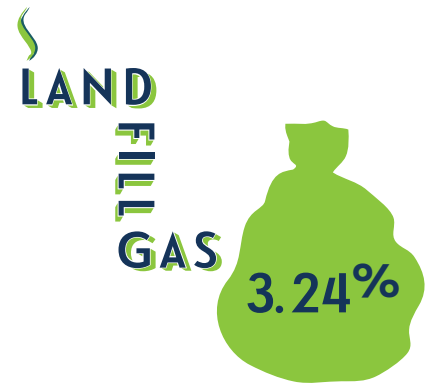
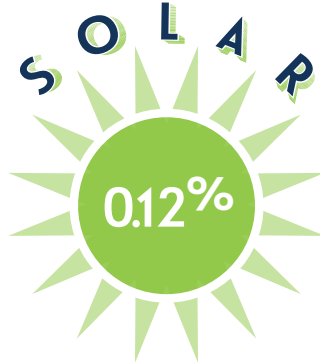




Renewable Energy Report

2018
COLUMBIA
WATER & LIGHT



15.70% of all energy sources for 2017 were renewable, **exceeding goal** of 5%

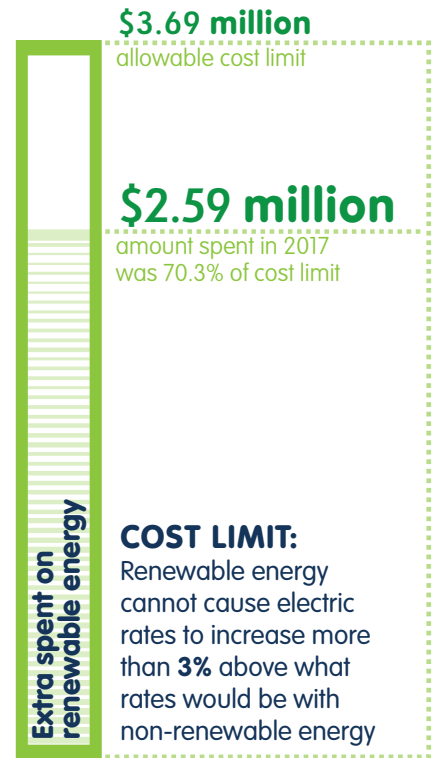
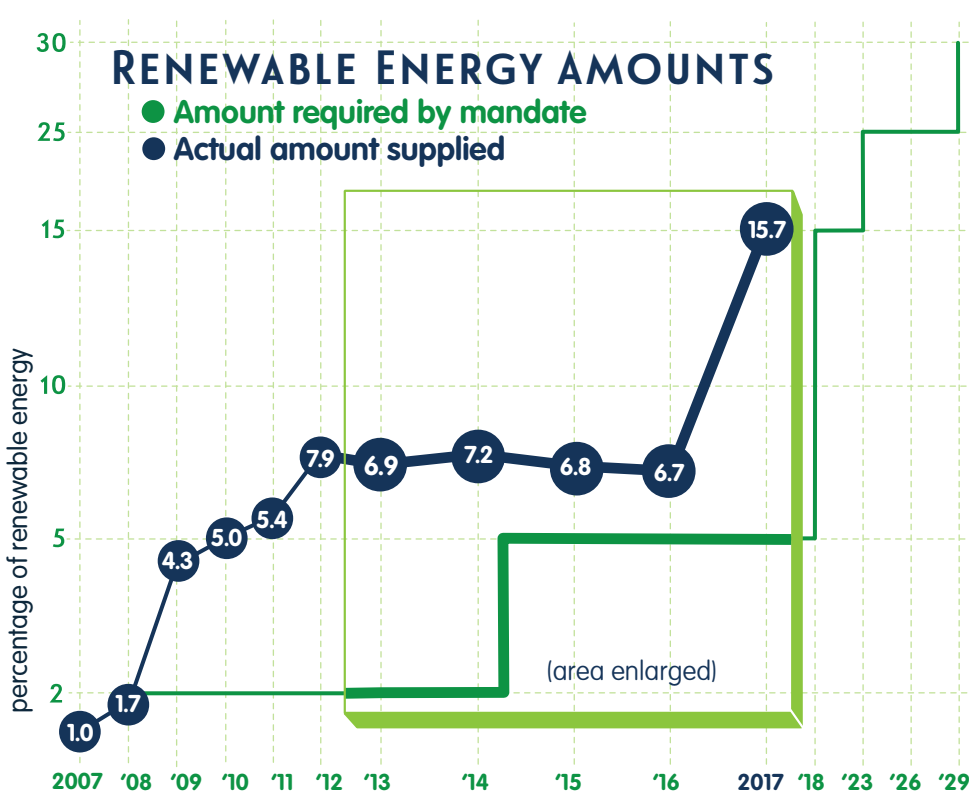


Table of Contents

Renewable Energy Overview	1
Renewable Energy Production Amounts Chart	2
Costs of Renewable Energy	3
Renewable Energy Portfolio Details	6
Renewable Energy Education	9
Future Renewable Energy Production	9
Appendix	11
Historical Renewable Energy Data	12
Approved Sources of Renewable Energy	17
Renewable Energy Ordinance 27-106	18
Columbia Wind Speed Study	19
Net Metered Solar Production by Rate Class	20
Rate Impacts on Renewables Report	23

2018 Renewable Energy Report

Columbia Water & Light

In November 2004, Columbians approved a renewable energy ordinance for the city's power supply portfolio. The ordinance mandates Columbia Water & Light purchase increasing levels of energy from renewable resources. Each year, the utility is required to submit a plan outlining compliance with the ordinance. The Water & Light Advisory Board and the Environment and Energy Commission review the report before it goes to the Columbia City Council for a public hearing.

Renewable Energy Overview

In 2017, Columbia generated 15.70% of the electric portfolio from renewable sources. The renewable portfolio comes from wind (12.34%), landfill gas (3.24%) and solar (0.12%). The total amount exceeds the requirement for 2017 of 5% by 10.7%. The additional cost is 70.3% of what is allowed by the renewable energy ordinance. City also operates residential, commercial, and industrial demand side management (energy efficiency) programs for the purpose of reducing overall energy demand. Information on available city demand side management programs can be found at <http://columbiapowerpartners.com>.

2017 Renewable Energy Sources

Columbia system load: 1,170,456 megawatt hours (MWH)

Renewable energy total: 183,785 megawatt hours or 15.70%

- Bluegrass Ridge wind energy: 1.12% of electric system @ \$68.69/MWH
- Crystal Lake wind energy – Contract 1: 2.92% of electric system @ \$45.96/MWH
- Crystal Lake wind energy – Contract 2: 8.30% of electric system @ \$19.55/MWH
- Jefferson City landfill gas: 1.82% of electric system @ \$53.00/MWH
- Columbia landfill gas: 1.17% of electric system @ \$63.72/MWH
- Free Power Solar: 0.03% of the electric system @ \$54.95/MWH
- Net metered customer production: 0.06% of the electric system. The average retail rate for net metered energy was \$93.50/MWH
- Columbia Water & Light solar production: 0.04% of the electric system @ \$62.30/MWH

2017 Renewable Energy Supply Activities

- Responses to a Request for Proposal for wind energy were evaluated and a contract was finalized. The new contract became effective January 1, 2017. The new contract provided 8.30% of the energy to the Columbia system which is in addition to the existing contracts for wind generated power.
- There was a 91% increase in the rated capacity of customer installed photovoltaic systems from 2016 to 2017.
- Cooling systems for two units at the Columbia Landfill Gas Plant were replaced in July 2016. The third generator had a routine overhaul in September 2016. Both of these actions decreased the production of electricity in 2016.

Renewable Energy Ordinance Requirements

According to the current standards, the city shall generate or purchase electricity generated from eligible renewable energy sources at the following levels: 2% of electric retail sales by December 31, 2007, 5% of electric retail sales by December 31, 2012; 15% of electric retail sales by December 31, 2017; 25% of electric retail sales by December 31, 2022, and 30% of electric retail sales by December 31, 2028.

The renewable energy ordinance was revised by the Columbia City Council on January 6, 2014 to increase the required amounts of renewable energy in the future. The full text of the Renewable Energy Standard and the approved list of renewable resources are listed in the appendix of this report.

2017 Renewable Energy Production Amounts

Month	System MWH's	Bluegrass Wind MWH's	Crystal Lake Wind Contract 1 MWH's	Crystal Lake Wind Contract 2 MWH's	Columbia Landfill MWH's	Jeff City Landfill MWH's	Free Power Solar MWH's	Net Meter Solar MWH's	Columbia Solar MWH's	Total Renew MWH's	YTD Annual % of System
1-17	103,317	1,041	3,023	7,946	1,094	1,921	11.23	11.80	15.63	15,064	14.58%
2-17	84,331	1,287	3,821	9,821	1,075	1,365	22.87	29.77	27.92	17,449	17.33%
3-17	87,865	1,461	3,968	10,176	1,306	2,171	26.75	39.64	32.21	19,180	18.76%
4-17	83,932	1,336	3,175	7,699	168	1,503	30.69	50.99	37.40	14,000	18.28%
5-17	90,845	1,154	2,785	7,285	1,859	1,310	40.32	75.59	47.52	14,556	17.82%
6-17	108,284	918	2,303	6,713	1,847	1,871	41.56	72.20	50.19	13,816	16.84%
7-17	126,747	533	1,350	4,226	1,949	1,952	40.15	57.88	49.49	10,158	15.21%
8-17	109,516	377	1,329	4,140	1,913	1,965	32.63	66.83	44.49	9,867	14.35%
9-17	102,229	743	2,355	7,374	1,623	1,834	30.76	67.86	43.47	14,071	14.29%
10-17	89,532	1,626	3,459	11,032	1,331	1,652	20.35	67.17	29.66	19,217	14.94%
11-17	83,094	1,310	3,391	10,716	1,232	1,820	16.57	41.31	26.02	18,553	15.51%
12-17	100,764	1,381	3,161	10,020	1,279	1,881	14.55	60.41	22.97	17,820	15.70%
Total	1,170,456	13,167	34,120	97,148	16,676	21,245	328	674	427	183,785	
% of System		1.12%	2.92%	8.30%	1.42%	1.82%	0.02%	0.06%	0.04%	15.70%	

Note: Energy production amounts are listed in megawatt hours (MWH)

Costs of Renewable Energy

As outlined in Section 27-106(b) of the Renewable Energy Standard ordinance, renewable energy cannot cause electric rates to increase more than 3% above what rates would be with non-renewable energy. The 3% impact on rates limit is determined as 3% of total revenue from regulated rate sources. An outside utility consultant was hired in 2014 to review the cost impact of renewable energy. A copy of this report can be found in the appendix.

The City of Columbia has a fiscal year that does not match the calendar year outlined in the Renewable Energy Standard. Renewable energy costs for this report include information from January through September of the prior fiscal year and October through December of the current fiscal year. For calendar year 2017, the additional cost to address the renewable portfolio requirement was \$2,594,727.74 and the limit was \$3,694,423 as outlined in the following tables. The additional money spent on renewable energy was 70.3% of what was allowed according to the ordinance. From calendar year 2016 to calendar year 2017, the total amount of renewable energy increased by 102,787 megawatt hours, or 127%, at a renewable cost increase of \$848,146.70 or 48.5%.

The latest change in costs for 2017 was due to:

- Increased renewable energy production.
- Increased base load resource efficiency that reduced the cost of non-renewable base load resources.
- The Columbia Landfill Gas Plant produced less energy due to issues with the cooling system for two of the generators and the scheduled outage for maintenance of the third generator. The fixed cost of the plant therefore impacted the overall cost for this energy more than in previous years.

Cost of 2017 Renewable Energy Portfolio

Renewable Resource	Total 2017 MWH's	Additional Cost/(Savings) Per MWH	Total Impact on Rates
Bluegrass Ridge Wind (Associated Electric)	13,167	\$48.15	\$593,173.35
Crystal Lake Wind Contract 1 (NextEra)	34,120	\$40.08	\$1,367,529.60
Crystal Lake Wind Contract 2 (NextEra)	97,148	\$3.11	\$302,130.28
Columbia Landfill	16,676	\$0.47	\$7,837.72
Jefferson City Landfill (Ameresco)	21,245	(\$1.59)	(\$33,779.55)
Free Power Photovoltaic Production	328	\$9.68	\$3,175.04
Net Metered Photovoltaic Production	674	\$40.40	\$27,229.60
Columbia Water & Light Solar Production	427	\$18.10	\$7,728.70
Total Renewable Resource Impact on Rates			\$2,275,772.88
2017 Photovoltaic Rebates to Customers			\$319,703
Total 2017 Renewable Standard Impact on Rates			\$2,594,727.74

Maximum Renewable Portfolio Cost Calculations

Revenue Source	January – September (FY17)	October – December (FY18)
Residential	\$39,761,843	\$11,362,712
Commercial/Industrial	\$54,605,912	\$17,416,953
Total Revenue During Calendar Year 2017		\$123,147,420
3% Impact Limit on Rates		\$3,694,423

Calculating Renewable Energy Costs

Renewable and non-renewable energy prices are divided into the three resource categories below. The cost or savings associated with a renewable resource is determined through comparison with cost of the non-renewable resource(s) in the same category. Definitions of the types of electric supply resources are listed at the beginning of each category.

1. Base Load Resources
 - a. A dispatchable resource that provides capacity and energy at a high capacity factor, on a year-round basis.
 - b. Current non-renewable base load resources
 - i. Sikeston
 - ii. Iatan II
 - iii. Prairie State – units 1 and 2
 - c. Current renewable base load resources
 - i. Columbia landfill gas plant
 - ii. Ameresco landfill gas plant contract
 - d. All-in cost (capacity, energy and transmission) comparisons are calculated for a monthly average cost per megawatt hour. The cost per megawatt hour variance between each renewable resource and non-renewable resources are applied to the total monthly megawatt hour output of each renewable resource to determine the annual renewable cost variation. The average non-renewable cost in 2017 was \$54.40/MWH.
 - i. Columbia landfill gas plant
 - Produced 16,676 megawatt hours
 - The average cost was \$54.87/MWH
 - There was a renewable resource cost of \$0.47/MWH (\$54.87-\$54.40)
 - Columbia landfill gas impact on rates for 2017 was a cost of \$7,837.72 (16,676 MWH @ \$0.47/MWH)
 - ii. Jefferson City (Ameresco) landfill gas plant
 - Produced 21,245 megawatt hours
 - The cost was \$52.81/MWH
 - There was a renewable resource savings of \$1.59/MWH (\$52.81-\$54.40)
 - Jefferson City landfill gas impact on rates for 2017 was a savings of \$33,779.55 (21,245 MWH @ \$1.59/MWH)
2. Intermittent Resources
 - a. A limited or non-dispatchable resource that may provide capacity and energy.
 - b. Current renewable intermittent resources
 - i. Bluegrass Ridge wind
 - ii. Crystal Lake wind
 - iii. Free Power
 - iv. Net metered customer production
 - v. Solar One
 - vi. West Ash Solar Field
 - c. All-in cost (energy and transmission) for intermittent resources will be compared to the appropriate Midcontinent Independent System Operator's (MISO) Locational Marginal Price (LMP) for energy at the pricing node where Columbia Water & Light takes delivery of the energy. The renewable cost per megawatt hour will include any additional fees invoiced under the contract, such as transmission costs. The cost per megawatt hour variance between the renewable energy and the market energy will be applied to the total megawatt hour output of the renewable resources to determine the annual renewable cost variation. Qualified intermittent resources are credited with a capacity offset value to recognize the corresponding reduction in capacity requirements during peak periods. The capacity credit values are: \$3.10 per MWH for wind resources and \$15.80 per MWH for solar resources.
 - i. Bluegrass Ridge: This resource is not in MISO so a fixed charge for transmission to MISO is necessary in addition to the purchase price. For calendar year 2017, the average real-time Columbia LMP for the hours when this wind resource was producing energy was \$20.18 per megawatt hour. The total cost of energy, including transmission, was \$68.34 per megawatt hour. The difference in these two values is the renewable cost of \$48.15 per megawatt hour.
 - Produced 13,167 megawatt hours at a renewable cost of \$48.15 per MWH
 - A capacity credit of \$3.10 per MWH reduces the renewable cost to \$45.05 per MWH.

- Total renewable expense and impact on rates for 2017 was \$593,173.35 (13,167 MWH's @ \$45.05/MWH).
- ii. Crystal Lake Contract 1: This resource is in MISO so no fixed transmission charge exists. This contract requires Columbia Water & Light to pay for "deemed" energy. This is energy that would have been produced had Columbia Water & Light not requested production curtailment due to a negative LMP. A negative LMP means that Columbia Water & Light would be paying the energy market to take the energy. Columbia Water & Light currently requests curtailment at negative twenty dollars (-\$20.00). For calendar year 2017, the average real-time Crystal Lake LMP for the hours when this wind resource was producing energy was \$15.70 per megawatt hour. As part of adding the second Crystal Lake contract, Columbia Water & Light renegotiated contract 1 with the University of Missouri to provide a blended cost based on the weighted average of the two contracts. The total blended cost of energy to UMC was \$55.78 per megawatt hour. The difference in these two values is the renewable cost of \$40.08 per megawatt hour.
- Produced 34,120 megawatt hours at a renewable cost of \$40.08 per MWH
 - This resource does not qualify for a capacity credit because purchase occurs at Crystal Lake
 - Total renewable expense and impact on rates for 2017 was \$1,367,529.60 (34,120 MWH's @ \$40.08/MWH)
- iii. Crystal Lake Contract 2: A second contract began in January 2017 with energy provided from the same wind resource. While this contract also requires Columbia Water & Light to pay for "deemed" energy, there is a deemed energy credit provided. This means that Columbia Water & Light can incur a level of deemed energy without cost. Columbia Water & Light requests curtailment, for this contract, at negative ten dollars (-\$10.00). For calendar year 2017, the average real-time Crystal Lake LMP for the hours when this wind resource was producing energy was \$16.44 per megawatt hour. The total cost of energy, including deemed energy, was \$19.55 per megawatt hour. The difference in these two values is the renewable cost of \$3.11 per megawatt hour.
- Produced 97,148 megawatt hours at a renewable cost of \$3.11 per MWH
 - This resource does not qualify for a capacity credit because purchase occurs at Crystal Lake
 - Total renewable expense and impact on rates for 2017 was \$302,130.28 (97,148 MWH's @ \$3.11/MWH):
- iv. Free Power: These photovoltaic systems are connected to the Columbia Water & Light electric distribution system, so they operate behind the meter in MISO. For calendar year 2017, the average real-time Columbia LMP for the hours when the Free Power solar resource was producing energy was \$29.47 per megawatt hour. The Free Power contract price is \$54.95 per megawatt hour. The difference in these two values is the renewable cost of \$25.48 per megawatt hour.
- Produced 328 megawatt hours at a renewable cost of \$25.48 per MWH
 - A capacity credit of \$15.80 per MWH reduces the renewable cost to \$9.68 per MWH
 - Total renewable expense and impact on rates for 2017 was \$3,175.04 (328 MWH's @ \$9.68/MWH)
- v. Net metered customer production: These customer-owned photovoltaic developments are connected to the Columbia Water & Light electric distribution system. Columbia Water & Light uses a single meter to measure the energy provided to the customer and the energy provided to the utility by the customer. This energy is considered "in front of the meter" and the energy information is used in the evaluation of net-metered cost. Energy produced and consumed "behind the customer meter" results in a load reduction for the utility. For calendar year 2017:
- Customer-owned net metered photovoltaic developments produced an estimated.
 - 1406 megawatt hours of total production of which
 - 674 megawatt hours was metered in to the utility system and
 - 732 megawatt hours resulted in load reduction for the utility system
 - \$28.72 per megawatt hour was the weighted average real-time Columbia LMP for the hours when customer-owned solar resources were providing energy to the utility.
 - \$93.50 per megawatt hour was the retail rate for each customer, based on the weighted average retail energy price paid for the energy delivered.
- Application of this renewable rate impact methodology starts with energy impacts by
- Taking the \$93.50 per megawatt hour weighted average retail rate, then subtracts the renewable cost of \$28.72 per megawatt hour.

- With a final result of \$64.78 per megawatt hour (\$93.50-\$28.72).

Then the capacity benefits are included by

- Taking a capacity credit of \$15.80 per MWH for 674 megawatt hours delivered to the utility system plus
- a capacity credit of 50% of \$15.80 per megawatt hour for 732 megawatt hours estimated to have resulted in load reduction behind the meter, then applied as a credit to the 674 megawatt hours delivered to the utility, resulting in a \$8.58 credit.
- With a final result of \$40.40 per megawatt hour (\$93.50-\$28.72-\$15.80-\$8.58)

Total renewable expense and impact on rates for 2017 was \$27,229.60 (674 MWH @ \$40.40/MWH)

- vi. Columbia Water & Light Solar Production: The combined output of the West Ash Solar Field and the Solar One contracts was 427 MWH's in calendar 2017. Production is connected with the Columbia Water & Light electric distribution system and operates behind the meter in MISO. For calendar year 2017, the average real-time Columbia LMP for the hours when solar production occurred was \$28.40 per MWH. The West Ash Solar Field the average cost was \$62.30 per MWH. Estimated energy production was based on the installed cost over a 25 year period with a .5% degradation rate and did not include cost of money or operation and maintenance. The difference in these two values is the renewable cost of \$33.90 per megawatt hour
 - Produced 427 megawatt hours at a renewable cost of \$33.90 per MWH
 - A capacity credit of \$15.80 per MWH reduces the renewable cost to \$18.10 per MWH
 - Total renewable expense and impact on rates for 2017 is \$7,728.70 (427 MWH @ \$18.10/MWH)

3. Peaking Resources

- a. All electric utilities are required to maintain resources to meet the megawatt system peak requirements plus a reserve requirement. This capacity requirement is typically met with the lowest cost resource available. The cost is calculated and/or paid on a per megawatt basis, not on a megawatt hour basis. These resources fulfill a specific requirement that typically does not include energy production. Non-renewable capacity resources are the Columbia Energy Center and two natural gas generators at the Columbia Power Plant. No renewable resources are in place only for capacity purposes. For the purpose of evaluating non-renewable versus renewable energy costs, capacity resources are excluded from the calculations.

4. The total additional cost of renewable energy is the sum of the calculations described in section 1, 2 and 3 above, plus the rebate amount provided to customers that installed qualifying photovoltaic systems in the current year. The total additional cost of renewable energy for calendar year 2017 was \$2,595,475.88

2017 Renewable Energy Portfolio Details

Bluegrass Ridge Wind Energy

Columbia started receiving wind power from turbines near King City, Missouri on September 5, 2007. The Columbia contract is for one ninth of the electric output from the Bluegrass Ridge Wind Farm from Associated Electric Cooperative. At the maximum output, Columbia Water & Light could receive up to 6.3 megawatts. In 2017, Columbia received 13,167 megawatt hours of power from this contract or 1.12% of the electric system total. The amount of wind energy Columbia receives is variable. There is a fixed transmission cost for this energy, so it is more expensive when less energy is received. The average cost for 2017 for wind power from the Bluegrass Ridge Wind Farm was \$68.34 per megawatt hour.

Crystal Lake Wind Energy

In 2012, Columbia Water & Light began a 20-year contract for energy produced from 21 megawatts of wind generation at the Crystal Lake III Wind Energy Center located in Hancock County, Iowa. The University of Missouri purchased half of the energy from the City of Columbia contract. This arrangement can be terminated by either party at any time.

In late 2016, Columbia Water & Light established a second contract with NextEra Energy Resources to receive additional energy from the Crystal Lake III Wind Energy Center located in Hancock County, Iowa. In January 2017, Columbia Water & Light began receiving energy produced from 27 megawatts of wind generation. In 2023, the second contract amount will increase to the energy produced from 45 megawatts of wind generation. While the University of Missouri is not participating in the second contract, Columbia Water & Light did agree to provide the University with a blended cost based on the weighted average cost of the two contracts.

Both contracts require Columbia Water & Light to pay for deemed energy. Deemed energy is energy that would have been produced had Columbia Water & Light not requested production curtailment due to a negative Locational Marginal Price (LMP). A negative LMP means that Columbia Water & Light would be paying the energy market to take the energy. For the original contract, Columbia Water & Light currently requests curtailment at negative twenty dollars (-\$20.00). The fixed cost of the wind energy delivered to Columbia, from the original

contract, will remain at \$45.00 for the rest of the contract. The second contract includes a deemed energy credit and therefore Columbia Water & Light currently requests curtailment at negative ten dollars (-\$10.00). The second contract has an annual price escalation of 2%. The initial charge per MWH was \$19.55. The second contract will end in 2032, which coincides with the ending of the first contract.

In 2017, the utility received 34,120 megawatt hours from the original contract which represents 2.92% of the electric system total. The total cost of energy, including deemed energy, was \$55.78 per megawatt hour.

In 2017, the utility received 97,148 megawatt hours from the second contract. This represents 8.30% of the electric system total. The total cost of energy, including deemed energy was \$19.55 per megawatt hour.

Columbia Landfill Gas

The Columbia Landfill Gas Energy Plant was constructed in 2008 using the gas created from decomposing waste at the landfill. The amount of energy received from the Columbia Landfill Gas Energy Plant is fairly consistent aside from times when there is routine maintenance work. The plant can currently generate 3.1 megawatts of renewable power. In 2017, the landfill gas plant produced 16,676 megawatt hours of energy at a cost of \$54.87 per megawatt hour which was 1.42% of Columbia's energy system total.

Units 1 & 2 received a major engine replacement in the spring of 2017. Air permitting work required for the installation of a fourth engine is completed, with installation expected in 2018. All of the units were and will be paid for from bond funding.

Jefferson City Landfill Gas

Columbia Water & Light has a 20-year power purchase agreement with Ameresco for 3.2 megawatts of energy from the landfill gas plant at the Jefferson City landfill. Columbia started receiving energy from the plant in April 2009. The total amount of energy received in 2017 was 21,245 megawatt hours which is 1.82% of the electric system total. The utility paid \$52.81 per megawatt hour for the electricity. Both Columbia and Jefferson City are located within the MISO territory so transmission fees do not substantially change the cost of the energy.

Wood Fuel at the Columbia Power Plant

Columbia Water & Light burned waste wood along with coal at the local power plant from 2008 until September 2015. Columbia stopped burning coal and waste wood due to new federal emission regulations and the age of some of the equipment. Columbia Water & Light continues to investigate biomass alternatives for the Municipal Power Plant and will present any new options to the Water & Light Advisory Board, the City Council and customers in the future.

Free Power

The Columbia City Council approved a lease agreement with the Free Power Company, Inc. in December 2010 for the electricity generated from photovoltaic modules at \$54.95 per megawatt hour. In 2017, Free Power solar projects produced 328 megawatt hours which are 0.02% of Columbia's electric portfolio. The systems are located at the Transload Facility and are rated at 0.33 megawatts. Columbia Water & Light is only paying for the electricity generated from the panels.

Net Metered Customer Production

The Columbia City Council passed an ordinance in 2007 to allow customers to enter into a net metering agreement with Columbia Water & Light. During 2017, there was an increase in customers installing their own photovoltaic systems from 85 to 155 and the rated capacity grew from 0.788 megawatts to 1.505 megawatts. In 2017, the amount of energy sold to the electric utility was 674 megawatt hours at \$93.50 per megawatt hour. The increase in cost per megawatt-hour in 2017 is attributed to an increase in net metered customers whose excess energy is purchased at the highest tier in the rate structure. A breakdown of net-metered energy by each rate class and rate tier is provided in the appendix. Net-metered production represented 0.06% of Columbia's electric portfolio in 2017.

A net metering arrangement keeps track of both the amount of electricity provided by the utility to the customer and the amount of electricity provided by the customer to the utility. At the end of the month, the customer is billed for the difference or the 'net' amount of electricity used over the month. Columbia Water & Light credits the net metering customer's account for the electricity provided to the Columbia system at the following rates:

- Solar: Columbia Water & Light will credit the customer's current electric rate, and defer the associated PILOT assessment, for the delivered solar generated electricity when the utility retains the Renewable Energy Credits (REC). If the customer wants to keep the solar RECs, the customer will receive a credit based on the avoided average energy market price at the Columbia pricing node. There is a 100 kilowatt capacity cap on the net metering arrangement.
- Other: For non-solar renewable generated energy, the customer shall receive a credit based on the avoided average energy market price at the Columbia pricing node, and the associated PILOT assessment will be deferred.

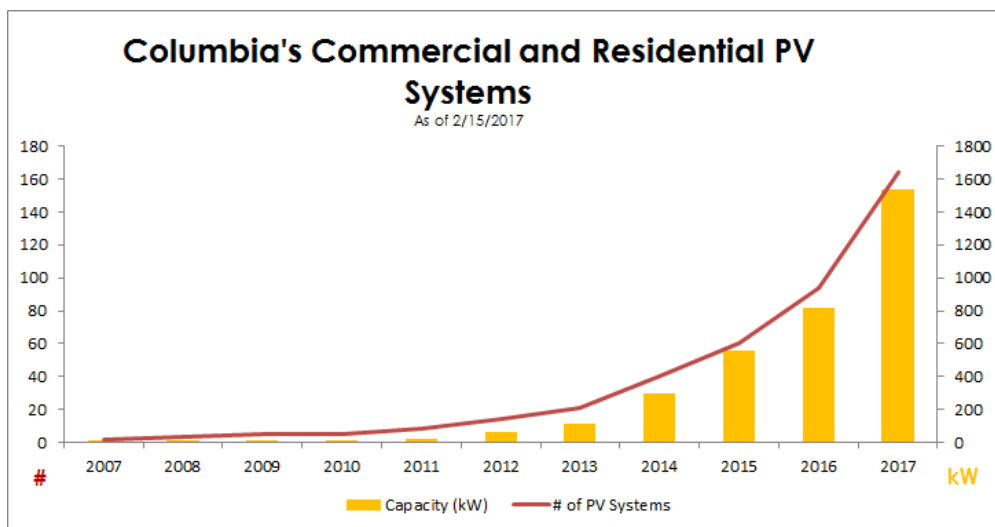
An Interconnection and Net Metering Agreement must be in place for the customer to receive a credit for the energy they deliver to Columbia Water & Light. For billing periods in which the net energy is less than zero, credits for the amount of net energy will be applied to the account. Credits can be carried over and applied to the next billing cycle.

Columbia Water & Light offers a one-time rebate for qualifying photovoltaic systems of \$500 per kilowatt up to ten kilowatts and a tiered and performance based rebate is offered for larger systems. Customers installing a solar water heating system can qualify for up to \$800 in rebates. In calendar year 2017, \$319,703 in solar electric system rebates were provided. In 2014, Solar Energy Loans were made available to customers with the same terms as the existing Home Performance with Energy Star Loan program. To be eligible for a Solar Energy Loan, customers' property must meet specific energy efficiency improvement requirements. In calendar year 2017, there were three solar loans issued totaling \$45,081.

Columbia Water & Light Solar Projects

Columbia Water & Light started the Solar One program in November 2008 as a way for customers to have an affordable way to invest in local solar energy projects. Solar One helped the community start developing local projects which led to Columbia receiving national attention for being a supporter of solar energy. Energy for the Solar One program is partially generated through 10-year power purchase agreements with two local businesses. Some of the energy is also produced at the solar electric field on Bernadette. The Bernadette site was expanded by Columbia Water & Light staff members in 2015. In order to keep the cost down for this 267.8 kilowatt project, Columbia Water & Light employees were used to install the panels. These solar resources produced 433 megawatt hours or 0.04% of the electric portfolio at a cost of \$62.30 per megawatt hour.

A community solar project is being considered by the utility which will enable Columbia Water & Light customers to receive part of the solar energy output to power their homes and businesses. The City of Columbia Legal Department is reviewing the parameters of the program and customer agreements.



COMPLETED Commercial and Residential		
Year	# of PV Systems	Capacity (kW)
2007	2	4
2008	3	6
2009	5	10
2010	5	10
2011	8	21
2012	14	60
2013	21	114
2014	40	299
2015	60	554
2016	94	815
2017	164	1539

2/15/2018

Columbia Water & Light Solar Projects

Columbia Water & Light started the Solar One program in November 2008 as a way for customers to invest in local solar energy projects. Solar One helped the community start developing local projects which led to Columbia receiving national attention for being a supporter of solar energy. Energy for the Solar One program is partially generated through 10-year power purchase agreements with two local businesses. Some of the energy is also produced at the solar electric field on Bernadette. The Bernadette site was expanded by Columbia Water & Light staff members in 2015. These solar resources produced 427 megawatt hours or 0.04% of the electric portfolio at a cost of \$62.30 per megawatt hour.

A community solar project is being considered by the utility which will enable Columbia Water & Light customers to receive similar benefits as a system owned by a customer. The City of Columbia Legal Department is reviewing the parameters of the program and customer agreements.

Renewable Energy Education

Advancing Renewables in the Midwest

On April 24 and 25, 2017, the 12th annual Advancing Renewables in the Midwest conference hosted around 200 attendees. Dr. Marie Mapes from the U.S. Department of Energy gave the keynote address on the potential growth opportunities and economic benefits of the solar market. The financial aspects of renewable power, including the value, economics and trends in jobs were topics of discussion at the conference. The conference was hosted by Columbia Water & Light, the University of Missouri's School of Natural Resources and the Missouri Department of Economic Development. The 2018 conference will be held at the University of Missouri on April 18-19.

Civic and Environmental Group Outreach

In 2017, Columbia Water & Light staff visited a number of groups to present information about Columbia's renewable energy portfolio and the availability of net metering to customers. At Earth Day, the Sustainable Living Fair, the Parks and Recreation Department's Family Fun Fests, and other events, nearly 3,000 attendees were able to receive information about installing solar systems from utility representatives. Paid advertising was also placed to inform customers about the availability of solar rebates, low-interest loans and net metering agreements.

K-12 Educational Programs

Renewable energy is often a focus of outreach efforts in the local public and private schools along with public events. In 2017, approximately 8,000 young people were reached. Students at Battle High School learned about solar water heating and electricity as part of the Bottle Battle engineering project. In April, Columbia Water & Light staff participated in the Derby Ridge Elementary School Earth Day event with an interactive, all-school lesson; and summer presentations at Fun City Youth Academy and Camp Kid Connect focused on the value of energy efficiency and renewable energy.

Columbia Public Schools Solar Installations

Energy from the sun is helping to power the Columbia Area Career Center and Benton Elementary School, providing a unique learning opportunity for students. In 2007, Columbia Water & Light purchased a 2-kilowatt photovoltaic system for the Career Center which generates around 2,700 kilowatt-hours of electricity for the building annually. In January 2014, Benton Elementary School utilized a \$5,000 grant from the UPS Foundation to purchase and install a 1.5-kilowatt system, expected to produce approximately 1,600 kilowatt-hours per year. Information about the amount of solar radiation, weather conditions and electricity output are available to students at both sites.

Future Renewable Energy Production

The fourth and final generator for the existing building design at the Columbia landfill has been funded and is expected to be installed in late 2018.

In February 2018, the City Council approved a purchase power agreement and a solar interconnection agreement with Truman Solar, LLC for the purchase of energy from a 10 MW solar facility to be constructed by Truman Solar. The facility will be connected to Columbia Water & Light's Rebel Hill substation with a scheduled commercial operation date of April 1, 2019. The solar installation is expected to produce 23,000 MWH's in its first year of operation.

In June 2017, the City Council approved a contract with the Missouri Joint Municipal Electric Utility Commission (MJMEUC) for the purchase of 35 MW of wind energy from western Kansas. Delivery of this energy depends upon the construction of the Grain Belt Express Clean Line transmission line and a converter station in northeast Missouri, with a projected delivery date starting in 2021. Additionally, a second contract amount will increase to the energy produced from 45 megawatts of wind generation by Crystal Lake III in 2023.

Columbia Water & Light continues to develop a potential project to convert assets at the Municipal Power Plant to use 100% biomass fuel. The required air permit has been approved by the Missouri Department of Natural Resources and a scope of work and preliminary cost estimate for the project has been developed. The Biomass Conversion Project could potentially supply 18.3 MW of dispatchable capacity and 82,000 to 106,000 MWH's of biomass fueled energy per year. The project will be evaluated as part of the electric utility's upcoming Integrated Resource and Master Plan process.

Based on a system energy requirement of 1,220,000 MWH's and similar renewable energy production levels, it is estimated that over 15% of Columbia's electric portfolio will come from existing renewable resources in 2018.

2018 Estimated Renewable Portfolio

	Location	Amount of Energy	% of Portfolio	Cost
Bluegrass Ridge	King City, MO	13,000 MWH	1.07%	\$67/MWH
Crystal Lake Contract #1	Hancock County, IA	34,000 MWH	2.79%	\$45/MWH
Crystal Lake Contract #2	Hancock County, IA	97,000 MWH	7.95%	\$19.75/MWH
Jefferson City landfill gas	Jefferson City, MO	22,000 MWH	1.80%	\$53/MWH
Columbia landfill gas	Columbia, MO	22,000 MWH	1.80%	\$55/MWH
Free Power Solar	Columbia, MO	300 MWH	0.02%	\$55/MWH
Net Metered Customer Production	Columbia, MO	800 MWH	0.07%	\$72/MWH
West Ash Solar Field	Columbia, MO	400 MWH	0.03%	\$62/MWH
Total		189,500 MWH	15.53%	

The amount of energy is measured in megawatt hours (MWH)

Appendix

Historical Renewable Energy Data

2005 Renewable Energy

The first renewable energy was delivered to Columbia through a short-term contract for landfill gas energy from Illinois.

2007 Renewable Energy Production Amounts

Columbia started receiving wind energy from Bluegrass Ridge.

Month	Total System MWH	Wind MWH	Columbia Landfill MWH	Waste Wood MWH	Jeff City Landfill MWH	Total Renew MWH	Monthly % of System	Annual % of System
9-07	104,618	592				592	0.6%	
10-07	91,357	1,030				1,030	1.1%	
11-07	84,135	1,153				1,153	1.4%	
12-07	97,985	969				969	1.0%	
TOTAL	378,095	3,744				3,744		

The amount of energy is measured in megawatt hours (MWH)

2008 Renewable Energy Production Amounts

The initial phase of the landfill gas to energy project was completed in Columbia. The Columbia Power Plant started burning waste wood along with coal. The Solar One program was launched. Cracked blades on the wind turbines lowered production amounts by approximately 5,557 megawatt hours over 9 months. Solar energy amounts were not included in the totals due to the small amount.

Month	System Total MWH	Wind MWH	Columbia Landfill MWH	Waste Wood MWH	Jeff City Landfill MWH	Solar MWH	Total Renew MWH	Monthly % of System	Annual % of System
1-08*	102,167	1,080					1,080	1.1%	1.1%
2-08*	95,852	671					671	0.7%	0.9%
3-08*	89,178	798					798	0.9%	0.9%
4-08*	83,215	782		158			940	1.1%	0.9%
5-08*	85,467	485		185			670	0.8%	0.9%
6-08*	104,001	321	672	802			1,795	1.7%	1.1%
7-08*	116,895	250	874	594			1,718	1.5%	1.1%
8-08*	111,956	229	1,279	821			2,329	2.1%	1.3%
9-08*	92,891	539	1,204	765			2,508	2.7%	1.4%
10-08	83,693	1,169	998	243		0.265	2,410	2.9%	1.5%
11-08	82,509	646	1,216	0		0.362	1,862	2.3%	1.6%
12-08	98,719	1,205	1,039	334		0.294	2,578	2.6%	1.7%
TOTAL	1,146,543	8,128	7,282	3,902	0	1	19,313		

The amount of energy is measured in megawatt hours (MWH)

2009 Renewable Energy Production Amounts

Columbia started receiving landfill gas energy from Jefferson City.

Month	System Total MWH	Wind MWH	Columbia Landfill MWH	Waste Wood MWH	Jeff City Landfill MWH	Solar MWH	Total Renew MWH	Monthly % of System	Annual % of System
1-09	101,445	979	1,167	853		0.369	2,999	3.0%	3.0%
2-09	83,491	933	1,043	670		0.459	2,646	3.2%	3.1%
3-09	84,038	2,807	1,236	146		0.643	4,189	5.0%	3.7%
4-09	80,857	3,208	1,216	0	1,220	0.610	5,644	7.0%	4.4%
5-09	84,508	2,696	1,083	379	1,427	0.807	5,585	6.6%	4.8%
6-09	104,689	761	1,181	75	1,711	0.831	3,728	3.6%	4.6%
7-09	106,500	480	1,145	175	1,583	0.812	3,383	3.2%	4.4%
8-09	107,081	691	1,113	102	1,729	0.746	3,635	3.4%	4.2%
9-09	89,941	533	402	576	1,590	0.606	3,101	3.4%	4.1%
10-09	83,335	1,279	44	854	1,769	0.373	3,946	4.7%	4.2%
11-09	79,725	1,439	695	76	1,849	0.356	4,059	5.1%	4.3%
12-09	99,645	992	551	1,265	1,352	0.221	4,160	4.2%	4.3%
TOTAL	1,105,255	16,798	10,876	5,171	14,227	7	47,079		

The amount of energy is measured in megawatt hours (MWH)

In 2008, the amount of wind energy Columbia received was low due to some of the turbine blades cracking. Due to this shortfall of energy, Associated Electric Cooperative provided the first 6.3 MW of energy produced from the wind farm for March, April and May of 2009 and again in January, February and March of 2010.

2010 Renewable Energy Production Amounts

Three additional solar projects were added to the Solar One program. The amount of wind energy Columbia received was low due to some of the turbine blades cracking. Due to this shortfall of energy, Associated Electric Cooperative provided the first 6.3 MW of energy produced from the wind farm for March, April and May of 2009 and again in January, February and March of 2010.

Month	System Total MWH	Wind MWH	Columbia Landfill MWH	Waste Wood MWH	Jeff City Landfill MWH	Solar MWH	Total Renew MWH	Monthly % of System	Annual % of System
1-10	106,770	2,088	1,090	1,119	982	0.233	5,279	4.9%	4.9%
2-10	92,910	2,132	1,112	734	1,656	0.352	5,634	6.1%	5.5%
3-10	86,980	3,327	1,219	623	2,002	0.539	7,172	8.2%	6.3%
4-10	80,544	1,798	1,151	368	1,914	0.694	5,232	6.5%	6.3%
5-10	90,412	1,018	1,135	0	2,212	0.735	4,366	4.8%	6.0%
6-10	114,129	746	1,253	367	1,846	0.781	4,213	3.7%	5.6%
7-10	123,263	523	1,127	495	1,556	0.741	3,702	3.0%	5.1%
8-10	128,815	688	911	773	1,890	0.819	4,263	3.3%	4.8%
9-10	95,840	1,154	832	804	1,744	1.372	4,535	4.7%	4.8%
10-10	83,554	1,107	966	690	2,037	1.335	4,801	5.7%	4.9%
11-10	81,674	1,691	1,196	866	2,058	1.262	5,812	7.1%	5.1%
12-10	100,461	1,068	1,060	593	1,811	0.541	4,533	4.5%	5.0%
TOTAL	1,185,352	17,340	13,052	7,432	21,708	9	59,541		

The amount of energy is measured in megawatt hours (MWH)

2011 Renewable Energy Production Amounts

Columbia started receiving solar energy through a contract with the Free Power Company.

Month	System Total MWH	Bluegrass Wind MWH	Columbia Landfill MWH	Waste Wood MWH	Jeff City Landfill MWH	Solar MWH	Total Renew MWH	Monthly % of System	Annual % of System
1-11	104,370	1,050	1,255	950	2,018	0.7	5,274	5.1%	5.1%
2-11	89,644	1,369	1,043	1,305	1,931	1.2	5,649	6.3%	5.6%
3-11	88,683	1,358	1,269	1,380	2,220	1.9	6,229	7.0%	6.1%
4-11	79,860	1,646	1,187	985	1,685	2.4	5,505	6.9%	6.2%
5-11	88,794	1,363	1,301	0	2,099	2.8	4,766	5.4%	6.1%
6-11	111,595	1,312	771	814	1,510	3.2	4,410	4.0%	5.7%
7-11	137,604	631	1,133	1,389	1,632	3.3	4,788	3.5%	5.2%
8-11	124,170	531	1,116	1,929	1,956	3.0	5,535	4.5%	5.1%
9-11	90,389	874	604	1,350	1,679	2.7	4,510	5.0%	5.1%
10-11	84,257	1,260	1,344	497	1,870	2.4	4,973	5.9%	5.2%
11-11	81,591	1,968	1,299	37	2,033	1.1	5,338	6.5%	5.3%
12-11	92,894	1,407	1,362	1,182	2,215	3.0	6,170	6.6%	5.4%
TOTAL	1,173,851	14,769	13,684	11,818	22,848	28	63,148		

The amount of energy is measured in megawatt hours (MWH)

2012 Renewable Energy Production Amounts

Columbia started purchasing wind energy from Crystal Lake

Month	System Total MWH	Bluegrass Wind MWH	Columbia Landfill MWH	Waste Wood MWH	Jeff City Landfill MWH	Crystal Lake Wind MWH	Solar MWH	TOTAL Renew MWH	Monthly % of System	Annual % of System
1-12	97,016	1,764	1,260	1,201	2,219	0	5.7	6,450	6.6%	6.6%
2-12	87,788	1,352	1,261	1,129	2,057	1,496	8.7	7,303	8.3%	7.4%
3-12	86,349	1,730	1,442	693	1,661	8,646	19.6	14,192	16.4%	10.3%
4-12	81,262	1,331	1,334	0*	1,887	9,014	21.2	13,584	16.7%	11.8%
5-12	99,813	1,323	1,218	0*	1,749	7,483	28.5	11,791	11.8%	11.8%
6-12	111,843	1,218	1,227	0*	1,658	2,177	29.3	6,310	5.6%	10.6%
7-12	137,598	734	1,328	542	1,551	935	27.8	5,118	3.7%	9.2%
8-12	120,822	661	1,326	1,234	1,719	873	28.4	5,841	4.8%	8.6%
9-12	93,415	756	1,140	722	1,476	885	31.1	5,010	5.4%	8.3%
10-12	86,334	1,418	1,156	443	1,890	1,576	23.0	6,506	7.5%	8.2%
11-12	83,778	1,324	1,300	0*	1,702	1,467	27.9	5,821	6.9%	8.1%
12-12	94,136	1,246	1,248	0*	1,860	1,447	19.8	5,821	6.2%	7.9%
Total MWH	1,180,154	14,844	15,240	5,964	21,429	35,998	271	93,746		
% of Total		1.26%	1.29%	0.51%	1.82%	3.05%	0.02%	7.94%		

The amount of energy is measured in megawatt hours (MWH)

*Waste wood was not used at the Columbia Power Plant while it was down for maintenance and during a condition assessment in the spring and during the fall so natural gas was used to generate electricity.

2013 Renewable Energy Production Amounts

Installed a third generator at the Columbia Landfill Gas Energy Plant

Month	System Total MWH	Bluegrass Wind MWH	Crystal Lake Wind MWH	Jeff City Landfill MWH	Columbia Landfill MWH	Waste Wood MWH	Free Power Solar MWH	Net Metered & Solar One MWH	TOTAL Renew MWH	Monthly % of System	Annual % of System
1-13	101,588	1,492	3,038	1,723	1,196	71	23.99	5.55	7,549	7.43%	7.43%
2-13	90,544	1,392	1,418	1,817	964	1,194	27.26	6.31	6,819	7.53%	7.48%
3-13	95,182	1,334	1,740	1,650	803	280	31.37	7.54	5,846	6.14%	7.04%
4-13	84,918	1,360	2,771	2,050	743	688	36.24	10.82	7,659	9.02%	7.49%
5-13	92,147	13,006	2,454	1,803	923	986	41.09	11.95	7,525	8.17%	7.62%
6-13	103,711	1,093	1,898	1,561	1,201	694	46.59	13.30	6,506	6.27%	7.38%
7-13	115,604	667	1,846	1,498	1,194	1,086	49.21	14.29	6,355	5.50%	7.06%
8-13	118,489	534	1,189	2,035	984	1,161	48.02	13.18	5,964	5.03%	6.76%
9-13	103,749	775	2,023	2,010	1,017	1,115	43.12	11.74	6,994	6.74%	6.76%
10-13	88,624	1,309	1,756	1,938	1,576	652	36.74	10.72	7,278	8.21%	6.89%
11-13	88,152	1,561	1,845	1,942	1,557	0*	25.33	7.59	6,938	7.87%	6.97%
12-13	105,775	1,162	2,213	1,813	1,168	1,044	15.33	6.79	7,422	7.02%	6.97%
Total MWH	1,188,483	13,985	24,189	21,840	13,326	8,971	424.29	119.77	82,855		
% of Total		1.18%	2.04%	1.84%	1.12%	0.75%	0.04%	0.01%	6.97%		

*Waste wood was not used at the Columbia Power Plant in November while it was down for regular maintenance.

2014 Renewable Energy Production Amounts

Month	System Total MWH	Bluegrass Wind MWH	Crystal Lake Wind MWH	Jeff City Landfill MWH	Columbia Landfill MWH	Waste Wood MWH	Free Power Solar MWH	Net Metered MWH	Solar One MWH	TOTAL Renew MWH	Monthly % of System	Annual % of System
1-14	113,677	1,882	2,794	1,917	1,418	428	25.2	7.79	2.77	8,475	7.45%	7.45%
2-14	101,423	1,006	2,295	1,825	1,597	1,078	26.55	7.18	2.42	7,837	7.73%	7.58%
3-14	93,794	1,640	2,640	1,461	1,638	566	43.29	13.66	4.24	8,006	8.54%	7.87%
4-14	82,590	1,594	1,989	1,905	1,004	0	38.84	13.25	3.84	6,548	7.93%	7.88%
5-14	96,277	1,042	2,151	1,490	957	0	48.49	18.57	4.43	5,712	5.93%	7.50%
6-14	108,638	875	1,653	1,864	811	1,380	43.25	17.1	4.22	6,648	6.12%	7.25%
7-14	109,772	694	1,703	2,001	1,633	1,316	51.86	20.11	4.82	7,424	6.76%	7.17%
8-14	120,073	518	917	1,808	1,871	1,085	44.17	18.46	4.35	6,266	5.22%	6.89%
9-14	95,125	675	1,253	1,813	1,953	159	39.48	17.59	3.64	5,914	6.22%	6.82%
10-14	84,624	1,266	1,882	1,954	1,903	129	32.75	15.22	3.29	7,185	8.49%	6.96%
11-14	91,886	1,866	3,344	2,049	1,662	0	24.30	16.66	2.62	8,964	9.76%	7.19%
12-14	98,873	841	2,675	1,956	1,819	110	14.66	10.68	1.40	7,428	7.51%	7.22%
Total MWH	1,196,752	13,899	25,295	22,043	18,266	6,251	433	176	42	86,405		
% of Total		1.16%	2.11%	1.84%	1.53%	0.52%	0.04%	0.01%	0.00%	7.22%		

2015 Renewable Energy Production Amounts

Month	System MWH's	Bluegrass Wind MWH's	Crystal Lake Wind MWH's	Columbia Landfill MWH's	Jeff City Landfill MWH's	Free Power Solar MWH's	Net Meter Solar MWH's	Columbia Solar MWH's	Total Renew MWH's	YTD Annual % of System
1-16	106,439	1,244	2,587	1,242	2,200	23.48	31.37	25.79	7,354	6.91%
2-16	94,654	1,452	2,901	976	1,981	25.66	39.84	28.46	7,404	7.34%
3-16	85,957	1,360	2,848	1,060	1,830	30.34	51.64	32.83	7,213	7.65%
4-16	83,451	1,567	3,317	1,143	1,775	41.75	76.16	44.29	7,964	8.08%
5-16	90,312	754	2,136	884	2,025	45.05	83.19	46.99	5,975	7.79%
6-16	121,086	697	1,938	598	1,952	49.25	94.10	51.14	5,380	7.10%
7-16	126,177	671	1,348	703	2,172	40.95	82.02	44.66	5,061	6.55%
8-16	121,427	531	1,162	1,684	1,796	34.90	73.30	40.64	5,322	6.23%
9-16	107,419	917	2,350	1,220	1,804	36.44	75.66	43.71	6,447	6.20%
10-16	89,128	1,137	2,341	1,805	2,142	26.46	56.90	33.53	7,542	6.40%
11-16	83,060	1,251	2,627	1,491	1,931	21.57	48.19	27.45	7,397	6.59%
12-16	104,028	1,119	3,315	1,343	2,083	14.86	41.58	23.27	7,939	6.68%
Total	1,213,138	12,700	28,871	14,149	23,691	391	754	443	80,998	
% of Total		1.05%	2.38%	1.17%	1.95%	0.03%	0.06%	0.04%	6.68%	

2016 Renewable Energy Production Amounts

Month	System MWH's	Bluegrass Wind MWH's	Crystal Lake Wind MWH's	Columbia Landfill MWH's	Jeff City Landfill MWH's	Waste Wood MWH's	Free Power Solar MWH's	Net Meter Solar MWH's	West Ash Solar MWH's	Solar One MWH's	Total Renew MWH's	YTD Annual % of System
1-15	105,552	1,501	2,777	1,605	2,024	982	28.06	21.39	0	2.92	8,942	8.47%
2-15	101,106	1,039	2,784	1,744	1,910	127	25.83	16.82	0	2.52	7,649	8.03%
3-15	90,810	1,193	2,384	1,650	1,879	0	36.35	34.00	0	3.83	7,180	7.99%
4-15	81,568	1,233	1,175	1,475	2,094	0	38.90	37.68	0	3.97	6,058	7.87%
5-15	90,340	1,035	2,316	1,040	2,157	0	40.28	40.59	0	4.16	6,633	7.77%
6-15	107,377	748	1,329	1,020	1,620	0	40.25	37.73	0	3.77	4,799	7.15%
7-15	122,348	455	1,291	1,003	2,009	595	43.87	43.38	0	4.29	5,445	6.68%
8-15	114,671	549	1,779	927	1,996	812	43.11	44.61	4.28	4.39	6,160	6.50%
9-15	106,316	978	2,041	958	1,965	338	42.30	40.74	40.24	4.13	6,408	6.44%
10-15	86,400	1,140	2,609	1,122	1,986	0	33.50	34.32	33.02	3.44	6,961	6.58%
11-15	84,283	1,676	2,798	818	1,914	0	23.54	24.38	23.90	2.52	7,281	6.74%
12-15	94,107	1,400	2,603	997	2,225	0	17.45	18.24	17.86	1.99	7,280	6.82%
Total	1,184,878	12,947	25,889	14,359	23,779	2,854	413	394	119	42	80,796	
% of Total		1.09%	2.18%	1.21%	2.01%	0.24%	0.03%	0.03%	0.01%	0.00%	6.82%	

The amount of energy is measured in megawatt hours (MWH)

Approved Sources of Renewable Energy

The following sources of renewable energy were approved by the Columbia City Council in March 2006 as sources of compliance with the Renewable Energy Standard ordinance.

Wind Energy: All electricity generated through wind power would qualify as a renewable resource, including wind energy that is stored in any form for later use as electrical power.

Solar Energy: All active solar energy systems would qualify as a renewable resource, including solar photovoltaics, solar water heating, solar space heating, and any other method of using the sun that requires 'active' collection techniques. In this regard 'passive' solar heating, or systems which do not employ the use of mechanical equipment to move or distribute the heat, would not be considered as eligible items.

Biomass Energy: Biomass energy is typically considered to be derived from plants which have accumulated solar energy through photosynthesis. This definition, however, is somewhat open-ended as virtually all our current fossil fuels are derived from plants, even though their life span may have occurred in the geologic past. To create a definition of biomass that would correspond with its commonly understood meaning; biomass energy is considered to be energy derived from plant origin, considering only those plants that have been harvested within the recent past, certainly within the last 100 years.

Columbia Water & Light suggests that eligible biomass energy specifically include (but not be limited to) the following materials:

- Landfill Gas
- Paper based products, such as cardboard and newsprint
- Wood and wood wastes
- Cellulose based products that originate from trees or shrubbery
- Other materials that come directly from trees or plants.

In the event that an energy source would be derived from a mixture of biomass and other non-renewable materials Columbia Water & Light would make a rigorous assessment to determine what energy content of the fuel is biomass derived, and only claim that portion for compliance with the renewable energy ordinance.

Hydropower: By all definitions, hydropower fits the definition of renewable power in that it is renewed by the earth's water cycle.

Geothermal Power: Columbia Water & Light considers that geothermal power, or any energy that may be extracted from the earth, is eligible as a renewable resource. This would only be in reference to active mechanical systems that extract the heat energy from the earth. Passive systems would not be eligible under this definition. It would be the utility's responsibility to provide details on what constitutes energy provided through geothermal power on a case-by-case basis.

Green Tags: The Green Tag system that has originated throughout the country allows a utility to make purchases of Green Tags and thus participate in the development of green, or renewable, energy without actually receiving that energy in the utility's system. In such situations the developer of the renewable resource is paid an agreed-to amount for the Green Tag for each Megawatt-hour sold; however, the electricity is not delivered to the utility. Thus Green Tags simply represent the value of the renewable portion of the project or the premium that is above the cost of conventional electricity project. Green Tags are commonly sold and traded across the US.

Although this works for other utilities, Columbia Water & Light has every intention of complying with the renewable energy ordinance by finding sources located close enough to Columbia that the power can be transmitted into our system. In the future, however, the higher compliance requirements may force the utility to look at Green Tags as an option. Columbia Water & Light would pursue this avenue only as a last resort and would seek approval before purchasing renewable energy in this manner.

Future Projects: The above list is not intended to be final because there may be new sources of power that could be a renewable resource in the future. Columbia Water & Light could come back to the city's governing bodies in the future should a new renewable resource become available.

City of Columbia Ordinance Section 27-106: Renewable energy standard

(a) The city shall generate or purchase electricity generated from eligible renewable energy sources at the following levels:

- (1) Two (2) percent of electric retail sales (kWhs) by December 31, 2007;
- (2) Five (5) percent of electric retail sales (kWhs) by December 31, 2012;
- (3) Fifteen (15) percent of electric retail sales (kWhs) by December 31, 2017; and
- (4) Twenty-five (25) percent of electric retail sales (kWhs) by December 31, 2022.
- (5) Thirty (30) percent of electric retail sales (kWhs) by December 31, 2028.

(b) This renewable energy shall be added up to these kilowatt hour levels only to the extent that it is possible without increasing electric rates more than three (3) percent higher than the electric rates that would otherwise be attributable to the cost of continuing to generate or purchase electricity generated from one hundred (100) percent non-renewable sources (including coal, natural gas, nuclear energy and other nonrenewable sources).

(c) Eligible renewable energy generation may be provided by wind power, solar energy, bio-energy sources or other renewable sources which meet the environmental criteria approved by the city council after review by the environment and energy commission and the water and light advisory board. Electricity purchased from on-site renewable energy systems owned by Columbia Water & Light customers ("net metering") may be included within the calculation of the levels required in subsection (a).

(d) Renewable energy generation sources located within Missouri may receive preferential consideration in the selection process.

(e) Each year prior to February 1, the water and light department shall publicly release a renewable energy plan detailing a proposal for how the city would comply with this section during the following year. The plan will explain the city's due diligence in pursuing renewable energy opportunities and detail all cost assumptions and related utility rate calculations, except with regard to confidential information that may be withheld pursuant to state law. The plan will then be reviewed by the environment and energy commission and water and light advisory board and submitted to the city council for approval following a public hearing.

(Ord. No. 18196, § 1, 8-16-04; Ord. No. 21935, § 1, 1-6-14)

Editors Note: Ord. No. 18196, passed by city council on Aug. 16, 2004, called for election; said ordinance was passed by the voters on Nov. 2, 2004.

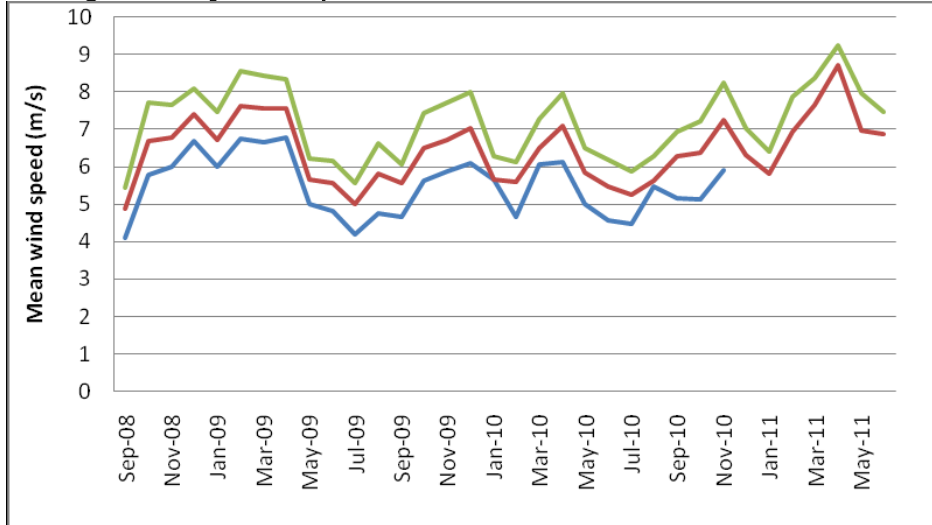
Secs. 27-107--27-110. Reserved.

Columbia Wind Speed Study

The University of Missouri's Atmospheric Sciences Department collected wind speed data for the City of Columbia at the KOMU tower on Columbia's south side from 2008 through 2011. The anemometers are no longer collecting accurate data so the study was ended.

The data was collected to evaluate the wind speeds for utility scale wind generation in Columbia. The site for the anemometers was placed in an open area of land with minimal obstructions at two different heights. In each case it can be seen that the average annual wind speed observed at the tower sites is significantly lower than that estimated in the AWS Truewind map of Missouri. The difference is of the order of 0.7 meters per second at the 70 meter level and 0.4 meters per second at the 100 meter level. These differences are similar to those found at other sites around the state.

Average Monthly Wind Speed at Each Anemometer



The green line represents observations at 147 meters, the red line is for 98 meters, and the blue line shows the measurements at 68 meters.

68 Meter Tower: As time goes on the instruments suffer declining performance and those operating at the 68 m height became too inconsistent to determine accurate observations in December 2010.

Note: One meter equals 3.28 feet, one meter per second equals 2.237 miles per hour

Net Metered Solar Production by Rate Class

(P01) Residential Gas Heat

Monthly Net-Meter Production (KWH)

	Non-Summer	Summer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tier 1	\$0.0767	\$0.0767	1,558	7,505	10,941	15,264	15,483	10,532	2,981	6,854	9,265	8,918	9,852	4,825
Tier 2	\$0.1000	\$0.1000	3,324	4,228	5,312	5,774	7,860	8,883	9,587	12,360	13,624	9,766	8,597	8,481
Tier 3	\$0.1155	\$0.1363	701	230	145	1,074	1,830	3,072	6,731	5,119	4,694	9,440	10,994	9,582
Tier 4	\$0.1155	\$0.1474	1	0	0	338	1,716	998	1,331	5,046	3,880	6,966	11,110	12,939
		TOTAL	5,584	11,963	16,398	22,450	26,889	23,485	20,630	29,379	31,463	35,090	40,553	35,827

Percentage of Monthly Net-Meter Production

	Non-Summer	Summer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tier 1	\$0.0767	\$0.0767	27.9%	62.7%	66.7%	68.0%	57.6%	44.8%	14.4%	23.3%	29.4%	25.4%	24.3%	13.5%
Tier 2	\$0.1000	\$0.1000	59.5%	35.3%	32.4%	25.7%	29.2%	37.8%	46.5%	42.1%	43.3%	27.8%	21.2%	23.7%
Tier 3	\$0.1155	\$0.1363	12.6%	1.9%	0.9%	4.8%	6.8%	13.1%	32.6%	17.4%	14.9%	26.9%	27.1%	26.7%
Tier 4	\$0.1155	\$0.1474	0.0%	0.0%	0.0%	1.5%	6.4%	4.2%	6.5%	17.2%	12.3%	19.9%	27.4%	36.1%

(PA1) Residential Electric Heat

Monthly Net-Meter Production (KWH)

	Non-Summer	Summer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tier 1	\$0.0767	\$0.0767	0	382	764	1,545	1,594	1,340	1,096	1,066	1,074	3,522	623	42
Tier 2	\$0.1000	\$0.1000	53	1,004	1,190	1,433	1,252	1,527	1,115	1,468	1,942	4,240	3,833	1,362
Tier 3	\$0.9610	\$0.1363	855	659	763	500	1,032	976	1,147	848	999	1,328	2,374	2,515
Tier 4	\$0.9610	\$0.1474	128	0	0	0	0	0	0	0	0	0	0	458
		TOTAL	1,036	2,045	2,717	3,478	3,878	3,843	3,358	3,382	4,015	9,090	6,830	4,377

Percentage of Monthly Net-Meter Production

	Non-Summer	Summer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tier 1	\$0.0767	\$0.0767	0.0%	18.7%	28.1%	44.4%	41.1%	34.9%	32.6%	31.5%	26.7%	38.7%	9.1%	1.0%
Tier 2	\$0.1000	\$0.1000	5.1%	49.1%	43.8%	41.2%	32.3%	39.7%	33.2%	43.4%	48.4%	46.6%	56.1%	31.1%
Tier 3	\$0.9610	\$0.1363	82.5%	32.2%	28.1%	14.4%	26.6%	25.4%	34.2%	25.1%	24.9%	14.6%	34.8%	57.5%
Tier 4	\$0.9610	\$0.1474	12.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.5%

(PB1) Residential Heat Pump

Monthly Net-Meter Production (KWH)

	Non-Summer	Summer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tier 1	\$0.0767	\$0.0767	26	139	953	2,171	2,827	2,940	1,501	2,005	2,276	768	185	38
Tier 2	\$0.1000	\$0.1000	5	407	1,920	2,622	3,313	3,015	2,868	3,067	2,794	2,684	1,352	703
Tier 3	\$0.9110	\$0.1363	668	1,482	1,381	920	247	632	1,101	506	391	913	1,490	1,075
Tier 4	\$0.9110	\$0.1474	524	567	140	171	671	598	361	544	659	266	704	829
		TOTAL	1,223	2,595	4,394	5,884	7,058	7,185	5,831	6,122	6,120	4,631	3,731	2,645

Percentage of Monthly Net-Meter Production

	Non-Summer	Summer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tier 1	\$0.0767	\$0.0767	2.1%	5.4%	21.7%	36.9%	40.1%	40.9%	25.7%	32.8%	37.2%	16.6%	5.0%	1.4%
Tier 2	\$0.1000	\$0.1000	0.4%	15.7%	43.7%	44.6%	46.9%	42.0%	49.2%	50.1%	45.7%	58.0%	36.2%	26.6%
Tier 3	\$0.9110	\$0.1363	54.6%	57.1%	31.4%	15.6%	3.5%	8.8%	18.9%	8.3%	6.4%	19.7%	39.9%	40.6%
Tier 4	\$0.9110	\$0.1474	42.8%	21.8%	3.2%	2.9%	9.5%	8.3%	6.2%	8.9%	10.8%	5.7%	18.9%	31.3%

(ES1) Small General Service – Gas Heat

Monthly Net-Meter Production (KWH)

	Non-Summer	Summer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tier 1	\$0.0816	\$0.0816	0	302	1,180	2,741	4,668	4,374	3,025	3,070	3,237	1,853	1,000	1,000
Tier 2	\$0.1040	\$0.1040	4	2,430	3,076	3,771	5,698	5,361	5,538	4,893	5,016	3,141	2,235	2,022
Tier 3	\$0.1040	\$0.1435	2,163	4,795	4,912	5,826	11,901	10,122	7,459	9,925	6,305	4,792	10,590	7,455
		TOTAL	2,167	7,527	9,168	12,338	22,267	19,857	16,022	17,888	14,558	9,786	13,825	10,477

Percentage of Monthly Net-Meter Production

	Non-Summer	Summer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tier 1	\$0.0816	\$0.0816	0.0%	4.0%	12.9%	22.2%	21.0%	22.0%	18.9%	17.2%	22.2%	18.9%	7.2%	9.5%
Tier 2	\$0.1040	\$0.1040	0.2%	32.3%	33.6%	30.6%	25.6%	27.0%	34.6%	27.4%	34.5%	32.1%	16.2%	19.3%
Tier 4	\$0.1040	\$0.1435	99.8%	63.7%	53.6%	47.2%	53.4%	51.0%	46.6%	55.5%	43.3%	49.0%	76.6%	71.2%

ES2) Small General Service – Electric Heat

Monthly Net-Meter Production (KWH)

	Non-Summer	Summer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tier 1	\$0.0816	\$0.0816	0	0	0	301	568	677	490	410	462	33	0	0
Tier 2	\$0.1040	\$0.1040	13	240	316	153	88	1	101	44	14	245	326	0
Tier 3	\$0.0959	\$0.1435	44	0	0	0	0	0	0	0	0	0	96	256
		TOTAL	57	240	316	454	656	678	591	454	476	278	422	256

Percentage of Monthly Net-Meter Production

	Non-Summer	Summer	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Tier 1	\$0.0816	\$0.0816	0.0%	0.0%	0.0%	66.3%	86.6%	99.9%	82.9%	90.3%	97.1%	11.9%	0.0%	0.0%
Tier 2	\$0.1040	\$0.1040	22.8%	100.0%	100.0%	33.7%	13.4%	0.1%	17.1%	9.7%	2.9%	88.1%	77.3%	0.0%
Tier 4	\$0.0959	\$0.1435	77.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.7%	100.0%

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT
RATE IMPACTS ON RENEWABLES
JANUARY 26, 2015

Utility Financial Solutions, LLC
185 Sun Meadow Court
Holland, MI USA 49424
(616) 393-9722
Fax (616) 393-9721
Email: mbeauchamp@ufsweb.com

Submitted Respectfully by:
Mark Beauchamp, CPA, CMA, MBA
President, Utility Financial Solutions



COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

TABLE OF CONTENTS

	PAGE NO.
INTRODUCTION	2
REVIEW OF CURRENT METHODOLOGY	2
SUMMARY OF SCOPE OF SERVICES	4
CWL'S SYSTEM LOAD PROFILES	4
ANALYSIS OF RENEWABLES	
WIND LOAD PROFILES AND PRODUCTION CHARACTERISTICS	6
SOLAR LOAD PROFILES AND PRODUCTION CHARACTERISTICS	9
VALUE OF RENEWABLE CAPACITY	12
RECOMMENDATIONS	14
APPENDICES:	
ONE – INITIAL PRESENTATION TO BOARD OF DIRECTORS	
TWO – PRESENTATION OF RESULTS TO BOARD OF DIRECTORS	

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

INTRODUCTION

This report was prepared to provide guidance on the valuation of renewable generation for the Columbia Water and Light (CWL) Electric Department. In 2004, the City passed a renewable energy ordinance setting goals for renewable energy production. The ordinance was modified in 2014 and established the following renewable energy goals:

- 15% of electric retail sales from renewables by December 31, 2017
- 25% from renewables December 31, 2022
- 30% from renewables by December 31, 2028

To minimize rate impacts on customers that could result from investments in renewable generation, the City's ordinance required that rates would not increase by greater than 3% due to the potentially higher cost. The electric department periodically produces a report detailing the cost to purchase renewables with a comparison of the cost to purchase energy from the market.

In 2013, the Columbia Water and Light's Electric Department produced 82,855 megawatt hours from renewable generation accounting for 6.97% of the total energy consumed by the Columbia Water and Light Ratepayers. The renewable production as a percent of total City production is listed below:

1. Wind accounted for - 3.2% of total energy production
2. Landfill Gas – 3.0%
3. Waste wood – 0.75%
4. Solar - 0.04%
5. Net Metered Solar from customer installed solar units - .01%

Review of Current Methodology

To determine the cost for renewables and the impact on ratepayers, CWL uses a combination of market prices of electricity and avoided cost. The table below is the 2013 cost and credits for renewables used by CWL. (The values vary slightly from 2014 Renewable Energy Report due to rounding)

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

Table One – Rate Impacts on 2013 Rates Using Current Methodology

2013 Report Values								
	Blue Grass - Wind	Crystal Lake - Wind	Jefferson City Land Fill	Columbia Landfill	WasteWood	Solar - Free Power	Net Metered Solar One	Total
mWh's Produced	13,985	24,189	21,840	13,326	8,971	424	120	82,855
Value per mWh	32.59	18.30	54.88	54.88	54.25	36.47	36.81	40.25
Value- Total	455,771	442,659	1,198,579	731,331	486,677	15,474	4,409	3,334,899
Cost - mWh	67.76	56.76	53.05	47.38	38.11	54.95	94.40	54.16
Total Cost	947,624	1,372,968	1,158,612	631,386	341,885	23,315	11,306	4,487,095
Total Value	\$ 491,852	\$ 930,309	\$ (39,967)	\$ (99,945)	\$ (144,792)	\$ 7,841	\$ 6,898	\$ 1,152,196
2013 North American Renewable Registry Membership								\$ 14,000
2013 Photovoltaic Rebates to Customers								43,305
2013 Capacity Credit for Wind Resources								(6,570)
Total Impact on 2013 Rates								\$ 1,202,931

To determine the value to CWL each resource was classified based on production characteristics into base load and intermittent units to assign a value to the resource.

Units considered base load:

- o Columbia landfill gas plant
- o Jefferson landfill gas plant contract

Units considered intermittent

- o Bluegrass Ridge wind
- o Crystal Lake wind
- o Net metered customer production
- o Free Power
- o Solar One

Units (Fuel) considered load following

- o Waste wood

The table below shows the cost of each resource, value of the resource and how the valuation was determined.

Table Two – Resource Valuation Current Methodology

Resource	Cost	Value	Valuation
Columbia landfill gas plant	47.38	54.88	Average cost of base load non-renewable
Ameresco landfill gas plant contract	53.05	54.88	Average cost of base load non-renewable
Bluegrass Ridge wind	67.76	32.59	LMP - Market Prices
Crystal Lake wind	56.76	18.30	LMP - Market Prices
Free Power	54.95	36.47	LMP - Market Prices
Solar One	94.40	36.81	LMP - Market Prices
Wastewood	38.11	54.25	Cost of Fuel

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

Summary of Scope of Services

Utility Financial Solutions completed a review of the current methodology to identify the potential value of renewables. The following analysis was completed:

1. Reviewed methodologies used by Public Service Commissions
2. Analyzed system loads and profiles
 - a. Identified actual time peak demands occurred on the system for each month and each season
 - b. Identified potential time that peak demands have potential to occur (On Peak hours)
3. Analyzed wind and solar production from for each resource
 - a. Identified production of each unit at time CWL’s peak occurred
 - b. Identified production of each unit during on-peak hours of system
4. Valuation of capacity from renewables
5. Identified capacity value of each renewable resource
6. Presented results to Board of Directors for review and comment

Revenue methodologies used by Public Service Commissions

In June, 2014 UFS reviewed scope of services and valuation methods used by the Minnesota Public Service Commission and potential areas of valuation that may not be present in the existing methodology. A copy of this presentation is included as Appendix One to this report.

CWL’s system load profiles

UFS analyzed the hourly loads for 2013 to identify the time of the system peaks and the area that potential peaks could occur.

Table Three - CWL’s MWH’s, peak demand of system, date and time of peak demand

DISTRIBUTION SYSTEM (Using 2013 system data)									
Month	Assigned Season	MWWhs in Month	Peak Demand Month (MW)	Days in Month	Hours in Month	Monthly Load Factor	System Peak Hour	System Peak Date	System Peak Day
January	W	98,583	162.20	31	744	82%	19	1/14/2013	Monday
February	W	86,756	152.40	28	672	85%	19	2/13/2013	Wednesday
March	W	85,661	138.40	31	744	83%	20	3/4/2013	Monday
April	INTER4	82,583	141.00	30	720	81%	21	4/21/2013	Sunday
May	INTER4	91,298	174.20	31	744	70%	17	5/28/2013	Tuesday
June	INTER2	107,496	213.00	30	720	70%	17	6/22/2013	Saturday
July	S	121,129	229.00	31	744	71%	17	7/31/2013	Wednesday
August	S	119,144	230.20	31	744	70%	17	8/5/2013	Monday
September	INTER2	95,866	179.00	30	720	74%	17	9/4/2013	Wednesday
October	INTER4	85,679	165.00	31	744	70%	16	10/1/2013	Tuesday
November	INTER4	83,816	155.60	30	720	75%	18	11/27/2013	Wednesday
December	W	93,769	164.60	31	744	77%	19	12/4/2013	Wednesday
TOTAL		1,151,800	2,105	365	8,760				

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

CWL’s average usage by hour and season was identified to determine when peaks could occur and the on-peak period that will be used to identify the peak production of wind and solar.

Table Four hourly CWL usages by season and hour

Hour	AVERAGE MWh BY SEASON			
	S	W	INTER2	INTER4
1	135.26	110.71	117.51	99.72
2	126.42	107.74	109.97	95.74
3	120.02	106.18	104.80	92.50
4	116.13	105.62	101.45	90.79
5	114.40	106.82	100.26	91.18
6	116.70	111.94	102.83	95.06
7	122.65	123.20	111.03	104.91
8	133.21	131.28	121.82	113.61
9	145.14	132.89	131.08	118.90
10	157.88	133.69	140.72	122.93
11	169.49	134.40	150.12	126.85
12	179.15	133.14	157.01	128.74
13	186.32	131.17	161.85	129.04
14	192.87	129.46	166.96	129.74
15	197.35	127.73	170.08	129.80
16	200.48	127.10	172.50	129.90
17	202.36	129.95	174.07	131.27
18	200.48	137.15	172.01	133.13
19	196.20	141.26	168.69	133.40
20	188.85	140.48	165.46	132.50
21	185.42	138.92	162.42	132.85
22	178.21	133.58	155.89	127.73
23	163.05	124.54	142.54	117.44
24	147.34	115.66	128.31	106.81

S = Summer (July, August)

W = Winter (December, January, February, March)

Inter 2 – (June, September)

Inter 4 – Valley period (April, May, October, November)

Determination of on peak hours

The analysis of hourly system data identified the following on-peak hours:

Summer – 14:00 – 19:00

Winter – 17:00 – 22:00

Inter 2 – 14:00 – 19:00

Inter 4 – 16:00 – 21:00

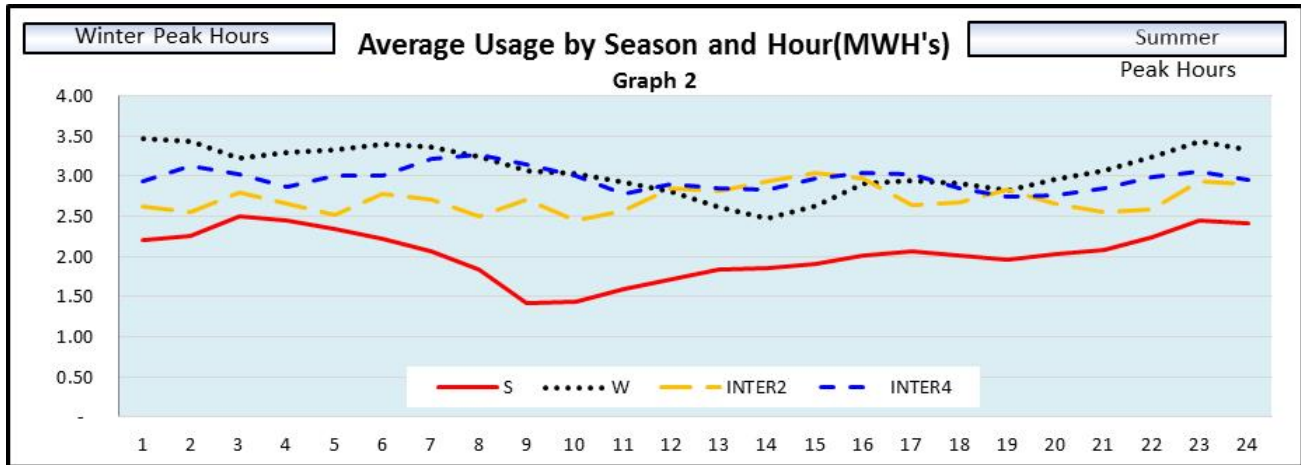
COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

Analysis of Renewables Production

The hourly production for 2013 was analyzed for the wind and solar resources. The graph below is the production from Crystal Lake for each hour broken down by season.

Graph One – Hourly Wind Production – Crystal Lake



The table below is the MWH's produced each month for Crystal Lake, the peak production and the time the unit produced at its maximum capacity.

Table Five – Crystal Lake Production Characteristics

CRYSTAL LAKE (BILLED MWh)									
Month	Assigned Season	MWhs in Month	Peak Demand Month (MW)	Days in Month	Hours in Month	Monthly Load Factor	System Peak Hour	System Peak Date	System Peak Day
January	W	2,789	8.14	31	744	46%	11	1/13/2013	Sunday
February	W	2,219	8.09	28	672	41%	2	2/22/2013	Friday
March	W	1,729	8.19	31	744	28%	13	3/18/2013	Monday
April	INTER4	2,722	8.30	30	720	46%	23	4/3/2013	Wednesday
May	INTER4	2,376	8.91	31	744	36%	24	5/14/2013	Tuesday
June	INTER2	1,897	11.49	30	720	23%	9	6/5/2013	Wednesday
July	S	1,846	8.24	31	744	30%	13	7/13/2013	Saturday
August	S	1,188	8.06	31	744	20%	3	8/25/2013	Sunday
September	INTER2	2,022	8.24	30	720	34%	8	9/30/2013	Monday
October	INTER4	1,755	7.93	31	744	30%	8	10/27/2013	Sunday
November	INTER4	1,844	8.13	30	720	32%	23	11/3/2013	Sunday
December	W	2,212	8.13	31	744	37%	5	12/29/2013	Sunday
TOTAL		24,600	102	365	8,760				

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

Graph Two – Hourly Wind Production– Bluegrass

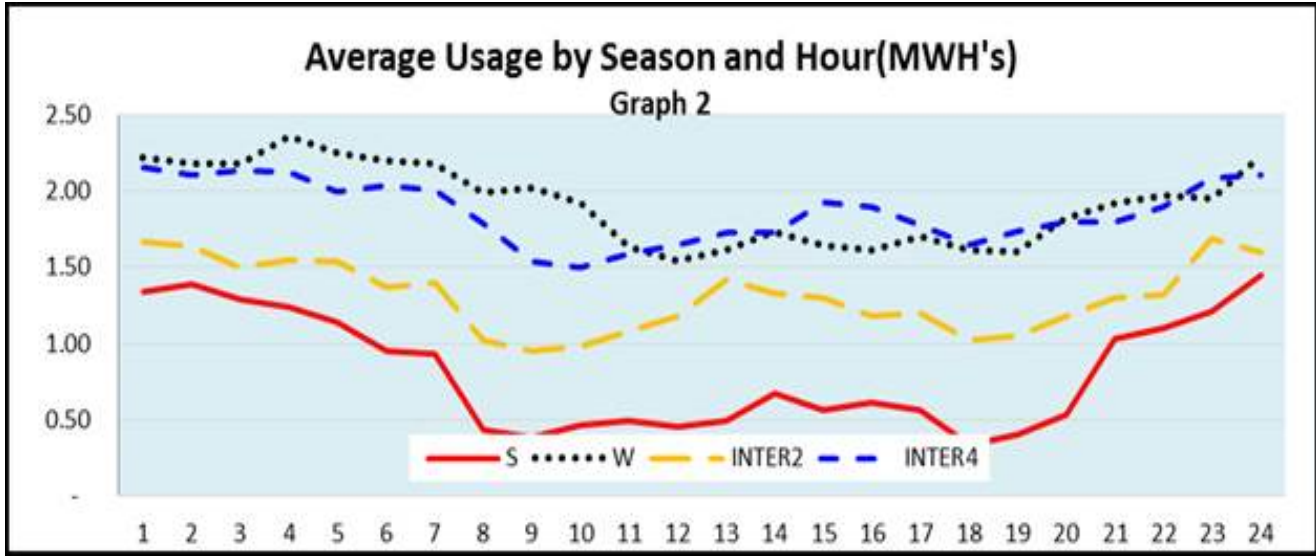


Table Six – Bluegrass Production Characteristics

BLUEGRASS WIND PRODUCTION									
Month	Assigned Season	MWhs in Month	Peak Demand Month (MW)	Days in Month	Hours in Month	Monthly Load Factor	System Peak Hour	System Peak Date	System Peak Day
January	W	1,696	6.00	31	744	38%	7	1/6/2013	Sunday
February	W	1,007	6.00	28	672	25%	24	2/11/2013	Monday
March	W	1,700	6.00	31	744	38%	18	3/3/2013	Sunday
April	INTER4	1,610	6.00	30	720	37%	16	4/3/2013	Wednesday
May	INTER4	972	6.00	31	744	22%	11	5/13/2013	Monday
June	INTER2	1,101	6.00	30	720	25%	13	6/11/2013	Tuesday
July	S	670	5.00	31	744	18%	24	7/7/2013	Sunday
August	S	540	6.00	31	744	12%	3	8/2/2013	Friday
September	INTER2	786	5.00	30	720	22%	2	9/9/2013	Monday
October	INTER4	1,311	6.00	31	744	29%	20	10/14/2013	Monday
November	INTER4	1,560	6.00	30	720	36%	11	11/3/2013	Sunday
December	W	1,168	6.00	31	744	26%	23	12/9/2013	Monday
TOTAL		14,100	70	365	8,760				

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

The wind resources were combined and the average production during on peak hours was identified and is listed in the table below:

Table Seven – Total Production Characteristics of Wind Generation

Combined Wind Production and Production at System Peak							
		Capacity Factor				Production @ System Peak	
Month	Peak	Hours	mWh Produced	100% Load Factor	Capacity Factor	Average Production during On-Peak Hours	
						Capacity Factor	Capacity Factor @ Peak
January	14.14	744	4,485	13,013	34%	4.8	27%
February	14.09	672	3,226	11,753	27%	4.8	27%
March	14.19	744	3,429	13,013	26%	4.8	27%
April	14.30	720	4,332	12,593	34%	4.7	27%
May	14.91	744	3,348	13,013	26%	4.7	27%
June	17.49	720	2,998	12,593	24%	4.0	23%
July	13.24	744	2,516	13,013	19%	2.5	14%
August	14.06	744	1,728	13,013	13%	2.5	14%
September	13.24	720	2,808	12,593	22%	4.0	23%
October	13.93	744	3,066	13,013	24%	4.7	27%
November	14.13	720	3,404	12,593	27%	4.7	27%
December	14.13	744	3,380	13,013	26%	4.8	27%

The average production from the wind units during the on peak hours was used to value the capacity component of wind generation and is listed below.

Table Seven – Average production of Wind during on peak hours

Season	Average Production
Summer	2.5 MW
Winter	4.8 MW
Inter 2	4.0 MW
Inter 4	4.7 MW

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

Load Characteristics of Solar Generation.

Graph Three – Hourly Solar Production Characteristics – Quaker 10 MW Unit

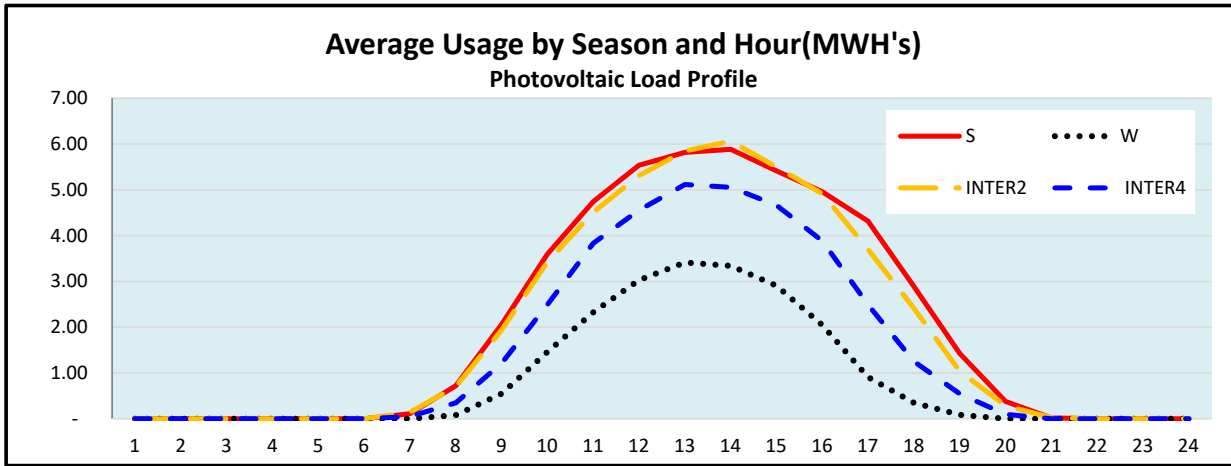


Table Eight – Quaker 10 MW Production Characteristics

QuakerSolar 10kW (2013)									
Month	Assigned Season	MWhs in Month	Peak Demand Month (MW)	Days in Month	Hours in Month	Monthly Load Factor	System Peak Hour	System Peak Date	System Peak Day
January	W	565	6.40	31	744	12%	13	1/25/2013	Friday
February	W	670	8.07	28	672	12%	13	2/19/2013	Tuesday
March	W	791	8.66	31	744	12%	15	3/20/2013	Wednesday
April	INTER4	1,217	9.04	30	720	19%	14	4/24/2013	Wednesday
May	INTER4	1,348	9.07	31	744	20%	14	5/11/2013	Saturday
June	INTER2	1,508	8.24	30	720	25%	14	6/3/2013	Monday
July	S	1,538	8.18	31	744	25%	14	7/1/2013	Monday
August	S	1,430	8.33	31	744	23%	14	8/17/2013	Saturday
September	INTER2	1,241	7.61	30	720	23%	14	9/21/2013	Saturday
October	INTER4	1,045	7.06	31	744	20%	14	10/8/2013	Tuesday
November	INTER4	733	6.60	30	720	15%	14	11/3/2013	Sunday
December	W	454	5.82	31	744	10%	14	12/31/2013	Tuesday
TOTAL		12,500	93	365	8,760				

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

Load Characteristics of Solar Generation.

Graph Four – Hourly Solar Production Characteristics – Quaker 5 MW Unit

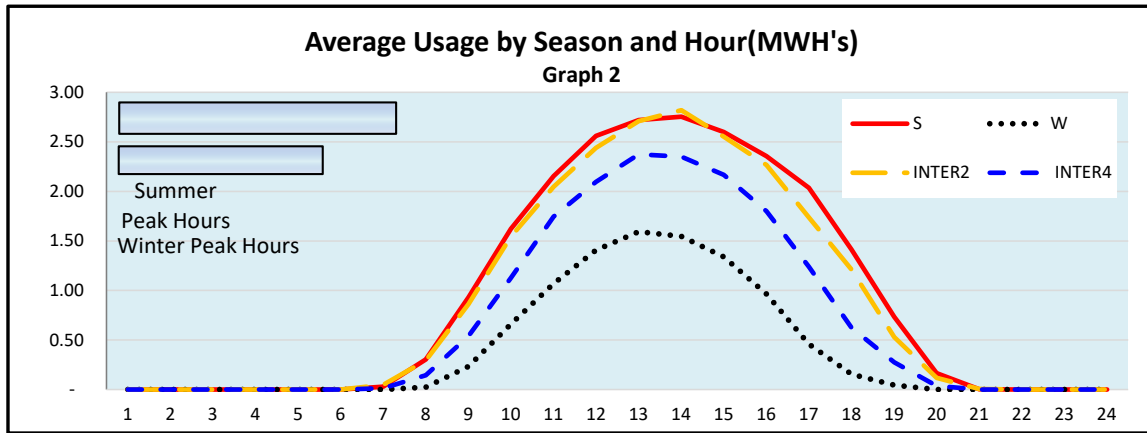


Table Nine – Quaker 5 MW Production Characteristics

QuakerSolar 5kW (2013)									
Month	Assigned Season	MWhs in Month	Peak Demand Month (MW)	Days in Month	Hours in Month	Monthly Load Factor	System Peak Hour	System Peak Date	System Peak Day
January	W	267	2.98	31	744	12%	13	1/25/2013	Friday
February	W	307	3.79	28	672	12%	13	2/19/2013	Tuesday
March	W	368	4.11	31	744	12%	15	3/20/2013	Wednesday
April	INTER4	573	4.27	30	720	19%	14	4/24/2013	Wednesday
May	INTER4	627	4.28	31	744	20%	14	5/11/2013	Saturday
June	INTER2	696	3.87	30	720	25%	14	6/3/2013	Monday
July	S	725	3.85	31	744	25%	14	7/1/2013	Monday
August	S	662	3.92	31	744	23%	14	8/17/2013	Saturday
September	INTER2	575	3.54	30	720	23%	14	9/21/2013	Saturday
October	INTER4	481	3.24	31	744	20%	14	10/1/2013	Tuesday
November	INTER4	337	3.02	30	720	15%	14	11/12/2013	Tuesday
December	W	207	2.68	31	744	10%	13	12/7/2013	Saturday
TOTAL		5,800	44	365	8,760				

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

The solar resources were combined and the average production during on peak hours was identified and is listed in the table below:

Table Ten – Total Production Characteristics of Solar Generation

Combined Solar Production and Production at System Peak							
		Capacity Factor				Production @ System Peak	
Month	Peak	Hours	kwh Produced	100% Load Factor	Capacity Factor	Average Production during On-Peak Hours	
						Capacity Factor	Capacity Factor @ Peak
January	9.37	744	832	11,160	7%	0.3	2%
February	11.86	672	977	10,080	10%	0.3	2%
March	12.76	744	1,159	11,160	10%	0.3	2%
April	13.31	720	1,789	10,800	17%	2.0	14%
May	13.35	744	1,974	11,160	18%	2.0	14%
June	12.11	720	2,204	10,800	20%	5.8	39%
July	12.03	744	2,263	11,160	20%	6.1	41%
August	12.25	744	2,092	11,160	19%	6.1	41%
September	11.15	720	1,816	10,800	17%	5.8	39%
October	10.29	744	1,526	11,160	14%	2.0	14%
November	9.62	720	1,071	10,800	10%	2.0	14%
December	8.50	744	661	11,160	6%	0.3	2%

The average production from the wind units during the on peak hours was used to value the capacity component of wind generation and is listed below.

Table Eleven – Average production of Wind during on peak hours

Season	Average Production
Summer	6.1 KW
Winter	0.3 KW
Inter 2	5.8 KW
Inter 4	2.0 KW

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

Value of Renewable Capacity

CWL obtained bids on market value of capacity from 2017 – 2027 and is listed in the table below. The average value of capacity over this period was \$3.46/KW-Month when the reserve component of 14% is added the capacity value increases to \$3.94/KW-Month or \$47.33 KW Year. The current methodology used by CWL does not include a capacity component and it is recommended a capacity component be added to the renewables valuation.

Table Twelve – Capacity Value for 2017 - 2027

Year	Market Capacity Value
2017	\$ 2.50
2018	2.70
2019	2.90
2020	3.10
2021	3.30
2022	3.50
2023	3.70
2024	4.00
2026	4.30
2027	4.60
Average Value	\$ 3.46
Reserve Capacity	14%
Adjusted Capacity Value - Monthly	\$ 3.94
Annual Capacity Value	\$ 47.33

The capacity value of \$47.33 was applied to the estimated production from wind and solar during the on peak hours. The wind production at the time of the system peak for the summer was 2,497 KWH (2.5 MWH) and resulted in a value of \$118,189. When the value is divided by the total KWH production of wind resulted in a capacity value of 0.0031/kWh.

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

Table Thirteen – Capacity Value of Wind Generation

Wind Capacity Value			
Estimated Production at Annual Peak of System - kW			2,497
Marginal Cost of Capacity - kW			\$ 47.33
Total Value			118,189
kWh Production			38,719,796
Capacity Value per kWh			0.0031

Solar production at the time of CWL’s peak was 6.1 KW and resulted in a value of 0.0158/kWh of solar production.

Solar Capacity Value			
Estimated Production at Annual Peak of System			6.1
Marginal Cost of Capacity			\$ 47.33
Total Value			\$ 290.09
kWh Production			18,364
Capacity Value per kWh			0.0158

These values were applied to the production of each renewable generating unit and resulted in the following modifications to adjust for capacity values.

2013 Report Values								
	Blue Grass - Wind	Crystal Lake - Wind	Jefferson City Land Fill	Columbia Landfill	WasteWood	Solar - Free Power	Net Metered Solar One	Total
mWh's Produced	13,985	24,189	21,840	13,326	8,971	424	120	82,855
Value per mWh	32.59	18.30	54.88	54.88	54.25	36.47	36.81	40.25
Value- Total	455,771	442,659	1,198,579	731,331	486,677	15,474	4,409	3,334,899
Cost - mWh	67.76	56.76	53.05	47.38	38.11	54.95	94.40	54.16
Total Cost	947,624	1,372,968	1,158,612	631,386	341,885	23,315	11,306	4,487,095
Total Value	\$ 491,852	\$ 930,309	\$ (39,967)	\$ (99,945)	\$ (144,792)	\$ 7,841	\$ 6,898	\$ 1,152,196
2013 North American Renewable Registry Membership								\$ 14,000
2013 Photovoltaic Rebates to Customers								43,305
2013 Capacity Credit for Wind Resources								(6,570)
Total Impact on 2013 Rates								\$ 1,202,931
Avoided Capacity Costs	0.0031	0.0031					0.0158	0.0158
Capacity Value	\$ 42,688	\$ 73,835	-	-	-	\$ 6,702	\$ 1,892	\$ 125,117
Adjusted Value (Cost) for 3% Rate Determination								\$ 1,077,813

- 1) The value per MWH for landfill gas is based on the average production cost of existing base load generation which includes a capacity component. No changes are recommended in the valuation
- 2) Waste wood does not add capacity but replaces natural gas and the valuation is determined using the difference in the variable cost of fuel to the cost of waste wood. No changes to the existing methodology is recommended

COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

Recommendations

1. CWL should apply the following capacity values in the determination of rate impacts to customers.

Wind - 0.0031/KWH

Solar - 0.0158/KWH

2. No change from the current methodology is recommended for landfill gas and waste wood.
3. The analysis completed by UFS used the market capacity values provided by CWL. It is recommended the capacity values be periodically reviewed
4. The analysis is based on the system load profile data for 2013. System load profile data can change periodically due to addition of load or weather patterns. It is recommended CWL periodically review the load profile data to ensure the on peak hours are consistent with the hours used in this analysis.
5. The load profiles for Wind and Solar are not anticipated to change unless new technologies such as battery back-up are installed on the renewable generation. As technology changes it may have an impact on the results of this analysis
6. It is recommended CWL review this analysis every three years.