Program Design Features that Cultivate Industrial Mega-Projects

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ABSTRACT

Since its inception in 2009, Bonneville Power Administration's Energy Smart Industrial (ESI) program has achieved over 120 average megawatts of verified electrical energy savings in the Pacific Northwest. Mega-projects are generally defined as those with savings greater than one average megawatt and they play an increasingly important role in helping industries and demand side management programs reach their energy savings and cost-effectiveness goals. Successfully implemented, Mega-projects also further build the foundation for long-lasting partnerships between industry, utilities, and programs.

While Mega-projects may take the form of either large capital upgrades or strategic energy management (SEM) initiatives, they often involve process-oriented measures that require not only a deep understanding of manufacturing operations but also, unique approaches to program implementation and support. An organization's energy management practices are key factors in how Mega-projects originate, progress through the development phase, and are ultimately implemented and sustained.

This paper explores the unique blend of program design features that lead to successful Mega-projects, with an emphasis on the complementary nature of capital projects and strategic energy management program components. The importance of developing trust and strong working relationships between industry, utilities, and program implementers is also explored. Finally, the paper will outline specific strategies for managing the implementation and persistence of Mega-projects, drawing from lessons learned from eight Mega-projects completed since 2012.

ESI Program Overview

The Bonneville Power Administration (BPA) is a federal nonprofit agency, based in the Pacific Northwest. BPA markets wholesale electrical power from 31 federal hydro projects in the Columbia River Basin to over 120 utility customers. As part of its responsibilities, BPA promotes energy efficiency, renewable energy, and new technologies.

In 2005, BPA recognized the need to boost the industrial sector's contribution to the region's annual energy conservation goals. Following three years of missed targets and the completion of a detailed program Best Practices study, BPA contracted with Cascade Energy to collaboratively design and implement a new industrial energy efficiency program to meet this challenge. Months in the making, the design team recognized that technical expertise, industrial experience, the ability to forge lasting professional relationships, and exceptional communication skills would be critical to a successful and long-lasting program. (Eskil, Wood, and Wilcox 2011). The new energy efficiency program -- Energy Smart Industrial (ESI) -- was designed to serve a diverse range of industrial customers across BPA's service territory. The rollout of a comprehensive program with complementary component offerings laid the groundwork to develop and implement several of the largest, most cost-effective energy efficiency projects completed in BPA program history.

Program Design

ESI offers a unique and fully integrated set of program offerings (see Figure 1 below). Industrial end users participate in the program through three main channels: custom capital projects, strategic energy management (SEM) projects, and trade ally-driven projects. These offerings are facilitated and administered by a team of Energy Smart Industrial Partners (ESIPs) who act as the single point of contact for all stakeholders. If additional technical support is required for custom projects or SEM engagements, ESIPs request services from an ESI-managed pool of Technical Service Provider (TSP) consultants.

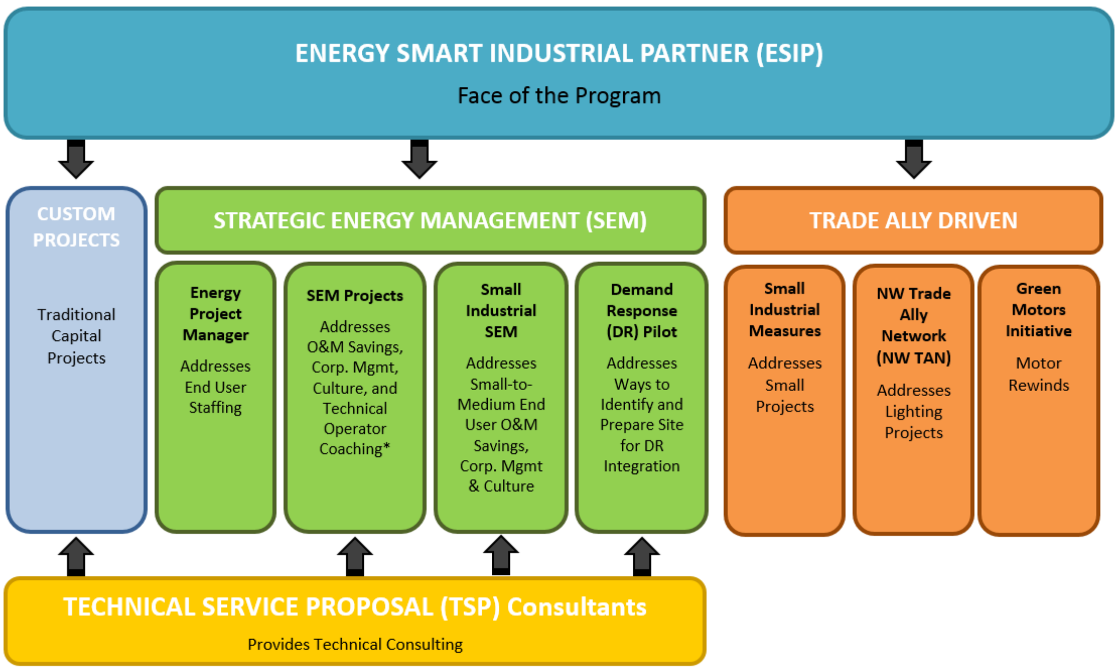

Figure 1. ESI Program Components

Regional Results

The ESI program has delivered unprecedented energy savings in the industrial sector. Since its launch in 2009, ESI has delivered approximately 120 aMW (over 1 billion kWh), significantly exceeding its targeted delivery for this period of 79 aMW. The program boasts an enrollment of 115 utilities, representing a 94% sign up rate and 99% of BPA's overall industrial load. Ninety-nine of these enrolled utilities have used one or more ESI component, and 57 have completed an industrial energy efficiency project for the first time. The ESI SEM program, which dropped its pilot designation in October of 2015, currently manages 80 active projects and has booked approximately 13 aMW of behavior-based and operations and maintenance (O&M) energy savings.

ESI customer engagement is high and feedback has been overwhelmingly positive. Consultants from Research into Action, a program evaluation and market research firm, completed a thorough process evaluation of the program in 2012 (McRae et al 2012). Approximately eight out of 10 survey respondents from the industrial sector said they were highly satisfied with services received through the program, and three out of four utilities said

ESI helped them complete more energy efficiency projects in the industrial sector. Utilities of all sizes have found the right program component mix for their industries through the ESI program.

Mega-Projects

For the purposes of this paper, the term Mega-project is defined as a custom project or strategic energy management engagement resulting in annual savings of one average megawatt (8,760,000 kWh) or more. This project size was chosen as the definition of the term Mega-project because of how unusual a project of that size is (only 8 of the 1,360 projects completed) and because they represent such a significant percentage of the program's savings (about 25% of the program's savings to date).

Table 1 provides a summary of the eight Mega-projects implemented since the inception of the program, sorted in a descending order of savings in aMW.

Table 1. Summary of ESI Mega-Projects

ESI Mega-Project Summary						
Mega-Project	Completion Date	Industry Type	Savings (aMW)	Project Cost	Incentive Paid	Program Component
1	Jun-2012	Pulp and Paper	6.9	$ 25,166,783	$ 12,630,088	Custom Project
2	Apr-2016	Pulp and Paper	5.5	$ 1,374,262	$ 961,983	Custom Project
3	Feb-2017	High Tech	5.3	$ 8,778,860	$ 4,192,819	Custom Project
4	Apr-2014	Pulp and Paper	5.0	$ 25,300,417	$ 10,927,757	Custom Project
5	Sep-2016	Pulp and Paper	3.8	$ 299,848	$ 209,897	SEM-Track and Tune
6	Sep-2015	Chemical Processing	1.3	$ 11,840,839	$ 2,926,328	Custom Project
7	Jun-2016	Pulp and Paper	1.3	$ 97,770	$ 766,633	SEM-Track and Tune
8	Jun-2015	Food Processing	1.0	$ 606,534	$ 303,267	Custom Project
Totals:			**30.1**	**$73,465,313**	**$ 32,918,771**	

Figure 2 shows the distribution of projects binned by project size (e.g., "0.02" represents 0.01 to 0.02 aMW savings range), followed by the distribution of total program savings also binned by project size. This data shows that 24.6% of ESI's total program savings from 2010 to present were acquired by just over one-half of one percent of the total projects by count.

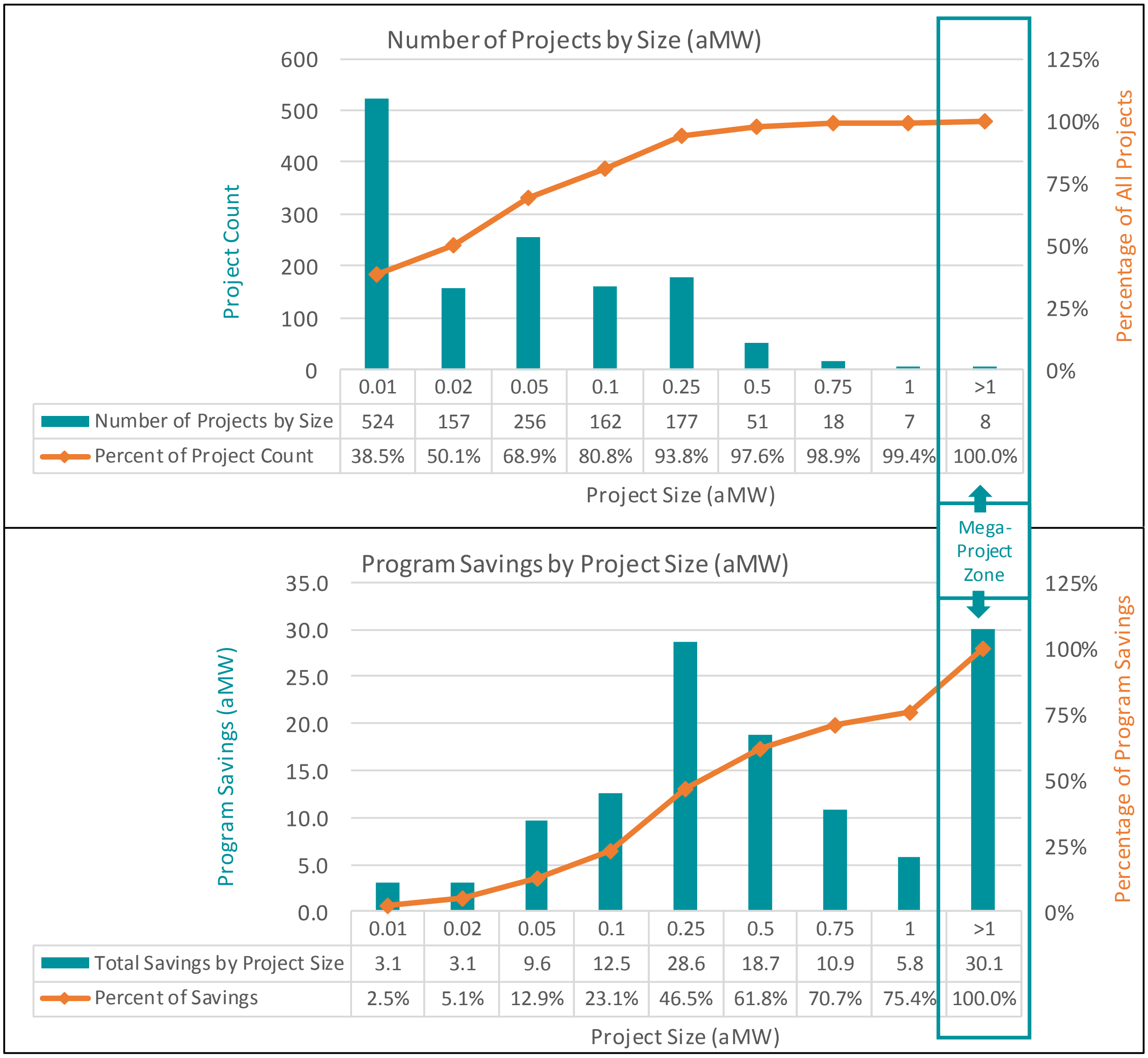

Figure 2. Distribution of ESI Program Projects Binned by Project Size

Why Mega-Projects are Important

Mega-projects are an essential part of a top performing regional industrial energy efficiency program. As programs mature and market participation increases, the low hanging fruit becomes scarce. Large projects that address process-oriented measures can help offset this tendency and help the program continue to meet aggressive goals in a cost effective manner. The eight projects discussed in this paper achieved an average savings of 3.8 aMW. All other projects average approximately 0.07 aMW of savings. This means that it would take about 55 average sized projects to replace a Mega-project. Assuming that program overhead roughly scales with the quantity of projects being handled, to acquire the same level of savings without these Mega-projects, the program would need to be 33% larger. One-third more ESIP resources, one third-more technical service provider resource, one-third more administrative support, etc.

Success Factors

ESI has identified several key elements that have worked in our favor for making such inroads. They include program flexibility with complementary offerings, the importance of collaboration, and leveraging characteristics common among successful Mega-projects.

Mega-projects are unlikely to be a facility's first interaction with their utility's EE program. It has been the program's collective experience that these types of projects generally are the result of several successful interactions. Because these Mega-projects often address opportunities within the participants' core processes and technologies, the privilege of discussing Mega-projects with an end user requires a strong professional relationship and a high degree of trust. There is also a heightened sensitivity to risk taking and information sharing. Generally speaking, you have to earn the right to suggest changes to any company's core process.

For example, Table 2 shows a site with 38 utility incentivized, successful energy efficiency projects implemented over a five-year period prior to completing their Mega-project.

Table 2. Project History Leading to Mega-Project 7

Path to a Mega-Project: One End User's Journey					
Fiscal Year	Completed Custom Projects	Custom Project Savings (aMW)	Completed SEM Engagements	SEM Savings (aMW)	Total Savings (aMW)
2010	14	2.1	0	0.0	2.1
2011	11	2.1	0	0.0	2.1
2012	4	1.0	0	0.0	1.0
2013	3	2.1	0	0.0	2.1
2014	1	0.0	0	0.0	0.0
2015	3	0.7	3	0.8	1.5
2016	2	0.8	0	0.0	0.8
Mega-Project Completed in June 2016!					1.27
Totals:	**38**	**8.8**	**3**	**0.8**	**10.9**

Flexible Program with Complementary Offerings

The Mega-projects referenced in this paper occurred at large industrial plants, each with over $10 million of annual electrical energy spend. A flexible program design, consisting of complementary offerings, was critical to achieving deep savings over a multi-year horizon. ESI's programmatic flexibility took three important forms.

First, ESI's program components were structured to address common barriers to the implementation of energy efficiency projects. For example, the Energy Project Manager (EPM) component was designed to address personnel resource limitations in industrial facilities. Seven of the eight Mega-projects listed in Table 1 were managed by individuals who enrolled as EPMs in the fiscal year 2010. As a condition of receiving salary co-funding, these EPMs were accountable for establishing and achieving annual savings goals, and reporting progress to internal and utility stakeholders. Over a multi-year period, these EPMs became skilled in identifying energy efficiency opportunities, particularly those large process-oriented measures that ultimately became Mega-projects (Amundson, Eskil, and Martin 2011). Table 1 shows that two of the projects were supported and incented through ESI's Track and Tune component, further illustrating the importance of complementary program components. Track and Tune provided a pathway to address a large-scale operations and maintenance (O&M) based efforts during a period of limited capital availability for the participants. With an emphasis on low-cost O&M measures, Track and Tune helped these participants achieve significant savings with existing equipment, at a modest impact to the serving utilities' incentive budget. Both pulp and paper mills also had exposure to the program's Strategic Energy Management (SEM) cohort training component, which built management support and employee awareness, and provided a resource for monitoring, targeting and reporting (MT&R). The adoption of SEM had a clear linkage to the development of these Mega-projects, and these practices will help ensure the durability of the energy savings.

Second, the lack of readily available industry-specific technical expertise was another commonly-referenced barrier, which informed the makeup of ESI's Technical Service Provider (TSP) pool. In the majority of cases, the concept for a Mega-project originated with the facility but was advanced with the direct support of TSPs. For example, a large portion of the savings for Mega-project 5 involved the optimization of a paper mill's vacuum system, with the balance of the O&M measures coming from the pumping and agitation systems. Due to the size of the project, ESI called on the support of a TSP with a background in pulp and paper, and two additional TSPs with specialized expertise in vacuum and compressed air systems. This combination was essential to maximizing the potential of this specific project. In a similar manner, ESI enlisted the resources of a TSP that specialized in industrial refrigeration to support Mega-project 8. Each of the eight projects involved TSP support for project development and for measurement and verification (M&V) and TSP selection was based on industry knowledge and existing relationships with the sites.

Third, the two Mega-projects managed under the Track and Tune component benefited from flexibility related to measure definition. While these two projects had a heavy emphasis on O&M opportunities, a number of higher-cost 'action items' were identified in the course of the project. For example, Mega-project 7 involved a large number of pump impeller trims, which fell within the program's cost guidelines for O&M co-funding. However, an opportunity was identified to install brand new application-specific (low wear) impellers on two pumps. While this cost element exceeded the O&M cost guideline, it was promptly reviewed by the program and the local utility, and ultimately received co-funding under the existing Track and Tune project. By allowing this measure to be included in Track and Tune, ESI and the serving utility avoided the administrative complexity and cost associated with opening a separate project, thereby reducing the potential for a lost opportunity had the participant decided to forgo implementation. Flexibility in the measurement and verification strategy also played an enabling role in this decision. Specifically, the availability of a meter-level M&V option was a key factor in ESI's ability to incorporate the additional measures without the need for a system-specific baseline, or concern regarding upstream or downstream interactive effects.

Challenges

Big projects are tough for lots of reasons. Managing project timelines, budgets, and savings expectations are just some of the challenges that are magnified for a Mega-project. Just getting to the start line can be problematic.

Utility Program Limitations

Big projects often command big incentives that can rapidly deplete or, completely wipe out a utility's limited incentive funds. It can make it very difficult politically to offer one end user a substantial financial incentive if it puts the utility in a position where they might have to turn down another end user's request for EE support. Even if the project was a great investment for the utility, creating a situation where a perception exists of end user inequity would be unacceptable. This is especially problematic if they happen to be competitors.

Situations like this can be prevented with a proactive approach. Rather than distributing energy efficiency funds a first-come-first-served basis, a more comprehensive approach is needed. ESI has placed a premium on account planning both at the utility level and at the end user level. This is needed to safeguard against situations like the one described above. By better understanding the budgeting cycle of the end users and being involved in their long term planning, information can be provided to the utility to help guide their EE budget allocations. In the event two end users are ready for Mega-projects in the same biennium, expectations and budgets can be managed to maximize utility support while maintaining equity between end users.

Generally, BPA utility customer incentive budgets are on a two-year budget cycle, as are ESI program savings targets. This can make it quite problematic to book several years' worth of savings in just one biennium. *Too much* savings can be a real obstacle. Again, the flexibility of an EE program can really help utilities by allowing incentive rates to be customized so that the utility can support these projects without exhausting budgets. As for booking savings beyond the original goal, it is critical that merits of the project are communicated to the highest levels of the utility. These include supporting the economic vitality of a large customer and the resource acquisition value of the energy savings to the utility.

End User Considerations

Big projects generally require big capital investments and can take several months or years to implement with potential for key personnel or business condition changes happening in that time. Even with a substantial incentive from their utility, floating that kind of money for that long can create a cash flow pinch. For Mega-project 1, this constraint was overcome with the progress payment option allowed under the ESI program.

These types of projects typically require lots of end user bandwidth. Not only for the implementation but, there is a considerable time burden for the designing, planning, and management of the upgrades. Often it is the case that organizations will need to debate the technical, financial, and logistical feasibility of the proposed project. There is generally a lengthy process of winning over opponents before a project of this size can even be put in front of the company's decision makers. It falls to the EE program to translate the technical opportunities to business opportunities. This is typically done with clear communications that meet company decision maker needs. For example, early on in the project development stages ESI program staff will work with facility staff to gather sufficient information for each of the identified measures to develop a custom project proposal or SEM report that captures estimated project costs and energy savings and an M&V plan. With that information, the utility staff can develop a formal agreement with their customer that clarifies project milestones and magnitudes for potential incentive amount(s).

Managing for Successful Implementation and Persistence

Early in the program, as these types of projects started coming in, ESI realized that it was critically important that large projects be handled with a high level of due diligence and rigor. It is critical that expectations are well managed and snap decisions are avoided throughout the project's implementation. As ESI managed more and more projects of this size, a set of best practices began to evolve. They can be divided into three categories:

Communication

Keeping all stakeholders on the same page is vital to bringing a Mega-project to fruition. In order for an endeavor of this magnitude to proceed, every person involved needs to say "yes" but, it only takes one person saying "no" to stop the whole effort in its tracks. On the end user's side, stakeholders with veto power may include lead operators, the maintenance supervisor, process engineers, the production manager and the corporate executive. On the utility side of things there is the energy services specialist, the department director, the utility manager, and often the utility's board of directors all need to affirm the project for it to move ahead.

As an example, the ESIP who managed Mega-project 3 says "Mega-projects need a lot more attention and strong lines of communications with all parties. Recurring monthly internal meetings with BPA, monthly meetings with the utility, and monthly meetings at the site all helped ensure all parties were attuned, as well as stave off any surprises along the way." These routine meetings included a savings performance update, implementation status update, and discussions pertaining to issues and next steps.

Measurement and Verification

Designing and showcasing an accurate, cost-effective and reliable M&V plan is a key step to getting end user and utility buy-in for a Mega-project. ESI program staff are well versed in designing and implementing industrial custom project M&V plans based upon the BPA M&V Protocols (BPA 2012) as well as relying on the BPA ESI Monitoring, Targeting and Reporting (MT&R) Reference Guide (BPA 2015) for SEM projects.

For Mega-projects, developing the M&V plan requires collaboration with end-user and utility staff early on to understand the process measurement boundaries, and identify existing baseline energy and production flows. Following that, they will then collect one or more years of baseline energy, production, and other key independent variable data when available. Where data gaps exist, or enhancements to existing metering and data acquisition are needed, then all parties must agree upon the preferred corrective actions to take. When production data has proprietary business information, programs should consider the masking of production data (e.g., multiply production data by a constant unknown outside of the end users, or to weigh different process production values in a consistent manner). Non-disclosure agreements can also apply.

All parties must agree upon an optimal start for the performance period, and specify an appropriate duration to capture the process systems' full range of typical operating conditions. For the Mega-projects, performance periods have ranged from three months up to a full year.

While the magnitude of Mega-project energy savings potential may justify extra efforts and costs to "bottom-up" sub-meter a select number of affected loads within the system measurement boundary, followed by data analysis and management, this approach has not been preferred for reporting overall energy savings. For Mega-projects, applying the International Performance Measurement and Verification Protocol (IPMVP) Option C, whole building or whole process system "top-down" measurement boundary has been the preferred M&V method for reporting reliable energy savings. Whole facility M&V plans for Mega-projects are more likely to be familiar to end user staff who have some level of an energy management system in place and have developed Key Performance Indictors (KPI's) – Energy per Unit of Production – that are monitored, tracked and reported.

For a number of the Mega-projects, the ESI program has provided technical expertise to develop a multivariable regression baseline energy model of the existing process. This energy model is then forecasted into the project performance period (driven by independent variable data) and compared to the actual energy usage of the upgraded process system. A facilities Performance Tracking System (PTS) can be employed to report on energy savings trends including a cumulative sum (CUSUM) of differences chart that compares the difference between the predicted (baseline) energy consumption and the and actual energy consumption.

Best practice for communicating Mega-project M&V Plan actions and updates have been for all parties to meet on a regular basis throughout measure implementation and performance period time periods to report on measure installation and commissioning (Mega-projects can have 20+ measures, often with interactive effects), savings trends, and to discuss where actions may be needed and by whom to address energy savings back-sliding.

In most cases, the Mega-projects M&V Plan have required one or more Non-Routine adjustments to account for non-project related changes within the measurement boundary. Sometimes these were understood in advance and sometimes they were identified at energy performance review meetings followed by a further investigation. For example, during the performance period of one Mega-project unbeknownst to the EPM the facility had added electrical load by upgrading equipment at their existing water treatment system for environmental regulation reasons. This was noticeable in the cumulative sum of differences (CUSUM) chart, and the EPM investigated the source and the added electrical consumption was identified. ESI staff assisted the EPM by sub-metering the new equipment and providing engineering calculations that were then documented as a non-routine adjustment within the Mega-project completion report. In other cases, due to the length of the Mega-project, a number of smaller, EE incentivized capital projects were completed during the performance period and netted out of the gross savings from the Mega-project.

Ensuring Persistence

Because of the significant investment of capital and effort, it is critical that Mega-project savings persist. Extra diligence should be put forth to ensure that the projects truly deliver on their promised paybacks. As a best practice, ESI has developed a risk analysis and backsliding mitigation method. This is a collaborative process that involves key stakeholders for the project and is loosely based on the Failure Mode Effects Analysis (FMEA) methodology. Like FMEA, ESI's risk analysis process takes a step-by-step approach to identify likely failure modes and assigns scores for Impact, Likelihood, and Detectability. The individual scores are then multiplied together to give an overall score that provides a useful means of prioritizing the different failure modes. Table 3 provides an example of a risk analysis for two specific measures.

Table 3. Example Risk Analysis and Backsliding Mitigation Summary

EEM	Failure Mode	Failure Risk Assessment Ratings				Existing Controls	Required Action
		Impact	Likelihood	Detectability	Score		
Install VFDs On Air Handling Unit	Set point erroneously changed	5	2	4	**40**	Set point is password protected	Add verification to 6-month PM
Reduce static pressure in controlled space	Pressure sensor fails	2	4	4	**16**	Pressure sensor is calibrated annually	Program alarm if delta of pressure sensors exceeds value

The energy risk analysis exercise has proven to be an effective employee engagement and awareness tool, and the countermeasures often involve the creative use of existing technologies and systems. For example, sites have made targeted enhancements to scheduled preventative maintenance procedures. Others have enhanced control systems with specific abnormal condition alarm notifications. Ultimately the goal is to bring a sense of focus to a prioritized list of high-impact, high-likelihood failure modes, and implement solutions that reduce the potential for the failure mode to adversely impact project performance.

Effective performance monitoring strategies are essential to ensuring the persistence of large industrial energy efficiency projects. While this is especially true for projects that emphasize improvements to O&M or behavioral practices, capital projects may also be prone to mechanical issues and human error. As such, all large projects will likely benefit from ongoing performance monitoring. Industrial SEM programs generally promote the use of top-down MT&R models to measure performance at a plant-level or system-level. These are very effective tools, but often involve a time-delay to incorporate production and weather data. A more robust strategy often involves the combined use of MT&R models and control system based KPIs that are automatically tracked in real-time. For instance, the performance monitoring strategy for Mega-project 3 leverages a whole-facility MT&R model in conjunction with a chilled water KPI (kW/ton) and key compressed air system parameter (system pressure). Likewise, the persistence strategy for Mega-project 5 involves the daily verification of a range of KPIs, along with the periodic update of the MT&R model.

ESI has also begun to promote the installation of submetering in the project design phase, and these costs are generally considered eligible implementation expenses for large custom projects. In addition to the obvious performance monitoring benefit, permanent submetering also provides a safety benefit during the measurement and verification phase by eliminating exposure to energized loads during data logging activities.

Conclusion

This paper aimed to explore ESI program design features that led to successful implementation of eight Mega-projects that had a combination of capital and SEM program components. These projects culminate several years after inception, often led to implementation by ESI co-funded industrial facility Energy Program Managers. Mega-projects typically develop after a number of smaller EE projects were successfully implemented and energy savings measured and verified. The time for these earlier EE project successes allowed for the development of trust and a strong working relationship between industry, utility and program implementer.

Mega-projects are often process-oriented in nature, feature multiple-measures with interactive effects, require an extended time from inception to completion, and have considerable financial impacts to both the utility and the participant. Ultimately, incentives are based on the measured and verified energy savings at the conclusion of the project. Therefore, developing and showcasing an accurate, cost-effective and reliable site-specific M&V plan is a critical step to getting end user and utility buy-in for the Mega-project. ESI program development and application of "top-down" whole building or process system-wide multi-variable regression baseline energy models are most often relied upon for M&V of Mega-project energy savings.

Regular meetings with utility, facility and ESI staff throughout measure implementation and performance period for reporting on measure installation and commissioning, savings trends and corrective actions to address energy savings back-sliding (when necessary) is a best practice with Mega-projects.

Finally, the paper outlined specific strategies for managing the implementation and persistence of Mega-projects, sharing lessons learned that have helped the ESI program meet and exceed annual energy conservation targets throughout its eight-year history.

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