Appendix 5

ENERGY ANALYSIS REPORT
FOR INITIATIVE 937
Chehalis, WA

Energy Analysis Report

Plant-wide Energy Conservation Measures

Initiative 937

Located At:

Chehalis Generation Facility – Chehalis, WA

1813 Bishop Rd

Chehalis, WA 98532

Presented To:

PACIFIC POWER

Submitted By:

CascadeEnergy

Cascade Project Number: 3535.011

Revision Number: 3

September 28, 2021

Disclaimer

The intent of this energy analysis report is to estimate energy savings associated with recommended upgrades. Appropriate detail is included in Sections 2-4 of this report. However, this report is not intended to serve as a detailed engineering design document. It should be noted that detailed design efforts may be required in order to implement several of the improvements evaluated as part of this energy analysis. As appropriate, costs for those design efforts are included as part of the cost estimate for each measure.

While the Energy Conservation Measures in this report have been reviewed for technical accuracy and are believed to be reasonably accurate, the findings are estimates and actual results may vary. As a result, Cascade Energy Inc. is not liable if projected estimated savings or economics are not actually achieved. All savings and cost estimates in the report are for informational purposes, and are not to be construed as a design document or as guarantees. At this time, project cost estimates have not been provided by PacifiCorp, so budgetary cost estimates have been used for the economic analysis.

PacifiCorp shall independently evaluate any advice or direction provided in this report. In no event will Cascade Energy Inc. be liable for the failure of the customer to achieve a specified amount of energy savings, the operation of customer's facilities, or any incidental or consequential damages of any kind in connection with this report or the installation of recommended measures.

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Report Revision Tracker

Aug 2021	Removed *ECM 3 – Install High Efficiency Lighting System* and *ECM 5 - Reverse Osmosis Pump VFDs* from the report, as these were completed.
	Removed *ECM 6 – Reduce LP Economizer Recirculation Pump Use* as these pumps are no longer operated, they stopped running prior to 2017.
	Increased project costs by 14% to account for inflation from 2013 to 2021.
	Updated energy savings for ECM 1 and 2 by updating annual generation data, which effected system cooling loads.
	Removed Section 7 Additional Systems/Equipment Reviewed as Part of this Plant Analysis
	Removed Section 8 Quality Assurance Comments

1 Executive Summary

1.1 Background

PacifiCorp Energy operates the Chehalis Generation Facility which provides electricity to the State of Washington. The State of Washington passed legislation requiring PacifiCorp to complete all cost-effective energy efficiency measures at this facility.

The purpose of this report is to outline the systems investigated and detail the cost of the measures at this facility. This information should be used by PacifiCorp as a starting point. Additional reliability and engineering studies may be needed on the outlined measures to identify further project lifecycle costs and impacts on facility availability.

1.2 Energy Conservation Measures (ECMs)

Multiple individual energy conservation improvements have been considered for the site. These improvements are packaged into measures, each of which is an incremental improvement to the system. Below is a brief description of each measure. More detailed descriptions can be found in Section 2.

ECM 1: Closed Cooling Water (CCW) Pump Variable Speed Drive
Baseline: Two fixed speed 550 HP centrifugal pumps serve the closed cooling water system, with one pump operating at a time. The system is a closed loop with a flow requirement of 8,400 gpm. The pumps are delivering 9,650 gpm. A pump was operating for 76% of the time during the baseline year. Based on the forecasted plant runtimes, part-load operation of this system will decrease significantly.

Proposed: This measure would upgrade each 550 HP centrifugal pumps with a variable speed drive. During the March 21, 2013 conference call, the plant indicated that VFDs would need to be installed on both pumps to enable pump operation to be rotated.

This measure would add the following equipment:

- Two 6,600V 550 HP VFD, one for each of the two centrifugal CCW pumps
- VFD controls to operate pump speed based on unit operation

ECM 2: Closed Cooling Water (CCW) Fan VFDs and Temperature Reset
Baseline: The CCW fans currently cycle on and off to maintain the desired leaving water temperature. The target temperature floats based on the outdoor ambient temperature, with a minimum set-point of 73°F and a maximum of 98°F.

Proposed: By installing VFDs to the fans, the temperature would be controlled using fan speed modulation rather than cycling. Additional energy savings would be realized by raising the minimum temperature set-point for the closed cooling water system.

In an email dated April 29, 2013, the PacifiCorp personnel indicated that increasing the cooling water temperature would reduce the total available output of the generator. Thus, recommended reducing the set-point of the leaving water temperature based on percent load as follows:

a) 90 °F for cooling loads less than 40%
b) 80 °F for loads between 40% and 60 %
c) Max cooling for all other loads.

This set-point recommendation will result in controlling fans to a lower leaving cooling water temperature than the current operation. Currently, the last stage of cooling fans is not enabled until the leaving cooling tower water temperature reaches 98°F. This will require additional fan energy use to operate at these lower set-points and the plant should consider increasing these temperature set-points to more closely reflect current operations.

Energy savings for this ECM were estimated based on the set-point recommendations provided by the PacifiCorp personnel. The set-point of the leaving cooling water temperature was modeled as follows:

a) 90 °F for no turbine operation
b) 80 °F for one turbine operation
c) 73 °F for two turbine operation

This measure would add the following equipment:

- VFDs on each of the 40 hp CCW fans along with appropriate controls to control fan speed to leaving water temperature.

ECM 4: Smaller Condensate Pump for Auxiliary Use

Baseline: System pressure is maintained with the auxiliary boiler when the plant is taken off line for short durations between startups. The condensate flow required for the auxiliary boiler and the gland steam system is much less than during normal operation. However, the only pumps available to provide condensate flow for the Auxiliary Boiler and Gland Steam are the 450 HP constant-speed condensate pumps.

Proposed: This measure would install a smaller pump (approximately 50 HP) to pump condensate to the auxiliary boiler and gland seals during operator determined offline periods. Note that further engineering calculations will be required to properly select this condensate pump. Pump selection in this report was done solely to quantify energy savings and should not be considered a design selection.

This measure would add the following equipment:

- Install a small, high efficiency pump. Include the following energy efficient features with the pump:
    - Select pump for pressure and flow requirements, minimize or eliminate pump throttling and bypass flow
    - Premium efficient motor

1.3 ECM Cost and Savings

Table 1 below shows the costs and savings of electrical efficiency for Chehalis Generation Facility.

Table 1: ECM Economics for Chehalis Generation Facility

ECM			Ann. Benefits	Initial Investments				Ann. Investment	Net
		Measure	Annual Energy	Installed	EM&V	Engineering	Spare Parts	O & M	Present
		Life	Savings	Costs	Costs	Fees	Costs	Costs	Cost
No.	Description	(yrs)	(MWh/yr)	($)	($)	($)	($)	($/yr)	($)
2	CCW Fan VFDs and Temp. Reset	10	750	$209,391	$11,400	$23,871	$7,161	$7,161	($301,727)
4	Install Small Condensate Pump	10	108	$76,779	$4,376	$19,950	$2,626	$2,626	($122,030)
1	CCW Pump Variable Speed Drive	10	936	$762,946	$10,260	$86,976	$26,093	$26,093	($1,068,108)

NOTES:

1. All vendor quotes are high-level estimates and are not based on as-built drawings or a site visit.
2. Estimates for engineering fees were based on 10% of installed cost.
3. Estimates for spare parts were based on 3% of installed cost.
4. 2013 costs were increased by 14% to account for inflation to 2021 values.

2 Plant Auxiliary Baseline Energy Use

2.1 Plant Description

The Chehalis Generation Facility began commercial operation in June 2003. Power is generated by two GE model 7FAe+ combustion turbines operated in combined cycle mode with a single steam turbine. The facility has a nominal generating capacity of 520 MW. Power is generated at 18 kV and transformed up to a distribution voltage of 525 kV. An air-cooled condenser system is used in lieu of a wet cooling tower system to minimize water consumption. A 16.9 MMBtu/hr auxiliary boiler was commissioned in 2010 to provide steam to the facility to reduce the duration of startup events. During periods of lighter loading the plant operates just one combustion turbine in conjunction with the steam turbine.

Auxiliary systems at the plant include a compressed air system served by a single 125 HP compressor, boiler feed-water treatment using high pressure pumps in a reverse osmosis demineralization process, and several wastewater pumps. The main turbine building is not cooled, but has 26 twenty kilowatt space heaters for heating when necessary. A carbon dioxide fire suppression system is connected to several chilled liquid CO2 storage vessels throughout the turbine building. Lighting at the plant consists mostly of LEDs throughout the turbine building and exterior, with linear fluorescents within the office building.

2.2 Plant Baseline Description

The baseline energy use per sub-system for the Chehalis generation facility is outlined in the table and show in the figure below.

Table 2: Baseline Energy Use per Sub-system for Chehalis Generation Facility

Subsytem	*Energy Use (MWh/yr.)*	*% of Total*
Gland Seal Blowers	25	0.2%
Fuel Gas Heaters	62	0.4%
Electric Heat	76	1%
Reverse Osmosis	175	1%
Emissions Control	200	1%
Lighting	437	3%
HVAC	456	3%
Vacuum Pumps	486	3%
Compressed Air	631	4%
Other Pumps and Fans	767	5%
Transformers	771	5%
Condensate System	1,254	8%
Air Cooled Condenser	2,181	15%
Closed Cooling Water	3,201	21%
Boiler Feed Water	4,180	28%
Total:	**16,108**	**100%**

The energy use per sub-system for the Chehalis Generation Facility is shown in Figure 1.

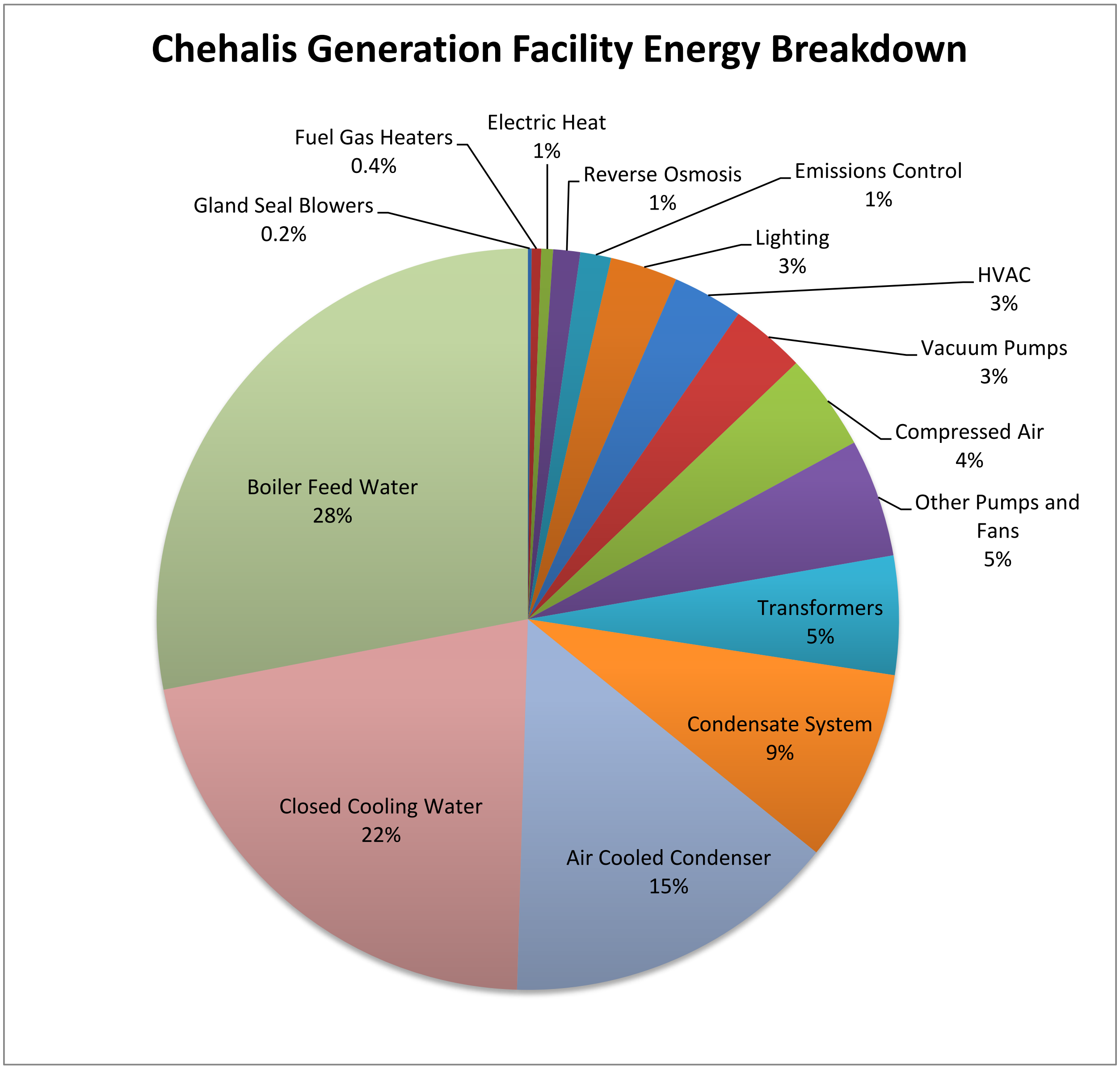

Figure 1: Energy Breakout per Sub-system for Chehalis Generation Facility

2.3 Impact of Energy Savings Based on Forecasted Plant Runtime

The Randy Eddy Grid Model 2013 forecasted a significant increase in plant runtime over the following ten years as compared to historical runtimes. The 2013 energy study utilized 2018 forecasted plant runtimes to update energy saving estimates. Table 3 outlines the 10 year forecast provided by PacifiCorp personnel.

Table 3: Percent Online Hours from Randy Eddy Grid Model 2013

	Percent online hours												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Online%
2013			0	0	0	0	63	100	79	100	100	54	**41**
2014	56	77	0	100	87	94	95	62	0	0	0	79	**54**
2015	56	83	81	100	100	95	95	81	0	0	0	83	**64**
2016	55	86	85	100	87	95	94	95	0	0	0	56	**63**
2017	73	86	100	100	87	95	94	95	0	0	0	77	**67**
2018	81	87	100	100	87	95	94	84	0	0	0	76	**67**
2019	85	87	100	100	23	94	95	59	8	0	52	99	**67**
2020	89	89	72	100	95	70	90	71	96	0	99	100	**81**
2021	85	83	0	100	82	70	89	94	96	83	100	100	**82**
2022	58	54	0	84	82	66	65	56	95	0	95	100	**63**
Avg	71	81	54	88	73	77	87	80	37	18	45	82	**65**

One year of hourly plant net generation trend data from 6/1/2020 – 5/31/2021 was collected, and is shown in the figures below.

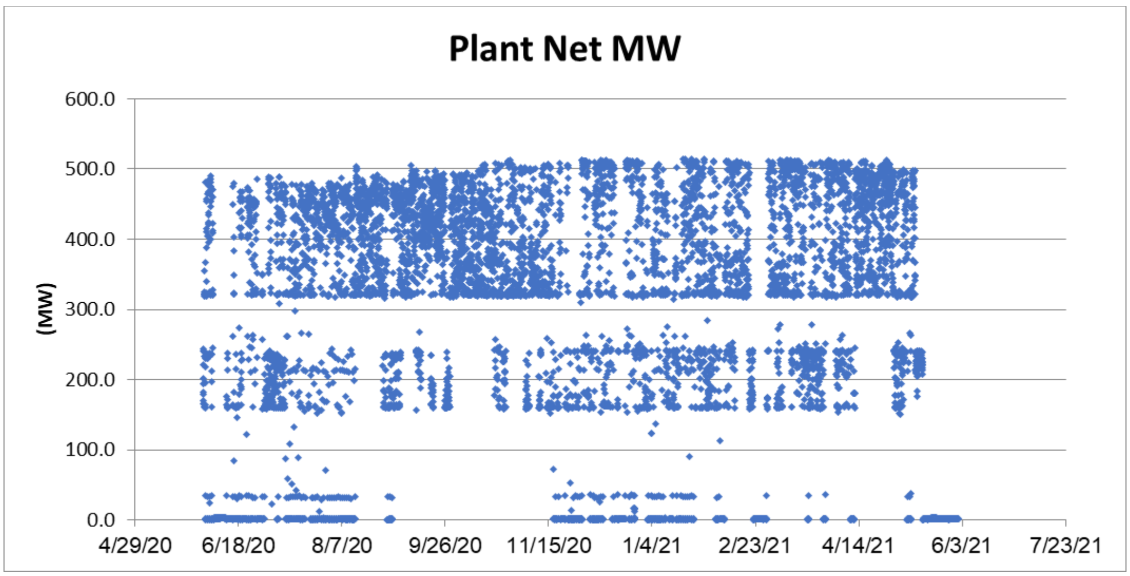

Figure 2: Plant Net Generation Data

This data was converted to plant runtime, and is compared to the predicted 2018 data (from the 2013 study) by month in the following figure:

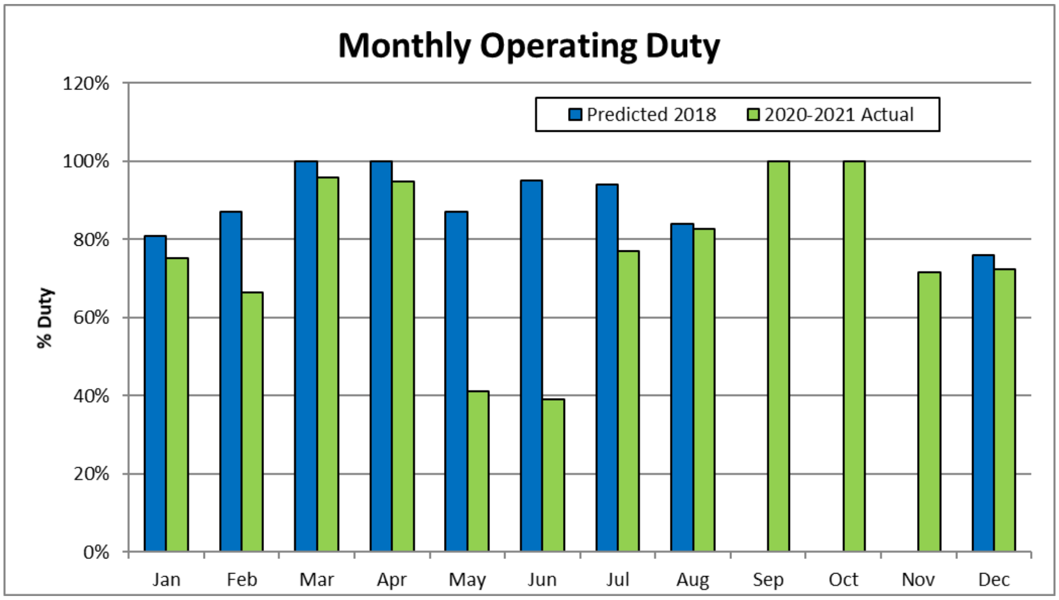

Figure 3: Monthly Operation Comparison

Runtime increased from 67% online in 2018 (predicted) to 76% in 2020-2021.

Energy savings from the original report have been revised with the following results:

ECM 1: Closed Cooling Water (CCW) Pump Variable Speed Drive

Annual energy savings increased with the updated annual generation data.

ECM 2: Closed Cooling Water (CCW) Fan VFDs and Temperature Reset

Annual energy savings increased with the updated annual generation data.

ECM 4: Smaller Condensate Pump for Auxiliary Use

Plant runtime increased by 14%, compared to the 2013 report, reducing the run hours and savings for this measure. Since this measure had low savings in the 2013 report, the savings were left as-is, since it still has low savings relative to costs.

3 Detailed Description of Proposed Equipment and Operation

3.1 ECM 1: Closed Cooling Water (CCW) Pump Variable Speed Drive

3.1.1 Source of Energy Savings

This measure would save energy by reducing the flow rate of the system.

- Since the pump operates in a closed loop, there is no minimum head requirement for the pump to deliver and the pump follows a cubic relationship between speed and power.
- The pump can be slowed at all operating conditions, realizing energy savings whenever the pump is operating.

3.1.2 Specific Equipment Recommendations

- Install a VFD on each of the two 550 HP, 6,600V CCW pump motors.
- Wire each VFD to the central plant control system.

3.1.3 Set-points Recommended to Achieve Energy Performance

Set each pump to operate at two speeds, one for when the plant is generating, and one for when the plant is idling.

- Set the generating speed to 90% (54 Hz) or lower. The plant design flow requirement will be delivered at 87% speed.
- Set the idling speed to 60% (36 Hz) or lower.
    - Check temperatures at the lube oil heat exchangers to determine if the minimum speed can be reduced beyond 60%. Energy savings are maximized by implementing the lowest speeds possible.
- Only operate one pump at a time.

3.2 ECM 2: Closed Cooling Water (CCW) Fan VFDs and Temperature Reset

3.2.1 Source of Energy Savings

- Fan speed control is more energy efficient than fan cycling on/off control.
- Controlling multiple fans together at the same speed is more efficient than cascading fan speeds.
- Increasing the target water temperature will reduce fan power during normal operation.

3.2.2 Specific Equipment Recommendations

- Install fourteen 40 HP VFDs on each of the CCW fans.
- Wire the VFDs to the central plant control system.

3.2.3 Set-points Recommended to Achieve Energy Performance

- Set the minimum fan speed to 20% (12 Hz) and the maximum speed to 100% (60 Hz).
- Control all fans to the same speed. Only cycle fans off once all fans have reached minimum speed.
- Reset leaving cooling water temperature as recommend by the Project Manager.
    - 90 °F for no turbine operation
    - 80 °F for one turbine operation
    - 73 °F for one turbine operation

3.3 ECM 4: Install Small Condensate Pump for Auxiliary Use

3.3.1 Source of Energy Savings

This measure would save energy by reducing the flow rate of the system while only the auxiliary boiler is in use.

- A properly sized pump will eliminate the recirculation and throttling currently required.
- Installing a high efficiency pump will improve the power draw at the required pressure and flow rate.

3.3.2 Specific Equipment Recommendations

Install a small, high efficiency pump. Include the following energy efficient features with the pump:

- Install smaller condensate pump for pressure and flow requirements, minimize or eliminate pump throttling.
- Select pump with a pump efficiency minimum of 60% at design conditions.
- Install premium efficient motor.

3.3.3 Set-points Recommended to Achieve Energy Performance

- Supply condensate to Auxiliary Boiler and Gland Seal System with smaller condensate pump.
- 450 HP Condensate Pumps shall remain off when the smaller condensate pump is operating.

4 Energy Conservation Measure Costs

The tables below provide an itemized cost breakout for each ECM. A contingency of 10% was included if the analysis believes that the project cost maybe higher than the bid obtained. If not, a contingency provision was not provided. Costs for ECM-4 were based on information provided for the Hermiston Generation Facility.

Table 4: Project Costs for ECM 1

ECM 1: CCW Pump Variable Speed Drive					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	550-hp 6,600V Pump VFD	Christenson Elec.	2	$327,942	$655,884
2	Control Wiring	Christenson Elec.	2	$2,683	$5,367
3	Programming	Estimate	2	$4,000	$8,000
Sub-Total					$669,251
2013 - 2021 Inflation				14%	$93,695
Total Cost:					**$762,946**

Table 5: Project Costs for ECM 2

ECM 2: CCW Fan VFDs and Temp. Reset					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	40-hp CCW Fan VFDs	Christenson Elec.	1	$149,892	$149,892
2	Control Wiring	Christenson Elec.	7	$2,683	$18,784
3	Installation of Temperature Sensors	General Mechanical	3	$3,667	$11,000
4	Programming	Estimate	1	$4,000	$4,000
Sub-Total					$183,676
2013 - 2021 Inflation				14%	$25,715
Total Cost:					**$209,391**

Table 6: Project Costs for ECM 4

ECM 4: Install Small Condensate Pump					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Install Small Condensate Pump	Estimate	1	$40,000	$40,000
2	Pump and Motor	Estimate	1	$17,350	$17,350
3	Electrical and Controls	Estimate	1	$10,000	$10,000
Sub-Total					$67,350
2013 - 2021 Inflation				14%	$9,429
Total Cost:					**$76,779**

5 Baseline and Analysis Overview

5.1 ECMs 1 & 2: Closed Cooling Water System

5.1.1 ECMs 1 & 2 - Baseline Description

The closed cooling water system supplies cooling water to the two combustion turbine generators, the steam turbine generator, the heat recovery steam generators (HRSGs), and the sample analysis coolers. A single air-cooled loop of water is used to deliver the required cooling. The water recirculates via one of two 550 HP centrifugal pumps and is cooled by fourteen 40 HP axial fans. One pump runs continuously whenever there is a need for cooling anywhere in the plant or whenever the ambient temperature is below 40°F for freeze protection. The fans cycle to maintain the leaving cooling water temperature between 73°F and 98°F. The cooling coils are also equipped with pneumatically controlled outlet dampers that are closed during very cold weather for freeze protection. The demineralized water (or reverse osmosis) system provides demineralized make-up water to the system.

Figure 4: Closed cooling water system with cooler on the left and one of the two 550 HP pumps on the right

5.1.2 ECMs 1 & 2 - Overview of Technical Approach

Baseline pump and fan operation for the CCW system was obtained from plant PI data. Fan power was measured using a hand-held power meter and fan motor current was measured for two weeks in order to correlate fan power to ambient air temperature. In order to characterize energy use of the proposed system, a baseline cooling load had to be developed. The loads on the CCW system were calculated using the pump flow rate and the change in temperature of the water through the cooler. The flow rate was inferred using the pump power (estimated from current) and measured head across the pump. Inlet water temperature to the cooler was measured for a period of two weeks and coupled with the outlet temperature data recorded in PI. The heat load was then compared to the plant power output to create a cooling profile for the entire baseline year. The correlation between cooling load and plant output can be seen in the following figure.

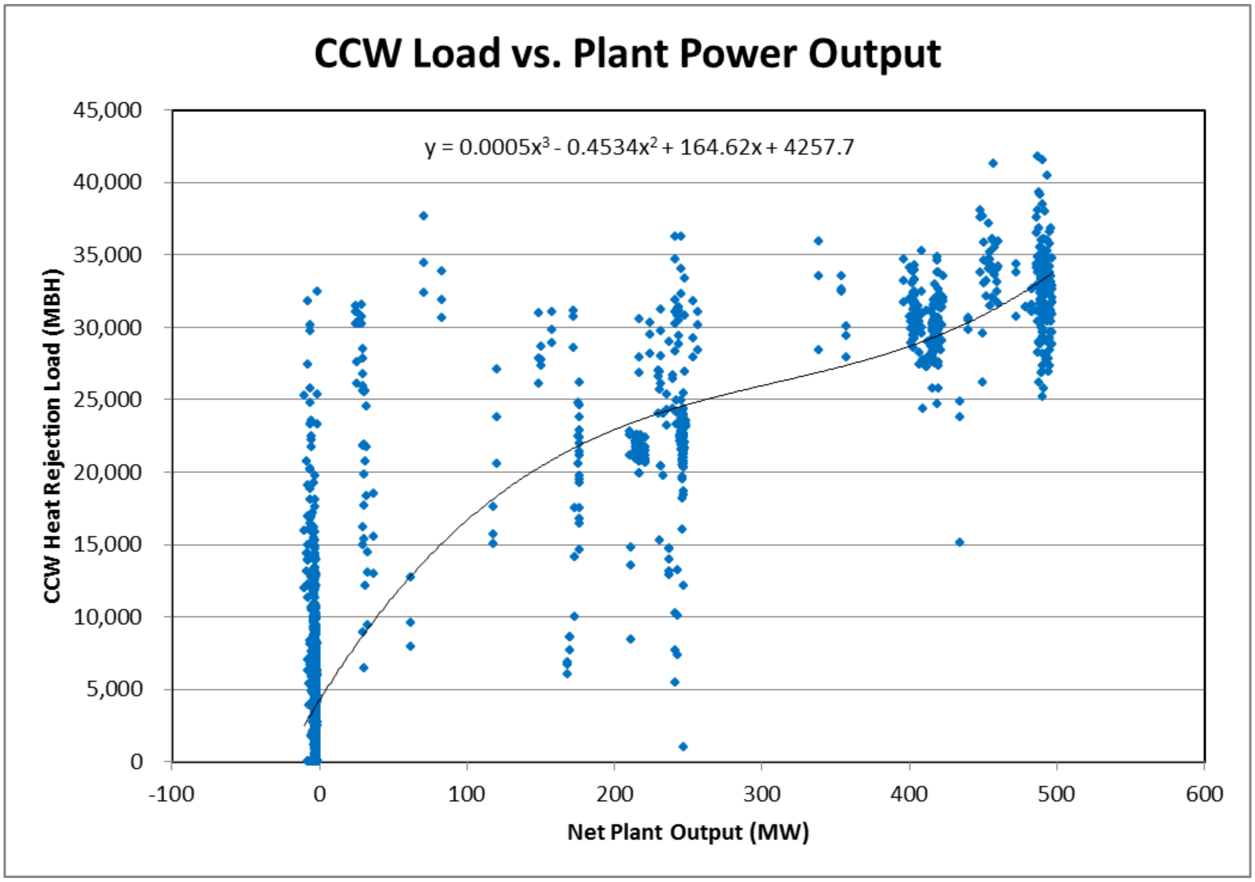

Figure 5: Plant Power Output vs. CCW Cooling Load

Fan duty was then calculated as a function of the cooling load and ambient temperature. The cooling profile was adjusted slightly until the modeled fan power matched the fan operations from the PI data. Typical meteorological year (TMY3) weather data from the National Renewable Energy Laboratory (NREL) was then substituted for actual weather data to finalize the calibrated baseline model.

ECM fan power was calculated by adjusting the target discharge temperature in the model and by substituting fan speed for fan duty cycle. The target discharge temperatures are as follows:

- 90 °F for no turbine operation
- 80 °F for one turbine operation
- 73 °F for one turbine operation

All fans were assumed to operate unless the required fan speed was less than 20%, at which point the appropriate number of fans would operate at 20% speed.

ECM pump power was calculated by assuming the pump operates at 90% speed whenever the plant was generating power and at 60% speed, whenever the CCW system was idling. The reduction in pump power was used to adjust the heat load on the system and recalculate the CCW fan power in the pump VFD case.

5.1.3 ECM 1 - Key Assumptions

- The pump draws 382.5 kW whenever it is operating in the baseline. An amp measurement from the control system verified this power within 2.3% accuracy during the 2021 site visit.
- In the ECM case the pump runs at 90% speed whenever the plant is generating power and at 60% speed the rest of its operating hours.
- The pump speed to power exponent is 2.7.
- The pump VFD is 97% efficient.
- 90% of the power reduction of the pump is a cooling load reduction on the fans.

5.1.4 ECM 2 - Key Assumptions

- Fan power is directly related to ambient temperature.
- All CCW fans are equipped with a VFD and ramp together to maintain the desired leaving water temperature.
- The fan speed to power exponent is 2.7.
- VFDs are 96% efficient.
- The CCW system targets a minimum leaving water temperature of:
    - 90 °F for no turbine operation
    - 80 °F for one turbine operation
    - 73 °F for one turbine operation
- ECMs 1 & 2 - Summary of Baseline and Estimated Energy Savings
- The summary of baseline and estimated energy savings for ECMs 1 and 2 are shown in the following tables.

Table 7: Summary of Baseline and Estimated Energy Savings for ECM 1

ECM 1: CCW Pump Variable Speed Drive				
Equipment	***Baseline***	***ECM***	***Savings***	
	MWh/yr	MWh/yr	MWh/yr	%
CCW Pumps	2,555	968	1,586	62.1%
CCW Fans	191	191	0	0.2%
TOTAL	**2,555**	**968**	**1,586**	**62.1%**

Table 8: Summary of Baseline and Estimated Energy Savings for ECM 2

ECM 2: CCW Fan VFDs and Temp. Reset				
Equipment	***Baseline*** MWh/yr	***ECM*** MWh/yr	***Savings*** MWh/yr	%
CCW Pumps	2,482	2,482	0	0.0%
CCW Fans	1,631	881	750	46.0%
TOTAL	**4,113**	**3,363**	**750**	**18.2%**

5.2 ECM 4: Install Small Condensate Pump for Auxiliary Use

5.2.1 ECM 4 - Baseline Description

In December of 2010, the auxiliary boiler was commissioned to maintain system pressures during short shutdown durations, which intern reduces start-up time. To do so, condensate must be provided to the auxiliary boiler and gland seal system. Currently, the plant has three 450 HP constant-speed turbine style pumps (Pump 1A, Pump 2A and Pump 3A) that pump condensate from the condensate tank to the low pressure drum during normal operation.

The condensate flow rate needed for the auxiliary boiler and gland seal system is much less than during production. At maximum fire, the condensate flow to the auxiliary boiler is about 20 gpm. The maintenance manager agreed with the assumption that the gland seal system requires less flow than the auxiliary boiler during auxiliary use.

However, condensate flow is provided with one 450 HP constant speed turbine style pump because the plant does not have any smaller condensate pumps. A smaller pump would be able to maintain condensate flow during auxiliary operation and use much less electrical energy to do so.

5.2.2 ECM 4 - Overview of Technical Approach

The analysis was performed using 15-minute interval data from the PI System. Interval data was provided from 11/1/2010 to 10/31/2011. The following steps outline the technical approach for the baseline analysis.

1. Motor power for each pump was calculated from motor amps, average voltage and motor manufacturer's specifications for power factor and efficiency.
2. Any time the pump was on and the turbine(s) was off was determined.
3. Any time a pump turned-on 45 minutes before start-up was determined.
4. If the pump criteria were satisfied for auxiliary boiler use, then the pump power for that 15-minute interval was calculated.
5. A new pump was conservatively selected for auxiliary pumping.
    a. Flow rate: 100 gpm
    b. Pressure: 800 ft.

   Note: 450 HP condensate pumps operate at about 800 ft. of head and auxiliary boiler requires about 20 gpm at full fire. The boiler specified operating pressure is 200 psig.
6. Manufacturer's pumps selection and a motor efficiency of 93% were used to determine motor input power at 800 ft. of pressure and 100 gpm of flow to be 27 kW. To be conservative, this number was rounded up to 28 kW.

7. Pump operation for Auxiliary Boiler use was calculate from 6/1/2011 to 10/31/2011 if the pumps were on and the turbine(s) was off and if the pump was not in operation for start-up.
8. The average pump power was calculated from 6/1/2011 to 10/31/2011.

Note that pump runtime and pump power for the baseline analysis was calculated from 5 months of data. This was because the condensate pumps operated about 1.5% when the turbines were neither producing nor in startup or shut-down before the auxiliary boiler was installed. Furthermore, the plant's highest frequency of plant startups occurred during June through October when the auxiliary boiler would be operational to maintain system pressures during short downtime durations. This appears to provide a conservative, but realistic annual operation for the auxiliary boiler.

5.2.3 ECM 4 - Control System Trend Data

Control system data was obtained for each pump for the following variables:

- Pump 1A motor current (A)
- Pump 1B motor current (A)
- Pump 1C motor current (A)
- Plant net power (MW)
- Voltage

5.2.4 ECM 4 - Control System Trend Results

The following summarizes the trends from the control system.

- Pumps operated for auxiliary use 8.9% of the time.
- The average pump power for auxiliary use was 308 kW.

5.2.5 ECM 4 - Key Assumptions

- Auxiliary pump will operate a minimum of 4.4% of the year based on forecasted plant operation.
- The average pump power for the small auxiliary pump will be 28.0 kW.
- All three 450 HP condensate pumps will remain off when the small pump is in operation.

5.2.6 ECM 4 - Summary of Baseline and Estimated Energy Savings

The summary of baseline and estimated energy savings for ECM 4 are shown in the table below.

Table 9: Summary of Baseline and Estimated Energy Savings for ECM 4

ECM 4: Install Small Condensate Pump				
Equipment	***Baseline***	***ECM***	***Savings***	
	MWh/yr	MWh/yr	MWh/yr	%
Condensate Pump 1A, 1B, 1C	119	0	119	100.0%
Small Condensate Pump	0	11	(11)	-
TOTAL	**119**	**11**	**108**	**90.9%**

6 Evaluation, Measurement and Verification

6.1 Purpose of Evaluation, Measurement and Verification

The purpose of Evaluation, Measurement, and Verification is to ensure that the ECMs are properly installed and working as intended. In addition, EM&V verifies the final energy savings from each ECM. The basic steps of this process are outlined below:

1. **Development an EM&V Plan:** Develop an EM&V plan for each ECM that was installed.
2. **Evaluation:** Evaluate the equipment to ensure that the equipment was installed as intended.
3. **Measurement:** System operation is reviewed and fine-tuned as necessary to maximize energy savings.
4. **Verification:** Energy savings are verified in a written report.

6.2 Monitoring Points Where Performance Must be Demonstrated Over Time

Power measurements and data logging for measurement and verification of energy savings will be ECM specific. Unless noted otherwise, all data logging shall be for a period of 4 weeks at intervals of five minutes or less.

If ECM 1 is installed, the following variables will need to be monitored:
- CCW pump speed.
- CCW pump amps.
- Plant operating mode.

If ECM 2 is installed, the following variables will need to be monitored:
- CCW fan speed and on/off signal for all fourteen fans.
- CCW leaving water temperature.
- Plant operating mode.

If ECM 4 is installed, the following variables will need to be monitored:
- Plant output from the PI system.
- Motor amps for Condensate Pumps 1A, 1B and 1C.
- Motor amps for new condensate pump.

6.3 Personnel Required

One maintenance/electrical person will be required for approximately 4 hours for each ECM to assist in the inspection and monitoring of equipment. Chehalis Generation Facility may also be asked to retrieve data logging equipment and mail it to the Commissioning Engineer.

6.4 Logistical Requirements

Commissioning should be done during typical operation of each respective ECM.

6.5 List of Settings/Equipment to be Observed/Confirmed/Recorded

If ECM 1 is installed:

- Installed VFD.
- Pump speed set-points for each mode of operation for the plant.

If ECM 2 is installed:

- Installed VFDs.
- Fan minimum and maximum speed set-points.
- Verify that all operating fans are at the same speed.
- Fan power measurements at minimum and maximum speeds and two speeds in between to verify speed to power relationship.
- Target leaving water temperature.

If ECM 4 is installed:

- Installation of a small condensate pump.
- New pump operates during the recommended time frame.
- Power measurement on the new pump.
- Condensate Pumps 1A, 1B and 1C remain off when small condensate pump operates.

6.6 Reporting Requirements

- For each ECM, the report should document all key operating parameters in graphical form. All graphs need to be titled, the X & Y axis should be labeled properly, and a legend should be included if more than one series of data is shown on a graph.
- For each ECM, the report should document any differences between commissioned operations and the targeted operations outlined in the Evaluation, Measurement and Verification Plan. For example, if a minimum setting of 95 was recommended in the EAR but it was possible to achieve only 97, then this and similar differences should be noted.
- All EM&V data must be put into electronic format such that it can be reviewed and opened with a standard spreadsheet program.
- The final report must be submitted in electronic format.