental cost of transitioning to 100% renewable energy electric service would vary by year and by the timing of the acquisition of the renewable energy. Figure 2 compares the average rates in cents per kWh paid by Residential, Commercial, and Industrial customers for the Base Case and the three renewable energy scenarios. In 2032, under business-as-usual, the average rate paid would be 12.45 cents per kWh. The average rate paid under the three renewable energy scenarios would be 13.85 to 13.96 cents per kWh, or 11% to 12% more. For an average residential customer, the difference would mean paying \$7.41 to \$8.28 more for their monthly electric bill in 2032.

The steady, incremental acquisition of renewable energy shown in the Straight-Line scenario results in rates that gradually diverge from business-as-usual, reaching the 11% difference in 2032. Under the Front-End Loaded scenario, Salt Lake City would meet its 100% renewable energy goal by 2022. However, residents and businesses would experience more rate shock in the first three years, as rates would be about 16% higher than under business as usual in 2021.

Figure 2: Salt Lake City Average Rates for Base Case and Renewable Energy Cases

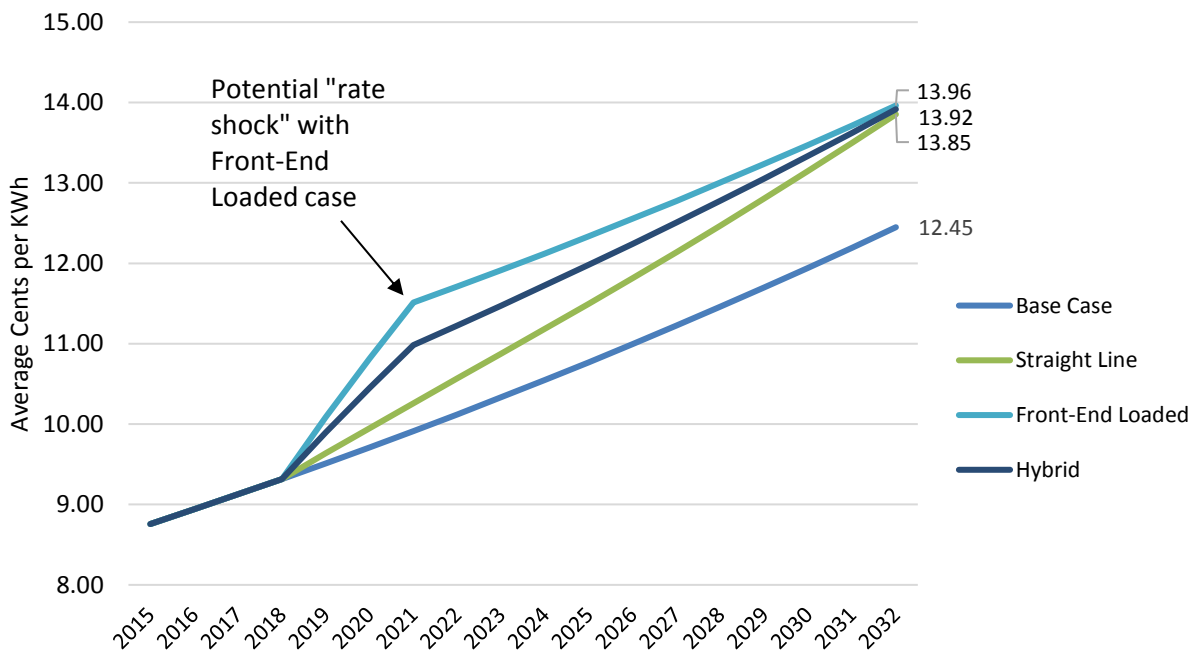


Figure 2 shows the results for the CRET cases compared to the Base Case. If Salt Lake City were to achieve its 100% renewable energy goal through CCA, the costs would be higher. For example, in 2032, rather than 11% to 12% higher than Base Case, the CCA

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Straight-Line case would be about 14% higher than business-as-usual, with an average rate of 14.15 cents per kWh.

This Study did not test the sensitivity of many of its assumptions, but the underlying model allows for this flexibility. Some of the most important assumptions that these reported results rely on include:

- the capital cost of acquiring (or contracting for) renewable resources and their location;
- the rate at which Rocky Mountain Power's standard-offer service rate increases;
- the effectiveness of new energy efficiency programs; and
- the penetration levels reached by new distributed generation.

Changes in any one of these assumptions could mean that the cost difference between business as usual and a 100% renewable energy path would be less than the 11% to 14% results shown in this Study. For example, using lower-cost Wyoming wind would reduce the cost difference. The costs of utility-scale solar PV technology could fall over time more than this Study assumed, which would also reduce the impact of choosing a 100% renewable path. Alternatively, Rocky Mountain Power may face cost increases in their operations that result in higher costs than the 2.13% estimated annual cost increase that was assumed in this Study. Moreover, the value of avoiding fuel-cost risk by having Salt Lake City's electricity supply generated by 100% renewable energy is not captured in this Study nor are the compliance cost risks of future regulatory or legislative environmental standards. Rocky Mountain Power's resource portfolio is projected to move away from coal-fired resources towards natural gas-fired generation. Wholesale natural gas prices have historically been highly volatile, bouncing from \$2 to \$13 per million Btu and back down again over the span of just a few years.¹³ In recent years, natural gas prices have been more stable and low, but if prices were to dramatically rise, a 100% renewable energy supply would protect customers from this rising fuel expense.

The results of this Study should be viewed as providing guidance as to direction and magnitude of the cost impacts for choosing a 100% renewable energy path. There are many inherent uncertainties in a Study that looks out to 2032, and these results reflect one set of assumptions.

The more detailed discussion that follows first reviews the 2032 Base Case and then the two alternative renewable energy futures, CRET and CCA. The discussion is focused on the Residential, Commercial, and Industrial customer classes.

¹³ U.S. Energy Information Administration, Henry Hub Natural Gas Spot Price, eia.gov/dnav/ng/hist/rngwhhdm.htm

2032 Base Case

In 2032, the number of Salt Lake City residents and businesses taking electricity service from Rocky Mountain Power is projected to total 98,192, or 8,085 more electric customers than in 2015. Residential class customers will continue to be the single largest class of service with 86,462 accounts.

Demand for electricity in Salt Lake City is expected to grow 8.6% between 2015 and 2032, which is the year Salt Lake City has set for attaining its 100% renewable energy goal. This growth projection is electricity demand before the effect of new energy efficiency programs or new distributed generation, and is based on PacifiCorp's load projections (as detailed more fully in the methodology section). The projected electricity load for the Residential, Commercial, and Industrial customers in 2032 is forecast to be approximately 3.5 million MWh, with the Commercial sector being responsible for about 68% of Salt Lake City's total load in 2032. The Industrial class customers will represent the second highest end use by sector, followed by the Residential sector. The 86,462 residential customers' average electricity use per household in 2032 is estimated to be 6,055 kWh, again, before new energy efficiency programs.

Table 5: Salt Lake City Base Case Electricity Profile for 2032

Community	Customer Class	Number of Customers	Annual Energy MWh	Annual Expenditure \$000	Monthly Average Expenditure per Customer	Cost \$/kWh
Salt Lake City	Residential	86,462	523,549	\$85,229	\$82	\$0.163
	Commercial	10,978	2,358,422	\$278,211	\$2,112	\$0.118
	Industrial	752	571,577	\$66,487	\$7,366	\$0.116
	Total	98,192	3,453,548	\$429,927	–	\$0.124

Between 2015 and 2032, Rocky Mountain Power's revenue requirements to serve electricity customers in Salt Lake City, and therefore, customers rates, are expected to increase. In the 2032 Base Case, Rocky Mountain Power's customers' spending on electricity is expected to increase 54% compared to 2015, with total electricity expenditures for Residential, Commercial, and Industrial customers growing from \$279 million to \$430 million per year. Residential customers' rates are forecast to increase from an average of \$0.114/kWh in 2015 to \$0.163/kWh in 2032, an increase of 43%. Similarly, electricity rates for Rocky Mountain Power Commercial and Industrial customers are expected to increase. By 2032, the average rate for all electricity customers of Rocky Mountain Power is expected to be \$0.124 per kWh compared to \$0.088 per kWh in 2015, representing an increase in customer rates of 41%.

2032 Community Renewable Energy Tariff

The CRET scenario acquires 830 MW of Utah-based PV solar by 2032 at an assumed capacity factor of 32%. Depending on the speed of acquisition of the renewable resource, the levelized cost of this portfolio is about \$44 to \$48 per MWh. This Study has found that the average electricity rate in 2032 for Residential, Commercial, and Industrial customers would be 13.85 to 13.96 cents per kWh for these renewable scenarios, versus a Base Case rate of 12.45 cents.

The following discussion walks through the renewable energy requirements for Salt Lake City, the variations in cost in the three timing scenarios, and then provides more detail for the rate and expenditure impacts.

Renewable Energy Requirements

Although the total Residential, Commercial, and Industrial load in 2032 is estimated to be approximately 3.5 million MWh, 1.2 million MWh of Salt Lake City's electricity demand will be met with existing hydroelectric power supplied by Rocky Mountain Power, new energy efficiency program savings, and new customer-owned distributed generation. As a result, to meet Salt Lake City's 100% renewable energy goal, the community will need to acquire an additional 2.3 million MWh of renewable energy generated electricity by 2032.

The renewable energy and hydroelectricity supply projected to be part of the Rocky Mountain Power portfolio in 2032 could be counted towards partial fulfillment of Salt Lake City's renewable energy goal. However, for renewable energy accounting purposes, Salt Lake City will not credit the renewable electricity in Rocky Mountain Power's resource portfolio towards its goal. One of the distinguishing features of renewable generated electricity is the environmental attributes that are created with the electricity. For energy accounting purposes, these environmental attributes are represented as Renewable Energy Certificates (RECs). RECs are severable from the actual MWh and can be sold separately. However, doing so means the power becomes "null" power and is no longer eligible to be defined as renewable generated electricity.

The Utah Public Service Commission has approved Rocky Mountain Power unbundling and selling the RECs associated with the renewable power currently being paid for in Utah customers' rates to Pacific Power. Pacific Power applies the Utah RECs towards the utility's compliance obligation with the Oregon Renewable Portfolio Standard. Even though Rocky Mountain Power's Salt Lake City customers' rates include the company's procurement of renewable energy, because the RECs have been sold, the power delivered to Rocky Mountain Power's Salt Lake City's customers is no longer eligible to be considered renewable. Accordingly, Salt Lake City will not count the renewable

electricity supply in Rocky Mountain Power energy portfolio towards achieving its 100% renewable energy goal.

Renewable Energy Supply Portfolios

Energy Strategies evaluated three renewable energy procurement scenarios Salt Lake City could pursue to achieve its renewable energy targets: Front-End Loaded, Straight-Line, and Hybrid.

The Front-End Loaded scenario assumed the transition to 100% renewable electricity would take place on an accelerated basis to get the full benefit of the federal renewable energy Production Tax Credit before it expires at the end of 2021. Under this procurement scenario, renewable energy capacity needed to enable Salt Lake City to meet its 100% goal is acquired between 2019 and 2021. Based on Salt Lake City's projected load, 277 MW of new solar PV generation capacity would be procured in 2019 and 2020, and 276 MW in 2021. The average of the annual levelized cost is \$48.15 per MWh. Table 6 shows the MW, MWh, and annual levelized cost for this scenario.

Table 6: Salt Lake City Front-End Loaded Renewable Energy Portfolio

	2019	2020	2021	2022	2025	2030	2032	Total	Average Levelized Cost
MW	277	277	276	–	–	–	–	830	–
Cumulative MWh (000's)	776	1,553	2,327	2,327	2,327	2,327	2,327	2,327	–
Levelized Costs \$/ MWh	\$50.14	\$47.89	\$46.40	–	–	–	–	–	\$48.15

The Straight-Line procurement scenario assumed renewable electricity supplies would be acquired in equal annual amounts between 2019 and 2032. Under this procurement scenario, the renewable energy capacity needed to enable Salt Lake City to meet its 100% goal is acquired in 60 MW increments between 2019–2022. Thereafter, Salt Lake City adds additional generation capacity in 59 MW increments through 2032. The average levelized cost of energy for this scenario is \$44.50 per MWh. Table 7 summarizes this scenario.

Table 7: Salt Lake City Straight-Line Renewable Energy Portfolio

	2019	2020	2021	2022	2025	2030	2032	Total	Average Levelized Cost
MW	60	60	60	60	59	59	59	830	–
Cumulative MWh (000's)	168	336	505	673	1,169	1,996	2,327	2,327	–
Levelized Costs \$/ MWh	\$50.14	\$47.89	\$46.40	\$44.85	\$42.85	\$43.38	\$43.60	–	\$44.50

The third renewable energy procurement scenario, Hybrid, is intended to take advantage of the federal renewable energy Production Tax Credit before it expires at the end of 2021 and assumes that Salt Lake City would acquire renewable energy capacity needed to meet 67% of its goal (555 MW) in the years 2019-2021. The remaining 275 MW would be acquired in equal annual capacity increments until Salt Lake City's target of 2.3 million MWh is reached in 2032. Levelized costs of renewable energy acquired following this purchasing strategy is \$46.60 per MWh. Table 8 summarizes this scenario.

Table 8: Salt Lake City Hybrid Renewable Energy Portfolio

	2019	2020	2021	2022	2025	2030	2032	Total	Average Levelized Cost
MW	185	185	185	25	25	25	25	830	830
Cumulative MWh (000's)	519	1,037	1,556	1,626	1,836	2,186	2,327	2,327	2,327
Levelized Costs \$/MWh	\$50.14	\$47.89	\$46.40	\$44.85	\$42.85	\$43.38	\$43.60	–	\$46.60

Costs and Rate Impacts

The analysis of costs and rate impacts under the CRET procurement path assumed that renewable generated electricity would be procured by Rocky Mountain Power on behalf of Salt Lake City from projects located in Utah and from the lowest cost renewable energy sources in the state, i.e., large scale solar PV. As described more fully in the methodology section, Energy Strategies used PacifiCorp cost estimates for capital and fixed operations and maintenance, adjusting these estimates for expected changes in these costs in the future.

In all three renewable energy supply scenarios in which Salt Lake City meets its 2.3 million MWh community renewable energy goal, the cost of power is higher than it would be if the community's residents and businesses continued to receive standard-offer electricity service from Rocky Mountain Power. However, the power supply the community would receive from Rocky Mountain Power in 2032 would still be heavily dependent on fossil energy sources, along with its associated negative externalities.

On a strict cost basis, the lowest cost renewable energy supply scenario for Salt Lake City is the Straight-Line scenario in which the community contracts to acquire equal, annual increments of renewable energy capacity over the period 2019-2032. Salt Lake City would achieve its renewable energy goal in 2032. Residents' and businesses' expenditures on electricity are estimated to be \$48.5 million more than the Rocky Mountain Power Base Case, and average electricity rates for all residential and business customers will be 1.40 cents per kWh higher. For the average Salt Lake City household, that translates into 9% higher electricity costs, or a monthly electricity bill that is \$7.41 higher than the cost of standard-offer Rocky Mountain Power electricity service in 2032.

The lowest cost renewable energy supply scenario for Salt Lake City is the Straight-Line scenario. For the average Salt Lake City household, that translates into a monthly electricity bill that is \$7.41 higher than the cost of standard-offer Rocky Mountain Power electricity service in 2032.

The Hybrid scenario is the second lowest cost approach among the renewable energy scenarios we evaluated. Following this scenario, approximately 67% of Salt Lake City's renewable energy goal is met by 2022, but the full goal is not achieved until 2032. If Salt Lake City follows this procurement path, residents' and businesses' annual electricity expenditures are estimated to be \$50.7 million higher than in the Rocky Mountain Power Base Case. The higher amount of electricity expenditures translates into a higher rate for the three primary customer classes of 1.47 cents per kWh in 2032. Most of this increase comes in the first three years, when two-thirds of the renewable energy portfolio is being added. For Salt Lake City's residential customers, this procurement path would mean paying \$7.91 more on average for their monthly electricity bill compared to continuing to receive standard-offer electricity service from Rocky Mountain Power.

The Front-End Loaded procurement approach is the fastest path to meeting Salt Lake City's renewable energy goal and will reduce the most emissions over the time period, but it is also the costliest. Adopting this strategy will enable Salt Lake City to meet its renewable energy goal by 2022, but it will also result in electricity that is more expensive than the Rocky Mountain Power Base Case, and the other two renewable energy scenarios. Under this scenario, rates would rise quickly, with 2021 rates 16% above the

business-as-usual Base Case. By 2032, however, the difference between this scenario and the Hybrid and Straight-Line scenarios have mostly been erased. Electricity expenditures by residential customers and businesses under this procurement approach are estimated to be \$52.3 million higher in 2032 than the Base Case, or 12% higher. Electricity rates for all residential and businesses customers will be higher than the Base Case by an average of 1.51 cents per kWh. For the average Salt Lake City household, that translates into 10% higher electricity rates, or a monthly electricity bill that is on average \$8.28 higher than it would be if the community continued to receive standard-offer electric service from Rocky Mountain Power.

Table 9 summarizes the cost impacts of the three renewable scenarios against the Base Case, using 2032 data and a present value sum of all 29 years of the Study.

Table 9: Comparison of CRET Renewable Energy Scenarios to Base Case

Renewable Energy Scenario	2032 Electricity Expenditures for Residential, Commercial, and Industrial Customers in Millions \$	2032 Average Monthly Expenditures per Residential Customer	2032 Average Electricity Rates for Residential, Commercial, and Industrial Customers	29 Year Present Value of Expenditures in Millions \$
Base Case	\$429.90	\$82.14	\$0.1245	\$5,264
Straight-Line	\$478.40	\$89.55	\$0.1385	\$5,624
Hybrid	\$480.60	\$90.05	\$0.1392	\$5,747
Front-End Loaded	\$482.20	\$90.42	\$0.1396	\$5,838

The differences in 2032 among the three 100% renewable scenarios are small, with the difference in a household's monthly bill only \$0.87 higher with Front-End Loaded than with Straight-Line. However, there would be significant rate shock with attempting to achieve the 100% renewable energy transition by 2022 in order to take advantage of the Production Tax Credits. Slow, incremental additions to the renewable energy portfolio carry a lower price tag overall and reduce the near-term impact on customers.

Based on our modeling assumptions, Salt Lake City can minimize the impact on electricity expenditures and rates of its 100% renewable energy goal by spreading the procurement of renewable energy sources over a longer time frame. The trade-off, of course, is postponing the substantial environmental co-benefits and the economic co-benefits associated with Salt Lake City's achievement of its clean energy goals.

2032 Community Choice Aggregation

The second alternative procurement path evaluated in the Study, CCA, requires a higher level of administrative commitment (and cost) for Salt Lake City than the utility procurement-based CRET pathway. Under CCA, Salt Lake City would become the purchaser of electricity supplies on behalf of retail customers within its municipal government's jurisdiction as an alternative to customers receiving a predominantly fossil fuel-based electricity supply from Rocky Mountain Power. Rocky Mountain Power remains involved in the delivery of electricity through its transmission and distribution system and, for purposes of this analysis, is assumed to provide billing, metering, and other standard utility program services. One potential benefit of CCA is enhanced flexibility for local governments to make procurement decisions on behalf of community members and greater ability to influence how local electricity needs are serviced.

The Study assumed that startup costs and annual operating costs associated with management and procurement of renewable energy resources would be entirely borne by the community choosing this path. The Study estimates and applies these costs based on a survey of costs projected and incurred by existing CCA programs in Sonoma County, Alameda County, and Marin County, California. Startup cost estimates of \$0.79 per MWh were applied to each MWh projected to be consumed by Salt Lake City residents and businesses in 2017, the assumed CCA program startup year. Operating cost estimates of \$4.46 per MWh were applied on a \$/MWh basis each year of the Study period. Table 10 compares the costs of renewable energy procurement for the CRET and the CCA paths.

Table 10: Comparative Costs of CRET and CAA Procurement for a PV Solar Resource Portfolio

	2019	2020	2021	2022	2025	2030	2032	Average of Levelized Cost
Community Renewable Energy Tariff \$/MWh	\$50.14	\$47.89	\$46.40	\$44.85	\$42.85	\$43.38	\$43.60	\$44.50
Community Choice Aggregation \$/MWh	\$54.60	\$52.35	\$50.86	\$49.31	\$47.31	\$47.84	\$48.06	\$50.05

The CCA procurement path is the most expensive means for Salt Lake City to meet its renewable energy goal among the renewable energy scenarios we evaluated and is the least likely. Current Utah statute has established a regulatory structure that supports vertically integrated, monopoly electric service in the state for residents and businesses

that are not provided electric service through a municipal utility. As a result, in order for Salt Lake City to engage in CCA procurement, the Utah legislature would have to pass legislation establishing Utah as an open access state that allows communities to sell electricity to retail customers. An alternative approach would be for Salt Lake City to form a municipal utility, but this approach is beyond the scope of this Study. For this analysis, the only difference between the CRET procurement scenarios and the CCA procurement path are the initial startup costs and the annual operating costs. In all renewable energy scenarios, the CCA path will be higher cost. Accordingly, we have limited the scope of the cost and rate impact analysis to the Straight-Line renewable energy procurement scenario. Following the CCA procurement path for the Straight-Line scenario, residents' and businesses' annual electricity expenditures in 2032 are estimated to be \$58.7 million more than the Base Case, and \$10.2 million more than the CRET Straight-Line procurement approach. The higher electricity expenditures translate into an incrementally higher average rate for the main customer classes of 1.70 cents per kWh in 2032, compared to 1.40 cents per kWh higher under the CRET Straight-Line scenario. For Salt Lake City's residential customers, the CCA procurement path would mean 11% higher monthly electric bills, or \$8.97 more per month compared to continuing to receive standard-offer electricity service from Rocky Mountain Power.

While CCA is higher cost, the difference in electricity expenditures and rates between the CCA Straight-Line and the CRET Straight-Line scenarios is less than 2.2%. Table 11 compares the cost impacts of the CCA Straight-Line case to the Base Case and the CRET Straight-Line Case.

Table 11: Comparison of a CRET Scenario to a CCA Scenario and Base Case

Renewable Energy Scenario	2032 Electricity Expenditures for Residential, Commercial, and Industrial Customers	2032 Average Monthly Expenditures per Residential Customer	2032 Average Electricity Rates for Residential, Commercial, and Industrial Customers	29 Year Present Value of Expenditures in Millions \$
	in Millions \$			
Base Case	\$429.90	\$82.14	\$0.1245	\$5,264
CRET Straight-Line	\$478.40	\$89.55	\$0.1385	\$5,624
CCA Straight-Line	\$488.60	\$91.11	\$0.1415	\$5,702

Economic and Environmental Co-Benefits Analysis

The co-benefits derived by Salt Lake City choosing 100% renewable energy by 2032 include avoided CO₂ emissions, avoided SO₂ and NO_x emissions, avoided water use, and economic development impacts. The environmental co-benefits do not change based on the pathway that Salt Lake City pursues (CRET or CCA) because these co-benefits are based on an estimate of the energy that is replaced by renewable sources, which does not change.

Economic Co-Benefits

A key outcome of Salt Lake City's 100% renewable electricity goal is the opportunity to generate new economic development in the state through the community's investments or power purchase agreements with Utah-based renewable energy projects. These types of projects create jobs and add additional wages and economic output to the local and Utah economy during both construction and the operational phases.

In order to supply 100% renewable electricity to Salt Lake City's residents and businesses by 2032, an additional 830 MW of new solar PV would need to be developed in Utah at an estimated cost of \$1.96 billion. For a solar PV project of this size, the JEDI model estimates 6,000 direct jobs and 7,600 indirect and induced jobs will be created during the construction phase of the project. Individuals employed during construction will generate nearly \$595 million of new economic output and take home in new wages \$338 million. Indirect and induced economic benefits due to construction activities are projected to add almost \$1.2 billion to Utah's economy.

Following construction, ongoing operations of the solar PV plant are estimated to support over 300 direct, indirect, and induced jobs and contribute an additional \$33 million annually to the Utah economy. The economic co-benefits from constructing and operating an 830 MW PV solar power plant in Utah are summarized in Table 12. Note that the JEDI model defines construction jobs as full-time equivalent for one year.

Table 12: Economic Impacts of New 830 MW Solar Plant – Front-End Loaded Scenario

Economic Measure	Economic Effects			
	Direct	Indirect	Induced	Total
Construction Operations				
Jobs	6,028	4,774	2,826	13,628
Wage and Salary (\$ millions)	\$338	\$265	\$142	\$746
Economic Output (\$ millions)	\$595	\$747	\$428	\$1,770
During Operation				
Jobs	210	68	45	324
Wage and Salary (\$ millions)	\$12.63	\$4.31	\$2.28	\$19.22
Economic Output (\$ millions)	\$12.63	\$13.13	\$6.85	\$32.62

Environmental Co-Benefits

Figure 3 shows the effect of choosing 100% renewable energy on CO₂ emissions relative to the Rocky Mountain Power Base Case. We do expect the CO₂ emissions created by Rocky Mountain Power's generation to decrease over the period of this analysis. The drop in emissions is attributable to the company gradually transitioning its generation portfolio away from higher-emitting coal-fired sources and towards lower-emitting natural gas-fired resources. All three renewable electricity supply pathways result in significantly lower CO₂ emissions than if Salt Lake City were to continue to receive power from Rocky Mountain Power's generation portfolio. While the different pathways achieve the renewable goal in different timeframes, by 2032, CO₂ emissions associated with Salt Lake City's electricity use will have fallen to zero for all scenarios. In contrast, the power supplied to Salt Lake residents and businesses by Rocky Mountain Power under the business-as-usual scenario will still be emitting approximately 1.9 million short tons of CO₂.

Figure 3: Salt Lake CO₂ Scenarios, High-End, 2032 Goal

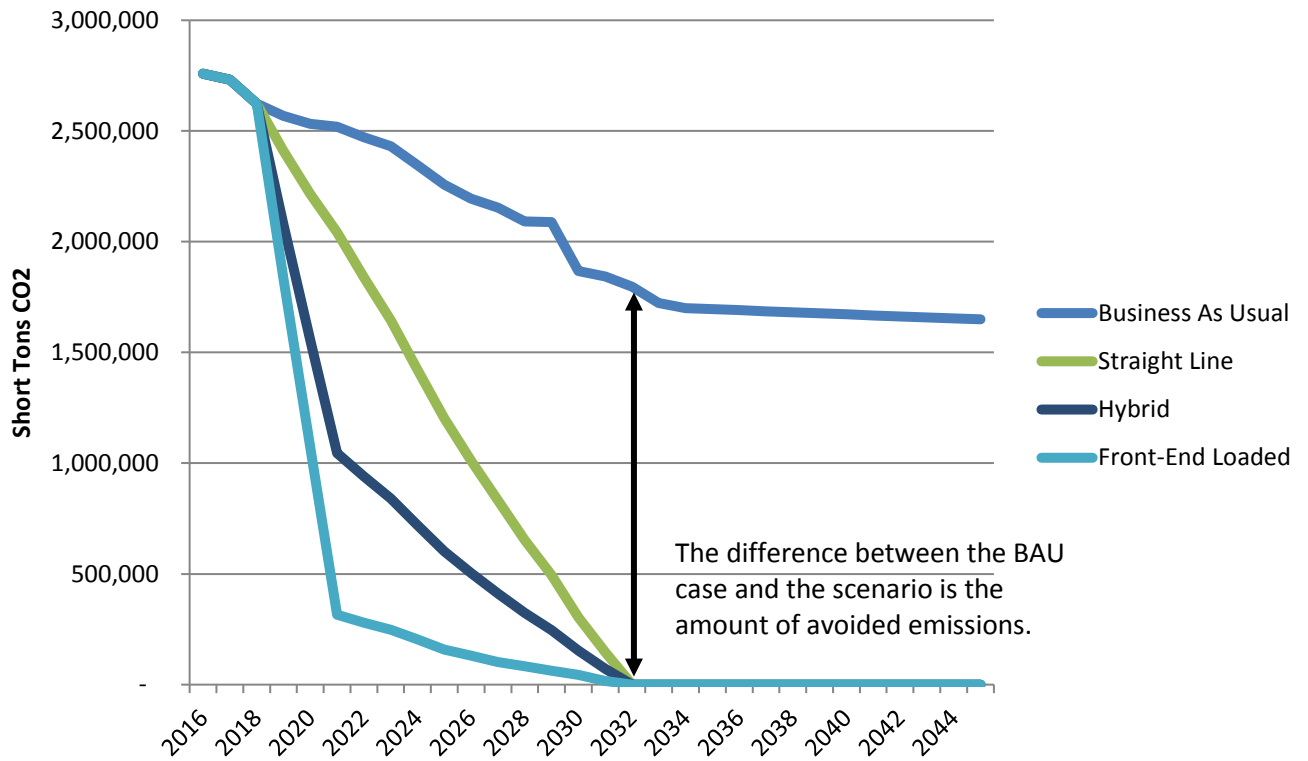


Figure 3 shows the amount of CO₂ emissions that would be avoided at the high-end. The Front-End Loaded scenario shows the emissions dropping faster and earlier, as expected, and the Straight-Line scenario reflects the gradual reductions. As described in the methodology section, Energy Strategies developed a range of avoided emissions that varies based on the generation that is displaced by the new renewable energy. The high-end reflects a proportional reduction in Rocky Mountain Power generation resources, whereas the low-end reflects a reduction in wholesale market power purchases.

Table 13 shows the low-end and high-end amounts of avoided emissions for the year 2032 when the renewable energy goal is fully implemented by following the Straight-Line procurement strategy. If Salt Lake City were to adopt a more aggressive procurement strategy either under the Hybrid or Front-End Loaded approaches, the cumulative avoided CO₂ emissions achieved would be significantly higher than the Straight-Line approach, not only because a carbon-emitting resource is replaced sooner, but also because in the early years, Rocky Mountain Power's portfolio is more coal-intensive.

Table 13: Salt Lake City’s Avoided Emissions in the Year the Goal is Achieved

Emissions	Low-End		High-End	
	Annual Tons Avoided in 2032	Cumulative Tons Avoided in 2019-2032	Annual Tons Avoided in 2032	Cumulative Tons Avoided in 2019-2032
Avoided CO₂ Emissions	775,245	5,975,659	1,798,714	14,948,385
Avoided SO₂ Emissions	407	3,219	1,009	9,569
Avoided NO_x Emissions	646	5,069	1,539	14,222

Applying the value of the Social Cost of Carbon adopted by the IWG, as described in the methodology section, enables Salt Lake City to assign a dollar value to the avoided CO₂ emissions. This monetized value represents benefits to society of reducing the CO₂ emissions in its electricity supply. Table 14 summarizes the results for Salt Lake City for the year 2032. Following best practices, a range of monetized values has been calculated using different discount rates for the Social Cost of Carbon. For 2032, the estimated monetized value of societal benefits of avoided CO₂ emissions is between \$12 million and \$122 million, depending on the actual displaced generation and the discount rate used.

Table 14: Value of Salt Lake City’s Avoided CO₂ Emissions in 2032

Social Cost of Carbon Discount Rate	Low-End Avoided CO ₂ Benefit in Millions for 2032	High-End Avoided CO ₂ Benefit in Millions for 2032
5%	\$12.00	\$27.70
3%	\$36.60	\$84.90
2.5%	\$52.70	\$122.40

CO₂ emissions are associated with climate change, which has far-reaching economic implications. The monetization of avoided CO₂ emissions represents the net present value of 280 years of economic damage that would result from these incremental emissions in that single year.

As described in the methodology section, there is no similar federal methodology for applying a dollar value to avoided emissions of criteria pollutants. Accordingly, Energy Strategies used the avoided emissions values published by the Minnesota Public Utilities Commission to show a sample monetization of avoided NO_x. For the avoided emissions

resulting from Salt Lake City pursuing 100% renewable energy, this would be a range of about \$17,000 to \$214,000 for the avoided NO_x emissions in 2033. The range is derived from multiplying low-end avoided emissions with the low Minnesota value per ton, and high with high.

Energy Strategies also calculated the high-end potential for avoided water use for the various scenarios. As described in the methodology section, low-end values were not calculated due to data availability issues. Table 15 summarizes the results for 2032.

Table 15: Water Co-Benefits: Salt Lake City

High-End Estimate of Avoided Water Use	659 million gallons in 2032
High-End Estimate of Avoided Water Use divided by the 79,568 residential customer accounts (a proxy for households) in Salt Lake City	About 23 gallons per household per day for 2032

Conclusions

This Study analyzed the impacts and benefits of Salt Lake City transitioning to a 100% renewable energy electricity supply. Energy Strategies' analysis indicates that implementation of Salt Lake City's 100% renewable electricity supply goal would provide important economic and environmental benefits, and would be achieved by modestly increasing the electricity rates of residents and businesses. Residents and businesses would spend 11% to 12% more for electricity in 2032 than would be expected if they continued to receive standard-offer electricity service from Rocky Mountain Power. For the average residential customer, this translates into a \$7 to \$8 increase in their monthly electricity bill. Depending on the renewable energy acquisition scenario, the impact could be 3% to 16% higher rates in 2021, with 3% representing the slower Straight-Line acquisition strategy, and 16% representing the Front-End Loaded accelerated schedule that would have Salt Lake City meeting its 100% renewable energy goal in 2022. These ranges are for the CRET procurement path. As noted in the analysis, these results are dependent on the assumptions, including the cost of renewable energy and the rate of increase in Rocky Mountain Power standard-offer service.

In this analysis, regardless of the renewable energy procurement scenario chosen, the CCA pathway is always more expensive than the CRET path. Salt Lake City residents and businesses expenditures on electricity are expected to be at least 14% more in 2032 compared to business-as-usual electricity service under Rocky Mountain Power. The CCA path relies on the same assumptions as the CRET path, but also assumes there are startup costs to create a CCA program and annual operating costs for the program.

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It was beyond the scope of this study to evaluate or quantify the value of removing fuel-price risk from the Communities' electricity rates, but Rocky Mountain Power's increased reliance on natural gas generation in the future will expose customers to natural gas price volatility and potential rate shocks. This is a financial risk Salt Lake City customers would not be exposed to if their power was generated by renewable resources.

The benefits of a transition to 100% renewable energy are apparent in the economic and environmental co-benefits analysis. Salt Lake City's \$1.96 billion investment to acquire 830 MW of new Utah-based renewable energy will result in almost 14,000 new direct, indirect and induced jobs during the construction phase and \$750 million in wages. The project will also contribute an additional \$1.8 million in economic output to the Utah economy. After the project is completed and operating, 320 new permanent jobs will be created paying \$19 million in annual wages and generating \$33 million in annual economic outputs.

While Rocky Mountain Power proposes to reduce its reliance on coal, its 2032 resource portfolio remains dominated by fossil fuels, as it replaces coal with natural gas. While GHG emissions associated with the electric supply would decline if Salt Lake City residents and businesses continued to receive standard-offer service from Rocky Mountain Power, they certainly do not fall to zero, as they would under a 100% renewable energy scenario. Depending on the assumed generation that is displaced by a transition to renewable electricity supply, Salt Lake City's efforts could mean the avoidance of 775,000 to 1,800,000 tons of CO₂ emissions in 2032 alone. Avoiding the emission of other criteria pollutants and fresh water use is another significant co-benefit of this transition that is quantified in this Study.

Because CO₂ is a long-lived pollutant once released into the atmosphere, cumulative avoided CO₂ emissions are an important consideration. Based on the Straight-Line procurement path and the assumption that Rocky Mountain Power generation is being displaced, almost 15 million tons of cumulative CO₂ emissions will be avoided over the 2019-2032 period. Adopting a more aggressive renewable energy procurement strategy, such as the Front-End Loaded path, would result in a higher amount of cumulative emissions being avoided.

While these results are based on one set of assumptions, and attempt to forecast results 15 years into the future, they provide Salt Lake City important guidance as to the direction and magnitude of the impact of achieving its 100% renewable energy goal. Salt Lake City residents and businesses could expect modestly higher electricity expenditures compared to continuing to receive standard-offer electricity service from Rocky Mountain Power. The benefits of a transition to 100% renewable energy are, of course, in providing more affordable and stable electricity prices in the future, enhancing economic resiliency, improving air quality, and reducing GHG emissions.

Appendix A: Renewable Energy Portfolio Costs

As noted in the body of the report, Energy Strategies used the PacifiCorp preliminary 2017 IRP Supply-Side Resource Table¹⁴ for its starting place for renewable energy portfolio costs. Energy Strategies also reviewed a number of renewable energy contract prices. The sources that Energy Strategies reviewed include:

- U.S. Energy Information Administration, "Levelized Cost and Levelized Avoided Cost of New Generation Resource in the Annual Energy Outlook 2016," August 2016.
- Lawrence Berkeley National Laboratory, "Forecasting Wind Energy Costs and Cost Drivers," June 2016.
- Lawrence Berkeley National Laboratory, "Utility-Scale Solar 2015: An Empirical Analysis of Project Cost, Performance, and Pricing Trends in the United States," August 2016.
- Rocky Mountain Power, "Program Costs Model," Subscriber Solar (Schedule 73) docket 15-035-61, Utah PSC webpage Sept 21, 2015.

Many of these costs were lower than those cited in the PacifiCorp preliminary 2017 Supply-Side Resource table, but there was no consensus. Table 16 lists the renewable resource costs, in \$ per MWh, for the PacifiCorp report and the market survey.

¹⁴ Supply-Side Resource Options, PacifiCorp, September 8, 2016.

pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2017_IRP/SSR_Database_2016.pdf

Table 16: Renewable Energy Resource Costs, PacifiCorp and Market Survey

PacifiCorp 2017 IRP Resource Costs				
Resource Study ID	Resource Description	State	2017 \$/MWh (before Tax Credit)	Tax Credit
Solar 1	PV Poly-Si Fixed Tilt	UT	66.00	(4.23)
Solar 2	PV Poly-Si Single Tracking	UT	58.72	(3.76)
Solar 3	PV Poly-Si Fixed Tilt	OR	87.16	(4.60)
Solar 4	PV Poly-Si Single Tracking	OR	80.35	(4.26)
Wind 1	2.0 MW turbine	ID	54.49	(18.37)
Wind 2	2.0 MW turbine CF	UT	62.27	(18.37)
Wind 3	2.0 MW turbine	WY	46.58	(18.37)
Geothermal	Greenfield Binary	Undefined	87.96	(16.33)
Market Survey Resource Costs				
Resource Study ID	Resource Description	State	2017 \$/MWh (before Tax Credit)	Tax Credit
Solar 5	PV Solar Generic	Undefined	37.84	(3.76)
Solar 6	PV Solar Generic	Undefined	42.43	(3.76)
Wind 4	Wind Generic	Undefined	53.24	(18.37)
Wind 5	Wind Generic	Undefined	58.25	(18.37)

Energy Strategies used the PacifiCorp costs as the starting point, but the costs were escalated or decreased in future years according to the schedule in Table 17. The source for these year-over-year adjustments was three different publications.¹⁵

¹⁵ National Renewable Energy Laboratory, Navigant Consulting report for PacifiCorp, and Sun Shot/UBS

Table 17: Capital Cost Changes for Wind and Solar PV by Year

Capital Cost Change by Year and Technology Type		
Year	Utility-Scale PV	Wind
2017	-4.3%	0.1%
2018	-4.3%	0.1%
2019	-4.4%	0.1%
2020	-4.5%	0.2%
2021	-3.1%	0.4%
2022	-3.4%	0.4%
2023	-1.4%	0.5%
2024	-1.5%	0.5%
2025	-1.6%	0.5%
2026	0.1%	0.5%
2027	0.1%	0.6%
2028	0.0%	0.6%
2029	0.0%	0.6%
2030	0.0%	0.6%
2031	0.1%	1.1%
2032	0.0%	1.1%
2033	0.0%	1.1%
2034	0.0%	1.2%
2035	0.0%	1.2%
2036	0.2%	1.2%
2037	0.8%	1.2%

The results in this report are based on the adjusted PacifiCorp cost data, but the model allows users to input different costs.

Appendix B: Environmental Co-Benefit Methodology

Appendix B provides additional information on the methodology for the calculation of the environmental co-benefits.

For GHG emissions and criteria pollutants, Energy Strategies estimated a range, based on a high case and a low case. The high case assumes that the renewable energy displaces PacifiCorp resources proportionally. Energy Strategies used the PacifiCorp energy mix as provided in the PacifiCorp 2015 IRP.¹⁶ This energy mix was adjusted to remove new energy efficiency and hydroelectric power (as these were accounted for separately in the Energy Strategies model) and to remove the planned renewable energy (as the associated renewable energy credits will likely be used in states with Renewable Portfolio Standards). The energy mix is a forecast for the years 2016 through 2034. Over that time, coal-fired electricity gradually decreases, replaced in part by an increase in gas-fired electricity. For 2035 and later, Energy Strategies held the energy mix constant, with no change to the relative proportions of coal- and gas-fired generation.

For the low case, Energy Strategies assumed the additional renewable energy displaces wholesale electricity market purchases. Rocky Mountain Power purchases and sells electricity in the wholesale market. Depending on the amount of energy replaced by renewable energy in any given year, Rocky Mountain Power may not change the dispatch of its owned and leased resource, but may instead adjust the amount of wholesale market transactions. PacifiCorp refers to these market purchases as Front Office Transactions (FOTs). FOTs might be sourced from any resource connected to the Western grid. Therefore, Energy Strategies used the energy mix from the Western Electricity Coordinating Council for the low-end. Energy Strategies developed a trend line to connect the 2015 historical energy mix with the 2026 Common Case¹⁷ expected energy mix; after 2026, the mix was held constant. This energy mix includes significantly more non-emitting resources, such as hydroelectric power. This is the primary reason it represents the low end of avoided emissions.

For freshwater use, Energy Strategies reviewed the plant characteristics of the various coal- and gas-fired power plants in PacifiCorp's fleet to estimate the average rate of water consumption by fuel type. Most of PacifiCorp's coal plant capacity is closed-cycle cooling, subcritical pulverized coal. Energy Strategies therefore used the median

¹⁶ 2015 Integrated Resource Plan Volume 1, PacifiCorp, March 31, 2015, Figure 8.25, page 193.
pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2015IRP/PacifiCorp_2015IRP-Vol1-MainDocument.pdf

¹⁷ Data related to the 2026 Common Case can be downloaded from here:
wecc.biz/SystemAdequacyPlanning/Pages/Datasets.aspx

rate of water use for this plant type from a 2011 NREL study,¹⁸ 471 gallons per MWh. Gas plants use significantly less water than coal plants. The critical factor in water use by gas-fired plants is whether the plant is dry-cooled (air-cooled) or wet-cooled (evaporative cooling). Slightly more than half of PacifiCorp's current natural gas capacity is wet-cooled. Therefore, Energy Strategies used the median values from the 2011 NREL study for dry- and wet-cooled natural gas plants, and created a weighted average using PacifiCorp's fleet capacities. The result is an average water use by gas-fired plants of 117.4 gallons per MWh.

¹⁸ *A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies*, National Renewable Energy Laboratory, March 2011, nrel.gov/docs/fy11osti/50900.pdf

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