ENGINEERING

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SOFTWARE

CONSULTING

ASHRAE Level II Audit

SAMPLE

Keith,

Foresight is pleased to present the following ASHRAE Level II Audit for your campus. In this audit report you will find valuable information concerning the various mechanical, electrical, and controls systems that serve the plant.

This report is broken down into the following sections:

I. Table of Contents
II. Executive Summary – ECM Overview
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Our hope is that this report will help you and the staff at CLIENT feel empowered to achieve more energy efficiency through both behavioral and technological changes. We are grateful for the opportunity to provide you with this report and look forward to working with you more in the future. If you have any questions regarding the information on the following pages, please do not hesitate to ask.

Sincerely,

Ryan Kerrigan, C.E.M.
Energy Engineer

Brian Haverdink
Client Experience Director

Table of Contents:

Executive Summary

Overview

Foresight performed an ASHRAE II audit at Plant 4 Eastern Ave, Town, MI in order to assess the potential for cost effective Energy Conservation Measures (ECMs).

Currently, the 332,780 square foot manufacturing building consumes ~13,200 MWh of electricity and ~124,000 decatherms of natural gas per year. In total CLIENT's annual energy expenditure for Plant 4 is ~$1,400,000 per year.

The facility has an annual Energy Use Intensity (EUI) of 508 kBtu/square foot. The EnergyStar rating is not applicable to this facility. Please see the "Benchmarking" section for other measures of performance.

Impact of this study

While we have broken some new ground for CLIENT in this study, it was somewhat surprising to learn how much attention has been paid to energy use at this facility in the past several years. The result for Plant 4 is that the facility is already performing very well. We compliment your staff for this unusual and highly effective effort. We appreciate greatly a client who is actively engaged in the pursuit of greater understanding about their facilities.

Some of the energy conservation measures (ECMs) identified in this report need additional analysis to confirm cost and assumptions. With more detailed sub-metering and analysis, savings can be dialed in. To look at the holistic impact of each ECM, it could be worth exploring a whole building energy model. Keeping this in mind, if all of the 15+ ECMs are implemented, CLIENT could expect to see annual energy-related savings of up to **20%** of their total energy expenditure.

Site Challenges

With every project comes a different challenge. As an example, some sites don't have architectural/mechanical /electrical plans for the facility. In the case of Plant 4, a significant challenge was that there is ***one electric meter for the entire campus*** with a number of buildings being fed by this line. Our assumptions are that the production facilities use roughly the same amount of energy per square foot. This made analysis difficult without methods to more accurately determine impact.

Recommended Follow-up

1. Continue current efforts using holistic analysis of energy conservation measures. Occasionally, measures are adopted with insufficient information and do not return the investment as quickly as expected. CLIENT appears to be considering their ECMs holistically and should continue doing so.
2. Implement the low/no cost ECMs that we have identified
3. Study and develop other ECMs to refine their design and ROI.
4. Add sub-metering for key energy users, including different production lines, in order to understand in more detail what is happening in the building. This would start with correcting the system that is in place to sub-meter the individual plants. During the course of this audit, it was found that plant 4 had a meter, but the meter was no longer operational. You cannot manage what you don't understand; and properly active meters help increase understanding dramatically.

Understanding the specific energy that goes into coating and tablet production processes can open up further projects to help reduce energy consumption.

a. The Building Management System should be considered as a type of sub-metering because it trends performance patterns and can be used to identify operation faults. Proper use of a BMS will enable greater understanding and more effective management of the systems it controls.
b. Power monitoring should be used for monitoring and measurement of power usage. This will also help predict equipment failure in advance so as to avoid costly, unplanned shutdowns.

5. Conduct ongoing performance reviews to see and correct developing problems as well as adapt to changing product and production practices. This could be looked at by reviewing energy usage vs. production stats within each facility which can lead to the identification of areas that need further exploration.

ECM Overview (Sorted by Payback Period)

Project	Initial Cost	Utility Rebate	Energy Savings (kWh)	Energy Savings (MCF)	Energy Cost Savings ($)	Simple Payback (Years)
Compressed Air Leak Study	$ 10,000.00	($ 6,750.00)	300,000.00	-	$ 18,450.00	0.18
Fault Detection	$ 30,000.00	$ -	396,000.00		$ 24,354.00	1.23
VSD Compressor Pumps	$ 6,000.00	($ 1,200.00)	52,280.00		$ 3,215.00	1.50
Interior LED Lighting	$ 300,000.00	($ 47,750.00)	1,000,040.00	-	$ 125,000.00	2.02
VSD Compensate Pumps	$ 6,000.00	($ 750.00)	26,280.00		$ 1,616.00	3.16
VSD Deaerator Pump	$ 3,000.00	($ 600.00)	9,855.00		$ 606.00	3.96
Seal Process Suites	$ 100,000.00	$ -		6,417.11	$ 24,000.00	4.17
Exterior LED Lighting	$ 30,000.00	($ 3,000.00)	51,500.00	-	$ 6,150.00	4.39
UV-C for AHUs	$ 100,000.00	$ -	343,200.00	-	$ 21,107.00	4.74
Totals	**$ 585,000.00**	**($ 60,050.00)**	**2,179,155**	**6417.11**	**$ 224.498.00**	**2.34**

ECM Overview (continued)

The below measures all require upgraded BMS controls. This could be in phases, or as a complete overhaul. Each measure will have the additional cost of BMS controllers, which varies from measure to measure.

Project	Initial Cost	Rebate	Energy Savings (kWh)	Energy Savings (MCF)	Annual Energy Cost Savings
Update BMS Controllers	$ 3,000/Controller	N/A	-		
Optimize Chilled Water Setpoint*	$ 3,000.00	($ 35,500.00)	270,600.00	-	$ 16,642.00
Poll CHW Valves*	$ 3,000.00	N/A	167,850.00	-	$ 10,323.00
Disable Duhumidification*	$ 13,000.00	N/A	-	684.00	$ 2,557.00
Stage Chillers*	$ 5,000.00	($ 5,680.00)	541,200.00	-	$ 33,284.00
Control Side-Stream Filter*	$ 4,000.00	N/A	98,024.00	-	$ 6,029.00

Introduction

Energy assessors from Foresight conducted an ASHRAE Level 2 energy audit at CLIENT's Plant 4 located in Town, MI. The auditors included Ryan Kerrigan and Brian Haverdink, who were accompanied onsite by various CLIENT staff, including Mr. Smith and Mr. Jones.

The goals of this assessment are consistent with CLIENT's ongoing commitment to sustainability and are intended to strengthen their efforts by providing new ideas and measures via an in-depth look at all equipment and supporting processes. The assessed building systems at this site included:

1. Buidling Envelope
2. Interior and Exterior Lighting
3. Heating and Cooling
4. Domestic Hot Water
5. Compressed Air System
6. Manufacturing

The scope of this assessment adheres to the guidelines developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) for a Level 2 energy audit. As described in ASHRAE's Procedures for Commercial Building Energy Audits, a Level 2 "Energy Survey and Analysis" will identify and provide the savings and cost analyses of all practical energy efficiency measures that meet the owner's/operator's constraints and economic criteria, along with the proposed changes to Operation and Maintenance (O&M) procedures.

A Level 2 audit includes a more detailed survey than a Level 1. Utility analysis is performed based on historical energy bills which may cover consumption data as well as peak demand. It may also provide a listing of potential capital-intensive improvements that require more thorough data collection and engineering analysis. Cost and savings analysis is performed for each measure recommended for implementation. This level of analysis should provide adequate information for CLIENT to act upon recommendations for most buildings and for most measures.

Facility Description

Building Description

Plant 4 is a 3-story building, located on the CLIENT campus in Town, MI. The building comprises 332,780 square feet, with roughly 36,000 square feet of office. The walls are masonry facade on steel frame construction, with a flat roof. The building is a single-use facility incorporating manufacturing and office spaces. The facility is in use (3) shifts throughout the entire week. While the facility has roughly 15 holidays/year, their are few setbacks in place.

Renovations and Additions

CLIENT has had significant additions to Plant 4 since its original construction. These additions have included both office space and process area.

Lighting

There is a wide variety of lighting in the facility. The predominant lighting is T8 fluorescent fixtures. Other lighting includes LED and T12 fluorescent fixtures.

The exterior of the building uses a variety of HID fixtures for the parking lot and wall lighting.

Cooling

The building is cooled using chilled water to feed a number of air handlers. There are both process and facility AHUs that have chilled water coils. The chilled water is produced by (4) chillers, totaling 2058 HP.

Heating

Heating is provided by (3) natural gas-fired boilers, totaling 2300HP, that feed air handlers. Again, these hot water coils are used for process and facility heating. During the summer months, the facility is able to mostly be handled by a single boiler.

Compressed Air System

Compressed air is used throughout Plant 4 for process. There are (2) 200HP and (2) 250HP air compressors.

Manufacturing

Plant 4 runs (3) shifts and mostly consists of suites that are used in the production of pharmaceuticals. These suites are used to press, mix, and coat the chemical powders resulting in a pill/tablet. In addition to suites, there is an area of warehouse, office, and R&D. In comparison to the suites, these areas use minimal energy.

Major Equipment

CLIENT Tag	Manufaturer	Model #
CH-401	York	YKEDETQ7-ERG
CH-402	Trane	CVHE071FA1U
CH-403	Trane	CVHE071FA1U
CH-404	York	YKGEEXP9-EUG
CT-401	Marley	NC-6021
CT-402	Marley	NC-6021
CT-403	Marley	NC-6021
CT-404	Marley	NC8407VAS1SGF
Boiler #1	Johnston	PFTA750 4G 150S
Boiler #2	Johnston	PFTA750 4G 150S
Boiler #3	Cleaver-Brooks	CBEX-E-700-800-150-ST
AC-401	Kobelco	KNWA2-A/H
AC-402	Kobelco	KNWA2-A/H
AC-403	Kobelco	KNWA2-B/H
AC-404	Kobelco	KNWA2-B/H

Energy/Resource Types for Plant 4

Electricity: Used for cooling, ventilation, lighting, compressed air, manufacturing equipment and miscellaneous other loads.

Natural Gas: Used for space heating, process heating, and both process/domestic hot water.

Utility Summary

Utility Provider Information

Utility	Account #	Meter #	Rate	Notes
Electricity	Consumers/First Energy	N/A	3rd Party	Includes transmission, generation and distribution charges (excludes regular monthly charges)
Natural Gas	MGU/Constellation	N/A	3rd Party	Includes transmission, generation and distribution charges (excludes regular monthly charges)

Reported Utility Data

Utility	Annual Usage	$/unit	Total Cost ($)
Electricity	~13,200 MWh [1]	$.0459/kWh $0.046 / kW	$820,000
Natural Gas	124,000 DTH [2]	$4.67/ DTH	$580,000

1 Estimated from building square footage
2 From MGU bills

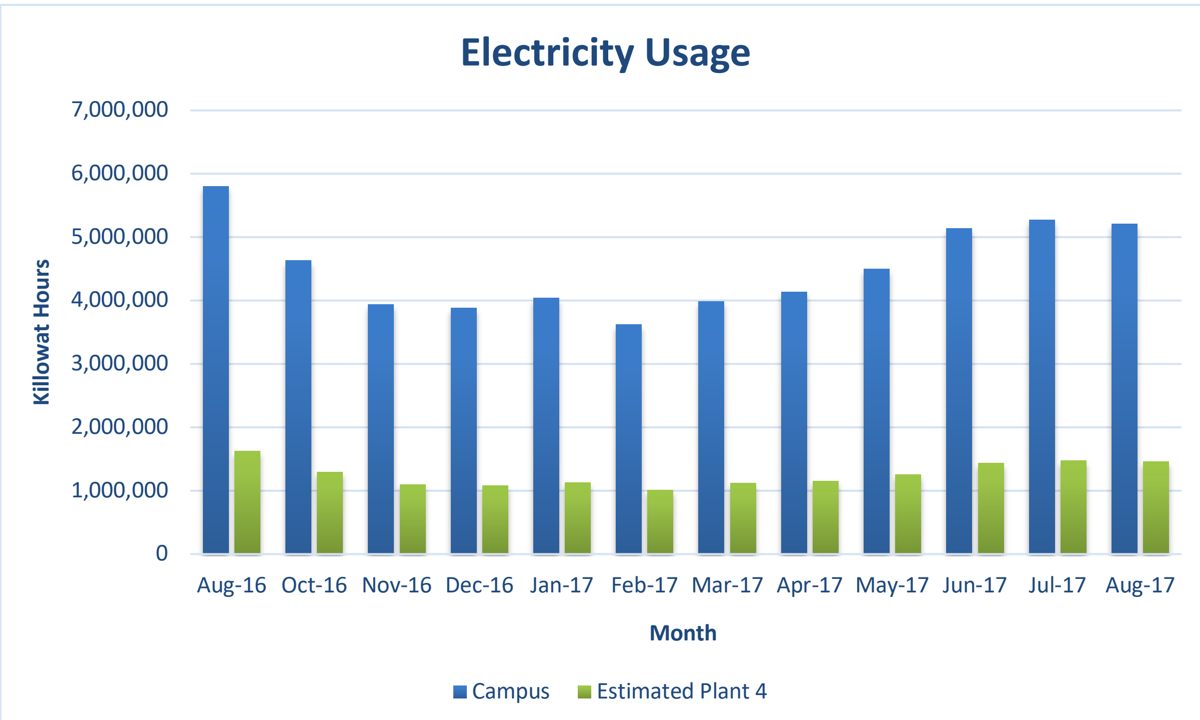
Energy Analysis of Electricity and Fuel Trends

An energy assessment benefits from a review of past energy use. Year-over-year consumption can help facility personnel identify trends in consumption, particularly seasonal, which can depict areas for improvement.

Electricity Use Previous Year

CLIENT has a single electrical service which serves the entire Eastern Campus. Based on the feed providing power to three similarly sized plants and one smaller, it is estimated that Plant 4 uses 28% of the electrical power.

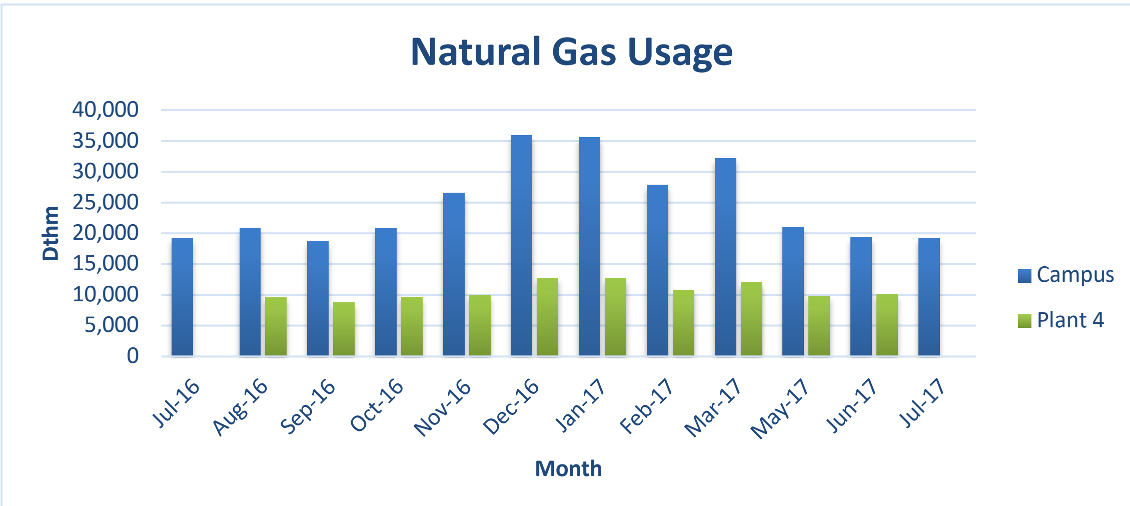
The charts below shows a comparison between the data we have from the main feed electricity usage and the estimated 28% for Plant 4. Looking at seasonal usage, it appears that CLIENT has roughly a ***20% increase*** from cooling during the summer months.



Natural Gas Use Previous Years

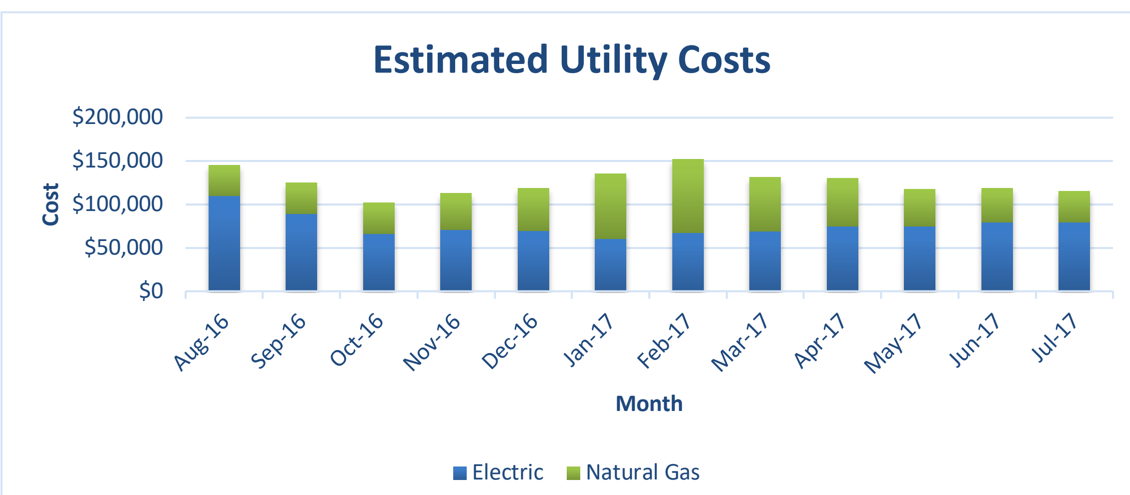
CLIENT has a single third-party natural gas service. This service totals all natural gas usage at individual meters for different buildings.

The charts below shows a comparison between data for overall gas usage and Plant 4 specifically. Looking at seasonal usage, it appears that Plant 4 has roughly a 25-30% increase from heating during the winter months.



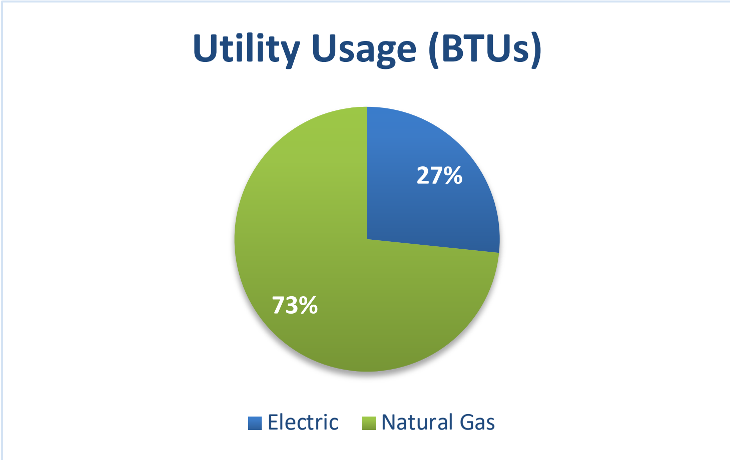
Monthly Energy Expenditure

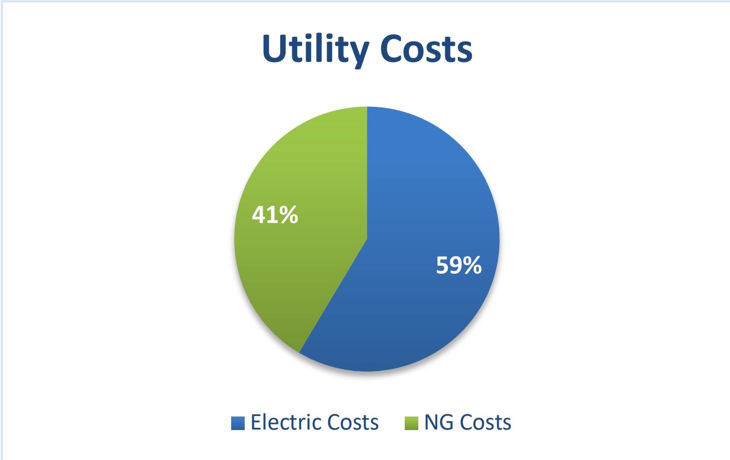
The following chart depicts the ***predicted*** monthly energy expenditure at the facility. The stacked profile indicates how each utility impacts the monthly energy bill, while the annual profile sheds light on any seasonal variations. A flat annual profile may indicate potential opportunities for reduction in non-seasonal loads, while a highly seasonal profile can indicate areas for improvement with the heating and cooling systems.

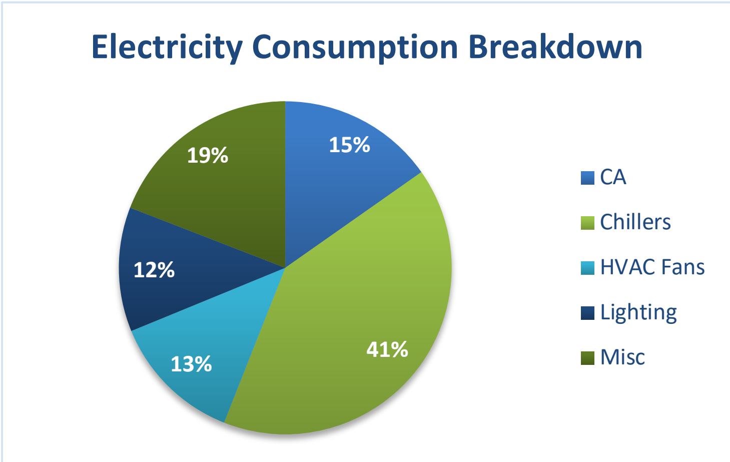


Current Annual Energy Use by Fuel Type

Total Consumption at this site is **169,038 MMBTU** (millions of BTUs). This includes all natural gas and electricity used on-site, expressed in the same units. While gas dominates the energy use, electricity is more costly. Also included is a breakdown of electricity consumption by demand source.







Benchmarking

ENERGY STAR and Energy Use Index (EUI)

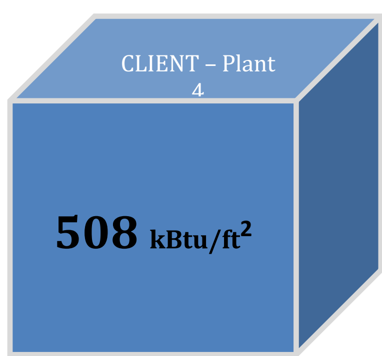
For certain common building occupancies such as offices and warehouses, the ENERGY STAR Performance Rating is a useful methodology to benchmark a building against other similar buildings. ENERFY STAR is a national energy performance rating system and serves as an external benchmark that helps energy managers assess how efficiently their buildings use energy relative to similar buildings nationwide. The rating systems' 1-100 scale allows interested parties to quickly understand how a building is performing. For example, a rating of 50 indicates a very average energy performance for a given building, while a rating of 75 or better indicates efficient performance.

Organizations can use this rating system to evaluate energy performance among their portfolio of buildings while also comparing performance with other similar buildings nationwide. Additionally, building owners and managers can use these performance ratings to help identify buildings that offer the best opportunity for improvement and track and measure their performance over time. To qualify for ENERGY STAR certification, a building must have a rating of 75 or greater.

A manufacturing facility such as CLIENT's Plant 4 is not tracked by ENERGY STAR. However, another benchmark that is useful, especially for comparing year-over-year performance is the Energy Use Index (EUI), which represents total energy use per square foot. In order to do calculate the EUI, the normal measure of electricity use, kWH, is converted to BTU/hr in order to have the same units as natural gas usage.

Plant 4 uses **508 kBTU/sq.ft.** each year. This value is more than 5 times larger than a typical office, but is reasonable for the high level of manufacturing machinery in use at this site. As energy costs change from year to year, this value is useful to compare overall energy performance.

Energy Use Index (EUI):



Energy Conservation Measure (ECM) Overview

Interior LED Lighting Upgrade

Description:

A large portion of the fixtures in the plant are still T8 fluorescent lighting. While these are better than some of the older fixtures still utilizing T12 fluorescent lamps, it is recommended to update all to LED. Newer LED fixtures operate with significantly less energy consumption, and longer lifetime. There are roughly (1,020) 2x4 T8 fixtures throughout the facility, these would be best to be replaced by a new LED fixture. There are (50) 4L T5 highbays that should looked to be replaced by LED highbays. There are (280) 2L T8 fixtures that should be replaced by new LED fixtures. And there are (170) 2L T12 8' fixtures, these would be best replaced by a new 8' LED strip.

The below table shows an outline for the Interior Lighting project at CLIENT's Plant 4:

Interior LED Lighting Upgrade							
Location Number	*Existing Fixture*	*Quantity*	*Watts*	*Hours of Operation*	*Annual Consumption (kWh)*	*Cost/kWh*	*Annual Energy Cost*
1	2' x 4' T8 Office Troffers	1020	116	8736	1,033,643	$ 0.12	$ 124,037.16
2	4 Lamp T5 Highbay	50	242	8736	105,705	$ 0.12	$ 12,684.60
3	2 Lamp T8	280	58	8736	141,872	$ 0.12	$ 17,024.64
4	2 Lamp T12 8' Strips	170	227	8736	337,122	$ 0.12	$ 40,454.64
				Total Existing kWh Consumption:	***1,618,342***	***$ 0.12***	***$ 194,201.04***
	Replacement Fixture	*Quantity*	*Watts*	*Hours of Operation*	*Annual Consumption (kWh)*	*Cost/kWh*	*Annual Energy Cost*
1	2' x 4' LED 4,500L	1020	39.5	8736	351,973	$ 0.12	$ 42,236.76
2	LED Highbay 20,000L	50	150.1	8736	65,563	$ 0.12	$ 7,867.56
3	2' x 2' LED 3,000L	280	27.3	8736	66,777	$ 0.12	$ 8,013.24
4	LED 8' Strip 8,000L	170	61	8736	90,592	$ 0.12	$ 10,871.04
				Total Replacement kWh Consumption:	***574,905***	***$ 0.12***	***$ 68,988.60***
Total Interior Lighting Upgrade				***Total kWh Savings:***			***1,043,437***
				Total Cost Savings:	***$***		***125,212.440***

Measurement and Verification (M&V):

Lighting can be easily verified. Given the wattage of the current system, and the new lighting system, the savings is calculated simply. Then based on hours of operation the annual savings can be seen.

Budget (±10%):

Initial Cost:	$300,000
Rebate (One-time):	$47,750
Energy Savings (Per year):	1,000,040 kWh
Cost Savings (Per year):	$125,000
Simple Payback:	2.02 Years

Exterior LED Lighting Upgrade

Description: The exterior fixtures of the plant are still HID lighting. These are very outdated and use far more energy than the new LED fixtures. Additionally, LEDs will come with a longer lifetime and better color quality.

The below table shows an outline for the Exterior Lighting project at CLIENT's Plant 4:

Exterior LED Lighting Upgrade							
Location Number	*Exisiting Fixture*	*Quantity*	*Watts*	*Hours of Operation*	*Annual Consumption (kWh)*	*Cost/kWh*	*Annual Energy Cost*
1	150 Watt HID	15	175	4368	11,466	$ 0.12	$ 1,375.92
2	400 Watt HID	28	455	4368	55,648	$ 0.12	$ 6,677.76
	Total Existing kWh Consumption:				***67,114***	***$ 0.12***	***$ 8,053.68***
	Replacement Fixture	*Quantity*	*Watts*	*Hours of Operation*	*Annual Consumption (kWh)*	*Cost/kWh*	*Annual Energy Cost*
1	LED Wall Pack	15	31	4368	2,031	$ 0.12	$ 243.72
2	LED Parking Lot Area Light	28	110	4368	13,453	$ 0.12	$ 1,614.36
	Total Replacement kWh Consumption:				***15,484***	***$ 0.12***	***$ 1,858.08***
Total Exterior Lighting Upgrade				***Total kWh Savings:***			***51,630***
				Total Cost Savings:	***$***		***6,195.600***

M&V: Lighting can be easily verified. Given the wattage of the current system, and the new lighting system, the savings is calculated simply. Then based on hours of operation the annual savings can be seen.

Budget (±10%):

Initial Cost:	$30,000
Rebate (One time):	$3,000
Energy Savings (Per year):	51,500 kWh
Cost Savings (Per year):	$6,150
Simple Payback:	4.39 Years

Update BMS Controllers

Description: The current control system in place has many outdated components. Many of the additional ECMs in this report would benefit from the increased capacity and reliability that would come with an upgraded system. This would be a large undertaking, and while it would not necessarily have much of a direct savings, it would open the option for a number of energy savings opportunities.

M&V: This measure does not have a savings attached directly to it as there is nothing to measure.

Budget (±10%):

Initial Cost:	(TBD) Estimated $3,000 per controller
Savings (Per year):	$TBD (Labor savings due to less repair)
Simple Payback:	TBD

Optimize Chilled Water Setpoint

Description: The current controls utilize a simple virtual switch based on a fixed outdoor air temperature and dewpoint to change the chilled water setpoint temperature from one value to another. Using the BMS to poll the facility and better understand the actual need for cooling and relative humidity control in the plant spaces would allow the chilled water temperature to be continually optimized for maximum efficiency. Based on industry standards, this saves roughly 5% of chiller energy. Chiller energy is based on a total of 2,058HP of chillers, but only 50% being used roughly 80% of the time.

$$Chiller\ Energy * 5\% = 5{,}412{,}000 * .05 = 270{,}600kWh$$

M&V: Trends records in the BMS show the past chilled water setpoints. These will be compared to the new / ongoing setpoints. Using manufacturer data for efficiency of the chillers at the new operating conditions, the savings can be estimated. Savings will change from yer to year due to weather variations, but a trend should be evident which verifies that savings are being achieved.

Budget (±10%):

Initial Cost:	$3,000 (needs updated controllers)
Rebate (One time):	$35,500
Energy Savings (Per year):	270,600 kWh
Cost Savings (Per year):	$16,642

Poll CHW Valves to Determine Pump Speed

Description: The current system has a fixed pressure setpoint of 30psi. This is ***triple*** commonly seen values for such a system and is almost certainly not needed year-round. Using the BMS to understand the specific needs throughout the plant will allow for the pumps to operate at a lower speed, thus lowering the psi and saving energy. The below numbers are based on a 15% reduction in CHW pumps. Running at an estimated 5000 hours per year, the 300HP pumps would show significant savings.

$$Chiller\ Pumps * Hours * 15\% = 224kW * 5000hrs * .15 = 167{,}850kWh$$

M&V: Trends records in the BMS show the past pump speeds needed to maintain the system pressure setpoint. These will be compared to the new / ongoing setpoints. Using manufacturer data and the pump speed vs power relationship, the savings can be estimated. Savings will change from yer to year due to weather and load variations, but a trend should be evident which verifies that savings are being achieved.

Budget (±10%):

Initial Cost:	$3,000 (programming only, but needs updated controllers)
Energy Savings (Per year):	167,850 kWh
Cost Savings (Per year):	$10,323

Disable Dehumidification during Washdown

Description: During our discussions with CLIENT staff, we learned that certain suites are required to stay within a certain relative humidity range. These suites are washed down throughout the week and their HVAC system attempts to maintain the relative humidity setpoint during washdown. This wastes cooling and reheat energy. It would be suggested that the washdown cycle turns off the humidification controls during the wash down cycles. Cycling the system in this way would reduce the cooling and heating energy used to dehumidify the air for that suite. The average suite has an AHU that provides about 15,000 CFM. We estimated that 20 suites would save roughly 4 hourrs of dehumidification per week. This is an O&M measure.

$$\frac{(Room\ CFM * Rooms * Heating\ Coil\ rise * 1.08 * Weekly\ hours\ avoided * weeks)}{Boiler\ Eff * 920000}$$
$$= \frac{15{,}000CFM * 20 * 7F * 1.08 * 4 * 52}{.75 * 920000} = 684MCF$$

M&V: Washdown cycle time and duration will be recorded using BMS trends or maintenance records, along with the current weather and suite operating loads. Using this information, annual savings for cooling, heating and dehumidification will be calculated.

Budget (±10%):

Initial Cost:	$13,000 (approx. 20 rooms; programming + local “initiate” button)
Energy Savings (Per year):	684 MCF
Cost Savings (Per year):	$2,557

Stage Chillers

Description: The chillers currently stage on one at a time, always in the same order. Controlling the staging to use the most efficient combination for each part load condition throughout the year will improve overall plant efficiency. Depending on the exact efficiencies of all chillers, and the specific usage throughout the year, CLIENT could see a decrease of 10% in chiller energy.

$$Chiller\ Energy * 10\% = 5{,}412{,}000 * .1 = 541{,}200kWh$$

M&V: Ongoing chiller staging will be recorded by BMS trends and compared to the staging scheme. Using manufacturer data for efficiency of the chillers during the actual conditions, and comparing this to the previous scheme, the savings can be estimated. Savings will change from year to year due to weather variations, but a trend should be evident which verifies that savings are being achieved.

Budget (±10%):

Initial Cost:	$5,000 (programming only, but needs updated controllers)
Rebate (One time):	$5,680* *(Estimated)*
Energy Savings (Per year):	541,200 kWh
Cost Savings (Per year):	$33,284

Control Side-Stream Filter Schedule

Description: There is a sand filter that helps clean the water used in the cooling towers. The daily schedule could be updated to more optimally use this filter. In addition, *does the filter need to be used in the winter months, when there are fewer solids in the outdoor air?* Reducing the number of hours the filter is used throughout the year would extend the life of the pump motor, and reduce electricity. There are two ways that this would save energy throughout the year: first, it would optimize the cooling tower pumps and second, it would reduce the load of a chiller pump. We calculated a savings of 40% to the 20HP of cooling tower pumps, and 70% savings to the 10HP chiller pump.

$$Cooling\ Tower\ kW * hours * 40\% + Chiller\ pump\ kW * hours * 70\%$$
$$= 15 * 8760 * .4 + 7 * 8760 * .7 = 98{,}024 kWh$$

M&V: Filter operation time will be recorded using BMS trends and compared with the previous schedule ofoperation. Using this information, annual pump power and filter maintenance savings will be calculated and compared to the current constant operation.

Budget (±10%):

Initial Cost:	$4,000 (programming plus control valve)
Energy Savings (Per year):	98,024 kWh
Cost Savings (Per year):	$6,029

Add VSD for Compressor Cooling Pumps

Description: Many of the pumps throughout the plant have a VSD in place. We noticed that the compressor cooling pumps do not, despite varying compressor usage and, therefore, varying need for cooling. Further analysis would determine the best variable to measure and control the VSD. Just like with the other pumps, a VSD will substantially reduce energy use. The pumps are 20HP, and assuming a 40% savings with the VSD account for the below savings.

$$Cooling\ Pump\ kW * hours * 40\% = 15 * 8760 * .4 = \ 52{,}280 kWh$$

M&V: Many VSDs have a built in savings read out. This would show the overall savings the drive has implemented over time. A more robust approach will be to add the VSD's internal data points to the BMS. All power usage less than 100% will represent savings for this application.

Budget (±10%):

Initial Cost:	$6,000
Rebate (One time):	$1,200**(Estimated)*
Energy Savings (Per year):	52,280 kWh
Cost Savings (Per year):	$3,215
Simple Payback:	1.5 Years

Add VSD for Condensate Pumps

Description: Many of the pumps throughout the plant have VSDs in place. However, we noticed that the condensate pumps do not, despite varying condensate usage resulting in varying need for pump operation. Further analysis would determine the best variable to measure and control the VSD. Just like with the other pumps, a VSD will substantially reduce energy use and should be looked into to lower energy use. The pumps are 12.5HP which, assuming a 30% savings with the VSD, would account for the below savings.

$$Condensate\ Pump\ kW * hours * 30\% = 10 * 8760 * .3 = \ 26{,}280kWh$$

M&V: The savings for this measure will be the difference between cycling pump operation and the reduced power associated with varaible speed operation. The savings will be calculated using VSD trend data for power or speed, vs the equivalent average power due to a cycling pump.

Budget (±10%):

Initial Cost:	$6,000
Rebate (One time):	$750* *(Estimated)*
Energy Savings (Per year):	26,280 kWh
Cost Savings (Per year):	$1,616
Simple Payback:	3.16 Years

Add VSD for Deaerator Pumps

Description: Many of the pumps throughout the plant have VSDs in place. We noticed that the deaerator pumps do not, despite varying makeup water usage resulting in varying need for pump operation. Just like with the other pumps, a VSD will substantially reduce energy use. The pumps are 10HP which, assuming a 15% savings with a VSD, would account for the below savings.

$$Deaerator\ Pump\ kW * hours * 15\% = 8 * 8760 * .15 = \ 9{,}855kWh$$

M&V: The savings for this measure will be the difference between cycling pump operation and the reduced power associated with varaible speed operation. The savings will be calculated using VSD trend data for power or speed, vs the equivalent average power due to a cycling pump.

Budget (±10%):

Initial Cost:	$3,000
Rebate (One time):	$600* *(Estimated)*
Energy Savings (Per year):	9,855 kWh
Cost Savings (Per year):	$606
Simple Payback:	3.96 Years

Seal Process Suites

Description: Suite pressure control throughout the facility is accomplished using outdoor air and different areas have different pressurization needs. Foresight recommends ensuring all suites are sealed well so that less outdoor air is required to maintain the required suite pressure. This would include seals around ducts, conduits, and other wall penetrations, and the weather-stripping on the suite doors. The reduction in outdoor air will result in less heating, cooling and dehumidification load. Using weather bin data and efficiencies of the AHUs, the reduction in outdoor air load results in the below savings. This assumes a reduction of 30% OA. This is an O&M measure.

M&V: The savings for this measure will be the difference between prior outdoor airflow and the new, reduced outdoor airflow, both used as inputs in a degree day or bin data calculation of typical annual energy usage, and assuming a typical discharge air condition for the suites.

Budget (±20%):

Initial Cost:	$100,000 (approximately 100 suites)
Energy Savings (Per year):	6,417 MCF
Cost Savings (Per year):	$24,000
Simple Payback:	4.17 Years

UV-C Systems for AHUs

Description: There are systems available that use UV-C lights to prevent biological growth on the always-wet cooling coils, thus keeping coils clean within the AHUs and reducing airside pressure drop. Not only does this help the AHU operate more efficiently because it has less work to accomplish, it also reduces the maintenance of these units. Based on similar systems, the savings can be as much as 20% of fan power, with additional savings coming from the chiller not having to work as hard. This is an O&M measure. Fan power based on 431HP running 60% of the time.

$$Fan\ power * 20\% = 1{,}716{,}000 * .2 = 343{,}200 kWh$$

M&V: Airflow and fan power will be measured before adding the UV-C lights. After 3-6 months of operation (provding time for the lights to clean the coils), airflow will be measured and adjusted, and fan power re-measured. The savings for this measure will be the determined by the difference between pre-ECM fan power and post-ECM fan power, applied to the entire year of operation.

Budget (±20%):

Initial Cost:	$100,000 (assumes 40 CHW Coils)
Energy Savings (Per year):	343,200 kWh
Cost Savings (Per year):	$21,107
Simple Payback:	4.74 Years

Fault Detection

Description: Most Building Management Systems, including CLIENT's, monitor but do not diagnose/identify operational problems. Adding a fault detection capability to your current BMS can provide savings a couple of ways. First, it can reduce maintenance costs as it helps maintenance staff more directly target problem areas. Second, it can provide better understanding of issues resulting in quicker resolution, allowing the system to get back in to proper operation more quickly. A system like this has been shown to save roughly 3% energy costs, with internal maintenance savings on top of that. This is an O&M measure.

$$Annual\ kWh * 3\% = 13{,}200{,}000 * .03 = 396{,}000 kWh$$

M&V: Based on the faults that are detected throughout the year, analysis can be done to calculate the savings. When an HVAC fault is found, the time between getting this alert vs the current PM schedule would account for the savings.

Budget (±10%):

Initial Cost:	$30,000 plus annual subscription to cloud service (approximately 5000 points in approximately 125 systems)
Energy Savings (Per year):	396,000 kWh
Cost Savings (Per year):	$24,354
Simple Payback:	1.23 Years

Compressed Air Leak Study

Description: Over time compressed air systems develop leaks that cause compressors to create the extra air needed to keep air pressure up in the system. Most of these leaks are at nozzles and other usage areas. While walking the facility, there were areas that leaking CA could be heard. Identifying these leaks and repairing the equipment will create savings. Until performing the study, the savings is unknown, but in most facilities we find under an 18 month payback. The budget and savings below are based on a similar study done for CLIENT in Plant 5 earlier this year. This is an O&M measure.

M&V: Based on the plant air pressure, and the CFM of leaks that are found, the savings can be calculated to show the annual savings. Trend data of the compressors can be used to verify the savings.

Budget (±10%):

Initial Cost:	$10,000
Rebate (One time):	$6,750
Energy Savings (Per year):	300,000 kWh
Cost Savings (Per year):	$18,450
Simple Payback:	0.18 Years

Other Measures

Below are measures that were considered, but found to have minimal savings when compared to the capital costs. As well, other measures listed below could be viable but would require further investigation into direct system usages.

Filter Change Out Scheduling

Description: Over time filters will become plugged and require more fan power to provide the same amount of CFM to the suites. Based on conversations with CLIENT, the filters are on a regular change out schedule and are a priority due to process. The savings that would be achieved by increasing change out frequency is minimal based on the current schedules.

Preheat Deaerator Water

Description: There are plenty of sources within the facility that are giving off ambient heat. With a further study to understand the complexities of deaerator system, and heat requirements, an idea of how to use heat recovery for this process could be found to be viable.

Add Domestic Hot Water Condensing Boiler

Description: Currently, domestic hot water is generated by the main (steam) boilers via a heat exchanger. The steam boiler efficiency is no better than 80% and, considering part load impacts, may be lower. A condensing boiler will allow the efficiency for domestic hot water usage to rise above 90%.

Calibrate CHW deltaT Sensors

Description: Maintaining the chilled water temperature difference is an excellent strategy for reducing pump power, since chilled water plants often operate at lower-than-desired temperature difference and thus use more pump power. Temperature sensors are normally installed without calibration and the factory accuracy is often ± 2F. For a system with a 10F design temperature differential, a compounded (worst case) error will result in a 4F error – 40%. Better calibration may improve overall pump energy usage. This would require further investigation for savings.

Control City Water Booster

Description: The city water booster pumping system is controlled to maintain a constant discharge pressure sufficient for water use at the far reaches of the plant – regardless of whether it's needed. Adding pressure sensors at major remote water usage locations will allow the city water booster pump to slow when city water demand is lower at remote locations. This would require further investigation for savings.

Use OA DOAS for All AHUs

Description: Most of the AHUs introduce the needed outdoor air individually and therefore must heat, cool and reheat individually and without the benefit of energy recovery. Combining the outdoor air introduction and control in a single (or several larger) DOAS units allows energy recovery schemes for the AHUs' outdoor air usage. This would require further investigation for savings.

Review Dust Collector System

Description: Over time filters will become plugged and require more fan power to provide the same amount of CFM to the suites. Based on conversations with CLIENT, the filters are on a regular change out schedule and are a priority due to process. The savings that would be achieved by increasing change out frequency is minimal based on the current schedules. This would require further investigation for savings.

HVAC Analysis – Plant 5

As part of the ASHRAE Level II audit, the HVAC equipment was analyzed to better understand its condition and life expectancy. At CLIENT's request, Plant 5 was analyzed in place of Plant 4. CLIENT felt that the equipment in Plant 4 was newer and in better shape than that of Plant 5. To optimize the information from this report, the Plant 5 systems were analyzed to find areas for significant improvement. Below is a table showing the approximate age and condition of these pieces of equipment. For comments on condition, please see the full spreadsheet.

AHUs – 20-year Coil Rated Life:

Plant	Designator	Manufactured Year	Age	Rating out of 10
5	AHU 503-2	1981	36	5
5	AHU 506-R	2009	8	9
5	AHU 508-1	1990	27	3
5	AHU 509-2	1981	36	6
5	AHU 510-2	1981	36	4
5	AHU 513-2	1981	36	5
5	AHU 516-2	1990	27	4
5	AHU 517-R	1981	36	Unit Removed
5	AHU 518-1	1990	27	Unit Removed
5	AHU 519-R	2014	3	Unit Removed
5	AHU 521-R	1981	36	8
5	AHU 522-2	1981	36	4
5	AHU 529-2	1990	27	4
5	AHU 533-1	1990	27	5
5	AHU 534-2	1981	36	5
5	AHU 535-2	1981	36	5

Plant	Designator	Manufactured Year	Age	Rating out of 10
5	AHU 536-G	2003	14	6
5	AHU 540-R	1990	27	4
5	AHU 541-R	1990	27	3
5	AHU 542-R	1994	23	6
5	AHU 543-R	1995	22	2
5	AHU 544-2	1995	22	?
5	AHU 545-R	2001	16	5
5	AHU 546-R	2011	6	10
5	AHU 551-R	1990	27	6
5	AHU 552-R	1990	27	5
5	MUA 553-R	2017	0	Unit Removed
5	MUA 554-R	1990	27	Unit Removed
5	AHU 555-R	1990	27	4
5	AHU 556-R	1990	27	3
5	AHU 557-R	1990	27	3
5	AHU 558-R	1990	27	3
5	AHU 559-R	1990	27	4
5	AHU 560-R	1990	27	4
5	AHU 561-R	1990	27	6
5	AHU 562-2	1990	27	6
5	AHU 564-R	2016	1	10
5	AHU 565-2	2012	5	10
5	AHU 566-2	2012	5	8
5	AHU 567-2	2012	5	9
5	AHU 568-2			7
5	AHU 569-2	2012	5	10
5	AHU 570-2	2012	5	10
5	AHU 571-1	2014	3	10
5	AHU 572-R	2015	2	10
5	AHU 573-R	2016	1	10
5	AHU 574-R	2016	1	9

Cooling Towers – 20-year Rated Life:

Plant	Designator	Manufactured Year	Age	Rating out of 10
5	CT-501	1990	27	6
5	CT-502	1990	27	6
5	CT-503	1990	27	6
5	CT-504	1992	25	6
5	CT-505	2005	12	6

Chillers – 20-23 Year Rated Life

Plant	Designator	Manufactured Date	Age	Rating out of 10
5	CH-501	1990	27	5
5	CH-502	1990	27	5
5	CH-503	1990	27	5
5	CH-504	1995	22	3
5	CH-505	2005	12	5

Boilers – 25-30 Year Rated Life

Plant	Boiler Number	Manufactured Date	Age	Rating out of 10
5	Boiler #1	1973	44	4
5	Boiler #2	1978	39	4
5	Boiler #3	1981	36	3
5	Boiler #4	1992	25	3