SUCCESSFUL FACILITY WIDE ENERGY MANAGEMENT SYSTEM ADDITION AT A MINERALS PROCESSING PLANT

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***Abstract* - Many minerals processing plants across the globe have been operational for several years and are filled with legacy electrical systems of multiple vintages with disparate control and monitoring components. The purpose of this paper is to present a case study of one such plant, which has been operating for over 80 years. As the original plant was built before the latest innovations in metering and monitoring devices, the plant made a decision to purchase and self-install metering to create a facility wide monitoring and energy management system. The project was funded by a corporate program that granted capital funding for programs focused on saving energy. The energy monitoring devices were integrated with the plant distributed control system so that operators now have visibility to energy usage throughout the plant. As a result, plant operations are making informed decisions based on optimized energy usage. Today, the plant is running more efficiently as energy usage is measured and visible at all levels across the plant organization.**

Index Terms – Minerals Processing Plant, Energy Efficiency, Energy Management, Metering, Power Monitoring.

I. INTRODUCTION

Challenges in the cement industry across the United States are many. During the calendar year 2010, there were 102 clinker producing plants with 154 cement kilns. These plants operated at a collective capacity of 58.3%, producing 103.6 million metric tons of clinker to support the US market [1]. At this low production level, many older inefficient plants have long since been closed or shuttered, yielding way for newer more efficient production. Several facilities have been idled for months at a time, opting for “market related downtime” in lieu of producing cement beyond the market demand. Although the economic cycle is expected to one day recover, at the time of this writing, key drivers for the industry such as new housing starts, continue to remain at depressed levels. Adding to the business challenges for the industry, new regulations enacted by the US Environmental Protection Agency (EPA) now require operating cement plants to reduce emissions of some airborne contaminants by over 90%, with new environmental remedies expected to be in place before the end of the year 2013.

In this environment, it is clear that continuing to produce without making fundamental changes to the operation, is simply not an option. Business leaders and facility operators together need to be committed to continuous improvement, finding new ways to optimize the manufacturing process, or run the risk of permanent closure. In 2007 a US based Cement Company developed an Energy Initiative for its minerals processing facilities to address power usage, fuel usage and environmental responsibility. The company policy states the company is committed to acquiring and using energy in the most efficient, cost effective and environmentally responsible manner possible, minimizing its carbon footprint. They also state that they will improve energy efficiency by establishing and implementing effective energy management programs that support all operations, customer satisfaction and minimize greenhouse gas emissions while providing a safe work environment. The purpose of this paper is to present a case study of one of the company plants, located in the Pacific Northwest of the United States, and their quest for improvement via optimizing energy use. The paper discusses a unique energy management program available to the facility at the enterprise level that was used to financially support the decision to install a state of the art energy monitoring system. In-plant resources were effectively used to specify, procure, install and integrate new energy meters during a scheduled market related outage, delivering the new system at an optimal cost. Because of its creation by in-plant resources, the new energy management system was embraced by operations and was well understood from the beginning. An inspiring story of a plant that decided to do something, rather than do nothing – with impressive results!

II. THE CASE FOR IMPROVED ENERGY MANAGEMENT

The existing minerals processing plant produces 750,000 tonnes/year of cement and was originally built in 1927! The facility was rebuilt in 1991, when the cement making process was converted from wet to dry. As a result of this change, much of the site electrical systems related to the kiln operation were upgraded while the systems and process post-clinker production remained fundamentally unchanged. The primary kiln fuels are either coal or natural gas, a choice by operations based on cost and availability of these two sources. The facility also burns whole tires as an alternative fuel source. The total electrical load at the plant is 13MW and monthly electrical energy bills frequently exceed US $400,000 – a significant component of total operating cost for the facility. Incoming utility service at the plant is distributed at 4160V and most of the larger electrical motor loads operate at this voltage. In-plant transformation converts the 4160V systems to 480V, the potential where the balance of plant load is supported. Because of the vintage of the facility, standard dial-type ammeters, voltmeters, and kilowatt-hour meters were installed at the incoming utility point of service and also at the primary and secondary substations. Historic energy management procedures in the plant included manual meter reading and recording of energy at each substation, which took place on the last day operating day of the month. Kilowatt-hour readings were transferred to a spreadsheet and distributed to accounting, where the information was used by operations to determine electrical energy efficiency in kilo-watt hours (kWh) per ton produced by each operational department. In this way, "energy owners" of each individual process such as the raw mill, the kiln and the finish mill, could be aware of the energy usage based on the previous month production. Although the recorded energy metrics offered visibility to total electrical energy consumed, the legacy system had many drawbacks, including:

- Operators were unaware of real-time energy usage and were notified the following month of the prior-month performance data.
- Operations had no real mechanism to evaluate and respond to changes in monthly energy usage.
- Departments were "energy owners" but had no way to use data/respond with operational changes.
- Inability to respond to peak power usage events that would trigger a utility demand charge.
- No clear method to track electrical system efficiency.
- No real-time method to identify and manage electrical loads with the largest demand.
- No immediate means to alert an operator of a potential energy savings.

Because of multiple deficiencies in the way energy information was gathered and used across the plant, the decision was made to investigate alternative methods and new technology that could be deployed to improve management of electrical energy.

In evaluating alternatives, the staff recognized that at this facility nearly every piece of equipment needed to be running in order to produce cement. Existing systems were sized with little extra capacity, leaving little room for peak-demand and on-peak energy management. One operational exception to this is when the kiln is shut down. In this operational scenario, the finish mill can be operated during off-peak hours. Another identified operational exception was when the kiln is running primarily on natural gas there is reduced need for pulverized coal, so this equipment can again be run during off-peak hours. The utility rate structure includes an attractive cost alternative for off-peak electricity, so moving large loads to off-peak operations was desired.

III. Enterprise Energy Management Program

As stated previously, the company in this case study owns and operates several plants across the United States. The corporate initiative across the company was to adopt an Enterprise Wide Energy Management Program. This initiative offers corporate funding to operating plants based on a formal submission request. The company actively manages expectations for each plant in terms of improvement of production energy efficiency. If a plant submission meets operating improvement metrics and return on investment hurdles, the plant is eligible to receive corporate funding for an energy improvement project. One element of the enterprise wide program is that each plant is expected to address the issue of metering and sub-metering for energy systems. Sub-metering was defined as necessary metering so that each operating department had clear real-time visibility to energy usage. The thinking behind this requirement is "If you can't measure it, you can't manage it". As such, accurate real-time metering was identified as a required first step before other energy saving process changes such as retrofitting motor driven systems with variable speed drives could be considered or funded.

IV. The Path Forward For A New Energy Management System

The local plant assembled a multi-disciplined team to investigate alternatives for a new electrical energy management system that could be used in real-time for the multiple energy users across the facility. The group completed a fairly detailed work-scope for the project. The decided intent was to essentially duplicate the functionality of the dial-type metering at each 4160V and 480V substation and low-voltage motor control center. The plan was to upgrade the metering with new technology that could offer energy readings in real-time and would also communicate across the existing facility wide distributed control system (DCS) so that operators would have the real-time information necessary to make informed energy decisions. The defined scope also included a requirement for power quality data to be available in real-time. Parameters such as power factor, harmonics, power sags and swells and utility momentary outages were included as the group recognized that most new electronic based metering systems included this functionality.

A. Justification and Funding of the Project

This plant's multi-disciplined team believed a new energy management system was the first necessary step toward improved process optimization via accurate monitoring and utilization of energy data. Plant personnel felt that though a mixture of increased operator awareness, electrical diagnostic capability, and the potential for new development in process controls the new power monitoring system was going to be a significant asset to the plant. This was the primary justification for the energy management system project. This was ultimately supported by the company corporate leadership as funding was approved via the Enterprise Wide Energy Management Program.

Accurately estimating the return on investment (ROI) for the new energy management system proved to be a difficult task! In an effort to minimize the financial impact, the plant gained corporate approval based on project completion in two phases. The first phase would include the two main point-of-service power meters/power quality analyzers, and five of the plant's 4160 volt feeders for the newer half of the plant. Phase two would cover all of the rest of the plant equipment: seven new meters of the remaining main feeders for the old half of the plant, plus 28 meters for individual MCCs and large motors, and network integration of all new devices.

B. Hiring a Contractor or Self-Managed & Installed?

In an effort to get started, the local plant team decided to complete the written scope document and sent a request for proposal out to multiple contractors. The company required that three bids be submitted, so the plant site solicited bids from local reputable contracting firms as a first step. Review of the bids of outside contractors was the first major stumbling block for the project team. It was determined that although the outside firms were well qualified to do the work, the total proposed price was close to double the budget outlined for the project. In order for the project to stay within budget, the work scope needed to be drastically reduced. This resulted in significantly fewer metering points being updated with new meters and integrated into the site-wide energy management system. The group discussed the idea of perhaps ending up with a "hybrid" energy management system where some of the existing meters would be left in service and a combination of real-time metering and end-of-month metering via manual meter reading would be used. This approach was rejected as this type of system would not deliver the real-time data to operations that was a functional requirement for the new system. More importantly, this approach would not fulfill the prerequisites of the Enterprise-wide Energy Management Program which required sub-metering for all "energy users" as a first step of energy management implementation.

The team realized that one very positive feature of this plant was the advantage of a very progressive, visionary plant engineering staff, anxious to try new things and unafraid of new technology. Programming of in-house programmable logic controllers (PLC) was performed on a routine basis and integration of PLC system data into the existing plant-wide DCS system was already a common practice. The in-plant resources were confident they could self-install a new energy management system. Furthermore, there was a planned "market related outage" in the coming months when the plant electrical systems would be down – a perfect time to use existing resources to begin to install the new energy management system. The group decided to proceed based on a self-installed system based on a two phase approach as mentioned above. Phase 1 would include upgrading of the primary point of service metering and would take place during one two-month scheduled outage during the winter of 2009 and Phase 2 would be scheduled during a planned outage the following winter, including installation of the remaining sub-metering devices. Spreading the entire project over two scheduled outages would help assure the work could be completed in a timely manner without disrupting production and this would also spread the installed cost over a two year period, reducing the financial impact to the plant.

C. Technology Advancements

The plant set forth with a plan to review available technologies in metering and sub-metering and select the most current and cost effective solution. The work scope included replacing/upgrading the protection relaying at the incoming 4160V plant service and integrating these new protective devices with point of service energy/power quality metering, combined with sub-metering as the downstream substations so that real-time energy data would be available and visible to all energy users across the plant.

1) *Point of Service Meters and Protective Relays:* The plant wanted metering at the point of incoming service to deliver the greatest accuracy and diagnostic capabilities. The electrical distribution system began at the utility service with two main transformers that feed the plant. One transformer served the newer dry process systems built in the early 90's and the other supported the balance of existing equipment from the original plant back when the operation was a wet process. The team decided to install two main energy meters, which when totalized would provide accurate energy measurement. This allowed the plant accounting department to use kilowatt-hour monthly totals from new meters and compare them with the existing utility metering. Accuracy Class of the new meters was "revenue grade" in accordance with American National Standards Institute ANSI C12.20 [2]. The new meters included current accuracy of 0.05% of reading +/- 0.025% of full scale, voltage accuracy of 0.1% reading +/- 0.025% of full scale and energy/demand power accuracy of 0.2% full scale. Exceeding the requirements of this Standard was important as the utility serving the plant would recognize the energy readings from the new metering devices as being valid/accurate.

The selected meters also included capability to measure power quality parameters. This included measuring system harmonics up to 127 times the fundamental frequency, system sags, swells and transients. These could be captured via user selected triggers and used from power systems analysis. High-end portable power quality metering that were historically used by power systems engineers to measure and analyze system problems was essentially replaced by an on-line meter with similar functionality, including measurement and graphing of sub-cycle disturbances with resolution over 4000 samples per cycle. Finally, the meters selected included a unique embedded Web server. Each meter is assigned its unique Internet Protocol (IP) address so that any meter could be interrogated from the plant and the enterprise Wide Area Network. The engineering staff at the plant was interested in this capability as trending and event recording including captured waveforms could be easily accessed via the network, without impacting operations/production. Fig. 1 shows one of the meters used at the point of service and also a sample of a user interface screen displaying a captured waveform event, accessible from the plant network via the device Web server.

The existing overcurrent protective relays at the incoming plant switchgear were of the old induction-disk variety, manufactured in the 1950's and 60's. These relays were used to trip the plant incoming 4160 volt circuit breakers in the event of a fault at the plant incoming feeders. As the protective relays had reached their end of life and parts were no longer available, the project included replacing incoming relays with new solid-state microprocessor designs. Relay installation was accomplished by retrofit of the existing 4160 volt medium-voltage switchgear doors. All existing electro-mechanical relays were removed and a large opening was cut into the existing panel door. A local steel fabricator delivered a painted panel that filled-in the door cut-out; replacing the antiquated group of relays supporting functions including phase and ground overcurrent, over/under voltage and over/under frequency, with a single multi-function protective relay as shown in Fig. 2 below. One advantage of the multi-function relay selected was this device included full

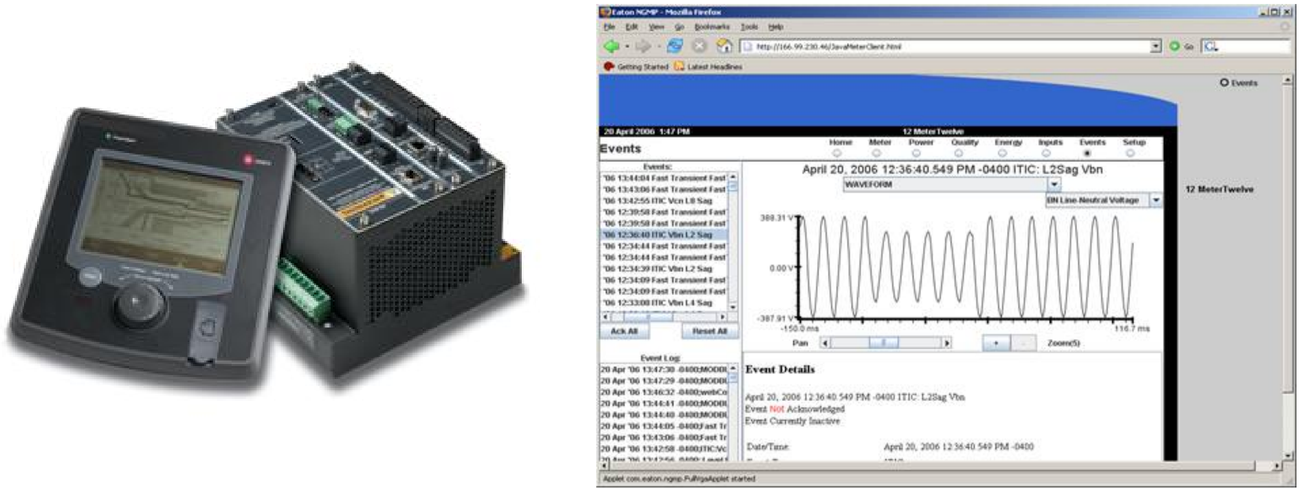

Fig. 1: New energy/power quality meter devices installed at the plant point of service shown at left. Current waveform analysis capability available from the meter embedded Web server shown at right.

metering capabilities. The relays also included the capability of network communications. So the panel mounted device could be used for protective functions, plus local and network monitoring of energy data.

2) *Sub-Metering:* The concept of sub-metering was well understood by the project team. Legacy dial-type energy meters had been installed for many years at most every low-voltage MCC load. Energy readings were recorded at the end of each month so accounting could determine cost by operating department in terms of kilowatt-hours per ton of minerals processed. The new system also needed to include this functionality. This approach allowed for accurate measurement across the plant and established "energy users" in each department that were ultimately responsible for improving efficiency for their portion of the process.

At this facility the plan was to install a new energy meter at almost every individual MCC, major large motor, and at some of the individual facility buildings. Although the majority of plant equipment from each of the main process departments was already naturally separated by its own dedicated MCC, there were a few exceptions where this was not the case. Some equipment and the associated electrical loads were shared between multiple plant processes. It was necessary to be able to accurately account for power usage by department. This meant it was necessary to assure the new system had the capability to break out percentages of power usage for equipment that operated under a shared-meter.

Fig. 2: Vintage protective relays were replaced by a single multi-function relay mounted on a common panel and affixed to the existing switchgear door. The original relay panel is at the left and the upgraded panel is at the right.

A sub-meter device for the low-voltage MCC loads was installed as shown in Fig. 3. The sub-meter was a much lower cost device than the point-of-service meters. This was a much better fit for the sub-metering applications since there were multitudes of these devices. The lower cost device offered less functionality than the point of service meters, particularly in the area of power quality monitoring. This was not really important at the multiple secondary sub-meter applications in the plant. However, the sub-metering device did also include its own Web server, similar to the point-of-service devices, as the project engineering team believed this feature would be important in analyzing power factor and energy trending via the in-plant and enterprise networks.

D. Integration into existing process monitoring system

The primary purpose of installing a complete online metering system was for data collection and monitoring. As such, plant staff decided that the installed energy meters and the resulting energy data needed to be integrated into the plant distributed control system (DCS). The intent was to avoid the mistake of installing a new isolated monitoring system that would only be utilized by a few people in the plant. If the system could be integrated into the plant DCS, plant operators would be able to use the additional energy information to improve operational efficiency on a real-time basis. This would also open the door to new ways of using the energy information to operate the plant more efficiently and validate the return on investment associated with future energy projects.

The plant process engineering team was familiar with integration of programmable logic controllers (PLCs) into the DCS system. Much of the data from PLC control systems in the existing plant systems was imported into the DCS via register data. Registers associated with PLC input/output signals were mapped to the DCS system via Ethernet protocol and were then made visible at the plant operator user interface screen by creating tags in the DCS associated with specific discrete input or output signals. For the new energy management system, a similar system topology was selected. All meters in the new system were connected via fiber-optic cables or copper conductors communicating Modbus/TPC protocol (essentially, Modbus over Ethernet). The data was then accumulated into a new host PLC via a Modbus/TCP serial port. Then the DCS interrogated pre-mapped PLC registers and the plant human machine interface (HMI) displayed real-time energy data visible to the plant operators. This systems programming has historically been considered to be fairly complex and is typically considered in the exclusive domain of the systems software provider or a process consultant. However, the local plant personnel were knowledgeable and comfortable with this systems integration task and completed all of the programming using in-house resources. This greatly reduced the overall systems cost, and perhaps more importantly, assured that in-house resources were capable of adding system upgrades in the future and troubleshooting the system during the commissioning stages of the project.

E. A Step Change in Functionality Via Network Topology

Because the newly installed meters, both point of service metering and sub-metering included built-in Web servers, the system network communication topology delivered some unique capabilities. While the metering devices were communicating via Modbus/TPC top the PLCs for interface to the plant wide distributed control system, they were also communications to the business Wide Area Network (WAN) via Ethernet TCP/IP. This allowed the meters to be accessible to multiple users across the enterprise. The plant Electrical and Instrumentation engineers could utilize department PC based software to download power quality event waveforms for analysis and review. Triggers for power disruptions were set at the point of service meters to record waveforms based on power system excursions such as during system transients, sags and swells. Waveform data is recorded and stored at the meter and then system analysis can be performed following an event to determine root cause of the disruption and fix the issue to prevent a reoccurrence. Meters were also accessible by the plant accounting department.

Fig. 3: Sub-meters were installed at most every low-voltage MCC and switchgear panel so that departments could easily track the consumed electrical energy used in their respective process. In the photo at the right above, the old analog meters were left in the panel and shown just to the left of the new digital sub-meters.

Trending of a particular meter that was linked to a specified process would often reveal significant changes in energy based on plant operations. Finally, since the information across the WAN was available across the company, engineers or operational managers at headquarters could also interrogate every meter and access energy data real-time from a single meter or a designated group of meters that were linked to a specific process in the plant. Fig. 4 shows a diagram of the system topology. Note that although the Modbus/TCP and the Ethernet TCP/IP are shown as different communications media, this is only shown to identify the different networks. In actual practice, the same copper communication cable or fiber-optic cable is used to transmit both protocols across a single media or communication conductor.

F. Overall change in the plant operations from an energy perspective

With the new system in place, plant personnel set their sights on developing ways to utilize the new visible energy information. Integration into the DCS system and how the energy information was displayed were important factors in improving operations. The project team took the approach that all plant personnel should be able to make use of the new information. The best way to assure the energy information was meaningful and therefore relevant, was to stay away from screens filled with miscellaneous electrical data. Electrical personnel could individually access each of the meters via the Web browser feature in each meter as discussed previously, when they needed that type of data. Instead the information presented at the DCS needed to be easy to understand, and each HMI screen was designed to be directed at a particular issue.

Since the system was installed during a major plant shutdown, it was a good time to get plant personnel focused on finding new ways to save electrical energy (kilowatts). The first step to accomplishing this task was to clearly show where and how much energy was being used across the plant processes. To answer this first question the engineering staff designed a “System Single-Line Page” that through simple green, and red indicators on a basic one-line diagram, identifies the plant power users at a glance. This screen helped any user (no matter what their level of electrical knowledge) understand where energy was being used in the plant. If greater detail was desired then demand for each individual meter could be displayed with one click. If a user is unfamiliar with the equipment layout of the plant each of the indicators can be clicked on to display a list of the connected equipment. Fig. 5 shows a sample of the system single-line page that was created in the DCS system screen. Note that power circuit breakers in the closed position are designated as green and those in the open position are designated as red. This one screen shows the utility and plant meters, total plant kilowatts (kW), kilovolt-amperes (kVA), power factor and demand at the incoming service and also sub-meter measurements of the same energy parameters.

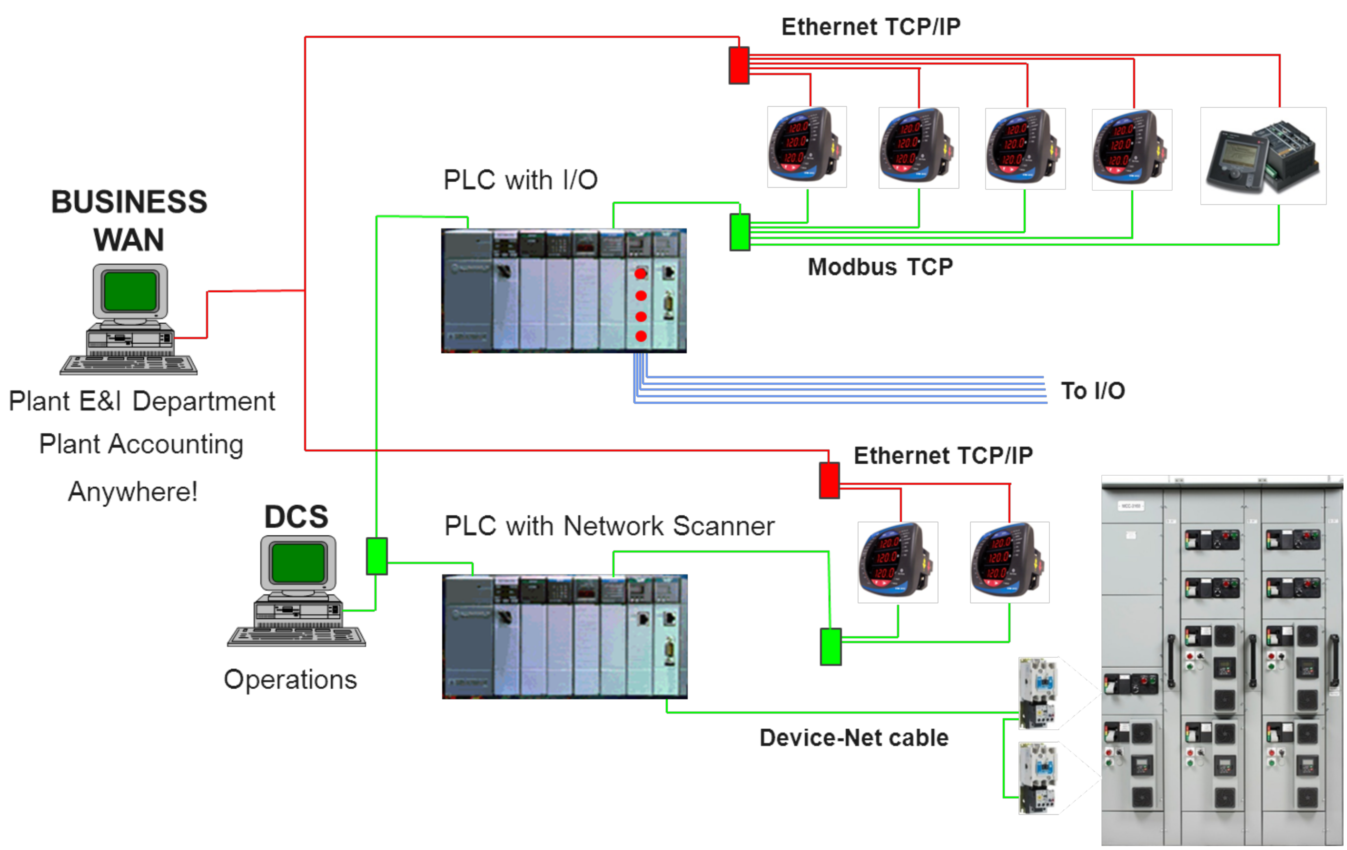

Fig. 4: Network topology for the new system. Modbus/TPC connects the new meters via PLC network communication card to the DCS. Ethernet TCP/IP is used for communication to the business Wide Area Network.

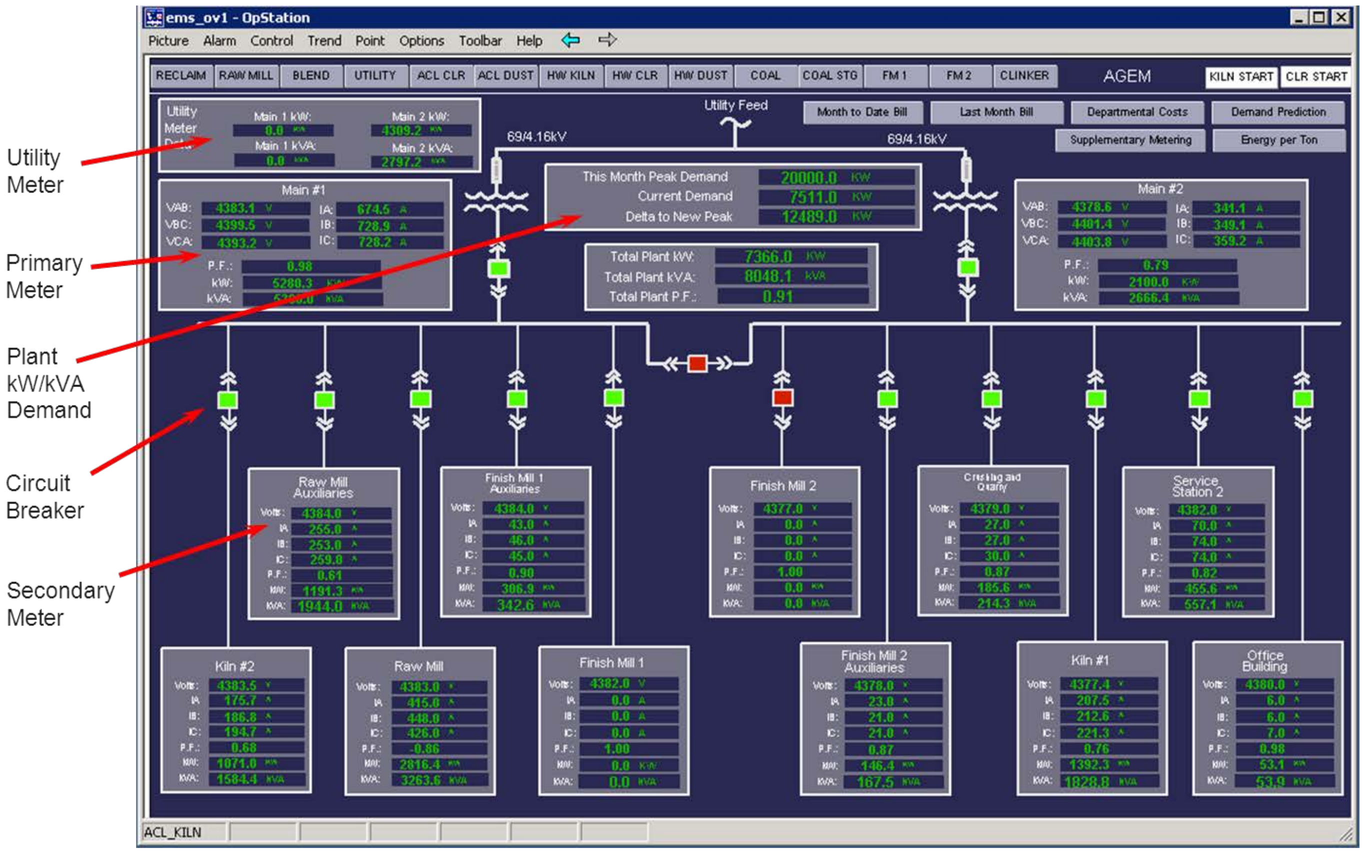

Fig. 5: Plant System Single-Line Page showing entire facility electrical power usage and metered energy data including kW, kVA, power factor and demand for each department.

The next issue the team wanted to tackle was improved visibility and control of plant demand. The utility serving the plant had established a rate structure based on a 15-minute peak demand charge. Typical for most utilities, the rate agreement included both a total kW energy charge and also a kW demand charge. The kW demand peak recorded within a 15 minute operating interval set the billing rate for the entire month of service. It was obviously very important to the plant to have visibility of this metric. When a new kW demand level was approaching, operators were instructed to selectively shed non-critical loads within the 15-minute window to assure a new peak kW charge would not occur. The "System Demand Page" allowed operators to set and view the plant monthly goal for total kW demand. If the demand goal was about to be exceeded, operators are alerted to this system energy event by an alarm. This allows plant operations to make system energy adjustments within the 15-minute demand window to assure a new peak demand level was not set. Fig. 6 shows the system demand page.

Next up was a good DCS interface screen that would measure energy in kilowatt-hours (kWh) for each of the designated energy users in the plant. A slightly different approach was used for the kWh totalizing page. It was difficult to find any way around the natural tendency to create a page full of numerical data for this one. One recognized limitation that was identified in the absence of an energy monitoring system was the inability to identify the cause for large variations in energy consumption for individual processes in the plant over the course of an operational month. With the former system, at the end of every month after taking the meter readings manually, the kWh usage was broken out by percent of total for each department for accounting purposes. Although some months showed large changes in percent of total kWh usage for some equipment, without the ability to trend the data over the course of the month, there was really no way to accurately determine the cause for the differences. To address this issue, the new energy management system also included a "Departmental Billing Page": a totalizing page that continuously totalized energy used throughout the current month including the total kW used, the kW demand and the fuel surcharge. The fuel surcharge measured the contribution of non-electrical energy used in the process. Another page showing total energy by department broken down by month-to-date versus previous month-to-date was created as well. This information was key in delivering answers to questions regarding changes in system operation as plant operators were now able to trend the percent difference between the previous and current month's energy usage. For example, at the end of a month after a 10% difference in the raw mill main fan energy usage was recorded, all accrued on the 9th and 10th day of the month, it was then easy to isolate this back to a period when the raw mill was not operating properly. Corrective action would resolve the problem and improve

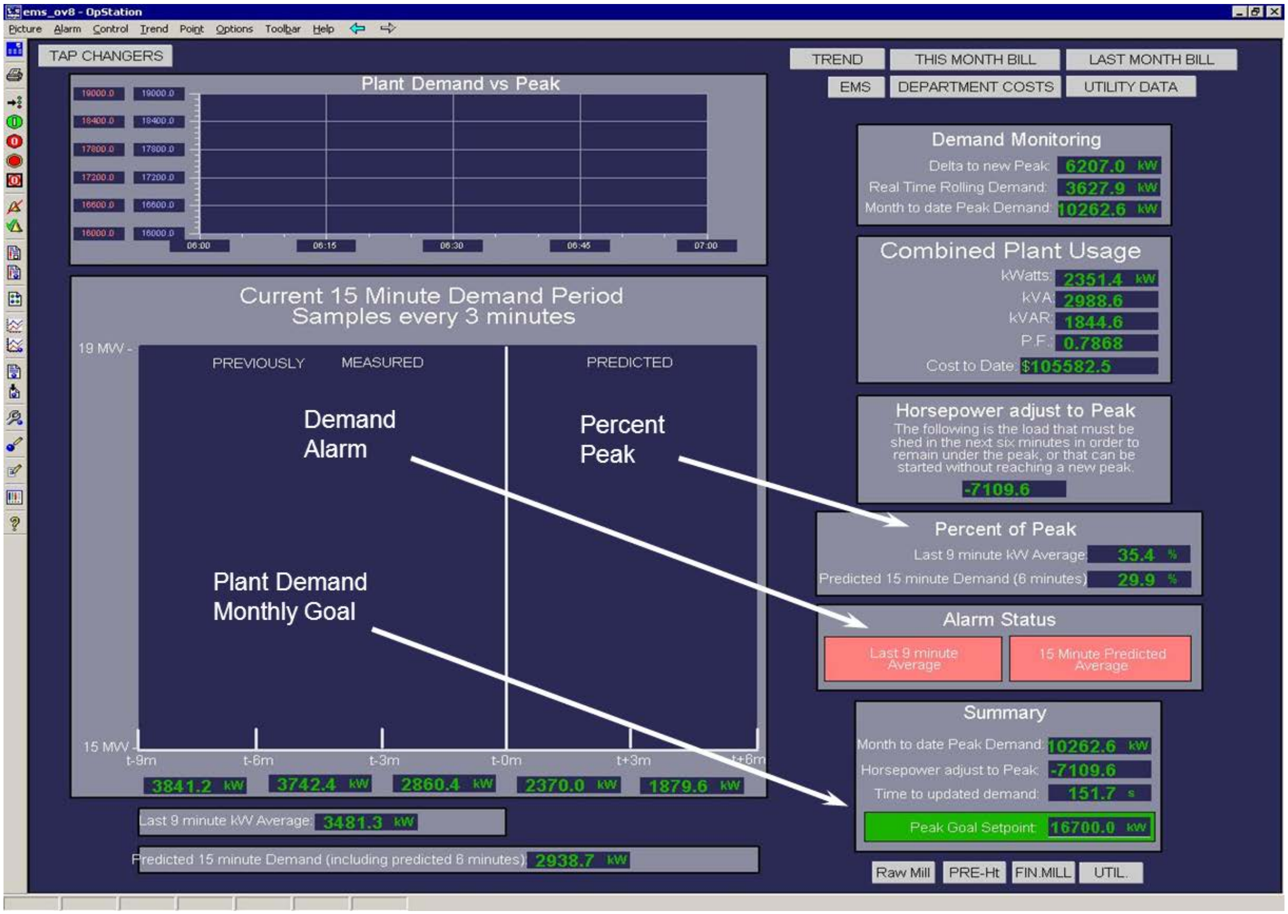

Fig. 6: Plant System Demand Page allows operators to set a kW demand "goal": for the month and shed non-critical loads before a new demand is set within the 15-minute utility demand window.

operating efficiency for the balance of the month, reducing overall cost per ton produced. Fig. 7 shows an example of the plant departmental billing page display with all metered data broken down by energy user.

V. Results

Producing cement at the facility is a continuous process that requires most every system to be operating at rated load when the plant is operating at capacity. The interdependent electrical systems across this plant make it very difficult when the plant is at full production to realize savings from shutting loads down or running on off-peak hours. All the same, the energy management system is delivering measureable benefit in isolating equipment or system inefficiencies as described in previous sections. Currently the system is being utilized to monitor the process and collect usage data that will be used as a baseline for justification of future energy savings projects.

With the new added capability to measure and record power quality data, an electrical outage event occurrence is now quickly followed by the electrical staff utilizing the new metering and Web browser capability to quickly determine the source of the problem. Power quality events can be evaluated on the plant site or from any personal computer across the enterprise with only a standard internet connection. This system is still very new to the plant and new ways of utilizing the data are still being evaluated and developed. With these new monitoring tools at the plant's disposal, plant operators have the ability as never before to easily monitor process efficiency, gain immediate insight into power and energy usage, and analyze past usage trends or power quality events.

From the effort put forth by the installation of the Energy Management System in this plant, corporate objectives for best practices were developed outlining what other facilities in the company would be required to install. The objectives are as followed:

1) Reduce labor requirements by eliminating manual meter readings.
2) Provide a means to review utility billing information by month by supplying real time power and cost information at the plant's DCS system. This will be accomplished by installation of primary and sub metering devices to allow for accounting breakout by department usage.
3) Information will integrate into existing control system so the plants have total control over changes to the system.

4) Energy information will be integrated into the plant DCS/HMI system.
5) Information will be captured and stored in both plant and corporate Historian databases.
6) All departments in the plants will use standardized beginning and ending points for department power comparisons on the corporate level.
7) Systems will be installed so that all power distribution is visible by departments and operators will be able to control department efficiency, demand, on peak – off peak operations and power factor as means to energy savings.
8) Accounting information will be provided as real time values calculated from power usage and factors in billing for each individual facility.

It is the recommendation of the company to utilize third party metering software as a separate source of evaluating electrical issues outside of operations. If installed correctly as it was in the pilot plant, it will prove a useful tool. In this case, information was easily available through an open communications protocol and a simple web-server interface so any plant meters can be accessed from any company server. This has allowed for assistance in troubleshooting plant power issues from the corporate level.

VI. Lessons Learned

From the perspective of the plant team, after the new system was installed and fully operational, one best practice in the company is to review the project and identify lessons learned. The intent of this review is in perhaps helping another plant of the company, should they make plans to install a similar system. In brief:

Things that happened according to plan:

- The system did meet the plant's energy management goals
- The project was completed on time and also met the budget
- The system delivers detailed electrical analysis information for plant electrical personnel
- The system was installed by plant personnel, which provided great value to the company by improving system knowledge, lowering installed cost and increasing "ownership"

Things that took longer than expected:

- Utilizing plant personnel for installation resulted in a longer project schedule. This was depending on the demand to perform their regular duties.

Things the plant personnel would do differently:

- Add greater network infrastructure. There is no such thing as too many communication cables!
- Even though the plant's network was easily up to the task of handling the new equipment bandwidth, there was still a need for small scale expansion of network edge equipment. Having edge equipment that is not as capable as core network equipment can be an obstacle to future network needs.

VII. Conclusions

In the North American Minerals Processing Industry, business leaders and plant operators must work together to create an environment of continuous improvement for existing production assets, constantly focusing on efficiency. The case study presented in this paper serves as a model in the valuable role an energy management system played in creating an improved efficiency environment via an engaged and talented workforce.

Stepping back to look at the bigger picture, energy efficiency will likely become increasingly significant for not only short term efficiency improvements, but also for long-term cement plant viability. Today, it is well understood that emerging environmental standards initiated by the US Environmental Protection Agency are pushing toward further limitation of airborne emission of chemicals such as mercury. Although not presently ratified, these new laws require that all producing facilities conform to new National Emission Standards for Hazardous Air Pollutants (NESHAP) Standards [3], or face fines and potential closure. Because of this, most committed capital in the industry will be dedicated to the addition of containment systems such as improved bag houses, as well as measurement systems to verify compliance. Looking forward, the political climate in the US could follow the path of regulated carbon emissions for industries. New regulations here could have a significant impact on minerals processing plants. For this process, one ton of cement produced generally results in nearly one ton of carbon emissions [4]. Since these emissions can be linked to the energy required as a part of the process, improving the energy consumed per ton of product produced will also have a direct impact on reducing carbon emissions per ton produced. Thus, the focus on energy efficiency at this minerals processing plant will have a positive impact immediately by improving operating costs and perhaps in the future on reducing the carbon footprint of the facility.

The payback period on investment for the four company facilities that are currently on-line at the end of 2011 is 2.5 years, calculated from the plants kwh/ton cost evaluation. From the time of installation to the end of 2011 the utility billing per kilowatt-hour at these facilities has increased an average of 15%. With energy costs only increasing in the future, clearly the time to do this project is now!

VIII. References

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