PacifiCorp
2022-2023 Biennial Conservation Plan

Appendix 5

Production Efficiency Studies

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:

Cascade Energy

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 No.	Description	Measure Life (yrs)	Ann. Benefits: Annual Energy Savings (MWh/yr)	Initial Investments: Installed Costs ($)	EM&V Costs ($)	Engineering Fees ($)	Spare Parts Costs ($)	Ann. Investment: O & M Costs ($/yr)	Net Present Cost ($)
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.

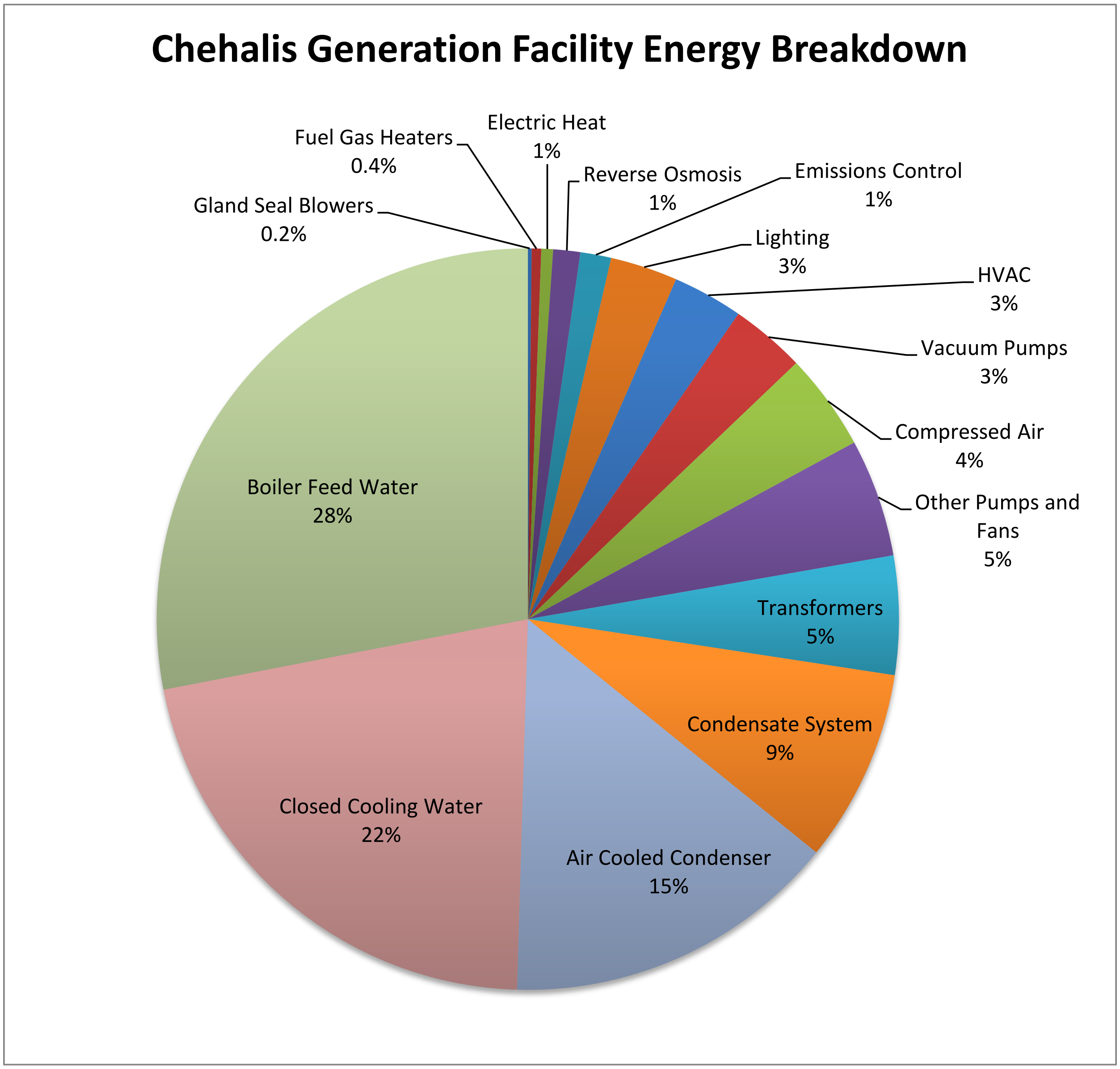

Figure 1: Energy Breakout per Sub-system for Chehalis Generation Facility

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.

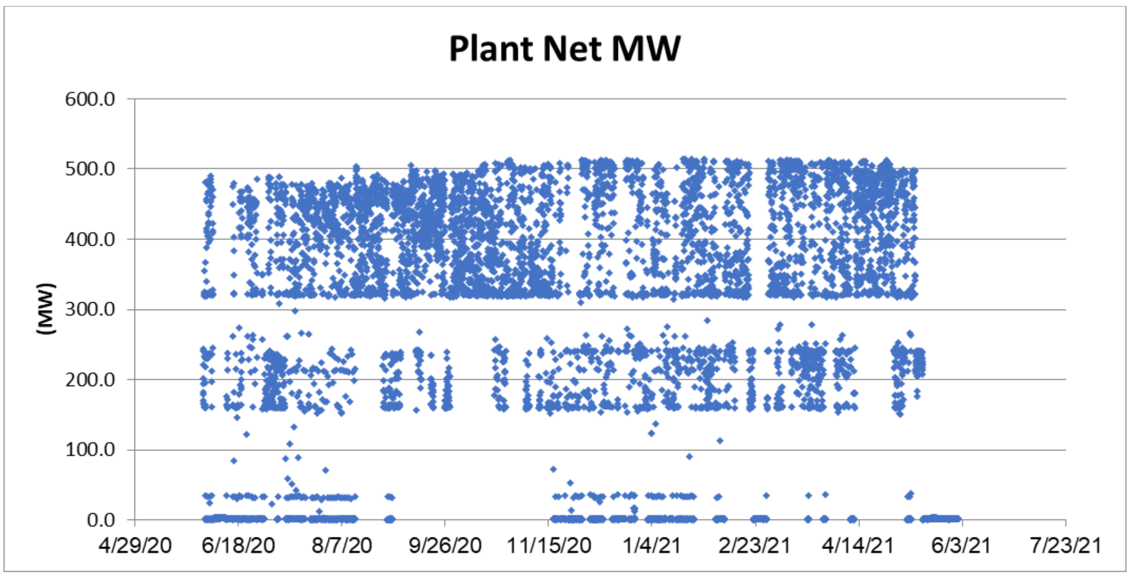

Figure 2: Plant Net Generation Data

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:

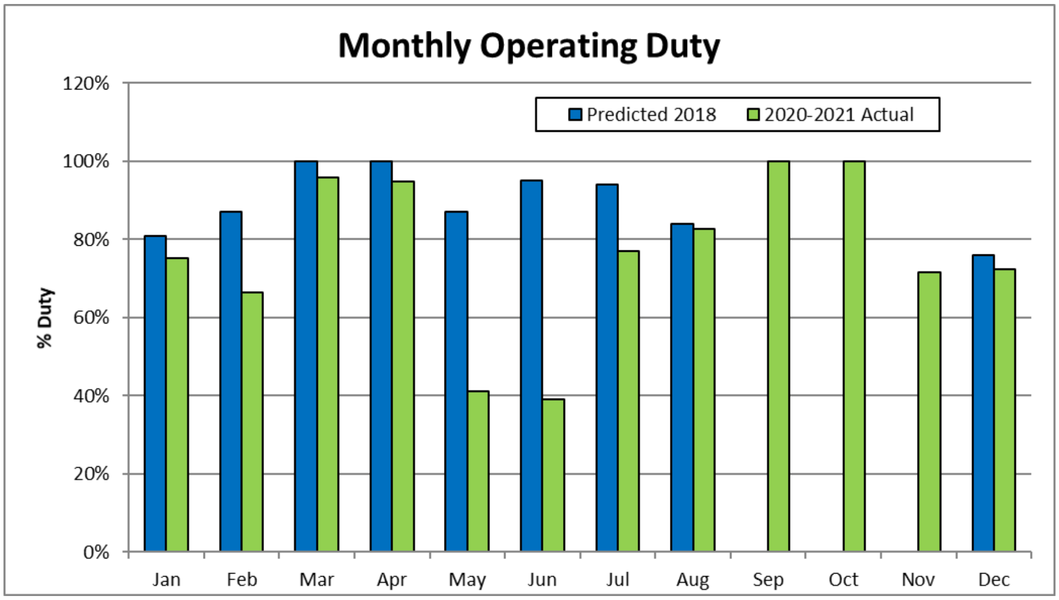

Figure 3: Monthly Operation Comparison

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.

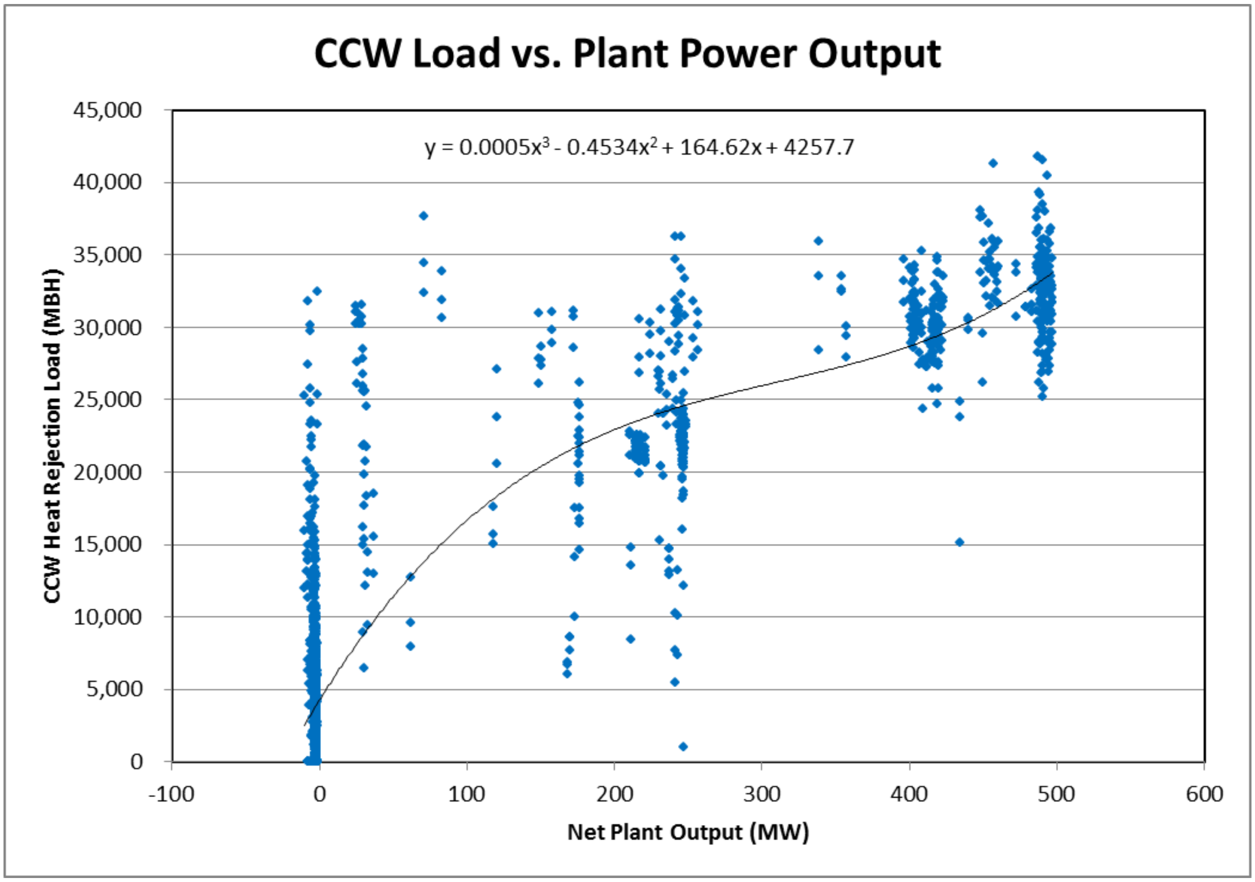

Figure 5: Plant Power Output vs. CCW Cooling Load

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*** MWh/yr	***ECM*** MWh/yr	***Savings*** 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.

ENERGY ANALYSIS REPORT
FOR
INITIATIVE 937

Plant-wide Energy Conservation Measures

Located At:

Hermiston Generating Facility – Hermiston, OR

Presented to:

PacifiCorp

Submitted By:

Cascade Energy

19 E. Cherry St.
Walla Walla, WA
(509) 524-8623

CAS 3535-12

Revision: September 27, 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. Project cost estimates shown in this report represent Cascade's best effort to work within the given time frame and with each facility's personnel.

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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8.0 APPENDIX

1.0 EXECUTIVE SUMMARY

1.1 Introduction and Background

PacifiCorp has seven generation facilities in their fleet that provide electricity to the State of Washington. These units vary from coal-fired to natural gas to wind. In 2006 the State of Washington passed clean energy legislation requiring PacifiCorp to complete all cost-effective energy efficiency measures in these generation facilities. A study of those measures at the Hermiston Generating Facility in Hermiston, OR was completed in 2013 by Cascade Energy and submitted to Pacific Power.

The purpose of this report is to update the systems investigated in that 2013 study and estimate savings for the measures that have not been completed. Therefore, the baseline for each measure is unchanged from the 2013 report. The updates noted since the 2013 study are based on a site visit conducted by Craig Phillips, Senior Project Engineer at Cascade Energy, on 15 July, 2021 and subsequent conversations with operations and maintenance managers at Hermiston Generating.

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 Summary of Opportunities for Hermiston Generation Facility

1.2.1 Energy Conservation Measures (ECMs)

ECM 1: Lighting

Baseline: The exterior lighting consisted of various high-pressure sodium (HPS) fixtures that operated continuously because the existing sensors are not working correctly. Most of these fixtures have a significant amount of discoloration on the lenses that further reduces the lighting output. The interior lighting has a mixture of HPS, T12, and T8 fixtures. Most of the interior lighting is manually controlled and operates continuously.

Proposed: The recommended upgrade for this measure includes continuing the lighting retrofit efforts for both the remaining interior and exterior fixtures. For the exterior areas, it is recommended that the existing fixtures be replaced with LED fixtures. The recommendation for the interior lighting covers replacing the existing HPS and fluorescent T12 fixtures with more efficient LED fixtures with occupancy sensors.

ECM 2: Small Condensate Pump for Auxiliary Use

Baseline: Turbine gland seals in each unit are maintained by a 250-hp constant speed condensate pump when the plant is taken offline for short durations between startups. The condensate flow required for the gland steam system is much less than during normal operation. However, the only pumps available to provide condensate flow are the 250 hp condensate pumps.

Proposed: Since Hermiston Generating does not cycle either HRSG unit like they did in 2013, this ECM is no longer recommended.

ECM 3: HVAC
Baseline: Air Handling Units (AHUs) in the Raw Water building, Demin building, and Warehouse maintain internal air temperatures of 72-75°F despite the fact that these buildings are rarely occupied. Except for a small office in the Warehouse, operators typically spend from one to three hours per day in any of those facilities as they make their rounds each shift.

Proposed: This measure originally only included installing a programmable thermostat in each building that is occupied less than three hours per day, and maintain a temperature of 80°F in the summer and 60°F in the winter. The AHU is now close to end of useful life so it is also recommended that a more efficient unit be purchased when a new unit is needed.

This measure would add the following equipment:

- Thermostat controls in the Raw Water building that will:
    - Remain off unless the room temperature is above 80°F or below 60°F
    - Have the ability to be turned on manually for a short duration when needed, then automatically shut off again
- New, more efficient AHU for the Raw Water building

ECM 4: Compressed Air System Upgrades
Baseline: The facility compressed air system currently operates as two separate systems, Unit #1 and Unit #2. The header piping for Unit #1 and Unit #2 are connected, but the cross-connect valve between the two is closed so that each unit operates independently so that loss of air in one unit does not trip the other unit. The Unit #1 system consists of a 60 hp Sullair oil-flooded screw with VFD control and a 50 hp Atlas Copco oil-free screw that uses load/unload control. Both compressors are connected to heatless desiccant dryers. The Unit #2 system consisted of a single 60 hp Kaeser oil-flooded screw compressor with a heatless desiccant dryer, but this was upgraded to a 50 hp Atlas Copco compressor with VFD control. A new heatless desiccant dryer was also added. Both systems utilize the Combustion Turbine's compressor and AirTek Air Processing Unit's (APU) as the primary method of providing compressed air to the facility when generating power. Normally, the Sullair and Kaeser compressors operate continuously providing make-up air to the systems when the turbine compressors do not produce enough air.

Proposed: The recommended upgrades consist of installing dew-point demand controls on the heatless desiccant dryers. In addition, the facility should continue their leak reduction program to reduce the plant air demand.

1.3 ECM Costs and Savings for Hermiston Generating Facility

The table below shows the costs and savings of electrical efficiency measures for the Hermiston Generating Facility.

Table 1: ECM Economics for Hermiston Generating Facility

			Ann. Benefits	Initial Investments				Ann. Invest.	
ECM No.	Description	Measure Life (yrs)	Annual Energy Savings (MWh/yr)	Installed Costs ($)	EM&V Costs ($)	Engineering Fees ($)	Spare Parts Costs ($)	O & M Costs ($/yr)	Net Present Cost ($)
1	Lighting	10	505	$52,216	$500	$5,222	$1,566	$1,566	($70,421)
3	HVAC	10	4	$322	$2,500	$32	$10	$10	($2,932)
4	Compressed Air System Upgrades	10	106	$11,547	$4,000	$1,155	$346	$346	($19,462)
	Totals		**615**	**$64,086**	**$7,000**	**$6,409**	**$1,923**	**$1,923**	**($92,815)**

NOTES:

1. Estimates for engineering fees were based on 10% of installed cost.
2. Estimates for spare parts were based on 3% of installed cost.
3. Estimates for O&M fees were based on 3% of installed cost.
4. 2013 costs were increased by 14% to account for inflation to 2021 values

2.0 PLANT AUXILIARY BASELINE ENERGY USE

2.1 Plant Description

The Hermiston Generating Facility began commercial operation in July 1996. Power is generated by two GE model MS7001FA combustion turbines operated in combined cycle mode, each with a synchronous 3600 RPM GE steam turbine. Each of these turbine sets is referred to respectively as Unit 1 and Unit 2. The facility has a nominal generating capacity of 474 MW. Power is generated in the combustion turbines at 18 kV and in the steam turbines at 13.8 kV, then transformed up to a distribution voltage of 230 kV. The cooling water for each unit's condenser is supplied by a four-cell, counterflow, mechanically-induced draft cooling tower.

The plant operated Unit 1 75% of the time and Unit 2 94% of the time over fiscal year 2020 (4/1/2020 to 3/31/2021), and both units ran continuously from October through March. During periods of lighter loading, the plant varies its capacity and occasionally operates just one combustion turbine in conjunction with its steam turbine. The facility has a contractual obligation to provide up to 100,000 lb/hr of intermediate pressure steam to a neighboring potato processing plant (50,000 lb/hr from each unit) when operating and when the potato plant can take it..

Auxiliary systems at the plant include a compressed air system for each unit, boiler feed-water treatment from a demineralization process, closed cooling water for numerous plant system cooling needs, and several wastewater pumps that send cooling tower discharge to the neighboring potato processing plant. A carbon dioxide fire suppression system is employed on the gas turbines while a 2,000 gpm electric motor-driven fire pump with diesel backup draws water from the cooling tower basins for fire suppression throughout the rest of the facility. Lighting at the plant consists of high pressure sodium fixtures 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 Hermiston Generation Facility is outlined in the table and show in the figure below.

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

Subsytem	Energy Use (MWh/yr)	% of Total
Condensate System	2,652	7%
Boiler Feed Water	13,804	35%
Lighting	747	2%
HVAC	71	0%
Circulating Water	11,673	29%
Closed Cooling Water	790	2%
Compressed Air	367	1%
Cooling Tower	9,374	24%
Emissions Control	245	1%
Fire Protection	12	0%
Total	39,735	100%

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

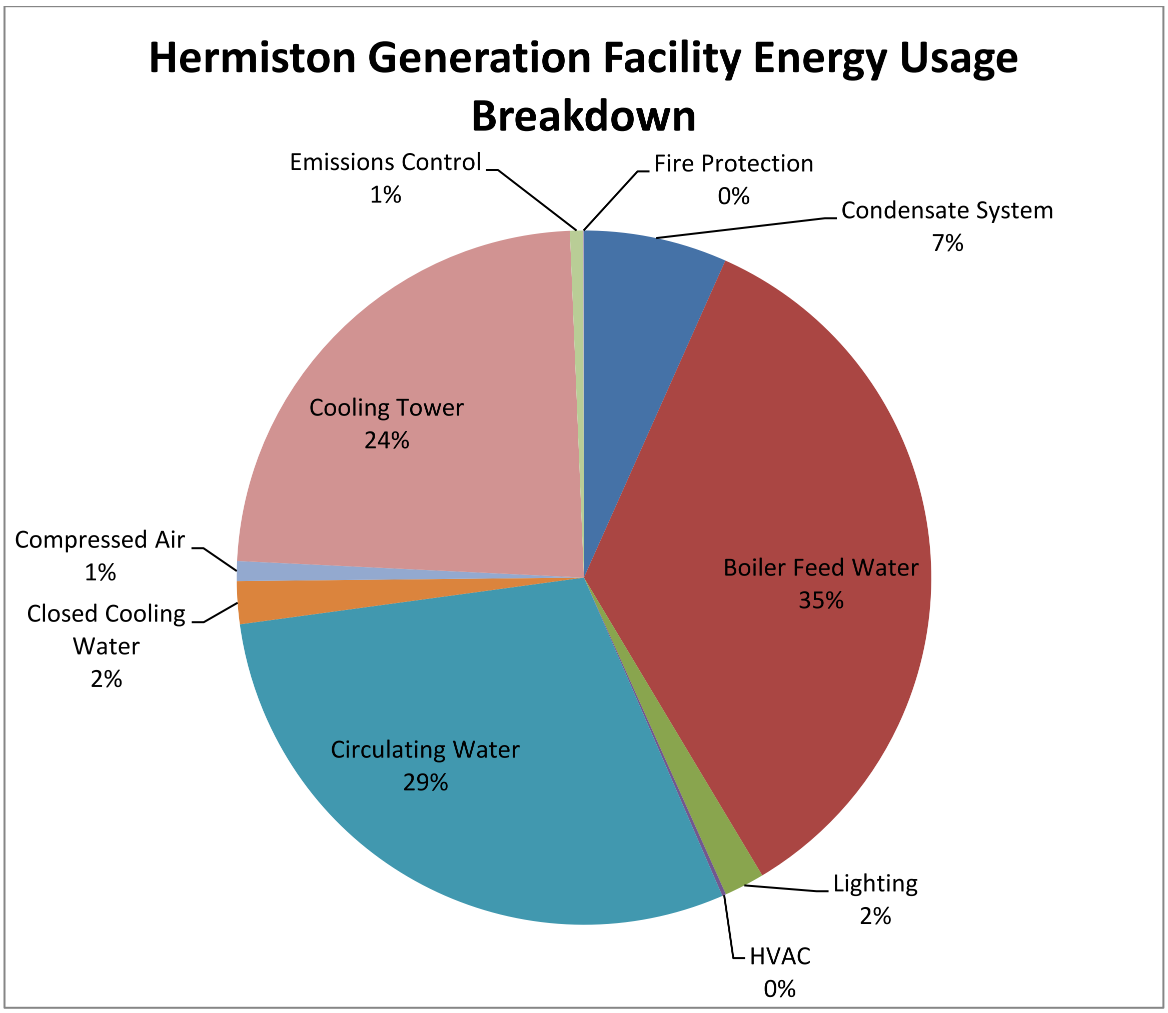

Figure 1: Energy Breakout per Sub-system for Hermiston Generating Facility

3.0 DETAILED DESCRIPTION OF PROPOSED EQUIPMENT AND OPERATION

3.1 ECM 1: Lighting

3.1.1 Changes Since 2013 Report

Approximately 33% of all facility lights have been replaced with LED (light-emitting diode) lights.

- An estimated 25% of field lights and 80% of indoor lights in administrative areas have been upgraded. Motion sensor controls have been installed with most of the upgraded field lights. Occupancy sensors were not added to the new light fixtures in the Admin building, but those are consistently switched off at the close of business hours each day.
- During the verification site visit, more than 100 upgraded light fixtures were inspected but an exact count of the total number of upgraded lights was not made. Instead, the estimate for the total percentage of new lights was provided by the maintenance manager who believes this is a conservative estimate.

3.1.2 Source of Energy Savings

- The remaining fixtures and lamps that have not been replaced are inefficient and many lamps are on continuously.
- Installing more energy efficient fixtures and reducing operating hours where appropriate will reduce energy usage.

3.1.3 Specific Equipment Recommendations

- Install high efficiency lighting system with occupancy sensors.
- The facility is planning on replacing the remaining high-intensity discharge (HID) and T12 lights in the Main Warehouse before the end of 2022.
- The remaining inefficient lights in the Raw Water building will likely be the last to be replaced due to the difficulty in accessing the lights, and the very low occupancy.
- Based on the facility's experience with lights they have already replaced, they should either choose future replacements based on the LED's that have resulted in the lowest cost of ownership, or consult with an experienced lighting contractor for specific upgrade recommendations.

3.1.4 Set-points Recommended to Achieve Energy Performance

- Install high efficiency lighting system.
- Install occupancy sensors on lighting system as outlined in the Appendix.
- Set-occupancy sensor time delay to the minimum delay time allowed by the manufacturer's warranty.

3.2 ECM 2: Small Condensate Pump for Auxiliary Use

3.2.1 Changes Since 2013 Report

The facility's scheduled operational time has dramatically increased since 2013; they rarely cycle either Unit now and have no plans to cycle the Units in the foreseeable future. As a result, the potential savings from this ECM is negligible.

3.2.2 Source of Energy Savings

If the Units cycled, this measure would save energy by reducing the flow rate of the system when the turbine is idle but condensate must still flow to the gland steam and other systems.

- A properly sized pump will eliminate the recirculation and throttling currently required.
- Installing a smaller pump will improve the power draw at the required pressure and flow rate, while condensate circulation is required.

3.2.3 Specific Equipment Recommendations

- This measure is no longer recommended.

3.2.4 Set-points Recommended to Achieve Energy Performance

- No longer applicable.

3.3 ECM 3: HVAC

3.3.1 Changes Since 2013 Report

A programmable thermostat was added to the Main Warehouse building but not to the Demin building due to the humid environment, and because the minimum required temperature in that building is higher so that the caustic soda does not freeze. The Main Warehouse thermostat is programmed to maintain 78°F between 5:30 AM and 5:30 PM, Monday through Friday, and either 85°F or 55°F the remaining 108 hours of the week during the summer or winter, respectively.

In addition, several air conditioning systems have been replaced since 2013. These were not specifically recommended in the original report, but the new systems are more efficient than the replaced units. The facility also has plans to replace all aging R-22 systems with new air conditioning units by the end of 2023.

3.3.2 Source of Energy Savings

This measure would save energy by reducing the operating time of the system.

- Since the Raw Water, Demin and Warehouse buildings are rarely occupied, heating and cooling the conditioned space as if they were continuously occupied wastes energy.

3.3.3 Specific Equipment Recommendations

- Install a programmable thermostat in the Raw Water building.
- Replace all R-22 air conditioning units with heat pumps with a SEER rating of at least 16.

3.3.4 Set-points Recommended to Achieve Energy Performance

Set the thermostat in the Raw Water building to only turn on the AHUs when the following indoor air temperatures are met:

- 80°F between May and September
- 60°F between October and March

Note: this recommended temperature range (60-80°F) is more narrow – and not quite as energy efficient – as the range maintained in other areas of the plant (55-85°F) due to the electrical equipment in that building.

Check temperature storage requirements for product inventory stored in any of these buildings to ensure product damage does not occur. Energy savings are maximized by maintaining the highest possible temperatures in the summer and the lowest possible temperatures in the winter.

3.4 ECM 4: Compressed Air System Upgrades

3.4.1 Changes Since 2013 Report

The 60 hp fixed speed Kaeser air compressor on Unit 2 has been replaced with a smaller and more efficient 50 hp variable speed Atlas Copco ZT37 air compressor. The facility determined that opening the cross-connection between the Unit 1 and Unit 2 compressed air systems was not worth the increased risk of tripping both units due to an interruption in compressed air, so this has been removed from the recommendation list. The facility is achieving the same savings by operating each unit with a variable speed compressor.

The facility's fittings supplier has been performing site leak inspections approximately every 2-3 years, and the plant is working on creating a PM for regularly scheduled in-house leak sweeps.

In addition, the discharge pressure setpoint on the both Unit compressors was reduced from 113 psi to 105 psi, with low pressure alarms at 90 psi.

A new 75 hp Atlas Copco ZT55 fixed-speed, oil-free compressor and heatless desiccant dryer with timer purge control were also added to the Demin building compressed air system. This system replaced a similarly sized fixed-speed Kaeser compressor and desiccant dryer. Since the equipment was similar, no energy savings resulted from this capital investment.

3.4.2 Source of Energy Savings

Changing the compressor control set-points for the Sullair variable speed compressor will reduce its average energy use by approximately 2.5%. Dew-point demand controls on the heatless desiccant dryers will reduce the purge airflow based on plant air demand. A leak identification and elimination program will reduce the demand on the compressors.

3.4.3 Specific Equipment Recommendations

- Install dew point demand controls on the Sullair and Atlas Copco dryers.
- When the desiccant dryers are at end of useful life, consider replacing them with heated desiccant dryers, or blower purge desiccant dryers, both of which are more efficient than heatless dryers.

3.4.4 Set-points Recommended to Achieve Energy Performance

- Change the compressor set-point as follows
    - Sullair

        - Load/start: 105 psi
        - Target: 105 psi
        - Unload/off: 115 psi
    - Atlas Copco
        - Load/start: 93 psi
        - Unload: 103 psi
        - Unload delay to off: 10 minutes or less
- Operate the dryers in demand control mode
- Institute a leak identification and elimination program at the facility

4.0 ENERGY CONSERVATION MEASURE COSTS

The tables below provide an itemized cost breakout for each ECM based on information gathered for the 2013 report. A contingency of 10% was included and a 14% adder to account for inflation between 2013 and 2021.

Table 3: Project Costs for ECM 1

ECM 1: Lighting					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Interior Fixture Upgrade	Evergreen	1	$28,780	$28,780
2	Exterior Fixture Upgrade	Evergreen	1	$55,440	$55,440
3	Estimated 50% of work already completed		1	-$42,110	-$42,110
Sub-Total					$42,110
Contingency				10%	$4,211
2013-2021 Inflation				14%	$5,895
Total Cost:					**$52,216**

Table 4: Project Costs for ECM 3

ECM 3: HVAC					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Controls	Estimate	1	$100	$100
2	Installation	Estimate	1	$80	$80
3	Programming	Estimate	1	$80	$80
Sub-Total					$260
Contingency				10%	$26
2013-2021 Inflation				14%	$36
Total Cost:					**$322**

Table 5: Project Costs for ECM 4

ECM 4: Compressed Air System Upgrades					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Dew-point Demand Controls	Rogers Machinery	2	$4,300	$8,600
2	Dew-point Demand Controls Installation	Rogers Machinery	2	$356	$712
Sub-Total					$9,312
Contingency				10%	$931
2013-2021 Inflation				14%	$1,304
Total Cost:					**$11,547**

5.0 BASELINE AND ANALYSIS OVERVIEW

5.1 ECM 1: LIGHTING

5.1.1 Baseline Description

The exterior lighting consists of various high pressure sodium (HPS) fixtures, most operate continuously because the existing sensors are not working correctly. Most of these fixtures have a significant amount discoloration on the lenses that reduces the lighting output. The interior lighting has a mixture of HPS, T12, and T8 fixtures. Most of the interior lighting is manually controlled and operates continuously.

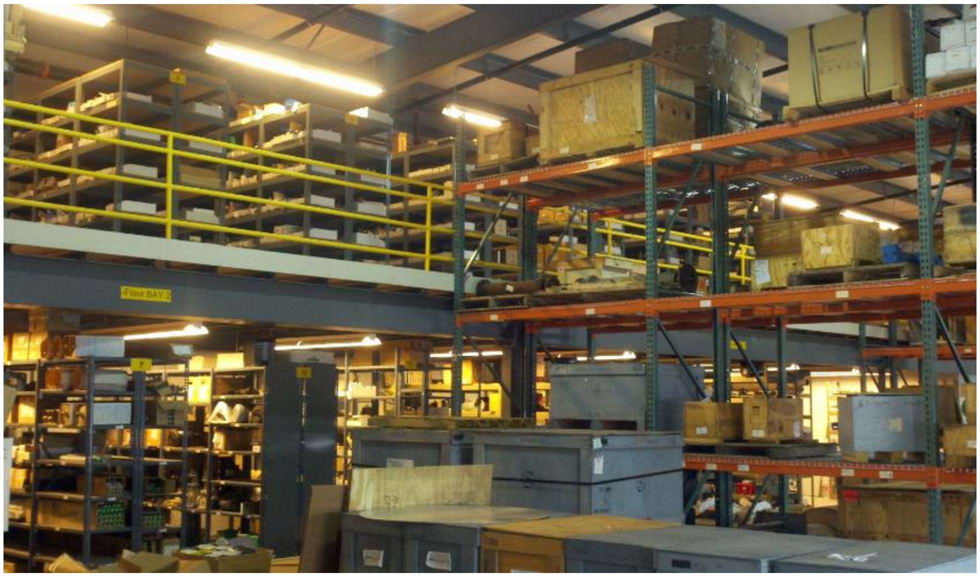

Figure 2: Fluorescent Lighting in Warehouse

Figure 3: High Pressure Sodium Lighting Outside Demin Building

5.1.2 Upgrade Description

The new exterior lighting consists of various LED fixtures, most with daylight sensors so they are only on at night. The new interior lighting also consists of various LED fixtures. Most of the new interior lighting is automatically controlled if occupancy is high, but for areas that are rarely occupied (once or twice a day for a few minutes), lights are manually controlled.

Figure 3: Outdoor LED Lighting on Unit 2 with Light Sensor

Figure 4: Maintenance Building LED Lighting with Occupancy Sensors

Figure 5: Unit 1 Steam Turbine Building LED Lighting

5.1.3 Overview of Technical Approach

A facility wide lighting count was performed and the control of each fixture was obtained for the 2013 study. In that study, the Pacific Power lighting calculator was used to determine baseline energy usage for the 279 interior fixtures while an excel spreadsheet was created to determine the baseline usage for the 346 exterior fixtures.

Most of the proposed indoor lighting upgrades in the 2013 study consisted of 32W fluorescent T8 fixtures, while most of the proposed outdoor lighting upgrades consisted of 100W or 150W pulse start metal halide fixtures. The exact make/model numbers of the upgraded LED lights were not collected, but based on experience with other lighting replacement projects, a conservative assumption is that the new LED lights use less than two-thirds of the energy as those T8 and lower wattage metal halide lights proposed in the 2013 study (i.e. each new fixture saves at least 150% as much as originally projected). Estimated savings is then the original savings estimate multiplied by the percentage of replaced fixtures, multiplied by the 150% fixture savings factor.

5.1.4 Control System Trend Data

- No trend data was collected for this analysis.

5.1.5 Key Assumptions

- 80% of interior lights have been replaced with lights that use only two-thirds of the energy projected in the 2013 study.
- 25% of the exterior lights have been replaced with lights that use only two-thirds of the energy projected in the 2013 study.
- The remaining savings opportunity is equal to the 2013 projected energy savings multiplied by the 150% fixture savings factor, minus the savings already achieved.

5.1.6 Summary of Baseline and Estimated Energy Savings

The summary of baseline and estimated achieved energy savings for ECM 1 are shown in the following table.

Table 8: Summary of Baseline and Estimated Achieved Energy Savings for ECM 1

	Baseline Energy	**2013 Projected Energy Savings**	**% of Lights Already Replaced**	**Fixture Savings Factor**	**Energy Saved From Replaced Lights**	**Remaining Savings Opportunity**	**% Savings Remaining**
Lighting	MWh/yr	MWh/yr	%	%	MWh/yr	MWh/yr	%
Interior	244	147	80%	150%	176	45	18%
Exterior	503	177	25%	150%	66	200	40%
Total	**747**	**324**			**242**	**244**	**33%**

5.2 ECM 2: Small Condensate Pump for Auxiliary Use

5.2.1 Baseline Description

Each unit employs a 250 hp, 4,160 V, 6-stage vertical turbine condensate pump to circulate condensate from the condenser, through the steam jet air ejector and gland steam condenser, and then to the low pressure drum. Each of these large pumps must still operate during periods of non-operation (when the turbine is idling and not producing power) in order to maintain flow to the gland seal and other auxiliary systems. The condensate flow rate needed for these auxiliary systems is much less than when generating electricity. However, condensate flow is still provided with the 2,080 gpm capacity 250 hp pump because the plant does not have any smaller condensate pumps. Currently, the condensate pumps must maintain a minimum flow rate of 375 gpm which is controlled by means of an automatic recirculation check valve and restricted flow orifice which recirculates excess flow back to the condenser. A smaller pump would be able to maintain the required condensate flow to the auxiliary systems when the turbines are not operational and use much less electrical energy to do so.

5.2.2 Overview of Technical Approach

The analysis was performed using hourly data from the PI System. Interval data was provided from 8/6/2011 to 8/6/2012. The following steps outline the technical approach for the baseline analysis.

5.2.3 Key Assumptions

- Plant availability will remain near or higher than 97%

5.2.4 Summary of Baseline and Estimated Energy Savings

Due to the reduced turbine downtime, this ECM is no longer recommended.

5.3 ECM 3: HVAC

5.3.1 Baseline Description

A single, 6-ton AHU provides conditioned air to the Raw Water building, while two 7.5-ton AHUs provide conditioned air to the Warehouse. These have thermostats that maintain temperatures between 72-75°F during the summer despite the fact that these buildings are only occupied between one and three hours a day. The Warehouse has an 8'x8' office for the inventory manager, but that person also has an office space in the main Administration building, and is only in the Warehouse part-time.

5.3.2 Overview of Technical Approach

A time-of-use data logger was installed on the southern Warehouse AHU unit from 8/8/12 to 9/24/12. A current transducer data logger was installed on the northern Warehouse AHU unit during the same time period. Power snapshots were taken for both units to correlate current and time-of-use to power. Ambient temperatures were also recorded during this same time.

Duty cycle was calculated as a function of ambient temperature. Typical meteorological year (TMY3) weather data from the National Renewable Energy Laboratory (NREL) for McNary Dam near Hermiston was then used to extrapolate the duty cycle during the data logging period to the entire year to finalize the calibrated baseline cooling model. The blue data points in Figure 4 show the linear relationship exhibited during the data logging period. Since data was not available during the winter months, the mirrored image of this linear relationship was assumed for the baseline heating model. The extrapolated model for both cooling and heating duty cycles can be seen for a typical meteorological year in Figure 5.

Power snapshot data of real power was combined with projected time of use from this baseline model to determine the estimated annual energy use for the Warehouse, Raw Water and Demin buildings.

ECM power was calculated by assuming that the AHU did not operate unless the ambient temperature was above 85°F for the cooling model, and below 36°F for the heating model. For ambient temperatures beyond these trigger points, ECM power was assumed to be equal to the baseline power.

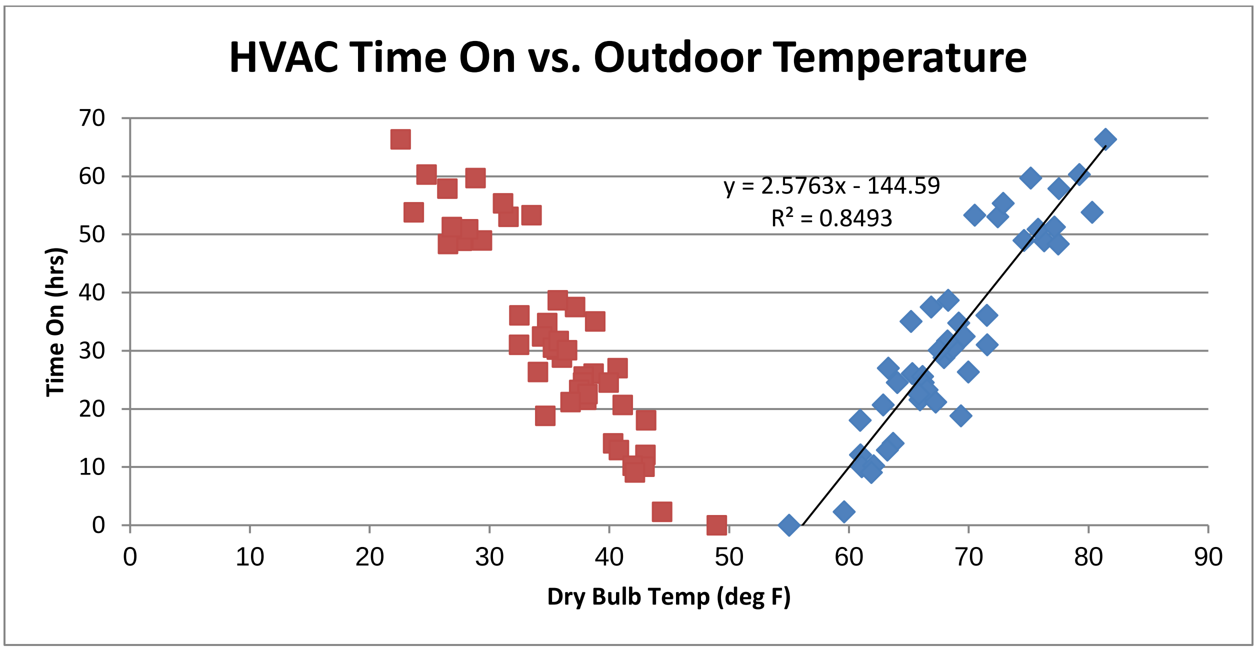

Figure 4: Warehouse AHU Logged Operating Time vs. Ambient Temperature

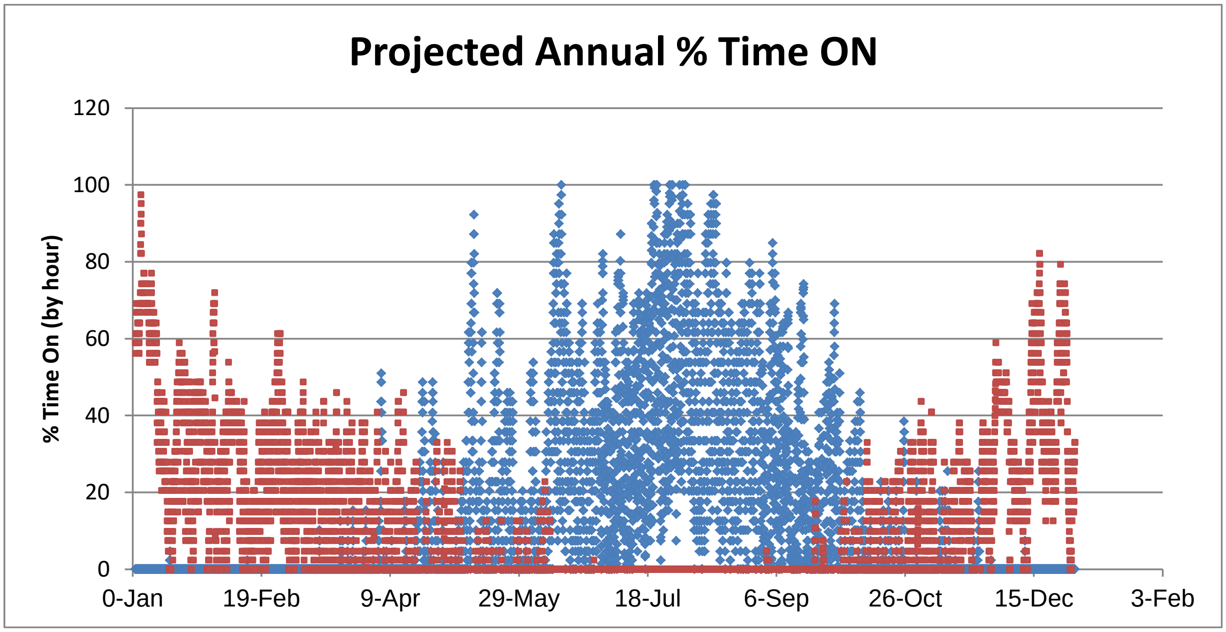

Figure 5: Heating and Cooling Model for TMY3

The 2013 savings analysis was updated to account for the reduction in total cooling capacity (6 tons in the Raw Water building versus 21 tons in the Raw Water and Warehouse) and for the tighter temperature control band (60-80°F instead of 55-85°F).

5.3.3 Control System Trend Results

The flowing summarizes the trends from the control system.

- A linear relationship existed between the duty cycle (% time on) and the ambient air temperature.
- The linear relationship is defined by a slope of 2.57 (i.e. a change in duty cycle of a little more than 2.5% per degree change in ambient temperature).

5.3.4 Key Assumptions

- Power snapshots are representative of the entire operational year.
- The heating duty cycle vs. ambient temperature model mirrors the cooling duty cycle (i.e. slope of -2.57).
- Historical TMY3 data from McNary Dam is representative of ambient conditions at Hermiston Generating facility.

5.3.5 Summary of Baseline and Estimated Energy Savings

The summary of baseline and estimated energy savings for ECM 3 is shown in the following table.

Table 10: Summary of Baseline and Estimated Energy Savings for ECM 3

Baseline	
Annual Operating Hours	8,760
Average kW	1.46
Annual kWh	12,801

ECM 3	
Average kW	0.98
Annual kWh	8,603
Annual kWh Savings	4,198

5.4 ECM 4: COMPRESSED AIR SYSTEM UPGRADES

5.4.1 Baseline Description of Compressed Air System

The facility compressed air system currently operates as two separate systems, Unit #1 and Unit #2. The compressed air system is used to provide dry, high pressure compressed air for both instrumentation and service tools throughout the plant. The header piping for Unit #1 and Unit #2 are connected, but the cross-connect valve between the two is closed. The Unit #1 system consists of a 60 hp Sullair oil-flooded screw with VFD control and a 50 hp Atlas Copco oil-free screw that uses load/unload control. The Atlas Copco compressor is back-up and did not operate during the system analysis period. Both compressors are connected to heatless desiccant dryers (250 SCFM).

The Unit #2 system consists of a single 50 hp oil-flooded Atlas Copco compressor. The Atlas compressor also has a heatless desiccant dryer (370 SCFM). Both systems utilize the Combustion Turbine's compressor and AirTek Air Processing Unit's (APU) to provide the facility with compressed air when the facility is generating power. Normally, the Sullair and Atlas compressors operate continuously providing make-up air to the systems when the turbine compressors do not produce enough air.

5.4.2 Overview of Technical Approach

The Sullair and Kaeser compressors were instrumented with temporary current logging equipment from 8/7/2012 to 9/24/2012. These loggers recorded the motor amps for the two compressors every five minutes. One time power measurements using a three-phase demand meter were used to correlate compressor amps to kW during this period. The recorded data was coupled with manufacturer's ratings to generate a flow profile from the monitoring period. The figures below outline the compressor current for the Sullair and Kaeser compressors.

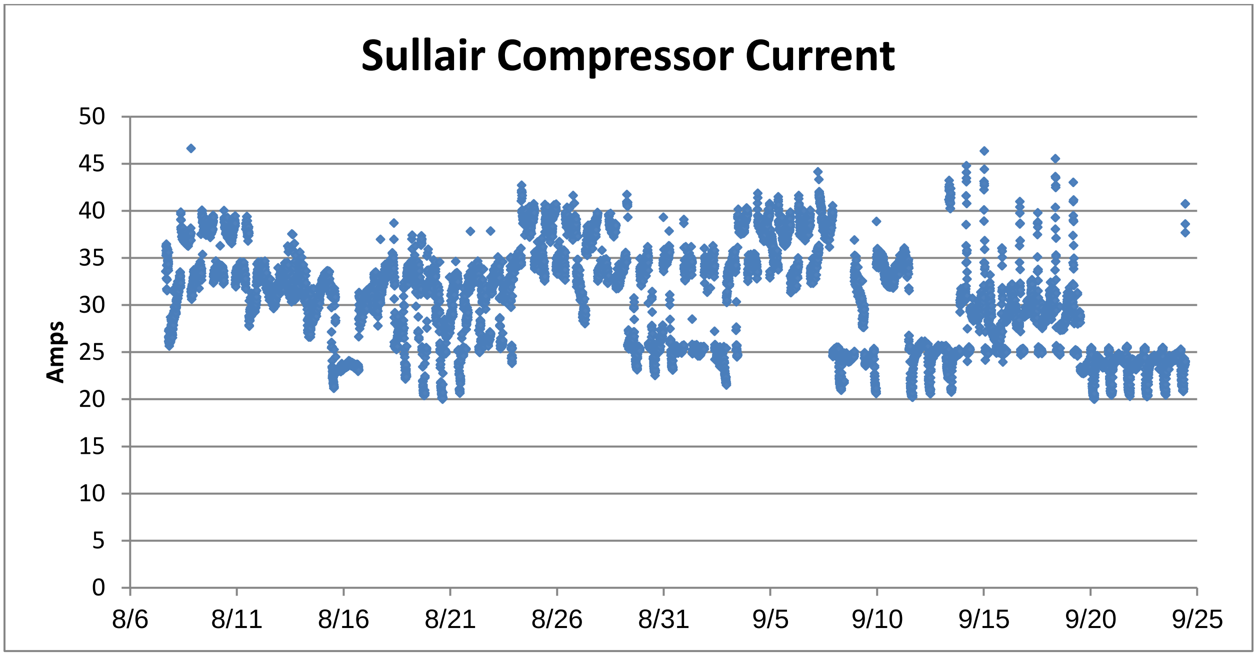

Figure 6: Unit 1 Air Compressor Motor Current

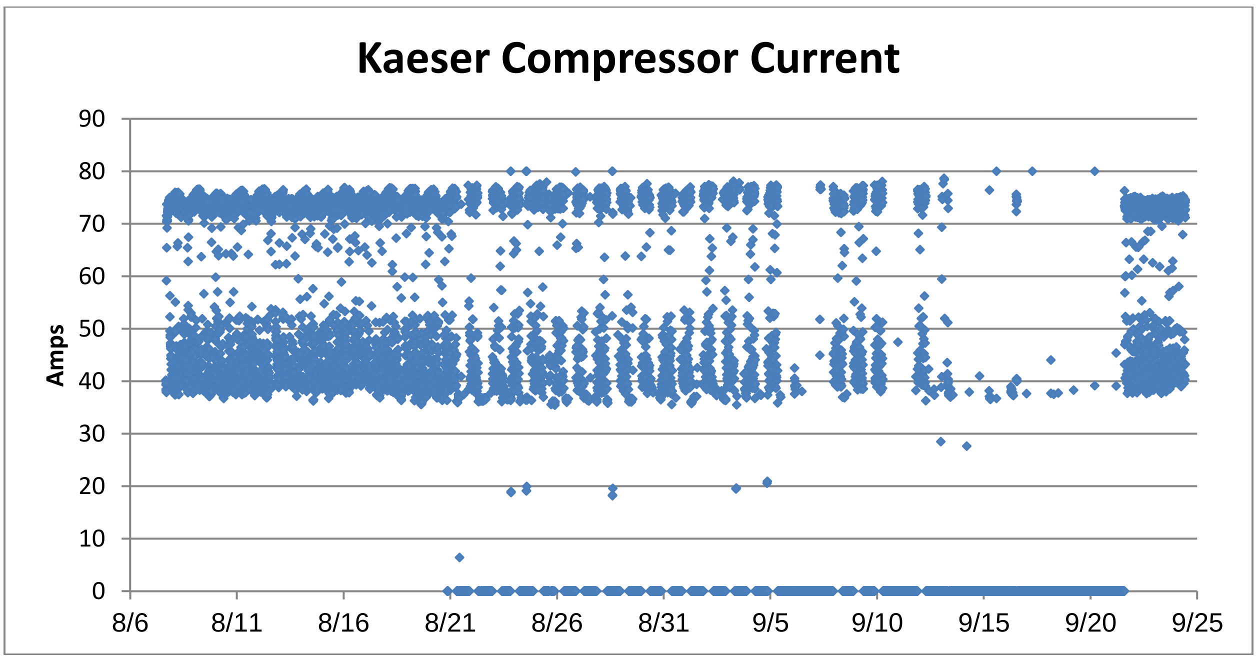

Figure 7: Unit 2 Air Compressor Motor Current

The motor current and power snapshots were used in conjunction with the compressor ratings to determine the airflow profile of both of the compressors. The power profiles for the two compressors were added together and averaged over the analysis period to determine the baseline energy usage, 366,545 kWh/yr. This was then reduced by 4% based on the 8 psi reduction in average operating pressure since 2013 and an estimated 1% savings for every 2 psi reduction in pressure. The new baseline energy use is therefore 351,889 kWh/yr The figure below displays the total airflow profile for all of the compressors.

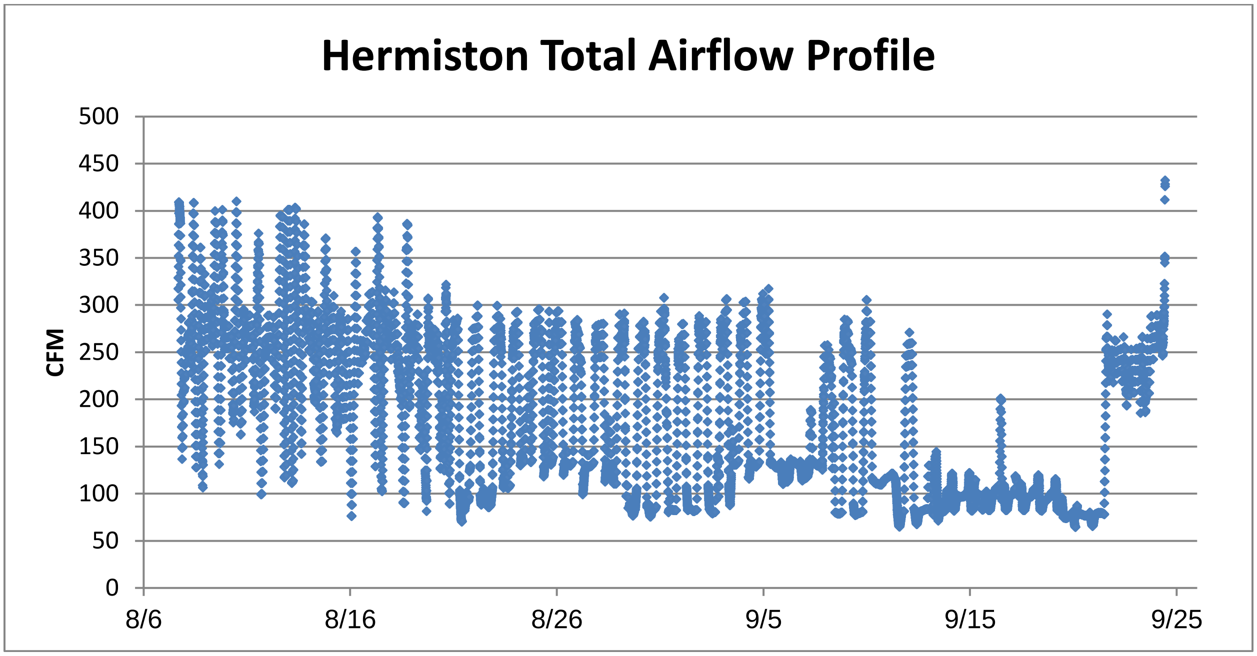

Figure 8: Hermiston Compressed Air Total Airflow Profile

The above airflow profile is averaged over 120 minutes to smooth out the data. The airflow of both compressors is added together because it is recommended the two systems be combined. The dryer purge air for the Sullair and Kaeser dryers was subtracted from the total airflow profile to create the plant airflow profile. The plant airflow profile was used as the starting point of the ECM analysis.

The plant airflow profile was used to determine the number of compressors needed. The number of compressors was used to determine the number of dryers needed. The number of dryers and capacity of the dryers was used to determine the purge rate for the compressors. The purge rate was added to the plant airflow profile to determine the total ECM airflow profile. The ECM total airflow profile was used to calculate the compressor capacity and power. The total compressor power profile was then averaged over the analysis period to determine the ECM energy usage, 245,970 kWh/yr.

5.4.3 Control System Trend Data

The calculated flow and power for the baseline and ECMs are shown in the following table.

Table 11: Compressed Air Overview

Operational Overview

Baseline Conditions	Full Load Capacity, ACFM	Average Airflow (Purge), ACFM	Peak Airflow, ACFM	Average Operating Plant Pressure, psig	Average Power, kW	Specific Efficiency, kW / 100 CFM	Annual Energy Consumption, kWh/yr
Sullair	260	103	164	110	21.4	20.8	187,371
Kaeser	197	80	291	113	20.5	25.7	179,174
Altas Copco	291	0	0	0	0.0	0.0	0
Sullair Dryer	254	38					
Kaeser Dryer	254	56					
Altas Copco Dryer	376	0					
Total	748	182	455	111	41.8	23.0	366,545

EEM	Full Load Capacity, ACFM	Average Airflow (Purge), ACFM	Peak Airflow, ACFM	Average Discharge Pressure, PSIG	Average Power, kW	Specific Efficiency, kW / 100 CFM	Annual Energy Consumption, kWh/yr
Sullair	260	136	260	105	27	20.0	238,546
Kaeser	197	2	138	105	1	34.6	7,424
Altas Copco	291	0	0	0	0	0	0
Sullair Dryer	254	19					
Kaeser Dryer	254	6					
Altas Copco Dryer	376	0					
Total	748	139	398	105	28	20.2	245,970

5.4.4 Control System Trend Results

The following summarizes the trends from the control system.

- In the baseline, the Sullair compressor operates 100% and the Kaeser compressor operates 55% of the time.

5.4.5 Key Assumptions for Baseline and ECM

- The compressed air system is pressurized year round.
- The total airflow profile represents year around operation.
- Heatless desiccant dryers operate when their respective compressor is on.
- The compressor ratings represent actual air production.
- The ECM compressors sequence as modeled.

5.4.6 Summary of Baseline and Estimated Energy Savings

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

Table 6: Summary of Baseline and Estimated Energy Savings for ECM 4

Baseline	
Annual Operating Hours	8,760
Average kW	40.17
Annual kWh	351,889

ECM 4	
Average kW	28.08
Annual kWh	245,970
Annual kWh Savings	105,919

6.0 EVALUATION, MEASUREMENT AND VERIFICATION

6.1 Purpose of Evaluation, Measurement and Verification

The purpose of Evaluation, Measurement, and Verification is to ensure 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:

- No variables need to be monitored

If ECM 3 is installed, the following variables will need to be monitored:

- Ensure controls have been installed as outlined
- Temperature control set points

If ECM 4 is installed, the following variables will need to be monitored:

- Motor amps on all three air compressors
- Compressor discharge pressure of all three compressors
- Desiccant dryer tower pressure on one tower for each of the three dryers

6.3 Personnel Required

One maintenance/electrical person will be required for approximately four hours for each ECM to assist in the inspection and monitoring of equipment. Hermiston Generating 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:

- Ensure new fixtures are installed as described
- Delay time for sensors, 15 minutes or less

If ECM 3 is installed:

- New temperature controls have been installed and set up as recommended

If ECM 4 is installed:

- Compressor control set-points for all three compressors
- Target discharge pressure for the system, 105 psi
- Installed and operating dryer demand controls
- One time power measurements for each compressor in order to verify the part load performance of the compressor

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.

7.0 ADDITIONAL SYSTEMS/EQUIPMENT REVIEWED

The following measures were identified and investigated to various levels in the 2013 report, and reexamined as part of this study update. They are not included in the final list of opportunities at this time due to low potential savings or reliability concerns. Some measures may be good candidates for further investigation in the future.

7.1 CURRENT EXEMPLARY PRACTICES

Several exemplary practices with regards to energy efficiency are already being implemented at Hermiston Generating. A VFD was installed on the Demin feedwater pump. Lighting has been upgraded in the Admin building. Heat trace controls and alarms appear to be functioning properly. Facility personnel are proactive in making their rounds, identifying problems, writing work orders and maintaining the equipment.

7.2 BOILER FEED WATER PUMP MODIFICATION

For each HRSG, condensate is pumped from the low pressure drum to both the intermediate pressure drum and the high pressure drum with a 1,750 HP boiler feed-water pump. Each pump has a total of 10 stages and the intermediate pressure take-off occurs at stage 3. Based on control system data, the pressure drop across the level control valves for the high pressure drum is about 600 ft. of H_2O and 500 ft. of H_2O for Unit 1 and Unit 2 respectively. Three alternatives exist to reduce this pressure drop and thus save electrical energy:

1. Install a VFD on the motor drive
2. De-stage the pump from 10 stages to 9 stages for the HP feed
3. Replace the impeller or impeller/diffuser combination

A VFD was not considered for this application because of the need to meet both HP and IP flow needs independently. If a VFD were to be installed and programmed to maintain a certain HP discharge pressure, then the IP flow would be affected which would require additional programming time and expense. An experienced design engineer for this pump manufacturer cautioned against de-staging these types of pumps without careful review by the designer, noting that the impact on the diffuser can cause major and unexpected problems with the pump performance. The most common approach for this particular pump is to replace the impeller or impeller/diffuser combination.

The energy savings were modeled the same way for both of the latter options so the determining factors are cost, complexity and reliability. The energy savings for both boiler feed water pumps is estimated to be 358 MWh/yr.

7.3 SCR BLOWERS

Selective catalyst reactor (SCR) blowers feed hot exhaust air (~570°F) through an ammonia vaporizer. The vapor is then fed through a feed header and distributed into an SCR to remove NO_x from the exhaust air. The temperature of the air must remain high enough to prevent the formation of undesired compounds that can foul the catalyst and downstream equipment. The vapor flow rate and pressure must meet minimum requirements for effective distribution through the distribution header. There is one 580 SCFM blower per HRSG, powered by a 25 hp, 460 V 3-phase Teco motor. The blowers do not have any controls, but simply blow the maximum amount of air available.

Premium efficiency motors were investigated as potential replacements for the existing blower motors, which would increase their efficiency from 90% to 94%. This resulted in an energy savings of only 0.6 MWh/yr per motor and therefore did not justify implementation.

VFDs were also considered for the blowers, but the blowers have been designed for specific operating conditions. The flow rate and pressure need to be maintained to guarantee even distribution through the SCR Feed Header. Without significant study and possible retrofits to the distribution header or the entire SCR system, the blowers cannot be slowed down without risking a reduction in NOx abatement.

7.4 Cooling Tower Fan VFDs

Both Units 1 and 2 have a water cooled condenser with an associated cooling tower. Each cooling tower has four 200 HP axial fans driven by single-speed, 460 V, 1800 RPM motors. Upgrading these fans with VFDs was considered as an energy efficiency measure. However, the only opportunity to reduce speed is when one, two, or three fans are shut down. When all fans are running, maximum cooling is achieved which results in increased turbine efficiency. When no fans are running, the unit is shut down. Turning off a portion of the fans is typically only done during winter operations in order to reduce risk of freezing. In addition, a separate air-conditioned building would be required to house the VFDs, which would also required significant rewiring.

A review of historical data showed that Unit 1 operated all four fans at 100% capacity for 277 days of the year, and Unit 2 255 days of the year. The days in which at least one fan was shut off for any portion of the day were analyzed for potential savings with a VFD. The estimated savings for Unit 1 were 117 MWh/yr and the savings for Unit 2 were 202 MWh/yr.

7.5 Electric Heat Trace

Most of the exterior piping has electrical heat tracing to prevent freezing during the winter. The facility provides this capability via four electric heat trace panels, each of which has a primary and secondary temperature sensor that enables and disables the electric heat trace based on outdoor temperature. Power is supplied to each heat trace panel transformer at 480 volts, then stepped down to 208/120 volts at that panel transformer. These panels can be switched from “Auto” to “Hand” or “Off”. Thermostats that are not functioning properly or are controlled manually have the potential to run when not needed and waste energy. Hermiston Generating has incorporated the heat trace control panels into its DCS, which indicates loss of voltage to a circuit, and indicates on which panel it has occurred. Each circuit rated for at least 20 amps also has a trip time delay to prevent false trouble alarms.

All panels were in “Auto” mode during our site visit. There is a prescribed maintenance work order to periodically check that the circuit indication lights are working properly. The DCS did not indicate any problems with any of these control panels during our site visit and operators confirmed that the system works well. Based on these controls and O&M practices, data logging was not viewed as worthwhile, nor were any energy savings opportunities judged to be likely.

7.6 Water Fire Suppression System

The source of fire protection water for the facility is the circulating water stored in the cooling tower basins. Each basin can supply two hours of water at system rated capacity. Each basin can be filled within eight hours via the plant raw water makeup line from the Columbia River. An underground fire main supplies water to plant fire hydrants and fixed water-based suppression systems.

The primary fire protection pump is a 3-stage, vertical Fairbanks Morse pump, rated for 2,000 gpm at 120 psig which takes suction from the Unit 1 cooling tower basin. This is powered by a 200 hp US Electric motor. A Metron Series M420 controller activates the pump if the system pressure falls below 90 psi.

This electric fire pump is backed up by a diesel-fueled fire pump which is identical to the electric fire pump (3-stage, vertical Fairbanks Morse 15H-7000F pump), but is powered by a 208 hp Cummins diesel engine and is connected to the Unit 2 cooling tower basin. The pump controller automatically starts the diesel fire pump when system pressure falls below 75 psi.

Finally, a 5 hp Fairbanks Morse jockey pump maintains a normal system operating pressure of 95-105 psig on each Unit while the system is in standby. If the jockey pump cannot maintain system pressure, the fire pump controller starts the main electric fire pump.

Since the main electric and diesel pumps are designed to only operate during a fire, no energy savings opportunities were investigated for them. However, a time-of-use logger was installed on the jockey pump to determine if system leaks were excessive and calculate potential energy savings that would result from fixing those leaks. This pump only operated 0.1% of the time, or only 16 hours of the year. Thus this system was judged to be very tight and no energy savings opportunities were identified.

7.7 Zero Discharge System

The Zero Discharge Waste Cooling Tower is a two cell (1 fan per cell), counterflow cooling tower designed to circulate 2,600 gpm of waste water from the main cooling tower blow down discharge. This cooling tower, coupled with the associated chemical treatment in the reactor clarifier, is designed to remove all solids from the cooling tower blow down streams, and thereby not discharge any water from the plant site. Each cooling tower fan is powered by a single speed, 30 hp General Electric motor. This cooling tower has not been used in many years, and the facility has no intentions of operating it in the near future, therefore there were no opportunities to pursue. If the plant chooses to operate this cooling tower in the future, it should be evaluated for potential ECMs.

7.8 Condensate Make-up Pumps

Two 15-hp Goulds centrifugal condensate make-up pumps provide demineralized water from the Demin water storage tank to the condenser of each unit. These two pumps are also piped such that they provide redundancy to each other – either can provide make-up water to either condenser, as well as wash water to either turbine. These pumps are controlled by a flow control valve that responds to the condenser water level, but which is also tied to the condensate pumps.

For the 2013 report, a time-of-use logger was installed on these make-up pumps and a power snapshot was taken to determine their baseline energy use and potential for energy savings if a VFD were installed to regulate flow instead of relying on the control valve. It was discovered that these pumps only draw an estimated 3,400 kWh/yr each because they only ran an average of 243 hours per year. Plant personnel indicated these run even less now than they did in 2013. These pumps are primarily used at start-up only. Once a vacuum is established within the condensers, condensate make-up water flows from the Demin storage tank to the condenser hotwell by means of that pressure differential. Because of this low baseline energy use, a VFD was determined to not be economical.

7.9 Condensate Pumps

Condensate is pumped from the condenser hotwell to the low pressure drum of the HRSG by means of a 250 HP, 4160 V, 2080 gpm capacity condensate pump. A three-way valve directs condensate to the LP drum either through or around the LP feedwater heater. A second flow control valve regulates feedwater flow from either the feedwater heater or bypass to the LP drum to maintain a constant drum water level.

Typically a pump drawing full power followed by a partially open control valve is an opportunity for energy savings. However, the cost to install a VFD on this pump is relatively expensive because the pump is medium voltage, and because of the additional complexity involved because of the three-way valve and interdependent flows. For these reasons, further investigation of pressure drops and flow rates of the various condensate streams was not undertaken.

7.10 Gland Steam Exhausters

Two gland steam exhausters operate in parallel on the gland steam condenser of each unit to remove non-condensable gases from the gland steam condenser. Only one exhauster operates at a time, and use is alternated to promote balanced equipment wear. Each blower inlet has a butterfly valve which is partially closed. Installing a VFD on a motor and allowing the butterfly valve to fully open is more energy efficient than operating the blower at full power and choking flow through this valve. Since 2013, three of the four fans and motors have been replaced and are now being controlled by the plant's DCS.

For the 2013 report, a time-of-use logger was installed on one of the 5 hp Unit, 2 exhauster blower motors and a power snapshot was taken to determine the baseline energy use. It was discovered that each operating blower only draws an estimated 2,900 kWh/yr while only operating approximately 1,989 hours per year. Because of this low baseline energy use, a VFD was determined to not be economical.