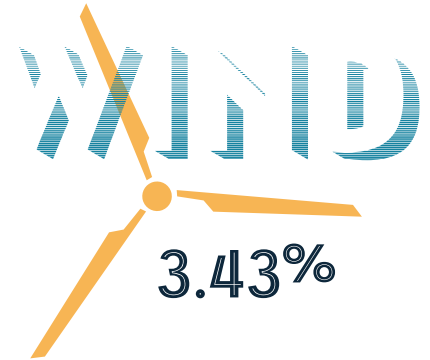
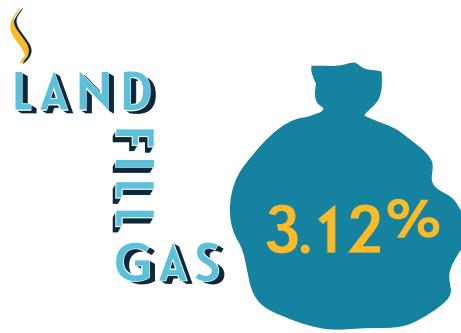
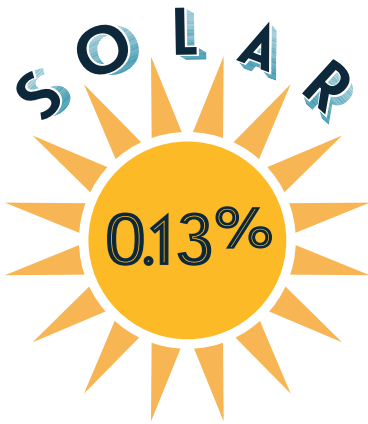


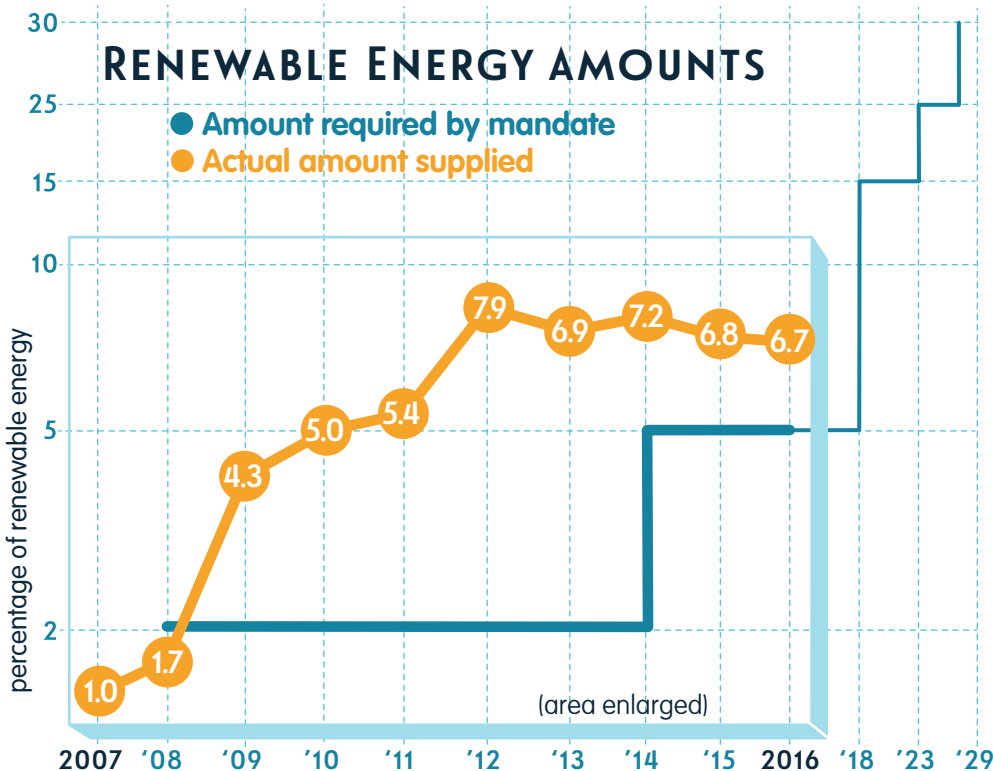
# Renewable Energy Report

2017  
COLUMBIA  
WATER & LIGHT



6.68%

of all energy sources for 2016 were renewable, **exceeding goal** of 5%



**\$3.48 million**  
allowable cost limit

**COST LIMIT:**  
Renewable energy cannot cause electric rates to increase more than **3%** above what rates would be with non-renewable energy

**\$1.86 million**  
amount spent in 2016 was 53.3% of cost limit

Extra spent on renewable energy

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# 2017 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 2016, Columbia had 6.68% of the electric portfolio generated from renewable sources. The renewable portfolio comes from wind (3.43%), landfill gas (3.12%) and solar (0.13%). The total amount exceeds the requirement for 2016 of 5% by 1.68%. The additional cost is 53.3% of what is allowed by the renewable energy ordinance.

### 2016 Renewable Energy Sources

Columbia system load: 1,213,138 megawatt hours (MWH)

Renewable energy total: 80,998 megawatt hours or 6.68%

- Bluegrass Ridge wind energy: 1.05% of electric system @ \$68.69/MWH
- Crystal Lake wind energy: 2.38% of electric system @ \$45.96/MWH
- Jefferson City landfill gas: 1.95% 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 \$80.88/MWH
- Columbia Water & Light solar production: 0.04% of the electric system @ 62.30/MWH

### 2016 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 is expected to provide about 6% of energy to the Columbia system which is in addition to the existing contracts for wind generated power.
- There was a 33% increase in the rated capacity of customer installed photovoltaic systems from 2015 to 2016.
- 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.

### 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.

## 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 | 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%                  |
| <b>Total</b>            | <b>1,213,138</b> | <b>12,700</b>        | <b>28,871</b>           | <b>14,149</b>           | <b>23,691</b>            | <b>391</b>             | <b>754</b>            | <b>443</b>           | <b>80,998</b>     |                        |
| <b>Percent of Total</b> |                  | <b>1.05%</b>         | <b>2.38%</b>            | <b>1.17%</b>            | <b>1.95%</b>             | <b>0.03%</b>           | <b>0.06%</b>          | <b>0.04%</b>         | <b>6.68%</b>      |                        |

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 2016, the additional cost to address the renewable portfolio requirement was \$1,855,196.72 and the limit was \$3,477,855.45, as outlined in the following tables. The additional money spent on renewable energy was 53.3% of what was allowed according to the ordinance.

The latest change in costs for 2016 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 2016 Renewable Energy Portfolio

| Renewable Resource                                   | Total 2015 MWH's | Additional Cost/(Savings) Per MWH | Total Impact on Rates |
|--|------------------|-----------------------------------|-----------------------|
| Bluegrass Ridge Wind (Associated Electric)           | 12700            | \$50.75                           | \$644,525.00          |
| Crystal Lake Wind (NextEra)                          | 28,871           | \$32.15                           | \$928,202.65          |
| Columbia Landfill                                    | 14,149           | \$8.25                            | \$116,729.25          |
| Jefferson City Landfill (Ameresco)                   | 23,691           | (\$2.46)                          | (\$34,806.54)         |
| Free Power Photovoltaic Production                   | 391              | \$17.15                           | \$6,705.65            |
| Net Metered Photovoltaic Production                  | 794              | \$38.47                           | \$29,006.38           |
| Columbia Water & Light Solar Production              | 443              | \$24.31                           | \$10,769.33           |
| <b>Total Renewable Resource Impact on Rates</b>      |                  |                                   | <b>\$1,701,131.72</b> |
| 2016 Photovoltaic Rebates to Customers               |                  |                                   | \$154,065             |
| <b>Total 2016 Renewable Standard Impact on Rates</b> |                  |                                   | <b>\$1,855,196.72</b> |

### Maximum Renewable Portfolio Cost Calculations

| Revenue Source                                 | January – September (FY16) | October – December (FY17) |
|--|----------------------------|---------------------------|
| Residential                                    | \$38,861,017.92            | \$9,561,271.75            |
| Commercial/Industrial                          | \$44,954,884.12            | \$12,669,340.43           |
| Street Lights                                  | \$62,134.66                | \$23,335.38               |
| Public Authority                               | \$6,203,641.61             | \$2,400,735.80            |
| Inter-Departmental                             | \$857,363.73               | \$334,322.89              |
| <b>Total Revenue During Calendar Year 2016</b> |                            | <b>\$115,928,515.00</b>   |
| <b>3% Impact Limit on Rates</b>                |                            | <b>\$3,477,855.45</b>     |

## 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 2016 was \$55.46/MWH.
    - i. Columbia landfill gas plant
      - Produced 14,149 megawatt hours
      - The average cost was \$63.72/MWH
      - There was a renewable resource cost of \$8.25/MWH (\$63.72-\$55.46)
      - Columbia landfill gas impact on rates for 2016 was a cost of \$116,729.25 (14,149 MWH @ \$8.25/MWH)
    - ii. Jefferson City (Ameresco) landfill gas plant
      - Produced 23,691 megawatt hours
      - The cost was \$53.00/MWH
      - There was a renewable resource savings of \$2.46/MWH (\$53.00-\$55.46)
      - Jefferson City landfill gas impact on rates for 2016 was a savings of \$34,806.54 (23,691 MWH @ \$2.46/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 2016, the average real-time Columbia LMP for the hours when this wind resource was producing energy was \$14.84 per megawatt hour. The total cost of energy, including transmission, was \$68.69 per megawatt hour. The difference in these two values is the renewable cost of \$53.85 per megawatt hour.
      - Produced 12,700 megawatt hours at a renewable cost of \$53.85 per MWH
      - A capacity credit of \$3.10 per MWH reduces the renewable cost to \$50.75 per MWH.
      - Total renewable expense and impact on rates for 2016 was \$644,525.00 (12,700 MWH's @ \$50.75/MWH).

- ii. Crystal Lake: 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 2016, the average real-time Crystal Lake LMP for the hours when this wind resource was producing energy was \$13.81 per megawatt hour. The total cost of energy, including deemed energy, was \$45.96 per megawatt hour. The difference in these two values is the renewable cost of \$32.15 per megawatt hour.
    - Produced 28,871 megawatt hours at a renewable cost of \$32.15 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 2016 was \$928,202.65 (28,871 MWH's @ \$32.15/MWH)
  - iii. 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 2016, the average real-time Columbia LMP for the hours when the Free Power solar resource was producing energy was \$22.00 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 \$32.95 per megawatt hour.
    - Produced 391 megawatt hours at a renewable cost of \$32.95 per MWH
    - A capacity credit of \$15.80 per MWH reduces the renewable cost to \$17.15 per MWH.
    - Total renewable expense and impact on rates for 2016 was \$6,705.65 (391 MWH's @ \$17.15/MWH)
  - iv. Net metered customer production: These customer-owned photovoltaic developments are also connected to the Columbia Water & Light electric distribution system, so they operate behind the meter in MISO. For calendar year 2016, the average real-time Columbia LMP for the hours when customer-owned solar resources were producing energy was \$26.62 per megawatt hour. The average retail energy price is \$80.88 per megawatt hour. The difference in these two values is the renewable cost of \$54.27 per megawatt hour.
    - Produced 754 megawatt hours at a renewable cost of \$54.27 per MWH
    - A capacity credit of \$15.80 per MWH reduces the renewable cost to \$38.47 per MWH
    - Total renewable expense and impact on rates for 2016 was \$29,006.38 (754 MWH @ \$38.47/MWH)
  - v. Columbia Water & Light Solar Production: The combined output of the West Ash Solar Field and the Solar One contracts is 443 MWH's in calendar 2016. Production is connected with the Columbia Water & Light electric distribution system and operates behind the meter in MISO. For calendar year 2016, the average real-time Columbia LMP for the hours when solar production occurred was \$22.19 per MWH. Based on the installed cost of the West Ash Solar Field and estimated energy production over a 25 year period with a 0.5% degradation rate and no cost of money or operation and maintenance cost included, the average cost was \$62.30 per MWH. The difference in these two values is the renewable cost of \$40.11 per megawatt hour.
    - Produced 443 megawatt hours at a renewable cost of \$40.11 per MWH
    - A capacity credit of \$15.80 per MWH reduces the renewable cost to \$24.31 per MWH
    - Total renewable expense and impact on rates for 2016 is \$10,769.33 (443 MWH @ \$24.31/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 which equals \$1,446,068.35.

## 2016 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 2016, Columbia received 12,700 megawatt hours of power from this contract or 1.05% 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 2016 for wind power from the Bluegrass Ridge Wind Farm was \$68.69 per megawatt hour.

### Crystal Lake Wind Energy

Columbia Water & Light has a 20-year contract for 21 megawatts of power produced at the Crystal Lake III Wind Energy Center located in Hancock County, Iowa. The University of Missouri purchased part of the energy from the City of Columbia contract. This arrangement can be terminated by either party at any time. In 2016, the utility received 12,700 megawatt hours from NextEra Energy Resources which represents 2.38% of the electric system total. The total cost of energy, including deemed energy, was \$45.96 per megawatt hour. 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. Columbia Water & Light currently requests curtailment at negative twenty dollars (-\$20.00). The fixed cost of the wind energy delivered to Columbia will remain at \$45.00 for the rest of the contract.

### 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 2016, the landfill gas plant produced 14,149 megawatt hours of energy at a cost of \$63.72 per megawatt hour which was 1.17% of Columbia's energy system total.

Energy production at this facility was down in 2015 and 2016 due to the condition of the cooling system for the two oldest units. The cooling systems were replaced in July 2016, restoring the plant to full capacity. Unit 3 was out of service for two weeks in September for a routine 20,000-hour overhaul. Units 1 & 2 are scheduled for a major engine replacement in the spring of 2017. Air permitting work required for the installation of a fourth engine is underway, 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 2016 was 23,691 megawatt hours which is 1.95% of the electric system total. The utility paid \$53.00 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 2016, Free Power solar projects produced 391 megawatt hours which are 0.03% of Columbia's electric portfolio. The systems are located at the COLT Railroad's 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 2016, there was an increase in customers installing their own photovoltaic systems from 51 to 85 and the rated capacity grew from 0.446 megawatts to 0.788 megawatts. In 2016, the estimated output of the net metered sites was 754 megawatt hours at \$80.88 per megawatt hour.



A net metering arrangement keeps track of the amount of electricity being consumed or being produced for the Columbia system by the customer. 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 pay the customer's current electric rate 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.

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 except for the March billing in which any credits remaining after the March billing will be removed without compensation to the customer.

Columbia Water & Light offers a one-time rebate for qualifying photovoltaic systems of \$500 per kilowatt up to ten kilowatts and a tiered rebate system for larger systems. Customers installing a solar water heating system can qualify for up to \$800 in rebates. In calendar year 2016, \$154,065 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 2016, there were two solar loans issued totaling \$23,859.

### **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.

### **Renewable Energy Education**

#### **Advancing Renewables in the Midwest**

On April 11 and 12, 2016, the 11th annual Advancing Renewables in the Midwest conference hosted around 200 attendees. American Public Power Association President, Sue Kelly, gave the keynote address on how a combination of resources can help drive renewable energy projects. 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 Department of Soil, Environmental and Atmospheric Sciences and the Missouri Department of Economic Development. The 2017 conference will be held at the University of Missouri on April 24-25.

#### **Civic and Environmental Group Outreach**

In 2016, 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, over 2,000 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 2016, approximately 1,100 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**

A new contract for wind energy from the Crystal Lake Wind Farm became effective January 1, 2017. An additional 27 megawatts of wind generation should produce around 70,000 megawatt hours of wind energy during 2017. The last generator for the existing building at the landfill is expected to be installed in late 2018.

It is estimated that over 12% of Columbia's electric portfolio will come from existing renewable resources in 2017. The additional amount needed to reach the 15% goal for 2018 is being researched. Columbia Water & Light staff members will be investigating options for more wind and/or solar energy.

**2017 Estimated Renewable Portfolio**

| Project                         | 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 | 28,000 MWH       | 2.31%          | \$45/MWH    |
| Crystal Lake Contract #2        | Hancock County, IA | 70,000 MWH       | 5.77%          | \$19.75/MWH |
| Jefferson City landfill gas     | Jefferson City, MO | 23,000 MWH       | 1.90%          | \$53/MWH    |
| Columbia landfill gas           | Columbia, MO       | 14,000 MWH       | 1.15%          | \$55/MWH    |
| Free Power Solar                | Columbia, MO       | 400 MWH          | 0.03%          | \$55/MWH    |
| Net Metered Customer Production | Columbia, MO       | 1,000 MWH        | 0.08%          | \$72/MWH    |
| West Ash Solar Field            | Columbia, MO       | 400 MWH          | 0.04%          | \$62/MWH    |

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

# Appendix

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## 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%                |                    |
| <b>TOTAL</b> | <b>378,095</b>   | <b>3,744</b> |                       |                |                        | <b>3,744</b>    |                     |                    |

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%               |
| <b>TOTAL</b> | <b>1,146,543</b> | <b>8,128</b> | <b>7,282</b>          | <b>3,902</b>   | <b>0</b>               | <b>1</b>  | <b>19,313</b>   |                     |                    |

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%               |
| <b>TOTAL</b> | <b>1,105,255</b> | <b>16,798</b> | <b>10,876</b>         | <b>5,171</b>   | <b>14,227</b>          | <b>7</b>  | <b>47,079</b>   |                     |                    |

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%               |
| <b>TOTAL</b> | <b>1,185,352</b> | <b>17,340</b> | <b>13,052</b>         | <b>7,432</b>   | <b>21,708</b>          | <b>9</b>  | <b>59,541</b>   |                     |                    |

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%               |
| <b>TOTAL</b> | <b>1,173,851</b> | <b>14,769</b>      | <b>13,684</b>         | <b>11,818</b>  | <b>22,848</b>          | <b>28</b> | <b>63,148</b>   |                     |                    |

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%               |
| <b>Total MWH</b>  | <b>1,180,154</b> | <b>14,844</b>      | <b>15,240</b>         | <b>5,964</b>   | <b>21,429</b>          | <b>35,998</b>         | <b>271</b>   | <b>93,746</b>   |                     |                    |
| <b>% of Total</b> |                  | <b>1.26%</b>       | <b>1.29%</b>          | <b>0.51%</b>   | <b>1.82%</b>           | <b>3.05%</b>          | <b>0.02%</b> | <b>7.94%</b>    |                     |                    |

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%              |
| <b>Total MWH</b>  | <b>1,188,483</b> | <b>13,985</b>      | <b>24,189</b>         | <b>21,840</b>          | <b>13,326</b>         | <b>8,971</b>   | <b>424.29</b>        | <b>119.77</b>               | <b>82,855</b>   |                     |                    |
| <b>% of Total</b> |                  | <b>1.18%</b>       | <b>2.04%</b>          | <b>1.84%</b>           | <b>1.12%</b>          | <b>0.75%</b>   | <b>0.04%</b>         | <b>0.01%</b>                | <b>6.97%</b>    |                     |                    |

\*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%              |
| <b>Total MWH</b>  | <b>1,196,752</b> | <b>13,899</b>      | <b>25,295</b>         | <b>22,043</b>          | <b>18,266</b>         | <b>6,251</b>   | <b>433</b>           | <b>176</b>      | <b>42</b>     | <b>86,405</b>   |                     |                    |
| <b>% of Total</b> |                  | <b>1.16%</b>       | <b>2.11%</b>          | <b>1.84%</b>           | <b>1.53%</b>          | <b>0.52%</b>   | <b>0.04%</b>         | <b>0.01%</b>    | <b>0.00%</b>  | <b>7.22%</b>    |                     |                    |

## 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 | 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%                  |
| <b>Total</b>      | <b>1,184,878</b> | <b>12,947</b>        | <b>25,889</b>           | <b>14,359</b>           | <b>23,779</b>            | <b>2,854</b>     | <b>413</b>             | <b>394</b>            | <b>119</b>           | <b>42</b>       | <b>80,796</b>     |                        |
| <b>% of Total</b> |                  | <b>1.09%</b>         | <b>2.18%</b>            | <b>1.21%</b>            | <b>2.01%</b>             | <b>0.24%</b>     | <b>0.03%</b>           | <b>0.03%</b>          | <b>0.01%</b>         | <b>0.00%</b>    | <b>6.82%</b>      |                        |

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.

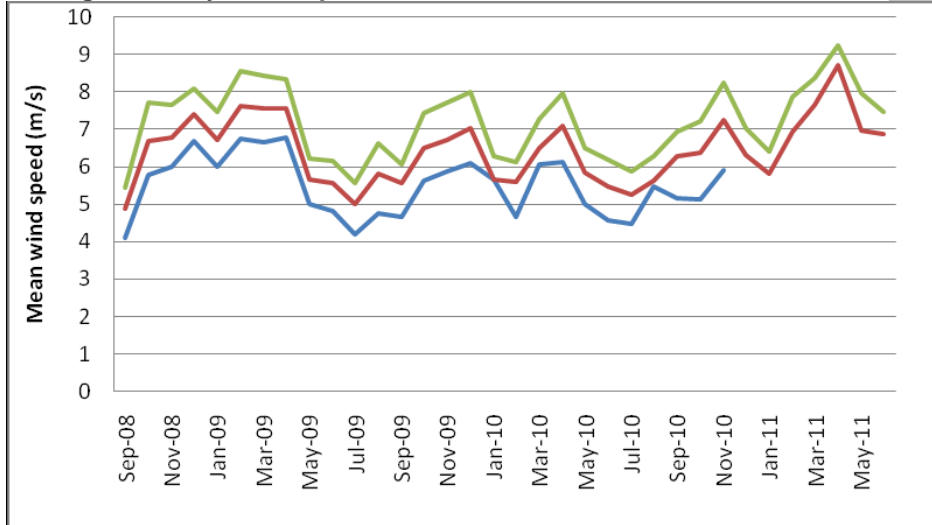
Secs. 27-107--27-110. Reserved.

## 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

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

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Submitted Respectfully by:  
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# COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

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# COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

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## EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

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### 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 -<br>Wind | Crystal Lake -<br>Wind | Jefferson<br>City Land Fill | Columbia<br>Landfill | WasteWood           | Solar -<br>Free<br>Power | Net<br>Metered<br>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           |
| <b>Total Value</b>                                       | <b>\$ 491,852</b>    | <b>\$ 930,309</b>      | <b>\$ (39,967)</b>          | <b>\$ (99,945)</b>   | <b>\$ (144,792)</b> | <b>\$ 7,841</b>          | <b>\$ 6,898</b>             | <b>\$ 1,152,196</b> |
| <b>2013 North American Renewable Registry Membership</b> |                      |                        |                             |                      |                     |                          |                             | \$ 14,000           |
| <b>2013 Photovoltaic Rebates to Customers</b>            |                      |                        |                             |                      |                     |                          |                             | 43,305              |
| <b>2013 Capacity Credit for Wind Resources</b>           |                      |                        |                             |                      |                     |                          |                             | (6,570)             |
| <b>Total Impact on 2013 Rates</b>                        |                      |                        |                             |                      |                     |                          |                             | <b>\$ 1,202,931</b> |

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**

| <b>DISTRIBUTION SYSTEM (Using 2013 system data)</b> |                 |                  |                        |               |                |                     |                  |                  |                 |
|---|-----------------|------------------|------------------------|---------------|----------------|---------------------|------------------|------------------|-----------------|
| 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               | 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       |
| <b>TOTAL</b>  |                 | <b>1,151,800</b> | <b>2,105</b>           | <b>365</b>    | <b>8,760</b>   |                     |                  |                  |                 |



# COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

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## EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

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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**

| AVERAGE MWh BY SEASON |        |        |        |        |
|-----------------------|--------|--------|--------|--------|
| Hour                  | 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

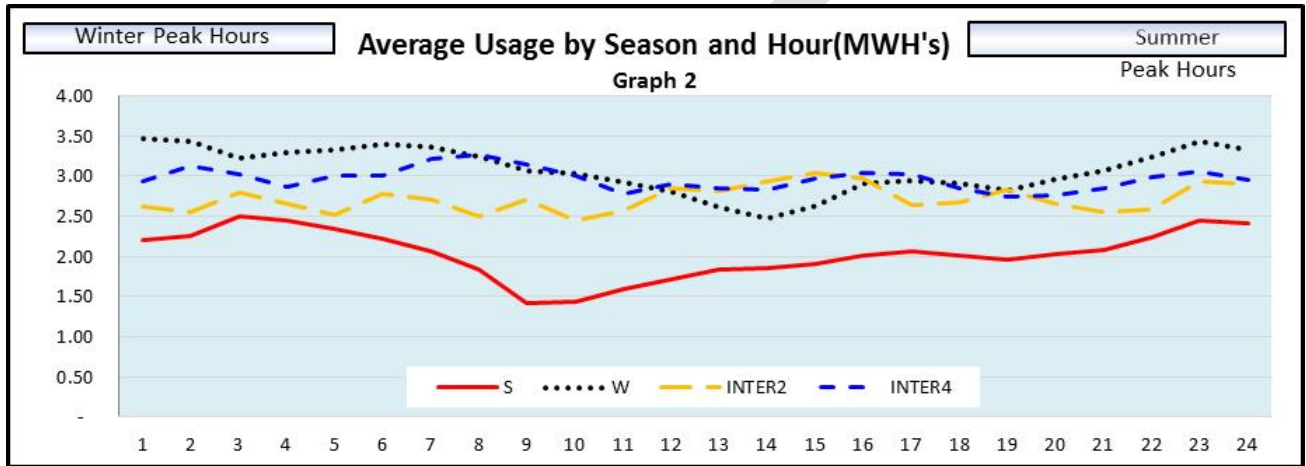
# COLUMBIA WATER AND LIGHT ELECTRIC DEPARTMENT

## 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.

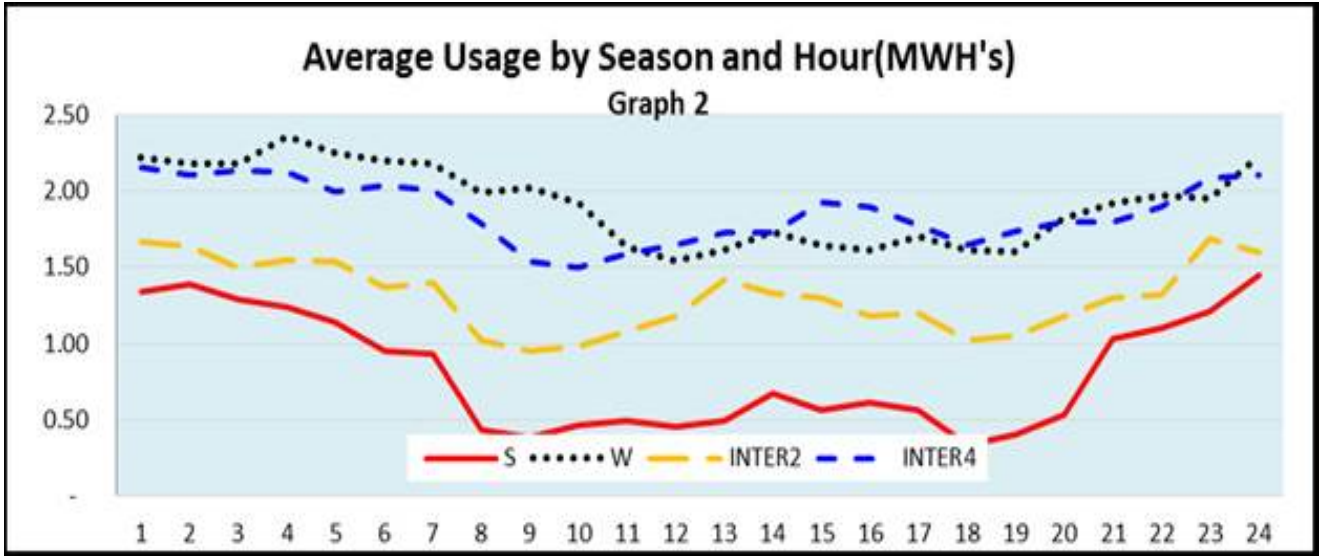
**Table Five – Crystal Lake Production Characteristics**

| 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          |
| <b>TOTAL</b>              |                 | <b>24,600</b> | <b>102</b>             | <b>365</b>    | <b>8,760</b>   |                     |                  |                  |                 |

# 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          |
| <b>TOTAL</b>              |                 | <b>14,100</b> | <b>70</b>              | <b>365</b>    | <b>8,760</b>   |                     |                  |                  |                 |

# 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**

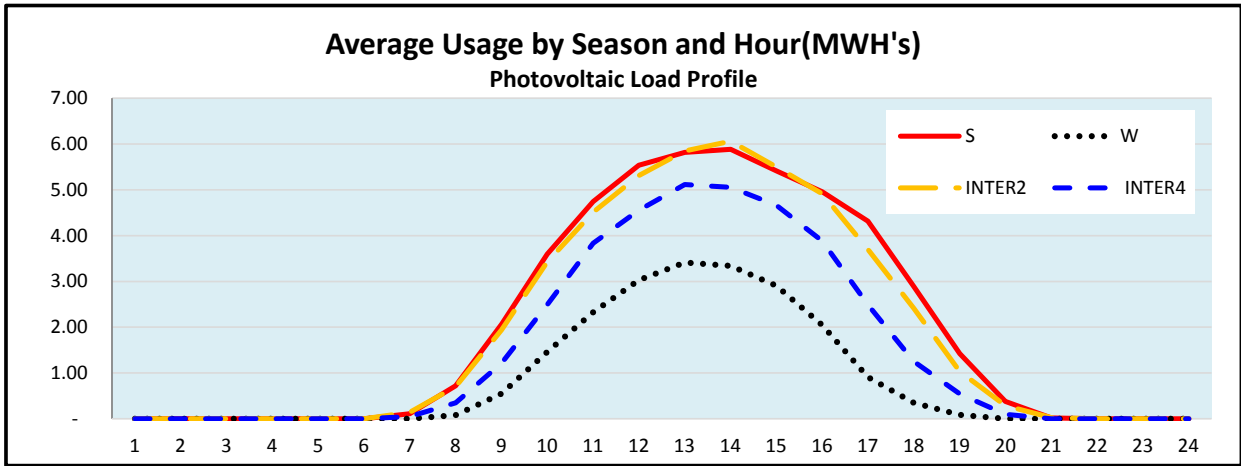
| Season  | Average Production |
|---------|--------------------|
| Summer  | 2.5 MW             |
| Winter  | 4.8 MW             |
| Inter 2 | 4.0 MW             |
| Inter 4 | 4.7 MW             |

# 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**

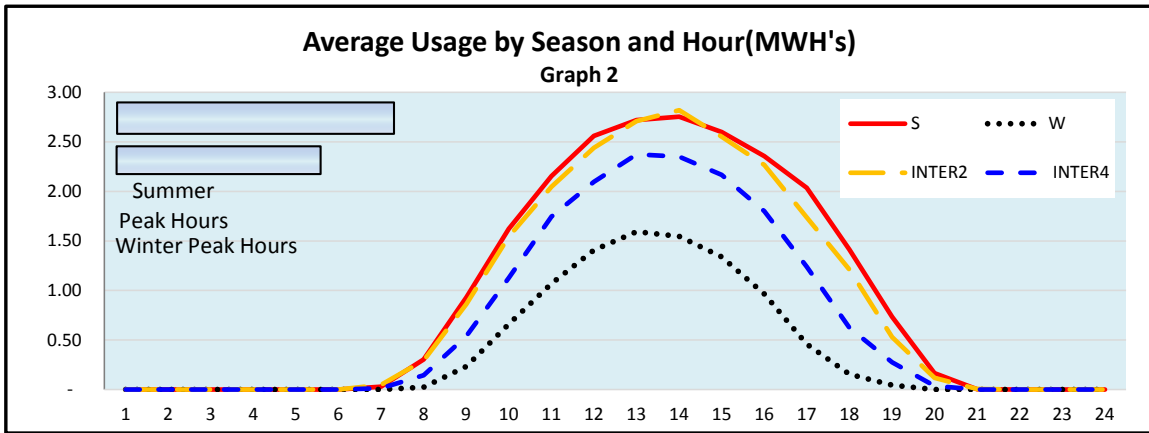
| <b>QuakerSolar 10kW (2013)</b> |                 |               |                        |               |                |                     |                  |                  |                 |
|--------------------------------|-----------------|---------------|------------------------|---------------|----------------|---------------------|------------------|------------------|-----------------|
| 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         |
| <b>TOTAL</b>                   |                 | <b>12,500</b> | <b>93</b>              | <b>365</b>    | <b>8,760</b>   |                     |                  |                  |                 |

# 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        |
| <b>TOTAL</b>           |                 | <b>5,800</b>  | <b>44</b>              | <b>365</b>    | <b>8,760</b>   |                     |                  |                  |                 |

# 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 |       |                 |              |                  |                 |   |                        |
|---|-------|-----------------|--------------|------------------|-----------------|---|------------------------|
| Month   | Peak  | Capacity Factor |              |                  |                 | Production @ System Peak                |                        |
|   |       | Hours           | kwh Produced | 100% Load Factor | Capacity Factor | Average Production during On-Peak Hours | 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

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## EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

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### 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<br>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                     |
| <b>Average Value</b>                     | <b>\$ 3.46</b>           |
| Reserve Capacity                         | 14%                      |
| <b>Adjusted Capacity Value - Monthly</b> | <b>\$ 3.94</b>           |
| <b>Annual Capacity Value</b>             | <b>\$ 47.33</b>          |

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       |
| <b>Total Value</b>                                 |  |  | <b>118,189</b> |
| kWh Production                                     |  |  | 38,719,796     |
| <b>Capacity Value per kWh</b>                      |  |  | <b>0.0031</b>  |

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         |
| <b>Total Value</b>                            |  |  | <b>\$ 290.09</b> |
| kWh Production                                |  |  | 18,364           |
| <b>Capacity Value per kWh</b>                 |  |  | <b>0.0158</b>    |

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 -<br>Wind | Crystal Lake -<br>Wind | Jefferson<br>City Land Fill | Columbia<br>Landfill | WasteWood           | Solar -<br>Free<br>Power | Net<br>Metered<br>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           |
| <b>Total Value</b>                                     | <b>\$ 491,852</b>    | <b>\$ 930,309</b>      | <b>\$ (39,967)</b>          | <b>\$ (99,945)</b>   | <b>\$ (144,792)</b> | <b>\$ 7,841</b>          | <b>\$ 6,898</b>             | <b>\$ 1,152,196</b> |
| 2013 North American Renewable Registry Membership      |                      |                        |                             |                      |                     |                          |                             | \$ 14,000           |
| 2013 Photovoltaic Rebates to Customers                 |                      |                        |                             |                      |                     |                          |                             | 43,305              |
| 2013 Capacity Credit for Wind Resources                |                      |                        |                             |                      |                     |                          |                             | (6,570)             |
| <b>Total Impact on 2013 Rates</b>                      |                      |                        |                             |                      |                     |                          |                             | <b>\$ 1,202,931</b> |
| Avoided Capacity Costs                                 | 0.0031               | 0.0031                 |                             |                      |                     | 0.0158                   | 0.0158                      |                     |
| Capacity Value   | \$ 42,688            | \$ 73,835              | -                           | -                    | -                   | \$ 6,702                 | \$ 1,892                    | \$ 125,117          |
| <b>Adjusted Value (Cost) for 3% Rate Determination</b> |                      |                        |                             |                      |                     |                          |                             | <b>\$ 1,077,813</b> |

- 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

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## EXECUTIVE SUMMARY – RATE IMPACTS OF RENEWABLES

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### 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.