Industrial Energy Management and Information Systems for Strategic Energy Management (SEM) Applications

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ABSTRACT

Energy Management Information Systems (EMIS) are software tools that store, analyze, and display energy consumption data. The number of available EMIS has increased dramatically over the past ten years. The market is characterized by a growing pool of EMIS vendors and varying levels of rigor and analytical approaches.

Application of EMIS in industrial Strategic Energy Management (SEM) programs or pilots is rare partly due to low understanding of EMIS functionality and the needs of SEM programs that EMIS could solve. Additionally, there is little guidance on how to integrate EMIS into an SEM program framework. However, utilities see the potential of integrating EMIS into SEM programs. The application of EMIS for measurement and verification (M&V) of capital and operations and maintenance (O&M) project savings has the potential to increase confidence in savings estimates and reduce utility program costs. This would facilitate expansion of SEM to more facilities and with improved program cost-effectiveness. Further, the ongoing monitoring and tracking capabilities of EMIS are very complementary to SEM principles.

This paper describes the research to establish the relevant criteria for assessing industrial EMIS to meet utility SEM program needs and best address the needs of utility industrial customers. It details the results of utility and customer needs assessments and lays out a framework for categorizing EMIS products. Results of an inventory effort project are briefly presented. Finally, the paper summarizes the approaches that can see the benefits of EMIS fully realized.

Introduction

Industrial SEM Programs are growing in popularity as a means of achieving energy savings through operational improvements. The Consortium for Energy Efficiency (CEE) has documented 15 SEM programs nationwide (CEE 2014). The Pacific Northwest has seen an evolution of industrial SEM approaches through pilots and programs since 2007 (Jones et al 2011).

As with any program approach that is built around operational improvements, industrial SEM programs face a significant challenge in M&V of energy savings. Established M&V methods include energy modeling using monthly or interval data, typically aligned with the International Performance Measurement and Verification Protocol (IPMVP), Option C. Development and tracking of SEM program savings is a manual spreadsheet-based process which is highly complex and labor-intensive. Utilities are seeing the potential of EMIS not only to reduce M&V costs but also to expedite energy efficiency projects and improve customer engagement in the commercial and institutional sectors.

EMIS are software tools that store, analyze, and display energy consumption data (Granderson et al 2009). Based on this definition they exclude systems used to directly control process equipment, HVAC, lighting, etc., although these may be referred to by some as "energy management systems." The number of commercially available EMIS has increased dramatically over the past ten years, as have the analytical and reporting capabilities of the tools. One driver of this evolution has been the expansion of advanced metering infrastructure that provides electric consumption data at intervals of 15 minutes or less ("interval data"). EMIS are showing promise as a means of addressing some of the M&V challenges regarding O&M-based program approaches, increasing confidence in savings claims and at lower cost than established M&V methods for SEM programs. Realizing this potential requires a concerted effort, however. NEEA has been supporting its northwest funder utilities in developing resources to help move towards EMIS adoption for SEM programs.

Current Industry Status

In 2014 CEE developed the SEM Program Case Studies Report (CEE 2014), documenting program details for 15 SEM programs nationwide. The programs included in the Case Studies Report account for 421 enrolled customers. Of those enrolled customers 60% (254) are in Northwest programs managed by the Bonneville Power Association (BPA), Energy Trust of Oregon (ETO), Snohomish Public Utility District (SnoPUD), and Idaho Power. Seven of the fifteen programs list EMIS as an offered feature of the program, but none reports using the EMIS to report project savings.

Developing methods to use interval data for M&V has been explored for several years (for example: Jump et al 2012). Exploring the use of EMIS for M&V has also been the subject of several research projects over the past few years (Price et al 2013. Kramer et al 2013). Many barriers still exist for integrating EMIS into programs for M&V purposes, such as:

- Lack of transparency in energy modeling algorithms for EMIS (many EMIS vendors consider them to be proprietary);
- Lack of a protocol for evaluating the accuracy of EMIS modeling engines;
- A critical need (in some regions) to confirm attribution of savings to specific measures, which precludes taking a whole building approach; and
- A generally low level of understanding of EMIS capabilities and the means by which they may be used in programs.

Natural Resources Canada (NRCan) has been working to promote EMIS adoption in Canada, including the development of a web-based toolkit and training[1].

[1] EMIS Toolkit is available at: http://www.nrcan.gc.ca/energy/efficiency/industry/training-awareness/5463

To support increased understanding of EMIS capabilities NEEA funded research into EMIS functionality with a focus on M&V potential for commercial applications (Kramer et al 2013). This was followed by similar research relating to industrial applications (Crowe et al 2014). Both research projects explored utility and end user needs and documented EMIS features relative to those key needs.

Stakeholder Needs

Successful use of EMIS for SEM programs depends upon meeting the needs of both utility implementers and industrial facility staff. Rigorous M&V capability is a major concern for utilities, where facility staff have different needs to support ongoing energy management.

Under contract with NEEA CLEAResult conducted phone interviews with five program implementation staff and four representatives of industrial facilities. The topics covered through the interviews included:

- Past or current use of EMIS;
- How EMIS was used, and by whom;
- Outcomes of using the EMIS;
- Data input issues;
- Training required;
- Essential and desirable features;
- Approach to quantifying energy savings and ongoing energy monitoring;
- Future interest and needs relating to EMIS; and
- Barriers to be overcome in expanding use of EMIS.

The needs assessment interviews provided first-hand accounts of the challenges of documenting baseline energy use for industrial facilities. When using EMIS for commercial M&V energy models are typically weather and/or schedule-driven, data inputs that are easy to obtain. For industrial applications weather and schedule may be significant contributors to energy consumption but are rarely the only driving variables. Production metrics such as number of units produced or the volume/weight of material shipped are often key drivers of energy consumption. Utilities and program implementers discussed the complexity of developing regression calculations that characterize a facility's energy consumption relative to independent variables. In some cases there may be just one key variable in addition to weather, but interviewees had seen up to five.

Beyond the core energy modeling engine interviewees also expressed interest in EMIS providing flexibility and automation features such as:

- Automatically screening/flagging or excluding invalid data points;
- Automatically flagging conditions that fall outside of those observed during the baseline period (this is helpful for checking if the regression still applies outside of the conditions observed in the baseline period); and

- Omitting data from facility shutdown periods, or applying a different regression model for those periods.

Data acquisition was another key issue raised through the needs assessment interviews. Energy metering and communications is relatively straightforward to configure, but production data can be challenging to obtain. More sophisticated industrial facilities may have a wide range of production data stored in networked software applications but accessing that data from outside the company can be challenging with IT security protocols; in some cases the key production variables are only available via manual reporting methods such as Microsoft® Excel® Files.

In all cases cited in the needs assessment interviews the EMIS was used to monitor facility electricity consumption, and in some cases natural gas monitoring was also mentioned. Two industrial owners were in the process of setting up monitoring for diesel, as it is factored into the long term site energy reduction goals.

Facility staff interviewed through the needs assessment stressed the need for simplicity. Examples included:

- Having the EMIS send an automated report by email, rather than requiring a user to login to a software application;
- The use of simple energy consumption comparisons like ‘today vs. yesterday’, or ‘this week vs. last week;’
- Color coding of dashboard graphics so that a user can instantly identify anything that needs attention; and
- A simple interface that will require no special training.

The ability of EMIS to support project tracking was mentioned as desirable by all interviewees, in two respects: firstly, the ability to ‘flag’ events in time so that they are marked on time series charts (equipment tune-ups or incidence of maintenance issues for example); secondly using EMIS to support project implementation by defining project tasks, timelines, documentation, key metrics, etc.

Technical Considerations

The technical complexity of using EMIS for M&V applications has been documented in several publications, mostly focused on the commercial sector. The fundamental building block for M&V is to establish an accurate baseline energy model. *Baselining* is the process whereby energy use data from the period prior to an energy efficiency project is analyzed to derive a model (equation or set of equations) that characterizes and predicts how the building uses energy. This model may take into account varying weather conditions, time of day/week, occupancy, and potentially other variables that impact energy use (“independent variables”). The primary test of baseline model performance is the accuracy of its prediction of building energy use over time. Ongoing research sponsored by Pacific Gas & Electric is working to address many of the key questions relating to creating baselines with interval meter data (Kramer et al 2013):

- **Independent variables:** How should the independent variables for the open-source models be determined and how should these variables be included in the test protocol?
- **Analysis time interval:** What impact does the analysis time interval (e.g. energy data collected every 15 minutes, 60 minutes, etc.) have on baseline accuracy?
- **Length of the baseline (or training) period:** How do building grouping, confidence level, and analysis time interval influence baseline length?
- **Test dataset:** Should the test dataset only include buildings that are well-suited to interval data models or should the dataset provide a range of buildings to test the limits of tools' modeling ability?
- **Building screening:** What are the characteristics and/or criteria that make a building type well suited for interval meter data models?
- **Performance metrics and criteria:** Which performance metrics best represent baseline model quality? How might performance criteria be determined for the performance metrics?
- **Prediction time interval and prediction time horizon:** How much does model performance change as the prediction time intervals increase (i.e., how well the model can predict hourly, daily, or monthly energy use)?
- **Portfolio-level analysis:** If pooling, or aggregating, energy use data from multiple projects across a program portfolio, how does this affect baseline performance at the portfolio level?

As noted in the prior section, developing energy models for industrial M&V applications has added complexity compared with the commercial sector. While there are precedents for using interval data modeling for industrial M&V it is not typical practice, and there is no published literature on the use of EMIS for performing M&V. Evaluation of NEEA's SEM pilot noted the use of monthly data for developing baseline energy models (DNV KEMA and Research Into Action 2014). An Energy Trust workshop summary and presentation noted that availability of data beyond monthly and bi-monthly (especially gas data) is a common challenge in modeling savings for SEM programs, implying that the use of energy interval data is not typical (Energy Trust of Oregon 2014). Existing research on the use of EMIS for commercial M&V can support efforts to expand application to the industrial sector however, as the modeling approach, performance metrics, and other factors may be common to both.

EMIS Inventory

To assist its Pacific Northwest utility stakeholders, NEEA contracted with CLEAResult[2] to develop an EMIS inventory for commercial applications in 2013 (Kramer et al 2013). The objective of the inventory was to document EMIS features that could support utility programs and financial transactions based on energy efficiency improvements. Following the publication of the commercial EMIS inventory, a similar inventory for industrial applications (Crowe et al 2014) was developed as a way to clarify the capabilities and options for EMIS-enabled M&V, and encourage incorporation of EMIS into industrial Strategic Energy Management programs.

[2] EMIS Inventory development was initiated by PECI. PECI's assets have since been acquired by CLEAResult, and so references to PECI in this paper have been replaced by CLEAResult.

With the support of a technical advisory group, and built around the findings of the stakeholder needs assessment described above, CLEAResult designed an EMIS features matrix comprising the features considered most important to stakeholders. While M&V was a key driving factor for the inventory development, other categories of feature were also considered important: data input; user interface/reporting; project tracking; applications.

Once the EMIS features matrix was developed CLEAResult initiated research to identify commercially-available EMIS that might qualify for inclusion in the inventory. CLEAResult applied three key screening criteria to an initial target list of 43 EMIS (Table 1).

Table 1. EMIS Screening Criteria for NEEA Industrial EMIS Inventory

Screening Criteria	Rationale
1. EMIS must have the ability to automatically quantify energy savings	- Goal is to replace Excel-based M&V tools - Supports M&V and ongoing facility management
2. EMIS must be able to incorporate production data into energy consumption regression analysis	- Owners could gain some benefit from an energy-only solution, but the program administrator's M&V requires normalization for production
3. Tool must be able to track energy data at a daily or more frequent resolution	- Existing spreadsheet-based tools handle monthly data; intent is for EMIS to provide extra value - Daily frequency is a manageable unit for facilities, and can support 'actionability'

Of the initial list of 43 EMIS, 13 passed screening, 8 were rejected due to nonresponsive vendors, and the remaining EMIS were rejected as not meeting the screening criteria. CLEAResult contacted vendors of the EMIS that passed screening to schedule web demonstrations and obtain information for the inventory. Of the thirteen tools that were passed screening, three declined to provide a demonstration due to lack of time or resources. Information from a 2013 demonstration, in combination with published literature, was sufficient to complete inventory entries for one of these tools (eSight Energy). Based on demonstrations, a further five EMIS were rejected as not meeting the screening criteria.

The final industrial EMIS inventory contains six tools (Table 2). Of these final six tools four had also appeared in the NEEA commercial EMIS inventory. While there are fewer EMIS for industrial applications (a total of 14 EMIS appear in the commercial inventory) the applicability, flexibility, and usability of the tools is high.

Table 2. EMIS appearing in the EMIS inventory for industrial applications

Vendor	EMIS	Number of utility programs/pilots***	Number of installations***
Cascade Energy	SENSEI	8	272
Energent	EnergentET	11	<50
EnerNOC	Energy Intelligence Software	Not specified	>6,000
eSight Energy*	eSight Energy	Not specified	Unknown
Panevo**	Energy Desktop	1	>1,000
RtTech Software	rtEMIS	None	7

* eSight did not provide a demonstration for this project
** Energy Desktop was developed by Verco, and is supplied by Panevo
*** Self-reported by EMIS vendors

The six tools in NEEA's EMIS inventory appear to have a set of features that make them an attractive proposition for industrial SEM programs. All have robust M&V capabilities with transparent reporting of uncertainty metrics,[3] and they offer a range of reporting and other features that are desirable to industrial facility staff and program implementers.

It is important to note that the industrial EMIS inventory reports the claimed features of the tools; actual performance was not verified as part of the project. However, the inventory provides a solid starting point for selecting tools for future technical research.

Following the publication of the industrial EMIS inventory NEEA is continuing its efforts around the application of EMIS across all market sectors (commercial, industrial, and residential). One such example is NEEA-funded research by EnerNOC into the business case for utilities and owners to adopt EMIS (Gilless and Hart 2015). High level points coming out of that research include:

- M&V is one of the most painful aspects of energy efficiency;
- EMIS has the potential to make huge strides in automating M&V;
- EMIS doesn't really do this now but there are lots of other value propositions for utilities and for end-use customers;
- EMIS is not a "plug-and-play" technology. It takes work to get the best results from EMIS;
- Utilities have done great work in getting their customers to make good use of EMIS, especially as part of an SEM program; and
- Vendors are also helping customers increase their adoption over time.

A common finding from the EnerNOC research and the CLEAResult needs assessment is that EMIS adoption is a long term proposition. Adoption by utilities requires addressing

[3] Uncertainty metrics indicate the extent to which a modeled prediction of energy use is a true representation of actual energy use. Examples of uncertainty metrics include R^2 and CV RMSE,

technical and regulatory barriers as well as developing a framework for integration with SEM programs. For industrial owners it first requires a willingness to adopt a structured approach to energy management, and then a multi-year process of internal education and integration with standard working practices.

Conclusions

EMIS show great promise for supporting industrial SEM programs. Applying EMIS for M&V has the potential to increase confidence in reported savings at a lower cost than manual M&V methods using spreadsheets. Beyond M&V there are a number of other benefits to implementers and industrial facility staff in using EMIS for reporting, tracking, and supporting project management efforts.

Realizing the potential of EMIS for SEM programs will take a concerted effort to address technical, programmatic, and (in some cases) regulatory barriers. NEEA's has produced an inventory of EMIS for industrial M&V that can help drive industry dialog around a desirable feature set and a common taxonomy for describing EMIS functionality. NEEA is continuing its research in this topic area, with the support of its northwest stakeholder utilities, towards a vision of robust automated M&V for industrial SEM programs and other market sectors.

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