

Advanced Energy Monitoring with Wireless Submetering

A Case Study Report
Saint-Gobain NorPro
Soddy-Daisy, TN

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SGNA Sustainability Network

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Executive Summary

Electrical submetering is an energy management method of installing meters to measure electrical consumption at a more granular level than that of the utility meter. Utility meters measure the building-level consumption, while submeters can measure at the system- and/or device-level. Saint-Gobain North America's (SGNA) Sustainability Network has developed a partnership with submetering provider Centrica Business Solutions, who sells low-cost, wireless submeters that clip on to an electrical wire.

The Ceramics NorPro manufacturing facility in Soddy-Daisy, TN served as a pilot project for the Centrica Business Solutions technology, led by World Class Manufacturing (WCM) Manager Patrick Sick. The sensors were placed on 49 electrical loads in the facility, including on the system level (extruder zones and lines, HVAC panels) and the device level (air compressors, low pressure blowers). The online dashboard shows energy consumption of each individual load on a continuous time scale.

The visualization of the site's energy usage allowed them to identify and implement energy reduction projects, four of which are case studies showcased in this report. The combined electrical savings of these projects amounted to 15% of the site's annual electricity spend. This does not include the added benefit of increasing operational efficiency and improving product quality, incurring maintenance, quality, production, and labor savings as well.

Now that a Master of Service Agreement has been developed, it is the Sustainability Network's recommendation that all SGNA sites consider installing submeters to better manage their electrical usage and incur the added benefits.

Table of Contents

Introduction	4
Site Description & Intentions.....	4
The Technology.....	5
Implementation	5
Metering Point Selection	5
Other Metering Point Selection Factors to Consider	5
Installation Procedure.....	6
Case Studies.....	7
Case Study #1: Device Analyzer KPIs.....	7
Case Study #2: Low Pressure Blower Batch Process.....	8
Case Study #3: Identical Equipment with Different Loads	10
Case Study #4: Future Project – Dryer Fan Efficiency.....	11
Conclusions	12
Appendix.....	13
Appendix A. Final Costs.....	13
Appendix B. Validation of Metering Point Selection – A Comparison of the Plant Utility Meter with the Selected Centrica Business Solutions Submeters.....	13
Appendix C. Sensor/Bridge Installation Photos	14
Appendix D. Other Dashboard Features.....	14
Appendix D-1. Site Dashboard	14
Appendix D-2. Individual Load Phases	15
Appendix D-3. Sankey Diagram	15
Appendix D-4. Heat Map	16
Appendix D-5. Alert System	16

Introduction

Saint-Gobain's current goal in energy monitoring is to gain more granular data on energy usage within our manufacturing sites to accelerate the achievement of our sustainability goals; namely reducing carbon and lowering energy intensity. All facilities have utility meters that measure site-level energy consumption for billing purposes. Submetering breaks this data down from site-level to equipment- or system-level monitoring. The Sustainability Network has developed a partnership with the company Centrica Business Solutions to provide the technology and support service for implementing energy monitoring technology at SGNA plants. The first early adopter of this technology is the Ceramics NorPro plant in Soddy-Daisy, Tennessee.

Saint-Gobain NorPro specializes in advanced ceramic technology solutions for fixed bed reactor processing and heat and mass transfer applications in the refining, petrochemical, chemical, environmental, and gas processing industries. The site's team works continuously to reduce their energy consumption. However, most completed projects have been simple, obvious fixes that are reactive in nature. To find these less obvious opportunities and be more proactive with their energy management, Soddy-Daisy wants more sophisticated information to address these more complex problems. Their focus is mainly on reducing energy and maintenance costs. This report explores the use of Centrica Business Solutions' submetering technology in data collection and analytics for the completion of these more complex projects.

Site Description & Intentions

Soddy-Daisy is billed on both energy use and peak demand on a monthly basis. Demand accounted for almost 30% of the annual electrical energy costs in 2016. The plant WCM Manager, Patrick Sick, sought to focus on decreasing the peak demand to limit the variable costs incurred by the site. If the peak demand was decreased by 50 kW each month, the site would save thousands of dollars annually. Submetering equipment energy usage could help find these opportunities, as well as several maintenance benefits.

An ancillary benefit of submetering is the ability to monitor run hours and trends in energy consumption of individual loads. This information gives the plant the ability to more efficiently maintain equipment. Equipment maintenance is often planned on time intervals such as monthly, quarterly and annually. These intervals are set based on the estimated operating hours of the equipment, rather than actual run hours, which can result in equipment maintenance being performed too often or not enough. In the case of performing maintenance too frequently, additional costs are incurred by the organization for the time of the maintenance technicians, the cost of materials and supplies, the cost of waste (disposal of oily waste) and possible downtime. If maintenance is not performed often enough, the risk of premature failure increases, leading to large repair costs and unplanned downtime for the equipment.

Another possible benefit for maintenance is the ability to move from preventative maintenance to predictive maintenance. Accumulating energy usage information over a period of time will allow patterns to be recognized that can identify when components such as fans, bearings and shafts are starting to deteriorate, along with estimates of when major failures will occur. This knowledge allows maintenance to intercede at just the right time to reduce total maintenance costs and operational costs from unplanned downtime.

The Technology

Centrica Business Solutions was founded in 2009 and has worked with hundreds of industrial facilities over the last 10 years, installing about 50,000 energy sensors globally. A schematic describing how the technology works is shown in Figure 1.

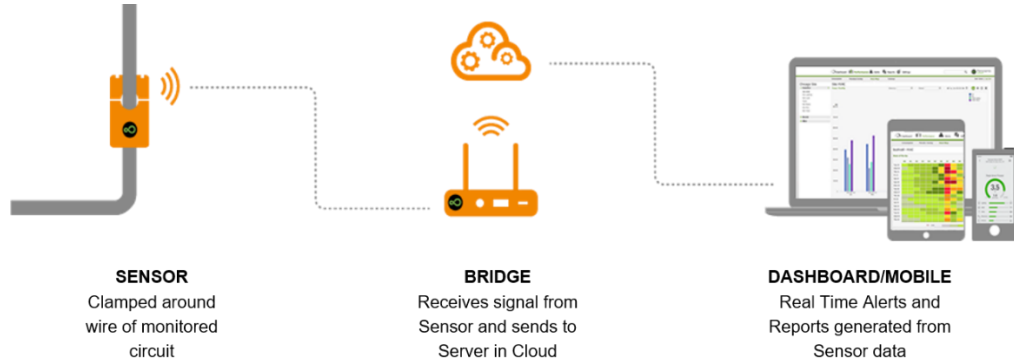


Figure 1. Schematic Diagram of Centrica Business Solutions's Sensor Technology

What differentiates Centrica Business Solutions from its competitors is the low-cost, wireless, clip-on nature of the sensors. The sensors are self-powered and do not require any maintenance. This enables the plant to install the sensors in much less time than their wired counterparts, and also decreases the need to de-energize electrical equipment. The dashboard is easy-to-use and produces on-demand analysis and reporting of real-time energy consumption using data analytics. This visualization of energy consumption on a device level can help plants to determine the driving loads to their energy bill and inefficiencies that they would not have known otherwise. Centrica Business Solutions' support team also offers periodic money-saving insights based on the energy consumption data. Other important features of the dashboard system are showcased in [Appendix D](#).

Implementation

Metering Point Selection

Installing submeters at every electrical load in the plant is beneficial, but not economical or necessary. Enough submeters should be installed so that the modeled energy consumption mimics the actual energy curve, as shown in [Appendix B](#). To determine which electrical loads the plant would benefit from determining the energy consumption, Patrick developed a load profile that showed each electrical load and operational hours with the subsequent electricity consumption, cost, and savings if they were able to decrease electricity consumption by an assumed 5%. The loads resulting in savings that were more than the cost of a sensor were chosen as strategic metering points. In addition, nine other factors were considered in the metering point selection.

Other Metering Point Selection Factors to Consider

1. Monitoring one phase versus three phases
2. Equipment run hours to determine the impact of monitoring: equipment with more run hours are a higher priority
3. Monitoring fixed versus variable loads: Steady state loads that operate continuously at a constant consumption rate, such as lighting that is on all of the time, is easily calculated and is therefore a lower priority for metering.

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4. Voltage and power factors: Energy estimates are based on current with an assumed voltage and power factor
 5. Consult data from other systems, such as the utility meter, to verify if the metering point selection covers enough of the electric load ([Appendix B](#))
 6. Arc-flash and power interruption implications for installation
 7. Network capabilities
 8. Centralized power distribution
 9. 120 VAC power is needed for the bridges

The total capital cost of the installation amounted to 8.5% of their electrical spend for 2017, which included the sensors and bridges, hiring electricians, setting up an Ethernet connection, network equipment, and converters. All subsequent costs are the annual service fee for the software platform, which amounts to only 1.4% of their annual electricity spend. See [Appendix A](#) for more details on the costs.

Installation Procedure

In total, the Soddy-Daisy team installed 49 sensors and 12 bridges in strategic locations throughout the plant. The manpower included: two external electricians, one internal electrician, one Centrica Business Solutions field technician, Patrick, and a worker to set up the network cables and equipment four days after the installment. It took two hours to set up the sensors and bridges in the conference room, and eight hours to fully install them in the plant. Photos of the installation are shown in [Appendix C](#).



The team decided to install the sensors on a day the plant was shut down for inventory adjustment, though this may not be necessary. Having to be shut down for installation depends on the plant and how well it can turn off individual loads. Flash precautions are imperative so that there is no risk to the employees. The Arc flash ratings for each load should be known so that the correct PPE is worn to avoid risk. Some loads cannot be accessed and have to be first de-energized because of the high Arc flash rating. All of these factors need to be considered when determining whether or not to shut down the plant for installation.

Case Studies

The following case studies depict four instances where Soddy-Daisy realized energy savings they would not normally because of the advanced energy monitoring technology and analytics. Financial savings information is provided where estimates can be made based on data from the Centrica Business Solutions dashboard. All savings are presented as the percentage of the annual spend on electricity for the plant, assuming the identified problem were to persist for a full year.

Case Study #1: Device Analyzer KPIs

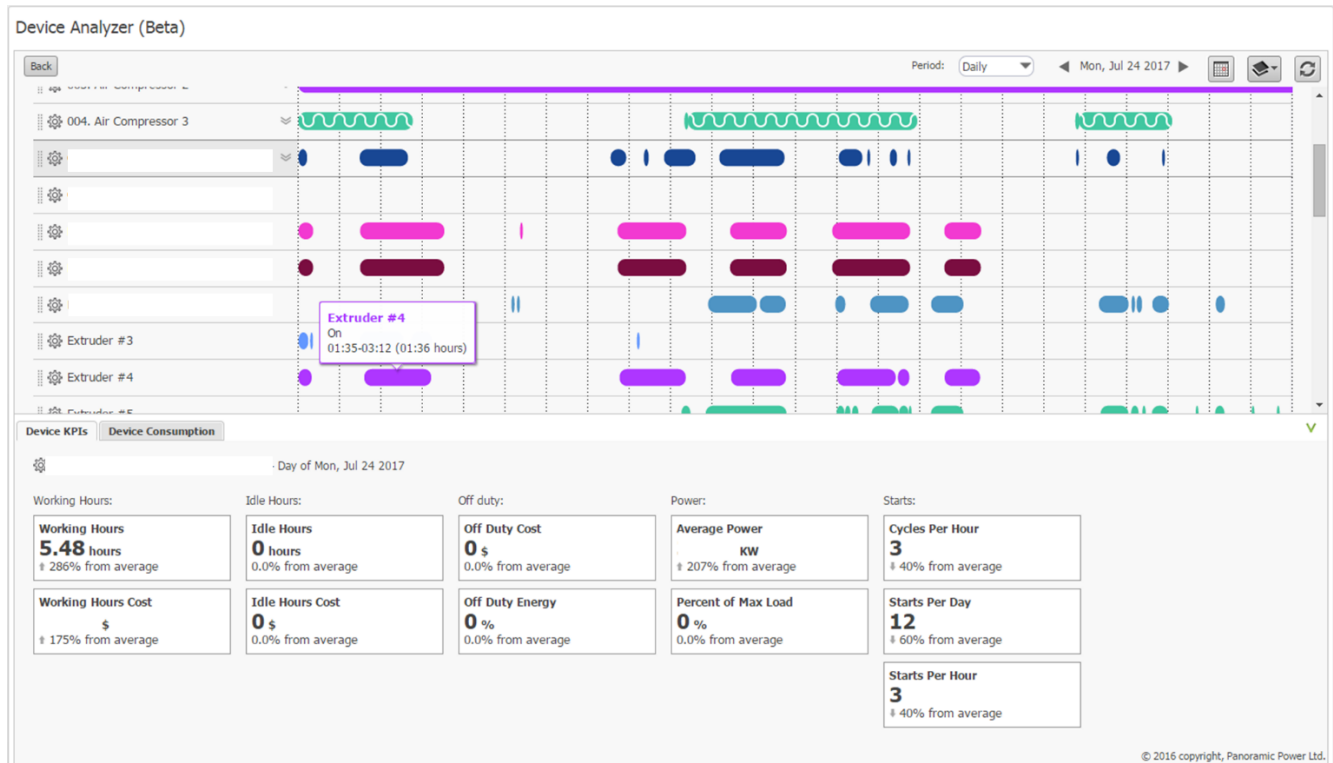


Figure 2. Screenshot of the Device Analyzer Page of the Dashboard

Equipment maintenance is often planned on time intervals (such as monthly, quarterly and annually), which are set based on the estimated operating hours of the equipment, rather than actual run hours. The impact of this assumption can be costly, due to expenses such as unnecessary increased downtime, loss of materials, and discarding the maintenance waste. The **Device Analyzer** tool in Figure 2 shows the actual run time for each piece of equipment being monitored, which allows Soddy-Daisy to extend the maintenance cycle and make maintenance operations more predictive. This reduces the cost of labor, materials, waste, and the related environmental impacts (such as reduced energy consumption and reduced waste). Knowing the actual runtime of each device also allows for better budgeting on a product basis, since there are more accurate estimates of which products use more energy to manufacture. This also opens opportunities to determine and reduce the embodied energy for each product.

Case Study #2: Low Pressure Blower Batch Process

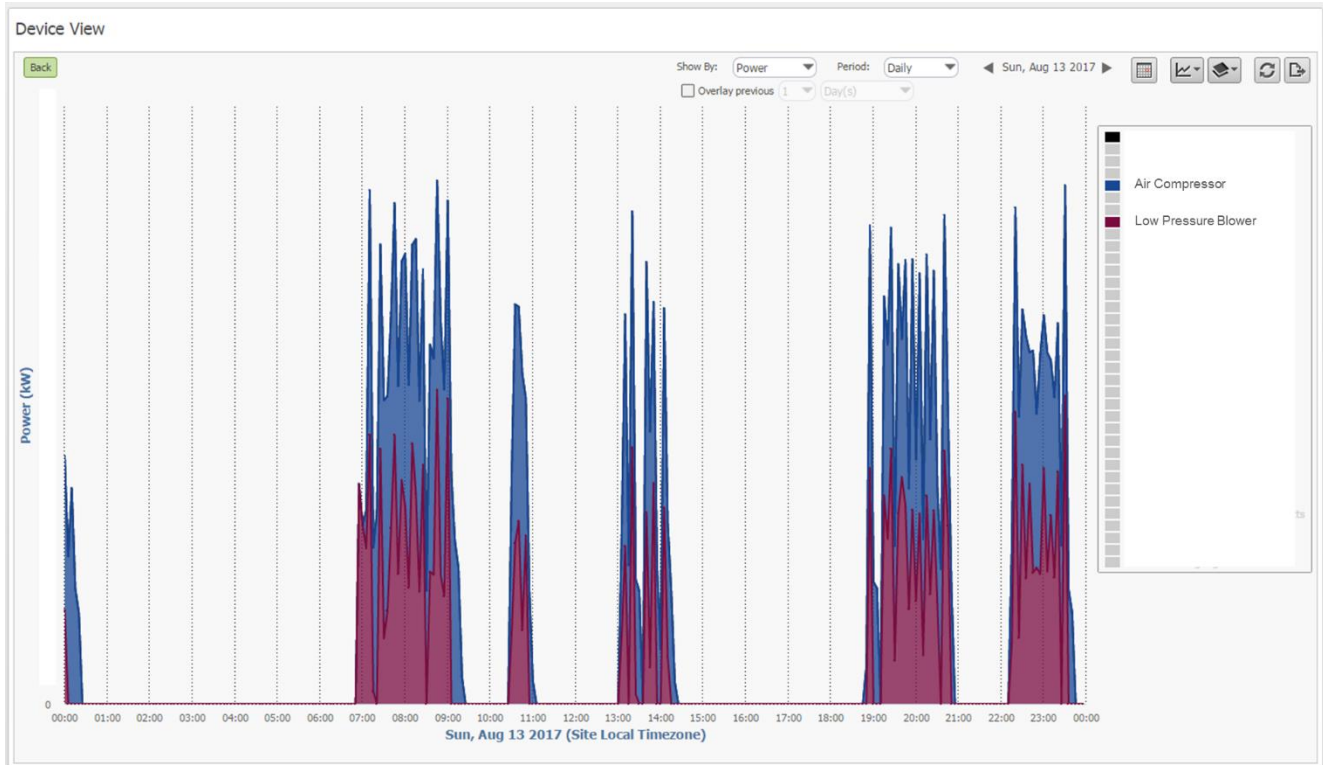


Figure 3. Electricity Consumption Device View of Air Compressor and Low Pressure Blower

A low pressure blower (red) is used to convey material in a seven-minute-cycled batch process. There is a submeter on this blower, as well as on a nearby air compressor (blue). The **Device View** tool shows the electricity consumption in kilowatts, trending daily for these two equipment systems. From the graph, there is a definite positive correlation between the blower and air compressor. The site previously decided to convert fluidization air from the low pressure blower to compressed air so that whenever batching takes place, a second air compressor starts to provide the additional air required for fluidization. Air compressors are much more energy-intensive pieces of equipment as shown in Figure 3. Because of this comparison, the site is now investigating reverting back to just using the low pressure blower for fluidization to save on energy use and charges. For example, on a given day (shown in the Figure 3), the air compressor was left on for over ten hours, which potentially cost the company the equivalent of 4% if their 2017 electrical spend, if left unfixed for a full year.

While investigating the low pressure blower for that project, the team identified that the blower's batch cycle ran for 30 minutes instead of the required seven minutes, because of an equipment issue involving an intermittently stuck valve. The intermittent nature of the problem made it difficult to identify, since the valve worked correctly whenever maintenance was performed. This failure resulted in excessive energy usage due to the previous problem of the low pressure blower and air compressor running concurrently. On the date shown in Figure 3, the low pressure blower ran 13 cycles that lasted for almost five hours more than needed, costing the site an additional 3% of their electrical spend for the year.



More importantly, this issue effectively stopped the batching process because subsequent batches could not be run until the previous batch completed, slowing the sites' production rate. The stuck valve was repaired and alarms have now been installed to alert maintenance when the low pressure blower has been operating for an excessive period of time. In subsequent investigations, quality issues were identified at the batching system as a result of investigating this problem that was identified by submetering. This example showcases the "domino effect" of having more granular information, and being able to identify multiple solutions. This is a key benefit to Patrick, who stated "The system is helping us to not only identify excessive energy usage but also helping to identify and correct operating efficiency and quality issues."

"The system is helping us to not only identify excessive energy usage but also helping to identify and correct operating efficiency and quality issues."

Case Study #3: Identical Equipment with Different Loads



Figure 4. Site Air Compressors Daily Energy Usage Comparison, Device Level View



Figure 5. Site Air Compressor 1 and 2 Monthly Energy Usage Comparison, Device Level View

Figures 4 and 5 showcase the energy usage of the site air compressors from different spatial perspectives. The loads are stacked (combined), showcasing the peak load from the air compressors alone. The different colors

indicate one of the three different compressors onsite. Although all compressors are identical, the **Device View** shows that each of the electrical loads vary. Each air compressor is rated at 50 horsepower and uses 37 kilowatts. Over the week-long period shown in Figure 4, the lead compressor, Air Compressor 1, ran consistently over its power rating at 43 kilowatts on average. Over that period, this issue cost the site an extra 2% of their electrical spend for the year if this problem persisted. In this particular example, operators now use Air Compressor 2 or 3 as the lead, which runs closer to 35 kilowatts, and only include Air Compressor 1 as a backup.

These differences indicate an equipment issue, which quickly becomes a plant reliability issue. Without the dashboard, the inefficient compressor would have continued to run, possibly resulting in premature failure. The site would have gone through unwanted downtime to do maintenance, and cost extra resources such as labor, production capacity, and energy losses.

As a result of this determination, Soddy-Daisy chooses which air compressor to act as lead compressor on a periodic basis based on its performance and energy efficiency. Being able to know when equipment will fail and when to take action is a major maintenance win for Soddy-Daisy. An operator looking at the machines is just able to tell that they are running, not the electrical load; this level of granularity is only possible by seeing the consumption data visually.

Case Study #4: Future Project – Dryer Fan Efficiency

In addition to the three case studies shown in this report, Soddy-Daisy has an additional opportunity its team is currently working on. The site's green ware product dryers have five 5-kilowatt fans that operate to dry product by blowing waste heat from the kiln over the product. These fans need to operate only when there is product in the dryer. Because the fans are manually turned on and off by the kiln operator, they are often left on continuously even though there is product in the dryer approximately 12 hours per day only. The site has started a project to sense when product is on the dryer belt to automatically turn fans on and off. This could save approximately 5% of the annual electrical spend, the highest savings yet. Centrica Business Solutions's energy monitoring dashboard helped call attention to this problem, from looking at the load curve for the kiln and comparing it to the load that the dryer fans created.

Conclusions

Seeing electricity use on a more granular level will allow plants to better manage maintenance cycles, determine excess electricity loads, and find problems proactively. Essentially, the operations at the Soddy-Daisy plant are better optimized with Centrica Business Solutions's technology than they would be from normal operations. The four projects presented offer a total of 15% reduction in annual electricity spending just from identifying issues through Centrica Business Solutions's dashboard system. This does not include the other maintenance, quality, production, and labor savings that went along with each of the solutions. Some recommendations from Patrick Sick on using the technology effectively include: "Develop a routine for reviewing electrical usage. New issues will always arise, so do not become complacent after realizing the 'quick wins' from first installing the submeters. Reviewing the software should be a part of the maintenance schedule to ensure no opportunities are missed."



Soddy-Daisy is the pilot SGNA plant working with Centrica Business Solutions. A Master Service Agreement has been developed to fully commit to a partnership the company, offering lower executive group pricing. This is especially attractive to those sites with low capital expenditure budgets, because the partnership allows sites to account for the technology and dashboard as a monthly or annual service fee, rather than a capital expense. All SGNA sites are encouraged to consider installing submeters to realize the benefits of monitoring electricity usage on a more sophisticated basis.

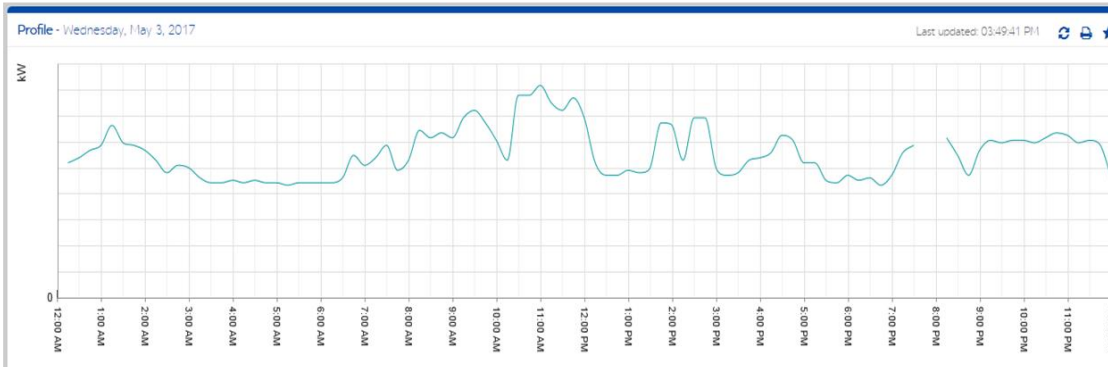
Appendix

Appendix A. Final Costs

Description	Cost as a % of Annual Electrical Spend
Sensors and Bridges	4%
Electricians	0.5%
Ethernet Connection	2.2%
Network Equipment & Convertors	1.5%
Total	8.5%
2 nd Year Service Fee	1.4%

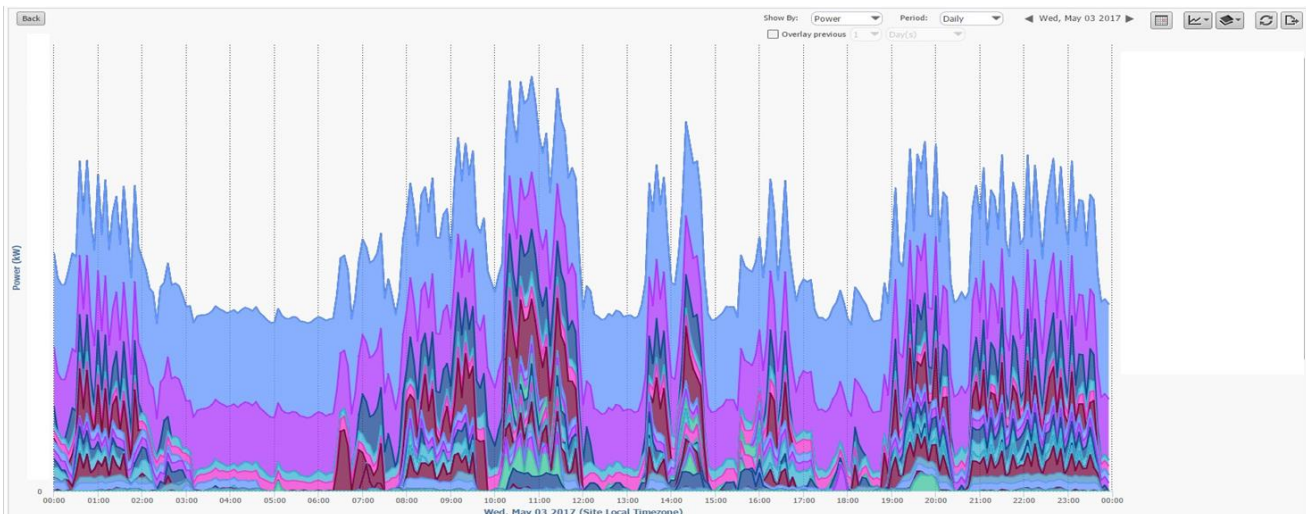
Appendix B. Validation of Metering Point Selection – A Comparison of the Plant Utility Meter with the Selected Centrica Business Solutions Submeters

Utility Meter – Whole Site



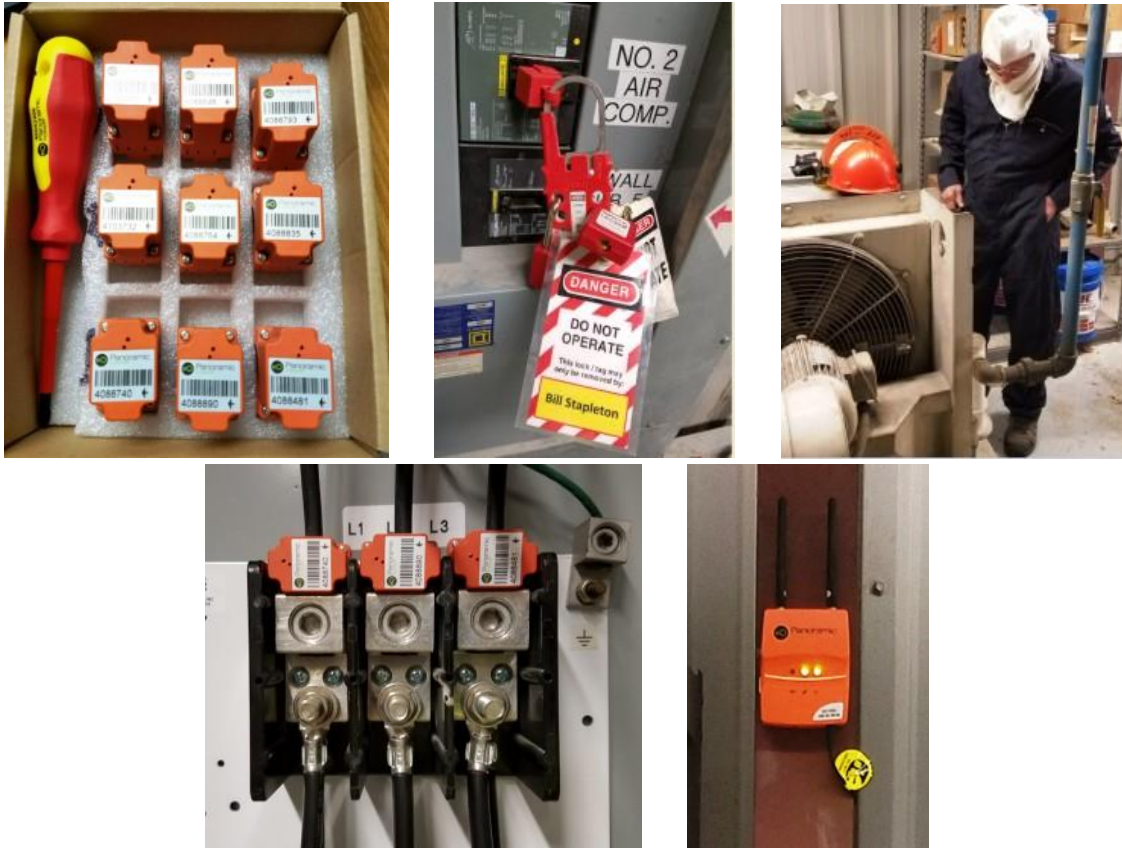
**~ 80%
Load
Coverage**

Panoramic Power Meters



Note: Electrical load names and values have been omitted

Appendix C. Sensor/Bridge Installation Photos



Appendix D. Other Dashboard Features

Appendix D-1. Site Dashboard



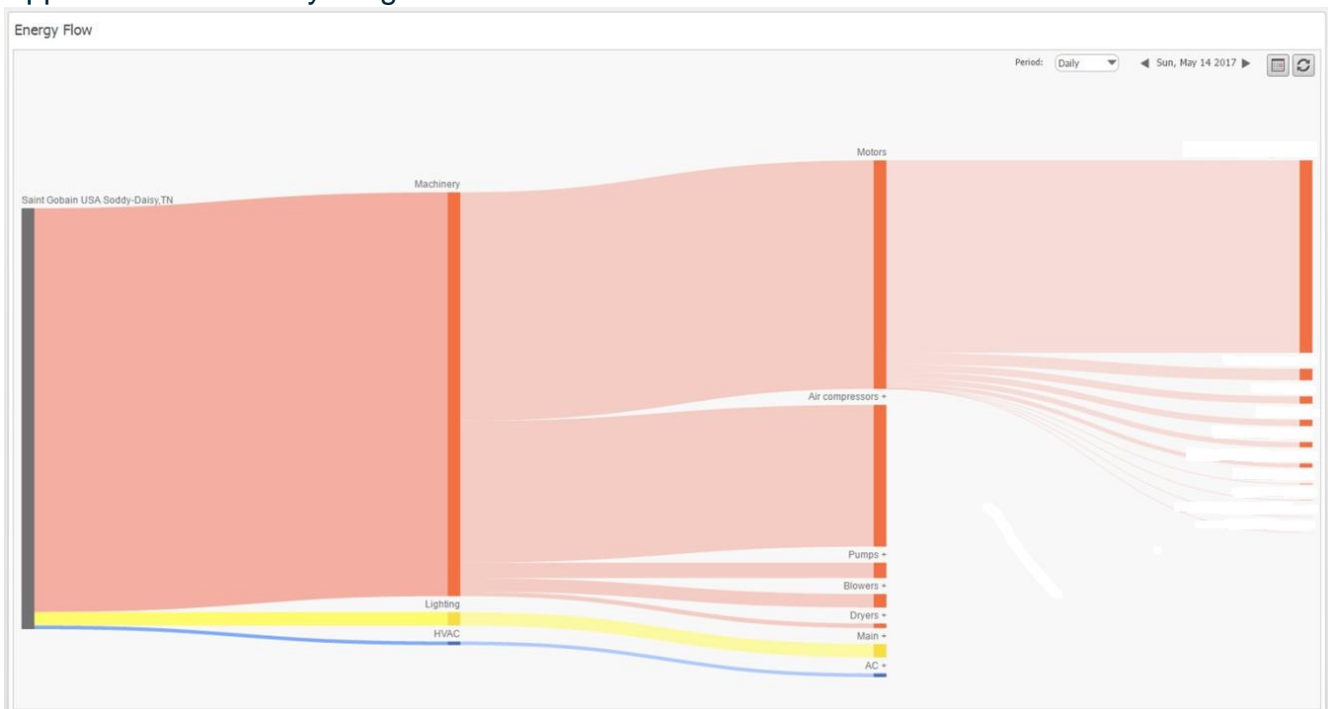
Note: Electrical load names and values have been omitted

Appendix D-2. Individual Load Phases



Note: Electrical load names and values have been omitted

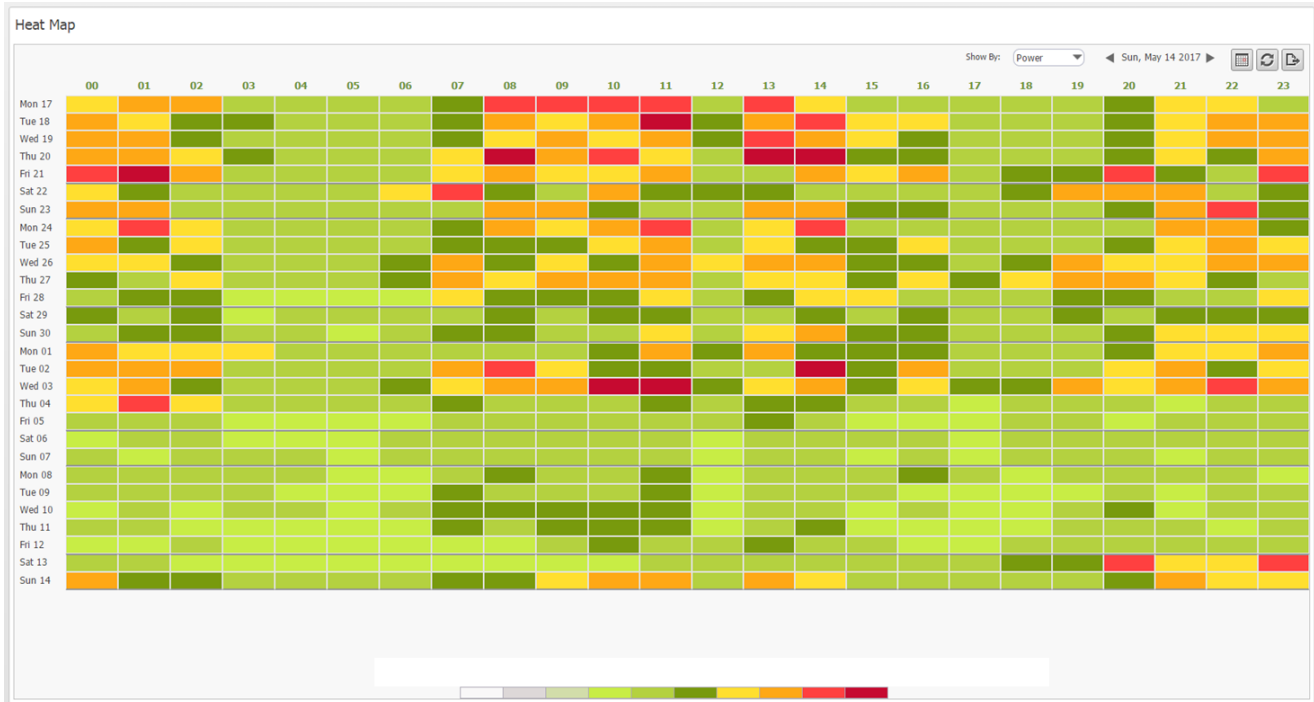
Appendix D-3. Sankey Diagram



This Sankey diagram parses out where in the plant the incoming electricity is consumed. This is another way to visualize which devices, or equipment, are consuming the most energy.

Note: Electrical load names have been omitted

Appendix D-4. Heat Map



A heat map shows a different visualization of the overall energy consumption for the site, on an hourly basis. The range of colors demonstrate the intensity of energy use in one hour in relation to the other hours. Those hours highlighted in red signify a high energy usage in that period. Pinpointing when these peak usages occur can help determine what is causing them.

Appendix D-5. Alert System

Status	Date	Event Type	Severity	Origin	Site	Details	Comments
New	2017-05-15 03:17:53	System disconnected from internet	High	Bridge (981873)	Saint Gobain USA So...	Bridge is disconnected for over 30.2 minutes	
New	2017-05-13 10:20:28	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.5 minutes	
New	2017-05-13 04:38:33	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.5 minutes	
New	2017-05-12 00:03:16	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.8 minutes	
New	2017-05-12 18:50:23	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.7 minutes	
New	2017-05-12 00:18:08	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.9 minutes	
New	2017-05-10 19:31:08	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.9 minutes	
New	2017-05-10 01:49:18	System disconnected from internet	High	Bridge (981744)	Saint Gobain USA So...	Bridge is disconnected for over 30.8 minutes	
New	2017-05-09 21:07:33	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.5 minutes	
New	2017-05-09 06:33:59	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.1 minutes	
New	2017-05-08 12:48:20	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.7 minutes	
New	2017-05-08 10:23:35	System disconnected from internet	High	Bridge (981792)	Saint Gobain USA So...	Bridge is disconnected for over 30.5 minutes	
New	2017-05-08 00:05:22	System disconnected from internet	High	Bridge (981792)	Saint Gobain USA So...	Bridge is disconnected for over 30.7 minutes	
New	2017-05-07 23:55:15	System disconnected from internet	High	Bridge (981759)	Saint Gobain USA So...	Bridge is disconnected for over 30.8 minutes	
New	2017-05-07 21:25:03	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.9 minutes	
New	2017-05-07 07:46:18	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.8 minutes	
New	2017-05-07 07:28:50	System disconnected from internet	High	Bridge (981873)	Saint Gobain USA So...	Bridge is disconnected for over 30.2 minutes	
New	2017-05-07 07:18:21	System disconnected from internet	High	Bridge (984586)	Saint Gobain USA So...	Bridge is disconnected for over 30.7 minutes	
New	2017-05-07 02:32:57	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.1 minutes	
New	2017-05-06 15:49:56	System disconnected from internet	High	Bridge (981728)	Saint Gobain USA So...	Bridge is disconnected for over 30.1 minutes	

The alert system sends out warnings to respond to abnormal electrical activity about a device, sensor, or bridge. Alerts can be sent to specific individuals depending on the equipment in question. Currently, the alerts are only device level and are not able to scale up to the system level (i.e. all air compressors instead of just one), however this is a feature Centrica Business Solutions intends to include in the future.