

# **Klamath Settlement Process Greenhouse Gas Emissions from Power Replacement Technical Memorandum**

**Klamath Settlement**





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## Abbreviations and Acronyms

|                   |   |
|-------------------|---|
| CARB              | California Air Resources Board                      |
| CEC               | California Energy Commission                        |
| CH <sub>4</sub>   | methane   |
| CO <sub>2</sub>   | carbon dioxide                                      |
| CO <sub>2</sub> e | carbon dioxide equivalent                           |
| eGRID             | Emissions & Generation Resource Integrated Database |
| GHG               | Greenhouse gas                                      |
| GWP               | global warming potential                            |
| IPCC              | Intergovernmental Panel on Climate Change           |
| lb/GWh            | pounds per gigawatt hours                           |
| lb/MWh            | pounds per megawatt hour                            |
| MWh               | megawatt-hours                                      |
| N <sub>2</sub> O  | nitrous oxide                                       |
| PCA               | Power Control Area                                  |
| RPS               | Renewable Portfolio Standard                        |
| USEPA             | United States Environmental Protection Agency       |

# Chapter 1

## Introduction

This greenhouse gas (GHG) technical memorandum (TM) completed for the Secretarial Determination Overview Report (SDOR) evaluated the following three pollutants: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O). The other three pollutants commonly evaluated in various mandatory and voluntary reporting protocols (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) are not expected to be emitted in large quantities and are not discussed further in this TM.

A quantitative GHG emissions inventory was completed to estimate emissions that could occur in the future if the J.C. Boyle, Copco 1, Copco 2, and Iron Gate hydroelectric plants (“Four Facilities”) were removed. GHG emissions would result from possible replacement power following the removal of the Four Facilities. The emissions from replacement power would be somewhat offset by CH<sub>4</sub> emissions that currently occur from the reservoirs and this offset was factored into the overall emissions that would result from removal of the Four Facilities. This analysis provides a quantitative comparison between the estimated emissions that would result from removing the renewable energy generated by the Four Facilities and the estimated emissions from use of alternative power sources, such as fossil fuels, biomass, or other renewable energy sources.

Fossil fuels are formed by natural processes like the decomposition of dead organisms and consist of common fuels like coal and natural gas. These fuels are non-renewable because they take millions of years to form and are being depleted faster than they can be formed. Biomass is a renewable energy source that results from living or recently living plant or animal matter. Examples include wood, yard clippings, and other such waste, as well as gas generated from decaying material from a wastewater treatment plant or a landfill. Renewable sources could include hydropower, wind, solar, geothermal, and others.

The average amount of electricity currently generated at the Four Facilities and consequently needing replacement if the Four Facilities were removed was derived from the Bureau of Reclamation’s *Hydropower Benefits Technical Report: For the Secretarial Determination on Whether to Remove Four Dams on the Klamath River in California and Oregon* (August 2011). Monthly projected generation data was also provided electronically by the Bureau of Reclamation and was used to complete the calculations; 50 years of data (from 2012 to 2061) was provided. It is important to understand that, due to different

projected operating conditions, the Hydropower Benefits Technical Report assumed there would be greater electricity generation under the status quo (i.e., “No Action”) compared to electricity generation following removal of the Four Facilities.

To analyze potential emissions, the analysis in this TM used two scenarios of the replacement of lost hydropower. The two scenarios include:

- Removal of the Four Facilities and no change to PacifiCorp’s resource generation mix;
- Removal of the Four Facilities and PacifiCorp reaching the Renewable Portfolio Standard (RPS) goals; and,

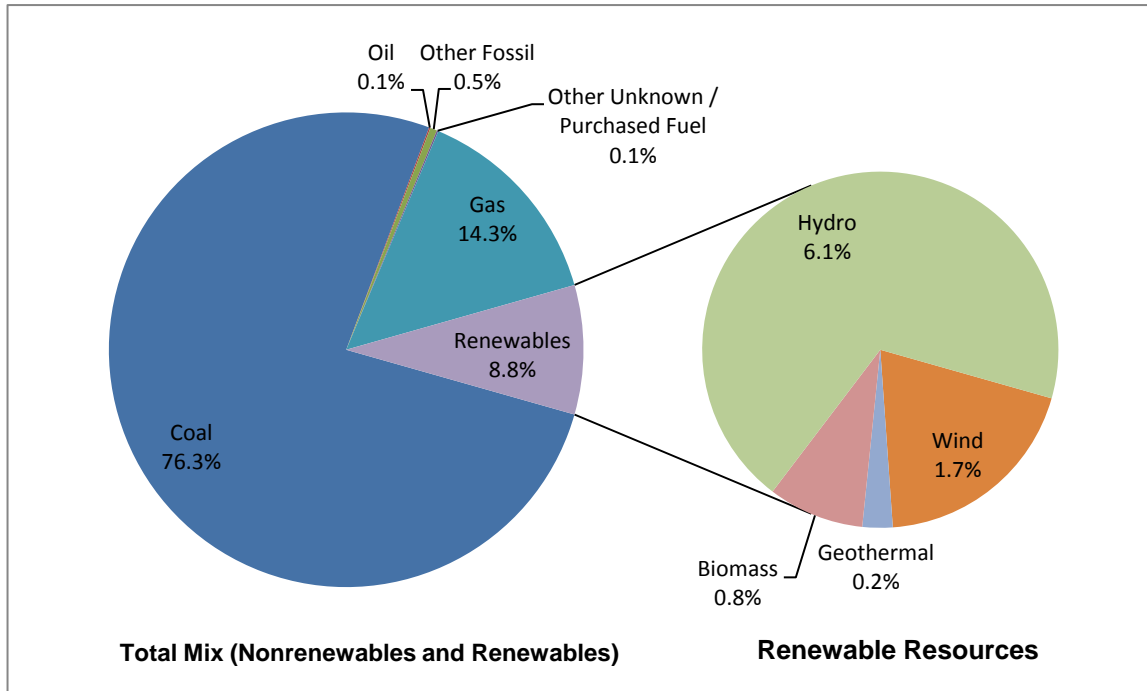
These scenarios are discussed in Sections 1.1- 1.3.

## **1.1 No Change to PacifiCorp Resource Generation Mix**

Electricity originally produced from the Four Facilities, if removed, would likely be replaced by another source within the PacifiCorp PCA because the amount of electricity provided by the Four Facilities is approximately 2 percent of PacifiCorp’s total generation capacity (California Energy Commission [CEC] 2006). Emission factors were developed using the Emissions & Generation Resource Integrated Database (eGRID) (USEPA 2010) for 2007.

eGRID is maintained by the USEPA and consists of data for electric power generated in the United States. It includes data on air emissions, emissions rates, net generation, resource mix, and other attributes. eGRID integrates many different Federal data sources on power plants and parent companies from the USEPA, the Energy Information Administration, and the Federal Energy Regulatory Commission. Using eGRID data was consistent with inventory requirements of multiple voluntary and mandatory reporting protocols and provides a worst-case estimation of emissions.

This scenario assumed that there would be no change in the current portfolio between now and when the facilities are removed in 2020 in the PacifiCorp Power Control Area (PCA), a region of the power grid in which all power plants are centrally dispatched. As shown in Figure 1, the 2007 electricity generation resource mix for the PacifiCorp PCA (estimated from eGRID) is dominated by coal (76 percent), natural gas (14 percent), and hydroelectricity (6 percent), with the remainder made up of smaller sources such as wind, biomass, and geothermal. The data provided was the most recent data available from the United States Environmental Protection Agency (USEPA) (2010) and represented the resource mix that would be available if any replacement energy was obtained from PacifiCorp’s resource mix as of 2007.



Source: USEPA 2010

**Figure 1. PacifiCorp Power Control Area Generation Resource Mix (as of 2007)**

Alternative emission factors were developed for the scenario that would occur immediately after the Four Facilities are removed in 2020. According to eGRID, the Four Facilities generated approximately 614,143 megawatt-hours (MWh) of electricity in 2007, which was 0.9 percent of the total electricity generation in the PacifiCorp PCA (net generation in 2007 was 67,961,660 MWh). While eGRID also contains archived data from 1996 and other years, the most recent data was used to estimate emissions, consistent with the requirements in various voluntary and mandatory reporting regulations. Assuming that the facilities were removed instantaneously at midnight on January 1, 2020, this action would serve to decrease the total amount of renewable resources in PacifiCorp's generation mix, thereby increasing its GHG emissions.

Table 1 summarizes the differences in emission factors between the status quo (no change in resource generation mix between 2007 and 2020) and the scenario under which the Four Facilities are removed instantaneously in 2020.

**Table 1. Emission Factors Used for PacifiCorp PCA  
(2007 eGRID)**

| Scenario  | Emission Factors         |                          |                           |
|---|--------------------------|--------------------------|---------------------------|
|   | CO <sub>2</sub> (lb/MWh) | CH <sub>4</sub> (lb/GWh) | N <sub>2</sub> O (lb/GWh) |
| No Change to Fuel Mix <sup>1</sup><br>(continued operation of the<br>Four Facilities) | 1,839.49                 | 26.34                    | 30.02                     |
| Four Facilities<br>Removed <sup>2</sup>   | 1,856.27                 | 26.59                    | 30.30                     |

Source: USEPA 2010

Notes:

1. Emission factors for “No Change to Fuel Mix” from eGRID using all power plants within the control of the PacifiCorp PCA, including plants other than the Four Facilities.
2. Emission factors for “Four Facilities Removed” from eGRID using all power plants within the control of the PacifiCorp PCA minus the Four Facilities. The emission factors are slightly higher than the “No Change to Fuel Mix” emission factors because less hydropower is available for electricity generation.

Key:

CH<sub>4</sub> = methane

CO<sub>2</sub> = carbon dioxide

eGRID = Emissions & Generation Resource Integrated Database

lb/GWh = pounds per gigawatt hours

lb/MWh = pounds per megawatt hour

N<sub>2</sub>O = nitrous oxide

PCA = power control area

The emission factors labeled “No Change to Fuel Mix” reflect no change in the fuel mix between 2007 and all future years. These factors were used to estimate the difference in emissions between 2012 and 2019. These emissions are discussed further in Section 2.1. The second set of emission factors in Table 1, labeled “Four Facilities Removed,” reflects the reduction in hydroelectricity generation following removal of the Four Facilities. These emission factors were used to estimate GHG emissions from the average annual amount of power that would need to be replaced following the instantaneous removal of the hydroelectric plants in 2020. These emissions are discussed further in Section 2.2.

## 1.2 Renewable Portfolio Goals Met By PacifiCorp

PacifiCorp is under obligation to meet the Renewable Portfolio Standard (RPS) goals in California and Oregon. The RPS goal for California is to have 33 percent of an electricity seller’s load served with renewable power by 2020 (Executive Order S-14-08; and SBX1 2), while Oregon’s RPS goal is for 25 percent of a utility’s retail sales of electricity to be from renewable energy by 2025 (Senate Bill 838). PacifiCorp is currently on track to meet its Oregon RPS target, but is expected to be under California’s RPS target (PacifiCorp 2011). PacifiCorp plans on using flexible compliance mechanisms (e.g., banking, earmarking, and tradable renewable energy credits) to meet California’s RPS standards.



Since PacifiCorp is on a trajectory to increase its use of renewable energy, any modifications to the Four Facilities, either by demolition or power generation reductions, would decrease the amount of renewable power that PacifiCorp has in its portfolio. Although short-term effects could occur from modifications to the hydroelectric facilities, these effects would be offset in the long-term because PacifiCorp would be required to continue increasing its renewable energy share to meet the RPS goals in the two states.

The current resource generation mix for the PacifiCorp PCA contains approximately 8.8 percent renewable power (Figure 1). A ratio was used to estimate emission factors that would result from the removal of the Four Facilities assuming the percentage of renewable power was increased to 33 percent. It was assumed that the renewable energy percentage in PacifiCorp's fuel mix would increase linearly between 2007 (the most recent eGRID data) and 2020. Table 2 summarizes the estimated emissions and RPS percentage for each year of analysis. Emissions are discussed further in Section 2.2.

**Table 2. Emission Factors Assuming that PacifiCorp Meets 2020 RPS Goal**

| Year | RPS   | CO <sub>2</sub> | CH <sub>4</sub> | N <sub>2</sub> O |
|------|-------|-----------------|-----------------|------------------|
|      | (%)   | (lb/MWh)        | (lb/GWh)        | (lb/GWh)         |
| 2007 | 8.8%  | 1,839.49        | 26.34           | 30.02            |
| 2008 | 10.7% | 1,801.94        | 25.81           | 29.41            |
| 2009 | 12.5% | 1,764.39        | 25.27           | 28.80            |
| 2010 | 14.4% | 1,726.84        | 24.73           | 28.18            |
| 2011 | 16.2% | 1,689.30        | 24.19           | 27.57            |
| 2012 | 18.1% | 1,651.75        | 23.66           | 26.96            |
| 2013 | 20.0% | 1,614.20        | 23.12           | 26.35            |
| 2014 | 21.8% | 1,576.65        | 22.58           | 25.73            |
| 2015 | 23.7% | 1,539.10        | 22.04           | 25.12            |
| 2016 | 25.6% | 1,501.55        | 21.51           | 24.51            |
| 2017 | 27.4% | 1,464.00        | 20.97           | 23.89            |
| 2018 | 29.3% | 1,426.45        | 20.43           | 23.28            |
| 2019 | 31.1% | 1,388.90        | 19.89           | 22.67            |
| 2020 | 33.0% | 1,351.35        | 19.35           | 22.06            |

Key:

CH<sub>4</sub> = methane

CO<sub>2</sub> = carbon dioxide

lb/GWh = pounds per gigawatt-hour

lb/MWh = pounds per megawatt-hour

N<sub>2</sub>O = nitrous oxide

RPS = renewable portfolio standard

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## Chapter 2 Greenhouse Gas Emissions Quantification

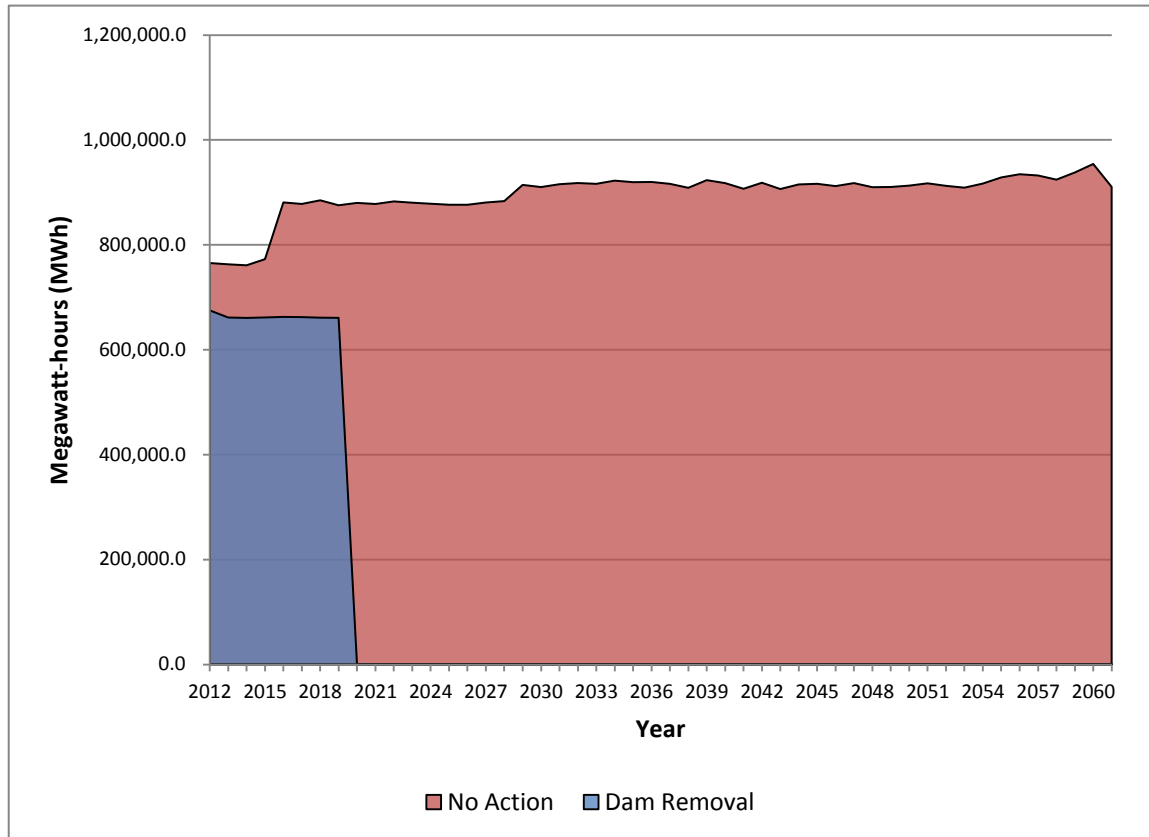
As described above, the analysis in this TM provides a quantitative comparison between the removal of a renewable energy source (hydropower generated by the Four Facilities) and the estimated emissions that could result from replacement power generated by an alternative power source.

Emissions of carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O), typical byproducts of combustion, were estimated for this analysis. Each GHG contributes to climate change differently, as expressed by its global warming potential (GWP). GHG emissions are discussed in terms of carbon dioxide equivalent (CO<sub>2</sub>e) emissions, which express, for a given mixture of GHG, the amount of CO<sub>2</sub> that would have the same GWP over a specific timescale. CO<sub>2</sub>e is determined by multiplying the mass of each GHG by its GWP<sup>1</sup>. This analysis used the GWP from the Intergovernmental Panel on Climate Change (IPCC) *Second Assessment Report* (IPCC 1996) for a 100-year time period to estimate CO<sub>2</sub>e. Although subsequent assessment reports have been published by the IPCC, the international standard, as reflected in various federal, state, and voluntary reporting programs, is to use GWPs from the *Second Assessment Report*.

Figure 2 shows the mean annual amount of electricity produced by the Four Facilities for 50 years (2012 to 2061), as provided by Reclamation (2011a). The red area shows the amount of electricity that would be generated annually if the Four Facilities were to remain in place; the blue portion shows the amount of electricity that would be generated annually if the Four Facilities were removed in 2020. As a result of the proposed removal of the Four Facilities, the electricity production drops to zero in 2020 for the “dam removal” alternative (blue area), as shown in Figure 2.

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<sup>1</sup> As an example, CH<sub>4</sub> has a GWP of 21, as specified in the Intergovernmental Panel on Climate Change's *Second Assessment Report* (1996). One metric ton of CH<sub>4</sub> is equal to 21 metric tons of CO<sub>2</sub>e (1 metric ton x 21).



Source: Reclamation 2011a

**Figure 2. Mean Annual Klamath Generation by Alternative**

## 2.1 Estimated Emissions Before Removal of Four Facilities

Although using the 2007 data provides emissions results that would be higher than the current (2011) resource mix, using eGRID data is consistent with inventory requirements of multiple voluntary and mandatory reporting protocols; therefore, the 2007 eGRID data was used for the analysis. The analysis was adjusted so that the base load was assumed to be served by the resources mix provided by the 2007 eGRID data, while peaking power would be supplied by natural gas. Approximately 64 percent of the annual average electricity would be on-peak and the remaining 36 percent of the generated power would be off-peak (PacifiCorp 2006).

Emissions were also calculated assuming that PacifiCorp met its RPS obligations (i.e., 33 percent renewable power in California). As a result, the off-peak emissions were calculated assuming that 33 percent of the power would be served by renewable power (an increase from the existing portfolio assumption of approximately nine percent renewable power).

Emissions were estimated using the following equation:

$$\begin{aligned}
 CO_2 \text{ Emissions } \left( \frac{\text{metric tons}}{\text{year}} \right) &= \text{Power Generation } \left( \frac{\text{MWh}}{\text{year}} \right) \times \text{Emission Factor } \left( \frac{\text{lb}}{\text{MWh}} \right) \\
 &\times \text{Conversion } \left( \frac{\text{metric ton}}{\text{lb}} \right)
 \end{aligned}$$

For example, emissions in 2012 were estimated as following:

CO<sub>2</sub> Emissions in 2012 (metric tons per year) = 90,266 MWh  
(difference between operating scenarios) x 1,839.49 lb/MWh (CO<sub>2</sub>  
emission factor from Table 1) x 0.0004536 metric tons per pound =  
75,318 metric tons per year.

Methane and N<sub>2</sub>O emissions were estimated by following the same method, but with the respective GWP used to estimate emissions. In other words, multipliers of 21 and 310, respectively, were used to estimate CH<sub>4</sub> and N<sub>2</sub>O emissions.

Table 3 estimates emissions that could occur in the period immediately before the Four Facilities would be removed in 2020 (2012 to 2019). Differences in operating conditions between the two alternatives causes a difference in the amount of electricity generated. If the Four Facilities were removed, then the amount of electricity that could be generated per year would be less for this time period; the difference in emissions would then need to be obtained from other sources within PacifiCorp's PCA.

As is shown on Table 3, power generation is expected to trend upwards if the Four Facilities remain, but would trend downwards if they were removed. It is important to understand that some of the existing capital equipment at these plants would reach the end of its engineering life during the 50-year analysis period. Replacement and refurbishment of aged equipment would be required to maintain continuing operations at these plants. The replacement of this equipment would increase the efficiency and the amount of generation capacity at these plants. As a result, generation would improve if the plants remain.

Table 3 estimates emissions assuming that there would be no change in the resource generation mix between now and 2020 and represents a worst-case scenario, as it is expected that PacifiCorp would decrease its reliance on coal and would increase dependence on natural gas. Emissions were also estimated assuming that PacifiCorp met California's 2020 RPS target. Table 4 summarizes estimated emissions assuming the 33 percent RPS target was met.

Klamath Settlement Process  
Greenhouse Gas Emissions from Power Replacement

**Table 3. Annual Average Electricity Generation GHG Emissions from Replacement Sources (2012 to 2019): Assumes Default eGRID Data**

| Year  | Power Generation (MWh) <sup>1</sup> |             |             | Emissions (MTCO <sub>2</sub> e/year) <sup>2</sup> |                              |                               |         |
|-------|-------------------------------------|-------------|-------------|---|------------------------------|-------------------------------|---------|
|       | Dams Remain                         | Dam Removal | Difference  | CO <sub>2</sub>                                   | CH <sub>4</sub> <sup>3</sup> | N <sub>2</sub> O <sup>4</sup> | Total   |
| 2012  | 765,108                             | 674,842     | (90,266)    | 51,737  | 19                           | 153                           | 51,909  |
| 2013  | 762,670                             | 661,196     | (101,474)   | 58,161  | 21                           | 172                           | 58,354  |
| 2014  | 760,781                             | 660,450     | (100,331)   | 57,506  | 21                           | 170                           | 57,697  |
| 2015  | 772,447                             | 661,298     | (111,150)   | 63,707  | 23                           | 188                           | 63,918  |
| 2016  | 880,638                             | 662,364     | (218,274)   | 125,107   | 45                           | 369                           | 125,521 |
| 2017  | 877,743                             | 662,002     | (215,741)   | 123,655   | 45                           | 365                           | 124,065 |
| 2018  | 884,686                             | 660,890     | (223,796)   | 128,271   | 46                           | 379                           | 128,697 |
| 2019  | 875,197                             | 660,605     | (214,592)   | 122,996   | 45                           | 363                           | 123,404 |
| Total | 6,579,270                           | 5,303,646   | (1,275,624) | 731,140   | 265                          | 2,159                         | 733,564 |

Source: Reclamation 2011a

Note:

1. Emissions only reflect power generated from the Four Facilities and not from other sources within the PacifiCorp PCA.
2. Emission factors from Table 1 for “No Change to Fuel Mix” were used to estimate emissions. Emissions reflect the difference in emissions as they demonstrate emissions that could occur if operational parameters change before the Four Facilities are removed in 2020.
3. Methane emissions multiplied by a GWP of 21.
4. Nitrous oxide emissions multiplied by a GWP of 310.

Key:

MWh = megawatt hours

MTCO<sub>2</sub>e/year = metric tons carbon dioxide equivalent per year

**Table 4. Annual Average Electricity Generation GHG Emissions from Replacement Sources (2012 to 2019): Assumes 33 Percent RPS Target Met**

| Year  | Power Generation (MWh) <sup>1</sup> |             |             | Emissions (MTCO <sub>2</sub> e/year) <sup>2</sup> |                              |                               |         |
|-------|-------------------------------------|-------------|-------------|---|------------------------------|-------------------------------|---------|
|       | Dams Remain                         | Dam Removal | Difference  | CO <sub>2</sub>                                   | CH <sub>4</sub> <sup>3</sup> | N <sub>2</sub> O <sup>4</sup> | Total   |
| 2012  | 765,108                             | 674,842     | (90,266)    | 48,992  | 18                           | 139                           | 49,149  |
| 2013  | 762,670                             | 661,196     | (101,474)   | 54,457  | 20                           | 153                           | 54,630  |
| 2014  | 760,781                             | 660,450     | (100,331)   | 53,234  | 20                           | 148                           | 53,402  |
| 2015  | 772,447                             | 661,298     | (111,150)   | 58,298  | 21                           | 161                           | 58,480  |
| 2016  | 880,638                             | 662,364     | (218,274)   | 113,157   | 42                           | 309                           | 113,508 |
| 2017  | 877,743                             | 662,002     | (215,741)   | 110,531   | 41                           | 299                           | 110,871 |
| 2018  | 884,686                             | 660,890     | (223,796)   | 113,297   | 42                           | 303                           | 113,642 |
| 2019  | 875,197                             | 660,605     | (214,592)   | 107,332   | 40                           | 284                           | 107,656 |
| Total | 6,579,270                           | 5,303,646   | (1,275,624) | 659,298   | 243                          | 1,796                         | 661,337 |

Source: Reclamation 2011a

Note:

1. Emissions only reflect power generated from the Four Facilities and not from other sources within the PacifiCorp PCA.
2. Emission factors from Table 2 were used to estimate emissions. Emissions reflect the difference in emissions as they demonstrate emissions that could occur if operational parameters change before the Four Facilities are removed in 2020.
3. Methane emissions multiplied by a GWP of 21.
4. Nitrous oxide emissions multiplied by a GWP of 310.

Key:

MWh = megawatt hours

MTCO<sub>2</sub>e/year = metric tons carbon dioxide equivalent per year

## 2.2 Estimated Emissions After Removal of Four Facilities

The previous analysis estimated GHG emissions that would occur during the period before the Four Facilities would be removed (2012 through 2019). On average, the Four Facilities would likely generate 909,835 MWh<sup>2</sup> annually over the 42-year period analyzed by Reclamation after dam removal (2020 through 2061). This generation number is higher than has been reported in the past for these Four Facilities because it assumes efficiency upgrades (e.g., turbines and generators) that PacifiCorp is currently making and would continue to make in the future if the facilities were to remain in place until 2061 (Reclamation 2011b). When the Four Facilities are removed, approximately 525,698 MTCO<sub>2</sub>e per year would be emitted from replacement power; this value assumes that the resource generation mix does not change between 2007 and 2020 with the exception of the loss of hydropower from the Four Facilities (see Table 1 – Emission Factors for “Four Facilities Removed.”). If PacifiCorp is able to meet California’s RPS goal, then approximately 450,878 MTCO<sub>2</sub>e per year would be emitted from replacement power sources. See Appendix A for detailed calculations.

The reservoirs are also a source of methane GHG emission. The Karuk Tribe (2006) estimated the total amount of CH<sub>4</sub> released from Keno, J.C. Boyle, Copco, and Iron Gate reservoirs, by multiplying the reservoirs' area by areal emissions rates from reservoirs around the world with similar characteristics (poor water quality). The resulting estimate ranged from approximately 8,000 to 29,000 MTCO<sub>2</sub>e per year<sup>3</sup>. Not including the Keno Impoundment in the assessment, CH<sub>4</sub> emissions would be approximately 4,000 to 14,000 MTCO<sub>2</sub>e per year (less than one percent) for Iron Gate, Copco, and J.C. Boyle reservoirs based on reduction of CH<sub>4</sub> gas emitted from reservoir bottom sediments.

Methane emissions from the reservoirs would cease to exist once the facilities are removed. As a result, the methane generation estimate would offset some of the GHG emissions generated from replacement power.

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<sup>2</sup> The annual average power generation (909,835 MWh) is not summarized in Tables 3 and 4. Rather, it is the average electricity produced between 2020 and 2061, while Tables 3 and 4 demonstrate emissions between 2012 and 2019. Detailed emission calculations for this section are provided in Appendix A.

<sup>3</sup> The emission estimation ranges provided in this section are based on a GWP of 21 for CH<sub>4</sub>; the original Karuk Tribe calculation assumed a GWP of 23, but the calculation was changed to be consistent with the rest of this analysis.

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## Chapter 3 Conclusions

To provide context for the emissions expected to be generated from replacement power, it is necessary to consider the fact that several air districts in California, including the Bay Area Air Quality Management District and the South Coast Air Quality Management District, established significance thresholds for GHG emissions of 10,000 MTCO<sub>2e</sub> emissions per year. Although not finalized, the Council on Environmental Quality recommended that climate change be discussed in any National Environmental Policy Act analyses if GHG emissions exceed 25,000 MTCO<sub>2e</sub> per year; however, the CEQ Draft Guidelines do not preclude analyses when emissions are expected to be less than this limit.

The California Air Resources Board (CARB) developed some metrics to convert one million metric tons of carbon dioxide to familiar equivalents. CARB estimated that one million metric tons of CO<sub>2</sub> would be equivalent to the following (CARB 2007):

- Annual emissions from 1.5 state-of-the-art 500 MW combined-cycle gas-fired power plants.
- 114 million gallons of gasoline per year
- 2.3 million barrels of oil per year
- 216,000 passenger cars not driven for one year

Removing the Four Facilities would result in a substantial increase in GHG emissions from replacement power sources. In the period from 2012 to 2020 before the dams are removed, a total of 661,337 MTCO<sub>2e</sub> would be emitted because of differences in modeled power generation differences between the two alternatives. On average the Four Facilities would generate 909,835 MWh annually over the 42-year period analyzed by Reclamation after dam removal (2020 through 2061). When the Four Facilities are removed, approximately 525,698 MTCO<sub>2e</sub> per year would be emitted from replacement power assuming PacifiCorp's current resource generation mix. This number would decrease to approximately 450,878 MTCO<sub>2e</sub> per year under the scenario where PacifiCorp is able to meet California's RPS goal. Removal of the reservoirs would reduce these emissions by approximately 4,000 to 14,000 MTCO<sub>2e</sub> per year.

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**Appendix A**  
**Greenhouse Gas Emissions –**  
**Power Replacement**

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**Greenhouse Gas Emissions from Power Replacement  
Summary - Before Dam Removal**

**Emission Factors from PacifiCorp Power Control Area (as of 2007)**

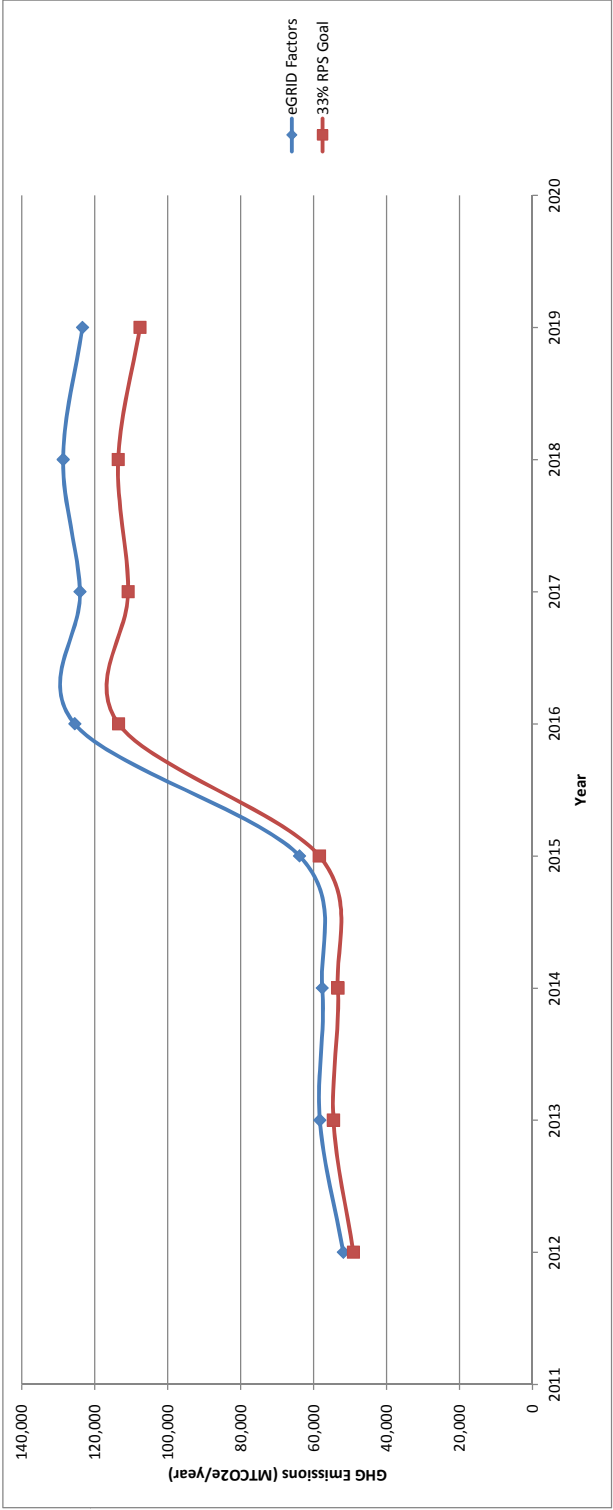
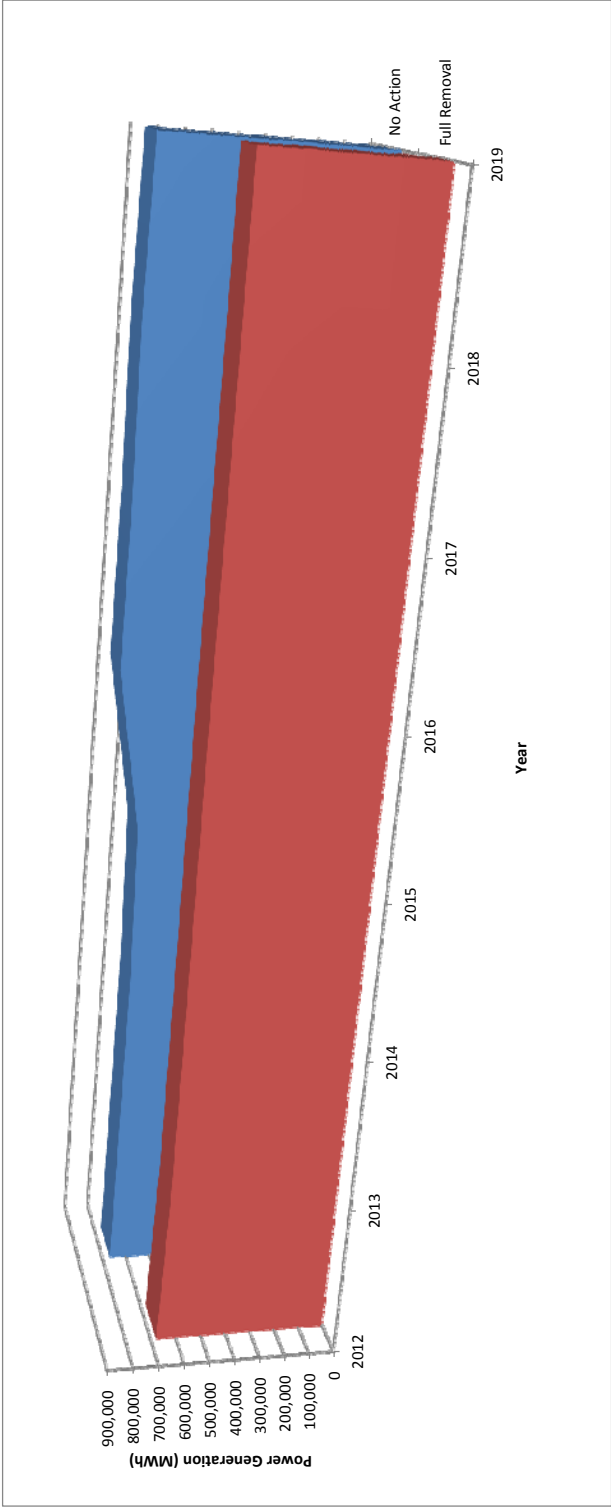
| Year         | Power Generation (MWh) |                  |                    | Off-Peak Emissions (MT/year) |                  |          | On-Peak Emissions (MT/year) |          |          | Emissions (MTCO2e/year) |          |          |                |            |                |
|--------------|------------------------|------------------|--------------------|------------------------------|------------------|----------|-----------------------------|----------|----------|-------------------------|----------|----------|----------------|------------|----------------|
|              | No Action              | Full Removal     | Difference         | Off-Peak                     | On-Peak          | (58,028) | CO2                         | CH4      | N2O      | CO2                     | CH4      | N2O      | Total          |            |                |
| 2012         | 765,108                | 674,842          | (90,266)           | (32,238)                     | (58,028)         |          | 26,899                      | 0        | 0        | 24,838                  | 1        | 0        | 51,737         | 153        | 51,909         |
| 2013         | 762,670                | 661,196          | (101,474)          | (36,241)                     | (65,233)         |          | 30,239                      | 0        | 0        | 27,922                  | 1        | 0        | 58,161         | 21         | 58,354         |
| 2014         | 760,781                | 660,450          | (100,331)          | (35,833)                     | (64,499)         |          | 29,899                      | 0        | 0        | 27,608                  | 1        | 0        | 57,506         | 21         | 57,697         |
| 2015         | 772,447                | 661,298          | (111,150)          | (39,696)                     | (71,453)         |          | 33,122                      | 0        | 1        | 30,584                  | 1        | 0        | 63,707         | 23         | 63,918         |
| 2016         | 880,638                | 662,364          | (218,274)          | (77,955)                     | (140,319)        |          | 65,045                      | 1        | 0        | 60,061                  | 1        | 0        | 125,107        | 45         | 125,521        |
| 2017         | 877,743                | 662,002          | (215,741)          | (77,050)                     | (138,691)        |          | 64,290                      | 1        | 1        | 59,364                  | 1        | 0        | 123,655        | 45         | 124,065        |
| 2018         | 884,686                | 660,890          | (223,796)          | (79,927)                     | (143,869)        |          | 66,691                      | 1        | 1        | 61,581                  | 1        | 0        | 128,271        | 46         | 128,697        |
| 2019         | 875,197                | 660,605          | (214,592)          | (76,640)                     | (137,952)        |          | 63,948                      | 1        | 1        | 59,048                  | 1        | 0        | 122,996        | 45         | 123,404        |
| <b>Total</b> | <b>6,579,270</b>       | <b>5,303,646</b> | <b>(1,275,624)</b> | <b>(455,580)</b>             | <b>(820,044)</b> |          | <b>380,133</b>              | <b>5</b> | <b>6</b> | <b>351,007</b>          | <b>7</b> | <b>1</b> | <b>731,140</b> | <b>265</b> | <b>733,564</b> |

Note:  
Calculated emissions represent the difference in emissions between the Full Dam Removal Alternative and the No Action Alternative.  
It represents the amount of power that would need to be obtained from other sources within the PacifiCorp PCA that would need to be replaced.

**Emission Factors from PacifiCorp Power Control Area (assumes 33% RPS Goal Met)**

| Year         | Power Generation (MWh) |                  |                    | Off-Peak Emissions (MT/year) |                  |          | On-Peak Emissions (MT/year) |          |          | Emissions (MTCO2e/year) |          |          |                |            |                |
|--------------|------------------------|------------------|--------------------|------------------------------|------------------|----------|-----------------------------|----------|----------|-------------------------|----------|----------|----------------|------------|----------------|
|              | No Action              | Full Removal     | Difference         | Off-Peak                     | On-Peak          | (58,028) | CO2                         | CH4      | N2O      | CO2                     | CH4      | N2O      | Total          |            |                |
| 2012         | 765,108                | 674,842          | (90,266)           | (32,238)                     | (58,028)         |          | 24,154                      | 0        | 0        | 24,838                  | 1        | 0        | 48,992         | 18         | 49,149         |
| 2013         | 762,670                | 661,196          | (101,474)          | (36,241)                     | (65,233)         |          | 26,535                      | 0        | 0        | 27,922                  | 1        | 0        | 54,457         | 20         | 54,630         |
| 2014         | 760,781                | 660,450          | (100,331)          | (35,833)                     | (64,499)         |          | 25,626                      | 0        | 0        | 27,608                  | 1        | 0        | 53,234         | 20         | 53,402         |
| 2015         | 772,447                | 661,298          | (111,150)          | (39,696)                     | (71,453)         |          | 27,713                      | 0        | 0        | 30,584                  | 1        | 0        | 58,298         | 21         | 58,480         |
| 2016         | 880,638                | 662,364          | (218,274)          | (77,955)                     | (140,319)        |          | 53,095                      | 1        | 0        | 60,061                  | 1        | 0        | 113,157        | 42         | 113,508        |
| 2017         | 877,743                | 662,002          | (215,741)          | (77,050)                     | (138,691)        |          | 51,167                      | 1        | 1        | 59,364                  | 1        | 0        | 110,531        | 41         | 110,871        |
| 2018         | 884,686                | 660,890          | (223,796)          | (79,927)                     | (143,869)        |          | 51,716                      | 1        | 1        | 61,581                  | 1        | 0        | 113,297        | 42         | 113,642        |
| 2019         | 875,197                | 660,605          | (214,592)          | (76,640)                     | (137,952)        |          | 48,284                      | 1        | 1        | 59,048                  | 1        | 0        | 107,332        | 40         | 107,656        |
| <b>Total</b> | <b>6,579,270</b>       | <b>5,303,646</b> | <b>(1,275,624)</b> | <b>(455,580)</b>             | <b>(820,044)</b> |          | <b>308,291</b>              | <b>4</b> | <b>5</b> | <b>351,007</b>          | <b>7</b> | <b>1</b> | <b>659,298</b> | <b>243</b> | <b>661,337</b> |

Note:  
Calculated emissions represent the difference in emissions between the Full Dam Removal Alternative and the No Action Alternative.  
It represents the amount of power that would need to be obtained from other sources within the PacifiCorp PCA that would need to be replaced.  
Emission factors assume a linear relationship between the RPS percentage and the year. Emission factors get incrementally smaller until 33% goal met in 2020.





**Greenhouse Gas Emissions Associated with Power Replacement Summary - After Dam Removal**

Average Electricity Generation After Removal of Four Facilities (mean of estimated power generation, 2020-2061)

909,835.1 MWh

| Pollutant | Emission Factors (lb/MWh) |          |
|-----------|---------------------------|----------|
|           | Current Mix               | 33% RPS  |
| CO2       | 1,856.27                  | 1,351.35 |
| CH4       | 0.02859                   | 0.01935  |
| N2O       | 0.03030                   | 0.02206  |

| Pollutant | CO2e Emissions (MT/year) |            |
|-----------|--------------------------|------------|
|           | Current Mix              | 33% RPS    |
| CO2       | 523,956.01               | 449,535.15 |
| CH4       | 189.61                   | 167.23     |
| N2O       | 1,552.52                 | 1,175.98   |
| Total     | 525,698.15               | 450,878.36 |

| Year  | Estimated Power Generation (MWh) |                |                | Estimated Emissions Using Current Resource Mix |              |       |                             |       |              |                             |      |              |                         |          |              |
|-------|----------------------------------|----------------|----------------|--|--------------|-------|-----------------------------|-------|--------------|-----------------------------|------|--------------|-------------------------|----------|--------------|
|       | Dam Removal Mean                 | No action Mean | delta          | Off-Peak Emissions (MT/year)                   |              |       | On-Peak Emissions (MT/year) |       |              | On-Peak Emissions (MT/year) |      |              | Emissions (MTCO2e/year) |          |              |
|       |                                  |                |                | CO2  | CH4          | N2O   | CO2                         | CH4   | N2O          | CO2                         | CH4  | N2O          | CO2                     | CH4      | N2O          |
| 2020  | 0.0                              | 879,743.4      | (879,743.4)    | (614,194.1)                                    | 264,552.1    | 3.8   | 4.3                         | 4.3   | 242,074.6    | 4.9                         | 0.5  | 506,626.7    | 183.3                   | 1,501.2  | 508,311.3    |
| 2021  | 0.0                              | 877,634.0      | (877,634.0)    | (313,440.7)                                    | 263,917.8    | 3.8   | 4.3                         | 4.3   | 241,494.2    | 4.9                         | 0.5  | 505,412.0    | 182.9                   | 1,497.6  | 507,092.5    |
| 2022  | 0.0                              | 882,566.0      | (882,566.0)    | (315,202.1)                                    | 265,400.9    | 3.8   | 4.3                         | 4.3   | 242,851.3    | 5.0                         | 0.5  | 508,252.2    | 183.9                   | 1,506.0  | 509,942.2    |
| 2023  | 0.0                              | 880,121.6      | (880,121.6)    | (314,329.9)                                    | 264,665.9    | 3.8   | 4.3                         | 4.3   | 242,178.7    | 4.9                         | 0.5  | 506,844.5    | 183.4                   | 1,501.8  | 508,529.8    |
| 2024  | 0.0                              | 878,172.3      | (878,172.3)    | (313,633.0)                                    | 264,079.7    | 3.8   | 4.3                         | 4.3   | 241,642.3    | 4.9                         | 0.5  | 505,722.0    | 183.0                   | 1,498.5  | 507,403.5    |
| 2025  | 0.0                              | 876,212.1      | (876,212.1)    | (312,932.9)                                    | 263,490.2    | 3.8   | 4.3                         | 4.3   | 241,102.9    | 4.9                         | 0.5  | 504,593.2    | 182.6                   | 1,495.2  | 506,270.9    |
| 2026  | 0.0                              | 876,190.4      | (876,190.4)    | (312,925.1)                                    | 263,483.7    | 3.8   | 4.3                         | 4.3   | 241,097.0    | 4.9                         | 0.5  | 504,580.7    | 182.6                   | 1,495.1  | 506,258.4    |
| 2027  | 0.0                              | 880,525.9      | (880,525.9)    | (314,473.5)                                    | 264,787.5    | 3.8   | 4.3                         | 4.3   | 242,289.9    | 4.9                         | 0.5  | 507,077.4    | 183.5                   | 1,502.5  | 508,763.4    |
| 2028  | 0.0                              | 883,160.0      | (883,160.0)    | (315,414.3)                                    | 265,579.6    | 3.8   | 4.3                         | 4.3   | 243,014.7    | 5.0                         | 0.5  | 508,594.3    | 184.1                   | 1,507.0  | 510,285.4    |
| 2029  | 0.0                              | 914,045.5      | (914,045.5)    | (326,444.8)                                    | 274,867.3    | 3.9   | 4.5                         | 4.5   | 251,513.3    | 5.1                         | 0.5  | 526,380.7    | 190.5                   | 1,559.7  | 528,130.9    |
| 2030  | 0.0                              | 909,936.6      | (909,936.6)    | (324,977.4)                                    | 273,631.7    | 3.9   | 4.5                         | 4.5   | 250,382.7    | 5.1                         | 0.5  | 524,014.5    | 189.6                   | 1,552.7  | 525,756.8    |
| 2031  | 0.0                              | 915,391.4      | (915,391.4)    | (326,925.5)                                    | 275,272.0    | 3.9   | 4.5                         | 4.5   | 251,883.7    | 5.1                         | 0.5  | 527,155.7    | 190.8                   | 1,562.0  | 528,908.5    |
| 2032  | 0.0                              | 917,610.7      | (917,610.7)    | (327,718.1)                                    | 275,939.4    | 4.0   | 4.5                         | 4.5   | 252,494.4    | 5.2                         | 0.5  | 528,433.8    | 191.2                   | 1,565.8  | 530,190.8    |
| 2033  | 0.0                              | 916,072.1      | (916,072.1)    | (327,168.6)                                    | 275,476.8    | 3.9   | 4.5                         | 4.5   | 252,071.0    | 5.1                         | 0.5  | 527,547.8    | 190.9                   | 1,563.2  | 529,301.9    |
| 2034  | 0.0                              | 922,171.7      | (922,171.7)    | (329,347.0)                                    | 277,311.0    | 4.0   | 4.5                         | 4.5   | 253,749.4    | 5.2                         | 0.5  | 531,060.4    | 192.2                   | 1,573.6  | 532,826.1    |
| 2035  | 0.0                              | 919,228.8      | (919,228.8)    | (328,296.0)                                    | 276,426.0    | 4.0   | 4.5                         | 4.5   | 252,939.6    | 5.2                         | 0.5  | 529,365.6    | 191.6                   | 1,568.6  | 531,125.8    |
| 2036  | 0.0                              | 919,655.4      | (919,655.4)    | (328,448.4)                                    | 276,554.3    | 4.0   | 4.5                         | 4.5   | 253,057.0    | 5.2                         | 0.5  | 529,611.3    | 191.7                   | 1,569.3  | 531,372.3    |
| 2037  | 0.0                              | 916,084.8      | (916,084.8)    | (327,173.1)                                    | 275,480.6    | 3.9   | 4.5                         | 4.5   | 252,074.5    | 5.1                         | 0.5  | 527,555.1    | 190.9                   | 1,563.2  | 529,309.2    |
| 2038  | 0.0                              | 908,532.9      | (908,532.9)    | (324,476.0)                                    | 273,209.6    | 3.9   | 4.5                         | 4.5   | 249,996.5    | 5.1                         | 0.5  | 523,206.1    | 189.3                   | 1,550.3  | 524,945.7    |
| 2039  | 0.0                              | 923,130.6      | (923,130.6)    | (329,689.5)                                    | 277,599.3    | 4.0   | 4.5                         | 4.5   | 254,913.3    | 5.2                         | 0.6  | 531,612.6    | 192.4                   | 1,575.2  | 533,380.2    |
| 2040  | 0.0                              | 917,481.1      | (917,481.1)    | (327,671.8)                                    | 275,900.4    | 4.0   | 4.5                         | 4.5   | 252,458.7    | 5.2                         | 0.5  | 528,359.2    | 191.2                   | 1,565.6  | 530,115.9    |
| 2041  | 0.0                              | 906,681.8      | (906,681.8)    | (323,814.9)                                    | 272,652.9    | 3.9   | 4.5                         | 4.5   | 249,487.1    | 5.1                         | 0.5  | 522,140.1    | 189.0                   | 1,547.1  | 523,876.2    |
| 2042  | 0.0                              | 918,181.3      | (918,181.3)    | (327,921.9)                                    | 276,111.0    | 4.0   | 4.5                         | 4.5   | 252,651.4    | 5.2                         | 0.5  | 528,762.4    | 191.4                   | 1,566.8  | 530,520.5    |
| 2043  | 0.0                              | 906,193.4      | (906,193.4)    | (323,640.5)                                    | 272,506.1    | 3.9   | 4.4                         | 4.4   | 249,352.7    | 5.1                         | 0.5  | 521,858.8    | 188.9                   | 1,546.3  | 523,594.0    |
| 2044  | 0.0                              | 914,962.1      | (914,962.1)    | (326,772.2)                                    | 275,143.0    | 3.9   | 4.5                         | 4.5   | 251,765.6    | 5.1                         | 0.5  | 526,908.5    | 190.7                   | 1,561.3  | 528,680.5    |
| 2045  | 0.0                              | 916,162.0      | (916,162.0)    | (327,200.7)                                    | 275,503.8    | 3.9   | 4.5                         | 4.5   | 252,095.7    | 5.1                         | 0.5  | 527,599.5    | 190.9                   | 1,563.3  | 529,353.8    |
| 2046  | 0.0                              | 911,786.5      | (911,786.5)    | (325,638.1)                                    | 274,188.0    | 3.9   | 4.5                         | 4.5   | 250,391.8    | 5.1                         | 0.5  | 526,079.8    | 190.0                   | 1,555.9  | 526,825.7    |
| 2047  | 0.0                              | 917,510.3      | (917,510.3)    | (327,682.3)                                    | 275,909.2    | 4.0   | 4.5                         | 4.5   | 252,466.8    | 5.2                         | 0.5  | 528,376.0    | 191.2                   | 1,565.6  | 530,132.8    |
| 2048  | 0.0                              | 908,687.1      | (908,687.1)    | (324,888.3)                                    | 273,556.7    | 3.9   | 4.5                         | 4.5   | 250,314.1    | 5.1                         | 0.5  | 523,870.8    | 189.6                   | 1,552.3  | 525,612.6    |
| 2049  | 0.0                              | 910,107.1      | (910,107.1)    | (325,038.3)                                    | 273,683.0    | 3.9   | 4.5                         | 4.5   | 250,429.7    | 5.1                         | 0.5  | 524,112.6    | 189.7                   | 1,553.0  | 525,855.3    |
| 2050  | 0.0                              | 912,665.9      | (912,665.9)    | (325,952.1)                                    | 274,452.5    | 3.9   | 4.5                         | 4.5   | 251,133.7    | 5.1                         | 0.5  | 525,586.2    | 190.2                   | 1,557.4  | 527,333.8    |
| 2051  | 0.0                              | 917,045.0      | (917,045.0)    | (327,516.1)                                    | 275,769.3    | 3.9   | 4.5                         | 4.5   | 252,338.7    | 5.2                         | 0.5  | 528,108.0    | 191.1                   | 1,564.8  | 529,864.0    |
| 2052  | 0.0                              | 912,285.5      | (912,285.5)    | (325,816.2)                                    | 274,338.1    | 3.9   | 4.5                         | 4.5   | 251,029.1    | 5.1                         | 0.5  | 525,367.1    | 190.1                   | 1,556.7  | 527,113.9    |
| 2053  | 0.0                              | 908,761.9      | (908,761.9)    | (324,557.8)                                    | 273,278.5    | 3.9   | 4.5                         | 4.5   | 250,059.5    | 5.1                         | 0.5  | 523,338.0    | 189.4                   | 1,550.7  | 525,078.0    |
| 2054  | 0.0                              | 916,586.9      | (916,586.9)    | (327,352.5)                                    | 275,631.6    | 3.9   | 4.5                         | 4.5   | 252,212.7    | 5.1                         | 0.5  | 527,844.2    | 191.0                   | 1,564.0  | 529,599.3    |
| 2055  | 0.0                              | 928,281.7      | (928,281.7)    | (331,529.2)                                    | 279,148.4    | 4.0   | 4.6                         | 4.6   | 255,430.7    | 5.2                         | 0.6  | 534,579.0    | 193.5                   | 1,584.0  | 536,356.3    |
| 2056  | 0.0                              | 934,390.9      | (934,390.9)    | (333,711.0)                                    | 280,985.5    | 4.0   | 4.6                         | 4.6   | 257,111.7    | 5.2                         | 0.6  | 538,097.2    | 194.7                   | 1,594.4  | 539,886.3    |
| 2057  | 0.0                              | 932,029.8      | (932,029.8)    | (332,867.8)                                    | 279,162.0    | 4.0   | 4.6                         | 4.6   | 256,462.0    | 5.2                         | 0.6  | 536,737.4    | 194.2                   | 1,590.4  | 538,522.1    |
| 2058  | 0.0                              | 924,062.8      | (924,062.8)    | (330,022.4)                                    | 277,879.7    | 4.0   | 4.5                         | 4.5   | 254,269.8    | 5.2                         | 0.6  | 532,149.4    | 192.6                   | 1,576.8  | 533,918.8    |
| 2059  | 0.0                              | 937,739.0      | (937,739.0)    | (334,906.8)                                    | 281,992.3    | 4.0   | 4.6                         | 4.6   | 258,033.0    | 5.3                         | 0.6  | 540,025.3    | 195.4                   | 1,600.1  | 541,820.8    |
| 2060  | 0.0                              | 953,975.1      | (953,975.1)    | (340,705.4)                                    | 286,874.8    | 4.1   | 4.7                         | 4.7   | 262,800.6    | 5.4                         | 0.6  | 549,375.3    | 198.8                   | 1,627.8  | 551,202.0    |
| 2061  | 0.0                              | 910,312.6      | (910,312.6)    | (325,111.6)                                    | 273,744.8    | 3.9   | 4.5                         | 4.5   | 250,486.2    | 5.1                         | 0.5  | 524,231.0    | 189.7                   | 1,553.3  | 525,974.0    |
| Total | 0.0                              | 38,213,076.2   | (38,213,076.2) | (13,647,627.2)                                 | 11,491,250.4 | 164.6 | 187.6                       | 187.6 | 10,514,902.2 | 214.6                       | 22.8 | 22,006,162.5 | 7,963.7                 | 65,206.0 | 22,079,322.2 |

| Year  | Estimated Power Generation (MWh) |                   |                |                         | Estimated Emissions Assuming 33% RPS Goal is Met |                              |       |                         |       |      |              |         |          |              |
|-------|----------------------------------|-------------------|----------------|-------------------------|--|------------------------------|-------|-------------------------|-------|------|--------------|---------|----------|--------------|
|       | Dam Removal<br>Mean              | No action<br>Mean | delta          | Off-Peak<br>(314,194.1) | On-Peak<br>(565,549.3)                           | Off-Peak Emissions (MT/year) |       | Emissions (MTCO2e/year) |       |      |              |         |          |              |
|       |                                  |                   |                |                         |  | CO2                          | CH4   | CO2                     | CH4   | N2O  | Total        |         |          |              |
| 2020  | 0.0                              | 879,743.4         | (879,743.4)    | (314,194.1)             | (565,549.3)                                      | 192,592.7                    | 2.8   | 242,074.6               | 4.9   | 0.5  | 434,667.3    | 161.7   | 1,137.1  | 435,966.1    |
| 2021  | 0.0                              | 877,634.0         | (877,634.0)    | (313,440.7)             | (564,193.3)                                      | 192,130.9                    | 2.8   | 241,494.2               | 4.9   | 0.5  | 433,625.1    | 161.3   | 1,134.4  | 434,920.8    |
| 2022  | 0.0                              | 882,566.0         | (882,566.0)    | (315,202.1)             | (567,363.8)                                      | 193,210.6                    | 2.8   | 242,861.3               | 5.0   | 0.5  | 436,061.9    | 162.2   | 1,140.7  | 437,364.8    |
| 2023  | 0.0                              | 880,121.6         | (880,121.6)    | (314,329.1)             | (565,792.4)                                      | 192,875.5                    | 2.8   | 242,178.7               | 4.9   | 0.5  | 434,854.1    | 161.4   | 1,137.6  | 436,153.5    |
| 2024  | 0.0                              | 878,172.3         | (878,172.3)    | (313,633.0)             | (564,539.3)                                      | 192,248.7                    | 2.8   | 241,642.3               | 4.9   | 0.5  | 433,891.0    | 161.4   | 1,135.1  | 435,187.5    |
| 2025  | 0.0                              | 876,212.1         | (876,212.1)    | (312,932.9)             | (563,279.2)                                      | 191,819.6                    | 2.7   | 241,102.9               | 4.9   | 0.5  | 432,922.5    | 161.0   | 1,132.5  | 434,216.1    |
| 2026  | 0.0                              | 876,190.4         | (876,190.4)    | (312,925.1)             | (563,265.3)                                      | 191,814.9                    | 2.7   | 241,097.0               | 4.9   | 0.5  | 432,911.8    | 161.0   | 1,132.5  | 434,205.4    |
| 2027  | 0.0                              | 880,525.9         | (880,525.9)    | (314,473.5)             | (566,052.4)                                      | 192,764.0                    | 2.8   | 242,289.9               | 4.9   | 0.5  | 435,053.9    | 161.8   | 1,138.1  | 436,353.9    |
| 2028  | 0.0                              | 883,160.0         | (883,160.0)    | (315,414.3)             | (567,745.7)                                      | 193,340.6                    | 2.8   | 243,014.7               | 5.0   | 0.5  | 436,355.4    | 162.3   | 1,141.5  | 437,659.2    |
| 2029  | 0.0                              | 914,045.5         | (914,045.5)    | (326,444.8)             | (587,600.7)                                      | 200,102.1                    | 2.9   | 251,513.3               | 5.1   | 0.5  | 451,615.4    | 168.0   | 1,181.4  | 452,964.8    |
| 2030  | 0.0                              | 909,936.6         | (909,936.6)    | (324,977.4)             | (584,959.3)                                      | 199,202.6                    | 2.9   | 250,382.7               | 5.1   | 0.5  | 449,585.3    | 167.2   | 1,176.1  | 450,928.7    |
| 2031  | 0.0                              | 915,391.4         | (915,391.4)    | (326,925.5)             | (588,465.9)                                      | 200,396.7                    | 2.9   | 251,883.7               | 5.1   | 0.5  | 452,280.4    | 168.2   | 1,183.2  | 453,631.8    |
| 2032  | 0.0                              | 917,610.7         | (917,610.7)    | (327,718.1)             | (589,892.6)                                      | 200,882.6                    | 2.9   | 252,494.4               | 5.2   | 0.5  | 453,376.9    | 168.7   | 1,186.0  | 454,731.6    |
| 2033  | 0.0                              | 916,072.1         | (916,072.1)    | (327,168.6)             | (588,903.5)                                      | 200,545.7                    | 2.9   | 252,071.0               | 5.1   | 0.5  | 452,616.8    | 168.4   | 1,184.0  | 453,969.2    |
| 2034  | 0.0                              | 922,171.7         | (922,171.7)    | (329,347.0)             | (592,824.6)                                      | 201,881.0                    | 2.9   | 253,749.4               | 5.2   | 0.5  | 455,630.4    | 169.5   | 1,191.9  | 456,991.8    |
| 2035  | 0.0                              | 919,228.8         | (919,228.8)    | (328,296.0)             | (590,932.8)                                      | 201,236.8                    | 2.9   | 252,939.6               | 5.2   | 0.5  | 454,176.4    | 169.0   | 1,188.7  | 455,533.5    |
| 2036  | 0.0                              | 919,655.4         | (919,655.4)    | (328,448.4)             | (591,207.1)                                      | 201,330.2                    | 2.9   | 253,057.0               | 5.2   | 0.5  | 454,387.2    | 169.0   | 1,188.7  | 455,744.9    |
| 2037  | 0.0                              | 916,084.8         | (916,084.8)    | (327,173.1)             | (588,911.6)                                      | 200,548.5                    | 2.9   | 252,074.5               | 5.1   | 0.5  | 452,623.0    | 168.4   | 1,184.1  | 453,975.4    |
| 2038  | 0.0                              | 908,532.9         | (908,532.9)    | (324,476.0)             | (584,056.9)                                      | 198,995.3                    | 2.8   | 249,996.5               | 5.1   | 0.5  | 448,891.7    | 167.0   | 1,174.3  | 450,233.0    |
| 2039  | 0.0                              | 923,130.6         | (923,130.6)    | (329,689.5)             | (593,441.1)                                      | 202,091.0                    | 2.9   | 254,013.3               | 5.2   | 0.6  | 456,104.2    | 169.7   | 1,193.2  | 457,467.1    |
| 2040  | 0.0                              | 917,481.1         | (917,481.1)    | (327,671.8)             | (589,809.3)                                      | 200,854.2                    | 2.9   | 252,458.7               | 5.2   | 0.5  | 453,312.9    | 168.6   | 1,185.9  | 454,667.4    |
| 2041  | 0.0                              | 906,681.8         | (906,681.8)    | (323,814.9)             | (582,866.9)                                      | 198,490.0                    | 2.8   | 249,487.1               | 5.1   | 0.5  | 447,977.1    | 166.6   | 1,171.3  | 449,315.7    |
| 2042  | 0.0                              | 918,181.3         | (918,181.3)    | (327,921.9)             | (590,259.4)                                      | 201,007.5                    | 2.9   | 252,651.4               | 5.2   | 0.5  | 453,658.9    | 168.8   | 1,186.8  | 455,014.4    |
| 2043  | 0.0                              | 906,193.4         | (906,193.4)    | (323,640.5)             | (582,552.9)                                      | 198,383.1                    | 2.8   | 249,352.7               | 5.1   | 0.5  | 447,358.8    | 166.6   | 1,171.3  | 449,073.7    |
| 2044  | 0.0                              | 914,962.1         | (914,962.1)    | (326,772.2)             | (588,189.9)                                      | 200,302.7                    | 2.9   | 251,765.6               | 5.1   | 0.5  | 452,068.3    | 168.2   | 1,182.6  | 453,419.1    |
| 2045  | 0.0                              | 916,162.0         | (916,162.0)    | (327,200.7)             | (588,961.3)                                      | 200,565.4                    | 2.9   | 252,095.7               | 5.1   | 0.5  | 452,661.2    | 168.4   | 1,184.2  | 454,013.7    |
| 2046  | 0.0                              | 911,786.5         | (911,786.5)    | (325,638.1)             | (586,148.5)                                      | 199,607.5                    | 2.9   | 250,891.8               | 5.1   | 0.5  | 450,499.3    | 167.6   | 1,178.5  | 451,845.4    |
| 2047  | 0.0                              | 917,510.3         | (917,510.3)    | (327,682.3)             | (589,828.1)                                      | 200,860.6                    | 2.9   | 252,466.8               | 5.2   | 0.5  | 453,327.3    | 168.6   | 1,185.9  | 454,681.9    |
| 2048  | 0.0                              | 909,687.1         | (909,687.1)    | (324,888.3)             | (584,798.9)                                      | 199,147.9                    | 2.9   | 250,314.1               | 5.1   | 0.5  | 449,462.0    | 167.2   | 1,175.8  | 450,805.0    |
| 2049  | 0.0                              | 910,107.1         | (910,107.1)    | (325,038.3)             | (585,068.9)                                      | 199,239.9                    | 2.9   | 250,429.7               | 5.1   | 0.5  | 449,669.5    | 167.3   | 1,176.3  | 451,013.2    |
| 2050  | 0.0                              | 912,665.9         | (912,665.9)    | (325,952.1)             | (586,713.8)                                      | 199,800.1                    | 2.9   | 251,133.7               | 5.1   | 0.5  | 450,933.8    | 167.7   | 1,179.6  | 452,281.2    |
| 2051  | 0.0                              | 917,045.0         | (917,045.0)    | (327,516.1)             | (589,528.9)                                      | 200,758.7                    | 2.9   | 252,338.7               | 5.2   | 0.5  | 453,097.4    | 168.6   | 1,185.3  | 454,451.3    |
| 2052  | 0.0                              | 912,285.5         | (912,285.5)    | (325,816.2)             | (586,469.2)                                      | 199,716.8                    | 2.9   | 251,029.7               | 5.1   | 0.5  | 450,745.8    | 167.7   | 1,179.1  | 452,092.7    |
| 2053  | 0.0                              | 908,761.9         | (908,761.9)    | (324,557.8)             | (584,204.1)                                      | 198,945.4                    | 2.8   | 250,059.5               | 5.1   | 0.5  | 449,004.9    | 167.0   | 1,174.6  | 450,346.5    |
| 2054  | 0.0                              | 916,586.9         | (916,586.9)    | (327,352.5)             | (589,234.4)                                      | 200,658.4                    | 2.9   | 252,212.7               | 5.1   | 0.5  | 452,871.1    | 168.5   | 1,184.7  | 454,224.3    |
| 2055  | 0.0                              | 928,281.7         | (928,281.7)    | (331,529.2)             | (596,752.5)                                      | 203,218.6                    | 2.9   | 255,430.7               | 5.2   | 0.6  | 458,649.3    | 170.6   | 1,199.8  | 460,019.7    |
| 2056  | 0.0                              | 934,390.9         | (934,390.9)    | (333,711.0)             | (600,679.9)                                      | 204,556.1                    | 2.9   | 257,111.7               | 5.2   | 0.6  | 461,667.8    | 171.7   | 1,207.7  | 463,047.2    |
| 2057  | 0.0                              | 932,029.8         | (932,029.8)    | (332,867.8)             | (599,162.0)                                      | 204,039.2                    | 2.9   | 256,462.0               | 5.2   | 0.6  | 460,501.2    | 171.3   | 1,204.7  | 461,877.1    |
| 2058  | 0.0                              | 924,062.8         | (924,062.8)    | (330,906.8)             | (594,040.4)                                      | 202,295.0                    | 2.9   | 254,269.8               | 5.2   | 0.6  | 456,564.8    | 169.8   | 1,194.4  | 457,929.0    |
| 2059  | 0.0                              | 937,739.0         | (937,739.0)    | (334,906.8)             | (602,832.2)                                      | 205,289.0                    | 2.9   | 258,033.0               | 5.3   | 0.6  | 463,322.0    | 172.4   | 1,212.0  | 464,706.4    |
| 2060  | 0.0                              | 953,975.1         | (953,975.1)    | (340,705.4)             | (613,269.7)                                      | 208,843.4                    | 3.0   | 262,500.6               | 5.4   | 0.6  | 471,344.0    | 175.3   | 1,233.0  | 472,752.4    |
| 2061  | 0.0                              | 910,312.6         | (910,312.6)    | (325,111.6)             | (585,201.0)                                      | 199,284.9                    | 2.9   | 250,486.2               | 5.1   | 0.5  | 449,771.1    | 167.3   | 1,176.6  | 451,115.0    |
| Total | 0.0                              | 38,213,076.2      | (38,213,076.2) | (13,647,527.2)          | (24,565,549.0)                                   | 8,365,574.3                  | 119.8 | 10,514,902.2            | 214.6 | 22.8 | 18,890,476.5 | 7,023.6 | 49,391.2 | 18,936,891.3 |

**Electricity Emissions Profile - Base Load (Of+Peak)**

**PacifiCorp Power Control Area**

Capacity (MW): 12,171.2  
 Net Generation (MWh): 67,961,659.9  
 Heat Input (MMBtu): 646,819,058.7

Natural Gas Capacity (MW): 437,528.6  
 Net Generation (MWh): 864,494,854.6  
 Heat Input (MMBtu): 7,049,211,251.1

**Annual Emissions**

| Pollutant | Emissions    | Units |
|-----------|--------------|-------|
| CO2       | 62,507,461.8 | tons  |
| CH4       | 1,790,449.1  | lbs   |
| N2O       | 2,040,423.8  | lbs   |

**Output Emission Rates - No Action Alternative**

| Pollutant | Emission Rate | Units  |
|-----------|---------------|--------|
| CO2       | 1,839.49      | lb/MWh |
| CH4       | 26.34         | lb/GWh |
| N2O       | 30.02         | lb/GWh |

**Annual Emissions**

| Pollutant | Emissions     | Units |
|-----------|---------------|-------|
| CO2       | 422,030,953.7 | tons  |
| CH4       | 17,230,682.8  | lbs   |
| N2O       | 1,829,313.3   | lbs   |

**Output Emission Rates**

| Pollutant | Emission Rate | Units  |
|-----------|---------------|--------|
| CO2       | 943.64        | lb/MWh |
| CH4       | 19.26         | lb/GWh |
| N2O       | 2.05          | lb/GWh |

**Output Emission Rates - 33% RPS**

| Pollutant | Emission Rate | Units  |
|-----------|---------------|--------|
| CO2       | 1,351.35      | lb/MWh |
| CH4       | 19.35         | lb/GWh |
| N2O       | 22.06         | lb/GWh |

**Generation Capacity (MW)**

|               |                  |              |
|---------------|------------------|--------------|
| Iron Gate     | 119,206.0        | 18.0         |
| Coppco 1      | 95,316.0         | 20.0         |
| Coppco 2      | 119,854.0        | 27.0         |
| John C. Boyle | 279,767.0        | 98.7         |
| <b>Total</b>  | <b>614,143.0</b> | <b>163.7</b> |

0.90%

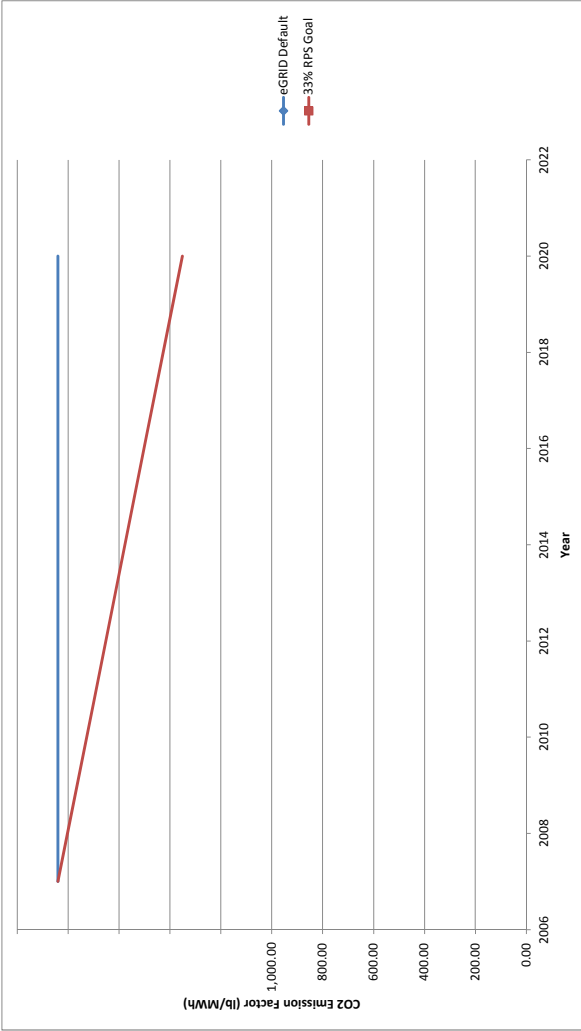
**Emission Factors Assuming Linear Change in RPS**

| Year | RPS   | CO2 lb/MWh | CH4 lb/GWh | N2O lb/GWh |
|------|-------|------------|------------|------------|
| 2007 | 8.6%  | 1,839.49   | 26.34      | 30.02      |
| 2008 | 10.7% | 1,801.94   | 25.81      | 29.41      |
| 2009 | 12.5% | 1,764.39   | 25.27      | 28.80      |
| 2010 | 14.4% | 1,726.84   | 24.73      | 28.18      |
| 2011 | 16.2% | 1,689.30   | 24.19      | 27.57      |
| 2012 | 18.1% | 1,651.75   | 23.66      | 26.96      |
| 2013 | 20.0% | 1,614.20   | 23.12      | 26.35      |
| 2014 | 21.8% | 1,576.65   | 22.58      | 25.73      |
| 2015 | 23.7% | 1,539.10   | 22.04      | 25.12      |
| 2016 | 25.6% | 1,501.55   | 21.51      | 24.51      |
| 2017 | 27.4% | 1,464.00   | 20.97      | 23.89      |
| 2018 | 29.3% | 1,426.45   | 20.43      | 23.28      |
| 2019 | 31.1% | 1,388.90   | 19.89      | 22.67      |
| 2020 | 33%   | 1,351.35   | 19.35      | 22.06      |

Delta Years 24% 13

**Adjusted Emissions - Iron Gate, Coppco 1, Coppco 2, and Iron Gate Removed**

|                                      |                 |
|--------------------------------------|-----------------|
| Net Generation (MWh):                | 67,347,516.9    |
| <b>Pollutant Emission Rate Units</b> |                 |
| CO2                                  | 1,656.27 lb/MWh |
| CH4                                  | 26.59 lb/GWh    |
| N2O                                  | 30.30 lb/GWh    |

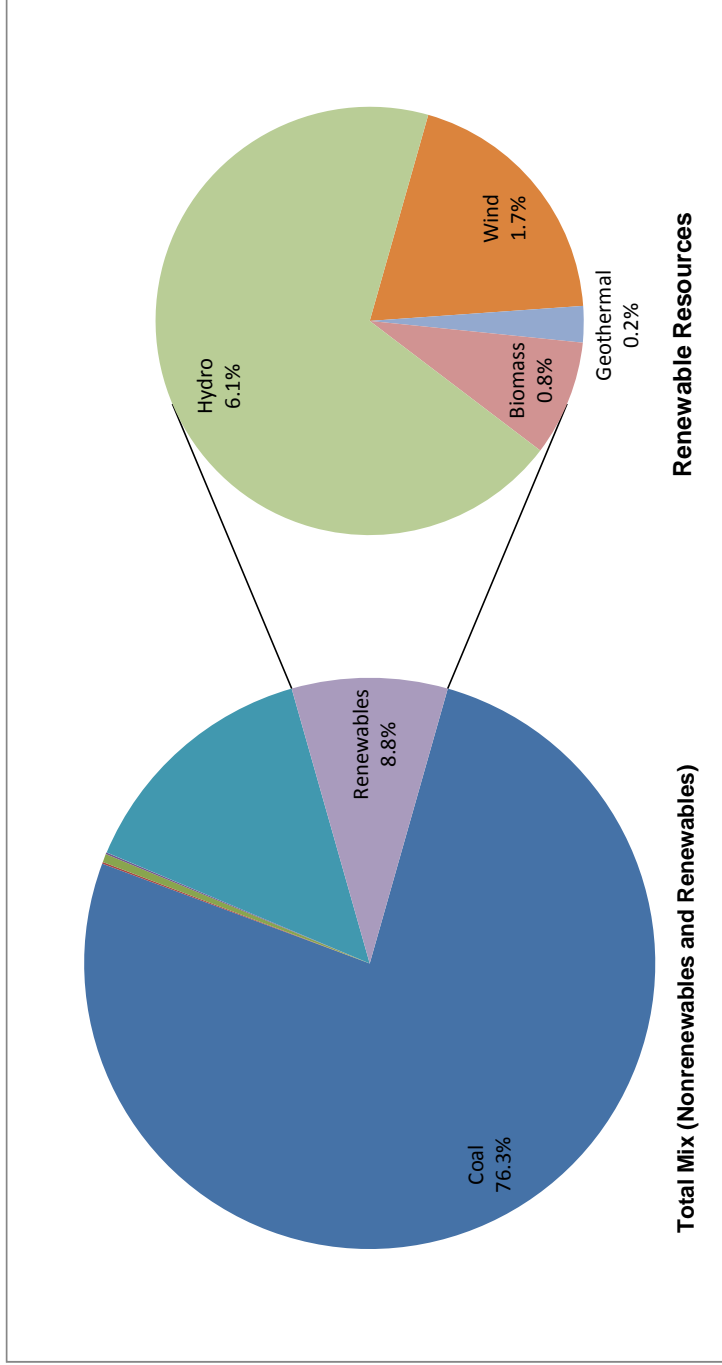


## Generation Resource Mix for Electricity Emissions

### PacifiCorp Power Control Area

| Nonrenewable Resources         | Fuel Mix %    | MWh                 |
|--------------------------------|---------------|---------------------|
| Coal                           | 76.3%         | 51,841,990.6        |
| Oil                            | 0.1%          | 65,065.4            |
| Gas                            | 14.3%         | 9,689,122.8         |
| Other Fossil                   | 0.5%          | 317,120.2           |
| Nuclear                        | 0.0%          | 0.0                 |
| Other Unknown / Purchased Fuel | 0.1%          | 69,033.7            |
| <b>Nonrenewable Total</b>      | <b>91.2%</b>  | <b>61,982,332.8</b> |
| <b>Grand Total</b>             | <b>100.0%</b> | <b>67,961,659.9</b> |

| Renewable Resources             | Fuel Mix %  | MWh                |
|---------------------------------|-------------|--------------------|
| Wind                            | 1.7%        | 1,164,651.0        |
| Solar                           | 0.0%        | 0.0                |
| Geothermal                      | 0.2%        | 163,925.0          |
| Biomass                         | 0.8%        | 521,601.6          |
| Hydro                           | 6.1%        | 4,129,149.6        |
| <b>Renewable Total</b>          | <b>8.8%</b> | <b>5,979,327.2</b> |
| <b>Nonhydro Renewable Total</b> | <b>2.7%</b> | <b>1,850,177.6</b> |



Source: eGRID

<http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html>