ENERGY ANALYSIS REPORT
FOR
INITIATIVE 937

Plant-wide Energy Conservation Measures

Located At:

Jim Bridger Plant – Point of Rocks, Wyoming
Chehalis Generation Facility – Chehalis, WA
Goodnoe Hills Wind Project – Goldendale, WA

Presented to:

PACIFICORP

Version 1

Submitted By:

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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 facilities 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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1.0 EXECUTIVE SUMMARY

1.1 Introduction and Background

PacifiCorp Energy 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. The State of Washington has recently passed legislation requiring PacifiCorp to complete all cost effective energy efficiency measures in these generation facilities.

The purpose of this report is to outline the systems investigated and detail the cost effective measures at three of the seven locations: Jim Bridger (Unit #1 only), Chehalis and Goodnoe Hills. 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 Jim Bridger Plant

1.2.1 Energy Conservation Measures (ECMs)

ECM 1: HVAC – 4th Floor Air Handler SE Corner (1VSF3)

Baseline: This system consists of a mixer box and one 75 HP fan blowing continually on the Mezzanine level. The mixer box is designed to provide as close to 60 ˚F air as possible using outside air and ambient air temperature from the top of the Turbine Room. The mixing louvers are not operating correctly and the operators report too much cool air on the Mezzanine level 50% of the year.

Proposed: Repair the mixer box louvers to operate correctly when cooling or heating (pneumatic controllers are suggested to prevent freezing damage). Install a VFD on the fan motor and control the speed with a new controller. Install a programmable thermostat to the controller that allows programming of maximum and minimum temperature band for heating and cooling modes. Set fan speeds to slow as temperature approaches targets.

This measure would add the following equipment:

- One 75 HP VFD with a controller and filters
- One programmable thermostat with heating and cooling bands to control VFD speed

ECM 2: HVAC – 9th Floor Fans (1VSF 1&2)

Baseline: This system consists of two 75 HP fans drawing air from the same mixer box that is designed to provide 60˚F air. Fan 1VSF1 sends air to the MCC on the Turbine Deck and fan 1VSF2 sends air to the 1st floor around the pulverizers. Currently, the mixer box does not operate properly, and cool air is sent to the locations regardless of the temperature around the MCC or the pulverizers. Bay heaters blow hot air on the same location that the fan blows cold air on the pulverizers. The fans run continuously throughout the year.

Proposed: Repair the mixer room louvers to operate correctly when cooling or heating (pneumatic controllers are suggested to prevent freezing damage). Install two VFDs on the fan motors and control the speeds with new controllers and thermostats. These should be located at the MCC on the turbine deck and at two locations in front of the pulverizers. Install a programmable thermostat to the controller that allows programming of maximum and minimum temperature bands for heating and cooling modes. Set fan speeds to slow as temperature approaches targets.

This measure would add the following equipment:

- Two 75 HP fan VFDs with controllers and filters.
- Two programmable thermostats with heating and cooling bands to control VFD speed.

ECM 3: HVAC – Chiller Controls

Baseline: This system consists of two chillers that cool water used in heat exchangers for the control room. These systems would require little cooling if the A-line Fans were working properly; as the control room is surrounded by the Turbine room air. There are two 10 HP pumps that transport water through the chillers continuously, whether or not the chiller is running. These pumps should be shut off when the chillers are not operating.

Proposed: Install an on/off controller for these two pumps that shuts them off when the respective chiller is off.

This measure would add the following equipment:

- Shut-Off controllers on the two chilled water pumps

ECM 4: RO Feed Pumps

Baseline: This system consists of three RO system trains; A, B and C. Trains A and B utilize three 60 HP RO feed pumps and train C has two 75 HP pumps. Trains A and B use a discharge control valve to deliver about 270 gpm of filtered water to the RO membranes. During normal operation two of the three trains are in operation. When Trains A and B are in operation only 2 of the three pumps are needed. Train C only needs one of two pumps to operate.

Proposed: RO feed pumps on Trains A and B should be upgraded with VFDs and controls to vary pump speed to deliver the required flow to the RO membranes.

This measure would add the following equipment:

- Six 60 HP pump VFDs
- VFD controls

ECM 5: Condensate Pumps

Baseline: The condensate pump system consists of three 700 HP 7,200 volt pumps that transport condensate from the discharge of the main turbine to the Deaerator (DA) tank. During normal operation two of the three pumps are needed to maintain the tank level in the DA tank. Two parallel discharge control valves are modulated to the desired DA tank level.

Proposed: The proposed changes would install new inverter rated motors with VFDs and necessary controls to regulate the pump speed. The pump speed will be varied to maintain the DA tank level. The existing control valves should be fully opened during normal operation.

This measure would add the following equipment:

- Three 700 HP 7,200 volt pump VFDs
- Three 700 HP 7,200 volt inverter duty motors
- VFD controls

ECM 6: HVAC – Turbine Room Fan and Mixer Bank

Baseline: This system consists of fourteen 20 HP fans that provide the bulk of the air to the power plant. These fans feed directly to the Turbine Room floor, the Mezzanine level and the 1st floor; all on the west wall. These fans are designed to mix outside air with inside air and heated air to continuously feed 60 ˚F air to these locations. They also control the ventilation fans that are on the ceiling of the Turbine Room. These fans are run and set manually. Existing mixer controls are not working on all fans. Newer gravity controlled louvers return hot ceiling air through the system regardless of what temperature air is needed. A few fans are not running properly or are turned off. Heating coils are not maintained and are bypassed in a few locations. Exhaust louvers are manually adjusted and are optimized for heating, even though the rooms are cooled a majority of the time. The result is higher temperatures than desired/needed throughout the plant and increased ventilation and blowing requirements at many locations in the plant.

Proposed: This measure would add the following equipment:

- Repair external and heating louver controls to function properly (pneumatic controls are recommended to reduce failures due to freezing). Repair all heating tube lines and turn on all fan units.
- Replace gravity controlled louvers with pneumatically controlled louvers tied to a new sequencing controller.
- Install VFDs on each fan pair (1 VFD per pair) and control to thermostat on the Turbine floor (away from diffuser on west wall).
- Install new digital temperature probes to replace current controllers. Use controller to mix air temperature (outside with ceiling air or heated air) to a desired range for cooling, and a desired range for heating. Use turbine floor thermostat to determine air flow requirements. Use a ceiling thermostat to control ceiling vent fans.
- Open all manual plenum louvers on the turbine floor to increase cooling capacity.

ECM 7: RO Supply Pumps

Baseline: This system consists of three 50 HP pumps; two pumps operate continuously. These pumps provide water from the filtered water storage tank to the RO feed pumps. There is a recirculation line back to the filtered water storage tank with a control valve that modulates in order to supply a pressure of 100 psi to the RO feed pumps.

Proposed: Upgrade each of the three, 50HP, RO Supply pumps with VFD control. Install controls to change pump speed to maintain a header pressure of 100 psi to the inlet of the RO feed pumps. Close the recirculation control valve and use pump speed only to control header line pressure.

This measure would add the following equipment:

- Three 50 HP pump VFDs
- VFD controls

ECM 8: Primary Air Fans

Baseline: This system consists of two 1,750 HP 7,200 volt centrifugal fans operating in parallel to supply air to the pulverizers and into the coal burners. Capacity control is achieved on both fans with variable inlet vanes. The fans maintain a static pressure of approximately 32 in WC in the air duct. Both fans are needed during normal operation.

Proposed: The proposed ECM is to install new 7,200 volt invertor duty motors and VFDs and speed controls. The existing inlet vane dampers should be removed and speed control used to meet the required flow and pressure based on unit load.

This measure would add the following equipment:

- Two 1,750 HP invertor duty 7,200 volt motors
- Two correctly sized VFDs
- VFD controls

ECM 9: Forced Draft Fans

Baseline: This system consists of two 2,250 HP 7,200 volt centrifugal fans that operate in parallel to provide secondary and overfire combustion air to the boiler. Capacity control is achieved by variable inlet vanes. The fans maintain a static pressure of approximately 16 in WC in the duct. Both fans are needed during normal operation.

Proposed: The proposed ECM is to install new 7,200 volt invertor duty motors and VFDs with controls. The existing inlet vane dampers should be removed and speed control used to meet the required flow and pressure based on unit load.

This measure would add the following equipment:

- Two 2,250 HP invertor duty 7,200 volt motors
- Two correctly sized VFDs
- VFD controls

Note: There is a possibly that operating the forced draft fans at reduced speed with a VFD could result in unstable operation. The fan manufacturer should be consulted before proceeding with this ECM.

ECM 10: Lighting
Baseline: The interior and exterior lighting of the Unit #1 building area and corresponding coal handling areas have a variety of high pressure sodium and T12 fluorescent fixtures and lamps. With the exception of some minor offices the lighting is on continuously.

Proposed: The proposed system would replace the existing fixtures and lamps with a combination of T5/T8 fluorescent, Metal Halide Pulse Start and LED. Daylight and occupancy controls are recommended in areas as appropriate.

This measure would add the following equipment:

- Combination of T5/T8 fluorescent, metal halide pulse start and LED fixtures and lamps
- Daylight and occupancy controls as appropriate

1.3 Summary of Opportunities for Chehalis Generation Facility

1.3.1 Energy Conservation Measures (ECMs)

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.

Proposed: This measure would upgrade one of the 550 HP centrifugal pumps with a variable speed drive. The pump is delivering flow beyond the design requirements in its current state. The pump only needs to operate at 87% speed to deliver the design flow required by the system. When the plant is down, the pump could be slowed significantly more.

This measure would add the following equipment:

- One 6,600V 550 HP VFD on one 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 from 73°F to 92°F

This measure would add the following equipment:

- Fourteen 40 HP VFDs on each of the CCW fans along with appropriate controls.

ECM 3: High Efficiency Lighting System
Baseline: High pressure sodium (HPS) fixtures illuminate the Turbine Building, Maintenance Shop, Air Compressor Room and the building's exterior. The interior HPS lighting fixtures are manually controlled and operate continuously and the exterior lighting fixtures are controlled with a photo-eye and turn-off during the daytime. The other areas of the facility such as office, mechanical and electrical areas are illuminated with T8 lighting with the exception of the Maintenance Office, which is illuminated with T12 lighting. With the exception of lighting in individual offices, it was observed that all interior lighting operated continuously.

Proposed: Perform a complete lighting retrofit, replacing all interior HPS and fluorescent T12 fixtures with more efficient T5HO or T8 fluorescent fixtures with occupancy sensors. Office areas that are already equipped with T8 fixtures would be retrofit with additional occupancy sensors.

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

ECM 5: Reverse Osmosis Pump VFDs
Baseline: The facility uses demineralized water for makeup water. Raw water is pretreated before being fed through two reverse osmosis (RO) filter passes and an electrolysis E-Cell. The E-Cell requires stable feed conditions, and flow rate is carefully controlled. The first RO filter pass is fed by one of two 100 HP torpedo pumps. The second RO filter pass is fed by one of two 75 HP torpedo pumps. Both sets of pumps are manually throttled at the discharge to reduce

the pressure from over 500 psig to around 300 psig to protect the RO filters and maintain flow rate.

Proposed: Install a VFD on one 100 HP RO pump and one 75 HP RO pump. Operating the pumps at a reduced speed will allow the pumps to operate at lower discharge pressures while maintaining the required flow to the reverse osmosis system.

This measure would add the following equipment:

- One 100 HP VFD
- One 75 HP VFD
- VFD controls

ECM 6: LP Economizer Recirculation Pumps

Baseline: One 75 HP low pressure (LP) economizer recirculation pump serves each Heat Recovery Steam Generator (HRSG). The pumps recirculate a portion of the LP Economizer discharge back to the inlet to maintain the exhaust stack gas temperature above 200°F to prevent the formation of sulfuric acid. To improve temperature control, another bypass line was added to the condensate line. This line has a temperature control valve (TCV) which allows condensate to bypass the LP economizer based on stack temperature. The plant occasionally operates without the pumps, but with compromised stack temperature control.

Proposed: By controlling exhaust gas temperature using the LP Economizer Bypass Control Valve to regulate condensate flow to the LP Economizer, the 75 HP LP Economizer Recirculation Pumps can be turned off. The facility currently cannot consistently operate the existing TCV without operating the pumps because of reduced control of exhaust gas temperatures. This measure recommends, as a first step, a thorough commissioning of the TCV to ensure proper operation. If the valve is found to be working properly, additional control logic should be added to coordinate the TCV and the two motorized ball valves that feed and bypass the low pressure economizer. With proper flow control through these valves the recirculation pump is not necessary.

This measure would add the following equipment:

- Pump controls if needed

ECM 7: New Variable Speed Air Compressor

Baseline: A single two-stage Kobelco oil free load/unload screw compressor serves the compressed air needs of the entire plant. The plant has a rented diesel powered compressor that can be connected in case of a failure of the Kobelco compressor.

Proposed: This energy efficiency measure consists of installing an oil lubricated variable speed compressor. This would improve the part load efficiency of the compressor and also allow the system to be operated at a lower average discharge pressure, further reducing the load on the compressor. The existing oil free load/unload compressor would be used as the backup compressor and the rental compressor could be returned.

This measure would add the following equipment:

- One 125 HP oil-free variable speed twin screw air compressor with appropriate filters

ECM 8: Reduce Runtime of Electric Heat Trace
Baseline: Most of the exterior piping has electrical heat tracing to prevent freezing during the winter. The electric heat trace panels have thermostats that enable and disable the electric heat trace based on outdoor temperature. However, these thermostats are not functioning properly and thus are controlled manually. Manual control of the electric heat trace results in additional runtime.

Proposed: Install new thermostats to disable the electric heat trace when ambient conditions permit.

This measure would add the following equipment:

- Fix or replace the thermostats controlling the electric heat trace panels in the following locations:
  - 685-HTCP-40001
  - 685-HTCP-50000
  - Heat Trace near Air Cooled Condenser
  - Two heat trace panels in Turbine Building

ECM 9: Adjust Thermostat on One Electric Heater
Baseline: Twenty-seven 20 kW electric heaters provide heating to the Turbine building. The electric heaters are controlled with integral thermostats. Data logging indicated that most of the electric heaters were off, but the electric heater located on the second column of the southeast corner of the Turbine Building operated 92.9% of the time.

Proposed: Adjust thermostat such that 20 kW electric heater operates in the same manner as the other twenty-six 20-kW electric heaters.

ECM 10: Demand-based Dew Point Controls
Baseline: Two Ingersoll Rand TZ300 heatless dryers serve the Instrument Airline on the compressed air system. They are set to “Dryer On” mode and are reading a dew point of -95°C. This mode results in the continuous use of purge air by the dryers.

Proposed: This measure requires repairing, calibrating, or replacing the moisture sensors in the desiccant dryers. Once the sensors are functioning properly, the dryers can be set to operate in their “EMS” mode. This mode only regenerates the dryers enough to maintain the desired dew point in the Instrument Air stream, rather than continuously regenerating as is the case currently. The amount of purge air and subsequent load on the compressors would be reduced.

This measure would add the following equipment:

- Two new hygrometers, one on each of the two Ingersoll Rand TZ300 heatless dryers serving the Instrument Air line

1.4 Summary of Opportunities for Goodnoe Hills Wind Project

1.4.1 Energy Conservation Measures (ECMs)

ECM 1: Lighting Occupancy Sensors in O&M Building Garage Area
Baseline: 48 CFL fixtures in the O&M building garage remain in operation during facility operating hours whereas the space is mainly occupied in the morning period.

Proposed: Install occupancy sensors to control the 48 CFL fixtures in the O&M garage room.

This measure would add the following equipment:

- Two occupancy sensors in O&M garage area

ECM 2: Instant Water Heater in the O&M Building
Baseline: A conventional electric water heater with storage is used for domestic hot water applications.

Proposed: Replace the existing conventional water heater with an instantaneous water heater.

This measure would add the following equipment:

- Instantaneous Water Heater

1.5 ECM ECONOMICS FOR JIM BRIDGER PLANT

Table 1 below shows the life cycle cost effective electrical efficiency for Jim Bridger Plant. The avoided cost resource for the 10 year measure life was obtained from Pete Warnken of PacifiCorp's IRP Group. The avoid cost table was created with the following parameters; 0.56 MW Program (Motor), September 2010 BP FPC $19 CO2. The resource used resulted in a 20 year leveled cost of $93.51/MWh at a discount rate of 7.17%. With the 10% multiplier, the leveled cost for with a discount rate of 7.17% is $102.69 /MWh.

Table 1: ECM Economics for Jim Bridger Plant

				Ann. Benefits	Initial Investments				Ann. Invest.			
ECM No.	Description	Avoid Cost Resource	Measure Life (yrs)	Annual Energy Savings (MWh/yr)	Installed Costs ($)	EM&V Costs ($)	Engineering Fees ($)	Spare Parts Costs ($)	O & M Costs ($/yr)	Net Present Benefit ($)	Net Present Cost ($)	Total Resource Cost Test
1	Air Handler 4th Floor SE Corner (1VSF3)	JB Model	10	199	$28,404	$6,000	$2,840	$852	$852	$128,470	($44,035)	2.92
2	9th Floor Fans (1VSF 1&2)	JB Model	10	370	$48,558	$6,000	$4,856	$1,457	$1,457	$238,864	($71,023)	3.36
3	Chiller Controls	JB Model	10	67	$3,960	$6,000	$396	$119	$119	$43,254	($11,303)	3.83
4	RO Feed Pumps	JB Model	10	136	$118,396	$4,000	$11,840	$3,552	$3,552	$88,007	($162,539)	0.54
5	Condensate Pumps	JB Model	10	5,074	$1,776,313	$10,000	$177,631	$53,289	$53,289	$3,275,590	($2,388,592)	1.37
6	Turbine Room Fan and Mixer Bank	JB Model	10	262	$115,253	$6,000	$11,525	$3,458	$3,458	$169,142	($160,330)	1.05
7	RO Supply Pumps	JB Model	10	124	$50,696	$4,000	$10,000	$1,521	$2,000	$80,158	($80,154)	1.00
8	Primary Air Fans	JB Model	10	4,838	$1,462,142	$10,000	$146,214	$43,864	$43,864	$3,123,309	($1,967,898)	1.59
9	Forced Draft Fans	JB Model	10	1,865	$1,598,542	$10,000	$159,854	$47,956	$47,956	$1,204,004	($2,150,546)	0.56
10	Lighting	JB Model	12	2,323	$745,883	$4,000	$37,294	$22,376	$22,376	$1,721,271	($985,683)	1.75

NOTES:

1. ECMs 4 and 9 do not pass the Total Resource Cost Test.
2. Vendor quotes for installed costs were obtained were possible. Some information was not received at deadline.
3. Estimates for engineering fees were based on 10% of installed cost.
4. Estimates for spare parts were based on 3% of installed cost.
5. Estimates for O&M fees were based on 3% of installed cost.

1.6 ECM Economics for Chehalis Generation Facility

Table 2 below shows the life cycle cost effective electrical efficiency for Chehalis Generation Facility. The avoided cost resource for the 10 year measure life was obtained from the PacifiCorp – 2011 IRP Addendum Table 10 – Annual Nominal Class 2 DSM Avoided Costs, Medium CO_2 Tax Scenario, 2011 – 2030. The resource used is West – Water Heating with a 10% multiplier, which resulted in a leveled cost of $105.73/MWh at a discount rate of 7.17%. Without the 10% multiplier, the leveled cost for West Water Heating with a discount rate of 7.17% is $96.12 /MWh.

Table 2: ECM Economics for Chehalis Generation Facility

ECM No.	Description	Avoided Cost Resource	Measure Life (yrs)	Ann. Benefits: Annual Energy Savings (MWh/yr)	Initial Investments: Installed Costs ($)	Initial Investments: EM&V Costs ($)	Initial Investments: Engineering Fees ($)	Initial Investments: Spare Parts Costs ($)	Ann. Investment: O & M Costs ($/yr)	Net Present Benefit ($)	Net Present Cost ($)	Total Resource Cost Test (-)
1	CCW Pump Speed Control	Chehalis Model	10	1,586	$368,088	$9,000	$36,809	$11,043	$11,043	$1,038,262	($501,892)	2.07
2	CCW Fan VFDs and Temp. Reset	Chehalis Model	10	455	$202,044	$10,000	$20,204	$6,061	$6,061	$297,919	($280,549)	1.06
3	High Efficiency Lighting	Chehalis Model	10	246	$100,682	$5,034	$10,068	$3,020	$3,020	$161,292	($139,853)	1.15
4	Install Small Condensate Pump	Chehalis Model	10	219	$98,043	$4,902	$9,804	$2,941	$2,941	$143,452	($136,188)	1.05
5	(2) Reverse Osmosis Pump VFDs	Chehalis Model	10	178	$63,920	$5,216	$6,392	$1,918	$1,918	$116,307	($90,809)	1.28
6	Reduce LP Economizer Recirculation Pump Use	Chehalis Model	10	83	$26,400	$5,216	$2,640	$792	$792	$54,078	($40,567)	1.33
7	New Variable Speed Air Compressor	Chehalis Model	10	52	$16,985	$5,000	$1,699	$510	$510	$34,187	($27,744)	1.23
8	Reduce Runtime of Electric Heat Trace	Chehalis Model	10	39	$10,000	$2,500	$1,000	$300	$300	$25,244	($15,891)	1.59
9	Adjust Thermostat on One Electric Heater	Chehalis Model	10	37	$200	$500	$0	$0	$0	$24,334	($700)	34.76
10	Demand-based Dew Point Controls	Chehalis Model	10	29	$2,420	$500	$242	$73	$73	$18,877	($3,741)	5.05

NOTES:

1. All vendor quotes were provided without the benefit of as built drawings and 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. Estimates for O&M fees were based on 3% of installed cost.

1.7 ECM Economics For Goodnoe Hills Wind Project

Table 3 below shows the life cycle cost effective electrical efficiency for Goodnoe Hills Wind Project. The avoided cost resource for the 10 year measure life was obtained from the PacifiCorp – 2011 IRP Addendum Table 10 – Annual Nominal Class 2 DSM Avoided Costs, Medium CO_2 Tax Scenario, 2011 – 2030. The resource used is West – Water Heating with a 10% multiplier, which resulted in a leveled cost of $105.73/MWh at a discount rate of 7.17%. Without the 10% multiplier, the leveled cost for West Water Heating with a discount rate of 7.17% is $96.12 /MWh.

Table 3: ECM Economics for Goodnoe Hills Wind Project

				Ann. Benefits	Initial Investments				Ann. Invest.			
ECM No.	Description	Avoid Cost Resource	Measure Life (yrs)	Annual Energy Savings (MWh/yr)	Installed Costs ($)	EM&V Costs ($)	Engineering Fees ($)	Spare Parts Costs ($)	O & M Costs ($/yr)	Net Present Benefit ($)	Net Present Cost ($)	Total Resource Cost Test
1	O&M Building Lighting: Controls	JB Model	12	1.092	$193	$0	$0	$6	$6	$832	($244)	3.41
2	Instant Water Heater	JB Model	10	0.488	$990	$0	$0	$30	$30	$319	($1,227)	0.26

NOTE: ECM 2 does not pass the Total Resource Cost Test.

1.8 Two-Year Plan and Ten-Year Savings For Jim Bridger Plant

Table 4 shows the two and ten-year cost effective production efficiency for Jim Bridger Plant.

Table 4: Two and Ten-Year Plan for Jim Bridger Plant

2 Year Biennium Targets: Jim Bridger Unit #1		
Years	2012	2013
Energy Conservation Measures Implemented	1,2,3	6,7,10

Years	2012	2013
Energy Conservation, MWh	636	2,709
Energy Conservation, MW	0.073	0.309

10 Year Goal: Jim Bridger Unit #1					
Years	2012/2013	2014/2015	2016/2017	2018/19	2020/2022
Energy Conservation Measures Implemented	1,2,3,6,7,10	5,8			

Years	2012	2013	2014	2015	2016
Energy Conservation, MWh	636	2,709	9,912	0	0
Energy Conservation, MW	0.073	0.309	1.131	0	0

Years	2017	2018	2019	2020	2021
Energy Conservation, MWh	0	0	0	0	0
Energy Conservation, MW	0	0	0	0	0

1.9 Two-Year Plan and Ten-Year Savings For Chehalis Generation Facility

Table 5 shows the two and ten-year cost effective production efficiency for Chehalis.

Table 5: Two and Ten-Year Plan for Chehalis Generation Facility

2 Year Biennium Targets: Chehalis		
Years	**2012**	**2013**
Energy Conservation Measures Implemented	8,9,10	3,6,7

Years	**2012**	**2013**
Energy Conservation, MWh	105	382
Energy Conservation, MW	0.012	0.044

10 Year Goal: Chehalis					
Years	**2012/2013**	**2014/2015**	**2016/2017**	**2018/19**	**2020/2022**
Energy Conservation Measures Implemented	8,9,10,3,6,7	1,2,4,5			

Years	**2012**	**2013**	**2014**	**2015**	**2016**
Energy Conservation, MWh	487	2,453	0	0	0
Energy Conservation, MW	0.056	0.280	0	0	0

Years	**2017**	**2018**	**2019**	**2020**	**2021**
Energy Conservation, MWh	0	0	0	0	0
Energy Conservation, MW	0	0	0	0	0

1.10 Two-Year Plan and Ten-Year Savings For Goodnoe Hills Wind Project

Table 6 shows the ten year cost effective production efficiency for the Goodnoe Hills Wind Project.

Table 6: Two and Ten-Year Plan for Goodnoe Hills

2 Year Biennium Targets: Goodnoe Hills		
Years	**2012**	**2013**
Energy Conservation Measures Implemented	1	

Years	**2012**	**2013**
Energy Conservation, MWh	1.092	0
Energy Conservation, MW	0.000	0

10 Year Goal: Goodnoe Hills					
Years	**2012/2013**	**2014/2015**	**2016/2017**	**2018/19**	**2020/2022**
Energy Conservation Measures Implemented	1				

Years	**2012**	**2013**	**2014**	**2015**	**2016**
Energy Conservation, MWh	1.092	0	0	0	0
Energy Conservation, MW	0.000	0	0	0	0

Years	**2017**	**2018**	**2019**	**2020**	**2021**
Energy Conservation, MWh	0	0	0	0	0
Energy Conservation, MW	0	0	0	0	0

2.0 PLANT AUXILIARY BASELINE ENERGY USE FOR JIM BRIDGER PLANT

2.1 Plant Description

The Jim Bridger is a coal-fired power plant located 30 miles east of Rock Springs, WY. The facility is 66% owned by PacifiCorp and 33% owned by Idaho Power. The facility produces approximately 2,200 MW of electricity at full load between 4 operating units. Jim Bridger is one of PacifiCorp's flagship generating stations and produces energy for customers in six regional states.

2.2 Plant Baseline Description

The plant operates continuously with one extended outage per unit every four years. The energy to operate the facility is provided via three transformers, the auxiliary load and two start-up/common transformers. The auxiliary transformer pulls power directly off the generation line and provides power back into the facility to operate all of the dedicated unit equipment. The start-up/common transformers provide power from the grid to the facility to commonly shared pieces of equipment; i.e. air compressors, coal handlings and fuel gas clean-up equipment, etc.

During initial site visits, estimated energy usage by all of the equipment throughout the facility was calculated to determine the breakdown of energy use by system. The chart below shows the energy breakdown for the Jim Bridger Unit #1 and common equipment. A full list of the equipment as located in the Appendix.

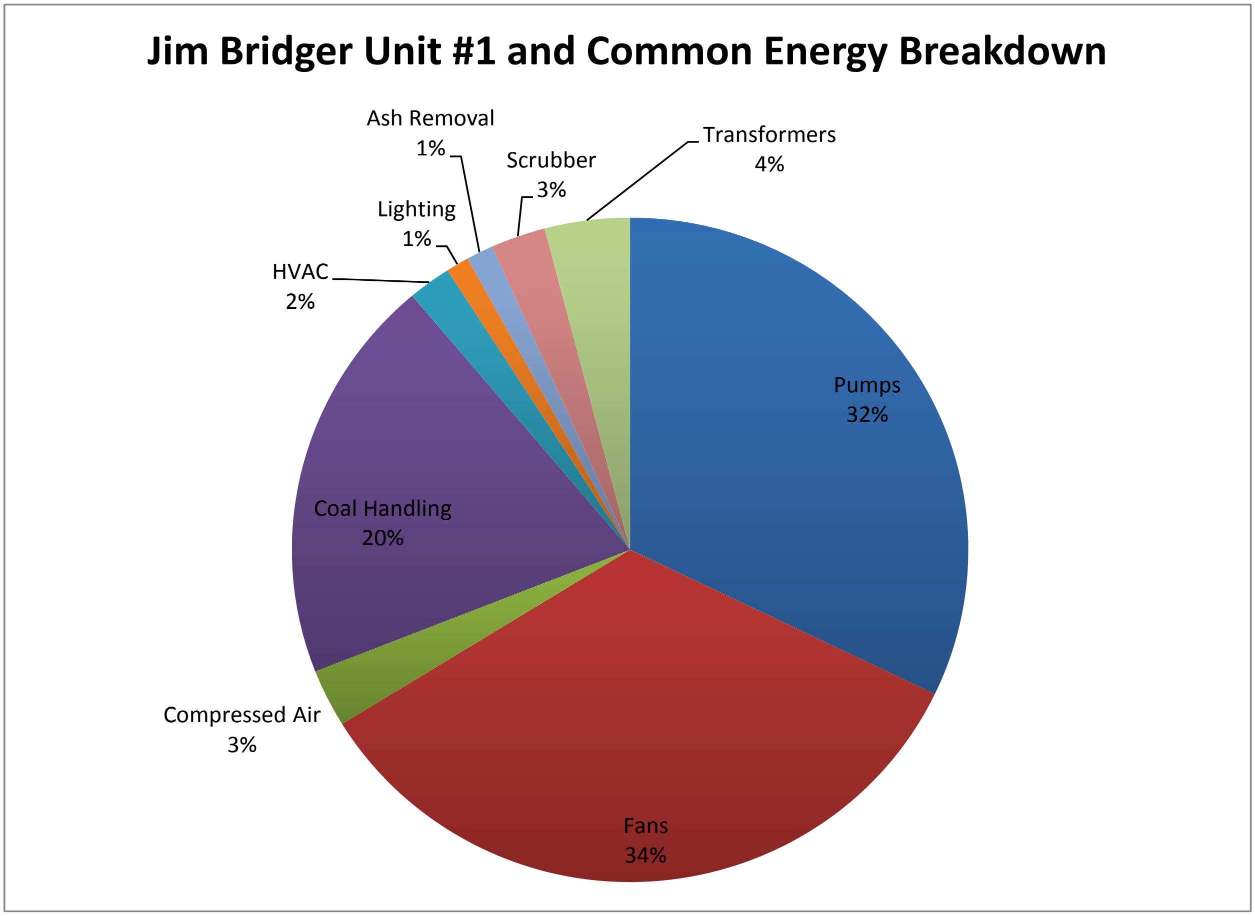


Figure 1: Jim Bridger Energy Breakdown

3.0 DETAILED DESCRIPTION OF PROPOSED EQUIPMENT AND OPERATION FOR JIM BRIDGER PLANT

3.1 ECM 1: 4TH FLOOR AIR HANDLER SE CORNER

3.1.1 ECM 1 – Source of Energy Savings

Slowing the speed of the fans when less cooling or heating is needed will require less energy. Controlling fans with speed control is more energy efficient than damper control or operating the fan at full speed when full speed is not needed. By mixing the air correctly, cooling and heating will be achieved more efficiently and the fans can be slowed more often.

3.1.2 ECM 1 – Specific Equipment Recommendations

- Repair the existing louver mixer controls, replacing broken actuators with pneumatic ones.
- Install a programmable thermostat on the Mezzanine level. Ensure that the thermostat can be programmed for automatic heating and cooling with a range of acceptable temperatures for both where the VFD can be programmed to slow the fan speed.
- Install a VFD controller on the fan that is programmed to a minimum speed (20%), and is controlled by the programmable thermostat.
- Install any recommended line reactors and filters.

3.1.3 ECM 1 – Set-points Recommended to Achieve Energy Performance

- The programmable thermostat should be programmed to heat at full speed when temperatures are 60˚F or lower.
- The thermostat should be programmed to cool at full speed when the temperature is 80 ˚F or higher.
- Between 60 and 80˚F, the fan should be programmed to slow from 60˚F to 70˚F where its minimum speed is maintained. The fan should increase its speed, cooling from 70 to 80˚F.

3.2 ECM 2: 9TH FLOOR FANS

3.2.1 ECM 2 – Source of Energy Savings

Slowing the speed of the fans when less cooling or heating is needed will require less energy. Controlling fans with speed control is more energy efficient than damper control or operating the fan at full speed when full speed is not needed. By mixing the air correctly, cooling and heating will be achieved more efficiently and the fans can be slowed more often.

3.2.2 ECM 2 – Specific Equipment Recommendations

- Repair the existing louver mixer controls, replacing broken actuators with pneumatic ones.

- Install a programmable thermostat both on the MCC on the Turbine floor and on the 1st floor near the pulverizers. Ensure that the thermostats can be programmed for automatic heating and cooling with a range of acceptable temperatures for both where the VFD can be programmed to slow the fan speed.
- Install a VFD controller on the fan that is programmed to a minimum speed (20%), and is controlled by the programmable thermostat.
- Install any recommended line reactors and filters.

3.2.3 ECM 2 – Set-points Recommended to Achieve Energy Performance

- The programmable thermostats should be programmed to heat at full speed when temperatures are 60˚F or lower.
- The thermostat should be programmed to cool at full speed when the temperature is 80 ˚F or higher.
- Between 60 and 80˚F, the fan should be programmed to slow from 60˚F to 70˚F where its minimum speed is maintained. The fan should increase its speed, cooling from 70 to 80˚F.

3.3 ECM 3: Chillers Controls

3.3.1 ECM 1 – Source of Energy Savings

- When the chillers are not running, the chilled water does not need to be pumped in the loop. Turning off the pumps when they are not required will save energy.

3.3.2 ECM 1 – Specific Equipment Recommendations

- Install an On/Off controller on the chiller pumps that are tied to the power on the chillers.

3.3.3 ECM 1 – Set-points Recommended to Achieve Energy Performance

- None

3.4 ECM 4: RO Feed Pumps

3.4.1 ECM 4 – Source of Energy Savings

- Controlling pump flow rate using speed control is more energy efficient than using a discharge control valve.
- The existing system uses a discharge control valve to maintain a target flow rate to the RO membranes.
- The VFD driven RO feed pumps will use speed control instead of a control valve to provide the required flow and pressure to the system.
- To maximize energy savings, control both operating RO feed pumps to the same speed in order to obtain the required permeate flow rate.

3.4.2 ECM 4 – Specific Equipment Recommendations

- Install six 60 HP VFDs and any recommended line reactors and filters on the six RO feed pumps.
- Install controls to control pump speed to the required flow rate.

3.4.3 ECM 4 – Set-points Recommended to Achieve Energy Performance

- Use the existing flow meter to control the VFD pump speed to target a 250 gpm permeate flow.
- Eliminate the use of the discharge control valve for flow control. Use the existing control valve for isolation purposes only.

3.5 ECM 5: CONDENSATE PUMPS

3.5.1 ECM 5 – Source of Energy Savings

- Controlling pump flow rate using speed control is more energy efficient than using a discharge control valve.
- The existing pump system uses parallel control valves to maintain a DA tank level.
- The VFD driven condensate pumps will use speed control instead of parallel control valves to provide the required DA tank level.
- To maximize energy savings, control both operating condensate pumps to the same speed in order to obtain the required DA tank level.

3.5.2 ECM 5 – Specific Equipment Recommendations

- Install three 700 HP 7,200 volt VFDs with any recommended line reactors and filters on the three condensate pumps.
- Install controls to control pump speed to maintain DA tank level. Use the existing control valves for isolation purposes only.

3.5.3 ECM 5 – Set-points Recommended to Achieve Energy Performance

- Control the condensate pump speed to target the same DA tank level as currently used.
- Control both condensate pumps to the same pump speed.
- Program the VFDs to have a minimum pump speed as recommended by the pump manufacturer.

3.6 ECM 6: TURBINE ROOM FAN AND MIXER BANK

3.6.1 ECM 6 – Source of Energy Savings

Slowing the speed of the fans when less cooling or heating is needed will require less energy. Controlling fans with speed control is more energy efficient than damper control or operating the fan at full speed when full speed is not needed. By mixing the air correctly, cooling and heating will be achieved more efficiently and the fans can be slowed more often.

3.6.2 ECM 6 – Specific Equipment Recommendations

- Repair the existing louver mixer controls, replacing broken actuators with pneumatic ones.

- Install a programmable thermostat on the Turbine floor. Ensure that the thermostats can be programmed for automatic heating and cooling with a range of acceptable temperatures for both where the VFD can be programmed to slow the fan speed.
- Install a VFD controller on the fourteen fans that is programmed to a minimum speed (20%), and are controlled by the programmable thermostat.
- Install any recommended line reactors and filter on the VFD.
- Install a thermostat on the ceiling that is tied to the programmable controller that will turn on the ceiling ventilation fans when cooling.

3.6.3 ECM 6 – Set-points Recommended to Achieve Energy Performance

- The programmable thermostat installed on the turbine room floor should be programmed to heat at full speed when temperatures are 60˚F or lower.
- The thermostat should be programmed to cool at full speed when the temperature is 80 ˚F or higher.
- Between 60 and 80 ˚F , the fan should be programmed to slow from 60 ˚F to 70 ˚F where its minimum speed is maintained. The fan should increase its speed, cooling from 70 to 80˚F .
- When heating is required, the louvers that open to the ceiling air should be opened at 65˚F . When the temperature reaches 62˚F , the heated coil louvers should be opened as well. When temperatures reach 60˚F , only the heated louvers should be opened.
- When ceiling temperatures reach 85˚F , the ceiling vents should be turned on to release the heat.

3.7 ECM 7: RO Supply Pumps

3.7.1 ECM 7 – Source of Energy Savings

- Controlling pump discharge pressure using speed control is more energy efficient than using a recirculation loop.
- The existing pump system uses a recirculation line with a control valve to maintain a header line pressure.
- The VFD driven RO supply pumps will use speed control instead of a recirculation line to maintain the required header line pressure.
- To maximize energy savings control both operating RO supply pumps to the same speed in order to obtain the required header pressure.

3.7.2 ECM 7 – Specific Equipment Recommendations

- Install three 50 HP VFDs and any recommend line reactors and filters on the supply pumps.
- Install any controls needed to control pump speed to the header line pressure.

3.7.3 ECM 7 – Set-points Recommended to Achieve Energy Performance

- Use the existing header line pressure reading to control the pump speed.
- Program both operating RO supply pumps to run at the same pump speed.
- Program the minimum VFD speed as recommended by the pump manufacturer.

3.8 ECM 8: Primary Air Fans

3.8.1 ECM 8 – Source of Energy Savings

- Controlling fan flow rate and pressure using speed control is more energy efficient than damper controls.
- The existing primary air fans use inlet vane damper control to modulate flow and pressure.
- The VFD driven primary air fans will use speed control instead of damper control to maintain the required pressure and flow.
- To maximize energy savings, control both primary air fans to the same speed in order to obtain the required flow and pressure.

3.8.2 ECM 8 – Specific Equipment Recommendations

- Install two new premium efficiency 1,750 HP inverter duty motors.
- Install two new correctly sized VFDs and any recommended line reactors and filters on both primary air fans.
- Install any controls needed to control fan speed to the required flow and pressure.

3.8.3 ECM 8 – Set-points Recommended to Achieve Energy Performance

- Use the existing control points to control the fan speed.
- Program both forced draft fans to operate at the same fan speed.
- Program the minimum VFD speed as recommended by the fan manufacturer.

3.9 ECM 9: Forced Air Fans

3.9.1 ECM 9 – Source of Energy Savings

- Controlling fan flow rate and pressure using speed control is more energy efficient than damper controls.
- The existing forced draft fans use inlet vane damper control to modulate flow and pressure.
- The VFD driven forced draft fans will use speed control instead of damper control to maintain the required pressure and flow.
- To maximize energy savings, control both forced draft fans to the same speed in order to obtain the required flow and pressure.

3.9.2 ECM 9 – Specific Equipment Recommendations

- Install two new premium efficiency 2,250 HP inverter duty motors.
- Install two new correctly sized VFDs and any recommended line reactors and filters on both forced draft fans.
- Install any controls needed to control fan speed to the required flow and pressure.

3.9.3 ECM 9 – Set-points Recommended to Achieve Energy Performance

- Use the existing control points to control the fan speed.
- Program both forced draft fans to operate at the same fan speed.
- Program the minimum VFD speed as recommended by the fan manufacturer.

3.10 ECM 10: LIGHTING

3.10.1 ECM 10 – Source of Energy Savings

- The existing fixtures and lamps are inefficient and on continuously. Installing more energy efficient fixtures and reducing operating hours where appropriate will reduce energy usage.

3.10.2 ECM 10 – Specific Equipment Recommendations

- The recommended fixture and lamps with controls are outlined in the Appendix.

3.10.3 ECM 10 – Set-points Recommended to Achieve Energy Performance

- No set-points recommended

4.0 ENERGY EFFICIENCY MEASURE COSTS FOR JIM BRIDGER PLANT

The table below shows the collected vendor and estimated project cost for each ECM.

Table 7: EEM 1-10

EEM 1: Air Handler 4th Floor SE Corner (1VSF3)					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	VFD, Frame, I/O kit and Closet	Codale	1	$9,472	$9,472.00
2	Installation	Estimate	1	$3,400	$3,400
3	Cableing, control conduits, materials	Estimate	1	$2,100	$2,100
4	Programmable / smart thermostat	Johnson	1	$850	$850
5	Thermostat installation	Estimate	1	$2,500	$2,500
6	Repair Existing Mixer Controls	Estimate	1	$7,500	$7,500
Sub-Total					$25,822
Contingency				10%	$2,582.20
Total Cost:					**$28,404**

EEM 2: 9th Floor Fans (1VSF 1&2)					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	VFD, Frame, I/O kit and Closet	Codale	2	$9,472	$18,944.00
2	Installation	Estimate	2	$3,400	$6,800
3	Cableing, control conduits, materials	Estimate	2	$2,100	$4,200
4	Programmable / smart thermostat	Johnson	2	$850	$1,700
5	Thermostat installation	Estimate	2	$2,500	$5,000
6	Repair Existing Mixer Controls	Estimate	1	$7,500	$7,500
Sub-Total					$44,144
Contingency				10%	$4,414.40
Total Cost:					**$48,558**

EEM 3: Chiller Controls					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	On/Off controller	Johnson	2	$300	$600.00
2	Installation	Estimate	2	$1,500	$3,000
Sub-Total					$3,600
Contingency				10%	$360.00
Total Cost:					**$3,960**

EEM 4: RO Feed Pumps					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	VFD and controls	Codale	6	$8,272	$49,632.60
2	Shipping	Estimate	1	$4,000	$4,000
3	Installation	Estimate	6	$9,000	$54,000
Sub-Total					$107,633
Contingency				10%	$10,763.26
Total Cost:					**$118,396**

EEM 5: Condensate Pumps					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	VFD hardware	Siemens	3	$375,000	$1,125,000.00
2	Drive startup cost	Siemens	3	$17,110	$51,330
3	Drive start-up training	Siemens	1	$16,000	$16,000
4	Installation	Estimate	3	$52,500	$157,500
5	Motors	Dykman	3	$84,000	$252,000
6	Shipping	Estimate	1	$13,000	$13,000
Sub-Total					$1,614,830
Contingency				10%	$161,483.00
Total Cost:					**$1,776,313**

EEM 6: Turbine Room Fan and Mixer Bank					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Repair Existing Mixer Controls	Estimate	1	$2,500	$2,500.00
2	Replace Gravity Louvers w/ Auto	Johnson	14	$2,550	$35,700
3	Repair Heating Coils	Estimate	7	$1,500	$10,500
4	New Digital Controllers	Johnson	7	$2,800	$19,600
5	VFD, Frame, I/O kit, Controls	Codale	7	$3,125	$21,875
6	New wiring and conduit, misc. material	Estimate	7	$650	$4,550
7	Programable / smart thermostat	Johnson	3	$850	$2,550
8	Thermostat installation	Estimate	3	$2,500	$7,500
Sub-Total					$104,775
Contingency				10%	$10,477.50
Total Cost:					**$115,253**

EEM 7: RO Supply Pumps					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	VFD and Controls	Codale	3	$7,196	$21,587.07
2	Shipping	Estimate	1	$2,000	$2,000
3	Installation	Estimate	3	$7,500	$22,500
Sub-Total					$46,087
Contingency				10%	$4,608.71
Total Cost:					**$50,696**

EEM 8: Primary Air Fans					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Drives and controls	Siemens	2	$375,000	$750,000.00
2	Motors	Dykman	2	$164,000	$328,000
3	Installation	Estimate	2	$66,000	$132,000
4	Shipping	Estimate	1	$13,000	$13,000
5	Startup	Estimate	2	$17,110	$34,220
6	Training	Siemens	1	$16,000	$16,000
7	Cableing, Conduit, misc mat.	Estimate	1	$56,000	$56,000
Sub-Total					$1,329,220
Contingency				10%	$132,922.00
Total Cost:					**$1,462,142**

EEM 9: Forced Draft Fans					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Drives and controls	Siemens	2	$375,000	$750,000.00
2	Motors	Dykman	2	$204,000	$408,000
3	Installation	Estimate	2	$76,000	$152,000
4	Shipping	Estimate	1	$15,000	$15,000
5	Startup	Siemens	2	$17,110	$34,220
6	Training	Siemens	1	$16,000	$16,000
7	Cableing, Conduit, misc mat.	Estimate	1	$78,000	$78,000
Sub-Total					$1,453,220
Contingency				10%	$145,322.00
Total Cost:					**$1,598,542**

EEM 10: Lighting					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Materials	Estimate	1	$395,025	$395,025.00
2	Labor	Estimate	1	$201,650	$201,650
3	Other	Estimate	1	$81,400	$81,400
Sub-Total					$678,075
Contingency				10%	$67,807.50
Total Cost:					**$745,883**

NOTE ON AIR HANDLER COSTS: The air handler measures will only produce the savings recommended if the system components are maintained. This includes control louvers, filters, diffuser louvers, heating coils and actuator maintenance. It is strongly recommended that if these measures are implemented that maintenance personnel be dedicated to their operation. Not doing so would likely result in the mis-operation or bypassing of efficiency controls, and no savings being realized. Since the air mixes from all the HVAC projects, a failure in one system has direct impact on all the other systems. Maintenance costs for personnel are far cheaper than the power costs are annually if the system is not working properly.

5.0 BASELINE AND ANALYSIS OVERVIEW FOR JIM BRIDGER PLANT

5.1 ECM 1: 4TH FLOOR AIR HANDLER SE CORNER

5.1.1 ECM 1 – Baseline Description

This system consists of a mixer box and one 75 HP fan blowing continually on the Mezzanine level. The mixer box is designed to provide as close to 60˚F air as possible using outside air and ambient air temperature from the top of the Turbine Room. The mixing louvers are not operating correctly and the operators report too much cool air on the Mezzanine level 50% of the year.

5.1.2 ECM 1 – Overview of Technical Approach

The annual energy for the ECM was calculated by estimating what percentage of the year cooling beyond 80˚F and heating below 60˚F was needed on the Mezzanine Level. This time estimated includes the effect of more efficient cooling from the A-line fans. This is based on the assumption of the A-line project being completed. Then, the total time that the full fan speed would be used was calculated. For the remaining time, it was assumed that the VFD would be working at a reduced speed while in the programmed temperature band. The average speed during this time was conservatively estimated to be 75% speed.

This section describes the technical approach for modeling ECM 1 in broad terms. Readers interested in more analytical detail should refer to the Appendix.

5.1.3 ECM 1 – Key Assumptions

- Old fan motor operates at 90% efficiency with 0.90 power factor
- A-Line fans work correctly and produce cooler and warmer air as needed
- Annual operating hours are 8,760
- Full-speed operations for 2.5 months for heating
- Full-speed operations for 3 months for cooling
- Partial fan speed for 6.5 months per year at an average of 75% speed.
- 3% parasitic VFD load
- 95% efficiency on new motor
- 2.7 factor on the Cubic law power reduction for speed reduced operations
- Power factor of 1.0 with VFD installed

5.1.4 ECM 1 – Summary of Estimated Energy Savings

The following tables show the summary of the energy baseline and ECM calculations:

Table 8: Baseline Energy Calculation Summary

Baseline		
Assume .95 Power Factor and 90% efficiency on motor		
75 HP = 55.9 kW		
55.9kW/.95/.90=	65.4	kW
Annual Operating Hours =	8,760	
Annual Energy Use=	572,730	kWh

Table 9: ECM 2 Energy Calculation Summary

ECM	
Power consumption for full speed operation, kW	60.6
Annual power consumtion for full speed operations, kWh	240,005
Power consumption for partial speed operations, kW	27.9
Annual power consumtion for reduced speed operations, kWh	133,792
Total annual power consumption, kWh	373,797
Total annual energy savings, kWh	198,933
Demand savings, kW	5

5.2 ECM 2: 9TH FLOOR FANS

5.2.1 ECM 2 – Baseline Description

This system consists of two 75 HP fans drawing air from the same mixer box that is designed to provide 60˚F air. Fan 1VSF1 sends air to the MCC on the Turbine Deck and fan 1VSF2 sends air to the 1st floor around the pulverizers. Currently, the mixer box does not operate properly, and cool air is sent to the locations regardless of the temperature around the MCC or the pulverizers. Bay heaters blow hot air on the same location that the fan blows cold air on the pulverizers. The fans run continuously throughout the year.

5.2.2 ECM 2 – Overview of Technical Approach

The annual energy for the ECM was calculated by estimating what percentage of the year cooling beyond 80˚F and heating below 60˚F was needed on the MCC at the Turbine Floor and at the pulverizers on the 1st Floor. This time estimated includes the effect of more efficient cooling from the A-line fans. This is based on the assumption of the A-line project being completed. The total time that the full fan speed would be used was calculated. For the remaining time, it was assumed that the VFD would be working at a reduced speed while in the programmed temperature band. The average speed during this time was conservatively estimated to be 75% speed. The annual baseline energy use was calculated by multiplying the present power consumption of both fans by 8,760 hours a year.

This section describes the technical approach for modeling ECM 2 in broad terms. Readers interested in more analytical detail should refer to the Appendix.

5.2.3 ECM 2 – Key Assumptions

- Old fan motor has 90% efficiency and 0.90 power factor
- A-Line fans work correctly and produce cooler and warmer air as needed
- Annual operating hours are 8,760
- Full-speed operations for 1VSF1 on the 1st Floor is 3 months for heating
- Full-speed operations for 1VSF1 on the 1st Floor is 3 months for cooling
- Partial fan speed for 1VSF1 on the 1st Floor is 6months per year at an average of full 75% speed
- Full-speed operations for 1VSF2 on the Turbine Floor MCC is 2 months for heating
- Full-speed operations for 1VSF2 on the Turbine Floor MCC is 4 months for cooling
- Partial fan speed for 1VSF2 on the Turbine Floor MCC is 6 months per year at an average of 75% of full speed
- 3% parasitic VFD load
- 95% efficiency on new motor
- 2.7 factor on the Cubic law power reduction for speed reduced operations
- Power factor of 1.0 with VFD installed

5.2.4 ECM 2 – Summary of Estimated Energy Savings

The following tables show the summary of the energy baseline and ECM calculations:

Table 10: Baseline Energy Calculation Summary

Baseline		
75 HP = 55.9 kW		
55.9kW/.95/.90= for one fan	65.4	kW
Annual Operating Hours=	8,760	
2 Fans;		
Total Annual Energy Use, kWh	1,145,460	

Table 11: ECM 2 Energy Calculation Summary

ECM 1VSF 1	
Power consumption for full speed operation, kW	60.6
Annual power consumtion for full speed operations, kWh	265,460
Power consumption for partial speed operations, kW	27.9
Annual power consumption for reduced speed operations, kWh	122,085
Total annual power consumption, kWh	387,545
ECM 1VSF 2	
Power consumption for full speed operation, kW	60.6
Annual power consumtion for full speed operations, kWh	265,460
Power consumption for partial speed operations, kW	27.9
Annual power consumtion for reduced speed operations, kWh	122,085
Total annual power consumption, kWh	387,545.5
Combined Annual Energy Consumption, kWh	775,090.91
Total annual energy savings, kWh	370,369
Demand savings, kW	10

5.3 ECM 3: Chiller Controls

5.3.1 ECM 3 – Baseline Description

This system consists of two chillers that cool water used in heat exchangers for the control room. These systems would require little cooling if the A-line Fans were working properly; as the control room is surrounded by the Turbine room air. There are two 10 HP pumps that transport water through the chillers continuously, whether or not the chiller is running. These pumps should be shut off when the chillers are not operating.

5.3.2 ECM 3 – Overview of Technical Approach

The annual energy for the ECM was calculated by estimating what percentage of the year cooling was required, and multiplying the current power consumption of the two pumps by the estimated hours per year the chillers would be operating.

This section describes the technical approach for modeling ECM 3 in broad terms. Readers interested in more analytical detail should refer to the Appendix.

5.3.3 ECM 3 – Key Assumptions

- Old pump motor operates with 90% efficiency and 0.90 power factor
- A-Line fans are working correctly and produce cooler and warmer air as needed, reducing operating hours for the chillers
- Baseline annual operating hours are 8,760
- EEM operating hours are 5,110

5.3.4 ECM 3 – Summary of Estimated Energy Savings

The following tables show the summary of the energy baseline and ECM calculations:

Table 12: Baseline Energy Calculation Summary

Baseline		
10 HP = 7.457 kW		
7.457kW/.90/.90=	9.2	kW
Annual Operating Hours =	8,760	
2 Pumps		
Annual Energy Use=	161,292	kWh

Table 13: ECM 2 Energy Calculation Summary

ECM	
Power consumption for chilling operations, kW	18.4
Annual Operating Hours	5,110
Annual power consumtion for full speed operations, kWh	94,087
Total annual energy savings, kWh	67,205
Demand savings, kW	-

5.4 ECM 4: RO Feed Pumps

5.4.1 ECM 4 – Baseline Description

This system consists of three RO system trains; A, B and C. Trains A and B utilize three 60 HP RO feed pumps and train C has two 75 HP pumps. Trains A and B use a discharge control valve to deliver about 270 gpm of filtered water to the RO membranes. During normal operation two of the three trains are in operation. When Trains A and B are in operation only 2 of the three pumps are needed. Train C only needs one of two pumps to operate.

The following figure outlines the RO system.

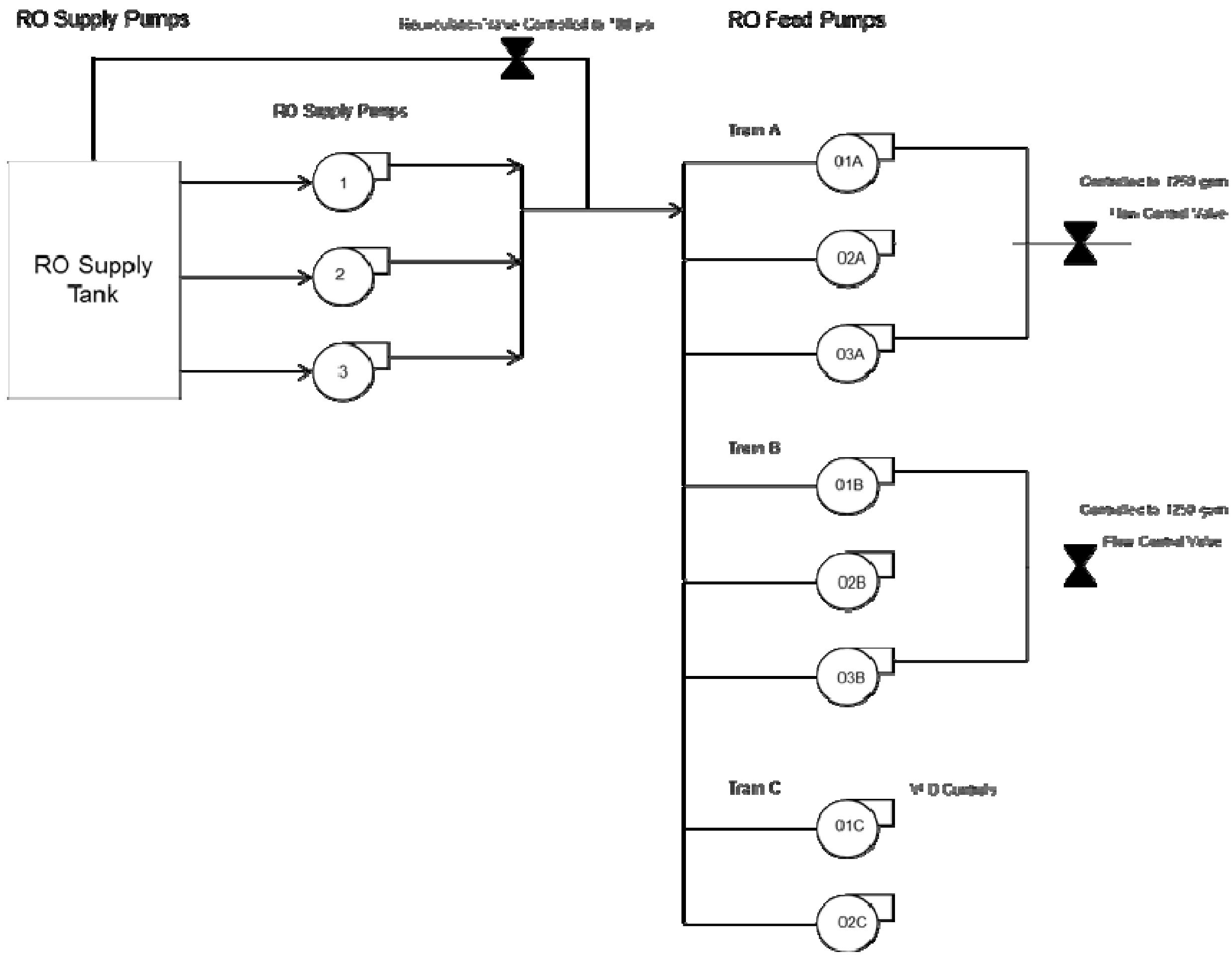


Figure 2: RO System

5.4.2 ECM 4 – Overview of Technical Approach

The analysis of this system was performed using five months of operator log sheets, equipment power measurements and pump curve information. The log sheets interval was from June 1, 2011 through Nov 27, 2011. The following steps outline the technical approach for the baseline analysis.

1. Power measurements were obtained on feed pumps 2A and 2B. Operating power for the other feed pumps was assumed to be the same as these two pumps.
2. The pump curves were obtained from the manufacturer and used as part of this analysis.
3. The pump curve information was input into Cascade Energy's Pump VFD Tool. This spread sheet uses curve fits to match flow, head, efficiency and power curves.
4. The operator logs were used to determine the pressure drop across the control valves during normal operation.
5. The average required pressure and flow during the monitored time frame was used as the required flow and pressure for the energy analysis.

6. The Pump VFD tool was used with the average operating hours of Train A and B and the required flow and pressure for Trains A and B.
7. The baseline energy for the RO feed pumps was calculated to be 511,365 kWh/yr.
8. The ECM energy for the RO feed pumps was calculated to be 375,042 kWh/yr.
9. The energy savings for the RO feed pumps was calculated to be 136,323 kWh/yr.

This section describes the technical approach for modeling ECM 4 in broad terms. Readers interested in more analytical detail should refer to the Appendix.

5.4.3 ECM 4 – Control System Trend Data

No control system data was available for this system because the historian for this Ovation system was not operating correctly. The Ovation system displays a large amount of operating information that was used as reference to the operator logs.

5.4.4 ECM 4 – Operator Log Results

The operator logs were used to evaluate the RO water system operation. The log sheet has two data points per day, 0:00 and 12:00 hours. The following data points were collected from the log sheets.

- Recirculation valve position, % open
- RO supply pump flow rate, GPM
- Total permeate flow rate, GPM
- RO feed pump discharge pressure, PSI
- RO feed pressure after control valve, PSI

5.4.5 ECM 4 – Key Assumption

The following are the key assumption for the RO feed pumps.

- Operating data obtained from the operator logs represents current operation.
- Train A operates 53% of the time.
- Train B operates 58% of the time.
- Train A requires 264 psi during normal operation.
- Train B requires 320 psi during normal operation.

5.4.6 ECM 4 – Summary of Estimated Energy Savings

The following table shows the summary of the energy baseline and ECM calculations:

Table 14: ECM 4 Baseline and ECM Energy Usage

ECM 4: RO Feed Pumps			
Baseline	**Skid A**	**Skid B**	**Total**
Annual Operating Hours	5,694	5,256	
Average Operating Power, MW	0.05	0.05	
Baseline System Energy, MWh/yr	266	245	511

Energy Conservation Measure	Skid A	Skid B	Total
Average Operating Power, MW	0.030	0.039	
ECM System Energy, MWh/yr	172	203	375
Energy Savings, MWh/yr	94	42	136

5.5 ECM 5: Condensate Pumps

5.5.1 ECM 5 – Baseline Description

The condensate pump system consists of three 700 HP 7,200 volt pumps that transport condensate from the discharge of the main turbine to the Deaerator (DA) tank. During normal operation, two of the three condensate pumps are needed to maintain the level in the DA tank. Two parallel discharge control valves are modulated to control the flow to the DA tank level. From the discharge of the condensate pumps to the DA tank is about a 75 foot increase in elevation. In addition, the water travels through several pre-heater units.

Below is a diagram that outlines the condensate pump system.

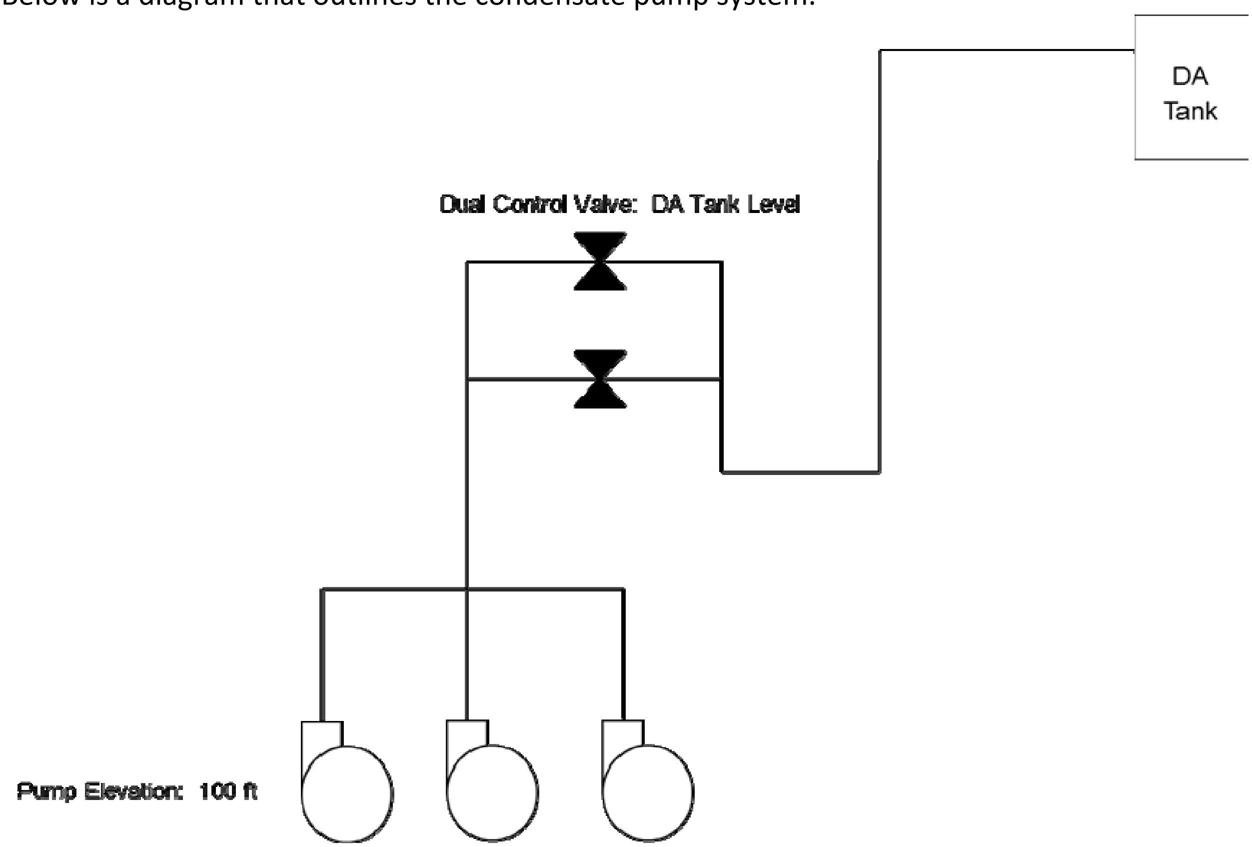


Figure 3: Condensate Pump System

5.5.2 ECM 5 – Overview of Technical Approach

Baseline Analysis Method:

The plant wide Ovation system had a great amount of operating data on the condensate pump system. One year of data at one hour increments was downloaded and used for the system baseline and ECM model. The following steps outline the technical approach for the baseline analysis.

1. Control system data was downloaded from the period of September 2010 to October 2011.

2. The pump motor amps and average system voltage were used with an estimated power factor of 0.89 to calculate the motor power during the logged time frame.
3. The calculated power for each pump was added together and the average total pump power for the logged data was determined.
4. The total average pump power was multiplied by 8,760 operating hours. The average total power accounted for any down time of the system.
5. The total baseline energy usage for the condensate pump system was determined to be 8,609 MWH/yr.

ECM Analysis Method:
The following steps outline the technical approach for the ECM analysis.

1. Pressure transducers with data loggers were installed on the front side and back side of the parallel control valves.
2. The logged data recorded the pressure drop across the control valves for a 14 day period at three minute increments.
3. Ovation operating data for the condensate system was obtained at 3 minute intervals during the same time frame. This data was used to compare pressure drop to operating parameters.
4. The 14 day data was used to create a system curve for the condensate pumps for unit operating loads from 100 MW to 560 MW.
5. The system curve was used to determine the required condensate pump discharge pressure at varying flow rates.
6. The flow rate information received from the Ovation control system is the total flow rate from two condensate pumps.
7. In order to analyze the three condensate pumps individually, the total flow rate was divided by the number of operating condensate pumps.
8. The condensate required flow and pressure were input into the Cascade Pump VFD tool. One Pump VFD tool was created for each condensate pump. Screen shots of the Cascade Pump VFD tool are shown in the Appendix.
9. The Pump VFD tool uses the pump curve, operating data and the affinity laws to determine the required pump speed at a given flow rate and discharge pressure.
10. The Pump VFD tool calculated the required VFD speed for each point.
11. The Pump VFD sheet used the Ovation data to calculate the ECM energy usage for each of the three condensate pumps.
12. The calculated energy used for each pump was averaged over the 13 month period of data and multiplied by 8,760 operating hours. The average pump power over the time period takes any pump off time into consideration.
13. The total energy usage from each pump was totaled and compared to the baseline energy usage to determine the energy savings.
14. The calculated total energy usage for the ECM condensate pump system is 3,368 MWH/yr.
15. The calculated energy savings for the condensate pumping system is 5,241 MWH/yr.

This section describes the technical approach for modeling ECM 5 in broad terms. Readers interested in more analytical detail should refer to the Appendix.

5.5.3 ECM 5 – Control System Trend Data

The long term (one year of 1 hour data) and short term (14 days of 3 minute data) data downloaded from the Ovation control system consisted of the following parameters.

- Pump motor current for all three pumps
- Control valve percent (%) open for both valves
- Total flow rate of condensate to the DA tank
- DA tank pressure
- Condensate pump discharge pressure
- Unit 1 Load, MW

5.5.4 ECM 5 – Control System Trend Results

The following summarizes the trends identified from the analysis of the condensate pumping system trend data.

- The pumping system was on 98% of the time.
- Control valve A averaged 72% open and valve B averaged 12% open.
- Unit #1 operated at an average load of 416 MW.
- The average discharge pressure of the pumps was 293 PSI.
- The average pressure drop across the control valve was 167 PSI.

The Ovation trend data is displayed in the Appendix.

5.5.5 ECM 5 – Key Assumptions

The following are the assumptions used for the energy modeling of the condensate pumping system.

Baseline:

- Pump power was calculated using 7,220 volts with an estimated motor power factor of 0.89.
- The pump operation shown in the control system data from Sept 2010 to Oct 2011 will be representative of future operation.

ECM:

- The pump curve and operating data represent normal operation for the pump.
- The system curve created using temporary logging and ovation data represent normal operation.
- Future Unit load will be similar to trend data.

5.5.6 ECM 5 – Summary of Baseline and Estimated Energy Savings

The summary of baseline and estimated energy savings for ECM 5 are shown below.

Table 15: ECM 5 Savings Summary

ECM 5: Condensate Pumps				
Baseline	**Pump 1**	**Pump 2**	**Pump 3**	**Total**
Annual Operating Hours	8,760	8,760	8,760	
Average Operating Power, MW	0.360	0.469	0.154	0.983
Baseline System Energy, kWh/yr	3,158	4,105	1,347	8,610
Energy Conservation Measure	**Pump 1**	**Pump 2**	**Pump 3**	**Total**
Average Operating Power, kW	0.148	0.186	0.070	0.404
ECM System Energy, kWh/yr	1,301	1,626	609	3,536
Energy Savings, kWh/yr	1,857	2,479	737	5,074

5.6 ECM 6: TURBINE ROOM FAN AND MIXER BANK

5.6.1 ECM 6 – Baseline Description

This system consists of fourteen 20 HP fans that provide the bulk of the air to the power plant. These fans feed directly to the Turbine Room floor, the Mezzanine level and the 1st floor; all on the west wall. These fans are designed to mix outside air with inside air and heated air to continuously feed 60˚F air to these locations. They also control the ventilation fans that are on the ceiling of the Turbine Room. These fans are run and set manually. Existing mixer controls are not working on all fans. Newer gravity controlled louvers return hot ceiling air through the system regardless of what temperature air is needed. A few fans are not running properly or are turned off. Heating coils are not maintained and are bypassed in a few locations. Exhaust louvers are manually adjusted and are optimized for heating, even though the rooms are cooled a majority of the time. The result is higher temperatures than desired/needed throughout the plant and increased ventilation and blowing requirements at many locations in the plant.

5.6.2 ECM 6 – Overview of Technical Approach

The annual energy for the ECM was calculated by estimating what percentage of the year cooling beyond 80˚F and heating below 60˚F was needed on the Turbine Floor, the Mezzanine and the 1st Floor. The total time that the full fan speed would be used was calculated. For the remaining time, it was assumed that the VFD would be working at a reduced speed while in the programmed temperature band. The average speed during this time was conservatively estimated to be 75% speed. The annual baseline energy use was calculated by multiplying the present power consumption of the 14 fans by 8,760 hours a year.

This section describes the technical approach for modeling ECM 6 in broad terms. Readers interested in more analytical detail should refer to the Appendix.

5.6.3 ECM 6 – Key Assumptions

- Old fan motors operate with 90% efficiency and 0.90 power factor
- Annual operating hours are 8,760
- Full-speed operations are three months for heating
- Full-speed operations are five months for cooling
- Partial fan speed is four months per year at an average of 75% speed
- 3% parasitic VFD load

- 95% efficiency on new motor
- 2.7 factor on the Cubic Law power reduction for speed reduced operations
- Power factor of 1.0 with VFD installed

5.6.4 ECM 6 – Summary of Estimated Energy Savings

The following tables show the summary of the energy baseline and ECM calculations:

Table 16: Baseline Energy Calculation Summary

Baseline		
20 HP = 14.9kW		
14.9kW/.90/.90=	18.4	kW
Annual Operating Hours =	8,760	
Total Annual Energy Use=	2,255,970	kWh

Table 17: ECM 2 Energy Calculation Summary

ECM	
Power consumption for full speed operation, kW	279.3
Annual power consumtion for full speed operations, kWh	1,608,726
Power consumption for partial speed operations, kW	128.4
Annual power consumtion for reduced speed operations, kWh	385,340
Total annual power consumption, kWh	1,994,066
Total annual energy savings, kWh	261,905
Demand savings, kW	(22)

5.7 ECM 7: RO Supply Pumps

5.7.1 ECM 7 – Baseline Description

This system consists of three 50 HP pumps; two pumps operate continuously. These pumps provide water from the filtered water storage tank to the RO feed pumps along with other minor users. There is a recirculation line back to the filtered water storage tank with a control valve that modulates in order to maintain a header pressure of 100 psi to the RO feed pumps. Below is a diagram that outlines the RO Supply Pumps.

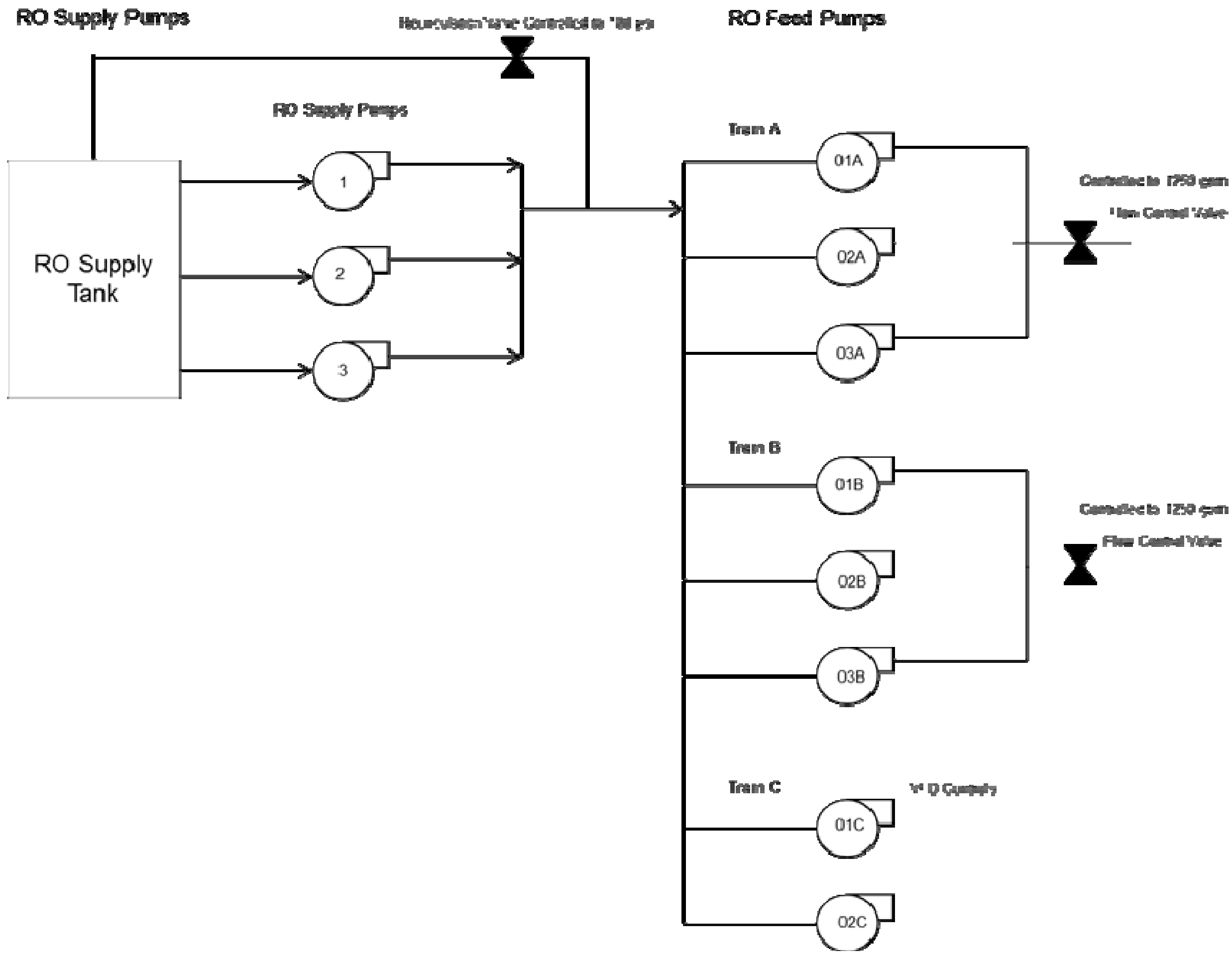


Figure 4: RO System

5.7.2 ECM 7 – Overview of Technical Approach

Baseline Analysis Method:

The following steps outline the technical approach for the baseline analysis.

1. Operator log information for recirculation control valve position, RO feed water pressure and RO supply pump flow was used to determine pump operation.
2. The recirculation valve position was used to determine the flow rate for the recirculation line.
3. A pump curve was not available from the plant, so a curve was obtained from the manufactures website. The obtained pump curve seemed to fit the operator log sheet data.
4. The operator log feed water pressure, RO supply flow rate and pump curve were used to determine the total RO supply pump flow rate at various operating points.
5. The pump curve information was inserted into the Cascade Pump VFD tool.
6. The baseline operating parameters were entered into the
7. The pump motor power measurements were compared to the baseline power determined by the Pump VFD tool to ensure the pump tool was correct.
8. The baseline energy was estimated to be 571,943 kWh/yr.

ECM Analysis Method:
The following steps outline the technical approach for the ECM analysis.

1. The ECM analysis assumed the RO supply pumps needed to provide full flow (481 gpm per pump) when the control valve position was 0% open, 298 GPM (67% flow) per pump when the control valve position was around 15% open and 170 GPM (38% flow) when the control valve position was 50% open.
2. The pump tool was set-up to operate at full flow 5% of the year, 67% flow 60% of the year and 38% flow 35% of the year.
3. The Pump VFD tool calculated an ECM energy usage of 447,556 kWh/yr.
4. The total calculated energy savings for the ECM is 124,387 kWh/yr.

This section describes the technical approach for modeling ECM 1 in broad terms. Readers interested in more analytical detail should refer to the Appendix.

5.7.3 ECM 7 – Control System Trend Data

The water treatment Ovation system had a great amount of operating data on the condensate pump system. Unfortunately, the historian for this system was not operating correctly and no trend data was available for the RO supply pumps. Instead, six months of operating log sheets were used to determine system operating trends. The operator logs were obtained from June 1, 2011 to November 27, 2011. The log sheets provided the following information

- Recirculation valve position (% open)
- Feed water pressure, psi
- RO supply flow rate, gpm

5.7.4 ECM 7 – Control System Trend Results

The log sheet information revealed the following operating trends for the RO supply pumps.

- Two RO supply pumps are on continuously.
- The recirculation control valve position when 3 RO systems are in use average 0% open, 18% when 2 RO systems were in use and 53% open when 1 RO system was in use.
- The RO supply flow rate averaged 875 GPM with three RO systems, 596 GPM with 2 RO systems and 339 GPM with 1 RO system.

5.7.5 ECM 7 – Summary of Estimated Energy Savings

The following table outlines the baseline and ECM energy usage.

Table 18: ECM Energy Usage

ECM 7: RO Supply Pumps				
Baseline	**Condition 1**	**Condition 2**	**Condition 3**	**Total**
Annual Operating Hours (2 pumps)	876	10,512	6,132	
Average Operating Power, MW	0.033	0.033	0.033	
Baseline System Energy, MWh/yr	29	343	200	572

Energy Conservation Measure	Condition 1	Condition 2	Condition 3	Total
Average Operating Power, MW	0.034	0.028	0.020	
ECM System Energy, MWh/yr	29	295	124	448
Energy Savings, MWh/yr	-1	49	77	124

5.8 ECM 8: PRIMARY AIR FANS

5.8.1 ECM 8 – Baseline Description

This system consists of two 1,750 HP 7,200 volt centrifugal fans operating in parallel to supply air to the pulverizers and into the coal burners. Capacity control is achieved on both fans with variable inlet vanes. The fans maintain a static pressure of approximately 32 in WC in the air duct. Both fans are needed during normal operation.

5.8.2 ECM 8 – Overview of Technical Approach

Annual, hourly data was collected from the plant management system. The manufacturer's fan curves and the system data were combined to produce performance profiles. A fan model was created to determine flow and power consumption at discrete operating conditions. Curves of this performance were created and coefficients of performance were determined. This information was used to calculate energy use at each hourly reading.

Using the fan model created in the baseline assessment, the performance at different fan speeds was evaluated. The various fan speeds and flow were used to determine the horsepower requirement for the fan. The horsepower was converted to kilowatts and adjusted for motor efficiency of the new motor to determine the final power requirement in kW. The motor power was multiplied by the number of operating hours annually to determine annual power consumption.

This section describes the technical approach for modeling ECM 8 in broad terms. Readers interested in more analytical detail should refer to the Appendix.

5.8.3 ECM 8 – Control System Trend Data

Data available from the operations control system included the following:

- Fan inlet vane position (% open) for both fans
- Fan Amps for both fans
- Pressure log of the combined fan duct

5.8.4 ECM 8 – Key Assumptions

The following key assumptions were made in the calculations for the baseline and ECM cases:

- Maximum flow is 312,000 CFM
- Discharge pressure over all vane positions averages 31.2 in WC, within reasonable error.
- Motor efficiency for existing motors is 90%
- Motor efficiency new motors would be 95%
- VFD and filter losses will be 3% of total energy requirements

5.8.5 ECM 8 – Summary of Estimated Energy Savings

The following tables are a summary of the results of the logged system trends and calculated data:

Table 19: Summary of Baseline Calculations

PA Fan Baseline

PA Fan 11 & 12 Average Power, kW	1,405.0
PA Fan 11 &12 Average Flow, 1000 CFM	227
Annual Operating Hours	8,577
PA Fan 1 & 2 Annual Energy Consumption, MWh	24,101
PA Fan 1 & 2 Peak Monthly Demand, MW	3.58

Table 20: Summary of ECM Calculations

VFD EEM

PA Fan 11 & 12 Average Power, kW	1,123.0
PA Fan 11 &12 Average Flow, 1000 CFM	227
Annual Operating Hours	8,577
PA Fan 1 & 2 Annual Energy Consumption, MWh	19,263
PA Fan 1 & 2 Peak Monthly Demand, kW	3.68
Annual Energy Savings, mWh	4,837
Annual Demand Savings, mW	-0.099

5.9 ECM 9: FORCED DRAFT FANS

5.9.1 ECM 9 – Baseline Description

This system consists of two 2,250 HP 7,200 volt centrifugal fans that operate in parallel to provide secondary and overfire combustion air to the boiler. Capacity control is achieved by variable inlet vanes. The fans maintain a static pressure of approximately 16 in WC in the duct. Both fans are needed during normal operation.

5.9.2 ECM 9 – Overview of Technical Approach

Baseline power calculations were made using logged data from the plant management system. Hourly values for inlet vane position, pressure, flow and amps were obtained for one year. Manufacturer's fan curves were obtained and used with logged data to determine other needed parameters.

Operation schedules and process limitations were discussed with operators, and taken into consideration in ECM recommendations. The manufacturer's fan curves and hourly data were combined to produce performance profiles. A fan model was created to determine flow and power consumption at discrete operating conditions. Curves of this performance were created and coefficients of performance were determined. This information was used to calculate energy use at each hourly reading.

This section describes the technical approach for modeling ECM 9 in broad terms. Readers interested in more analytical detail should refer to the Appendix.

5.9.3 ECM 9 – Control System Trend Data

Data available from the operations control system included the following

- Fan inlet vane position (% open) for both fans
- Flow as a percentage of maximum flow
- Fan current for both fans
- Pressure log of the combined fan duct

5.9.4 ECM 9 – Key Assumptions

The following key assumptions were made in the calculations for the baseline and ECM cases:

- Maximum flow is 770,000 CFM
- Discharge pressure over all vane positions averages 16 in WC, within reasonable error
- Motor efficiency for existing motors is 90%
- Motor efficiency for new motors would be 95%
- VFD and filter losses will be 3% of total energy requirements

5.9.5 ECM 9 – Summary of Estimated Energy Savings

The following tables are a summary of the results of the logged system trends and calculated data:

Table 21: Summary of Baseline Calculations

FD Fan Baseline

FD Fan 11 & 12 Average Power, kW	1,221.8
FD Fan 11 &12 Average Flow, 1000 CFM	474
Annual Operating Hours	8,577
FD Fan 1 & 2 Annual Energy Consumption, MWh	20,958
FD Fan 1 & 2 Peak Monthly Demand,MW	3.79

Table 22: Summary of ECM Calculations

VFD ECM

FD Fan 11 & 12 Average Power, kW	1,113.0
FD Fan 11 &12 Average Flow, 1000 CFM	474
Annual Operating Hours	8,577
FD Fan 1 & 2 Annual Energy Consumption, MWh	19,093
FD Fan 1 & 2 Peak Monthly Demand, MW	4.19
Annual Energy Savings, MWh	1,865.50
Annual Demand Savings, mW	-0.397

5.10 ECM 10: Lighting

5.10.1 ECM 10 – Baseline Description

The interior and exterior lighting of the Unit #1 building area and corresponding coal handling areas have a variety of high pressure sodium and T12 fluorescent fixtures and lamps. With the exception of some minor offices the lighting is on continuously.

5.10.2 ECM 10 – Overview of Technical Approach

The analysis for the lighting project was completed using the method.

- A detailed accounting of all of the interior and exterior lighting was completed by Richard Wood of Evergreen Energy.
- ECM lighting for each location was recommended based on required lighting levels, environment conditions, opportunity for lighting controls and available technology.
- This information was input into the Rocky Mountain Power lighting calculator to determine baseline and ECM energy usage.

This section describes the technical approach for modeling ECM 10 in broad terms. Readers interested in more analytical detail should refer to the Appendix.

5.10.3 ECM 10 – Control System Trend Data

No logging or trend information was used for this analysis. All lights with the exception of office areas were assume on continuously. Office lighting was assumed on 50 hours per week.

5.10.4 ECM 10 – Summary of Estimated Energy Savings

The following table displays the baseline, ECM and annual energy savings for the lighting upgrade.

Table 23: Lighting Energy Summary

Baseline

Annual Operating Hours	8,497
Average Operating Power, MW	0.5437
Baseline System Energy, MWh/yr	4,620

Energy Conservation Measure

Average Operating Power, MW	0.270
ECM System Energy, MWh/yr	2,297
Energy Savings, kWh/yr	2,323

6.0 EVALUATION, MEASUREMENT AND VERIFICATION FOR JIM BRIDGER PLANT

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 5 minute intervals.

If ECM 1 is installed, the following variables will need to be monitored:

- Motor amps for the fan during heating and cooling seasons

If ECM 2 is installed, the following variables will need to be monitored:

- Motor amps for the fan during heating and cooling seasons

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

- Motor amps for the chillers and chiller pumps during heating and cooling seasons

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

- Motor amps for all of the feed pumps
- Discharge pump pressure
- Power measurements for each feed pump

If ECM 5 is installed, the following variables will need to be monitored:

- Motor current for Condensate Pumps 1, 2 and 3, amps
- Condensate pump discharge pressure, PSI
- Condensate pump flow rate, GPM
- Control valve position, % open
- DA tank pressure, PSI
- Unit production rating, MW
- Read VFD input power from VFD to determine motor current to power relationship

If ECM 6 is installed, the following variables will need to be monitored:

- Motor Amps of the 14 fans during heating and cooling seasons

If ECM 7 is installed, the following variables will need to be monitored:

- Motor current for all three supply pumps
- Power measurements on each pump at varying pump speeds
- Recirculation control valve position
- Supply pump flow rates
- Determine the number of RO systems in operation to ensure overall system operation is similar

If ECM 8 is installed, the following variables will need to be monitored:

- Plant output from the PI system
- Motor amps for both fans
- Air Flow for both fans
- Discharge pressure for both fans
- Power measurements for new fan motors

If ECM 9 is installed, the following variables will need to be monitored:

- Plant output from the PI system
- Motor amps for both fans
- Air Flow for both fans
- Discharge pressure for both fans
- Power measurements for new fan motors

If ECM 10 is installed, the following variables will need to be monitored:

- Perform post-installation audit to determine what fixtures have been installed
- Determine if lighting controls are working as recommended, install time of use loggers as necessary to monitor run times

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. Plant personnel able to download needed Ovation data might also be needed depending on the ECM. Bridger personnel 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:

- VFD is installed
- Thermostat is installed and correctly programmed
- Heating and cooling bands correctly reduce fan speed in appropriate range
- Louver controls open and close at correct settings to optimize cooling and heating
- Power measurements on fan motors

If ECM 2 is installed:

- VFD is installed
- Thermostat is installed and correctly programmed
- Heating and cooling bands correctly reduce fan speed in appropriate range
- Louver controls open and close at correct settings to optimize cooling and heating
- Power measurements on fan motors

If ECM 3 is installed:

- On/Off controller is installed and working in conjunction with the chillers

If ECM 4 is installed:

- Installation of a small, approximately 50 HP pump
- Pump is selected for minimum throttling at design conditions
- Condensate Pumps 1A, 1B and 1C remain off when small condensate pump operates

If ECM 5 is installed:

- New pump motors and VFDs are installed on each of the condensate pumps
- Ensure the pump speed is controlled to maintain a target DA tank level
- Ensure the control valves are not being used to control flow
- Ensure that both pumps are operating at the same pump speed

If ECM 6 is installed:

- VFDs are installed
- Vent controls are tied to new ceiling thermostat
- Turbine floor thermostat is installed and correctly programmed
- Heating and cooling bands correctly reduce fan speed in appropriate range
- Louver controls open and close at correct settings to optimize cooling and heating

If ECM 7 is installed:

- VFDs are installed on each of the three RO supply pumps

- Ensure the recirculation control valve remains closed and the pump speed is varied to control system flow rate as needed
- Ensure both operating pumps are running at similar pump speed

If ECM 8 is installed:

- Variable inlet vanes are removed
- VFD is correctly maintaining pressure and flow to control point
- Minimum speed settings are set to flow control point

If ECM 9 is installed:

- Variable inlet vanes are removed
- VFD is correctly maintaining pressure and flow to control point
- Minimum speed settings are set to flow control point

If ECM 10 is installed:

- Ensure installed lighting controls are operating as intended

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 AS PART OF THIS PLANT ANALYSIS

7.1 Jim Bridger Power Plant

1. **Main Transformers:**

   Ratings- 22kV to 345kV transform; 7.83% impedance

   Operations- Runs all year, 24/7. 4 fan banks with 3 fans per bank; one oil pump per bank; fan HP unknown, but estimated to be fractional HP. Normal operation is two banks running. High production has all four banks running. Banks are controlled as two banks at a time (on/off) based on internal oil temperature.

   Potential Measures-
   If a lower impedance transformer were used, plant engineering reports that an extensive number of internal equipment as well as external transmission equipment would have to be replaced to handle greater current flow in the event of a short inside the plant or downstream of the transmission system. It would also create safety and arc-flash issues within the plant that would be extremely difficult to work around. Install cost of a replacement transformer is estimated to be ~ $4 million with ~$1-1.5 million to install and turn up. This does NOT include all other equipment changes reported to be necessary.

   Action: No measure found.

2. **Auxiliary Transformer:**

   Ratings- 22kV to 7.2kV transform; 15.27% impedance estimated.

   Operations- Runs all year, 24/7. The fans and pumps have not been seen running by technicians, although they say if they do, it is only very short durations during the hottest summer.

   Action: No measure found. See Main Transformer section for explanation.

3. **Startup Transformers (2):**

   Ratings- 345kV to 7.2 transform; estimated 13.2% impedance

   Operations- Both startup transformers are USUALLY energized, but only one was during the site visit. Transformers are redundant and have plenty of capacity to cover the common bus loads and starting up two production units simultaneously. Power to these transformers comes from the transmission grid and at the market rate. Fans and oil pumps on the transformer are usually not on, but have been seen running during long startup processes (a couple days maximum).

Action: No measures found

4. **Induced Draft Fans 11 and 12:**

   Ratings- 11,000 HP; 7,200 V; 836 A rated

   Operations- No intake or exit louvers- VFD speed control. Runs 24/7, all year. Glycol cooled VFD control. Redundant glycol pumps (one at a time). At pumps- 32.7 psi intake, 91 psi discharge. Bank of 8 cooling fans; one fan was running when observed, but never more than two ever running in summer. Fans are controlled by glycol temp ON/Off. ID Fans VFD controlled off of boiler backpressure. There was some discussion about putting larger process fans on the VFDs, so this cooling capacity may be needed in the future, but it is not needed now.

   Action: No measures were found with these systems

5. **Coal Pulverizers 11-16:**

   Ratings- Grinder motor- 600 HP, 7,200V; 66A- 34-49A measured
   Feeder motors are on VFDs to control coal flow.

   Operations- These pulverizers have a very even amp history. The feeder motor is VFD controlled to keep grinder full. 5 grinders run all the time when plant runs 360 MW or more. 6 grinders are used sometimes. Air flow is controlled and mixed by radial intake louvers and straight mixing louvers prior to entering the pulverizers. This is combined hot and cold air used to dry the coal and move product. Air is provided by the by the primary air fans (for cooler air), and a combination of the preheated forced draft fan air and primary air fan flows.

   Action: No measures were identified on the pulverizers, the control feeders or the grinding motors.

6. **Fly Ash Transport Blowers/ Compressors 11-13:**

   Rating- 250 HP; 7,200V; no amps available

   Operations- Used to transport ash from precipitators and hoppers out to filters. A reduction of pressure and flow would mean recalibrating timers on all precipitator discharge hopper solenoids. Some of these solenoids are programmable and some are mechanically timed (with a camshaft) at the switch controller. Adjustments cannot be made to line #10, but can on line #2. No pressures were available at discharge. Two blowers run at any time. Long lines require the higher pressure to overcome losses. There are six lines fed by two blowers. Any back-pressure trips alarms, since backpressure means blockages are forming. Timing is dictated by the build-up of ash in the hoppers. Operators indicated that they would not know if they had too much flow, as they had never tried reducing it.

The inability to change the timing of the ash solenoids, the pressure required to produce air through various piping systems, and the cost prohibitive nature of replacing blowers with ones that can use a VFD precludes the implementation of any project to slow the blowers.

Action: No measure found.

7. **Spent Liquor Pumps (2):**
   Rating- 125 HP; 460V, 140 A

   Operations- One runs at a time from scrubber to sump tank. It is tank-level controlled with an ON/OFF controller and no discharge throttling. Estimates are that the pump runs for 8 hours a day, 7 days a week.

   Action: No measure found.

8. **Liquor Recycle Pumps (3):**
   Rating- 300 HP; 480V; 364 Amps; measured amps = 276; 296; 235

   Operations- 3 units run 24/7. Cannot change amount of water sent to scrubbers, as depth of water in the scrubber troughs determines SO4 removal. Pressure is strictly dependent on the trough water heights and will not change. No throttling occurs.

   Action: No measures found.

9. **Soda Liquor Supply Pumps (2):**
   Rating- 100 HP, 460V, 113A

   Operations- Pumps run intermittently (assume 8 hours per day) and are used to supply soda liquor to the scrubbers from the storage tank. Pumps are turned on as needed from destination tank level with ON/ OFF controllers.

   Action: No measures found.

10. **Treated Water Pumps (3):**
    Rated- 125 HP; 460 V; 113 A

    Operations- 1 of the 3 runs normally, 24/7, but occasionally, 2 will run (~1 month a year). Discharge pressure was measured at 83 psi. Pumps move water from the Scrubber Settling Tank back to the scrubbers. According to the pump curve, this pump is performing at its high efficiency rating and full power.

    Action: No measures were found.

11. Liquor Unloading Pumps (2):
Rating- 10 HP; 460 V; 75 A

Operations- One runs at a time when unloading trucks into the tank (~ 8 hours a day)

Action: No measures found.

12. Clarifier Bottom Pumps (4):
Rated- 15 HP; 460 V; 43 A

Operations- One runs all the time, two on occasionally. Removes sludge from the clarifier tank. On/Off controllers.

Action: No measures found.

13. Precipitators (24):
Rating- 460 V; 44 Amps for whole field measured at controllers.

Operations- Precipitator arrays thumped mechanically (camshaft driven hammers), air powered sound horns used to clean off ash. All equipment needed specifically for Environmental compliance.

Action: No measures found.

14. Primary Coal Crushers (2):
Rating- 150 HP, 460 V, Amps Estimate 84 kW

Operations- Run 5 days/week; 18 hours/day

Action: No measures found.

15. Secondary Coal Crushers 1,2:
Rating- 600 HP; 7,200 V; 51 A; #1 and #2 run at 45 Amp measured; #3 runs at 42 A measured.

Operations- All secondary crushers run 24/7.

Action: No measures found.

16. Secondary Coal Crushers 3,4:
Rating- 700 HP; 7,200 V; 68 A; 42 A measured
Both run 24/7

Action: No measures found.

17. Reclaim Lift:

Rating- Includes 150 HP bucket motor; 2-75 HP belts; 1-100 HP belt; 200 HP belt

Operations- Runs approximately 20 hours /week, building up coal piles on week days and feeding the plant on weekends.

Action: No measures found.

18. Primary Conveyors 01-A, 01-B:

Rating- 600 HP each; 7,200 V; 48 A rating; 800W heater; 125 W heater;

Operations- From "Coal Board" amp reading was 64 Amps (We believe this was for both belts, so assume 32A each). These run 5 days a week, 18 hours per day.

Action: No measures found.

19. Secondary Conveyors 01-W, 01-X:

Rating- 350 HP each; 7,200 V

Operations- These run 5 days a week, 7 hours per day

Action: No measures found.

20. Other Conveyors:

Four other minor conveyors were identified.   Two different source belt-feed these lines so a failure in one will not stop the line production.

Action: No measure found.

21. Other Conveyors That Run 20 hours /week:

Little 05- 60 HP; 460 V
Little 98- 20 HP; 460 V
03 Short- 100 HP; 460 V
04 Long- ~200 HP; 460 V

Action: No measures found.

22. Dust Collector Fans and Filters:

Present for safety reasons. They are 30 minutes after the belt is turned off. This is safety related and will not be changed. The following fans are located and many locations around the coal transport systems:
2; 15 HP
5: 20 HP

2; 40 HP
1; 50 HP
1; 60 HP
7; 75 HP
1; 120 HP
2; 150 HP
All 460 V

Action: No measure found.

23. Effluent Pumps (3):

Rating- 200 HP; 460 V; 43.9 A

Operations- There are three identical pumps, but only one runs at a time. Pump runs 24/7. The pumps feed the #1 Effluent Pond. These are manually controlled to maintain levels in pond, or divert to ditches or other ponds to evaporate.

Action: No measures found.

24. "91 Effluent Pump" (2):

Rating- 150 HP; 460V, 170A

Operations-Runs eight hours per day, manually controlled. Runs one of two pumps at a time.

Action: No measures found.

25. South Mine Pump:

Rating- 60 HP; 460 V

Operations- Runs 12 hours a day, 5 days a week. Provides water to mining process. Manually turned on and off.

Action: No measures found.

26. Sewage treatment aerators (small) and tiny level pumps (5 HP each):

Operations- Needed to oxygenate the water and keep settling pond level. Aerators run continuously, year-round. Level pumps run only when water level triggers on/off switches.

Action: No measures found.

27. Evaporator Pumps (11):

Rating- 50 HP each, 460 V

Operations- Submerged pumps, run for environmental balance of evaporator pond and spend liquor pond. Title 5 balance required flows, and operators cannot change settings. All pumps run all the time.

Action: No measures found.

28. Lift Pumps (2):

Ratings- 30 HP and 100 HP, 460 V

Operations- 100 HP pump runs 24/7. 30 HP only runs when operators choose (45 days per year)

Action: No measures found.

29. Roof Exhaust Fans (8)-(Tied to A-line Controls):

Rating- 1.5 HP each, 460 V

Operations- 24/7 year-round. Currently tied to A-Line controls. Set to turn on when a fan is cooling. Tie to new control system for the A-Line Fans. Program to turn on when ceiling air temperature reaches 90˚F .

Action: No energy savings measure found.

30. 8th Floor, East Side Exhaust Fans (16):

Ratings- 7.5 HP each, 460 V

Operations- 12 running during inspection. Operate 24/7 operation. Exhaust hot air from around the boiler sections. The system is manually controlled at various locations. Airflow is required to eliminate coal dust. Heating patterns preclude a cost effective thermostatic control.

Action: No measures found.

31. Air Handler (above Unit 1 &2 Control Room):

Rating- 15 HP; 460 V

Operations set to room temperature. Mixer boxes and economizers working when inspected.

Action: No measures found.

32. 4th Floor Boiler Space Air Fans (4):

Rating- 25 HP each, 460 V

Operations- These run 24/7 year round to cool air around boilers.

Action: No measures found

33. Turbine Floor Exciter Trailer Coolers (4):

Rating- 460 V; 10 A

Operations- These are dedicated to cool the Exciter units and are required for the turbine warranty. They run 24/4 year round.

Action: No measures found.

34. Air Handler Units, NE Acid Tank Area (2):

Rating- 30 HP each; 460 V

Operations- These systems run 24/7, and cool the local area on the floor. They appear to have chilled water cooling.

Action: No measure found.

35. Plant Compressed air system:

Three compressors, 4 stage centrifugal, 1,250 HP. One compressor operates continuously, others are off. Each Unit has its own heated desiccant purge control dryer, 18 kW heater. Plant compressor feeds all 4 units. The compressors operate with a 125 psi discharge pressure. The compressors are at the end of useful life.

Action: No energy efficiency measure found.

36. Bottom Ash System:

The bottom ash system removes unburned material that was fallen to the bottom of the boiler. This system operates 24/7 except for down time of the boiler which is 1 month every 4 years. The system consists of two trains of pumps for the economizer and pyrite pumping systems. Each economizer train consists of two 30 HP pumps, it is estimated from operator discussions that these pumps operates about 10 hours per day. Each pyrite train consists of three 50 HP pumps that operate 30 minutes per day. The overflow sump pump is a 20 HP VFD controlled pump that maintains a constant water level. The drag chain and transfer conveyor operate continuously when the unit is in operation.

Action: No measures found.

37. Cooling Tower Fans:

The cooling tower system provides cooling water to the unit. The main use of the cooling is to condense the waste steam after its final pass through the turbine. There are 11 200 HP fans. Each fan has a VFD installed on the fans. The fan speed is controlled to an existing water temperature. The target water temperature is 70˚F.

Action: No measures found.

38. Boiler Circulating Water Pumps – No. 11, 12, 13, 14:

Ratings – 900 HP; 7200 V

All 4 pumps run 24/7 when the plant is generating, circulating water from the suction header to the lower water wall drum. Each pump typically draws 50-55 amps with an average pressure differential of 26 psig across the pumps.

Action: No measure found.

39. Boiler Feed Water Booster Pumps – No. 11, 12:

Ratings – 1500 HP; 7200 V; avg. measured amps = 87 A (#11), 79 A (#12)

Both pumps run 24/7 when the plant is generating, circulating water from the DA storage tank, through preheaters #11 and #12, to the steam-driven, variable-speed, main boiler feed water pumps. Booster pump #11 average measured flow rate was 4173 gpm. Booster pump #12 averaged measured flow rate was 3437 gpm.

Action: No measures found.

40. Cooling Water Circulation Pumps – No. 11, 12:

Ratings – 2250 HP; 7200V; measured amps = 183, 176

Both pumps run 24/7 when the plant is generating, circulating water from the cooling tower, through the condenser and then back to the cooling tower, with various other cooling systems taking water from this loop. The circa water temperature to the condensers is set to 70˚F and controlled by the cooling tower operation. The control valves downstream of the circa pumps are typically wide open.

Action: No measures found.

41. Bearing Cooling Water Pumps – No. 11, 12:

Ratings – 75 HP; 460 V

At least one, and sometimes both, bearing water pumps run 24/7 when the plant is generating, drawing water from the service water pump discharge, and then going through the turbine bearing coolers. The second pump starts automatically if the discharge pressure drops below 70 psig. A by-pass valve bypasses the heat exchangers if the cooling water temperature drops. Temp set point = 81˚F. Observed temp 73-76˚F with bypass fully open.

Action: No measure found.

42. Service Water Pumps – No. 11, 12:

Ratings – 200 HP; 460 V; 236 FLA

One service water pump runs 24/7 when the plant is generating, drawing water from the main cooling water circulation header, passing through the main turbine lube oil cooler and several other cooling systems, then returning to the cooling water circulation system going back to the cooling towers.

Action: No measure found.

43. Raw Water Pumps – No. 1, 2, 3, 4:

Rating – 150 HP; 460 V; 191 FLA

Typically 3 of the 4 raw water pumps (or surge water pumps) run 24/7 when the plant is generating. Since these supply water to the cooling tower, it is a common system for all 4 units. These pumps draw water from the surge pond and send it to the cooling towers as makeup water to maintain a basin level of ~80%. There is a makeup control valve (LV168) that controls the flow rate into the cooling tower basin. It was observed at 34% open, allowing 2407 gpm.

Action: No measure found.

44. Fire Water Pumps – No. 11, 12, 13:

Rating (No. 11, 12) – 200 HP; 460 V; 232 FLA; measured discharge pressure = 167 psig
Rating (No. 13) – 75 HP; 460 V; 92.6 FLA; VFD control

One of the two 200 HP pumps operates with the 75 HP, VFD-controlled pump 24/7. Measured flow was 340 gpm.

Action: No measure found.

45. Generator Stator Cooling Water Pumps – No. 1, 2:

Rating – 50 HP each; 460 V; 101 psi discharge pressure

There are two identical pumps but only one runs at a time. System operates whenever generator is operating. The system recirculates cooling water from the water storage tank through a set of coolers to the generator stator and back to the water storage tank. A three-way mixing valve allows some percentage of the water to bypass the coolers controlling stator water supply temperature. A pressure control valve (Set to 50 psig) installed after the coolers to maintain the stator water supply pressure. Changing this system would void warranty on the unit turbines.

Action: No valid measure found.

8.0 EXTRAPOLATION TO JIM BRIDGER PLANT TO UNITS 2, 3 &4

The Jim Bridger Generating Station has a total of 4 unit. The current analysis for energy efficiency opportunities was only performed on unit #1. From the limited understanding of the operation of Units #2, 3 and 4 it is assumed that the opportunities outlined for Unit #1 will be potential opportunities at the other units. The chart below shows the production history for the four units since 2008. The average operating loads between the four units only vary about 5%.

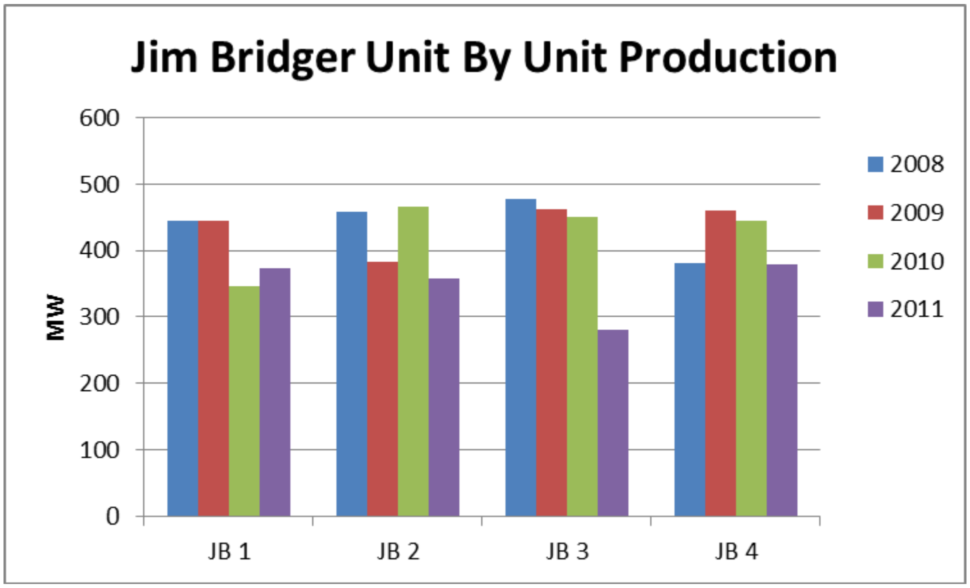


Figure 5: Jim Bridger Operating Loads

The table below outlines the extrapolated potential energy savings at units 2, 3 and 4.

Table 24: Extrapolated Savings for Jim Bridger Units 2, 3 and 4

	Unit #2	Unit #3	Unit #4
Energy Conservation Measure	MHW/yr	MHW/yr	MHW/yr
Air Handler 4th Floor SE Corner (1VSF3)	199	199	199
9th Floor Fans (1VSF 1&2)	370	370	370
2 Chillers	67	67	67
Condensate Pumps	5,074	5,074	5,074
Turbine Room Fan and Mixer Bank	262	262	262
RO Supply Pumps	124	124	124
Primary Air Fans	4,838	4,838	4,838
Lighting	2,323	2,323	2,323

In order to determine if Units 2, 3 and 4 have the same opportunities, it is recommended a detailed energy analysis be performed on these units.

9.0 PLANT AUXILIARY BASELINE ENERGY USE FOR CHEHALIS GENERATION FACILITY

9.1 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. The plant operated 19% of the time over the past 12 months (11/1/2010 to 10/31/2011) at a range of capacities. 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 CO_2 storage vessels throughout the turbine building. Lighting at the plant consists of high pressure sodium fixtures throughout the turbine building and exterior, with linear fluorescents within the office building.

9.2 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 25: 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 4.

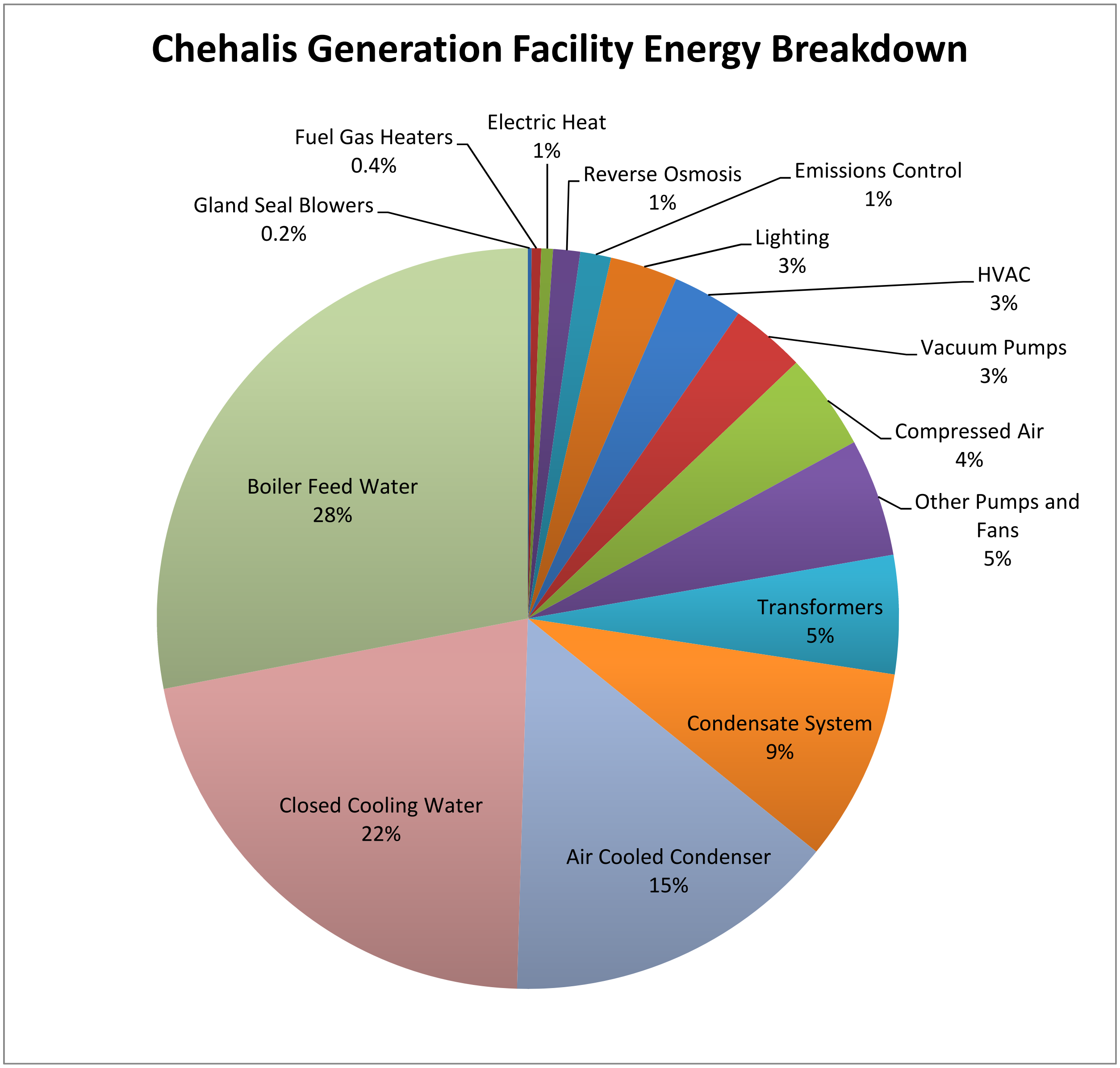


Figure 6: Energy Breakout per Sub-system for Chehalis Generation Facility

10.0 DETAILED DESCRIPTION OF PROPOSED EQUIPMENT AND OPERATION FOR CHEHALIS GENERATION FACILITY

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

10.1.1 ECM 1 – Source of Energy Savings

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

- Since the pump operates on 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.

10.1.2 ECM 1 – Specific Equipment Recommendations

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

10.1.3 ECM 1 – Set-points Recommended to Achieve Energy Performance

Set the 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.

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

10.2.1 ECM 2 – 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.

10.2.2 ECM 2 – Specific Equipment Recommendations

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

10.2.3 ECM 2 – Set-points Recommended to Achieve Energy Performance

- Raise the minimum leaving water temperature set point from 73°F to 92°F.
- 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.

10.3 ECM 3: Install High Efficiency Lighting System

10.3.1 ECM 3 – Source of Energy Savings

- Installing more efficient lighting fixtures and lamps will reduce lamp power while the lamps are on.
- Turning off these lamps when areas are unoccupied will reduce electricity usage.

10.3.2 ECM 3 – Specific Equipment Recommendations

Install high efficiency lighting system with occupancy sensors. Consult electrical contractor and/or lighting vendor for optimum energy efficiency. The lighting fixtures listed below are based on previous projects and a discussion with the electrical contractor, but a detailed lighting analysis needs to be performed before fixtures are purchased and installed.

- Replace seventy-four 400-W HPS fixtures with 6-lamp T5 HO fixtures controlled with occupancy sensors in the Turbine Building.
- Replace ten 250-W HPS fixtures with 4-lamp T5 HO fixtures controlled with occupancy sensors in the Turbine Building.
- Replace nine 400-W HPS fixtures with 6-lamp T5 HO fixtures controlled with occupancy sensors in the Maintenance Shop.
- Replace six 400-W HPS fixtures with 6-lamp T5 HO fixtures controlled with occupancy sensors in the Air Compressor Room.
- Replace seven 8 ft. 2-lamp T12 fixtures with fourteen 4 ft. 2-lamp T8 fixtures controlled with occupancy sensors in the Maintenance Office.
- Install occupancy sensors in the following locations:
    - Men’s Restroom
    - Women’s Restroom
    - IT Room
    - Electric Room
    - ACC MCC Room
    - Back MCC Room
    - BFW-1 Pump Room
    - BFW-2 Pump Room

Note that in all critical work areas occupancy sensors shall have manual over rides to prevent lights from shutting off when work is being performed in those areas.

10.3.3 ECM 3 – Set-points Recommended to Achieve Energy Performance

- Install high efficiency lighting system.
- Install occupancy sensors on lighting system as noted above.
- Set-occupancy sensor time delay to the minimum delay time allowed by the manufacturer's warranty.
- Lower height of lighting fixtures in the Turbine Building as directed by the Maintenance Manager.

10.4 ECM 4: Install Small Condensate Pump for Auxiliary Use

10.4.1 ECM 4 – 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.

10.4.2 ECM 4 – 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.

10.4.3 ECM 4 – 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.

10.5 ECM 5: Install Reverse Osmosis (RO) Feed Pump VFDs

10.5.1 ECM 5 – Source of Energy Savings

Pump speed control is more energy efficient than a discharge control valve. The existing system uses a manual plug valve to reduce flow rate and pressure.

10.5.2 ECM 5 – Specific Equipment Recommendations

- Install one 100 HP VFD and any recommended line reactors and filters on one of the first stage RO feed pumps.
- Install one 75 HP VFD and any recommended line reactors and filters on one of the booster stage RO feed pumps.

10.5.3 ECM 5 – Set-points Recommended to Achieve Energy Performance

- Only operate the pumps with VFDs. Do not throttle the pump discharges.
- The system operates at nearly constant flow rate and pressures. The facility can control to flow rate or pressure, but to simplify the implementation, operators could adjust VFD speed to meet flow rate and pressure requirements. Once the operating conditions have been met, a set operating speed would be determined.

10.6 ECM 6: Reduce LP Economizer Recirculation Pump Use

10.6.1 ECM 6 – Source of Energy Savings

Using control valves to maintain Exhaust Stack Gas temperature will reduce or eliminate the need to operate the Low Pressure (LP) Economizer Recirculation Rumps, saving energy.

10.6.2 ECM 6 – Specific Equipment Recommendations

- Perform maintenance on the existing TCV to verify that the valve is opening and closing fully.
- If necessary, replace the existing TCV.

10.6.3 ECM 6 – Set-points Recommended to Achieve Energy Performance

- Use exhaust gas temperature to control LP Economizer bypass TCV.
- Lockout or remove LP Economizer Recirculation pumps.
- Average stack exhaust gas temperature should be approximately 225°F.

10.7 ECM 7: Install a New Variable Speed Air Compressor

10.7.1 ECM 7 – Source of Energy Savings

Variable speed compressors are more energy efficient at reduced load than load/unload control.

10.7.2 ECM 7 – Specific Equipment Recommendations

- Install a variable speed screw compressor; QNW-V125 or equivalent (487 acfm at 125 psig) in lieu of a load/unload back-up compressor.

10.7.3 ECM 7 – Set-points Recommended to Achieve Energy Performance

- Set the new compressor to target a discharge pressure of 110 psig or lower.
- Set the existing Kobelco compressor to operate with the following control points:
  - Set the Kobelco to turn on and load at 100 psig and to unload at 115 psig.
  - Set the controls to turn off automatically after 20 minutes or less of unloaded operation.

10.8 ECM 8: Reduce Runtime of Electric Heat Trace

10.8.1 ECM 8 – Source of Energy Savings

Installing thermostats on the electric heat trace panels will reduce the runtime of the electric heat trace.

10.8.2 ECM 8 – Specific Equipment Recommendations

Fix or replace the thermostats controlling the electric heat trace panels in the following locations:

- 685-HTCP-40001
- 685-HTCP-50000
- Heat Trace near Air Cooled Condenser
- Two heat trace panels in Turbine Building

10.8.3 ECM 8 – Set-points Recommended to Achieve Energy Performance

- Turn on electric heat trace at 37 °F and turn-off at 42 °F.
- Operate heat trace panels in auto mode, not manual mode.

10.9 ECM 9: Adjust Thermostat on One Electric Heater

10.9.1 ECM 9 – Source of Energy Savings

- Using the thermostat controls to turn electric heaters on/off will reduce runtime and ensure that they are on only when needed.

10.9.2 ECM 9 – Specific Equipment Recommendations

- If necessary, replace thermostat on the second column of the southeast corner of the Turbine Building.

10.9.3 ECM 9 – Set-points Recommended to Achieve Energy Performance

- Adjust thermostat such that the electric heater operates less than 15% of the time when the outdoor air temperature is between 40 °F and 55 °F.
- The heater remains off when ambient temperature is greater than 55 °F.

10.10 ECM 10: Demand-based Dew Point Controls

10.10.1 ECM 10 – Source of Energy Savings

Operating the dryers in “EMS On” mode is more energy efficient that operating in “Dryer On” mode because EMS mode uses less purge air, which reduces the flow requirements on the air compressor.

10.10.2 ECM 10 – Specific Equipment Recommendations

- Replace the hygrometers with accurate, functioning ones on each of the two TZ300 dryers.

10.10.3 ECM 10 – Set-points Recommended to Achieve Energy Performance

- Operate the dryers in “EMS On” mode only.
- Set the dryers to target a dew point of 20°F.

Figure 7: Operating desiccant dryer set to "Dryer On" mode. Set to “EMS On” after ECM implementation

11.0 ENERGY EFFICIENCY MEASURE COSTS FOR CHEHALIS GENERATION FACILITY

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.

Table 26: Project Costs for ECM 1

ECM 1: CCW Pump Speed Control					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	550-hp 6,600V Pump VFD	Christenson Elec.	1	$327,942	$327,942
2	Control Wiring	Christenson Elec.	1	$2,683	$2,683
3	Programming	Estimate	1	$4,000	$4,000
Sub-Total					$334,625
Contingency				10%	$33,463
Total Cost:					**$368,088**

Table 27: 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
Contingency				10%	$18,368
Total Cost:					**$202,044**

Table 28: Project Costs for ECM 3

ECM 3: High Efficiency Lighting					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	High Efficiency Lighting Upgrade	Christenson Elec.	1	$91,529	$91,529
Sub-Total					$91,529
Contingency				10%	$9,153
Total Cost:					**$100,682**

Table 29: Project Costs for ECM 4

ECM 4: Install Small Condensate Pump					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Install Small Condensate Pump	General Mechanical	1	$38,000	$38,000
2	Condensate Pump	Flow Serve	1	$51,000	$51,000
3	Electrical and Controls	Christenson Elec.	1	$9,043	$9,043
Sub-Total					$98,043
Contingency				0%	$0
Total Cost:					**$98,043**

Table 30: Project Costs for ECM 5

ECM 5: (2) Reverse Osmosis Pump VFDs					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	100-hp RO Pump VFD	Christenson Elec.	1	$28,348	$28,348
2	75-hp RO Pump VFD	Christenson Elec.	1	$21,261	$21,261
3	Control Wiring	Estimate	4	$1,000	$4,000
4	Pressure Transducer	General Mechanical	2	$1,750	$3,500
5	Programming	Estimate	1	$1,000	$1,000
Sub-Total					$58,109
Contingency				10%	$5,811
Total Cost:					**$63,920**

Table 31: Project Costs for ECM 6

ECM 6: Reduce LP Economizer Recirculation Pump Use					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	TCV Replacement (if needed)	General Mechanical	2	$11,000	$22,000
2	Control Modifications	Estimate	2	$1,000	$2,000
Sub-Total					$24,000
Contingency				10%	$2,400
Total Cost:					**$26,400**

Table 32: Project Costs for ECM 7

ECM 7: New Variable Speed Air Compressor					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Baseline oil-lubed L/UL Compressor	Rogers Machinery	-1	$42,015	-$42,015
2	125-hp Oil-lubed VFD Air Compressor	Rogers Machinery	1	$59,000	$59,000
Sub-Total					$16,985
Contingency				0%	$0
Total Cost:					**$16,985**

Table 33: Project Costs for ECM 8

ECM 8: Reduce Runtime of Electric Heat Trace					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	New Thermostats	Estimate	5	$1,000	$5,000
2	Labor	Estimate	5	$1,000	$5,000
Sub-Total					$10,000
Contingency				0%	$0
Total Cost:					**$10,000**

Table 34: Project Costs for ECM 9

ECM 9: Adjust Thermostat on One Electric Heater					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Labor	Estimate	1	$200	$200
Sub-Total					$200
Contingency				0%	$0
Total Cost:					**$200**

Table 35: Project Costs for ECM 10

ECM 10: Demand-based Dew Point Controls					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Replacement Hygrometers	Rogers Machinery	2	$900	$1,800
2	Labor	Rogers Machinery	2	$200	$400
Sub-Total					$2,200
Contingency				10%	$220
Total Cost:					**$2,420**

12.0 BASELINE AND ANALYSIS OVERVIEW FOR CHEHALIS GENERATION FACILITY

12.1 ECMs 1 & 2: Closed Cooling Water System

12.1.1 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 8: Closed cooling water system with cooler on the left and one of the two 550 HP pumps on the right

12.1.2 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 demand 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.

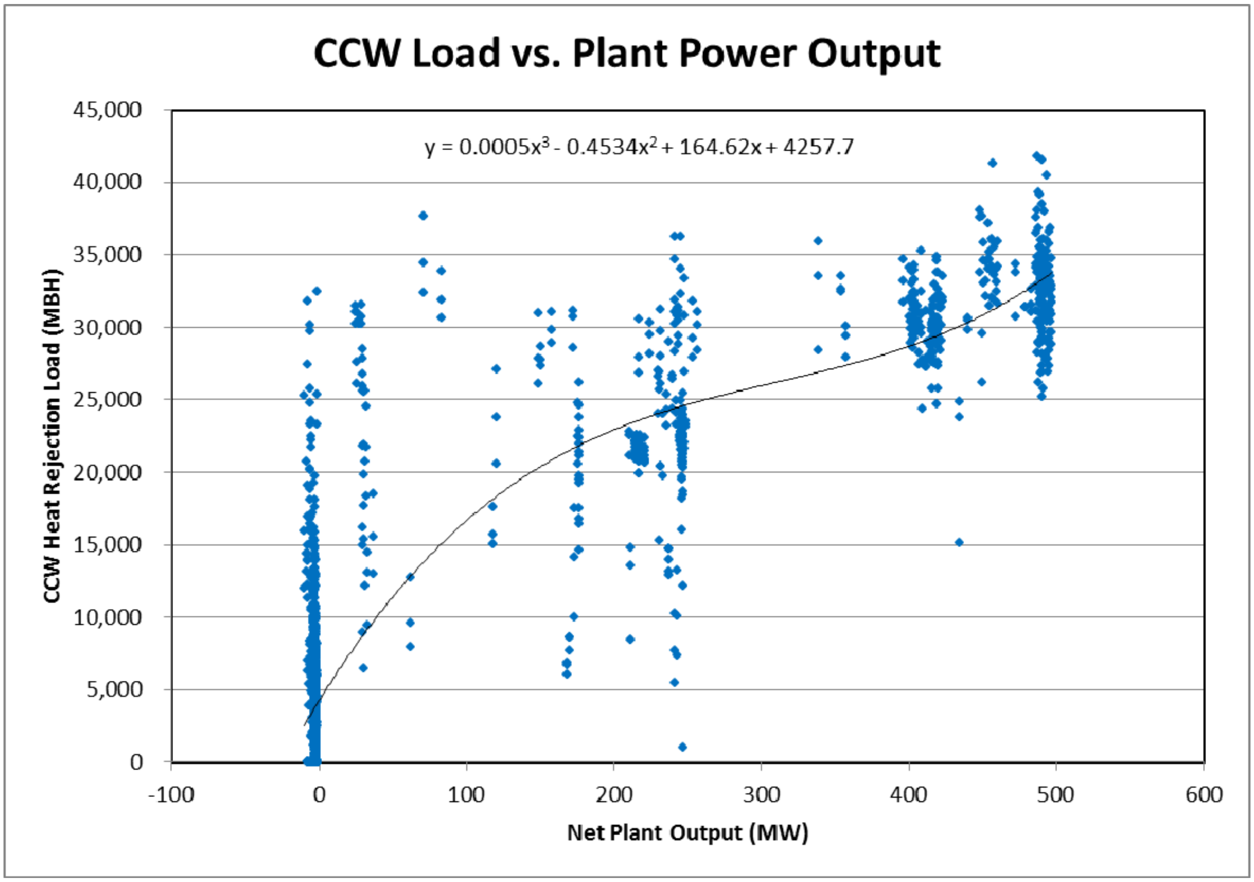


Figure 9: Plant Power Output vs. CCW Cooling Load

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 from the average 77°F to 92°F and by substituting fan speed for fan duty cycle. All fans were assumed to operate unless the required duty cycle was less than 20%, at which point the appropriate number of fans would operate at 20% speed.

ECM pump power was calculated by assuming that 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.

12.1.3 ECMs 1 & 2 - Trend Data Results

The following figure shows the baseline CCW operation as obtained from the plant PI data. One of the two pumps was running for 76% of the time, even though the plant was only generating power 19% of the time.

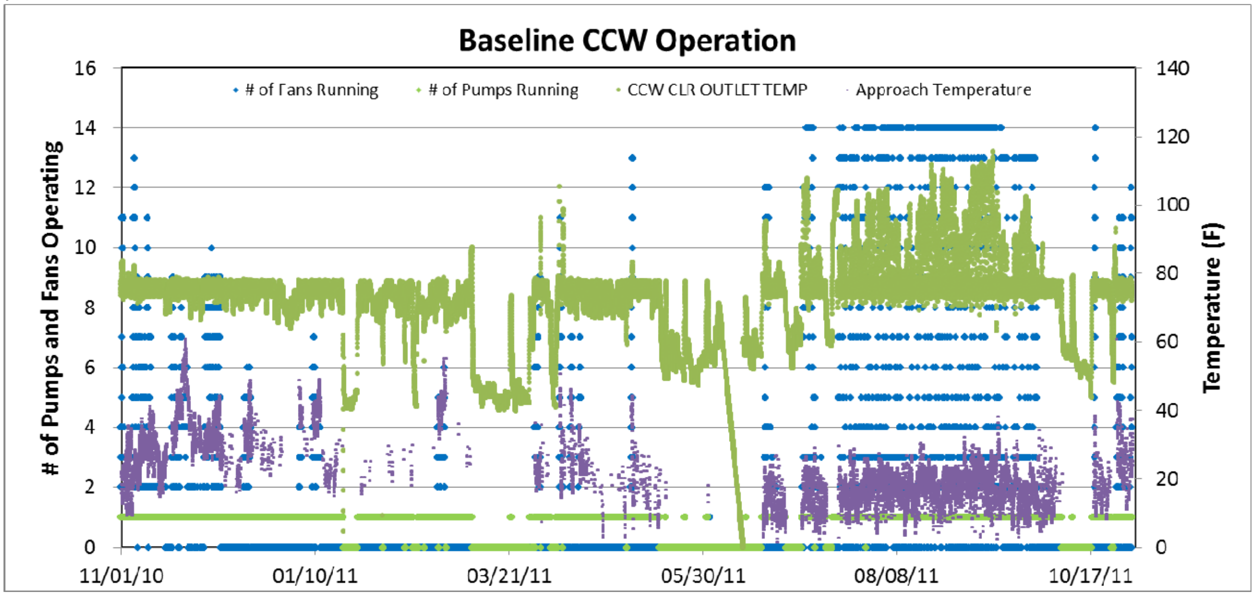


Figure 10: CCW Operating Data

- The pump operates with a fixed head of 75 psig (173.2 ft.)
- The pump draws 382.5 kW whenever it is operating in the baseline.
- 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. (The medium voltage VFD has higher more input inverters and is inherently more efficient than the 480V fan VFDs.)
- 90% of the power reduction of the pump is a cooling load reduction on the fans.

12.1.5 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 92°F.

12.1.6 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 36: Summary of Baseline and Estimated Energy Savings for ECM 1

ECM 1: CCW Pump Speed Control				
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 37: 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	2,555	2,555	0	0.0%
CCW Fans	647	191	455	70.4%
TOTAL	**3,201**	**2,746**	**455**	**14.2%**

12.2 ECM 3: High Efficiency Lighting

12.2.1 ECM 3 - Baseline Description

High pressure sodium (HPS) fixtures illuminate the Turbine Building, Maintenance Shop, Air Compressor Room and the building's exterior. The interior HPS lighting fixtures are manually controlled and operate continuously and the exterior lighting fixtures are controlled with a photo-eye and turn-off during the daytime. The other areas of the facility such as office, mechanical and electrical areas are illuminated with T8 lighting with the exception of the Maintenance Office, which is illuminated with T12 lighting. It was observed that the majority of the interior lighting operates continuously.

The Maintenance Manager indicated that the typical occupancy in the Turbine Building is four hours per day. However, because of the long restrike time for HPS fixtures, the lights operate continuously. In addition, much of the lighting in the Turbine Building is located near the ceiling. This lighting should be lowered as directed by the Maintenance Manager. Lighting heights shall not interfere with overhead equipment.

Figure 11 shows the HPS lighting in the Turbine Building.

Figure 11: High Pressure Sodium Lighting in Turbine Building

12.2.2 ECM 3 - Overview of Technical Approach

A facility wide lighting count was performed and the control of each fixture was obtained. In addition, a data logger was placed on the lighting circuit in the ACC MCC room to verify that the lighting operated continuously. All fixtures that were either turned-off or burnt-out were noted and were not included in the baseline energy calculations.

Table 38 shows the baseline lighting analysis based on number of fixtures that were on and off during the site visit.

Table 38: Baseline Lighting Analysis

Location	Fixture & Lamp Type (-)	Total Fixtures (-)	Fixtures On (-)	Fixtures Off (-)	Control Method (-)	Watts per Fixture (W/fixture)	Duty Cycle (%)	Annual Operation (h/yr)	Annual Energy Use (kWh/yr)
Turbine Building	400-W HPS	74	59	15	Manual	457	100%	8,760	236,196
Turbine Building	250-W HPS	10	5	5	Manual	295	100%	8,760	12,921
Exterior Lighting	400-W HPS	27	21	6	Photo eye	457	50%	4,338	41,632
Exterior Lighting	70-W HPS	170	54	116	Photo eye	86	50%	4,338	20,146
Control Room	4 ft- 2L T8 32 W	12	12	0	Manual	55	100%	8,760	5,782
Conference Room	4 ft- 2L T8 32 W	8	8	0	Manual	55	23%	2,000	880
Lunch Room	4 ft- 2L T8 32 W	8	8	0	Manual	55	100%	8,760	3,854
Lab	4 ft- 2L T8 32 W	3	3	0	Manual	55	23%	2,000	330
Men	4 ft- 2L T8 32 W	7	7	0	Manual	55	90%	7,884	3,035
Women	4 ft- 2L T8 32 W	5	5	0	Manual	55	1%	100	28
Open Office	4 ft- 2L T8 32 W	11	11	0	Manual	55	100%	6,000	3,630
IT Room	4 ft 2L T8 32W	6	6	0	Manual	55	100%	8,760	2,891
Maintenance Shop	400-W HPS	9	8	1	Manual	457	100%	8,760	32,027
Maintenance Office	8 ft - 2L T12 110 W	7	7	0	Manual	237	100%	8,760	14,533
Air Compressor Room	400-W HPS	6	5	1	Manual	457	100%	8,760	20,017
Electric Room	4 ft 2L T8 32W	6	6	0	Manual	55	100%	8,760	2,891
ACC MCC	4 ft 2L T8 32W	33	33	0	Manual	55	100%	8,760	15,899
Back MCC	4 ft 2L T8 32W	33	33	0	Manual	55	100%	8,760	15,899
BFW-1 Pump Room	4 ft 2L T8 32W	5	5	0	Manual	55	100%	8,760	2,409
BFW-2 Pump Room	4 ft 2L T8 32W	5	5	0	Manual	55	100%	8,760	2,409
Total (MWh/yr)									**437**

12.2.3 ECM 3 - Control System Trend Data

- One time of use logger was placed on the lighting circuit in the ACC MCC room.

12.2.4 ECM 3 - Control System Trend Results

- The time of use logger on ACC MCC lighting circuit operated 100% of the time.

12.2.5 ECM 3 - Key Assumptions

- Lighting that is manually controlled and not in the office areas operates 100% of the time.
- Lighting fixtures that were off during the site visit is typical of normal operation.
- A lighting upgrade would result in all lighting fixtures being operational.
- 400-W high pressure sodium (HPS) fixtures would be replaced with 6-lamp T5 High Output High Bay Fluorescent (HO HBF) fixtures.
- 250-W high pressure sodium (HPS) fixtures would be replaced with 4-lamp T5 High Output High Bay Fluorescent (HO HBF) fixtures.
- Each 8 ft. 2-lamp T12 fixtures would be replaced with two 4 ft. 2-lamp T8 fixtures
- The runtime of the new lighting fixtures controlled with occupancy sensors in the Turbine Building, ACC Rooms, Electric Room, IT Room and Pumps Rooms would be 30%.
- The runtime of the new lighting fixtures controlled with occupancy sensors in the Maintenance Shop, Maintenance Office and Air Compressor Room would be 50%.

12.2.6 ECM 3 - Summary of Baseline and Estimated Energy Savings

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

Table 39: Summary of Baseline and Estimated Energy Savings for ECM 3

ECM 3: High Efficiency Lighting				
Equipment	***Baseline*** MWh/yr	***ECM*** MWh/yr	***Savings*** MWh/yr	%
Lighting System	437	191	246	56.3%
TOTAL	**437**	**191**	**246**	**56.3%**

12.3 ECM 4: Install Small Condensate Pump for Auxiliary Use

12.3.1 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 Steam 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.

12.3.2 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.
    - Flow rate: 100 gpm
    - 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.

12.3.3 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

12.3.4 ECM 4 - Control System Trend Results

The flowing 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.

12.3.5 ECM 4 - Key Assumptions

- Auxiliary pump will operate a minimum of 8.9% of the year.
- 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.

12.3.6 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 40: 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	241	0	241	100.0%
Small Condensate Pump	0	22	(22)	-
TOTAL	**241**	**22**	**219**	**90.9%**

12.4 ECM 5: Reverse Osmosis Pump VFDs

12.4.1 ECM 5 - Baseline Description

The facility uses demineralized water for makeup water. Raw water is pretreated before being fed through two reverse osmosis (RO) filter passes and an electrolysis E-Cell. The E-Cell requires stable feed conditions, and flow rate is carefully controlled. The first RO filter pass is fed by one of two 100 HP torpedo pumps. The second RO filter pass is fed by one of two 75 HP torpedo pumps. Both sets of pumps are throttled at the discharge to reduce the pressure from over 500 psig to around 300 psig to protect the RO filters and maintain flow rate.

The RO system is not incorporated into the PI system.

12.4.2 ECM 5 - Overview of Technical Approach

The analysis was performed using manual log data collected from 8/31/2011 to 9/28/2011. Average power draw was determined using power snapshots and logged data from 10/31/2011 to 11/23/2011. The following steps outline the technical approach for the baseline analysis.

1. Anytime the pumps were on was determined using a combination of manual data logs, logged current data, plant operating data, and plant personnel input.
2. The average operating pump power was calculated using a linear relationship between power snapshot data and logged current data from 10/31/2011 -11/23/2011.
3. Average operating pump total head, pressure drop across the control valve, and flow rate were calculated using the manual logs.

4. The percent runtime for the RO pump use was calculated from 11/1/2010 to 10/31/2011.
5. Energy use for the ECM was calculated applying the baseline runtime and flow rates, and reduced total head.

12.4.3 ECM 5 - Control System Trend Data

The demineralized water system is separate from the main control system.

Data was collected from manual log sheets from 8/31/2011 to 9/28/2011. The following manually recorded data was obtained for each pump for the following variables:

- Flow rate
- Inlet pressure
- Discharge pressures before and after the control valve

12.4.4 ECM 5 - System Trend Results

The following summarizes the trends from the RO system.

- During power generation, the RO pumps operate 71% of the time.
- When not generating, the RO pumps are run for 12 hours twice per week to keep the system clean.
- Manual logs demonstrated consistent operating conditions. The table below shows the average pressures and flow rates.

Table 41: Average RO Pumps Operating Conditions

Equipment	Inlet Pressure (psig)	Discharge Pressure (psig)	Discharge Pressure after Control Valve (psig)	Pressure Drop across Control Valve (psig)	Flow Rate (gpm)
100 HP RO Pump	47.2	532.6	274.9	257.7	268.5
75 HP RO Pump	45.8	600.0	202.8	397.3	162.5

- The average First Pass 100 HP Pump power was 84 kW.
- The average Booster75 HP Pump power was 62 kW.

The following summarizes the snapshot measurements on the RO Pumps.

- First Pass Pump – 85.5 kW
- Booster Pump – 63.5 kW

12.4.5 ECM 5 – Key Assumptions

- Operating hours during non-generating periods are 12 hours long, 2 days per week.
- 90% of the average pressure drop across the control valve was recovered.
- VFD efficiency is 97%.
- VFD exponent is 2.7.

12.4.6 ECM 5 – Summary of Baseline and Estimated Energy Savings

The summary of baseline and estimated energy savings for ECM 5 are shown in the table below.

Table 42: Summary of Baseline and Estimated Energy Savings for ECM 5

ECM 5: (2) Reverse Osmosis Pump VFDs				
Equipment	***Baseline*** MWh/yr	***ECM*** MWh/yr	***Savings*** MWh/yr	%
First Stage Pump	175	79	96	54.8%
Booster Pump	129	48	82	63.2%
TOTAL	**304**	**127**	**178**	**58.4%**

12.5 ECM 6: Reduce LP Economizer Recirculation Pump Use

12.5.1 ECM 6 – Baseline Description

One 75 HP recirculation pump serves each heat recovery steam generator (HRSG). The pumps recirculate a portion of the LP Economizer discharge back to the inlet to maintain the exhaust stack gas temperature above 200°F to prevent the formation of sulfuric acid. The original design included a temperature control valve (TCV) which would have used stack temperature to modulate the pump discharge. However, the TCV never worked properly and the insides were removed.

To improve temperature control, another bypass line was added to the condensate line. This line has a TCV which allows condensate to bypass the LP economizer based on stack temperature. By reducing flow through the economizer, the bypass reduces the load on the exhaust stack gas and increases stack temperature. The facility has found that running the bypass line alone without the LP pumps results in reduced stack temperatures.

12.5.2 ECM 6 – 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. Average power draw was determined using a power snapshot and logged data from 10/19/2011 to 11/23/2011. The following steps outline the technical approach for the baseline analysis.

1. Pump on/off status was determined.
2. Pump operation for each HRSG was calculated from 11/1/2010 to 10/31/2011.
3. The average operating pump power was calculated using a linear relationship between power snapshot data and logged current data from 10/19/2011 to 11/23/2011.
4. The percent runtime for the LP Economizer pump use was calculated from 11/1/2010 to 10/31/2011.

12.5.3 ECM 6 – Control System Trend Data

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

- LP Economizer Recirculation Pump On/Off Status
- LP Economizer Feed TCV Position
- Duct Gas Temperature after LP Economizer

12.5.4 ECM 6 – Control System Trend Results

The following summarizes the trends from the control system.

- HRSG 1 LP Economizer Recirculation Pump operated 7.0% of the year.
- HRSG 2 LP Economizer Recirculation Pump operated 11.7% of the year.
- HRSG 1 LP Economizer Recirculation Pump did not operate for the first half of the year although CT 1 generated power during this time period.
    - While the pump operated, the average exhaust gas temperature directly following the LP Economizer was 233°F.
    - While only the bypass valve operated, the average exhaust gas temperature directly following the LP Economizer was 226°F.
- The average pump power was 53 kW.

The following summarizes the snapshot measurement on the LP Pump.

- LP Pump, HRSG 1 – 55.0 KW

12.5.5 ECM 6 – Key Assumptions

- Pumps will be turned off for 95% of the current operating time. The remaining 5% is included to provide conservative savings in the case of valve failure or if the pumps need to be turned on to raise the exhaust gas temperature.

12.5.6 ECM 6 – Summary of Baseline and Estimated Energy Savings

The summary of baseline and estimated energy savings for ECM 6 are shown in the following table:

Table 43: Summary of Baseline and Estimated Energy Savings for ECM 6

ECM 6: Reduce LP Economizer Recirculation Pump Use				
Equipment	***Baseline*** MWh/yr	***ECM*** MWh/yr	***Savings*** MWh/yr	%
HRSG 1 LP Recirc. Pump	32	2	31	95.0%
HRSG 2 LP Recirc. Pump	55	3	52	95.0%
TOTAL	**87**	**4**	**83**	**95.0%**

12.6 ECMs 7 and 10: Compressed Air System

12.6.1 ECMs 7 and 10 – Baseline Description of Compressed Air System

One Kobelco KNW1A-B/H 125 HP oil free, two stage rotary screw air compressor provides compressed air for both instrumentation and service tools throughout the plant. The compressor uses load/unload controls to maintain tank pressure between 110 psig and 125 psig. The system remains pressurized at all times to maintain the shaft seals on the hydrogen cooled generators. The other 125 HP air compressor that was used as a backup is at the end of its useful life. The plant is currently renting a portable diesel powered compressor for a backup and is looking to install a permanent compressor to have in place of the rented compressor. Lack of compressed air for instrumentation will shut down the plant. The costs for this measure are based on the assumption that the plant will purchase a new back-up compressor comparable to the operating load/unload compressor.

The compressor discharges into a large wet receiver (approximately 15,000 gallons). Two lines, Service Air and Instrument Air, leave the receiver to feed the compressed air needs at the plant. The Service Air line is fed by the priority valve, which is a back pressure regulator that will close air flow to this line if air pressure in the receiver falls. This ensures that the Instrument Air system remains at full pressure at all times. The Instrument Air line feeds into two Ingersoll Rand TZ300 heatless desiccant dryers. The dryers are operated one at a time and are sized to handle 300 cfm each. At the time of the site visit the operating dryer was set to "Dryer On" mode and the dew point was reading about -95°C. The dryers have the ability to control to an operator-specified dew point using the Energy Management System (EMS) feature. Each dryer requires about 40 cfm of compressed air to operate while in the "Dryer On" mode.

12.6.2 ECMs 7 and 10 – Overview of Technical Approach

Air compressor current was measured at 5 second intervals for a two week period from 10/19/11 through 11/4/11 on the Kobelco compressor. This period covered a period of all plant operating modes (off, one & one, and full load). The recorded data was coupled with manufacturer's ratings to generate a flow profile from the monitoring period. One time power measurements using a three-phase demand meter were used to correlate compressor amps to kW during this period. The average power for each mode of plant operation was calculated and then multiplied by the annual hours that the plant operates in each mode (based on PI data from 11/1/10 to 10/31/11) in order to calculate the baseline compressor energy use.

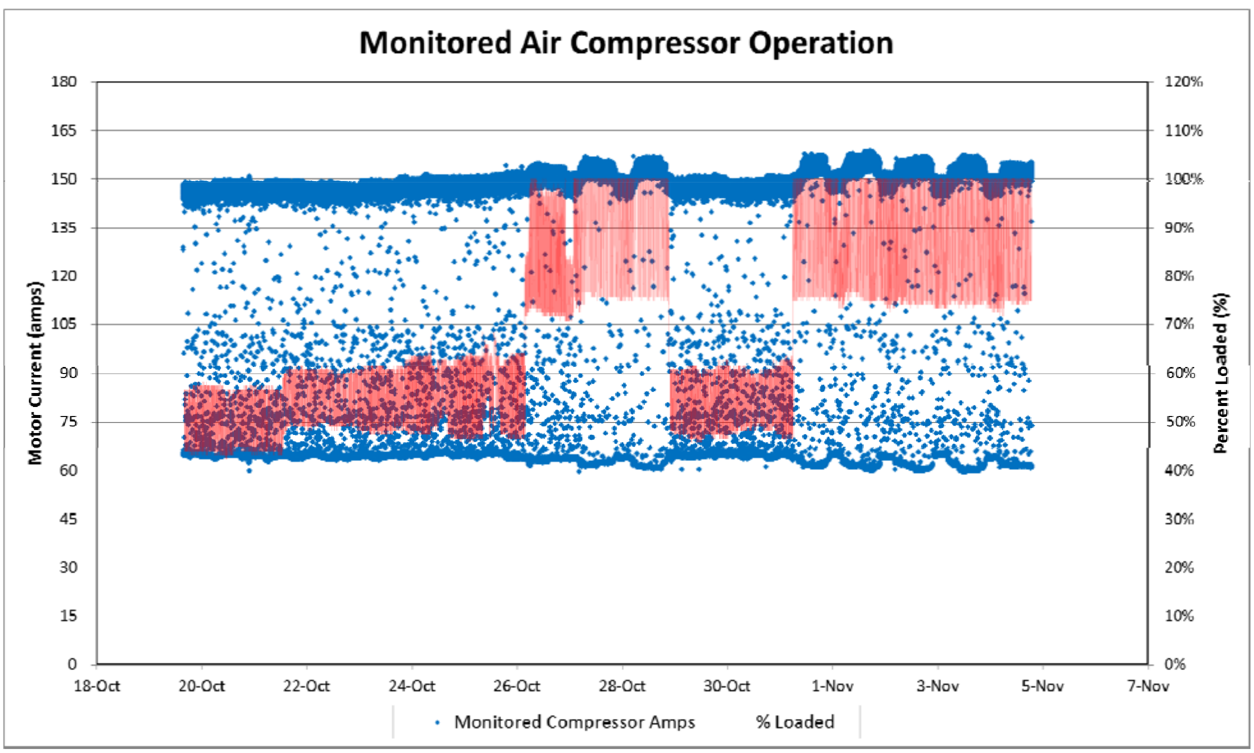


Figure 12: Monitored Air Compressor Operation

In order to calculate ECM energy use, manufacturer flow and power ratings for the proposed VFD compressor were coupled with the calculated flow profile to calculate compressor power. The analysis assumes a fixed discharge pressure of 110 psig. The average power for each mode of plant operation was calculated and multiplied by the respective hours of operation in each mode to calculate ECM compressor energy.

For the two demand reduction ECMs, the flow was subtracted from the baseline flow profile for each operating mode. VFD compressor power was then recalculated at the new flow rates in order to calculate ECM system energy. Dryer purge air was assumed to be 12% of the rated dryer flow, or 36 acfm. Because only the Instrument Air passes through the dryers, an approximation had to be made for the percentage of the total flow that passes through the Instrument Air line. It was assumed that when the plant is not operating, half of the air use goes into the instrumentation air line. The increased air flow during production is all assumed to go to Instrument Air. Purge cycles for the dew-point demand dryer controls were assumed to be proportional to the rate of Instrument Air. It was assumed that half of the non-production Instrument Air flow could be saved by installing the automated isolation valve.

12.6.3 ECMs 7 and 10 – Data Monitoring Results

The calculated flow and power for the baseline and ECMs are shown in the following tables:

Table 44: Compressed Air Modeling Results

Power	Baseline	VFD	Dew-point Controls	
No Production:	67.4	60.3	56.4	kW
One & one:	89.4	86.6	85.7	kW
Three turbines:	97.7	98.7	98.7	kW

Flow	Baseline	VFD	Dew-point Controls	
No Production:	293.8	293.8	293.8	acfm
One & one:	414.1	414.1	414.1	acfm
Three turbines:	461.7	461.7	461.7	acfm

12.6.4 ECM 7 – Key Assumptions for

- The compressed air system is pressurized year round.
- The plant operates with all three turbines for 804 hours per year and with two turbines for 862 hours per year.
- The VFD compressor targets a fixed discharge pressure of 110 psig.
- Baseline and VFD compressor part load performance is as shown in the following figure:

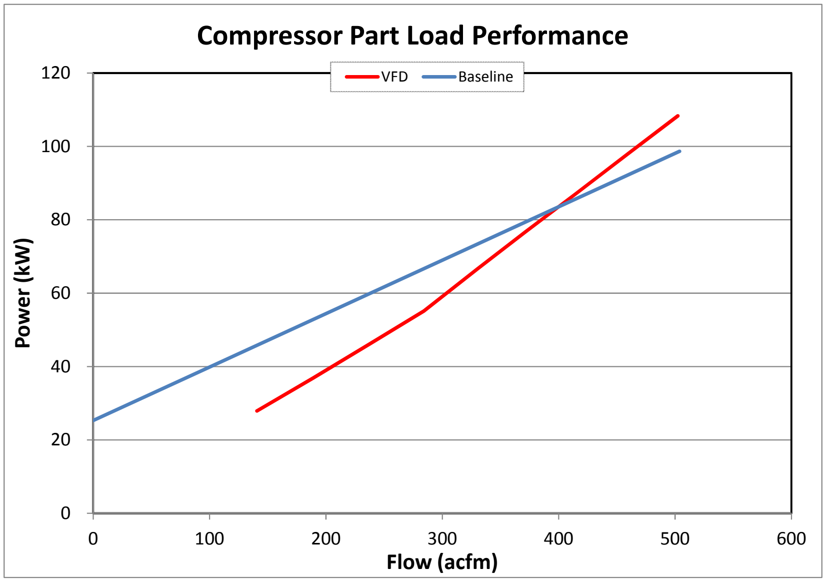


Figure 13: Baseline and ECM Compressor Performance

12.6.5 ECM 10 – Key Assumptions

- Non-production compressed air demand is reduced by 18.4 acfm on average due to the reduced Instrument Air requirements.
- One & one compressed air demand is reduced by 3.9 acfm on average due to the reduced Instrument Air requirements.
- Full production air flow does not change because the full output of the dryers is required on the Instrument Air line.

12.6.6 ECMs 7 and 10 – Summary of Baseline and Estimated Energy Savings

The summary of baseline and estimated energy savings for ECMs 7 and 10 are shown in the following tables:

Table 45: Summary of Baseline and Estimated Energy Savings for ECM 7

ECM 7: New Variable Speed Air Compressor				
Equipment	***Baseline*** MWh/yr	***ECM*** MWh/yr	***Savings*** MWh/yr	%
Air compressors	631	579	52	8.3%
TOTAL	**631**	**579**	**52**	**8.3%**

Table 46: Summary of Baseline and Estimated Energy Savings for ECM 10

ECM 10: Demand-based Dew Point Controls				
Equipment	***Baseline*** MWh/yr	***ECM*** MWh/yr	***Savings*** MWh/yr	%
Air compressors	579	550	29	5.0%
TOTAL	**579**	**550**	**29**	**5.0%**

12.7 ECM 8: Reduce Runtime of Electric Heat Trace

12.7.1 ECM 8 – Baseline Description

Much of the exterior piping is heat traced to prevent freezing during the winter. During the site visit, five electric panels were identified that control the heat tracing throughout the plant. The combined power from these five circuits was measured at 86 kW. The thermostats on these panels are not functioning properly and consequently the electric heat trace is operated manually. This results in additional runtime of the electric heat trace.

12.7.2 ECM 8 – Overview of Technical Approach

The analysis was performed using data from time of use loggers installed by the consultant showing the on/off state of each circuit and one-time measurements of power. Interval data was logged from 10/31/2011 to 11/23/2011. The following steps outline the technical approach for the baseline analysis.

1. The on/off time of each of five electric heat trace panels was recorded.
2. 15-minute ambient temperature data for East Olympia, WA was obtained from AgWeatherNet (http://weather.wsu.edu/).
3. The average runtime of all five electric heat trace panels when the outdoor air temperature was above 42 °F was calculated. It is assumed that automatic controls will turn off electric heat trace when the ambient temperature is above 42°F.
4. From typical meteorological year (TMY3) weather data for Olympia Airport, WA, the amount of hours when the ambient temperature was greater than 42 °F and less than 60 °F was calculated for the following months:
   - January, February, March, November and December
5. The number of hours that the heat trace could be turned-off was calculated by multiplying the average time the heat trace was operating above 42 °F and the amount of average annual average hours the ambient temperature is between 42 °F and 60 °F during the five aforementioned months.
6. Energy savings were calculated by multiplying the average time the heat trace could be turned off by the amount of total electric heat trace power from snapshot measurements.

12.7.3 ECM 8 – Control System Trend Data

Time of use loggers were placed on the following five electric heat trace panels:

- 685-HTCP-40001
- 685-HTCP-50000
- Heat Trace near Air Cooled Condenser
- Two heat trace panels in Turbine Building

In addition, onetime measurements were taken on 4 of the 5 electric heat trace panels.

12.7.4 ECM 8 – Control System Trend Results

The following summarizes the trends from the control system.

- Heat Trace Panel 685-HTCP-40001 operated 83.6% of the time
- Heat Trace Panel 685-HTCP-50000 operated 82.7% of the time
- Heat Trace near Air Cooled Condenser operated 13.7% of the time
- One of the heat trace panels in the Turbine Building operated 78.4% of the time and the other operated 65.6% of the time
- The minimum, maximum, and average outdoor air temperatures during the monitoring period were 25.9 °F, 60.7 °F, and 40.2 °F respectively.
- 44% of the time the average outdoor air temperature was above 42 °F.
- 21.3% of the heat trace operation during the monitoring period occurred when the temperature was greater than 42°F.
- From typical meteorological year weather data, the number of hours for the five aforementioned months that are between 42°F and 60°F is 2,127.

The following summarizes the snapshot measurements on the electric heat trace panels.

- 685-HTCP-40001 – 18.7 KW
- 685-HTCP-50000 – Measurement not attainable
- Heat Trace near Air Cooled Condenser – 22.9 kW
- Line 1 heat trace panels in Turbine Building – 13.4 kW
- Line 2 heat trace panels in Turbine Building – 12.0 kW

12.7.5 ECM 8 – Key Assumptions

- Controlling electric heat trace with thermostatic controls will reduce electric heat trace runtime by 450 h/yr (21% of 2,127 hours) for each panel.
- The electric heat trace for panel 685-HTCP-50000 is same as 685-HTCP-40001.
- When operating, electric heat trace operates at 85.7 kW total for all five circuits.

12.7.6 Summary of Baseline and Estimated Energy Savings ECM 8

The summary of baseline and estimated energy savings for ECM 8 are shown in the following table:

Table 47: Summary of Baseline and Estimated Energy Savings for ECM 8

ECM 8: Reduce Runtime of Electric Heat Trace				
Equipment	***Baseline*** MWh/yr	***ECM*** MWh/yr	***Savings*** MWh/yr	%
Elect. Heat Trace - Manual	182	0	182	100.0%
Elect. Heat Trace - Auto	0	144	(144)	-
TOTAL	**182**	**144**	**39**	**21.2%**

12.8 ECM 9: Adjust Thermostat on One Electric Heater

12.8.1 ECM 9 – Baseline Description

Twenty-seven 20-kW electric heaters provide heating to the Turbine building. The electric heaters are controlled with an integral thermostat. During the initial site visit, six electric heaters were operating when the outdoor air temperature was approximately 55 °F. During a subsequent site visit, data logging was installed on three of these six electric heaters. The data logging indicated that one of these units had significant runtime. This unit is located on the second column of the southeast corner of the Turbine Building and it will be referenced in this report as Heater 3.

12.8.2 ECM 9 – Overview of Technical Approach

The analysis was performed using 15-minute interval data from time of use loggers installed by the consultant. Interval data was logged from 10/31/2011 to 11/23/2011. The following steps outline the technical approach for the baseline analysis.

1. The on/off times of three of the six electric heaters operating during the initial site visit were recorded.
2. From TMY3 data for Olympia Airport, WA, the amount of hours when the ambient temperature was greater than 40 °F and less than 55 °F was calculated for the following months:
    - January, February, March, November and December
3. For the same aforementioned weather file and period, the number of hours below 55 °F was calculated.
4. The runtime of Heater 3 was calculated as 92.9% of the time when the ambient air temperature for the five month period was below 55 °F.
5. The runtime for Heater 3 with a thermostat adjustment was calculated as 30% of all hours when the ambient temperature was between 40 °F and 55 °F and any time the ambient temperature was below 40 °F.

12.8.3 ECM 9 – Control System Trend Data

Time of use loggers were placed on three electric heaters.

12.8.4 ECM 9 – Control System Trend Results

The following summarizes the trends from the control system.

- Heater 1 operated 1.2% of the time
- Heater 2 operated 0% of the time
- Heater 3 operated 92.9% of the time
- The minimum, maximum, and average ambient temperature when Heater 3 was operating was 25.9 °F, 56.4 °F and 39.5 °F.
- The minimum, maximum, and average ambient temperature was 25.9 °F, 60.7 °F and 40.2 °F during the monitoring period.

12.8.5 ECM 9 - Key Assumptions

- Improved thermostat control will decrease the run time of Heater 3 to 35% of the time when the ambient temperature is between 40 °F and 55 °F.
- The power for Heater 3 is 20 kW, which is the heater's name plate value. (wiring obstructions prohibited measurements of this unit)

12.8.6 Summary of Baseline and Estimated Energy Savings ECM 9

The summary of baseline and estimated energy savings for ECM 9 are shown in the following table:

Table 48: Summary of Baseline and Estimated Energy Savings for ECM 9

ECM 9: Adjust Thermostat on One Electric Heater				
Equipment	***Baseline*** MWh/yr	***ECM*** MWh/yr	***Savings*** MWh/yr	%
SE Electric Heater	76	39	37	48.9%
TOTAL	**76**	**39**	**37**	**48.9%**

13.0 EVALUATION, MEASUREMENT AND VERIFICATION FOR CHEHALIS GENERATION FACILITY

13.1 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.

13.2 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 3 is installed, the following variables will need to be monitored:

- On/off status of a minimum of one lighting circuit in each area.

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.

If ECM 5 is installed, the following variables will need to be monitored:

- RO First Pass Pump current or power
- RO Booster pump current or power
- Manual control room logs of system pressures and flow rate should also be gathered

If ECM 6 is installed, the following variables will need to be monitored:

- LP Economizer Recirculation Pumps On/Off Status
- Exhaust stack temperature
- Temperature control valve position

If ECM 7 is installed, the following variables will need to be monitored:

- Air compressor discharge pressure at the receiver (from PI)
- Air compressor power or motor amps on both compressors

If ECM 8 is installed, the following variables will need to be monitored:

- Ambient air temperature
- On/off status of each electric heat trace panel

If ECM 9 is installed, the following variables will need to be monitored:

- Turbine building air temperature near electric heater.
- On/off status of the electric heaters

If ECM 10 is installed, the following variables will need to be monitored:

- Air compressor discharge pressure (from PI)
- Air compressor power or motor amps
- Dryer tower pressure to determine dryer duty cycle

13.3 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.

13.4 Logistical Requirements

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

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

If ECM 1 is installed:

- Installed VFD
- Pump speed setpoints 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 3 is installed:

- New fixtures have been installed
- Occupancy sensor delays should be set to the minimum allowed by the manufacturer's warranty.

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.

If ECM 5 is installed:

- VFDs are installed
- VFD controls to appropriate setpoint

If ECM 6 is installed:

- Pumps are not operating unless additional heat is needed to maintain exhaust gas temperature.
- TCV is operating correctly

If ECM 7 is installed:

- VFD compressor installed
- Load/unload and start/stop setpoints for each compressor
- Target discharge pressure of new compressor
- One time power measurements of the compressor at loaded and unloaded states in order to verify the part load performance of the compressor.

If ECM 8 is installed:

- New thermostats installed or fixed.
- Electric heat turns on at 37 °F and turns off at 42 °F. Heat trace panels operate in auto mode.

If ECM 9 is installed:

- Electric heat remains off when ambient air temperature is above 55°F.
- Heater operates a minimum of 30% of all hours when the ambient temperature is between 40 °F and 55 °F

If ECM 10 is installed:

- Dryer operating mode set to "EMS On"
- Dryer dew point temperature setting

13.6 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.

14.0 ADDITIONAL SYSTEMS/EQUIPMENT REVIEWED AS PART OF THIS PLANT ANALYSIS

The following measures were identified and investigated to various levels. They are not included in the final list of opportunities at this time due to either poor return on investment (high cost relative to potential savings) or due to reliability concerns. Some measures may be good candidates for further investigation in the future.

14.1 Condensate Pump VFD

Condensate is pumped from the condensate drum to each of two low pressure drums located on each HRSG. To do so, the plant has three 450 HP condensate pumps: Pump 1A, 1B and 1C. Pump 1A operates as the lead pump and Pump 1B operates when the second turbine comes online. Pump 1C primarily operates in standby.

The energy savings for this measure were quantified assuming Pump 1A would operate as the trim pump and Pump 1B would operate as a base pump when two turbines were operating.

More energy savings from this measure would be realized when one of the turbines is in start-up or stand-by mode. Based on plant operations from 11/2010 to 10/2011, one 450 HP pump operated about 15.9% of the time in start-up mode or to provide condensate for the Auxiliary Boiler. A more cost effective way to obtain energy savings to provide condensate to the Auxiliary Boiler would be to install a smaller pump, which is provided as an ECM in this report.

Energy savings for installing a VFD on the lead pump, Pump 1A, was quantified and are estimated to be 131 MWh/yr. or 15.9% of the baseline. However, the cost to install a VFD on this pump is relatively expensive because the pump is medium voltage. The total Net Present Cost is estimated to be $403,923 resulting in a low Total Resource Cost Test of 0.21.

In addition to relatively low energy savings for this measure, this measure would be difficult to implement because the pumping system must maintain condensate level in each low pressure drum. Thus, a sophisticated control algorithm would be required to do so.

14.2 Boiler Feed Water Pump Modification

At each HRSG, condensate is pumped from the low pressure drum to both the intermediate pressure drum and the high pressure drum with a 2,000 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 1,000 ft. of H_2O and 1,500 ft. of H_2O for BFW-1 and BFW-2 respectively. Based on manufacturer's data, each pump could be de-staged from 10 stages to 9 stages.

The energy savings for de-staging both boiler feed water pumps is estimated to be 425 MWh/yr. However, this would be a major project with an estimated net-present cost of $559,633 resulting in a Total Resource Cost Test of 0.5.

14.3 Electric Fuel Pre-heaters

Fuel gas is preheated prior to combustion. After scrubbing, the gas is fed through two steam heat exchangers or one electric heater. The heated gas then is fed to the fuel gas separator. The feed steam to the heat exchangers comes from the Intermediate Pressure Economizer and is returned to the Low Pressure Economizer Inlet. For the first 30 minutes to 2 hours after start-up, there is insufficient steam available to heat the gas, and an electric 410 kW heater is used to preheat the gas.

No measures were identified related to these heaters due to insufficient operating time. The average operating time was between 20 and 40 minutes. The hourly combined run time for both heaters is 74 hours per year for 2011, which is approximately 30 MWh/yr.

14.4 SCR Blower Upgrades

Selective catalyst reactor (SCR) blowers feed hot exhaust air (~700°F) through an ammonia vaporizer. The vapor is then fed through a feed header and distributed into an SCR to remove NOx 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 are two blowers per HRSG. One operates per HRSG in operation. The blowers do not have any controls, but simply blow the maximum amount of air available.

The blowers require frequent maintenance, and the facility would like to upgrade the system to reduce maintenance costs. The following paths were investigated for this system:

14.4.1 Upgrade Blowers

The blower manufacturer, Industrial Air Products (IAP), was contacted. There were no recommended energy efficiency upgrades for the fan wheel or general blower. In regard to the blower reliability issue, IAP ran a bearing analysis that suggested that replacing the carbon composite shafts currently in use with stainless steel shafts, the bearing temperature could be reduced by 60°F. The temperature reduction would not affect energy savings. IAP can be contacted for more information about the stainless steel shafts.

14.4.2 Change SCR Air Source

Sourcing the SCR air from ambient was considered, but not determined as a valid solution. The benefit of using ambient air is that the lower temperature would put less strain on the blowers. However, lower temperature air is denser, and driving air at 60°F demands substantially more work than supplying the same volumetric flow rate of air at 700°F. Since sourcing from ambient increased overall power use, it is not eligible for implementation.

14.4.3 SCR VFDs

VFDs were 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.

14.5 Air Cooled Condenser Fan VFDs

The air cooled condenser includes thirty 150 HP axial fans that are all on two speed motors. Upgrading these fans with VFDs was considered as an energy efficiency measure. However, the existing control strategy with the two speed motors provides efficient part load performance and the energy savings do not justify the expense of retrofitting so many motors with VFDs and the associated control work that would be required. Plant personnel did indicate that VFDs on these fans would provide some operational benefits, but these have not been quantified.

14.6 Hogging and Holding Vacuum Pumps

Two liquid ring vacuum pumps, a 60 HP holding pump and 250 HP hogging pump, serve the air cooled condenser in order to remove air from the system, prepare the condenser for operation, and assist in maintaining the required vacuum pressure. These pumps are required to operate more than the design conditions would indicate. Experimentation could be done with turning off the holding vacuum pump during plant operation, but no capital project was found with this system in order to achieve energy savings. Repairing leaks in the ACC would also help to reduce the necessary operation of these two pumps.

14.7 Compressed Air Demand Reductions

When the plant is not operating compressed air demand is only reduced by about 1/3. This is an indication that much of the compressed air is being wasted through leaks. This measure would reduce the leak load on the plant during down periods by adding automated isolation valve to the instrument air line serving the combustion turbines. By cutting off air to portions of the plant, the leaks would not waste energy unless the plant is operating. Because the plant is down the majority of the time, there would be significant demand reductions, allowing the compressor to operate at reduced loads.

Additional savings could be realized through the addition of any of the following. Note that savings from these items have not been calculated in this report:

- Install additional isolation valves on major lines that are not needed when the plant is down.
- Replace timed solenoid drains with zero loss drains. Zero loss drains act like float valves and only allow liquid to escape from a line, rather than compressed air and liquid.
- Replace compressed air cooling applications with either water cooling or mechanical cooling. Several electrical cabinets may be good candidates for this upgrade.

These opportunities could be cost-effective, but additional investigation is necessary to identify which valves are safe to remove pressure from and which areas must remain pressurized at all times. There were not enough plant resources to fully design an optimal solution during the course of this investigation. This opportunity could be revisited once other ECMs have been implemented.

15.0 QUALITY ASSURANCE COMMENTS FOR CHEHALIS GENERATION FACILITY

15.1 GE PROPOSAL: CPD EXTRACTION AIR FOR SCR BLOWER REPLACEMENT

GE Energy Services provided a proposal to the Chehalis Generation Facility dated February 14, 2011 to replace the 50 HP SCR blowers feeding ammonia into each HRSG with compressor discharge air from the combustion turbine compressor (CPD aid). This proposal was intended to address reliability issues of the existing blowers due to the large number of maintenance issues that have surfaced with this equipment. The SCR blowers take 700°F exhaust gas from upstream in the HRSG, mix ammonia into the air stream and blow the ammonia-exhaust gas mixture back into the HRSG for NOx control.

Replacing the blowers from turbine compressor air would reliably eliminate both the maintenance issues and power draw of the 50 HP SCR blowers. However, removing mass flow from the turbine results in a decrease in generator power output far in excess of the energy saved from the blowers. By removing 1% of the air from the compressor, the plant output would decrease by 1.4%. This decrease in plant output is far too great to justify the maintenance advantages of the proposed project.

16.0 EXTRAPOLATION TO HERMISTON GENERATING PLANT

The Hermiston Generating Plant is a 474 MW natural gas fired combined cycle generating facility. The facility is slightly smaller than the Chehalis Generation Plant, but based on more than three years of generation data for each facility, the operating hours of the Hermiston Generating Plant were about two to three times more depending on the time period. The additional runtime of the plant should provide additional cost effective energy savings opportunities.

The table below summarizes the Chehalis Generating Plant net generation output for the previous 3.1 years.

Table 49: Summary of Chehalis Total Net Generation Output for 6 months to 3.1 Years

Summary of Chehalis Total Net Generation			
Time period	9/1/2008 - 10/1/2011	10/1/2010 - 10/1/2011	4/1/2011 - 10/1/2011
Minimum (MW)	0	0	0
Maximum (MW)	525	516	479
Average when on (MW)	354	345	332
% On	0.43	0.24	0.23
Years	3.1	1.0	0.5

The figure below shows that the runtime for the Chehalis Generation Facility has been decreasing over the past three years.

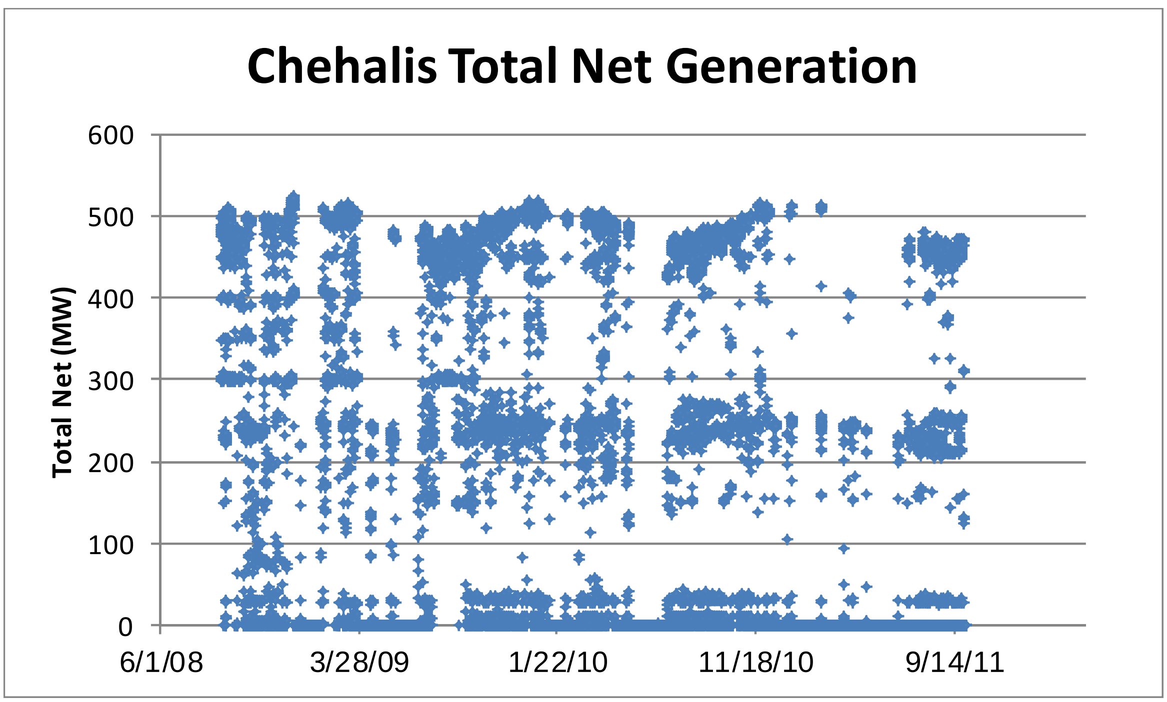


Figure 14: Chehalis Total Net Generation (MW)

The table below summarizes the Hermiston Generating Plant net generation output for the previous 3.8 years.

Table 50: Summary of Hermiston Total Net Generation Output for 6 months to 3.8 Years

Summary of Hermiston Total Net Generation			
Time period	1/1/2008 - 10/1/2011	10/1/2010 - 10/1/2011	4/1/2011 - 10/1/2011
Minimum (MW)	0	0	0
Maximum (MW)	490	485	460
Average when on (MW)	390	332	270
% On	0.90	0.82	0.65
Years	3.8	1.0	0.5

The figure below shows the runtime for the Hermiston Generation Facility, like the Chehalis Generation Facility, has been decreasing over the past three plus years. In addition, in the past six months, plant runtime and output has significantly decreased.

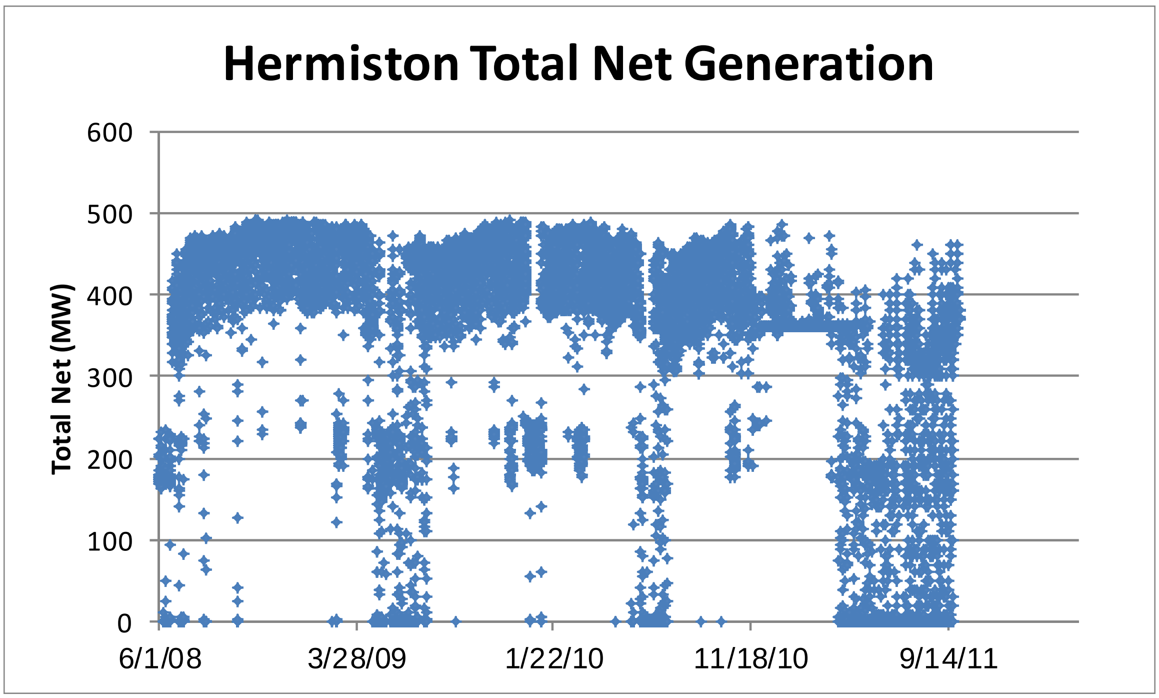


Figure 15: Hermiston Total Net Generation (MW)

An email from Shane Holst on December 8th indicated that the plant has opportunity to optimize the boiler feed-water pumps. This opportunity was identified at the Chehalis Generation Facility, but the estimated energy savings from available reduction in pump discharge pressure and pump runtime did provide a cost effective ECM. However, based on the email and plant runtime, the opportunity to optimize boiler feed water pumps maybe larger and cost effective at the Hermiston Generation Facility.

Based on the cost effective energy savings identified at the Chehalis Generation Plant, the runtime history of each plant over the past three years and information about the boiler feed-water pumps at the Hermiston Generation Facility, the estimated cost effective energy savings potential at the Hermiston Facility is estimated at 3,664 MWh/yr or 25% more than the Chehalis Generation Plant. This energy savings potential may vary considerably based on a detailed energy analysis of the site. The following table shows the energy savings potential for the Hermiston Generation Facility.

Table 51: Energy Savings Potential at the Hermiston Generation Facility

	Chehalis Identified Cost Effective Energy Savings (MWh/yr)	Hermiston Estimated Cost Effective Energy Savings Potential (MWh/yr)	Percent Increase of Energy Savings Potential (%)
Pumping	2,066	2,066	0%
Fans	455	455	0%
Compressed Air	81	81	0%
Lighting	246	246	0%
Electric Heat	76	76	0%
Boiler Feedwater Pumps	0	725	-
Total	2,924	3,649	25%

17.0 PLANT AUXILIARY BASELINE ENERGY USE FOR GOODNOE HILLS WIND PROJECT

17.1 PLANT DESCRIPTION

The 94 MW Goodnoe Hills Wind Project, completed in 2008, comprises of forty-seven 2-MW Repower MM92 wind turbines, at a wind farm located near Goldendale, WA.

The facility structures include a ~3,000 sq. ft. one-story O&M building, turbines and associated pad-mount transformers, and a collector substation. All generated power is transmitted through the Bonneville Power Administration (BPA) transmission lines. Klickitat County PUD provides primary service for the O&M building and back-up service for the rest of the facility (which is primarily served by Pacific Power, using the same BPA transmission lines).

The wind project is located in a Class II wind zone, and turbines are programmed with a cut-in and cut-out wind speed of 3 m/s and 25 m/s respectively. Turbines produce electricity at 575 V, which is stepped up to 34.5 kV at the padmount transformers, before being further stepped up to 34.5 kV at the main collector substation. The site operates at a capacity factor of about 30%, with annual energy production from October 2010 to October 2011 measured at 266,887 MWh/yr.

17.2 PLANT BASELINE DESCRIPTION

The baseline energy use per sub-system for the Goodnoe Hills Wind Project is shown in the table below.

Table 52: Baseline Energy Use per Sub-system for Goodnoe Hills Wind Project

Subsystem	Annual Energy Use (MWh/yr)	% of Total
Turbines	3,705	44%
Underground Circuits	1,321	16%
O&M Building	39	0.5%
Padmount Transformers	2,347	28%
Substation & Misc Loads	1,070	13%
Total	**8,482**	**100%**

The energy use per sub-system for the Goodnoe Hills Wind Project is shown in the figure below.

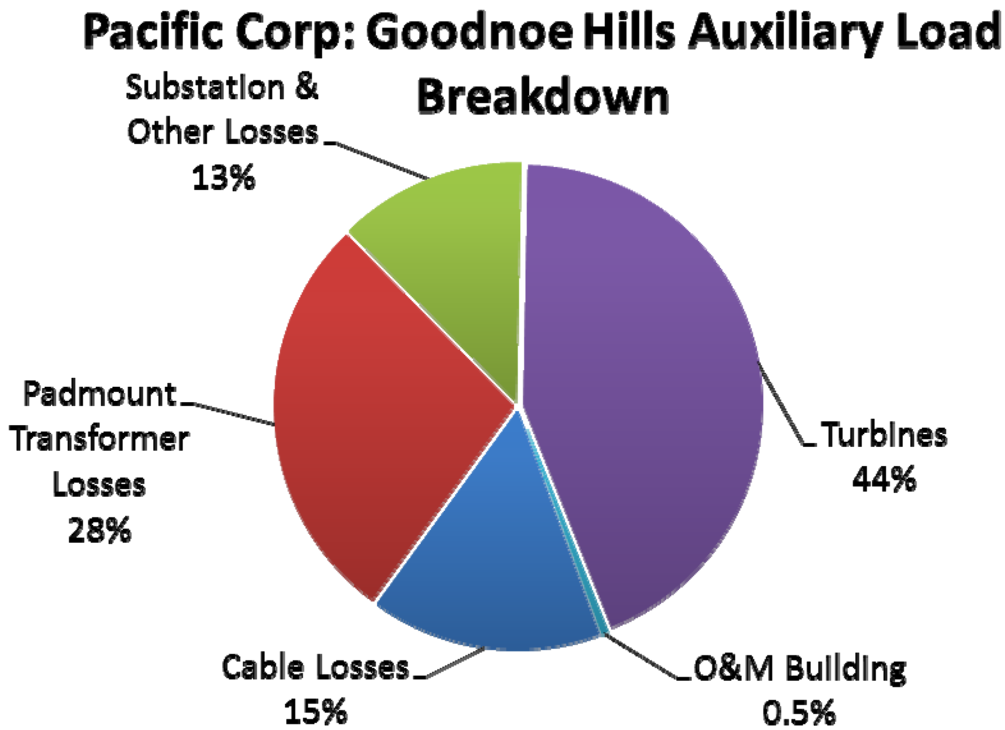


Figure 16: Energy Breakout per Sub-system for Goodnoe Hills Wind Project

18.0 DETAILED DESCRIPTION OF PROPOSED EQUIPMENT AND OPERATION GOODNOE HILLS WIND PROJECT

18.1 ECM 1: OCCUPANCY SENSORS FOR O&M GARAGE AREA

18.1.1 ECM 1 – Source of Energy Savings

Occupancy sensors save energy by detecting activity in work areas and automatically turning lights off when spaces are vacant.

18.1.2 ECM 1 – Specific Equipment Recommendations

- Install two occupancy sensors to control the 48 13W CFL fixtures in the O&M garage room.

18.1.3 ECM 1 – Set-points Recommended to Achieve Energy Performance

- Set the occupancy sensor time delay settings to no longer than 15 minutes.

18.2 ECM 2: INSTANT WATER HEATER

18.2.1 ECM 2 – Source of Energy Savings

Instant water heaters provide hot water on demand, thereby precluding the need for hot water storage and the associated storage energy losses.

18.2.2 ECM 2 – Specific Equipment Recommendations

- Decommission the existing water heater and install an instant water heater to serve the O&M building.

18.2.3 ECM 2 – Set-points Recommended to Achieve Energy Performance

- Set water temperature set-point to no more than 140 °F

19.0 ENERGY EFFICIENCY MEASURE COSTS FOR GOODNOE HILLS WIND PROJECT

The tables below provide an itemized cost breakout for each ECM.

Table 53: Project Costs for ECM 1

ECM 1: Occupancy Sensors for O&M Garage Area					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Occupancy Sensors	Estimate	2	$50	$100
2	In-house Occ Sensor Installation	Estimate	1	$75	$75
Sub-Total					$175
Contingency				10%	$18
Total Cost:					**$193**

Table 54: Project Costs for ECM 2

ECM 2: Instant Water Heater					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Instant Water Heater with Installation	Estimate	1	$900	$900
Contingency				10%	$90
Total Cost:					**$990**

20.0 BASELINE AND ANALYSIS OVERVIEW FOR GOODNOE HILLS WIND PROJECT

20.1 ECM 1: OCCUPANCY SENSORS FOR O&M GARAGE AREA

20.1.1 ECM 1 - Baseline Description

The O&M garage area is lit by 48 13 Watt CFL fixtures which remain on during facility operating hours, regardless of occupancy.

20.1.2 ECM 1 - Overview of Technical

Two occupancy sensors can control the garage area lights, providing illumination only when the area is occupied.

20.1.3 ECM 1 - Key Assumptions

- The O&M building operates 8 hours per day, 5 days per week and 50 weeks per year for annual operating time of 2000 hours per year.
- After installation of occupancy sensors, the garage area lights will be in operation for 250 hours per year.

20.1.4 ECM 1 - Summary of Estimated Energy Savings

The following table summarizes the anticipated energy savings:

Table 55: Goodnoe Hills ECM 1 Calculations

Number of Fixtures	48	
Power/Fixture	0.013	kW
Baseline Annual Operating Hours	2000	hrs/year
EEM Annual Operating Hours	250	hrs/year
Baseline Energy Consumption	1248	kWh/yr
EEM Energy Consumption	156	kWh/yr
Annual Energy Savings	**1092**	**kWh/yr**

20.2 ECM 2: INSTANT WATER HEATER

20.2.1 ECM 2 - Baseline Description

The faucets in the O&M building are served by a 40-gallon electric water heater. Although the facility does not use much hot water, electricity is used to maintain water temperature inside the tank year round.

20.2.2 ECM 2 - Overview of Technical Approach

Since the electric hot water heater in the O&M building is not in use often, much of the energy that is used on the heater is used to maintain water temperature inside the tank. This measure would replace the water heater with an instant tank-less hot water heater.

20.2.3 ECM 2 - Key Assumptions

- Each water faucet uses 0.75 GPM of hot water when in use.
- Each water faucet is used for 1 minute, 20 times per day, and 5 days per week.
- Existing energy factor is 0.9, based on water heater specifications.

20.2.4 ECM 2 - Summary of Estimated Energy Savings

The following table summarizes the anticipated energy savings:

Table 56: Goodnoe Hills ECM 2 Calculations

Number of Faucets	2	(1 in bathroom and 1 in kitchen)
Flow/Faucet	0.75	GPM
Time/Use	1	minute
Times Used/Day	20	
Days Used	5	days/week
Baseline Annual Hot Water	7500	Gallons/year
Temperature Rise	70	deg F
Cwater	1	BTU/lb deg F
Energy Use of Faucets	11,996	BTU hot water drawn per day
Existing Energy Factor	0.9	
Energy Use of Faucets	1,426	kWh/yr
Losses Associated with Tank	488	kWh/yr
Baseline Energy Consumption	1,914	kWh/yr
EEM Energy Consumption	1,426	kWh/yr
Annual Energy Savings	**488**	**kWh/yr**

21.0 EVALUATION, MEASUREMENT AND VERIFICATION FOR GOODNOE HILLS WIND PROJECT

21.1 EVALUATION, MEASUREMENT AND VERIFICATION REQUIREMENTS

Due to the relatively small savings potential and non-complex nature of the measure, no EM&V activities are proposed other than confirming that the equipment is installed as specified.

22.0 ADDITIONAL SYSTEMS/EQUIPMENT REVIEWED AS PART OF THIS PLANT ANALYSIS

22.1 CURRENT EXEMPLARY PRACTICES

Several exemplary practices with regards to energy efficiency are already being implemented at the facility. Thermostats in the O&M building operate on timers, and night-setback settings are also employed. Incandescent light fixtures have been replaced with energy efficient CFLs. Tower lighting is also only employed when the tower is occupied.

In addition, facility personnel at the site are proactive in maintaining the turbines and associated equipment.

22.2 TURBINES

The energy consuming equipment within the turbines include cooling fans, yaw motors, oil pumps, oil heaters, hydraulic systems, lights and switchgear. In addition, the turbine rotors require excitation power before being able to generate electricity.

The turbines are “packaged” units and do not comprise of built-up modular components installed separately by the facility. Consequently, most set-point and control algorithm optimization opportunities are already pre-established before installation.

Nonetheless, the performance of all energy using equipment in the turbine was surveyed for opportunities. It was noted that the turbine oil heaters turn on only when the oil temperature gets down to 46 °F and turn off when oil temperatures reach 59 °F. Due to the existing low temperature set points and the significantly high cost of a gearbox failure, oil temperature control was not further investigated.

The wind turbines are equipped with variable speed generator/converter systems, which allow the speeds to be adjusted within a range of +/- 40% of the synchronous speed. Together with the electrical pitch adjusting system, variable speed operation assures good results as regards energy yield, efficiency, mechanical stressing and power quality. PI data obtained from Goodnoe Hills showed that power is generated from each turbine with power factor consistently at or very near to one.

There were some potential operational (wind cut-in speed) and aerodynamic improvements (EVO Package and Vortex generators) identified that could potentially improve turbine output, but further investigation was necessary, and these were outside the scope of this report.

As most systems function “on-demand” and are shut off when not required, no significant opportunities were identified. In addition, the biannual turbine maintenance procedures were also evaluated and were deemed adequate with regards to ensuring energy efficient operation of the equipment.

22.3 Padmount Transformers

The site currently employs 34.5 kV amorphous core padmount transformers manufactured by Fortune Electric. However, due to reliability issues, transformers are being replaced by a different brand with conventional cores upon failure (up to 2 transformers per year).

Based on the specifications of the present Fortune Electric transformers and the proposed replacement transformers, there is a non-trivial energy penalty associated with employing the non-amorphous core transformers.

This issue was not studied in-depth for the purposes of this report.

22.4 Underground Cables

Underground cable loss calculations were evaluated and found within acceptable range.

22.5 Collector Substation

VFDs on the main transformer cooling fans were considered, but were not found cost effective.

23.0 EXTRAPOLATION TO LEANING JUNIPER WIND PROJECT, MARENGO AND MARENGO II WIND PROJECT

An energy savings potential of 1.6 MWh/yr was identified for the 94 MW Goodnoe Hills project. However, PacifiCorp owns and operates three additional wind projects in the state of Washington (Leaning Juniper, Marengo and Marengo II), which were not studied for the purposes of this report.

Using production capacity as a scaling factor, Table 57 below is a preliminary estimate of the potential savings potential for the remaining sites.

Table 57: Wind Project Energy Savings Potential Extrapolation

Wind Poject	Installed Capacity (MW)	Savings Potential (MWh/yr)
Leaning Juniper I	100.5	1.7
Marengo	140.4	2.4
Marengo II	70.2	1.2
Total	**311.1**	**5.3**

It should be emphasized that actual savings potential may differ from the above estimates significantly, and a scoping level survey of the sites may yield a more adequate assessment.

26.0 APPENDIX

26.1 Jim Bridger: Data Logging and Model Charts

ECM 1-Air Handler 4th Floor SE Corner (1VSF3)

No logging data performed; no models created.

ECM 2- 9th Floor Fans (1VSF 1&2)

No logging data performed; no models created.

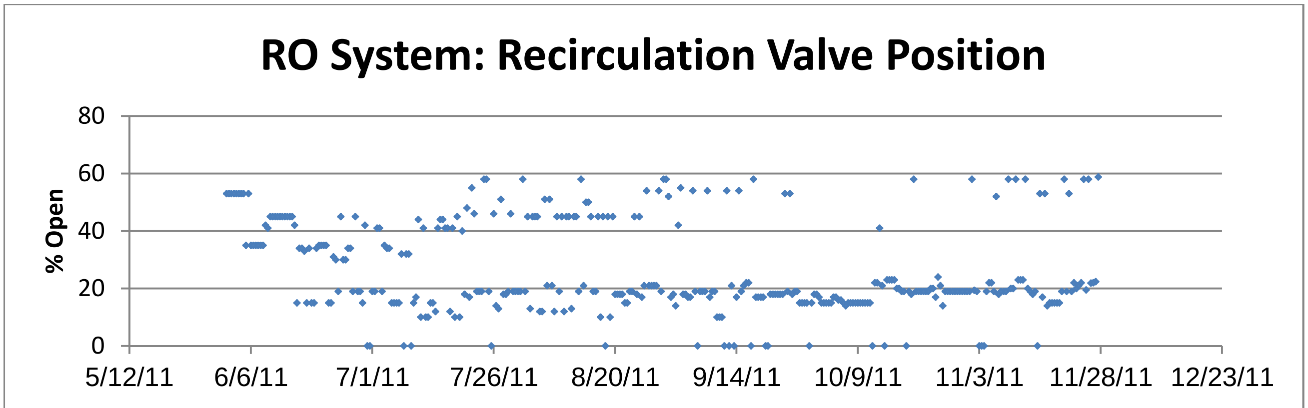
ECM 3- 2Chillers

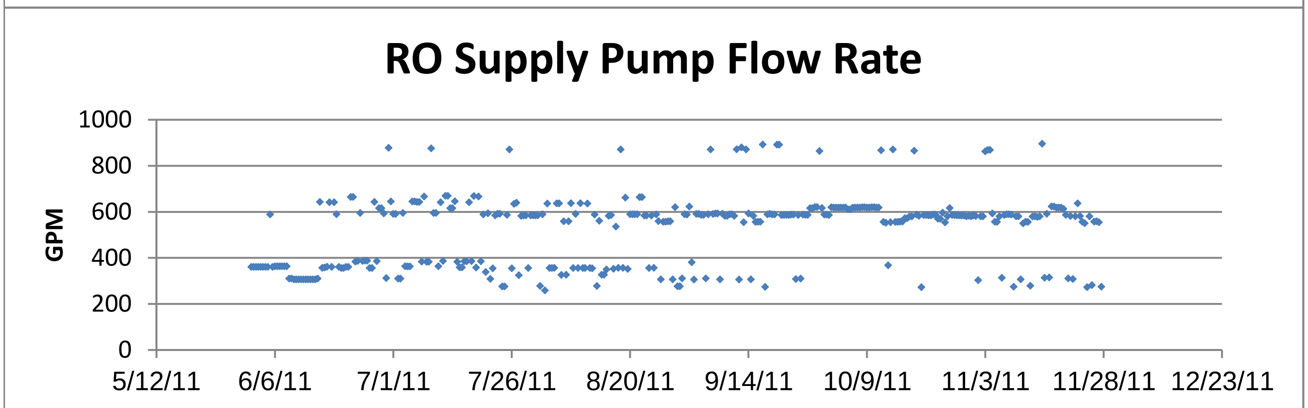
No logging data performed; no models created.

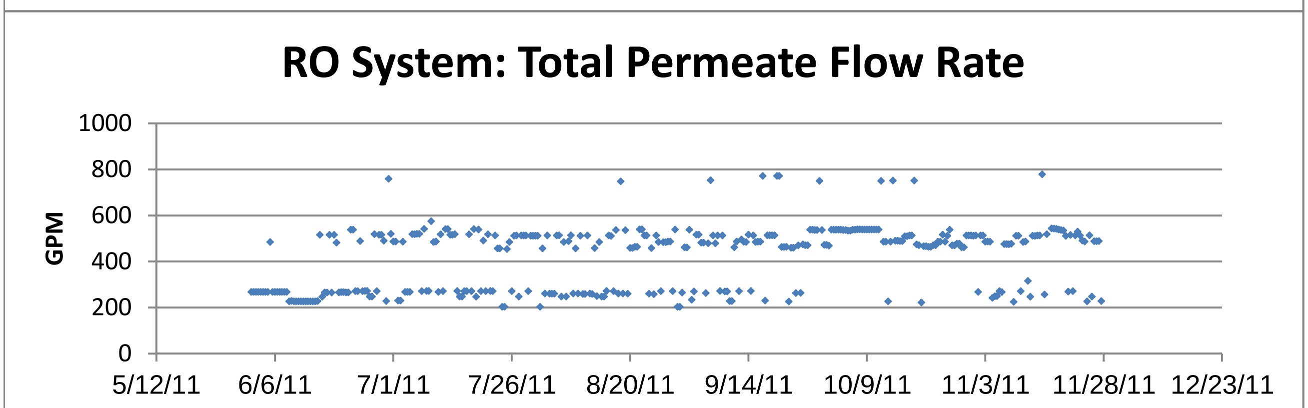
ECM 6- Turbine Room Fan and Mixer Bank

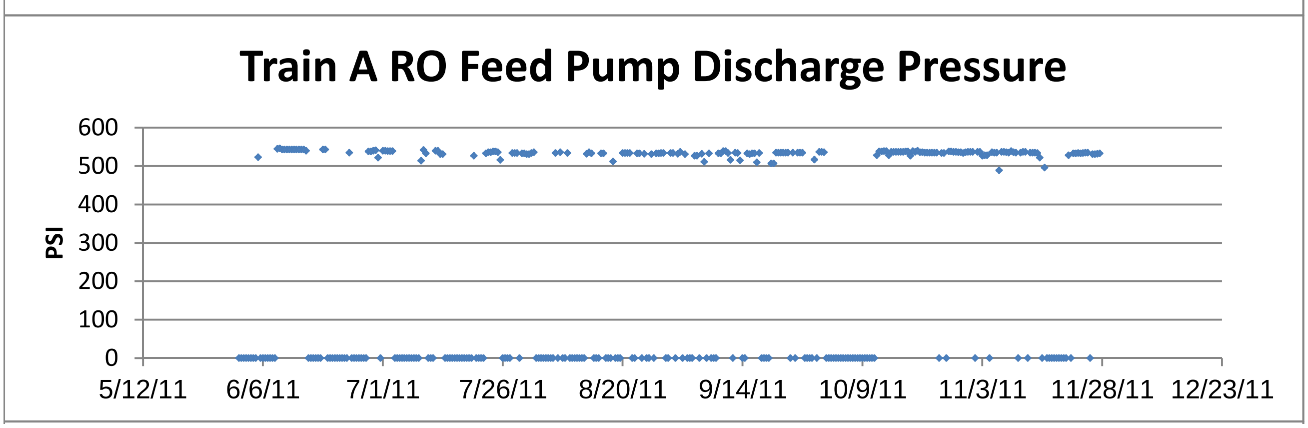
No logging data performed; no models created.

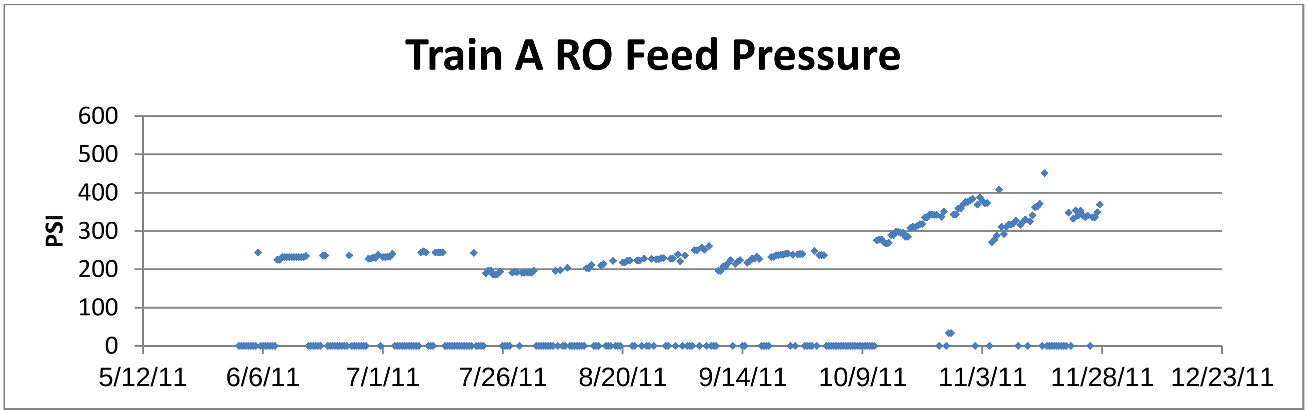
ECM 4


RO System: Recirculation Valve Position
% Open
80
60
40
20
0
5/12/11 6/6/11 7/1/11 7/26/11 8/20/11 9/14/11 10/9/11 11/3/11 11/28/11 12/23/11

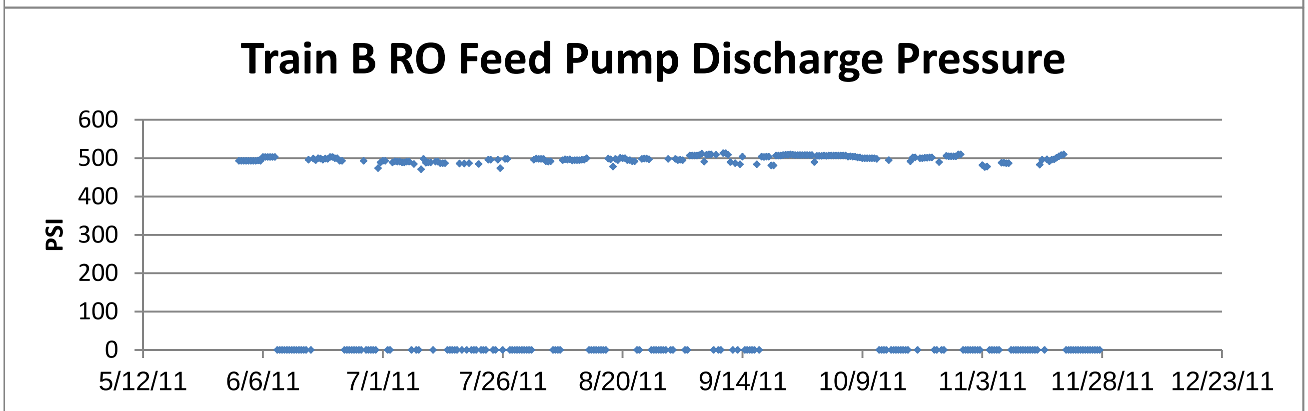

RO Supply Pump Flow Rate
GPM
1000
800
600
400
200
0
5/12/11 6/6/11 7/1/11 7/26/11 8/20/11 9/14/11 10/9/11 11/3/11 11/28/11 12/23/11


RO System: Total Permeate Flow Rate
GPM
1000
800
600
400
200
0
5/12/11 6/6/11 7/1/11 7/26/11 8/20/11 9/14/11 10/9/11 11/3/11 11/28/11 12/23/11

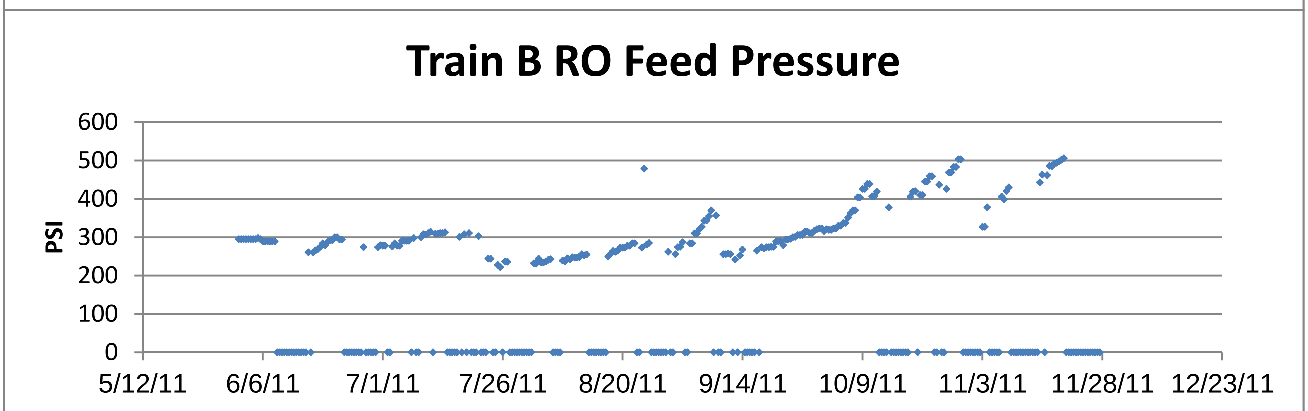

Train A RO Feed Pump Discharge Pressure
PSI
600
500
400
300
200
100
0
5/12/11 6/6/11 7/1/11 7/26/11 8/20/11 9/14/11 10/9/11 11/3/11 11/28/11 12/23/11



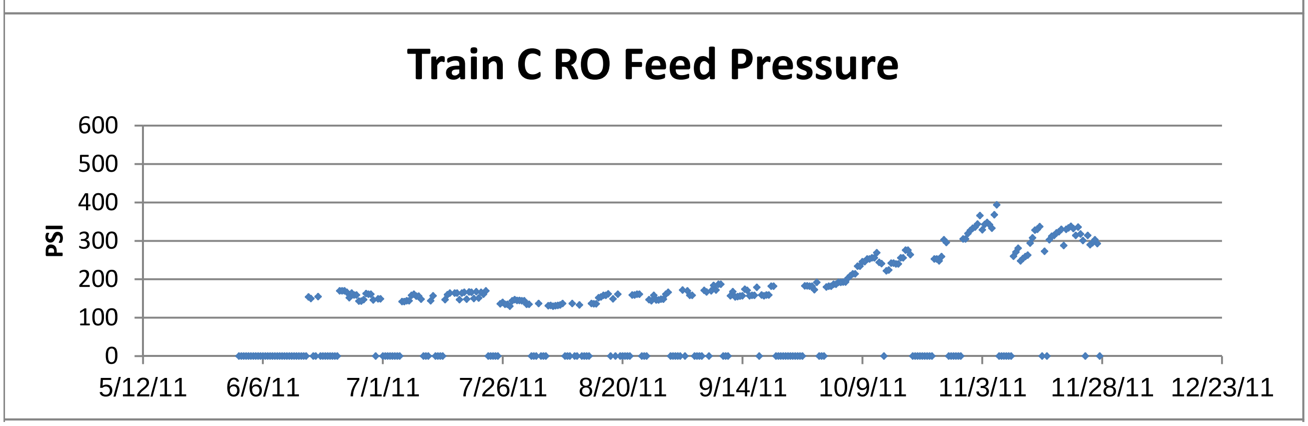
Train A RO Feed Pressure
PSI
600
500
400
300
200
100
0
5/12/11
6/6/11
7/1/11
7/26/11
8/20/11
9/14/11
10/9/11
11/3/11
11/28/11
12/23/11



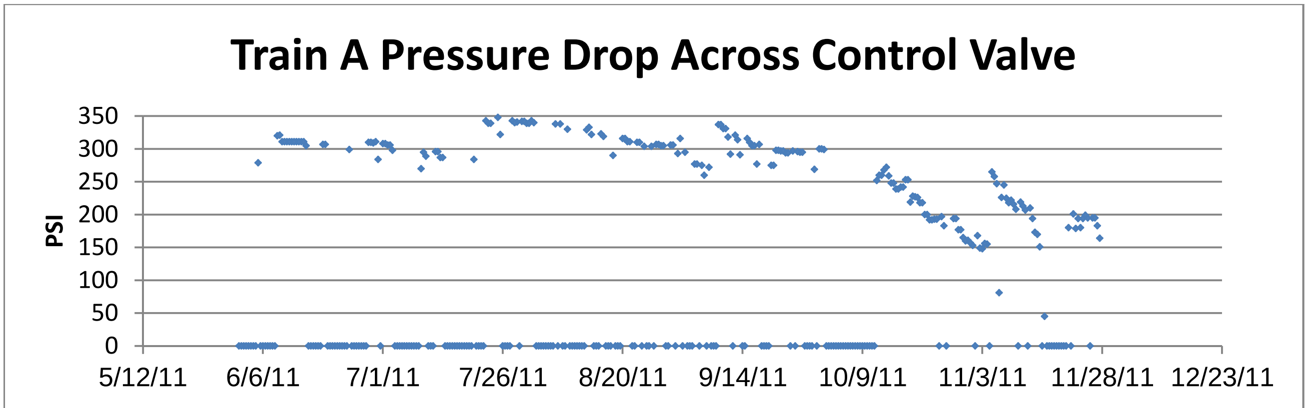
Train B RO Feed Pump Discharge Pressure
PSI
600
500
400
300
200
100
0
5/12/11
6/6/11
7/1/11
7/26/11
8/20/11
9/14/11
10/9/11
11/3/11
11/28/11
12/23/11

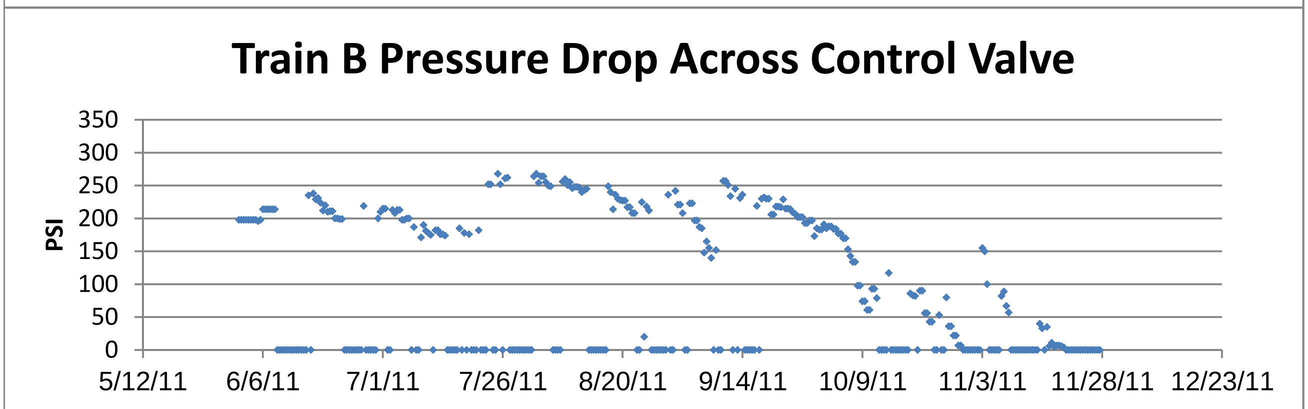


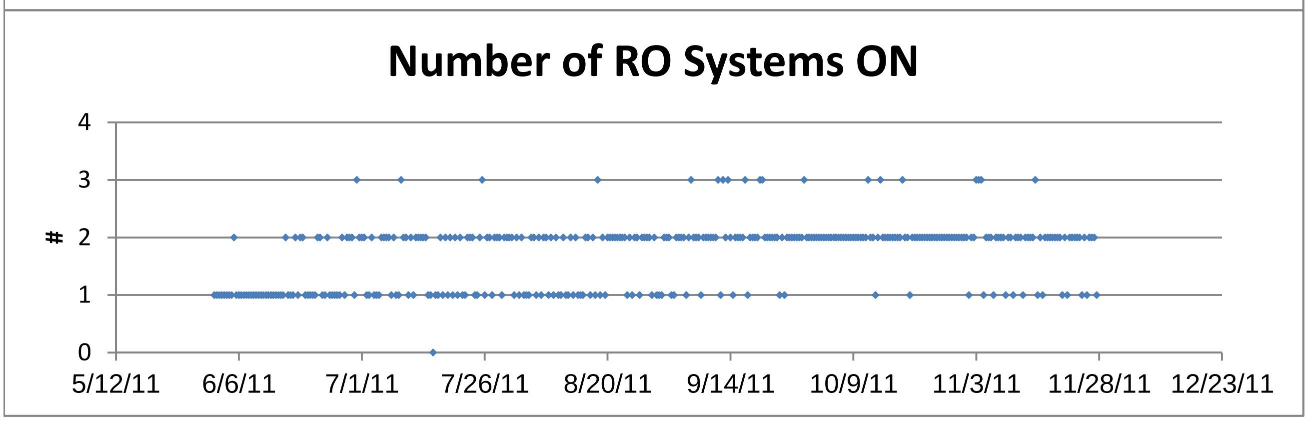
Train B RO Feed Pressure
PSI
600
500
400
300
200
100
0
5/12/11
6/6/11
7/1/11
7/26/11
8/20/11
9/14/11
10/9/11
11/3/11
11/28/11
12/23/11



Train C RO Feed Pressure
PSI
600
500
400
300
200
100
0
5/12/11
6/6/11
7/1/11
7/26/11
8/20/11
9/14/11
10/9/11
11/3/11
11/28/11
12/23/11

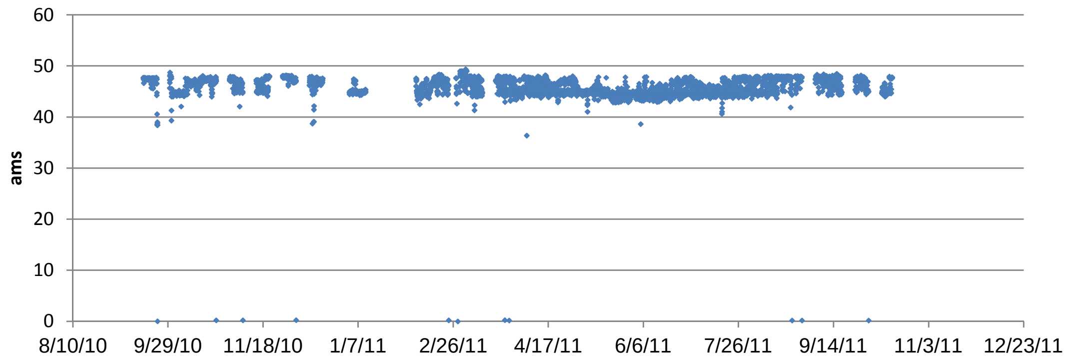

Train A Pressure Drop Across Control Valve
PSI
350
300
250
200
150
100
50
0
5/12/11
6/6/11
7/1/11
7/26/11
8/20/11
9/14/11
10/9/11
11/3/11
11/28/11
12/23/11


Train B Pressure Drop Across Control Valve
PSI
350
300
250
200
150
100
50
0
5/12/11
6/6/11
7/1/11
7/26/11
8/20/11
9/14/11
10/9/11
11/3/11
11/28/11
12/23/11

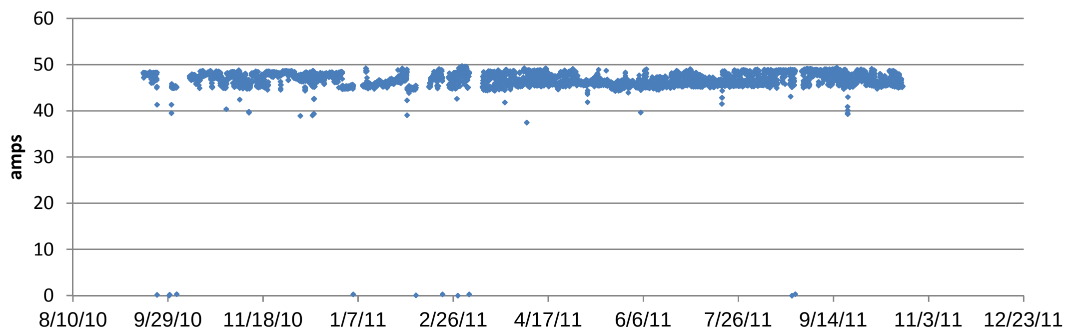

Number of RO Systems ON
#
4
3
2
1
0
5/12/11
6/6/11
7/1/11
7/26/11
8/20/11
9/14/11
10/9/11
11/3/11
11/28/11
12/23/11

ECM 5

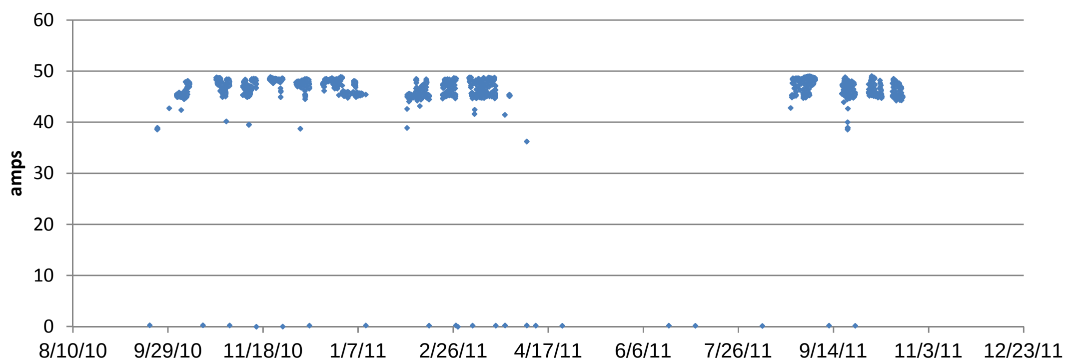
Condensate Pump #1 Current



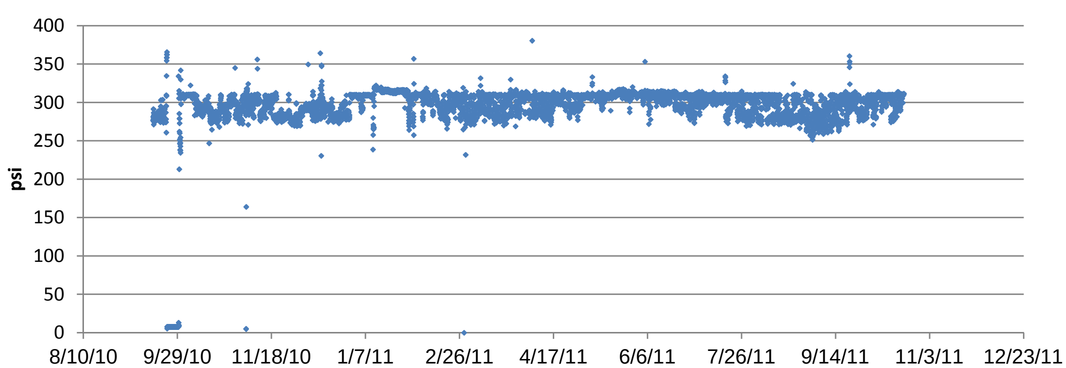
Condensate Pump #2 Current

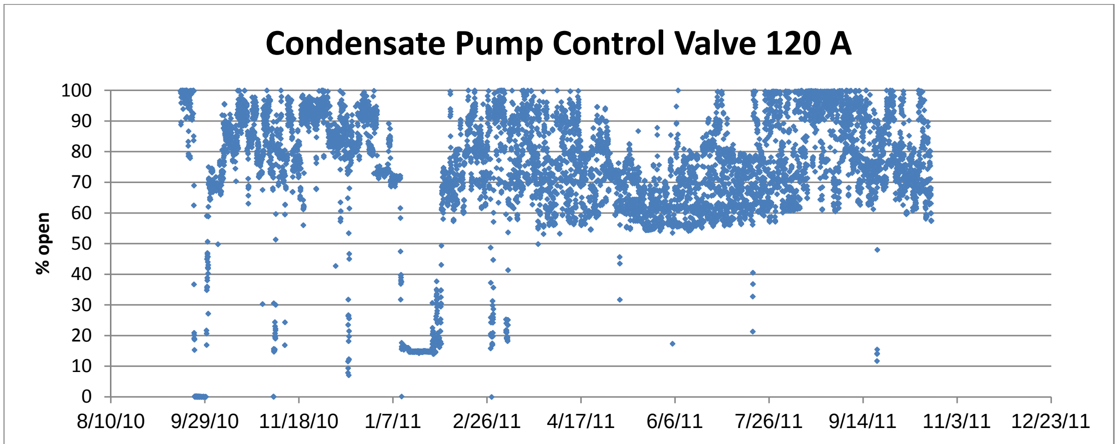


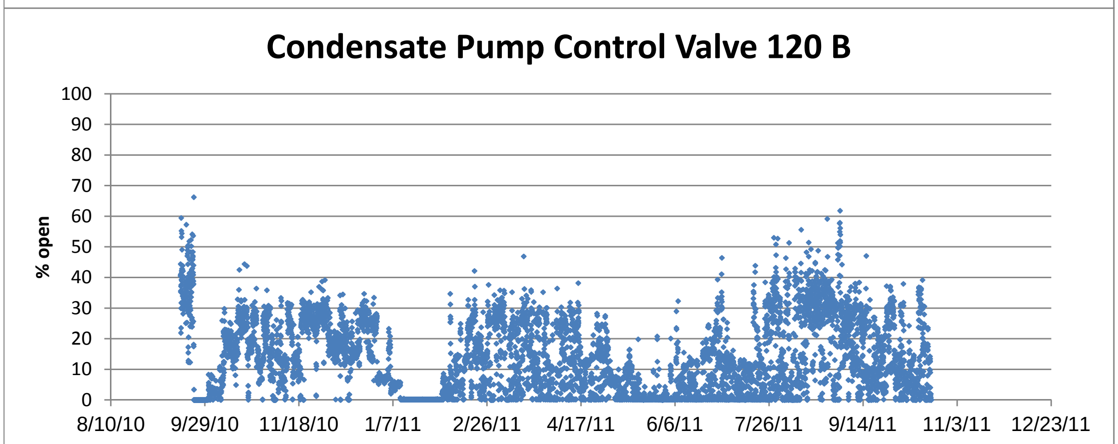
Condensate Pump #3 Current

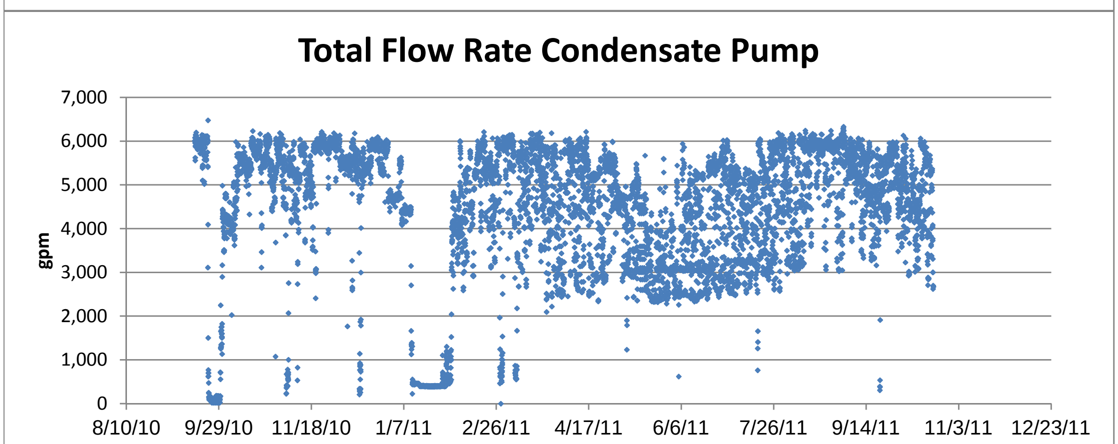


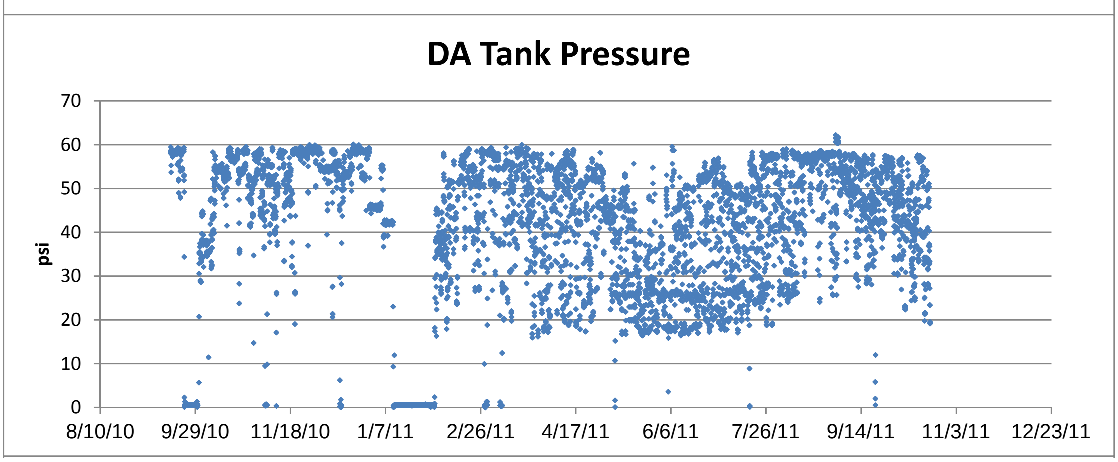
Condensate Pump Discharge Pressure

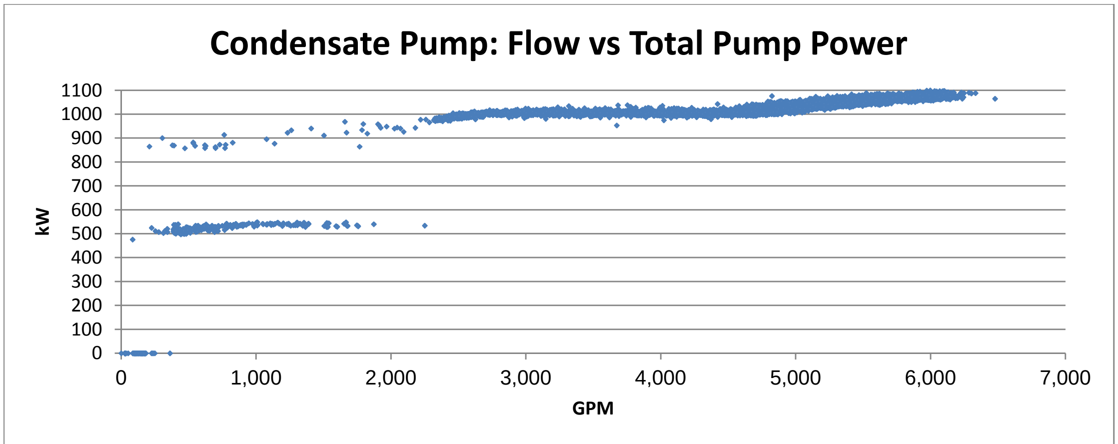


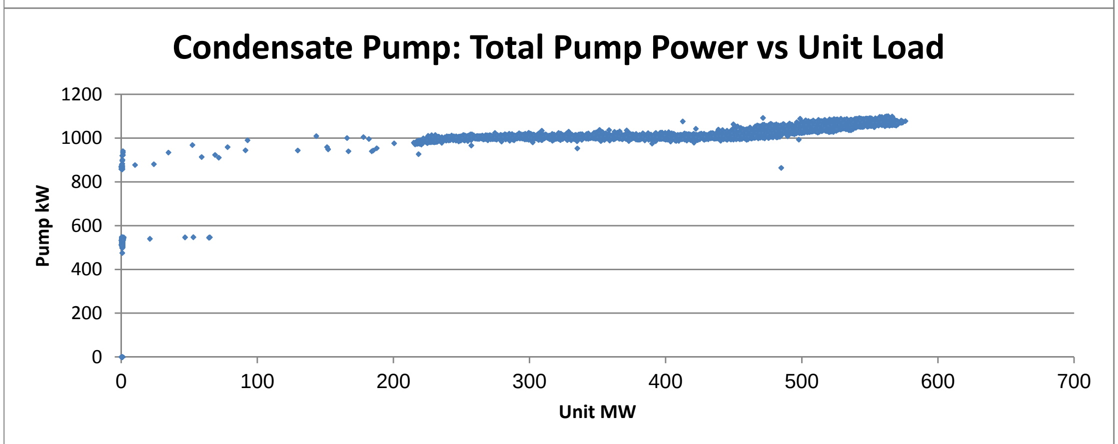

Condensate Pump Control Valve 120 A
% open
100
90
80
70
60
50
40
30
20
10
0
8/10/10
9/29/10
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

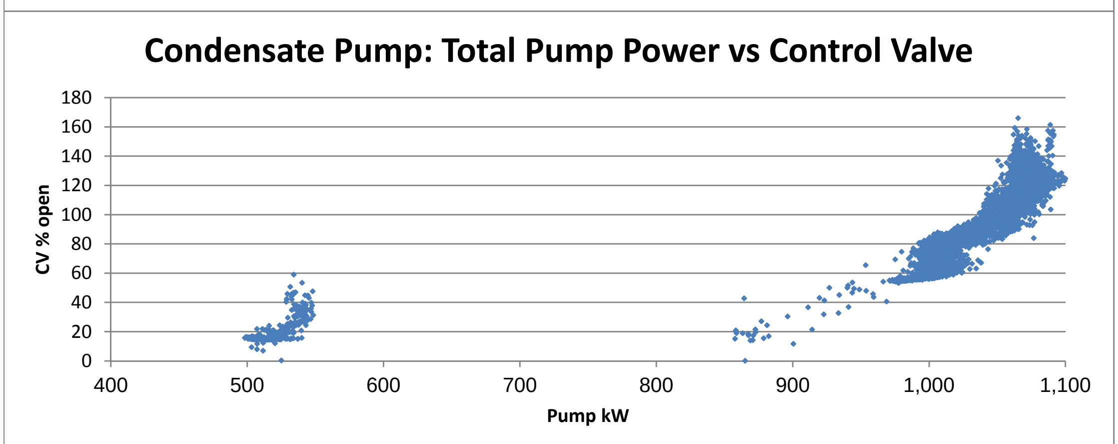

Condensate Pump Control Valve 120 B
% open
100
90
80
70
60
50
40
30
20
10
0
8/10/10
9/29/10
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

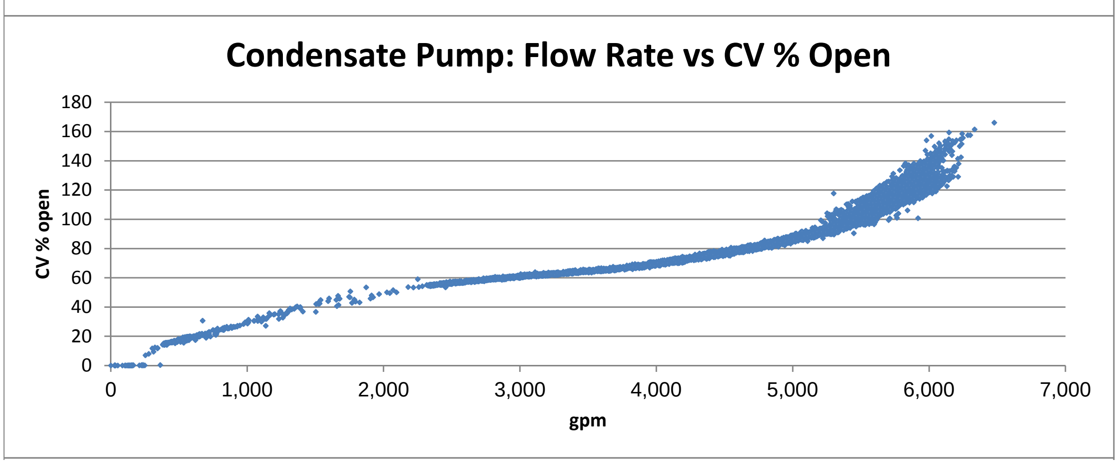

Total Flow Rate Condensate Pump
gpm
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
8/10/10
9/29/10
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

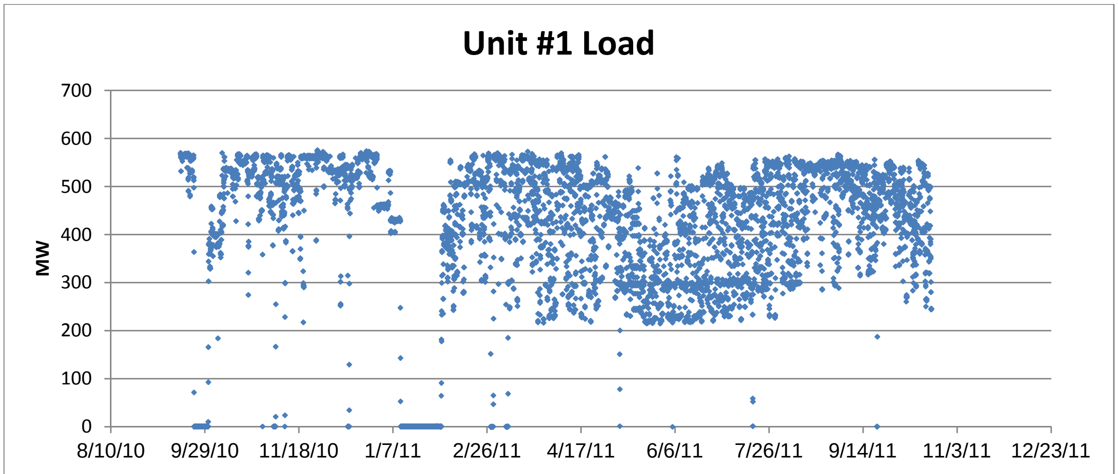

DA Tank Pressure
psi
70
60
50
40
30
20
10
0
8/10/10
9/29/10
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

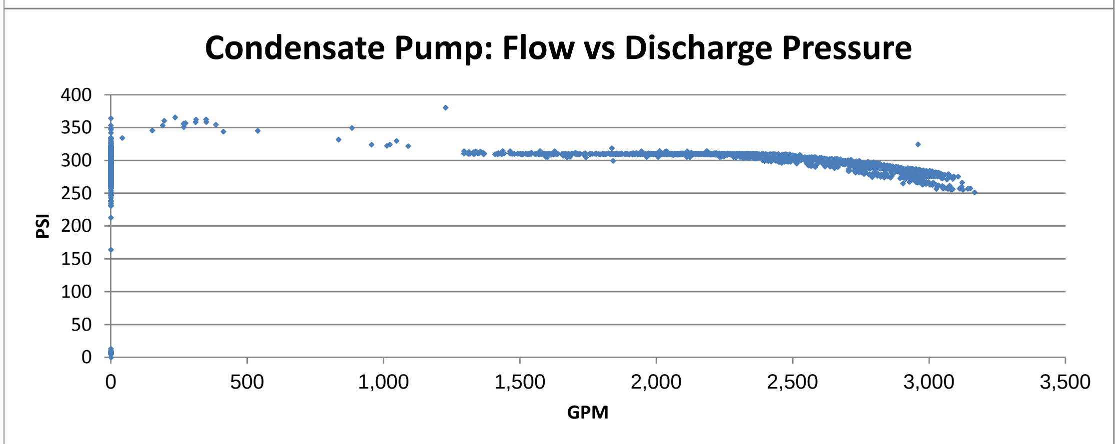

Condensate Pump: Flow vs Total Pump Power
kW
1100
1000
900
800
700
600
500
400
300
200
100
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
GPM

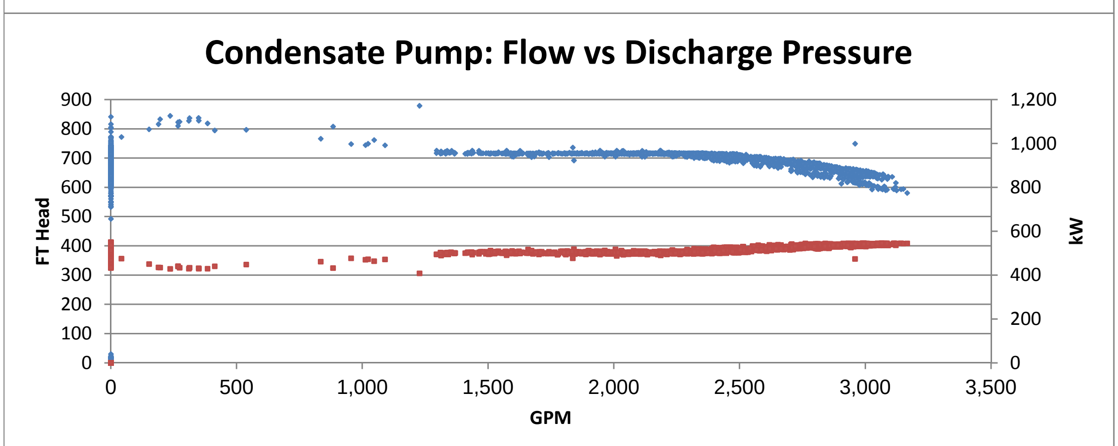

Condensate Pump: Total Pump Power vs Unit Load
Pump kW
1200
1000
800
600
400
200
0
0
100
200
300
400
500
600
700
Unit MW

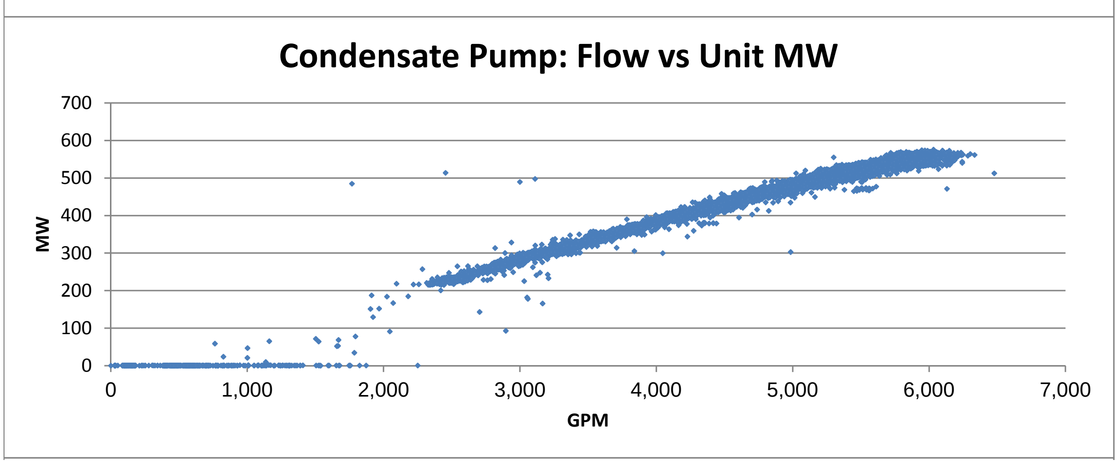

Condensate Pump: Total Pump Power vs Control Valve
CV % open
180
160
140
120
100
80
60
40
20
0
400
500
600
700
800
900
1,000
1,100
Pump kW

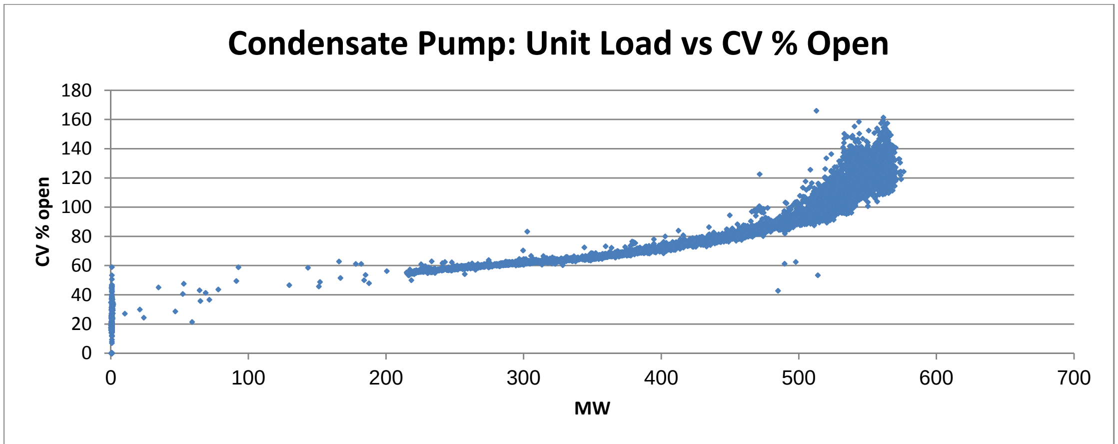

Condensate Pump: Flow Rate vs CV % Open
CV % open
180
160
140
120
100
80
60
40
20
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
gpm


Unit #1 Load
MW
700
600
500
400
300
200
100
0
8/10/10
9/29/10
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

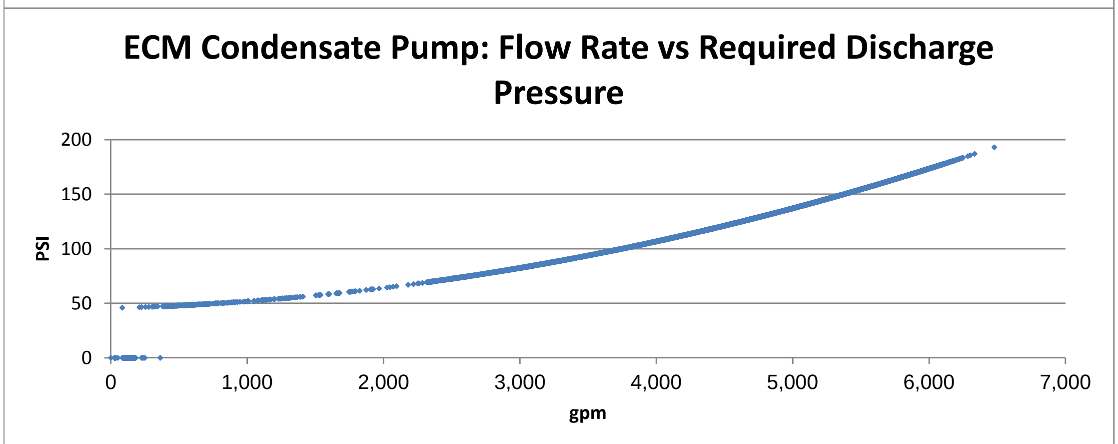

Condensate Pump: Flow vs Discharge Pressure
PSI
400
350
300
250
200
150
100
50
0
0
500
1,000
1,500
2,000
2,500
3,000
3,500
GPM


Condensate Pump: Flow vs Discharge Pressure
FT Head
900
800
700
600
500
400
300
200
100
0
kW
1,200
1,000
800
600
400
200
0
0
500
1,000
1,500
2,000
2,500
3,000
3,500
GPM

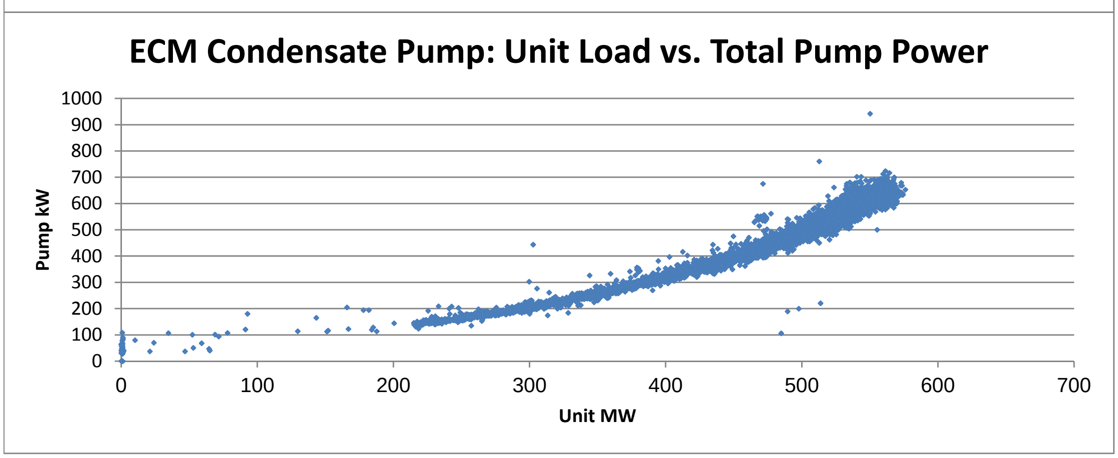

Condensate Pump: Flow vs Unit MW
MW
700
600
500
400
300
200
100
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
GPM



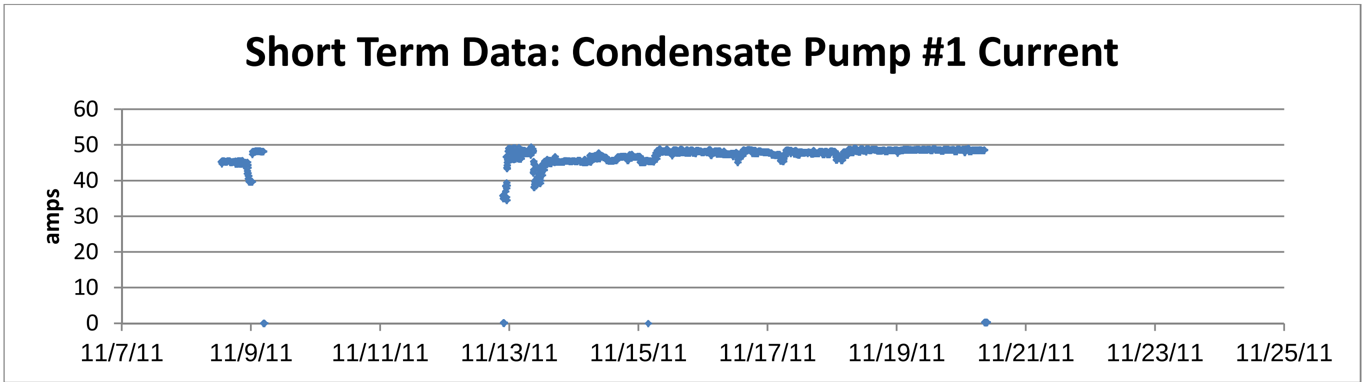
Condensate Pump: Unit Load vs CV % Open
CV % open
MW

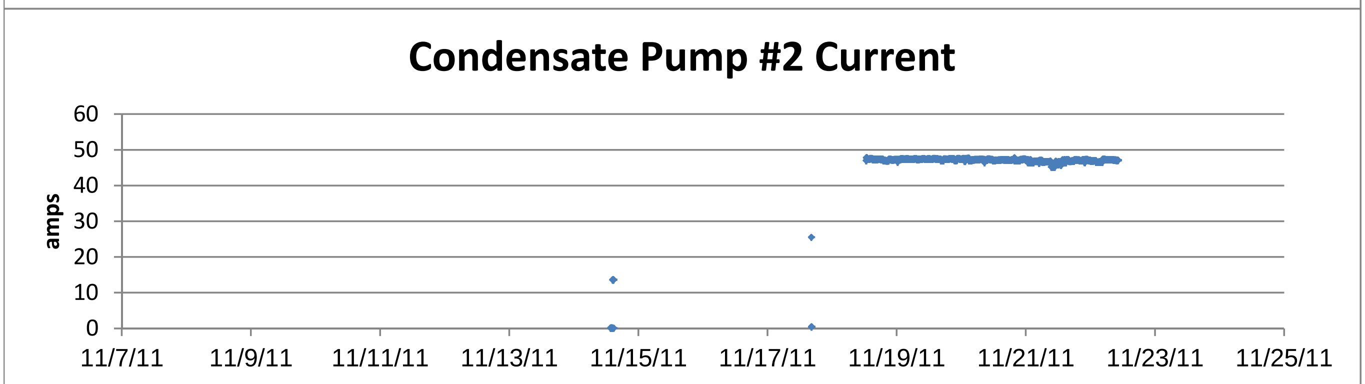


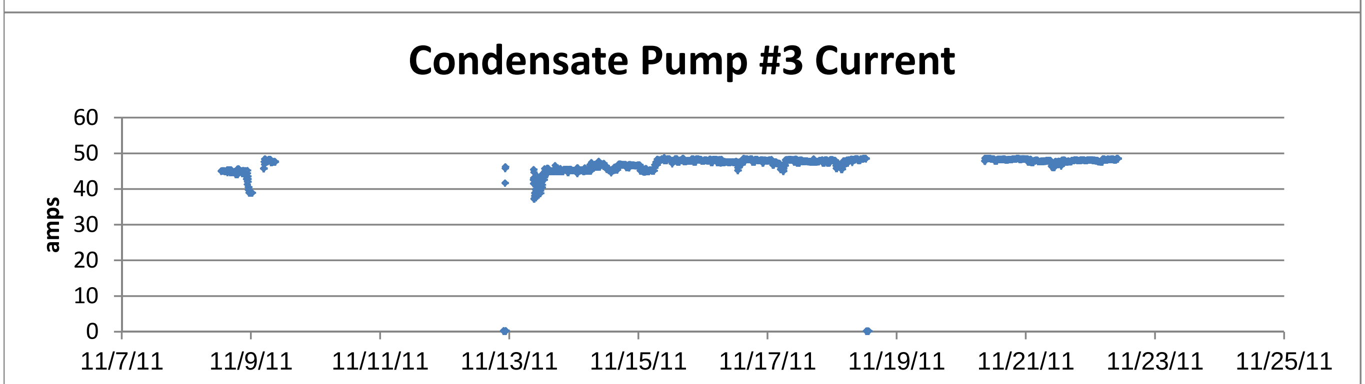
ECM Condensate Pump: Flow Rate vs Required Discharge Pressure
PSI
gpm

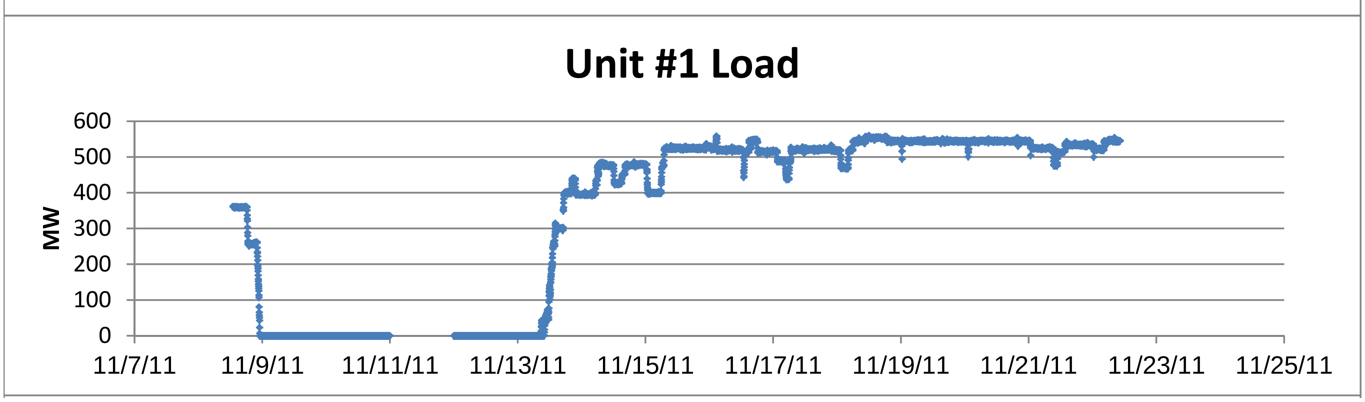


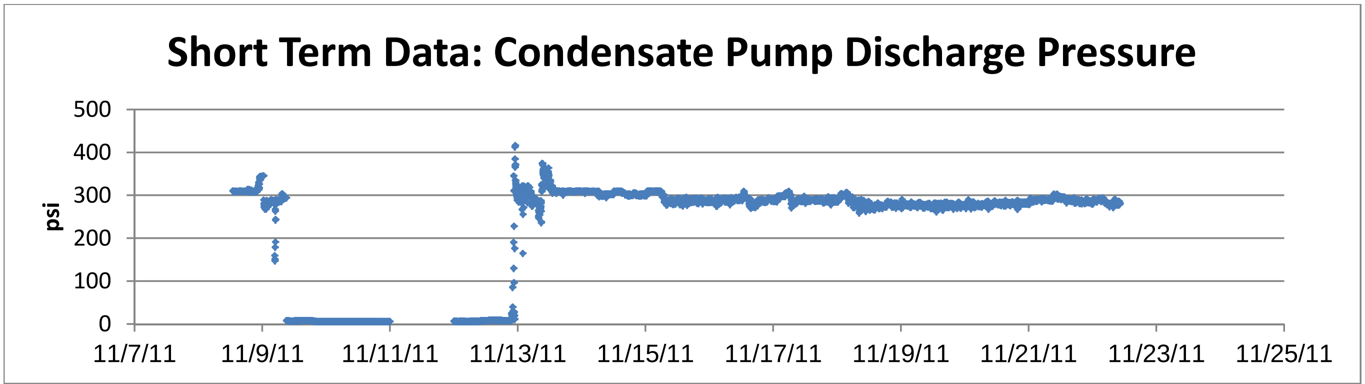
ECM Condensate Pump: Unit Load vs. Total Pump Power
Pump kW
Unit MW

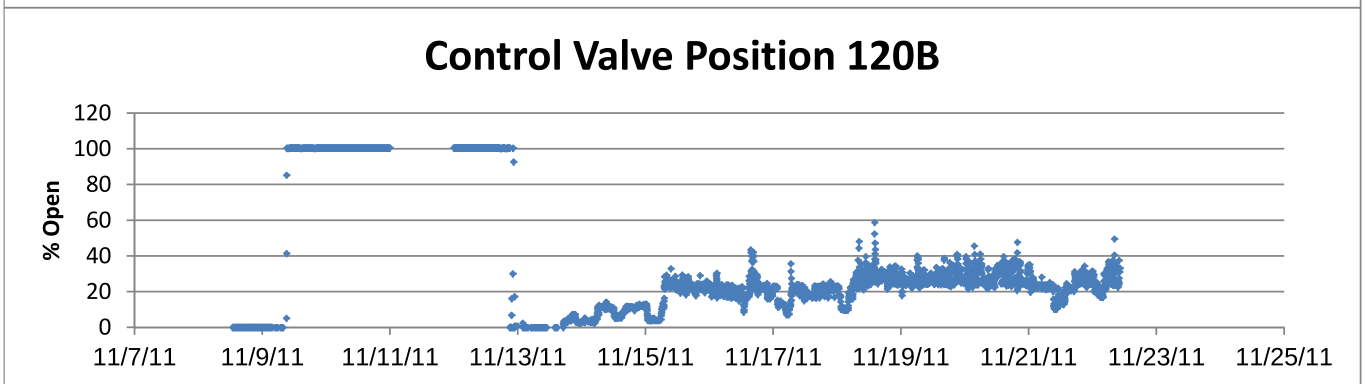

Short Term Data: Condensate Pump #1 Current
amps
0
10
20
30
40
50
60
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

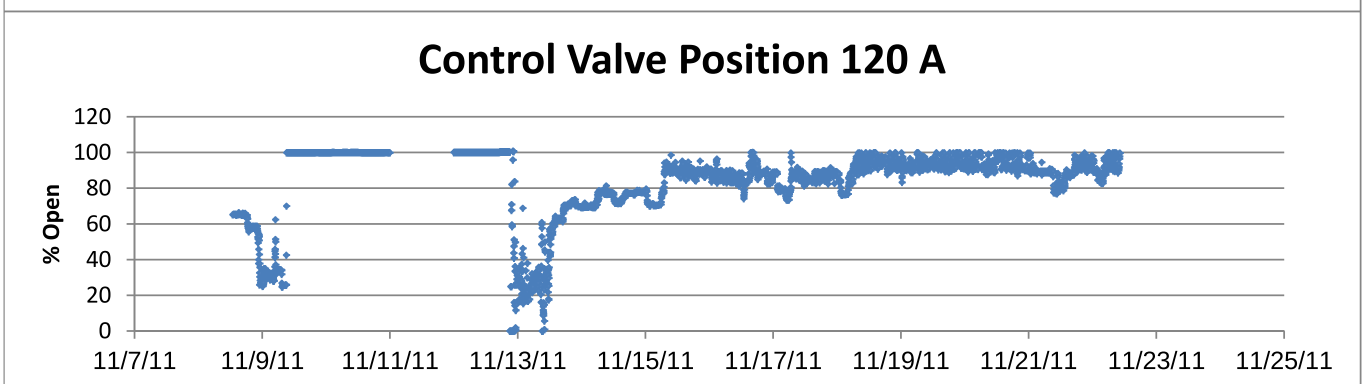

Condensate Pump #2 Current
amps
0
10
20
30
40
50
60
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

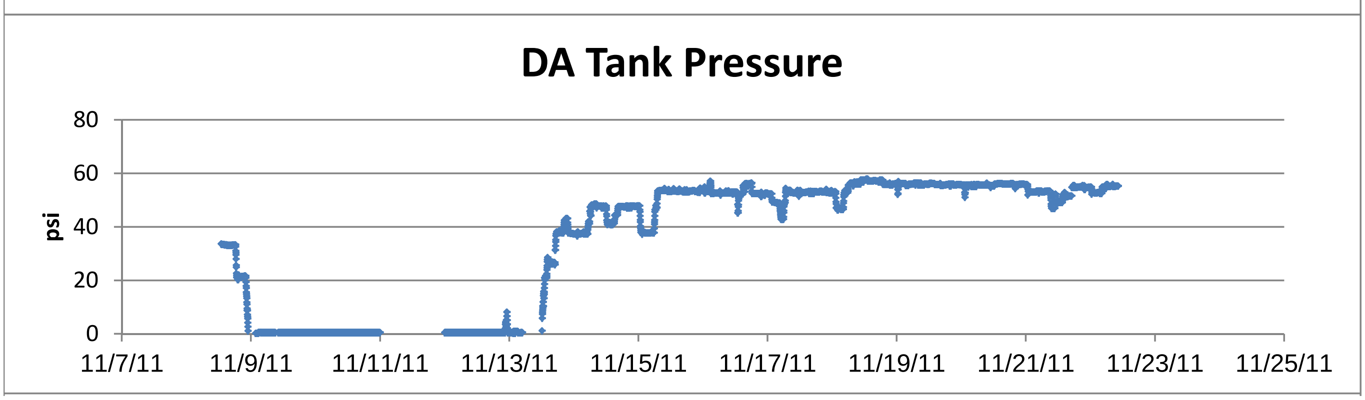

Condensate Pump #3 Current
amps
0
10
20
30
40
50
60
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

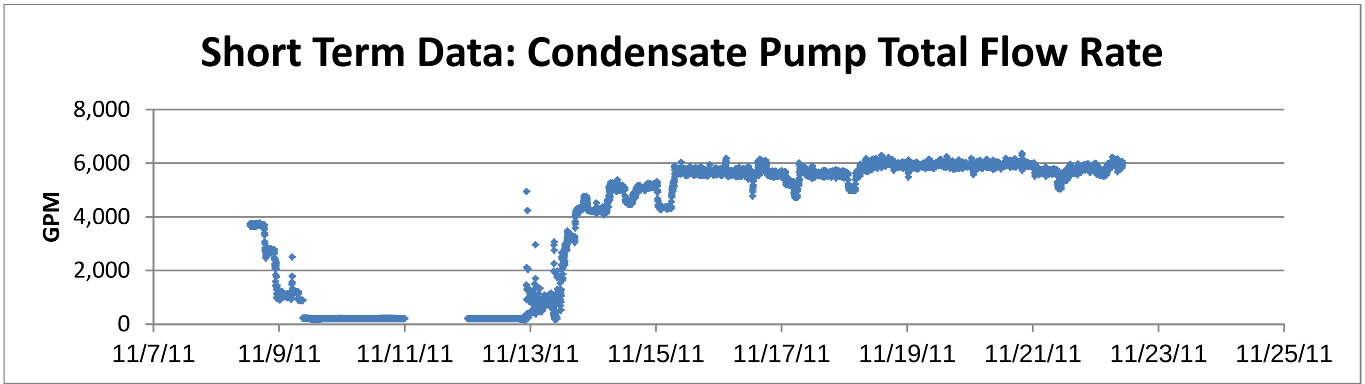

Unit #1 Load
MW
0
100
200
300
400
500
600
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

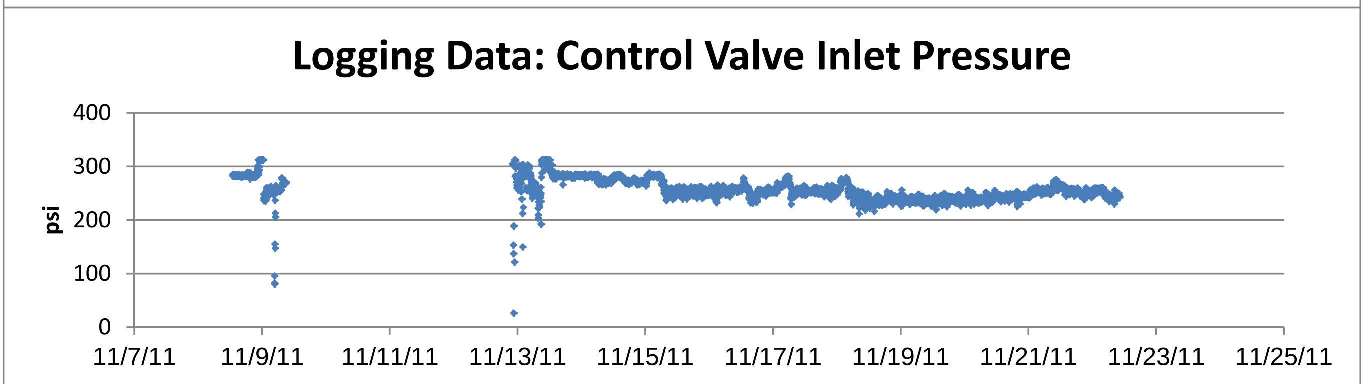

Short Term Data: Condensate Pump Discharge Pressure
psi
500
400
300
200
100
0
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

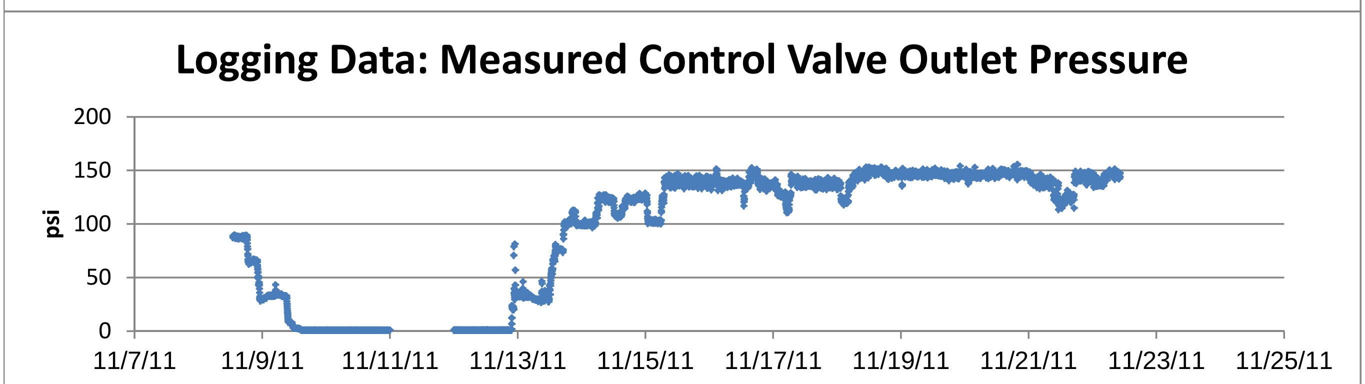

Control Valve Position 120B
% Open
120
100
80
60
40
20
0
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

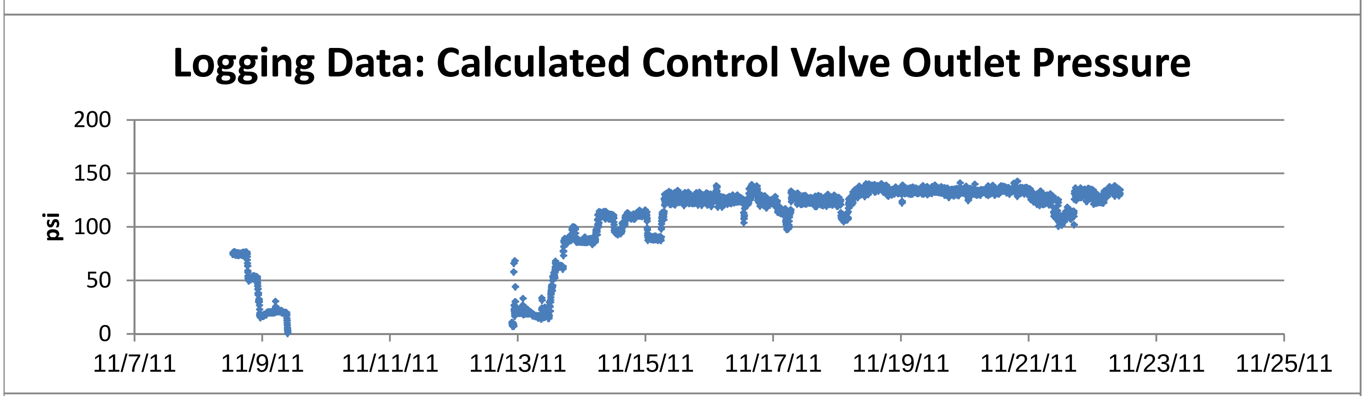

Control Valve Position 120 A
% Open
120
100
80
60
40
20
0
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

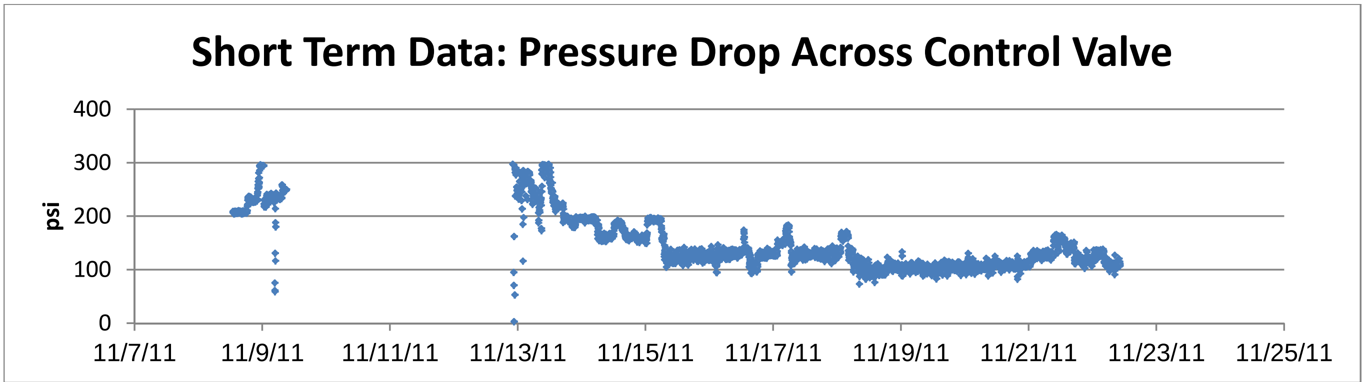

DA Tank Pressure
psi
80
60
40
20
0
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

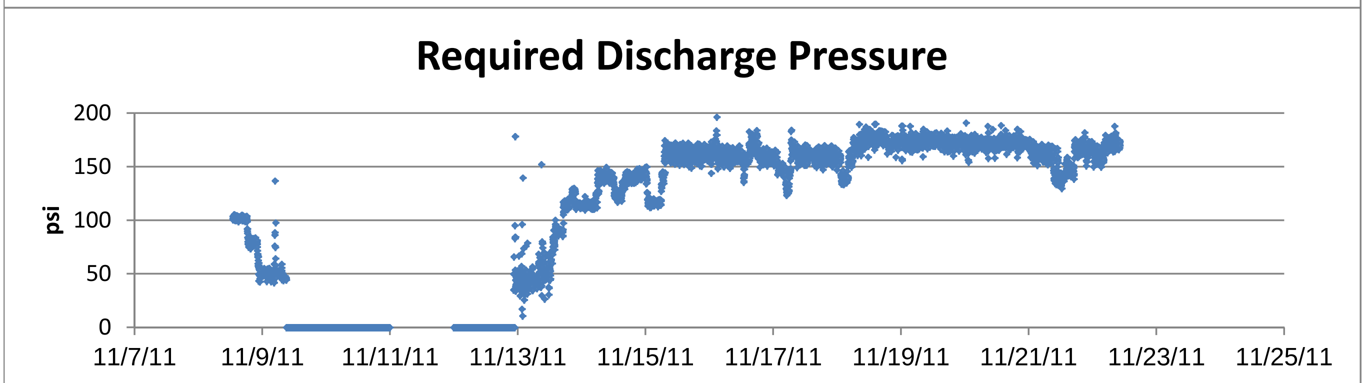

Short Term Data: Condensate Pump Total Flow Rate
8,000
6,000
4,000
2,000
0
GPM
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

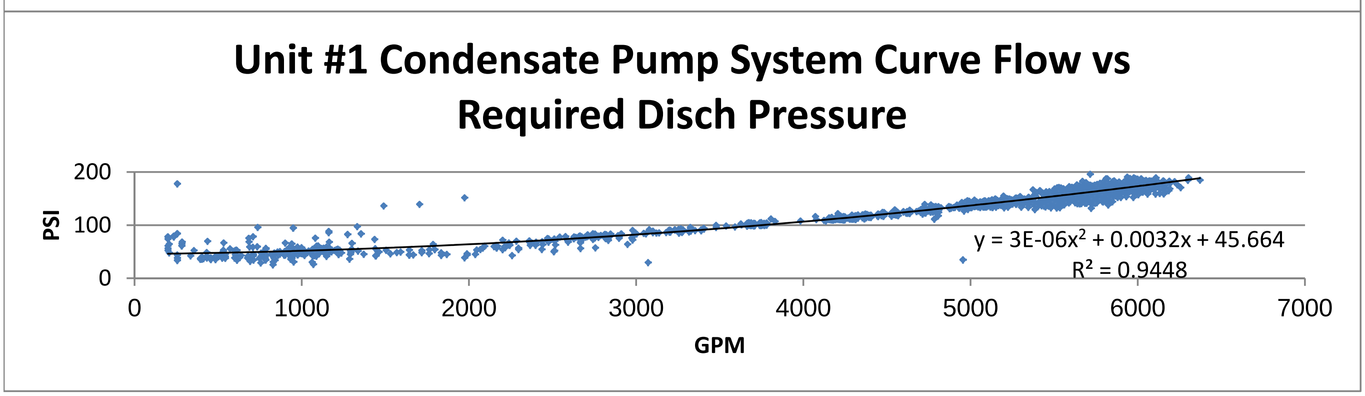

Logging Data: Control Valve Inlet Pressure
400
300
200
100
0
psi
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

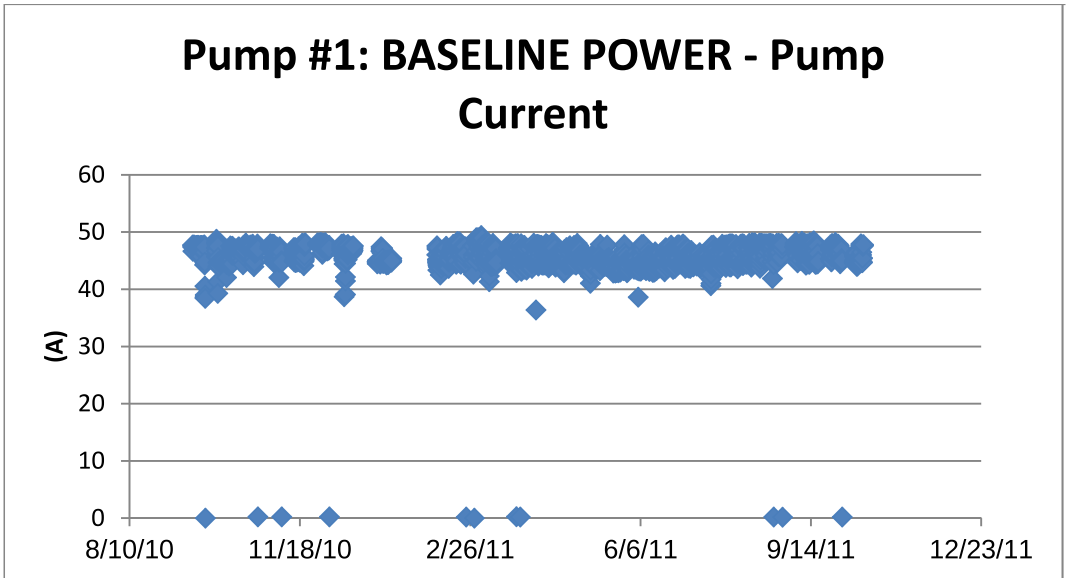

Logging Data: Measured Control Valve Outlet Pressure
200
150
100
50
0
psi
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

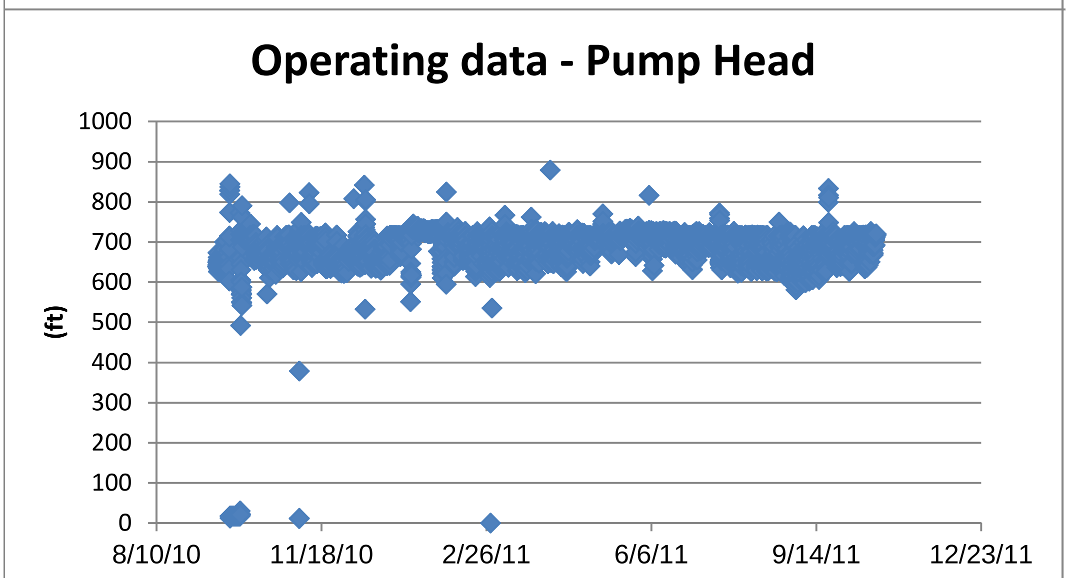

Logging Data: Calculated Control Valve Outlet Pressure
200
150
100
50
0
psi
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

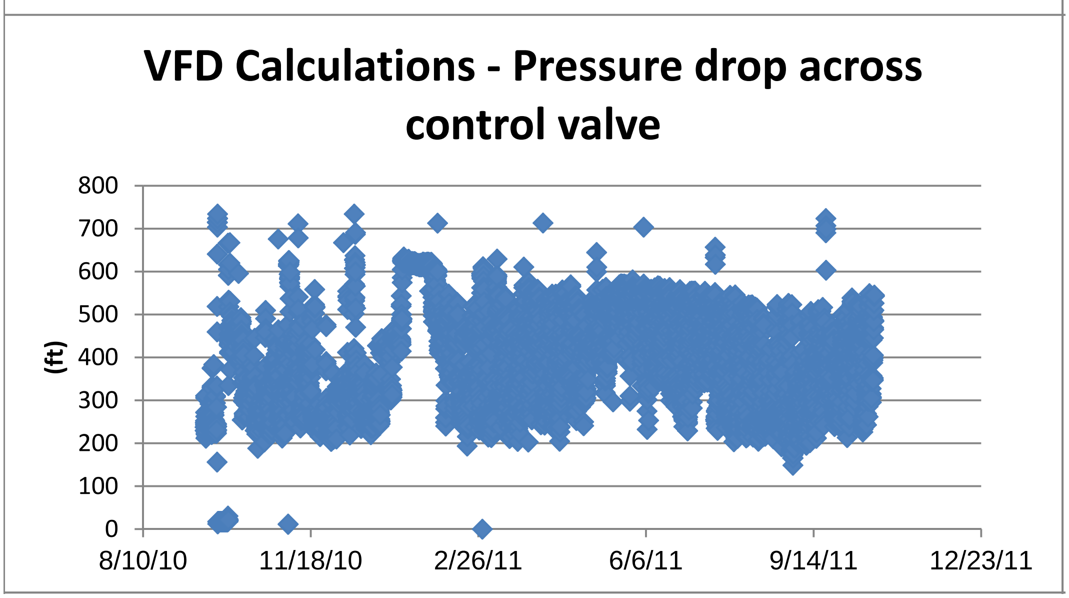

Short Term Data: Pressure Drop Across Control Valve
psi
0
100
200
300
400
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

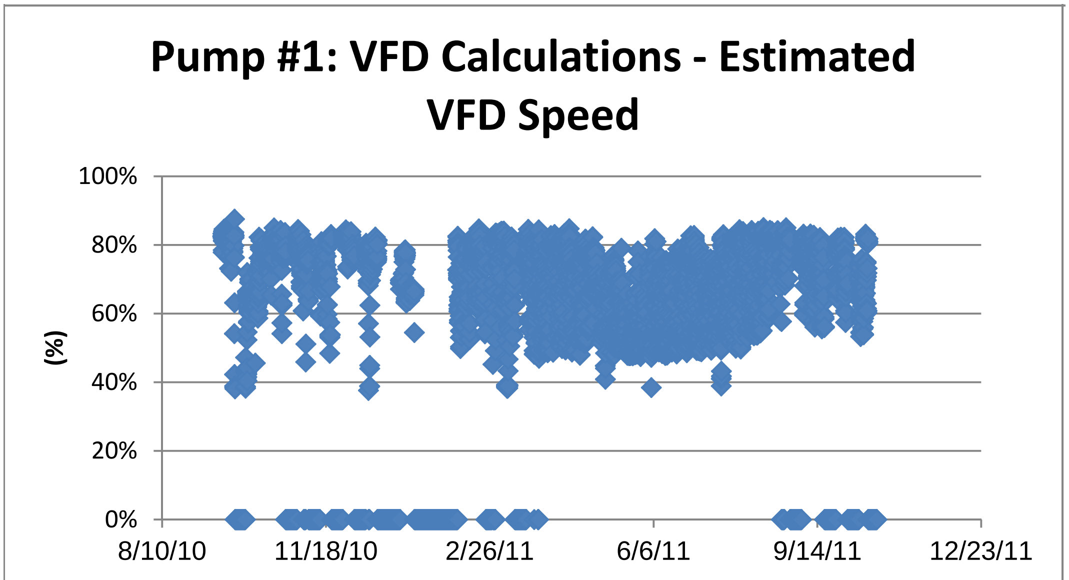

Required Discharge Pressure
psi
0
50
100
150
200
11/7/11
11/9/11
11/11/11
11/13/11
11/15/11
11/17/11
11/19/11
11/21/11
11/23/11
11/25/11

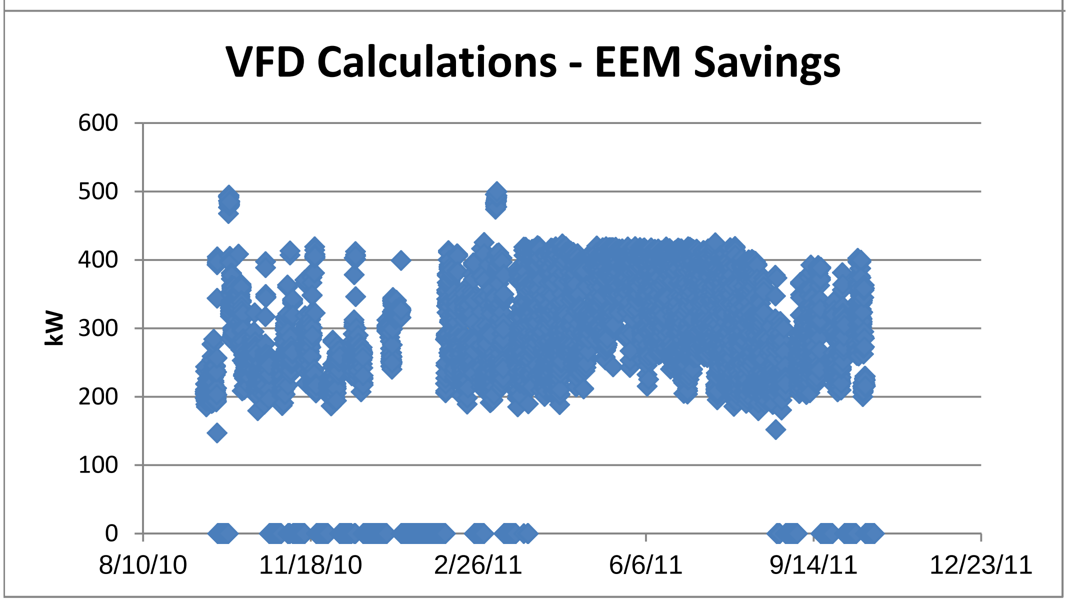

Unit #1 Condensate Pump System Curve Flow vs Required Disch Pressure
PSI
0
100
200
y = 3E-06x² + 0.0032x + 45.664
R² = 0.9448
0
1000
2000
3000
4000
5000
6000
7000
GPM

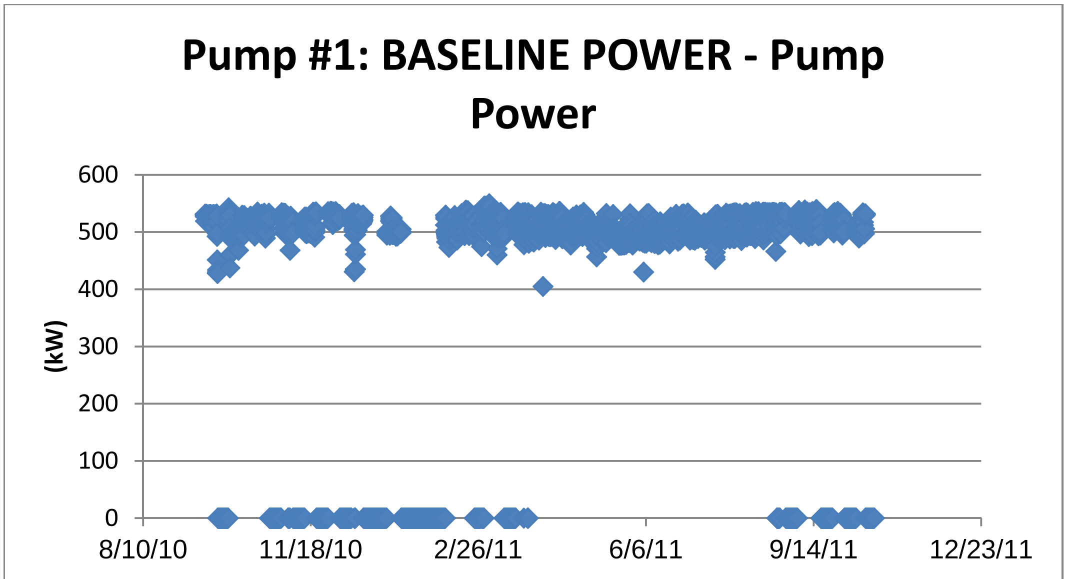

Pump #1: BASELINE POWER - Pump Current
(A)
60
50
40
30
20
10
0
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

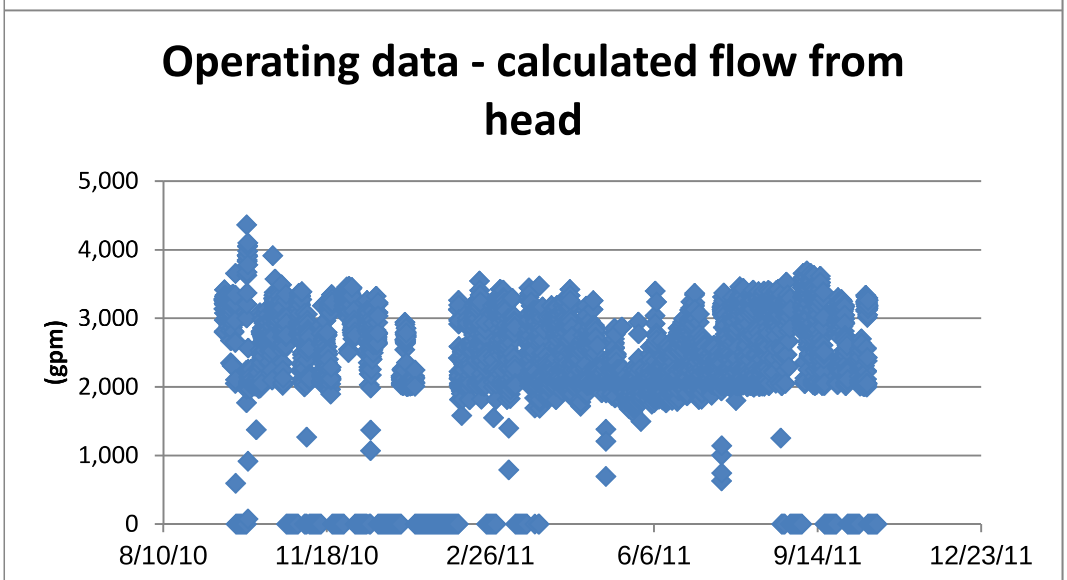

Operating data - Pump Head
(ft)
1000
900
800
700
600
500
400
300
200
100
0
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

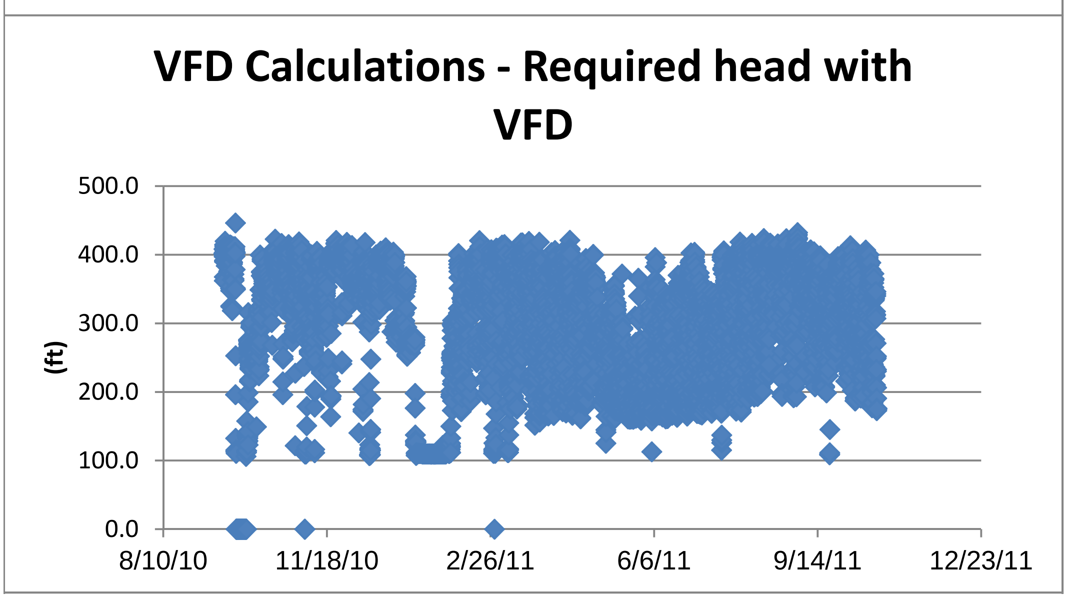

VFD Calculations - Pressure drop across control valve
(ft)
800
700
600
500
400
300
200
100
0
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

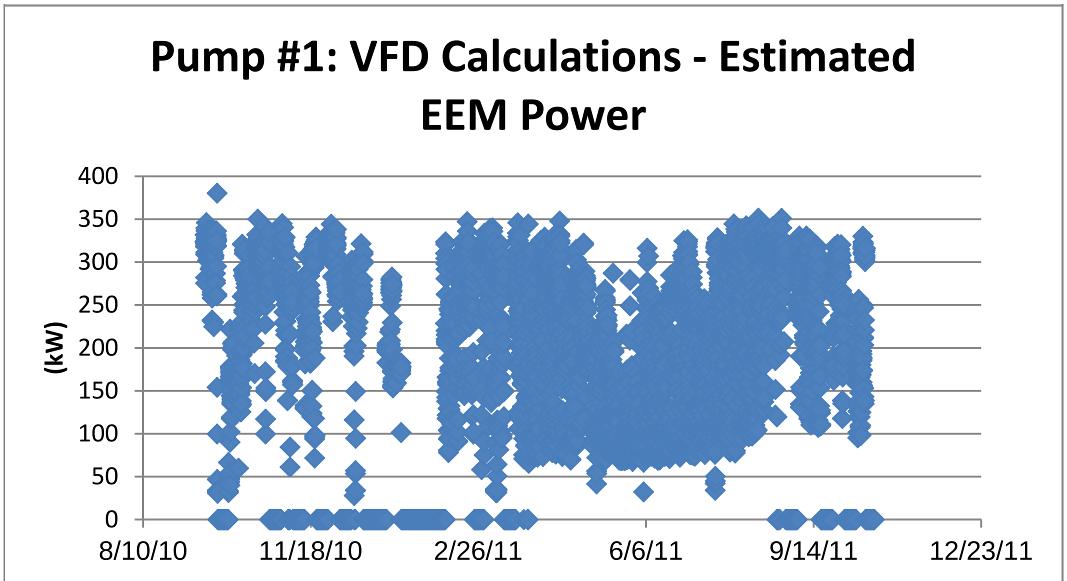

Pump #1: VFD Calculations - Estimated VFD Speed
100%
80%
60%
40%
20%
0%
(%)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

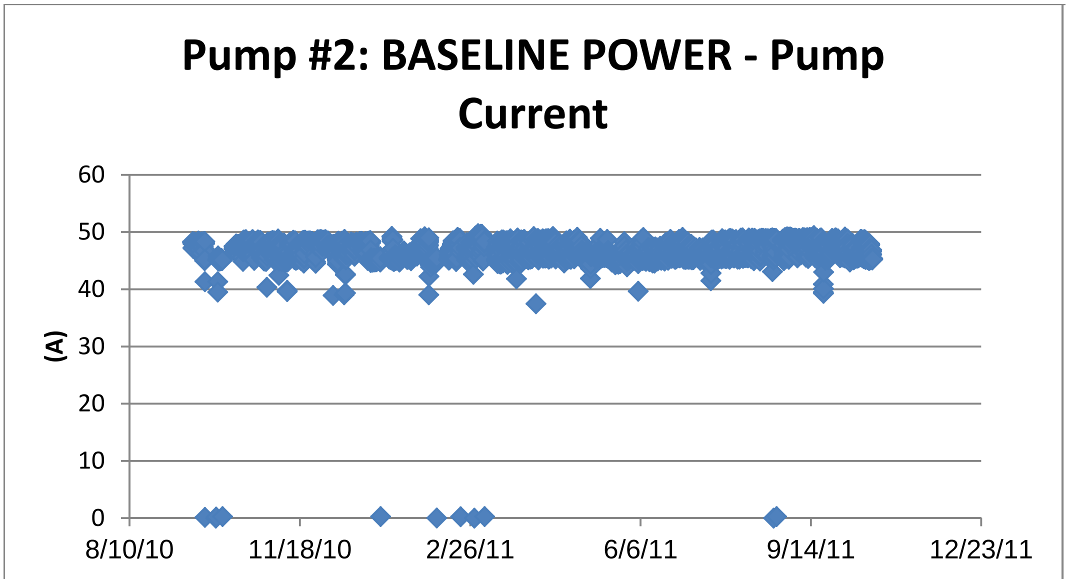

VFD Calculations - EEM Savings
600
500
400
300
200
100
0
kW
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

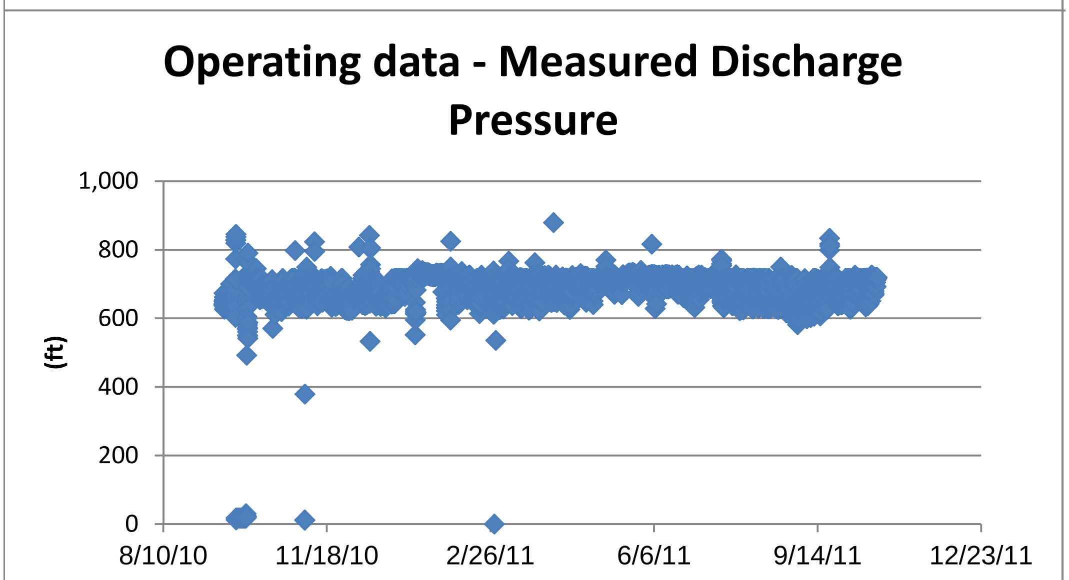

Pump #1: BASELINE POWER - Pump Power
600
500
400
300
200
100
0
(kW)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

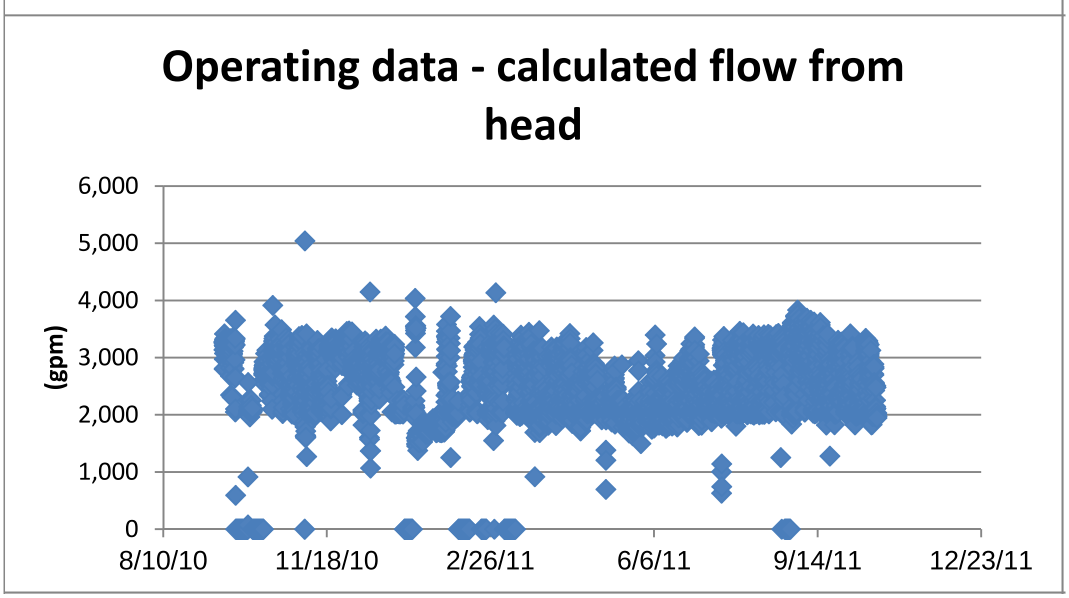

Operating data - calculated flow from head
5,000
4,000
3,000
2,000
1,000
0
(gpm)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

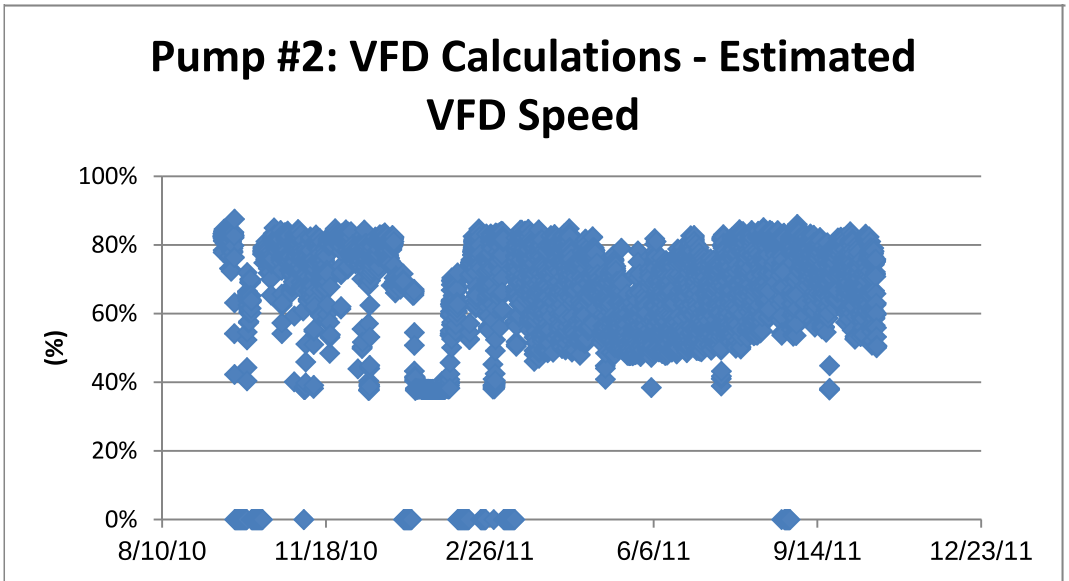

VFD Calculations - Required head with VFD
500.0
400.0
300.0
200.0
100.0
0.0
(ft)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

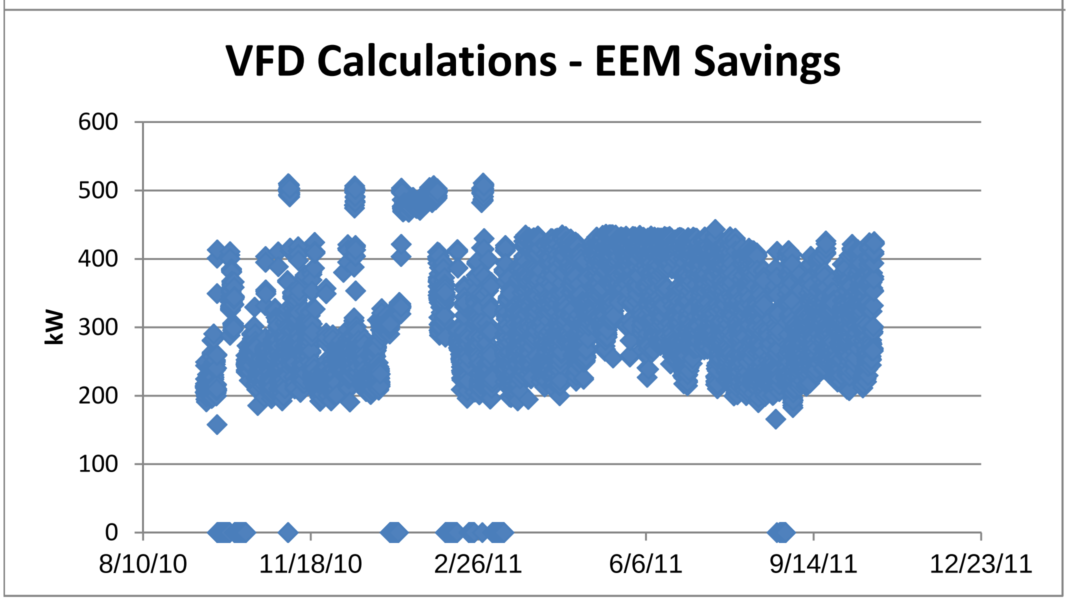

Pump #1: VFD Calculations - Estimated EEM Power
(kW)
400
350
300
250
200
150
100
50
0
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

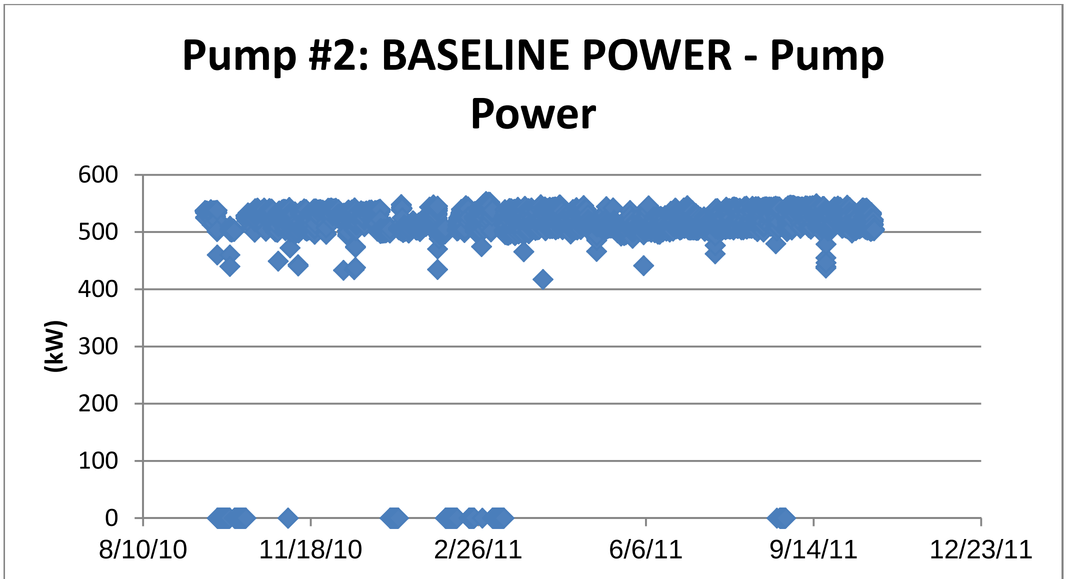

Pump #2: BASELINE POWER - Pump Current
60
50
40
30
20
10
0
(A)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11


Operating data - Measured Discharge Pressure
1,000
800
600
400
200
0
(ft)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

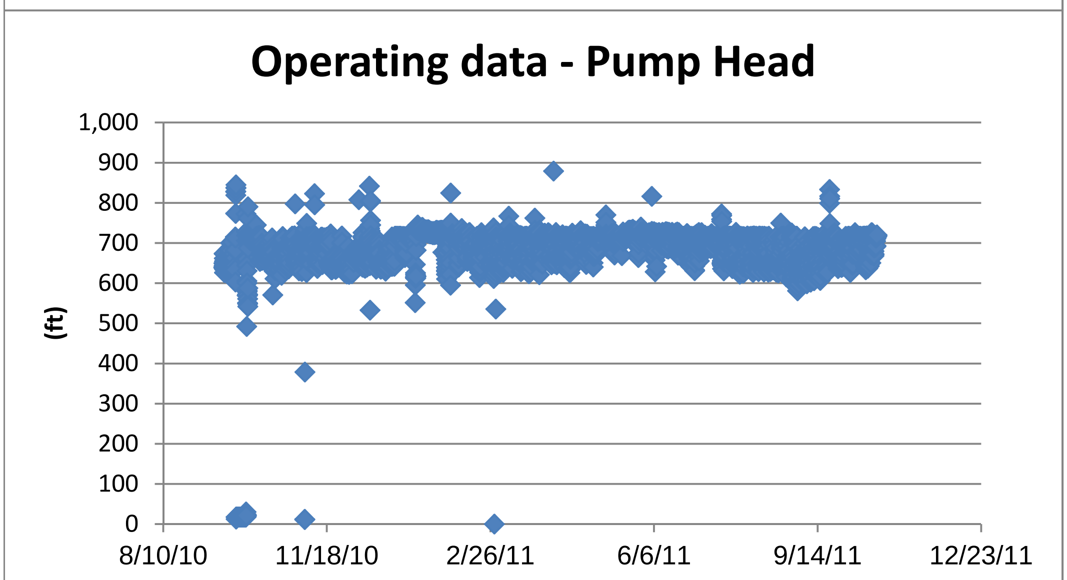

Operating data - calculated flow from head
6,000
5,000
4,000
3,000
2,000
1,000
0
(gpm)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11


Pump #2: VFD Calculations - Estimated VFD Speed
100%
80%
60%
40%
20%
0%
(%)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

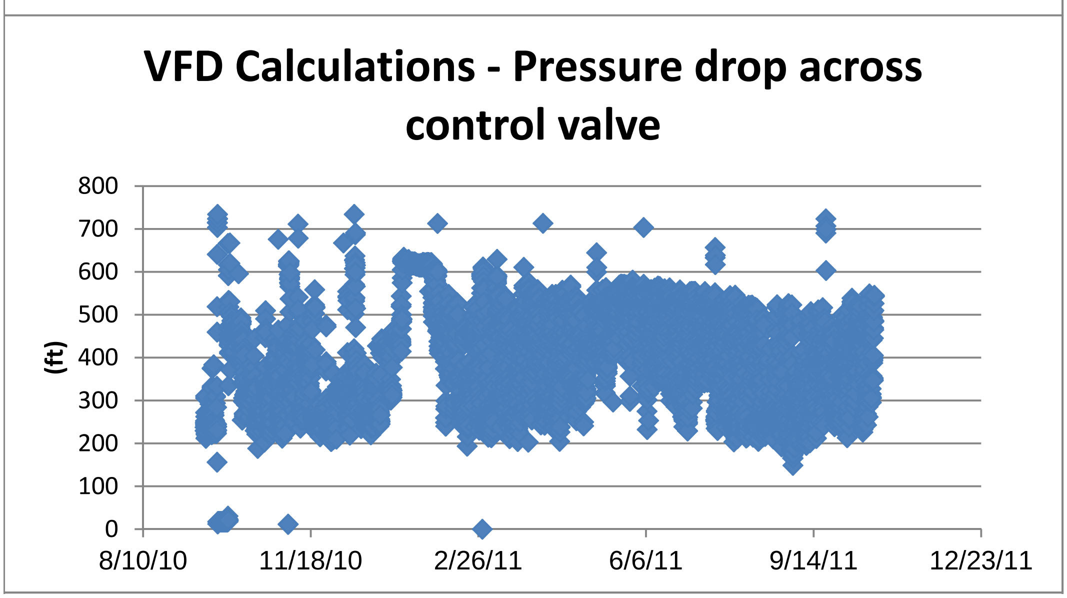

VFD Calculations - EEM Savings
600
500
400
300
200
100
0
kW
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11



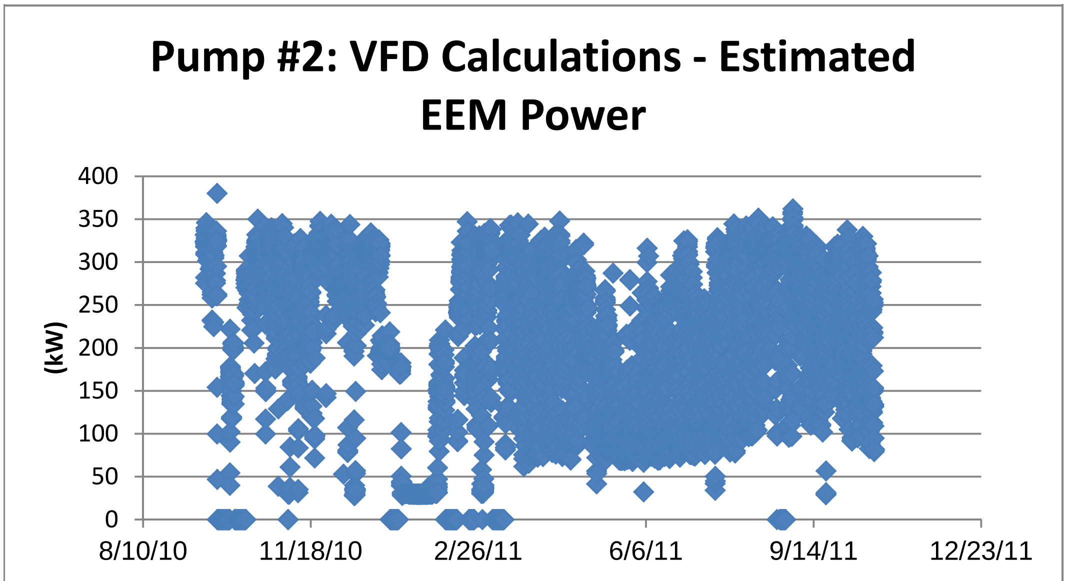
Pump #2: BASELINE POWER - Pump Power
(kW)
600
500
400
300
200
100
0
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

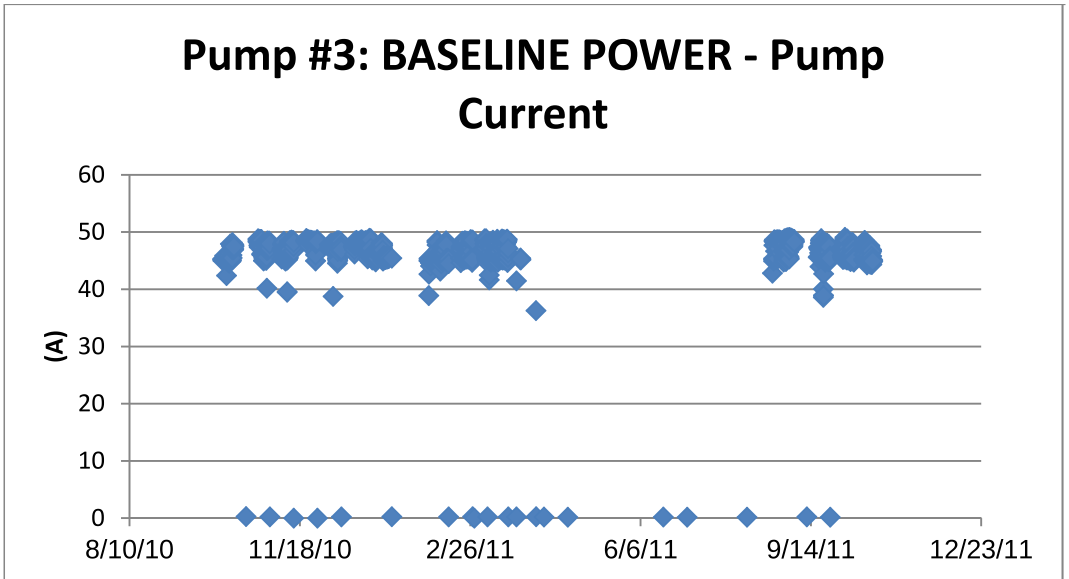


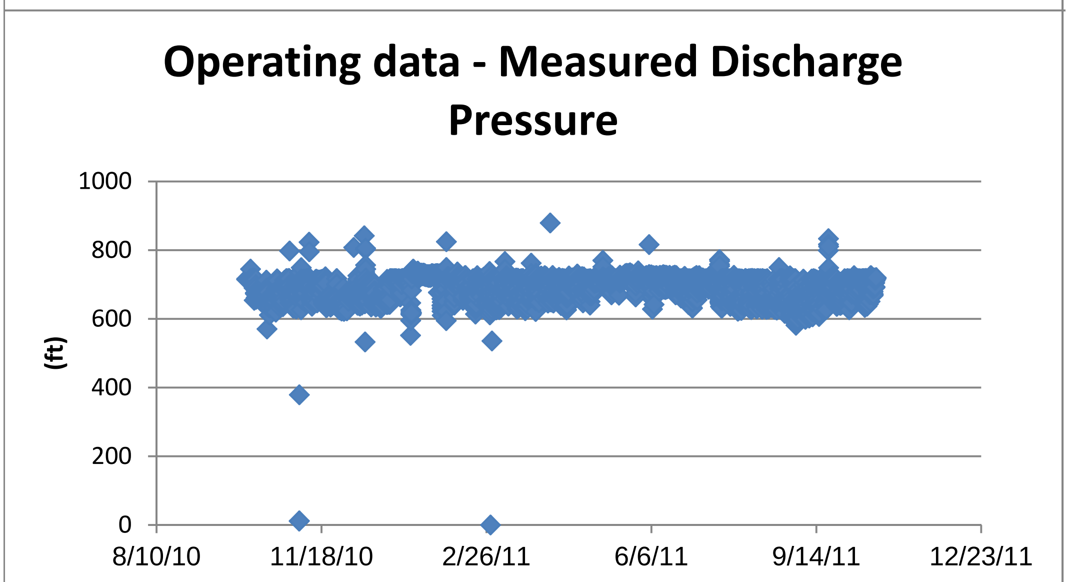
Operating data - Pump Head
(ft)
1,000
900
800
700
600
500
400
300
200
100
0
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

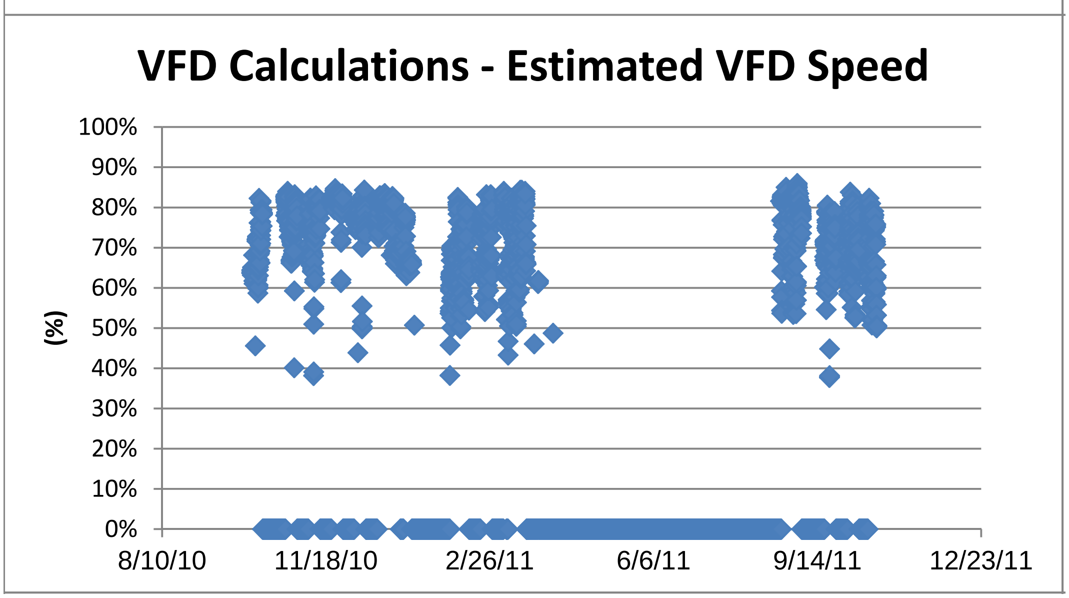


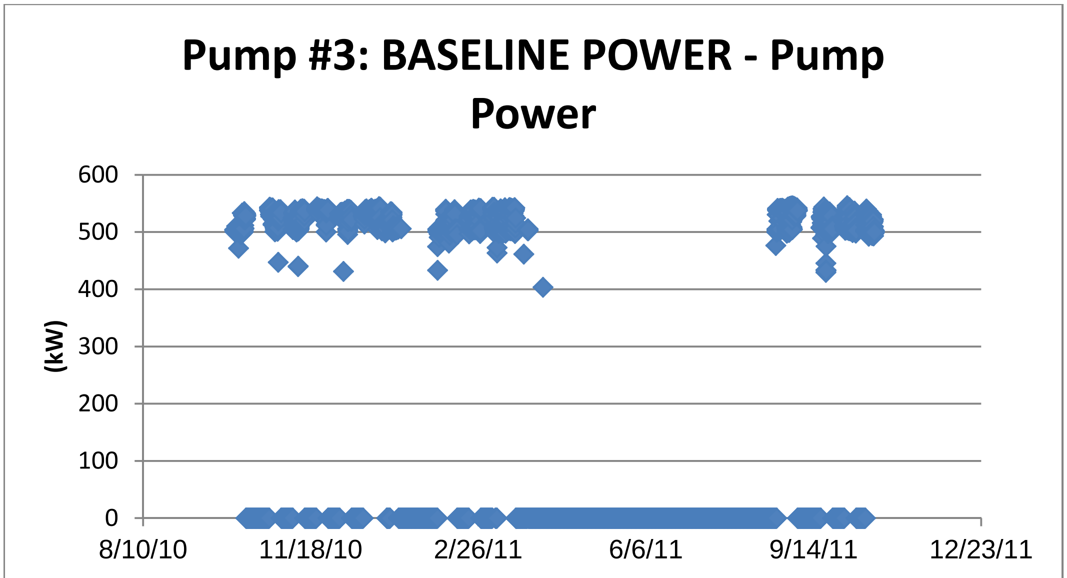
VFD Calculations - Pressure drop across control valve
(ft)
800
700
600
500
400
300
200
100
0
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

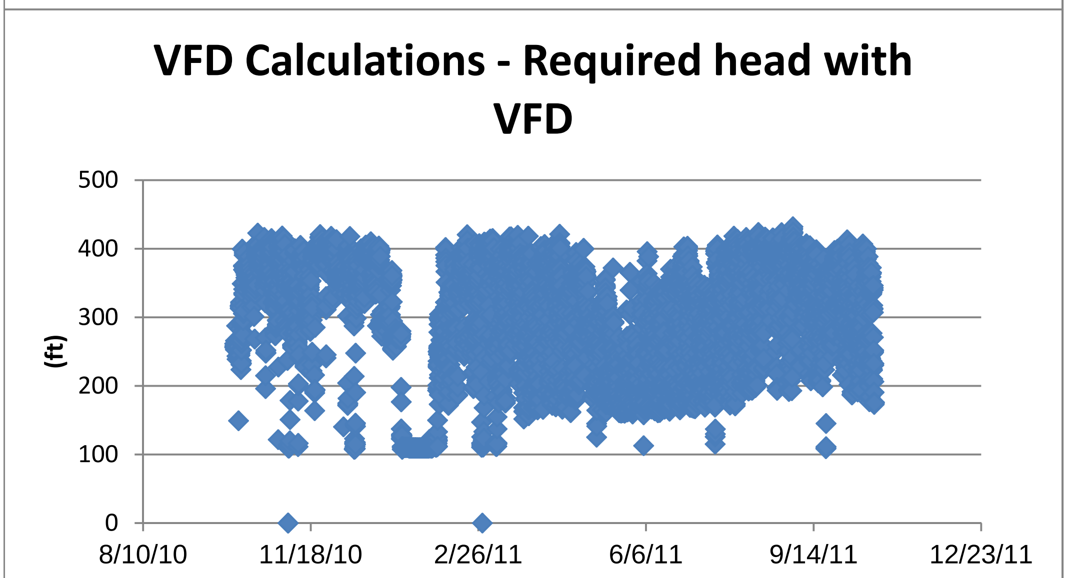

Pump #2: VFD Calculations - Estimated EEM Power
400
350
300
250
200
150
100
50
0
(kW)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

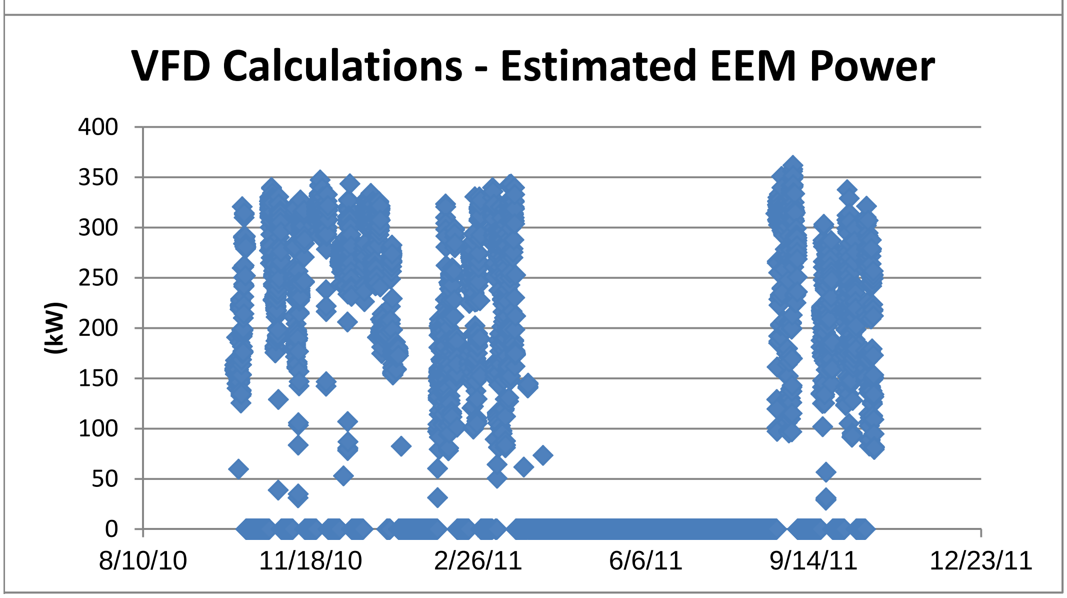

Pump #3: BASELINE POWER - Pump Current
60
50
40
30
20
10
0
(A)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

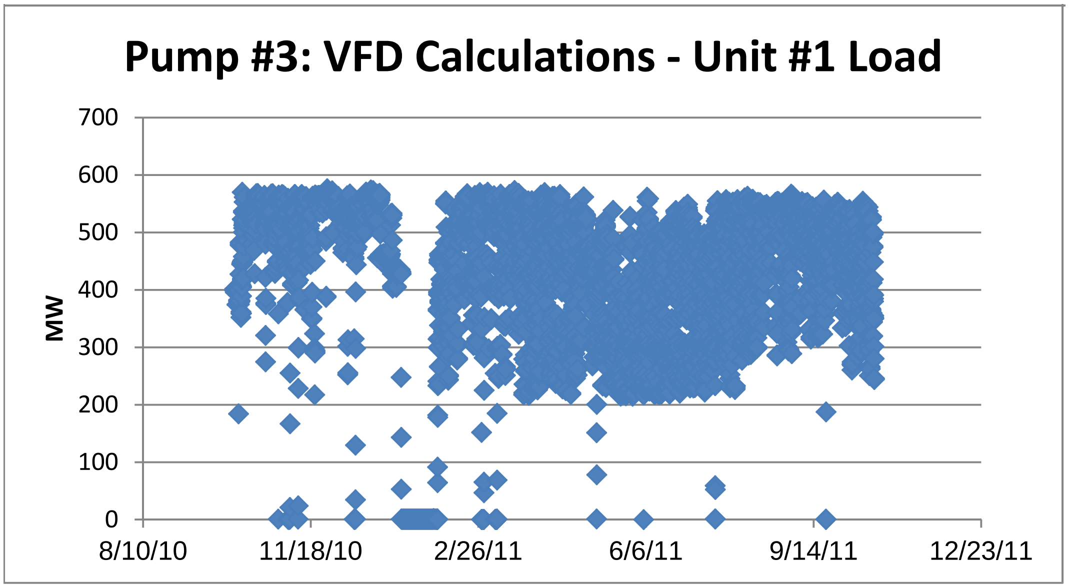

Operating data - Measured Discharge Pressure
1000
800
600
400
200
0
(ft)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11


VFD Calculations - Estimated VFD Speed
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
(%)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

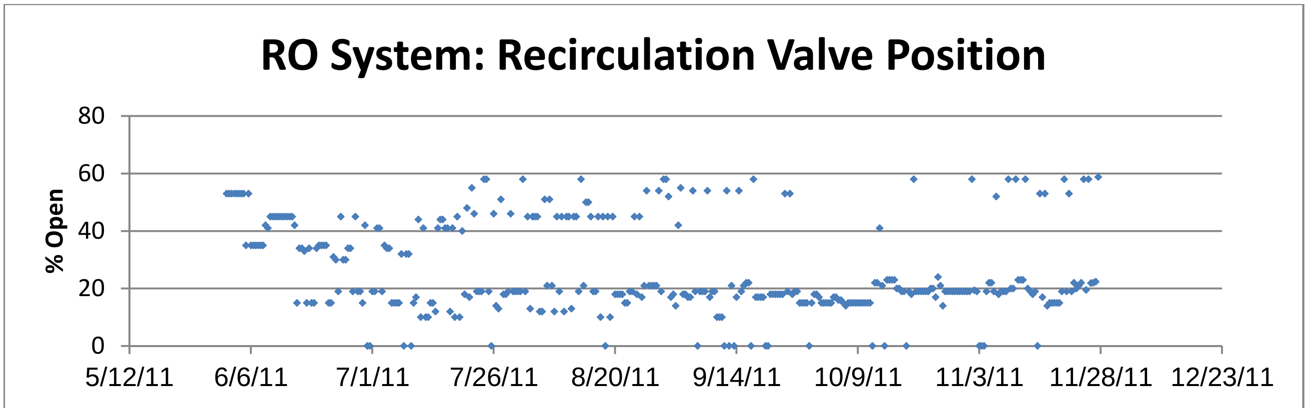

Pump #3: BASELINE POWER - Pump Power
600
500
400
300
200
100
0
(kW)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

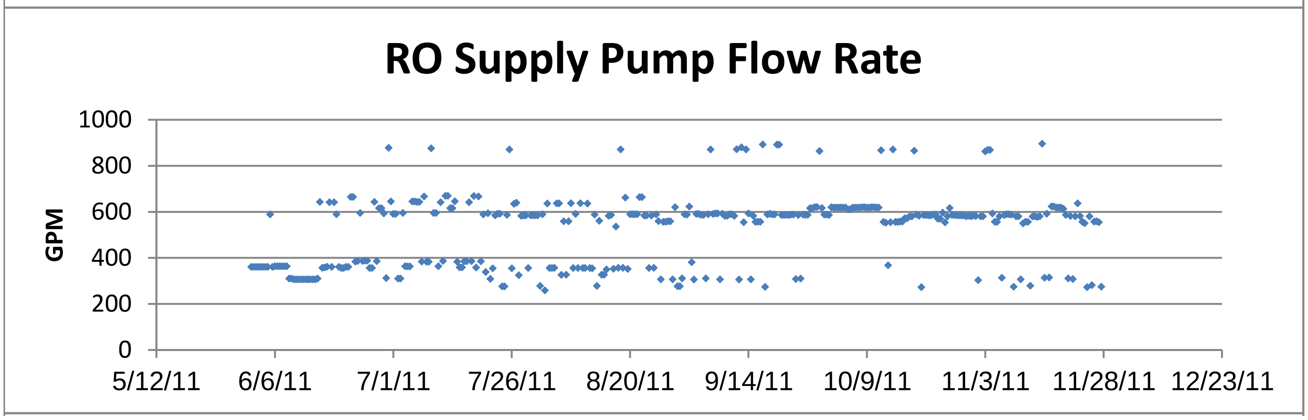

VFD Calculations - Required head with VFD
500
400
300
200
100
0
(ft)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11


VFD Calculations - Estimated EEM Power
400
350
300
250
200
150
100
50
0
(kW)
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

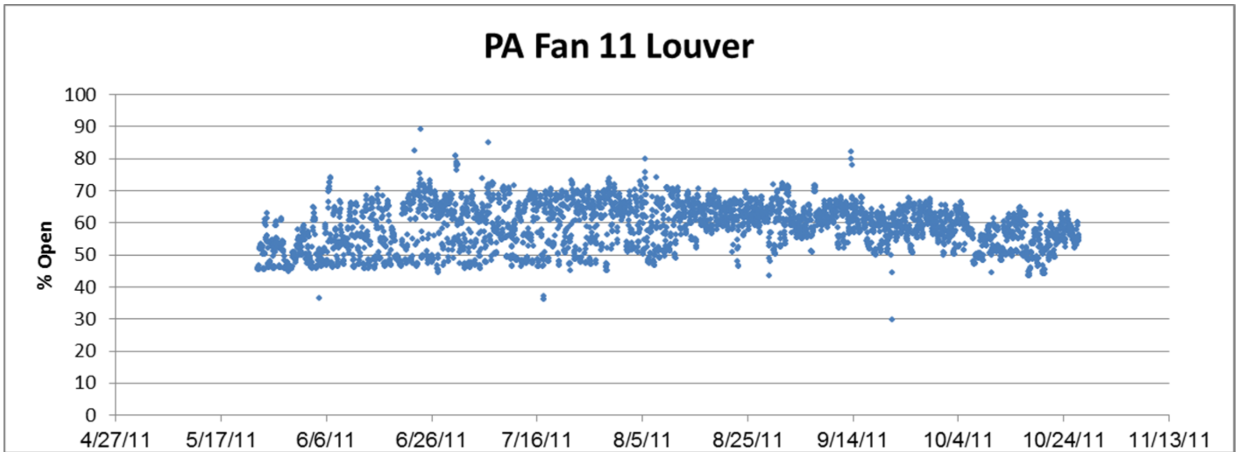

Pump #3: VFD Calculations - Unit #1 Load
MW
700
600
500
400
300
200
100
0
8/10/10
11/18/10
2/26/11
6/6/11
9/14/11
12/23/11

ECM 7

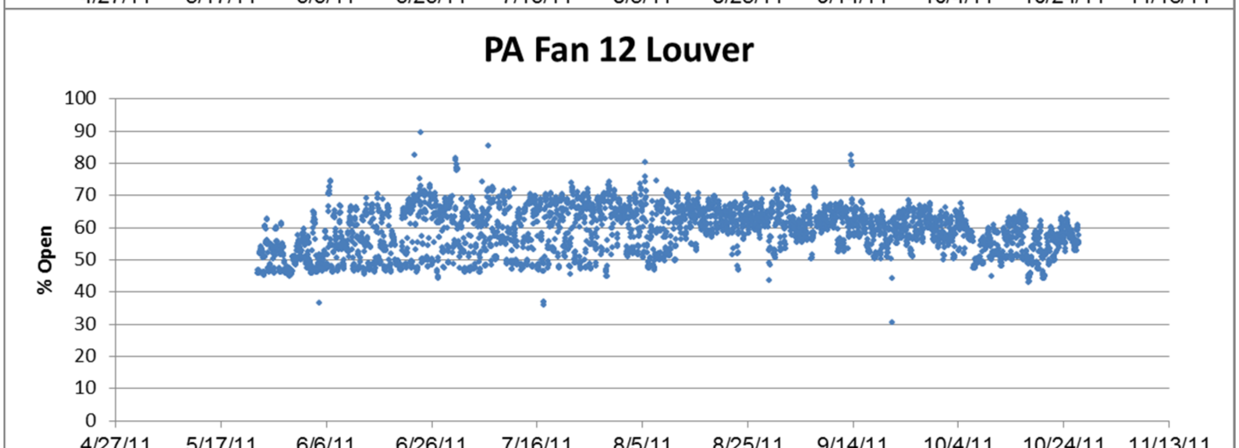

RO System: Recirculation Valve Position
% Open
80
60
40
20
0
5/12/11
6/6/11
7/1/11
7/26/11
8/20/11
9/14/11
10/9/11
11/3/11
11/28/11
12/23/11


RO Supply Pump Flow Rate
GPM
1000
800
600
400
200
0
5/12/11
6/6/11
7/1/11
7/26/11
8/20/11
9/14/11
10/9/11
11/3/11
11/28/11
12/23/11

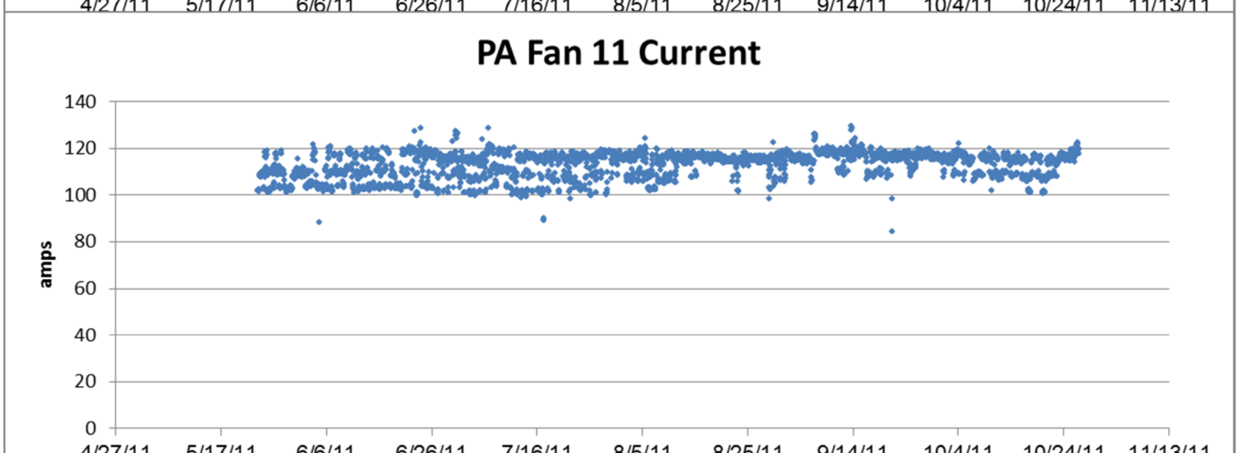
ECM 8



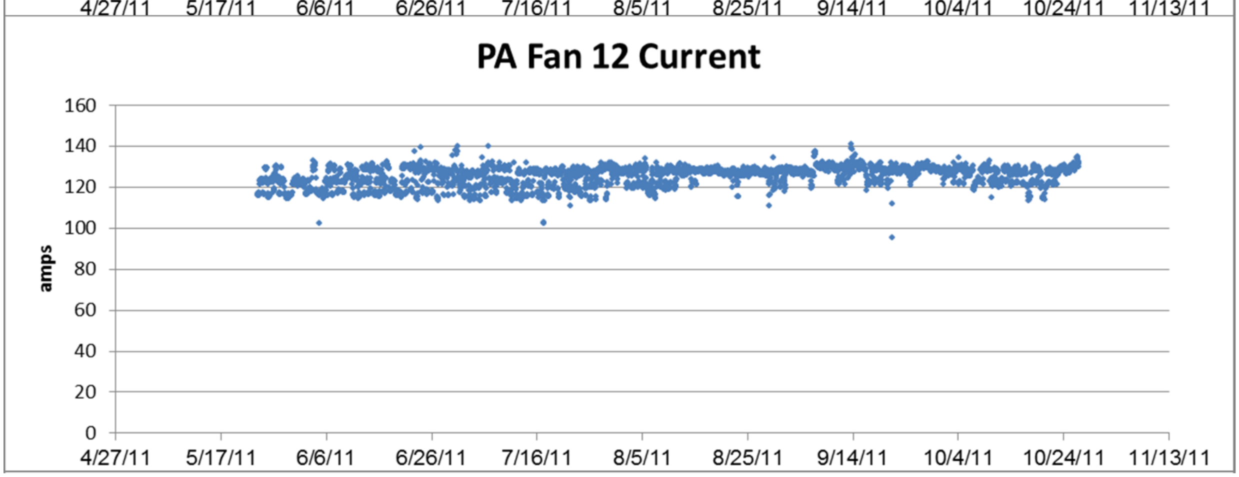
PA Fan 11 Louver
% Open
100
90
80
70
60
50
40
30
20
10
0
4/27/11
5/17/11
6/6/11
6/26/11
7/16/11
8/5/11
8/25/11
9/14/11
10/4/11
10/24/11
11/13/11



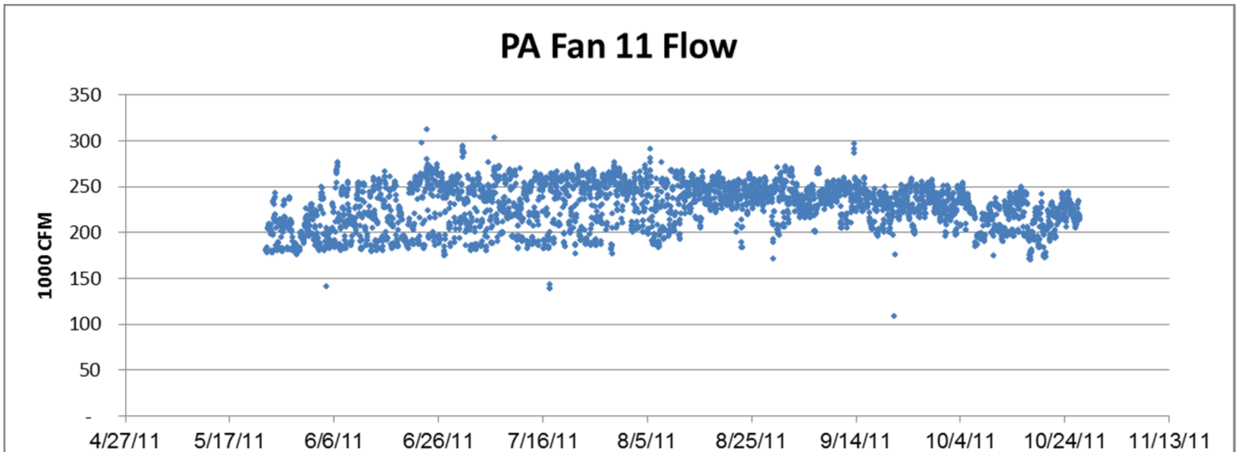
PA Fan 12 Louver
% Open
100
90
80
70
60
50
40
30
20
10
0
4/27/11
5/17/11
6/6/11
6/26/11
7/16/11
8/5/11
8/25/11
9/14/11
10/4/11
10/24/11
11/13/11

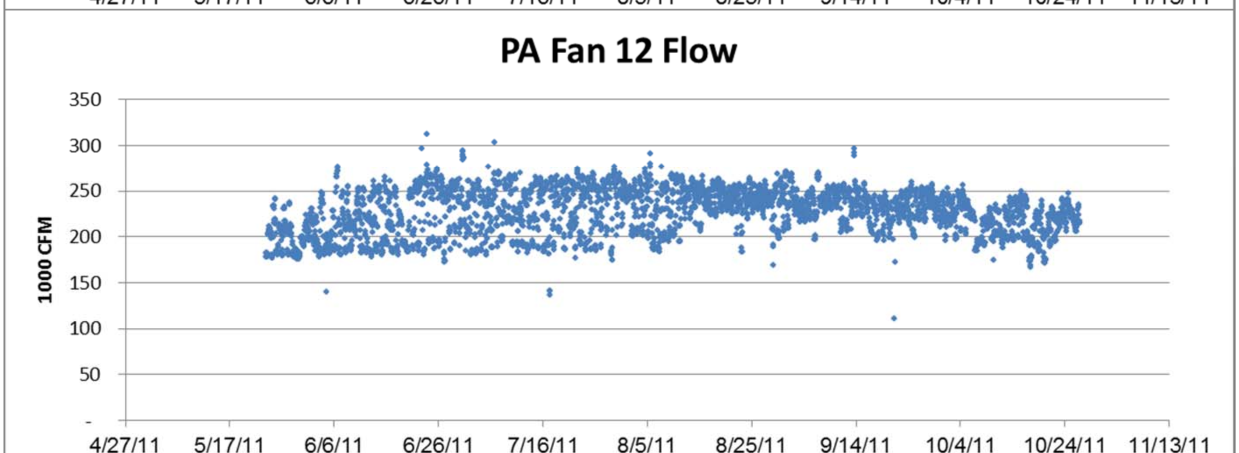


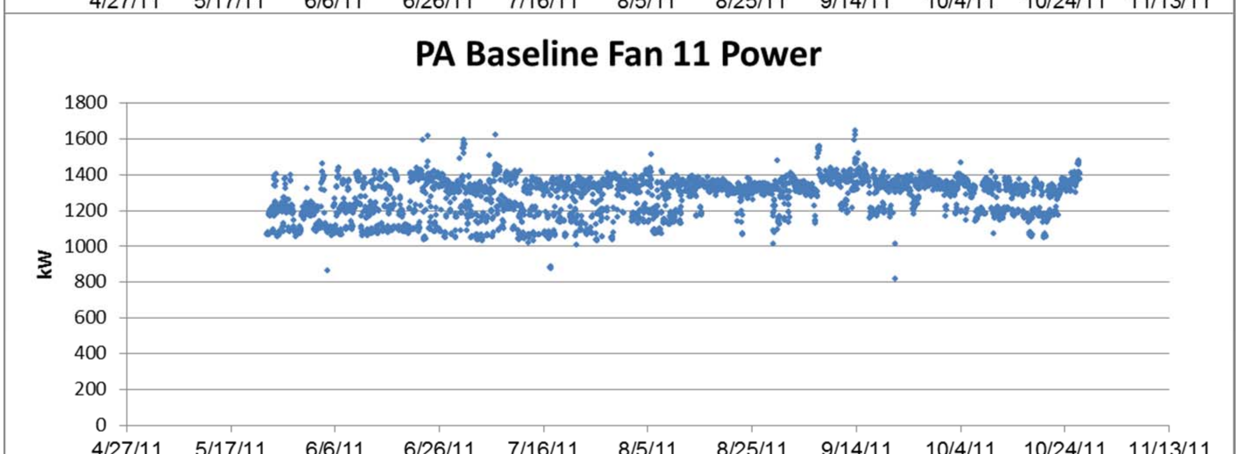
PA Fan 11 Current
amps
140
120
100
80
60
40
20
0
4/27/11
5/17/11
6/6/11
6/26/11
7/16/11
8/5/11
8/25/11
9/14/11
10/4/11
10/24/11
11/13/11

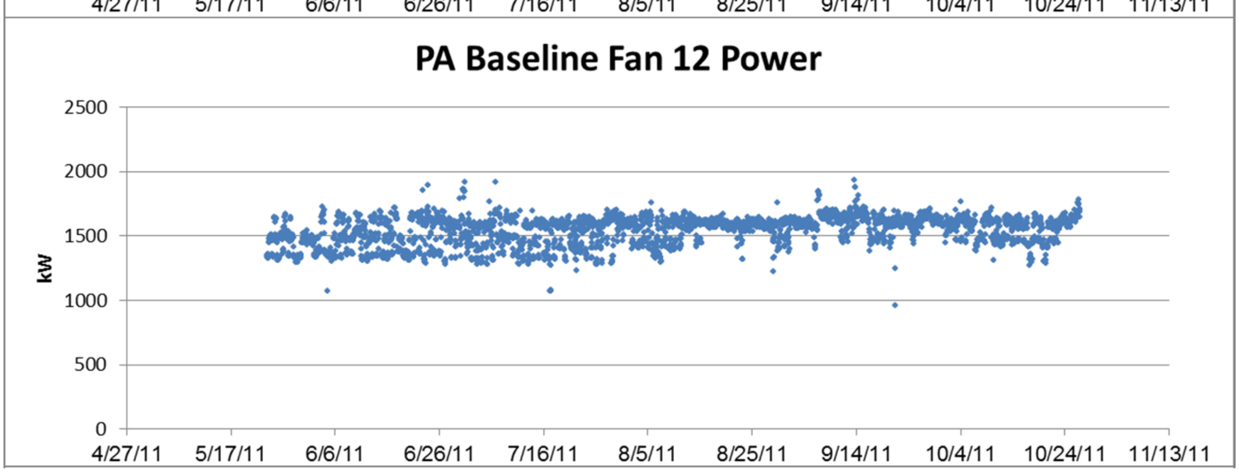


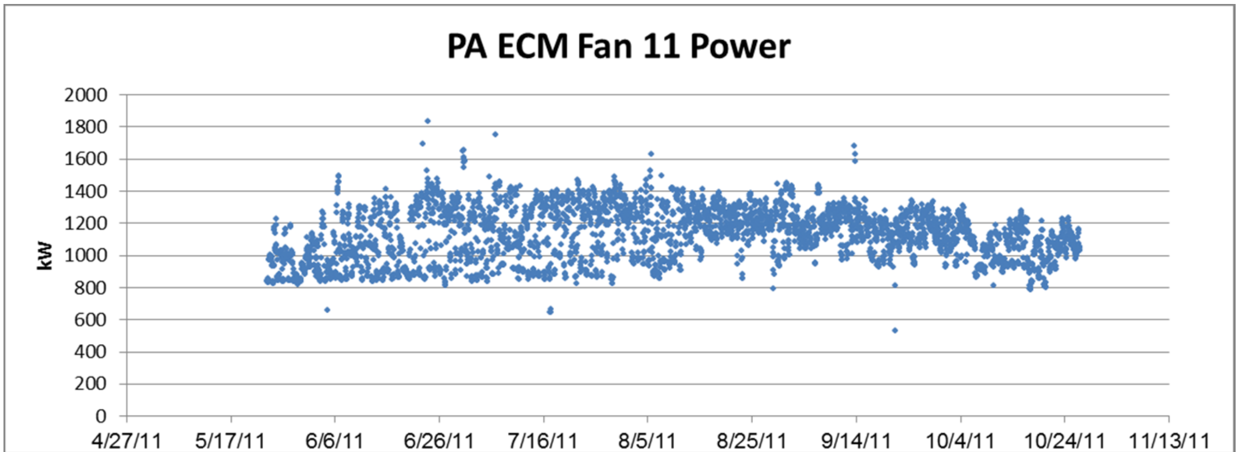
PA Fan 12 Current
amps
160
140
120
100
80
60
40
20
0
4/27/11
5/17/11
6/6/11
6/26/11
7/16/11
8/5/11
8/25/11
9/14/11
10/4/11
10/24/11
11/13/11

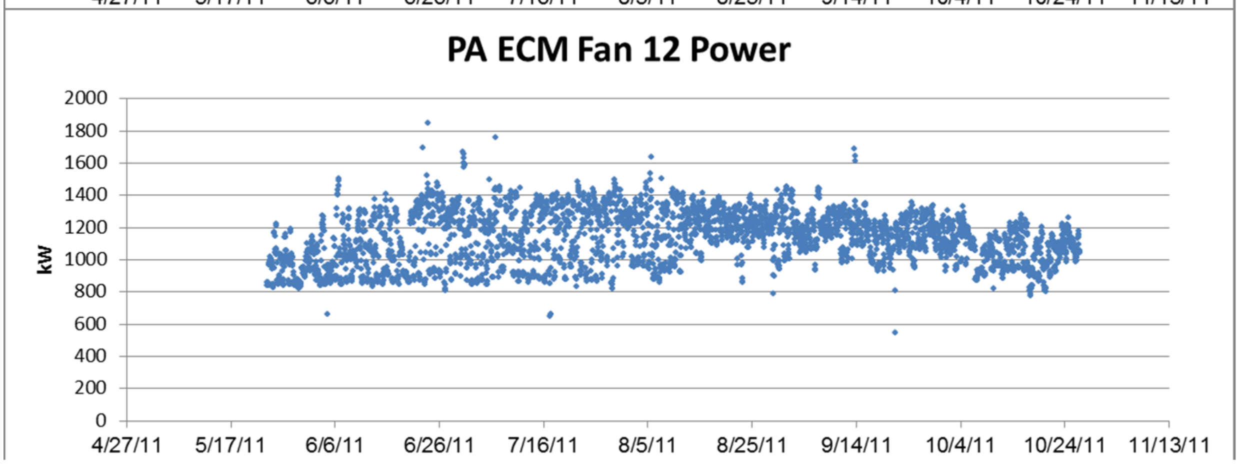

PA Fan 11 Flow
1000 CFM
350
300
250
200
150
100
50
-
4/27/11
5/17/11
6/6/11
6/26/11
7/16/11
8/5/11
8/25/11
9/14/11
10/4/11
10/24/11
11/13/11


PA Fan 12 Flow
1000 CFM
350
300
250
200
150
100
50
-
4/27/11
5/17/11
6/6/11
6/26/11
7/16/11
8/5/11
8/25/11
9/14/11
10/4/11
10/24/11
11/13/11

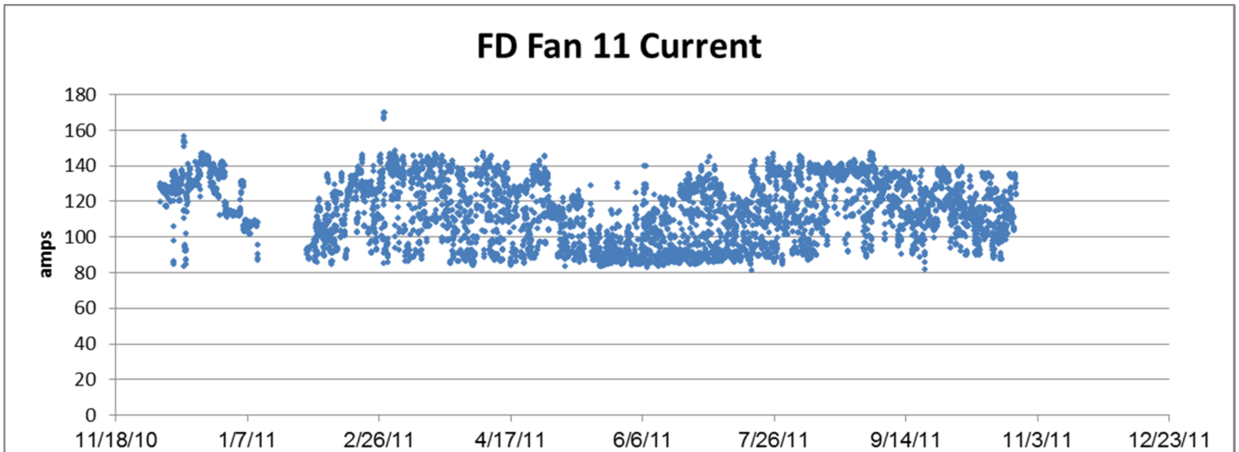

PA Baseline Fan 11 Power
kW
1800
1600
1400
1200
1000
800
600
400
200
0
4/27/11
5/17/11
6/6/11
6/26/11
7/16/11
8/5/11
8/25/11
9/14/11
10/4/11
10/24/11
11/13/11

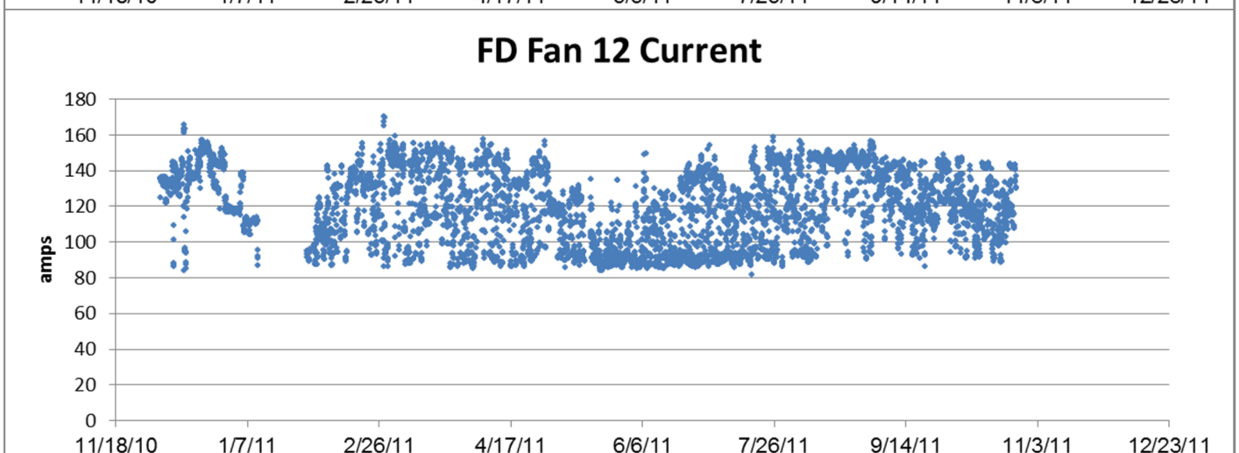

PA Baseline Fan 12 Power
kW
2500
2000
1500
1000
500
0
4/27/11
5/17/11
6/6/11
6/26/11
7/16/11
8/5/11
8/25/11
9/14/11
10/4/11
10/24/11
11/13/11

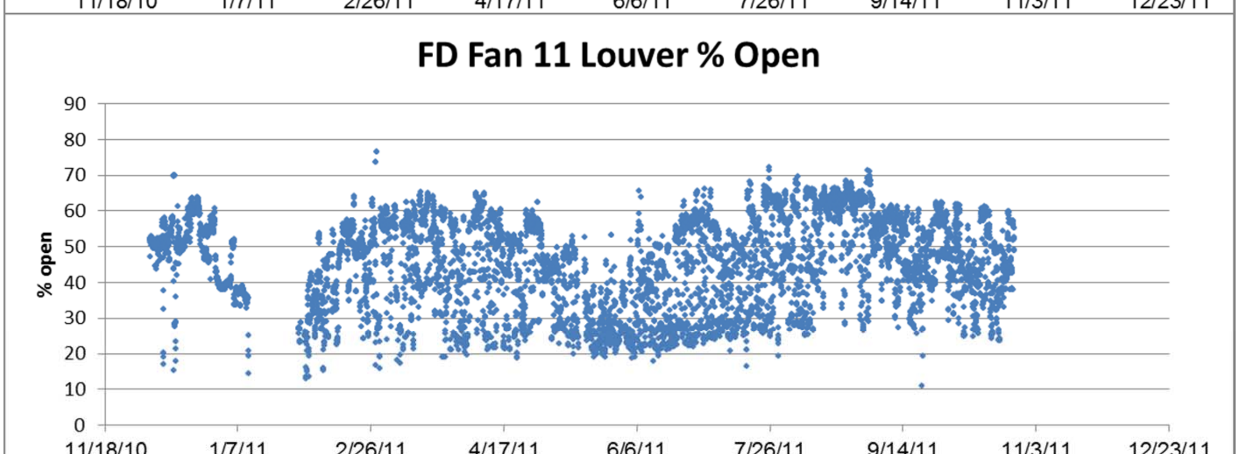

PA ECM Fan 11 Power
kW
2000
1800
1600
1400
1200
1000
800
600
400
200
0
4/27/11
5/17/11
6/6/11
6/26/11
7/16/11
8/5/11
8/25/11
9/14/11
10/4/11
10/24/11
11/13/11

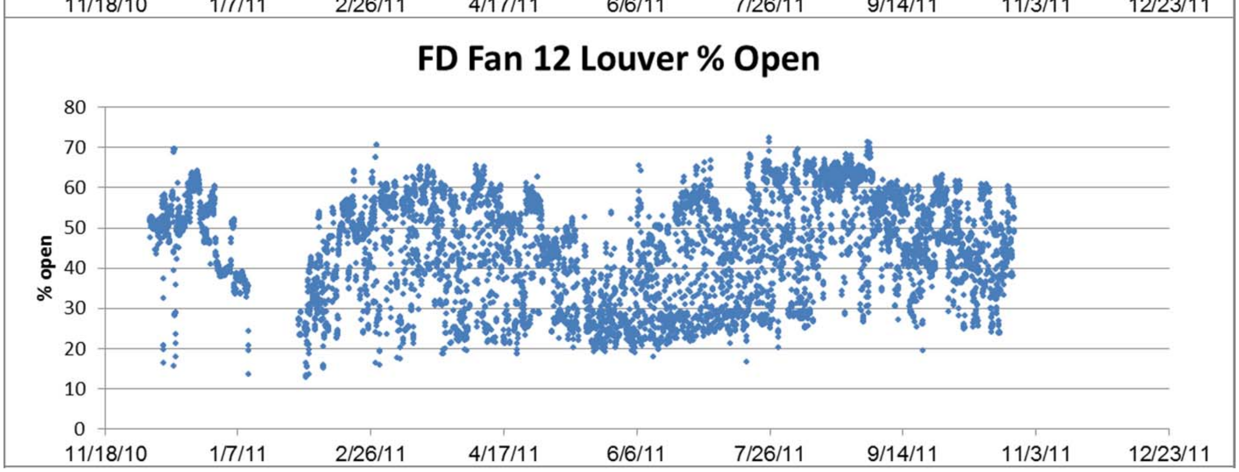

PA ECM Fan 12 Power
kW
2000
1800
1600
1400
1200
1000
800
600
400
200
0
4/27/11
5/17/11
6/6/11
6/26/11
7/16/11
8/5/11
8/25/11
9/14/11
10/4/11
10/24/11
11/13/11

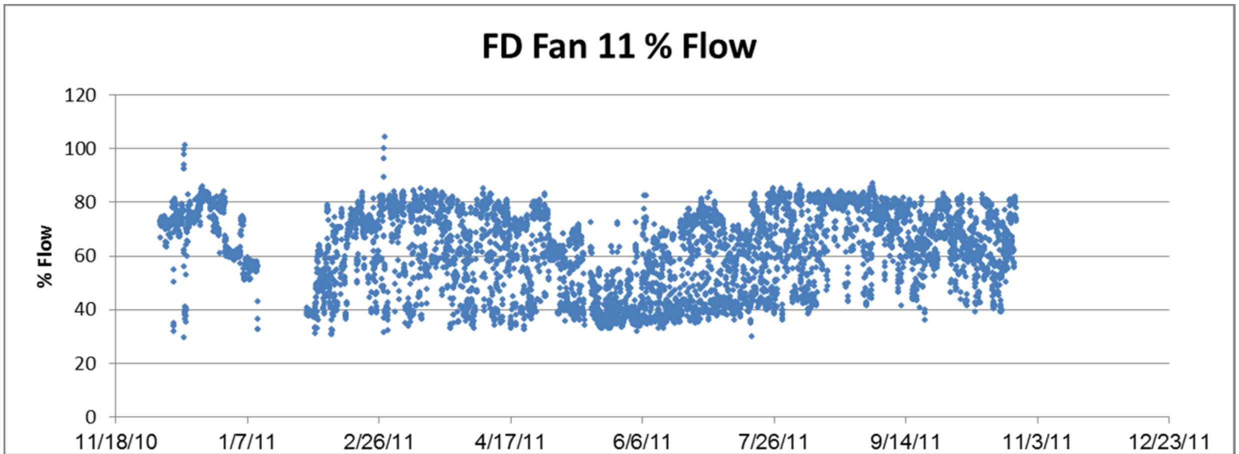
ECM 9

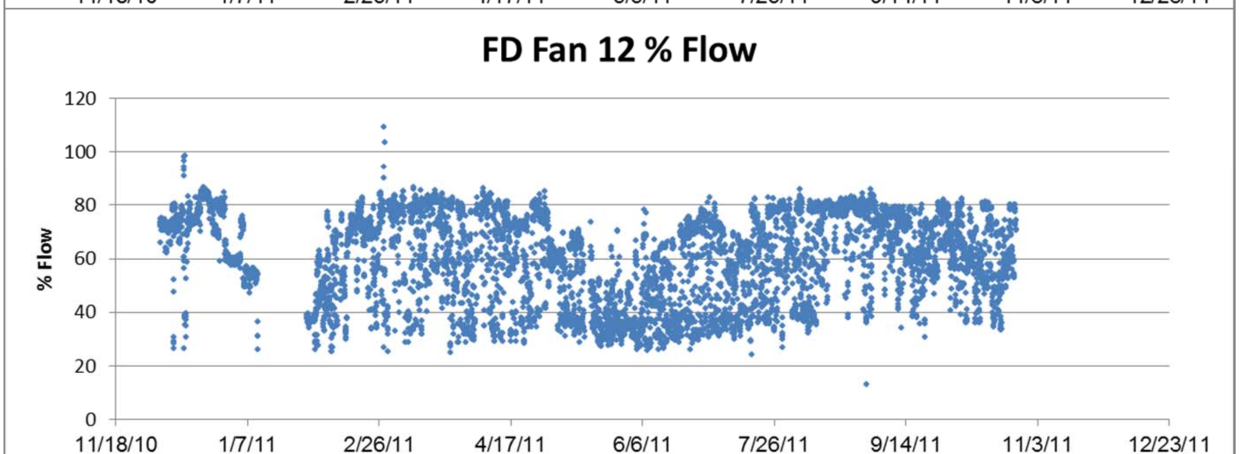

FD Fan 11 Current
amps
180
160
140
120
100
80
60
40
20
0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

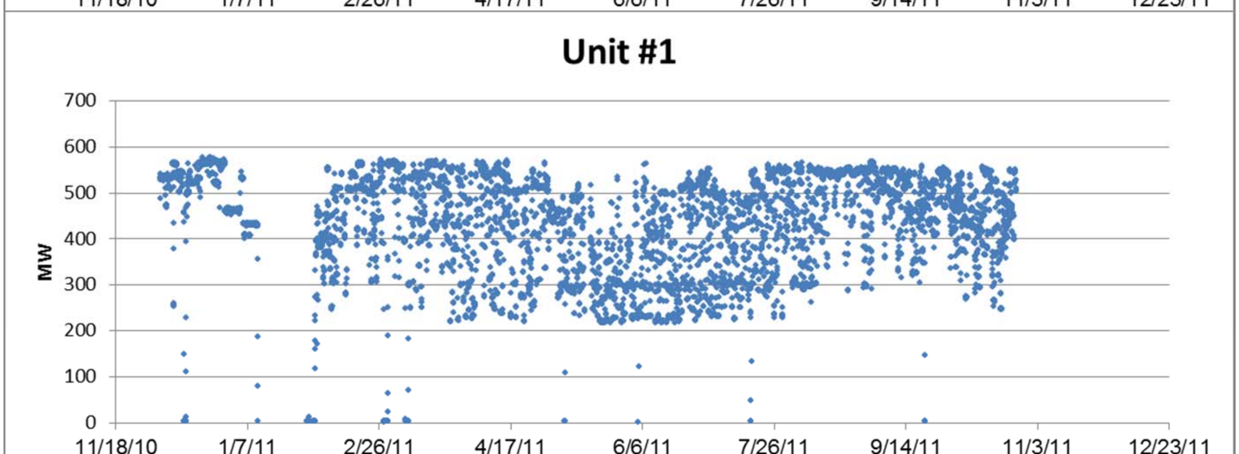

FD Fan 12 Current
amps
180
160
140
120
100
80
60
40
20
0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

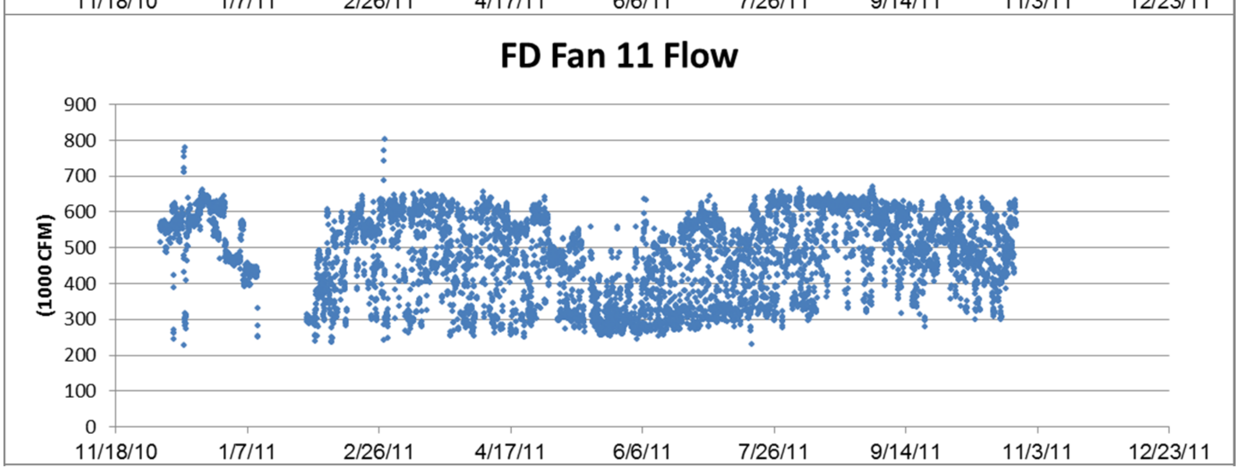

FD Fan 11 Louver % Open
% open
90
80
70
60
50
40
30
20
10
0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

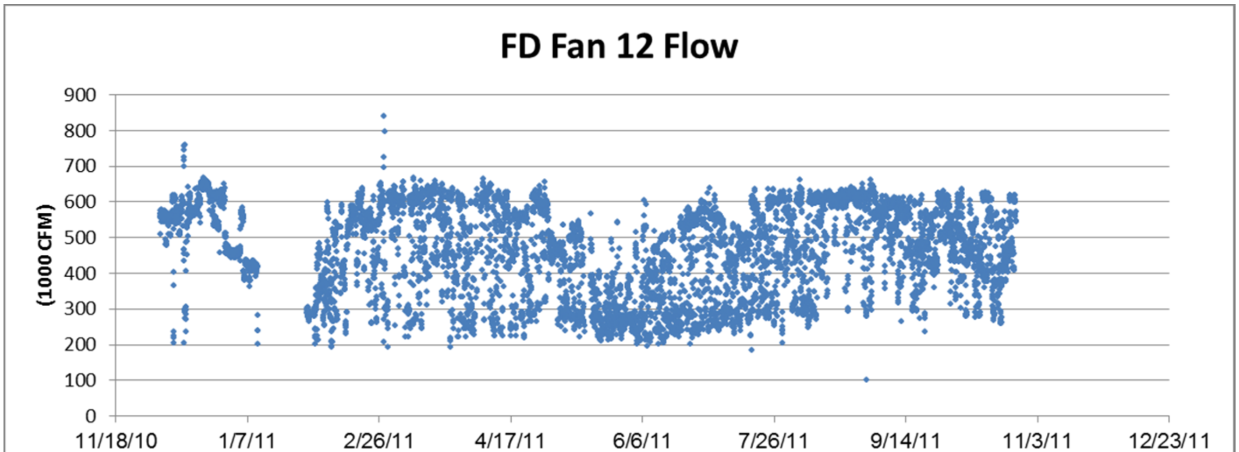

FD Fan 12 Louver % Open
% open
80
70
60
50
40
30
20
10
0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

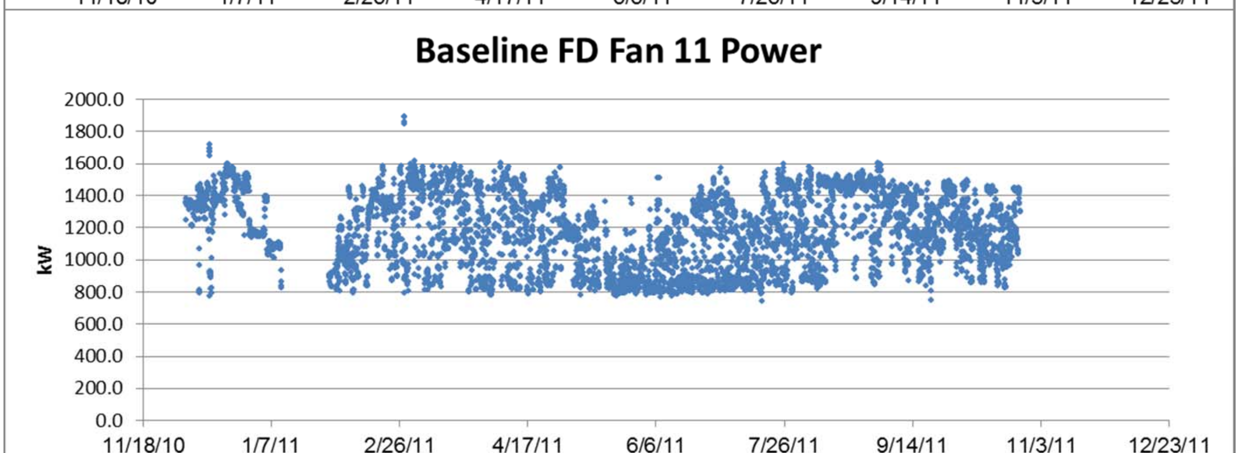

FD Fan 11 % Flow
% Flow
120
100
80
60
40
20
0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

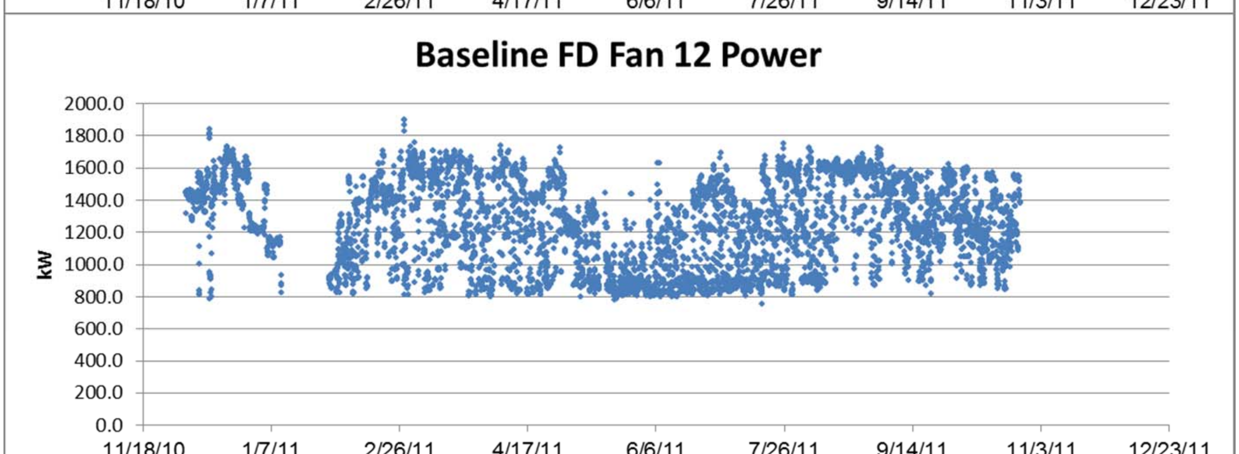

FD Fan 12 % Flow
% Flow
120
100
80
60
40
20
0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

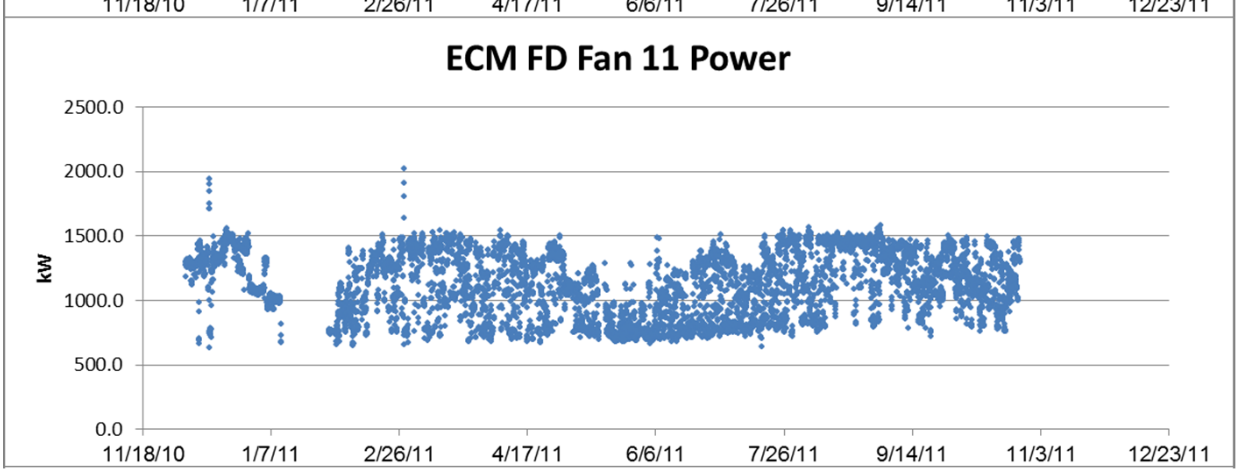

Unit #1
MW
700
600
500
400
300
200
100
0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

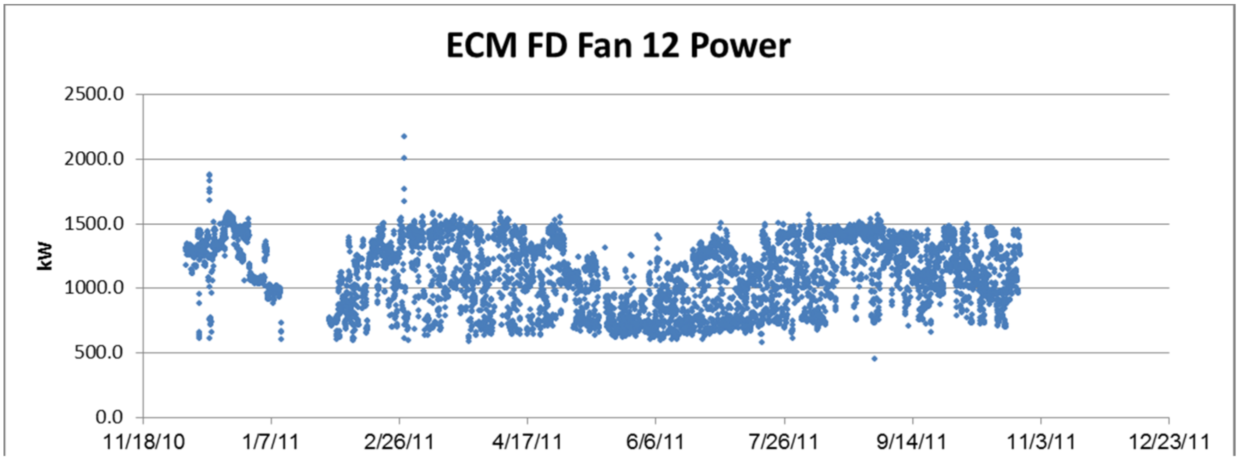

FD Fan 11 Flow
(1000 CFM)
900
800
700
600
500
400
300
200
100
0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11


FD Fan 12 Flow
(1000 CFM)
900
800
700
600
500
400
300
200
100
0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11


Baseline FD Fan 11 Power
kW
2000.0
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11


Baseline FD Fan 12 Power
kW
2000.0
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11


ECM FD Fan 11 Power
kW
2500.0
2000.0
1500.0
1000.0
500.0
0.0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11


ECM FD Fan 12 Power
kW
2500.0
2000.0
1500.0
1000.0
500.0
0.0
11/18/10
1/7/11
2/26/11
4/17/11
6/6/11
7/26/11
9/14/11
11/3/11
12/23/11

26.2 Jim Bridger: Model Calculations
ECM 1-Air Handler 4th Floor SE Corner (1VSF3)

Baseline

75 hp Fan; 460 V; runs continuously, enough mixer box set to always provide adequate air for full flow.

Baseline		
Assume .95 Power Factor and 90% efficiency on motor		
75 HP = 55.9 kW		
55.9kW/.95/.90=	65.4	kW
Annual Operating Hours =	8,760	
Annual Energy Use=	572,730	kWh

EEM

Operators report too much cooling on Mezzanine for 1/2 the year with A-lines working improperly.

Assume A-Line fans operating correctly to provide air to Mezzanine Level
Assume full-speed heating for 2.5 months a year
Assume full speed cooling for 3 months a year
Assume partial fan speed for 6.5 months per year averaging 75% full speed

Assume 3% VFD parasitic load
Assume 95% effciency on new fan motor and power factor of 1
Assume typical cubic law power reduction for reduced speed operations

EEM	
Power consumption for full speed operation, kW	60.6
Annual power consumtion for full speed operations, kWh	240,005
Power consumption for partial speed operations, kW	27.9
Annual power consumtion for reduced speed operations, kWh	133,792
Total annual power consumption, kWh	373,797
Total annual energy savings, kWh	198,933
Demand savings, kW	5

ECM 2- 9th Floor Fans (1VSF 1&2)

Baseline

Two- 75 hp Fan; 460 V; runs continuously, enough mixer box air set to always provide adequate air

Assume .95 Power Factor and 90% efficiency on motor

Baseline		
75 HP = 55.9 kW		
55.9kW/.95/.90= for one fan	65.4	kW
Annual Operating Hours=	8,760	
2 Fans;		
Total Annual Energy Use, kWh	1,145,460	

EEM

Assume A-Line fans operating correctly to provide air to 1st floor and Turbine Deck (cooling correc

1VSF 1

Assume full-speed heating on 1st floor for 3 months a year
Assume full speed cooling on 1st floor for 3 months a year
Assume partial fan speed for 6 months per year averaging 75% full speed

Assume 3% VFD parasitic load
Assume 95% effciency on new fan motor and power factor of 1
Assume typical cubic law power reduction for reduced speed operations

ECM 1VSF 1	
Power consumption for full speed operation, kW	60.6
Annual power consumtion for full speed operations, kWh	265,460
Power consumption for partial speed operations, kW	27.9
Annual power consumption for reduced speed operations, kWh	122,085
Total annual power consumption, kWh	387,545

1VSF 2

Assume full-speed heating on Turbine deck for 2 months a year
Assume full speed cooling on Turbine Deck for 4 months a year
Assume partial fan speed for 6 months per year averaging 75% full speed

Assume 3% VFD parasitic load
Assume 95% effciency on new fan motor and power factor of 1
Assume typical cubic law power reduction for reduced speed operations

ECM 1VSF 2	
Power consumption for full speed operation, kW	60.6
Annual power consumtion for full speed operations, kWh	265,460
Power consumption for partial speed operations, kW	27.9
Annual power consumtion for reduced speed operations, kWh	122,085
Total annual power consumption, kWh	387,545.5
Combined Annual Energy Consumption, kWh	775,090.91
Total annual energy savings, kWh	370,369
Demand savings, kW	10

ECM 3- 2Chillers

Baseline

10 hp pump; 460 V; runs continuously, even when chiller air hadlers ar shut off

Assume .90 Power Factor and 90% efficiency on motor

Baseline		
10 HP = 7.457 kW		
7.457kW/.90/.90=	9.2	kW
Annual Operating Hours =	8,760	
2 Pumps		
Annual Energy Use=	161,292	kWh

EEM

Assume A-Line fans operating correctly to provide air to room arround control room

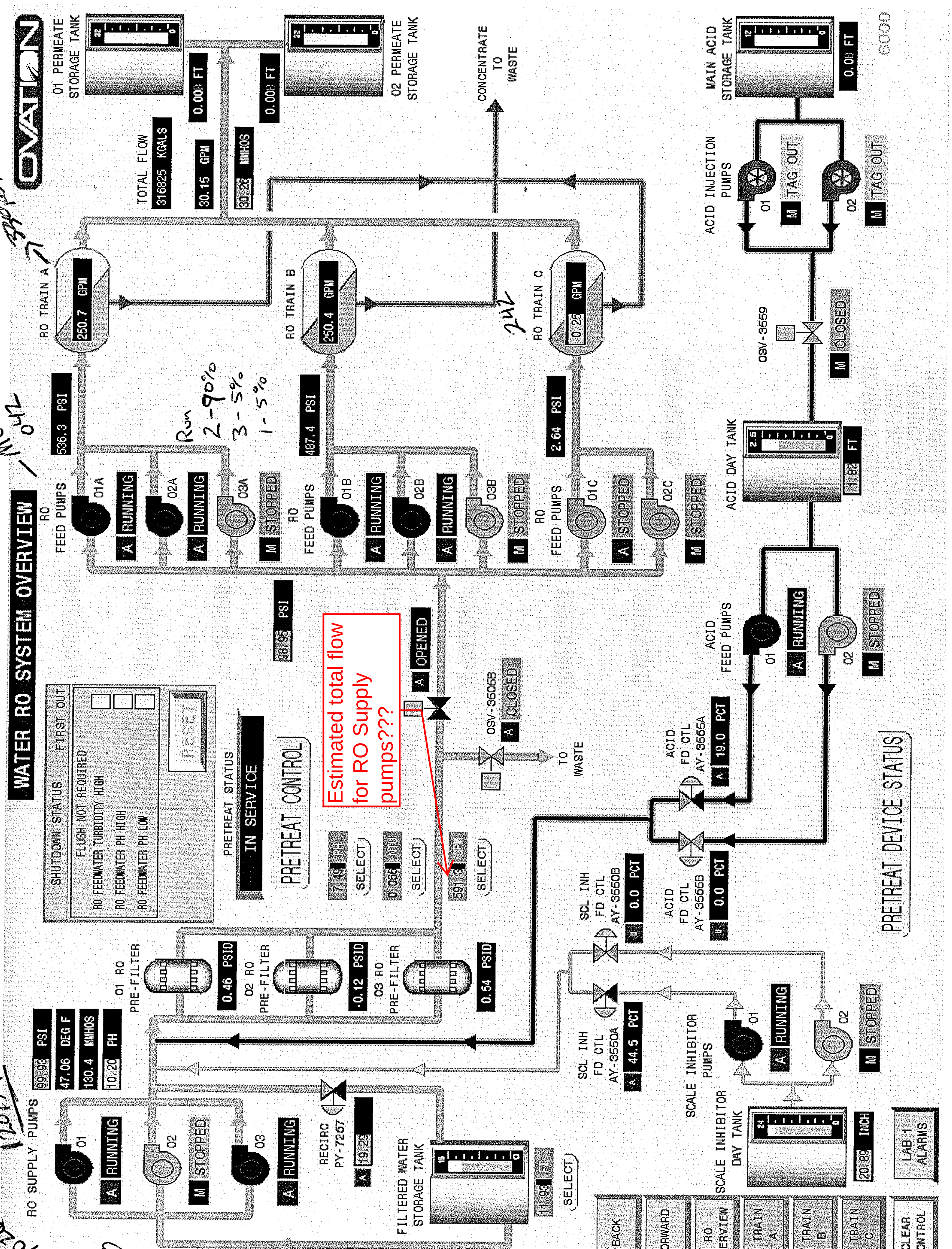
Assume cooling for 7 months a year

ECM	
Power consumption for chilling operations, kW	18.4
Annual Operating Hours	5,110
Annual power consumtion for full speed operations, kWh	94,087
Total annual energy savings, kWh	67,205
Demand savings, kW	-

ECM 4

ECM 4: RO Feed Pumps			
Baseline	**Skid A**	**Skid B**	**Total**
Annual Operating Hours	5,694	5,256	
Average Operating Power, MW	0.047	0.047	
Baseline System Energy, MWh/yr	266	245	511

Energy Conservation Measure	Skid A	Skid B	Total
Average Operating Power, MW	0.030	0.039	
ECM System Energy, MWh/yr	172	203	375
Energy Savings, MWh/yr	94	42	136


WATER RO SYSTEM OVERVIEW
OVATION
RO SUPPLY PUMPS
01 RUNNING
02 STOPPED
03 RUNNING
99.93 PSI
47.06 DEG F
130.4 MMHOS
10.20 PH
RECIRC PY-7267
19.23
FILTERED WATER STORAGE TANK
11.93 FT
SELECT
01 RO PRE-FILTER 0.46 PSID
02 RO PRE-FILTER -0.12 PSID
03 RO PRE-FILTER 0.54 PSID
SHUTDOWN STATUS FIRST OUT
FLUSH NOT REQUIRED
RO FEEDWATER TURBIDITY HIGH
RO FEEDWATER PH HIGH
RO FEEDWATER PH LOW
RESET
PRETREAT STATUS
IN SERVICE
PRETREAT CONTROL
7.49 PH SELECT
0.066 NTU SELECT
591.3 GPM SELECT
98.95 PSI
OPENED
OSV-3505B CLOSED
TO WASTE
Estimated total flow for RO Supply pumps???
RO FEED PUMPS
01A RUNNING
02A RUNNING
03A STOPPED
01B RUNNING
02B RUNNING
03B STOPPED
01C STOPPED
02C STOPPED
536.3 PSI
487.4 PSI
2.64 PSI
RO TRAIN A 250.7 GPM
RO TRAIN B 250.4 GPM
RO TRAIN C 0.25 GPM
TOTAL FLOW 316825 KGALS
30.15 GPM
30.23 MMHOS
01 PERMEATE STORAGE TANK 0.008 FT
02 PERMEATE STORAGE TANK 0.009 FT
CONCENTRATE TO WASTE
MAIN ACID STORAGE TANK 0.08 FT
ACID INJECTION PUMPS
01 TAG OUT
02 TAG OUT
OSV-3559 CLOSED
ACID DAY TANK 1.82 FT
ACID FEED PUMPS
01 RUNNING
02 STOPPED
ACID FD CTL AY-3565A 19.0 PCT
ACID FD CTL AY-3565B 0.0 PCT
SCL INH FD CTL AY-3550B 0.0 PCT
SCL INH FD CTL AY-3550A 44.5 PCT
SCALE INHIBITOR PUMPS
01 RUNNING
02 STOPPED
SCALE INHIBITOR DAY TANK 20.89 INCH
PRETREAT DEVICE STATUS
LAB 1 ALARMS
BACK
FORWARD
RO OVERVIEW
RO TRAIN A
RO TRAIN B
RO TRAIN C
CLEAR CONTROL
6000

RO Feed Pumps

3 Trains A, B and C. C has VFDs already.
Trains A and B have three pumps, 60 hp
Train A and B, two pumps operate when the RO unit is in operation.
Assume they have equal run hours on each system.

Power Snapshots

	Volts	Amps	kW	PF
2B	484	62.6	46.71	0.889
2A	484	63.4	46.3	0.87

Snap shot Readings
The discharge control valve on Trains A and B control to 250 gpm through the filters.

	Discharge Pressure	Pressure after control Valve	Pressure Drop
Train A	538.1	276.9	261.2
Train A	536	330	206
Train B	486	415	71

RO FEED Pumps: Questions

Ques 1 Control valves are set to target 250 gpm on trains A and B. I understand over time the filters plug up causing the control valves to open more and more until you guys clean the system.
Ans 1 Yes, 250 gpm of permeate. The control valve will open as the membranes foul and the inlet pressure will go up.
Ques 2 What is the normal clean pressure after the control valve, (270 psi)? See attached PDF.
Ans 2 That sounds about right.
Ques 3 When clean the RO feed pump discharge pressure is 550 psi and the pressure downstream of the valve is 270 psi so it is at 280 psi delta P when it is clean. When they are dirty I have seen as little as 0 psi delta P.
Ans 3 What is the normal range for the pressure drop across the control valve?
Ques 4 What is the normal length between cleaning the system, 3 month? What is the thing that indicates a cleaning is needed?
Ans 4 Normal clean is at 6-8 weeks or 20,000 gallons of permeate. I watch the differential pressure across each stage and the inlet pressure. I don’t mess with a normalized flow but that is basically what I’m watching.
Ques 5 I need pump curves on the RO Feed Pumps for Train A and B. Dan Zimmer has not be able to find these.
Ans 5 I believe Dave Christiansen can get them for you. His extension is 4330.
Ques 6 If you have any written logs outlining this information, please pass them to me.
Ans 6 I have an RO log with pressures and flows. Do you want me to send these? How far back do you want me to go?
Ques 7 Would we need to install VFDs on all three pumps? The system can run with 2 VFDs.
Ans 7 Three VFD’s would work better from a control standpoint when we put it into ovation.

Average			26	523	420	280	139	286	184	125	141	102	1.00	0.53	0.58	0.61	1.71	
Operating Average						534	264	498	320		270	178					123	146
																	360	157.1614
Log Sheet Data																	0.341667	154.7244

Date	time	Date and Time	Raw Data Recirc Valve Position % Open	RO Supply Pump Flow GPM	Total Permeate Flow GPM	Skid A RO Pump Disch Press PSI	Skid A RO Feed Press PSI	Skid B RO Pump Press PSI	Skid B RO Feed Press PSI	Skid C RO Feed Press PSI	Calc Skid A Press Drop PSI	Skid B Press Drop PSI	RO System ON	Skid A ON	Skid B ON	Skid C ON	# RO Systems ON	Flow per Pump GPM
11/27/2011	0:00	11/27/2011 0:00	22.4	555	489	532	349	0	0	293	183	0	1	1	0	1	2	138.75
11/27/2011	12:00	11/27/2011 12:00	58.81	275	228	533	369	0	0	0	164	0	1	1	0	0	1	137.5
11/26/2011	0:00	11/26/2011 0:00	21.9	558	488	531	336	0	0	295	195	0	1	1	0	1	2	139.5
11/26/2011	12:00	11/26/2011 12:00	22	559	488	531	336	0	0	303	195	0	1	1	0	1	2	139.75
11/25/2011	0:00	11/25/2011 0:00	19.5	581	514	535	340	0	0	314	195	0	1	1	0	1	2	145.25
11/25/2011	12:00	11/25/2011 12:00	58	282	248	0	0	0	0	290	0	0	1	0	0	1	1	141
11/24/2011	0:00	11/24/2011 0:00	22	551	487	534	340	0	0	301	194	0	1	1	0	1	2	137.75
11/24/2011	12:00	11/24/2011 12:00	58	273	227	535	336	0	0	0	199	0	1	1	0	0	1	136.5
11/23/2011	0:00	11/23/2011 0:00	20	582	513	534	340	0	0	336	194	0	1	1	0	1	2	145.5
11/23/2011	12:00	11/23/2011 12:00	21	557	491	533	353	0	0	318	180	0	1	1	0	1	2	139.25
11/22/2011	0:00	11/22/2011 0:00	19	581	513	533	332	0	0	332	201	0	1	1	0	1	2	145.25
11/22/2011	12:00	11/22/2011 12:00	22	637	530	533	354	0	0	314	179	0	1	1	0	1	2	159.25
11/21/2011	0:00	11/21/2011 0:00	19	582	515	528	348	0	0	334	180	0	1	1	0	1	2	145.5
11/21/2011	12:00	11/21/2011 12:00	53	308	271	0	0	0	0	338	0	0	1	0	0	1	1	154
11/20/2011	0:00	11/20/2011 0:00	19	587	511	0	0	510	506	288	0	4	1	0	1	1	2	146.75
11/20/2011	12:00	11/20/2011 12:00	58	311	269	0	0	0	0	330	0	0	1	0	0	1	1	155.5
11/19/2011	0:00	11/19/2011 0:00	15	619	537	0	0	505	498	324	0	7	1	0	1	1	2	154.75
11/19/2011	12:00	11/19/2011 12:00	15	613	535	0	0	508	502	330	0	6	1	0	1	1	2	153.25
11/18/2011	0:00	11/18/2011 0:00	15	619	542	0	0	497	492	314	0	5	1	0	1	1	2	154.75
11/18/2011	12:00	11/18/2011 12:00	15	619	539	0	0	501	494	321	0	7	1	0	1	1	2	154.75
11/17/2011	0:00	11/17/2011 0:00	14	624	544	0	0	492	486	303	0	6	1	0	1	1	2	156
11/17/2011	12:00	11/17/2011 12:00	15	623	543	0	0	496	485	312	0	11	1	0	1	1	2	155.75
11/16/2011	0:00	11/16/2011 0:00	17	592	519	496	451	0	0	273	45	0	1	1	0	1	2	148
11/16/2011	12:00	11/16/2011 12:00	53	315		0	0	497	462	0	0	35	1	0	1	0	1	157.5
11/15/2011	0:00	11/15/2011 0:00	0	896	779	522	371	483	443	337	151	40	1	1	1	1	3	149.3333
11/15/2011	12:00	11/15/2011 12:00	53	314	257	0	0	496	463	0	0	33	1	0	1	0	1	157
11/14/2011	0:00	11/14/2011 0:00	18	578	513	535	362	0	0	328	173	0	1	1	0	1	2	144.5
11/14/2011	12:00	11/14/2011 12:00	19	581	513	534	364	0	0	330	170	0	1	1	0	1	2	145.25
11/13/2011	0:00	11/13/2011 0:00	20	580	512	535	325	0	0	294	210	0	1	1	0	1	2	145
11/13/2011	12:00	11/13/2011 12:00	19	581	511	535	341	0	0	308	194	0	1	1	0	1	2	145.25
11/12/2011	0:00	11/12/2011 0:00	23	556	316	537	330	0	0	259	207	0	1	1	0	1	2	139
11/12/2011	12:00	11/12/2011 12:00	58	279	247	0	0	0	0	263	0	0	1	0	0	1	1	139.5
11/11/2011	0:00	11/11/2011 0:00	23	550	485	535	316	0	0	248	219	0	1	1	0	1	2	137.5
11/11/2011	12:00	11/11/2011 12:00	23	557	487	537	324	0	0	254	213	0	1	1	0	1	2	139.25
11/10/2011	0:00	11/10/2011 0:00	20	581	512	535	327	0	0	271	208	0	1	1	0	1	2	145.25
11/10/2011	12:00	11/10/2011 12:00	58	307	271	0	0	0	0	281	0	0	1	0	0	1	1	153.5
11/9/2011	0:00	11/9/2011 0:00	58	275	225	539	317	0	0	0	222	0	1	1	0	0	1	137.5
11/9/2011	12:00	11/9/2011 12:00	20	581	512	536	320	0	0	260	216	0	1	1	0	1	2	145.25
11/8/2011	0:00	11/8/2011 0:00	19	590	475	536	311	487	420	0	225	67	1	1	1	0	2	147.5
11/8/2011	12:00	11/8/2011 12:00	19	588	477	535	317	487	430	0	218	57	1	1	1	0	2	147
11/7/2011	0:00	11/7/2011 0:00	18	586	476	537	311	488	406	0	226	82	1	1	1	0	2	146.5
11/7/2011	12:00	11/7/2011 12:00	19	590	476	537	292	488	399	0	245	89	1	1	1	0	2	147.5
11/6/2011	0:00	11/6/2011 0:00	19	581	271	535	288	0	0	394	247	0	1	1	0	1	2	145.25
11/6/2011	12:00	11/6/2011 12:00	52	314	267	489	408	0	0	0	81	0	1	1	0	0	1	157
11/5/2011	0:00	11/5/2011 0:00	22	557	249	536	271	0	0	333	265	0	1	1	0	1	2	139.25
11/5/2011	12:00	11/5/2011 12:00	22	556	250	535	277	0	0	368	258	0	1	1	0	1	2	139
11/4/2011	0:00	11/4/2011 0:00	0	869	486	528	373	478	378	348	155	100	1	1	1	1	3	144.8333
11/4/2011	12:00	11/4/2011 12:00	19	593	242	0	0	0	0	342	0	0	1	0	0	1	1	296.5
11/3/2011	0:00	11/3/2011 0:00	0	863	486	527	379	482	327	329	148	155	1	1	1	1	3	143.8333
11/3/2011	12:00	11/3/2011 12:00	0	869	487	528	372	477	327	343	156	150	1	1	1	1	3	144.8333
11/2/2011	0:00	11/2/2011 0:00	19.37	581	513	537	369	0	0	344	168	0	1	1	0	1	2	145.25

Pump VFD Energy Savings Calculator

Macros must be enabled to properly use this tool.

Click here to go to help tab

CascadeEnergy

PROJECT INFORMATION

Customer: Jim Bridger

Pump ID: RO Feed Pump

This calculator can be used to calculate energy savings from controlling a pump with a VFD, replacing a pump, or trimming the impeller diameter

PUMP CURVE INFORMATION

Open or closed system	open
Liquid pumped:	water (Specific Gravity of 1.00)
Custom specific gravity:	

Motor hp:	60
efficiency if known:	94.1% (or leave blank if unknown)

	Design	Actual	
Speed:	3500	3560	rpm
Impeller Diameter:	10.00	10.00	(length)

This difference between actual and design conditions will result in a 1.017 correction factor for motor speed, and a 1 correction factor for impeller diameter.

Read off eleven (11) points from the baseline pump curve to fill in the following table:

	Flow (gpm)	Head (ft)	Select input: efficiency (%)	Power (hp)
1)	50	1,320	0.360	46.3
2)	60	1,300	0.410	48.0
3)	70	1,280	0.460	49.2
4)	80	1,260	0.500	50.9
5)	90	1,240	0.540	52.2
6)	100	1,220	0.570	54.0
7)	110	1,180	0.590	55.6
8)	120	1,140	0.605	57.1
9)	130	1,100	0.615	58.7
10)	140	1,040	0.615	59.8
11)	150	960	0.610	59.6

Note: errors will occur if this table is not completed accurately

Every pump has a unique operating curve at a given impeller diameter and speed. To accurately estimate performance, it is necessary to enter representative points on manufacturer's published curve and correct for speed and impeller diameter. Choose points to the right of the maximum head, or errors may occur. Three inputs are required at each of the 11 points: flow, head, and *either* power (hp) or efficiency (%).

☐ Check this box if a new pump with a different pump curve will be installed as part of this energy efficiency measure

SYSTEM OPERATION INFORMATION

1) Enter baseline system information (inputs are tan)

		1		2	3	4	5	6	7	8	
		Hours (hrs/year)	at	Suction pressure** (ft)	Flow (leave blank if unknown) (gpm)	Operating Power (kW)	Baseline discharge pressure (psig)	Calculated flow from operating power (gpm)	Calculated flow from head (gpm)	Calculated flow after speed correction (gpm)	Where all three parameters are known, which would you describe as the least accurate?
A	1)	5,694	@	100.0	146	46.7	533.0	90	146	146	Power
B	2)	5,256	@	100.0	157	46.7	497.0	90	156	157	Power
	3)		@								
	4)		@								
	5)		@								

Total hours/yr: 10,950

**If pulling from a raised tank, enter the height of liquid as a POSITIVE number
** For well pumps - height above water level at given flowpoint; For circulation pumps, intake pressure at flowpoint

Enter available information in columns 1 through 5. Assuming the pump is operating on the manufacturer's curve, an operating point can be defined by only one of flow, power or pressure. If more than one parameter is known at one or more operating points, the tool will adjust the pump curve to pass as close as possible to the measured points.

Speed Adjustment Ratio: 1.026

NOTE: The ECM Data was based on operating averages for log sheet data from June 1 to Nov 27th 2011.

Adjust pump curve

Reset speed adjustment ratio

2) Enter upgrade system information

		9		10	11	12		13	14
		Hours (hrs/year)	at	Upgrade suction pressure (ft)	Flow (gpm)	Upgrade discharge pressure (psig)	or	ΔP across baseline control valve (ft)	Calculated head for open loop system (ft)
A	1)	5,694	@	100.0	146	264.0	or		509.8
B	2)	5,256	@	100.0	157	320.0	or		639.2
	3)		@				or		
	4)		@				or		
	5)		@				or		

Total hours/yr: 10,950

Enter upgrade system information in columns 9-13. For each point, enter a number in column 12 *or* 13 but not both. Column 14 is for reference only, and shows the calculated pump head requirement.

For closed loop systems, the upgrade discharge pressure only needs to be entered for the first operating point. Other operating pressures are calculated from a quadratic system curve with no static

Check Errors

The flow you have entered/calculated is within the bounds of the pump curve.
The head you have entered/calculated is within the bounds of the pump curve.
The power you have entered/calculated is within the bounds of the pump curve.
Click the button to the right or click on the next tab to calculate energy savings

Adjust pump curve and go to output tab

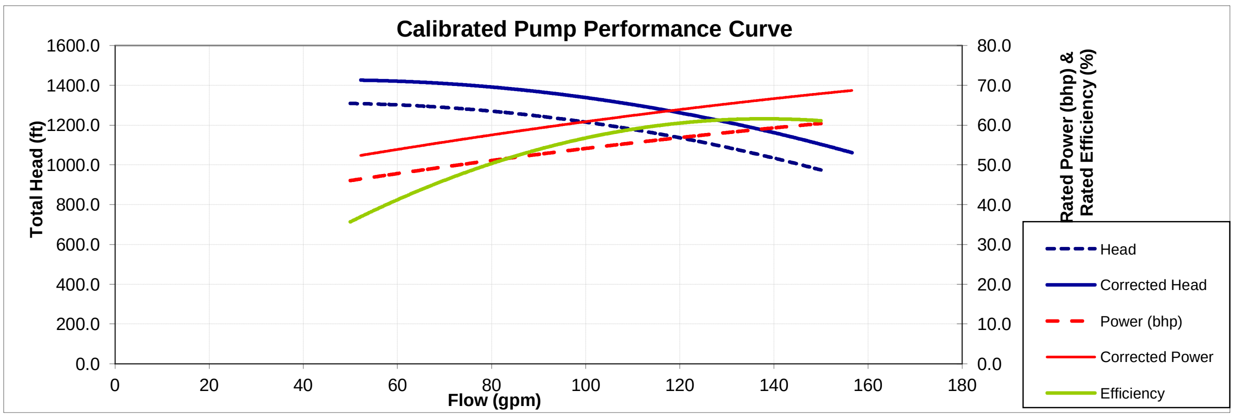
Calculations and Results - VFD control - RO Feed Pump

CALCULATION ASSUMPTIONS AND METHOD

1) The baseline pump motor efficiency is 94.1%.
2) The efficiency of the VFD is 97%.
3) A pump speed reduction results in:
   1) a reduction in flow directly proportional to the speed reduction
   2) a reduction in head proportional to the speed reduction squared
   3) a reduction in power proportional to the speed reduction to the 2.7th power
4) The liquid pumped is water and the specific gravity is 1
5) The speed of the pump is adjusted by a 1.026 multiplier to account for discrepancies between the operating points and the pump curve
6) The difference between actual and design conditions for the baseline pump results in a 1.017 correction factor for motor speed, and a 1 correction factor for impeller diameter. Affinity laws are used to calculate the effect on the system curve.

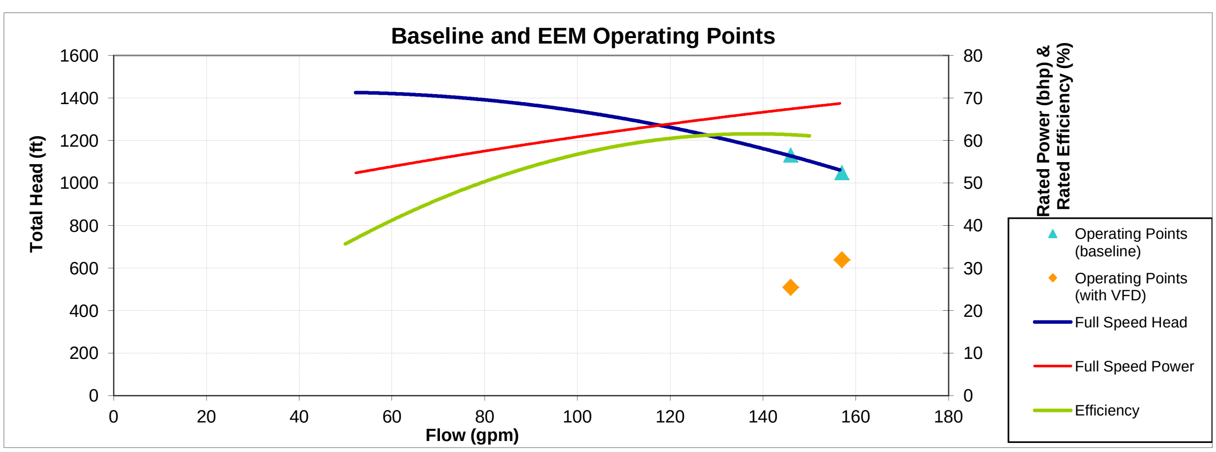
BASELINE ENERGY USE CALCULATIONS (Existing System)

	Operating Hours (hours/yr)	Flowrate (gpm)	Pump head (ft)	Hydraulic Efficiency (%)	Shaft Power (bhp)	Electric Power (kW)	Annual Energy Use (kWh/yr)
1)	5,694	146	1131.2	71%	58.9	46.7	265,910
2)	5,256	157	1048.1	71%	58.9	46.7	245,455
3)							
4)							
5)							
					Total Annual Energy Use (kWh/yr):		511,365



EEM ENERGY USE CALCULATIONS (With VFD)

	Operating Hours (hours/yr)	Flowrate (gpm)	Pump Head (ft)	Hydraulic Efficiency (%)	VFD Speed (%)	Shaft Power (bhp)	Electric Power (kW)	Annual Energy Use (kWh/yr)
1)	5,694	146	509.8	51%	78%	36.9	30.2	171,766
2)	5,256	157	639.2	54%	86%	47.3	38.7	203,276
3)								
4)								
5)								
						Total Annual Energy Use (kWh/yr):		375,042



SUMMARY OF RESULTS

Baseline energy use:	**511,365**	kWh/yr	**Annual energy savings:**	**136,323**	kWh/yr
Upgrade energy use:	**375,042**	kWh/yr	**Percent savings:**	**27%**	

Quadratic Pump Curve Fits : Baseline Pump Curve

Curvefit		Head Vs. Flow
c	c	1299.084696
x	b	2.57201998
x2	a	-0.029370629

CFM	CFM^2	Pump Data Head	Curve Fit Head	Error	Abs Error
51	2586	1365.65	1353.92	-0.87%	0.87%
61	3724	1344.95	1346.66	0.13%	0.13%
71	5069	1324.26	1333.32	0.68%	0.68%
81	6621	1303.57	1313.90	0.79%	0.79%
92	8380	1282.88	1288.41	0.43%	0.43%
102	10346	1262.19	1256.83	-0.43%	0.43%
112	12518	1220.80	1219.18	-0.13%	0.13%
122	14898	1179.42	1175.46	-0.34%	0.34%
132	17484	1138.04	1125.65	-1.10%	1.10%
142	20278	1075.96	1069.77	-0.58%	0.58%
153	23278	993.20	1007.81	1.45%	1.45%

Curvefit		BHP Vs. Flow
c	c	38.10234436
x	b	0.222198437
x2	a	-0.00036227

CFM	CFM^2	Pump Data BHP	Curve Fit BHP	Error	Abs Error
51	2586	48.7	48.5	-0.52%	0.52%
61	3724	50.6	50.3	-0.48%	0.48%
71	5069	51.8	52.1	0.63%	0.63%
81	6621	53.6	53.8	0.39%	0.39%
92	8380	54.9	55.4	0.88%	0.88%
102	10346	56.9	57.0	0.14%	0.14%
112	12518	58.5	58.4	-0.06%	0.06%
122	14898	60.1	59.8	-0.44%	0.44%
132	17484	61.8	61.1	-1.05%	1.05%
142	20278	62.9	62.4	-0.83%	0.83%
153	23278	62.7	63.6	1.32%	1.32%

Curvefit		Efficiency Vs. Flow
c	c	-0.021573427
x	b	0.009086768
x2	a	-3.23882E-05

CFM	CFM^2	Pump Data Efficiency	Curve Fit Efficiency	Error	Abs Error
51	2586	36.0%	35.7%	-0.90%	0.90%
61	3724	41.0%	41.2%	0.57%	0.57%
71	5069	46.0%	46.1%	0.26%	0.26%
81	6621	50.0%	50.3%	0.67%	0.67%
92	8380	54.0%	53.9%	-0.22%	0.22%
102	10346	57.0%	56.8%	-0.42%	0.42%
112	12518	59.0%	59.0%	-0.06%	0.06%
122	14898	60.5%	60.5%	0.00%	0.00%
132	17484	61.5%	61.4%	-0.22%	0.22%
142	20278	61.5%	61.6%	0.10%	0.10%
153	23278	61.0%	61.1%	0.14%	0.14%

Quadratic Pump Curve Fits : Baseline Corrected Pump Curve

Curvefit		Head Vs. Flow
c	c	1368.074224
x	b	2.63943174
x2	a	-0.029370629

CFM	CFM^2	Pump Data Head	Curve Fit Head	Error	Abs Error
52	2724	1438.17	1425.83	-0.87%	0.87%
63	3922	1416.38	1418.18	0.13%	0.13%
73	5339	1394.59	1404.13	0.68%	0.68%
84	6973	1372.80	1383.68	0.79%	0.79%
94	8825	1351.01	1356.83	0.43%	0.43%
104	10895	1329.22	1323.58	-0.43%	0.43%
115	13183	1285.64	1283.93	-0.13%	0.13%
125	15689	1242.06	1237.88	-0.34%	0.34%
136	18413	1198.47	1185.43	-1.10%	1.10%
146	21355	1133.10	1126.58	-0.58%	0.58%
157	24514	1045.94	1061.33	1.45%	1.45%

Curvefit		BHP Vs. Flow
c	c	41.1775012
x	b	0.233998565
x2	a	-0.000371765

CFM	CFM^2	Pump Data BHP	Curve Fit BHP	Error	Abs Error
52	2724	52.7	52.4	-0.52%	0.52%
63	3922	54.6	54.4	-0.48%	0.48%
73	5339	55.9	56.3	0.63%	0.63%
84	6973	57.9	58.1	0.39%	0.39%
94	8825	59.4	59.9	0.88%	0.88%
104	10895	61.5	61.6	0.14%	0.14%
115	13183	63.2	63.1	-0.06%	0.06%
125	15689	64.9	64.7	-0.44%	0.44%
136	18413	66.8	66.1	-1.05%	1.05%
146	21355	68.0	67.4	-0.83%	0.83%
157	24514	67.8	68.7	1.32%	1.32%

Curvefit		Efficiency Vs. Flow
c	c	-0.021573427
x	b	0.008854689
x2	a	-3.07549E-05

CFM	CFM^2	Pump Data Efficiency	Curve Fit Efficiency	Error	Abs Error
52	2724	36.0%	35.7%	-0.90%	0.90%
63	3922	41.0%	41.2%	0.57%	0.57%
73	5339	46.0%	46.1%	0.26%	0.26%
84	6973	50.0%	50.3%	0.67%	0.67%
94	8825	54.0%	53.9%	-0.22%	0.22%
104	10895	57.0%	56.8%	-0.42%	0.42%
115	13183	59.0%	59.0%	-0.06%	0.06%
125	15689	60.5%	60.5%	0.00%	0.00%
136	18413	61.5%	61.4%	-0.22%	0.22%
146	21355	61.5%	61.6%	0.10%	0.10%
157	24514	61.0%	61.1%	0.14%	0.14%

Quadratic Pump Curve Fits : Upgrade Pump Curve

Curvefit		Head Vs. Flow
c	c	1368.074224
x	b	2.63943174
x2	a	-0.029370629

CFM	CFM^2	Pump Data Head	Curve Fit Head	Error	Abs Error
52	2724	1438.17	1425.83	-0.87%	0.87%
63	3922	1416.38	1418.18	0.13%	0.13%
73	5339	1394.59	1404.13	0.68%	0.68%
84	6973	1372.80	1383.68	0.79%	0.79%
94	8825	1351.01	1356.83	0.43%	0.43%
104	10895	1329.22	1323.58	-0.43%	0.43%
115	13183	1285.64	1283.93	-0.13%	0.13%
125	15689	1242.06	1237.88	-0.34%	0.34%
136	18413	1198.47	1185.43	-1.10%	1.10%
146	21355	1133.10	1126.58	-0.58%	0.58%
157	24514	1045.94	1061.33	1.45%	1.45%

Curvefit		BHP Vs. Flow
c	c	41.1775012
x	b	0.233998565
x2	a	-0.000371765

CFM	CFM^2	Pump Data BHP	Curve Fit BHP	Error	Abs Error
52	2724	52.7	52.4	-0.52%	0.52%
63	3922	54.6	54.4	-0.48%	0.48%
73	5339	55.9	56.3	0.63%	0.63%
84	6973	57.9	58.1	0.39%	0.39%
94	8825	59.4	59.9	0.88%	0.88%
104	10895	61.5	61.6	0.14%	0.14%
115	13183	63.2	63.1	-0.06%	0.06%
125	15689	64.9	64.7	-0.44%	0.44%
136	18413	66.8	66.1	-1.05%	1.05%
146	21355	68.0	67.4	-0.83%	0.83%
157	24514	67.8	68.7	1.32%	1.32%

Curvefit		Efficiency Vs. Flow
c	c	-0.021573427
x	b	0.008854689
x2	a	-3.07549E-05

CFM	CFM^2	Pump Data Efficiency	Curve Fit Efficiency	Error	Abs Error
52	2724	36.0%	35.7%	-0.90%	0.90%
63	3922	41.0%	41.2%	0.57%	0.57%
73	5339	46.0%	46.1%	0.26%	0.26%
84	6973	50.0%	50.3%	0.67%	0.67%
94	8825	54.0%	53.9%	-0.22%	0.22%
104	10895	57.0%	56.8%	-0.42%	0.42%
115	13183	59.0%	59.0%	-0.06%	0.06%
125	15689	60.5%	60.5%	0.00%	0.00%
136	18413	61.5%	61.4%	-0.22%	0.22%
146	21355	61.5%	61.6%	0.10%	0.10%
157	24514	61.0%	61.1%	0.14%	0.14%

ECM 5

ECM 5: Condensate Pumps				
Baseline	**Pump 1**	**Pump 2**	**Pump 3**	**Total**
Annual Operating Hours	8,760	8,760	8,760	
Average Operating Power, MW	0.360	0.469	0.154	0.983
Baseline System Energy, kWh/yr	3,158	4,105	1,347	8,610

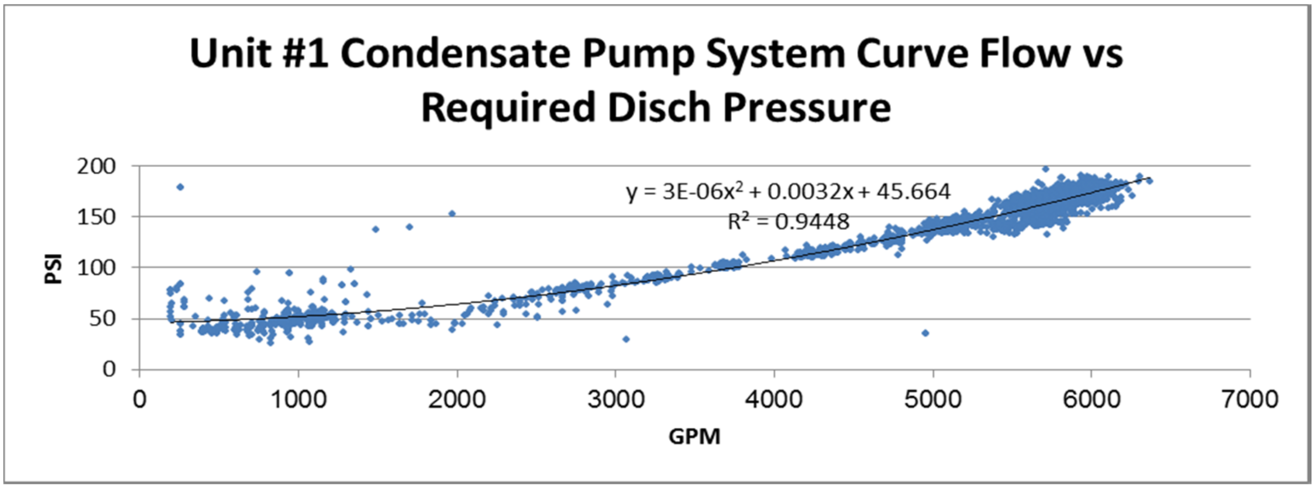
Energy Conservation Measure	**Pump 1**	**Pump 2**	**Pump 3**	**Total**
Average Operating Power, kW	0.148	0.186	0	0
ECM System Energy, kWh/yr	1,301	1,626	609	3,536
Energy Savings, kWh/yr	1,857	2,479	737	5,074

Condensate Pump Set-up

Estiate Power Calculations

Voltage	7220
Est. pf	0.89

System Curve from Short Term data



Coefficients for System curve	
C	45.66399235
X	3.21E-03
X2	3.02E-06

Average	32.3	42.1	13.7	0.706	0.900	0.295	1.901

Date/Time	Cond. Pump 1 P1 Amps	Cond. Pump 2 P2 Amps	Cond. Pump 3 P3 Amps	Cond. Pump 1 ON	Cond. Pump 2 ON	Cond. Pump 3 ON	Total Pumps ON
9/16/2010 0:00:00	47.7	48.3	-0.2	1	1	0	2
9/16/2010 0:59:54	47.6	48.2	-0.2	1	1	0	2
9/16/2010 1:59:48	47.4	48.1	-0.2	1	1	0	2
9/16/2010 2:59:42	47.5	48.1	-0.2	1	1	0	2
9/16/2010 3:59:36	47.5	48.1	-0.2	1	1	0	2
9/16/2010 4:59:30	47.5	48.0	-0.2	1	1	0	2
9/16/2010 5:59:24	46.6	47.3	-0.2	1	1	0	2
9/16/2010 6:59:18	46.7	47.1	-0.2	1	1	0	2
9/16/2010 7:59:12	47.4	47.9	-0.2	1	1	0	2
9/16/2010 8:59:06	47.6	48.1	-0.2	1	1	0	2
9/16/2010 9:59:00	47.5	48.1	-0.2	1	1	0	2
9/16/2010 10:58:54	47.5	48.0	-0.2	1	1	0	2
9/16/2010 11:58:48	47.4	48.0	-0.2	1	1	0	2
9/16/2010 12:58:42	47.4	48.0	-0.2	1	1	0	2
9/16/2010 13:58:36	47.6	48.2	-0.2	1	1	0	2
9/16/2010 14:58:30	47.6	48.2	-0.2	1	1	0	2
9/16/2010 15:58:24	47.5	48.0	-0.2	1	1	0	2
9/16/2010 16:58:18	47.6	48.1	-0.2	1	1	0	2
9/16/2010 17:58:12	47.5	48.0	-0.2	1	1	0	2
9/16/2010 18:58:06	47.7	48.2	-0.2	1	1	0	2
9/16/2010 19:58:00	47.5	48.0	-0.2	1	1	0	2
9/16/2010 20:57:54	47.7	48.2	-0.2	1	1	0	2
9/16/2010 21:57:48	47.6	48.1	-0.2	1	1	0	2
9/16/2010 22:57:42	47.7	48.2	-0.2	1	1	0	2
9/16/2010 23:57:36	47.6	48.2	-0.2	1	1	0	2
9/17/2010 0:57:30	47.6	48.0	-0.2	1	1	0	2
9/17/2010 1:57:24	47.6	48.0	-0.2	1	1	0	2
9/17/2010 2:57:18	47.5	48.1	-0.2	1	1	0	2
9/17/2010 3:57:12	47.6	48.2	-0.2	1	1	0	2

Average	0.98	0.92	360.5	468.6	153.8	982.9		72.8	12.2
Date/Time	Pump System ON	2 Pumps ON	Cond. Pump 1 kW	Cond. Pump 2 kW	Cond. Pump 3 kW	Total Pump kW	Pump kW per pump kW	CV 120 A % Open	CV 120 B % Open
9/16/2010 0:00:00	1	1	531.2	537.6	0.0	1068.9	534.4	99.8	40.5
9/16/2010 0:59:54	1	1	530.0	536.9	0.0	1066.9	533.4	99.8	44.4
9/16/2010 1:59:48	1	1	527.1	535.9	0.0	1063.0	531.5	99.8	41.0
9/16/2010 2:59:42	1	1	528.9	535.6	0.0	1064.5	532.2	99.9	35.3
9/16/2010 3:59:36	1	1	528.5	535.3	0.0	1063.8	531.9	99.1	35.6
9/16/2010 4:59:30	1	1	528.4	534.1	0.0	1062.6	531.3	99.9	37.1
9/16/2010 5:59:24	1	1	519.0	526.1	0.0	1045.1	522.6	88.8	21.9
9/16/2010 6:59:18	1	1	519.2	524.6	0.0	1043.8	521.9	89.6	23.5
9/16/2010 7:59:12	1	1	527.6	533.4	0.0	1061.0	530.5	95.9	30.0
9/16/2010 8:59:06	1	1	529.2	535.5	0.0	1064.7	532.4	97.8	31.7
9/16/2010 9:59:00	1	1	528.3	534.8	0.0	1063.2	531.6	99.9	37.6
9/16/2010 10:58:54	1	1	528.5	534.3	0.0	1062.8	531.4	99.9	59.5
9/16/2010 11:58:48	1	1	527.1	533.8	0.0	1060.9	530.5	99.9	39.3
9/16/2010 12:58:42	1	1	527.9	533.9	0.0	1061.8	530.9	99.6	55.2
9/16/2010 13:58:36	1	1	530.3	536.1	0.0	1066.4	533.2	99.6	53.2
9/16/2010 14:58:30	1	1	529.5	535.9	0.0	1065.4	532.7	99.7	42.2
9/16/2010 15:58:24	1	1	529.1	534.7	0.0	1063.8	531.9	99.6	41.7
9/16/2010 16:58:18	1	1	529.5	535.6	0.0	1065.1	532.6	99.6	38.9
9/16/2010 17:58:12	1	1	528.8	534.3	0.0	1063.1	531.6	99.6	42.8
9/16/2010 18:58:06	1	1	531.1	536.9	0.0	1068.0	534.0	99.7	54.4
9/16/2010 19:58:00	1	1	529.0	534.0	0.0	1063.1	531.5	99.6	35.1
9/16/2010 20:57:54	1	1	531.0	536.4	0.0	1067.3	533.7	99.1	49.1
9/16/2010 21:57:48	1	1	529.9	535.2	0.0	1065.1	532.5	99.7	35.8
9/16/2010 22:57:42	1	1	530.6	536.9	0.0	1067.6	533.8	99.6	38.8
9/16/2010 23:57:36	1	1	529.9	536.7	0.0	1066.6	533.3	99.6	42.7
9/17/2010 0:57:30	1	1	529.6	534.6	0.0	1064.1	532.1	99.8	34.9
9/17/2010 1:57:24	1	1	529.6	534.7	0.0	1064.2	532.1	99.0	40.6
9/17/2010 2:57:18	1	1	529.0	535.5	0.0	1064.5	532.3	99.8	34.0
9/17/2010 3:57:12	1	1	529.7	536.1	0.0	1065.7	532.9	99.9	43.9

Average	85.0	2127.7	4432.8	1646.8	2023.3	743.3	41.6	416.7	0.915	293.8	678.7

Date/Time	Total CV % Open	Flow Rate KLBH	Flow Rate GPM	Pump 1 Flow GPM	Pump 2 Flow GPM	Pump 3 Flow GPM	Deaerator Tank PSI DA Tank	Unit 1 MW	Unit 1 ON	Disch Press PSI	Disch Press feet head
9/16/2010 0:00:00	140.3	2,883.9	6,008.1	3,004.1	3,004.1	-	58.3	568.2	1	276.7	639.3
9/16/2010 0:59:54	144.2	2,918.0	6,079.2	3,039.6	3,039.6	-	58.6	565.4	1	276.3	638.1
9/16/2010 1:59:48	140.8	2,882.9	6,006.1	3,003.0	3,003.0	-	59.5	570.4	1	281.1	649.4
9/16/2010 2:59:42	135.2	2,886.8	6,014.1	3,007.1	3,007.1	-	58.7	560.7	1	277.1	640.0
9/16/2010 3:59:36	134.7	2,859.4	5,957.2	2,978.6	2,978.6	-	58.1	561.1	1	281.3	649.7
9/16/2010 4:59:30	137.0	2,875.4	5,990.4	2,995.2	2,995.2	-	58.0	565.7	1	278.5	643.4
9/16/2010 5:59:24	110.7	2,698.5	5,621.8	2,810.9	2,810.9	-	55.3	532.1	1	291.5	673.3
9/16/2010 6:59:18	113.1	2,667.4	5,557.2	2,778.6	2,778.6	-	53.7	532.1	1	291.2	672.6
9/16/2010 7:59:12	125.9	2,820.2	5,875.4	2,937.7	2,937.7	-	57.8	560.7	1	286.4	661.7
9/16/2010 8:59:06	129.5	2,830.3	5,896.5	2,948.2	2,948.2	-	58.0	562.9	1	283.2	654.3
9/16/2010 9:59:00	137.5	2,868.6	5,976.3	2,988.1	2,988.1	-	58.7	563.9	1	279.0	644.6
9/16/2010 10:58:54	159.4	2,950.0	6,145.9	3,073.0	3,073.0	-	58.7	561.1	1	271.1	626.3
9/16/2010 11:58:48	139.2	2,913.9	6,070.7	3,035.4	3,035.4	-	58.8	562.1	1	275.1	635.5
9/16/2010 12:58:42	154.8	2,949.6	6,145.1	3,072.5	3,072.5	-	58.2	562.1	1	275.0	635.3
9/16/2010 13:58:36	152.8	2,936.8	6,118.3	3,059.1	3,059.1	-	59.0	562.1	1	275.0	635.3
9/16/2010 14:58:30	141.9	2,899.4	6,040.3	3,020.2	3,020.2	-	58.7	564.3	1	274.9	635.0
9/16/2010 15:58:24	141.2	2,901.4	6,044.5	3,022.3	3,022.3	-	58.1	564.3	1	274.3	633.6
9/16/2010 16:58:18	138.6	2,890.0	6,020.8	3,010.4	3,010.4	-	58.0	562.1	1	278.3	642.9
9/16/2010 17:58:12	142.4	2,897.7	6,036.8	3,018.4	3,018.4	-	58.8	561.4	1	278.1	642.4
9/16/2010 18:58:06	154.1	2,976.0	6,200.0	3,100.0	3,100.0	-	58.2	556.8	1	274.2	633.4
9/16/2010 19:58:00	134.8	2,882.2	6,004.6	3,002.3	3,002.3	-	58.5	566.4	1	278.8	643.9
9/16/2010 20:57:54	148.1	2,942.9	6,131.0	3,065.5	3,065.5	-	58.5	565.4	1	274.6	634.3
9/16/2010 21:57:48	135.4	2,868.3	5,975.7	2,987.8	2,987.8	-	58.4	563.2	1	279.4	645.3
9/16/2010 22:57:42	138.4	2,871.1	5,981.5	2,990.8	2,990.8	-	57.7	557.9	1	279.4	645.3
9/16/2010 23:57:36	142.3	2,922.4	6,088.4	3,044.2	3,044.2	-	58.4	558.9	1	274.6	634.3
9/17/2010 0:57:30	134.7	2,886.1	6,012.7	3,006.4	3,006.4	-	57.2	552.8	1	278.8	643.9
9/17/2010 1:57:24	139.6	2,916.3	6,075.6	3,037.8	3,037.8	-	57.9	562.1	1	275.2	635.8
9/17/2010 2:57:18	133.8	2,881.3	6,002.8	3,001.4	3,001.4	-	58.2	563.2	1	279.3	645.1
9/17/2010 3:57:12	143.8	2,888.8	6,018.3	3,009.1	3,009.1	-	58.8	562.9	1	277.0	639.8

Average 126.0 291.1 167.8

Date/Time	Required Discharge Pressure PSI	Required Discharge Pressure FT	Press Drop PSI	Pump #1 VFD kW	Pump #2 VFD kW	Pump #3 VFD kW	Total Pump VFD kW	Pump #1 VFD Pump % Speed	Pump #2 VFD Pump % Speed	Pump #3 VFD Pump % Speed
9/16/2010 0:00:00	173.9	401.7	102.8	323.7	323.7	0.0	647.3	83%	83%	0%
9/16/2010 0:59:54	176.7	408.2	99.5	331.8	331.8	0.0	663.6	83%	83%	0%
9/16/2010 1:59:48	173.8	401.5	107.3	323.5	323.4	0.0	646.9	83%	83%	0%
9/16/2010 2:59:42	174.1	402.3	102.9	324.4	324.3	0.0	648.7	83%	83%	0%
9/16/2010 3:59:36	171.9	397.1	109.4	318.0	317.9	0.0	635.9	82%	82%	0%
9/16/2010 4:59:30	173.2	400.1	105.3	321.7	321.7	0.0	643.4	82%	82%	0%
9/16/2010 5:59:24	159.1	367.5	132.4	282.0	281.9	0.0	563.9	78%	78%	0%
9/16/2010 6:59:18	156.7	362.0	134.5	275.4	275.4	0.0	550.7	78%	78%	0%
9/16/2010 7:59:12	168.7	389.7	117.7	308.9	308.9	0.0	617.7	81%	81%	0%
9/16/2010 8:59:06	169.5	391.6	113.7	311.2	311.2	0.0	622.4	81%	81%	0%
9/16/2010 9:59:00	172.7	398.8	106.4	320.1	320.1	0.0	640.2	82%	82%	0%
9/16/2010 10:58:54	179.4	414.4	91.7	339.6	339.6	0.0	679.2	84%	84%	0%
9/16/2010 11:58:48	176.4	407.5	98.7	330.9	330.8	0.0	661.7	83%	83%	0%
9/16/2010 12:58:42	179.4	414.3	95.6	339.5	339.5	0.0	679.0	84%	84%	0%
9/16/2010 13:58:36	178.3	411.9	96.7	336.4	336.3	0.0	672.7	84%	84%	0%
9/16/2010 14:58:30	175.2	404.7	99.7	327.4	327.3	0.0	654.7	83%	83%	0%
9/16/2010 15:58:24	175.4	405.1	98.9	327.9	327.8	0.0	655.7	83%	83%	0%
9/16/2010 16:58:18	174.4	402.9	103.9	325.1	325.1	0.0	650.3	83%	83%	0%
9/16/2010 17:58:12	175.0	404.4	103.1	327.0	326.9	0.0	653.9	83%	83%	0%
9/16/2010 18:58:06	181.6	419.5	92.6	346.0	345.9	0.0	691.9	85%	85%	0%
9/16/2010 19:58:00	173.8	401.4	105.0	323.3	323.3	0.0	646.6	83%	83%	0%
9/16/2010 20:57:54	178.8	413.0	95.8	337.8	337.8	0.0	675.7	84%	84%	0%
9/16/2010 21:57:48	172.6	398.8	106.7	320.0	320.0	0.0	640.0	82%	82%	0%
9/16/2010 22:57:42	172.9	399.3	106.5	320.7	320.6	0.0	641.3	82%	82%	0%
9/16/2010 23:57:36	177.1	409.1	97.5	332.9	332.9	0.0	665.8	83%	83%	0%
9/17/2010 0:57:30	174.1	402.1	104.7	324.2	324.2	0.0	648.4	83%	83%	0%
9/17/2010 1:57:24	176.6	407.9	98.7	331.4	331.4	0.0	662.8	83%	83%	0%
9/17/2010 2:57:18	173.7	401.2	105.6	323.1	323.1	0.0	646.1	82%	82%	0%
9/17/2010 3:57:12	174.3	402.7	102.6	324.9	324.8	0.0	649.7	83%	83%	0%

Short Term data

Date/Time	Pump 11 amps	Pump 12 amps	Pump 13 amps	Unit #1 MW	Discharge Pressure	CV 120B % Open	CV 120 A % Open	DA Tank Pressure	Flow Rate KLBH	Measured CV Inlet Press psi (2)	Measured CV Outlet Press psi (3)
11/8/2011 12:52:48	45.3	-0.3	45.0	360.9	310.4	0.1	65.3	33.7	1765.8	282.8	88.8
11/8/2011 12:55:12	45.3	-0.3	45.1	362.1	310.4	0.1	65.3	33.7	1765.8	283.3	87.3
11/8/2011 12:57:36	45.3	-0.3	45.1	362.0	310.2	0.1	65.3	33.7	1801.0	283.9	87.9
11/8/2011 13:00:00	45.3	-0.3	45.1	362.0	310.2	0.1	65.3	33.7	1801.0	285.3	88.6
11/8/2011 13:02:24	45.3	-0.3	45.1	360.9	310.2	0.1	65.3	33.7	1761.8	285.3	88.6
11/8/2011 13:04:48	45.3	-0.3	45.1	360.9	310.2	0.1	65.3	33.5	1761.8	283.3	88.5
11/8/2011 13:07:12	45.3	-0.3	45.1	360.9	310.1	0.1	65.3	33.5	1761.8	282.6	89.3
11/8/2011 13:09:36	44.7	-0.3	45.1	360.9	310.1	0.1	65.3	33.5	1761.8	282.5	88.3
11/8/2011 13:12:00	45.5	-0.3	45.1	360.9	310.1	0.1	65.6	33.5	1800.8	283.6	87.8
11/8/2011 13:14:24	45.5	-0.3	45.1	359.8	310.1	0.1	65.6	33.5	1762.4	283.6	87.8
11/8/2011 13:16:48	45.5	-0.3	45.1	360.1	310.1	0.1	65.6	33.5	1762.4	283.2	88.2
11/8/2011 13:19:12	45.5	-0.3	45.1	360.1	310.1	0.1	65.6	33.5	1762.4	283.7	89.2
11/8/2011 13:21:36	45.5	-0.3	45.1	360.0	309.9	0.1	65.6	33.5	1798.6	281.5	89.7
11/8/2011 13:24:00	45.5	-0.3	45.1	361.2	310.0	0.1	65.6	33.5	1798.6	283.8	88.6
11/8/2011 13:26:24	45.5	-0.3	45.1	360.1	310.0	0.1	65.6	33.5	1798.6	283.8	88.6
11/8/2011 13:28:48	45.5	-0.3	45.1	360.1	310.0	0.1	65.6	33.5	1763.3	283.2	87.6
11/8/2011 13:31:12	45.5	-0.3	45.1	360.2	310.0	0.1	65.6	33.5	1763.3	283.1	87.5
11/8/2011 13:33:36	45.5	-0.3	45.1	360.4	310.0	0.1	65.6	33.5	1763.3	282.1	87.9
11/8/2011 13:36:00	45.5	-0.3	45.1	357.6	310.3	0.1	65.6	33.5	1763.3	282.0	89.8
11/8/2011 13:38:24	45.5	-0.3	45.1	359.7	310.3	0.1	65.6	33.5	1798.4	282.0	89.8
11/8/2011 13:40:48	45.5	-0.3	45.1	359.7	310.3	0.1	65.6	33.5	1798.4	284.9	87.7
11/8/2011 13:43:12	45.5	-0.3	45.1	360.9	310.3	0.1	65.6	33.5	1798.4	285.1	88.8
11/8/2011 13:45:36	45.5	-0.3	45.1	362.0	310.3	0.1	65.6	33.5	1762.4	285.4	88.4
11/8/2011 13:48:00	45.5	-0.3	45.1	362.0	310.3	0.1	65.6	33.5	1762.4	282.6	89.2
11/8/2011 13:50:24	45.5	-0.3	45.1	362.0	309.7	0.1	65.6	33.5	1798.2	282.6	89.2
11/8/2011 13:52:48	45.5	-0.3	45.1	360.9	309.8	0.1	65.6	33.5	1798.2	282.8	88.0
11/8/2011 13:55:12	45.5	-0.3	45.1	361.0	309.8	0.1	65.6	33.5	1798.2	284.0	87.9
11/8/2011 13:57:36	45.5	-0.3	45.1	360.9	309.8	0.1	65.6	33.5	1798.2	283.8	86.6

Short Term data

	4	5			
Date/Time	Calc CV Outlet Press psi	System ON	CV Press Drop	Calc. Required Disch Press psi	Flow GPM
11/8/2011 12:52:48	75.9	1.0	206.8	103.6	3678.7
11/8/2011 12:55:12	74.4	1.0	208.9	101.5	3678.7
11/8/2011 12:57:36	75.0	1.0	208.9	101.3	3752.1
11/8/2011 13:00:00	75.7	1.0	209.6	100.6	3752.1
11/8/2011 13:02:24	75.7	1.0	209.6	100.6	3670.4
11/8/2011 13:04:48	75.6	1.0	207.7	102.5	3670.4
11/8/2011 13:07:12	76.4	1.0	206.1	103.9	3670.4
11/8/2011 13:09:36	75.4	1.0	207.1	103.0	3670.4
11/8/2011 13:12:00	74.9	1.0	208.8	101.3	3751.7
11/8/2011 13:14:24	74.9	1.0	208.8	101.3	3671.6
11/8/2011 13:16:48	75.3	1.0	207.9	102.2	3671.6
11/8/2011 13:19:12	76.3	1.0	207.4	102.6	3671.6
11/8/2011 13:21:36	76.8	1.0	204.6	105.2	3747
11/8/2011 13:24:00	75.7	1.0	208.1	101.9	3747
11/8/2011 13:26:24	75.7	1.0	208.1	101.9	3747
11/8/2011 13:28:48	74.7	1.0	208.4	101.5	3673.5
11/8/2011 13:31:12	74.6	1.0	208.4	101.5	3673.5
11/8/2011 13:33:36	75.0	1.0	207.1	102.8	3673.5
11/8/2011 13:36:00	76.9	1.0	205.1	105.3	3673.5
11/8/2011 13:38:24	76.9	1.0	205.1	105.3	3746.6
11/8/2011 13:40:48	74.8	1.0	210.1	100.3	3746.6
11/8/2011 13:43:12	75.9	1.0	209.1	101.2	3746.6
11/8/2011 13:45:36	75.5	1.0	209.9	100.4	3671.7
11/8/2011 13:48:00	76.3	1.0	206.3	104.0	3671.7
11/8/2011 13:50:24	76.3	1.0	206.3	103.4	3746.3
11/8/2011 13:52:48	75.1	1.0	207.7	102.1	3746.3
11/8/2011 13:55:12	75.0	1.0	209.0	100.8	3746.3
11/8/2011 13:57:36	73.7	1.0	210.1	99.7	3746.3

Pump VFD Energy Savings Calculator

Macros must be enabled to properly use this tool.

Click here to go to help tab

PROJECT INFORMATION

Customer: Jim Bridger

Pump ID: Test Pump

This calculator can be used to calculate energy savings from controlling a pump with a VFD, replacing a pump, or trimming the impeller diameter

PUMP CURVE INFORMATION

Open or closed system	open
Liquid pumped:	water (Specific Gravity of 1.00)
Custom specific gravity:	

Motor hp:	700
efficiency if known:	(or leave blank if unknown)

	Design	Actual	
Speed:	1789	1780	rpm
Impeller Diameter:	10.00	10.00	(length)

This difference between actual and design conditions will result in a 0.995 correction factor for motor speed, and a 1 correction factor for impeller diameter.

Read off eleven (11) points from the baseline pump curve to fill in the following table:

	Flow (gpm)	Head (ft)	Select input: efficiency (%)	Power (hp)
1)	500	780.0	0.200	492.4
2)	1,000	760	0.370	518.7
3)	1,500	740	0.525	533.9
4)	2,000	710	0.650	551.7
5)	2,500	690	0.750	580.8
6)	3,000	675	0.805	635.2
7)	3,250	650	0.830	642.7
8)	3,500	615	0.840	647.1
9)	4,000	550	0.840	661.4
10)	4,500	470	0.815	655.3
11)	5,000	385	0.750	648.1

Note: errors will occur if this table is not completed accurately

Every pump has a unique operating curve at a given impeller diameter and speed. To accurately estimate performance, it is necessary to enter representative points on manufacturer's published curve and correct for speed and impeller diameter. Choose points to the right of the maximum head, or errors may occur. Three inputs are required at each of the 11 points: flow, head, and *either* power (hp) or efficiency (%).

☐ Check this box if a new pump with a different pump curve will be installed as part of this energy efficiency measure

SYSTEM CALIBRATION INFORMATION

1) Enter up to 5 system calibration points or binned operating points (inputs are tan)

	1		2	3	4	5	6	7	8	
	Hours (hrs/year)	at	Suction pressure** (ft)	Flow (leave blank if unknown) (gpm)	Operating Power (kW)	Baseline discharge pressure (psig)	Calculated flow from operating power (gpm)	Calculated flow from head (gpm)	Calculated flow after speed correction (gpm)	Where all three parameters are known, which would you describe as the least accurate?
1)	1,301	@	0.0	2,968	536.0	279.5	5,295	3,187	2,968	Power
2)	1,104	@	0.0	2,692	524.0	294.4	4,534	2,692	2,692	Power
3)	632	@	0.0	2,266	504.0	308.9	3,580	2,079	2,266	Power
4)	285	@	0.0	1,901	503.0	309.4	3,541	2,055	1,901	Power
5)	314	@	0.0	1,636	503.0	310	3,541	2050	1,636	Power

Total hours/yr: 3,636

**If pulling from a raised tank, enter the height of liquid as a POSITIVE number
** For well pumps - height above water level at given flowpoint; For circulation pumps, intake pressure at flowpoint

Speed Adjustment Ratio: 1.004

Enter available information in columns 1 through 5. Assuming the pump is operating on the manufacturer's curve, an operating point can be defined by only one of flow, power or pressure. If more than one parameter is known at one or more operating points, the tool will adjust the pump curve to pass as close as possible to the measured points.

Adjust pump curve

Reset speed adjustment ratio

2) Enter up to 5 upgrade operating points

	9		10	11	12		13	14
	Hours (hrs/year)	at	Upgrade suction pressure (ft)	Flow (gpm)	Upgrade discharge pressure (psig)	or	ΔP across baseline control valve (ft)	Calculated head for open loop system (ft)
1)	1,301	@	0.0	2,968	171.2	or		395.5
2)	1,104	@	0.0	2,692	150.6	or		347.9
3)	632	@	0.0	2,266	122.3	or		282.5
4)	285	@	0.0	1,901	101.5	or		234.5
5)	314	@	0.0	1,636	88.6	or		204.7

Total hours/yr: 3,636

Enter upgrade system information in columns 9-13. For each point, enter a number in column 12 *or* 13 but not both. Column 14 is for reference only, and shows the calculated pump head requirement.

For closed loop systems, the upgrade discharge pressure only needs to be entered for the first operating point. Other operating pressures are calculated from a quadratic system curve with no static

Check Errors

The flow you have entered/calculated is outside the bounds of the pump curve.
The head you have entered/calculated is within the bounds of the pump curve.
The power you have entered/calculated is within the bounds of the pump curve.
For accurate analysis, re-enter fan curve points that bound the operating points.

Quadratic Pump Curve Fits : Baseline Pump Curve

Pump #1

Curvefit		Head Vs. Flow
c	c	747.3128655
x	b	0.028350994
x2	a	-2.01754E-05

CFM	CFM^2	Pump Data Head	Curve Fit Head	Error	Abs Error
497	247491	772.17	756.42	-2.08%	2.08%
995	989964	752.37	755.55	0.42%	0.42%
1492	2227419	732.57	744.69	1.63%	1.63%
1990	3959855	702.87	723.84	2.90%	2.90%
2487	6187274	683.08	693.00	1.43%	1.43%
2985	8909674	668.23	652.18	-2.46%	2.46%
3234	10456493	643.48	628.03	-2.46%	2.46%
3482	12127057	608.83	601.37	-1.24%	1.24%
3980	15839421	544.48	540.58	-0.72%	0.72%
4477	20046767	465.28	469.80	0.96%	0.96%
4975	24749096	381.14	389.03	2.03%	2.03%

Curvefit		BHP Vs. Flow
c	c	432.8150067
x	b	0.083064452
x2	a	-7.79034E-06

CFM	CFM^2	Pump Data BHP	Curve Fit BHP	Error	Abs Error
497	247491	485.8	472.2	-2.87%	2.87%
995	989964	511.7	507.7	-0.78%	0.78%
1492	2227419	526.7	539.4	2.36%	2.36%
1990	3959855	544.2	567.3	4.06%	4.06%
2487	6187274	573.0	591.2	3.09%	3.09%
2985	8909674	626.6	611.3	-2.50%	2.50%
3234	10456493	634.0	620.0	-2.27%	2.27%
3482	12127057	638.3	627.6	-1.71%	1.71%
3980	15839421	652.4	640.0	-1.94%	1.94%
4477	20046767	646.5	648.6	0.32%	0.32%
4975	24749096	639.4	653.2	2.12%	2.12%

Curvefit		Efficiency Vs. Flow
c	c	-0.020573077
x	b	0.000459163
x2	a	-6.10748E-08

CFM	CFM^2	Pump Data Efficiency	Curve Fit Efficiency	Error	Abs Error
497	247491	20.0%	19.3%	-3.61%	3.61%
995	989964	36.9%	37.6%	1.70%	1.70%
1492	2227419	52.4%	52.9%	0.84%	0.84%
1990	3959855	64.9%	65.1%	0.35%	0.35%
2487	6187274	74.9%	74.4%	-0.70%	0.70%
2985	8909674	80.4%	80.6%	0.25%	0.25%
3234	10456493	82.9%	82.6%	-0.38%	0.38%
3482	12127057	83.9%	83.8%	-0.12%	0.12%
3980	15839421	83.9%	83.9%	0.09%	0.09%
4477	20046767	81.4%	81.1%	-0.35%	0.35%
4975	24749096	74.9%	75.2%	0.44%	0.44%

Quadratic Pump Curve Fits : Baseline Corrected Pump Curve

Pump #1

Curvefit		Head Vs. Flow
c	c	753.3679457
x	b	0.028465619
x2	a	-2.01754E-05

CFM	CFM^2	Pump Data Head	Curve Fit Head	Error	Abs Error
499	249496	778.43	762.55	-2.08%	2.08%
999	997985	758.47	761.67	0.42%	0.42%
1498	2245466	738.51	750.72	1.63%	1.63%
1998	3991940	708.57	729.70	2.90%	2.90%
2497	6237406	688.61	698.62	1.43%	1.43%
2997	8981865	673.64	657.47	-2.46%	2.46%
3247	10541216	648.69	633.12	-2.46%	2.46%
3496	12225316	613.76	606.25	-1.24%	1.24%
3996	15967760	548.89	544.96	-0.72%	0.72%
4495	20209196	469.05	473.61	0.96%	0.96%
4995	24949624	384.22	392.18	2.03%	2.03%

Curvefit		BHP Vs. Flow
c	c	438.0859538
x	b	0.08373748
x2	a	-7.82184E-06

CFM	CFM^2	Pump Data BHP	Curve Fit BHP	Error	Abs Error
499	249496	491.7	478.0	-2.87%	2.87%
999	997985	517.9	513.9	-0.78%	0.78%
1498	2245466	533.1	546.0	2.36%	2.36%
1998	3991940	550.8	574.2	4.06%	4.06%
2497	6237406	579.9	598.4	3.09%	3.09%
2997	8981865	634.3	618.8	-2.50%	2.50%
3247	10541216	641.8	627.5	-2.27%	2.27%
3496	12225316	646.1	635.2	-1.71%	1.71%
3996	15967760	660.4	647.8	-1.94%	1.94%
4495	20209196	654.3	656.5	0.32%	0.32%
4995	24949624	647.2	661.2	2.12%	2.12%

Curvefit		Efficiency Vs. Flow
c	c	-0.020573077
x	b	0.000457314
x2	a	-6.05839E-08

CFM	CFM^2	Pump Data Efficiency	Curve Fit Efficiency	Error	Abs Error
499	249496	20.0%	19.3%	-3.61%	3.61%
999	997985	36.9%	37.6%	1.70%	1.70%
1498	2245466	52.4%	52.9%	0.84%	0.84%
1998	3991940	64.9%	65.1%	0.35%	0.35%
2497	6237406	74.9%	74.4%	-0.70%	0.70%
2997	8981865	80.4%	80.6%	0.25%	0.25%
3247	10541216	82.9%	82.6%	-0.38%	0.38%
3496	12225316	83.9%	83.8%	-0.12%	0.12%
3996	15967760	83.9%	83.9%	0.09%	0.09%
4495	20209196	81.4%	81.1%	-0.35%	0.35%
4995	24949624	74.9%	75.2%	0.44%	0.44%

Quadratic Pump Curve Fits : Upgrade Pump Curve

Pump #1

Curvefit		Head Vs. Flow
c	c	753.3679457
x	b	0.028465619
x2	a	-2.01754E-05

CFM	CFM^2	Pump Data Head	Curve Fit Head	Error	Abs Error
499	249496	778.43	762.55	-2.08%	2.08%
999	997985	758.47	761.67	0.42%	0.42%
1498	2245466	738.51	750.72	1.63%	1.63%
1998	3991940	708.57	729.70	2.90%	2.90%
2497	6237406	688.61	698.62	1.43%	1.43%
2997	8981865	673.64	657.47	-2.46%	2.46%
3247	10541216	648.69	633.12	-2.46%	2.46%
3496	12225316	613.76	606.25	-1.24%	1.24%
3996	15967760	548.89	544.96	-0.72%	0.72%
4495	20209196	469.05	473.61	0.96%	0.96%
4995	24949624	384.22	392.18	2.03%	2.03%

Curvefit		BHP Vs. Flow
c	c	438.0859538
x	b	0.08373748
x2	a	-7.82184E-06

CFM	CFM^2	Pump Data BHP	Curve Fit BHP	Error	Abs Error
499	249496	491.7	478.0	-2.87%	2.87%
999	997985	517.9	513.9	-0.78%	0.78%
1498	2245466	533.1	546.0	2.36%	2.36%
1998	3991940	550.8	574.2	4.06%	4.06%
2497	6237406	579.9	598.4	3.09%	3.09%
2997	8981865	634.3	618.8	-2.50%	2.50%
3247	10541216	641.8	627.5	-2.27%	2.27%
3496	12225316	646.1	635.2	-1.71%	1.71%
3996	15967760	660.4	647.8	-1.94%	1.94%
4495	20209196	654.3	656.5	0.32%	0.32%
4995	24949624	647.2	661.2	2.12%	2.12%

Curvefit		Efficiency Vs. Flow
c	c	-0.020573077
x	b	0.000457314
x2	a	-6.05839E-08

CFM	CFM^2	Pump Data Efficiency	Curve Fit Efficiency	Error	Abs Error
499	249496	20.0%	19.3%	-3.61%	3.61%
999	997985	36.9%	37.6%	1.70%	1.70%
1498	2245466	52.4%	52.9%	0.84%	0.84%
1998	3991940	64.9%	65.1%	0.35%	0.35%
2497	6237406	74.9%	74.4%	-0.70%	0.70%
2997	8981865	80.4%	80.6%	0.25%	0.25%
3247	10541216	82.9%	82.6%	-0.38%	0.38%
3496	12225316	83.9%	83.8%	-0.12%	0.12%
3996	15967760	83.9%	83.9%	0.09%	0.09%
4495	20209196	81.4%	81.1%	-0.35%	0.35%
4995	24949624	74.9%	73.2%	0.44%	0.44%

This page can be used to set up a full analysis on logged data or control system data. Columns can be added or deleted as required. Grey column headers represent raw data inputs, but not all inputs are required and other inputs may need to be added.

Create sheet of charts from selected columns

Create sheet of images from selected columns

Detailed Pump VFD Analysis: Pump #1

Speed adjustment ratio (calculated on inputs page): 1.0

Baseline motor and operation Info		
Make		
Nameplate motor hp	700	hp
Nominal power	573.6	kW
Voltage	7200	V
Speed	1780	RPM
Full load current	52.5	A
Service factor	1.15	
Nominal efficiency	91%	
Annual duty cycle	100%	
operating hours	8760	hours/yr
minimum "on" amps	10	A

Pressure Requirements	
req. (ft)	*description*
0	water table
	height to scrubber
0	ft req'd pump head

Power Snapshots	
Logged Current (A)	Power (kW)

Current to power slope	#DIV/0!
Current to power intercept	#DIV/0!

Operating average: 3729

	Date	Pump Current (A)	Pump operating 1 - yes	Pump Power (kW)	Motor efficiency (%)	Pump Power (BHP)	Logged flow (gpm)	calculated flow from power (gpm)	Est'd Additional Lift (ft)	Measured Discharge Pressure (ft)
Min	9/16/2010 0:00	-0.3	0.0	0.0	0.9	491.9		414.3	0.0	-5.7
Ave	4/3/2011 15:07	32.3	0.7	360.5	0.9	622.1		3196.5	0.0	678.7
Max	10/20/2011 7:00	49.4	1.0	549.4	0.9	669.9		4822.2	0.0	879.0
		BASELINE POWER					Operating data			
	Set TRUE to make chart:	TRUE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
1	9/16/2010 0:00:00	47.7	1	531.2	91%	647.5	3,004.1	3881	0.0	639.3
2	9/16/2010 0:59:54	47.6	1	530.0	91%	646.0	3,039.6	3828	0.0	638.1
3	9/16/2010 1:59:48	47.4	1	527.1	91%	642.5	3,003.0	3709	0.0	649.4
4	9/16/2010 2:59:42	47.5	1	528.9	91%	644.6	3,007.1	3780	0.0	640.0
5	9/16/2010 3:59:36	47.5	1	528.5	91%	644.2	2,978.6	3766	0.0	649.7
6	9/16/2010 4:59:30	47.5	1	528.4	91%	644.0	2,995.2	3761	0.0	643.4
7	9/16/2010 5:59:24	46.6	1	519.0	91%	632.5	2,810.9	3404	0.0	673.3
8	9/16/2010 6:59:18	46.7	1	519.2	91%	632.7	2,778.6	3410	0.0	672.6
9	9/16/2010 7:59:12	47.4	1	527.6	91%	643.1	2,937.7	3729	0.0	661.7
10	9/16/2010 8:59:06	47.6	1	529.2	91%	645.1	2,948.2	3796	0.0	654.3
11	9/16/2010 9:59:00	47.5	1	528.3	91%	644.0	2,988.1	3758	0.0	644.6
12	9/16/2010 10:58:54	47.5	1	528.5	91%	644.2	3,073.0	3766	0.0	626.3
13	9/16/2010 11:58:48	47.4	1	527.1	91%	642.5	3,035.4	3709	0.0	635.5
14	9/16/2010 12:58:42	47.4	1	527.9	91%	643.4	3,072.5	3740	0.0	635.3
15	9/16/2010 13:58:36	47.6	1	530.3	91%	646.3	3,059.1	3839	0.0	635.3
16	9/16/2010 14:58:30	47.6	1	529.5	91%	645.4	3,020.2	3806	0.0	635.0
17	9/16/2010 15:58:24	47.5	1	529.1	91%	644.9	3,022.3	3790	0.0	633.6
18	9/16/2010 16:58:18	47.6	1	529.5	91%	645.4	3,010.4	3806	0.0	642.9
19	9/16/2010 17:58:12	47.5	1	528.8	91%	644.5	3,018.4	3777	0.0	642.4
20	9/16/2010 18:58:06	47.7	1	531.1	91%	647.3	3,100.0	3875	0.0	633.4
21	9/16/2010 19:58:00	47.5	1	529.0	91%	644.8	3,002.3	3788	0.0	643.9
22	9/16/2010 20:57:54	47.7	1	531.0	91%	647.2	3,065.5	3870	0.0	634.3
23	9/16/2010 21:57:48	47.6	1	529.9	91%	645.9	2,987.8	3825	0.0	645.3
24	9/16/2010 22:57:42	47.7	1	530.6	91%	646.8	2,990.8	3856	0.0	645.3
25	9/16/2010 23:57:36	47.6	1	529.9	91%	645.9	3,044.2	3825	0.0	634.3
26	9/17/2010 0:57:30	47.6	1	529.6	91%	645.4	3,006.4	3809	0.0	643.9

VFD affinity exponent:	2.7
VFD efficiency:	0.965

Upgrade motor and operation Info		
Make	0	
Nameplate motor hp	700	hp
Nominal power	549.5	kW
Voltage	7200	V
Speed	1780	RPM
Full load current	52.5	A
Service factor	1.15	
Nominal efficiency	95%	
Annual duty cycle	100%	
operating hours	8760	hours/yr
minimum "on" amps	10	A

Power Snapshots

Logged Current (A)	**Power (kW)**

Current to power slope	#DIV/0!
Current to power intercept	#DIV/0!

Baseline energy (kWh/yr):	3,157,748
Upgrade energy (kWh/yr):	1,300,555
Energy Savings (kWh/yr):	1,857,193
Percent savings:	59%

Operating average: 3127

Pump Head (ft)	calculated flow from head (gpm)	flow error	Hydraulic Efficiency (from head) (%)	Hydraulic Efficiency (from power) (%)	Pressure drop across control valve (ft)	Required head with VFD (ft)	Estimated VFD Speed (%)	Estimated EEM Power (bhp)	Hydraulic efficiency (%)	Estimated EEM Power (kW)	EEM Savings
-5.7	-3601.4	0.0	-1.6	0.2	-5.7	0.0	38%	3281%	-175%	0.0	0.0
678.7	2478.8	507.0	0.7	0.9	387.7	291.1	69%	24728%	80%	148.5	212.0
879.0	4362.0	4015.7	0.9	1.2	734.2	446.1	88%	44714%	257%	380.2	499.8
					VFD Calculations						
TRUE	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE
639.3	3266.2	614.6	81%	97%	237.5	401.7	83%	380.7	87%	323.7	207.5
638.1	3279.7	548.6	82%	95%	229.9	408.2	83%	390.3	87%	331.8	198.2
649.4	3139.1	570.0	80%	95%	247.9	401.5	83%	380.5	84%	323.5	203.7
640.0	3256.8	522.9	82%	95%	237.8	402.3	83%	381.5	87%	324.4	204.5
649.7	3135.4	630.8	80%	96%	252.6	397.1	82%	374.0	84%	318.0	210.6
643.4	3216.1	545.0	81%	95%	243.2	400.1	82%	378.4	86%	321.7	206.7
673.3	2799.2	604.6	75%	91%	305.8	367.5	78%	331.6	78%	282.0	237.1
672.6	2810.1	600.4	75%	92%	310.6	362.0	78%	323.8	79%	275.4	243.9
661.7	2972.1	757.4	77%	97%	271.9	389.7	81%	363.3	81%	308.9	218.8
654.3	3074.7	721.0	79%	97%	262.6	391.6	81%	366.0	83%	311.2	218.0
644.6	3201.2	557.2	81%	95%	245.7	398.8	82%	376.5	86%	320.1	208.2
626.3	3414.9	351.3	84%	92%	211.9	414.4	84%	399.4	89%	339.6	188.9
635.5	3311.4	397.7	83%	93%	228.0	407.5	83%	389.2	88%	330.9	196.3
635.3	3313.8	426.1	83%	93%	220.9	414.3	84%	399.3	87%	339.5	188.4
635.3	3313.0	526.2	82%	95%	223.5	411.9	84%	395.6	87%	336.4	193.9
635.0	3316.3	490.1	82%	95%	230.4	404.7	83%	385.1	88%	327.4	202.1
633.6	3333.5	457.0	83%	94%	228.5	405.1	83%	385.6	88%	327.9	201.3
642.9	3221.4	585.1	81%	96%	240.0	402.9	83%	382.4	86%	325.1	204.3
642.4	3227.5	549.4	81%	95%	238.1	404.4	83%	384.6	86%	327.0	201.8
633.4	3335.1	539.8	82%	96%	213.9	419.5	85%	407.0	87%	346.0	185.1
643.9	3209.1	578.6	81%	96%	242.5	401.4	83%	380.3	86%	323.3	205.7
634.3	3325.3	544.3	82%	96%	221.2	413.0	84%	397.4	87%	337.8	193.1
645.3	3191.4	634.0	81%	97%	246.6	398.8	82%	376.4	85%	320.0	209.9
645.3	3191.4	664.1	80%	97%	246.0	399.3	82%	377.2	85%	320.7	210.0
634.3	3324.5	500.9	82%	95%	225.2	409.1	83%	391.6	88%	332.9	197.0
643.9	3209.1	600.2	81%	96%	241.8	402.1	83%	381.3	85%	324.2	205.3

Curvefit		Head Vs. Flow
c	c	753.3679457
x	b	0.028465619
x2	a	-2.01754E-05

VFD Quadratic Solving

Target Flow GPM	Target Head ft	h2/Q2^2	"A" Coeff	"B" Coeff	"C" Coeff	sqrt(B2-4AC)	Orig Pump Flow- Root 1 GPM	Orig Pump Flow-Root 2 GPM	VFD Speed %	Max VFD Speed %	Full Speed Power BHP	VFD Power BHP
3004	401.73	0.00	0.00	0.03	753.37	0.44	-3200	3640	82.5%	83%	639.2	380.7
3040	408.25	0.00	0.00	0.03	753.37	0.44	-3207	3650	83.3%	83%	639.5	390.3
3003	401.55	0.00	0.00	0.03	753.37	0.44	-3199	3639	82.5%	83%	639.2	380.5
3007	402.28	0.00	0.00	0.03	753.37	0.44	-3200	3640	82.6%	83%	639.3	381.5
2979	397.10	0.00	0.00	0.03	753.37	0.44	-3194	3632	82.0%	82%	639.0	374.0
2995	400.12	0.00	0.00	0.03	753.37	0.44	-3198	3637	82.4%	82%	639.2	378.4
2811	367.54	0.00	0.00	0.03	753.37	0.45	-3154	3581	78.5%	78%	637.6	331.6
2779	362.02	0.00	0.00	0.03	753.37	0.45	-3146	3571	77.8%	78%	637.4	323.8
2938	389.75	0.00	0.00	0.03	753.37	0.44	-3185	3620	81.1%	81%	638.7	363.3
2948	391.63	0.00	0.00	0.03	753.37	0.44	-3187	3624	81.4%	81%	638.8	366.0
2988	398.83	0.00	0.00	0.03	753.37	0.44	-3196	3635	82.2%	82%	639.1	376.5
3073	414.43	0.00	0.00	0.03	753.37	0.44	-3214	3659	84.0%	84%	639.8	399.4
3035	407.47	0.00	0.00	0.03	753.37	0.44	-3206	3648	83.2%	83%	639.5	389.2
3073	414.35	0.00	0.00	0.03	753.37	0.44	-3214	3659	84.0%	84%	639.7	399.3
3059	411.86	0.00	0.00	0.03	753.37	0.44	-3211	3655	83.7%	84%	639.7	395.6
3020	404.68	0.00	0.00	0.03	753.37	0.44	-3203	3644	82.9%	83%	639.4	385.1
3022	405.06	0.00	0.00	0.03	753.37	0.44	-3204	3645	82.9%	83%	639.4	385.6
3010	402.89	0.00	0.00	0.03	753.37	0.44	-3201	3641	82.7%	83%	639.3	382.4
3018	404.35	0.00	0.00	0.03	753.37	0.44	-3203	3644	82.8%	83%	639.4	384.6
3100	419.48	0.00	0.00	0.03	753.37	0.44	-3220	3666	84.6%	85%	639.9	407.0
3002	401.41	0.00	0.00	0.03	753.37	0.44	-3199	3639	82.5%	83%	639.2	380.3
3065	413.04	0.00	0.00	0.03	753.37	0.44	-3213	3657	83.8%	84%	639.7	397.4
2988	398.78	0.00	0.00	0.03	753.37	0.44	-3196	3635	82.2%	82%	639.1	376.4
2991	399.31	0.00	0.00	0.03	753.37	0.44	-3197	3636	82.3%	82%	639.1	377.2
3044	409.10	0.00	0.00	0.03	753.37	0.44	-3208	3651	83.4%	83%	639.5	391.6
3006	402.15	0.00	0.00	0.03	753.37	0.44	-3200	3640	82.6%	83%	639.3	381.3

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Detailed Pump VFD Analysis: Pump #2

Speed adjustment ratio (calculated on inputs page):	1.0

Baseline motor and operation Info		
Make		
Nameplate motor hp	700	hp
Nominal power	573.6	kW
Voltage	7200	V
Speed	1780	RPM
Full load current	52.5	A
Service factor	1.15	
Nominal efficiency	91%	
Annual duty cycle	100%	
operating hours	8760	hours/yr
minimum "on" amps	10	A

Pressure Requirements	
req. (ft)	*description*
0	water table
	height to scrubber
0	ft req'd pump head

Power Snapshots	
Logged Current (A)	**Power (kW)**

Current to power slope	#DIV/0!
Current to power intercept	#DIV/0!

		BASELINE POWER					Operating data			
	Date	Pump Current (A)	Pump operating 1 - yes	Pump Power (kW)	Motor efficiency (%)	Pump Power (BHP)	Logged flow (gpm)	calculated flow from power (gpm)	Est'd Additional Lift (ft)	Measured Discharge Pressure (ft)
							Operating average:	3985		
Min	9/16/2010 0:00	-0.2	0.0	0.0	0.9	506.9		908.6	0.0	-5.7
Ave	4/3/2011 15:07	42.1	0.9	468.6	0.9	634.8		3534.0	0.0	678.7
Max	10/20/2011 7:00	49.7	1.0	553.3	0.9	674.6		5061.0	0.0	879.0
	Set TRUE to make chart:	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
1	9/16/2010 0:00:00	48.3	1	537.6	91%	655.4	3,004.1	4179	0.0	639.3
2	9/16/2010 0:59:54	48.2	1	536.9	91%	654.5	3,039.6	4142	0.0	638.1
3	9/16/2010 1:59:48	48.1	1	535.9	91%	653.2	3,003.0	4093	0.0	649.4
4	9/16/2010 2:59:42	48.1	1	535.6	91%	652.9	3,007.1	4081	0.0	640.0
5	9/16/2010 3:59:36	48.1	1	535.3	91%	652.5	2,978.6	4066	0.0	649.7
6	9/16/2010 4:59:30	48.0	1	534.1	91%	651.1	2,995.2	4012	0.0	643.4
7	9/16/2010 5:59:24	47.3	1	526.1	91%	641.1	2,810.9	3665	0.0	673.3
8	9/16/2010 6:59:18	47.1	1	524.6	91%	639.3	2,778.6	3608	0.0	672.6
9	9/16/2010 7:59:12	47.9	1	533.4	91%	650.2	2,937.7	3977	0.0	661.7
10	9/16/2010 8:59:06	48.1	1	535.5	91%	652.7	2,948.2	4075	0.0	654.3
11	9/16/2010 9:59:00	48.1	1	534.8	91%	652.0	2,988.1	4045	0.0	644.6
12	9/16/2010 10:58:54	48.0	1	534.3	91%	651.2	3,073.0	4018	0.0	626.3
13	9/16/2010 11:58:48	48.0	1	533.8	91%	650.6	3,035.4	3995	0.0	635.5
14	9/16/2010 12:58:42	48.0	1	533.9	91%	650.8	3,072.5	4000	0.0	635.3
15	9/16/2010 13:58:36	48.2	1	536.1	91%	653.5	3,059.1	4105	0.0	635.3
16	9/16/2010 14:58:30	48.2	1	535.9	91%	653.3	3,020.2	4096	0.0	635.0
17	9/16/2010 15:58:24	48.0	1	534.7	91%	651.7	3,022.3	4036	0.0	633.6
18	9/16/2010 16:58:18	48.1	1	535.6	91%	652.9	3,010.4	4081	0.0	642.9
19	9/16/2010 17:58:12	48.0	1	534.3	91%	651.3	3,018.4	4021	0.0	642.4
20	9/16/2010 18:58:06	48.2	1	536.9	91%	654.6	3,100.0	4145	0.0	633.4
21	9/16/2010 19:58:00	48.0	1	534.0	91%	650.9	3,002.3	4006	0.0	643.9
22	9/16/2010 20:57:54	48.2	1	536.4	91%	653.8	3,065.5	4117	0.0	634.3
23	9/16/2010 21:57:48	48.1	1	535.2	91%	652.3	2,987.8	4059	0.0	645.3
24	9/16/2010 22:57:42	48.2	1	536.9	91%	654.6	2,990.8	4145	0.0	645.3
25	9/16/2010 23:57:36	48.2	1	536.7	91%	654.2	3,044.2	4133	0.0	634.3

VFD affinity exponent:	2.7
VFD efficiency:	0.965

Upgrade motor and operation Info		
Make	0	
Nameplate motor hp	700	hp
Nominal power	549.5	kW
Voltage	7200	V
Speed	1780	RPM
Full load current	52.5	A
Service factor	1.15	
Nominal efficiency	95%	
Annual duty cycle	100%	
operating hours	8760	hours/yr
minimum "on" amps	10	A

Power Snapshots

Logged Current (A)	Power (kW)

Current to power slope	#DIV/0!
Current to power intercept	#DIV/0!

Baseline energy (kWh/yr):	4,105,163
Upgrade energy (kWh/yr):	1,625,930
Energy Savings (kWh/yr):	2,479,232
Percent savings:	60%

Operating average: 3127

-5.7	-3601.4	0.0	-1.6	0.4	-5.7	0.0	38%	3281%	-175%	0.0	0.0
678.7	2479.9	948.6	0.7	1.0	387.7	291.1	68%	24263%	84%	185.6	283.0
879.0	5039.8	4509.9	0.9	1.2	734.2	446.1	88%	44714%	374%	380.1	510.8

					VFD Calculations						
Pump Head (ft)	calculated flow from head (gpm)	flow error	Hydraulic Efficiency (from head) (%)	Hydraulic Efficiency (from power) (%)	Pressure drop across control valve (ft)	Required head with VFD (ft)	Estimated VFD Speed (%)	Estimated EEM Power (bhp)	Hydraulic efficiency (%)	Estimated EEM Power (kW)	EEM Savings
TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
639.3	3266.2	913.0	80%	103%	237.5	401.7	83%	380.7	87%	323.7	214.0
638.1	3279.7	862.0	81%	102%	229.9	408.2	83%	390.3	87%	331.8	205.1
649.4	3139.1	953.5	79%	103%	247.9	401.5	83%	380.5	84%	323.4	212.4
640.0	3256.8	824.1	81%	101%	237.8	402.3	83%	381.5	87%	324.3	211.3
649.7	3135.4	930.3	79%	102%	252.6	397.1	82%	374.0	84%	317.9	217.4
643.4	3216.1	796.1	80%	100%	243.2	400.1	82%	378.4	86%	321.7	212.5
673.3	2799.2	866.0	74%	97%	305.8	367.5	78%	331.6	78%	281.9	244.1
672.6	2810.1	797.9	75%	96%	310.6	362.0	78%	323.8	79%	275.4	249.2
661.7	2972.1	1005.0	76%	102%	271.9	389.7	81%	363.3	81%	308.9	224.5
654.3	3074.7	1000.0	78%	103%	262.6	391.6	81%	366.0	83%	311.2	224.3
644.6	3201.2	843.6	80%	101%	245.7	398.8	82%	376.5	86%	320.1	214.8
626.3	3414.9	603.0	83%	98%	211.9	414.4	84%	399.4	89%	339.6	194.7
635.5	3311.4	683.5	82%	99%	228.0	407.5	83%	389.2	88%	330.8	202.9
635.3	3313.8	686.6	82%	99%	220.9	414.3	84%	399.3	87%	339.5	194.4
635.3	3313.0	791.8	81%	101%	223.5	411.9	84%	395.6	87%	336.3	199.8
635.0	3316.3	779.4	81%	101%	230.4	404.7	83%	385.1	88%	327.3	208.6
633.6	3333.5	702.5	82%	99%	228.5	405.1	83%	385.6	88%	327.8	206.8
642.9	3221.4	859.5	80%	101%	240.0	402.9	83%	382.4	86%	325.1	210.5
642.4	3227.5	793.5	80%	100%	238.1	404.4	83%	384.6	86%	326.9	207.4
633.4	3335.1	809.9	82%	101%	213.9	419.5	85%	407.0	87%	345.9	191.0
643.9	3209.1	797.0	80%	100%	242.5	401.4	83%	380.3	86%	323.3	210.7
634.3	3325.3	791.7	81%	101%	221.2	413.0	84%	397.4	87%	337.8	198.6
645.3	3191.4	868.0	80%	101%	246.6	398.8	82%	376.4	85%	320.0	215.2
645.3	3191.4	953.5	79%	103%	246.0	399.3	82%	377.2	85%	320.6	216.3
634.3	3324.5	808.1	81%	101%	225.2	409.1	83%	391.6	88%	332.9	203.8

Curvefit		Head Vs. Flow
c	c	753.3679457
x	b	0.028465619
x2	a	-2.01754E-05

VFD Quadratic Solving

Target Flow GPM	Target Head ft	h2/Q2^2	"A" Coeff	"B" Coeff	"C" Coeff	sqrt(B2-4AC)	Orig Pump Flow- Root 1 GPM	Orig Pump Flow-Root 2 GPM	VFD Speed %	Max VFD Speed %	Full Speed Power BHP	VFD Power BHP
3004	401.73	0.00	0.00	0.03	753.37	0.44	-3200	3640	82.5%	83%	639.2	380.7
3040	408.25	0.00	0.00	0.03	753.37	0.44	-3207	3650	83.3%	83%	639.5	390.3
3003	401.55	0.00	0.00	0.03	753.37	0.44	-3199	3639	82.5%	83%	639.2	380.5
3007	402.28	0.00	0.00	0.03	753.37	0.44	-3200	3640	82.6%	83%	639.3	381.5
2979	397.10	0.00	0.00	0.03	753.37	0.44	-3194	3632	82.0%	82%	639.0	374.0
2995	400.12	0.00	0.00	0.03	753.37	0.44	-3198	3637	82.4%	82%	639.2	378.4
2811	367.54	0.00	0.00	0.03	753.37	0.45	-3154	3581	78.5%	78%	637.6	331.6
2779	362.02	0.00	0.00	0.03	753.37	0.45	-3146	3571	77.8%	78%	637.4	323.8
2938	389.75	0.00	0.00	0.03	753.37	0.44	-3185	3620	81.1%	81%	638.7	363.3
2948	391.63	0.00	0.00	0.03	753.37	0.44	-3187	3624	81.4%	81%	638.8	366.0
2988	398.83	0.00	0.00	0.03	753.37	0.44	-3196	3635	82.2%	82%	639.1	376.5
3073	414.43	0.00	0.00	0.03	753.37	0.44	-3214	3659	84.0%	84%	639.8	399.4
3035	407.47	0.00	0.00	0.03	753.37	0.44	-3206	3648	83.2%	83%	639.5	389.2
3073	414.35	0.00	0.00	0.03	753.37	0.44	-3214	3659	84.0%	84%	639.7	399.3
3059	411.86	0.00	0.00	0.03	753.37	0.44	-3211	3655	83.7%	84%	639.7	395.6
3020	404.68	0.00	0.00	0.03	753.37	0.44	-3203	3644	82.9%	83%	639.4	385.1
3022	405.06	0.00	0.00	0.03	753.37	0.44	-3204	3645	82.9%	83%	639.4	385.6
3010	402.89	0.00	0.00	0.03	753.37	0.44	-3201	3641	82.7%	83%	639.3	382.4
3018	404.35	0.00	0.00	0.03	753.37	0.44	-3203	3644	82.8%	83%	639.4	384.6
3100	419.48	0.00	0.00	0.03	753.37	0.44	-3220	3666	84.6%	85%	639.9	407.0
3002	401.41	0.00	0.00	0.03	753.37	0.44	-3199	3639	82.5%	83%	639.2	380.3
3065	413.04	0.00	0.00	0.03	753.37	0.44	-3213	3657	83.8%	84%	639.7	397.4
2988	398.78	0.00	0.00	0.03	753.37	0.44	-3196	3635	82.2%	82%	639.1	376.4
2991	399.31	0.00	0.00	0.03	753.37	0.44	-3197	3636	82.3%	82%	639.1	377.2
3044	409.10	0.00	0.00	0.03	753.37	0.44	-3208	3651	83.4%	83%	639.5	391.6

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Detailed Pump VFD Analysis: Pump #3

Speed adjustment ratio (calculated on inputs page):	1.0

Baseline motor and operation Info		
Make		
Nameplate motor hp	700	hp
Nominal power	573.6	kW
Voltage	7200	V
Speed	1780	RPM
Full load current	52.5	A
Service factor	1.15	
Nominal efficiency	91%	
Annual duty cycle	100%	
operating hours	8760	hours/yr
minimum "on" amps	10	A

Pressure Requirements	
req. (ft)	*description*
0	water table
	height to scrubber
0	ft req'd pump head

Power Snapshots	
Logged Current (A)	**Power (kW)**

Current to power slope	#DIV/0!
Current to power intercept	#DIV/0!

Operating average: #DIV/0!

	Date	Pump Current (A)	Pump operating 1 - yes	Pump Power (kW)	Motor efficiency (%)	Pump Power (BHP)	Logged flow (gpm)	calculated flow from power (gpm)	Est'd Additional Lift (ft)	Measured Discharge Pressure (ft)
Min	9/16/2010 0:00	-0.3	0.0	0.0	0.9	490.3		353.3	0.0	-5.7
Ave	4/3/2011 15:07	13.7	0.3	153.760	0.9	635.0		3561.1	0.0	678.7
Max	10/20/2011 7:00	49.1	1.0	546.1	0.9	665.8		4624.4	0.0	879.0
		BASELINE POWER					**Operating data**			
	Set TRUE to make chart:	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
	10/3/2010 15:17:36	45.3	1	503.9	91%	613.8	2,113.7	2940	0.0	714.9
	10/3/2010 16:17:30	45.2	1	503.6	91%	613.4	2,073.4	2931	0.0	714.5
	10/3/2010 17:17:24	45.1	1	502.0	91%	611.5	2,082.2	2889	0.0	716.3
	10/3/2010 18:17:18	45.3	1	504.5	91%	614.6	2,089.5	2957	0.0	716.5
	10/3/2010 19:17:12	45.2	1	502.7	91%	612.4	2,089.6	2909	0.0	714.8
	10/3/2010 20:17:06	45.0	1	500.3	91%	609.5	2,083.8	2847	0.0	716.7
	10/3/2010 21:17:00	45.2	1	502.6	91%	612.3	2,085.7	2906	0.0	716.4
	10/3/2010 22:16:54	45.2	1	502.7	91%	612.4	2,074.9	2907	0.0	716.5
	10/3/2010 23:16:48	45.1	1	502.3	91%	611.9	2,084.0	2898	0.0	714.9
	10/4/2010 0:16:42	45.3	1	503.9	91%	613.8	2,080.8	2940	0.0	716.7
	10/4/2010 1:16:36	45.2	1	502.6	91%	612.2	2,046.8	2904	0.0	716.1
	10/4/2010 2:16:30	45.3	1	504.0	91%	613.9	2,081.9	2941	0.0	714.9
	10/4/2010 3:16:24	45.0	1	500.5	91%	609.6	2,147.4	2850	0.0	716.3
	10/4/2010 4:16:18	45.2	1	503.3	91%	613.1	2,109.0	2923	0.0	716.3
	10/4/2010 5:16:12	45.1	1	502.0	91%	611.6	2,077.8	2891	0.0	714.8
	10/4/2010 6:16:06	45.1	1	502.2	91%	611.7	2,121.6	2894	0.0	714.8
	10/4/2010 7:16:00	45.2	1	502.9	91%	612.7	2,060.8	2914	0.0	714.8
	10/4/2010 8:15:54	45.4	1	505.4	91%	615.7	2,103.5	2981	0.0	716.4
	10/4/2010 9:15:48	45.4	1	504.8	91%	614.9	2,067.2	2964	0.0	714.8
	10/4/2010 10:15:42	45.2	1	503.2	91%	613.0	2,111.5	2921	0.0	714.8

VFD affinity exponent:	2.7
VFD efficiency:	0.965

Upgrade motor and operation Info		
Make	0	
Nameplate motor hp	700	hp
Nominal power	549.5	kW
Voltage	7200	V
Speed	1780	RPM
Full load current	52.5	A
Service factor	1.15	
Nominal efficiency	95%	
Annual duty cycle	100%	
operating hours	8760	hours/yr
minimum "on" amps	10	A

Power Snapshots

Logged Current (A)	Power (kW)

Current to power slope	#DIV/0!
Current to power intercept	#DIV/0!

Baseline energy (kWh/yr):	1,346,941
Upgrade energy (kWh/yr):	609,485
Energy Savings (kWh/yr):	737,456
Percent savings:	55%

Operating average:	#DIV/0!

Pump Head (ft)	calculated flow from head (gpm)	flow error	Hydraulic Efficiency (from head) (%)	Hydraulic Efficiency (from power) (%)	Pressure drop across control valve (ft)	Required head with VFD (ft)	Estimated VFD Speed (%)	Estimated EEM Power (bhp)	Hydraulic efficiency (%)	Estimated EEM Power (kW)	Unit #1 Load MW
-5.7	-3601.4	0.0	-1.6	0.2	-5.7	0.0	37%	3158%	-175%	0.0	0.0
678.7	2527.6	305.0	0.7	1.0	387.7	291.1	73%	27731%	76%	69.6	416.7
879.0	3833.0	3954.7	0.8	1.1	734.2	446.1	86%	42583%	99%	361.9	576.1
					VFD Calculations						
TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE
714.9	2050.9	888.7	60%	86%	453.5	261.4	64%	191.9	71%	163.2	398.9
714.5	2059.6	871.4	61%	86%	458.3	256.1	64%	185.5	72%	157.8	401.7
716.3	2023.1	866.1	60%	85%	459.0	257.3	64%	186.9	70%	159.0	399.6
716.5	2018.7	937.9	59%	87%	458.2	258.3	64%	188.0	70%	159.9	399.9
714.8	2053.8	855.4	61%	86%	456.5	258.3	64%	188.0	71%	160.0	399.9
716.7	2014.2	832.8	60%	85%	459.2	257.5	64%	187.1	70%	159.2	401.7
716.4	2020.1	885.9	60%	86%	458.6	257.8	64%	187.4	70%	159.4	399.6
716.5	2017.2	890.3	60%	86%	460.2	256.3	64%	185.7	70%	158.0	400.7
714.9	2050.9	846.7	61%	85%	457.4	257.5	64%	187.1	71%	159.2	399.6
716.7	2014.2	925.3	59%	87%	459.6	257.1	64%	186.6	70%	158.8	401.7
716.1	2026.0	878.2	60%	86%	463.4	252.7	63%	181.3	71%	154.3	395.7
714.9	2050.9	890.5	60%	86%	457.7	257.3	64%	186.8	71%	158.9	398.5
716.3	2021.6	828.5	60%	85%	450.4	266.0	65%	197.4	69%	167.9	401.3
716.3	2021.6	901.1	60%	86%	455.5	260.8	64%	191.1	70%	162.6	398.5
714.8	2052.3	838.6	61%	85%	458.1	256.7	64%	186.2	71%	158.4	399.6
714.8	2052.3	841.7	61%	85%	452.3	262.5	65%	193.2	70%	164.3	398.9
714.8	2053.8	860.4	61%	86%	460.3	254.5	63%	183.5	72%	156.1	401.4
716.4	2020.1	960.7	59%	88%	456.3	260.1	64%	190.2	70%	161.8	399.2
714.8	2052.3	911.2	60%	87%	459.5	255.3	64%	184.5	72%	156.9	399.2
714.8	2053.8	867.2	60%	86%	453.6	261.2	64%	191.5	71%	162.9	399.2

Curvefit		Head Vs. Flow
c	c	753.3679457
x	b	0.028465619
x2	a	-2.01754E-05

VFD Quadratic Solving

Target Flow	Target Head	h2/Q2^2	"A" Coeff	"B" Coeff	"C" Coeff	sqrt(B2-4AC)	Orig Pump Flow- Root 1	Orig Pump Flow-Root 2	VFD Speed	Max VFD Speed	Full Speed Power	VFD Power
GPM	ft						GPM	GPM	%	%	BHP	BHP
2114	261.45	0.00	0.00	0.03	753.37	0.49	-2919	3280	64.4%	64%	628.6	191.9
2073	256.14	0.00	0.00	0.03	753.37	0.49	-2900	3257	63.7%	64%	627.8	185.5
2082	257.29	0.00	0.00	0.03	753.37	0.49	-2904	3262	63.8%	64%	628.0	186.9
2090	258.25	0.00	0.00	0.03	753.37	0.49	-2908	3266	64.0%	64%	628.2	188.0
2090	258.26	0.00	0.00	0.03	753.37	0.49	-2908	3266	64.0%	64%	628.2	188.0
2084	257.50	0.00	0.00	0.03	753.37	0.49	-2905	3263	63.9%	64%	628.0	187.1
2086	257.75	0.00	0.00	0.03	753.37	0.49	-2906	3264	63.9%	64%	628.1	187.4
2075	256.33	0.00	0.00	0.03	753.37	0.49	-2901	3258	63.7%	64%	627.9	185.7
2084	257.53	0.00	0.00	0.03	753.37	0.49	-2905	3263	63.9%	64%	628.0	187.1
2081	257.11	0.00	0.00	0.03	753.37	0.49	-2904	3261	63.8%	64%	628.0	186.6
2047	252.69	0.00	0.00	0.03	753.37	0.49	-2888	3241	63.1%	63%	627.3	181.3
2082	257.25	0.00	0.00	0.03	753.37	0.49	-2904	3262	63.8%	64%	628.0	186.8
2147	265.95	0.00	0.00	0.03	753.37	0.49	-2933	3299	65.1%	65%	629.2	197.4
2109	260.83	0.00	0.00	0.03	753.37	0.49	-2916	3278	64.3%	64%	628.5	191.1
2078	256.71	0.00	0.00	0.03	753.37	0.49	-2902	3260	63.7%	64%	627.9	186.2
2122	262.50	0.00	0.00	0.03	753.37	0.49	-2922	3285	64.6%	65%	628.7	193.2
2061	254.50	0.00	0.00	0.03	753.37	0.49	-2894	3250	63.4%	63%	627.6	183.5
2104	260.09	0.00	0.00	0.03	753.37	0.49	-2914	3274	64.2%	64%	628.4	190.2
2067	255.33	0.00	0.00	0.03	753.37	0.49	-2897	3253	63.5%	64%	627.7	184.5
2112	261.15	0.00	0.00	0.03	753.37	0.49	-2918	3279	64.4%	64%	628.6	191.5

ECM 6- Turbine Room Fan and Mixer Bank

Baseline

14 fans, run in pairs; each fan run by a 20 hp motor; 460 V
All fans run all the time
Assume .90 Power Factor and 90% efficiency on motor

Baseline		
20 HP = 14.9kW		
14.9kW/.90/.90=	18.4	kW
Annual Operating Hours =	8,760	
Total Annual Energy Use=	2,255,970	kWh

EEM

Assume A-Line fans operating correctly, louvers and controls
working to provide air to 1st Floor, Mezzanine, and Turbine Floor
Assume full-speed heating for 3 months a year
Assume full speed cooling for 5 months a year
Assume partial fan speed for 4 months per year averaging 75% full speed

Assume 3% VFD parasitic load
Assume 95% effciency on new fan motor and power factor of 1
Assume a factor of 2.7 on the cubic law power reduction for reduced speed operations

ECM	
Power consumption for full speed operation, kW	279.3
Annual power consumtion for full speed operations, kWh	1,608,726
Power consumption for partial speed operations, kW	128.4
Annual power consumtion for reduced speed operations, kWh	385,340
Total annual power consumption, kWh	1,994,066
Total annual energy savings, kWh	261,905
Demand savings, kW	(22)

ECM 7

ECM 7: RO Supply Pumps				
Baseline	**Condition 1**	**Condition 2**	**Condition 3**	**Total**
Annual Operating Hours	876	10,512	6,132	
Average Operating Power, MW	0.033	0.033	0.033	
Baseline System Energy, MWh/yr	29	343	200	572

Energy Conservation Measure	**Pump 1**	**Pump 2**	**Pump 3**	**Total**
Average Operating Power, MW	0.034	0.028	0.020	
ECM System Energy, MWh/yr	29	295	124	448
Energy Savings, MWh/yr	(1)	49	77	124

3 Units
50 HP
480 V
2 run 95%
3 run 5%
Target line pressure 100 psi
noted discharge pressure 120 psi
Recir valve open 18-24 pct with 2 RO systems running

Power measurements

		V	A	kW	pf
Two Pump	#02	478	47.3	32.1	0.819
Operation	#03	478.8	52.2	35.5	0.819

		V	A	kW	pf
Three Pump	#02	478	47.3	32.1	0.819
Operation	#03	478.8	52.2	35.5	0.819

When 2 RO system run 588 gpm are needed

When 3 RO systems run 882 gpm is needed

Pump VFD Energy Savings Calculator

Macros must be enabled to properly use this tool.

Click here to go to help tab

CascadeEnergy

PROJECT INFORMATION

Customer: Jim Bridger

Pump ID: RO Supply Pump

This calculator can be used to calculate energy savings from controlling a pump with a VFD, replacing a pump, or trimming the impeller diameter

PUMP CURVE INFORMATION

Open or closed system	open
Liquid pumped:	water (Specific Gravity of 1.00)
Custom specific gravity:	

Motor hp:	50
efficiency if known:	94.1% (or leave blank if unknown)

	Design	Actual	
Speed:	3555	3555	rpm
Impeller Diameter:	8.69	8.69	(length)

This difference between actual and design conditions will result in a 1 correction factor for motor speed, and a 1 correction factor for impeller diameter.

Read off eleven (11) points from the baseline pump curve to fill in the following table:

	Flow (gpm)	Head (ft)	Select input: efficiency (%)	Power (hp)
1)	100	312.0	0.320	24.6
2)	200	305	0.522	29.5
3)	300	295	0.664	33.7
4)	350	290	0.720	35.6
5)	400	282	0.800	35.6
6)	450	275	0.820	38.1
7)	500	265	0.830	40.3
8)	550	255	0.770	46.0
9)	600	242	0.740	49.5
10)	650	225	0.720	51.3
11)	700	213	350.000	10.8

Note: errors will occur if this table is not completed accurately

Every pump has a unique operating curve at a given impeller diameter and speed. To accurately estimate performance, it is necessary to enter representative points on manufacturer's published curve and correct for speed and impeller diameter. Choose points to the right of the maximum head, or errors may occur. Three inputs are required at each of the 11 points: flow, head, and *either* power (hp) or efficiency (%).

☐ Check this box if a new pump with a different pump curve will be installed as part of this energy efficiency measure

SYSTEM OPERATION INFORMATION

1) Enter baseline system information (inputs are tan)

# RO		1: Hours (hrs/year)	at	2: Suction pressure** (ft)	3: Flow (leave blank if unknown) (gpm)	4: Operating Power (kW)	5: Baseline discharge pressure (psig)	6: Calculated flow from operating power (gpm)	7: Calculated flow from head (gpm)	8: Calculated flow after speed correction (gpm)
3	1)	876	@	12.0			122.0		481	481
2	2)	10,512	@	12.0			125.0		441	441
1	3)	6,132	@	12.0			125.0		441	441
	4)		@							
	5)		@							
	Total hours/yr:	17,520								

**If pulling from a raised tank, enter the height of liquid as a POSITIVE number
** For well pumps - height above water level at given flowpoint; For circulation pumps, intake pressure at flowpoint

Speed Adjustment Ratio: 1.000

Enter available information in columns 1 through 5. Assuming the pump is operating on the manufacturer's curve, an operating point can be defined by only one of flow, power or pressure. If more than one parameter is known at one or more operating points, the tool will adjust the pump curve to pass as close as possible to the measured points.

NOTE: The operating conditions below are based on needed flows of 596 gpm for 2 systems and 339 gpm for one system

Adjust pump curve

Reset speed adjustment ratio

2) Enter upgrade system information

	9: Hours (hrs/year)	at	10: Upgrade suction pressure (ft)	11: Flow (gpm)	12: Upgrade discharge pressure (psig)	or	13: ΔP across baseline control valve (ft)	14: Calculated head for open loop system (ft)
1)	876	@	12.0	481	122.0	or		269.8
2)	10,512	@	12.0	298	125.0	or		276.8
3)	6,132	@	12.0	170	125.0	or		276.8
4)		@				or		
5)		@				or		
Total hours/yr:	17,520							

Enter upgrade system information in columns 9-13. For each point, enter a number in column 12 *or* 13 but not both. Column 14 is for reference only, and shows the calculated pump head requirement.

For closed loop systems, the upgrade discharge pressure only needs to be entered for the first operating point. Other operating pressures are calculated from a quadratic system curve with no static

Check Errors

The flow you have entered/calculated is within the bounds of the pump curve.
The head you have entered/calculated is within the bounds of the pump curve.
The power you have entered/calculated is within the bounds of the pump curve.
Click the button to the right or click on the next tab to calculate energy savings

Adjust pump curve and go to output tab

Calculations and Results - VFD control - RO Supply Pump

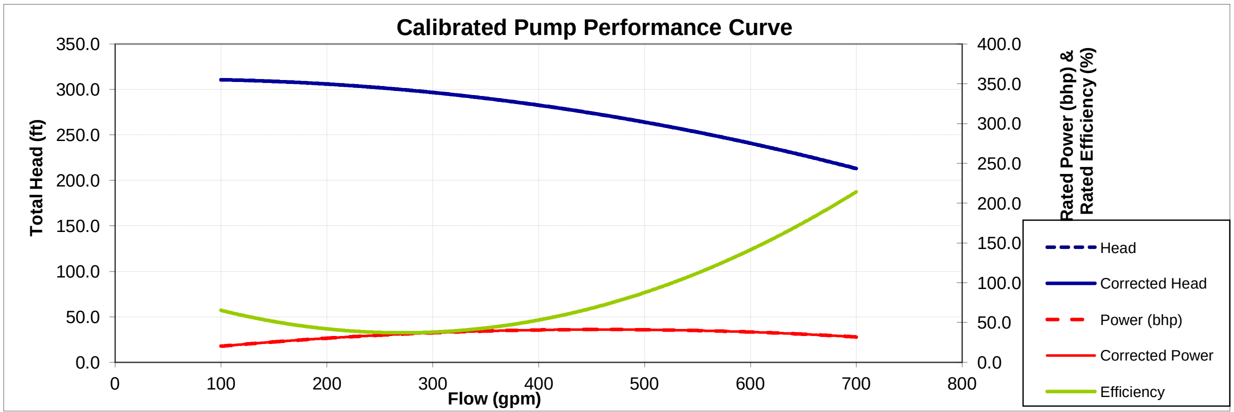
CascadeEnergy

CALCULATION ASSUMPTIONS AND METHOD

1) The baseline pump motor efficiency is 94.1%.
2) The efficiency of the VFD is 97%.
3) A pump speed reduction results in:
   1) a reduction in flow directly proportional to the speed reduction
   2) a reduction in head proportional to the speed reduction squared
   3) a reduction in power proportional to the speed reduction to the 2.7[th] power
4) The liquid pumped is water and the specific gravity is 1
5) The speed of the pump is adjusted by a 1.000 multiplier to account for discrepancies between the operating points and the pump curve
6) The difference between actual and design conditions for the baseline pump results in a 1 correction factor for motor speed, and a 1 correction factor for impeller diameter. Affinity laws are used to calculate the effect on the system curve.

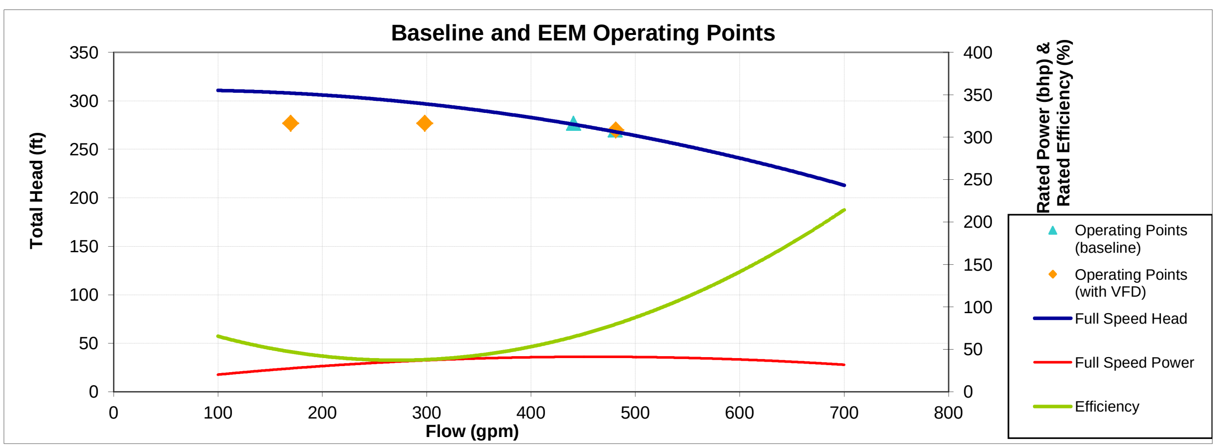
BASELINE ENERGY USE CALCULATIONS (Existing System)

	Operating Hours (hours/yr)	Flowrate (gpm)	Pump head (ft)	Hydraulic Efficiency (%)	Shaft Power (bhp)	Electric Power (kW)	Annual Energy Use (kWh/yr)
1)	876	481	269.8	80%	41.2	32.6	28,589
2)	10,512	441	276.8	75%	41.2	32.6	343,171
3)	6,132	441	276.8	75%	41.2	32.6	200,183
4)							
5)							
						Total Annual Energy Use (kWh/yr):	571,943



EEM ENERGY USE CALCULATIONS (With VFD)

	Operating Hours (hours/yr)	Flowrate (gpm)	Pump Head (ft)	Hydraulic Efficiency (%)	VFD Speed (%)	Shaft Power (bhp)	Electric Power (kW)	Annual Energy Use (kWh/yr)
1)	876	481	269.8	80%	100%	41.2	33.6	29,473
2)	10,512	298	276.8	61%	97%	34.3	28.0	294,580
3)	6,132	170	276.8	48%	95%	24.7	20.1	123,503
4)								
5)								
							Total Annual Energy Use (kWh/yr):	447,556



SUMMARY OF RESULTS

Baseline energy use:	**571,943**	kWh/yr	**Annual energy savings:**	**124,387**	kWh/yr
Upgrade energy use:	**447,556**	kWh/yr	**Percent savings:**	**22%**	

Quadratic Pump Curve Fits : Baseline Pump Curve

Curvefit		Head Vs. Flow
c	c	310.7375647
x	b	0.022693309
x2	a	-0.000231854

125

309.9515173

CFM	CFM^2	Pump Data Head	Curve Fit Head	Error	Abs Error
100	10000	312.00	310.69	-0.42%	0.42%
200	40000	305.00	306.00	0.33%	0.33%
300	90000	295.00	296.68	0.57%	0.57%
350	122500	290.00	290.28	0.10%	0.10%
400	160000	282.00	282.72	0.25%	0.25%
450	202500	275.00	274.00	-0.37%	0.37%
500	250000	265.00	264.12	-0.33%	0.33%
550	302500	255.00	253.08	-0.76%	0.76%
600	360000	242.00	240.89	-0.46%	0.46%
650	422500	225.00	227.53	1.11%	1.11%
700	490000	213.00	213.01	0.01%	0.01%

Curvefit		BHP Vs. Flow
c	c	6.887828783
x	b	0.149520966
x2	a	-0.000162634

CFM	CFM^2	Pump Data BHP	Curve Fit BHP	Error	Abs Error
100	10000	24.6	20.2	-21.81%	21.81%
200	40000	29.5	30.3	2.57%	2.57%
300	90000	33.7	37.1	9.30%	9.30%
350	122500	35.6	39.3	9.41%	9.41%
400	160000	35.6	40.7	12.46%	12.46%
450	202500	38.1	41.2	7.59%	7.59%
500	250000	40.3	41.0	1.65%	1.65%
550	302500	46.0	39.9	-15.20%	15.20%
600	360000	49.5	38.1	-30.22%	30.22%
650	422500	51.3	35.4	-45.05%	45.05%
700	490000	10.8	31.9	66.24%	66.24%

Curvefit		Efficiency Vs. Flow
c	c	1.080059571
x	b	-0.005226524
x2	a	9.63782E-06

CFM	CFM^2	Pump Data Efficiency	Curve Fit Efficiency	Error	Abs Error
100	10000	32.0%	65.4%	51.05%	51.05%
200	40000	52.2%	42.0%	-24.21%	24.21%
300	90000	66.4%	38.0%	-74.96%	74.96%
350	122500	72.0%	43.1%	-66.89%	66.89%
400	160000	80.0%	53.2%	-50.52%	50.52%
450	202500	82.0%	68.0%	-20.63%	20.63%
500	250000	83.0%	87.6%	5.28%	5.28%
550	302500	77.0%	112.1%	31.31%	31.31%
600	360000	74.0%	141.4%	47.66%	47.66%
650	422500	72.0%	175.5%	58.97%	58.97%
700	490000	350.0%	214.4%	-63.24%	63.24%

Quadratic Pump Curve Fits : Baseline Corrected Pump Curve

Curvefit		Head Vs. Flow
c	c	310.7375647
x	b	0.022693309
x2	a	-0.000231854

CFM	CFM^2	Pump Data Head	Curve Fit Head	Error	Abs Error
100	10000	312.00	310.69	-0.42%	0.42%
200	40000	305.00	306.00	0.33%	0.33%
300	90000	295.00	296.68	0.57%	0.57%
350	122500	290.00	290.28	0.10%	0.10%
400	160000	282.00	282.72	0.25%	0.25%
450	202500	275.00	274.00	-0.37%	0.37%
500	250000	265.00	264.12	-0.33%	0.33%
550	302500	255.00	253.08	-0.76%	0.76%
600	360000	242.00	240.89	-0.46%	0.46%
650	422500	225.00	227.53	1.11%	1.11%
700	490000	213.00	213.01	0.01%	0.01%

Curvefit		BHP Vs. Flow
c	c	6.887828783
x	b	0.149520966
x2	a	-0.000162634

CFM	CFM^2	Pump Data BHP	Curve Fit BHP	Error	Abs Error
100	10000	24.6	20.2	-21.81%	21.81%
200	40000	29.5	30.3	2.57%	2.57%
300	90000	33.7	37.1	9.30%	9.30%
350	122500	35.6	39.3	9.41%	9.41%
400	160000	35.6	40.7	12.46%	12.46%
450	202500	38.1	41.2	7.59%	7.59%
500	250000	40.3	41.0	1.65%	1.65%
550	302500	46.0	39.9	-15.20%	15.20%
600	360000	49.5	38.1	-30.22%	30.22%
650	422500	51.3	35.4	-45.05%	45.05%
700	490000	10.8	31.9	66.24%	66.24%

Curvefit		Efficiency Vs. Flow
c	c	1.080059571
x	b	-0.005226524
x2	a	9.63782E-06

CFM	CFM^2	Pump Data Efficiency	Curve Fit Efficiency	Error	Abs Error
100	10000	32.0%	65.4%	51.05%	51.05%
200	40000	52.2%	42.0%	-24.21%	24.21%
300	90000	66.4%	38.0%	-74.96%	74.96%
350	122500	72.0%	43.1%	-66.89%	66.89%
400	160000	80.0%	53.2%	-50.52%	50.52%
450	202500	82.0%	68.0%	-20.63%	20.63%
500	250000	83.0%	87.6%	5.28%	5.28%
550	302500	77.0%	112.1%	31.31%	31.31%
600	360000	74.0%	141.4%	47.66%	47.66%
650	422500	72.0%	175.5%	58.97%	58.97%
700	490000	350.0%	214.4%	-63.24%	63.24%

Quadratic Pump Curve Fits : Upgrade Pump Curve

Curvefit		Head Vs. Flow
c	c	310.7375647
x	b	0.022693309
x2	a	-0.000231854

CFM	CFM^2	Pump Data Head	Curve Fit Head	Error	Abs Error
100	10000	312.00	310.69	-0.42%	0.42%
200	40000	305.00	306.00	0.33%	0.33%
300	90000	295.00	296.68	0.57%	0.57%
350	122500	290.00	290.28	0.10%	0.10%
400	160000	282.00	282.72	0.25%	0.25%
450	202500	275.00	274.00	-0.37%	0.37%
500	250000	265.00	264.12	-0.33%	0.33%
550	302500	255.00	253.08	-0.76%	0.76%
600	360000	242.00	240.89	-0.46%	0.46%
650	422500	225.00	227.53	1.11%	1.11%
700	490000	213.00	213.01	0.01%	0.01%

Curvefit		BHP Vs. Flow
c	c	6.887828783
x	b	0.149520966
x2	a	-0.000162634

CFM	CFM^2	Pump Data BHP	Curve Fit BHP	Error	Abs Error
100	10000	24.6	20.2	-21.81%	21.81%
200	40000	29.5	30.3	2.57%	2.57%
300	90000	33.7	37.1	9.30%	9.30%
350	122500	35.6	39.3	9.41%	9.41%
400	160000	35.6	40.7	12.46%	12.46%
450	202500	38.1	41.2	7.59%	7.59%
500	250000	40.3	41.0	1.65%	1.65%
550	302500	46.0	39.9	-15.20%	15.20%
600	360000	49.5	38.1	-30.22%	30.22%
650	422500	51.3	35.4	-45.05%	45.05%
700	490000	10.8	31.9	66.24%	66.24%

Curvefit		Efficiency Vs. Flow
c	c	1.080059571
x	b	-0.005226524
x2	a	9.63782E-06

CFM	CFM^2	Pump Data Efficiency	Curve Fit Efficiency	Error	Abs Error
100	10000	32.0%	65.4%	51.05%	51.05%
200	40000	52.2%	42.0%	-24.21%	24.21%
300	90000	66.4%	38.0%	-74.96%	74.96%
350	122500	72.0%	43.1%	-66.89%	66.89%
400	160000	80.0%	53.2%	-50.52%	50.52%
450	202500	82.0%	68.0%	-20.63%	20.63%
500	250000	83.0%	87.6%	5.28%	5.28%
550	302500	77.0%	112.1%	31.31%	31.31%
600	360000	74.0%	141.4%	47.66%	47.66%
650	422500	72.0%	175.5%	58.97%	58.97%
700	490000	350.0%	214.4%	-63.24%	63.24%

ECM 8- Primary Air Fans

Primary Air Fans
Jim Bridger

Summary of Curve Fit Coefficients				
	Static Head	Fan Efficiency	BHP	Q/N vs. H/N^2
C	47.0129311	0.387995498	474.7240355	3.15862E-05
X1	0.023568676	0.003051218	4.232319276	1.93186E-05
X2	0.000233667	2.85126E-06	0.024113869	0.000233667
X3	-1.3916E-06	-3.03849E-08	-5.6302E-05	-0.001697757

Inputs Denoted by Blue Font and Gray Backround

Original Curve		Adjusted Curve		
RPM	1190	RPM	1220	Rpm
Impeller	45	Impeller	45	Inches
Density	0.6500	Density	0.6500	Lb/ft^3
Temperature	70	Temperature	70	Degrees F
Inlet Rel. P.	-1	Inlet Rel. P.	-1	Inches H2O
Inlet Abs. P	11.5	Inlet Abs. P	11.5	psig

Elevation	6700
P atm	11.5

Primary Air Fans						
Original Curve				Adjusted Curve		
Flow CFM (x1000)	Static Pressure Inches H2O	Fan Power BHP	Fan Efficiency	Flow CFM (x1000)	Static Pressure Inches H2O	Calculated Power (BHP)
50	46.3	700	0.520	51.3	48.7	754.3
100	48.0	1000	0.754	102.5	50.5	1077.6
150	48.5	1400	0.817	153.8	51.0	1508.6
200	47.0	1750	0.844	205.0	49.4	1885.7
225	45.5	1900	0.847	230.7	47.8	2047.4
250	43.0	2050	0.824	256.3	45.2	2209.0
275	39.5	2100	0.813	281.9	41.5	2262.9
300	34.5	2250	0.723	307.6	36.3	2424.5
325	26.8	2300	0.595	333.2	28.2	2478.4
350	20.5	2350	0.480	358.8	21.5	2532.2
400	0.1	2200	0.003	410.1	0.1	2370.6

ECM 8- Primary Air Fans

The following is a sample of the logged data and calculations made from that data. Only a few samples of the logged data are shown for ease of reading:

Bridger PA Fans				
Average	58.44	58.34	112.88	125.36
Max	89.09	89.34	129.66	140.89
Min	29.70	30.12	84.34	95.34
	Fan 11 Louver % Open	Fan 12 Louver % Open	Fan 11 Amps	Fan 12 Amps
Date/Time	1FZ69A-ZT.UNIT1@ONE	1FZ69B-ZT.UNIT1@ONE	1M118-IT.UNIT1@ONE	1M218-IT.UNIT1@ONE
5/24/2011 12:00:05.0 AM	45.732	45.351	101.978	116.26
5/24/2011 1:02:28.9 AM	46.03	46.411	101.84	116.962
5/24/2011 2:04:52.8 AM	45.473	45.48	101.718	115.771
5/24/2011 3:07:16.7 AM	45.351	45.351	102.206	117.038
5/24/2011 4:09:40.6 AM	46.564	46.465	102.328	117.542
5/24/2011 5:12:04.5 AM	45.488	45.595	102.252	115.894
5/24/2011 6:14:28.4 AM	45.869	45.503	101.993	115.97
5/24/2011 7:16:52.3 AM	45.877	45.732	101.581	116.855
5/24/2011 8:19:16.2 AM	51.805	51.408	108.661	122.958
5/24/2011 9:21:40.1 AM	52.11	51.866	108.203	121.722
5/24/2011 10:24:04.0 AM	51.904	51.523	107.837	121.265
5/24/2011 11:26:27.9 AM	52.507	52.209	108.752	123.676
5/24/2011 12:28:51.8 PM	52.538	52.896	109.241	122.058

Baseline				**VFD EEM**	
227	226	1270	1540	1124	1122
312	312	1641	1938	1836	1841
108	110	812	959	531	539
Fan 11 Flow	Fan 12 Flow	Fan 11 Power	Fan 12 Power	Fan 11 Power	Fan 12 Power
1000 CFM	1000 CFM	kW	kW	kW	kW
180	178	1064	1334	838	830
181	183	1062	1349	844	852
179	179	1060	1324	833	833
178	178	1068	1351	830	830
183	183	1070	1361	856	854
179	179	1069	1327	833	835
181	179	1064	1328	841	833
181	180	1058	1347	841	838
204	202	1183	1481	969	961
205	204	1175	1453	976	971
204	203	1168	1443	972	963
207	205	1185	1498	985	978
207	208	1194	1461	986	994

The following are data used to calculate the fan power for both the baseline and ECM cases:

BASELINE						
kW vs. Measured Amps						
Degrees Closed	% Vanes Open	Measured Amps	Calculated HP	Calculated kW	Assume 90% motor Efficiency	Calculated Value Check
80	11.1	36	690	572	kW vs Amps	579
60	33.3	89	1120	928	Coefficients	870
50	44.4	110	1360	1,127	842.7843986	1209
40	55.6	117	1630	1,351	-12.50772817	1350
23	74.4	126	1830	1,516	0.143945731	1552
20	77.8	128	2000	1,657		1600
10	89.0	134	2125	1,761		1751

Flow vs Percent Vane Open					
				Flow vs Vane % Open	
Vane Open %	Vane Closed %	Static Pressure In H20	Calc Flow 1000 CFM	Coefficients	Calculated Values Check
				-57.14907267	
80	20	31.2	290	6.289194507	292
63	37	31.2	246	-0.024132948	243
60	40	31.2	234		233
40	60	31.2	155		156
27	73	31.2	90		95
20	80	31.2	63		59

ECM					
Performance Curves From Fan Model				Assume 95% motor efficiency	
Speed RPM	Flow 1000 CFM	Static Pressure In H20	Calc Power BHP	Calc Power kW	Power w/ 3% VFD use (kW)
970	50	31.2	418.6	329	338
969	100	31.2	619.5	486	501
968	150	31.2	861.3	676	696
1000	200	31.2	1170.3	919	946
1017	225	31.2	1363.2	1070	1102
1060	250	31.2	1583.6	1243	1280
1121	275	31.2	1830.3	1437	1480
1165	300	31.2	2123.4	1667	1717
1220	325	31.2	2453.5	1926	1984

Power vs. Flow Coefficients		Calculated Value Check		
180.9218553		338		
3.249347287		502		
-0.003762462		696		
3.33118E-05		947		
		1101		
		1279		
		1483		
		1717		
		1983		

PA Fan 1 & 2	
Fan Max Flow at 100% flow, (1000 CFM)	312
Fan Vane min Degrees Closed	37
Fan Min Flow Recorded, (1000 CFM)	108
Fan Vane Min Degree Closed	73
Discharge pressure over all vane positions averages 31.2 " H20 within expected error.	

The following is the summary of the calculation results from the data above:

PA Fan Baseline	
PA Fan 11 & 12 Average Power, kW	1,405.0
PA Fan 11 &12 Average Flow, 1000 CFM	227
Annual Operating Hours	8,577
PA Fan 1 & 2 Annual Energy Consumption, MWh	24,101
PA Fan 1 & 2 Peak Monthly Demand, MW	3.58

VFD EEM

PA Fan 11 & 12 Average Power, kW	1,123.0
PA Fan 11 &12 Average Flow, 1000 CFM	227
Annual Operating Hours	8,577
PA Fan 1 & 2 Annual Energy Consumption, MWh	19,263
PA Fan 1 & 2 Peak Monthly Demand, kW	3.68
Annual Energy Savings, mWh	4,837
Annual Demand Savings, mW	-0.099

ECM 9- Forced Draft Fans

The following is a sample of the logged data and calculations made from that data. Only a few samples of the logged data are shown for ease of reading:

Bridger FD Fans					
Average	115.21	120.51	44.39	44.44	62.62
Max	169.82	170.08	76.63	72.39	104.37
Min	81.03	81.97	11.03	12.92	29.48
	Fan 11 Amps	Fan 12 Amps	Fan 11 Louver % Open	Fan 12 Louver % Open	Fan 11 % Flow
Date/Time	1M116-IT.UNIT1@ONE	1M216-IT.UNIT1@ONE	1FZ89A-ZT.UNIT1@ONE	1FZ89B-ZT.UNIT1@ONE	1FT-89AXS.UNIT1@ONE
1/29/2011 6:00:00.0 PM	90.106	91.632	25.652	25.88	37.989
1/29/2011 7:00:00.0 PM	92.181	93.188	27.345	27.437	38.699
1/29/2011 8:00:00.0 PM	93.005	95.233	27.361	27.452	39.712
1/29/2011 9:00:00.0 PM	92.776	94.76	27.177	27.315	40.571
1/29/2011 10:00:00.0 PM	93.021	93.906	27.155	27.17	39.777
1/29/2011 11:00:00.0 PM	93.448	93.86	27.086	27.086	40.015
1/30/2011 12:00:00.0 AM	93.661	94.44	27.078	27.078	39.03
1/30/2011 1:00:00.0 AM	93.066	94.287	27.048	27.071	39.191
1/30/2011 2:00:00.0 AM	93.661	94.135	27.055	27.071	38.134
1/30/2011 3:00:00.0 AM	93.219	94.409	27.025	27.055	38.504
1/30/2011 4:00:00.0 AM	93.112	93.936	27.017	27.048	38.837
1/30/2011 5:00:00.0 AM	92.975	94.44	27.01	27.04	38.341
1/30/2011 6:00:00.0 AM	92.303	94.775	27.04	27.048	37.69

		Baseline				**VFD Model**	
60.53	436.73	482	466	1187	1256	1129	1097
109.26	575.76	804	841	1895	1899	2025	2167
13.19	0.01	227	102	744	756	635	441
				Fan 11	Fan 12	Fan11 VFD	Fan 12 VFD
Fan 12 % Flow	Inut 1 MW Production	Fan 11 Flow	Fan 12 Flow	Calculated Power	Calculated Power	Calculated Power	Calculated Power
1FT-89BXS.UNIT1@ONE	1MWSEL.UNIT1@ONE	(1000 CFM)	(1000 CFM)	kW	kW	kW	kW
38.577	0.716	293	297	861.9	881.7	743.8	751.5
37.829	0.716	298	291	888.8	901.9	753.1	741.7
37.491	0.716	306	289	899.5	928.4	766.6	737.2
39.208	0.716	312	302	896.5	922.2	778.1	759.9
39.475	0.716	306	304	899.7	911.2	767.5	763.4
38.924	0.716	308	300	905.2	910.6	770.6	756.1
37.695	0.716	301	290	908.0	918.1	757.5	739.9
38.405	0.716	302	296	900.3	916.1	759.7	749.3
35.989	0.716	294	277	908.0	914.1	745.7	717.7
36.322	0.716	296	280	902.3	917.7	750.6	722.0
36.736	0.716	299	283	900.9	911.6	755.0	727.4
36.256	0.716	295	279	899.1	918.1	748.4	721.1
36.412	1.79	290	280	890.4	922.4	739.9	723.2

The following are data used to calculate the fan power for both the baseline and ECM cases:

FD Fan 1 & 2	
Fan Max Flow at 100% flow, (1000 CFM)	770
Fan Vane Max Degrees Closed	17
Fan Min Flow Recorded, (1000 CFM)	130
Fan Vane Min Degree Closed	80

Discharge pressure over all vane positions averages 16 " H20 within expected error.

Baseline

kW vs. Measured Amps

Degrees Closed	% Vanes Open	Measured Amps	Calculated kW		Assume 90% motor Effici	Calculated Value Check
80	11.1	81	646.273333	slope	12.97	743.8355077
60	33.3	96.5	1010.83778	int	-306.3621461	944.7992563
50	44.4	113.73	1226.26222			1168.193152
40	55.6	137.5	1458.25778			1476.380785
23	74.4	152.7	1739.96667			1673.454912
20	77.8	170	1822.82222			1897.756387

ECM

Performance Curves From Fan Model

Speed RPM	Flow 1000 CFM	Static Pressure In H20	Calc Power BHP	Calc Power kW	Power w/ 3% VFD use (kW)	Power vs. Flow Coefficients	Calculated Value
630	100	16	542.3	426	438	287.2997378	439
617	200	16	733.3	576	593	1.526343292	592
612	300	16	935.2	734	756	-0.000269034	757
612	400	16	1161.4	912	939	1.31926E-06	939
615	500	16	1418.7	1114	1147		1148
615	520	16	1478.3	1160	1195		1194
645	600	16	1721.9	1352	1392		1391
670	700	16	2071.8	1626	1675		1676
708	800	16	2488.7	1953	2012		2012

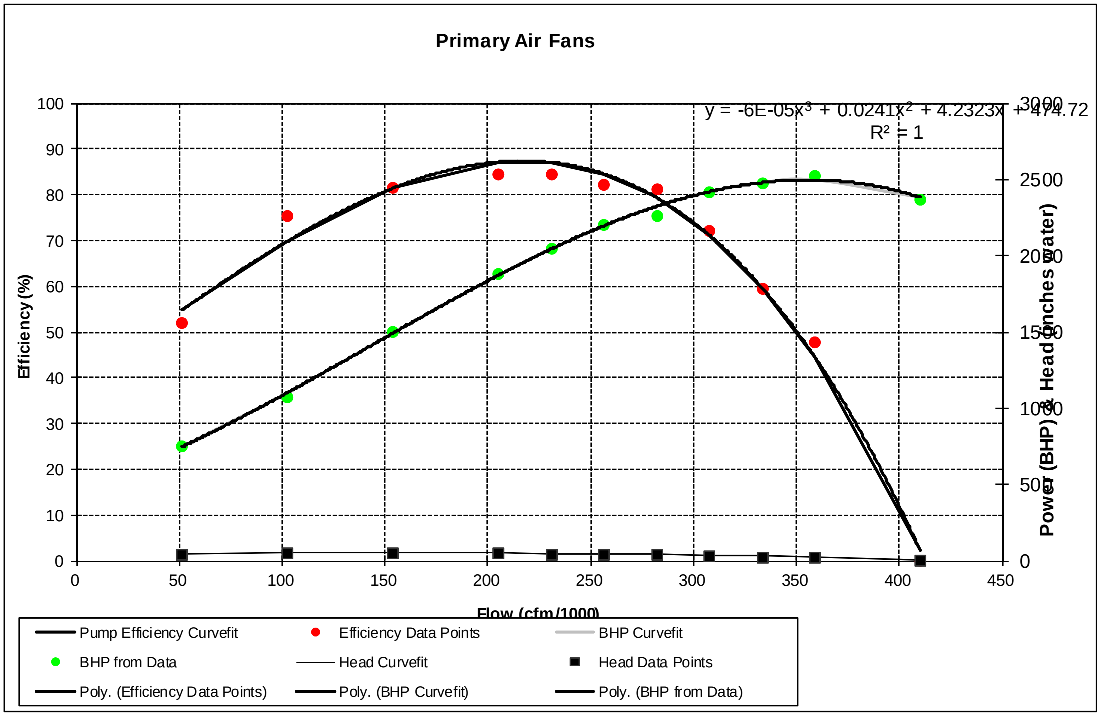
The following is the summary of the calculation results from the data above:

FD Fan Baseline

FD Fan 11 & 12 Average Power, kW	1,221.8
FD Fan 11 &12 Average Flow, 1000 CFM	474
Annual Operating Hours	8,577
FD Fan 1 & 2 Annual Energy Consumption, MWh	20,958
FD Fan 1 & 2 Peak Monthly Demand,MW	3.79

VFD ECM

FD Fan 11 & 12 Average Power, kW	1,113.0
FD Fan 11 &12 Average Flow, 1000 CFM	474
Annual Operating Hours	8,577
FD Fan 1 & 2 Annual Energy Consumption, MWh	19,093
FD Fan 1 & 2 Peak Monthly Demand, MW	4.19
Annual Energy Savings, MWh	1,865.50
Annual Demand Savings, mW	-0.397



Primary Air Fans
y = -6E-05x³ + 0.0241x² + 4.2323x + 474.72
R² = 1
Efficiency (%)
Power (BHP) & Head (inches water)
Flow (cfm/1000)
Pump Efficiency Curvefit
Efficiency Data Points
BHP Curvefit
BHP from Data
Head Curvefit
Head Data Points
Poly. (Efficiency Data Points)
Poly. (BHP Curvefit)
Poly. (BHP from Data)

Curve Fit Arrays and Calculations - Primary Air Fans

Curvefit	BHP vs. Discharge
c	474.7240355
x	4.232319276
x2	0.024113869
x3	-5.63019E-05

	Curve Fit Array		Curve Fit Power	Calculated Power	
GPM	GPM^2	GPM^3	BHP	BHP	Error
51	2.628E+03	1.347E+05	747.45	754.29	-0.91%
103	1.051E+04	1.078E+06	1101.41	1077.55	2.17%
154	2.365E+04	3.637E+06	1491.08	1508.57	-1.17%
205	4.204E+04	8.620E+06	1870.98	1885.72	-0.79%
231	5.321E+04	1.227E+07	2043.04	2047.35	-0.21%
256	6.569E+04	1.684E+07	2195.60	2208.98	-0.61%
282	7.949E+04	2.241E+07	2322.96	2262.86	2.59%
308	9.460E+04	2.909E+07	2419.44	2424.49	-0.21%
333	1.110E+05	3.699E+07	2479.34	2478.37	0.04%
359	1.288E+05	4.620E+07	2496.99	2532.25	-1.41%
410	1.682E+05	6.896E+07	2382.76	2370.62	0.51%

Curvefit	Q/N vs. H/N^2
c	3.15862E-05
x	1.93186E-05
x2	0.000233667
x3	-0.001697757

Pump Speed					
	Curve Fit Array		Curve Fit	Calculated	
Q/N	(Q/N)^2	(Q/N)^3	H/N^2	H/N^2	Error
0.04	0.00	0.00	3.268E-05	3.270E-05	-0.03%
0.08	0.01	0.00	3.385E-05	3.390E-05	-0.13%
0.13	0.02	0.00	3.433E-05	3.425E-05	0.25%
0.17	0.03	0.00	3.337E-05	3.319E-05	0.55%
0.19	0.04	0.01	3.212E-05	3.213E-05	-0.04%
0.21	0.04	0.01	3.022E-05	3.037E-05	-0.49%
0.23	0.05	0.01	2.758E-05	2.789E-05	-1.15%
0.25	0.06	0.02	2.411E-05	2.436E-05	-1.07%
0.27	0.07	0.02	1.971E-05	1.893E-05	3.96%
0.29	0.09	0.03	1.429E-05	1.448E-05	-1.33%
0.34	0.11	0.04	2.643E-09	7.062E-08	########

Curvefit	Head vs. Flow
c	47.0129311
x	0.023568676
x2	0.000233667
x3	0.00

	Curve Fit Array		Curve Fit PUMP	Data PUMP	
GPM	GPM^2	GPM^3	Head	Head	Error
51	2.628E+03	1.347E+05	48.65	48.66	-0.03%
103	1.051E+04	1.078E+06	50.39	50.45	-0.13%
154	2.365E+04	3.637E+06	51.10	50.98	0.25%
205	4.204E+04	8.620E+06	49.67	49.40	0.55%
231	5.321E+04	1.227E+07	47.80	47.82	-0.04%
256	6.569E+04	1.684E+07	44.97	45.20	-0.49%
282	7.949E+04	2.241E+07	41.05	41.52	-1.15%
308	9.460E+04	2.909E+07	35.88	36.26	-1.07%
333	1.110E+05	3.699E+07	29.33	28.17	3.96%
359	1.288E+05	4.620E+07	21.26	21.55	-1.33%
410	1.682E+05	6.896E+07	0.00	0.11	-2571.59%

Curvefit	Pump Eff. vs. Flow
c	0.387995498
x	0.003051218
x2	2.85126E-06
x3	-3.03849E-08

	Curve Fit Array		Curve Fit PUMP	Data PUMP	
GPM	GPM^2	GPM^3	EFF.	EFF.	Error
51	2.628E+03	1.347E+05	0.548	0.52	5.11%
103	1.051E+04	1.078E+06	0.698	0.75	-8.09%
154	2.365E+04	3.637E+06	0.814	0.82	-0.33%
205	4.204E+04	8.620E+06	0.872	0.84	3.13%
231	5.321E+04	1.227E+07	0.871	0.85	2.72%
256	6.569E+04	1.684E+07	0.846	0.82	2.54%
282	7.949E+04	2.241E+07	0.794	0.81	-2.41%
308	9.460E+04	2.909E+07	0.712	0.72	-1.53%
333	1.110E+05	3.699E+07	0.597	0.60	0.33%
359	1.288E+05	4.620E+07	0.446	0.48	-7.56%
410	1.682E+05	6.896E+07	0.023	0.00	87.73%

Curvefit	Flow vs. BHP
c	-158.740721
x	0.419613236
x2	-0.000228131
x3	5.74122E-08

	Curve Fit Array		Curve Fit PUMP	Data PUMP	
BHP	BHP^2	BHP^3	Flow	Flow	Error
747.5	5.587E+05	4.176E+08	51.42	51.26	0.31%
1101.4	1.213E+06	1.336E+09	103.39	102.52	0.84%
1491.1	2.223E+06	3.315E+09	150.06	153.78	-2.48%
1871.0	3.501E+06	6.550E+09	203.78	205.04	-0.62%
2043.0	4.174E+06	8.528E+09	235.92	230.67	2.22%
2195.6	4.821E+06	1.058E+10	270.48	256.30	5.24%
2323.0	5.396E+06	1.254E+10	304.64	281.93	7.45%
2419.4	5.854E+06	1.416E+10	334.19	307.56	7.97%
2479.3	6.147E+06	1.524E+10	354.28	333.19	5.95%
2497.0	6.235E+06	1.557E+10	360.47	358.82	0.46%
2382.8	5.678E+06	1.353E+10	322.56	410.08	-27.14%

Curvefit	Flow vs. Head
c	411.8449959
x	-9.665087029
x2	0.483346001
x3	-0.007951566

	Curve Fit Array		Curve Fit PUMP	Data PUMP	
Head	Head^2	Head^3	Flow	Flow	Error
48.7	2.368E+03	1.152E+05	169.8	51.3	69.81%
50.5	2.545E+03	1.284E+05	133.4	102.5	23.16%
51.0	2.599E+03	1.325E+05	121.9	153.8	-26.20%
49.4	2.440E+03	1.206E+05	155.3	205.0	-31.99%
47.8	2.287E+03	1.094E+05	185.4	230.7	-24.44%
45.2	2.043E+03	9.232E+04	228.3	256.3	-12.29%
41.5	1.724E+03	7.156E+04	274.7	281.9	-2.64%
36.3	1.315E+03	4.768E+04	317.8	307.6	3.22%
28.2	7.935E+02	2.235E+04	345.4	333.2	3.53%
21.5	4.643E+02	1.000E+04	348.5	358.8	-2.98%
0.1	1.105E-02	1.161E-03	410.8	410.1	0.18%

ECM 9- Forced Draft Fans

Forced Draft Fans
Jim Bridger

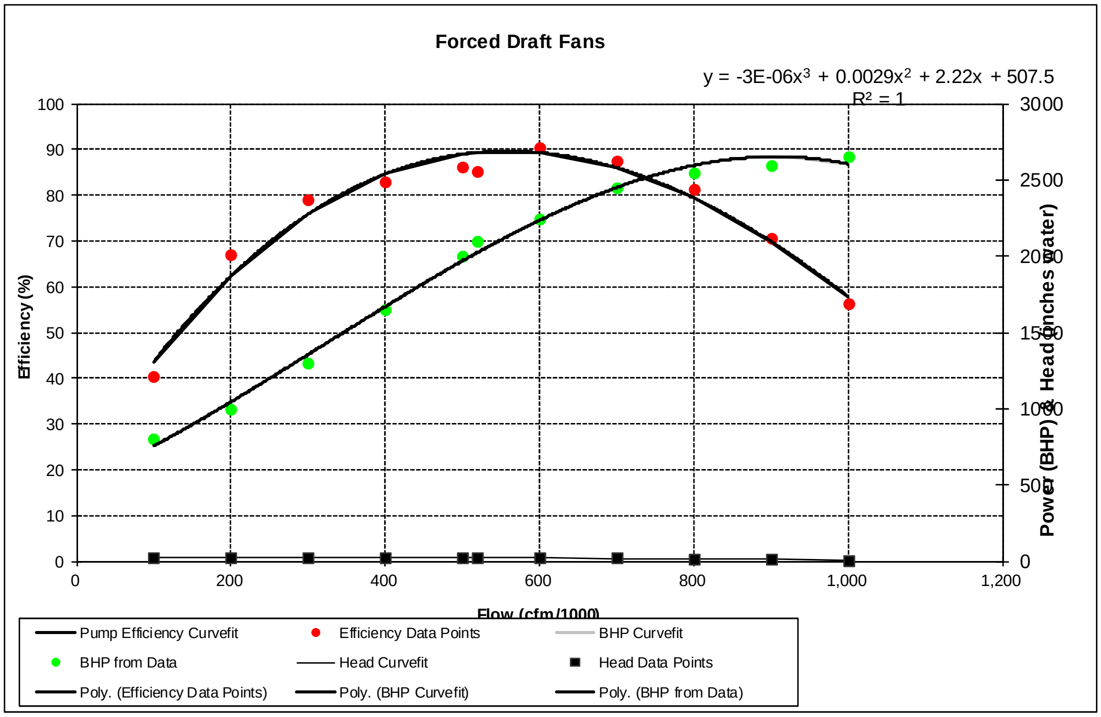
Inputs Denoted by Blue Font and Gray Backround

Summary of Curve Fit Coefficients				
	Static Head	Fan Efficiency	BHP	Q/N vs. H/N^2
C	19.17409586	0.194784933	507.5036166	3.75062E-05
X1	0.012707377	0.002705715	2.21995499	1.77726E-05
X2	-6.36954E-06	-2.94097E-06	0.002926177	-6.36954E-06
X3	-1.6385E-08	6.18933E-10	-3.0496E-06	-1.17153E-05

Original Curve		Adjusted Curve		
RPM	715	RPM	715	Rpm
Impeller	66	Impeller	66	Inches
Density	0.6500	Density	0.6500	Lb/ft^3
Temperature	70	Temperature	70	Degrees F
Inlet Rel. P.	-1	Inlet Rel. P.	-1	Inches H2O
Inlet Abs. P	11.5	Inlet Abs. P	11.5	psig

Elevation	6700
P atm	11.5

Forced Draft Fans						
Original Curve				Adjusted Curve		
Flow CFM (x1000)	Static Pressure Inches H2O	Fan Power BHP	Fan Efficiency	Flow CFM (x1000)	Static Pressure Inches H2O	Calculated Power (BHP)
100	20.5	800	0.403	100.0	20.5	800.0
200	21.3	1000	0.670	200.0	21.3	1000.0
300	21.8	1300	0.791	300.0	21.8	1300.0
400	21.8	1650	0.831	400.0	21.8	1650.0
500	21.9	2000	0.861	500.0	21.9	2000.0
520	21.9	2100	0.852	520.0	21.9	2100.0
600	21.6	2250	0.905	600.0	21.6	2250.0
700	19.5	2450	0.876	700.0	19.5	2450.0
800	16.5	2550	0.814	800.0	16.5	2550.0
900	13.0	2600	0.707	900.0	13.0	2600.0
1000	9.5	2650	0.563	1000.0	9.5	2650.0


Forced Draft Fans
y = -3E-06x³ + 0.0029x² + 2.22x + 507.5
R² = 1
Efficiency (%)
Power (BHP) & Head (inches water)
Flow (cfm/1000)
Pump Efficiency Curvefit
Efficiency Data Points
BHP Curvefit
BHP from Data
Head Curvefit
Head Data Points
Poly. (Efficiency Data Points)
Poly. (BHP Curvefit)
Poly. (BHP from Data)

Curve Fit Arrays and Calculations - Forced Draft Fans

Curvefit	BHP vs. Discharge
c	507.5036166
x	2.21995499
x2	0.002926177
x3	-3.04955E-06

Curve Fit Array			Curve Fit Power	Calculated Power	
GPM	GPM^2	GPM^3	BHP	BHP	Error
100	1.000E+04	1.000E+06	755.71	800.00	-5.86%
200	4.000E+04	8.000E+06	1044.15	1000.00	4.23%
300	9.000E+04	2.700E+07	1354.51	1300.00	4.02%
400	1.600E+05	6.400E+07	1668.50	1650.00	1.11%
500	2.500E+05	1.250E+08	1967.83	2000.00	-1.63%
520	2.704E+05	1.406E+08	2024.33	2100.00	-3.74%
600	3.600E+05	2.160E+08	2234.20	2250.00	-0.71%
700	4.900E+05	3.430E+08	2449.30	2450.00	-0.03%
800	6.400E+05	5.120E+08	2594.85	2550.00	1.73%
900	8.100E+05	7.290E+08	2652.54	2600.00	1.98%
1,000	1.000E+06	1.000E+09	2604.08	2650.00	-1.76%

Curvefit	Q/N vs. H/N^2
c	3.75062E-05
x	1.77726E-05
x2	-6.36954E-06
x3	-1.17153E-05

Pump Speed					
Curve Fit Array			Curve Fit	Calculated	
Q/N	(Q/N)^2	(Q/N)^3	H/N^2	H/N^2	Error
0.14	0.02	0.00	3.984E-05	4.010E-05	-0.66%
0.28	0.08	0.02	4.172E-05	4.166E-05	0.14%
0.42	0.18	0.07	4.298E-05	4.264E-05	0.78%
0.56	0.31	0.18	4.340E-05	4.264E-05	1.75%
0.70	0.49	0.34	4.281E-05	4.284E-05	-0.06%
0.73	0.53	0.38	4.256E-05	4.284E-05	-0.66%
0.84	0.70	0.59	4.101E-05	4.225E-05	-3.02%
0.98	0.96	0.94	3.781E-05	3.814E-05	-0.89%
1.12	1.25	1.40	3.301E-05	3.228E-05	2.22%
1.26	1.58	1.99	2.642E-05	2.543E-05	3.75%
1.40	1.96	2.74	1.785E-05	1.858E-05	-4.09%

Curvefit	Head vs. Flow
c	19.17409586
x	0.012707377
x2	-6.36954E-06
x3	0.00

Curve Fit Array			Curve Fit PUMP	Data PUMP	
GPM	GPM^2	GPM^3	Head	Head	Error
100	1.000E+04	1.000E+06	20.36	20.50	-0.66%
200	4.000E+04	8.000E+06	21.33	21.30	0.14%
300	9.000E+04	2.700E+07	21.97	21.80	0.78%
400	1.600E+05	6.400E+07	22.19	21.80	1.75%
500	2.500E+05	1.250E+08	21.89	21.90	-0.06%
520	2.704E+05	1.406E+08	21.76	21.90	-0.66%
600	3.600E+05	2.160E+08	20.97	21.60	-3.02%
700	4.900E+05	3.430E+08	19.33	19.50	-0.89%
800	6.400E+05	5.120E+08	16.87	16.50	2.22%
900	8.100E+05	7.290E+08	13.51	13.00	3.75%
1,000	1.000E+06	1.000E+09	9.13	9.50	-4.09%

Curvefit	Pump Eff. vs. Flow
c	0.194784933
x	0.002705715
x2	-2.94097E-06
x3	6.18933E-10

Curve Fit Array			Curve Fit PUMP	Data PUMP	
GPM	GPM^2	GPM^3	EFF.	EFF.	Error
100	1.000E+04	1.000E+06	0.437	0.40	7.74%
200	4.000E+04	8.000E+06	0.623	0.67	-7.44%
300	9.000E+04	2.700E+07	0.759	0.79	-4.25%
400	1.600E+05	6.400E+07	0.846	0.83	1.82%
500	2.500E+05	1.250E+08	0.890	0.86	3.28%
520	2.704E+05	1.406E+08	0.894	0.85	4.61%
600	3.600E+05	2.160E+08	0.893	0.91	-1.37%
700	4.900E+05	3.430E+08	0.860	0.88	-1.83%
800	6.400E+05	5.120E+08	0.794	0.81	-2.47%
900	8.100E+05	7.290E+08	0.699	0.71	-1.20%
1,000	1.000E+06	1.000E+09	0.578	0.56	2.59%

Curvefit	Flow vs. BHP
c	-578.459337
x	1.35391634
x2	-0.000746404
x3	1.69351E-07

Curve Fit Array			Curve Fit PUMP	Data PUMP	
BHP	BHP^2	BHP^3	Flow	Flow	Error
755.7	5.711E+05	4.316E+08	91.53	100.00	-9.25%
1044.1	1.090E+06	1.138E+09	214.25	200.00	6.65%
1354.5	1.835E+06	2.485E+09	306.87	300.00	2.24%
1668.5	2.784E+06	4.645E+09	389.27	400.00	-2.76%
1967.8	3.872E+06	7.620E+09	485.96	500.00	-2.89%
2024.3	4.098E+06	8.295E+09	508.47	520.00	-2.27%
2234.2	4.992E+06	1.115E+10	609.34	600.00	1.53%
2449.3	5.999E+06	1.469E+10	748.33	700.00	6.46%
2594.8	6.733E+06	1.747E+10	867.90	800.00	7.82%
2652.5	7.036E+06	1.866E+10	921.82	900.00	2.37%
2604.1	6.781E+06	1.766E+10	876.27	1000.00	-14.12%

Curvefit	Flow vs. Head
c	-2489.728465
x	760.2006941
x2	-51.48691271
x3	1.041598941

Curve Fit Array			Curve Fit PUMP	Data PUMP	
Head	Head^2	Head^3	Flow	Flow	Error
20.5	4.203E+02	8.615E+03	430.5	100.0	76.77%
21.3	4.537E+02	9.664E+03	409.0	200.0	51.11%
21.8	4.752E+02	1.036E+04	405.2	300.0	25.96%
21.8	4.752E+02	1.036E+04	405.2	400.0	1.29%
21.9	4.796E+02	1.050E+04	405.4	500.0	-23.33%
21.9	4.796E+02	1.050E+04	405.4	520.0	-28.26%
21.6	4.666E+02	1.008E+04	405.8	600.0	-47.86%
19.5	3.803E+02	7.415E+03	479.6	700.0	-45.95%
16.5	2.723E+02	4.492E+03	715.3	800.0	-11.85%
13.0	1.690E+02	2.197E+03	980.0	900.0	8.16%
9.5	9.025E+01	8.574E+02	978.5	1000.0	-2.19%

ECM 10

ROCKY MOUNTAIN POWER

Let's turn the answers on.

FinAnswer Express

Effective Tariff Date	WY 10/01/11
Project ID	

12/1/2011 | Lighting Calculator Tool | V 100111.5

You Can Now Access The Project Information Tab

Customer Information

Project Name	Jim Bridger Plant		
Business Name	PacifiCorp Energy (Idaho Power Company)		
Installation Address	WY-377 E/I-80 Srv Rd		
City, State, Zip	Point of Rocks	WY	82942
Contact, Title	Dan Zimmer	Electrical Facilities Manager	
Phone, Email	(307) 352-4224	Daniel.Zimmer@PacifiCorp.com	
Participant is: (check all that apply)	☑ Customer/Acct Holder	☑ Building Owner	
Account #		Lighting Coordinator	
Meter #, Rate	28	Jim Soukup	

Contractor Information

Contact		☐ EEA Participant
Business Name	Not Available (Must go out to bid)	
Address		
City, State, Zip		
Phone, Email		

Payee Information

Customer ◉	Contractor ○	Other (See below) ○
Business Name	PacifiCorp Energy (Idaho Power Company)	
Attention	Dan Zimmer	
Check Reference	Jim Bridger Plant	
Address	WY-377 E/I-80 Srv Rd	
City, State, Zip	Point of Rocks	WY 82942

Eligibility Information

Business Name	
Address	
City, State, Zip	
Account #	
Meter Base #, Rate	

Processing Information

Lighting Tool Prepared by: Richard Wood 801-850-8021

Construction Type	Retrofit	Project Status	Preliminary

Project Cost

Material	Labor	Other	Total Project Cost
$395,025.00	$206,850.00	$81,400.00	$683,275.00

Space Type & Size

Calculation Method	Whole Building	Watts Allowed by Code	120,000			
1	Storage, Industrial and Commercial	SQFT	150,000	0.80	W/FT^2	
2		SQFT		0.00	W/FT^2	
3		SQFT		0.00	W/FT^2	
4		SQFT		0.00	W/FT^2	
5		SQFT		0.00	W/FT^2	
	Storage, Industrial and Commercial	SQFT	150,000	0.80	W/FT^2	

Lighting Operation Schedule

Open Federal Holidays?	No
Operation Weeks Per Year	52
Schedule X is for Emergency Lighting (8760 hrs/yr)	

Day	A	B	C	D	E
Mon	24.0				
Tue	24.0				
Wed	24.0				
Thu	24.0				
Fri	24.0				
Sat	24.0				
Sun	24.0				
Total	8,497				

Note

Light Blue Fields Are Manually Entered

Red Fields Are Required

Gray Fields are Auto Filled

Fixture Wattage - Fixture Code	Fixture Filter
109 - CMH-100W-HIDLF	Category
125 - CMH-100W-SCWA	Fixture Type
154 - CMH-140W-HIDLF N	Lamp Type
166 - CMH-150W-HIDLF	Lamp Qty
189 - CMH-150W-SCWA	Lamp Wattage
214 - CMH-200W-HIDLF H	
26 - CMH-20W-HIDLF	
266 - CMH-250W-HIDLF H	
272 - CMH-250W-LR	
288 - CMH-250W-SCWA	← 1.Select Fixture
324 - CMH-300W-LR	↓2. Right Click to Insert
342 - CMH-300W-SCWA	
341 - CMH-320W-HIDLF H	

HID Ceramic Metal Halide Standard (100W x 1L) 1 HID Low Freq Ballast

ROCKY MOUNTAIN POWER

Let's turn the answers on.

V 100111.5

Project View	Preliminary
Pre-Inspector	
Date	
Post-Inspector	
Date	

Project Cost	$683,275.00
Total Incentive Standard Incentive	$180,978.00
26% of Project Cost Paid by Incentive	
Net Cost	$502,297.00
Cost Savings/yr	$122,086.30
Simple Payback (Yrs)	4.11
Avg Mo kW Savings	220.043
kWh/yr Savings	2,322,566
Exisiting LPD = 3.62	Proposed LPD = 2.10
42.2% Better Then Existing LPD	
50.3% Proposed Energy Savings	

Operation Hours

Day	A	B	C	D	E
Sun	24.0				
Mon	24.0				
Tue	24.0				
Wed	24.0				
Thu	24.0				
Fri	24.0				
Sat	24.0				
Total	8,497				

Ltg Tool Prepared by: Richard Woo 12/1/2011

Please Note:

Light Blue Fields Can Be Modified

Light Grey Fields Can Not Be Modified

Preliminary — 117 — Jim Bridger Plant

Rm Count	Schedule	Room Number Or Location	Existing Fixture	Qty	Controls (Optional)	Fixture Wattage	Space Wattage	Proposed Fixture	Qty	Controls (Optional)	Fixture Wattage	Space Wattage	Project Notes
				2,393	0		543,700		2,393	356		314,489	
1	A	14th Floor	HPS-150W	58		188	10,904	MHPS-100W-HIDLF	58	Daylighting	110	6,380	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
2	A	13 1/2 Floor	HPS-150W	10		188	1,880	MHPS-100W-HIDLF	10	Daylighting	110	1,100	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
3	A	13 Floor	HPS-150W	30		188	5,640	MHPS-100W-HIDLF	30	Daylighting	110	3,300	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
4	A	12 1/2 Floor	HPS-150W	44		188	8,272	MHPS-100W-HIDLF	44	Daylighting	110	4,840	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
5	A	12th Floor	HPS-150W	38		188	7,144	MHPS-100W-HIDLF	38	Daylighting	110	4,180	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
6	A	11th Floor	HPS-150W	25		188	4,700	MHPS-100W-HIDLF	25	Daylighting	110	2,750	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
7	A	10th Floor	HPS-150W	39		188	7,332	MHPS-100W-HIDLF	39	Daylighting	110	4,290	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
8	A	9th Floor	HPS-150W	28		188	5,264	MHPS-100W-HIDLF	28	Daylighting	110	3,080	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
9	A	8th Floor	HPS-150W	32		188	6,016	MHPS-100W-HIDLF	32	Daylighting	110	3,520	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
10	A	8th Floor	FLT12HO-60W x 2L x 4'-MG	2		145	290	FLT8CEE-32W x 2L x 4'-CEE IS CEE N	2		56	112	Industrial Strip
11	A	Mechanical RM	FLT12HO-60W x 2L x 4'-MG	2		145	290	FLT8CEE-32W x 2L x 4'-CEE IS CEE N	2		56	112	Industrial Strip
12	A	14 Floors of Elevator Land	HPS-150W	16		188	3,008	MHPS-100W-HIDLF	16	Daylighting	110	1,760	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
13	A	7th Floor	HPS-150W	30		188	5,640	MHPS-100W-HIDLF	30	Daylighting	110	3,300	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
14	A	6th Floor	HPS-150W	75		188	14,100	MHPS-100W-HIDLF	75	Daylighting	110	8,250	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
15	A	5th Floor	HPS-150W	44		188	8,272	MHPS-100W-HIDLF	44	Daylighting	110	4,840	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
16	A	5th Floor	FLT12-40W x 2L x 4'-MG	4		72	288	FLT8CEE-32W x 2L x 4'-CEE IS CEE N	4		56	224	Wrap
17	A	4th Floor	HPS-150W	45		188	8,460	MHPS-100W-HIDLF	45	Daylighting	110	4,950	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
18	A	4th Floor	HPS-250W	8		295	2,360	MHPS-175W-HIDLF	8		191	1,528	Lowbay Fixtures
19	A	3rd Floor	HPS-150W	36		188	6,768	MHPS-100W-HIDLF	36		110	3,960	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
20	A	2nd Floor	HPS-150W	63		188	11,844	MHPS-100W-HIDLF	63		110	6,930	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
21	A	Mechanical RM	FLT12HO-60W x 2L x 4'-MG	9		145	1,305	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	9		73	657	Industrial Strip/ Reflector
22	A	1st Floor	HPS-400W	11		465	5,115	FLT5HO-54W x 4L x 4'-RS/PRS H	11		229	2,519	Highbay fixture should be enclosed
23	A	1st Floor	HPS-150W	25		188	4,700	MHPS-100W-HIDLF	25		110	2,750	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
24	A	1st Floor Outside	HPS-400W	12		465	5,580	MHPS-320W-HIDLF	12		345	4,140	Lowbay Fixtures
25	A	Unique Area (Water Treatr	HPS-400W	38		465	17,670	FLT5HO-54W x 4L x 4'-RS/PRS H	38		229	8,702	Highbay Fixtures
26	A	1st Floor	HPS-150W	32		188	6,016	MHPS-100W-HIDLF	32		110	3,520	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
27	A	1st Floor	HPS-400W	6		465	2,790	MHPS-320W-HIDLF	6		345	2,070	Highbays
28	A	1st Floor	HPS-150W	21		188	3,948	MHPS-100W-HIDLF	21		110	2,310	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
29	A	1st Floor	HPS-1000W	1		1,100	1,100	FLT5HO-54W x 10L x 4'-3 RS/PRS H	1		585	585	Highbay
30	A	Elevator	FLT12-40W x 2L x 4'-MG	1		72	72	FLT8CEE-32W x 2L x 4'-CEE IS CEE L	1		48	48	Strip
31	A	HVAC Elevation	HPS-150W	20		188	3,760	MHPS-100W-HIDLF	20		110	2,200	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
32	A	HVAC Elevation	FLT12-60W x 2L x 8'-MG(E)	1		123	123	FLT8CEE-32W x 4L x 4'-CEE IS CEE L	1		95	95	Industrial Strip
33	A	Chiller RM	FLT12HO-110W x 2L x 8'-MG(E)	5		227	1,135	FLT8CEE-32W x 4L x 4'-CEE IS CEE H	5		142	710	Industrial Strip
34	A	Dariator Deck	HPS-150W	21		188	3,948	MHPS-100W-HIDLF	21		110	2,310	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
35	A	Dariator Deck	HPS-400W	6		465	2,790	FLT5HO-54W x 4L x 4'-RS/PRS H	6		229	1,374	Highbays
36	A	Fan RM	FLT12HO-60W x 2L x 4'-MG	15		145	2,175	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	15		73	1,095	Industrial Strip
37	A	Back RM Walkway	FLT12HO-60W x 2L x 4'-MG	12		145	1,740	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	12		73	876	Industrial Strip
38	A	Fan Mezzanine	HPS-150W	2		188	376	MHPS-100W-HIDLF	2		110	220	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
39	A	Dariator Deck	HPS-150W	15		188	2,820	MHPS-100W-HIDLF	15		110	1,650	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
40	A	Dariator Deck	HPS-400W	1		465	465	FLT5HO-54W x 4L x 4'-RS/PRS H	1	Integral	229	229	Highbays
41	A	Stock Feeder Deck	HPS-1000W	6		1,100	6,600	FLT5HO-54W x 10L x 4'-3 RS/PRS H	6	Integral	585	3,510	12 lamp unit Highbay/ Step dimming. 50%
42	A	Logic RM	FLT12HO-110W x 2L x 8'-MG(E)	20		227	4,540	FLT8CEE-32W x 4L x 4'-CEE IS CEE H	20		142	2,840	Industrial Strip
43	A	Stock Feeder Deck	FLT12HO-110W x 2L x 8'-MG(E)	24		227	5,448	FLT8CEE-32W x 4L x 4'-CEE IS CEE H	24		142	3,408	Industrial Strip
44	A	Common Area	HPS-1000W	10		1,100	11,000	FLT5HO-54W x 10L x 4'-3 RS/PRS H	10	Integral	585	5,850	12 lamp unit Highbay/ Step dimming. 50%
45	A	Turbine Bldg. Unit1	HPS-1000W	35		1,100	38,500	FLT5HO-54W x 10L x 4'-3 RS/PRS H	35	Integral	585	20,475	12 lamp unit Highbay/ Step dimming. 50%
46	A	Breakers	FLT12HO-110W x 2L x 8'-MG(E)	18		227	4,086	FLT8CEE-32W x 4L x 4'-CEE IS CEE H	18		142	2,556	Industrial Strip
47	A	Feed Water to Inlet	HPS-150W	21		188	3,948	MHPS-100W-HIDLF	21		110	2,310	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
48	A	Mezzanine	HPS-150W	37		188	6,956	MHPS-100W-HIDLF	37		110	4,070	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
49	A	Mezzanine	HPS-400W	7		465	3,255	FLT5HO-54W x 4L x 4'-RS/PRS H	7		229	1,603	Highbays
50	A	Basement FL	HPS-400W	32		465	14,880	FLT5HO-54W x 4L x 4'-RS/PRS H	32	Integral	229	7,328	Highbays
51	A	Basement FL	HPS-150W	24		188	4,512	MHPS-100W-HIDLF	24		110	2,640	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
52	A	Basement Large Walkway	HPS-400W	14		465	6,510	FLT5HO-54W x 4L x 4'-RS/PRS H	14	Integral	229	3,206	Highbays
53	A	Basement Common Area	HPS-400W	8		465	3,720	FLT5HO-54W x 4L x 4'-RS/PRS H	8	Integral	229	1,832	Highbays
54	A	Maintenance	HPS-400W	41		465	19,065	FLT5HO-54W x 4L x 4'-RS/PRS H	41	Integral	229	9,389	Dual Head HPS
55	A	Gone Fishing Office	FLT12-40W x 4L x 4'-2 MG	6		144	864	FLT8CEE-32W x 4L x 4'-CEE IS CEE L	6		95	570	2X4 Prismatic Troffer
56	A	Upstairs Offices	FLT12-40W x 4L x 4'-2 MG	28		144	4,032	FLT8CEE-32W x 4L x 4'-CEE IS CEE L	28		95	2,660	2X4 Prismatic Troffer
57	A	Upstairs Offices	FLT12-60W x 4L x 8'-MG	6		246	1,476	FLT8CEE-32W x 4L x 4'-CEE IS CEE H	6		142	852	Strip
58	A	Work Stations	FLT12-60W x 2L x 8'-MG	5		123	615	FLT8CEE-32W x 4L x 4'-CEE IS CEE L	5		95	475	Strip
59	A	Work Stations	FLT12HO-110W x 2L x 8'-MG(E)	1		227	227	FLT8CEE-32W x 4L x 4'-CEE IS CEE H	1		142	142	Strip
60	A	Work Stations	FLT12-40W x 2L x 4'-MG	1		72	72	FLT8CEE-32W x 2L x 4'-CEE IS CEE L	1		48	48	Strip/Reflector
61	A	Maintenance Shop	INE-15W x 2L	1		30	30	LEDIE-2W	1		2	2	Exits
62	A	Break RM	FLT12-40W x 4L x 4'-2 MG	12		144	1,728	FLT8CEE-32W x 4L x 4'-CEE IS CEE L	12		95	1,140	2X4 Prismatic Troffer
63	A	Phone RM	FLT12-40W x 4L x 4'-2 MG	2		144	288	FLT8CEE-32W x 4L x 4'-CEE IS CEE L	2		95	190	2X4 Prismatic Troffer
64	A	RR	FLT12-40W x 2L x 4'-MG	8		72	576	FLT8CEE-32W x 2L x 4'-CEE IS CEE L	8		48	384	1X4 Prismatic Troffer
65	A	RR	FLT12-40W x 2L x 4'-MG	9		72	648	FLT8CEE-32W x 2L x 4'-CEE IS CEE L	9		48	432	Vaportite
66	A	RR	INE-15W x 2L	2		30	60	LEDIE-2W	2		2	4	Exits
67	A	Locker RM	FLT12HO-60W x 2L x 4'-MG	12		145	1,740	FLT8CEE-32W x 2L x 4'-CEE IS CEE L	12	Occupancy	48	576	Strip/Reflector
68	A	MCC RM	FLT12HO-60W x 2L x 4'-MG	9		145	1,305	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	9		73	657	Strip/Reflector
69	A	Tech Shop	FLT12-40W x 4L x 4'-2 MG	55		144	7,920	FLT8CEE-32W x 4L x 4'-CEE IS CEE L	55		95	5,225	2X4 Prismatic Troffer
70	A	Coal RM	FLT12-40W x 4L x 4'-2 MG	4		144	576	FLT8CEE-32W x 4L x 4'-CEE IS CEE L	4		95	380	2X4 Prismatic Troffer
71	A	LAB	FLT12-40W x 4L x 4'-2 MG	41		144	5,904	FLT8CEE-32W x 4L x 4'-CEE IS CEE L	41		95	3,895	2X4 Prismatic Troffer
72													No change to 6- 400W HPS Exterior Fixtures
73	A	ID Fan	HPS-150W	24		188	4,512	MHPS-100W-HIDLF	24	Daylighting	110	2,640	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
74													No change to 4- 400W HPS Exterior Fixtures
75													No change to 4- 400W HPS Exterior Fixtures
76													Control RM is Already Retrofitted with T8s
77	A	Precipitator Exterior	HPS-150W	52		188	9,776	MHPS-100W-HIDLF	52	Daylighting	110	5,720	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
78	A	Precipitator Exterior	MV-175W-CWA	21		205	4,305	MHPS-100W-HIDLF	21	Daylighting	110	2,310	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
79	A	Precipitator Exterior	FLT12HO-60W x 2L x 4'-MG	102		145	14,790	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	102		73	7,446	Tandem 4' Strip/Reflector
80	A	Backside Precipitator	HPS-150W	24		188	4,512	MHPS-100W-HIDLF	24	Daylighting	110	2,640	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
81	A	Backside Precipitator	MV-175W-CWA	20		205	4,100	MHPS-100W-HIDLF	20	Daylighting	110	2,200	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
82	A	Tall Walkway Between	HPS-150W	31		188	5,828	MHPS-100W-HIDLF	31		110	3,410	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
83	A	Stairs(Front) Precipitators	HPS-150W	8		188	1,504	MHPS-100W-HIDLF	8	Daylighting	110	880	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
84	A	Outside	HPS-400W	22		465	10,230	MHPS-320W-HIDLF	22		345	7,590	Wall Mounted(See Pictures)
85	A	FA Export RM	HPS-400W	8		465	3,720	MHPS-320W-HIDLF	8		345	2,760	Wall Mounted(See Pictures)
86	A	Precipitator all floors	HPS-150W	24		188	4,512	MHPS-100W-HIDLF	24		110	2,640	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
87	A	Precipitator all floors	HPS-400W	48		465	22,320	MHPS-320W-HIDLF	48		345	16,560	
88	A	Scrubber Bldg.	HPS-150W	4		188	752	MHPS-100W-HIDLF	4		110	440	Wallpack
89	A	Pump RM	HPS-400W	7		465	3,255	FLT5HO-54W x 4L x 4'-RS/PRS H	7	Integral	229	1,603	Enclosed Highbay with polycarbonite lens
90	A	Bezzels	HPS-150W	6		188	1,128	MHPS-100W-HIDLF	6		110	660	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/

Fixture Wattage - Fixture Code	Fixture Filter
109 - CMH-100W-HIDLF	Category
125 - CMH-100W-SCWA	Fixture Type
154 - CMH-140W-HIDLF N	Lamp Type
166 - CMH-150W-HIDLF	Lamp Qty
189 - CMH-150W-SCWA	Lamp Wattage
214 - CMH-200W-HIDLF H	← 1.Select Fixture
26 - CMH-20W-HIDLF	↓2. Right Click to Insert
266 - CMH-250W-HIDLF H	
272 - CMH-250W-LR	
288 - CMH-250W-SCWA	
324 - CMH-300W-LR	
342 - CMH-300W-SCWA	
341 - CMH-320W-HIDLF H	

HID Ceramic Metal Halide Standard (100W x 1L) 1 HID Low Freq Ballast

ROCKY MOUNTAIN POWER

Let's turn the answers on.

V 100111.5

Project View	Preliminary
Pre-Inspector	
Date	
Post-Inspector	
Date	

Project Cost	$683,275.00
Total Incentive / Standard Incentive	$180,978.00
26% of Project Cost Paid by Incentive	
Net Cost	$502,297.00
Cost Savings/yr	$122,086.30
Simple Payback (Yrs)	4.11
Avg Mo kW Savings	220.043
kWh/yr Savings	2,322,566
Exisiting LPD = 3.62	Proposed LPD = 2.10
42.2% Better Then Existing LPD	
50.3% Proposed Energy Savings	

Operation Hours					
Day	A	B	C	D	E
Sun	24.0				
Mon	24.0				
Tue	24.0				
Wed	24.0				
Thu	24.0				
Fri	24.0				
Sat	24.0				
Total	8,497				

Ltg Tool Preparedby: Richard Woo 12/1/2011

Preliminary

Jim Bridger Plant

Please Note:

Light Blue Fields Can Be Modified

Light Grey Fields Can Not Be Modified

117		Existing						Proposed					
				2,393	0		543,700		2,393	356		314,489	
Rm Count	Schedule	Room Number Or Location	Fixture	Qty	Controls (Optional)	Fixture Wattage	Space Wattage	Fixture	Qty	Controls (Optional)	Fixture Wattage	Space Wattage	Project Notes
91	A	2nd Floor	HPS-150W	7		188	1,316	MHPS-100W-HIDLF	7		110	770	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
92	A	Control RM	FLT12-40W x 4L x 4'-2 MG	7		144	1,008	FLT8CEE-32W x 4L x 4'-CEE IS CEE L	7	Occupancy	95	665	2X4 Prismatic Troffer
93	A	RR/ Hallway	FLT12-40W x 2L x 4'-MG	2		72	144	FLT8CEE-32W x 2L x 4'-CEE IS CEE L	2		48	96	2X4 Prismatic Troffer
94	A	Breaker RM	FLT12HO-60W x 2L x 4'-MG	8		145	1,160	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	8	Occupancy	73	584	Industrial Strip
95	A	Observer Vessels	HPS-150W	12		188	2,256	MHPS-100W-HIDLF	12		110	1,320	Dusk to Dawn pole mounted fixtures/ Lowbay suface mounted/
96	A	Light Equipment Bldg	HPS-400W	22		465	10,230	FLT5HO-54W x 4L x 4'-RS/PRS H	22	Integral	229	5,038	New Highbay Fixtures
97	A	Storage	FLT12-40W x 2L x 4'-MG	2		72	144	FLT8CEE-32W x 2L x 4'-CEE IS CEE L	2		48	96	Strip
98	A	Upstairs Offices/ Hall	FLT12-40W x 3L x 4'-2 MG	39		115	4,485	FLT8CEE-32W x 3L x 4'-CEE IS CEE L	39		74	2,886	2X4 Parabolic/Prismatic Troffers
99	A	Restrooms	FLT12-40W x 2L x 4'-MG	13		72	936	FLT8CEE-32W x 2L x 4'-CEE IS CEE L	13	Occupancy	48	624	Vaportite
100	A	Restrooms	FLT12-40W x 3L x 4'-2 MG	6		115	690	FLT8CEE-32W x 3L x 4'-CEE IS CEE L	6		74	444	2X4 Prismatic Troffers
101	A	Upper Breakroom	FLT12-40W x 3L x 4'-2 MG	33		115	3,795	FLT8CEE-32W x 3L x 4'-CEE IS CEE L	33	Occupancy	74	2,442	2X4 Parabolic Troffers
102	A	Side Offices	FLT12-40W x 3L x 4'-2 MG	39		115	4,485	FLT8CEE-32W x 3L x 4'-CEE IS CEE L	39		74	2,886	2X4 Parabolic Troffers
103	A	Offices/ Hallway	FLT12-40W x 3L x 4'-2 MG	18		115	2,070	FLT8CEE-32W x 3L x 4'-CEE IS CEE L	18		74	1,332	2X4 Parabolic Troffers
104	A	Lockers/ Showers	FLT12-40W x 2L x 4'-MG	39		72	2,808	FLT8CEE-32W x 2L x 4'-CEE IS CEE L	39	Occupancy	48	1,872	Vaportite/Wall mounted
105	A	Locker RM	FLT12-40W x 4L x 4'-2 MG	32		144	4,608	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	32	Occupancy	73	2,336	2X4 Prismatic Troffers
106	A	Breaseway	FLT12-40W x 2L x 4'-MG	1		72	72	FLT8CEE-32W x 2L x 4'-CEE IS CEE L	1		48	48	Vaportite
107	A	Breaseway	FLT12-60W x 2L x 8'-MG(E)	12		123	1,476	FLT8CEE-32W x 4L x 4'-CEE IS CEE L	12		95	1,140	Strip
108	A	Restrooms	FLT12-40W x 4L x 4'-2 MG	2		144	288	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	2		73	146	2X4 Prismatic Troffers
109	A	Stock RM	FLT12-40W x 4L x 4'-2 MG	18		144	2,592	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	18		73	1,314	2X4 Prismatic Troffers
110	A	Light Equipment Office	FLT12-40W x 4L x 4'-2 MG	15		144	2,160	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	15		73	1,095	2X4 Prismatic Troffers
111	A	Light Equipment Shop	FLT12-40W x 4L x 4'-2 MG	38		144	5,472	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	38		73	2,774	2X4 Prismatic Troffers
112	A	Light Equipment Hall	FLT12-40W x 4L x 4'-2 MG	9		144	1,296	FLT8CEE-32W x 2L x 4'-CEE IS CEE H	9		73	657	2X4 Prismatic Troffers
113													
114	A	Coal Handling Bldg.	MV-175W-CWA	6		205	1,230	MHPS-100W-HIDLF	6		110	660	Highbay
115	A	Coal Handling Bldg.	HPS-400W	7		465	3,255	MHPS-320W-HIDLF	7		345	2,415	Floods/ Highbays
116	A	A & B Conveyor	HPS-150W	153		188	28,764	MHPS-100W-HIDLF	153	Integral	110	16,830	Integral stepdimming controls for Lowbays
117	A	A & B Conveyor	MV-175W-CWA	9		205	1,845	MHPS-100W-HIDLF	9		110	990	Lowbay
118	A	Pent House	HPS-150W	12		188	2,256	MHPS-100W-HIDLF	12		110	1,320	Lowbay
119	A	Second From Top	MV-175W-CWA	23		205	4,715	MHPS-100W-HIDLF	23		110	2,530	Lowbay
120	A	Second From Top	HPS-400W	3		465	1,395	MHPS-320W-HIDLF	3		345	1,035	Floods/ Highbays
121	A	Second From Top	HPS-150W	3		188	564	MHPS-100W-HIDLF	3		110	330	Lowbay
122	A	Transfer Bldg.	HPS-150W	20		188	3,760	MHPS-100W-HIDLF	20		110	2,200	Lowbay
123													
124													

ROCKY MOUNTAIN POWER

Let's turn the answers on.

FinAnswer Express

Effective Tariff Date	WY 10/01/11
Project ID	
Lighting	V 100111.5

Customer Information

Project	Jim Bridger Plant
Company	PacifiCorp Energy (Idaho Power Company)
Project Contact	Dan Zimmer

Contractor Information

Company			
Address			
City, State, Zip			

Incentive Payee Information

Company	PacifiCorp Energy (Idaho Power Company)		
Address	WY-377 E/I-80 Srv Rd		
	Point of Rocks	WY	82942

Project Details

'ool Prepared by: Richard Wood 801-850-8031 12/1/2011

Preliminary	Type	Retrofit
	Status	Preliminary

Energy Savings

	kWh / year	Avg Monthly kW	$ Savings
Lighting	1,947,652	220.0	$ 108,436
Controls	374,915	0.0	$ 13,651
Total	2,322,566	220.0	$ 122,086

Project Costs

Material	$ 395,025.00
Labor	$ 206,850.00
Other	$ 81,400.00
Total	$ 683,275.00
Incentive	$ 180,978.00
Net Project Cost	$ 502,297.00

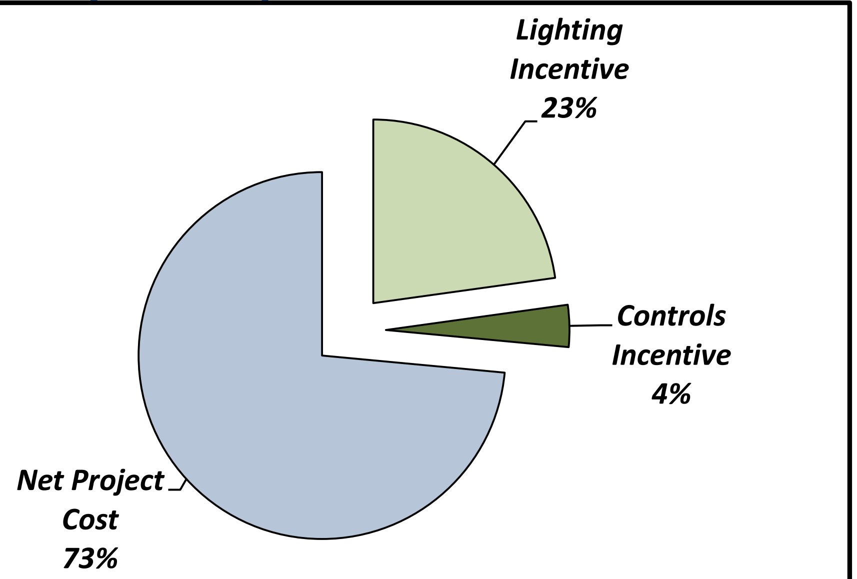
Simple Payback

Pre-incentive	5.6 Yrs
With Incentive	4.1 Yrs

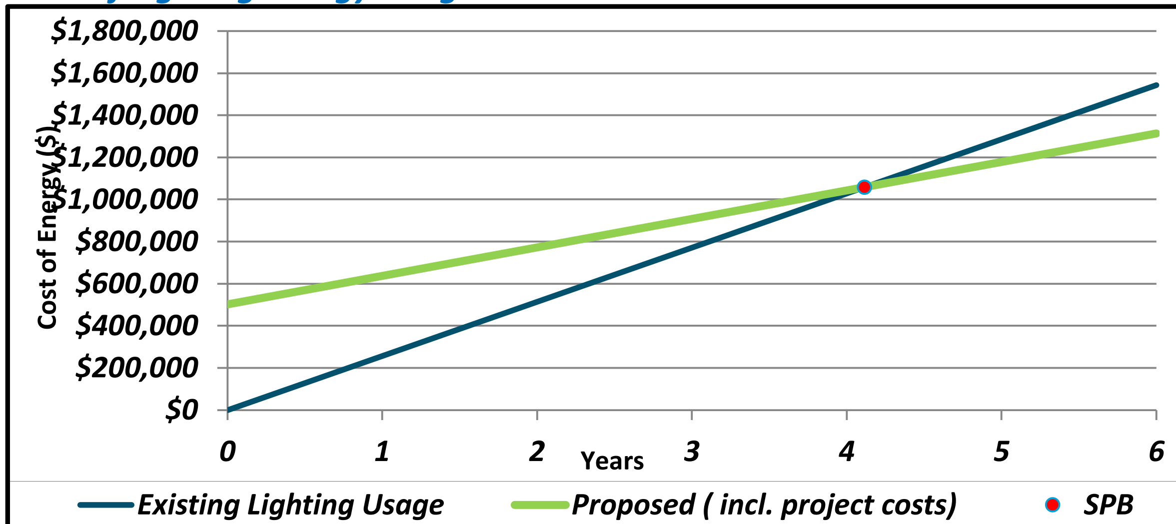
Incentive

Lighting	$ 155,778.00
Controls	$ 25,200.00
Total	$ 180,978.00

Percent of Initial Project Cost



Cost of Lighting Energy Usage Over Time



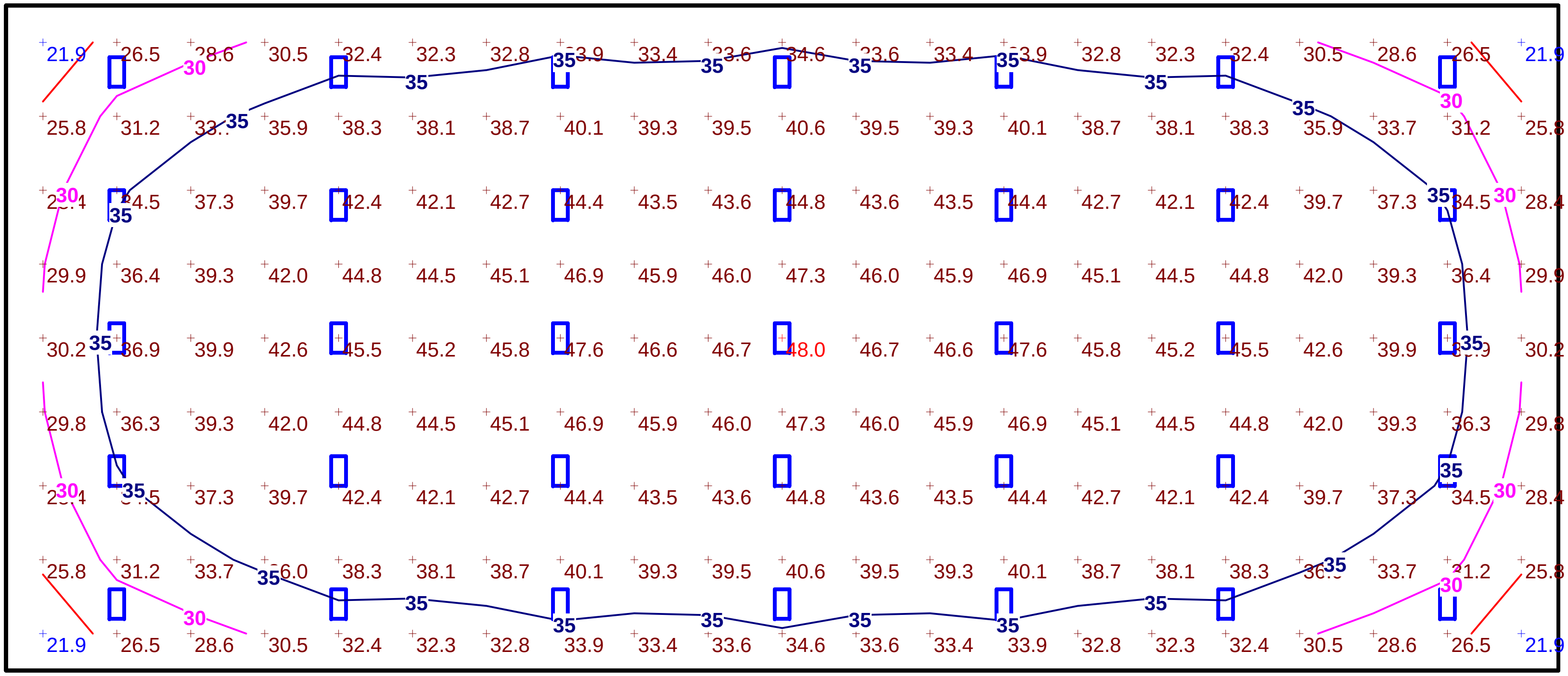
The incentive and energy savings above are estimates only.

The actual incentive paid will be determined based on the results of a post-installation inspection and review of project invoices(by Rocky Mountain Power).
Lighting incentives are capped at 70% of eligible energy efficiency project costs, and the minimum simple payback (with incentive) for the project is one year. If needed, incentives will be decreased to reflect a one-year payback. The simple payback with incentive is the net project cost divided by the annual electric cost savings (dollar savings).

To receive an incentive you MUST sign an Incentive Agreement before purchasing equipment.

Please work with your Rocky Mountain Power representive or Energy Efficiency Alliance vendor to assist you through the process.

Project Costs Estimation Table						
	Qty	Mat Unit	Tot Mat	Lab Unit	Tot Lab	Controls
MHPS-100W-HIDLF	1290	$ 200	$ 258,000	$ 100	$ 129,000	
FLT8CEE-32W x 2L x 4'-CEE IS CEE N	8	$ 75	$ 600	$ 50	$ 400	
MHPS-175W-HIDLF	8	$ 200	$ 1,600	$ 100	$ 800	
FLT5HO-54W x 4L x 4'-RS/PRS H	187	$ 200	$ 37,400	$ 100	$ 18,700	
FLT8CEE-32W x 2L x 4'-CEE IS CEE L	88	$ 75	$ 6,600	$ 50	$ 4,400	
FLT8CEE-32W x 3L x 4'-CEE IS CEE L	135	$ 75	$ 10,125	$ 50	$ 6,750	
FLT8CEE-32W x 4L x 4'-CEE IS CEE L	173	$ 75	$ 12,975	$ 50	$ 8,650	
FLT8CEE-32W x 4L x 4'-CEE IS CEE H	74	$ 75	$ 5,550	$ 50	$ 3,700	
FLT8CEE-32W x 2L x 4'-CEE IS CEE H	269	$ 75	$ 20,175	$ 50	$ 13,450	
MHPS-320W-HIDLF	106	$ 200	$ 21,200	$ 100	$ 10,600	
FLT5HO-54W x 10L x 4'-3 RS/PRS H	52	$ 400	$ 20,800	$ 100	$ 5,200	
Totals	2390		$ 395,025		$ 201,650	81400
Materials	$ 395,025					
Labor	$ 201,650					
Other	$ 81,400					



Plan View

Scale 1" = 25'

LUMINAIRE SCHEDULE

Symbol	Label	Qty	Catalog Number	Description	Lamp	File	Lumens	LLF	Watts
	LM-2	35	HBL-1054T5-N-UNV-EBT3-UPL-U	OPEN HIGH BAY LUMINAIRE WITH A SPECULAR, NARROW DISTRIBUTION WITH UPLIGHT	TEN 54 WATT T5 LINEAR FLUORESCENT LAMPS - 4400 LUMENS EA	HBL1054N-UPL.ies	4400	0.82	605

STATISTICS

Description	Symbol	Avg	Max	Min	Max/Min	Avg/Min
Floor FC Calc	+	38.0 fc	48.0 fc	21.9 fc	2.2:1	1.7:1

Calculated values include direct and interreflected components.

Lighting Estimator Tool

Layout is for Preliminary Evaluation Only

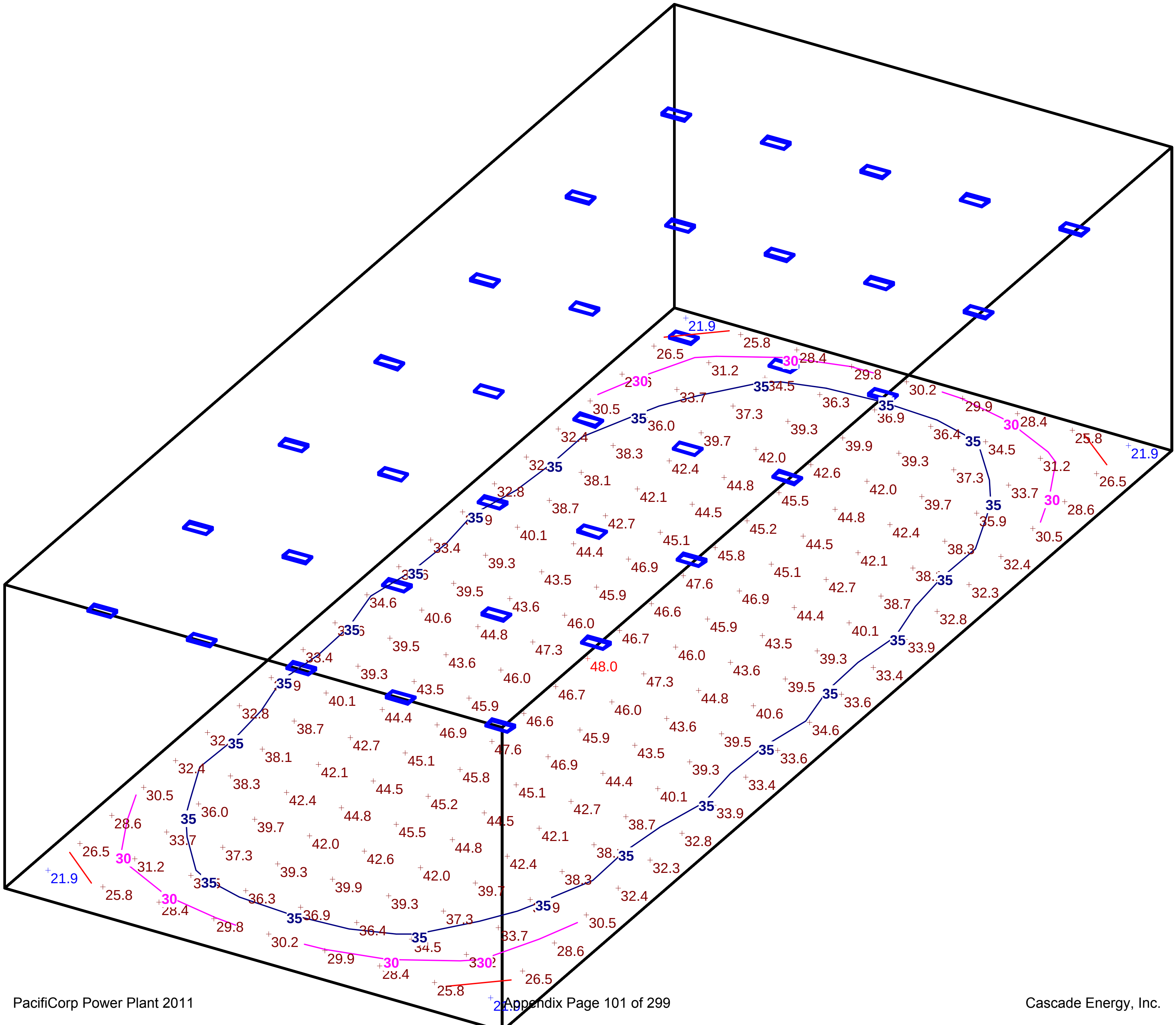
Designer
Richard Wood

Date
Dec 1 2011

Scale

Drawing No.
Jim Bridger Plant

1 of 1



Calculated values include direct and interreflected components.

Northeast View

26.3 Jim Bridger: Equipment Ratings
ECM 1-Air Handler 4th Floor SE Corner (1VSF3)

See HVAC VFD Drive Data Below for 75 hp drive.

ECM 2- 9th Floor Fans (1VSF 1&2)

See HVAC VFD Drive Data Below for 75 hp drive.

ECM 6- Turbine Room Fan and Mixer Bank

See HVAC VFD Drive Data Below for 20 hp drive.

PowerFlex® 750-Series AC Drives

Allen-Bradley

Cost-effective Solution Designed for Ease of Use, Integration & Application Flexibility.

The Allen-Bradley® PowerFlex 750-Series of AC Drives is aimed at maximizing your investment and improving productivity. Whether your need is for a general purpose or high performance application, the PowerFlex 750-Series offers more selection for control, communications, safety and supporting hardware options than any other drives in their class.

Leading the Class

- Simplified integration into the Logix environment reduces development time and related costs
- Cost effective solutions with standard features including DeviceLogix control, predictive diagnostics, embedded Ethernet port, embedded I/O, and safety options
- Reduce unnecessary add-ons with the slot based architecture that allows PowerFlex 750-Series drives to be built to suit application requirements
- Prevent unplanned downtime with predictive diagnostics and built-in protection features to help protect your investment
- Gain additional flexibility with packaging options to meet environmental protection requirements, high power cabinet and commonly used power options required for high power applications
- Help protect personnel and equipment with safety solutions up to and including PLe/SIL CL3, Cat 3 and Cat 4

The PowerFlex 750-Series is a robust family of AC drives that provide ease of use, flexibility, and performance for a variety of industrial applications. The PowerFlex 753 provides general purpose control for applications ranging up to 350 Hp and 250 kW. The PowerFlex 755 provides maximum flexibility and performance ranging up to 1350 Hp and 900 kW.

Maximize your productivity by taking advantage of the following key features offered in the PowerFlex 750-Series:

Integration with Logix – The PowerFlex 753 and 755 offer seamless integration into the Logix environment for simplified and enhanced configuration, programming, commissioning, diagnostics and maintenance. Using either Add-On Profiles or embedded instructions, you'll be able to reduce engineering time - and related costs - while improving the configuration, control and collection of data.
The option to program the drive using motor control instructions embedded in Logix controllers is exclusive to the PowerFlex 755 AC drive on EtherNet/IP. Automatic Device Configuration is another productivity-enhancing feature and is available with RSLogix 5000 V20. Now, the Logix controller can automatically detect a replaced PowerFlex 755 drive and download all configuration parameters. This eliminates the need for manual reconfiguration.

Communications – The PowerFlex 750-Series supports a comprehensive range of network protocols to ease integration into your architecture. The PowerFlex 755 features standard embedded Ethernet communication, allowing you to easily manage drive data over EtherNet/IP networks.

Safe Torque-Off and Safe Speed Monitor – These safety options provide a choice for safety levels depending on your application requirements.

DeviceLogix™ – Controls outputs and manages status information locally within the drive allowing you to operate the drive independently or complimentary to supervisory control.

Configure for your Application – Each drive has a slot-based architecture giving you the flexibility to select option cards to suit your application and expand your drive for future needs. Supported hardware control options are common for the series to help reduce your inventory and spare parts requirements.

Predictive Diagnostics – Allows the PowerFlex 750-Series to keep track of information that affects the life of drive components. PowerFlex 755 drives 315 kW/400 Hp and larger have additional standard protection features including built-in protection devices.

LISTEN. THINK. SOLVE.®

Allen-Bradley • Rockwell Software   Rockwell Automation

PowerFlex 750-Series AC Drive

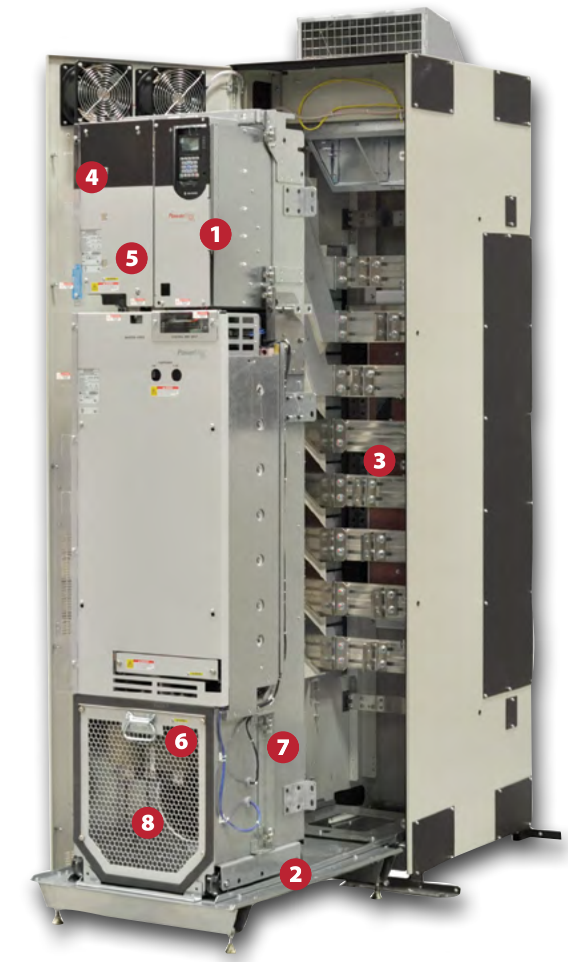
- **A** High-definition LCD display allows for six lines of text for more meaningful explanations of parameters and events
- **B** Standard I/O on the PowerFlex 753 provides a cost-effective solution
- **C** Real-time clock provides time stamped events vs. run-time data
- **D** Additional DPI for expanded programming capability
- **E** Increase safety performance levels with the Safe Speed Monitor option card which includes an embedded safety relay
- **F** Packaging options to meet application requirements
- **G** DeviceLogix embedded control technology provides function block programming for stand-alone control of basic applications
- **H** Easily configure, control and collect drive data with standard embedded Ethernet port on the PowerFlex 755
- **I** Slot-based mechanical architecture to support additional options for I/O, feedback, safety, communications and auxiliary power supply
- **J** Optional Auxiliary Power Supply maintains control and communications in event that main power is not present
- **K** Easily assessable heat sink and internal fans

PowerFlex 755 AC Drive

315…900 kW / 400…1350 Hp at 400/480V
250...1100 Hp / 200...1000 kW at 600/690V

In addition to all the options and benefits available in the PowerFlex 750-Series, the PowerFlex 755 drives 315 kW/400 Hp and larger offer added benefits for maintenance and installation flexibility.

1. Control pod is common with smaller ratings providing embedded Ethernet port and 5 slots for option modules, and can be remote mounted (up to 23 m) for hassle-free access to low voltage control
2. Roll in/out design makes the drive easy to install and service by allowing complete removal from cabinet, providing generous room for wiring behind the drive. Power wiring stays connected while unit is rolled out
3. Adjustable terminals provide flexibility for wiring preferences such as top or bottom entry
4. Integrated fusing eliminates need for separately mounted drive short circuit protection. Status is reported from the drive to ease troubleshooting
5. Replaceable surge protector reduces downtime after incoming transient voltage events. Status is reported from the drive to ease troubleshooting
6. Integrated DC link inductor enhances protection from power system events, and reduces input harmonics
7. Sealed cooling channel uses external air for main cooling, reducing contamination exposure for electronics
8. Modular construction allows fast and easy replacement of parts (e.g., main blower, capacitor assembly, circuit boards), minimizing production downtime



PowerFlex 755 Frame 8

e-Tools

RSLogix™ 5000 — Add-on Profiles

For simplified AC drive start-up and reduced development time, we've integrated Allen-Bradley PowerFlex drive configuration with RSLogix 5000 software. This single-software approach simplifies parameter and tag programming while still allowing stand - alone drive software tool use on the factory floor.

RSLogix 5000 – Embedded Instructions

The PowerFlex 755 AC drive can be configured with drive instructions embedded in Allen-Bradley ControlLogix and CompactLogix™* Programmable Automation Controllers (PAC). These are the same configuration parameters and programming instructions as those used by Allen-Bradley Kinetix® servo drives, providing a common, enhanced user experience.

DriveTools™ SP Software Suite

A powerful PC-based software suite, for programming, configuring, and troubleshooting.

- DriveExecutive™ – for online/offline configuration and management of drives and drive peripherals.
- DriveObserver™ – for real-time trending of drive information.

DriveExplorer™ Software

Allen-Bradley DriveExplorer software is an easy-to-use, cost-effective online programming tool designed for Microsoft® Windows™ 2000/XP/VISTA operating systems. It provides the user with the means to monitor and configure PowerFlex drive and communication adapter parameters.

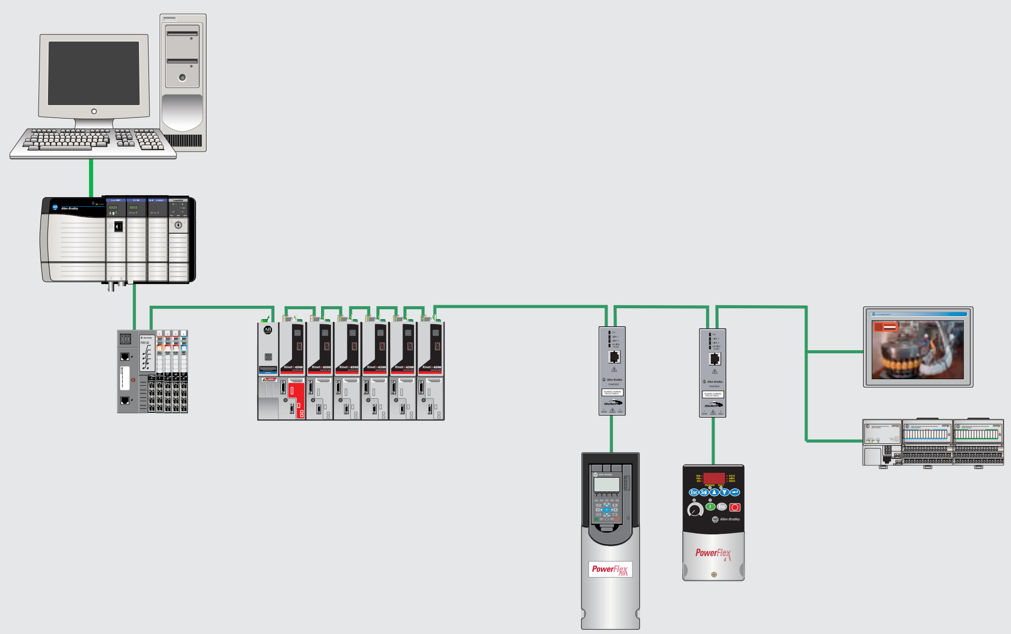
Enclosure & Ambient Operating Temperatures

Enclosure Rating	Temperature Range	Drive
Open Type Cabinet Mount IP00/IP20 & NEMA/UL Open Type	 0-50° C (32-122° F)	Frames 2-7
Extra Protection Flange Mount Front: IP00/IP20 & NEMA/UL Open Type Back: IP66 & NEMA/UL Type 4X	 0-50° C (32-122° F) 0-40° C (32-104° F)	Frames 2-7
Extra Protection Wall Mount IP54 & NEMA/UL Type 12	 0-40° C (32-104° F)	Frames 2-7
NEMA 1 Kit converts Open Type to NEMA/UL Type	 0-40° C (32-104° F)	Frames 2-7
IP20 & NEMA/UL Type 1 MCC Style	0-40° C (32-104° F)	Frames 8-9

The Powerflex 750-Series drives are available with a variety of enclosure options including IP54 (left) and an extra protection flange mount (right).

* CompactLogix integration available with RSLogix 5000 V20

EtherNet/IP–A Single Network for Complete Machine Control



Connect Your Entire Enterprise

Benefit from the EtherNet/IP network for complete machine control that simplifies and enhances machine design.

- Low cost, high performance and easy to use as compared to a multi-network architecture
- Easily integrate any PowerFlex drive, I/O, smart actuators and any other EtherNet/IP connected device
- EtherNet/IP is an established, broadly-adopted network
- The PowerFlex 755 AC drive and Kinetix 6500 servo drive can be programed with a common set of motor control instructions available in ControlLogix and CompactLogix Programmable Automation Controllers

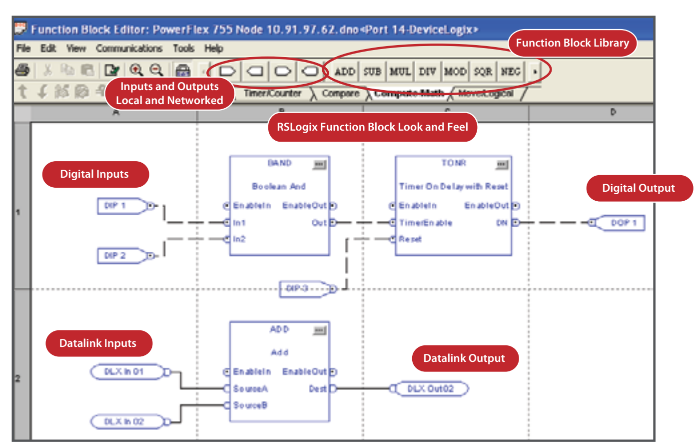
DeviceLogix™ Control Technology

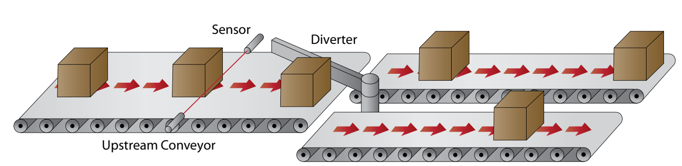
DeviceLogix control technology provides you with the flexibility to customize a drive to more closely match your application needs. DeviceLogix controls outputs and manages status information locally within the drive allowing you to operate the drive independently or complimentary to supervisory control helping to improve system performance and productivity.

You can use the PowerFlex 750-Series DeviceLogix to:

- Speed reaction time by processing in the drive–which reduces dependency on network throughput
- Provide scaling, selector switches, or other data manipulations not already built into the drive
- Read inputs/write outputs and exclusively control the drive
- Provide an option for decision making if communication is lost with main controller
- Control other PowerFlex drives via a Peer-to-Peer EtherNet/IP network

DeviceLogix is easily programmed via: RSLogix 5000, DriveExplorer v 6.01, and DriveTools SP v 5.01





Safety

The PowerFlex 750 - Series is available with two Safety options:
1. Safe Torque - Off option or
2. Safe Speed Monitor option.

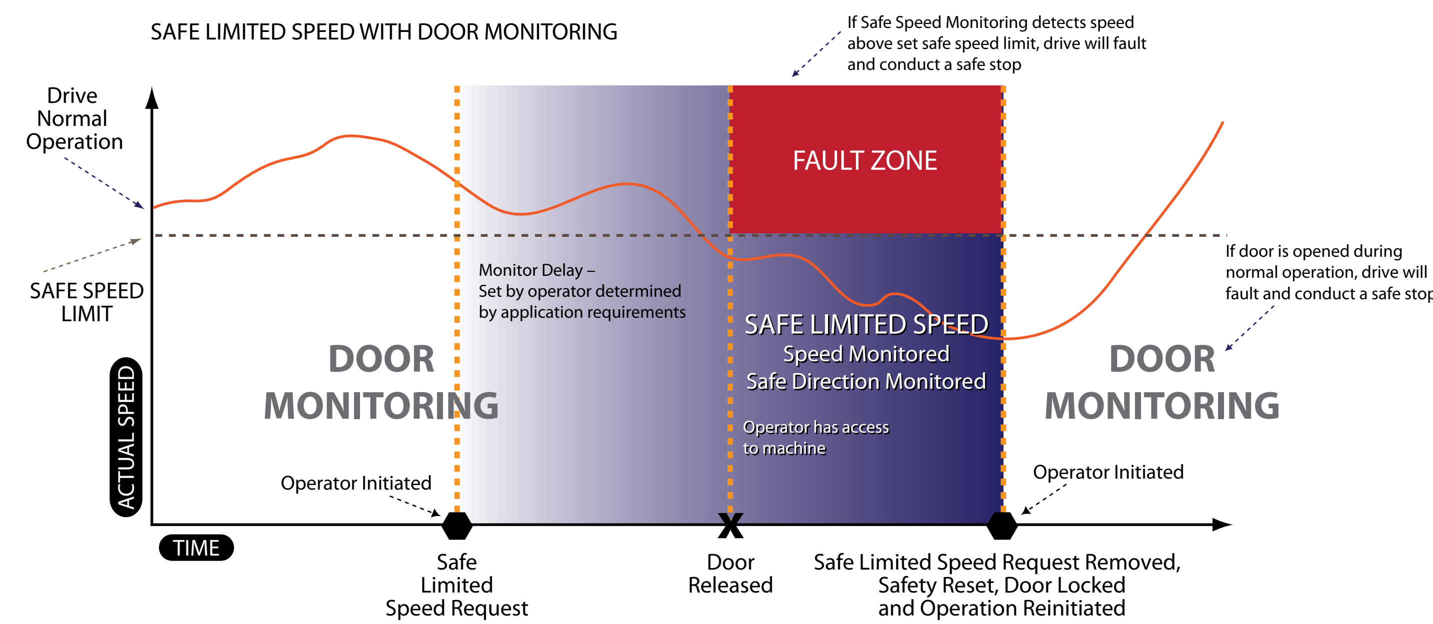
Safe Torque - Off is ideal for safety-related applications requiring removal of rotational power to the motor without removing power from the drive. Safe Torque - Off functionality offers the benefit of quick start-up after a demand on the safety system, helps reduce wear from repetitive start-up, and provides safety ratings up to and including SIL CL3, PLe, and CAT 3.

The Safe Speed Monitor provides a solution for applications that can benefit from access to a safety zone while there is limited motion. In addition, the Safe Speed Monitor has an integrated monitoring relay to save additional panel space installation labor. This option carries a safety rating up to and including SIL CL3, PLe, and Cat 4. With the Safe Speed Monitor option you can safely monitor and control the speed of your application which allows operators to perform process or maintenance work without stopping the machine.

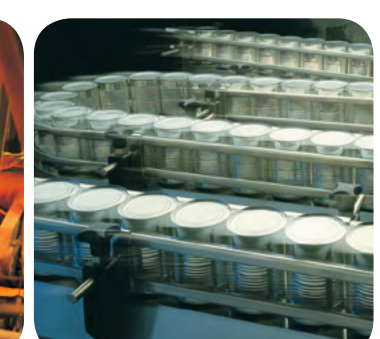
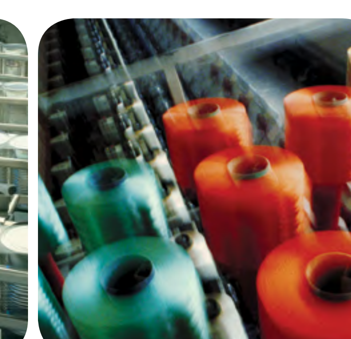
These safety options can help provide reduced downtime paired with an increase in productivity while protecting your personnel and equipment.

The Safe Speed Monitor option provides the following functionality:

- Safe Torque - Off
- Stop Categories 0, 1 and 2
- Safe Stop
- Safe Limited Speed
- Safe Maximum Speed
- Safe Maximum Acceleration
- Safe Direction
- Zero Speed Monitoring
- Door Control and Monitoring
- Enabling switch input





PowerFlex 753 AC Drive

The PowerFlex 753 is ideal for general purpose applications. Embedded I/O along with three option slots for safety, feedback, communications and additional I/O makes the drive a flexible, cost-effective solution.

PowerFlex 755 AC Drive

PowerFlex 755 is ideal for applications requiring advanced positioning, higher performance, or a higher power range. The PowerFlex 755 is easily integrated with the embedded Ethernet port and has five option slots to support additional options for feedback, I/O, safety, communications, and auxiliary 24V DC control power.

The PowerFlex 755 AC drive can be integrated with a ControlLogix or CompactLogix* Programmable Automation Controller (PAC) via drive parameters that are actually embedded in the PAC. This level of integration is specific to PowerFlex 755 drives on EtherNet/IP and allows the precise synchronization of multiple motors.

* CompactLogix integration available with RSLogix 5000 V20

	PowerFlex 753	PowerFlex 755
400/480V 600/690V	0.75…250 kW/1…350 Hp -	0.75...900 kW/1...1350 Hp 250...1100Hp / 200...1000kW
Logix Integration	• Add-on Profiles	• Embedded instructions in RSLogix 5000 • Automatic Device Configuration (RSLogix 5000 V20) • Add-on Profiles
DeviceLogix Control Technology	✓	✓
Safety Options: Safe Torque-Off, Safe Speed Monitor	✓	✓
Predictive Diagnostics	✓	✓
Option Slots	3	5
Communications	Option modules available for: • EtherNet/IP™ • ControlNet™ • DeviceNet™ • And a variety of industrial networks	Embedded Ethernet port standard Option modules available for: • ControlNet • DeviceNet • Additional modules to support variety of industrial networks
I/O	Embedded I/O standard • 3 Digital Inputs, 1 Relay Output, 1 Transistor Output, 1 Analog Input, 1 Analog Output, 1 PTC Input • Option cards for additional I/O	1 Digital Input standard • Option cards for additional I/O
Motor Types	• Induction Motors	• Induction Motors • Permanent Magnet Motors (Surface and Interior)
Positioning	• Indexing	• Indexing • PCaming • Electronic Gearing • Position/Speed Profiling
Feedback	• Incremental	• Incremental • EnDat, Hiperface, SSI and BiSS
Application Sets	Oil Well • Pump Jack & Pump Off Fibers • PJump & Traverse	Lifting • Torqprove Oil Well • Pump Jack & Pump Off Fibers • PJump & Traverse
Conformal Coating	✓	✓
ROHS Compliant Materials	✓	✓

PowerFlex 753 and PowerFlex 755 AC Drive Specifications

Frame/Rating Cross-Reference						
Frame[1]	400V AC (540V DC) Input			480V AC (650V DC) Input		
	Amps	Normal Duty kW	Heavy Duty kW	Amps	Normal Duty HP	Heavy Duty HP
2	2.1	0.75	0.75	2.1	1	1
	3.5	1.5	1.5	3.4	2	2
	5	2.2	2.2	5	3	3
	8.7	4	4	8	5	5
	11.5	5.5	5.5	11	7.5	7.5
	15.4	7.5	5.5	14	10	7.5
	22	11	7.5	22	15	10
3	30	15	11	27	20	15
	37	18.5	15	34	25	20
	43	22	18.5	40	30	25
4	60	30	22	52	40	30
	72	37	30	65	50	40
5	85	45	37	77	60	50
	104	55	45	96	75	60
6	140	75	55	125	100	75
	170	90	75	156	125	100
	205	110	90	186	150	125
	260	132	110	248	200	150
7	302	160	132	302	250	200
	367	200	160	361	300	250
	456	250	200	415	350	300

1 Frame ratings based on Open Type Cabinet mount enclosures.

PowerFlex 755 AC Drive Specifications 315 kW/400 Hp and Above

380…400V AC, Three-Phase and 540V DC Input Drives												
Frame	Light Duty				Normal Duty				Heavy Duty			
	Output Amps			kW / Hp	Output Amps			kW / Hp	Output Amps			kW / Hp
8	Cont.	1 Min.	3 Sec.	kW	Cont.	1 Min.	3 Sec.	kW	Cont.	1 Min.	3 Sec.	kW
	540	594	–	315	460	506	693	250	385	578	693	200
	585	644	–	315	540	594	821	315	456	684	821	250
	612	673	–	355	567	624	851	315	472	708	851	250
	750	825	–	400	650	715	975	355	540	810	975	315
	796	876	–	450	750	825	1125	400	585	878	1125	315
	832	915	–	450	770	847	1155	400	642	963	1155	355
9	1040	1144	–	560	910	1001	1365	500	750	1125	1365	400
	1090	1199	–	630	1040	1144	1584	560	880	1320	1584	500
	1175	1293	–	710	1090	1199	1638	630	910	1365	1638	500
	1465	1612	–	800	1175	1293	1872	710	1040	1560	1962	560
	1480	1628	–	850	1465	1612	2198	800	1090	1635	2198	630
	1600	1760	–	900	1480	1628	2220	850	1175	1763	2220	710
480V AC, Three-Phase and 650V DC Input Drives												
8	Cont.	1 Min.	3 Sec.	Hp	Cont.	1 Min.	3 Sec.	Hp	Cont.	1 Min.	3 Sec.	Hp
	485	534	–	400	430	473	666	350	370	555	666	300
	545	600	–	450	485	534	745	400	414	621	745	350
	590	649	–	500	545	600	818	450	454	681	818	350
	710	781	–	600	617	679	926	500	485	728	926	400
	765	842	–	650	710	781	1065	600	545	818	1065	450
	800	880	–	700	740	817	1110	650	617	926	1110	500
9	960	1056	–	800	800	880	1278	700	710	1065	1278	600
	1045	1150	–	900	960	1056	1440	800	795	1193	1440	700
	1135	1249	–	1000	1045	1150	1568	900	800	1200	1568	750
	1365	1502	–	1100	1135	1249	1728	1000	960	1440	1728	800
	1420	1562	–	1250	1365	1502	2048	1100	1045	1568	2043	900
	1540	1694	–	1350	1420	1562	2130	1250	1135	1703	2130	1000
600V AC, Three-Phase Drives												
8	Cont.	1 Min.	3 Sec.	Hp	Cont.	1 Min.	3 Sec.	Hp	Cont.	1 Min.	3 Sec.	Hp
	355	391	–	350	295	325	490	300	272	408	490	250
	395	435	–	400	355	391	533	350	295	443	533	300
	435	479	–	450	395	435	593	400	329	494	593	350
	460	506	–	500	435	479	639	450	355	533	639	350
	510	561	–	500	460	506	711	500	395	593	711	400
	545	600	–	550	510	561	765	500	425	638	765	450
9	630	693	–	700	595	655	918	600	510	765	918	500
	760	836	–	800	630	693	1071	700	595	893	1071	600
	835	919	–	900	760	836	1140	800	630	945	1140	700
	900	990	–	950	825	908	1260	900	700	1050	1260	750
	980	1078	–	1000	900	990	1368	950	760	1140	1368	800
	1045	1150	–	1100	980	1078	1470	1000	815	1223	1470	900
690V AC, Three-Phase Drives												
8	Cont.	1 Min.	3 Sec.	kW	Cont.	1 Min.	3 Sec.	kW	Cont.	1 Min.	3 Sec.	kW
	330	363	–	315	265	292	375	250	215	323	375	200
	370	407	–	355	330	363	473	315	265	398	473	250
	410	451	–	400	370	407	555	355	308	462	555	300
	460	506	–	450	415	457	639	400	370	555	639	355
	500	550	–	500	460	506	675	450	375	563	675	375
	530	583	–	530	500	550	750	500	413	620	750	400
9	650	715	–	630	590	649	885	560	460	690	885	450
	710	781	–	710	650	715	975	630	500	750	975	500
	790	869	–	800	710	781	1065	710	590	885	1065	560
	860	946	–	850	765	842	1170	750	650	975	1170	630
	960	1056	–	900	795	875	1350	800	750	1125	1350	710
	1020	1122	–	1000	960	1056	1440	900	795	1193	1440	800

Input Specifications

- 3-Phase Voltage: 380-480V +/- 10%
- Frequency: 47 – 63 Hz
- Logic Control Ride Through: 0.5 seconds

Output Specifications

- Voltage: Adjustable from 0V to rated motor
- Frequency Range: 0 – 650 Hz

Dimensions

Approximate Dimensions Millimeters (Inches)			
Frame	Height	Width	Depth
2	424.20 (16.7)	134.50 (5.30)	212.00 (8.35)
3	454.00 (17.87)	190.00 (7.48)	212.00 (8.35)
4	474.00 (18.66)	222.00 (8.74)	212.00 (8.35)
5	550.00 (21.65)	270.00 (10.63)	212.00 (8.35)
6	665.50 (26.20)	308.00 (12.13)	346.40 (13.64)
7	881.50 (34.70)	430.00 (16.93)	350.00 (13.78)
8	2453.0 (88.36)	600 (23.62)	600 (23.62)*
8	2453.0 (96.60)	600 (23.62)	800 (31.49)*
9	2453.0 (96.60)	1200.0 (47.20)	600.0 (23.6)*
9	2453.0 (96.60)	1200.0 (47.20)	800.0 (31.50)*

* Available in 600mm and 800mm depths to provide options based on cable entry and exit requirements. See publication PFLEX-SG002 or 750-TD001 for selection information.

Energy Savings Calculators

New energy savings calculators show you how installing a PowerFlex drive for your fan or pump applications can reduce energy costs when compared with a traditional control method.

Download the tools at:
www.rockwellautomation.com/solutions/intelligentcontrol

Drives and Motion Accelerator Toolkit

This collection of design tools can help you significantly reduce the time and cost of developing a new application using PowerFlex AC Drives and Kinetix Servo Drives. Toolkit provides sets of modules that are combined to produce:

- an initial Bill of Material
- a beginning set of CAD drawings for wiring diagrams and panel layouts
- an initial logic program written around the specific products used by the application
- initial HMI screens designed around the specific products used by the application

Download the tool at: www.ab.com/go/latools

Motion Analyzer

For applications requiring more than a constant load and steady speed, Motion Analyzer software can help by handling the necessary complex calculations.

Motion Analyzer features an easy-to-use format which can reduce design risk for speed and positioning applications that include PowerFlex drives or Kinetix servo drives.

Download the tool at:
http://ab.rockwellautomation.com/motion-control/motion-analyzer-software

www.rockwellautomation.com

Power, Control and Information Solutions Headquarters

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Publication 750-PP001C-EN-P – October 2011
Supersedes Publication 750-PP001B-EN-P – August 2010

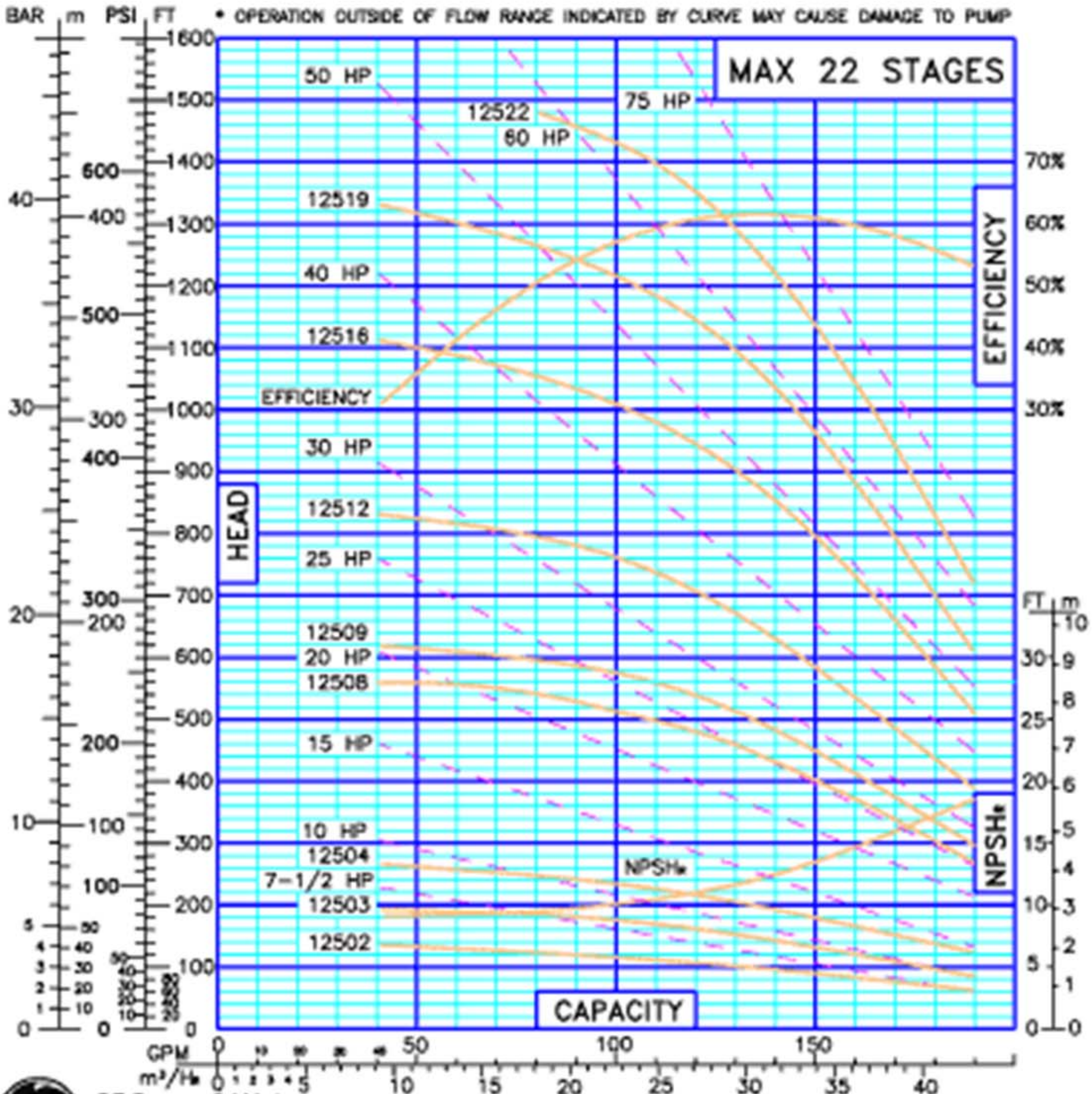
ECM 4

TONKAFLO® Pumps SERIES 12500

NORYL STAGED PUMP PERFORMANCE CURVES – 3500 RPM

CUSTOMER ______________________________ 60 Hz

MODEL ______________________________



GE Power & Water
Water & Process Technologies

HP CURVES INCLUDE BEARING FRAME

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• www.gewater.com

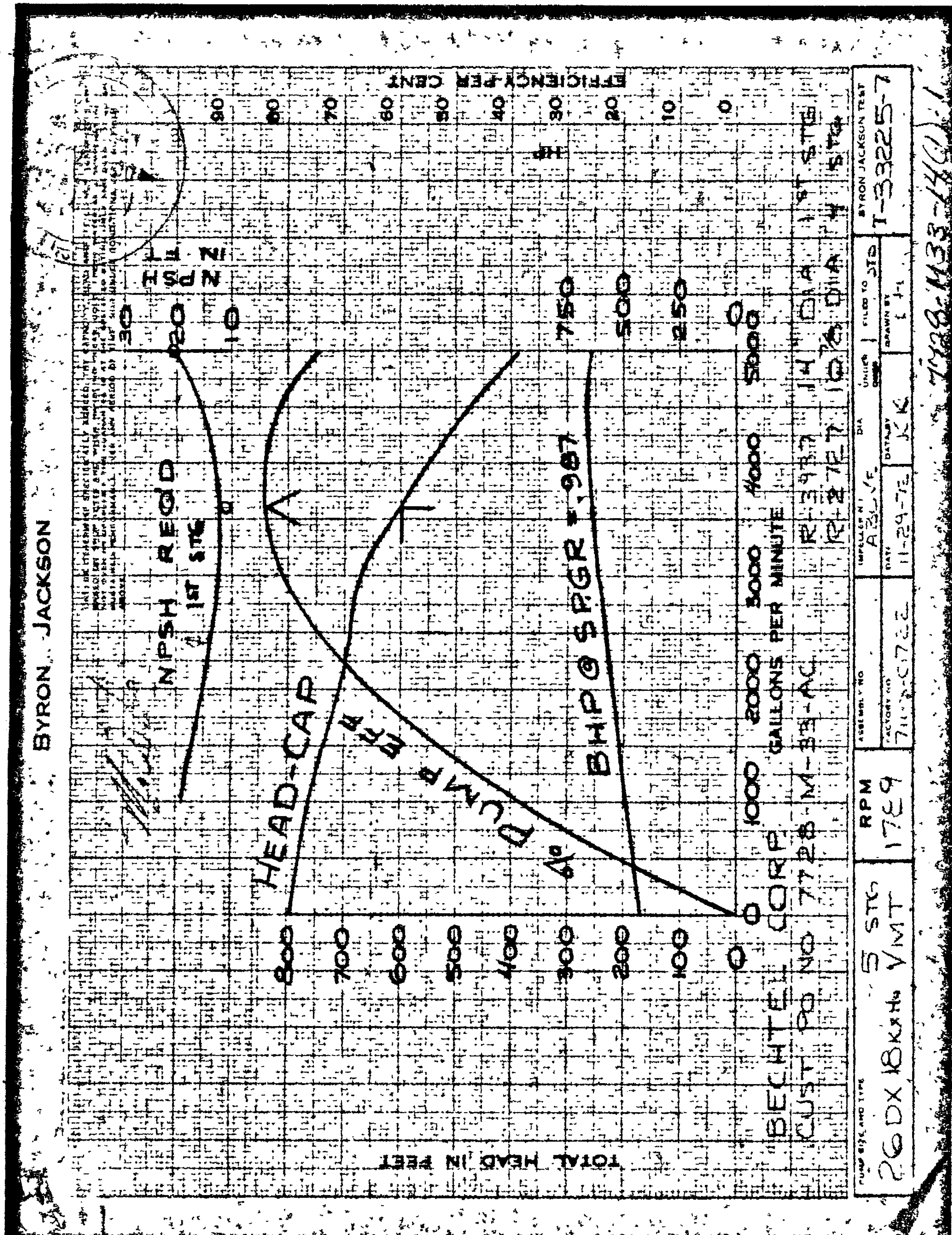
P/N 1114806 Rev 1

ECM 5

DRAWING NUMBER

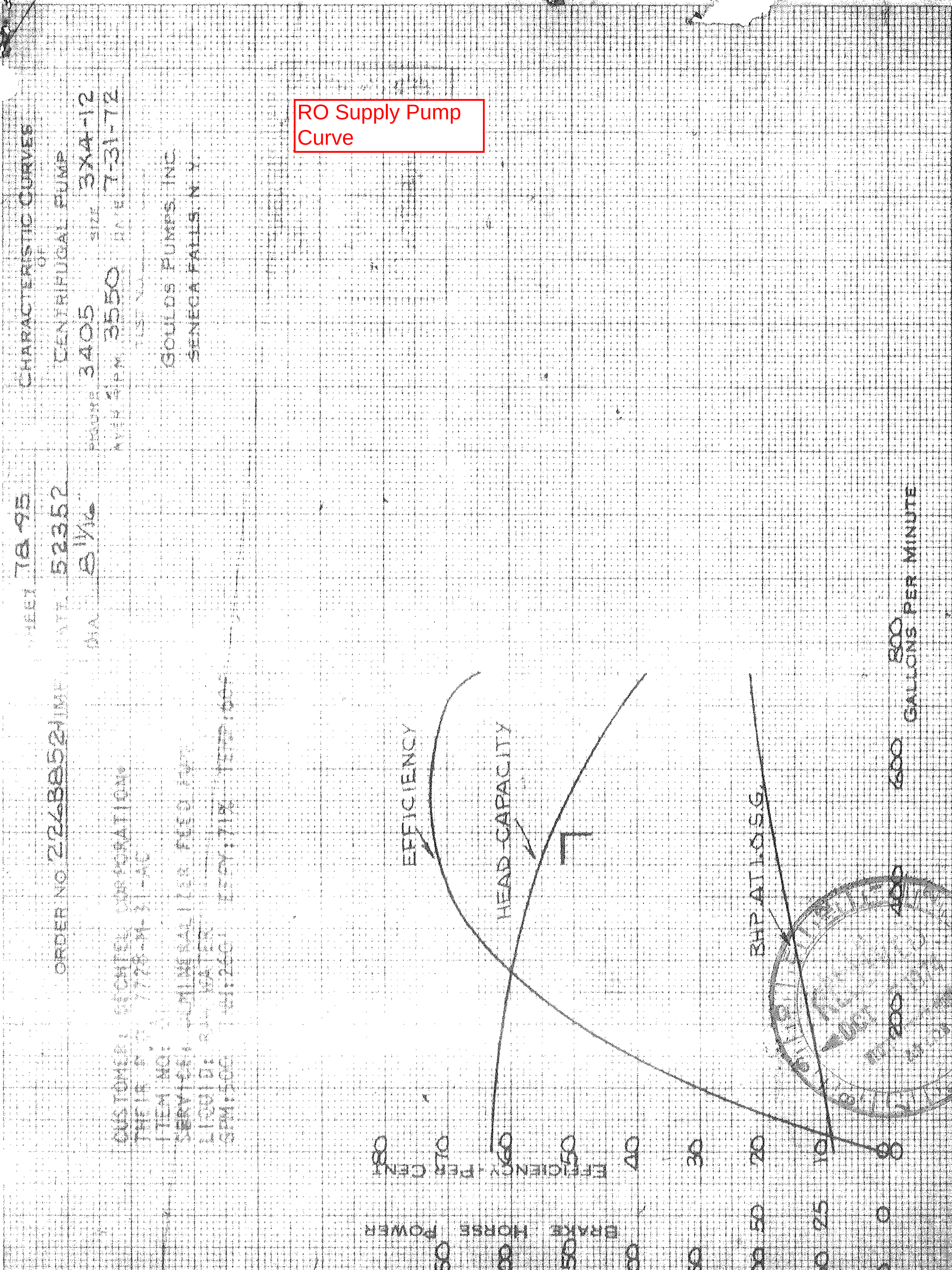
M33-14(1)-1

PLAN HOLD CORPORATION • IRVINE CALIFORNIA



ECM 7

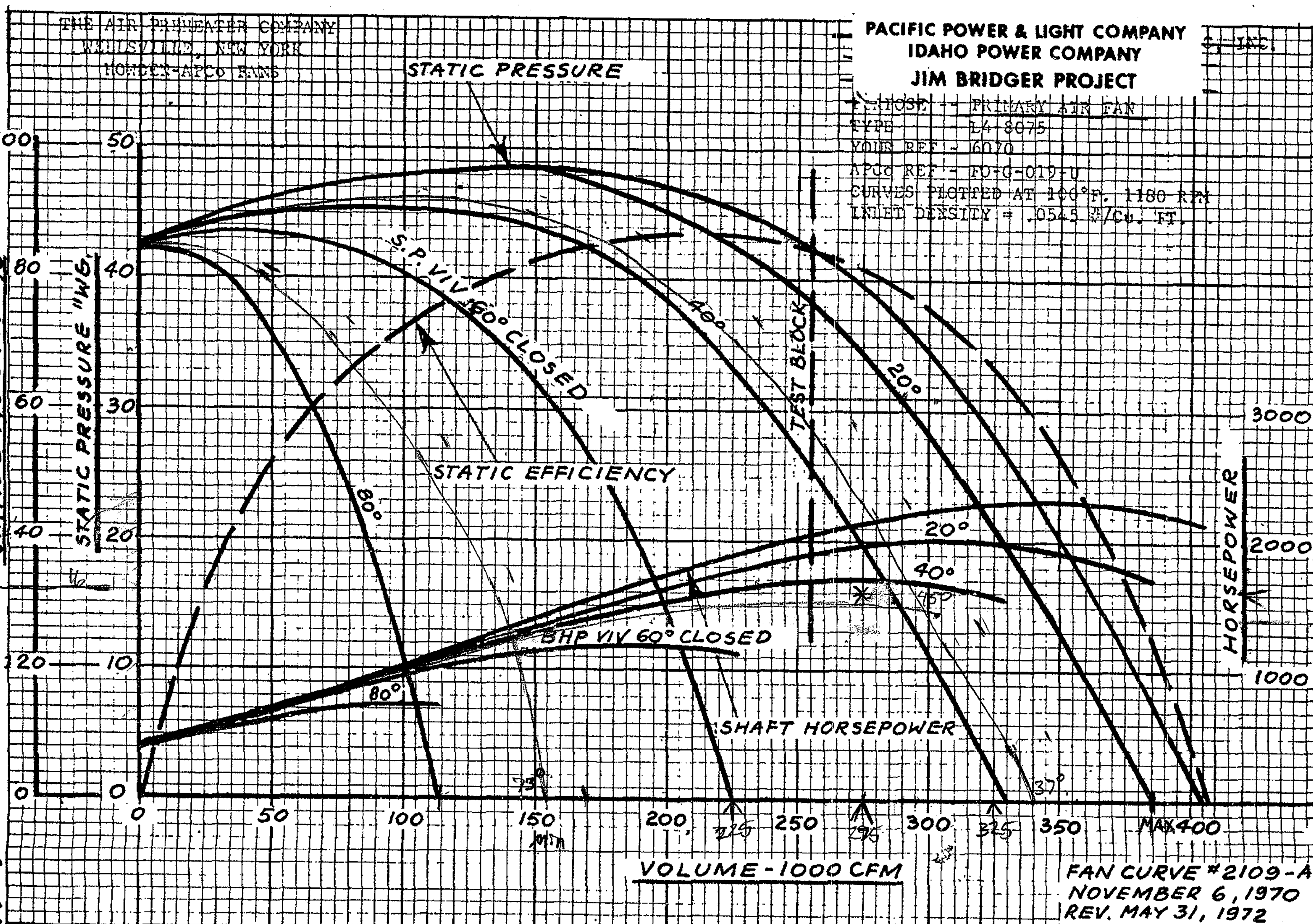
RO Supply Pump Curve



ECM 8

Primary Air Fan Curve

@31 "H_2O Max Flow = 326



UNITS 1-3 PRIMARY AIR FAN

4-40

ECM 9

Forced Draft Fan Curve

Flow Max = 770,000 CFM

Pressure Max = 15.5 "H2O

Max 170 Amps = 17° closed

Min = 81A = 80° closed

Assume PF = .8

Meff = .9

$\sqrt{3}$ 7200 (170) (PF) .85 / 1000 = KW 2046 / .9 = 2526 hp.

$\sqrt{3}$ 7200 (81) (.55) / 1000 = 554 / .9 PF = 561 KW = 752 hp

Assume .55 PF

Average Operating Discharge Pressure = 16 "H2O

Flow min = 130,000 CFM

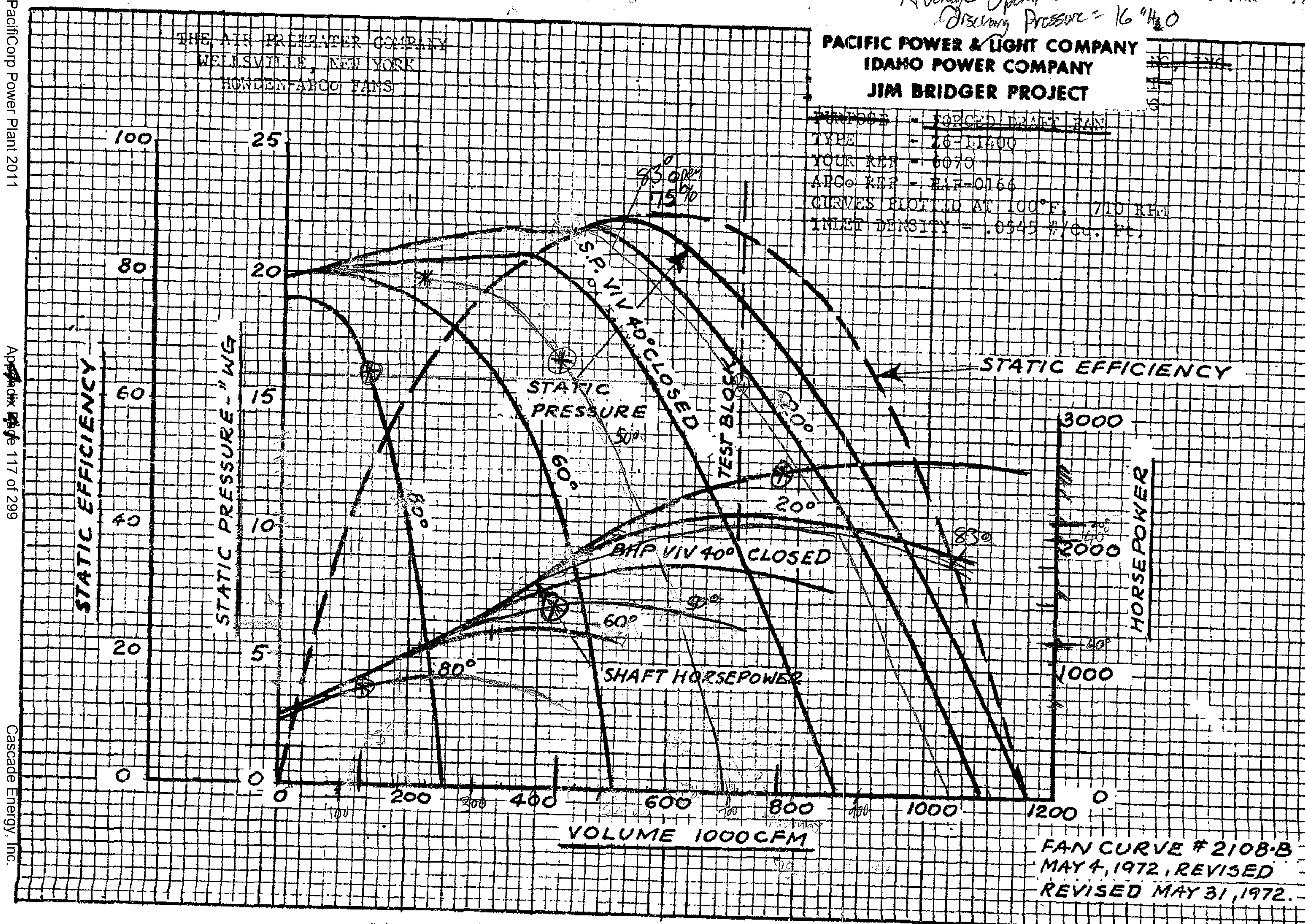
Pressure min = 16.5 "H2O

Average = 117A = 50° closed

$\sqrt{3}$ 7200 (117) (.85) / 1000 / .9 = 1053 KW = 1303 hp

Avg Flow = 430,000 CFM

Avg Pressure = 16 3/4 "H2O



UNITS 1-3 FORCED DRAFT FAN

26.4 Jim Bridger: Project Costs
ECM 1-Air Handler 4th Floor SE Corner (1VSF3)

EEM 1: Air Handler 4th Floor SE Corner (1VSF3)					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	VFD, Frame, I/O kit and Closet	Codale	1	$9,472	$9,472.00
2	Installation	Estimate	1	$3,400	$3,400
3	Cableing, control conduits, materials	Estimate	1	$2,100	$2,100
4	Programmable / smart thermostat	Johnson	1	$850	$850
5	Thermostat installation	Estimate	1	$2,500	$2,500
6	Repair Existing Mixer Controls	Estimate	1	$7,500	$7,500
7	Commissioning	Cascade	1	$900	$900
					$0
Sub-Total					$26,722
Sales Tax				0.00%	$0
Contingency				10%	$2,672.20
Total Cost:					**$29,394**

NOTE ON AIR HANDLER COSTS:
Much of the energy used by the HVAC systems today is wasted due to broken, ignored or incorrect manual settings. The HVAC ECMs, as proposed, would remove much of the manual control from the operators. However, if regular maintenance is not performed on the system, it is highly likely that energy savings will not be met for multiple ECMs. Failure of one system adversely affects others in this plant’s HVAC balance. It is strongly recommended that adequate staffing be provided to maintain the systems as designed. This includes actuators, louvers control lubrication, heating coil maintenance, thermostat calibration, filtering, and coordination of setting between systems. The energy savings from these ECMs and long term repair avoidance will more than offset the cost of a full-time HVAC maintenance person.

ECM 2- 9th Floor Fans (1VSF 1&2)

EEM 2: 9th Floor Fans (1VSF 1&2)					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	VFD, Frame, I/O kit and Closet	Codale	2	$9,472	$18,944.00
2	Installation	Estimate	2	$3,400	$6,800
3	Cableing, control conduits, materials	Estimate	2	$2,100	$4,200
4	Programmable / smart thermostat	Johnson	2	$850	$1,700
5	Thermostat installation	Estimate	2	$2,500	$5,000
6	Repair Existing Mixer Controls	Estimate	1	$7,500	$7,500
7	Commissioning	Cascade	1	$1,200	$1,200
					$0
Sub-Total					$45,344
Sales Tax				0.00%	$0
Contingency				10%	$4,534.40
Total Cost:					**$49,878**

NOTE ON AIR HANDLER COSTS:
Much of the energy used by the HVAC systems today is wasted due to broken, ignored or incorrect manual settings. The HVAC ECMs, as proposed, would remove much of the manual control from the operators. However, if regular maintenance is not performed on the system, it is highly likely that energy savings will not be met for multiple ECMs. Failure of one system adversely affects others in this plant's HVAC balance. It is strongly recommended that adequate staffing be provided to maintain the systems as designed. This includes actuators, louvers control lubrication, heating coil maintenance, thermostat calibration, filtering, and coordination of setting between systems. The energy savings from these ECMs and long term repair avoidance will more than offset the cost of a full-time HVAC maintenance person.

ECM 3- 2Chillers

EEM 3: 2 Chillers					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	On/Off controller	Johnson	2	$300	$600.00
2	Installation	Estimate	2	$1,500	$3,000
					$0
					$0
					$0
					$0
					$0
					$0
Sub-Total					$3,600
Sales Tax				0.00%	$0
Contingency				10%	$360.00
Total Cost:					**$3,960**

NOTE ON AIR HANDLER COSTS:
Much of the energy used by the HVAC systems today is wasted due to broken, ignored or incorrect manual settings. The HVAC ECMs, as proposed, would remove much of the manual control from the operators. However, if regular maintenance is not performed on the system, it is highly likely that energy savings will not be met for multiple ECMs. Failure of one system adversely affects others in this plant’s HVAC balance. It is strongly recommended that adequate staffing be provided to maintain the systems as designed. This includes actuators, louvers control lubrication, heating coil maintenance, thermostat calibration, filtering, and coordination of setting between systems. The energy savings from these ECMs and long term repair avoidance will more than offset the cost of a full-time HVAC maintenance person.

ECM 4

Jim Bridger Power Plant

Item	Product	Qty	Net (Ea)	Ext Net
50 Hp VFD RO Supply Pumps				
1	**20F11ND077AA0NNNNN** *PowerFlex 753 AC Drive, with Embedded I/O, Air Cooled, AC Input with DC Terminals, Open Type, 77 Amps, 60HP ND, 50HP HD, 480 VAC, 3 PH, Frame 5, Filtered, CM Jumper Removed, DB Transistor, Blank (No HIM)*	3	$ 6,700.09	$ 20,100.26
1.1	**20-750-NEMA1-F5** *PF750 NEMA 1 Kit, Frame 5*	3	$ 130.50	$ 391.50
1.2	**20-750-2262D-2R** *PF750 115V I/O Module 2AI,2AO,6DI,2RO*	3	$ 220.11	$ 660.33
1.3	**20-HIM-A6** *PowerFlex Architecture Class Enhanced HIM, NEMA 1*	3	$ 144.99	$ 434.96
60 Hp VFD RO Feed Pumps				
2	**20F11ND096AA0NNNNN** *PowerFlex 753 AC Drive, with Embedded I/O, Air Cooled, AC Input with DC Terminals, Open Type, 96 Amps, 75HP ND, 60HP HD, 480 VAC, 3 PH, Frame 5, Filtered, CM Jumper Removed, DB Transistor, Blank (No HIM)*	3	$ 7,776.50	$ 23,329.49
2.1	**20-750-NEMA1-F5** *PF750 NEMA 1 Kit, Frame 5*	3	$ 130.50	$ 391.50
2.2	**20-750-2262D-2R** *PF750 115V I/O Module 2AI,2AO,6DI,2RO*	3	$ 220.11	$ 660.33
2.3	**20-HIM-A6** *PowerFlex Architecture Class Enhanced HIM, NEMA 1*	3	$ 144.99	$ 434.96
Grand Total (USD): $ 46,403.33				

Vendor Quotes for
RO Feed and
Supply Pumps
Quote from Butch
Cassel Codale
307-922-5004

Product Details and Certifications

Product: 20F11ND077AA0NNNNN

Description: PowerFlex 753 AC Drive, with Embedded I/O, Air Cooled, AC Input with DC Terminals, Open Type, 77 Amps, 60HP ND, 50HP HD, 480 VAC, 3 PH, Frame 5, Filtered, CM Jumper Removed, DB Transistor, Blank (No HIM)

Representative Photo Only (actual product may vary based on configuration selections)

BASE DRIVE INFORMATION

Bulletin Number	PowerFlex 753 AC Drive, with Embedded I/O
Voltage Class	480 VAC, 3 PH
Current / Power Rating	77 Amps, 60HP ND, 50HP HD
Enclosure Type	Open Type
Input Type	AC Input with DC Terminals
Frame Size	Frame 5
Filtering & CM Cap Config	Filtered, CM Jumper Removed
Dynamic Braking	DB Transistor

ACCESSORIES

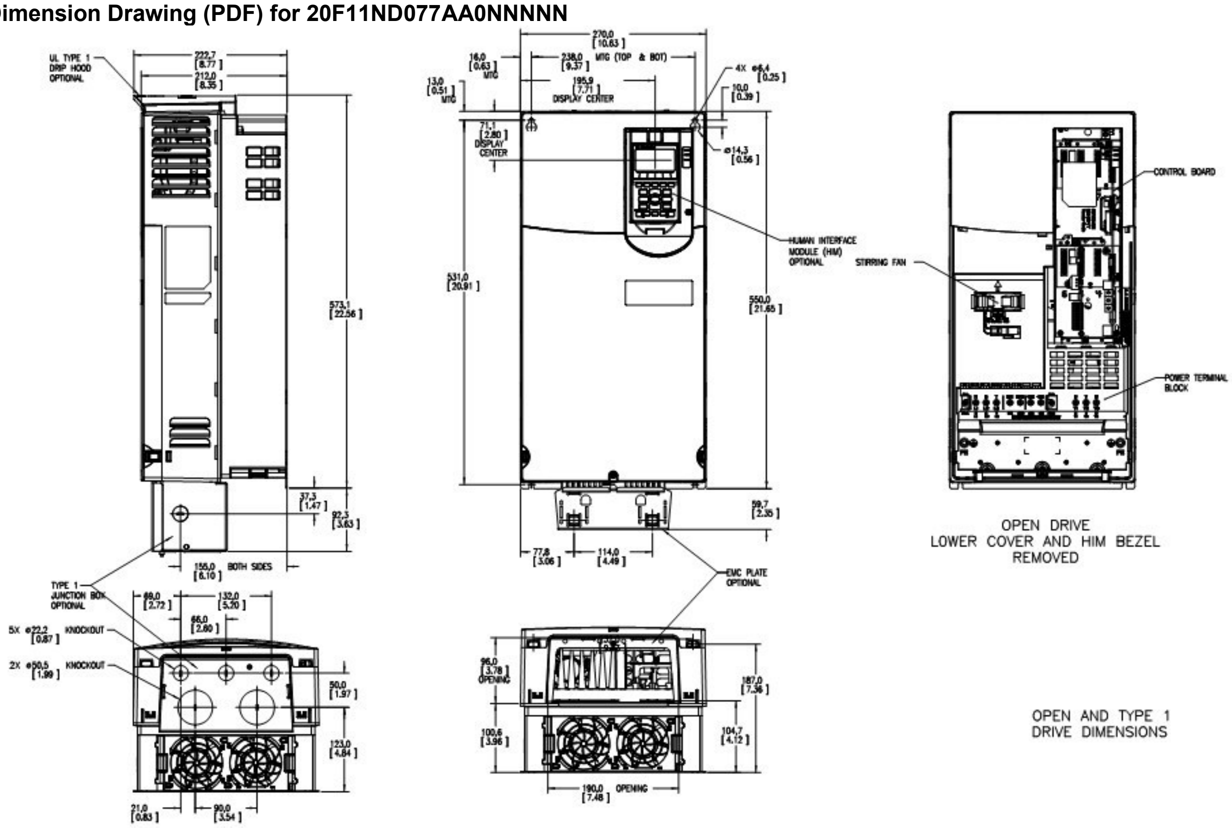
PowerFlex 750-Series Option Modules		
20-750-2262D-2R	1	PF750 115V I/O Module 2AI,2AO,6DI,2RO
20-HIM-A6	1	PowerFlex Architecture Class Enhanced HIM, NEMA 1
PowerFlex 750-Series Mechanical Accessories		
20-750-NEMA1-F5	1	PF750 NEMA 1 Kit, Frame 5

Recommended Spare Parts

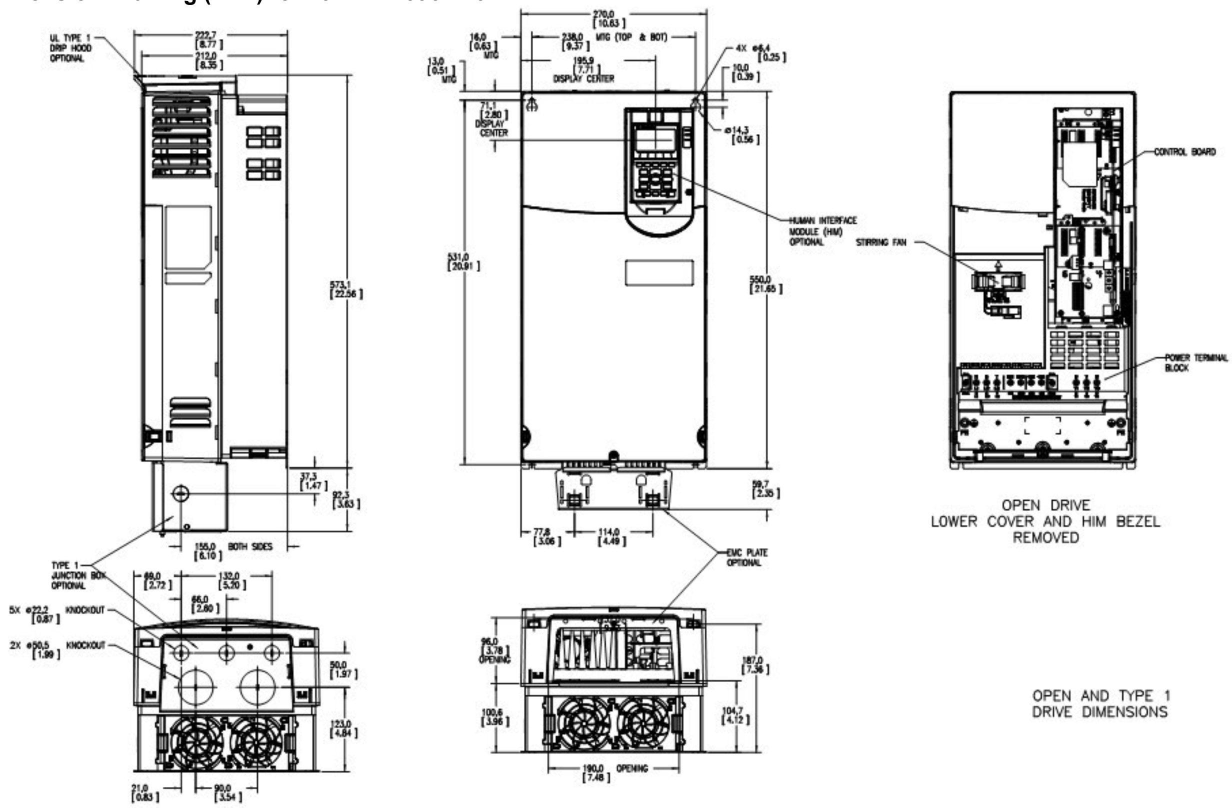
20-750-2262C-2R	1	PF750-24V I/O Module-2AI,2AO,6DI,2RO
20-750-2262D-2R	1	PF750-115V I/O Module-2AI,2AO,6DI,2RO
20-750-2263C-1R2T	1	PF750-24V I/O Module-2AI,2AO,6DI,1RO,2TO
20-750-ENC-1	1	PF750 Incremental Encoder Module
20-750-DENC-1	1	PF750 Dual Incremental Encoder Module
20-750-UFB-1	1	PF750 Universal Feedback Module
20-750-APS	1	PF750 24V Aux Power Supply Module
20-750-S	1	PF750 Safe Torque Off Module
20-750-S1	1	PF750 Safe Speed Monitor Module
20-750-FLNG1-F5	1	PF750 Flange Adapter, Type 1, Frame 5
20-750-EMC1-F5	1	PF750 EMC Plate & Cores, Frame 5
20-750-EMC2-F45	1	PF750 EMC Cores, Frames 4 and 5

20-750-NEMA1-F5	1	PF750 NEMA 1 Kit, Frame 5
20-750-CNETC	1	PF750-Series ControlNet Coax
20-750-DNET	1	PowerFlex 750-Series DeviceNet Option Card
20-750-20COMM	1	PowerFlex 750-Series 20-COMM-* Adapter Card
20-HIM-A6	1	PowerFlex Architecture Class Enhanced HIM, NEMA 1
20-HIM-C6S	1	PowerFlex Architecture Class Remote Enhanced HIM, IP66 (NEMA 4X/12) Indoor Use Only
SK-R1-MCB1-PF753	1	PF753 Main Control Board
SK-R1-TB-PF753	1	PF753 Main Control Board Terminal Blocks
SK-R1-POD1	1	PF750 Control Pod, Frames 2-7
SK-R1-BP1	1	PF750 Backplane Interface
SK-R1-CR1	1	PF750 Pod HIM Cradle
SK-R1-PC1	1	PF750 Power Interface Cable
SK-R1-PJ1-F25	1	PF750 Power Jumper Screws, Frames 2 - 5
SK-R1-TB-2262	1	PF750 2262 I/O Terminal Blocks
SK-R1-TB-APS	1	PF750 APS Terminal Block
SK-R1-TB-S	1	PF750 Safe Torque Off Terminal Block
SK-R1-TB-S1	1	PF750 Safe Speed Monitor Terminal Blocks
SK-R1-TB-ENC-1	1	PF750 Single Encoder Terminal Block
SK-R1-TB-DENC-1	1	PF750 Dual Encoder Terminal Block
SK-R1-CVR1-F5	1	PF750 Open / NEMA 1 Cover, Fr 5
SK-R9-CHSS1-F5	1	PF750 Open / NEMA 1 Chassis, Fr 5
SK-R9-FAN11-F5A	1	PF750 Open/NEMA1 HS Fan, Fr5, 480V, 75HP
SK-R9-FAN11-F5B	1	PF750 Open/NEMA1 HS Fan, Fr5, 400V, 55kW
SK-R9-FAN2-F45	1	PF750 Internal Fan Kit, Frames 4 and 5

Dimension Drawing (PDF) for 20F11ND077AA0NNNNN



Dimension Drawing (PDF) for 20F11ND096AA0NNNNN



ECM 5

Jeff Hare

From: Shearer, Tom <tom.shearer@siemens.com>
Sent: Friday, December 09, 2011 2:35 PM
To: Jeff Hare
Cc: 'DJ George'; Handrahan, Scott J

Subject: RE: Jim Bridger Medium Voltage Drives
Attachments: Synch Transfer Switchgear.xls

Importance: High

Drive Costs for ECMs 5, 8 and 9

Jeff,

Option #1: (7.2kV in/out)

All the drives need to be GenIIIE to get to 7.2kV out with an altitude of 6500ft, which puts us into an 18 cell configuration. All (1750HP, 2250HP and 700HP) will be the same price and dimensions. 121"H x 284"W x 54"D, 33,900lbs.

To add the sync transfer to the 700HP, would need a reactor and switchgear. Maybe a PLC depending on the functions. PLC adds 36" to above dims. Reactor would be outdoors and the switchgear would add 72" to the lineup as this would need to be 15kV due to altitude. You would be looking at about $123K per drive to add all this.

Budgetary Pricing Summary:

2250HP, 7.2kVin/out, 6500ft elevation = $375,000 net each
1750HP, 7.2kVin/out, 6500ft elevation = $375,000 net each
700HP, 7.2kVin/out, 6500ft elevation = $375,000 net each

Sync Transfer for the 700HP drives (includes PLC, Software, Switchgear and Reactor) = $123,000 net each per drive

We estimate 4 days of startup per drive if done individually. For budgetary purposes I would estimate about $17,110/drive which includes travel and expenses

4 day on site training for up to 5 people would be $16,000

Option #2: (7.2kVin/4.16kVout)

If we can get the voltage down into the 4KVoutput range, then we could do a smaller GenIIIe for 2250HP and a GenIV for the 1750HP and 700HP drives which would be considerably lower cost and smaller footprint.

Providing this option would eliminate the Synchronous Transfer option since the incoming voltage no longer matches the output voltage, but the cost of the drive reduces substantially to the point where putting a drive on each pump would be more cost effective.

If PacifiCorp will be open to a this option I can get something later next week.

Please call me if you have questions.

Regards,

Tom

Tom Shearer

Jeff Hare

From:	Shearer, Tom <tom.shearer@siemens.com>
Sent:	Friday, December 09, 2011 2:53 PM
To:	Shearer, Tom; Jeff Hare
Cc:	'DJ George'; Handrahan, Scott J
Subject:	RE: Jim Bridger Medium Voltage Drives

Jeff,

One thing I forgot to add to Option #2 was it would allow us to use the 12 cell design instead of the 18 cell, again reducing footprint and cost considerably.

Regards,

Drive Costs for ECMs 5, 8 and 9

Tom

Tom Shearer
West Region LDAM Manager
16101 SW 72nd Ave, Suite 130
Portland, OR 97224
503.407.2212

From: Shearer, Tom
Sent: Friday, December 09, 2011 1:35 PM
To: 'Jeff Hare'
Cc: 'DJ George'; Handrahan, Scott J
Subject: RE: Jim Bridger Medium Voltage Drives
Importance: High

Jeff,

Option #1: (7.2kV in/out)

All the drives need to be GenIIIE to get to 7.2kV out with an altitude of 6500ft, which puts us into an 18 cell configuration. All (1750HP, 2250HP and 700HP) will be the same price and dimensions. 121"H x 284"W x 54"D, 33,900lbs.

To add the sync transfer to the 700HP, would need a reactor and switchgear. Maybe a PLC depending on the functions. PLC adds 36" to above dims. Reactor would be outdoors and the switchgear would add 72" to the lineup as this would need to be 15kV due to altitude. You would be looking at about $123K per drive to add all this.

Budgetary Pricing Summary:

2250HP, 7.2kVin/out, 6500ft elevation = $375,000 net each
1750HP, 7.2kVin/out, 6500ft elevation = $375,000 net each
700HP, 7.2kVin/out, 6500ft elevation = $375,000 net each

Sync Transfer for the 700HP drives (includes PLC, Software, Switchgear and Reactor) = $123,000 net each per drive

We estimate 4 days of startup per drive if done individually. For budgetary purposes I would estimate about $17,110/drive which includes travel and expenses

Jeff Hare

From: Shearer, Tom <tom.shearer@siemens.com>
Sent: Friday, December 09, 2011 4:20 PM
To: Jeff Hare; Spencer Moore
Cc: 'DJ George'; Handrahan, Scott J
Subject: RE: Jim Bridger Medium Voltage Drives

Jeff,

The rule of thumb is 100BTU/HP.

Front access is only required on the drives so you can put them up against the wall.

I believe Dykman was going to provide motor pricing to you.

Regards,

Tom

Drive Costs for ECMs 5, 8 and 9

Tom Shearer
West Region LDAM Manager
16101 SW 72nd Ave, Suite 130
Portland, OR 97224
503.407.2212

From: Jeff Hare [mailto:jeff.hare@cascadeenergy.com]
Sent: Friday, December 09, 2011 2:53 PM
To: Shearer, Tom; Spencer Moore
Cc: 'DJ George'; Handrahan, Scott J
Subject: RE: Jim Bridger Medium Voltage Drives

Thanks Tom.

Do we have pricing for new motors?

Couple of questions.

- The BTU output for these units is about 100 BTU/100 HP is that correct?
- What is the required access around these unit, looking for the footprint required for out buildings?

CascadeEnergy

Jeff Hare
Senior Project Engineer
801-770-4332 direct
801-995-2982 *cell*

From: Shearer, Tom <tom.shearer@siemens.com>
Sent: Monday, December 12, 2011 10:26 AM
To: Jeff Hare
Cc: 'DJ George'
Subject: FW: Jim Bridger Medium Voltage Drives

Jeff,

Talking with the plant this morning they said losses are the better thing to look at. Losses for this drive are around 3.5%

HP * .746 * .35 will give you kW.

Regards,

Drive Costs for ECMs 5, 8 and 9

Tom

Tom Shearer
West Region LDAM Manager
16101 SW 72nd Ave, Suite 130
Portland, OR 97224
503.407.2212

From: Shearer, Tom
Sent: Friday, December 09, 2011 06:20 PM
To: Jeff Hare <jeff.hare@cascadeenergy.com>; Spencer Moore <spencer.moore@cascadeenergy.com>
Cc: 'DJ George' <djgeorge@dykman.com>; Handrahan, Scott J
Subject: RE: Jim Bridger Medium Voltage Drives

Jeff,

The rule of thumb is 100BTU/HP.

Front access is only required on the drives so you can put them up against the wall.

I believe Dykman was going to provide motor pricing to you.

Regards,

Tom

Tom Shearer
West Region LDAM Manager
16101 SW 72nd Ave, Suite 130
Portland, OR 97224
503.407.2212

SIEMENS

December 12, 2011

Jeff Hare
Cascade Energy
4587 West Cedar Hills Drive
Cedar Hills, UT 84062

O&M estimated cost for ECM 5, 8 and 9.

Tel: 801-770-4332
EMail: jeff.hare@cascadeenergy.com

Subject: Quote # Q000026787 - Cascade Energy 1 Visit PMA

Dear Jeff Hare,

On behalf of Siemens Customer Service group, I would like to thank you for providing us the opportunity to submit this quotation to Cascade Energy/PacifiCorp.

The following pages detail the prices, components and configurations for the service(s) outlined below:

- Fixed Price (Pre-Paid) Preventive Maintenance Services on two (2) 1750hp Gen3E VFDs, two (2) 2250hp Gen3E VFDs and two (2) 700hp Gen4 VFDs

All services are performed by factory trained and certified Field Service Representatives and our service network can be accessed at any time by calling 1-800-333-7421.

In addition to the products referenced above, we offer a complete line of services to maximize the availability of your equipment including:

- Training programs to allow you to operate and maintain your equipment at peak performance
- Refurbishment programs to replace aging materials and obsolete components
- Upgrade programs to enhance your legacy equipment with state-of-the-art features
- Startup and Commissioning to ensure the best performance from your equipment, right from the start

Should you have any questions regarding this proposal or would like additional information on our services, please feel free to contact me at 724-339-9581, your local Siemens representative, Colton Elliott, Dykman Electrical Inc at (801) 974-4440, or your Siemens Regional Service Sales Manager, Sandy Leff, at 702-804-6870.

Thank you for considering Siemens for your service needs, and we look forward to working with you in the near future.

Sincerely,

Wendy Urick
Siemens Industry, Inc.

CC: Colton Elliott, Dykman Electrical Inc
D.J. George, Dykman Electrical Inc
Sandy Leff, Siemens Industry Inc.
Tom Shearer, Siemens Industry Inc.
Scott Handrahan, Siemens Industry Inc.
Ben Ingle, Siemens Industry Inc.

Quote Price Summary and Agreement

Quote # Q000026787 - Cascade Energy 1 Visit PMA

Customer Contact

Jeff Hare
Cascade Energy
4587 West Cedar Hills Drive
Cedar Hills, UT 84062

Tel: 801-770-4332

O&M estimated cost for ECM 5, 8 and 9.

Quote Summary

Note: Where applicable, prices include a 10% discount in accordance with your contract.

Line #	Qty	Service	Description	Price
001	1	**Preventive Maintenance Services**	• Fixed Price: Pre-Paid Contract • 1 Visit Annually • Up to 9 x 10 hour days each Visit • Service Start Day: Tuesday • Service End Day: Wednesday • Includes travel time	$32,070.00
	1	**Preventive Maintenance Services Travel and Living Expenses**	• Remote Representative • Travel time included • Travel Days: 2 • Travel Start: Monday • Travel End: Thursday	Included
			Total Price for the First Year	$32,070.00

Note 1: Multi Year Option: Budgetary Fixed Pricing for fifteen (15) years as follows. Pre-Payment will be due annually at the beginning of each contract year. Please note on the Purchase Order the acceptance of the Multi Year Option.

Cascade Energy / PacifiCorp 15 Year PMA

Year	Contract Term	1 Year PMA Price
1	1/1/12 - 12/31/12	$32,070.00
2	1/1/13 - 12/31/13	$32,070.00
3	1/1/14 - 12/31/14	$32,070.00
4	1/1/15 - 12/31/15	$33,030.00
5	1/1/16 - 12/31/16	$34,020.00
6	1/1/17 - 12/31/17	$35,040.00
7	1/1/18 - 12/31/18	$36,090.00
8	1/1/19 - 12/31/19	$37,170.00
9	1/1/20 - 12/31/20	$38,285.00
10	1/1/21 - 12/31/21	$39,435.00
11	1/1/22 - 12/31/22	$40,620.00
12	1/1/23 - 12/31/23	$41,840.00
13	1/1/24 - 12/31/24	$43,095.00
14	1/1/25 - 12/31/25	$44,390.00
15	1/1/26 - 12/31/26	$45,720.00
	Fifteen Year Total	**$564,945.00**

Quote Price Summary and Agreement

Quote # Q000026787 - Cascade Energy 1 Visit PMA

Purchase Order and Payment Terms

- Payment is due Net (30 Days) from invoice date.
- Pricing is valid for 60 days from the date of proposal and assumes completion of services within 12 months from the date of proposal.
- Taxes will be assessed on the order if Customer does not provide Tax Exempt Certificate along with PO.
- The Purchase Order must have the quoted price on the order.
- For all Purchase Orders (PO) –

PO Address and Mail to:
Siemens Industry, Inc.
500 Hunt Valley Road
New Kensington, PA 15068

O&M estimated cost for ECM 5, 8 and 9.

Or you may fax the PO to 724-339-9562;
Or email the PO to Point of Contact listed below

- Freight charges will be prepaid by Siemens and added to the invoice. (If shipped collect payment will be the responsibility of the customer.)
- Point of shipment - FOB New Kensington, PA
- Customer assumes responsibility for goods upon shipment from factory.
- The attached Siemens Selling Policy for Aftermarket Services applies to all services.

General Notes

- For scheduling and coordination of services please call 800-333-7421.
- Travel time if not quoted will be billed according to the Large Drives Technical Service Rate Schedule. (These are included in PM and Training Services.)
- Travel & living expenses will be billed as outlined in the Large Drives Technical Service Rate Schedule. (These are included in PM and Training Services.)
- Additional labor hours will be billed according to the Large Drives Technical Service Rate Schedule.
- Any site-specific or safety training required will be billed to the purchaser, and pricing for scheduled services will be adjusted accordingly for these expenses.
- Any additional parts required for a service will require a change notice or separate purchase order.

Discounts

- Any services ordered while under a Blanket Purchase Order (BPO) will receive a discount of 5% on labor and 10% on parts.
- Any services ordered while under a pre-paid Preventive Maintenance Agreement (PMA) will receive a discount of 10% (if a 1-visit/year PMA) or 15% (if a 2-visit/year PMA) on labor and parts.
- Should you have a BPO and pre-paid PMA agreement with us, you will receive the greater of the two discounts offered under these agreements.
- Discounts are effective upon acceptance of the contract and receipt of payment, if applicable, and are effective for the term of the contract.

Quote Price Summary and Agreement

Quote # Q000026787 - Cascade Energy 1 Visit PMA

RESERVATION CLAUSE

Purchaser acknowledges that Siemens Industry, Inc. is required to comply with applicable export laws and regulations relating to the sale, exportation, transfer, assignment, disposal and usage of the *Preventive Maintenance Service* provided under the Contract, including any export license requirements. Purchaser agrees that such *Preventive Maintenance Service* shall not at any time directly or indirectly be used, exported, sold, transferred, assigned or otherwise disposed of in a manner which will result in non-compliance with such applicable export laws and regulations. It shall be a condition of the continuing performance by Siemens Industry, Inc. of its obligation hereunder that compliance with such export laws and regulations be maintained at all times. PURCHASER AGREES TO INDEMNIFY AND HOLD SIEMENS INDUSTRY, INC. HARMLESS FROM ANY AND ALL COSTS, LIABILITIES, PENALTIES, SANCTIONS AND FINES RELATED TO NON-COMPLIANCE WITH APPLICABLE EXPORT LAWS AND REGULATIONS."

Point of Contact

Please include the Quote # Q000026787 on all correspondence. For the purposes of this agreement, your primary point of contact will be:

Wendy Urick
Siemens Industry, Inc.
Large Drives Applications
100 Sagamore Hill Road
Pittsburgh, PA 15239 USA
Phone: 724-339-9581
Fax: 724-339-9507
E-mail: wendy.urick@siemens.com

O&M estimated cost for ECM 5, 8 and 9.

Preventive Maintenance Services

Quote # Q000026787 - Cascade Energy 1 Visit PMA

PREVENTIVE MAINTENANCE SERVICE – FIXED PRICE

Line#	Term	# of Visits	Description	Original SO#'s
001	01-JAN-2012 to 31-DEC-2012	1	Fixed Price: Pre-Paid Contract 1 Visit(s) Annually Up to 9 days each Visit Service Start Day: Tuesday Service End Day: Wednesday Includes travel time	TBD

EQUIPMENT & DETAILS

Qty	Product Type	Part # - Serial #
4	Robicon > Medium Voltage > GEN 3E Harmony Series, Air Cooled, 18 Cells	TBD - 1750hp TBD - 1750hp TBD - 2250hp TBD - 2250hp
2	Robicon > Medium Voltage > GEN 4 Harmony Series, Air Cooled, 15 Cells	TBD - 700hp TBD - 700hp

SITE LOCATION

PacifiCorp – Jim Bridger Plant
8 miles NE of Point of Rocks
Point of Rocks, WY 82942

O&M estimated cost for ECM 5, 8 and 9.

Important Notes

1. For pre-paid agreements, an invoice for services will be submitted upon acceptance of the contract. Payment must be received prior to scheduling the Siemens FSR.
2. Fixed price agreements are guaranteed not to fluctuate for the scope of services quoted herein, unless additional time is needed to complete the services due to circumstances beyond Siemens control.
3. Fixed price agreements include re-starting the drive upon completion of the PM service. Should the customer elect to postpone the startup to a later date, then the customer will be responsible for all travel and living expenses associated therewith.
4. Siemens and Customer shall work cooperatively in scheduling on-site activities, provide full access to the equipment while it is being serviced, and make an operator available during the final test and tuning phases.
5. Customer shall schedule the service at least 8 weeks in advance of the desired dates. Otherwise, Siemens reserves the right to adjust pricing.
6. Additional time needed to complete the PM services due to circumstances beyond Siemens control will be charged at the applicable rates as listed in the Siemens Large Drives Technical Service Rate Schedule (see attached).

ECM 6- Turbine Room Fan and Mixer Bank

EEM 6: Turbine Room Fan and Mixer Bank					
Item	**Description**	**Bidder**	**Qty.**	**Unit**	**Total**
1	Repair Existing Mixer Controls	Estimate	1	$2,500	$2,500.00
2	Replace Gravity Louvers w/ Auto	Johnson	14	$2,550	$35,700
3	Repair Heating Coils	Estimate	7	$1,500	$10,500
4	New Digital Controllers	Johnson	7	$2,800	$19,600
5	VFD, Frame, I/O kit, Controls	Codale	7	$3,125	$21,875
6	New wiring and conduit, misc. material	Estimate	7	$650	$4,550
7	Programable / smart thermostat	Johnson	3	$850	$2,550
8	Thermostat installation	Estimate	3	$2,500	$7,500
9	Commisssioning	Cascade	1	$1,500	$1,500
Sub-Total					$106,275
Sales Tax				0.00%	$0
Contingency				10%	$10,627.50
Total Cost:					**$116,903**

NOTE ON AIR HANDLER COSTS:
Much of the energy used by the HVAC systems today is wasted due to broken, ignored or incorrect manual settings. The HVAC ECMs, as proposed, would remove much of the manual control from the operators. However, if regular maintenance is not performed on the system, it is highly likely that energy savings will not be met for multiple ECMs. Failure of one system adversely affects others in this plant’s HVAC balance. It is strongly recommended that adequate staffing be provided to maintain the systems as designed. This includes actuators, louvers control lubrication, heating coil maintenance, thermostat calibration, filtering, and coordination of setting between systems. The energy savings from these ECMs and long term repair avoidance will more than offset the cost of a full-time HVAC maintenance person.

ECM 7

Jim Bridger Power Plant

Item	Product	Qty	Net (Ea)	Ext Net
50 Hp VFD RO Supply Pumps				
1	**20F11ND077AA0NNNNN** *PowerFlex 753 AC Drive, with Embedded I/O, Air Cooled, AC Input with DC Terminals, Open Type, 77 Amps, 60HP ND, 50HP HD, 480 VAC, 3 PH, Frame 5, Filtered, CM Jumper Removed, DB Transistor, Blank (No HIM)*	3	$ 6,700.09	$ 20,100.26
1.1	**20-750-NEMA1-F5** *PF750 NEMA 1 Kit, Frame 5*	3	$ 130.50	$ 391.50
1.2	**20-750-2262D-2R** *PF750 115V I/O Module 2AI,2AO,6DI,2RO*	3	$ 220.11	$ 660.33
1.3	**20-HIM-A6** *PowerFlex Architecture Class Enhanced HIM, NEMA 1*	3	$ 144.99	$ 434.96
60 Hp VFD RO Feed Pumps				
2	**20F11ND096AA0NNNNN** *PowerFlex 753 AC Drive, with Embedded I/O, Air Cooled, AC Input with DC Terminals, Open Type, 96 Amps, 75HP ND, 60HP HD, 480 VAC, 3 PH, Frame 5, Filtered, CM Jumper Removed, DB Transistor, Blank (No HIM)*	3	$ 7,776.50	$ 23,329.49
2.1	**20-750-NEMA1-F5** *PF750 NEMA 1 Kit, Frame 5*	3	$ 130.50	$ 391.50
2.2	**20-750-2262D-2R** *PF750 115V I/O Module 2AI,2AO,6DI,2RO*	3	$ 220.11	$ 660.33
2.3	**20-HIM-A6** *PowerFlex Architecture Class Enhanced HIM, NEMA 1*	3	$ 144.99	$ 434.96
Grand Total (USD): $ 46,403.33				

Vendor Quotes for
RO Feed and
Supply Pumps
Quote from Butch
Cassel Codale
307-922-5004

Product Details and Certifications

Product: 20F11ND077AA0NNNNN

Description: PowerFlex 753 AC Drive, with Embedded I/O, Air Cooled, AC Input with DC Terminals, Open Type, 77 Amps, 60HP ND, 50HP HD, 480 VAC, 3 PH, Frame 5, Filtered, CM Jumper Removed, DB Transistor, Blank (No HIM)

Representative Photo Only (actual product may vary based on configuration selections)

BASE DRIVE INFORMATION

Bulletin Number	PowerFlex 753 AC Drive, with Embedded I/O
Voltage Class	480 VAC, 3 PH
Current / Power Rating	77 Amps, 60HP ND, 50HP HD
Enclosure Type	Open Type
Input Type	AC Input with DC Terminals
Frame Size	Frame 5
Filtering & CM Cap Config	Filtered, CM Jumper Removed
Dynamic Braking	DB Transistor

ACCESSORIES

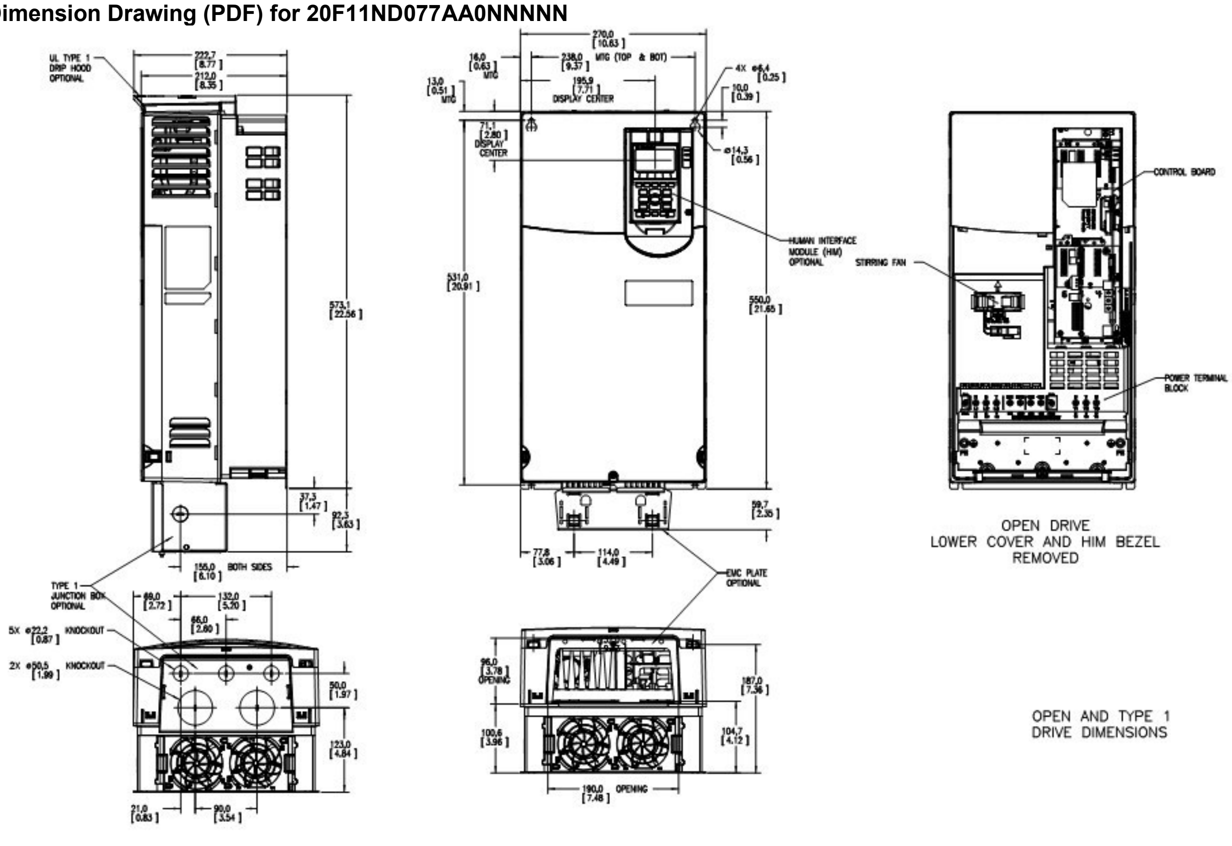
PowerFlex 750-Series Option Modules		
20-750-2262D-2R	1	PF750 115V I/O Module 2AI,2AO,6DI,2RO
20-HIM-A6	1	PowerFlex Architecture Class Enhanced HIM, NEMA 1
PowerFlex 750-Series Mechanical Accessories		
20-750-NEMA1-F5	1	PF750 NEMA 1 Kit, Frame 5

Recommended Spare Parts

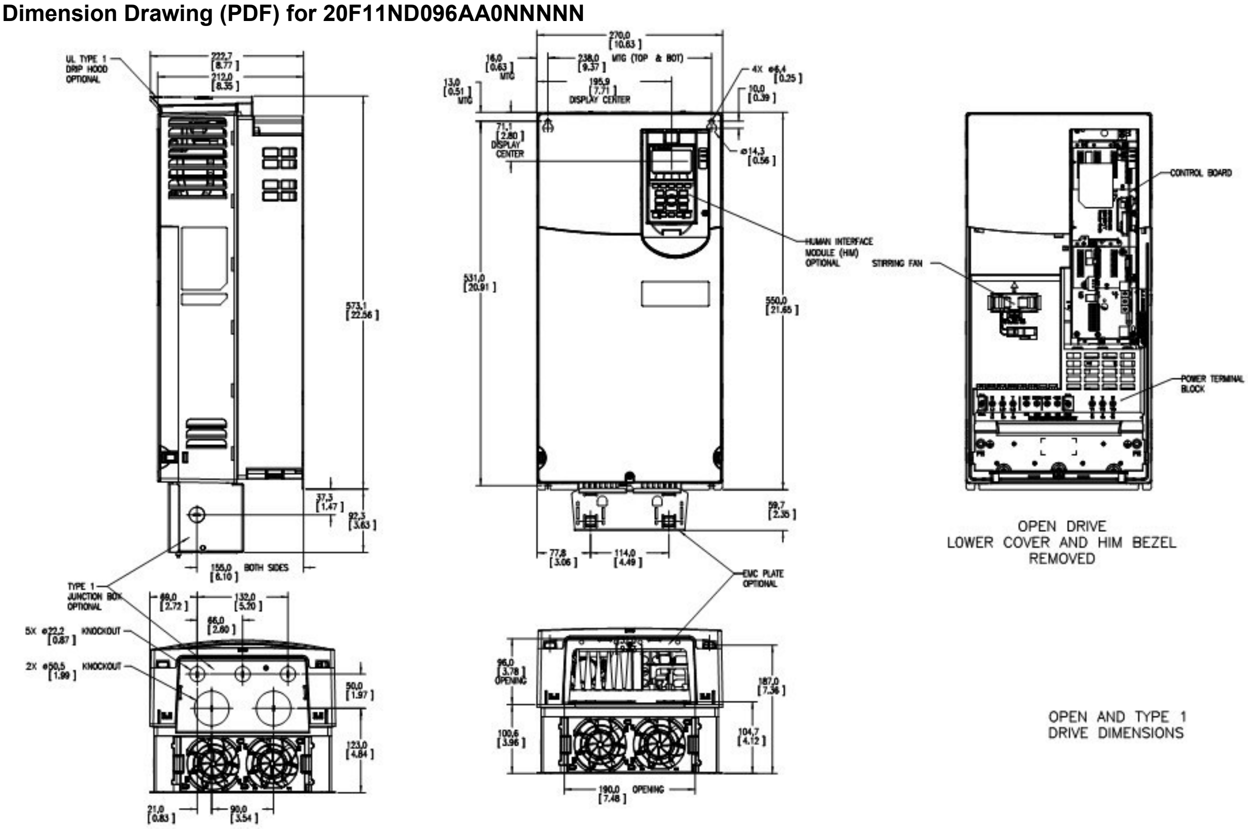
20-750-2262C-2R	1	PF750-24V I/O Module-2AI,2AO,6DI,2RO
20-750-2262D-2R	1	PF750-115V I/O Module-2AI,2AO,6DI,2RO
20-750-2263C-1R2T	1	PF750-24V I/O Module-2AI,2AO,6DI,1RO,2TO
20-750-ENC-1	1	PF750 Incremental Encoder Module
20-750-DENC-1	1	PF750 Dual Incremental Encoder Module
20-750-UFB-1	1	PF750 Universal Feedback Module
20-750-APS	1	PF750 24V Aux Power Supply Module
20-750-S	1	PF750 Safe Torque Off Module
20-750-S1	1	PF750 Safe Speed Monitor Module
20-750-FLNG1-F5	1	PF750 Flange Adapter, Type 1, Frame 5
20-750-EMC1-F5	1	PF750 EMC Plate & Cores, Frame 5
20-750-EMC2-F45	1	PF750 EMC Cores, Frames 4 and 5

20-750-NEMA1-F5	1	PF750 NEMA 1 Kit, Frame 5
20-750-CNETC	1	PF750-Series ControlNet Coax
20-750-DNET	1	PowerFlex 750-Series DeviceNet Option Card
20-750-20COMM	1	PowerFlex 750-Series 20-COMM-* Adapter Card
20-HIM-A6	1	PowerFlex Architecture Class Enhanced HIM, NEMA 1
20-HIM-C6S	1	PowerFlex Architecture Class Remote Enhanced HIM, IP66 (NEMA 4X/12) Indoor Use Only
SK-R1-MCB1-PF753	1	PF753 Main Control Board
SK-R1-TB-PF753	1	PF753 Main Control Board Terminal Blocks
SK-R1-POD1	1	PF750 Control Pod, Frames 2-7
SK-R1-BP1	1	PF750 Backplane Interface
SK-R1-CR1	1	PF750 Pod HIM Cradle
SK-R1-PC1	1	PF750 Power Interface Cable
SK-R1-PJ1-F25	1	PF750 Power Jumper Screws, Frames 2 - 5
SK-R1-TB-2262	1	PF750 2262 I/O Terminal Blocks
SK-R1-TB-APS	1	PF750 APS Terminal Block
SK-R1-TB-S	1	PF750 Safe Torque Off Terminal Block
SK-R1-TB-S1	1	PF750 Safe Speed Monitor Terminal Blocks
SK-R1-TB-ENC-1	1	PF750 Single Encoder Terminal Block
SK-R1-TB-DENC-1	1	PF750 Dual Encoder Terminal Block
SK-R1-CVR1-F5	1	PF750 Open / NEMA 1 Cover, Fr 5
SK-R9-CHSS1-F5	1	PF750 Open / NEMA 1 Chassis, Fr 5
SK-R9-FAN11-F5A	1	PF750 Open/NEMA1 HS Fan, Fr5, 480V, 75HP
SK-R9-FAN11-F5B	1	PF750 Open/NEMA1 HS Fan, Fr5, 400V, 55kW
SK-R9-FAN2-F45	1	PF750 Internal Fan Kit, Frames 4 and 5

Dimension Drawing (PDF) for 20F11ND077AA0NNNNN



Dimension Drawing (PDF) for 20F11ND096AA0NNNNN



ECM 10

Project Costs Estimation Table						
	Qty	Mat Unit	Tot Mat	Lab Unit	Tot Lab	Controls
MHPS-100W-HIDLF	1290	$ 200	$ 258,000	$ 100	$ 129,000	
FLT8CEE-32W x 2L x 4'-CEE IS CEE N	8	$ 75	$ 600	$ 50	$ 400	
MHPS-175W-HIDLF	8	$ 200	$ 1,600	$ 100	$ 800	
FLT5HO-54W x 4L x 4'-RS/PRS H	187	$ 200	$ 37,400	$ 100	$ 18,700	
FLT8CEE-32W x 2L x 4'-CEE IS CEE L	88	$ 75	$ 6,600	$ 50	$ 4,400	
FLT8CEE-32W x 3L x 4'-CEE IS CEE L	135	$ 75	$ 10,125	$ 50	$ 6,750	
FLT8CEE-32W x 4L x 4'-CEE IS CEE L	173	$ 75	$ 12,975	$ 50	$ 8,650	
FLT8CEE-32W x 4L x 4'-CEE IS CEE H	74	$ 75	$ 5,550	$ 50	$ 3,700	
FLT8CEE-32W x 2L x 4'-CEE IS CEE H	269	$ 75	$ 20,175	$ 50	$ 13,450	
MHPS-320W-HIDLF	106	$ 200	$ 21,200	$ 100	$ 10,600	
FLT5HO-54W x 10L x 4'-3 RS/PRS H	52	$ 400	$ 20,800	$ 100	$ 5,200	
Totals	2390		$ 395,025		$ 201,650	81400
Materials	$ 395,025					
Labor	$ 201,650					
Other	$ 81,400					

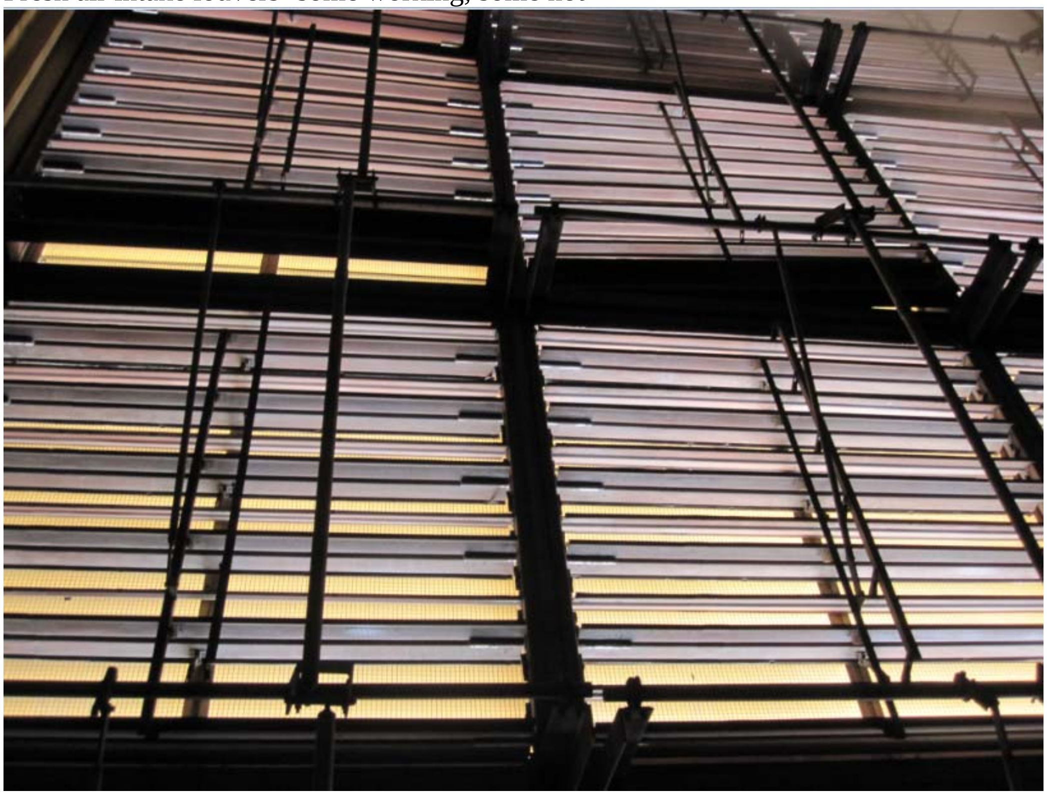
26.5 Jim Bridger: Pictures

ECM 2- 9th Floor Fans (1VSF 1&2)

Fan intake inside mixer room

Manual control panel

Fresh air intake louvers- some working, some not

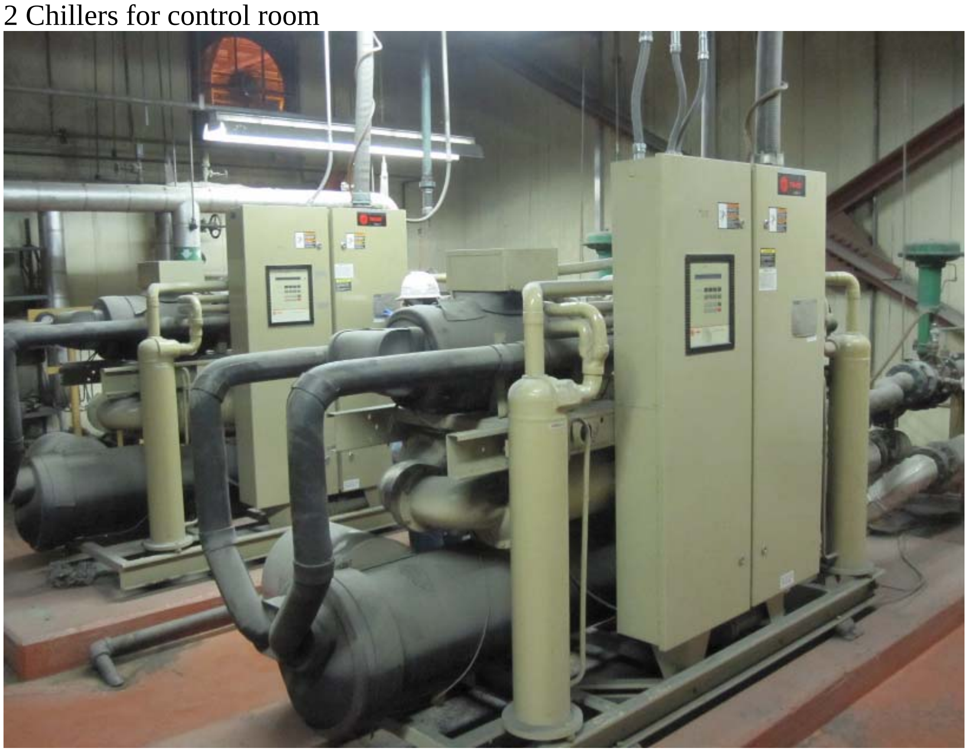


Electric controller (prone to freezing)

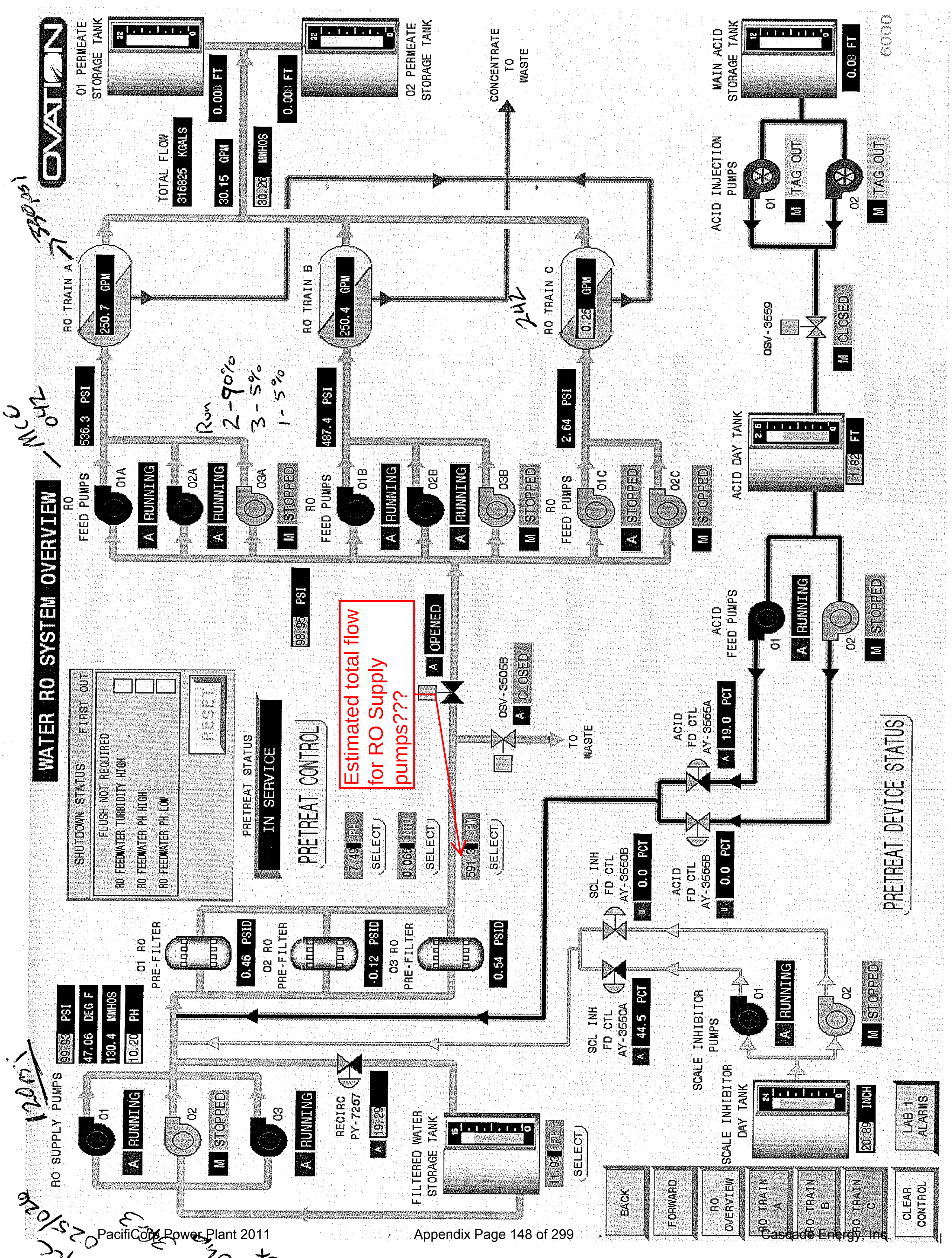
Intake Louvers for warm, recycled air

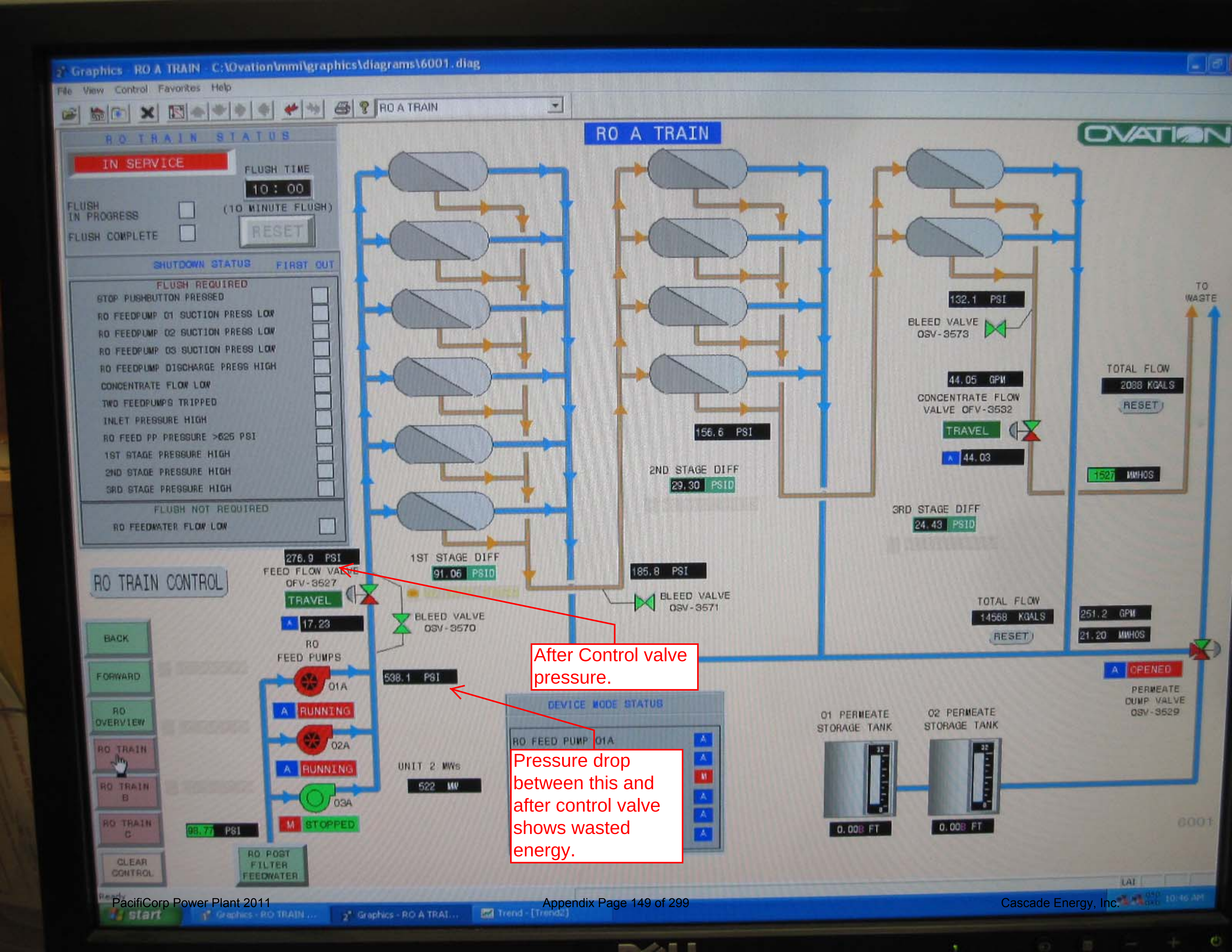
ECM 3- 2Chillers

2 Chillers for control room

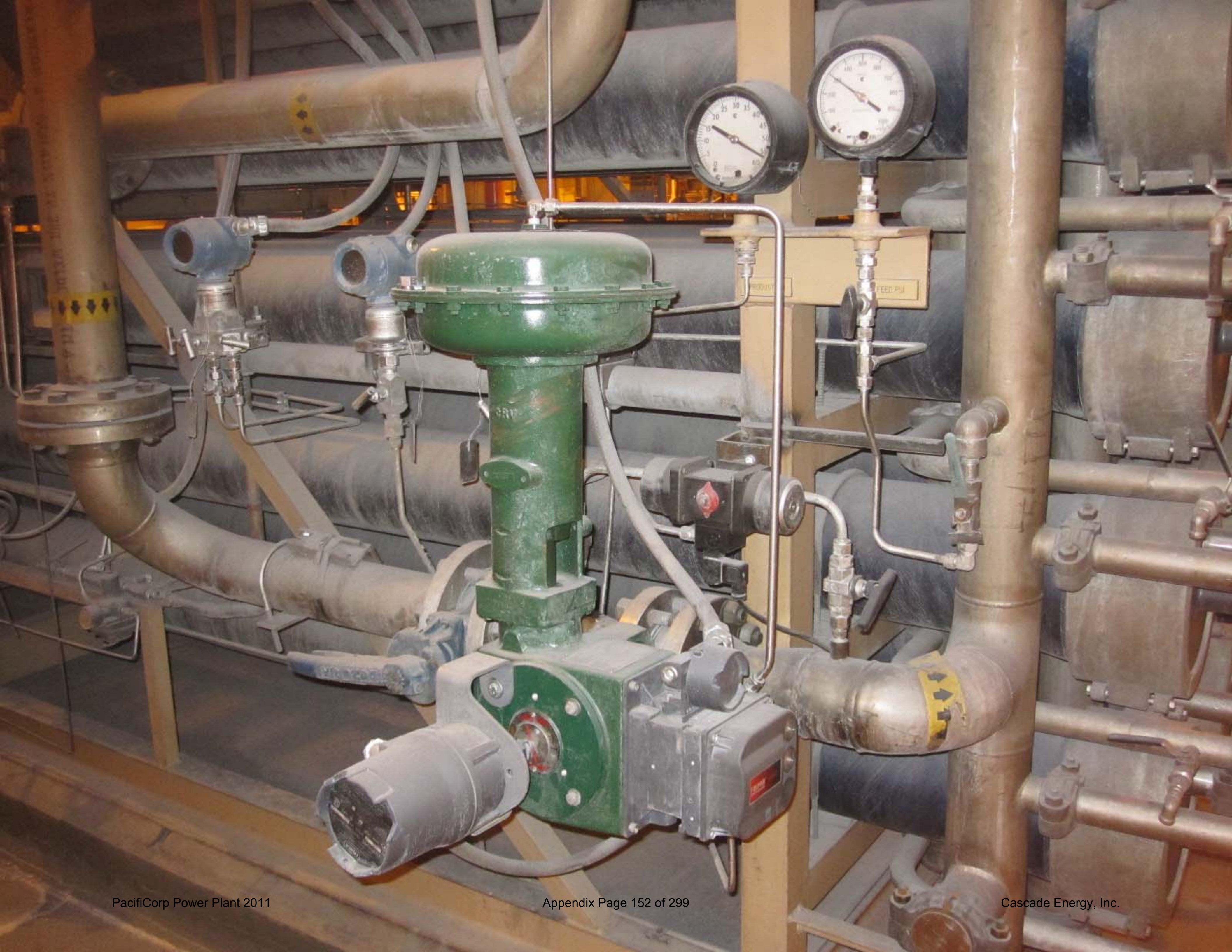


ECM 4

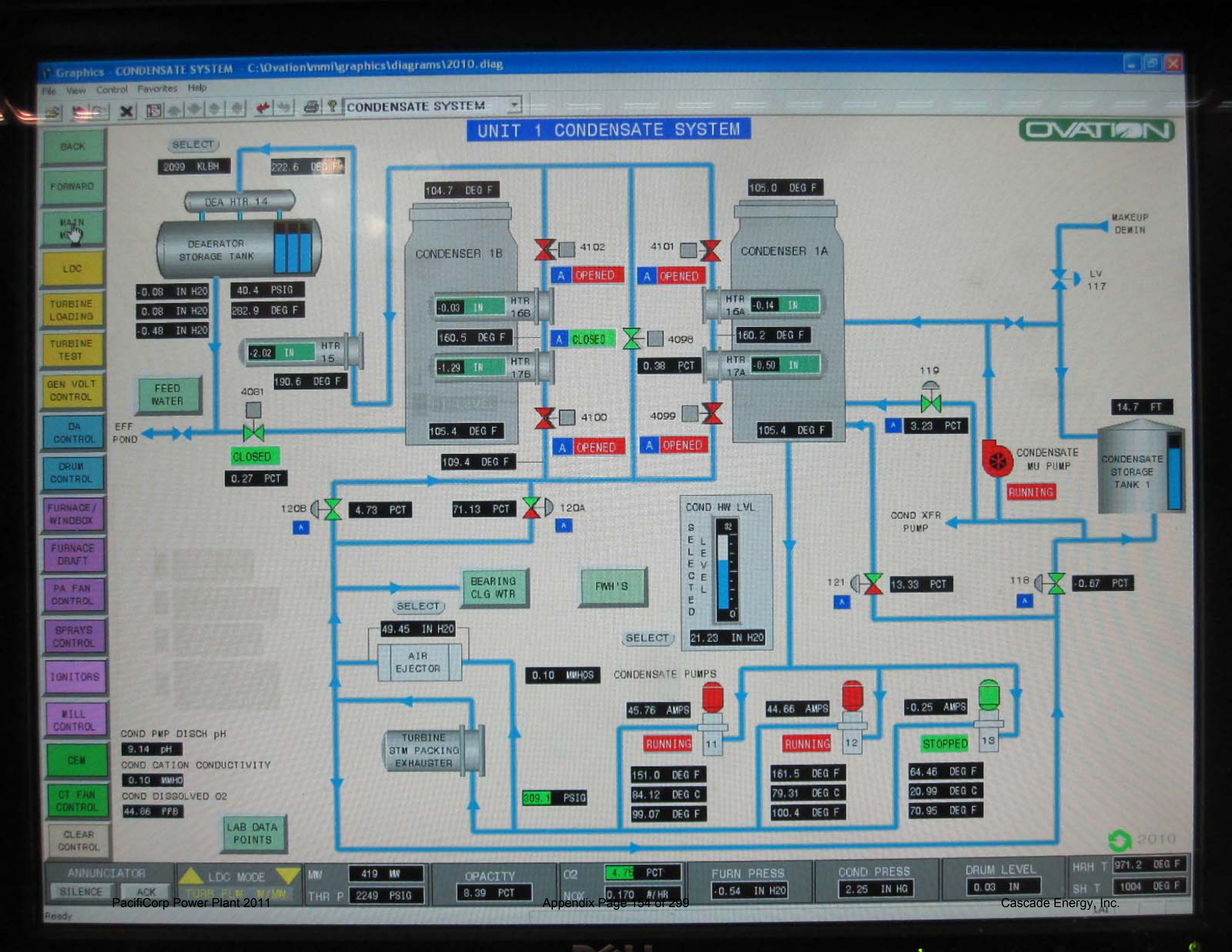

WATER RO SYSTEM OVERVIEW
OVATION
SHUTDOWN STATUS
FIRST OUT
FLUSH NOT REQUIRED
RO FEEDWATER TURBIDITY HIGH
RO FEEDWATER PH HIGH
RO FEEDWATER PH LOW
RESET
PRETREAT STATUS
IN SERVICE
PRETREAT CONTROL
7.49 PH
0.066 NTU
591.3 GPM
SELECT
Estimated total flow for RO Supply pumps???
RO SUPPLY PUMPS
01 RUNNING
02 STOPPED
03 RUNNING
99.93 PSI
47.06 DEG F
130.4 MMHOS
10.20 PH
RECIRC PY-7267
19.28
FILTERED WATER STORAGE TANK
11.93 FT
01 RO PRE-FILTER
0.46 PSID
02 RO PRE-FILTER
-0.12 PSID
03 RO PRE-FILTER
0.54 PSID
98.95 PSI
OPENED
OSV-3505B
CLOSED
TO WASTE
RO FEED PUMPS
01A RUNNING
02A RUNNING
03A STOPPED
01B RUNNING
02B RUNNING
03B STOPPED
01C STOPPED
02C STOPPED
536.3 PSI
487.4 PSI
2.64 PSI
RO TRAIN A
250.7 GPM
RO TRAIN B
250.4 GPM
RO TRAIN C
0.25 GPM
TOTAL FLOW
316825 KGALS
30.15 GPM
30.23 MMHOS
01 PERMEATE STORAGE TANK
0.008 FT
02 PERMEATE STORAGE TANK
0.009 FT
CONCENTRATE TO WASTE
MAIN ACID STORAGE TANK
0.08 FT
ACID INJECTION PUMPS
01 TAG OUT
02 TAG OUT
OSV-3559
CLOSED
ACID DAY TANK
1.82 FT
ACID FEED PUMPS
01 RUNNING
02 STOPPED
ACID FD CTL AY-3565A
19.0 PCT
ACID FD CTL AY-3565B
0.0 PCT
SCL INH FD CTL AY-3550B
0.0 PCT
SCL INH FD CTL AY-3550A
44.5 PCT
SCALE INHIBITOR PUMPS
01 RUNNING
02 STOPPED
SCALE INHIBITOR DAY TANK
20.89 INCH
PRETREAT DEVICE STATUS
LAB 1 ALARMS
BACK
FORWARD
RO OVERVIEW
RO TRAIN A
RO TRAIN B
RO TRAIN C
CLEAR CONTROL
6000
Run 2-90% 3-5% 1-5%
242
MCC 025/026
CT 52Wing E3


Graphics - RO A TRAIN - C:\Ovation\mmi\graphics\diagrams\6001.diag
File View Control Favorites Help
RO A TRAIN
OVATION
RO TRAIN STATUS
IN SERVICE
FLUSH TIME
10 : 00
(10 MINUTE FLUSH)
FLUSH IN PROGRESS
FLUSH COMPLETE
RESET
SHUTDOWN STATUS
FIRST OUT
FLUSH REQUIRED
STOP PUSHBUTTON PRESSED
RO FEEDPUMP 01 SUCTION PRESS LOW
RO FEEDPUMP 02 SUCTION PRESS LOW
RO FEEDPUMP 03 SUCTION PRESS LOW
RO FEEDPUMP DISCHARGE PRESS HIGH
CONCENTRATE FLOW LOW
TWO FEEDPUMPS TRIPPED
INLET PRESSURE HIGH
RO FEED PP PRESSURE >525 PSI
1ST STAGE PRESSURE HIGH
2ND STAGE PRESSURE HIGH
3RD STAGE PRESSURE HIGH
FLUSH NOT REQUIRED
RO FEEDWATER FLOW LOW
RO TRAIN CONTROL
BACK
FORWARD
RO OVERVIEW
RO TRAIN
RO TRAIN B
RO TRAIN C
CLEAR CONTROL
276.9 PSI
FEED FLOW VALVE OFV-3527
TRAVEL
17.23
RO FEED PUMPS
01A
RUNNING
02A
RUNNING
03A
STOPPED
98.77 PSI
RO POST FILTER FEEDWATER
BLEED VALVE OSV-3570
538.1 PSI
UNIT 2 MWs
522 MW
1ST STAGE DIFF
91.06 PSID
185.8 PSI
BLEED VALVE OSV-3571
156.6 PSI
2ND STAGE DIFF
29.30 PSID
132.1 PSI
BLEED VALVE OSV-3573
44.05 GPM
CONCENTRATE FLOW VALVE OFV-3532
TRAVEL
44.03
3RD STAGE DIFF
24.43 PSID
TO WASTE
TOTAL FLOW
2088 KGALS
RESET
1527 MMHOS
TOTAL FLOW
14568 KGALS
RESET
251.2 GPM
21.20 MMHOS
OPENED
PERMEATE DUMP VALVE OSV-3529
DEVICE MODE STATUS
RO FEED PUMP 01A
01 PERMEATE STORAGE TANK
02 PERMEATE STORAGE TANK
0.008 FT
0.008 FT
6001
After Control valve pressure.
Pressure drop between this and after control valve shows wasted energy.


RO 01A FEED PUMP
RO 02A FEED PUMP
WATER & POWER TECHNOLOGIES, INC.



ECM 5

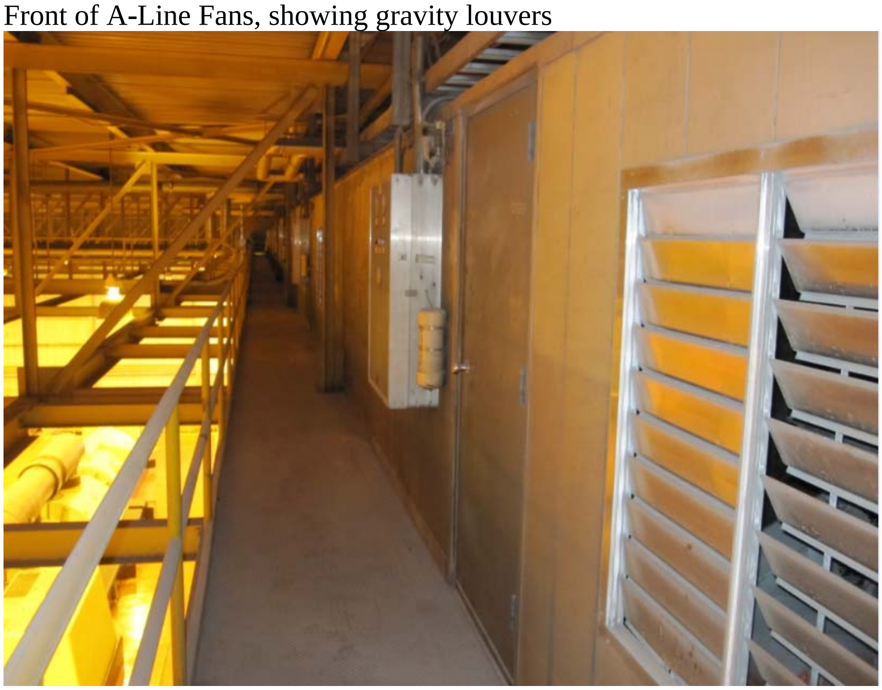

Graphics - CONDENSATE SYSTEM C:\Ovation\mmi\graphics\diagrams\2010.diag
File View Control Favorites Help
CONDENSATE SYSTEM
UNIT 1 CONDENSATE SYSTEM
OVATION
BACK
FORWARD
LDC
TURBINE LOADING
TURBINE TEST
GEN VOLT CONTROL
DA CONTROL
DRUM CONTROL
FURNACE/ WINDBOX
FURNACE DRAFT
PA FAN CONTROL
SPRAYS CONTROL
IGNITORS
MILL CONTROL
CEM
CT FAN CONTROL
CLEAR CONTROL
SELECT
2099 KLBH
222.6 DEG F
DEA HTR 14
DEAERATOR STORAGE TANK
-0.08 IN H20
0.08 IN H20
-0.48 IN H20
40.4 PSIG
282.9 DEG F
-2.02 IN
HTR 15
190.6 DEG F
FEED WATER
4081
EFF POND
CLOSED
0.27 PCT
104.7 DEG F
CONDENSER 1B
-0.03 IN
HTR 16B
160.5 DEG F
-1.29 IN
HTR 17B
105.4 DEG F
109.4 DEG F
4102
4101
OPENED
4098
CLOSED
0.38 PCT
4100
4099
105.0 DEG F
CONDENSER 1A
HTR 16A
-0.14 IN
160.2 DEG F
HTR 17A
-0.50 IN
105.4 DEG F
MAKEUP DEMIN
LV 117
119
3.23 PCT
14.7 FT
CONDENSATE MU PUMP
RUNNING
CONDENSATE STORAGE TANK 1
COND XFR PUMP
120B
4.73 PCT
71.13 PCT
120A
COND HW LVL
SELECTED LEVEL
32
0
21.23 IN H20
121
13.33 PCT
118
-0.67 PCT
BEARING CLG WTR
FWH'S
49.45 IN H20
AIR EJECTOR
0.10 MMHOS
CONDENSATE PUMPS
45.76 AMPS
44.66 AMPS
-0.25 AMPS
RUNNING
RUNNING
STOPPED
11
12
13
151.0 DEG F
84.12 DEG C
99.07 DEG F
161.5 DEG F
79.31 DEG C
100.4 DEG F
64.46 DEG F
20.99 DEG C
70.95 DEG F
TURBINE STM PACKING EXHAUSTER
309.1 PSIG
COND PMP DISCH pH
9.14 pH
COND CATION CONDUCTIVITY
0.10 MMHO
COND DISSOLVED O2
44.86 PPB
LAB DATA POINTS
2010
ANNUNCIATOR
SILENCE
ACK
LDC MODE
MW
419 MW
THR P
2249 PSIG
OPACITY
8.39 PCT
O2
4.76 PCT
NOX
0.170 #/HR
FURN PRESS
-0.54 IN H20
COND PRESS
2.25 IN HG
DRUM LEVEL
0.03 IN
HRH T
971.2 DEG F
SH T
1004 DEG F
Ready

Condensate Pump
control valves

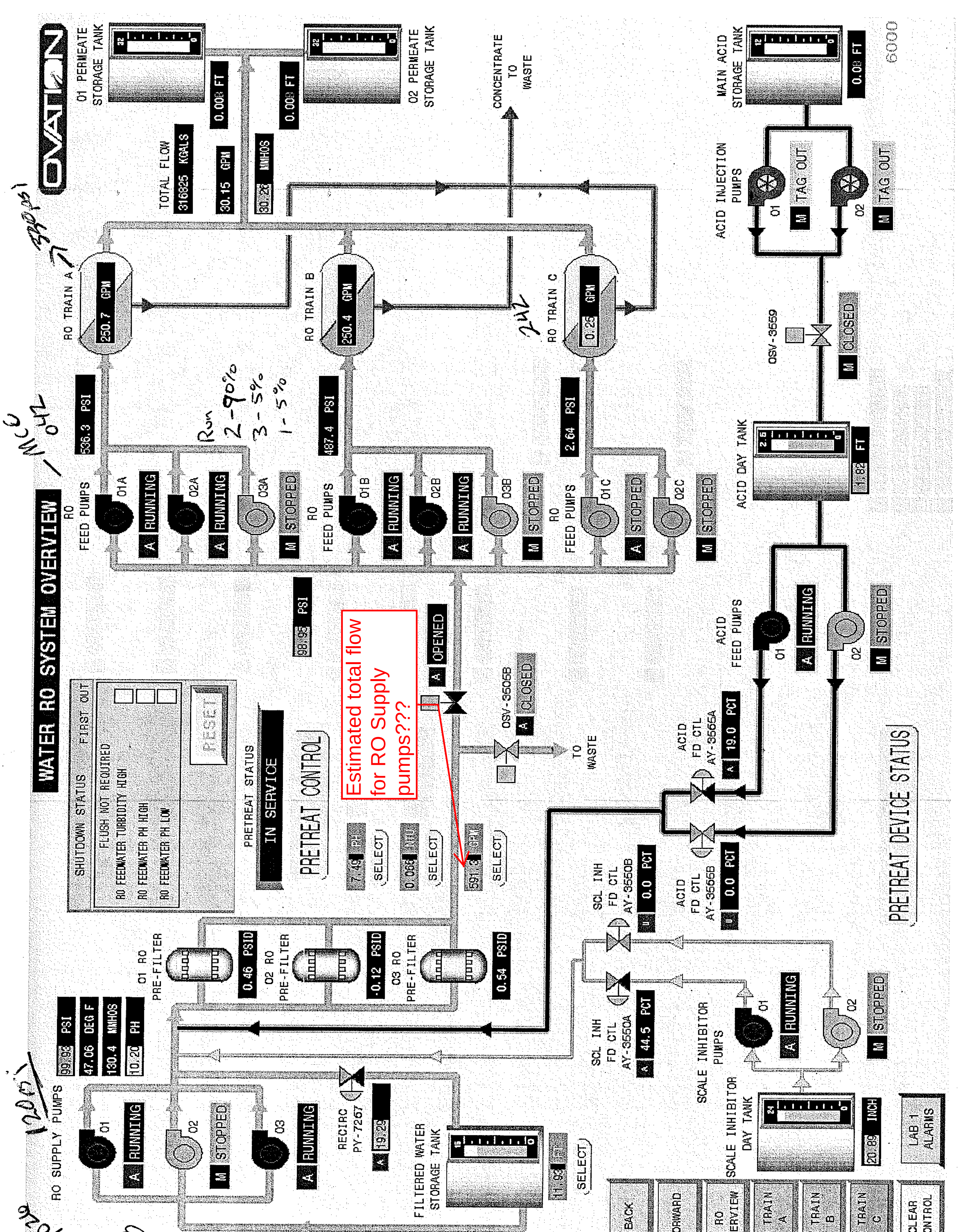
ECM 6- Turbine Room Fan and Mixer Bank

Typical fan of 14 fans in bank

Front of A-Line Fans, showing gravity louvers

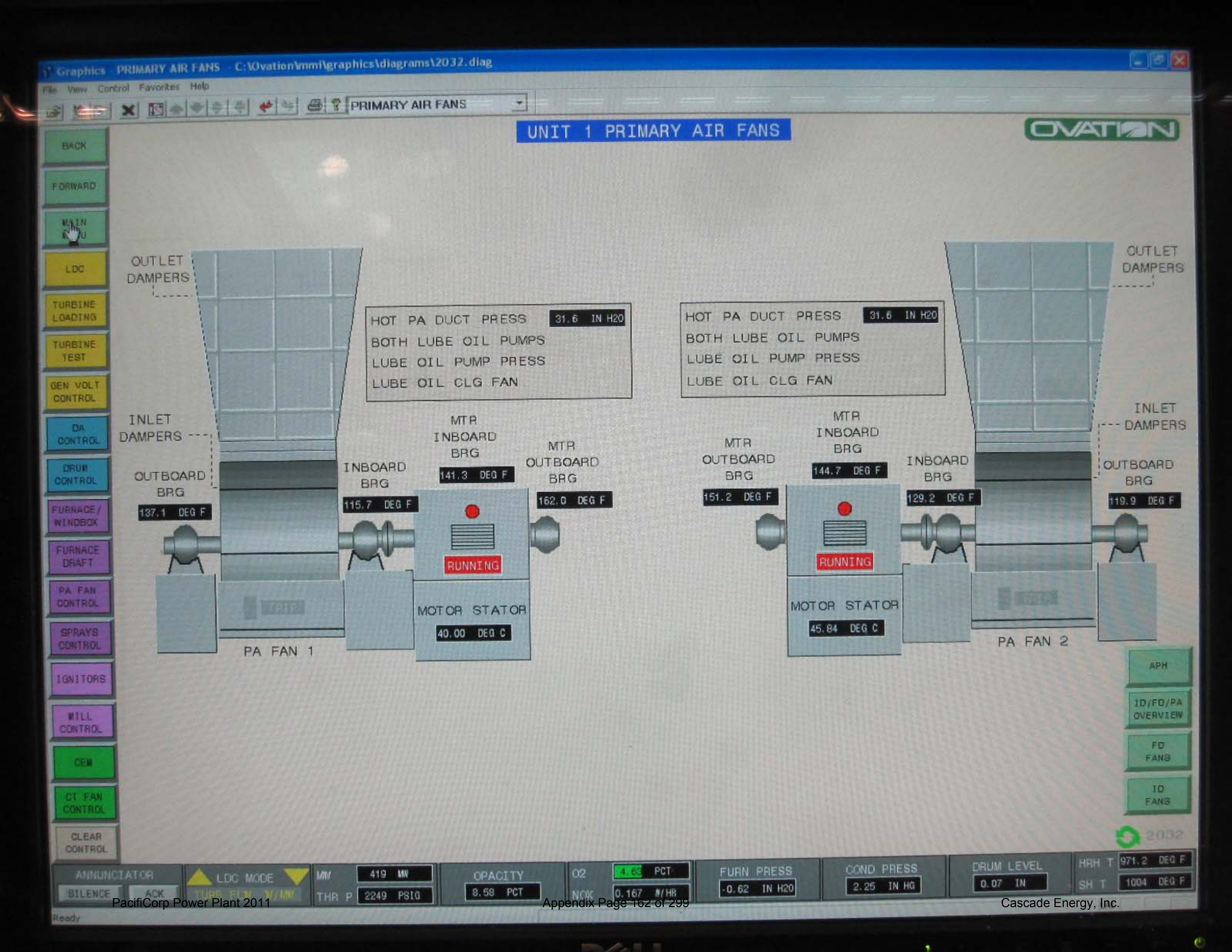


ECM 7


WATER RO SYSTEM OVERVIEW
OVATION
Estimated total flow for RO Supply pumps???
RO SUPPLY PUMPS
RUNNING
STOPPED
RECIRC PY-7257
FILTERED WATER STORAGE TANK
01 RO PRE-FILTER
02 RO PRE-FILTER
03 RO PRE-FILTER
SHUTDOWN STATUS
FIRST OUT
FLUSH NOT REQUIRED
RO FEEDWATER TURBIDITY HIGH
RO FEEDWATER PH HIGH
RO FEEDWATER PH LOW
RESET
PRETREAT STATUS
IN SERVICE
PRETREAT CONTROL
SELECT
OSV-3505B
CLOSED
OPENED
TO WASTE
RO FEED PUMPS
RO TRAIN A
RO TRAIN B
RO TRAIN C
TOTAL FLOW
01 PERMEATE STORAGE TANK
02 PERMEATE STORAGE TANK
CONCENTRATE TO WASTE
MAIN ACID STORAGE TANK
ACID INJECTION PUMPS
TAG OUT
OSV-3559
ACID DAY TANK
ACID FEED PUMPS
ACID FD CTL AY-3565A
ACID FD CTL AY-3565B
SCL INH FD CTL AY-3550A
SCL INH FD CTL AY-3550B
SCALE INHIBITOR PUMPS
SCALE INHIBITOR DAY TANK
PRETREAT DEVICE STATUS
LAB 1 ALARMS
BACK
FORWARD
RO OVERVIEW
RO TRAIN A
RO TRAIN B
RO TRAIN C
CLEAR CONTROL


RO Supply Pumps

ECM 8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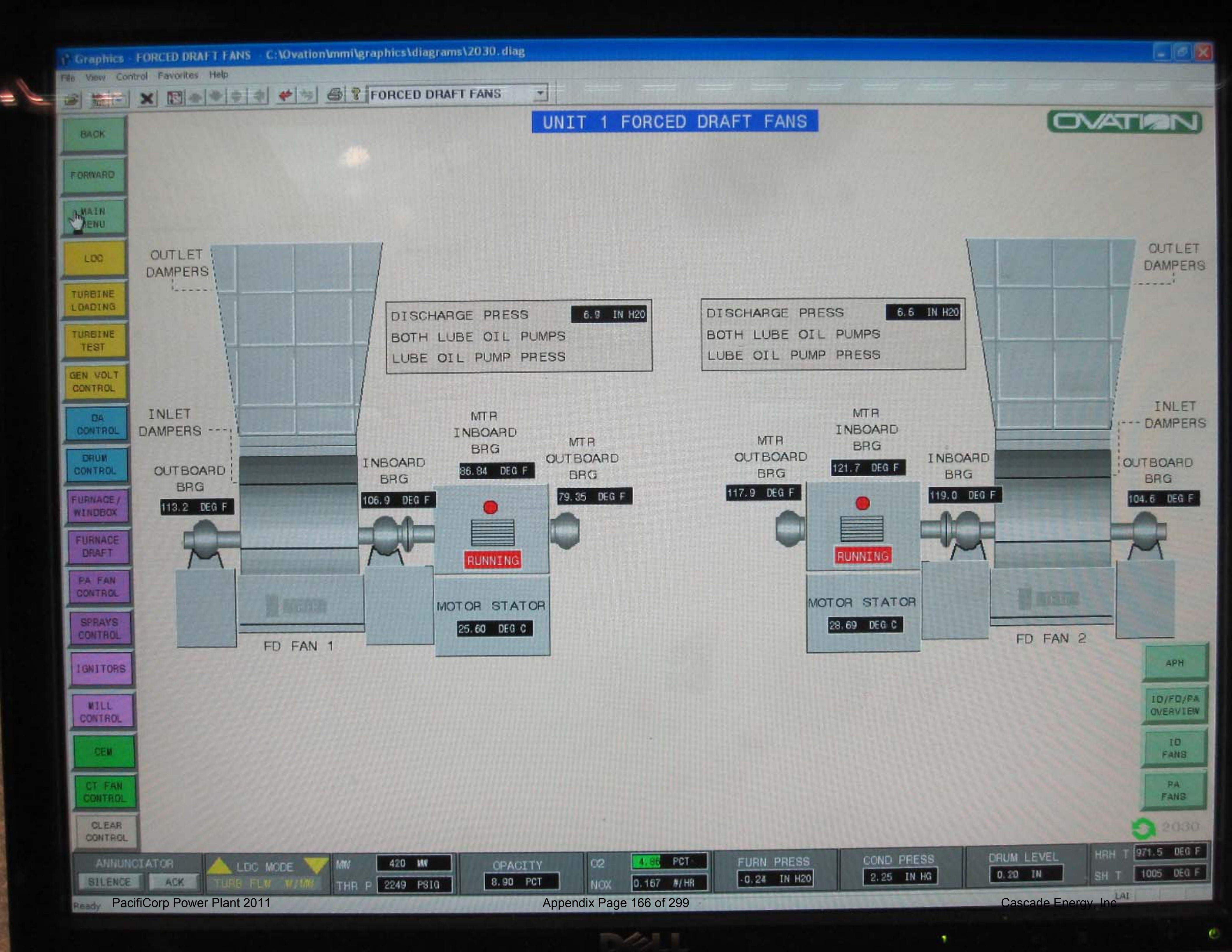
File View Control Favorites Help
PRIMARY AIR FANS
UNIT 1 PRIMARY AIR FANS
OVATION
BACK
FORWARD
LDC
TURBINE LOADING
TURBINE TEST
GEN VOLT CONTROL
DA CONTROL
DRUM CONTROL
FURNACE / WINDBOX
FURNACE DRAFT
PA FAN CONTROL
SPRAYS CONTROL
IGNITORS
MILL CONTROL
CEM
CT FAN CONTROL
CLEAR CONTROL
OUTLET DAMPERS
INLET DAMPERS
HOT PA DUCT PRESS 31.6 IN H20
BOTH LUBE OIL PUMPS
LUBE OIL PUMP PRESS
LUBE OIL CLG FAN
OUTBOARD BRG 137.1 DEG F
INBOARD BRG 115.7 DEG F
MTR INBOARD BRG 141.3 DEG F
MTR OUTBOARD BRG 162.0 DEG F
RUNNING
MOTOR STATOR 40.00 DEG C
PA FAN 1
OUTLET DAMPERS
INLET DAMPERS
HOT PA DUCT PRESS 31.6 IN H20
BOTH LUBE OIL PUMPS
LUBE OIL PUMP PRESS
LUBE OIL CLG FAN
MTR OUTBOARD BRG 151.2 DEG F
MTR INBOARD BRG 144.7 DEG F
INBOARD BRG 129.2 DEG F
OUTBOARD BRG 119.9 DEG F
RUNNING
MOTOR STATOR 45.84 DEG C
PA FAN 2
APH
ID/FD/PA OVERVIEW
FD FANS
ID FANS
2032
ANNUNCIATOR
SILENCE
ACK
LDC MODE
MW 419 MW
THR P 2249 PSIG
OPACITY 8.58 PCT
O2 4.63 PCT
NOX 0.167 #/HR
FURN PRESS -0.62 IN H20
COND PRESS 2.25 IN HG
DRUM LEVEL 0.07 IN
HRH T 971.2 DEG F
SH T 1004 DEG F
Ready

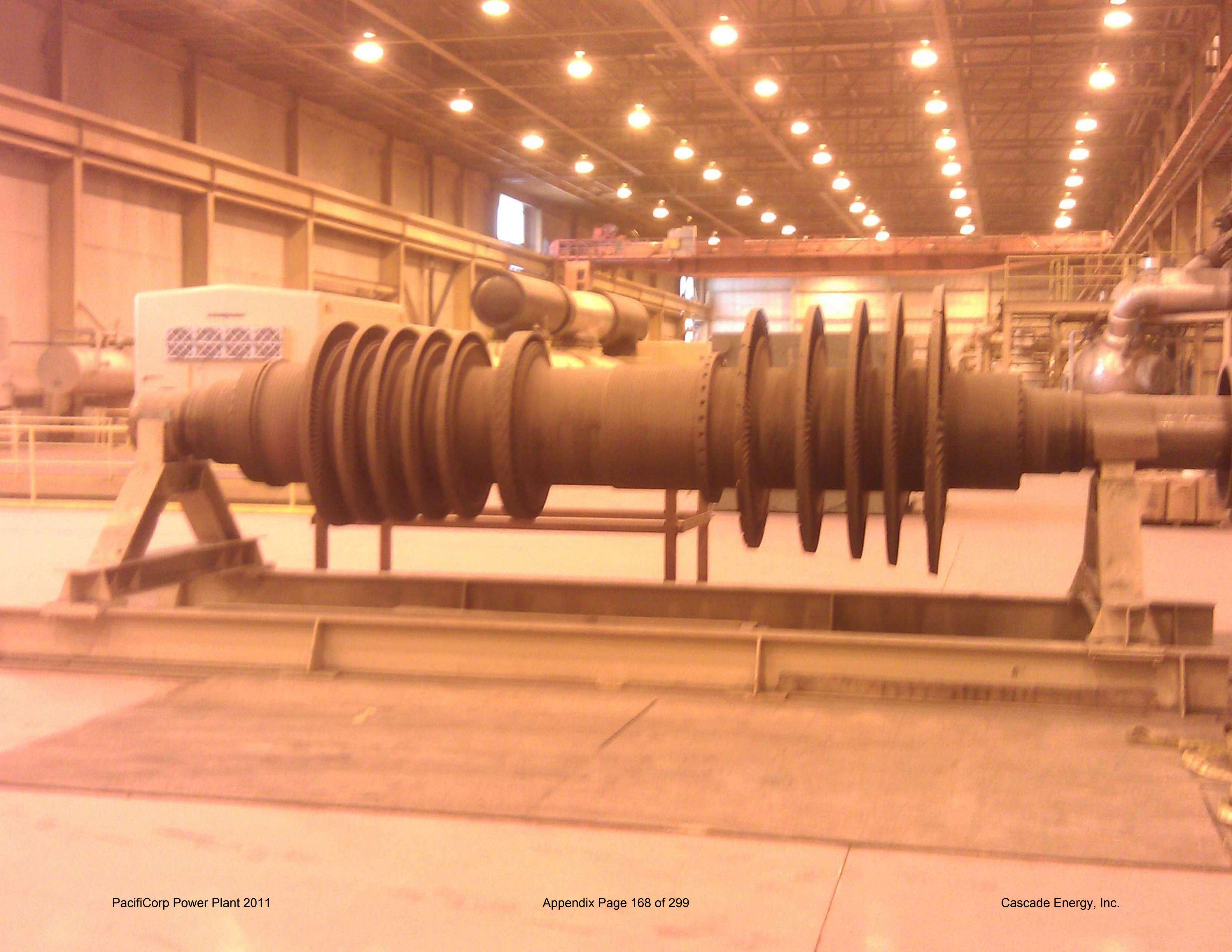
ECM 9- Forced Draft Fans

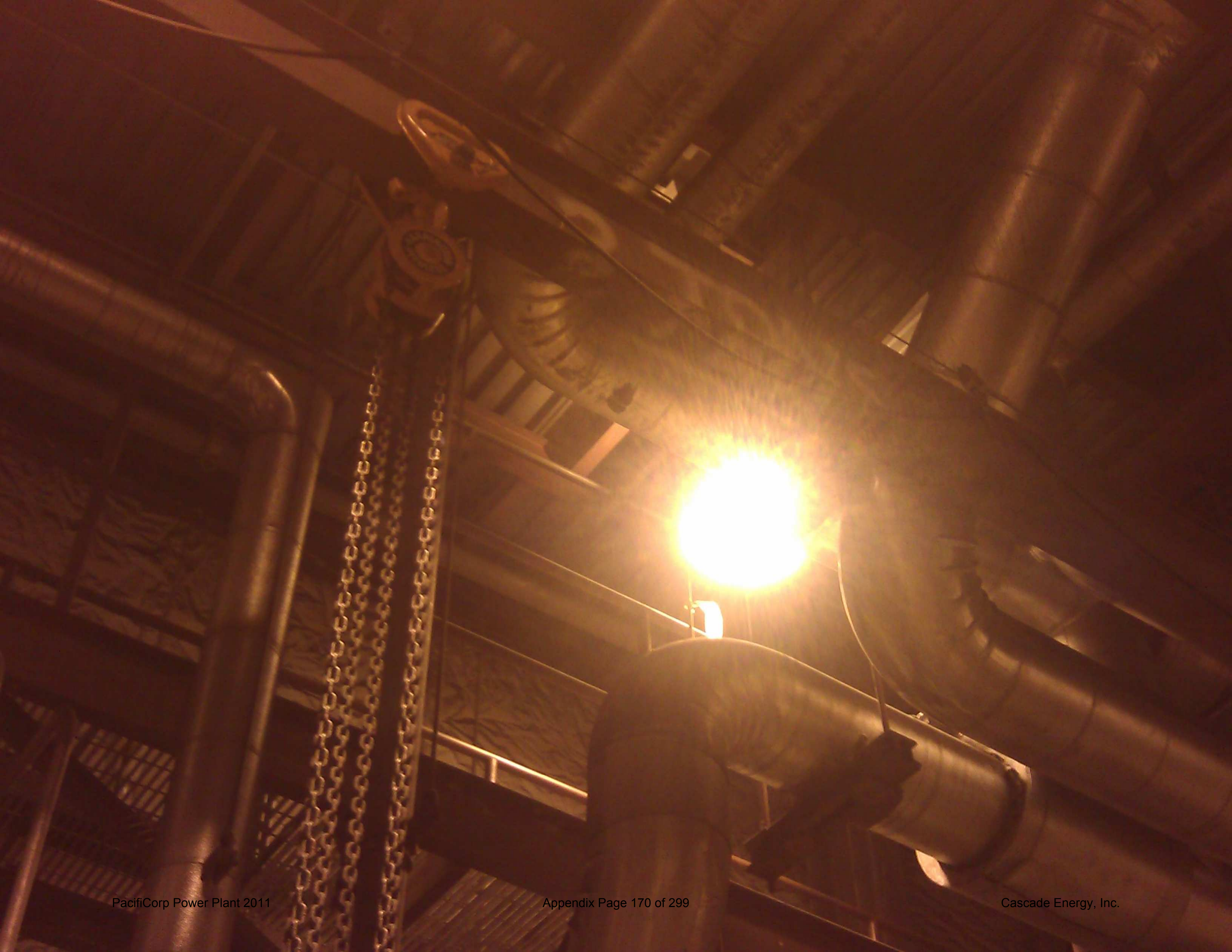
Inlet Vanes on Forced Draft Fans

Nameplate data


Graphics - FORCED DRAFT FANS C:\Ovation\mmi\graphics\diagrams\2030.diag
File View Control Favorites Help
FORCED DRAFT FANS
UNIT 1 FORCED DRAFT FANS
OVATION
BACK
FORWARD
MAIN MENU
LDC
TURBINE LOADING
TURBINE TEST
GEN VOLT CONTROL
DA CONTROL
DRUM CONTROL
FURNACE / WINDBOX
FURNACE DRAFT
PA FAN CONTROL
SPRAYS CONTROL
IGNITORS
MILL CONTROL
CEM
CT FAN CONTROL
CLEAR CONTROL
OUTLET DAMPERS
INLET DAMPERS
DISCHARGE PRESS 6.9 IN H20
BOTH LUBE OIL PUMPS
LUBE OIL PUMP PRESS
DISCHARGE PRESS 6.6 IN H20
BOTH LUBE OIL PUMPS
LUBE OIL PUMP PRESS
OUTBOARD BRG 113.2 DEG F
INBOARD BRG 106.9 DEG F
MTR INBOARD BRG 86.84 DEG F
MTR OUTBOARD BRG 79.35 DEG F
RUNNING
MOTOR STATOR 25.60 DEG C
FD FAN 1
MTR OUTBOARD BRG 117.9 DEG F
MTR INBOARD BRG 121.7 DEG F
INBOARD BRG 119.0 DEG F
OUTBOARD BRG 104.6 DEG F
RUNNING
MOTOR STATOR 28.69 DEG C
FD FAN 2
APH
ID/FD/PA OVERVIEW
ID FANS
PA FANS
2030
ANNUNCIATOR
SILENCE
ACK
LDC MODE
MW 420 MW
THR P 2249 PSIG
OPACITY 8.90 PCT
O2 PCT
NOX 0.167 #/HR
FURN PRESS -0.24 IN H20
COND PRESS 2.25 IN HG
DRUM LEVEL 0.20 IN
HRH T 971.5 DEG F
SH T 1005 DEG F
Ready

ECM 10






EXIT

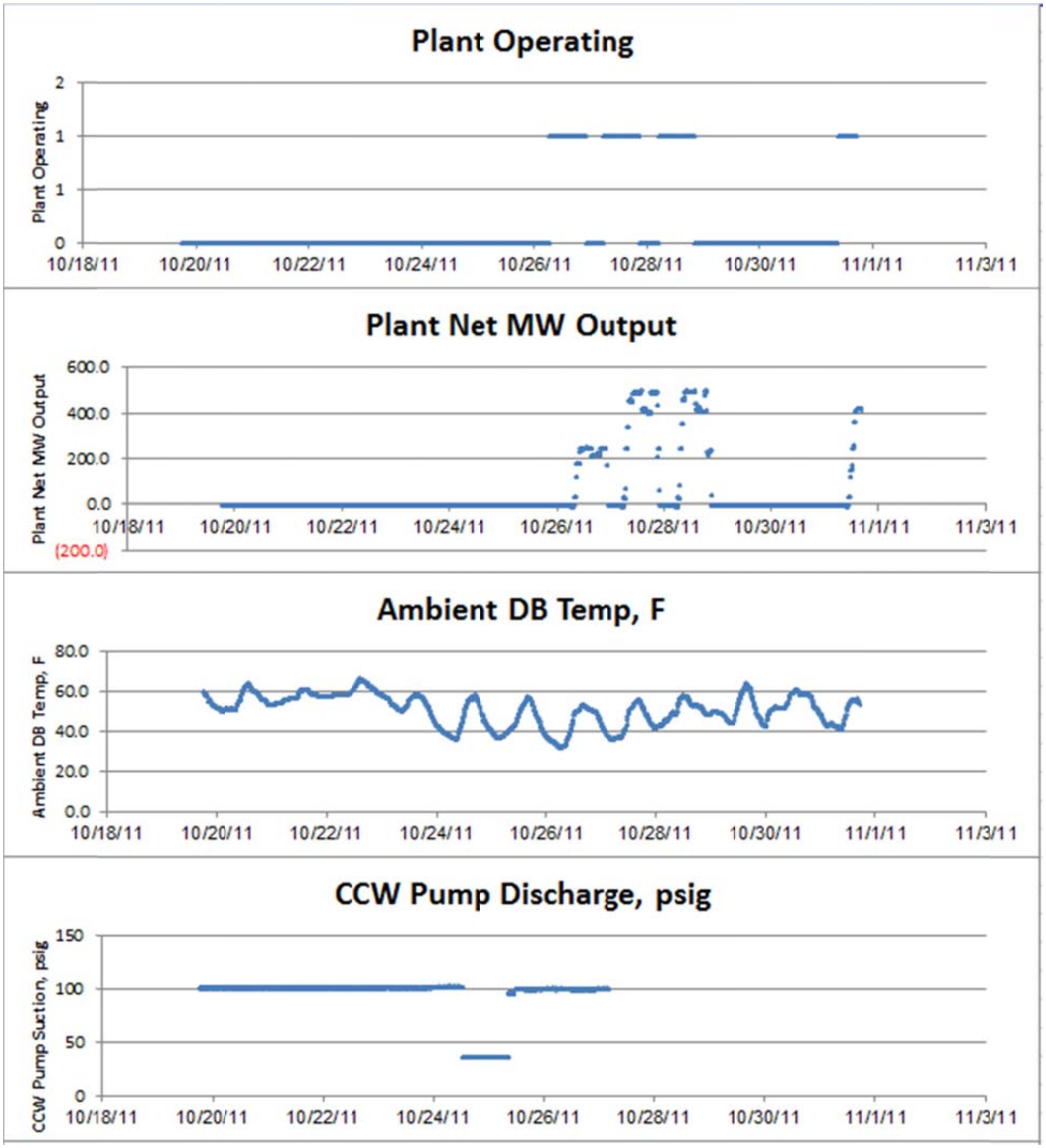

HAYWARD
FlowControl
M Croy
26031856
IDEX

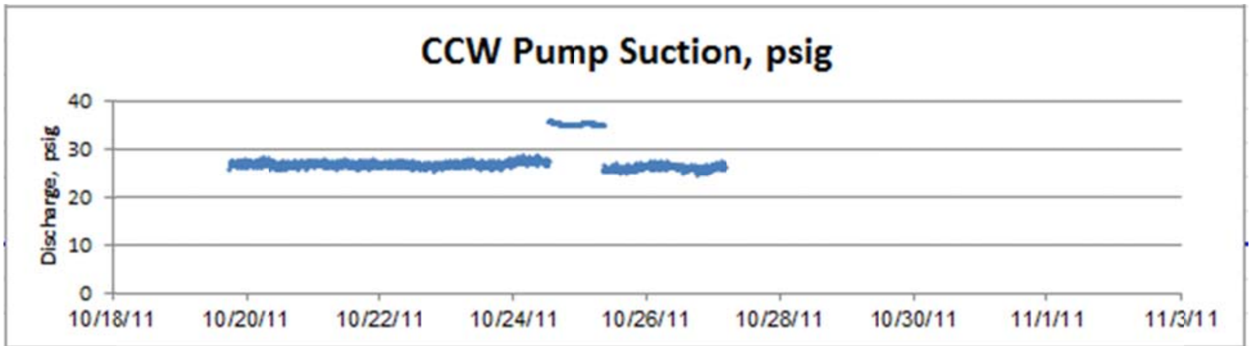

PHILIPS
F48T12/CW/HO
60 WATT
U.S.A.
Alto
C6
Hg

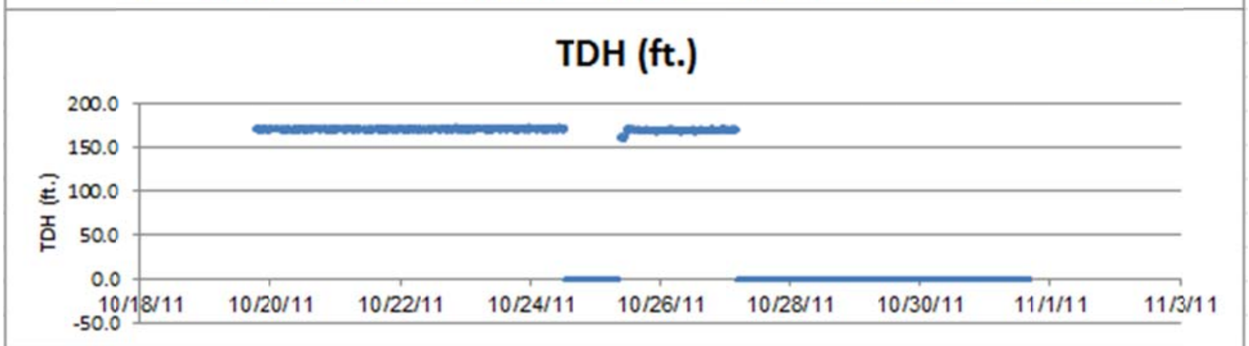

NOTICE
NO ENTRY
WITHOUT
PERMISSION

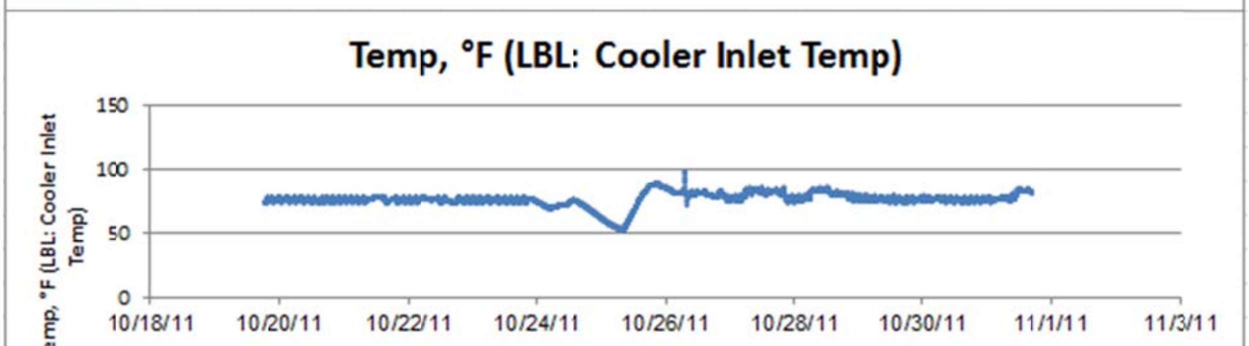
26.6 CHEHALIS: DATA LOGGING AND MODEL CHARTS

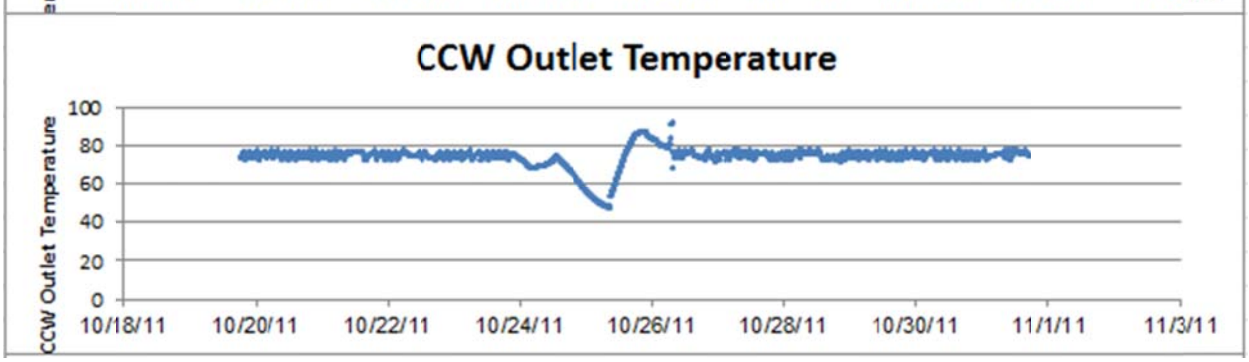
ECMs 1 & 2: CCW Pump Speed Control and Fan VFDs with Temperature Reset

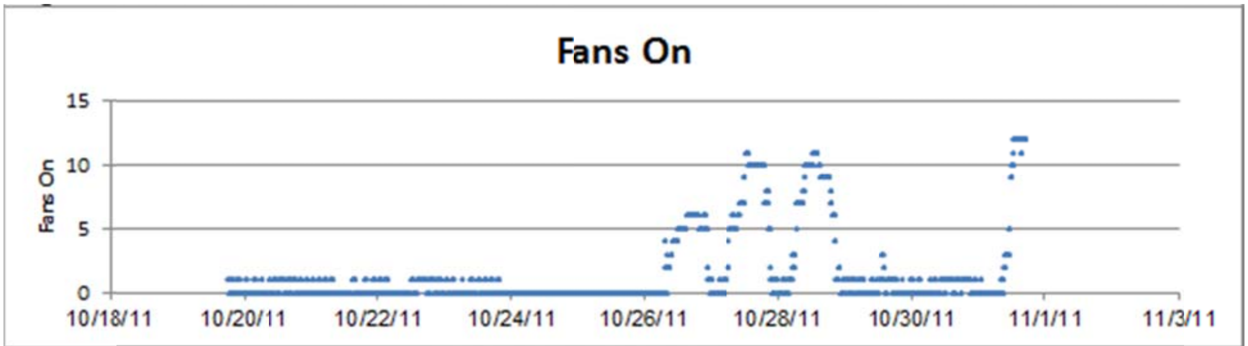


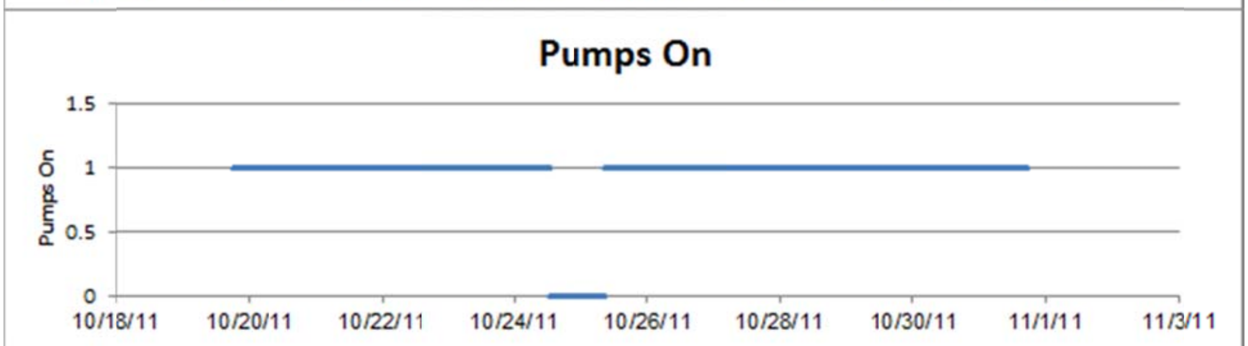

CCW Pump Suction, psig
Discharge, psig
40
30
20
10
0
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11

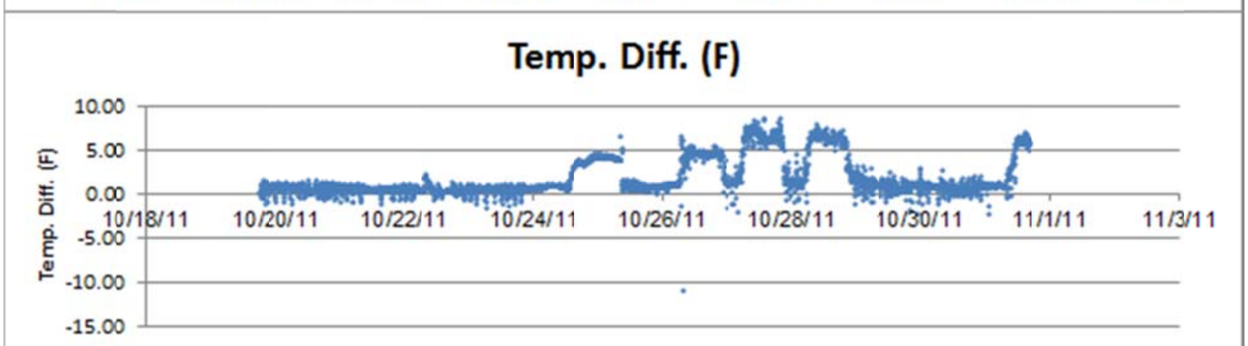

TDH (ft.)
TDH (ft.)
200.0
150.0
100.0
50.0
0.0
-50.0
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11

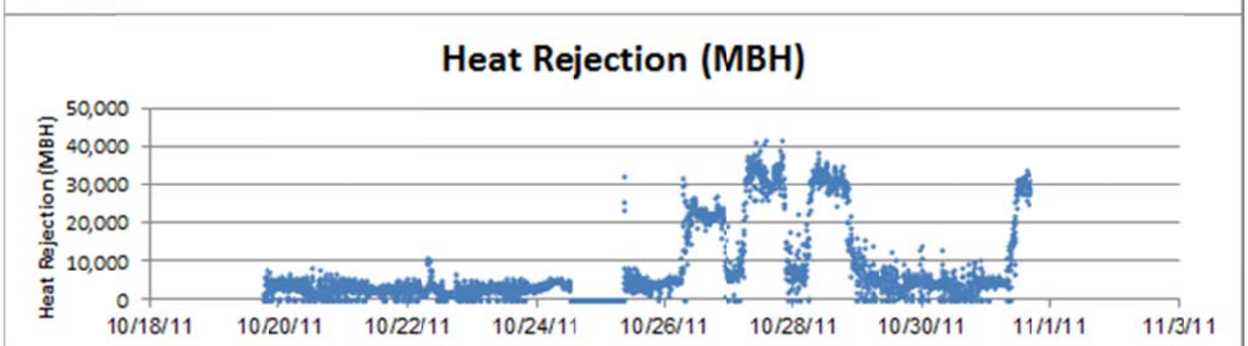

Temp, °F (LBL: Cooler Inlet Temp)
emp, °F (LBL: Cooler Inlet Temp)
150
100
50
0
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11

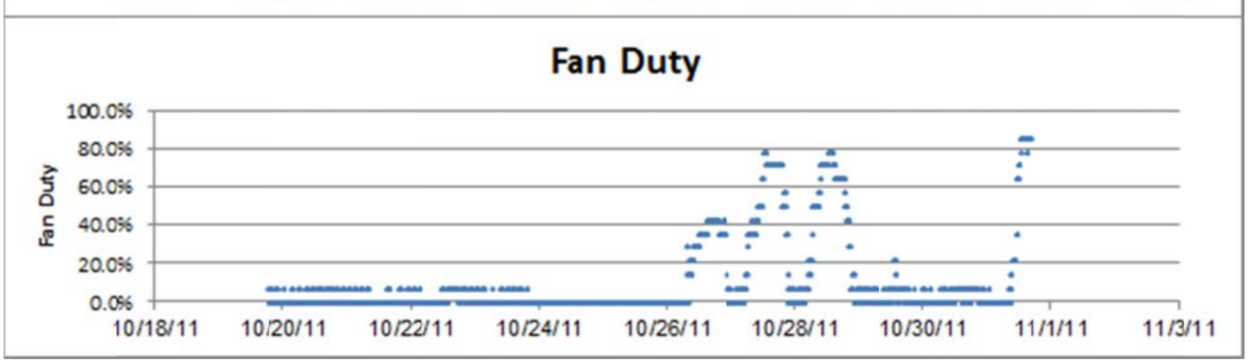

CCW Outlet Temperature
CCW Outlet Temperature
100
80
60
40
20
0
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11

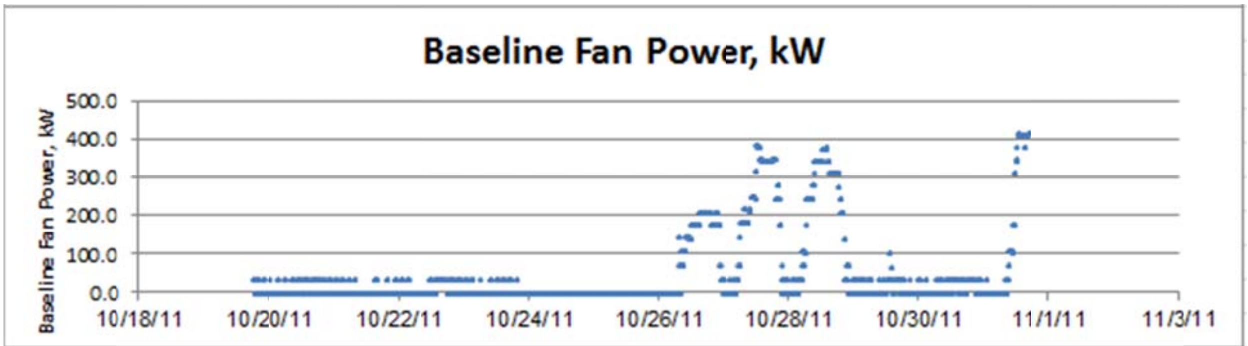

Fans On
Fans On
15
10
5
0
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11

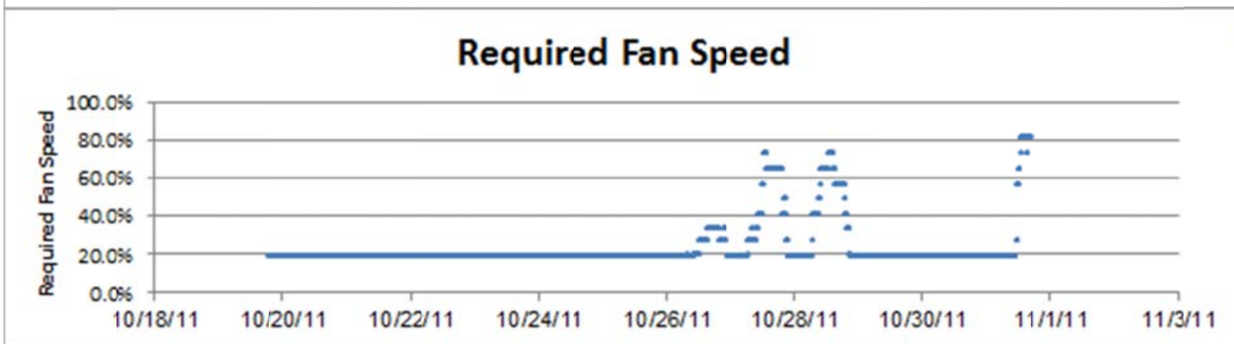

Pumps On
Pumps On
1.5
1
0.5
0
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11

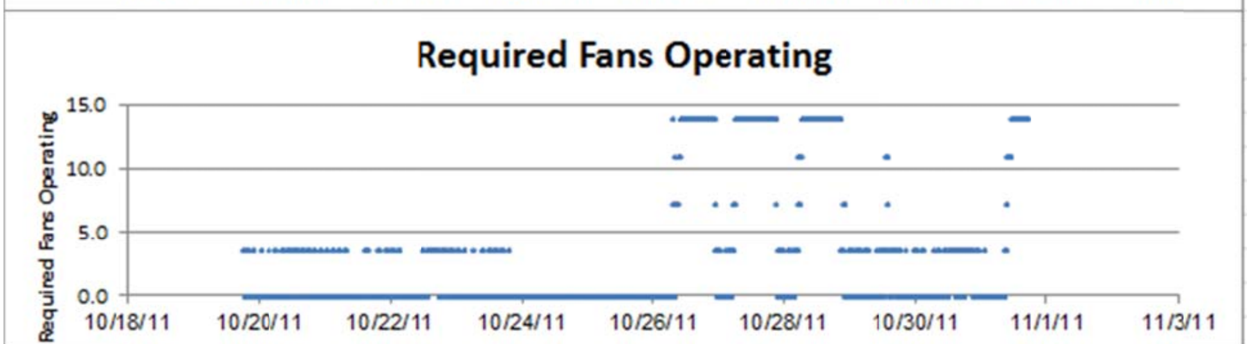

Temp. Diff. (F)
Temp. Diff. (F)
10.00
5.00
0.00
-5.00
-10.00
-15.00
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11

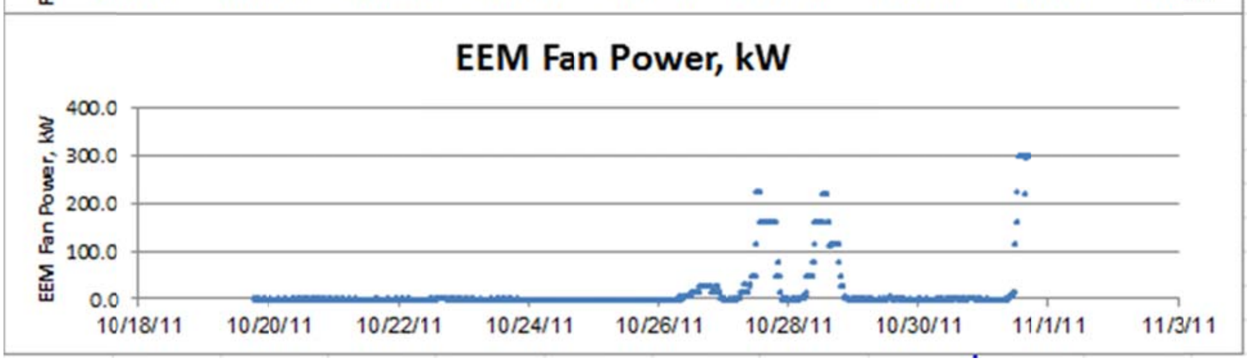

Heat Rejection (MBH)
Heat Rejection (MBH)
50,000
40,000
30,000
20,000
10,000
0
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11


Fan Duty
Fan Duty
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11

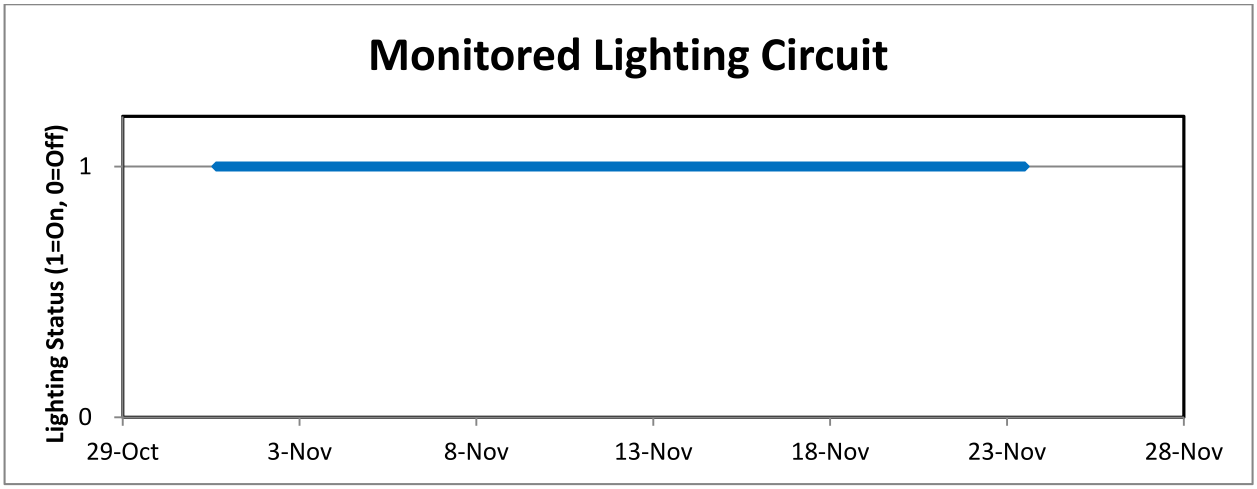

Baseline Fan Power, kW
Baseline Fan Power, kW
500.0
400.0
300.0
200.0
100.0
0.0
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11


Required Fan Speed
Required Fan Speed
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11


Required Fans Operating
Required Fans Operating
15.0
10.0
5.0
0.0
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11


EEM Fan Power, kW
EEM Fan Power, kW
400.0
300.0
200.0
100.0
0.0
10/18/11
10/20/11
10/22/11
10/24/11
10/26/11
10/28/11
10/30/11
11/1/11
11/3/11

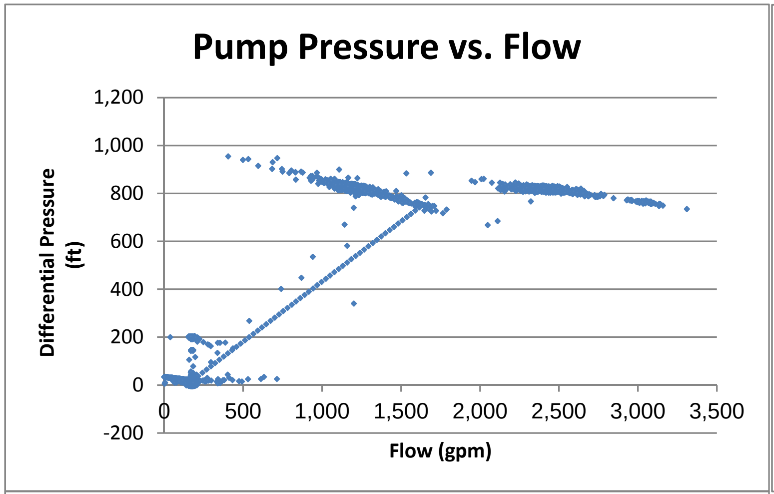
ECM 3: High Efficiency Lighting

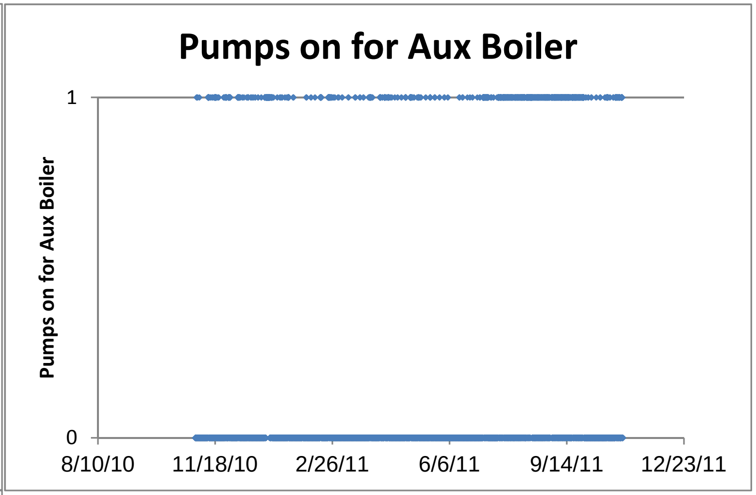


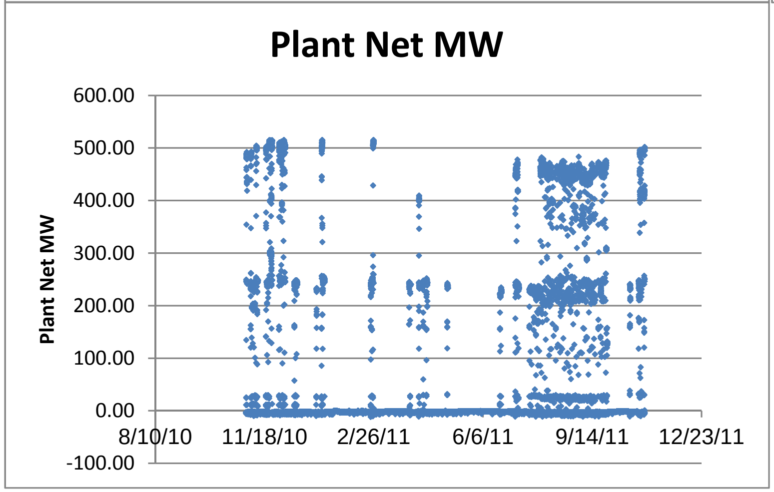
ECM 4: Install Small Condensate Pump

Small Condensate Pump Analysis

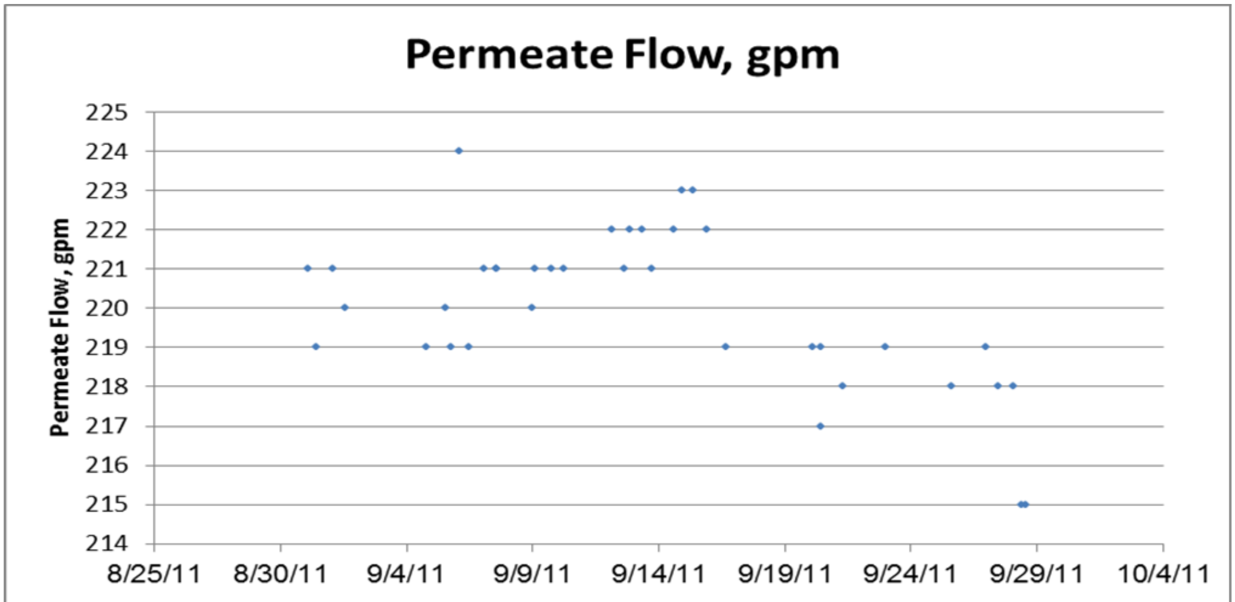
	Average Power (kW)	Duty Cycle (%)	Annual Energy Use (MWh/yr)
Baseline	308	8.9%	241
ECM	28.0	8.9%	22
Savings	-	-	219

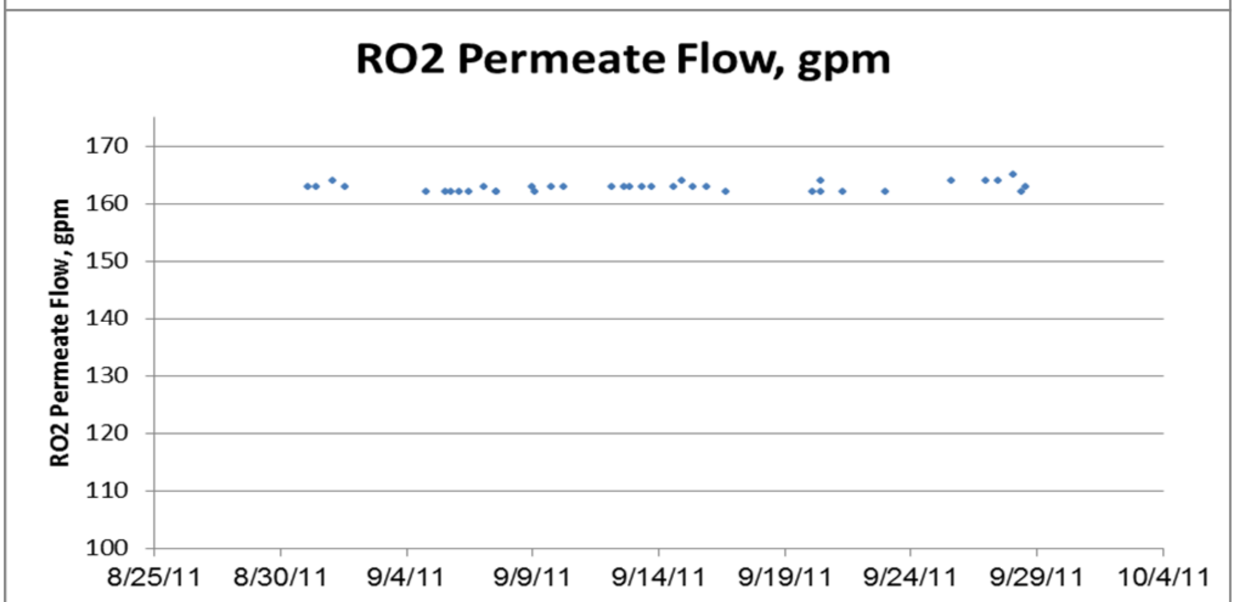


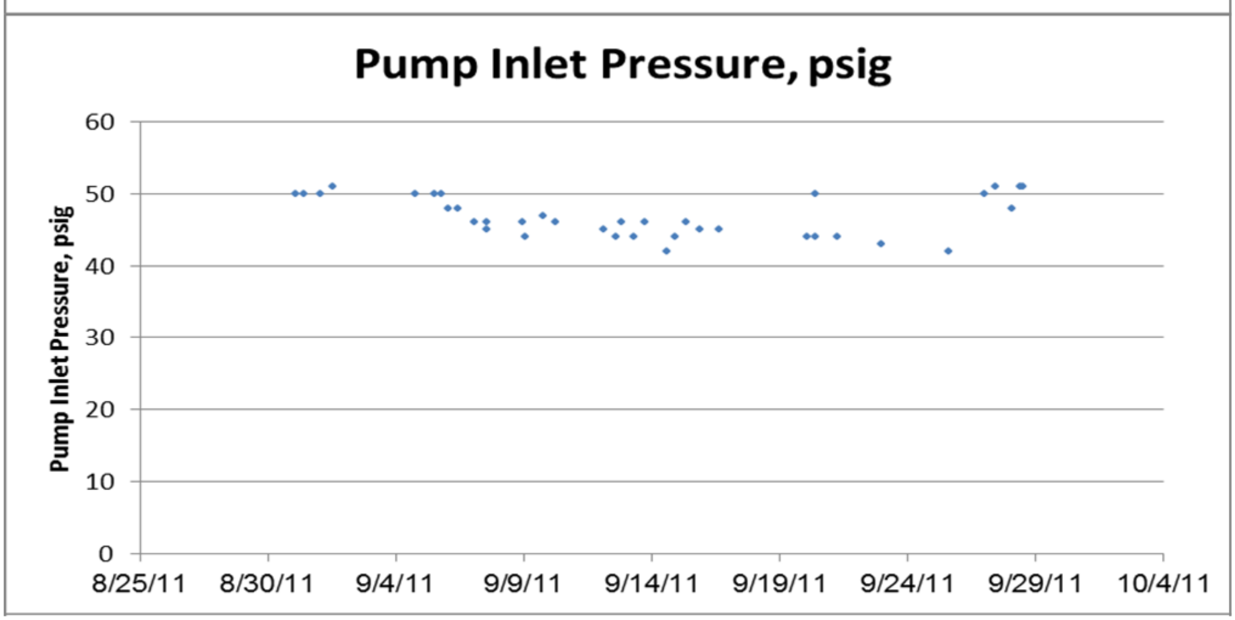


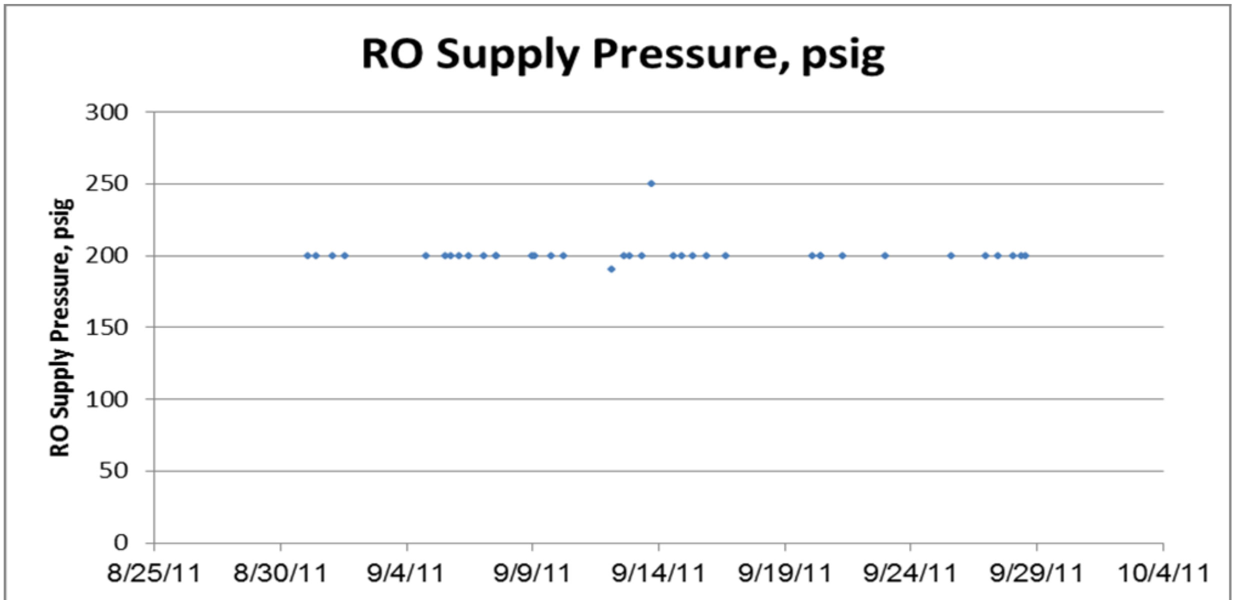


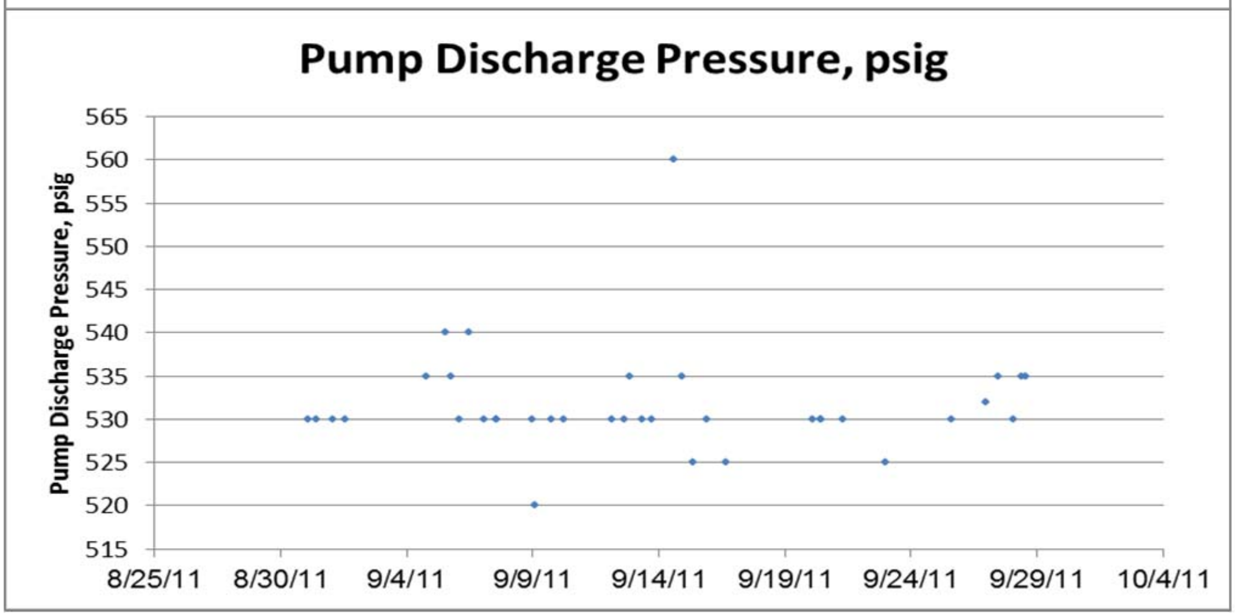
ECM 5: Reverse Osmosis Pump VFDs

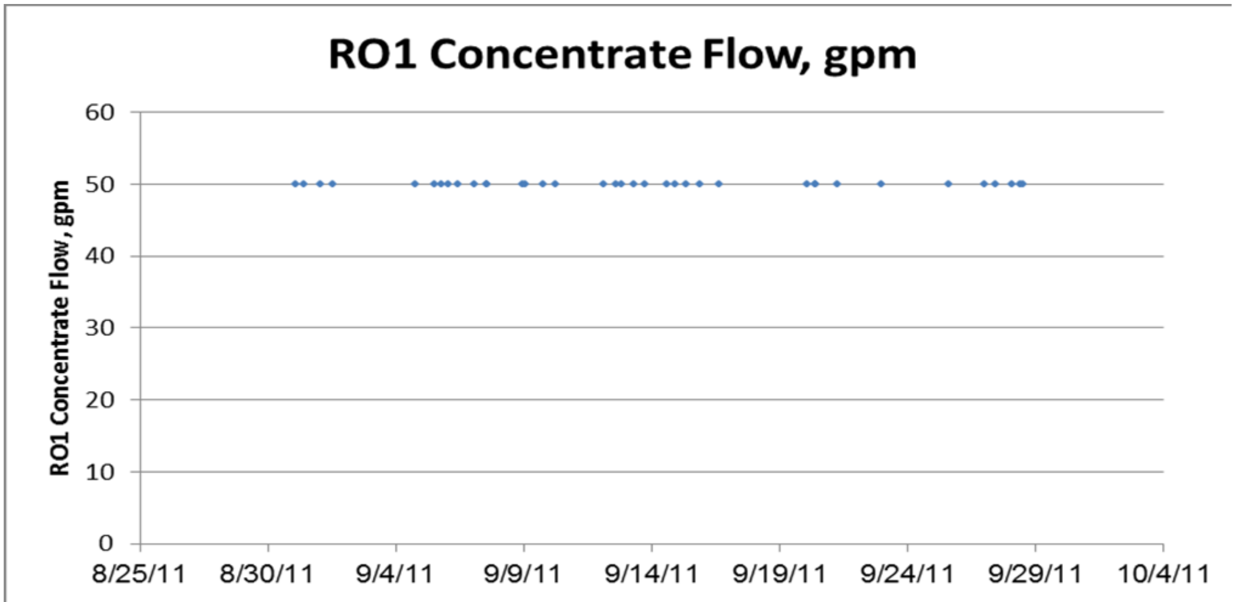

Permeate Flow, gpm
Permeate Flow, gpm
225
224
223
222
221
220
219
218
217
216
215
214
8/25/11
8/30/11
9/4/11
9/9/11
9/14/11
9/19/11
9/24/11
9/29/11
10/4/11

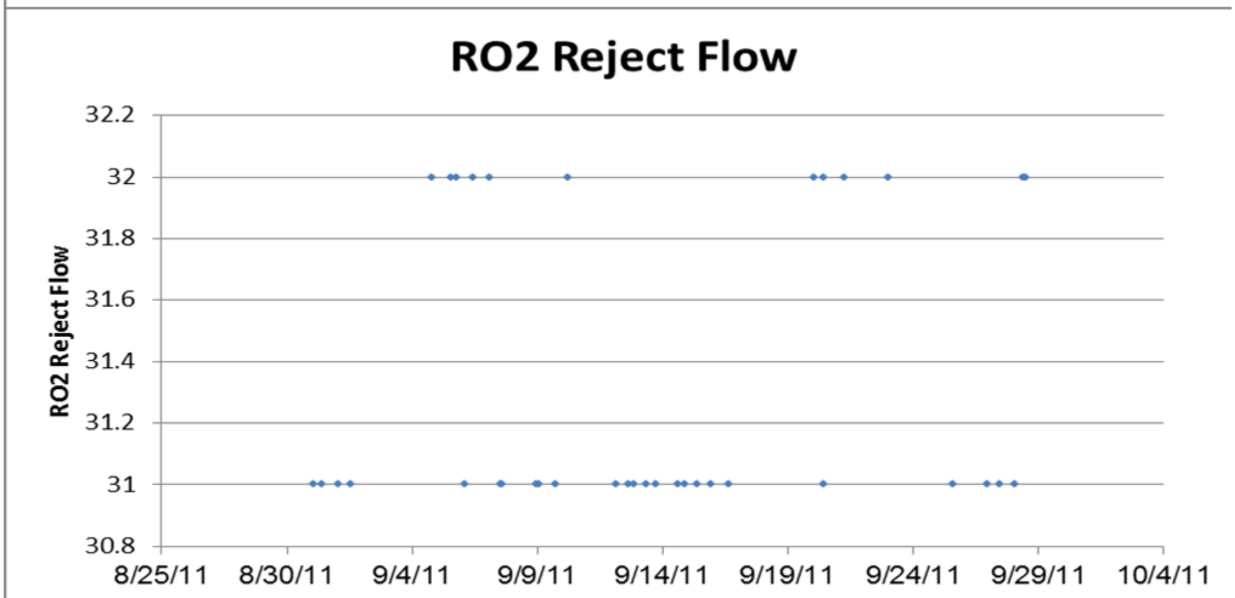

RO2 Permeate Flow, gpm
RO2 Permeate Flow, gpm
170
160
150
140
130
120
110
100
8/25/11
8/30/11
9/4/11
9/9/11
9/14/11
9/19/11
9/24/11
9/29/11
10/4/11

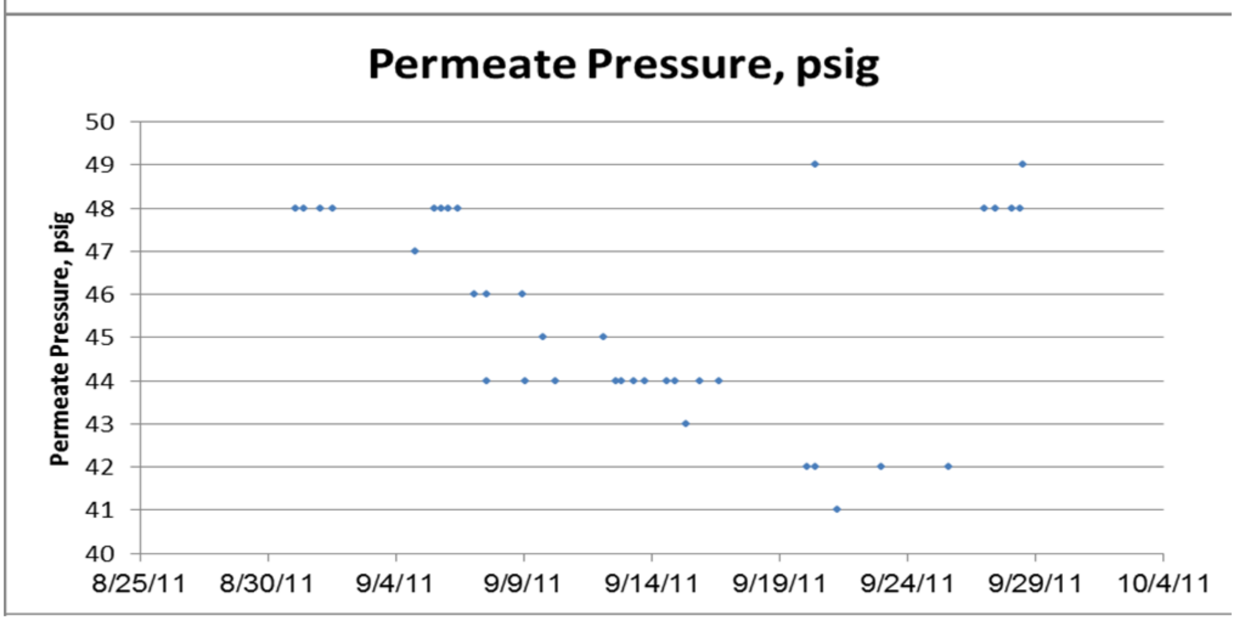

Pump Inlet Pressure, psig
Pump Inlet Pressure, psig
60
50
40
30
20
10
0
8/25/11
8/30/11
9/4/11
9/9/11
9/14/11
9/19/11
9/24/11
9/29/11
10/4/11

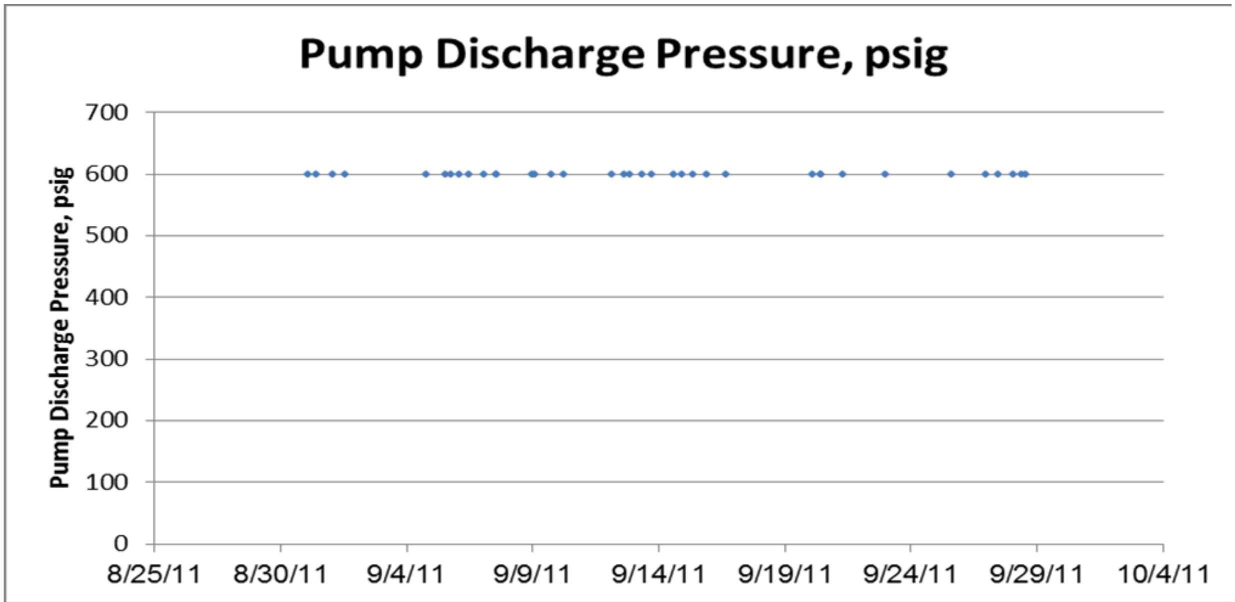

RO Supply Pressure, psig
RO Supply Pressure, psig
300
250
200
150
100
50
0
8/25/11
8/30/11
9/4/11
9/9/11
9/14/11
9/19/11
9/24/11
9/29/11
10/4/11

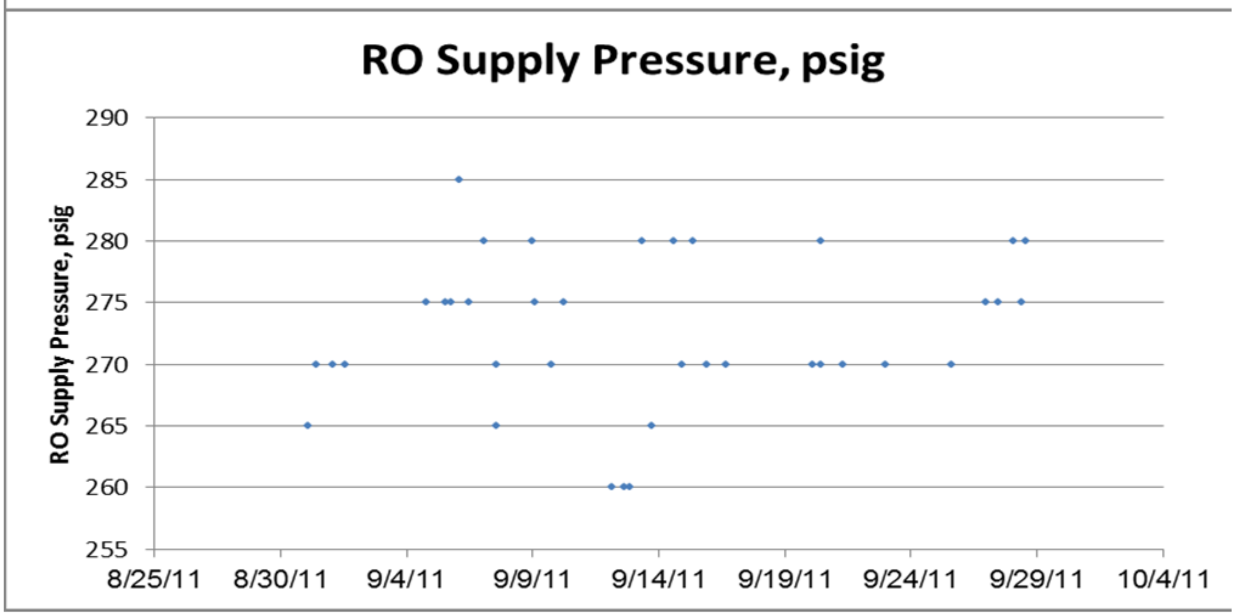

Pump Discharge Pressure, psig
Pump Discharge Pressure, psig
565
560
555
550
545
540
535
530
525
520
515
8/25/11
8/30/11
9/4/11
9/9/11
9/14/11
9/19/11
9/24/11
9/29/11
10/4/11

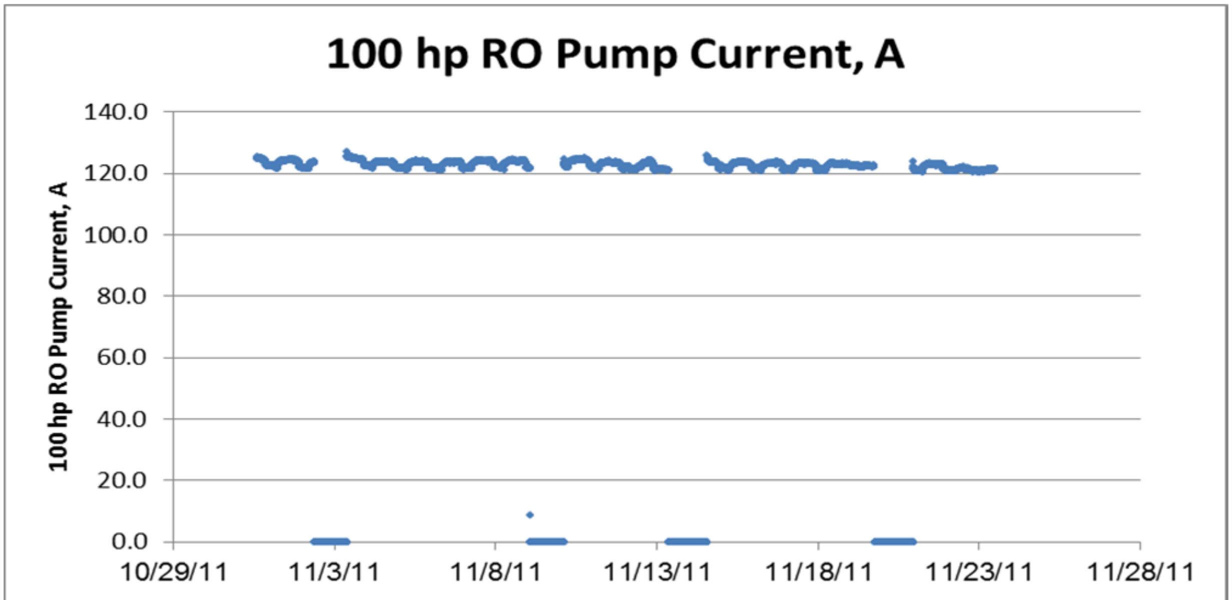

RO1 Concentrate Flow, gpm
RO1 Concentrate Flow, gpm
60
50
40
30
20
10
0
8/25/11
8/30/11
9/4/11
9/9/11
9/14/11
9/19/11
9/24/11
9/29/11
10/4/11

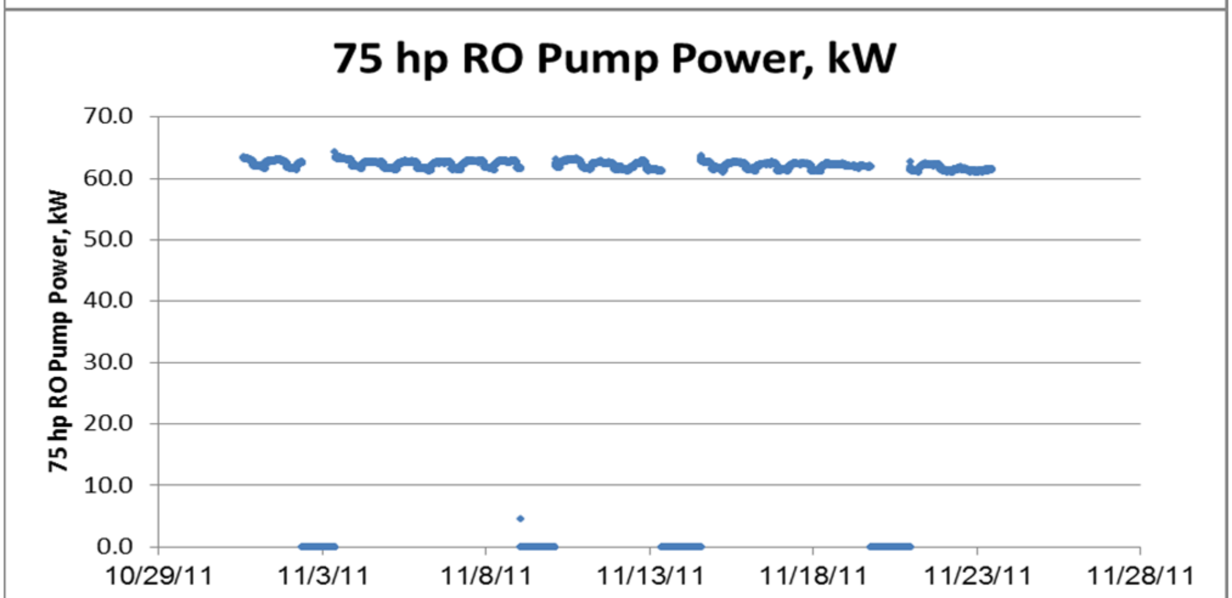

RO2 Reject Flow
RO2 Reject Flow
32.2
32
31.8
31.6
31.4
31.2
31
30.8
8/25/11
8/30/11
9/4/11
9/9/11
9/14/11
9/19/11
9/24/11
9/29/11
10/4/11

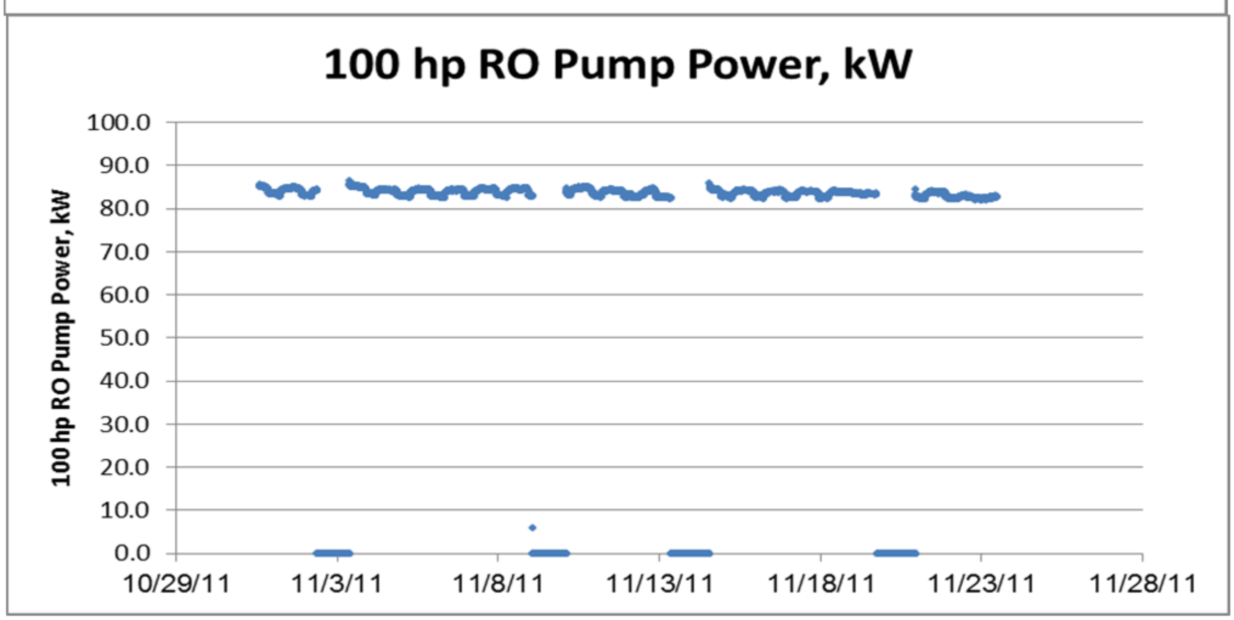

Permeate Pressure, psig
Permeate Pressure, psig
50
49
48
47
46
45
44
43
42
41
40
8/25/11
8/30/11
9/4/11
9/9/11
9/14/11
9/19/11
9/24/11
9/29/11
10/4/11


Pump Discharge Pressure, psig
Pump Discharge Pressure, psig
700
600
500
400
300
200
100
0
8/25/11
8/30/11
9/4/11
9/9/11
9/14/11
9/19/11
9/24/11
9/29/11
10/4/11

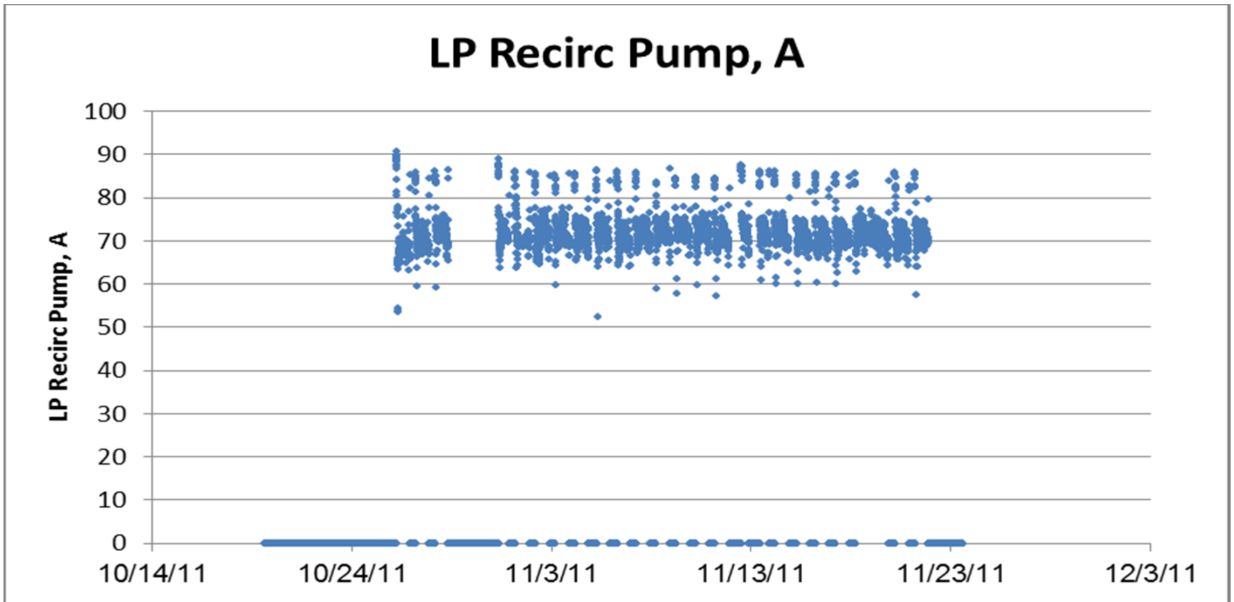

RO Supply Pressure, psig
RO Supply Pressure, psig
290
285
280
275
270
265
260
255
8/25/11
8/30/11
9/4/11
9/9/11
9/14/11
9/19/11
9/24/11
9/29/11
10/4/11

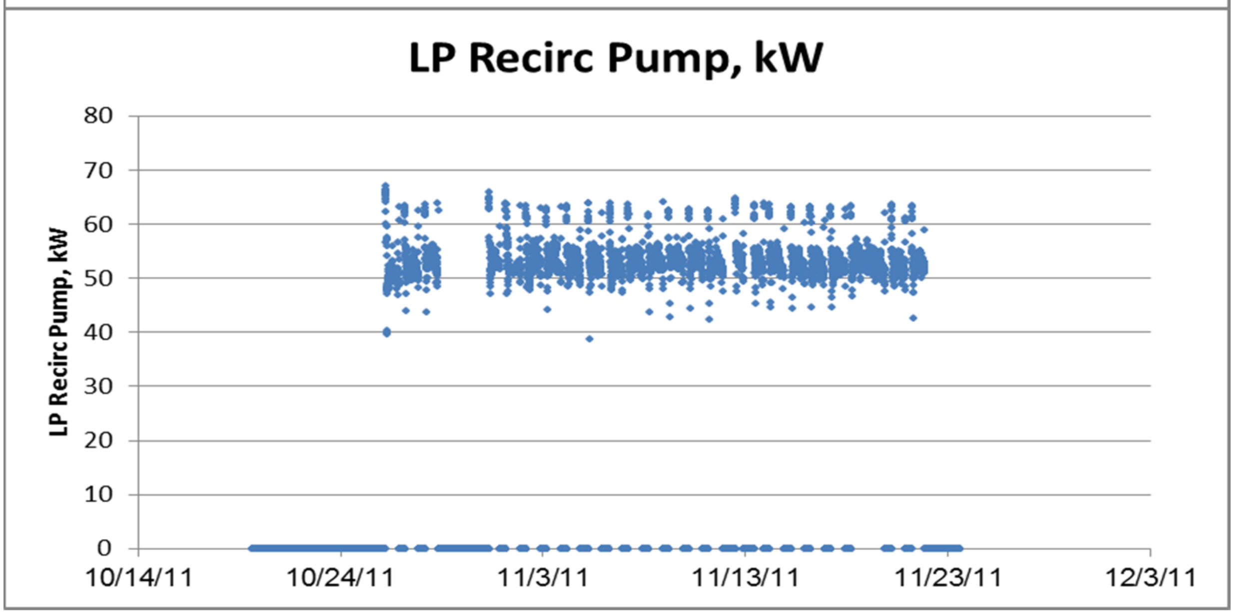

100 hp RO Pump Current, A
100 hp RO Pump Current, A
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
10/29/11
11/3/11
11/8/11
11/13/11
11/18/11
11/23/11
11/28/11

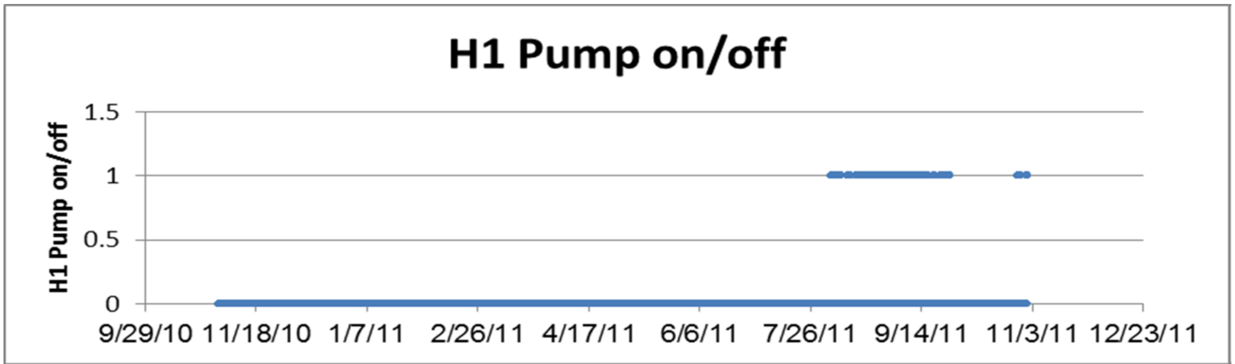

75 hp RO Pump Power, kW
75 hp RO Pump Power, kW
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
10/29/11
11/3/11
11/8/11
11/13/11
11/18/11
11/23/11
11/28/11


100 hp RO Pump Power, kW
100 hp RO Pump Power, kW
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
10/29/11
11/3/11
11/8/11
11/13/11
11/18/11
11/23/11
11/28/11

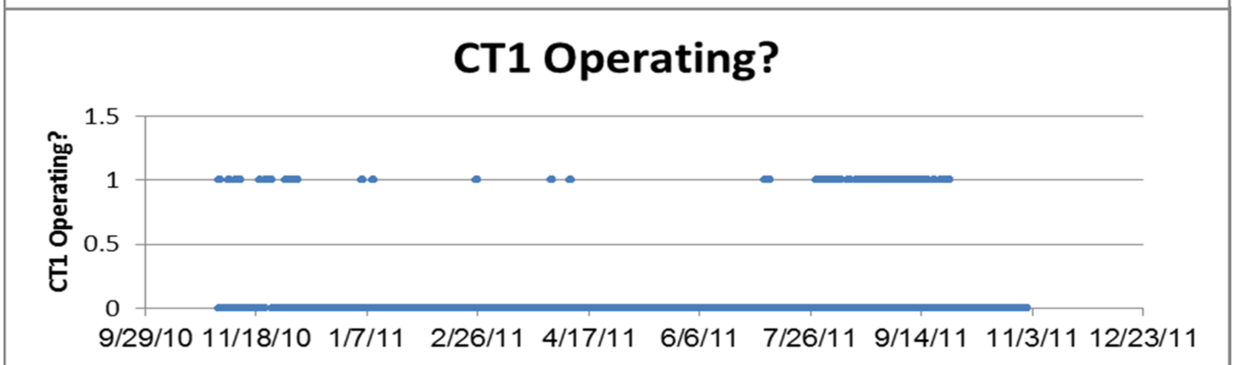
ECM 6: Reduce LP Economizer Recirculation Pump Use


LP Recirc Pump, A
LP Recirc Pump, A
100
90
80
70
60
50
40
30
20
10
0
10/14/11
10/24/11
11/3/11
11/13/11
11/23/11
12/3/11

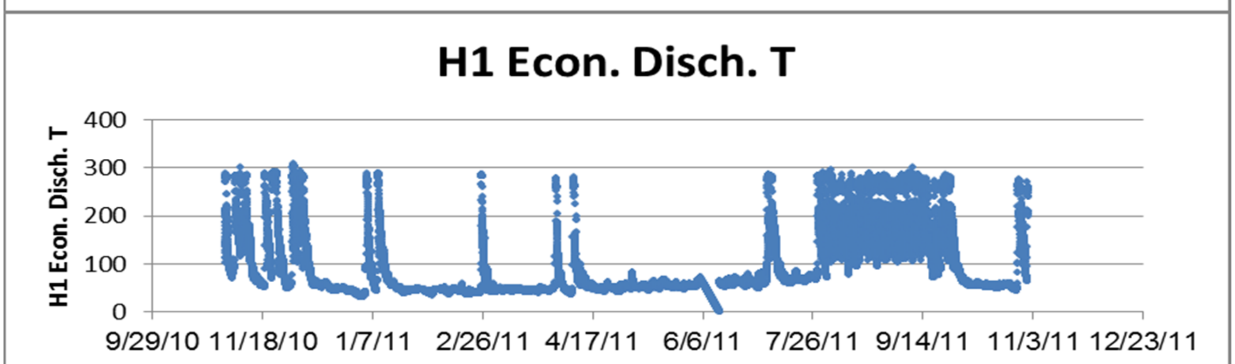

LP Recirc Pump, kW
LP Recirc Pump, kW
80
70
60
50
40
30
20
10
0
10/14/11
10/24/11
11/3/11
11/13/11
11/23/11
12/3/11



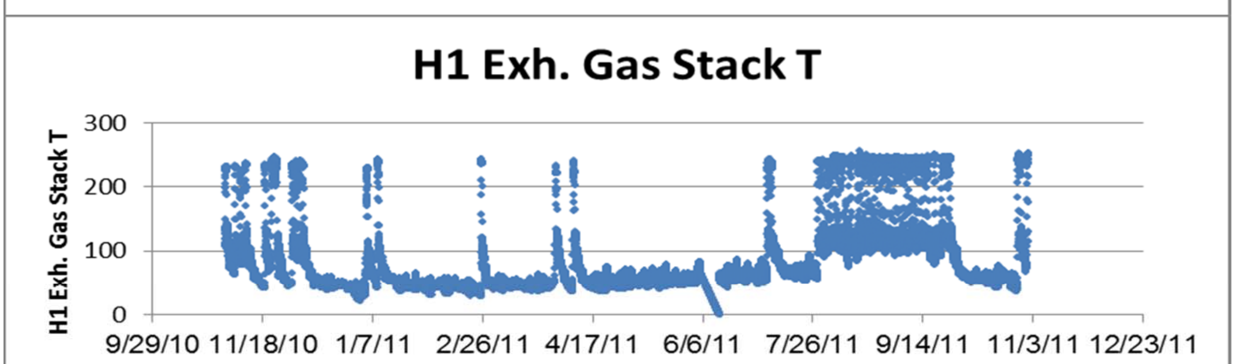
H1 Pump on/off
H1 Pump on/off
1.5
1
0.5
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11



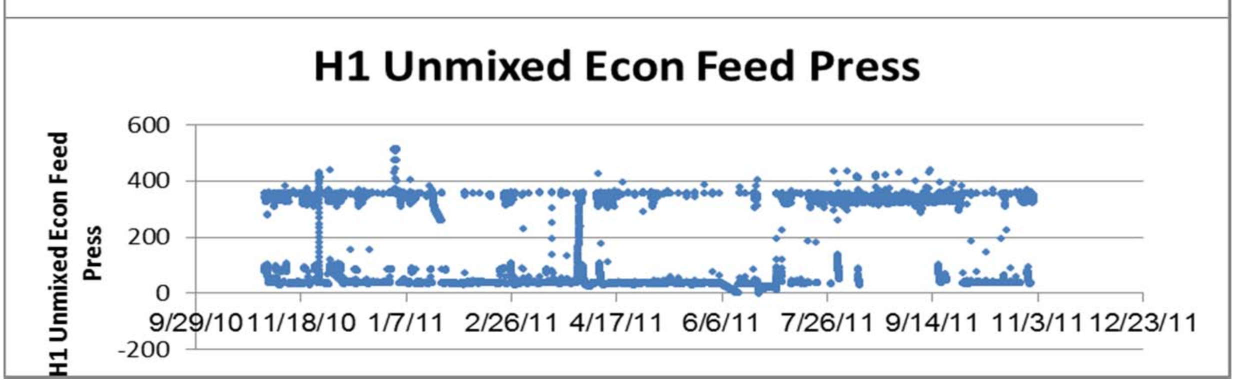
CT1 Operating?
CT1 Operating?
1.5
1
0.5
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11



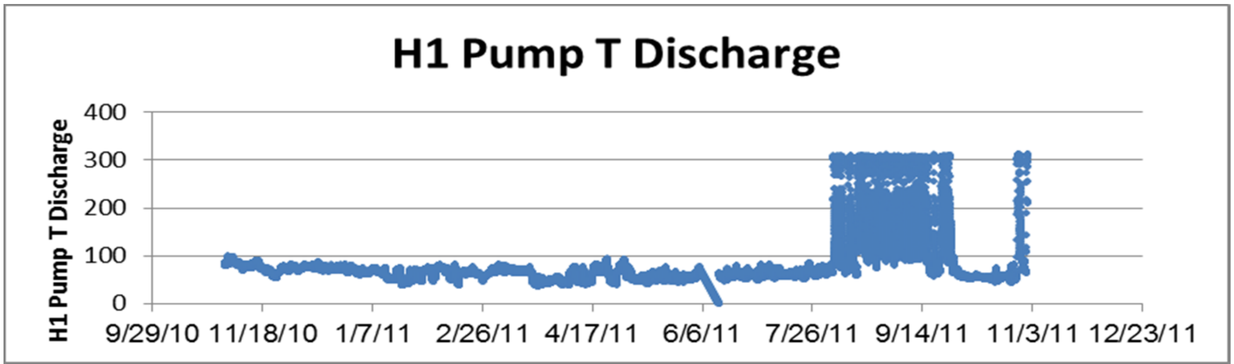
H1 Econ. Disch. T
H1 Econ. Disch. T
400
300
200
100
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

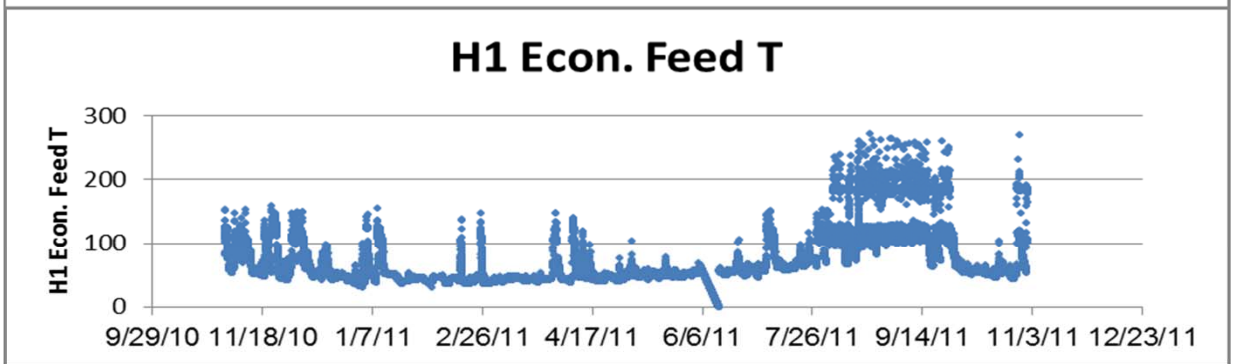


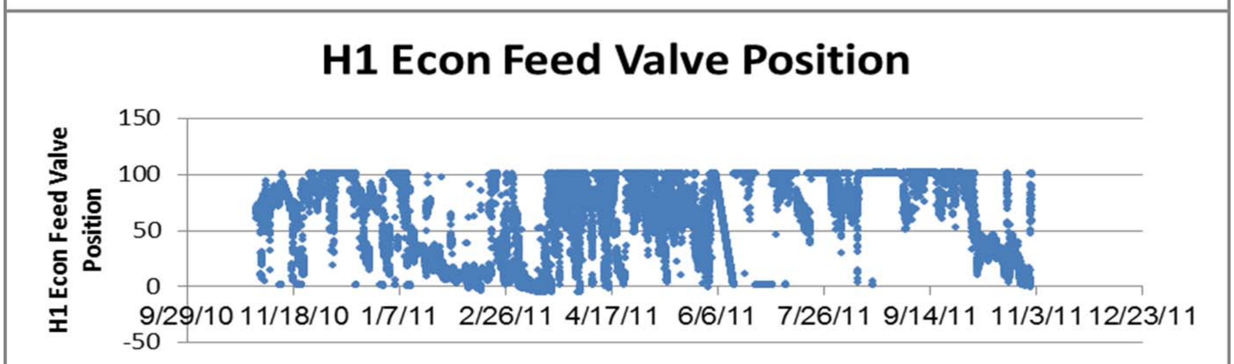
H1 Exh. Gas Stack T
H1 Exh. Gas Stack T
300
200
100
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

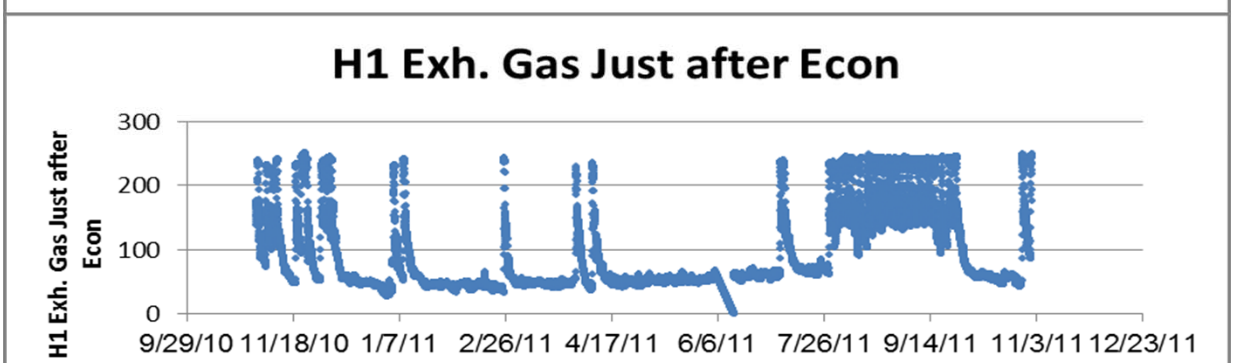


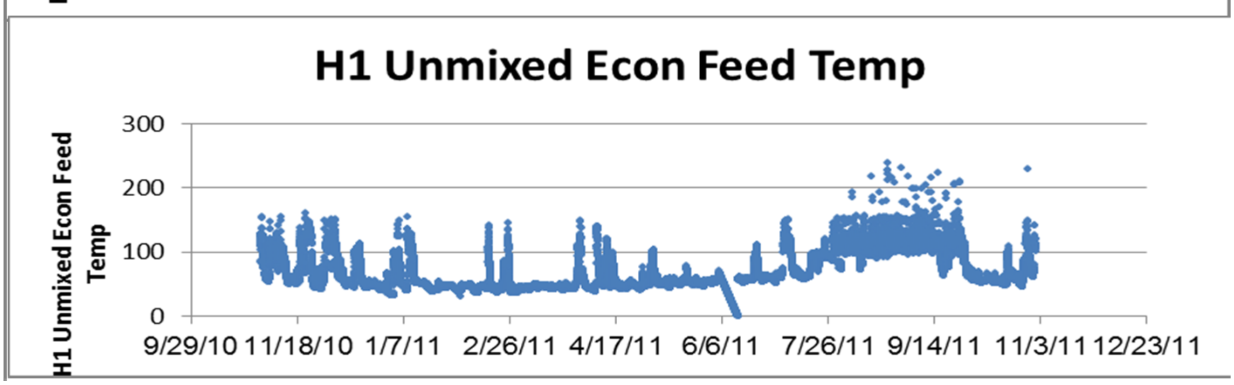
H1 Unmixed Econ Feed Press
H1 Unmixed Econ Feed Press
600
400
200
0
-200
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

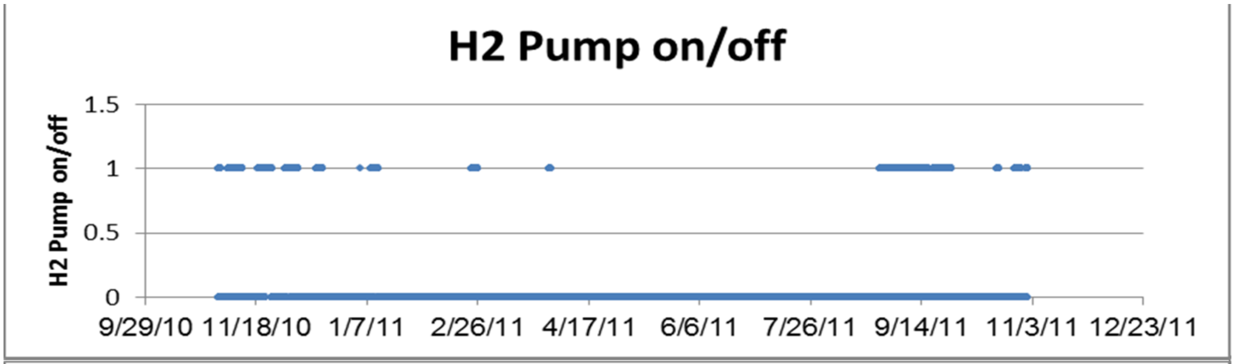

H1 Pump T Discharge
H1 Pump T Discharge
400
300
200
100
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

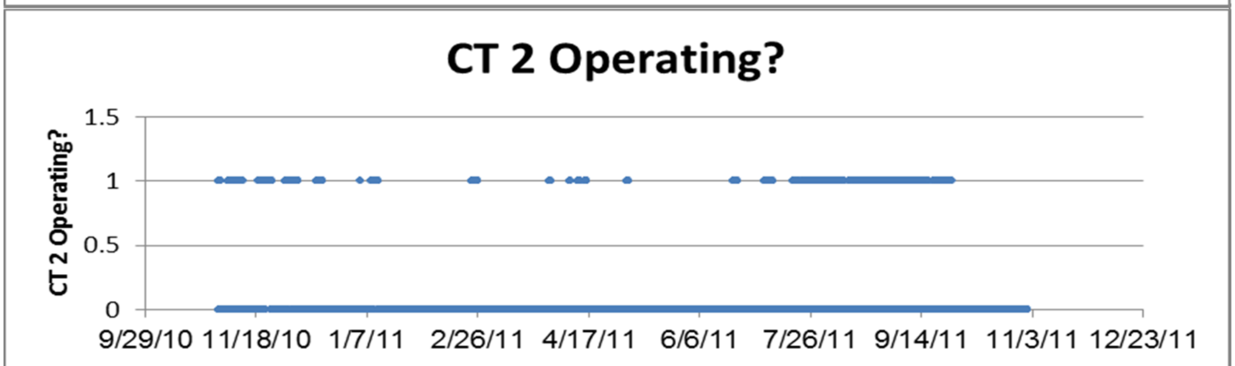

H1 Econ. Feed T
H1 Econ. Feed T
300
200
100
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

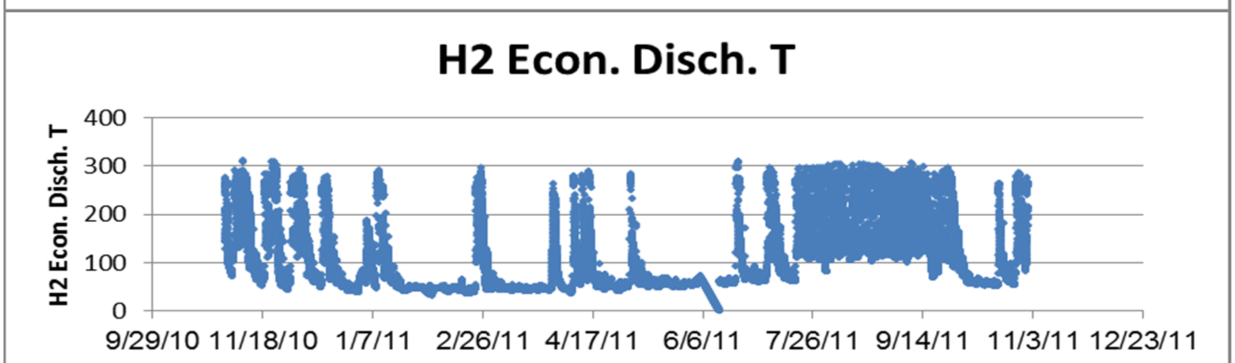

H1 Econ Feed Valve Position
H1 Econ Feed Valve Position
150
100
50
0
-50
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

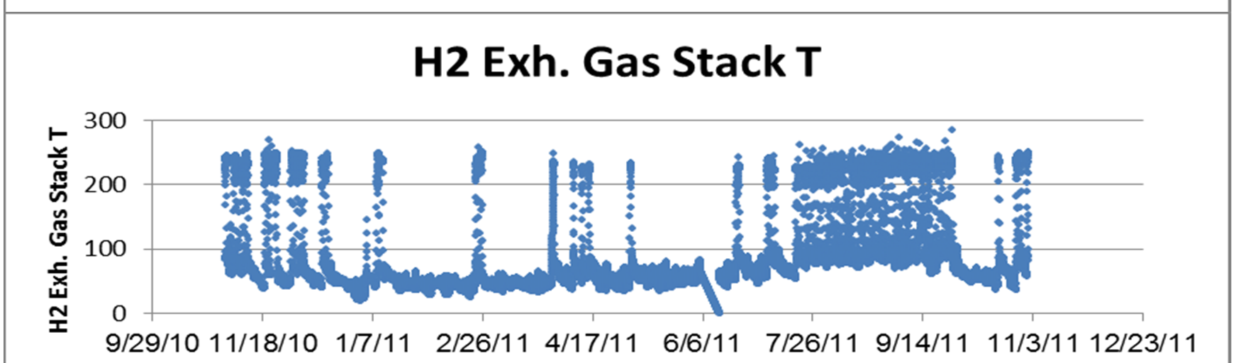

H1 Exh. Gas Just after Econ
H1 Exh. Gas Just after Econ
300
200
100
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

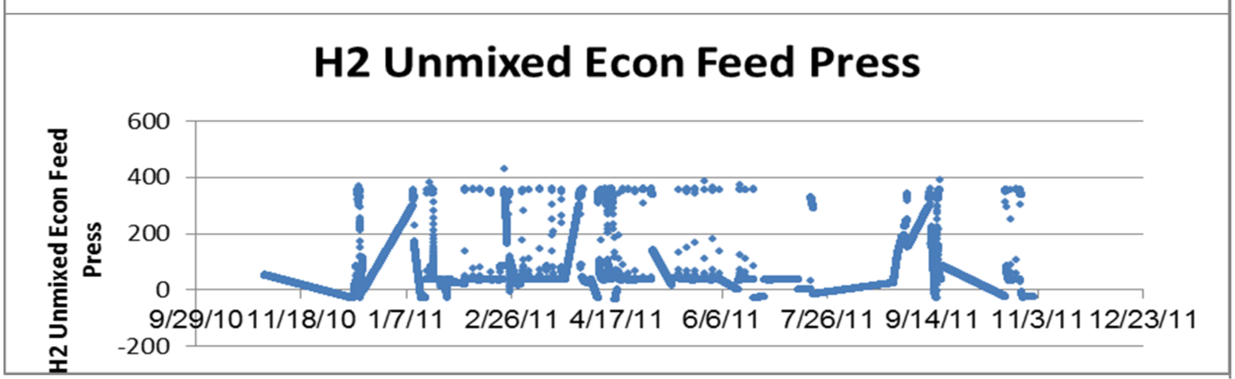

H1 Unmixed Econ Feed Temp
H1 Unmixed Econ Feed Temp
300
200
100
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

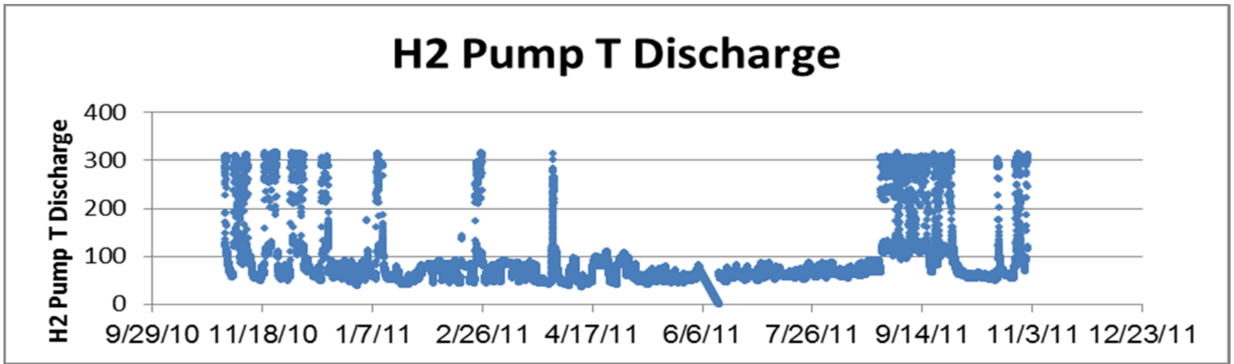

H2 Pump on/off
H2 Pump on/off
1.5
1
0.5
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

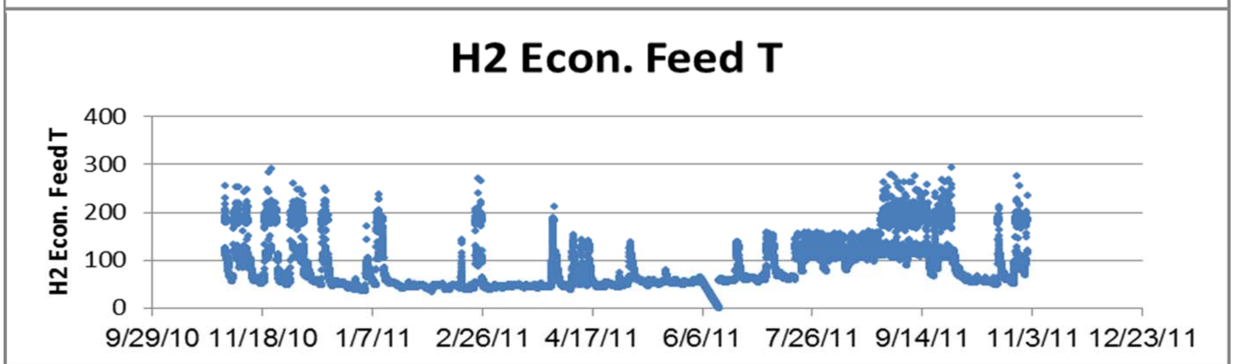

CT 2 Operating?
CT 2 Operating?
1.5
1
0.5
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

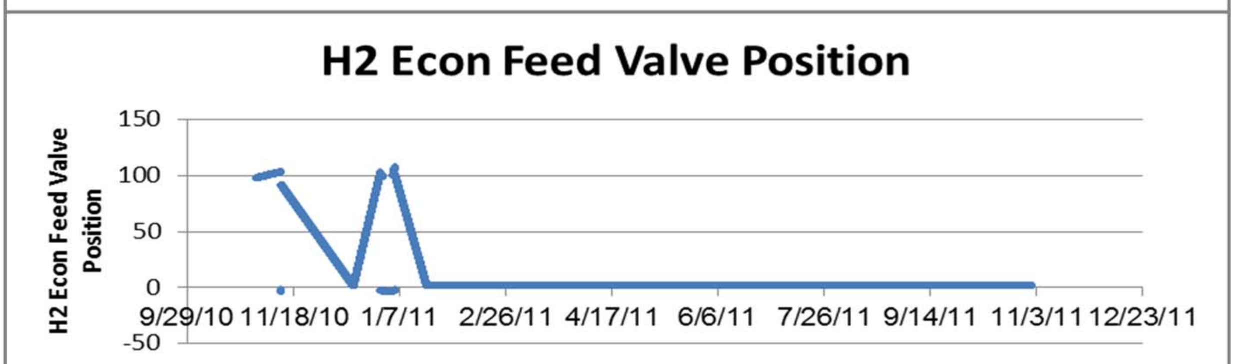

H2 Econ. Disch. T
H2 Econ. Disch. T
400
300
200
100
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

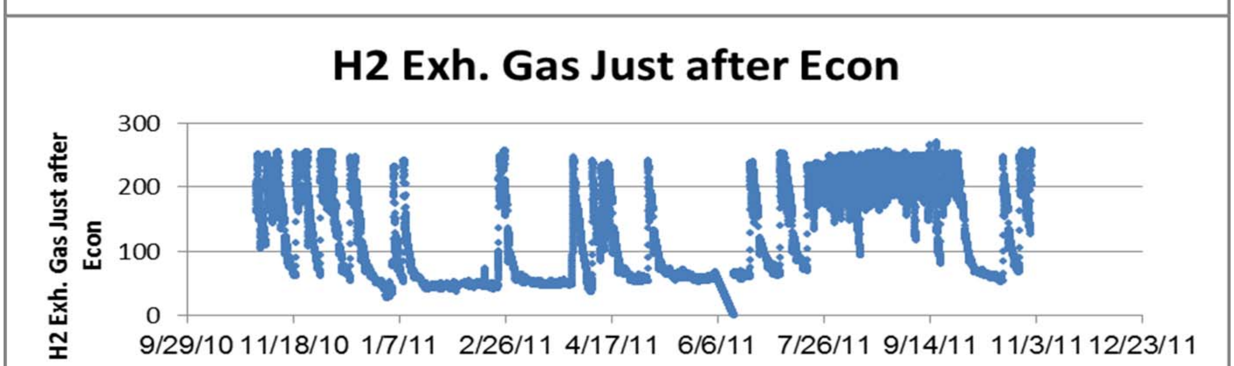

H2 Exh. Gas Stack T
H2 Exh. Gas Stack T
300
200
100
0
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

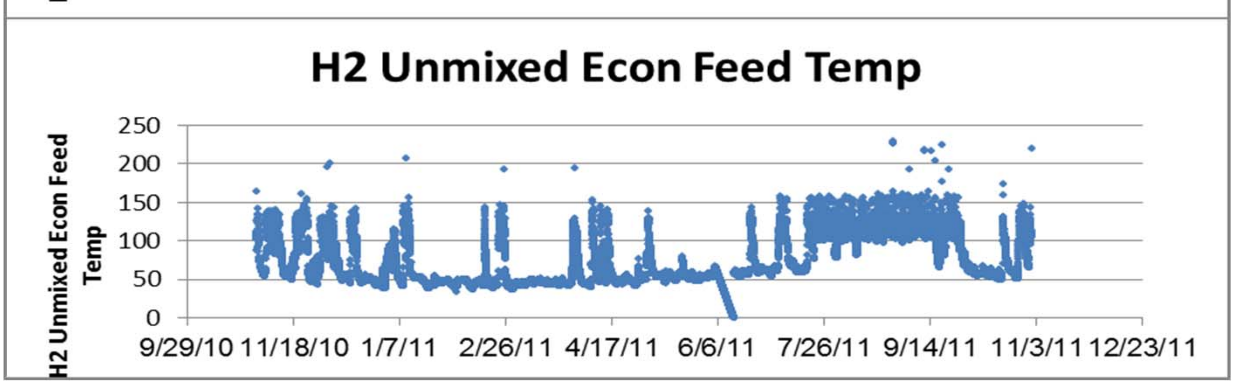

H2 Unmixed Econ Feed Press
H2 Unmixed Econ Feed Press
600
400
200
0
-200
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11


H2 Pump T Discharge
H2 Pump T Discharge
0
100
200
300
400
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

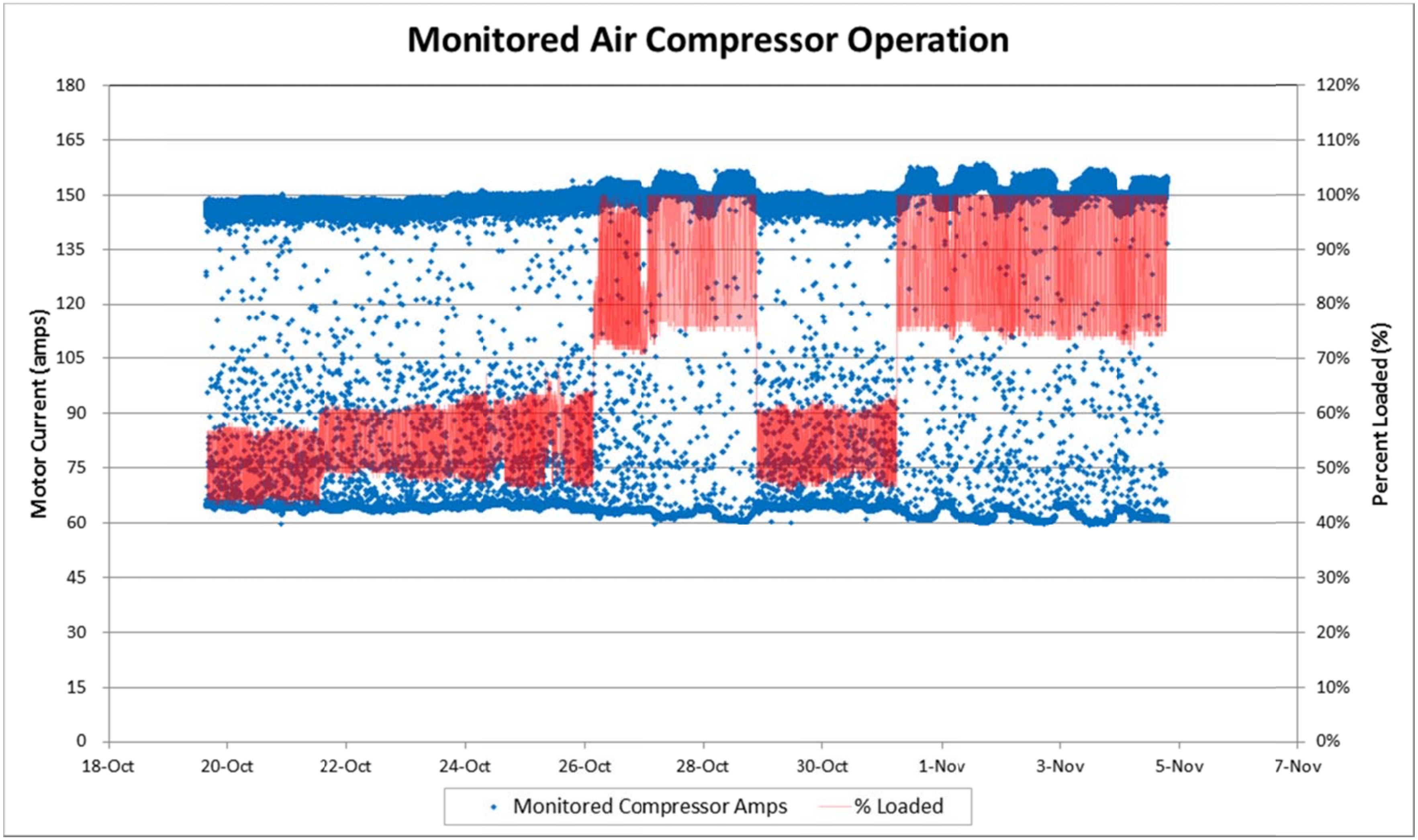

H2 Econ. Feed T
H2 Econ. Feed T
0
100
200
300
400
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11


H2 Econ Feed Valve Position
H2 Econ Feed Valve Position
-50
0
50
100
150
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11


H2 Exh. Gas Just after Econ
H2 Exh. Gas Just after Econ
0
100
200
300
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

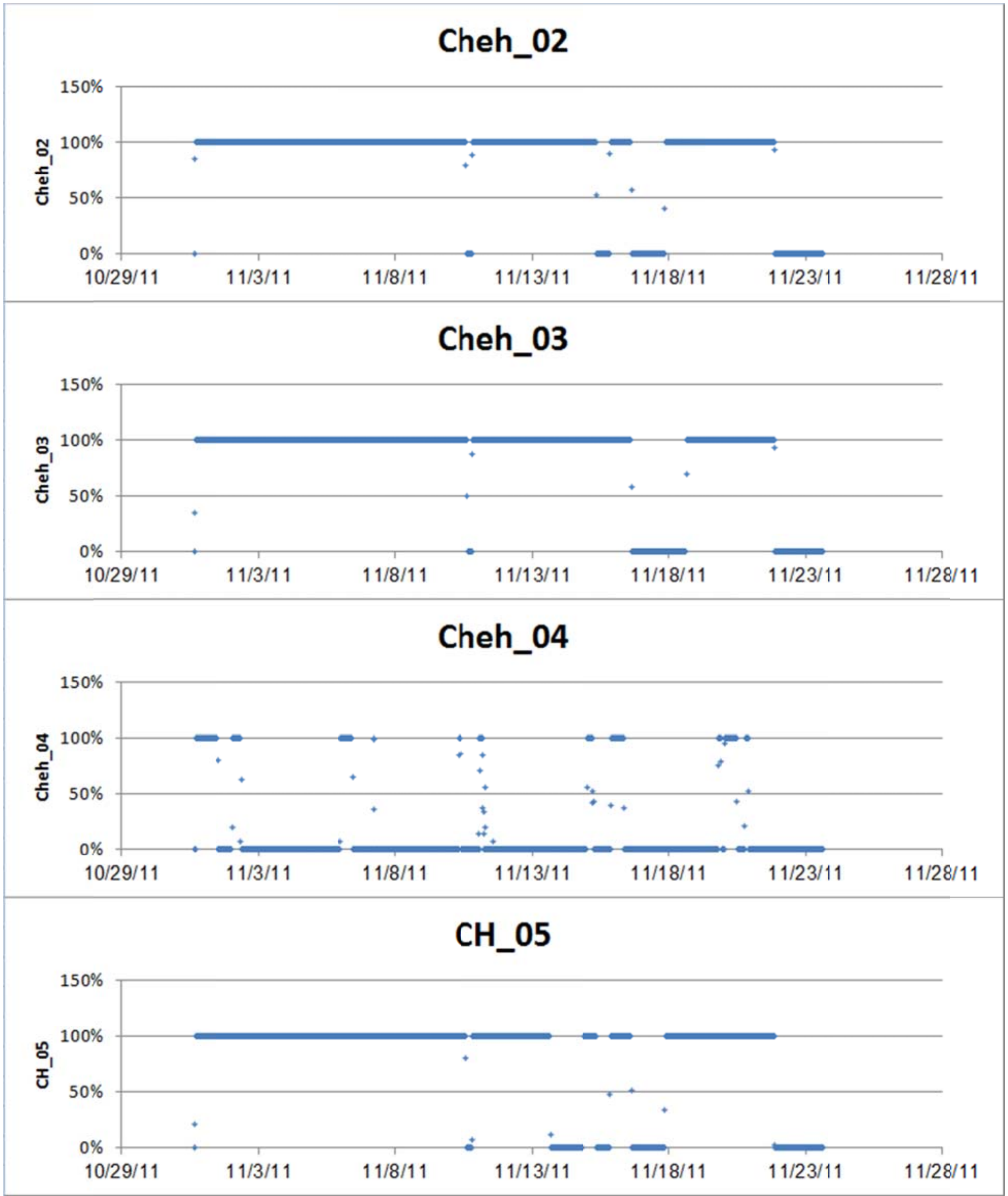

H2 Unmixed Econ Feed Temp
H2 Unmixed Econ Feed Temp
0
50
100
150
200
250
9/29/10 11/18/10 1/7/11 2/26/11 4/17/11 6/6/11 7/26/11 9/14/11 11/3/11 12/23/11

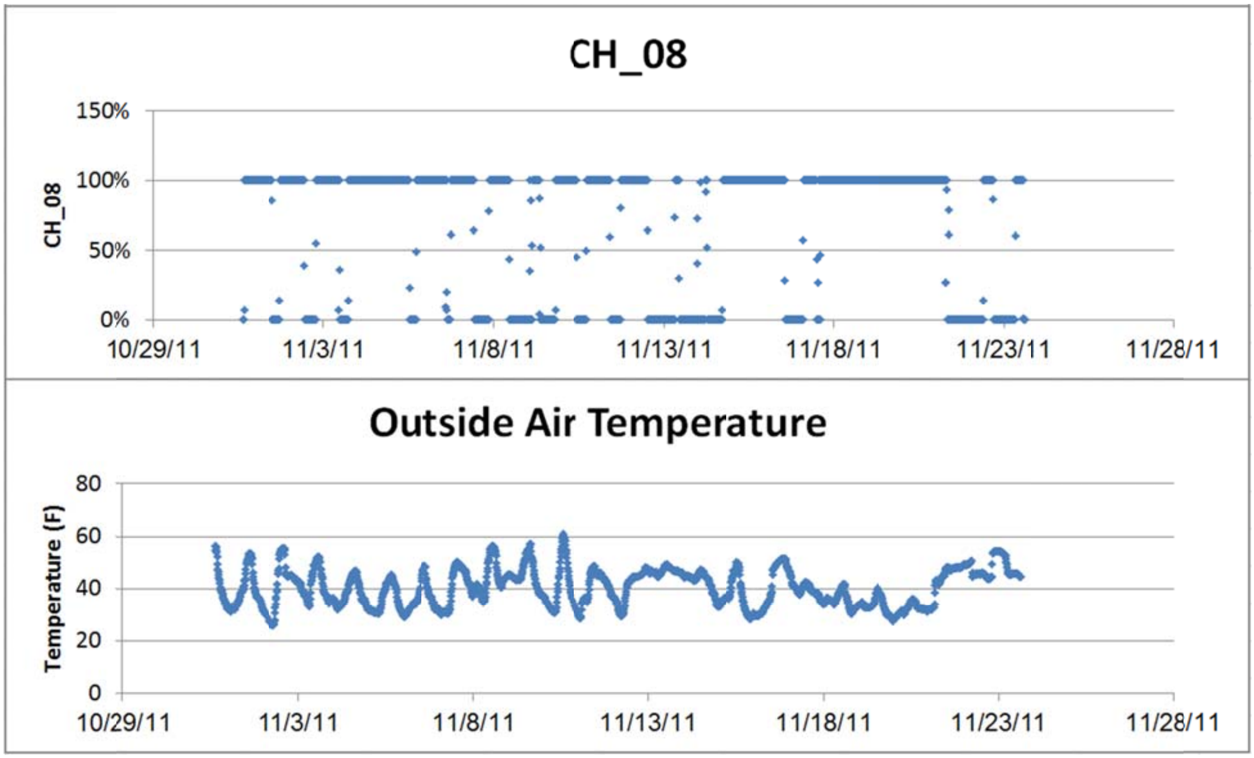
ECMs 7 & 10: New Variable Speed Air Compressor and Demand-based Dew Point Controls



ECM 8: Reduce Runtime of Electric Heat Trace

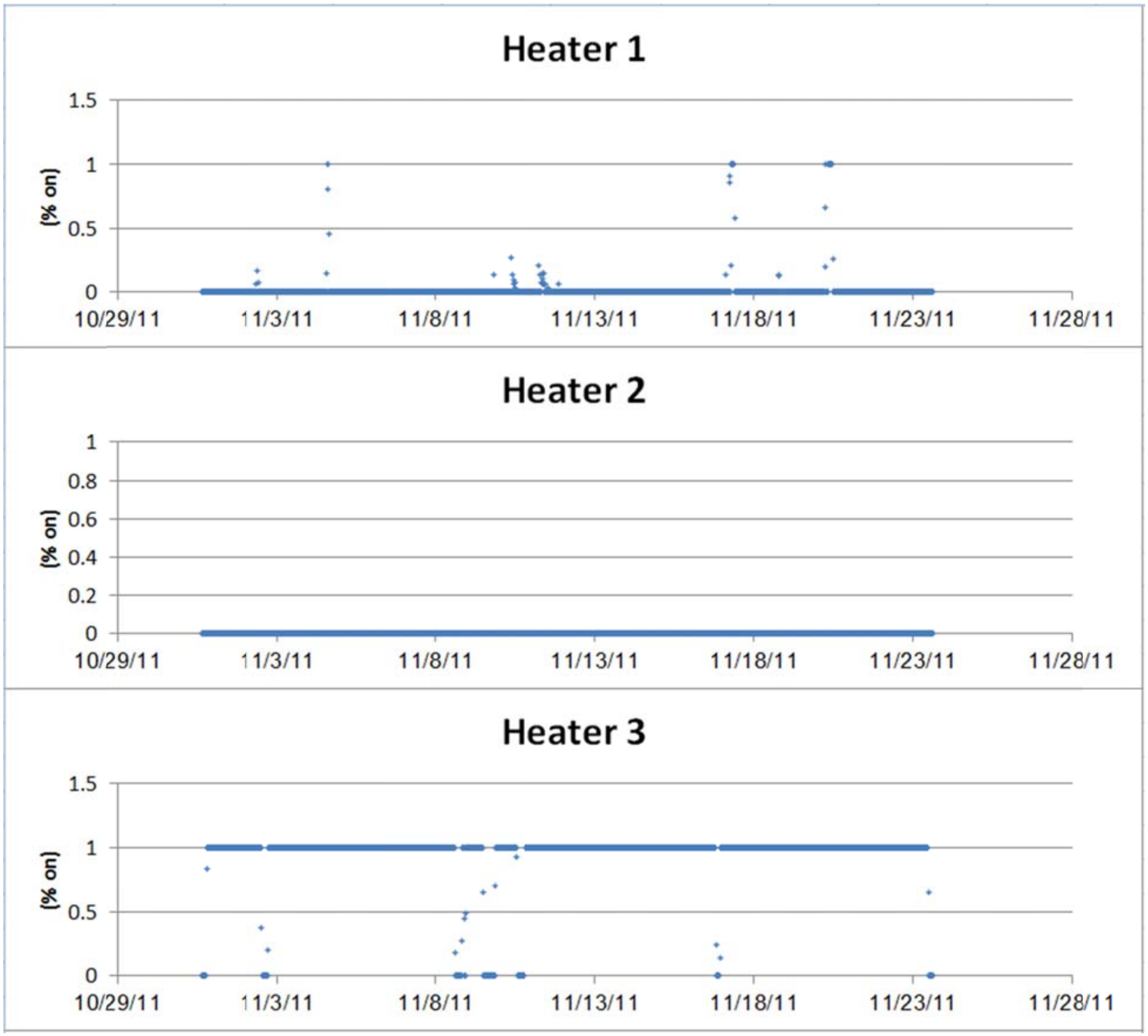
Monitored Heat Trace Circuits




CH_08
150%
100%
50%
0%
CH_08
10/29/11
11/3/11
11/8/11
11/13/11
11/18/11
11/23/11
11/28/11
Outside Air Temperature
80
60
40
20
0
Temperature (F)
10/29/11
11/3/11
11/8/11
11/13/11
11/18/11
11/23/11
11/28/11

ECM 9: Adjust Thermostat on One Electric Heater

Electric Space Heaters Serving the Turbine Building



26.7 Chehalis: Model Calculations

ECMs 1 & 2: CCW Pump Speed Control and Fan VFDs with Temperature Reset

Closed Cooling Water System Annual Model

		Coefficients:
Plant Power Output to Load:	c1	4257.668
(from CCW_Data.xlsx)	c2	164.6151
	c3	-0.45338
	c4	0.000486

Summary				
	Baseline	Temp. Reset	Fan VFDs	Pump VFD
Pump	2,554,640	2,554,640	2,554,640	968,475
Fans	646,604	422,675	191,470	191,063
Total	3,201,244	2,977,316	2,746,110	1,159,537
Savings		**223,929**	**231,205**	**1,586,573**

Non-production load: 3,980 MBH (linked to cell)

5,216 MBH

No-load Heat Rejection Scalar: **1.310482**

Loaded Heat Rejection Scalar: **1.021347**

MWh Summary				
	Baseline	Temp. Reset	Fan VFDs	Pump VFD
Pump	2,555	2,555	2,555	968
Fans	647	423	191	191
Total	3,201	2,977	2,746	1,160
Savings		**224**	**231**	**1,587**

Max Floating Setpoint	98 F	
Baseline Setpoint	76.7 F	
Reset Temperature	92 F	
# Fans	14	
Fan HP	40	hp
Fan Motor Amp Offset	2.5	amps
Temp to Fan Power		
Slope:	-0.084393	
Intercept:	39.16178	
Speed to Capacity	0.8	
Fan Speed to Power	2.7	
Fan VFD Efficiency	96%	
Fan Minimum Speed:	20%	
MBH per degree F at full capacity:	1,513	MBH/deg. F
Full Load Approach Temp:	19.28	F
No Fan Capacity:	158.35	MBH/deg. F

Pump Calculations:

Full Load Pump Speed:	90%	
Idling Pump Speed:	60%	
Pump Speed to Power	2.7	
Pump VFD Efficiency	97%	
Full Speed Load Cut-off	10,000	MBH
Estimated Pump Motor Efficiency	95.5%	
Claimed Pump Heat Load Reduction	90%	

Pump Flow	9,651	gpm
Pounds per gallon of H20:	8.33	
BTU per deg. F per Pound	1	
Pump Shaft Power	488.29	BHP
BHP to MBH	2.5444	
Pump Heat Load	1,242	MBH
Average Non-Production Load	3,984	MBH
Non-pump load	2,742	
Load Due to Pump Power	31%	

Total:										646,604	2,554,640
Average:										73.8	291.6
			Baseline								
Tag											
Descriptor	TMY3 DB Temperature	Heat Load	Temp Setpoint	TD	Available Fan Capacity	Pump Capacity	Fans Running	Pumps Running	Fan Power	Pump Power
Units					(MBH)	(MBH)	(#)	(#)	(kW)	(kW)
01-Nov-10 00:00:00	37.4	5,216	76.7	39.3	53,287.3	6,230.9	0.0	1	0.0	382.488
01-Nov-10 01:00:00	36.3	5,216	76.7	40.4	54,749.9	6,401.9	0.0	1	0.0	382.488
01-Nov-10 02:00:00	35.1	5,216	76.7	41.7	56,456.2	6,601.4	0.0	1	0.0	382.488
01-Nov-10 03:00:00	34.0	5,216	76.7	42.8	57,918.8	6,772.4	0.0	1	0.0	382.488
01-Nov-10 04:00:00	36.0	5,216	76.7	40.8	55,237.4	6,458.9	0.0	1	0.0	382.488
01-Nov-10 05:00:00	39.0	5,216	76.7	37.7	51,093.4	5,974.3	0.0	1	0.0	382.488
01-Nov-10 06:00:00	39.0	6,010	76.7	37.7	51,093.4	5,974.3	0.0	1	0.4	382.488
01-Nov-10 07:00:00	39.9	8,004	76.7	36.8	49,874.6	5,831.8	0.6	1	21.8	382.488
01-Nov-10 08:00:00	41.0	25,109	76.7	35.7	48,412.0	5,660.8	5.6	1	200.8	382.488
01-Nov-10 09:00:00	43.0	32,208	76.7	33.8	45,730.7	5,347.3	8.2	1	292.2	382.488
01-Nov-10 10:00:00	46.9	33,458	76.7	29.8	40,367.9	4,720.2	10.0	1	350.8	382.488
01-Nov-10 11:00:00	48.9	33,458	76.7	27.8	37,686.5	4,406.7	10.8	1	378.1	382.488
01-Nov-10 12:00:00	52.0	33,491	76.7	24.8	33,542.5	3,922.1	12.3	1	429.2	382.488
01-Nov-10 13:00:00	54.0	33,907	76.7	22.8	30,861.2	3,608.6	13.7	1	475.7	382.488
01-Nov-10 14:00:00	55.0	33,855	76.7	21.7	29,398.6	3,437.6	14.0	1	483.2	382.488
01-Nov-10 15:00:00	53.1	33,951	76.7	23.7	32,080.0	3,751.1	13.2	1	457.1	382.488
01-Nov-10 16:00:00	50.0	33,736	76.7	26.7	36,223.9	4,235.6	11.4	1	398.4	382.488
01-Nov-10 17:00:00	46.0	33,978	76.7	30.7	41,586.7	4,862.7	9.8	1	345.8	382.488
01-Nov-10 18:00:00	43.0	33,848	76.7	33.8	45,730.7	5,347.3	8.7	1	310.0	382.488
01-Nov-10 19:00:00	37.9	33,653	76.7	38.8	52,556.0	6,145.3	7.3	1	263.5	382.488
01-Nov-10 20:00:00	36.0	33,684	76.7	40.8	55,237.4	6,458.9	6.9	1	249.3	382.488
01-Nov-10 21:00:00	35.1	30,733	76.7	41.7	56,456.2	6,601.4	6.0	1	216.6	382.488
01-Nov-10 22:00:00	33.1	31,237	76.7	43.7	59,137.6	6,914.9	5.8	1	209.4	382.488
01-Nov-10 23:00:00	28.9	25,004	76.7	47.8	64,744.1	7,570.5	3.8	1	138.4	382.488
02-Nov-10 00:00:00	30.9	5,216	76.7	45.8	62,062.7	7,257.0	0.0	1	0.0	382.488
02-Nov-10 01:00:00	28.9	5,216	76.7	47.8	64,744.1	7,570.5	0.0	1	0.0	382.488
02-Nov-10 02:00:00	28.0	5,216	76.7	48.7	65,962.9	7,713.0	0.0	1	0.0	382.488
02-Nov-10 03:00:00	28.0	5,216	76.7	48.7	65,962.9	7,713.0	0.0	1	0.0	382.488
02-Nov-10 04:00:00	27.0	5,216	76.7	49.8	67,425.5	7,884.0	0.0	1	0.0	382.488
02-Nov-10 05:00:00	26.1	5,216	76.7	50.7	68,644.3	8,026.5	0.0	1	0.0	382.488
02-Nov-10 06:00:00	27.0	5,216	76.7	49.8	67,425.5	7,884.0	0.0	1	0.0	382.488
02-Nov-10 07:00:00	30.9	5,216	76.7	45.8	62,062.7	7,257.0	0.0	1	0.0	382.488
02-Nov-10 08:00:00	35.1	5,216	76.7	41.7	56,456.2	6,601.4	0.0	1	0.0	382.488
02-Nov-10 09:00:00	39.0	5,216	76.7	37.7	51,093.4	5,974.3	0.0	1	0.0	382.488
02-Nov-10 10:00:00	46.9	5,216	76.7	29.8	40,367.9	4,720.2	0.2	1	6.1	382.488
02-Nov-10 11:00:00	48.9	5,216	76.7	27.8	37,686.5	4,406.7	0.3	1	10.5	382.488
02-Nov-10 12:00:00	51.1	5,216	76.7	25.7	34,761.4	4,064.6	0.5	1	16.2	382.488

Total:							422,675	2,554,640
Average:							48.3	291.6
	Temperature Reset							
Tag								
Descriptor	Temp Setpoint	TD	Available Capacity	Pump Capacity	Fans Running	Pumps Running	Fan Power	Pump Power
Units			(MBH)	(MBH)	(#)	(#)	(kW)	(kW)
01-Nov-10 00:00:00	92.0	54.6	73,941.2	8,645.9	0.0	1	0.0	382.488
01-Nov-10 01:00:00	92.0	55.7	75,403.8	8,816.9	0.0	1	0.0	382.488
01-Nov-10 02:00:00	92.0	56.9	77,110.1	9,016.4	0.0	1	0.0	382.488
01-Nov-10 03:00:00	92.0	58.0	78,572.7	9,187.5	0.0	1	0.0	382.488
01-Nov-10 04:00:00	92.0	56.0	75,891.3	8,873.9	0.0	1	0.0	382.488
01-Nov-10 05:00:00	92.0	53.0	71,747.3	8,389.4	0.0	1	0.0	382.488
01-Nov-10 06:00:00	92.0	53.0	71,747.3	8,389.4	0.0	1	0.0	382.488
01-Nov-10 07:00:00	92.0	52.1	70,528.5	8,246.9	0.0	1	0.0	382.488
01-Nov-10 08:00:00	92.0	51.0	69,066.0	8,075.9	3.5	1	123.3	382.488
01-Nov-10 09:00:00	92.0	49.0	66,384.6	7,762.3	5.2	1	183.2	382.488
01-Nov-10 10:00:00	92.0	45.1	61,021.8	7,135.3	6.0	1	212.6	382.488
01-Nov-10 11:00:00	92.0	43.1	58,340.4	6,821.7	6.4	1	223.9	382.488
01-Nov-10 12:00:00	92.0	40.0	54,196.5	6,337.2	7.0	1	243.9	382.488
01-Nov-10 13:00:00	92.0	38.0	51,515.1	6,023.6	7.6	1	262.2	382.488
01-Nov-10 14:00:00	92.0	37.0	50,052.5	5,852.6	7.8	1	270.4	382.488
01-Nov-10 15:00:00	92.0	38.9	52,733.9	6,166.1	7.4	1	255.8	382.488
01-Nov-10 16:00:00	92.0	42.0	56,877.8	6,650.7	6.7	1	233.0	382.488
01-Nov-10 17:00:00	92.0	46.0	62,240.6	7,277.8	6.0	1	211.9	382.488
01-Nov-10 18:00:00	92.0	49.0	66,384.6	7,762.3	5.5	1	195.5	382.488
01-Nov-10 19:00:00	92.0	54.1	73,209.9	8,560.4	4.8	1	172.6	382.488
01-Nov-10 20:00:00	92.0	56.0	75,891.3	8,873.9	4.6	1	165.3	382.488
01-Nov-10 21:00:00	92.0	56.9	77,110.1	9,016.4	3.9	1	142.7	382.488
01-Nov-10 22:00:00	92.0	58.9	79,791.5	9,330.0	3.8	1	139.8	382.488
01-Nov-10 23:00:00	92.0	63.1	85,398.0	9,985.6	2.5	1	90.4	382.488
02-Nov-10 00:00:00	92.0	61.1	82,716.6	9,672.0	0.0	1	0.0	382.488
02-Nov-10 01:00:00	92.0	63.1	85,398.0	9,985.6	0.0	1	0.0	382.488
02-Nov-10 02:00:00	92.0	64.0	86,616.8	10,128.1	0.0	1	0.0	382.488
02-Nov-10 03:00:00	92.0	64.0	86,616.8	10,128.1	0.0	1	0.0	382.488
02-Nov-10 04:00:00	92.0	65.0	88,079.4	10,299.1	0.0	1	0.0	382.488
02-Nov-10 05:00:00	92.0	65.9	89,298.2	10,441.6	0.0	1	0.0	382.488
02-Nov-10 06:00:00	92.0	65.0	88,079.4	10,299.1	0.0	1	0.0	382.488
02-Nov-10 07:00:00	92.0	61.1	82,716.6	9,672.0	0.0	1	0.0	382.488
02-Nov-10 08:00:00	92.0	56.9	77,110.1	9,016.4	0.0	1	0.0	382.488
02-Nov-10 09:00:00	92.0	53.0	71,747.3	8,389.4	0.0	1	0.0	382.488
02-Nov-10 10:00:00	92.0	45.1	61,021.8	7,135.3	0.0	1	0.0	382.488
02-Nov-10 11:00:00	92.0	43.1	58,340.4	6,821.7	0.0	1	0.0	382.488
02-Nov-10 12:00:00	92.0	40.9	55,415.3	6,479.7	0.0	1	0.0	382.488

Total:								191,470	2,554,640
Average:					0.25	2.87	0.76	21.9	291.6
	Fan VFDs								
Tag									
Descriptor	Temp Setpoint	TD	Available Capacity	Pump Capacity	Fan Speed Required	Fans Running	Pumps Running	Fan Power	Pump Power
Units			(MBH)	(MBH)	(%)	(#)	(#)	(kW)	(kW)
01-Nov-10 00:00:00	92.0	54.6	73,941.2	8,645.9	20%	0.0	1	0.0	382.488
01-Nov-10 01:00:00	92.0	55.7	75,403.8	8,816.9	20%	0.0	1	0.0	382.488
01-Nov-10 02:00:00	92.0	56.9	77,110.1	9,016.4	20%	0.0	1	0.0	382.488
01-Nov-10 03:00:00	92.0	58.0	78,572.7	9,187.5	20%	0.0	1	0.0	382.488
01-Nov-10 04:00:00	92.0	56.0	75,891.3	8,873.9	20%	0.0	1	0.0	382.488
01-Nov-10 05:00:00	92.0	53.0	71,747.3	8,389.4	20%	0.0	1	0.0	382.488
01-Nov-10 06:00:00	92.0	53.0	71,747.3	8,389.4	20%	0.0	1	0.0	382.488
01-Nov-10 07:00:00	92.0	52.1	70,528.5	8,246.9	20%	0.0	1	0.0	382.488
01-Nov-10 08:00:00	92.0	51.0	69,066.0	8,075.9	20%	17.3	1	8.3	382.488
01-Nov-10 09:00:00	92.0	49.0	66,384.6	7,762.3	29%	14.0	1	17.8	382.488
01-Nov-10 10:00:00	92.0	45.1	61,021.8	7,135.3	35%	14.0	1	30.1	382.488
01-Nov-10 11:00:00	92.0	43.1	58,340.4	6,821.7	38%	14.0	1	36.2	382.488
01-Nov-10 12:00:00	92.0	40.0	54,196.5	6,337.2	42%	14.0	1	49.2	382.488
01-Nov-10 13:00:00	92.0	38.0	51,515.1	6,023.6	46%	14.0	1	63.6	382.488
01-Nov-10 14:00:00	92.0	37.0	50,052.5	5,852.6	48%	14.0	1	70.9	382.488
01-Nov-10 15:00:00	92.0	38.9	52,733.9	6,166.1	45%	14.0	1	58.2	382.488
01-Nov-10 16:00:00	92.0	42.0	56,877.8	6,650.7	40%	14.0	1	41.7	382.488
01-Nov-10 17:00:00	92.0	46.0	62,240.6	7,277.8	35%	14.0	1	29.6	382.488
01-Nov-10 18:00:00	92.0	49.0	66,384.6	7,762.3	31%	14.0	1	22.2	382.488
01-Nov-10 19:00:00	92.0	54.1	73,209.9	8,560.4	26%	14.0	1	14.1	382.488
01-Nov-10 20:00:00	92.0	56.0	75,891.3	8,873.9	25%	14.0	1	12.1	382.488
01-Nov-10 21:00:00	92.0	56.9	77,110.1	9,016.4	21%	14.0	1	7.3	382.488
01-Nov-10 22:00:00	92.0	58.9	79,791.5	9,330.0	20%	19.2	1	9.4	382.488
01-Nov-10 23:00:00	92.0	63.1	85,398.0	9,985.6	20%	12.3	1	6.1	382.488
02-Nov-10 00:00:00	92.0	61.1	82,716.6	9,672.0	20%	0.0	1	0.0	382.488
02-Nov-10 01:00:00	92.0	63.1	85,398.0	9,985.6	20%	0.0	1	0.0	382.488
02-Nov-10 02:00:00	92.0	64.0	86,616.8	10,128.1	20%	0.0	1	0.0	382.488
02-Nov-10 03:00:00	92.0	64.0	86,616.8	10,128.1	20%	0.0	1	0.0	382.488
02-Nov-10 04:00:00	92.0	65.0	88,079.4	10,299.1	20%	0.0	1	0.0	382.488
02-Nov-10 05:00:00	92.0	65.9	89,298.2	10,441.6	20%	0.0	1	0.0	382.488
02-Nov-10 06:00:00	92.0	65.0	88,079.4	10,299.1	20%	0.0	1	0.0	382.488
02-Nov-10 07:00:00	92.0	61.1	82,716.6	9,672.0	20%	0.0	1	0.0	382.488
02-Nov-10 08:00:00	92.0	56.9	77,110.1	9,016.4	20%	0.0	1	0.0	382.488
02-Nov-10 09:00:00	92.0	53.0	71,747.3	8,389.4	20%	0.0	1	0.0	382.488
02-Nov-10 10:00:00	92.0	45.1	61,021.8	7,135.3	20%	0.0	1	0.0	382.488
02-Nov-10 11:00:00	92.0	43.1	58,340.4	6,821.7	20%	0.0	1	0.0	382.488
02-Nov-10 12:00:00	92.0	40.9	55,415.3	6,479.7	20%	0.0	1	0.0	382.488

Total:						968,475						191,063
Average:						110.6			0.25	2.26	0.76	21.8
	Pump VFD											
Tag												
Descriptor	Temp Setpoint	TD	Available Fan Capacity	Pump Capacity	Pump Speed Required	Pump Power	Pump Heat Load Reduction	New Heat Load	Fan Speed Required	Fans Running	Pumps Running	Fan Power
Units			(MBH)	(MBH)	(%)	(kW)	(MBH)	(MBH)	(%)	(#)	(#)	(kW)
01-Nov-10 00:00:00	92.0	54.6	73,941.2	5,187.5	60%	99.278	831	4,386	20%	0.0	1	0.0
01-Nov-10 01:00:00	92.0	55.7	75,403.8	5,290.2	60%	99.278	831	4,386	20%	0.0	1	0.0
01-Nov-10 02:00:00	92.0	56.9	77,110.1	5,409.9	60%	99.278	831	4,386	20%	0.0	1	0.0
01-Nov-10 03:00:00	92.0	58.0	78,572.7	5,512.5	60%	99.278	831	4,386	20%	0.0	1	0.0
01-Nov-10 04:00:00	92.0	56.0	75,891.3	5,324.4	60%	99.278	831	4,386	20%	0.0	1	0.0
01-Nov-10 05:00:00	92.0	53.0	71,747.3	5,033.6	60%	99.278	831	4,386	20%	0.0	1	0.0
01-Nov-10 06:00:00	92.0	53.0	71,747.3	5,033.6	60%	99.278	831	5,180	20%	0.0	1	0.0
01-Nov-10 07:00:00	92.0	52.1	70,528.5	4,948.1	60%	99.278	831	7,173	20%	0.2	1	0.1
01-Nov-10 08:00:00	92.0	51.0	69,066.0	7,268.3	90%	296.689	252	24,857	20%	1.3	1	0.6
01-Nov-10 09:00:00	92.0	49.0	66,384.6	6,986.1	90%	296.689	252	31,956	29%	14.0	1	19.1
01-Nov-10 10:00:00	92.0	45.1	61,021.8	6,421.7	90%	296.689	252	33,206	36%	14.0	1	31.9
01-Nov-10 11:00:00	92.0	43.1	58,340.4	6,139.5	90%	296.689	252	33,207	38%	14.0	1	38.3
01-Nov-10 12:00:00	92.0	40.0	54,196.5	5,703.5	90%	296.689	252	33,239	43%	14.0	1	51.6
01-Nov-10 13:00:00	92.0	38.0	51,515.1	5,421.3	90%	296.689	252	33,655	47%	14.0	1	66.3
01-Nov-10 14:00:00	92.0	37.0	50,052.5	5,267.4	90%	296.689	252	33,604	49%	14.0	1	73.8
01-Nov-10 15:00:00	92.0	38.9	52,733.9	5,549.5	90%	296.689	252	33,700	46%	14.0	1	60.8
01-Nov-10 16:00:00	92.0	42.0	56,877.8	5,985.6	90%	296.689	252	33,484	40%	14.0	1	43.8
01-Nov-10 17:00:00	92.0	46.0	62,240.6	6,550.0	90%	296.689	252	33,726	35%	14.0	1	31.4
01-Nov-10 18:00:00	92.0	49.0	66,384.6	6,986.1	90%	296.689	252	33,596	32%	14.0	1	23.7
01-Nov-10 19:00:00	92.0	54.1	73,209.9	7,704.4	90%	296.689	252	33,401	27%	14.0	1	15.3
01-Nov-10 20:00:00	92.0	56.0	75,891.3	7,986.5	90%	296.689	252	33,432	26%	14.0	1	13.2
01-Nov-10 21:00:00	92.0	56.9	77,110.1	8,114.8	90%	296.689	252	30,482	21%	14.0	1	8.1
01-Nov-10 22:00:00	92.0	58.9	79,791.5	8,397.0	90%	296.689	252	30,986	21%	14.0	1	7.5
01-Nov-10 23:00:00	92.0	63.1	85,398.0	8,987.0	90%	296.689	252	24,752	20%	0.9	1	0.5
02-Nov-10 00:00:00	92.0	61.1	82,716.6	5,803.2	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 01:00:00	92.0	63.1	85,398.0	5,991.3	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 02:00:00	92.0	64.0	86,616.8	6,076.8	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 03:00:00	92.0	64.0	86,616.8	6,076.8	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 04:00:00	92.0	65.0	88,079.4	6,179.5	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 05:00:00	92.0	65.9	89,298.2	6,265.0	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 06:00:00	92.0	65.0	88,079.4	6,179.5	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 07:00:00	92.0	61.1	82,716.6	5,803.2	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 08:00:00	92.0	56.9	77,110.1	5,409.9	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 09:00:00	92.0	53.0	71,747.3	5,033.6	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 10:00:00	92.0	45.1	61,021.8	4,281.2	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 11:00:00	92.0	43.1	58,340.4	4,093.0	60%	99.278	831	4,386	20%	0.0	1	0.0
02-Nov-10 12:00:00	92.0	40.9	55,415.3	3,887.8	60%	99.278	831	4,386	20%	0.0	1	0.0

ECM 3: High Efficiency Lighting

Baseline Lighting

Location	Fixture & Lamp Type (-)	Total Fixtures (-)	Fixtures On (-)	Fixtures Off (-)	Control Method (-)	Watts per Fixture (W/fixture)	Duty Cycle (%)	Annual Operation (h/yr)	Annual Energy Use (kWh/yr)
Turbine Building	400-W HPS	74	59	15	Manual	457	100%	8,760	236,196
Turbine Building	250-W HPS	10	5	5	Manual	295	100%	8,760	12,921
Exterior Lighting	400-W HPS	27	21	6	Photo eye	457	50%	4,338	41,632
Exterior Lighting	70-W HPS	170	54	116	Photo eye	86	50%	4,338	20,146
Control Room	4 ft- 2L T8 32 W	12	12	0	Manual	55	100%	8,760	5,782
Conference Room	4 ft- 2L T8 32 W	8	8	0	Manual	55	23%	2,000	880
Lunch Room	4 ft- 2L T8 32 W	8	8	0	Manual	55	100%	8,760	3,854
Lab	4 ft- 2L T8 32 W	3	3	0	Manual	55	23%	2,000	330
Men	4 ft- 2L T8 32 W	7	7	0	Manual	55	90%	7,884	3,035
Women	4 ft- 2L T8 32 W	5	5	0	Manual	55	1%	100	28
Open Office	4 ft- 2L T8 32 W	11	11	0	Manual	55	100%	6,000	3,630
IT Room	4 ft 2L T8 32W	6	6	0	Manual	55	100%	8,760	2,891
Maintenance Shop	400-W HPS	9	8	1	Manual	457	100%	8,760	32,027
Maintenance Office	8 ft - 2L T12 110 W	7	7	0	Manual	237	100%	8,760	14,533
Air Compressor Room	400-W HPS	6	5	1	Manual	457	100%	8,760	20,017
Electric Room	4 ft 2L T8 32W	6	6	0	Manual	55	100%	8,760	2,891
ACC MCC	4 ft 2L T8 32W	33	33	0	Manual	55	100%	8,760	15,899
Back MCC	4 ft 2L T8 32W	33	33	0	Manual	55	100%	8,760	15,899
BFW-1 Pump Room	4 ft 2L T8 32W	5	5	0	Manual	55	100%	8,760	2,409
BFW-2 Pump Room	4 ft 2L T8 32W	5	5	0	Manual	55	100%	8,760	2,409
Total (MWh/yr)									**437**

ECM Lighting

Reduced Runtime W/Occ Sensor 1 **0.7**

Reduced Runtime W/Occ Sensor 2 **0.5**

Location	Fixture & Lamp Type	Total Fixtures (-)	Fixtures On (-)	Fixtures Off (-)	Control Method (-)	Watts per Fixture (W/fixture)	Duty Cycle (%)	Annual Operation (h/yr)	Annual Energy Use (kWh/yr)
Turbine Building	6L T5 HO HBF	74	74	0	Occ. Sensor	352	30%	2,628	68,454
Turbine Building	4L T5 HO HBF	10	10	0	Occ. Sensor	234	30%	2,628	6,150
Exterior Lighting	250-W HPS	27	21	6	Photo eye	457	50%	4,338	41,632
Exterior Lighting	70-W HPS	170	54	116	Photo eye	86	50%	4,338	20,146
Control Room	4 ft- 2L T8 32 W	12	12	0	Manual	55	100%	8,760	5,782
Conference Room	4 ft- 2L T8 32 W	8	8	0	Manual	55	23%	2,000	880
Lunch Room	4 ft- 2L T8 32 W	8	8	0	Manual	55	100%	8,760	3,854
Lab	4 ft- 2L T8 32 W	3	3	0	Manual	55	23%	2,000	330
Men	4 ft- 2L T8 32 W	7	7	0	Occ. Sensor	55	27%	2,365	911
Women	4 ft- 2L T8 32 W	5	5	0	Occ. Sensor	55	1%	50	14
Open Office	4 ft- 2L T8 32 W	11	11	0	Manual	55	100%	6,000	3,630
IT Room	4 ft 2L T8 32W	6	6	0	Occ. Sensor	55	30%	2,628	867
Maintenance Shop	400-W HPS	9	9	0	Occ. Sensor	352	50%	4,380	13,876
Maintenance Office	4 ft 2L T8 32W	14	14	0	Occ. Sensor	55	50%	4,380	3,373
Air Compressor Room	400-W HPS	6	6	0	Occ. Sensor	352	50%	4,380	9,251
Electric Room	4 ft 2L T8 32W	6	6	0	Occ. Sensor	55	30%	2,628	867
ACC MCC	4 ft 2L T8 32W	33	33	0	Occ. Sensor	55	30%	2,628	4,770
Back MCC	4 ft 2L T8 32W	33	33	0	Occ. Sensor	55	30%	2,628	4,770
BFW-1 Pump Room	4 ft 2L T8 32W	5	5	0	Occ. Sensor	55	30%	2,628	723
BFW-2 Pump Room	4 ft 2L T8 32W	5	5	0	Occ. Sensor	55	30%	2,628	723
Total (MWh/yr)									**191**

ECM 4: Install Small Condensate Pump

Small Condensate Pump Analysis

Voltage (V)	6900
Power Factor (kW/KVA)	0.86
Motor Eff	0.93

	Plant Net MW	Condensate Drum Pressure (psia)	Motor Current Pump 1A (A)	Motor Current Pump 1B (A)	Motor Current Pump 1C (A)	Pump Discharge Pressure (psig)	Pump Flow (gpm)	Actual Pump Flow (gpm)	Pump Differential Pressure (ft)	Pump 1A Status (1,0)	Pump 1B Status (1,0)	Pump 1C Status (1,0)	Total Pumps On (1,0)	Motor Power Pump 1A (kW)	Motor Power Pump 2A (kW)	Motor Power Pump 3A (kW)	Pumps on/ Turbine off	Pumps on for Start Up	Pumps on for Aux Boiler	Pump Power for Aux Boiler (kW)
Min	-11.6	0.0	-1.9	-1.7	-2.5	-1.9	0.2	0.0	-4.1	0.0	0.0	0.0	0.0	-19.2	-17.0	-25.6				0
Max	515.2	14.9	35.5	32.7	30.1	408.0	3310.2	3310.2	954.5	1.0	1.0	1.0	2.0	365.0	336.2	309.6				619
Avg (when on)	324.7	10.7	30.6	29.2	29.3	128.1	670.6	1607.5	816.8	25%	20%	1%	35%	314.4	300.7	301.3	15.8%	2.2%	8.9%	308
Total																				

No.	Time	Plant Net MW	Condensate Drum Pressure (psia)	Motor Current Pump 1A (A)	Motor Current Pump 1B (A)	Motor Current Pump 1C (A)	Pump Discharge Pressure (psig)	Pump Flow (gpm)	Actual Pump Flow (gpm)	Pump Differential Pressure (ft)	Pump 1A Status (1,0)	Pump 1B Status (1,0)	Pump 1C Status (1,0)	Total Pumps On (1,0)	Motor Power Pump 1A (kW)	Motor Power Pump 2A (kW)	Motor Power Pump 3A (kW)	Pumps on/ Turbine off	Pumps on for Start Up	Pumps on for Aux Boiler	Pump Power for Aux Boiler (kW)
1	11/1/10 12:00 AM	-3.06	14.61	0	0	0	8	169	0	18	0	0	0	0	0.5	-0.1	-1.1	0	0	0	0
2	11/1/10 12:15 AM	-3.07	14.60	0	0	0	8	169	0	18	0	0	0	0	0.5	-0.1	-1.1	0	0	0	0
3	11/1/10 12:30 AM	-2.97	14.58	0	0	0	8	169	0	18	0	0	0	0	0.5	-0.1	-1.1	0	0	0	0
4	11/1/10 12:45 AM	-3.07	14.58	0	0	0	8	169	0	18	0	0	0	0	0.5	-0.2	-1.1	0	0	0	0
5	11/1/10 1:00 AM	-3.38	14.59	0	0	0	8	169	0	18	0	0	0	0	0.5	-0.2	-1.1	0	0	0	0
6	11/1/10 1:15 AM	-3.02	14.59	0	0	0	8	170	0	18	0	0	0	0	0.5	-0.2	-1.1	0	0	0	0
7	11/1/10 1:30 AM	-3.07	14.60	0	0	0	8	162	0	18	0	0	0	0	0.5	-0.2	-1.1	0	0	0	0
8	11/1/10 1:45 AM	-2.84	14.59	0	0	0	8	169	0	18	0	0	0	0	0.5	-0.2	-1.1	0	0	0	0
9	11/1/10 2:00 AM	-4.53	14.60	0	0	0	8	169	0	18	0	0	0	0	0.4	-0.2	-1.1	0	0	0	0
10	11/1/10 2:15 AM	-2.84	14.60	0	0	0	8	169	0	18	0	0	0	0	0.3	-0.2	-1.1	0	0	0	0
11	11/1/10 2:30 AM	-2.84	14.60	0	0	0	8	169	0	18	0	0	0	0	0.4	-0.2	-1.1	0	0	0	0
12	11/1/10 2:45 AM	-2.85	14.59	0	0	0	8	169	0	18	0	0	0	0	0.4	-0.1	-1.1	0	0	0	0
13	11/1/10 3:00 AM	-2.87	14.59	0	0	0	7	169	0	18	0	0	0	0	0.4	-0.1	-1.0	0	0	0	0
14	11/1/10 3:15 AM	-4.72	14.60	0	0	0	7	182	0	17	0	0	0	0	0.4	-0.2	-1.0	0	0	0	0
15	11/1/10 3:30 AM	-2.96	14.60	0	0	0	7	172	0	17	0	0	0	0	0.4	-0.1	-1.0	0	0	0	0
16	11/1/10 3:45 AM	-3.07	14.60	0	0	0	7	172	0	17	0	0	0	0	0.4	-0.2	-1.0	0	0	0	0
17	11/1/10 4:00 AM	-3.08	14.59	0	0	0	7	172	0	17	0	0	0	0	0.4	-0.2	-1.0	0	0	0	0
18	11/1/10 4:15 AM	-3.07	14.59	0	0	0	7	182	0	17	0	0	0	0	0.4	-0.2	-1.0	0	0	0	0
19	11/1/10 4:30 AM	-5.50	14.58	0	29	0	357	1,210	1,210	825	0	1	0	1	0.3	299.2	-1.0	1	1	0	0
20	11/1/10 4:45 AM	-5.75	14.58	0	29	0	357	1,205	1,205	825	0	1	0	1	0.4	299.2	-1.0	1	1	0	0
21	11/1/10 5:00 AM	-5.98	14.60	0	29	0	357	1,204	1,204	824	0	1	0	1	0.4	299.2	-1.0	1	1	0	0
22	11/1/10 5:15 AM	11.07	12.51	0	29	0	357	1,190	1,190	831	0	1	0	1	0.4	299.0	-1.0	0	0	0	0
23	11/1/10 5:30 AM	11.09	6.88	0	29	0	347	1,200	1,200	820	0	1	0	1	0.4	297.3	-1.0	0	0	0	0
24	11/1/10 5:45 AM	10.97	3.98	0	29	0	346	1,203	1,203	823	0	1	0	1	0.4	299.2	-1.0	0	0	0	0
25	11/1/10 6:00 AM	11.05	2.69	0	29	0	347	1,185	1,185	830	0	1	0	1	0.4	299.2	-1.0	0	0	0	0
26	11/1/10 6:15 AM	24.60	4.87	30	29	0	348	2,435	2,435	826	1	1	0	2	308.5	299.3	-1.0	0	0	0	0
27	11/1/10 6:30 AM	25.38	3.54	31	29	0	347	2,395	2,395	828	1	1	0	2	319.8	295.1	-1.0	0	0	0	0
28	11/1/10 6:45 AM	24.35	2.17	31	29	0	344	2,420	2,420	824	1	1	0	2	319.7	298.8	-1.0	0	0	0	0
29	11/1/10 7:00 AM	134.53	1.94	31	29	0	341	2,422	2,422	817	1	1	0	2	319.7	299.3	-1.1	0	0	0	0
30	11/1/10 7:15 AM	249.56	1.96	31	29	0	341	2,354	2,354	817	1	1	0	2	319.7	299.2	-1.1	0	0	0	0
31	11/1/10 7:30 AM	245.13	1.70	31	29	0	340	2,338	2,338	816	1	1	0	2	319.7	296.3	-1.1	0	0	0	0
32	11/1/10 7:45 AM	246.91	1.57	31	29	0	343	2,415	2,415	823	1	1	0	2	319.7	299.2	-1.1	0	0	0	0
33	11/1/10 8:00 AM	354.28	1.71	31	29	0	341	2,402	2,402	818	1	1	0	2	320.1	300.8	-1.1	0	0	0	0
34	11/1/10 8:15 AM	443.57	1.23	31	29	0	344	2,315	2,315	825	1	1	0	2	321.0	295.0	-1.1	0	0	0	0
35	11/1/10 8:30 AM	458.23	1.21	31	29	0	341	2,460	2,460	818	1	1	0	2	319.7	301.8	-1.1	0	0	0	0
36	11/1/10 8:45 AM	462.60	1.12	31	29	0	342	2,523	2,523	821	1	1	0	2	319.7	301.9	-1.0	0	0	0	0
37	11/1/10 9:00 AM	479.60	1.11	31	29	0	344	2,378	2,378	826	1	1	0	2	319.7	299.4	-1.0	0	0	0	0
38	11/1/10 9:15 AM	479.80	1.12	31	29	0	342	2,405	2,405	823	1	1	0	2	319.7	302.6	-1.0	0	0	0	0
39	11/1/10 9:30 AM	482.18	1.10	31	29	0	345	2,338	2,338	827	1	1	0	2	319.6	302.0	-1.0	0	0	0	0
40	11/1/10 9:45 AM	482.36	1.10	31	29	0	341	2,449	2,449	820	1	1	0	2	319.7	301.2	-1.0	0	0	0	0
41	11/1/10 10:00 AM	482.91	1.10	31	30	0	342	2,367	2,367	822	1	1	0	2	319.8	304.4	-1.0	0	0	0	0
42	11/1/10 10:15 AM	482.43	1.11	31	29	0	342	2,415	2,415	821	1	1	0	2	319.8	299.4	-1.0	0	0	0	0
43	11/1/10 10:30 AM	482.02	1.16	31	29	0	345	2,347	2,347	827	1	1	0	2	319.8	299.3	-1.0	0	0	0	0
44	11/1/10 10:45 AM	482.36	1.14	31	29	0	341	2,463	2,463	818	1	1	0	2	319.7	302.3	-1.1	0	0	0	0
45	11/1/10 11:00 AM	482.49	1.15	31	29	0	343	2,373	2,373	825	1	1	0	2	319.7	299.8	-1.1	0	0	0	0
46	11/1/10 11:15 AM	482.82	1.14	31	30	0	341	2,493	2,493	820	1	1	0	2	319.7	303.7	-1.0	0	0	0	0
47	11/1/10 11:30 AM	483.09	1.10	31	29	0	344	2,378	2,378	827	1	1	0	2	319.7	299.8	-1.0	0	0	0	0
48	11/1/10 11:45 AM	482.84	1.16	31	29	0	343	2,343	2,343	823	1	1	0	2	319.7	300.0	-1.0	0	0	0	0
49	11/1/10 12:00 PM	483.55	1.15	31	29	0	345	2,338	2,338	828	1	1	0	2	319.7	299.3	-1.0	0	0	0	0
50	11/1/10 12:15 PM	487.83	1.19	31	29	0	343	2,441	2,441	823	1	1	0	2	319.7	299.3	-1.0	0	0	0	0
51	11/1/10 12:30 PM	488.40	1.27	31	29	0	341	2,433	2,433	820	1	1	0	2	319.8	299.8	-1.0	0	0	0	0
52	11/1/10 12:45 PM	488.79	1.25	31	29	0	341	2,444	2,444	819	1	1	0	2	319.7	299.4	-1.0	0	0	0	0
53	11/1/10 1:00 PM	489.50	1.22	31	30	0	344	2,472	2,472	827	1	1	0	2	319.8	304.3	-1.0	0	0	0	0
54	11/1/10 1:15 PM	488.13	1.21	31	30	0	343	2,465	2,465	822	1	1	0	2	319.7	304.9	-1.1	0	0	0	0
55	11/1/10 1:30 PM	488.56	1.21	31	29	0	342	2,382	2,382	821	1	1	0	2	319.7	299.3	-1.0	0	0	0	0
56	11/1/10 1:45 PM	488.07	1.23	31	29	0	344	2,455	2,455	826	1	1	0	2	319.7	299.3	-1.1	0	0	0	0
57	11/1/10 2:00 PM	485.66	1.21	31	29	0	346	2,300	2,300	829	1	1	0	2	319.7	302.2	-1.1	0	0	0	0
58	11/1/10 2:15 PM	485.91	1.14	31	29	0	342	2,438	2,438	822	1	1	0	2	319.7	299.5	-1.1	0	0	0	0
59	11/1/10 2:30 PM	485.81	1.16	31	29	0	342	2,445	2,445	822	1	1	0	2	319.7	302.3	-1.0	0	0	0	0
60	11/1/10 2:45 PM	489.41	1.11	31	29	0	345	2,316	2,316	829	1	1	0	2	319.7	300.7	-1.1	0	0	0	0
61	11/1/10 3:00 PM	487.59	1.12	31	29	0	343	2,424	2,424	823	1	1	0	2	319.7	298.4	-1.1	0	0	0	0
62	11/1/10 3:15 PM	486.53	1.13	31	29	0	344	2,415	2,415	827	1	1	0	2	319.7	299.3	-1.1	0	0	0	0
63	11/1/10 3:30 PM	486.26	1.12	31	29	0	340	2,509	2,509	816	1	1	0	2	319.7	299.3	-1.1	0	0	0	0
64	11/1/10 3:45 PM	486.38	1.15	31	29	0	343	2,382	2,382	824	1	1	0	2	319.7	301.1	-1.1	0	0	0	0
65	11/1/10 4:00 PM	485.85	1.22	31	29	0	342	2,391	2,391	822	1	1	0	2	319.8	299.3	-1.1	0	0	0	0
66	11/1/10 4:15 PM	487.57	1.21	31	29	0	342	2,503	2,503	821	1	1	0	2	319.7	299.3	-1.1	0	0	0	0
67	11/1/10 4:30 PM	488.98	1.20	31	29	0	342	2,446	2,446	821	1	1	0	2	319.7	299.3	-1.1	0	0	0	0
68	11/1/10 4:45 PM	489.77	1.15	31	29	0	342	2,413	2,413	822	1	1	0	2	319.7	299.3	-1.1	0	0	0	0
69	11/1/10 5:00 PM	486.79	1.13	31	29	0	342	2,390	2,390	821	1	1	0	2	319.8	299.3	-1.1	0	0	0	0
70	11/1/10 5:15 PM	489.43	1.13	31	29	0	342	2,424	2,424	821	1	1	0	2	319.8	300.5	-1.1	0	0	0	0
71	11/1/10 5:30 PM	486.81	1.13	31	29	0	342	2,445	2,445	821	1	1	0	2	319.8	303.1	-1.1	0	0	0	0
72	11/1/10 5:45 PM	487.96	1.12	31	29	0	344	2,363	2,363	827	1	1	0	2	319.8	299.3	-1.1	0	0	0	0
73	11/1/10 6:00 PM	492.07	1.14	31	29	0	345	2,319	2,319	829	1	1	0	2	319.8	299.3	-1.1	0	0	0	0
74	11/1/10 6:15 PM	488.31	1.21	31	29	0	344	2,357	2,357	826	1	1	0	2	319.8	299.3	-1.1	0	0	0	0
75	11/1/10 6:30 PM	486.95	1.27	31	29	0	341	2,396	2,396	819	1	1	0	2	319.7	299.3	-1.1	0	0	0	0
76	11/1/10 6:45 PM	485.19	1.26	31	29	0	342	2,448	2,448	820	1	1	0	2	319.7	299.3	-1.1	0	0	0	0
77	11/1/10 7:00 PM	488.15	1.23	31	29	0	345	2,433	2,433	828	1	1	0	2	319.8	299.3	-1.1	0	0	0	0
78	11/1/10 7:15 PM	490.69	1.17	31	29	0	342	2,420	2,420	822	1	1	0	2	319.8	298.7	-1.1	0	0	0	0
79	11/1/10 7:30 PM	488.34	1.15	31	29	0	344	2,398	2,398	825	1	1	0	2	319.8	299.3	-1.0	0	0	0	0
80	11/1/10 7:45 PM	485.63	1.18	31	29	0	342	2,456	2,456	822	1	1	0	2	319.8	302.2	-1.0	0	0	0	0

ECM 5: Reverse Osmosis Pump VFDs

RO Pump Analysis

100 hp pump current to power

Current	125.42
Power	85.5
Slope	0.68171
Intercept	0

75 hp pump power

Power, 100 hp	85.5
Power, 75 hp	63.5
Slope	0.74269
Intercept	0

Operating Hours

Plant Status	Plant Duty (%)	100 hp RO Pump Power, kW (hr/yr)	RO Duty (%)	RO Op. Hours (hr/yr)
Generating	17%	1,470	71%	1,044
Non-Generating	83%	7,290	14%	1,041
Total	100%	8,760		2,085

Average Baseline Conditions for Model
Average Conditions

Equipment	Inlet Pressure (psig)	Discharge Pressure (psig)	Discharge Pressure after CV (psig)	Total Head (psig)	Head from CV (psig)	Flow Rate (gpm)
100 hp RO Pump	**47.2**	**532.6**	**274.9**	**485.4**	**257.7**	**268.5**
75 hp RO Pump	**45.8**	**600.0**	**202.8**	**554.3**	**397.3**	**162.5**

Equipment	Inlet Pressure (ft)	Outlet Pressure (ft)	Outlet Pressure A (ft)	Total Head (ft)	Head from CV (ft)	Flow Rate (gpm)	Operating Power (kW)
100 hp RO Pump	**109**	**1,230**	**635**	**1,121**	**595**	**268**	**84**
75 hp RO Pump	**106**	**1,385**	**468**	**1,280**	**917**	**162**	**62**

Baseline Power

Min	0	0	0.0
Ave	98.7	67.3	50.0
Max	126.8	86.4	64.2
Op Ave	122.6	**83.6**	**62.1**

Manual Logs for Ba

Stdev	6	0	2	1
Min	197	50	157	31
Average	**218**	**50**	**162**	**32**
Max	224	50	165	34

#	Date/Time	100 hp RO Pump Current, A	100 hp RO Pump Power, kW	75 hp RO Pump Power, kW
1	10/31/2011 14:30	125.4	85.5	63.5
2	10/31/2011 14:35	125.0	85.2	63.3
3	10/31/2011 14:40	125.0	85.2	63.3
4	10/31/2011 14:45	125.1	85.3	63.3
5	10/31/2011 14:50	125.1	85.2	63.3
6	10/31/2011 14:55	124.8	85.0	63.2
7	10/31/2011 15:00	124.7	85.0	63.1
8	10/31/2011 15:05	124.9	85.2	63.2
9	10/31/2011 15:10	124.6	84.9	63.1
10	10/31/2011 15:15	124.8	85.1	63.2
11	10/31/2011 15:20	124.6	84.9	63.1
12	10/31/2011 15:25	124.7	85.0	63.1
13	10/31/2011 15:30	124.5	84.9	63.0
14	10/31/2011 15:35	124.7	85.0	63.1
15	10/31/2011 15:40	124.6	85.0	63.1
16	10/31/2011 15:45	124.8	85.1	63.2
17	10/31/2011 15:50	124.8	85.1	63.2
18	10/31/2011 15:55	124.9	85.2	63.3
19	10/31/2011 16:00	124.8	85.1	63.2
20	10/31/2011 16:05	124.9	85.1	63.2
21	10/31/2011 16:10	124.8	85.1	63.2
22	10/31/2011 16:15	124.7	85.0	63.1
23	10/31/2011 16:20	124.7	85.0	63.1
24	10/31/2011 16:25	124.7	85.0	63.1
25	10/31/2011 16:30	124.7	85.0	63.2
26	10/31/2011 16:35	124.6	85.0	63.1
27	10/31/2011 16:40	124.7	85.0	63.2
28	10/31/2011 16:45	124.8	85.1	63.2
29	10/31/2011 16:50	124.7	85.0	63.1
30	10/31/2011 16:55	124.7	85.0	63.1
31	10/31/2011 17:00	124.7	85.0	63.1
32	10/31/2011 17:05	124.7	85.0	63.1
33	10/31/2011 17:10	124.6	84.9	63.1
34	10/31/2011 17:15	124.8	85.0	63.2
35	10/31/2011 17:20	124.7	85.0	63.1
36	10/31/2011 17:25	124.8	85.1	63.2
37	10/31/2011 17:30	124.7	85.0	63.1

Date/Time	Permeate Flow, gpm	RO1 Concentrate Flow, gpm	RO2 Permeate Flow, gpm	RO2 Reject Flow
8/31/2011 2:00	221	50	163	31
8/31/2011 10:00	219	50	163	31
9/1/2011 2:00	221	50	164	31
9/1/2011 13:00	220	50	163	31
9/4/2011 18:50	219	50	162	32
9/5/2011 13:00	220	50	162	32
9/5/2011 19:00	219	50	162	32
9/6/2011 2:00	224	50	162	31
9/6/2011 11:00	219	50	162	32
9/7/2011 2:00	221	50	163	32
9/7/2011 13:00	221	50	162	31
9/7/2011 14:00	221	50	162	31
9/8/2011 23:00	220	50	163	31
9/9/2011 2:00	221	50	162	31
9/9/2011 18:00	221	50	163	31
9/10/2011 6:00	221	50	163	32
9/12/2011 3:00	222	50	163	31
9/12/2011 15:00	221	50	163	31
9/12/2011 20:30	222	50	163	31
9/13/2011 8:00	222	50	163	31
9/13/2011 17:30	221	50	163	31
9/14/2011 15:00	222	50	163	31
9/14/2011 22:00	223	50	164	31
9/15/2011 9:00	223	50	163	31
9/15/2011 22:00	222	50	163	31
9/16/2011 16:00	219	50	162	31
9/20/2011 2:00	219	50	162	32
9/20/2011 10:00	219	50	162	32
9/20/2011 10:00	217	50	164	31
9/21/2011 7:00	218	50	162	32
9/23/2011 0:00	219	50	162	32
9/25/2011 15:00	218	50	164	31
9/27/2011 0:00	219	50	164	31
9/27/2011 11:00	218	50	164	31
9/28/2011 2:00	218	50	165	31
9/28/2011 10:00	215	50	162	32
9/28/2011 13:00	215	50	163	32

aseline Operating Conditions

3	2	10	0	7	10
42	41	190	600	520	260
47	**46**	**203**	**600**	**533**	**275**
52	49	250	600	560	305

Operating Frequency

Op. Duty	69%	83%	**71%**

Pump Inlet Pressure, psig	Permeate Pressure, psig	RO Supply Pressure, psig	Pump Discharge Pressure, psig	Pump Discharge Pressure, psig	RO Supply Pressure, psig
50	48	200	600	530	265
50	48	200	600	530	270
50	48	200	600	530	270
51	48	200	600	530	270
50	47	200	600	535	275
50	48	200	600	540	275
50	48	200	600	535	275
48	48	200	600	530	285
48	48	200	600	540	275
46	46	200	600	530	280
46	46	200	600	530	270
45	44	200	600	530	265
46	46	200	600	530	280
44	44	200	600	520	275
47	45	200	600	530	270
46	44	200	600	530	275
45	45	190	600	530	260
44	44	200	600	530	260
46	44	200	600	535	260
44	44	200	600	530	280
46	44	250	600	530	265
42	44	200	600	560	280
44	44	200	600	535	270
46	43	200	600	525	280
45	44	200	600	530	270
45	44	200	600	525	270
44	42	200	600	530	270
44	42	200	600	530	270
50	49	200	600	530	280
44	41	200	600	530	270
43	42	200	600	525	270
42	42	200	600	530	270
50	48	200	600	532	275
51	48	200	600	535	275
48	48	200	600	530	280
51	48	200	600	535	275
51	49	200	600	535	280

Date	RO On	Plant Generating	RO On and Plant Generating
8/31/2011	1	1	1
9/1/2011	1	1	1
9/2/2011	-	1	0
9/3/2011	-	1	0
9/4/2011	1	1	1
9/5/2011	1	1	1
9/6/2011	1	1	1
9/7/2011	1	1	1
9/8/2011	1	1	1
9/9/2011	1	1	1
9/10/2011	1	1	1
9/11/2011	-	1	0
9/12/2011	1	1	1
9/13/2011	1	1	1
9/14/2011	1	1	1
9/15/2011	1	1	1
9/16/2011	1	1	1
9/17/2011	-	0	
9/18/2011	-	0	
9/19/2011	-	1	0
9/20/2011	1	0	
9/21/2011	1	0	
9/22/2011	-	1	0
9/23/2011	1	1	1
9/24/2011	-	1	0
9/25/2011	1	1	1
9/26/2011	-	1	0
9/27/2011	1	1	1
9/28/2011	1	0	

Calculations and Results - VFD control - 100hp First Pass RO Pump

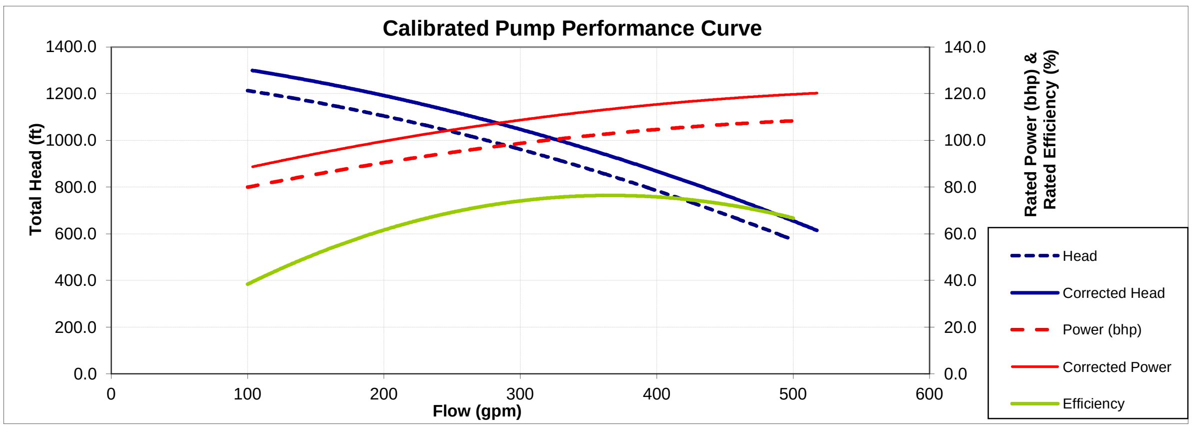
CascadeEnergy

CALCULATION ASSUMPTIONS AND METHOD

1) The baseline pump motor efficiency is 94.5%.
2) The efficiency of the VFD is 97%.
3) A pump speed reduction results in:
   1) a reduction in flow directly proportional to the speed reduction
   2) a reduction in head proportional to the speed reduction squared
   3) a reduction in power proportional to the speed reduction to the 2.7th power
4) The liquid pumped is water and the specific gravity is 1
5) The speed of the pump is adjusted by a 1.038 multiplier to account for discrepancies between the operating points and the pump curve
6) The difference between actual and design conditions for the baseline pump results in a 0.997 correction factor for motor speed, and a 1 correction factor for impeller diameter. Affinity laws are used to calculate the effect on the system curve.

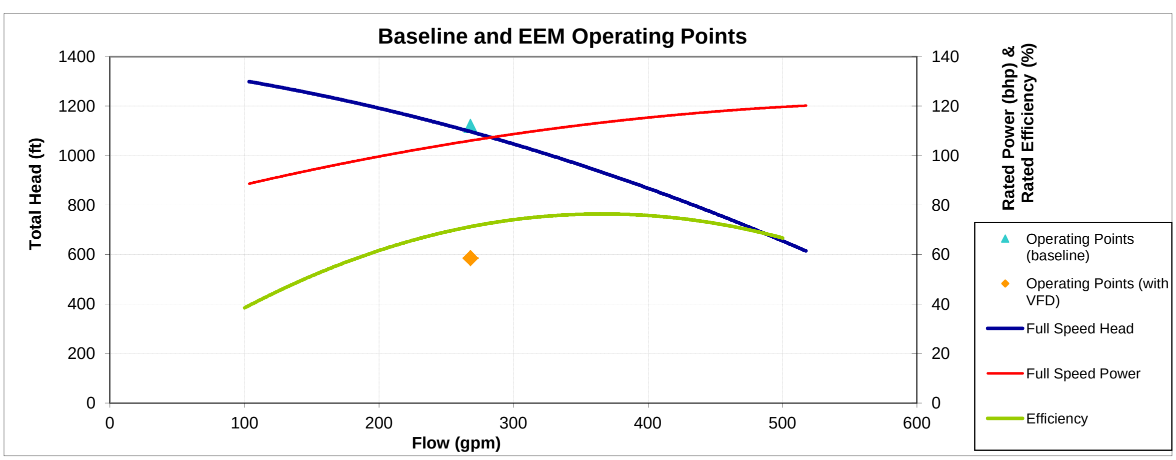
BASELINE ENERGY USE CALCULATIONS (Existing System)

	Operating Hours (hours/yr)	Flowrate (gpm)	Pump head (ft)	Hydraulic Efficiency (%)	Shaft Power (bhp)	Electric Power (kW)	Annual Energy Use (kWh/yr)
1)	2,085	268	1121.0	71%	106.4	84.0	175,140
2)							
3)							
4)							
5)							
					Total Annual Energy Use (kWh/yr):		175,140



EEM ENERGY USE CALCULATIONS (With VFD)

	Operating Hours (hours/yr)	Flowrate (gpm)	Pump Head (ft)	Hydraulic Efficiency (%)	VFD Speed (%)	Shaft Power (bhp)	Electric Power (kW)	Annual Energy Use (kWh/yr)
1)	2,085	268	585.5	70%	78%	56.6	46.1	96,017
2)								
3)								
4)								
5)								
						Total Annual Energy Use (kWh/yr):		96,017



SUMMARY OF RESULTS

Baseline energy use: **175,140** kWh/yr
Upgrade energy use: **96,017** kWh/yr

Annual energy savings: **79,123** kWh/yr
Percent savings: **45%**

Calculations and Results - VFD control - 75hp RO Booster Pump

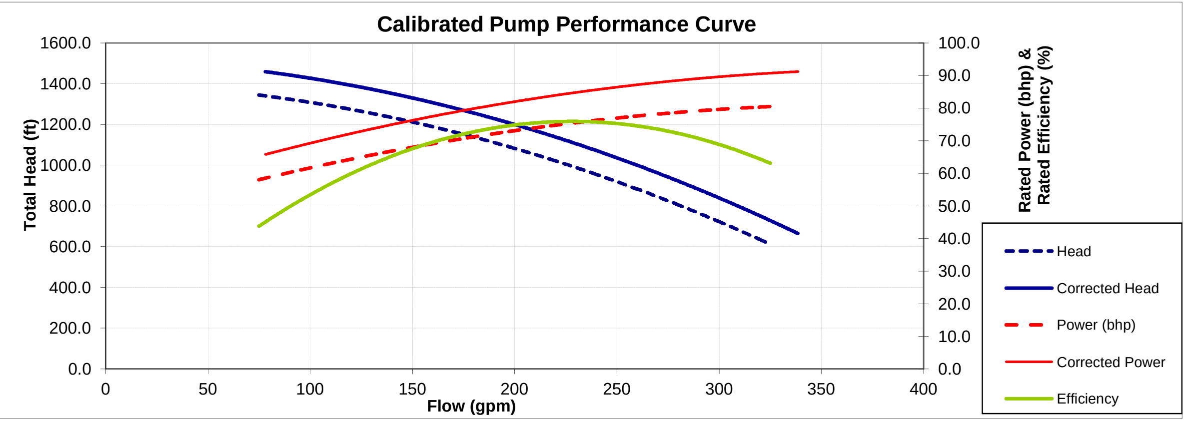
CascadeEnergy

CALCULATION ASSUMPTIONS AND METHOD

1) The baseline pump motor efficiency is 94.1%.
2) The efficiency of the VFD is 97%.
3) A pump speed reduction results in:
   1) a reduction in flow directly proportional to the speed reduction
   2) a reduction in head proportional to the speed reduction squared
   3) a reduction in power proportional to the speed reduction to the 2.7th power
4) The liquid pumped is water and the specific gravity is 1
5) The speed of the pump is adjusted by a 1.049 multiplier to account for discrepancies between the operating points and the pump curve
6) The difference between actual and design conditions for the baseline pump results in a 0.993 correction factor for motor speed, and a 1 correction factor for impeller diameter. Affinity laws are used to calculate the effect on the system curve.

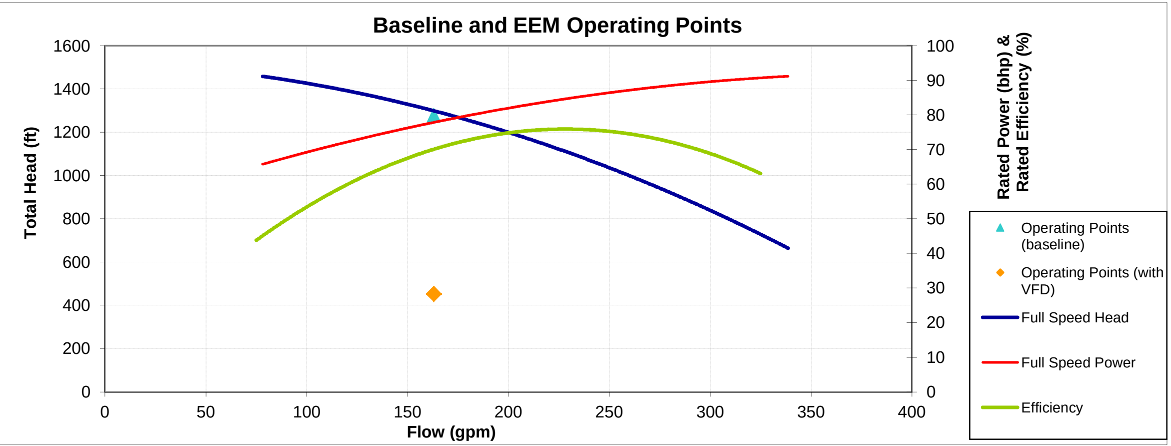
BASELINE ENERGY USE CALCULATIONS (Existing System)

	Operating Hours (hours/yr)	Flowrate (gpm)	Pump head (ft)	Hydraulic Efficiency (%)	Shaft Power (bhp)	Electric Power (kW)	Annual Energy Use (kWh/yr)
1)	2,085	163	1279.0	67%	78.2	62.0	129,270
2)							
3)							
4)							
5)							
						Total Annual Energy Use (kWh/yr):	129,270



EEM ENERGY USE CALCULATIONS (With VFD)

	Operating Hours (hours/yr)	Flowrate (gpm)	Pump Head (ft)	Hydraulic Efficiency (%)	VFD Speed (%)	Shaft Power (bhp)	Electric Power (kW)	Annual Energy Use (kWh/yr)
1)	2,085	163	453.7	67%	66%	27.9	22.8	47,604
2)								
3)								
4)								
5)								
							Total Annual Energy Use (kWh/yr):	47,604



SUMMARY OF RESULTS

Baseline energy use: **129,270** kWh/yr — **Annual energy savings:** **81,666** kWh/yr

Upgrade energy use: **47,604** kWh/yr — **Percent savings:** **63%**

ECM 6: Reduce LP Economizer Recirculation Pump Use

Min	0	0
Ave	35.44	26.24
Max	90.73	67.19
Ave Op	71.62	53.04
Time On	49%	49%

Hobo Current	74.3
Power Snapshot	55.0
Current to Power Slope	0.741
Current to Power Intercept	0.000

Plot Title: LP Econ Recirc Pump

#	Date Time, GMT-07:00	LP Recirc Pump, A	LP Recirc Pump, kW
1	10/19/2011 16:00	0	0
2	10/19/2011 16:05	0	0
3	10/19/2011 16:10	0	0
4	10/19/2011 16:15	0	0
5	10/19/2011 16:20	0	0
6	10/19/2011 16:25	0	0
7	10/19/2011 16:30	0	0
8	10/19/2011 16:35	0	0
9	10/19/2011 16:40	0	0
10	10/19/2011 16:45	0	0
11	10/19/2011 16:50	0	0
12	10/19/2011 16:55	0	0
13	10/19/2011 17:00	0	0
14	10/19/2011 17:05	0	0
15	10/19/2011 17:10	0	0
16	10/19/2011 17:15	0	0
17	10/19/2011 17:20	0	0
18	10/19/2011 17:25	0	0
19	10/19/2011 17:30	0	0
20	10/19/2011 17:35	0	0
21	10/19/2011 17:40	0	0
22	10/19/2011 17:45	0	0
23	10/19/2011 17:50	0	0
24	10/19/2011 17:55	0	0
25	10/19/2011 18:00	0	0
26	10/19/2011 18:05	0	0
27	10/19/2011 18:10	0	0
28	10/19/2011 18:15	0	0
29	10/19/2011 18:20	0	0
30	10/19/2011 18:25	0	0
31	10/19/2011 18:30	0	0
32	10/19/2011 18:35	0	0
33	10/19/2011 18:40	0	0
34	10/19/2011 18:45	0	0
35	10/19/2011 18:50	0	0
36	10/19/2011 18:55	0	0
37	10/19/2011 19:00	0	0
38	10/19/2011 19:05	0	0
39	10/19/2011 19:10	0	0

Equipment	Op. Duty (%)	Op. Hours (hr/yr)
CT 1 LP Recirc Pump	7.0%	611
CT 2 LP Recric Pump	11.7%	1,028
Total	19%	1,640

Baseline Average Power Draw	53.04	kW
Baseline Energy Use	86,963	kWh/yr
EEM Average Power Draw	53.04	kW
EEM Operating Hours	82	hr/yr
EEM Energy Use	4,349	kWh/yr

EEM Demand Savings	**0**	**kW**
EEM Energy Savings	**82,614**	**kWh/yr**

Min	-11.5912447	0	0.059841	0.054491	-6.23364	0.057895	0.053614	0.053751	0.055546	-1.05416	
Ave	60.060386	0.069777	83.91084	71.39116	63.81492	95.85739	90.37215	83.48731	69.77468	144.9678	
Max	515.1953125	1	311.39	271.3161	100.7165	307.5901	251.1929	256.0672	239.8408	515.4357	
Op Ave	325.0565862	1	83.91084	71.39116	65.60816	95.85739	90.37215	83.48731	69.77468	144.972	
% Op Time	19%	7%									11%
		2	6	8	11	18	20	21	24	26	
Tag	CL1TgnLODgnPlntTotNMW	210PMP11001ON	CL1AB210TI11085	CL1AB210TI11086	CL1AB210MBV11081ZT	CL1AB210TI11080	CL1AB210TI11087	CL1AB210TI11089	CL1AB210TI11083	CL1AB210PI11082	
Descriptor	Plant Net MW	H1 LP RECIRC PUMP STATUS	H1 LP PMP DISCH TEMP	H1 LP ECO IN TEMP	H1 LP ECON DRN VALVE POSITION	H1 LP ECO OUT TEMP	H1 OUT DUCT GAS TEMP-A	H1 STACK GAS TEMP	H1 LP FW TEMP	H1 LP FW IN PRESSURE	
Units		on/off	F	deg. F	%	deg. F	deg. F	deg. F			
	Plant Net MW	**H1 Pump on/off**	**H1 Pump T Discharge**	**H1 Econ. Feed T**	**H1 Econ Feed Valve Position**	**H1 Econ. Disch. T**	**H1 Exh. Gas Just after Econ**	**H1 Exh. Gas Stack T**	**H1 Unmixed Econ Feed Temp**	**H1 Unmixed Econ Feed Press**	**CT1 Operating?**
01-Nov-10 00:00:00	-3.060856819	0	84.47332	108.1657	60.67802	212.2251	138.3397	110.1556	107.9429	97.78785	0
01-Nov-10 00:15:00	-3.066732407	0	84.60098	109.3473	59.29502	210.7348	139.9009	113.0141	109.3116	86.82095	0
01-Nov-10 00:30:00	-2.96608448	0	84.72862	110.2802	66.29552	209.2656	143.0203	117.6072	110.9602	87.41148	0
01-Nov-10 00:45:00	-3.066732407	0	85.09147	111.798	66.00043	208.3054	147.0317	126.2151	112.8791	89.3406	0
01-Nov-10 01:00:00	-3.375767708	0	85.22507	112.8635	64.10906	206.8418	151.3114	128.5972	114.5201	88.18951	0
01-Nov-10 01:15:00	-3.020910263	0	85.34888	114.7529	67.5717	204.2422	155.1745	132.5759	117.0586	89.37808	0
01-Nov-10 01:30:00	-3.067541122	0	85.4727	115.8327	67.68458	201.0738	159.0011	135.3557	118.4201	88.64689	0
01-Nov-10 01:45:00	-2.843664169	0	85.58525	116.4058	67.53432	195.5285	162.347	135.0369	120.4007	88.15253	0
01-Nov-10 02:00:00	-4.532346725	0	85.53188	118.5731	70.02556	187.1646	164.6801	136.3853	122.6176	87.63156	0
01-Nov-10 02:15:00	-2.843999863	0	85.47852	120.1975	69.32702	178.2252	167.0132	135.2534	124.703	85.96379	0
01-Nov-10 02:30:00	-2.843542099	0	85.42516	121.4088	67.86924	170.2411	168.7076	133.351	125.8871	85.19833	0
01-Nov-10 02:45:00	-2.847356796	0	85.41572	122.5765	68.47516	162.6493	170.2885	131.1446	127.0615	83.92406	0
01-Nov-10 03:00:00	-2.870855331	0	85.4201	123.7298	66.13092	155.8427	171.0313	133.7795	128.3655	83.3314	0
01-Nov-10 03:15:00	-4.720067024	0	85.54467	124.8002	64.59048	150.019	171.9297	135.2594	128.4068	81.59467	0
01-Nov-10 03:30:00	-2.95781517	0	85.73405	125.4002	66.11868	145.1486	173.0858	135.3478	128.0517	79.76424	0
01-Nov-10 03:45:00	-3.073720932	0	86.03933	125.5288	63.9164	141.149	173.9117	136.1926	127.6285	78.15542	0
01-Nov-10 04:00:00	-3.078130722	0	86.21147	125.3676	64.51923	137.5482	174.5481	136.6208	126.0818	76.84572	0
01-Nov-10 04:15:00	-3.071889877	0	86.34789	125.2082	64.4448	134.6967	175.1844	133.7416	124.509	75.85987	0
01-Nov-10 04:30:00	-5.500523567	0	86.3817	103.6939	64.10685	126.114	175.4186	133.432	103.1595	354.4553	0
01-Nov-10 04:45:00	-5.752842903	0	86.41115	86.34391	68.31794	213.3654	168.0712	118.3871	85.66593	354.3016	0
01-Nov-10 05:00:00	-5.981061935	0	86.4016	82.52856	67.73418	197.7329	153.3294	106.7935	83.35493	353.7525	0
01-Nov-10 05:15:00	11.07339001	0	86.39204	82.60635	67.1895	185.7619	145.5365	107.9856	83.29489	354.4824	0
01-Nov-10 05:30:00	11.08877087	0	86.37325	82.13567	67.16108	110.9492	143.2272	107.639	83.25778	344.7251	0
01-Nov-10 05:45:00	10.97431374	0	86.08896	81.78446	67.04903	143.5473	143.1577	108.7556	83.01462	341.7884	0
01-Nov-10 06:00:00	11.05385017	0	85.78896	81.63798	66.47028	112.2972	144.4123	110.2549	82.39167	343.1099	0
01-Nov-10 06:15:00	24.60011482	0	85.59547	81.31728	66.65137	102.5198	145.7904	111.6102	81.91425	338.9687	0
01-Nov-10 06:30:00	25.38282967	0	85.08131	81.72105	67.57008	121.0639	147.2933	111.3984	83.61794	338.5179	0
01-Nov-10 06:45:00	24.3481102	0	84.70424	84.71979	67.11278	145.9602	148.8296	149.4929	85.78614	333.9707	0
01-Nov-10 07:00:00	134.5310211	0	84.32716	100.4219	64.46929	212.9904	163.7252	191.0755	104.8894	333.7147	0
01-Nov-10 07:15:00	249.5625	0	83.95008	136.3557	65.77901	288.4895	211.1613	218.3301	138.4647	333.153	0
01-Nov-10 07:30:00	245.1293945	0	83.573	153.3635	65.5694	271.1634	209.317	199.55	154.2502	332.1757	0
01-Nov-10 07:45:00	246.9052734	0	83.11409	151.2437	66.43654	271.3931	204.3292	198.1299	152.1269	330.9532	0
01-Nov-10 08:00:00	354.2753906	0	82.65239	135.839	63.55835	279.0385	204.6435	204.1498	136.3052	328.06	1
01-Nov-10 08:15:00	443.5664063	0	82.19069	124.5916	63.23903	272.549	211.2739	213.5428	125.3653	330.9647	1
01-Nov-10 08:30:00	458.234375	0	81.72899	109.5192	64.22096	283.9277	230.2234	230.5209	110.3179	326.0659	1
01-Nov-10 08:45:00	462.6015625	0	81.26729	109.002	62.55507	281.7259	236.3519	228.4381	109.8557	326.1875	1
01-Nov-10 09:00:00	479.6015625	0	80.80559	108.473	62.91673	281.052	237.8438	227.3281	109.4874	330.7835	1
01-Nov-10 09:15:00	479.796875	0	80.34388	108.4794	61.91235	280.6807	237.2877	226.7582	109.2981	327.6126	1

ECMs 7 & 10: New Variable Speed Air Compressor and Demand-based Dew Point Controls

Compressed Air System Analysis

kW	Amps
101.6	150.1
25.3	66.5
Slope	0.912679
Intercept	-35.39318

EEM Compressor

Flow to power Coefficients	
	2.031494007
	0.219323548
	-0.000447599
	1.65034E-06
	-1.57441E-09

Load Pressure: 110 psig
Unload Pressure: 125 psig

EEM Pressure: 110 psig

Baseline Pressure to Power:
Slope 0.299169
Intercept 66.14995

Rated Flow 504

Operating Hours
No Production: 7,094 hours per year
One & one: 862 hours per year
Three turbines: 804 hours per year

Power	Baseline	VFD	DP (Demand Controls)	Sol. Valves (Demand Controls)	
No Production:	67.4	60.3	56.4	43.0	kW
One & one:	89.4	86.6	85.7	85.7	kW
Three turbines:	97.7	98.7	98.7	98.7	kW

Flow	Baseline	VFD	DP	Sol. Valves	
No Production:	293.8	293.8	275.4	211.2	acfm
One & one:	414.1	414.1	410.1	410.1	acfm
Three turbines:	461.7	461.7	461.7	461.7	acfm

Energy	Baseline	VFD	DP (Demand Controls)	Sol. Valves (Demand Controls)	
No Production:	477,875	427,811	400,096	304,734	kWh/yr.
One & one:	77,089	74,650	73,893	73,893	kWh/yr.
Three turbines:	78,534	79,320	79,320	79,320	kWh/yr.
Total:	633,499	581,781	553,309	457,947	kWh/yr.
Savings:		**51,718**	**28,472**	**95,362**	kWh/yr.

MWh/yr.			
633.5	581.8	553.3	457.9

Variation 1	
Solving for: Time, Minutes	**4.07**
Volume, Gallons	15000
Volume, ft^3	2005.3
Initial Pressure, psig	110
Final Pressure, psig	95
Delta P, psi	-15
Atmospheric Pressure, psia	14.696
Net Flow Rate Into Tank, acfm	-503

Total Dryer Capacity: 300 cfm
Purge Rate: 12%
36 cfm

Estimated Instrumentation Flow:
No Production: 146.9 cfm
One & one: 267.2 cfm
Three turbines: 314.8 cfm

CFM savings with demand mode:
No Production: 18.4 cfm
One & one: 3.9 cfm
Three turbines: 0.0 cfm

CFM savings with control valves:
% of Service Air: 50%
No Production: 64.3 cfm
One & one: 0.0 cfm
Three turbines: 0.0 cfm

Compressed Air System Analysis

Current (amps)	Baseline Power (kW)	Baseline Loaded (0/1)	Baseline Pressure (psig)	Baseline Operating Mode 0=off,1=1&1, 2=3 turbines	Baseline Flow (acfm)	Baseline Smoothed Flow (5-min.) (acfm)	VFD Power (kW)	Demand-based dew point control flow (cfm)	Dew-point Power (kW)	Solenoid Valve Flow (cfm)	Solenoid Valve Power (kW)
10/19/2011 15:40:00	24.0	24.0	122.5	0.0	0.0	140.5	28.0	122.1	24.8	57.8	13.5
10/19/2011 15:45:00	96.7	96.7	114.5	0.0	504.0	314.0	62.5	295.6	58.4	231.3	44.7
10/19/2011 15:50:00	24.1	24.1	118.6	0.0	0.0	247.9	48.1	229.5	44.4	165.2	32.3
10/19/2011 15:55:00	98.3	98.3	118.4	0.0	504.0	198.3	38.4	179.9	35.0	115.7	23.7
10/19/2011 16:00:00	24.0	24.0	114.5	0.0	0.0	371.8	76.4	353.4	71.9	289.2	56.9
10/19/2011 16:05:00	99.2	99.2	122.5	0.0	504.0	82.6	18.0	64.3	14.7	0.0	0.0
10/19/2011 16:10:00	24.1	24.1	110.6	0.0	0.0	437.9	92.9	419.5	88.4	355.3	72.4
10/19/2011 16:15:00	24.1	24.1	123.3	0.0	0.0	107.4	22.3	89.0	19.1	24.8	7.2
10/19/2011 16:20:00	97.1	97.1	113.5	0.0	504.0	338.8	68.4	320.4	64.0	256.1	49.8
10/19/2011 16:25:00	24.0	24.0	119.4	0.0	0.0	223.1	43.1	204.7	39.6	140.4	28.0
10/19/2011 16:30:00	97.9	97.9	117.5	0.0	504.0	223.1	43.1	204.7	39.6	140.4	28.0
10/19/2011 16:35:00	24.3	24.3	115.4	0.0	0.0	347.0	70.4	328.6	66.0	264.4	51.5
10/19/2011 16:40:00	99.3	99.3	121.8	0.0	504.0	99.1	20.8	80.8	17.6	16.5	5.5
10/19/2011 16:45:00	23.9	23.9	111.1	0.0	0.0	437.9	92.9	419.5	88.4	355.3	72.4
10/19/2011 16:50:00	24.1	24.1	123.9	0.0	0.0	99.1	20.8	80.8	17.6	16.5	5.5
10/19/2011 16:55:00	96.5	96.5	113.2	0.0	504.0	347.0	70.4	328.6	66.0	264.4	51.5
10/19/2011 17:00:00	24.3	24.3	119.7	0.0	0.0	214.8	41.5	196.4	38.0	132.2	26.5
10/19/2011 17:05:00	98.0	98.0	117.2	0.0	504.0	231.3	44.7	213.0	41.1	148.7	29.4
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49.8
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10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55.1
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23.7
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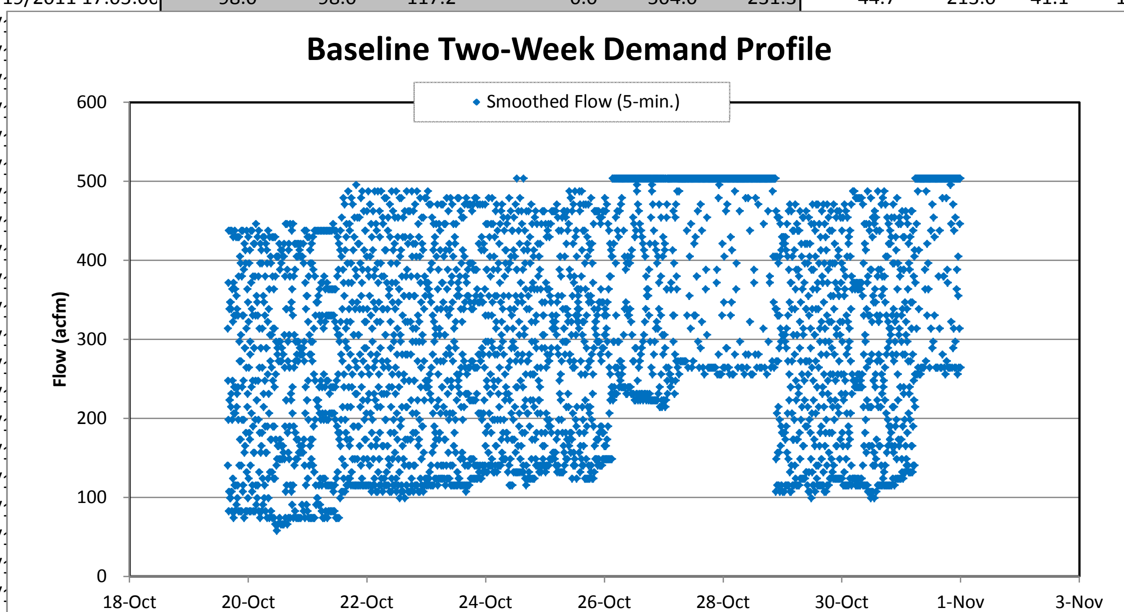
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	70.4
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0	0.0
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	56.9
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25.1
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30.9
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48.1
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.8
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	72.4
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.0	0.0
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55.1
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25.1
10/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30.9
10/19/2011 18:55:00	23.6	23.6	115.9	0.0	0.0	330.5	66.4	312.1	62.1	247.9	48.1
10/19/2011 19:00:00	98.8	98.8	121.3	0.0	504.0	115.7	23.7	97.3	20.5	33.0	8.8
10/19/2011 19:05:00	23.8	23.8	111.7	0.0	0.0	429.6	90.9	411.3	86.3	347.0	70.4
10/19/2011 19:10:00	23.9	23.9	124.2	0.0	0.0	90.9	19.4	72.5	16.2	8.2	3.8
10/19/2011 19:15:00	96.4	96.4	112.9	0.0	504.0	355.3	72.4	336.9	67.9	272.6	53.3



ECM 8: Reduce Runtime of Electric Heat Trace

Heat Trace Data Monitoring

Min								25.86779		
Max								60.66513		60.66513
On			83.6%	82.7%	13.7%	78.4%	65.6%	40.23372	44.0%	21.3%
				Electric Heat Trace On /off					Toa > 42 F	
Date	Time	Date + Time	Cheh_02	Cheh_03	Cheh_04	CH_05	CH_08	Toa (F)		
10/31/2011	3:00:00 PM	10/31/11 15:00	0%	0%	0%	0%	0%	54.8	1	0.0
10/31/2011	3:15:00 PM	10/31/11 15:15	0%	0%	0%	0%	0%	56.3	1	0.0
10/31/2011	3:30:00 PM	10/31/11 15:30	84%	35%	0%	22%	0%	56.2	1	1.4
10/31/2011	3:45:00 PM	10/31/11 15:45	100%	100%	0%	100%	7%	55.7	1	3.1
10/31/2011	4:00:00 PM	10/31/11 16:00	100%	100%	100%	100%	100%	54.7	1	5.0
10/31/2011	4:15:00 PM	10/31/11 16:15	100%	100%	100%	100%	100%	53.9	1	5.0
10/31/2011	4:30:00 PM	10/31/11 16:30	100%	100%	100%	100%	100%	52.1	1	5.0
10/31/2011	4:45:00 PM	10/31/11 16:45	100%	100%	100%	100%	100%	49.5	1	5.0
10/31/2011	5:00:00 PM	10/31/11 17:00	100%	100%	100%	100%	100%	47.5	1	5.0
10/31/2011	5:15:00 PM	10/31/11 17:15	100%	100%	100%	100%	100%	46.3	1	5.0
10/31/2011	5:30:00 PM	10/31/11 17:30	100%	100%	100%	100%	100%	45.2	1	5.0
10/31/2011	5:45:00 PM	10/31/11 17:45	100%	100%	100%	100%	100%	44.0	1	5.0
10/31/2011	6:00:00 PM	10/31/11 18:00	100%	100%	100%	100%	100%	43.4	1	5.0
10/31/2011	6:15:00 PM	10/31/11 18:15	100%	100%	100%	100%	100%	42.2	1	5.0
10/31/2011	6:30:00 PM	10/31/11 18:30	100%	100%	100%	100%	100%	40.3	0	0.0
10/31/2011	6:45:00 PM	10/31/11 18:45	100%	100%	100%	100%	100%	39.0	0	0.0
10/31/2011	7:00:00 PM	10/31/11 19:00	100%	100%	100%	100%	100%	39.6	0	0.0
10/31/2011	7:15:00 PM	10/31/11 19:15	100%	100%	100%	100%	100%	39.1	0	0.0
10/31/2011	7:30:00 PM	10/31/11 19:30	100%	100%	100%	100%	100%	39.0	0	0.0
10/31/2011	7:45:00 PM	10/31/11 19:45	100%	100%	100%	100%	100%	38.5	0	0.0
10/31/2011	8:00:00 PM	10/31/11 20:00	100%	100%	100%	100%	100%	37.8	0	0.0
10/31/2011	8:15:00 PM	10/31/11 20:15	100%	100%	100%	100%	100%	37.1	0	0.0
10/31/2011	8:30:00 PM	10/31/11 20:30	100%	100%	100%	100%	100%	36.4	0	0.0
10/31/2011	8:45:00 PM	10/31/11 20:45	100%	100%	100%	100%	100%	35.9	0	0.0
10/31/2011	9:00:00 PM	10/31/11 21:00	100%	100%	100%	100%	100%	35.5	0	0.0
10/31/2011	9:15:00 PM	10/31/11 21:15	100%	100%	100%	100%	100%	35.7	0	0.0
10/31/2011	9:30:00 PM	10/31/11 21:30	100%	100%	100%	100%	100%	35.1	0	0.0
10/31/2011	9:45:00 PM	10/31/11 21:45	100%	100%	100%	100%	100%	34.6	0	0.0
10/31/2011	10:00:00 PM	10/31/11 22:00	100%	100%	100%	100%	100%	34.3	0	0.0
10/31/2011	10:15:00 PM	10/31/11 22:15	100%	100%	100%	100%	100%	34.2	0	0.0
10/31/2011	10:30:00 PM	10/31/11 22:30	100%	100%	100%	100%	100%	34.3	0	0.0
10/31/2011	10:45:00 PM	10/31/11 22:45	100%	100%	100%	100%	100%	33.5	0	0.0
10/31/2011	11:00:00 PM	10/31/11 23:00	100%	100%	100%	100%	100%	33.0	0	0.0
10/31/2011	11:15:00 PM	10/31/11 23:15	100%	100%	100%	100%	100%	32.8	0	0.0
10/31/2011	11:30:00 PM	10/31/11 23:30	100%	100%	100%	100%	100%	32.3	0	0.0
10/31/2011	11:45:00 PM	10/31/11 23:45	100%	100%	100%	100%	100%	32.1	0	0.0
11/1/2011	12:00:00 AM	11/1/11 0:00	100%	100%	100%	100%	100%	31.9	0	0.0
11/1/2011	12:15:00 AM	11/1/11 0:15	100%	100%	100%	100%	100%	32.0	0	0.0
11/1/2011	12:30:00 AM	11/1/11 0:30	100%	100%	100%	100%	100%	32.2	0	0.0
11/1/2011	12:45:00 AM	11/1/11 0:45	100%	100%	100%	100%	100%	32.2	0	0.0
11/1/2011	1:00:00 AM	11/1/11 1:00	100%	100%	100%	100%	100%	32.2	0	0.0
11/1/2011	1:15:00 AM	11/1/11 1:15	100%	100%	100%	100%	100%	31.7	0	0.0
11/1/2011	1:30:00 AM	11/1/11 1:30	100%	100%	100%	100%	100%	31.6	0	0.0
11/1/2011	1:45:00 AM	11/1/11 1:45	100%	100%	100%	100%	100%	31.2	0	0.0
11/1/2011	2:00:00 AM	11/1/11 2:00	100%	100%	100%	100%	100%	31.3	0	0.0
11/1/2011	2:15:00 AM	11/1/11 2:15	100%	100%	100%	100%	100%	32.1	0	0.0
11/1/2011	2:30:00 AM	11/1/11 2:30	100%	100%	100%	100%	100%	32.6	0	0.0
11/1/2011	2:45:00 AM	11/1/11 2:45	100%	100%	100%	100%	100%	32.8	0	0.0

Heat Trace Data Monitoring and Analysis Summary

	Actual Weather	TMY3* Weather
Minimum	25.9	16.0
Maximum	60.7	73.9
Average	40.2	42.5
*5 Months		

TMY3 Weather Data

Hour	Total Toa	2127 Tdb > 42 & Tdb < 55
1	23	0
2	23	0
3	23	0
4	23	0
5	22.28	0
6	21.74	0
7	21.02	0
8	23	0
9	24.98	0
10	26.96	0
11	30.38	0
12	33.62	0
13	37.04	0
14	37.76	0
15	38.3	0
16	39.02	0
17	35.42	0
18	31.64	0
19	28.04	0
20	27.68	0
21	27.32	0
22	26.96	0
23	27.32	0
24	27.68	0
25	28.04	0
26	28.4	0
27	28.58	0
28	28.94	0
29	28.94	0
30	28.94	0
31	28.94	0
32	29.3	0
33	29.66	0
34	30.02	0
35	31.64	0
36	33.44	0
37	35.06	0
38	35.42	0
39	35.6	0
40	35.96	0
41	35.24	0
42	34.7	0
43	33.98	0
44	34.34	0
45	34.7	0
46	35.06	0
47	35.96	0
48	37.04	0
49	37.94	0
50	38.3	0
51	38.66	0
52	39.02	0
53	39.38	0
54	39.56	0
55	39.92	0

	Power (kW)	Time (h)	Energy Use (MWh/yr)
Baseline	85.7	2127	182.3
EEM	85.7	1677	143.7
Savings	-	450	38.6

ECM 9: Adjust Thermostat on One Electric Heater

Logged heater data and weather data obtained from WSU weather station						
Average			1.2%	0.0%	**92.9%**	40.2
Date	Time	Date+ Time	Heater 1	Heater 2	Heater 3	Toa
-	-		(% on)	(% on)	(% on)	(F)
10/31/2011	3:00:00 PM	3:00:00 PM	0.00%	0.00%	0.00%	54.8
10/31/2011	3:15:00 PM	3:15:00 PM	0.00%	0.00%	0.00%	56.3
10/31/2011	3:30:00 PM	3:30:00 PM	0.00%	0.00%	0.00%	56.2
10/31/2011	3:45:00 PM	3:45:00 PM	0.00%	0.00%	0.00%	55.7
10/31/2011	4:00:00 PM	4:00:00 PM	0.00%	0.00%	0.00%	54.7
10/31/2011	4:15:00 PM	4:15:00 PM	0.00%	0.00%	0.00%	53.9
10/31/2011	4:30:00 PM	4:30:00 PM	0.00%	0.00%	0.00%	52.1
10/31/2011	4:45:00 PM	4:45:00 PM	0.00%	0.00%	0.00%	49.5
10/31/2011	5:00:00 PM	5:00:00 PM	0.00%	0.00%	0.00%	47.5
10/31/2011	5:15:00 PM	5:15:00 PM	0.00%	0.00%	0.00%	46.3
10/31/2011	5:30:00 PM	5:30:00 PM	0.00%	0.00%	0.00%	45.2
10/31/2011	5:45:00 PM	5:45:00 PM	0.00%	0.00%	0.00%	44.0
10/31/2011	6:00:00 PM	6:00:00 PM	0.00%	0.00%	0.00%	43.4
10/31/2011	6:15:00 PM	6:15:00 PM	0.00%	0.00%	0.00%	42.2
10/31/2011	6:30:00 PM	6:30:00 PM	0.00%	0.00%	83.70%	40.3
10/31/2011	6:45:00 PM	6:45:00 PM	0.00%	0.00%	100.00%	39.0
10/31/2011	7:00:00 PM	7:00:00 PM	0.00%	0.00%	100.00%	39.6
10/31/2011	7:15:00 PM	7:15:00 PM	0.00%	0.00%	100.00%	39.1
10/31/2011	7:30:00 PM	7:30:00 PM	0.00%	0.00%	100.00%	39.0
10/31/2011	7:45:00 PM	7:45:00 PM	0.00%	0.00%	100.00%	38.5
10/31/2011	8:00:00 PM	8:00:00 PM	0.00%	0.00%	100.00%	37.8
10/31/2011	8:15:00 PM	8:15:00 PM	0.00%	0.00%	100.00%	37.1
10/31/2011	8:30:00 PM	8:30:00 PM	0.00%	0.00%	100.00%	36.4
10/31/2011	8:45:00 PM	8:45:00 PM	0.00%	0.00%	100.00%	35.9
10/31/2011	9:00:00 PM	9:00:00 PM	0.00%	0.00%	100.00%	35.5
10/31/2011	9:15:00 PM	9:15:00 PM	0.00%	0.00%	100.00%	35.7
10/31/2011	9:30:00 PM	9:30:00 PM	0.00%	0.00%	100.00%	35.1
10/31/2011	9:45:00 PM	9:45:00 PM	0.00%	0.00%	100.00%	34.6
10/31/2011	10:00:00 PM	10:00:00 PM	0.00%	0.00%	100.00%	34.3
10/31/2011	10:15:00 PM	10:15:00 PM	0.00%	0.00%	100.00%	34.2
10/31/2011	10:30:00 PM	10:30:00 PM	0.00%	0.00%	100.00%	34.3
10/31/2011	10:45:00 PM	10:45:00 PM	0.00%	0.00%	100.00%	33.5
10/31/2011	11:00:00 PM	11:00:00 PM	0.00%	0.00%	100.00%	33.0
10/31/2011	11:15:00 PM	11:15:00 PM	0.00%	0.00%	100.00%	32.8
10/31/2011	11:30:00 PM	11:30:00 PM	0.00%	0.00%	100.00%	32.3
10/31/2011	11:45:00 PM	11:45:00 PM	0.00%	0.00%	100.00%	32.1
11/1/2011	12:00:00 AM	12:00:00 AM	0.00%	0.00%	100.00%	31.9
11/1/2011	12:15:00 AM	12:15:00 AM	0.00%	0.00%	100.00%	32.0
11/1/2011	12:30:00 AM	12:30:00 AM	0.00%	0.00%	100.00%	32.2
11/1/2011	12:45:00 AM	12:45:00 AM	0.00%	0.00%	100.00%	32.2
11/1/2011	1:00:00 AM	1:00:00 AM	0.00%	0.00%	100.00%	32.2
11/1/2011	1:15:00 AM	1:15:00 AM	0.00%	0.00%	100.00%	31.7
11/1/2011	1:30:00 AM	1:30:00 AM	0.00%	0.00%	100.00%	31.6
11/1/2011	1:45:00 AM	1:45:00 AM	0.00%	0.00%	100.00%	31.2
11/1/2011	2:00:00 AM	2:00:00 AM	0.00%	0.00%	100.00%	31.3

TMY3 Weather Data for 5 Jan, Feb, Mar, Nov, Dec			
	Total	2,385	4,091
Hour	Toa	40 °F < Toa < 55 °F	Toa < 55 °F
(1-8760)	(F)	(0,1)	
1	23	0	1
2	23	0	1
3	23	0	1
4	23	0	1
5	22.28	0	1
6	21.74	0	1
7	21.02	0	1
8	23	0	1
9	24.98	0	1
10	26.96	0	1
11	30.38	0	1
12	33.62	0	1
13	37.04	0	1
14	37.76	0	1
15	38.3	0	1
16	39.02	0	1
17	35.42	0	1
18	31.64	0	1
19	28.04	0	1
20	27.68	0	1
21	27.32	0	1
22	26.96	0	1
23	27.32	0	1
24	27.68	0	1
25	28.04	0	1
26	28.4	0	1
27	28.58	0	1
28	28.94	0	1
29	28.94	0	1
30	28.94	0	1
31	28.94	0	1
32	29.3	0	1
33	29.66	0	1
34	30.02	0	1
35	31.64	0	1
36	33.44	0	1
37	35.06	0	1
38	35.42	0	1
39	35.6	0	1
40	35.96	0	1
41	35.24	0	1
42	34.7	0	1
43	33.98	0	1
44	34.34	0	1
45	34.7	0	1

	Toa when Heater 3 on	Toa all
	(F)	(F)
Min	25.9	25.9
Max	56.4	60.7
Average	39.5	40.2

	Power	Operation	Energy Use
	(kW)	(h/yr)	(MWh/yr)
Baseline*	20	3,802	76
EEM**	20	1,943	39
Savings	-	1,859	37

* Annual operating hours are 92.9% of 4,091

** Annual operating hours will decrease by 85% of 2,385

26.8 CHEHALIS: EQUIPMENT RATINGS

ECM 1: CCW Pump Speed Control

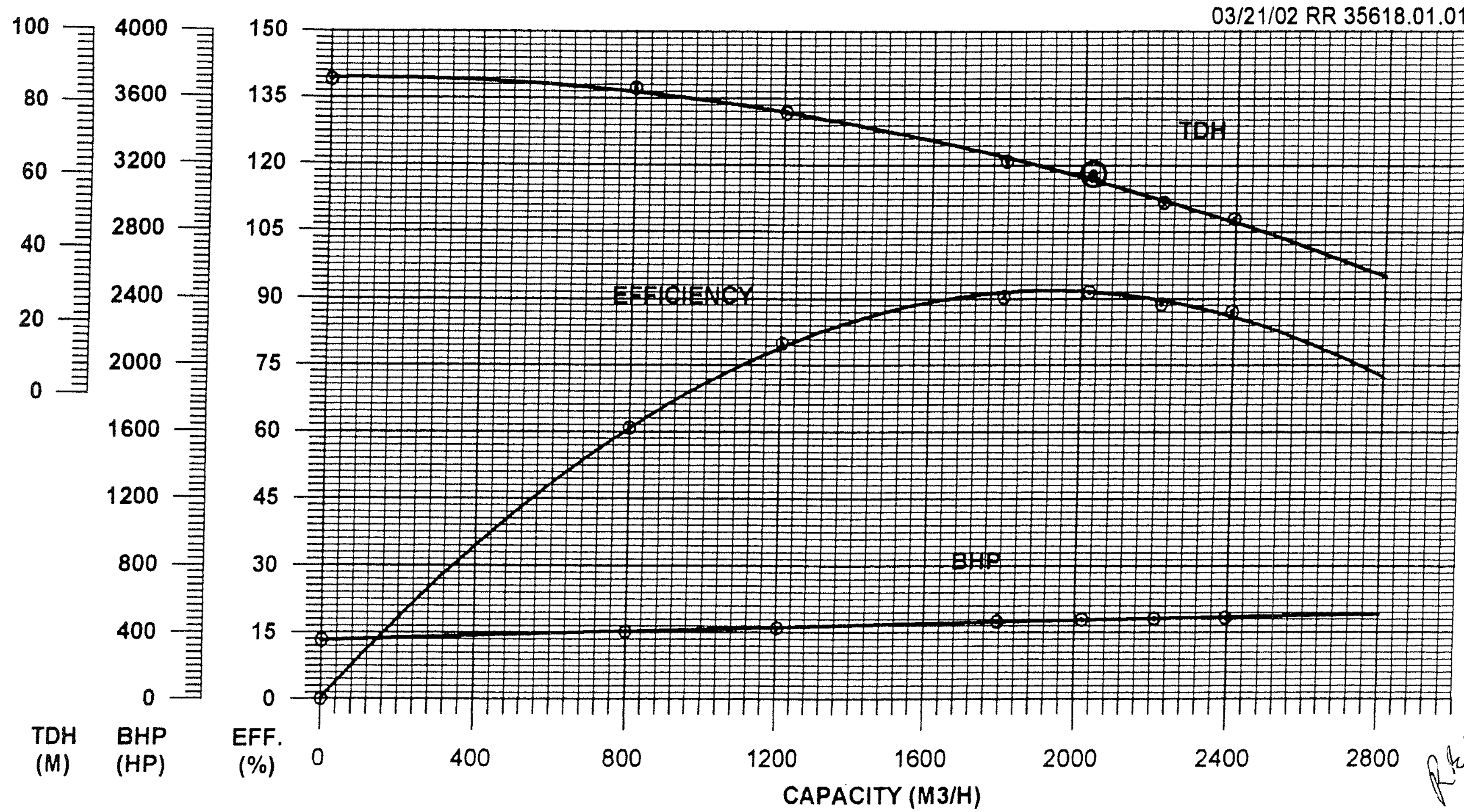
Ingersoll-Dresser Pumps

PERFORMANCE TEST

QUALITY DEPARTMENT

TEST DATE

03/21/02



GUARANTEED VALUES		PUMP		ITEM:	SERIAL NUMBER (BX): 35618.01.01
CAPACITY	EFFICIENCY	PUMP TYPE	300 LNE-450	CUSTOMER: FLOSERVE - TNTWN	BY.:
2021.0 M^3/H	87.7 %	IMPELLER			
TDH	SPEED	DIAMETER	TYPE	INSPECTION BY:	APPROVED BY: Mario [illegible] Gerente da Qualidade
61 [illegible]	1775 RPM	16.14"	"B"		

ECM 2: CCW Fan VFDs and Temperature Reset

Moore FANS

THE MOORE COMPANY

800 S. MISSOURI AVENUE
MARCELINE, MO 64658 USA
TELEPHONE: (660) 376-3575
FACSIMILE: (660) 376-2909

INSTALLATION MANUAL

JOB NO.: 67064

SOLD TO SMITHCO ENGINEERING INC.
PO BOX 571330
TULSA OK 74157-1330

SHIP TO METAL SERVICES, INC.
4019 S. JACKSON
TULSA, OK 74107

INVOICE DATE:
MODEL NO.: 5449/9B-M-13-A-8
PURCHASE ORDER NO: J25690
CUSTOMER JOB NO: 01B233
SHIP REQUIRED: 3-Jan-2002
PAYMENT TERMS: NET 30 DAYS
ROUTING: MOORE TULSA
F.O.B. POINT: MARCELINE, MO.
FREIGHT: PREPAID
CRATING: STANDARD DOMESTIC

QTY	DESCRIPTION
14	5449/9B-M-13-A-8
	Serial Nos.: F103590-103603

CLASS 5000 — ASSEMBLY DATA — MATERIAL: ALUMINUM

SERIES: 49 DIA.: 13.00
BLADES: 8 TYPE: **MANUAL**
ARRANGEMENT: 9B MOUNTS: **SMALL**
CLEVIS ANGLE: 13.4° WEIGHT:

HUB LENGTH C/L TO BASE: 2.8

4 INCH HOLE IN AIR SEAL: **NO**

BUSHING: **E** H DIM.: 3.014"
KEYWAY: 0.750" X 0.125" BORE: 2.938"
STD. BORE TOL.: +.001" -.000"
KEYS TO BE SUPPLIED BY TMC
AIR OFF: HUB TRAVEL: °
STOP DROOP: 9.5 CUT DROOP 0.0
CH TO TIP: 58.00
BALANCE WT.: COLOR CODE:

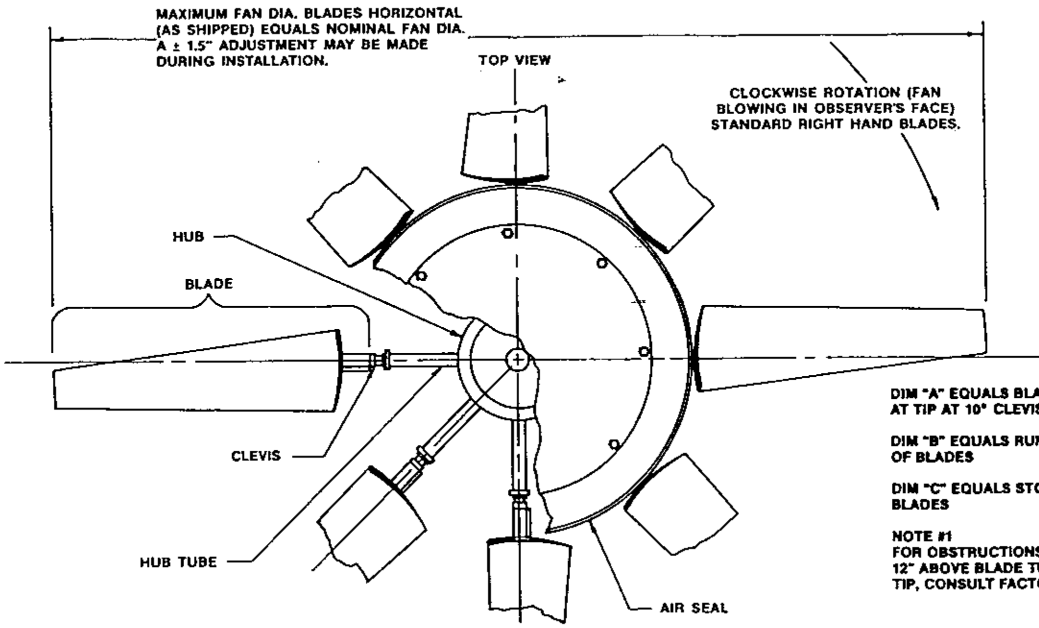
AIR PERFORMANCE DATA

ELEVATION: 240 Ft. AIR TEMPERATURE: 95 ° DENSITY RATIO: 0.947
ACFM/FAN: 226308 RPM: 255 PHUD: 1.77 INLET CORRECTION: 1.0
STATIC PRESSURE: 0.640"WG VELOCITY PRESSURE: 0.200"WG TOTAL PRESSURE: 0.840"WG
VELOCITY THROUGH FAN: 1843FPM TIP CLEARANCE: 0.39" EFFICIENCY: *.**
BHP REQUIRED: 36.0 *MOTOR HP: 40.0 *MAXIMUM APPLIED TORQUE: 1648 FT.LBS.
THEORETICAL NO. OF BLADES: 7.3 BLADE LOAD FACTOR: 0.92

CAUTION: * MAXIMUM APPLIED TORQUE USING FACTOR OF NOMINAL TIMES (FACTORY SHOULD BE NOTIFIED IF MAX. APPLIED TORQUE OR MOTOR HP IS GREATER THAN THE VALUE SHOWN.)

ADDITIONAL NOTES:
HUBS AND AIR SEALS TO BE MARKED WITH JOB 01B233

MARKS:
P.O. NO. J25690
JOB NO. 01B233

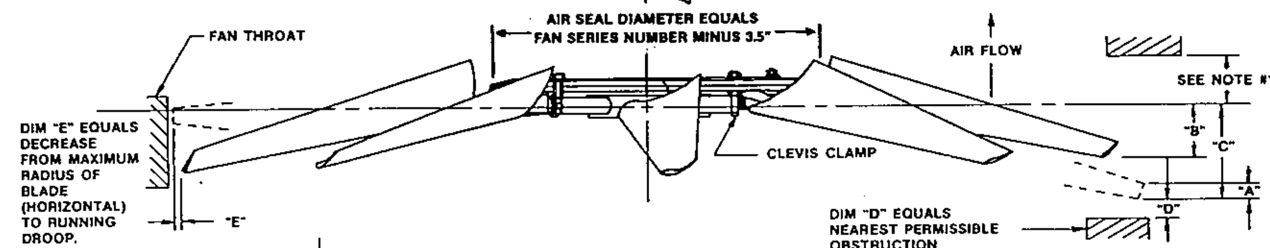


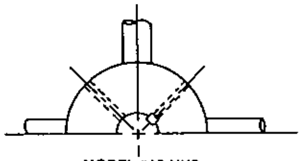
DIM "A" EQUALS BLADE THICKNESS AT TIP AT 10° CLEVIS ANGLE

DIM "B" EQUALS RUNNING DROOP OF BLADES

DIM "C" EQUALS STOP DROOP OF BLADES

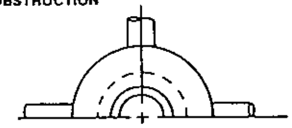
NOTE #1
FOR OBSTRUCTIONS NEARER THAN 12" ABOVE BLADE TUBE ℄ AT BLADE TIP, CONSULT FACTORY.





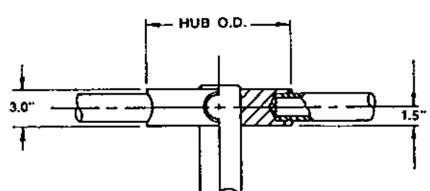
MODEL "A" HUB
STRAIGHT BORE

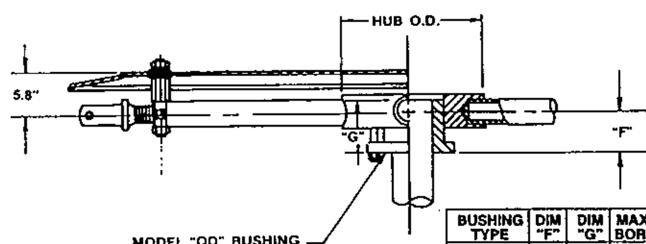
HUB O.D.	MAX.* BORE	MAX. NO. BLADES
8.0"	3.00"	6
9.0"	4.00"	8
12.0"	5.50"	10



MODEL "B"
"QD" BUSHING HUB

HUB O.D.	MAX. NO. BLADES	BUSHINGS AVAILABLE
8.0"	6	SF
9.0"	8	SF, E
12.0"	10	E, J





SHAFT BY OTHERS SHOULD GO COMPLETELY THROUGH HUB OR "QD" BUSHING
*MAXIMUM BORE DIMENSIONS ARE WITH U.S. STANDARD SQUARE KEY
**MAXIMUM BORE DIMENSIONS ARE WITH U.S. STANDARD SHALLOW KEYWAY

BUSHING TYPE	DIM "F"	DIM "G"	MAX* BORE	MAX** BORE
SF	2.5"	2.1"	2.313"	2.688"(60mm)
E	2.8"	2.7"	2.875"	3.50"(80mm)
J	3.2"	4.6"	3.750"	4.50"(100mm)

LETTER DIMENSIONS MAY VARY WITH BLADE ANGLE AND LOADING

NOTES

THE MOORE COMPANY JOB NO. 67064

SMITHCO ENGINEERING INC.

P.O. NO. J25690

JOB NO. 01B233

WITH FAN OPERATING AT 12000 FT./MINUTE BLADE TIP SPEED

FAN DIA.	DIM A	DIM B (PERCENT OF BLADE LOAD 100%)	DIM B (75%)	DIM C	DIM D	DIM E
8'	4.0"	3.4"	2.9"	6.3"	1.9"	.20"
9'	3.8"	4.1"	3.4"	7.4"	2.2"	.24"
10'	3.4"	4.8"	3.9"	8.4"	2.5"	.29"
11'	3.2"	5.6"	4.5"	9.5"	2.8"	.33"
12'	2.7"	6.4"	5.1"	10.6"	3.2"	.39"
13'	2.5"	7.2"	5.8"	9.5"	3.5"	.45"
14'	2.3"	8.2"	6.5"	12.7"	3.8"	.52"
15'	2.0"	9.2"	7.3"	13.8"	4.1"	.61"
16'	1.7"	10.3"	8.2"	14.9"	4.5"	.71"

SERIES 49 PRESSURE BLOWER

THE Moore COMPANY

ARRANGEMENT M
MANUAL ADJUSTMENT

CLASS 5000

CLASS 5000 SERIES 49 DIMENSIONS

The Moore Company
800 S. Missouri Ave.
Marceline, MO 64658
Telephone: (660) 376-3575
Facsimile: (660) 376-2909

Parsons Energy & Chemical	156093-131301					Item:	AC-1	
Class:	5000	VT Manual						
Series:	49		Diameter:	13.00	feet	Blades:	8	
Temperature:	95	Fahrenheit	Elevation:	240	feet	Density:	0.9470	Ratio
Volume:	226300	Ft3/Min	Air Vel.:	1843	fpm	RPM:	255	
Static:	0.640	In H2O	Pv:	0.200	In H2O	Pt:	0.840	In H2O
Power Reqd.:	35.97	bhp	Motor:	40.0	bhp	Efficiency:	83.3	
No. Blds Req.:	7.33		API Blds Req.:	8.00		Blade Load:	0.916	
Tip Speed:	10414	fpm	Deflection Angle:	46.1		Pitch Number:	1.8	
Entry Corr.:	1.0		Tip Clearance:	0.390	inches	Design Angle:	13.4	
Starting Torque:	2.0		Max Torque:	1648	Ft-Lbs	Torq/Bld:	206	Ft-Lbs

Appr fan weight: 153 Lbs
WR2 1146 Lbs Ft 2
Fan Thrust Load: 579 Lbs

Noise Level (per fan)	Forced Draft			based on VT Tips					
HZ	dBA	63	125	250	500	1k	2k	4k	8k
PWL	99.3	105.3	104.3	101.3	96.3	94.3	88.3	82.3	76.3
SPL 1m Below Fan	84.6	90.6	89.6	86.6	81.6	79.6	73.6	67.6	61.6
SPL 1m @ Side	79.8	85.8	84.8	81.8	76.8	74.8	68.8	62.8	56.8
SPL at R=13.5 & y=11.0 (ft)*	75.1	81.1	80.1	77.1	72.1	70.1	64.1	58.1	52.1
SPL for a 14 fan unit **	81.3	87.3	86.3	83.3	78.3	76.3	70.3	64.3	58.3

*Assuming 37.00% reflectivity - Fan centerline 11.00 feet above ground

** Assuming 37.00% reflectivity - Fan centerline 11.00 feet above ground
For unit consisiting of 7 bays with 2 fans each
Bays are 42.00 ft long x 14.00 ft wide, seperated by 0.50 ft
Maximum SPL 3 ft from periphery of bay, 11.00 ft below fan centerline

Rating generated by Moore Fans Version 1.25 at 08/13/01 09:04:50

ECM 3: High Efficiency Lighting

Lighting Ratings used in the report obtained from Bonneville Power Administration's Lighting Calculator

Baseline or ECM	Description of Proposed Lamp/Ballast Combination	Input Watts	Mean System Lumens
Baseline	High Pressure Sodium, 400 Watt Lamp	457	41000
	High Pressure Sodium, 250 Watt Lamp	295	22550
	High Pressure Sodium, 70 Watt Lamp	86	5166
	High Performance T8, 2-4' lamps with Normal Light Output ballast.	55	5183
	T12 8' Fluorescent, 2-110 Watt HO Lamps, Energy Efficient Ballast	237	13432
ECMs	4 Lamp T5 High Output (high bay) New Fixture	234	19000
	6 Lamp T5 High Output (high bay) New Fixture	352	28500
	High Performance T8, 2-4' lamps with Normal Light Output ballast. Consu	55	5183

ECM 4: Install Small Condensate Pump

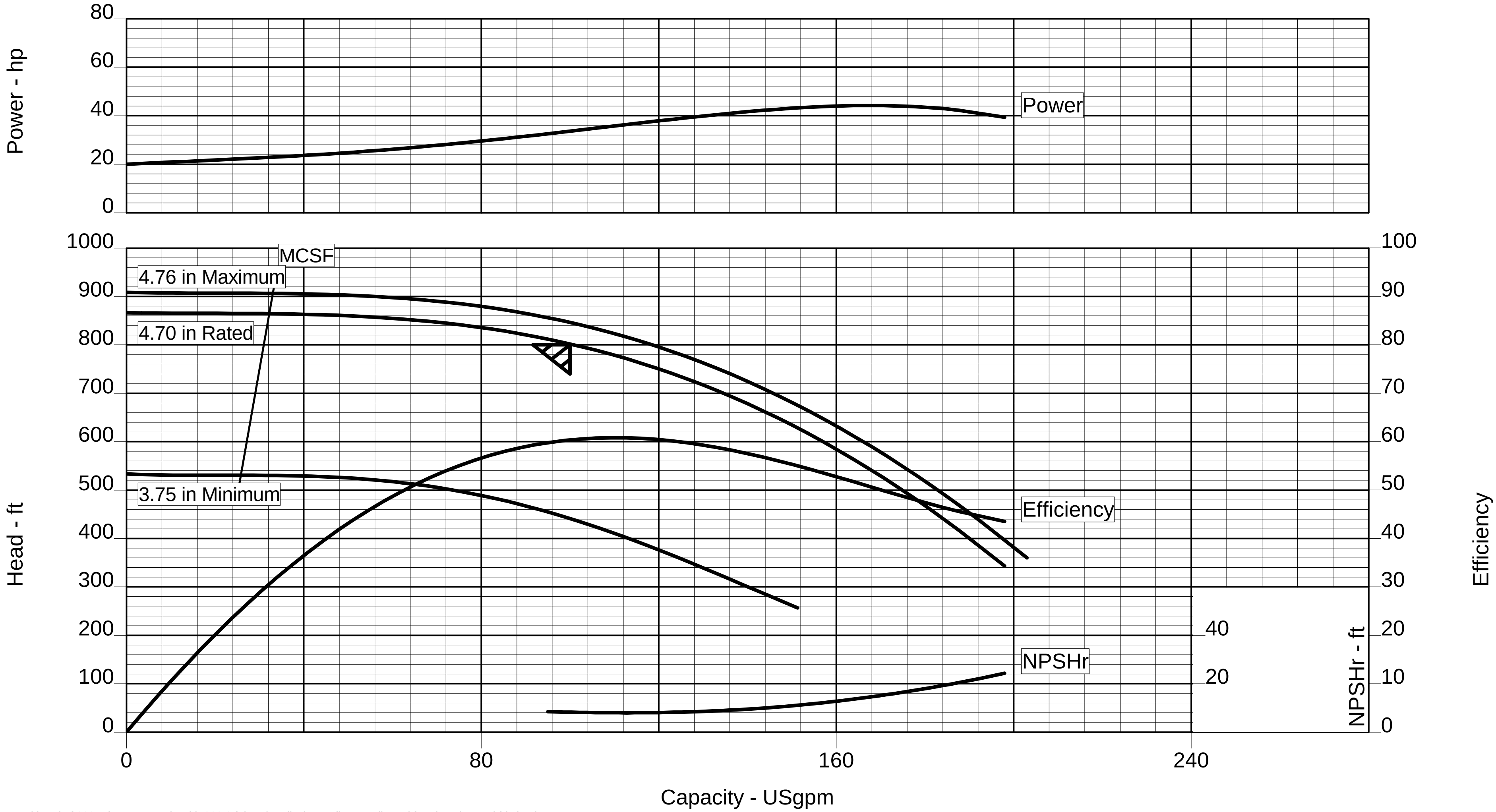
Customer	: **Cascade Energy**	Pump size & type	: **06EJH**
Item number	: **Condensate**	Based on curve no.	: **EC-1358**
Service	: **Condensate Pump**	Number of stages	: **12**
Vendor reference	: **1683-10014**	Test tolerance : Hydraulic Institute Level A	
Date	: **December 9, 2011**		

FLOWSERVE Pump Division

Capacity	: **100.0 USgpm**	Specific gravity	: **0.993**
Head	: **800.00 ft**	Pump speed	: **3500 rpm**

CURVES ARE APPROXIMATE, PUMP IS GUARANTEED FOR ONE SET OF CONDITIONS, CAPACITY, HEAD, AND EFFICIENCY.

Bowl performance shown below is corrected for materials, viscosity and construction.



Bowl head of 800.1 ft corresponds with 800.0 ft head at discharge flange adjusted for elevation and friction losses.

WinPROS+ V3.3.3

FLOWSERVE Pump Division

Hydraulic Datasheet

Customer	: Cascade Energy	Pump / Stages	: 06EJH / 12
Customer reference	: Pacific Corp	Based on curve no.	: EC-1358
Item number	: Condensate	Vendor reference	: 1683-10014
Service	: Condensate Pump	Date	: December 9, 2011

Operating Conditions

Capacity	: 100.0 USgpm
Water Capacity (CQ=1.00)	: -
Normal capacity	: -
Total Developed Head	: 800.00 ft
Water head (CH=1.00)	: -
NPSH available (NPSHa)	: 5.0 ft
NPSHa less NPSH margin	: -
Maximum suction pressure	: 0.0 psig

Liquid

Liquid type	: Water
Liquid description	: Water
Temperature	: 100 ℉
Specific gravity / Viscosity	: 0.993 / 1.0 cSt

Materials / Specification

Material column code	: CS
Pump specification	:

Other Requirements

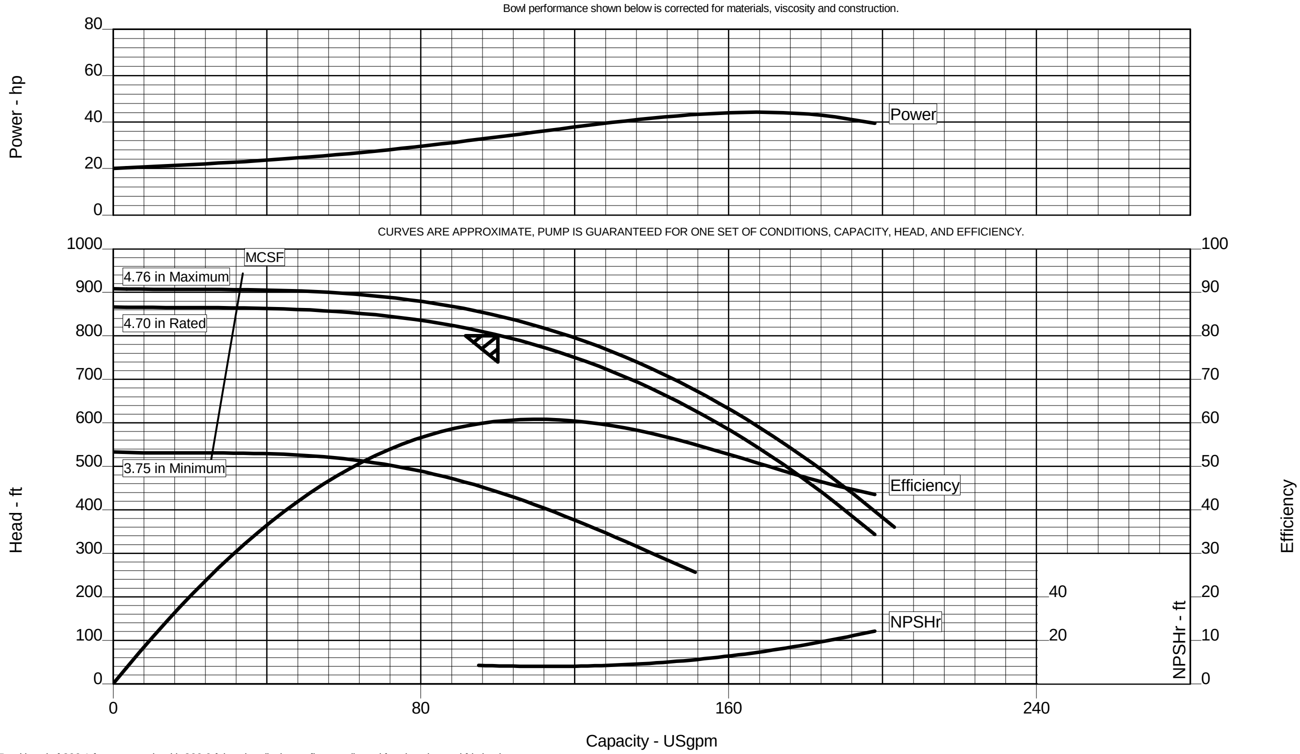
Hydraulic selection : No specification
Construction : No specification
Test tolerance : Hydraulic Institute Level A
Driver Sizing : Max Power(MCSF to EOC)with SF

Performance

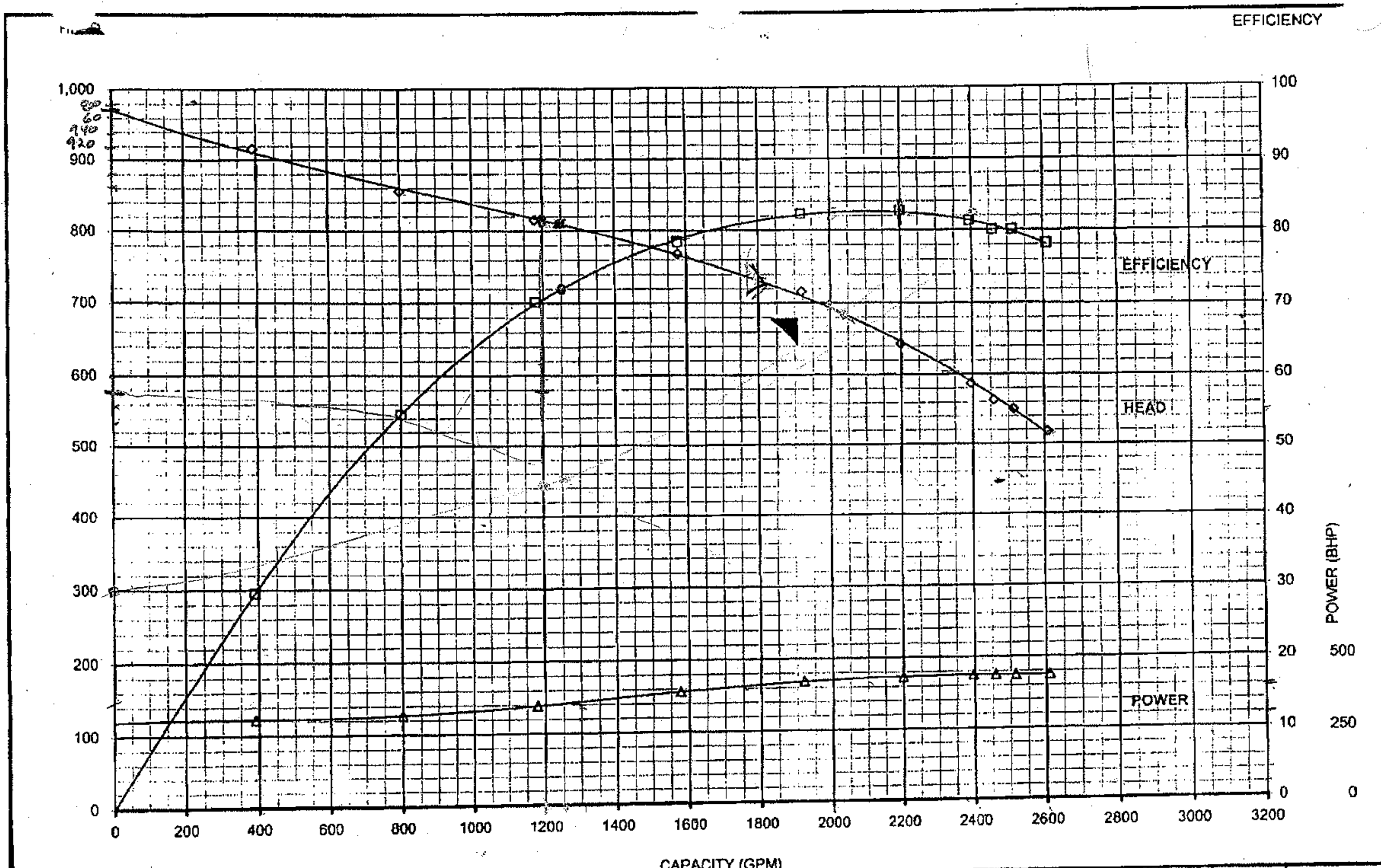
Hydraulic power	: 20.1 hp
Pump speed	: 3500 rpm
Efficiency (CE=1.00)	: 60.1 %
NPSH required (NPSHr)	: 7.9 ft
Rated power	: 33.4 hp
Maximum power	: 45.2 hp
Driver power	: 50.0 hp / 37.3 kW
Casing working pressure	: 372.4 psig
(based on shut off @ cut dia)	
Maximum allowable	: 371.7 psig
Bowl & column hydrotest	: 515.9 psig
Minimum submergence	: 14.00 in
Pump thrust at rated flow	: 529.4 lbf

Impeller diameter	
Rated	: 4.70 in
Maximum	: 4.76 in
Minimum	: 3.75 in
Suction specific speed	: 7040 US units
Minimum continuous flow	: 32.3 USgpm
Maximum head @ rated dia	: 866.3 ft
Flow at BEP	: 110.0 USgpm
Flow as % of BEP	: 90.9 %
Efficiency at normal flow	: -
Impeller dia ratio (rated/max)	: 98.7 %
Head rise to shut off	: 8.3 %
Total head ratio (rated/max)	: 94.7 %

Bowl performance shown below is corrected for materials, viscosity and construction.



Bowl head of 800.1 ft corresponds with 800.0 ft head at discharge flange adjusted for elevation and friction losses.



0207ME001045-1 SERIAL NO.	E1045-1 ORDER NO.	15EMM MODEL	7 STAGES	VTP TEST LOOP	PUMP TYPE OF TEST	Vertical 500hp @ 1800rpm TEST MOTOR	16 MAG FLOW METER	07/30/02 DATE TESTED	1WA CURVE NO

CASING DATA		IMPELLER DATA		CONDITIONS OF SERVICE	
CAST IRON MATERIAL		EMY-SS EMM-DI MATERIAL	POLISH FINISH	1910 GPM FLOW	680 FT HEAD
#2 FINISH		(1)EMY-11.80" (6)EMM-11.44" DIAMETER		1.00 SG	1785 RPM SPEED
N/A TONGUE		(Y)-.38 X 2.00 / (M)-DEBURR TIP			88 TEMP. (F)

I CERTIFY THAT WITHIN THE ACCURACY OF THE TEST INSTRUMENTATION, THIS TEST REPRESENTS THE PERFORMANCE OF 0207ME001045-1

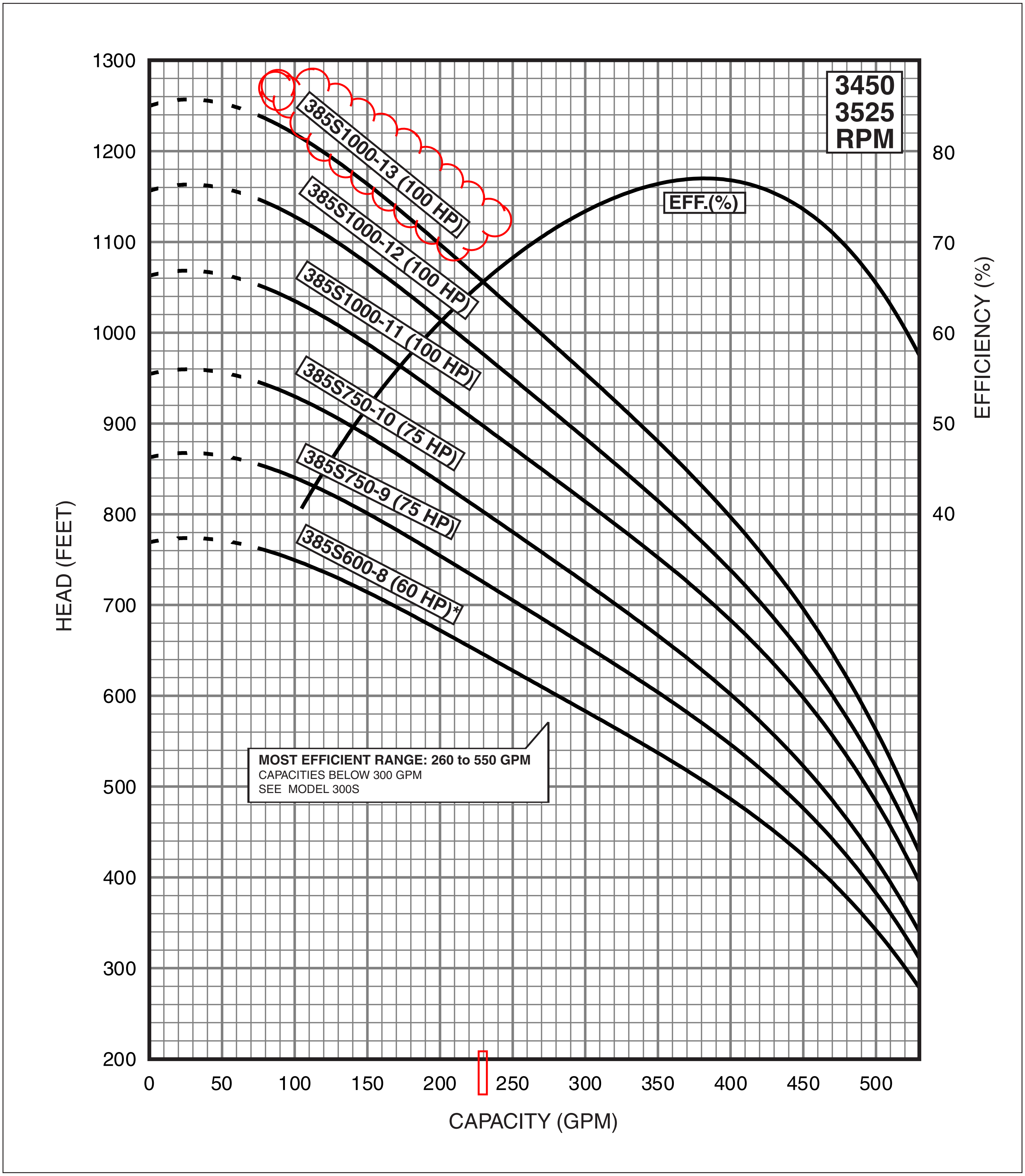
7-30-2

FLOWSERVE

ECM 5: Reverse Osmosis Pump VFDs

Model 385S 385 GPM Performance Curves

FLOW RANGE: 75 - 550 GPM **OUTLET SIZE: 4" NPT** **NOMINAL DIA. 8"**

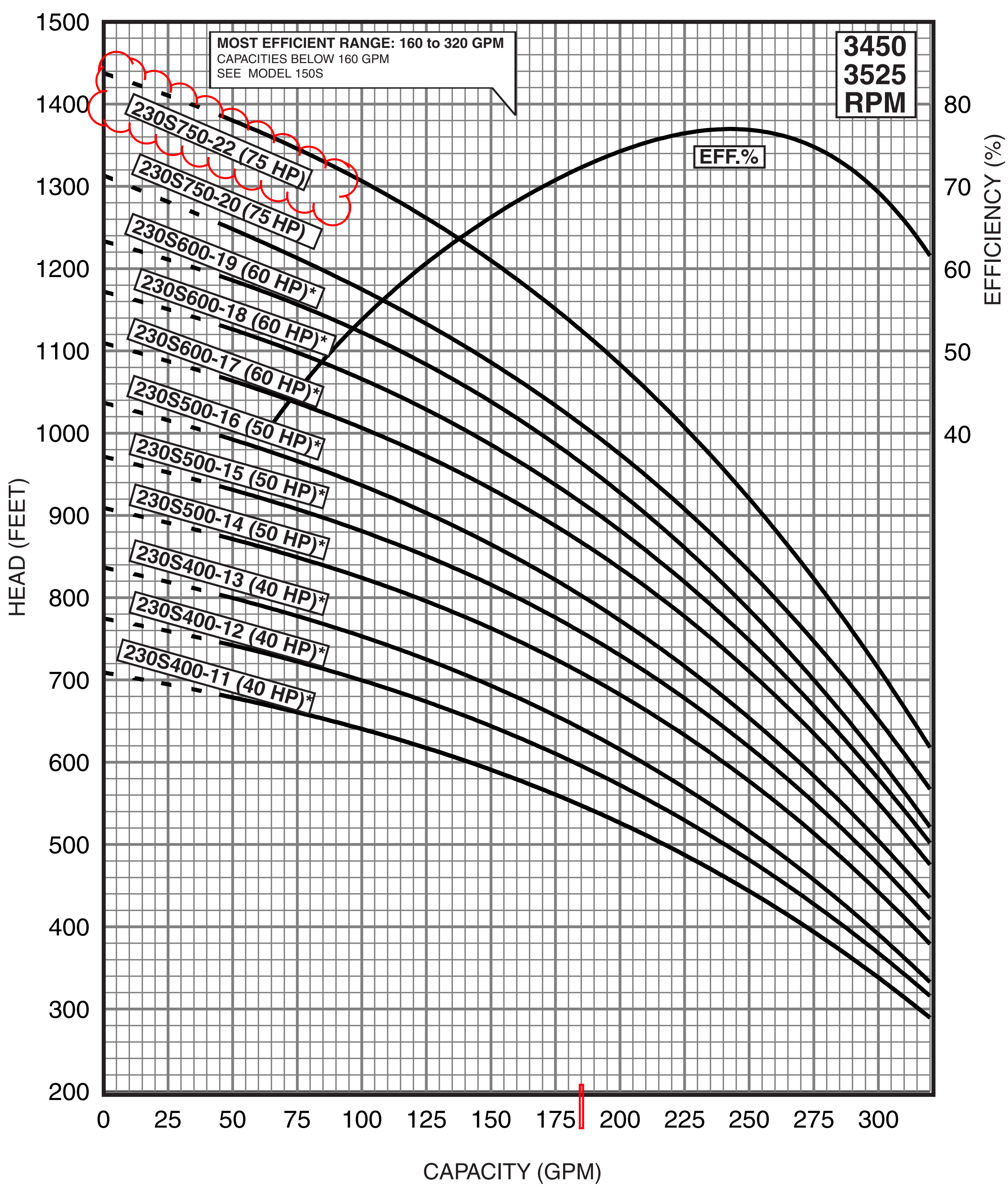


SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
6" MOTOR STANDARD, 7.5-60 HP/3450 RPM.
8" MOTOR STANDARD,75-100 HP/3525 RPM.
* Alternate motor sizes available.

Performance conforms to ISO 9906 Annex A
@ 8 ft. min. submergence.

Model 230S 230 GPM Performance Curves

FLOW RANGE: 160 -320 GPM **OUTLET SIZE: 3" NPT** **NOMINAL DIA. 6"**



SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.
4" MOTOR STANDARD, 7.5 HP/3450 RPM
6" MOTOR STANDARD, 10-60 HP/3450 RPM.
8" MOTOR STANDARD, 75 HP/3525 RPM.
* Alternate motor sizes available.

Performance conforms to ISO 9906 Annex A @ 8 ft. min. submergence.

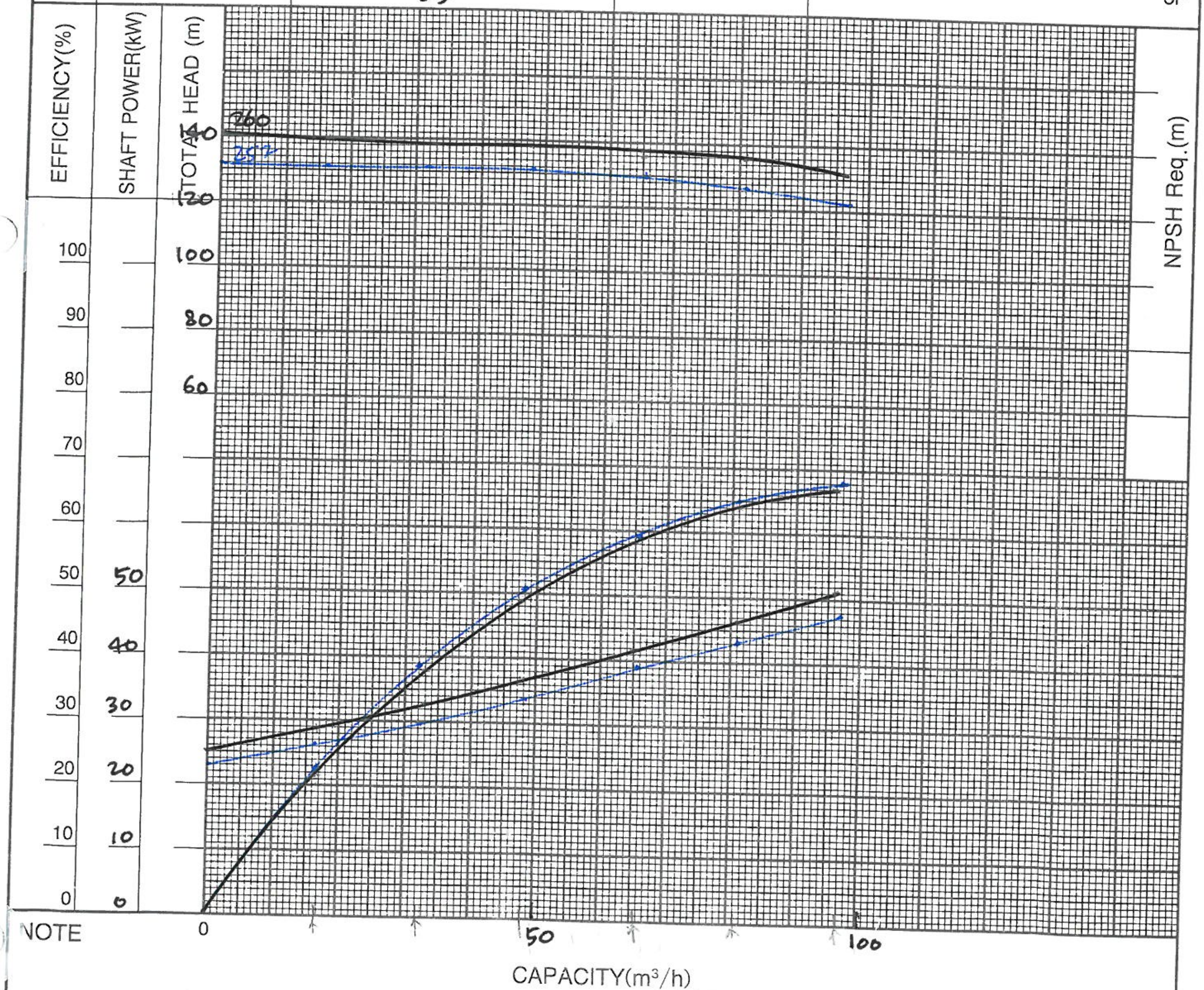
ECM 6: Reduce LP Economizer Recirculation Pump Use

☐PREDICTED
☒TEST RESULT

PERFORMANCE CURVE

ITEM No.		PRODUCT No.	
SERVICE		TYPE & SIZE	AHL 50A-2504

RATED SPECIFICATION				
TOTAL HEAD	124.0 m	LIQUID		
CAPACITY	80.2 m³/h	TEMPERATURE		℃
SPEED	3550 min⁻¹	SPECIFIC GRAVITY		
DRIVER OUTPUT	55 kW	VISCOSITY		cP



NOTE

APPROVED BY			
CHECKED BY			
DRAWN BY		DATE	

HANDOL PUMPS LIMITED

DWG No.

ECM 7: New Variable Speed Air Compressor

ROGERS *Rotary Screw Air Compressors*

PO BOX 23279, PORTLAND, OREGON 97224-0037 * (503) 639-6151 * (503) 639-1844

V Series

INDUSTRIAL ROTARY SCREW VARIABLE SPEED AIR COMPRESSORS SPECIFICATIONS

MODEL		**QNW V-125**											
RECORD OF CHANGE		WATER-COOLED				E		AIR-COOLED				F	
ROTOR DIAMETER, MM		204											
OPERATING PRESSURE		**100**				**125**				**150**			
MOTOR NP HP/ % EFF		125		95.4		125		95.4		125		95.4	
*- (KW INCLUDES DRIVE AND MOTOR LOSSES)		MAX RPM		3600		MAX RPM		3180		MAX RPM		2880	
DRIVE RPM	ROTOR TIP SPEED, METERS/SEC	ACFM	SHAFT BHP	KW*	ACFM/ KW	ACFM	SHAFT BHP	KW*	ACFM/ KW	ACFM	SHAFT BHP	KW*	ACFM/ KW
900	9.6	141	32.4	26.0	5.4	139	37.3	30.0	4.6	133	41.5	33.3	4.0
1200	12.8	189	42.9	34.4	5.5	186	49.4	39.7	4.7	179	54.9	44.1	4.1
1500	16.0	237	53.4	42.8	5.5	234	61.5	49.4	4.7	225	68.3	54.8	4.1
1800	19.2	284	62.9	50.5	5.6	280	72.5	58.2	4.8	270	80.5	64.6	4.2
2100	22.4	330	76.8	61.7	5.4	326	88.5	71.1	4.6	313	98.3	78.9	4.0
2400	25.6	371	88.3	70.9	5.2	371	101.8	81.7	4.5	357	113.1	90.8	3.9
2700	28.8	415	100.0	80.3	5.2	416	115.3	92.5	4.5	400	128.0	102.8	3.9
3000	32.0	459	111.8	89.8	5.1	461	128.9	103.5	4.5	X	X	X	X
3300	35.2	502	123.8	99.4	5.1	X	X	X	X	X	X	X	X
3600	38.5	545	135.9	109.1	5.0	X	X	X	X	X	X	X	X
MAXIMUM	38.5	545	135.9	109.1	5.0	487	137.1	110.1	4.4	426	137.0	110.0	3.9
ADD FAN POWER FOR AIR-COOLED MODELS		5.0 HP		3.7 KW		5.0 HP		3.7 KW		5.0 HP		3.7 KW	
MAX OPER.PRESS. @ FULL SPEED		110				135				150			
PRESSURE RELIEF VALVE SETTING, PSIG		160				160				225			
ELECTRICAL REQUIREMENTS: (460 VOLTS ONLY)													
MOTOR AMPS		182				195				215			
DRIVE INPUT AMPS		264				264				264			
FAN AMPS		6.5											

DATA BELOW IS FOR ALL V125 MODELS @MAX SPEED

COMPRESSOR HEAT REJECTION			**AIR-OIL SEPARATOR TANK**	
DESIGN PRESSURE, FULL LOAD	324,740 BTU/HR		GALLONS	45
AIR-COOLED AFTERCOOLER			CU. FT (@14.7 PSIA)	6.0
AIR-COOLED MODEL	R7983		CODE PRESSURE	160 PSIG(225 @ 150 PSIG)
MAX ADDITIONAL STATIC PRESSURE	0.15 " WATER COLUMN		MIN OPERATING PRESSURE	60 PSIG
REQUIRED CFM	9,500 CFM		MIN OIL INLET TEMP	160 ºF
HEAT REJECTION, MAX RPM	48,711 BTU/HR		MAX OPERATING TEMP	230 ºF
WATER-COOLED AFTERCOOLER			UNLOADED POWER REQUIREMENT	5.2 KW
WATER-COOLED MODEL	G2712		OIL SYSTEM CAPACITY	17 GAL
WATER RQD FOR LUBE COOLING	60ºF	80ºF	**MOISTURE SEPARATOR**	
GPM	7.5	10.0	MODEL	T3832
WATER CONNECTION	3/4 MNPT		PIPE SIZE, FNPT	2 1/2
COOLING WATER SYSTEM, DP	@ 9 GPM	@ 30 GPM	**APPROXIMATE DIMENSIONS & SHIPPING WEIGHT**	
PSID	7	35	116" L X 58" W X 74" H	
AFTERCOOLER MODEL	G1179		AIR-COOLED	4725 Lbs
WATER RQD FOR AIR COOLING	1.7 GPM		WATER-COOLED	4925 Lbs

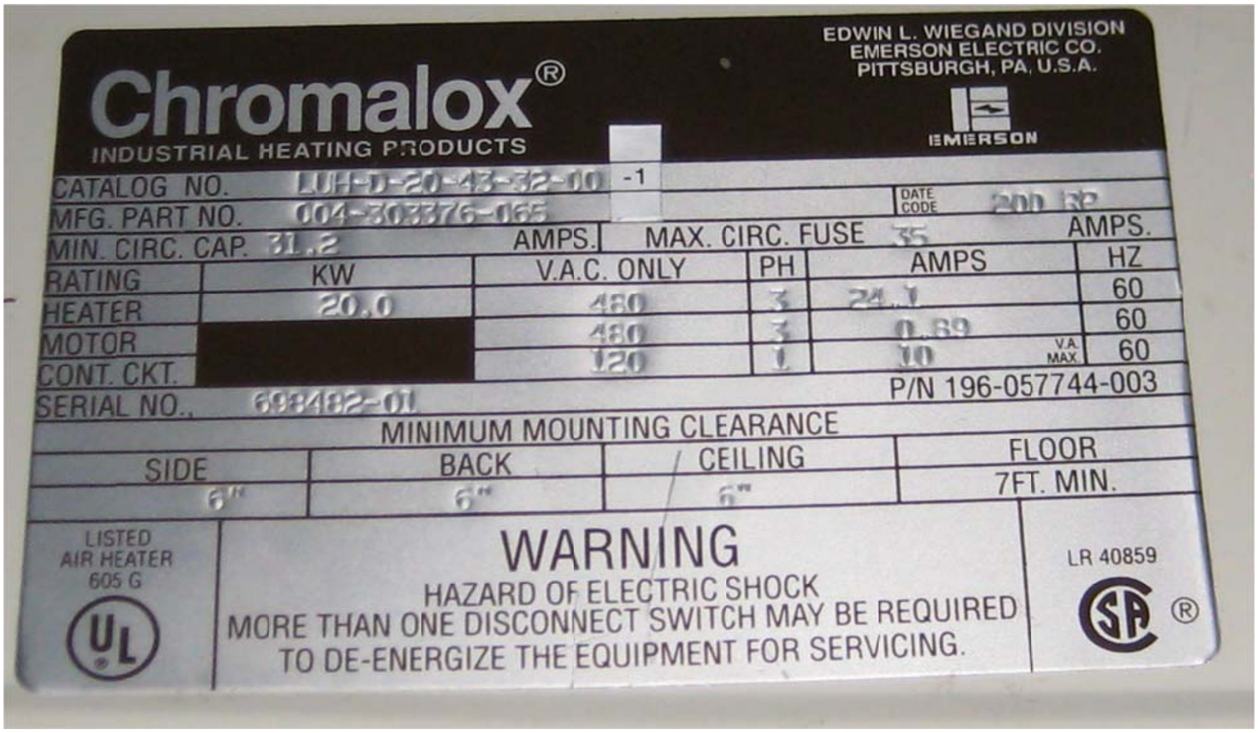
\\Nas04\cascade\Group\Projects\PacifiCorp\Power Plants 3535\Chehalis 3535-02\Subsystem Engineering Information\Compressed Air\V125SPEC_EF.xls0206EF

(Data is subject to change without notice)

ECM 8: Reduce Runtime of Electric Heat Trace

ECM 9: Adjust Thermostat on One Electric Heater

Electric heater nameplate. There are 27 of these units hanging in the facility.



ECM 10: Demand-based Dew Point Controls

Energy Management System

TZ heatless dryers provide a continuous supply of dry compressed air by automatically cycling the flow of air through two desiccant beds. While one bed is adsorbing moisture from the inlet air, the other bed is being regenerated by a portion of the dried air. The normal cycle, or Fixed Cycle, of a heatless dryer is 10 minutes. Each desiccant chamber is in service for 5 minutes, followed by a 5-minute regeneration cycle. The dryer will be sized to deliver a -40°C/F PDP. If inlet water loading to the dryer is less than the dryer is sized for then the desiccant bed will be underused.

The Energy Management System uses a precision digital hygrometer to measure the outlet dew point of the dryer, and match the capacity of the dryer to inlet moisture loading. Prior to the start of each regeneration cycle (before chamber depressurization) the EMS system will determine the dew point of the system. Should this reading be better than the EMS set point the purge exhaust valves shall remain closed and the depress and purge cycle will not take place. The dryer will continue to cycle without using purge air. This continuous cycling allows the desiccant bed to maintain internal heat of adsorption.

Once the dew point increases to the EMS set point the dryer will revert to the normal drying and purging cycle with the last chamber regenerated being the dryer chamber. The fixed cycle continues until the dew point is drier than the set point at the beginning of a purge cycle.

EMS Features:

- EMS is "fail-safe." Any hygrometer probe failure will force dryer to revert to fixed cycle and high humidity light will flash on and off repeatedly.
- Fixed cycle/EMS mode selector switch. Dryer can be operated in fixed cycle while hygrometer is serviced.
- Switch Failure Alarm and Light
- High Humidity Alarm and Light
- Nema 4 Enclosure
- Eliminates waste of compressed air
- A precision digital hygrometer and aluminum oxide sensor measures outlet dew point.
- Panel mounted direct reading dew point meter.
- Field adjustable set points for high and low dew point alarm set points.
- Fast acting aluminum oxide sensor with a dew point range of +68°F to -112°F.
- 4 - 20 mA output
- Probe can be calibrated in the field.

26.9 Chehalis: Project Costs

Electrical Project Costs (ECMs 1, 2, 3, & 5)

Christenson ELECTRIC, INC.
ENERGY SERVICES CONTRACTOR

To: Cascade Energy Engineering, Inc.
5257 NE MLK Jr. Blvd., Suite 301
Portland, OR 97211
Attn: Steve Mulqueen
Date: Thursday, December 15, 2011
Re: Budget Pricing for PacifiCorp's
Chehalis Generation Facility
Revised This Date

Steve,

We are pleased to offer, for your review, our budget proposal for the above referenced project. Our budget is based on information furnished by you; we have seen no drawings or specifications.

- Electrical Budget ——— **$2,302,816.00**
- The following breakout prices are informational only and should not be used as adds or deducts to budget proposal.
  - Furnish and install (30) new VFD'S for the 150HP axial condenser fans. **$1,067,632.00**
  - Furnish and install (14) new VFD'S for the 40HP axial cooler fans.
  - Please note this is a 'Close-Loop' fluid cooler and will be a 'Daisy-Chained' wiring method.
  - **$149,892.00**
  - Furnish and install (1) new VFD for the Medium Voltage 550HP CCW Pump. **$327,942.00**
  - Furnish and install (1) new VFD for the Medium Voltage 450HP condensate pump. **$291,297.00**
  - Provide High Efficiency Lighting Upgrade. **$91,529.00**
  - Provide control wiring (per your request) based on maximum 75' circuits. **$201,259.00**
  - Provide Nema 1 VFD's for (2) Reverse Osmosis Pumps. **$49,609.00**
  - Provide Nema 1 VFD's for (2) Low Pressure Recirculation pumps **$40,266.00**
  - Provide Nema 1 VFD's for (2) SCR Blowers. **$17,458.00**
  - Provide Nema 1 VFD's for (1) Gland Seal Blower. **$7,280.00**
  - Provide Nema 1 VFD's for (2) Reverse Osmosis Pumps. **$49,609.00**
  - Provide electrical connection (Maximum 100' circuit) for Condensate pump. **$9,043.00**
  - **Total Budget** ——— **$2,302,816.00**

  - **Pricing for the Tamperproof thermostats is unavailable at this time.**

Please note: All pricing is completely budgetary in nature; pricing will need to be re-confirmed via engineered drawings and a complete electrical spec. The above pricing is based on your request for budget pricing dated 12/7/11.

Price is good for thirty days and is based on normal hours. If you have any questions or if I can be of further assistance please do not hesitate to call.

Thank you,
Harry W. McClane
Electrical Services Estimator / Project Manager
Desk: 503.419.3340
Cell: 503.449.1338
Email: harry.mcclane@christenson.com

111 SW Columbia • Suite 480 • Portland • Oregon • 97201 • 503 419 3300 • Fax 503 419 3333
OR CCB 458 • WA CHRISE1497JK

Mechanical Project Costs (ECMs 2, 4, 5, 6, & 7)

Item 1: **Install New 125-hp Air Compressor:** Remove and dispose existing 125-hp air compressor. Install new 125-hp VFD air compressor purchased by plant and make required mechanical connections as necessary. All electrical work will be performed by others.

Labor and Material Budget Price: $ 44,000.00______

Item 2: **Install Automatic Compressed Air Isolation Valves:** Install automatic compressed air isolation valves in a total of five locations throughout the plant. Compressed air piping line size will be 2" or less.

Labor and Material Budget Price: $ 26,000.00______

Item 3: **Install Temperature Sensors on CCW System:** Install a total of three temperature sensors on the closed cooling water system. These will be located at the outlet of each lube oil heat exchanger. Verify necessary sensor output with controls contractor.

Labor and Material Budget Price: $ 11,000.00______

Item 4: **Remove and Re-install Two Boiler Feed-Water Pumps:** Provide rigging, material and labor to remove, re-install and start-up of two boiler feed-water pumps (2,000-hp each). This will include modifications to pump building enclosures. Pump building enclosures must be restored to original conditions. Pump stages will be removed and pumps will be re-built by pump manufacturer. Pump manufacturer will cover shipping costs.

Labor and Material Budget Price: $ 200,000.00______

Item 5: **Install Pressure Transducers on the Reverse Osmosis Pumps:** Install two pressure transducers, one on each of the two reverse osmosis pump discharge lines (first and second pass pumps). Verify necessary sensor output with controls contractor.

Labor and Material Budget Price: $ 3,500.00______

Item 6: **Selective Catalyst Reactor (SCR) Blower VFDs:** Install two pressure transducers, one per HRSG, in the vaporized ammonia supply line near the Selective Catalyst Reactor inlet header. Verify necessary sensor output with controls contractor.

Labor and Material Budget Price: $ 20,000.00______

Item 7: **Gland Seal Blower VFDs:** Install one pressure transducer on the Gland Seal Condensate Line. This pressure transducer will be located at the vapor exhaust duct. Verify necessary sensor output with controls contractor.

Labor and Material Budget Price: $ 11,000.00______

Item 8: **Maintenance on Bypass Valve on Low Pressure Economizer Line:** Verify that the TCV on the LP recirculation line is opening and closing fully. Replace TCV if necessary.

Labor and Material Budget Price: $ 11,000.00_______

Item 9: **Install Small Condensate Pump:** Install Small, approximately 100-hp, condensate pump near other 3 450-hp condensate pumps. Figure on 50 ft. of 3" welded piping for pump connections between existing condensate tank and condensate header. Provide housekeeping pad for pump. Pump will be located outdoors. Pump and electrical work will be supplied by others.

Labor and Material Budget Price: $ 38,000.00_______

ECM 4: Install Small Condensate Pump

FLOWSERVE

6EJH-12 Stage VTP Can

Firm

WFLT - 37954

		Flow Rate:	100	Requested By:	John Lemond
Pump Model:	6EJH	Head:	800 ft	Company:	Chehalis Power
# of Stages:	12	RPM:	3500	Prepared By:	Karthick S
				Date:	12/14/2011

Bowl Assembly: ☑ Flanged ☐ Threaded

			Accessories:	Material
Bowl Material:	Carbon Steel	☐	Bowl Wear Rings	None
Impeller Material:	Carbon Steel	☑	Impeller Wear Rings	410 SS
Bearing Material:	Carbon - CC40	☐	Strainer	None
Shaft Material:	416 SS	☑	Collets	Carbon Steel
Bolting Material:	Carbon Steel	☐	Keyed Impeller(s)	None
Outside Coating:	Rust Veto		Inside Coating:	None

Column Assembly: ☑ Flanged ☐ Threaded

			Accessories:	Material
Column Material:	Carbon Steel	☐	Lineshaft Sleeve	None
Column Dia:	4"	☐	Bearing Retainer	None
Lineshaft Material:	416 SS	☐	Enclosing Tube	None
Lineshaft Dia:	1"			
Bearing Material:	None		Max. Section Length:	30"
Bolting Material:	Carbon Steel			
Outside Coating:	Rust Veto		Inside Coating:	None

Discharge Head Assembly:

			Accessories:	Material
Head Size:	4TF16	☑	Packed Box	Steel Seal House
Head Material:	Carbon Steel	☑	Mechanical Seal	QB seal
Shaft Material:	416 SS	☐	Stuffing Box Sleeve	None
Bearing Material:	Carbon	☑	Driver Stand	Integral
Bolting Material:	Carbon Steel	☐	Baseplate	None
Coupling Type:	Precision Spacer		Baseplate Size:	NA
Coupling Material:	Steel			
Piping Plan Type:	Plan 13			
Piping Plan Material:	Steel Pipe			
Outside Coating:	FLS Gray Enamel		Inside Coating:	None

Suction Can Assembly:

		Accessories:	
Can Size:	10"		
Can Material:	Carbon Steel	Suction Flange Size:	6"
Can Length:	84"		
Outside Coating:	FLS Gray Enamel	Inside Coating:	Rust Veto

VTP with Can Sell Price Each: $51,000 USD **Leadtime:** 24 Weeks

Quoted price is direct sell price to Chehalis Power

Sell Price Adders:

Sell Price includes NIDEC vertical electric motor:
50 HP at 3600 RPM, VSS, 3 Phase, 60 Hz, 460 Volts, TEFC Enclosure.

Testing specified below included in Sell Price:

Non-Witnessed Performance Test(Bowl Assembly)
Non-Witnessed Bowl Hydrotest
Non-Witnessed Column Hydrotest
Non-Witnessed Head Hydrotest

Shipping Info:

Pump will be shipped ASSEMBLED from Taneytown, FCA Factory, Prepaid / Add

Disclaimers:

Commissions are not included in pump price.

Non-standard coatings are not included in Sell Price (unless otherwise specified).

Rationalized pump features duplicate hydraulics. However, parts are not interchangeable with non-rationalized models.

No specifications were reviewed and pricing was done based on pros+ scope only.

Lead-time begins after receipt of acceptable order & release to manufacture.

Although Flowserve may comment on suitability, final material selection/approval is the responsibility of the customer. The effects of corrosion, erosion, and normal wear are specifically excluded from warranty.

Please send the Purchase Order and Order Entry Forms to the Application Engineer and CC to Patricia Gamber <pgamber@flowserve.com>.

Taxes, duties, and fees of any kind are not included.

Flowserve Current Worldwide Terms and Conditions of Sale apply.

Quote valid for 60 days.

ECM 7: New Variable Speed Air Compressor

Fixed speed backup compressor

ROGERS
MACHINERY
COMPANY, INC.

COMPRESSORS
PUMPS
BLOWERS
VACUUM SYSTEMS
ENERGY AUDITS

March 29, 2011

Chehalis Power Generating LLC
Chehalis Power Plant
1813 Bishop Road
Chehalis, WA 98532

(PHONE 360/748-1300)
(FAX 360/740-1891)

rick.bradshaw@pacificorp.com

Attention: Rick Bradshaw

Subject: **Budget Quotation**
Quincy Northwest Rotary Screw Air Compressor

As requested, we are pleased to quote on the following Quincy Northwest rotary screw air compressor assembly and accessories.

ITEM 1. AIR COMPRESSOR.

Operating Conditions & Performance:

491 SCFM @ 150 PSIG
150 PSIG Maximum Working Pressure with 125 HP Motor
150 PSIG Operating Pressure
1780 RPM Compressor Male Rotor Speed
125 HP Motor Nominal Rating
132.0 BHP Actual Brake Horsepower Required @ Full Load Conditions

1-only Quincy Northwest rotary screw air compressor assembly, model QNW-503, with air-cooled lubricant cooler, complete with a 125 HP, 1800 RPM, C-flange mounted, 3/60/230/460 volt, open dripproof, energy efficient motor, with a 1.25 service factor. The assembly is complete with initial fill of Rogers CLS46 synthetic compressor lubricant and standard equipment, as listed in bulletin QNW-G-BRO(105).

Standard equipment:
a) Compressor air end with modulating valve.
b) High efficiency rotor profile with axial air inlet.

c) Slow rotor speed.
d) Triple lip shaft seal.
e) Positive displacement lubricant pump.
f) Direct driven at 1800 RPM with no high speed gearing.
g) Heavy-duty steel base.
h) Drop-out type coupling.
i) OSHA coupling guard.
j) Air-lubricant separation system consisting of **dual lubricant separator elements with sight glasses.**
k) Spin-on full flow lubricant filter with relief valve, 12 micron.
l) Air-cooled lubricant cooler with automatic temperature control.
m) Inlet air filter/silencer with filter condition indicator on panel.
n) ASME pressure relief valve.
o) Constant speed control with percent capacity display.
p) Discharge air check valve.
q) Solenoid operated blowdown valve with muffler.
r) Two (2) high temperature shutdowns.
s) Lubricant level gauge.
t) CSA listed control panel.

ITEM 2. GRAPHIC OPERATOR ACCESS TERMINAL.

1-only Graphic operator access terminal with the following status and service indicators:

a) Power on indicator.
b) Operating compressor indicator.
c) Loaded compressor indicator.
d) Unloaded compressor indicator.
e) Standby indicator.
f) Inlet air filter service indicator.
g) Lubricant filter service indicator.
h) Compressor lubricant service indicator.
i) Separator element service indicator.
j) Lamp test button.
k) Dry contacts for remote indication of all faults.
l) Lubricant filter status indication.
m) Motor bearings service indicator.

Also included are visual alarm and shutdown for the following conditions:

a) High air end discharge temperature.
b) High sump temperature.

c) Starter failure.
d) Main motor overload.
e) Cooling fan overload.
f) Control panel failure.
g) Spare unmarked fault for customer use.
h) Reset buttons for all alarm conditions.
i) Historical list of up to 100 faults..

Digital display of the following values:

a) Compressor percent capacity.
b) Separator inlet temperature.
c) Inlet lubricant temperature.
d) Pressure drop across air/lubricant separator elements.
e) Running hours.
f) Loaded hours
g) Aftercooler discharge pressure.
h) Aftercooler discharge temperature.

ITEM 3. AFTERCOOLER.

1-only Air-cooled aftercooler with moisture separator and automatic condensate trap, mounted, pre-piped and tested.

1-only Optional Variable speed drive package, installed, for the cooling fan motor (3/60/460 volt). This option maintains proper operating temperature by sensing lubricant temperature and reducing the fan motor speed, thus reducing KW consumption. In addition, slower fan speed reduces the sound level of the assembly.

NET PRICE $2,250.00

ITEM 4. MOTOR CONTROL.

1-only Magnetic X-line starter, 125 HP, 3/60/460 volt, in NEMA 1 enclosure with operator switch in compressor panel, mounted, wired and tested.

1-only Unloading control package to enable compressor to operate in Low Unloaded Horsepower mode with timed shutdown and automatic restart on a pressure signal. The compressor controls shall relieve sump pressure to zero (0) psig in the unloaded state to reduce energy consumption by the main motor to between 15 – 18% of full load –The lowest in the industry!

TOTAL NET PRICE FOR ITEMS 1 THROUGH 4 .... $42,015.00
Approximate Shipping Weight ... 4,925 lbs.
Shipping Point ... Centralia, Washington

ITEM 5. DEDUCT FOR WATER COOLED IN LEIU OF AIR COOLED.

1-only Net Price deduct to supply the above unit with water cooled heat exchangers in lieu of air cooled.

NET PRICE DEDUCT.. <$2,110.00>
NET PRICE FOR WATER COOLED W/ X-LINE............................ $35,000.00

ITEM 6. ADDER FOR SOLID STATE MOTOR STARTER .

1-only Net Price addition to supply either above units with 3/60/460 volt Benshaw solid state motor starter in lieu of the x-line starter listed in item 4 above.

NET PRICE ADDITION... $3,320.00

ITEM 7. OPTIONAL "INSTRUMENT QUALITY" (IQ) FILTER

1-only A Finite model HN8S-7DVPJ high temperature coalescing filter can be provided installed between the air/oil separator and the system check valve to additional insurance that oil does not make it into the compressed air system. This filter is the 3rd in a series of coalescing filters that removes entrained oil vapors from the airstream as the QNW's standard filtration uses two elements. The filter is rated 750 SCFM at 100 psig for minimal pressure drop and will be drained to the compressor inlet to reclaim any captured lubricant within the compressor system.

NET PRICE $1,400.00

ITEM 8. FACTORY SERVICE.

Our state-of-the-art control system provides you with an unprecedented opportunity to ensure long, trouble-free operation of your compressor. When you purchase a Quincy Northwest compressor assembly you receive our factory monitored preventive maintenance program at no additional charge. Simply call us, day or night if your graphic operator access terminal indicates a fault.

You are also entitled to participate in our factory service program. Our service department will put you on a regular service program that will provide notification, at no cost, when routine maintenance is due. We will provide needed maintenance parts, at a discount, and labor (if requested) to maintain your compressor at peak operating efficiency.

NET PRICE .... INCLUDED

ITEM 9. SERVICE GUARANTEE.

If you notify us that you have an emergency and require a standard part or service for your Quincy Northwest compressor, we will ship the part and/or initiate the service within 24 hours or you will not have to pay for either or both.

NET PRICE .... INCLUDED

ITEM 10. ENERGY SAVING OPTIONS.

NOTE: Quincy Northwest Series air compressors have the highest efficiencies of any comparable compressors on the market. The high capacity profile produces more actual CFM per input kilowatt than competitive units. For example, the model QNW-503 produces 4.67 SCFM per KW at 150 PSIG. Moreover, at 150 PSIG operation, the QNW-503 draws 132 BHP which is 5.0% less than comparable models. For a power cost of 5 cents per kilowatt hour, this efficiency can save approximately $1,500.00 per year in power costs based on a 3-shift operation.

1-only Compressed air capacity display to continuously show the percentage of total compressor capacity being used. This feature is particularly useful in determining compressed air leaks and in determining how much capacity remains for future use.

NET PRICE .... INCLUDED

ITEM 11. 15 GALLON WATER/OIL SEPARATOR.

1-only Summit model ConDePhase-Plus 15 water/oil separator, 15 gallon capacity is a gravity separation system with no moving parts The ConDePhase Plus has a patented external activated carbon filter polishing unit that provides additional effluent protection with impact resistant, high density polyproplylene construction, and with two coalescing packs for extra filtration. The lubricant is periodically drained from the unit. See the ConDePhase Plus bulletin for special features.

NET PRICE EACH $1,150.00

360/736-9356 • FAX 360/736-8630 • EMAIL: Centralia-Sales@rogers-machinery.com • www.rogers-machinery.com
3509 GALVIN ROAD • P0 BOX 548, CENTRALIA, WASHINGTON 98531

Approximate Shipping Weight ... 33 lbs.
Shipping Point ... Tyler Texas

WARRANTY:

Our warranty on the compressor assembly quoted is as follows:

a) One (1) year on the complete assembly.
b) Five (5) years on the air-end. A ten (10) year airend warranty is available with use of special synthetic lubricant, as specified by Quincy Compressor.
c) Five (5) years on the motor.

A five (5) year warranty covering the entire assembly, when coupled with our factory service program, is available for this compressor as explained in bulletin QNW-5Y (296) enclosed.

SERVICE CONSIDERATIONS

When you purchase a compressed air system from us, you get a product of the highest quality, and a commitment to provide you service on a 24-hour/day, 7-day/week basis. Prices quoted include the services of a factory trained field engineer to assist in the start-up of the compressor and accessory equipment, and to train your maintenance personnel. Our intent is to have an installation we can both be proud of and one that will perform reliably for you.

Our Factory Monitored Preventive Maintenance Program has the following components:

a) A log sheet to provide daily readings of important operating parameters taken by you and reviewed by us on a monthly basis. This program will insure that developing service problems are discovered and the solution diagnosed quickly. This program is included in the sale price.

b) Our computer generated Service Reminder Program will provide a telephone call to your designated maintenance person when regularly scheduled preventive maintenance is due to be performed on this equipment. At that time, we can supply the service recommendations, parts and, if you choose, a trained service technician to perform the service at a time of your choosing. (The parts, labor and mileage of the service technician will be charged on a time and material basis.)

Estimated time of delivery on the equipment quoted will be four to six (4-6) weeks after receipt of order, subject to confirmation at time of sale.

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All component parts for Quincy Northwest air compressors are stocked in all our Branches. Complete service facilities are available from all our Branches on a 24-hour/day, 7-day/week basis.

All prices quoted are net F.O.B. shipping point. All prices quoted are firm for thirty (30) days from this date. Our terms of payment are net 30 days, subject to approved credit. Prices quoted do not include any custom or duty fees, Federal, State or local taxes.

Thank you for your continued interest in our equipment. If you have any questions or would like additional information, please contact us.

Very truly yours,

ROGERS MACHINERY COMPANY, INC.

Eric Forslund

Enclosures
h:\15\sales\projects\2011\chehalis power\ef032811a.doc
cc: Mr. Brian Williams

ROGERS
MACHINERY
COMPANY, INC.

CENTRALIA BRANCH
3509 Galvin Road, Centralia, Washington 98531
P.O. BOX 548, Centralia, Washington 98531
PHONE # 360/736-9356 - FAX # 360/736-9630

Quincy Northwest
QNW SERIES
Oil-Lubricated, Rotary Screw Air Compressors

October 26, 2011

PacifiCorp Energy (PHONE 503/287-8788)
Chehalis Power Plant (FAX 503/928-3209)
1813 Bishop Road
Chehalis, WA 98532

Attention: Sam Skidmore sma.skidmore@cascadeenergy.com
Rick Bradshaw rick.bradshaw@pacificorp.com

Subject: Quincy Northwest V Series
Quote #73796

As requested, we are pleased to quote on the following Quincy Northwest variable speed rotary screw air compressor assembly and accessories.

ITEM 1. AIR COMPRESSOR.

Operating Conditions & Performance:

139-487 ACFM @ 125 PSIG
130 PSIG Maximum Full Load Working Pressure
125 PSIG Operating Pressure
900-3180 RPM Compressor Male Rotor Speed
137.1 BHP Required @ Full Load Conditions
113.8 Package KW @ Full Load (Includes fan motor, drive and motor losses)
9,500 CFM Cooling Fan Air Flow
373,451 BTU/Hour Heat Rejection @ Full Load Conditions

1-only Quincy Northwest rotary screw air compressor assembly, model QNW-V125, with air-cooled lubricant cooler, complete with open dripproof, premium efficient (95.4%), inverter duty motor optimized for constant torque operation. The assembly is complete with all standard equipment, as listed in bulletin QNW-V-BRO (301).

Standard equipment:

a) Compressor air end with inlet valve.
b) High efficiency rotor profile with axial air inlet.
c) Slow rotor speed.
d) Triple lip shaft seal.
e) Initial fill of Rogers CLS46 synthetic lubricant.

f) Direct drive with no high speed gearing.
g) Heavy-duty steel base.
h) Drop-out type coupling.
i) OSHA coupling guard.
j) Air/lubricant separation system consisting of dual lubricant separator elements with lubricant scavenging line sight glasses.
k) Spin-on full flow lubricant filter with relief valve, 12 micron.
l) Air-cooled lubricant cooler with automatic temperature control.
m) Inlet air filter/silencer with filter condition indicator on panel.
n) ASME pressure relief valve.
o) Discharge air check valve.
p) Solenoid operated blowdown valve with muffler.
q) Two (2) high temperature shutdowns.
r) Lubricant level gauge.
s) CSA listed control panel.

1-only Graphic operator access terminal with the following status and service indicators:

a) Power on indicator.
b) Compressor operating indicator.
c) Compressor load indicator.
d) Standby indicator.
e) Inlet air filter service indicator.
f) Lubricant filter service indicator.
g) Compressor lubricant change indicator.
h) Separator element service indicator.
i) Lamp test button.
j) Motor bearing service indicator.
k) Dry contacts for remote indication of fault status.
l) Dry contacts for remote indication of service required.

Also included are visual alarm and shutdown for the following conditions:

a) High air end discharge temperature.
b) High lubricant injection temperature.
c) High sump pressure.
d) Starter failure.
e) Main motor overload.
f) Cooling fan overload.
g) Control Panel failure.
h) Spare unmarked fault for customer use. (2)
i) Reset buttons for all alarm conditions.
j) Historical list of up to 100 faults. (Time and date stamped.)
k) Historical list of up to 100 services. (Time and date stamped.)

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Digital display of the following values:

a) Compressor capacity.
b) Compressor (air end) discharge temperature.
c) Lubricant injection temperature.
d) Pressure drop across air/lubricant separator elements.
e) Running hours.
f) Loaded hours
g) Aftercooler discharge pressure.
h) Aftercooler discharge temperature.

ITEM 2. VERTICAL DISCHARGE AFTERCOOLER WITH VSD FAN.

1-only QNW model R7983 air-cooled aftercooler with moisture separator and automatic condensate trap, mounted, pre-piped and tested.

1-only Adjustable speed drive package, installed, for the cooling fan motor (3/60/460 volt). This option maintains proper operating temperature by sensing lubricant temperature and reducing the fan motor speed, thus reducing KW consumption. In addition, slower fan speed reduces the sound level of the assembly.

ITEM 3. COMPRESSOR CONTROL MODE

1-only Unloading control package to enable compressor to be controlled in **proportional speed control mode**. Load/Unload pressure setpoints and timed shutdown are fully adjustable. The compressor controls shall relieve sump pressure to zero (0) psig in the unloaded state to reduce energy consumption by the main motor to between 6 - 9% of full load–The lowest in the industry!

ITEM 4. ADJUSTABLE SPEED DRIVE.

1-only Adjustable speed drive (ASD), complete with keypad and combination LED/LCD graphic display, rated 228 input amps., 3/60/460 volt, fully programmed, tested, and shipped loose with the assembly. Includes the following features:

- All steel, wall mounted, NEMA type 1 enclosure
- Menu driven programming with access to all parameters
- Real time clock
- Graphic LCD to aid in diagnostics, monitoring 43 parameters
- Serial communication options
- Programmable analog outputs
- Programmable relay outputs
- Automatic input voltage regulation: -10%/+10%

- Fault input and outputs are failsafe configured
- Historical list of up to 20 faults (time and date stamped), including 28 at trip diagnostic parameters to aid in trouble shooting.

TOTAL NET PRICE FOR ITEMS 1 THROUGH 4 .... $59,000.00
Approximate Shipping Weight ... 4,725 lbs.
Shipping Point ... Centralia, Washington

ITEM 5. FACTORY SERVICE.

Our state-of-the-art control system provides you with an unprecedented opportunity to ensure long, trouble-free operation of your compressor. When you purchase a Quincy Northwest compressor assembly you receive our factory monitored preventive maintenance program at no additional charge. Simply call us, day or night if your graphic operator access terminal indicates a fault.

You are also entitled to participate in our factory service program. Our service department will put you on a regular service program that will provide notification, at no cost, when routine maintenance is due. We will provide needed maintenance parts, at a discount, and labor (if requested) to maintain your compressor at peak operating efficiency.

NET PRICE .... INCLUDED

ITEM 6. SERVICE GUARANTEE.

If you notify us that you have an emergency and require a standard part or service for your Quincy Northwest compressor, we will ship the part and/or initiate the service within 24 hours or you will not have to pay for either or both.

NET PRICE .... INCLUDED

WARRANTY:

Our warranty on the compressor assembly quoted is as follows:

a) One (1) year on the complete assembly.
b) Five (5) years on the air-end.
c) Three (3) years on the ASD.
d) Five (5) years on the motor.

ITEM 7. RECOMMENDED COMPRESSED AIR FILTER

Prefilter.

1-only Finite model HN8L-6CUG coalescing filter assembly as described in Finite Bulletin 1300-993C, complete with DPG-15 differential pressure gauge, mounted. Filter is rated 625 SCFM at 100 PSIG and has 2" threaded inlet and outlet. Filter to be shipped loose for mounting upstream of dryer.

NET PRICE $1,305.00
Approximate Shipping Weight ... 16 lbs.
Shipping Point ... Centralia, Washington

SERVICE CONSIDERATIONS

When you purchase a compressed air system from us, you get a product of the highest quality, and a commitment to provide you service on a 24-hour/day, 7-day/week basis. Prices quoted include the services of a factory trained field engineer to assist in the start-up of the compressor and accessory equipment, and to train your maintenance personnel. Our intent is to have an installation we can both be proud of and one that will perform reliably for you.

Our Factory Monitored Preventive Maintenance Program has the following components:

a) A log sheet to provide daily readings of important operating parameters taken by you and reviewed by us on a monthly basis. This program will insure that developing service problems are discovered and the solution diagnosed quickly. This program is included in the sale price.

b) Our computer generated Service Reminder Program will provide a telephone call to your designated maintenance person when regularly scheduled preventive maintenance is due to be performed on this equipment. At that time, we can supply the service recommendations, parts and, if you choose, a trained service technician to perform the service at a time of your choosing. (The parts, labor and mileage of the service technician will be charged on a time and material basis.)

Estimated time of delivery on the equipment quoted will be ten to twelve (10-12) weeks after receipt of order, subject to confirmation at time of sale.

All component parts for Quincy Northwest air compressors are stocked in all our Branches. Complete service facilities are available from all our Branches on a 24-hour/day, 7-day/week basis.

All prices quoted are net F.O.B. shipping point. All prices quoted are firm for thirty (30) days from this date. Our terms of payment are net 30 days, subject to approved credit. Prices quoted do not include any customs or duty fees, Federal, State or local taxes.

Thank you for your continued interest in our equipment. If you have any questions or would like additional information, please contact us.

Very truly yours,

ROGERS MACHINERY COMPANY, INC.

Brian Williams

BMW;bmw
H:\15\SALES\Projects\2011\Chehalis Power\bw102611b.doc

Enclosure

cc: Eric Forslund

360/736-9356 • FAX 360/736-8630 • EMAIL: Centralia-Sales@rogers-machinery.com • www.rogers-machinery.com
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ECM 10: Demand-based Dew Point Controls

Sam Skidmore

From:	Brian Williams <Brian.Williams@Rogers-Machinery.com>
Sent:	Thursday, December 15, 2011 10:52 AM
To:	Sam Skidmore
Subject:	PacifiCorp, Chehalis

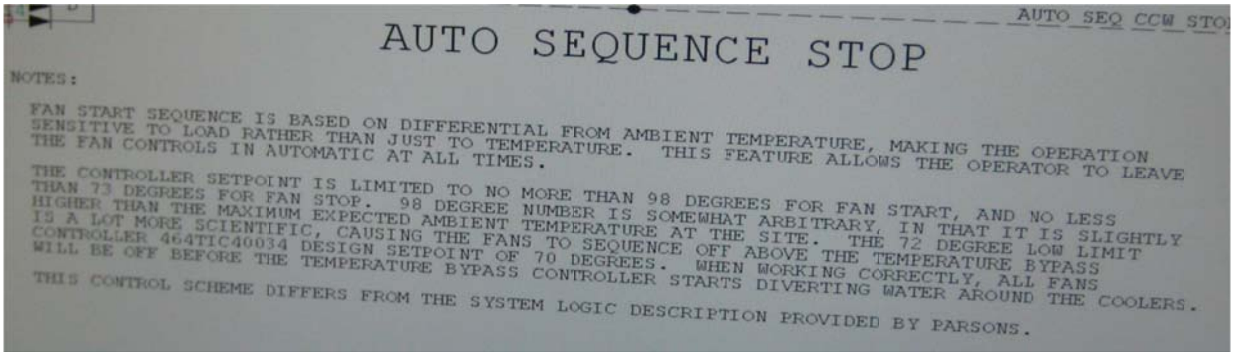
Sam,

An estimated cost to refurbish the Dew Point Demand feature on each I-R regenerative compressed air dryer at PacifiCorp, in Chehalis, would be $1,100.00. This price would cover the exchange price of $900.00 for a recalibrate dew point probe, 2 hours of labor, and miscellaneous supplies.

Best regards,
Brian Williams
Rogers Machinery Company
Cell: 360.269.7729
Email: brian.williams@rogers-machinery.com

26.10 CHEHALIS: PICTURES

ECMs 1 & 2: CCW Pump Speed Control and Fan VFDs with Temperature Reset



Fan Sequencing Logic Description as Given in the Control System

550 HP CCW Pump

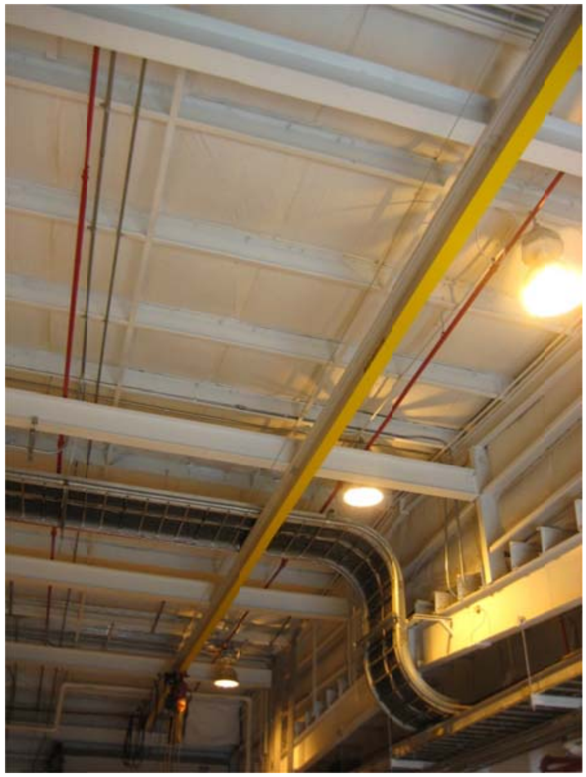
Louvers above CCW Heat Exchanger and Fans

CCW Fans and Underside of CCW Heat Exchanger

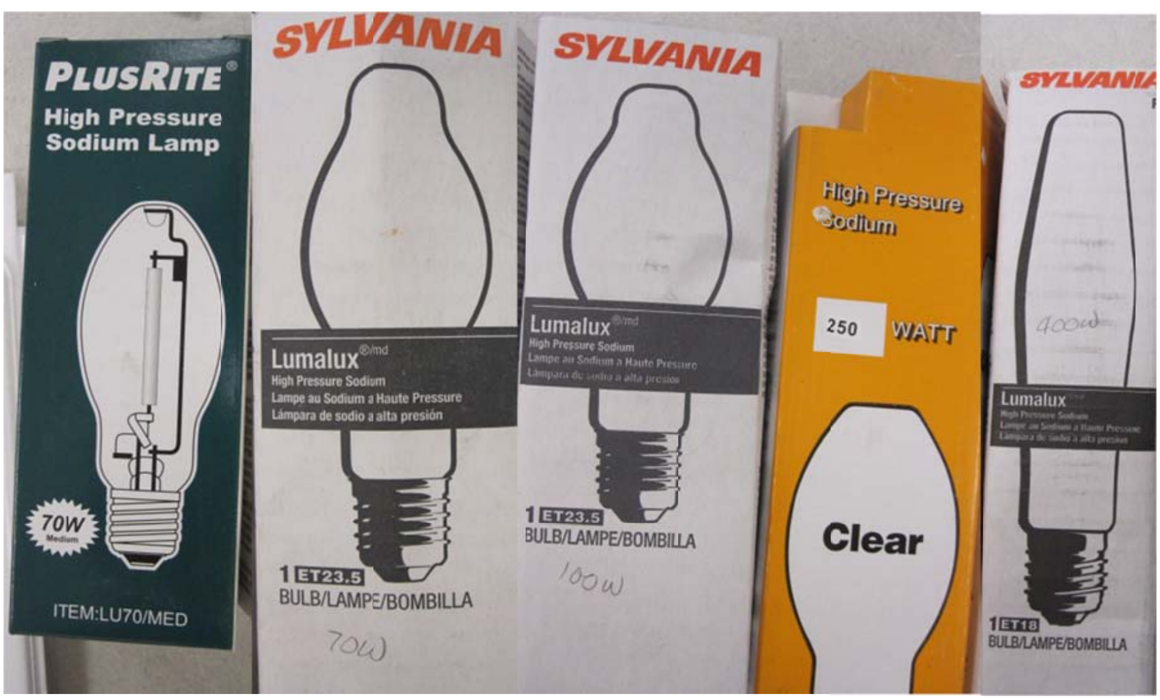
ECM 3: High Efficiency Lighting

Outdoor Lights at Dusk

Outdoor Light Nameplate Information



Indoor High Pressure Sodium Fixtures



Lamps Used in Chehalis Power Plant

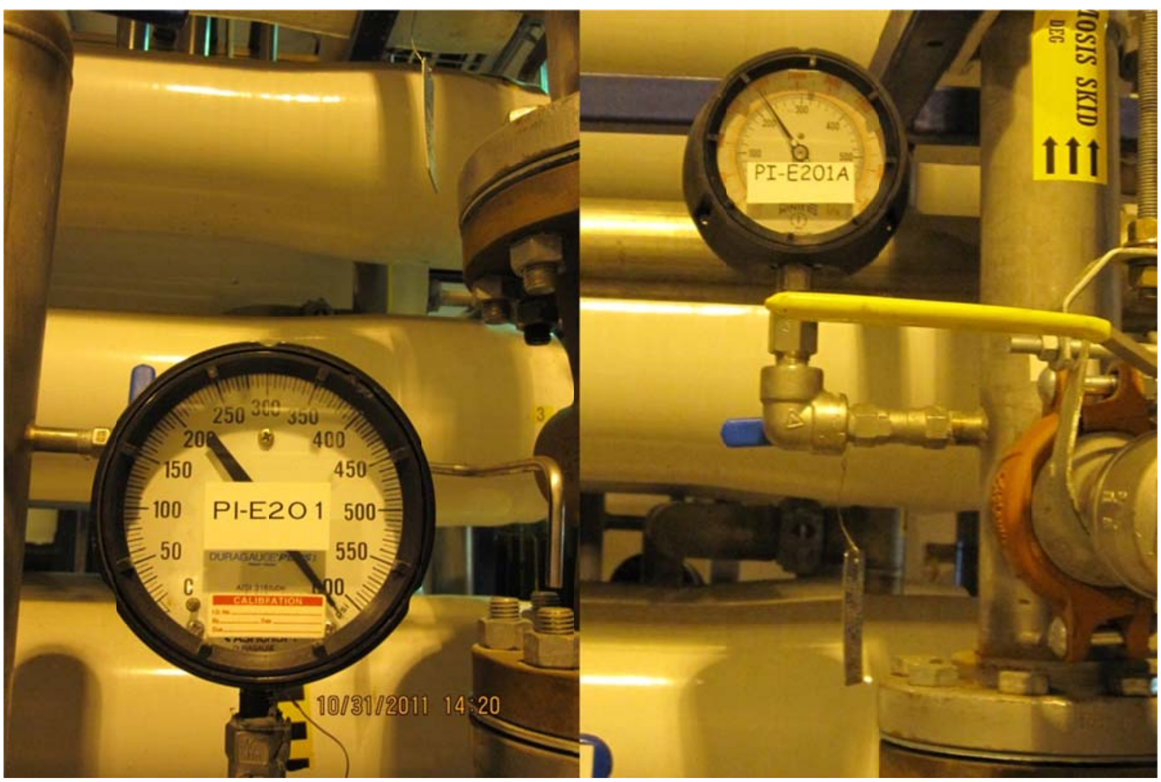
ECM 4: Install Small Condensate Pump

Existing 450 hp Turbine Style Condensate Pumps (1A, 2A, and 3A)

ECM 5: Reverse Osmosis Pump VFDs

Reverse Osmosis Pumps

First Pass Discharge Pressures Before (left) and After (right) Valve



Second Pass (or Booster) Discharge Pressures Before (left) and After (right) Valve

ECM 6: Reduce LP Economizer Recirculation Pump Use

Low Pressure Economizer Recirculation Pump

Gutted Temperature Control Valve Downstream of LP Economizer Recirulation Pump

ECMs 7 & 10: CCW Pump Speed Control and Fan VFDs with Temperature Reset

Existing Oil-free Load-unload Rotary Screw Air Compressor

Two Dual Tower Ingersoll-Rand ThermoZorb 300 Heatless Air Dryers

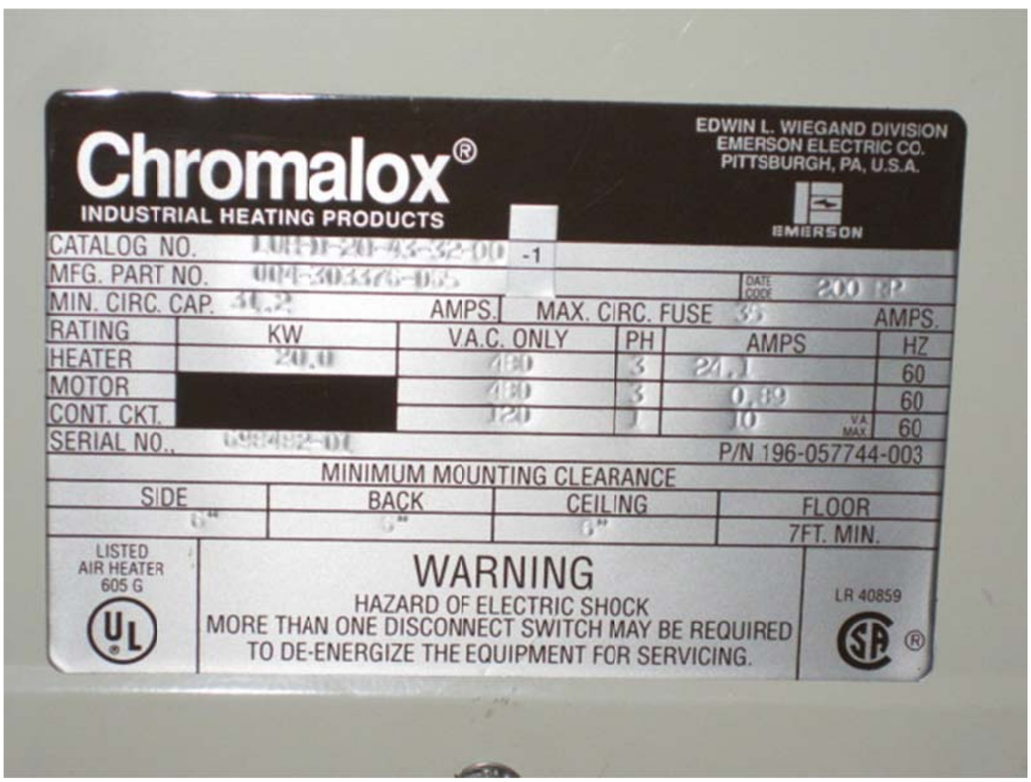
Compressed Air Receiver with the Priority Valve Feeding the Plant Air Lines

ECM 8: Reduce Runtime of Electric Heat Trace

Heat Trace Panel with Heaters On While Ambient Temperature was 50 - 60°F

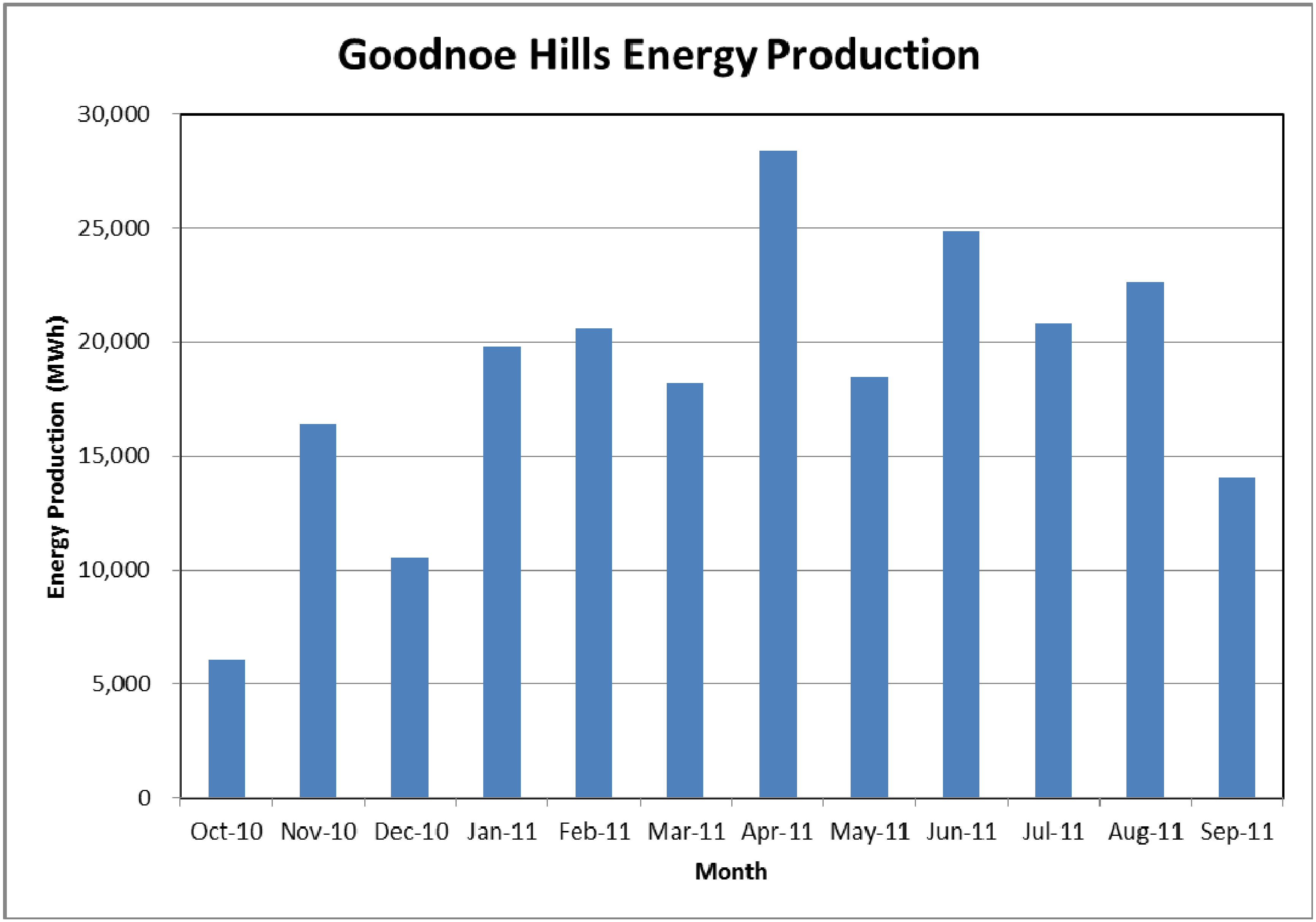
ECM 9: Adjust Thermostat on One Electric Heater

One of the 20 kW Space Heaters in the Turbine Building



Heater Nameplate

26.11 Goodnoe Hills: Data Logging and Model Charts



Goodnoe Hills Energy Production
Energy Production (MWh)
30,000
25,000
20,000
15,000
10,000
5,000
0
Oct-10
Nov-10
Dec-10
Jan-11
Feb-11
Mar-11
Apr-11
May-11
Jun-11
Jul-11
Aug-11
Sep-11
Month

26.12 Goodnoe Hills: Model Calculations
ECM 1

Baseline Energy Use Breakout Summary

Subsystem	Annual Energy Use (MWh/yr)	% of Total
Turbines	3,705	44%
Underground Circuits	1,321	16%
O&M Building	39	0.5%
Padmount Transformers	2,347	28%
Substation & Misc Loads	1,070	13%
Total	**8,482**	**100%**

Calculation Details

- Turbine energy use was determined from the average turbine power consumption across all 47 turbines, as per one year's worth of PI data provide by the facility.
- O&M building energy use was determined by scaling up energy consumption figures from seven months of billing data.
- Transformer and substation losses are based on calculations performed by Pacific Power previously (as shown on the next page).

Loss Calculation for 94 MW alternate.

Feeder	Total Number of TurbineS	Total Generation (MW)	Cable Loss From CymCap		Padmount Transformer Loss From Manufacturer Datasheet				Additional Losses						Total Loss	
					Transformer Loss (kW)*					Substation Xfmr Loss						
			Cable Loss (kW)	Cable Loss %	No Load Loss (kW)	Full Load Loss (kW)	Total Loss	Transformer Loss %	GND Bank No Load Loss @ 85C	No Load Loss (kW)	Full Load Loss**	600 V Cable Loss	Total Additional Loss (kW)	Additional Loss %	Total Loss (kW)	Total Loss %
Imrie Feeder 1	13	26.0	132.10	0.508	13.00	204.92	217.92	0.84	2.79						--	--
Imrie Feeder 2	15	30.0	67.38	0.225	15.00	236.45	251.45	0.84	2.79						--	--
Future Feeder 1	10	20.0	89.03	0.445	10.00	157.63	167.63	0.84	2.79						--	--
Future Feeder 2	9	18.0	119.88	0.666	9.00	141.87	150.87	0.84	2.79							
Total System	47	94.0	408.39	0.434	47.00	740.86	787.86	0.84	11.14	62.00	166.12	68.04	307.30	0.33	1503.55	**1.60**

* Amorphous Core Design used for Padmount Transformer.
** 94 MW load is considered for Substation Transformer.

Loss Factor (Calculation based on Normalized WSF)

29.12%

TOTAL 34.5 kV CABLE LOSS AT PEAK PRODUCTION (kW) 408.39

34.5 kV CABLE LOSS (kWH/yr)

1041759.666

575 V CABLE LOSS AT PEAK PRODUCTION (kW) 109.39
LV CABLE LOSS (kWH/yr) **279044.2637**

Padmount Transformer
Transformer No load Losses (kW) 47.00
Transformer No load Losses (kWH/yr) **411720.00**

Padmount Transformer
Transformer Full load loss at Peak Generation (kW) 740.86
Transformer Load Losses(kWH/yr) **1935300.812**

Grounding Bank No load Loss (kW) 11.14
Grounding Bank No load Loss (kWH/yr) **97586.4**

Substation Transformer no load Loss 62.00
Substation Transformer no load Loss (kWH/yr) **543120**

Substation Transformer load Loss 166.12
Substation Transformer load Loss (kWH/yr) **429477.378**

Total Loss (kWH/yr) **4738008.52**
Estimated Generation (kWH/yr) **327274019**

%loss **1.45**

26.13 Goodnoe Hills: Equipment Ratings

Amorphous Matel Core Transformer Specification

Customer: M.A. MORTESON		Spec. No. :AD96235			Date : 2007/2/15	
Type	PAD MOUNTED	Winding		H Winding	X Winding	Y Winding
Phase No.	3	Rated Voltage		34.5 kV	0.575 kV	--- kV
Frequency	60Hz	Insulation Class	BIL	150 kV	30 kV	--- kV
In Accordance Standards	ANSI		AC.	50 kV	10 kV	--- kV
Insulation Liquid	Mineral Oil	Neutral Insulation	BIL	--- kV	30 kV	--- kV
Vector Group	Dyn1		AC.	--- kV	10 kV	--- kV
Insulation Class	A class	Connection		Delta	Wye	----
Polarity and Phase Relation	Subtractive	Bushing Type		Oil to Air	Oil to Air	Oil to Air
Cooling Type	ONAN	Cooling Type	ONAN	2250kVA	2250kVA	
Equipment Location	Outdoor		ONAF			

Additional Tap Voltages			Tap Changer Type
H Winding :	36.225-35.363-34.5-33.638-32.775	kV	no-voltage
X Winding :	---	kV	---
Y Winding :	---	kV	---

Guarantee value base on the rated frequency and rate voltage at 85℃ reference temp.,tolerance base on ANSI/IEEE C57.12 .

Rating		Losses			Voltage Regulation %		Impedance HV-LV (%)		
Cooling Type	kVA	No Load Loss	Load Loss (W)	Total Loss (W)	1.0	0.8	IZ%	IR%	IX%
ONAN	2250	1000	19950	20950	1.07	4.4	5.8	0.89	5.68

Load Loss At Rated Voltage,85℃, PF=1.0 ,2250 kVA				
Load (%)	25%	50%	75%	
Loss (W)	1247	4988	11222	
Efficiencies (PF=1.0)				
Load (kVA)	Full Load	3/4 Load	1/2 Load	1/4 Load
2250	99.08%	99.28%	99.47%	99.60%
Ambient Temperature-Max.			40	℃
Average Ambient Temperature-Max.			30	℃
Oli Temperature Rise			65	℃
Winding Temperature Rise			65	℃
Protection Level :				
Average Sound Level :	According to NEMA std.			
Paint Color	MUNSELL 7GY 3.29/1.5			
Altitude Above Sea Level	1000 m			
Exciting Current 100% Rated Vol.	2.50%			

MECHANICAL DATA Not for Construction Purposes			
Outline DWG No. :13-15109			
Dimensions (Approximate)		mm	inch
Height	(A)	1905	75.00
Width	(B)	2530	99.61
Depth	(C)	2245	88.39
Height over cove	(D)	---	---
Untanking & Hoc	(E)	---	---
Weights (Approximate)		kg	lbs
Core & Coil		3205	7065
Tank & Fittings		2250	4960
Oil 506	(Gallons)	1725	3805
Total Weight		7180	15830

PACIFIC CREST
TRANSFORMERS

Customer Name: PACIFICORP
Serial Number: PQC-0056
Sales Order Number: Q2325 P/N: Q0423251
Date of Test: 3/17/2011
Purchase Order Number: 4500541858
Transformer Type: PADMOUNT
Customer Order Number:
KVA: 2250 Temperature Rise: 65
High Voltage: 34500 DELTA BIL: 150
Low Voltage: 575Y/332 BIL: 30
Conductor Type: COPPER
Conductor Type: COPPER
Fluid Type: Oil Type II Cooling: ONAN
Phase: Three Hertz: 60 Tested By: PA/RL

Resistance, losses, impedance, and regulation corrected to 85 degrees Celsius and are based on wattmeter measurements unless otherwise stated. Resistance for three phase transformers is the sum of all three phases in series.

Resistance (Ohms) H.V.	Resistance (Ohms) L.V.	% Exc. Amps	No Load Watts	Winding Watts	Total Watts
14.94024	0.00153	0.4236	4539	16989	21528

% IZ	%IR	%IX	X/R
5.69	0.755	5.64	7.5

Regulation @ Power Factor

100%	80%
0.91	4.07

Insulation Power Factor

H-GND	H-L	L-GND
0.270	0.445	0.267

Transformer Efficiency at given loading

Calculations for Efficiency based on load losses corrected to 85°C.

125%	100%	75%	50%	25%
98.91	99.05	99.17	99.23	99.01

Applied Potential Test

Windings	Applied Test Voltage	Duration of Test
H.V.	50 KV	60 Sec.
L.V.	10 KV	60 Sec.

Induced Potential Test

2 times normal voltage across full winding at 180 Hertz for 7200 Cycles.

Ratio Test Results

Tap Voltage	Phase A	Phase B	Phase C	Calc. Ratio
36225	109.062	109.084	109.062	109.111
35363	106.519	106.539	106.516	106.514
34500	103.974	103.991	103.970	103.916
33638	101.335	101.355	101.337	101.318
32775	98.703	98.721	98.700	98.720

Pressure Test

PSI	Duration
7 POUNDS	12 HOURS

HV - LV Angular Displacement

Dy1

This transformer contained a non-detectable level of polychlorinated biphenyls (PCB's) at the time of manufacture.
Pacific Crest certifies this to be a true report based on factory tests made, and that all tests are conducted in accordance with applicable ANSI and NEMA Standards. Pacific Crest is an ISO 9001 registered company. All test equipment is calibrated and traceable to the National Institute of Standards and Technology

Certified as a true copy by:

Electrical Design Engineer — Date 3/22/11

QF5849 Rev. 11/5/09

Eli Ricondo

From: Gary King <gking@howard-ind.com>
Sent: Tuesday, October 25, 2011 10:19 AM
To: Eli Ricondo; Richard Wood
Cc: Faizan Ahmad
Subject: RE: 2250 kVA Amorphous Core Padmount Transformers for Wind Farm

Eli,

The value Richard gave you is only the impedance of the transformer expressed in percent. The real component of impedance is a function of the transformer's load loss, but the reactive piece is not. Below are the typical values I would quote for your voltage and power rating.

No load = 1000 watts
Load loss = 17000 watts
Impedance = 5.75%

Gary King
Howard industries, Inc
Engineering Manager
Three Phase Padmount Division
P.O. Box 1588
Laurel, MS 39441
(office) 601-422-1579
(fax) 601-422-1431

From: Eli Ricondo [mailto:eli.ricondo@cascadeenergy.com]
Sent: Monday, October 24, 2011 10:51 AM
To: Richard Wood; Gary King
Cc: Faizan Ahmad
Subject: RE: 2250 kVA Amorphous Core Padmount Transformers for Wind Farm

Richard,

Thanks you for the quote.

Is there a way to convert this impedence to losses (W). Basically, the other bit of information we need is the no load losses (W) and the load losses (W).

Thanks,

26.14 Goodnoe Hills: Project Costs

No Cost Information

26.15 Goodnoe Hills: Pictures

ECM 1

ECM 2