Advancing Energy Efficiency: One Large Industrial Company's Unique Approach to Strategic Energy Management

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ABSTRACT

Since 2010, one of the Pacific Northwest's largest industrial end users, North Pacific Paper Company, LLC (NORPAC), has been reducing its energy use by leveraging the Bonneville Power Administration's (BPA's) Energy Smart Industrial (ESI) Strategic Energy Management (SEM) program offerings. Due to the site's size, instead of following the typical path of one plant-wide engagement, NORPAC has enrolled in three separate multi-year SEM efforts. Each engagement focuses on a different production area, resulting in staggered program start dates over the past seven years. One company, participating in multiple SEM offerings spanning three separate production areas over an extended time period provides a very unique case study on the impact and delivery of SEM.

This paper is a collaborative effort between NORPAC and ESI. From both site and program perspectives, this paper explores the successes and key learnings derived from the SEM engagements including:

- The human aspect involving the collaboration of site energy project managers, department supervisors, executive sponsors, and maintenance and operations staff with support from off-site BPA, utility, and program energy efficiency experts.
- The importance of flexible program offerings to best support the evolving needs of a large industrial plant.
- The best practices that drive long-term success, including energy mapping, action-item prioritization, active follow-up during implementation, incorporation of capital energy projects, and risk management documentation to reduce the potential for energy savings backsliding.

This paper will show how flexible SEM components drive long-term SEM and capital project energy savings while growing strong relationships among the end user, program, and utility.

Introduction

NORPAC, located in Longview, Washington, produces paper products. It is one of the largest electrical industrial energy users in the BPA's service area. NORPAC was originally formed in 1979 as a joint venture between Japan's Nippon Paper Industries and Weyerhaeuser. Since the mill's founding, employees have been actively and continually improving their processes.

NORPAC, Cowlitz Public Utility District (PUD), and BPA have a long history of working together to implement capital energy projects. For decades, BPA energy efficiency (EE) engineers have provided technical support to Cowlitz PUD for assistance with the development, and measurement and verification, of electrical energy savings projects at their industrial customer sites. In the past 10 years, BPA has assigned an EE engineer to be available approximately one to two days per week on-site at Cowlitz PUD's largest industrial customer, NORPAC, to provide custom project technical support. There are numerous energy efficiency and strategic energy management benefits – local, regional, and national – to this ongoing working relationship amongst BPA, ESI, Cowlitz PUD, and NORPAC.

Nearly twenty years ago, a newly-hired NORPAC electrical engineer ran across some feasibility studies that had been shelved prior to implementation. These studies outlined a number of appealing AC drive energy reduction opportunities, and in 1999 he started implementing these projects. In 2000, Cowlitz PUD and BPA Energy Conservation engineers met with the NORPAC engineer to discuss an upcoming Conservation & Renewables Discount (C&RD) rate credit. Under the CR&D and the following Conservation Rate Credit initiative, NORPAC, Cowlitz PUD, and BPA engineers developed a conservation renewal program and continued to pursue projects. BPA engineers provided technical assistance starting in the early 2000s, both using local resources and with the help of the Department of Energy's Industrial Technologies 'Save Energy Now' initiative (US DOE 2010).

This collaboration created a foundation enabling NORPAC, Cowlitz PUD, and BPA to work together to implement one of the Northwest's largest capital projects which developed over a decade of work, saved over 11.8 aMW and took over two years to implement (VanHoose, Swier, and Milan 2013). During this time, BPA assisted in co-funding a plant engineer to work on the project. The engineer's success helped provide direction to the ESI program's Energy Project Manager (EPM) offering.

In 2010, NORPAC hired their first official Energy Conservation Manager to oversee projects and create a framework for the mill's conservation program. This manager became one of the first to enroll in BPA ESI's new EPM pilot, which seeks to drive energy savings by co-funding an on-site engineer to focus on energy projects. In October 2010, mill staff, Cowlitz PUD, and BPA ESI met to discuss ESI's first SEM cohort pilot called High Performance Energy Management (HPEM). The NORPAC team was interested in the tools proposed and drawn to the ability to apply the program to a stand-alone process area.

By the following day, the EPM drafted a handout outlining HPEM start-up in the Deink area. The Deink process removes ink and contaminates from recycled paper and provides recycled paper pulp for paper production. The Deink plant was an attractive area because the plant had been designed for higher flow rates, and was currently underutilized. Underutilized equipment often runs inefficiently at part-load, and cost reduction is highly valued when production levels are below design.

The Deink plant was also appealing due to the personnel that were available and interested in participating in the area's energy team. NORPAC also felt confident the production-to-energy relationship could be modeled. The five-year program utilized the benefits of SEM to allow the EPM to focus on both SEM and capital projects.

After HPEM proved successful, the Paper Mill enrolled in a more technical-based SEM engagement called Track and Tune (T&T) in 2015. The Paper Mill includes three large paper machines which convert pulp to product. In the final program area, the Thermo-Mechanical Pulping (TMP) mills, there are two TMP mills which convert wood chips into pulp for paper production. The TMP mills began their energy engagement in 2016. Figure 1 summarizes the NORPAC SEM timeline. Table 1 summarizes the process areas by SEM program.

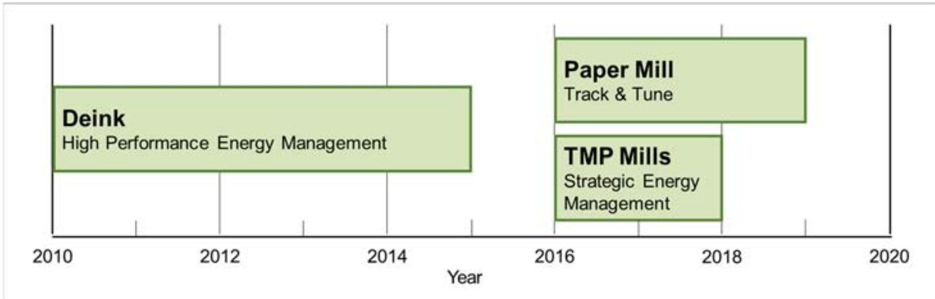

Figure 1. Summary of NORPAC SEM timeline by reporting period. Enrollment and planning periods prior to the reporting periods are not included.

Table 1. Summary of NORPAC SEM process areas and SEM program participation

Process Area	Site Process Description	ESI Energy Management Program
Deink	Removes ink from recycled paper and provides recycled paper pulp for paper production.	HPEM – Focus on applying continuous improvement practices and framework to energy efficiency.
Paper Mill (PM)	Includes three large paper machines and their auxiliary equipment. Converts pulp from Deink and TMP mills into various paper products.	T&T – Focus on technical (action item) identification and implementation.
Thermo-Mechanical Pulping (TMP) Mills	Includes two mills which convert wood chips into pulp for paper production.	SEM – Restructured to provide HPEM and T&T benefits tailored to the site. In this case, very similar to T&T.

Strategic Energy Management

Due to NORPAC's size, the facility's process areas are essentially siloed into quasi-independent sub-sites. Each sub-site has clear electrical and social differences which make them ideal candidates to divide into smaller SEM agreements. Some personnel, such as the mill's EPM(s), support the entire facility. EPMs at NORPAC have been strong drivers of SEM due to their knowledge of the energy efficiency programs and the inner-workings of the whole facility.

The initial SEM offering, HPEM, had potential to be beneficial to all parties. NORPAC gained a pathway to meet corporate commitments to reduce energy intensity by 2.5% per year for the next 10 years without large capital expenditures. The cost reductions associated with improved energy intensity were also appealing in NORPAC's competitive market. Cowlitz PUD had energy conservation targets set through Washington State Initiative 937 (An Act 2006), and BPA and their ESI program were committed to achieving energy efficiency improvements to meet targets set by the Northwest Power and Conservation Council.

However, there was also risk. HPEM attributed savings annually over a five-year period. While a multi-year program allowed the EPM to utilize the benefits of SEM to pursue both SEM and capital projects, five years is a long time to commit on-site energy team resources and coordinate support from off-site utility and program resources. Additionlly, bi-monthly cohort meetings during the first year would be a large time commitment for NORPAC, and the program time commitment would be compounded by site-specific support requirements. Nonetheless, NORPAC was highly interested in the HPEM tools, including energy mapping, energy scans, opportunity registers, and energy management assessments.

Deink Mill: First Engagement

Year 1: Overcoming a Late Start

NORPAC's Deink team and process showed promise, but the team faced immediate hurdles: in addition to fully populating the energy team and developing a comprehensive charter and action plan, metering had to be added. Without an improved measurement system, the team could not track or trend progress. Therefore, the team delayed rolling out HPEM to the Deink area for the first several months of year 1.

Once assembled, the energy team was an ideal mix of operators, supervisors, and plant engineers empowered to make and implement decisions (see Table 2). As the executive sponsor, the mill manager supported the efforts and was kept up to date on the project status. The two advisors – the EPM and the original intrepid electrical engineer – both provided energy efficiency and management support as their roles touched across the entire mill. Two co-energy champions knew the process very well and had enough autonomy and control to drive change. And finally, the team included an operator from each shift who knew the process well and who could take responsibility for operational changes.

Table 2. Deink energy team

HPEM Role	Title
HPEM Sponsor	Mill Manager
Advisor	Site Energy Conservation Manager
Advisor	Electrical Maintenance Manager
Co-Energy Champion	Fiber Products Team Leader
Co-Energy Champion	Fiberline Team Member
Team Member	Crew A
Team Member	Crew B
Team Member	Crew C
Team Member	Crew D

Including an operator from each shift is a scheduling challenge. Regardless of a team's meeting time, someone is on shift, someone has just finished a shift, someone will be starting a shift soon, and someone has the day off. The challenging logistics of including a member from each shift often prohibits operators from regularly attending meetings. Nonetheless, NORPAC made strong efforts to keep each shift involved. This was crucial since operations run 24/7 and long-term persistence required operator buy-in.

While the metering issues were being resolved, the energy team and ESI dedicated time to create an energy map of the Deink system. The energy map diagramed horse power, operating hours, and estimated load for key equipment in each process area. Figure 2 provides a simplified version of the energy map. This tool proved to be crucial to the team, clarifying major energy users and helping to direct the team's focus. An energy scan identified opportunities for savings and provided the team a platform for recording, prioritizing and assigning responsibility for action items. The team took the list and continued to add ideas. Many of the opportunities identified involved turning off idle or redundant equipment when production was low or improving system efficiencies (specific energy) at various production levels.

The BPA ESI energy coaches supported this effort by meeting with each shift. They presented the program and Deink energy map, fielded questions, and gained mutual understanding. BPA engineers and Cowlitz PUD representatives attended workshops and participated in on-site support, providing valuable technical and programmatic insights.

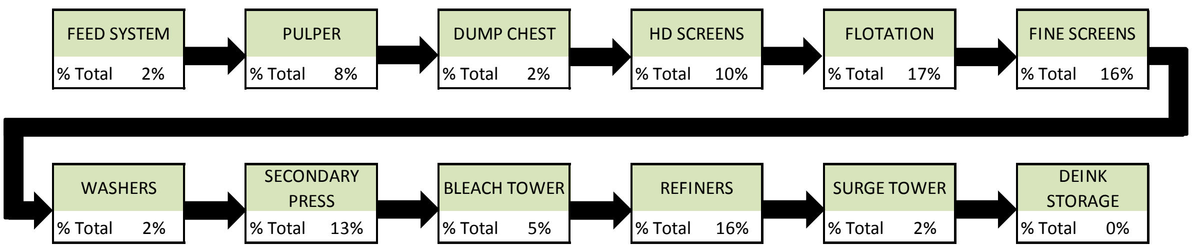

Figure 2. Simplified Deink energy map. Total percent power is less thant 100% due to the exclusion of some subsystems.

In March 2011, the Deink team began implementing action items. Although the metering issues delayed their start, the impact of their work was immediately apparent in the energy model's cumulative sum of residuals (CUSUM) chart (see Figure 3). The CUSUM was updated and shared at monthly meetings with production teams. The energy team crew members distributed updates and best operating practices to their crews, spreading a web of awareness and proactivity.

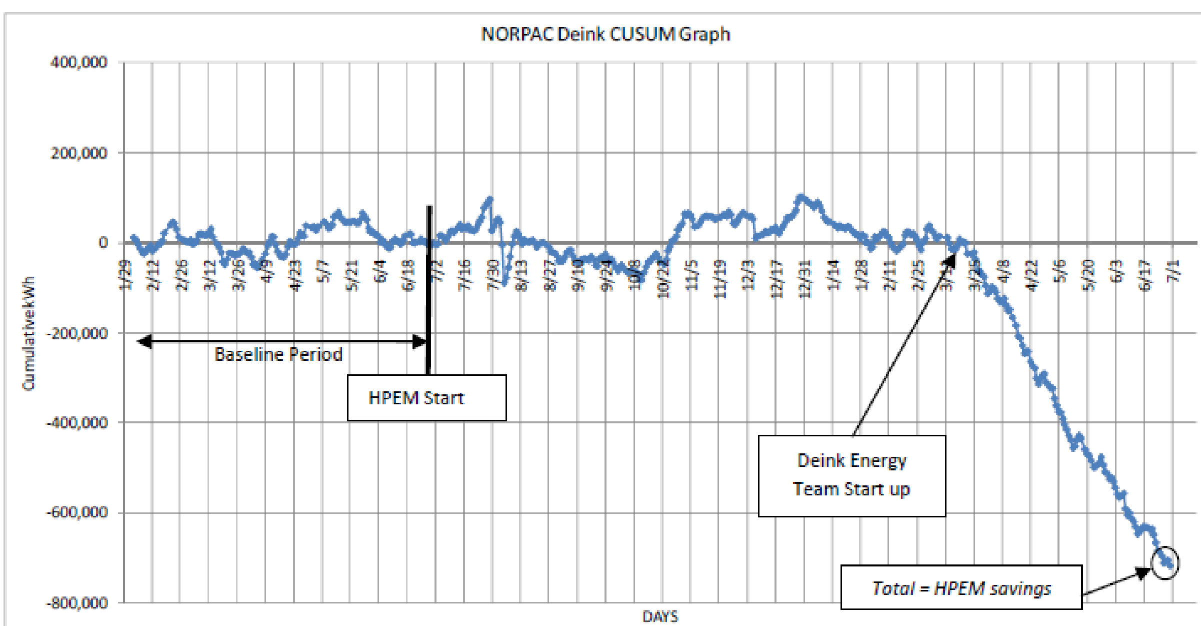

Figure 3. First-year cumulative savings (CUSUM) chart for Deink. Negative values indicate energy savings.

Years 2 through 5: Successes and Challenges

The two co-energy champions continued to hold responsibility for maintaining Deink's energy performance throughout the engagement. However, when the majority of identified operations and maintenance (O&M) opportunities were addressed, the Deink team transitioned to a sustaining mode. While the energy champions periodically reviewed the CUSUM tracking worksheet, energy performance was not as regularly communicated, and the energy team did not meet during the fourth year. Despite the lack of energy-related implementation activity, the team's early efforts to document best practices in the form of the Deink Energy Reduction Guidelines helped ensure ongoing adherence to efficient standard operating procedures.

During the final year of the engagement, market demand declined and the plant was underutilized, experiencing significant plant curtailments. Although the energy team had developed strategies to shut down or curtail underutilized systems during certain operating regimes, the degree of underutilization was too high to overcome during the final year (see Figure 4). The production rate was significantly lower, which also lowered the potential baseline. In addition to the curtailments, staff were increasingly faced with competing priorities which reduced the focus on energy efficiency.

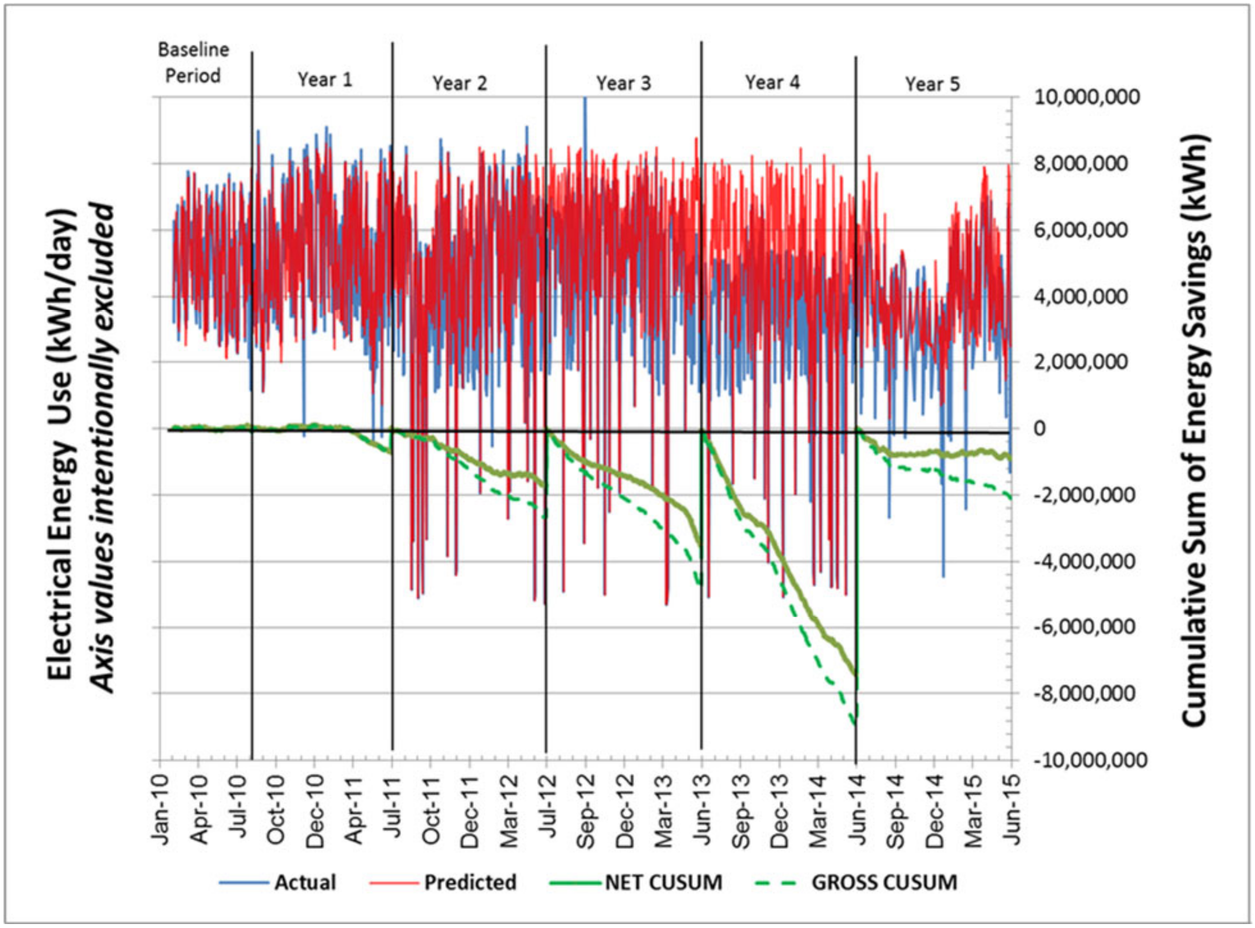

Figure 4. Deink predicted and actual energy use (scale intentionally excluded) and CUSUM over the five-year HPEM period

Reflecting back on the five-year experience, the Deink energy champions emphasized the importance of the foundation-building activities that occurred in the first year of HPEM. Specifically, power metering was installed and a baseline model was developed before employee involvement began. This delayed the start of HPEM, but it provided the team a good method by which to measure performance. The energy team included a balance of managers, area leaders, and at least one representative from each of the four shifts. The team received training from ESI on common sources of energy waste, and the group collaborated on the development of an energy map. With the team formed and foundational training in place, the group began identifying and addressing O&M opportunities. As new practices were identified, they were documented in the form of "Deink's Energy Reduction Guidelines."

This process followed an intentional approach that NORPAC has successfully applied in other areas of continuous improvement. While the energy team is no longer actively meeting, the energy map is still posted, the leadership group is using the CUSUM tool, and Deink employees continue to identify and submit energy savings ideas.

Paper Mill: Applying SEM Best Practices to a New Area

As HPEM concluded, NORPAC's EPM considered how energy management could be successfully transferred to the Paper Mill and TMP plants. Like the Deink plant, these two areas operate as their own micro-businesses within the site. Building on experience, the EPM focused on building internal support from the operating floor up and the executive management level down.

The new efforts would be different from the Deink HPEM engagement. HPEM focused heavily on SEM foundations and framework: building an energy team, engaging employees, properly characterizing energy use, etc. With the basic building blocks in place, the EPM and Deink team could help prepare other mill energy teams, freeing up the ESI program to apply a more technically focused offering.

Both the Paper Mill and TMP plantswere considered, but the TMP area was focused on implementing another large custom energy efficiency project and did not have the bandwidth for SEM. The Paper Mill, however, had management support and an energetic energy champion ready to lead. Co-funded through ESI, NORPAC brought in a system expert to evaluate over 20,000 hp of vacuum motors. Multi-day tune-ups of the remaining systems and compressed air use were supported through ESI-funded Technical Service Providers (TSPs). The tune-ups were highly collaborative efforts to identify and quantify potential action items. NORPAC's energy, maintenance, and operator teams provided ideas and feedback.

The NORPAC team repeatedly asked, "How else could we?" when confronted with challenges to the proposed improvements. The team only said no to ideas after they had evaluated potential alternatives and determined that adverse production, cost, safety, or reliability concerns rendered the potential solutions unviable at present. The energy team and TSPs identified and quantified over 100 measures with potential savings of more than 42 million kWh/yr.

Prioritizing Action Items

During the closing meeting of each tune-up event, the energy champion and TSP reviewed the action items identified, and prioritized them based on a risk/value quadrant system (see Figure 5). Without prioritization, long lists of action items often overwhelm energy teams resulting in limited adoption.

Figure 5. Paper Machine tune-up risk and savings prioritization

In this system, “gems” have both high savings and low risk potential. Normally three to five “gems” would be selected to implement first. However, the energy champion was able to delegate tasks to his very active team members. The team successfully implemented 69 action items over the course of a nine-month implementation period. All action items were evaluated, with potential process or quality impacts eliminating some and with some still in consideration for future implementation. Eleven custom or deemed lighting projects were also completed by the end of the implementation period.

The Paper Mill T&T also had another source of support. BPA collaborated with Cowlitz PUD and NORPAC to co-fund an energy intern from the University of Washington Bioresource Science and Engineering program, with a specific focus on electrical energy efficiency improvements. The intern was instrumental in providing program and TSP staff with data from the NORPAC Plant Information System for analysis in estimating action items’ savings potential. The intern provided critical technical assistance to the energy champion by moving action items towards implementation, establishing and reviewing key performance indicators to ensure savings persistence, and taking corrective action to address backsliding. The intern also helped develop and implement at least three energy efficiency capital projects during 2016.

Maintaining Savings

The substantial energy savings achieved through these efforts contributed over 40 million kWh towards the 2016 and 2017 Cowlitz PUD and ESI energy savings goals. For the biennium, these savings exceed Cowlitz PUD's I-937 requirements (EES Consulting 2016) and account for over 13% of ESI's target (BPA 2017). However, as the program and utility have observed over time, SEM savings can be vulnerable to backsliding, especially when many measures are implemented without clear documentation. To reduce risk of backsliding, the implementation process was carefully documented during monthly follow-up calls. Action item status updates were reviewed and potential issues noted. An energy savings risk assessment plan was developed and added to this tracking. The risk assessment numerically rates the likelihood of action item reversal and the magnitude of energy savings impact. Values with high scores are prioritized for documentation of the risk, warning signs, and the potential resolution. Figure 6 provides an example of evaluation methods.

Risk	Likelihood (1-5)	Savings Impact (1-5)	Score (LxI)	Risk Management Approach/Mitigating Actions	Warning Signs
General Items					
Competing priorities impede implementation progress.	4	4	16	Continue monthly T&T update calls, facilitated by TSP	Calls unexpectedly cancelled
Retirement of key Energy Champion team members	3	2	6	Intentional cross training efforts. Ensure systems put in place to verify effectiveness of implementation.	
PM #1 (Savings potential = 11.1 million kWh)					
NORPAC restarts Bel-Baie #5 Vacuum Pump	2	5	10	Implemented 9/17/2015. Involve TSP early if there's a concern about vacuum capacity. Determine how vacuump pump 0399 was decommissioned (e.g. removed, locked out, etc.)	

Figure 6. Rating guidelines for energy savings project risk assessment

This risk assessment addresses one of the key energy savings degradation pathways. SEM savings are often directly tied to site behavior rather than the removal of equipment or other hard-to-reverse changes. When standard operating procedure documentation includes settings to reduce energy consumption, there is a higher chance of persistence. But when energy champions (official or not) are the primary guardians of the implementation, the burden of maintaining energy savings is not readily transferrable. By generating a list of key action items and what settings or procedures are needed to maintain them, NORPAC now has a resource for anyone in the area to refer to if backsliding begins.

Tracking and Communicating Savings

The Paper Mill energy model was a challenging undertaking as it included three paper machines bundled into a single SEM agreement. This protects the PUD and BPA against claiming savings in areas where load could shift from one paper machine to another. For example, some of the refiners served by one paper machine's electrical meters can provide pulp to all three paper machines. Similarly, two of the paper machines share many auxiliary pumps, making the allocation of electrical consumption difficult.

In the end, the ESI program found that the most statistically significant model aggregated the energy use for all three machines into one model. However, a per machine energy model is more useful day-to-day for NORPAC. The ESI program worked to provide unofficial models and continues to update the official and unofficial models on a monthly basis. NORPAC's information technology team has integrated these unofficial individual paper machine models into their widely-used plant data historian. This allows the energy champion and anyone else on site to review the data on a frequent basis. Similarly, key performance indicator dashboards, created by the intern, provide transparency on individual action items. The CUSUM chart (Figure 7) is shared weekly at production meetings and monthly with executive sponsors.

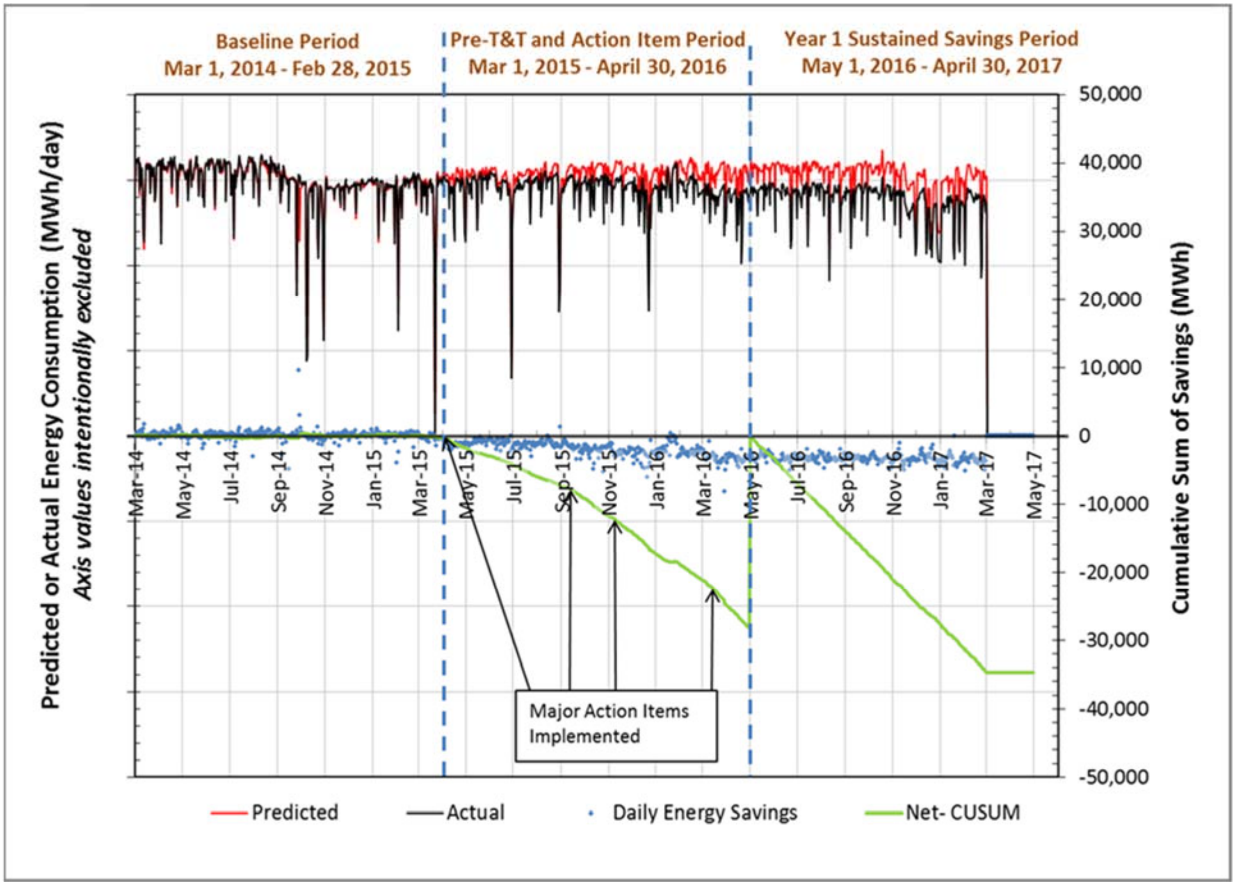

Figure 7. Paper Mill energy use (scale intentionally excluded) and CUSUM chart. Energy savings are indicated by a negative CUSUM slope.

The ESI team helps monitor changes in the data trends, and is currently undertaking a non-standard model adjustment to account energy intensity changes attributed to a new product. Moving forward, NORPAC and ESI plan to review additional O&M opportunities through on- and off-site technical support. NORPAC also continues to identify and implement capital and O&M projects in the area.

TMP: Good Opportunity, Challenging Circumstances

NORPAC implemented three mega-projects in the TMP mills from 2007 through 2015, including the well-documented interstage screen project (VanHoose 2013). In 2016, the TMP team entered an SEM agreement and turned their focus to an advanced controls project, which if successful, would improve pulp quality and substantially reduce the energy use per ton of pulp produced.

An enthusiastic and capable energy champion, management support, and energy team members were identified and willing to commit. Unlike the Deink and Paper Mill engagements, the TMP team's primary focus would be less disperse as the controls project required substantial bandwidth from the entire TMP team.

The TMP mills have faced challenges the Deink and Paper Mill areas have not seen. In addition to the complex nature of the controls upgrade, which to date has required consistent oversight from the energy champion, the site dynamics have changed. Right before the sustained savings period began, NORPAC was acquired by One Rock Capital Partners, LLC (Luck 2016). As with any change, resources are needed to understand and meet new priorities. Around the same time, several employees retired, including TMP's original energy champion. Clear communication and preparation allowed another founding team member to step directly into the energy champion role, but the TMP team is still resource-constrained.

Even with all of these challenges, initial savings from the controls project are promising, and the project has not yet reached its full potential. NORPAC and ESI have identified almost 3.5 million kWh of O&M action items during tune-up events, but these measures have been on hold during the transitions. Mill management and the site EPM are reviewing potential resources to lend TMP in the interim.

The energy champion shares CUSUM updates at regular production meetings. Monthly follow-up calls with mill, utility, and BPA ESI participants are held to review data and provide technical insight. Similar to the Paper Mill, the TMP models auto-calculate in the site's mill-wide data historian so data can be reviewed as needed.

Conclusions

NORPAC has participated in three SEM projects, multiple EPM agreements, and saved megawatts through capital projects. Their approach to energy efficiency is highly successful, and learnings from their work are applicable to other sites and programs. The following best practices have been critical to their success:

- Collaboration between NORPAC, Cowlitz PUD, and BPA energy efficiency programs is crucial. These long-term relationships build trust, enable identification of the right support, and drive energy savings, both capital and O&M.
- Large sites often have stand-alone unit operations. These production areas are good candidates for separate SEM engagements. Siloing keeps site-wide resources (maintenance, information technology (IT), and engineering, among others) from overloading and creates flexibility to pick an optimal initiation time for each area's SEM engagement.
- An energy team needs executive support, an enabler, operations, and maintenance to maximize success. Behind the scenes they need technical and logistical support including purchasing, storeroom, IT, and contractors.
- Tools such as energy maps, standard operating procedures, energy scans, opportunity registers, energy models, and risk assessments are valuable to driving site energy savings. Develop these tools early and consistently communicate process area energy reduction guidelines.
- Off-site technical resources enable energy savings by freeing up on-site bandwidth to maintain the needed production focus.

- Anchor projects are excellent "fast wins." All three areas started their engagements knowing that a large system had significant opportunity. By addressing these first, energy savings were immediately visible, which helped the energy teams get traction.
- Cultivate widespread energy conservation enthusiasm. In the Deink HPEM, the energy team led the charge. Recognize energy milestones and achievements, individually and collectively. Energy champions can truly be the galvanizing force that can help maintain focus, marshalling resources, support, and pride.

Along with best practices, NORPAC also experienced challenges that diverted focus from their energy efforts.

- People drive SEM savings. When competing priorities reduce their bandwidth, energy savings tend to backslide. Active site and program follow-up can help reduce this and identify opportunities for the program to provide support.
- Market changes cannot be controlled, and can impact SEM project savings by forcing the plant to operate at a more or less efficient production level (Deink years 4 and 5) or by shifting focus to other priorities.
- Energy team members will move on. Succession planning helps to minimize adverse impacts of energy team changes.

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