June 2014
REPORT #E14-295

Inventory of Industrial Energy Management Information Systems (EMIS) for M&V Applications

Prepared by:
PECI
503-248-4636
100 SW Main Street, Suite 1500
Portland, OR 97204

Northwest Energy Efficiency Alliance
PHONE
503-688-5400
FAX
503-688-5447
EMAIL
info@neea.org

Inventory of Industrial Energy Management Information Systems (EMIS) for M&V Applications

Prepared by PECI for the Northwest Energy Efficiency Alliance

June 2014

Acknowledgements

Prepared by PECI

Eliot Crowe, Hannah Kramer, Joan Effinger

Technical Advisory Group

As a part of this project, PECI assembled a Technical Advisory Group (TAG) made up of individuals from utilities, program implementers, and other relevant organizations to provide input and commentary on the inventory design, EMIS selection, and usability of the results. PECI and NEEA would like to thank the TAG members for their time and input:

- Nick Leritz — Northwest Energy Efficiency Alliance (Project sponsor)
- Todd Amundson — Bonneville Power Administration
- Pam Barrow — Northwest Food Processors Association
- JP Batmale — Energy Trust of Oregon
- Tamara Berger — BC Hydro
- Chao Chen — Puget Sound Energy
- Jennifer Eskil — Bonneville Power Administration
- Warren Fish — Northwest Energy Efficiency Alliance
- Chad Gilless — EnerNOC, Inc.
- Ted Jones — Consortium for Energy Efficiency
- Steve Martin — Cascade Energy
- Steve Mulqueen — Cascade Energy
- Jon Sanders — BC Hydro
- John Thornton — Northwest Food Processors Association
- Julia Ventromile — DNV GL

Table of Contents

EXECUTIVE SUMMARY i

Introduction i

Stakeholder Needs Assessment ii

EMIS Inventory iii

Findings iv

Conclusions and Recommendations v

1. INTRODUCTION 1

1.1. Background 2

1.2. EMIS Defined 3

1.3. Strategic Energy Management (SEM) Programs 4

1.4. ISO 50001 Energy Management Systems 5

2. NORTHWEST INDUSTRIAL EMIS STAKEHOLDER NEEDS ASSESSMENT 7

2.1. Needs Assessment Process 7

2.2. Needs Assessment Findings 7

2.2.1. Industrial Energy Modeling Is Far More Complex Than That for Commercial Entities. ... 8

2.2.2. Industrial SEM Stakeholders Need a High Degree of Flexibility in Data Management. ... 9

2.2.3. Simplicity Is Critical for Owners 10

2.2.4. ISO 50001 May Not Currently Be a Significant Market Driver for EMIS Adoption 11

2.2.5. Upfront Planning for EMIS Implementation Is Highly Beneficial 12

2.2.6. Project Tracking Functionality within an EMIS Is Desirable 12

2.2.7. Other Desirable Features 13

3. EMIS INVENTORY DEVELOPMENT 14

3.1. Inventory Design Process 14

3.2. EMIS Research 15

3.2.1. Screening 15

3.2.2. Web Demonstrations 18

3.2.3. Final Inventory Design 19

3.2.4. Feature List and Descriptions 19

3.3. EMIS Inventory Findings 20

3.3.1. The Field Is Small, but High-Quality 20

3.3.2. Manual Regression Equation Entry for M&V is Available on All EMIS 21

3.3.3. M&V Methodologies Follow IPMVP Option C 21

3.3.4. Several Options for Production Data Entry 22

3.3.5. Automated Alerting Functionality Comes in a Variety of Methods 23
3.3.6. Some EMIS Offer a Range of Project Tracking Capabilities 24
3.3.7. Common Features 24
4. CONCLUSIONS AND RECOMMENDATIONS 26
REFERENCES 28
APPENDIX A – Needs Assessment Interview Guide: Utilities and Program Implementers 30
APPENDIX B – Needs Assessment Interview Guide: Owners 33
APPENDIX C – Inventory Feature Definitions 36
APPENDIX D – EMIS Inventory Workbook 39
APPENDIX E – EMIS Screenshots 40

Executive Summary

Introduction

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

Utilities are seeing the potential of EMIS to expedite energy efficiency projects, reduce costs, and improve customer engagement in the commercial and institutional sectors. However, application of EMIS in utility programs or pilots for industrial customers is rare. Strategic Energy Management programs for industrial customers incorporate energy tracking as a key activity; however, it is typically based on spreadsheet analysis with monthly bills. The application of EMIS for measurement and verification of project savings using hourly or daily energy data shows promise for increasing confidence in savings estimates and reducing utility program costs. This would facilitate greater expansion of Strategic Energy Management approaches to more industrial customers and with improved program cost effectiveness.

To assist its Pacific Northwest utility stakeholders, the Northwest Energy Efficiency Alliance (NEEA) contracted with PECI in 2013 to develop an EMIS inventory for commercial applications. NEEA intended for the inventory 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, NEEA initiated this project to develop a similar inventory for industrial applications as a way to clarify the capabilities and options for EMIS-enabled measurement and verification (M&V), and to encourage incorporation of EMIS into industrial Strategic Energy Management programs.

This project included the following key tasks:

- A needs assessment to understand utilities', program implementers', and industrial owners' perspectives on requirements and opportunities related to use of EMIS in industrial facilities;
- Design of an EMIS inventory based on the most desirable EMIS features as determined through the needs assessment; and
- Population of the EMIS inventory based on research and web-based demonstrations of EMIS.

This report documents the EMIS inventory development process and summarizes the key findings from the research.

Stakeholder Needs Assessment

As the first task in this project, PECI contacted a sample of industrial Strategic Energy Management stakeholders to understand their needs related to EMIS and to document existing uses of such products. Early in 2014, the team conducted ten interviews with utilities, their Strategic Energy Management program implementers, and industrial owners (interview guides are included as Appendix A and Appendix B). Note that the small sample size for the needs assessment interviews may not be representative of overall market trends.

Following are the key findings from the needs assessment:

- Industrial energy modeling is far more complex than that for commercial entities. Production variables for industrial applications can significantly impact energy consumption, and must be factored into the energy consumption regression models. The complexity and variability of production, and the availability of production data, may result in a significant lead time for baseline energy model development.
- Industrial SEM stakeholders need a high degree of flexibility in data management. Gaining access to production data stored in a facility's IT or control systems may be complicated. Production data not available through automated means necessitates establishment of a manual data acquisition process. In either case, flexibility is required in the manners through which the data is collected and communicated. Additionally, analyzing non-aligned data is often a challenge; for example, energy data may be available in fifteen-minute intervals and production data may be daily.
- Simplicity is critical for owners. End users of EMIS for industrial facilities are typically resource-limited and have low levels of familiarity with energy analysis techniques. Needs assessment interview respondents cited as important criteria such as easy access to an EMIS, simple charts, and the use of color-coding (such as red indicating an area needing attention),.
- The ISO 50001 Energy Management Standard may currently lack value as a significant market driver for EMIS adoption. The needs assessment interview respondents did not cite ISO 50001 as a strong market driver for implementing EMIS.
- Upfront planning for EMIS implementation is highly beneficial. Respondents noted that conducting an internal needs assessment with all potential EMIS users at a facility would be very valuable when selecting an EMIS. They also recommended a best practice of using the internal needs assessment to develop a specification for obtaining EMIS bids.
- Project tracking functionality within an EMIS is desirable. The needs assessment interviews addressed two elements of project tracking: Firstly, respondents claimed that the ability to "flag" projects/events on time series charts was valuable for interpreting the data (in other words, for understanding the cause of a change in observed energy consumption). Second, project management also included activities such as defining tasks

and sub-tasks for facility projects, setting task timelines, allocating responsibilities, and attaching project-related documentation.

The needs assessment interviews informed the design of an inventory for industrial EMIS, as described below.

EMIS Inventory

Based on the needs assessment, the project team next developed a draft inventory that was subsequently reviewed by the project Technical Advisory Group. The final inventory is comprised of twenty-seven columns, divided into the following categories:

- Data Input
- Measurement and Verification
- User Interface/Reporting
- Project Tracking
- Applications

The project team carefully documented the feature definitions and data entry requirements for each of the columns in the inventory spreadsheet to ensure consistency and to enable comparisons across EMIS (Appendix C contains full descriptions of feature categories).

In order to populate the EMIS inventory, the team developed an initial list of forty-three EMIS and conducted a high-level screening of these tools against three primary screening criteria, as shown below and further described in Table 1 of this report:

1. EMIS must have the ability to automatically quantify energy savings.

2. EMIS must be able to incorporate production data into energy consumption regression analyses.

3. The tool must be able to track energy data at a daily or more frequent resolution.

The project team eventually included six of the initial list of forty-three EMIS in the final inventory. The team most commonly rejected EMIS at the screening stage due to the absence of production data input and nonresponsive vendors.

Findings

The final inventory is populated with the six EMIS listed below and further described in Table 3 of this report:

- EnergentET (Energent)
- Energy Desktop (Panevo)
- Energy Intelligence Software (EnerNOC)
- eSight Energy (eSight Energy)
- RtEMIS (RtTech Software)
- SENSEI (Cascade Energy)

Key findings from the EMIS inventory for industrial applications are:

- **The field is small, but meets the majority of user needs.** Four of the six EMIS in the industrial EMIS inventory also appear in the commercial inventory (the commercial inventory included fourteen EMIS). While fewer EMIS exist in the inventory for industrial facilities, the applicability, flexibility, and usability of those tools is high.
- **Manual regression equation entry for M&V is available on all the EMIS in the inventory.** While EMIS have been applied in Strategic Energy Management programs, none has been used to date for developing a baseline regression. All six tools in the industrial EMIS inventory provide the ability for users to manually enter regression calculations.
- **M&V methodologies follow IPMVP Option C.** All tools in the industrial EMIS inventory use the International Performance Measurement and Verification Protocol (IPMVP), Option C. While these tools can calculate savings for a given measurement period, none incorporates functionality for estimating annual savings from less than a year of post-implementation data (known as annualization).
- **Multiple options exist for production data entry.** A wide array of options exist for uploading data to an EMIS, including proprietary energy metering/communication devices, the ability to accept data from different types of industrial control systems, manual entry of data into a web interface, and emailing data to the EMIS vendor for upload.
- **Automated alerting functionalities are available in many forms.** The tools in the industrial EMIS inventory can flag unexpectedly high energy consumption in multiple ways. Alerting mechanisms include email or text alerts, on-screen color-coded data flagging (such as using red text or shading to highlight high values), and summary tables of high energy consumption "events."
- **Some EMIS offer a range of project tracking capabilities.** Three of the six tools' web demonstrations covered project tracking functionality, including the ability to flag projects/events on time-series charts (two EMIS) and task tracking features (three EMIS). Two EMIS also provide the capability to upload documentation relating to specific events, projects, or assets.
- **EMIS share many common features.** Many features appeared on all of the EMIS in the final inventory, including certain charts, the ability to create calculated values, reporting of cost savings, and automated periodic reporting.

- **The installed base for the EMIS in the inventory (self-reported by EMIS vendors) varied significantly,** ranging from seven installations to thousands. Four of the EMIS vendors additionally reported the number of utility pilots/programs that incorporated their tools.

Conclusions and Recommendations

Utilities, program implementers, and owners have a small but strong pool of EMIS from which to choose for Strategic Energy Management programs and other related energy management initiatives. The six tools in the final EMIS inventory offer very high standards of functionality and usability. While the tools vary in terms of user interface and flexibility, in general they all address the majority of the needs/desires identified in the needs assessment. Owners seeking to achieve and maintain ISO 50001 certification may benefit from the tools in the EMIS inventory in terms of developing energy baselines, conducting ongoing monitoring and analysis, and reporting.

The project team recommends additional study on certain aspects of the featured EMIS to further assist in determining suitability of tools for a given situation. Additional research could include evaluations of EMIS costs, assessments of the relative levels of ease in configuring data acquisition methodologies, and third-party testing of the tools' M&V capabilities. More general research could focus on streamlining and standardizing the baseline modeling process, and on increasing the level of automation for developing models.

In addition to further research, the following materials could support successful expansion of EMIS-based approaches to Strategic Energy Management:

- Training resources, templates, and other related guidance for owners;
- Owner or program case studies and other outreach activities;
- Standardized EMIS specifications (tailored to SEM applications); and
- Guidelines for integrating EMIS into industrial utility programs.

The tools in the industrial EMIS inventory are well-suited to the Strategic Energy Management process, can support ISO 50001 reporting requirements, and overcome several major challenges that exist for industrial applications.

This report documents the EMIS-related needs of industrial owners and program administrators, and classifies the features of six EMIS for industrial applications. The research lays the foundation for further efforts to validate technical capabilities and coordinated development to support successful expansion of EMIS-based Strategic Energy Management programs. EMIS show great potential for supporting expansion of Industrial Strategic Energy Management from an “early adopter” phase toward common industry practice.

1. Introduction

Energy Management Information Systems (EMIS) are software tools that store, analyze, and display energy consumption data. The number of commercially-available EMIS has increased dramatically over the past ten years, as have the analytical and reporting capabilities of the tools. This evolution has in part been driven by the increased availability of energy data at resolutions of one hour or less, due to utility smart meter installations and declining costs of data acquisition hardware. Tools are now available with features ranging from simple graphical display of time series data to sophisticated algorithms for identifying performance anomalies and for measuring energy savings. The market is characterized by a growing pool of EMIS vendors and varying levels of rigor and analytical approaches employed by the tools.

Utilities are seeing the potential of EMIS to expedite energy efficiency projects, reduce costs, and improve customer engagement in the commercial and institutional sectors. Strong interest in integrating EMIS with programs is leading many utilities to introduce EMIS pilots and programs, as the Consortium for Energy Efficiency has documented (CEE 2012). Application of EMIS in utility programs or pilots for industrial customers is rare; the Bonneville Power Administration's (BPA's) Track and Tune program and Energy Trust of Oregon's (ETO's) Refrigeration Operator Coaching program are exceptions. Strategic Energy Management (SEM) programs for industrial customers incorporate energy tracking as a key activity; however, it is typically based on spreadsheet analysis with monthly bills.

To assist its Pacific Northwest utility stakeholders, the Northwest Energy Efficiency Alliance (NEEA) contracted with PECI in 2013 (Kramer et al. 2013) to develop an EMIS inventory for commercial applications, which incorporates a spreadsheet documenting the features of EMIS that can meet utilities' core program needs. NEEA intended for the commercial inventory to document EMIS features that could support utility programs and financial transactions based on energy efficiency improvements. The commercial EMIS inventory focused primarily on EMIS with the ability to perform measurement and verification (M&V) of project energy savings. M&V using EMIS presents a potential solution to one of the energy efficiency industry's biggest challenges: making energy savings reporting more transparent, more reliable, and less costly. Following the publication of the commercial EMIS inventory, NEEA initiated this project to develop a similar inventory for industrial applications as a way to clarify the capabilities and options for EMIS-enabled M&V and to encourage incorporation of EMIS into industrial utility programs.

Industry experts consider industrial SEM programs particularly well-suited to the application of EMIS. SEM programs support improved energy management and reporting practices, and incorporate long-term M&V for operational improvements. This industrial-focused project supports a broader area of research into the use of EMIS as a means for enabling automated, integrated M&V for projects in commercial, industrial, and residential sectors.

This project included the following key tasks:

- A needs assessment to understand utilities', program implementers', and industrial owners' perspectives on requirements and opportunities related to use of EMIS in industrial facilities;
- Design of an EMIS inventory based on the most desirable EMIS features as determined through the needs assessment; and
- Population of the EMIS inventory, based on the project team's research and web-based demonstrations of EMIS.

This report documents the industrial EMIS inventory development process and summarizes the key findings from the research. The report concludes with recommendations for advancing the use of EMIS to support Northwest SEM programs.

1.1. Background

The Northwest Power and Conservation Council's Sixth Northwest Conservation and Electric Power Plan calls for meeting eighty-five percent of new energy needs through improved energy efficiency (NWPCC 2010). This aggressive goal is driving utilities to explore more comprehensive energy efficiency program approaches to achieve deeper savings. While utility programs have produced lasting savings, they are often single interventions as opposed to a comprehensive whole-facility approach, and reporting project benefits is rarely based on actual energy measurements. SEM programs take a more comprehensive approach to organizational energy management and operational improvements (see Section 1.3), but identifying, estimating, and subsequently verifying savings from energy efficiency improvements requires considerable time, expense, and high labor input.

The ability of utilities to successfully deploy large-scale, cost-effective programs with comprehensive savings requires technically robust, low-cost and scalable methods for enabling, estimating, and quantifying energy savings. Some have used manually-applied monthly data analysis to quantify savings on projects with high savings (typically greater than ten percent) and long time frames (minimum of one year baseline and post-implementation data). However, ongoing research and pilots are showing that the use of energy interval data can provide several benefits over the use of monthly data. This research shows that analyzing whole-facility data at intervals of one hour or less for M&V reduces data collection time frames and reliably detects lower levels of savings. Further, interval data is useful for day-to-day energy management and for troubleshooting problems that occur.

Analyzing whole-facility meter data may potentially support M&V and ongoing energy management; however, manual interval data analysis is typically time-consuming and may be applied differently by different analysts. Leveraging EMIS for whole-facility analysis offers a largely untapped opportunity to automate data analysis, reduce variations in the calculation methodologies, as well as to reduce costs.

The ongoing success of SEM programs in the Pacific Northwest provides a platform into which EMIS could be integrated. SEM programs focus on organizations' approaches to energy management and require ongoing tracking and quantification of incremental operational improvements over a long period – all of which can be complemented by EMIS. ISO 50001, an energy management standard released by the International Organization for Standardization (ISO), is another relevant market driver that defines energy management best practices, including requirements for monitoring and analysis of energy performance. ISO developed ISO 50001 to set the industry standard for energy management, thereby increasing the pool of potential customers for EMIS. EMIS are defined in more detail below, along with brief summaries of SEM programs and ISO 50001.

1.2. EMIS Defined

EMIS are enabling tools that support users' efforts to improve the energy efficiency of their facilities by providing better access to energy and system data and by applying analytics to this data. Researchers have developed several reports and guides over the last five years to characterize EMIS features and to develop an overall terminology framework, and are continuing these efforts, primarily focusing on commercial applications) (Granderson et al. 2009; Granderson et al. 2011; Friedman (Kramer) et al. 2011). The terminology and feature classifications used in this report align with other industry efforts to the extent possible.

EMIS are predominantly offered as web-based "software as a service" (SaaS), allowing users to view and analyze energy data online. They offer a variety of features driven by their respective target users, typically facility owners/managers, energy managers, process operators, maintenance technicians, and in some cases, electric and gas utilities. EMIS are distinct from industrial control systems in that they do not directly control any of the facility equipment. Conversely, control systems typically do not incorporate the sophisticated energy analytics offered by EMIS. While EMIS may monitor and display some equipment parameters, this is generally limited to those variables that have the most significant impact on facility energy consumption.

Certain core features are nearly universal for all EMIS, including:

- **Data security:** The vendor has systems and policies in place to ensure safe storage and transmittal of data;
- **Data quality assurance:** Flagging and resolution of corrupt or missing data downloaded from meters;
- **Data visualization:** At a minimum, this includes the ability to view energy consumption profiles over time in a graphical format. Many tools offer additional advanced data visualization features;
- **Data import/export:** The ability to upload historical data to the EMIS and also to export data from the EMIS for further analysis;
- **Portfolio benchmarking:** The ability to compare energy consumption across a portfolio of facilities to determine the best and worst performers; and
- **Energy cost estimation:** At a minimum, this includes the ability to estimate energy costs using a blended average cost per kWh or cost per therm.

In order for an EMIS to acquire and analyze energy data, it requires metering hardware, data storage, and communication devices. These infrastructure requirements may be met either by the utility interval meters and meter data management system or by third-party metering and communication hardware installed at the site.

EMIS features alone do not result in energy savings – facility staff must take actions based on the information. The facilities' staff and decision-makers are essential in the process of identifying specific issues and implementing improvements. From a utility program perspective, EMIS must be paired with a program design that integrates the EMIS to reduce cost, capture energy savings potential, and improve customer engagement. EMIS are well-suited to SEM applications, as they can help to reinforce communication between the customer and utility, and support long-term improvements in energy management practices.

1.3. Strategic Energy Management (SEM) Programs

SEM programs[1] apply a continuous-improvement approach to achieving energy savings. SEM programs are intended to go beyond individual interventions to effect long-term changes in how an organization manages and reduces its energy consumption. Such actions include resource commitment, development

[1] SEM is a generic term; programs may utilize other terms such as Continuous Energy Improvement or Superior Energy Performance.

of an energy baseline, goal-setting, project planning, ongoing monitoring, and reporting of energy performance. Industrial SEM programs are designed to achieve reportable savings through project implementation and ongoing improvements to the operation of equipment.

The Pacific Northwest has taken a lead in implementing industrial SEM programs (Jones et al. 2011) and similar programs are being implemented elsewhere in the United States. The Consortium for Energy Efficiency (CEE) recently launched the CEE Industrial Strategic Energy Management Initiative with the goal of accelerating SEM as a standard business practice across the industrial sector in the US and Canada (CEE 2014).

In the Pacific Northwest, SEM programs typically track savings through spreadsheet analyses of monthly energy bills. Savings calculations typically follow the International Performance Measurement & Verification Protocol (IPMVP), Option C: Whole Facility. Inputs to the regression-based savings calculation typically include energy consumption, ambient temperature, and production variables such as the number of units produced or volume/weight of output. No defined limit exists for the number of variables that may be incorporated into a regression model, but from a practical standpoint, creating a robust regression model with more than five production-related inputs is challenging. In some cases, just one production variable may be sufficient to meet a program’s Monitoring, Targeting, and Reporting (MT&R) requirements.

Some programs in the Pacific Northwest fund purchase and installation of an EMIS, such as BPA’s Energy Smart Industrial Program (Track & Tune option) and Energy Trust of Oregon’s Refrigeration Operator Coaching. For these projects, the EMIS supports the overall energy management strategy and serves as the repository for energy and production data, but it is not used for development of the energy baseline regression equation or for the final calculation of project savings.

1.4. ISO 50001 Energy Management Systems

In 2011, the International Organization for Standardization (ISO) released the specification “ISO 50001: Energy management systems – Requirements with guidance for use” (ISO 2011). The standard specifies requirements for establishing, implementing, maintaining, and improving an energy management system (EnMS). The purpose of an EnMS is to enable an organization to follow a systematic approach in achieving continual improvements in energy performance, including energy efficiency and energy security. ISO 50001 incorporates identification of key energy performance indicators (EnPIs), significant energy-consuming processes, and key driving variables for energy consumption.

The seven major components of ISO 50001 follow:

- General requirements
- Management responsibility
- Energy policy
- Energy planning
- Implementation and operation
- EnMS and energy performance checking
- Management review.

ISO 50001 has considerable overlap with SEM program activities that take holistic views of energy management, action planning, and ongoing measurement/reporting. Industrial users could potentially streamline the energy planning, baselining, monitoring and analysis, action plans, reporting, and record retention requirements of ISO 50001 through the use of an EMIS.

No one authoritative source of data establishes the number of companies certified to ISO 50001, but one source estimated 8,200 sites worldwide as of March 2014 (Authentic Energy Management Services 2014).

2. Northwest Industrial EMIS Stakeholder Needs Assessment

As the first task in this project, the project team contacted a sample of industrial SEM stakeholders for input on their needs related to EMIS and to document existing uses of such products. Early in 2014, the team conducted ten phone interviews with utilities, their SEM program implementers, and industrial owners. The needs assessment process and results are described below.

2.1. Needs Assessment Process

The project team conducted a needs assessment via guided interviews that allowed freedom to explore several topic areas within a structured discussion framework. The team developed interview guides for utilities/implementers (Appendix A) and industrial owners (Appendix B), which covered the following topic areas:

- 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
- Barriers to be overcome in expanding use of EMIS

The team conducted the interviews by phone. Interview lengths ranged between thirty and sixty minutes. The respondents represented the following industries:

- Utilities (3)
- Utility program implementation contractors (2)
- Cold food storage (1)
- Food processing (2)
- Mining (2)

2.2. Needs Assessment Findings

The needs assessment interviews provided a rich understanding of the ways in which EMIS are used for industrial applications, the benefits gained by users, and barriers to be addressed in utilizing EMIS for SEM programs and M&V. The findings from the interviews are summarized below.

2.2.1. Industrial Energy Modeling Is Far More Complex Than That for Commercial Entities.

When using EMIS for M&V in commercial applications, energy models are typically weather- and/or schedule-driven, data inputs that are relatively easy to obtain. For industrial applications, in contrast, while weather and schedule may be significant contributors to energy consumption, they 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. Utility and program implementer respondents discussed the complexity of developing regression calculations that characterize a facility's energy consumption relative to independent variables. Some cases may include just one key variable in addition to weather, but respondents had seen up to five.

The process of developing a baseline energy regression model for a facility can take up to six months and may include multiple site visits. This is due to the complexity of facility operations, changes in product mix over time, the lack of any "rules of thumb" for selecting driving variables, and the lack of availability of key data points. The baseline development process requires a high level of manual input, filtering of data, and experimentation with different sets of input variables. These activities are currently carried out using conventional spreadsheet tools and/or statistical software, and the respondents did not expect that an EMIS could automate that process or provide the same level of flexibility for analysis. Therefore, the respondents noted a need for EMIS to allow manual entry of regression equations that have been developed external to the EMIS software.

EMIS can best be used to quantify project savings by providing annualized savings (in other words, forecasting annual savings based on less than a full year of data). The interviews revealed that utilities use varying approaches to annualizing savings. For example, one utility uses sixty days of post-implementation data to develop an annualized savings estimate, and another utility uses three months of post-implementation data. Savings annualization can be useful for tracking progress toward annual energy budgets and for quantifying annual savings without needing a full year of post-implementation data. Given that SEM programs typically last multiple years, they generate enough data to provide full-year savings; however, savings annualization is still a desirable feature for projecting annual savings and energy costs against targets.

Program implementer and utility respondents expressed a desire for EMIS that incorporate flexibility in data management and calculations, 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 whether 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.

In terms of reporting regression model fit statistics, respondents mentioned BPA's Monitoring, Tracking, and Reporting (MT&R) Guidelines as a useful reference document. The MT&R Guidelines cite IPMVP as the official guideline of BPA's Energy Smart Industrial program, and note a requirement for an R^2 value exceeding 0.75. In addition to the R^2 requirement, the MT&R Guidelines also state a need to document adjusted R^2, the coefficient of variation, net determination bias, and the auto-correlation coefficient for an energy model.

2.2.2. Industrial SEM Stakeholders Need a High Degree of Flexibility in Data Management.

Energy data acquisition methods for industrial EMIS are relatively straightforward, with the same options as those for commercial applications: getting data from the utility, from third party hardware/communications installed on-site, or by connecting to a company's internal software systems (such as supervisory control and data acquisition (SCADA) or a historian) if they are already configured to monitor energy. Based on the needs assessment interviews, acquiring data directly from the utility is rare, and connecting to internal systems is challenging but feasible in some cases. Respondents cited installation of third-party hardware/ communications as the most common scenario. One respondent noted a potential issue s/he encountered when a specific meter experienced interrupted cellular communications, leading to a resultant gap in meter readings until the communications problem was fixed. This issue was subsequently remedied by adding storage capacity to the acquisition hardware, so that data could still be stored by the device even when during communications interruptions. These users need a continuous data stream and some means of alerting them to communication problems.

Acquiring production data is more complicated than acquiring energy consumption data. In some cases, production data may be accessible through a company's internal software systems, but the complexity of these systems and the stringency of IT security policies present challenges. Respondents described processes whereby on-site staff either emailed production data to a third party for upload to the EMIS (manual), or the on-site staff could upload a spreadsheet to an online FTP site which would then load the data into the EMIS (semi-manual). Either case adds manual labor effort for the facility staff and introduces potential for human error and/or delays. However, respondents did not report major issues such as data inaccuracy or gaps in data attributable to the manual/semi-manual upload of production data.

The data interval for energy consumption and production data can affect the ease of baselining and monitoring for industrial EMIS. Higher-frequency data may result in a higher statistical confidence in the dependent variables and lower uncertainty of predicted savings (Northwest Industrial SEM Collaborative 2014). Dealing with energy and production data with non-aligned intervals presents another challenge. One utility respondent cited problems with two EMIS in attempts to align and analyze data of different frequencies.

In addition to collecting production data as inputs for the regression analysis, some respondents described the benefits of collecting additional data for specific systems or pieces of equipment.

For example, one respondent mentioned a facility's boiler that was identified as having very high energy consumption, so the ability to track energy metrics for that single piece of equipment was useful. Collecting energy consumption and throughput data for that single piece of equipment can be used to generate a key performance indicator (KPI) such as kWh per pound of throughput. In the context of EMIS, this kind of metric is referenced as a "calculated value," meaning that the metric isn't a data input itself but is derived from other data inputs to the EMIS. Process-specific metrics provide value in that they help to hone in on issues, compared to a whole-facility approach whereby some energy use problems can be hard to identify relative to overall facility energy consumption fluctuations. Monitoring KPIs can also reduce uncertainty when verifying savings for a measure that affects only one piece of equipment.

In all cases cited in the needs assessment interviews, respondents' organizations used the EMIS to monitor facility electricity consumption, and in some cases to monitor natural gas consumption as well. Two industrial owners claimed to be in the process of setting up monitoring for diesel, as it is factored into their long-term site energy reduction goals. This illustrates the need for industrial EMIS to monitor energy sources beyond electricity and natural gas.

2.2.3. Simplicity Is Critical for Owners

The needs assessment interviews with owners yielded a strong desire for simplicity. Some of their comments regarding this desire included the following.

- One owner said that even requiring users to enter a username and password to access the EMIS served as a disincentive for some individuals. This user preferred to have a simple report emailed from the EMIS each morning, as checking email is already part of the user's normal daily routine.
- Owners want to see the use of simple energy consumption comparisons like "today vs. yesterday" or "this week vs. last week."
- They would also appreciate color coding of dashboard graphics (such as green for "good" and red indicating a problem) so that a user can instantly identify anything that needs attention.

- One owner cited the imposition of training time as a disincentive. EMIS should incorporate a simple interface with intuitive graphics/charts so that little or no training is required.
- In addition to the ongoing daily energy monitoring needs, one user foresaw a potential benefit in EMIS developing a simple monthly summary report that could be used for management reporting.

One program implementer noted that even weekly reviews of energy consumption would be a stretch for resource-limited facilities, but that it would be "a hundred times better than normal industry practice." However, given that owners' participation in utility SEM programs can last three to five years, over time some users may want to track energy performance more closely.

One energy manager described how a facility operations manager uses his facility's EMIS at daily meetings with his staff of thirteen maintenance technicians. This action helps not only to monitor and control energy costs, but also to train the technicians in the proper operation of equipment. Another respondent mentioned that his facility's EMIS saves him a lot of time in preparing for twice-weekly production meetings and in creating monthly cost reports.

While respondents did not talk in detail about specific chart types, they all generally understood and valued cumulative sum (CUSUM)[2] control charts as a tool for tracking the impact of ongoing energy improvements (see Figure 4 in Appendix E for an example). One owner considered CUSUM charts more useful as a monthly reporting tool rather than for daily monitoring and management. He preferred a time series chart showing actual vs. predicted energy consumption[3] as an ongoing monitoring tool (see Figure 3 in Appendix E for an example).

2.2.4. ISO 50001 May Not Currently Be a Significant Market Driver for EMIS Adoption

[2] CUSUM is an acronym for the Cumulative Sum of the Differences and is derived from comparison of a time series plot of actual values with a corresponding set of reference data. In the case of monitoring cumulative energy savings, the reference values are based on a prediction of expected energy use in the absence of an energy efficiency improvement. Figure 4 in Appendix E shows an example of a CUSUM chart.

[3] Figure 3 in Appendix E incorporates an example of a time series chart showing actual vs. predicted energy use.

Only one of the owners interviewed claimed to operate a program certified under ISO 50001. Other respondents considered ISO 50001 certification not currently a major driver for SEM programs or for general energy planning and reporting. One owner mentioned that his company has configured its energy management procedures to facilitate potential future ISO 50001 certification. He felt that the relatively low industry recognition and benefits of being ISO 50001-certified in their industry sub-sector do not currently justify the cost of obtaining certification.

2.2.5. Upfront Planning for EMIS Implementation Is Highly Beneficial

Most project examples respondents provided during the needs assessment interviews consisted of utility-sponsored SEM programs with third-party implementation support for installation and management of the EMIS. In one case in which the owner did not have third-party program support, he described the comprehensive process of implementing his company's EMIS. He referenced Natural Resource Canada (NRCan) training and online resources as highly beneficial (NRCan 2014) and said that he followed NRCan's guidelines "verbatim." He described the following two key activities:

- Conducting an internal needs assessment with stakeholders from multiple departments: Finance, Human Resources, maintenance, IT, procurement, mining, projects, process control, and environmental. The needs assessment resulted in a "purpose definition summary" that helped in setting EMIS requirements and operating procedures.
- Developing EMIS specifications that could be sent to multiple EMIS vendors for creating competitive bids.

The respondent recommended getting buy-in from multiple levels of the organization and providing clarity on how each stakeholder will use the EMIS.

2.2.6. Project Tracking Functionality within an EMIS Is Desirable

Respondents mentioned many desirable EMIS features in addition to energy analysis functionality. All respondents noted the desirability of project tracking functionality, and described two main types of functionality they'd like to see:

- The ability to "flag" projects on a time series chart is very useful for correlating actions to changes in energy consumption characteristics.[4] This is equally helpful for an owner

[4] Figures 3 and 4 in Appendix E show examples of time series charts that incorporate flags/markers for specific events and projects.

wanting to understand shifts in energy consumption and also to allow program implementers to attribute savings to projects. One owner noted that clear correlations between energy consumption changes and single events/projects frequently do not exist; more commonly, multiple events/projects will result in cumulative changes to energy consumption.

- Some respondents noted an additional use for EMIS: managing the details of implementing energy projects, such as allocating responsibilities, defining tasks and sub-tasks, maintaining schedules, and attaching drawings and other relevant documents.[5] One respondent, a corporate energy manager with responsibility over multiple sites, found EMIS highly beneficial for keeping track of multiple projects happening at different facilities.

2.2.7. Other Desirable Features

Respondents cited many other desirable features, as summarized below:

- Providing automated alerts when energy consumption is higher than expected is a common selling feature for EMIS; however, none of the owners interviewed actively use this function. One expressed concern over automated alerts potentially becoming a nuisance; users preferred to review EMIS dashboards manually and to take cues from color coding on the charts.
- Industry-wide energy benchmarks are not currently established for industrial sectors, although efforts are ongoing at the national level. However, owners of multiple facilities stated a need to be able to compare key energy metrics across their portfolios.
- Multiple owners noted the benefits of common-area displays, with one owner in the process of implementing this feature. These displays help to educate all facility staff on energy consumption and encourage them to link their daily working practices to the facility's energy performance. Common-area dashboards should auto-refresh in order to keep the data current, and may also cycle through multiple views to show different charts/data.
- Some respondents would also like to see EMIS access via a mobile device.

[5] Figure 5 in Appendix E shows an example of EMIS task management functionality.

3. EMIS Inventory Development

As the second task in this project, the project team designed an inventory framework to capture information about EMIS M&V capabilities and other features identified as important through the needs assessment. Once the framework was established, the team identified, screened, and documented the EMIS in the inventory.

3.1. Inventory Design Process

Using the commercial EMIS inventory design as a starting point, the project team reviewed the outcomes of the needs assessment interviews to establish a key set of features for an industrial EMIS inventory. The team then created a draft inventory reflecting the specific needs of industrial owners, utilities, and program support contractors, which it then presented to the project Technical Advisory Group (TAG) and updated based on the feedback received. The main differences between the industrial and commercial EMIS inventory are as follows:

- **Data entry:** Industrial EMIS need to accept production data, manually and/or automatically.
- **Regression equation entry:** Given that baseline regressions for industrial SEM projects are currently developed outside of an EMIS, the EMIS needs to provide a means for entering the equation manually.
- **Data manipulation capability:** Respondents in the needs assessment interviews for this project emphasized flexibility in how data is managed, as noted in the prior section.
- **Non-applicable features:** Some features offered by commercial EMIS are not currently available for industrial applications:
  - **Benchmarking:** Developing a facility benchmark score with reference to an industry-wide dataset
  - **Disaggregation:** Automatically disaggregating whole-facility interval data into end-use consumption estimates
  - **Measure identification:** Automatically identifying energy improvement opportunities based on analysis of whole-facility interval data

The inventory design continued to evolve through the EMIS research phase of the project. The team determined through the EMIS web demonstrations that some features overlapped, and in some cases, feature definitions changed based on the range of options available from vendors. For example, the initial design included the categories “ongoing monitoring” and “chart types,” which the team subsequently found to have a high degree of overlap; it combined those two categories into a single column for the final inventory. The final inventory is included as Appendix C.

3.2. EMIS Research

The following section describes the process the project team employed to identify, screen, and evaluate EMIS to populate the inventory. It outlines the tools included in the initial pool, why some tools were eliminated, and which tools were ultimately included in the inventory.

3.2.1. Screening

The high number of available EMIS (greater than forty) commercially available dictated a set of simple screening criteria to select EMIS for web demonstrations and deeper investigation. Based on the needs assessment interview results, the team chose three initial criteria for a tool to be considered for deeper research, as indicated in Table 1 below.

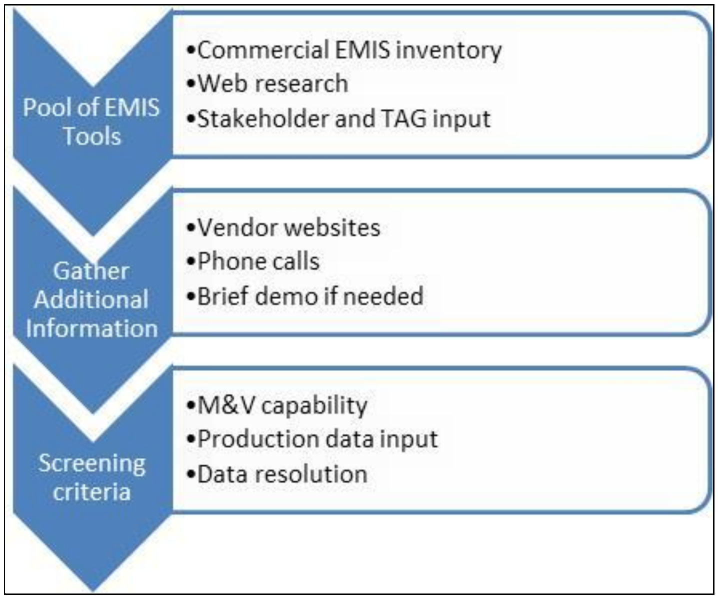
Table 1. Industrial EMIS Screening Criteria

Screening Criterion	Rationale
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
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
Tool must be able to track energy data at a daily or higher resolution.	- Existing spreadsheet-based tools can handle monthly data; intent is for EMIS to provide extra value. - Daily tracking frequency is a manageable unit for facilities, and can support "actionability."

Note: Quantification of savings is still considered automatic even in cases where the energy regression equation needs to be manually entered into the EMIS

The project team considered a total of forty-three EMIS for inclusion in the inventory, and put each one through a screening process as shown in Figure 1. The project team derived the starting list from the commercial EMIS inventory, suggestions from the needs assessment interviews and the TAG, and web searches. The project team assessed each EMIS to determine whether it met the screening criteria, possible in some cases based on review of the vendor's website or based on the experience of project team members and the TAG. In other cases of unclear tool capabilities, the project team contacted the vendor directly to determine suitability. The team ultimately rejected some vendors as nonresponsive after several contact attempts by phone and email.

Figure 1. EMIS Screening Process



While many of the EMIS met screening criteria 1 and 3, only thirteen appeared to meet all three screening criteria. Table 2 below summarizes reasons for EMIS rejection.

Table 2. Summary of Reasons for Screening out EMIS

Reason	Number of tools
Nonresponsive to requests for information/demo	7
No production data input	7
Grid-level monitoring for utilities	4
Enterprise software	3
Demand-response support tool	2

Document management software	2
Monthly data only	2
No M&V capability	1
Vendor not located	1
Excel-based analysis tool, not EMIS	1
Passed screening; selected for web demonstration	*13*
TOTAL	**43**

3.2.2. Web Demonstrations

To populate the inventory, the project team had in-depth conversations with each vendor and attended live web-based demonstrations of each tool that passed screening. These demonstrations focused on collecting the information needed to report on each feature in the inventory.

The project team often followed up a demonstration with email questions to clarify its understanding from the demonstration. The team emailed each vendor a copy of the inventory entries for their EMIS and invited it to provide clarifications on product functionality, where applicable.

The EMIS market is rapidly evolving with the continual release of new product offerings and additional features. This industrial EMIS inventory provides a snapshot of current features only, and does not report on features the vendors are developing, testing, or have on their roadmaps for future development.

Of the thirteen tools that appeared to meet the screening criteria, three vendors declined to provide demonstrations due to lack of time or resources. Information from a 2013 demonstration, in combination with published literature, sufficed to complete inventory entries for one of these three tools (eSight Energy). Based on demonstrations, the project team rejected an additional five EMIS for not meeting the screening criteria.

3.2.3. Final Inventory Design

The final EMIS inventory (Appendix D) is a Microsoft® Excel® workbook comprising two worksheets:

- The "Descriptions" worksheet shows all the inventory features included in the inventory, with the types of input expected for each feature and a definition of the feature.
- The "Inventory" worksheet presents the data collected for each EMIS, with one column for each EMIS feature and one row for each EMIS.

3.2.4. Feature List and Descriptions

The finalized list of twenty-seven inventory features is organized into five sections: Data input, M&V, User interface/reporting, Project tracking, and Applications. Some of the feature columns in the inventory have open data fields, while others offer a pre-defined list of options from which to select. A detailed description of the inventory and options for each feature can be found in Appendix C.

3.3. EMIS Inventory Findings

The final inventory is populated with six EMIS, shown in Table 3 below.

Table 3. Tools Included in the Industrial EMIS Inventory

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**	3	>750*
Panevo	Energy Desktop***	1	>1,000
RtTech Software	RtEMIS	None	7

Notes:

*Some installations serve multiple clients (as reported by vendor).

** eSight Energy did not provide a demonstration for this project.

*** Energy Desktop was developed by Verco, and is supplied by Panevo.

**** Self-reported by EMIS vendors.

General findings on the six EMIS in the inventory are summarized below.

3.3.1. The Field Is Small, but High-Quality

When compared to the commercial EMIS inventory (fourteen tools), the number of tools suitable for industrial applications is relatively small. Only six EMIS demonstrated the capability to perform M&V on datasets that incorporate production data, and that have a data interval of one day or less. Four of these tools – Energy Intelligence Software, Energent, eSight Energy, and SENSEI – also appeared in the commercial EMIS inventory.

While fewer EMIS are available for industrial applications, the applicability, flexibility, and usability of these tools is high. Dashboard designs are engaging, user-friendly, and relatively intuitive. Charting capability is highly flexible in terms of changing the time frame for displayed data and adding or removing data series from charts. The broad range of available charts and display options may increase the risk of user overload.

3.3.2. Manual Regression Equation Entry for M&V is Available on All EMIS

The need to develop a regression outside of a tool and then manually enter it into the EMIS constitutes one key distinction between the commercial and industrial EMIS inventories. Although all six EMIS in the industrial inventory offer this capability, they exhibited differences in how it is handled. All six tools allow the vendor to enter equations in the back end of the software; SENSEI, Energy Desktop, and RtEMIS also allow the user to enter equations through the user interface.

3.3.3. M&V Methodologies Follow IPMVP Option C

As expected, all EMIS in the inventory apply the IPMVP Option C method for calculating savings. In all cases, the savings estimates follow the "avoided energy use" approach, whereby savings are reported across the period for which data is available but are not extrapolated into the future to calculate annualized savings.

EnergentET, Energy Desktop, SENSEI, and RtEMIS all offer the capability for users to enter multiple regression equations that can apply under different circumstances, such as different equations on weekdays vs. weekends, or to cover a facility shutdown period. The other tools in the inventory did not report this capability.

The ability to report uncertainty metrics varied among the EMIS, as Table 4 shows.

Table 4. Summary of Uncertainty Metrics Reported by EMIS in the Final Inventory

Vendor	EMIS	Uncertainty Metrics Reported	Availability
Cascade Energy	SENSEI	R^2; Standard error; CV (RMSE); F statistic; Overall P value;	User interface

		Histogram of residuals	
Energent	EnergentET	R^2; CV (RMSE)	Back end
EnerNOC	Energy intelligence Software	R^2; CV (RMSE)	Back end
eSight Energy	eSight Energy	R^2; CV (RMSE); T Statistic; Mean Bias Error % (MBE); P Value	User interface
Panevo	Energy Desktop	R^2; CV (RMSE); Mean bias; Intercept coefficient; Intercept T statistic	User interface
RtTech Software	RtEMIS	R^2; Pearson Correlation Coefficient; Spearman Correlation Coefficient	User interface

Since vendors may continue to develop energy regression calculations outside of the EMIS, uncertainty statistics may initially be available prior to uploading the regression calculation to the EMIS, indicating lesser need for the EMIS to report those statistics initially. However, this feature may increase in value in order to re-establish a baseline, for example when a major energy upgrade necessitates development of a new baseline. Such cases may allow use of the EMIS to recalculate the regression equation using the same input variables, to see whether model uncertainty is acceptable (if the updated model is unacceptable, experimenting with different input variables or modeling approaches may be necessary).

3.3.4. Several Options for Production Data Entry

The ability to input production data constituted a key requirement for inclusion in the EMIS inventory. All tools offered compatibility with a wide range of automated input options, such as SCADA, JACE, and historians. EnerNOC, Energent, and Cascade Energy also offer proprietary data logger/communications gateways.

The six EMIS in the inventory supported one or more of the following three options for manual data entry:

- Web interface for entering individual values
- Secure FTP site transfer, with functionality to automatically upload data to the EMIS from the FTP site
- Emailing a data file to the vendor

The scope of this project included evaluations of neither the effectiveness and ease of data collection methodologies between the EMIS in the inventory, nor of the capability of each EMIS to consolidate data of different frequencies. Vendors generally stated that they can normalize data frequency depending on the required resolution of any chart. For example, in a situation in which an EMIS provides energy data in fifteen-minute intervals and production data daily:

- If the chart display has fifteen-minute intervals, it will show actual energy data and will divide production data into ninety-six equal values (twenty-four hours divided by fifteen minutes); and
- If the chart display is daily, it will sum the fifteen-minute energy data for each day and will show actual production data values.

Validation of the data collection and data aggregation methodologies for the EMIS in this inventory study may require additional research.

3.3.5. Automated Alerting Functionality Comes in a Variety of Methods

All EMIS in this inventory share as a core feature the ability to compare actual energy consumption with expected, and to define rules to issue alerts if energy performance veers outside of an expected range. The six EMIS is this inventory offer a variety of methods for applying this functionality, an illustrated in Table 5 below.

Table 5. EMIS Alerting Functionality

Vendor	EMIS	Color-Coded On-Screen Alert	Summary Table View	Automated Email	Automated SMS Message
Cascade Energy	SENSEI	●	●		
Energent	EnergentET	●		●	
EnerNOC	Energy Intelligence Software	●	●	●	●

eSight Energy	eSight Energy	●	●	●	
Panevo	Energy Desktop	●		●	
RtTech Software	RtEMIS		●	●	●

The needs assessment interviews and EMIS demonstrations failed to clarify the extent to which EMIS employed automated emails and SMS messages.

3.3.6. Some EMIS Offer a Range of Project Tracking Capabilities

Three of the EMIS web demonstrations covered project management features, which can be grouped into three main types:

- **Project flagging (SENSEI, EnergentET):** The ability to flag a project or incident so that it appears as a marker on time series charts helps in understanding why and when energy profiles change. Utility representatives, implementers, and owners in the needs assessment interviews found this feature desirable.
- **Project/task management (SENSEI, EnergentET, Energy Desktop):** Three of the EMIS in this inventory offer the ability to record and track multiple details relevant to on-site projects, such as describing tasks, allocating responsibilities, attaching project-related documents, and relating projects to specific assets.
- **Document management (SENSEI, Energy Desktop):** Two of the EMIS reported the ability to upload documents, which could include project-specific documents such as drawings and specifications or more general documents such as periodic energy/cost reports. This feature could also be used as a repository for training or project-related documents to support utility programs.

3.3.7. Common Features

Table 6 below provides a brief summary of key findings for features included in the inventory but not covered above.

Table 6. Other EMIS Features

Feature	Comments

Ability to create calculated values (e.g., metrics and KPIs)	Common to all EMIS
Charting	All EMIS incorporate actual vs. predicted energy consumption. Five of the six EMIS incorporate CUSUM charts. A wide variety of options exist beyond those two key chart types
Demand management	EnergentET and RtEMIS provide warning alerts when a facility is at risk of setting a new monthly peak demand value
Cost savings reported	All EMIS incorporate this functionality. SENSEI and RtEMIS reported using actual utility rate schedules
Demand savings reported	EnergentET emerged as the only tool that reportedly calculated peak demand savings
Data output	All EMIS incorporate simple data download functionality
Portfolio analysis	All EMIS incorporate portfolio analysis functionality
Emailed reporting	All EMIS allow users to configure the format and frequency of periodic reports that can be automatically emailed to users
Public/common area dashboard	Four of the six EMIS have implemented common area dashboards
Mobile access	Energy Intelligence Software is available as a mobile app. Other EMIS may be viewed via a browser on a mobile device.

4. Conclusions and Recommendations

Utilities, program implementers, and owners have a small but strong pool of EMIS from which to choose for SEM programs or related energy management initiatives. The six tools that appear in the final EMIS inventory all offer high standards of functionality and usability. The tools vary in terms of user interfaces and flexibility, which render some stronger than others in some respects, but in general all of the tools address the majority of the needs/desires identified by respondents in the needs assessment. However, all EMIS appear to lack the ability to annualize savings. Although respondents did not specify this feature as essential during the needs assessment, its inclusion may offer benefits to both owners and utilities in terms of tracking progress toward energy reduction goals and forecasting energy budgets.

Owners wanting to pursue ISO 50001 certification may potentially benefit from the use of EMIS in terms of developing energy baselines, tracking projects, operational control, ongoing monitoring and analysis, and reporting. The needs assessment interviews did not identify ISO 50001 as a major market driver in the Pacific Northwest, the limited sample size aside. However, implementing SEM and/or EMIS could help owners to obtain and maintain the energy management approaches specified in ISO 50001.

PECI recommends additional research into certain aspects of the featured EMIS to assist in determining suitability of the tools for specific situations: The first would be evaluation of relative costs for each EMIS. This would prove challenging given that each project is unique; however, some measure of relative costs would be valuable. Another key aspect meriting additional research would be a technical assessment of the tools' M&V capabilities and methods for dealing with inputs with varying data intervals, given that assessing these features proved difficult through the limited demonstrations under this project. This might be accomplished through a comparison of results from each EMIS using standard datasets, which could also be helpful in reviewing ease of implementation and ongoing monitoring.

More general research could focus on streamlining and standardizing the baseline modeling process and on increasing the level of automation for developing models.

Development of materials such as the following may supplement additional research in supporting successful expansion of EMIS-based approaches to SEM:

- Training resources, templates, and other related guidance for owners and utilities
- Owner or program case studies and other outreach activities
- Standardized EMIS specifications (tailored to SEM applications)
- Guidelines for integrating EMIS into industrial utility programs

This study reviewed the state-of-the-art for EMIS for industrial applications and found several high-quality options available to program administrators and industrial owners. These tools are well-suited to the SEM process, can support ISO 50001 reporting requirements, and overcome several major challenges that exist for industrial applications. The research lays the foundation for further efforts to validate technical capabilities and coordinated development to support successful expansion of EMIS-based SEM programs. EMIS show great potential for supporting expansion of industrial Strategic Energy Management from an "early adopter" phase toward common industry practice.

References

Authentic Energy Management Services (AEMS). *ISO 50001 around the world.* Dublin, Ireland: Authentic Energy Management Services. Accessed September 2014 from http://www.aems.ie/Pages/iso50001.aspx.

Consortium for Energy Efficiency (CEE). 2012. *Summary of Commercial Whole Building Performance Programs: Continuous Energy Improvement and Energy Management and Information Systems.* Boston, Massachusetts: Consortium for Energy Efficiency. Retrieved from http://library.cee1.org/content/summary-commercial-whole-building-performance-programs-continuous-energy-improvement-and-en-1.

Consortium for Energy Efficiency (CEE). 2014. *CEE Industrial Strategic Energy Management Initiative.* Boston, Massachusetts: Consortium for Energy Efficiency. Retrieved from http://library.cee1.org/content/cee-industrial-strategic-energy-management-initiative/

Friedman (Kramer), H., E. Crowe, E. Sibley, M. Effinger. 2011. *The Building Performance Tracking Handbook. California Commissioning Collaborative*. Portland, Oregon: PECI.

Granderson, J., M.A. Piette, B.Rosenblum, L.Hu, 2011. *Energy Information Handbook: Applications for Energy Efficient Building Operations* (Report No. LBNL-5272E). Berkeley, California: Lawrence Berkeley National Laboratory.

Granderson, J., M.A. Piette, G. Ghatikar, P. Price. 2009. *Building Energy Information Systems: State of the Technology and User Case Studies* (Report No. LBNL-2899E). Berkeley, California: Lawrence Berkeley National Laboratory.

International Organization for Standardization (ISO). 2011. *ISO 50001: Energy management systems – Requirements with guidance for use*. Geneva, Switzerland: International Organization for Standardization.

Jones, T., K. Crossman, J. Eskil, J. Wallner. 2011. *The Evolution of Continuous Energy Improvement Programs in the Northwest: An Example of Regional Collaboration.* Washington, DC: American

Council for an Energy-Efficient Economy. Retrieved from http://www.aceee.org/files/proceedings/2011/data/papers/0085-000034.pdf.

Kramer, H., J. Russell, E. Crowe, J. Effinger. 2013. *An Inventory of Commercial Energy Management and Information Systems (EMIS) for M&V Applications.* Portland, Oregon: Northwest Energy Efficiency Alliance. Retrieved from http://neea.org/docs/default-source/reports/inventory-of-commercial-energy-management-and-information-systems-for-m-v-applications.pdf?sfvrsn=6.

Natural Resources Canada (NRCan). Energy Management Information Systems. Ottawa, Ontario, Canada: Natural Resources Canada. Accessed September 2014 from http://www.nrcan.gc.ca/energy/efficiency/industry/training-awareness/5463.

Northwest Industrial SEM Collaborative. 2014. *Common Considerations in Defining Baselines for Industrial Strategic Energy Management Projects*. Portland, Oregon: Conduit (Northwest Energy Efficiency Alliance). Retrieved from https://conduitnw.org/_layouts/Conduit/FileHandler.ashx?RID=1937.

Northwest Power and Conservation Council (NWPCC). 2010. *Sixth Northwest Conservation and Electric Power Plan.* Portland, Oregon: Northwest Power and Conservation Council. Retrieved from http://www.nwcouncil.org/energy/powerplan/6/plan/.

APPENDIX A – Needs Assessment Interview Guide: Utilities and Program Implementers

1. Goal

Understand the EMIS-related needs of NEEA's utility stakeholders and their existing use of those tools for Strategic Energy Management programs.

2. Approach

1. Call respondent targets to explain the project and ask if they're willing to participate. If so, schedule 1-hr meeting.
    a. PECI has been hired by NEEA to investigate the use of Energy Management and Information Systems in industrial SEM programs, with a focus on their applications for monitoring, tracking, reporting energy performance, and calculating savings from energy efficiency changes. As the first step in this project, we are contacting NEEA's member organizations and their program implementation partners to understand their experience with and needs related to EMIS.
    b. Would you have a one-on-one discussion about your experience with and needs related to EMIS?
2. Eliot or Joan conducts 1-hr discussion following guide below.
3. PECI develops summary

3. Discussion Guide

EMIS Intro

1. For the purposes of this study, Energy Management and Information Systems are Software tools, normally hosted online, that display and analyze a continuous stream of energy and other types of data. The energy data is supplied by utility meters and onsite data sources such as process equipment monitoring and controls, and enterprise software.
2. Within the scope of this research we are also looking at tools which are offered to support compliance with ISO 50001, the Energy Management Systems Standard
3. We're currently designing an inventory that we will use to collect information on important characteristics of EMIS. We have some thoughts on what are the important characteristics, but in order to ensure that the inventory is valuable for NEEA's stakeholders, we want to ask you your thoughts on what's important.
4. See if they have any questions before you begin

Past and Present Activities

5. Have you brought EMIS into any programs or pilots?
    a. If so:
        i. What program, and what tool(s) used?
        ii. How was the tool(s) selected and did you consider any other tools?

iii. How was the EMIS planned to be used? E.g. Baseline development, M&V, persistence of savings, Benchmarking, opportunity ID, no specific plan…
iv. Who uses the tool? Customers? 3rd Party? Utilities?
v. How has it worked out? Any lessons learned that you can share?
vi. Are there data analysis/tracking needs that you have had to address outside of an EMIS (eg. Using a spreadsheet for analysis that's not offered through an EMIS)

6. What types of data have you seen being input to EMIS (ie. Acquired from what device/software, and using what data protocol?) (be ready with some examples: weather, throughput, shift number, etc.)
    a. For developing a baseline or establishing savings (one-off)
    b. For ongoing monitoring purposes (continuous)
    c. What challenges were encountered when installing, configuring, and using EMIS?
7. To what degree are your customers' meters and/or production equipment able to upload data via IP-enabled communications?
8. Are you able to communicate your customer's interval data
    a. To the customer themselves
    b. To a third party (eg. Cloud-based software provider)
    c. Via batch (eg. Day-behind) or realtime
9. How has EMIS software been used to support baseline development? Eg.
    a. Integral to the EMIS tool
    b. EMIS tool vendor has led identification of the driving variables for developing baseline regression models
    c. EMIS tool has been used, but identifying the driving variables was led by someone else
    d. EMIS not involved in baseline development
10. Is ISO 50001 incorporated into any of your industrial program designs?
    a. Have EMIS been used to satisfy these requirements?
    b. Have other software applications been used to support ISO 50001 compliance?
11. Do you use the tool for any purpose other than creating a baseline or ISO 50001
    a. Possible examples: DR, identifying ways to save $/energy, etc.
    b. Do owners have staff who could manually analyze data to hone in on areas of opportunity?
12. Do you have any other EMIS experience
    a. What tool?
    b. How was it used?
    c. Strengths/weaknesses?

Future Interests

13. Are you interested in using EMIS more in the future?
14. When we prepare our inventory, are there any specific tools you'd like us to look at?
    a. Why are you interested in these particular tools?

15. Are there specific things that you want to know about tools? Things that would help you decide whether to incorporate them in your operations?
    a. 'Must-have' features?
    a. Desirable features? (measure ID? Benchmarking? Smart alarms?)
    b. What do you think is the biggest hurdle EMIS need to overcome?
16. What types of data do you think EMIS need to accommodate for future applications?
    a. From specific devices or software
    b. Specific data communication protocols
17. Do what degree will EMIS be expected to support ISO 50001 compliance?

Closing

18. Any questions they have for us
19. Thank them and tell them you're available if they later think of any other questions or comments. Also say you'll point them to the final report when it's available

APPENDIX B – Needs Assessment Interview Guide: Owners

4. Goal

Understand the EMIS-related needs of industrial owners within NEEA's territory, and their existing use of those tools for industrial Energy Management.

5. Approach

1. Call participants to explain the project and ask if they're willing to participate. If so, schedule 1-hr meeting.
    a. PECI has been hired by NEEA to investigate the use of Energy Management and Information Systems in industrial SEM programs, with a focus on their application for monitoring, tracking, reporting energy performance, and calculating savings from energy efficiency changes. As the first step in this project, we are contacting industrial owners to understand their experience with and needs related to EMIS.
    b. Would you be willing to have a one-on-one discussion about your experience with and needs related to EMIS?
    c. Responses would be kept confidential; nothing will be published that mentions the respondent or their company by name
2. Eliot or Joan conducts 1-hr discussion following guide below.
3. PECI develops summary

6. Discussion Guide

Greetings

EMIS Intro

1. For the purposes of this study, Energy Management and Information Systems are Software tools, normally hosted online, that display and analyze a continuous stream of energy and other types of data. The energy data is supplied by utility meters and onsite data sources such as process equipment monitoring and controls, and enterprise software.
2. Within the scope of this research we are also looking at tools which are offered to support compliance with ISO 50001, the Energy Management Systems Standard.
3. We're currently designing an inventory that we will use to collect information on important characteristics of EMIS. We have some thoughts on what are the important characteristics, but in order to ensure that the inventory is valuable for NEEA's stakeholders, we want to ask you your thoughts on what's important.
4. See if they have any questions before you begin

Past and Present Activities

1. Have you previously used, or are you currently using, EMIS?
    a. If so:
        i. What tool(s) used?
        ii. Was the EMIS incorporated into a program offered by a utility or other third party? For example, offering incentives for installing an EMIS, or using an EMIS to measure savings.
        iii. How was the tool(s) selected and did you consider any other tools?
            1. Were there any key features or functions you were looking for?
        iv. How did you plan to use the EMIS? E.g. Benchmarking, Developing an energy use baseline, quantifying project savings, ensuring persistence of savings, no specific plan…
        v. Who within your organization uses the EMIS?
        vi. How has it worked out? Any lessons learned that you can share?
            1. Ease of setup and use (hardware/software/communications)
            2. How incorporated into normal management/reporting protocols
            3. Benefits (energy and non-energy)
        vii. Are there data analysis/tracking needs that you have had to address outside of an EMIS (eg. Using a spreadsheet for analysis that's not offered through an EMIS)
2. What types of data do you input into the EMIS (ie. Acquired from what device/software, and using what data protocol?) (be ready with some examples: weather, throughput, shift number, etc.)
    a. For developing a baseline or establishing savings (one-off)For ongoing monitoring purposes (continuous)
        i. What are the key drivers for energy use at your facility?
    b. How was your experience with setting up data acquisition (ease, time, labor)
        i. Working with the EMIS vendor?
        ii. Working with a utility or other third party?
3. To what degree are your meters and/or production equipment able to upload data via IP-enabled communications?
4. How has EMIS software been used to understand how your facility uses energy? Eg.
    a. Integral to the EMIS tool
    b. EMIS tool vendor has led identification of what drives energy use for developing baseline regression models
    c. EMIS tool has been used, but identifying the driving variables was led by someone else
    d. EMIS not involved in baseline development
5. How much training was required in order to use the EMIS
6. How much is the tool used? (eg. daily, monthly, not used any more)?
7. Is your organization certified to ISO 50001? Are currently pursuing certification, or plan to in the future?

   a. Have EMIS been used to satisfy these requirements?
   b. Have other software applications been used to support ISO 50001 compliance?
8. Do you use the tool for any purpose other than creating a baseline or ISO 50001
   a. Possible examples: Demand Response, identifying ways to save $/energy, etc.
   b. Do owners have staff who could manually analyze data to hone in on areas of opportunity?
9. Do you have any other EMIS experience
   a. What tool
   b. How was it used?
   c. Strengths/weaknesses

Future Interests

10. Are you interested in using EMIS more in the future?
11. When we prepare our inventory, are there any specific tools you'd suggest we look at?
    a. Why are you interested in these particular tools?
12. Are there specific things that you'd want to know about tools? Things that would help industrial owners decide whether to incorporate them in your operations?
    a. 'Must-have' features?
    b. Desirable features? (measure ID? Benchmarking? Smart alarms?)
    c. What do you think is the biggest hurdle EMIS need to overcome?
13. What types of data do you think EMIS need to accommodate for future applications?
    a. From specific devices or software
    b. Specific data communication protocols
14. To what degree will EMIS be expected to support ISO 50001 compliance?

Closing

15. Any questions they have for us
16. Thank them and tell them you're available if they later think of any other questions or comments. Also say you'll point them to the final report when it's available

APPENDIX C – Inventory Feature Definitions

	COLUMN HEADING	OPTIONS	DEFINITION / NOTES
DATA INPUT	Automated data entry - energy data	MDMS connection, Direct from meter/submeter, Other periodic file transfer, Enterprise software, Other [describe]	How energy use data may be automatically uploaded to the EMIS. Specify all that apply.
	Automated data entry - production/process data	SCADA; custom-installed devices; other [describe]	How production/process data may be automatically uploaded to the EMIS. This may be [a] production volume, such as units or lbs of product, or [b] process controls data such as compressed air pressure or boiler temperature. Specify all that apply.
	Manual data entry - production data	User-entered (simple); user-entered (complex); vendor-entered	Where applicable, specify how production data may be manually entered into the EMIS. If entered by the user, specify whether this is considered a simple or complex undertaking.
	Methodology for dealing with non-aligned data frequencies	Describe [open text entry]	Typically, energy use data can be provided at 15-minute intervals; it is untypical that production data is available at such high frequency, and the EMIS will have to manage that misalignment in order to quantify savings and track performance. Describe how the EMIS handles this.
	Ability to create calculated values	Yes/No	Ability to create values by combining more than one stream of input data. Two examples of this might be [a] additive - for example adding data from multiple meters to obtain a whole-facility value, and [b] metrics - for example, combining production volume and energy use to derive a value such as lbs per kWh.

	COLUMN HEADING	OPTIONS	DEFINITION / NOTES
M&V	Savings Calculation Method	Simple pre-post comparison (not normalized), Supports Option C: Actual vs. normalized baseline (avoided), Supports Option C: Actual vs. normalized baseline (avoided and annualized), Supports Option D: Calibrated simulation	**Simple pre-post comparison**: Compares energy use in the post-project period to the energy use in the baseline period. Baseline conditions are not normalized or adjusted for post conditions. **Supports Option C: Avoided Energy Use**: Baseline energy model created with pre-project data is adjusted or normalized to post-ECM conditions. Actual post-project energy use is compared with the normalized baseline energy use to determine savings. Savings are only reported over the period for which post-project energy use data is available. **Supports Option C: Annualized Savings:** Estimates annual savings using less than one year of post-project data through development of baseline and post-project period models that are normalized to a common set of conditions (e.g., typical year weather data), and extrapolated to the full year. Energy savings are determined by subtracting the post-project model energy use (extrapolated to a full year) from the baseline model energy use (under the same conditions).
	Regression equation entry	Vendor-entered, user-entered, NA	When baseline regression is developed outside of the EMIS, it will need to be entered into the EMIS for ongoing tracking and savings quantification. Specify here how the equation is entered. "NA" means the tool doesn't have this capability.
	Data Manipulation Capability	Describe [open text entry]	To accommodate the flexibility of production and occasional anomalies, the EMIS should ideally have some flexibility in how it manages data. For example, energy using during a scheduled production shutdown should not be counted as savings vs the baseline. Possible flexibility in data manipulation might include [a] excluding certain data periods, [b] isolating certain data periods and treating them differently, or [c] ignoring anomalous data points.
	Required User Expertise for Savings Quantification	Low, Medium, High	Representation of how familiar the <u>utility/implementer</u> needs to be with M&V principles and the EMIS to use the savings quantification functionality . **Low:** user needs little to no familiarity, high level of automation in calcs; Example: user would input baseline start & end dates, tool does everything else. Medium: user needs some knowledge, user has to enter more than start/stop dates or choose model options from a list. Example: User has to input start/stop dates and also have to pick from a list which model to use based on which variables are included, temperature only, temperature and occupancy, or HDD/CDD, etc. **High:** User needs expertise, low level of automation in calcs. Example: user would specify which variables to include in the analysis, which type of model to use for the analysis, judge model fit, etc.
	Statistics Reported	[open text entry, to include…]None, R2, CV (RMSE), F, FSU, Confidence interval	What statistics are available and reported for the savings quantification?
	Demand Management	Yes (Manual), Yes (Auto), No	Does the EMIS provide functionality to support load shifting that will reduce energy use at times when costs are high? "Manual" means the tool might provide charts or alerts such that facility staff may take action to avoid setting a new peak demand value. "Auto" means that the EMIS is configured to automatically adjust process settings based on a set of predefined parameters.
	Cost Savings Reported	Yes: Nominal unit cost, Yes: Utility rate schedule, Yes: Method unknown, No	If applicable, how the EMIS calculates cost savings from energy efficiency improvements. This applies to actual savings measurement, as opposed to estimating cost savings for measures prior to implementation
	Demand Savings Reported	Yes, No	If the tool calculates monthly peak demand savings in addition to energy savings. **This applies specifically to the kW saved; resultant cost savings is not included here.**
	Data output	Yes (simple), Yes (complex), NA	Indicate how data can be output from the EMIS (baseline, actual energy use, projected baseline, charts, etc.). Simple might be a "download" button next to the displayed data. "Complex" might require several menu steps to identify and download the data.

	COLUMN HEADING	OPTIONS	DEFINITION / NOTES
USER INTERFACE / REPORTING	Portfolio Analysis	Yes, No	Does the EMIS offer the ability to analyze a portfolio of facilities? (e.g., table/chart view of data from multiple sites)
	Charts / Monitoring	CUSUM, Current vs. prior day/week/month, Time-series vs. baseline, Scatter, KPIs, benchmarking, Other [specify]	Indicate the types of charts provided. Note whether data can be filtered by building/shift/production line (e.g. charts comparing night shift to day shift).
	Charting flexibility	Vendor-driven, user defined, dynamic	Vendor-driven means the vendor can configure charts but the user can only view them. User-defined means the user has the ability to develop chart types, and these cannot be tweaked "on the fly." Dynamic means the user can define charts and that these can be modified on the fly using checkboxes, drag & drop functionality, etc. It is assumed that all systems have unique user logins, and that different users have different default views and access levels - specify if this is **not** the case.
	Emailed Reporting	Yes (template), Yes (user-defined), No	Applies to regularly scheduled reporting, as opposed to alert-based reporting. May be daily, weekly, monthly. Maybe sent to one or multiple individuals. Content may vary.
	Alerting when energy use outside of expected range	On-screen alert, color-coded on-screen alert, automated email, phone call, text, Other, NA	Indicate what happens when ongoing energy tracking identifies energy use values significantly outside of the expected range. Indicate all that apply
	Public / common-area dashboard	Yes, No	Does the application have a specific interface designed for public display. This might incorporate a single set of simple charts & data points, or may advance through several screens of charts/data. Display must automatically refresh
	Mobile Access	Yes, No	Can EMIS be accessed from cell phone / tablet?

PROJECT TRACKIN	Projects/Events Flagged	Yes, No	The ability to enter projects/actions into the EMIS and have them visually "flagged" on time series charts
	Project Tracking & Management	[open data entry field]	General project management features not covered above, such as document management

APPLICATIONS	Fuel types covered	[open data entry field]	Document which fuel types have been tracked by the tool (electric, gas, water, oil, diesel, etc.)
	Industry Sectors Served	[open data entry field]	Informational only; sectors as defined by vendor (not providing a discrete pick-list)
	Number of Utility Pilots and Programs	[open data entry field]	# of pilots and programs. Includes completed and in-progress pilots/programs
	Total Number of Installations (can include non-utility applications)	[open data entry field]	# of individual facilities the EMIS has been used in/on (campus = one facility)
	Other Uses	[open data entry field]	Brief description of any non-energy uses such as building security applications, financial analysis, maintenance management, etc.

APPENDIX D – EMIS Inventory Workbook

Click here to open the EMIS inventory workbook

APPENDIX E – EMIS Screenshots

Example EMIS screenshots are shown below. Vendors contributed these examples at the time of publication. These examples are illustrative only, and are not intended as endorsements or recommendations for any specific EMIS.

Figure 2. Screenshot from Energy Desktop by Panevo

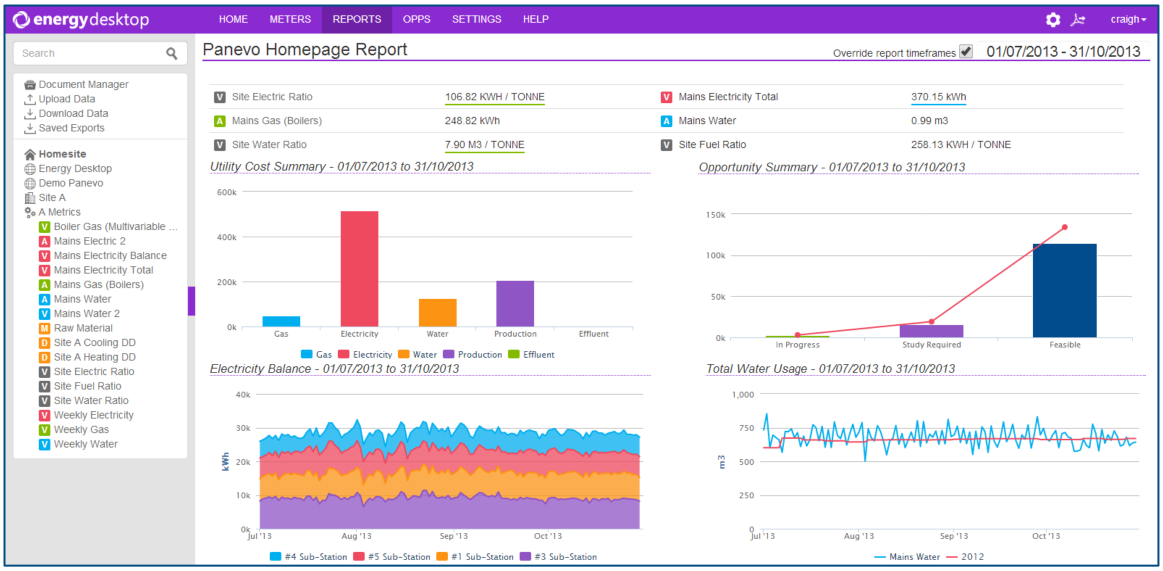


Figure 3. Screenshot from SENSEI by Cascade Energy

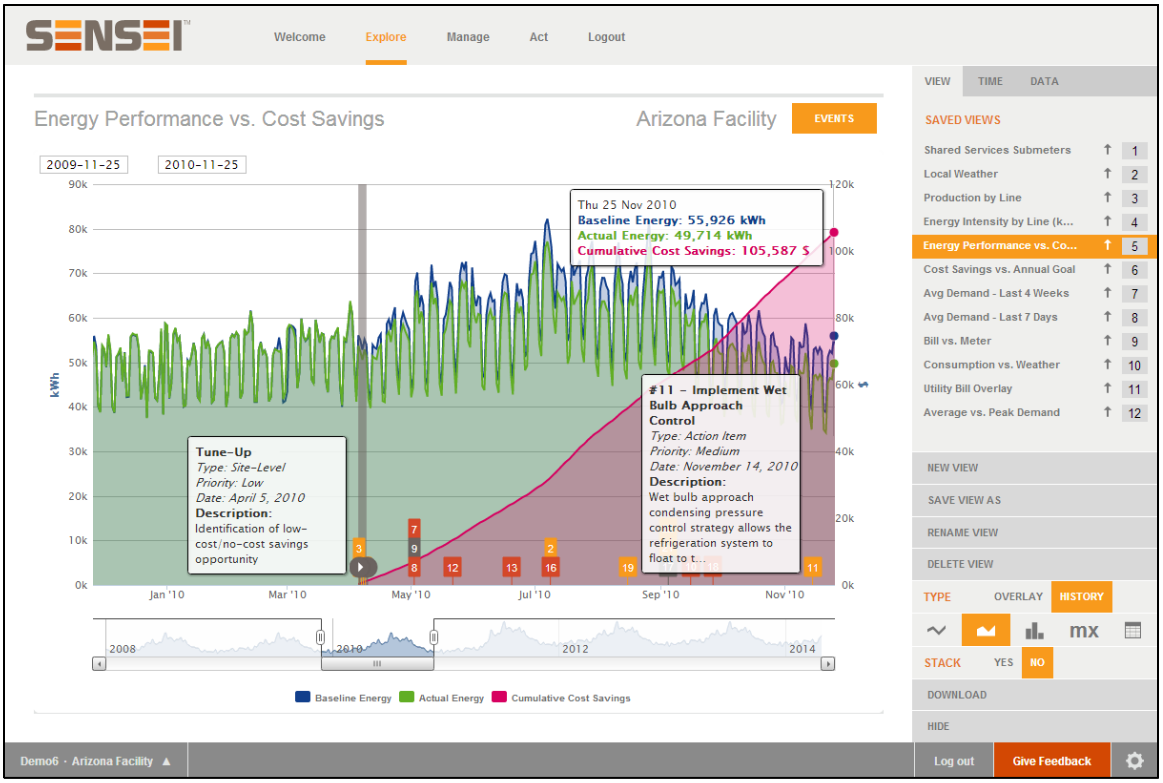


Figure 4. Screenshot from EnergentET by Energent

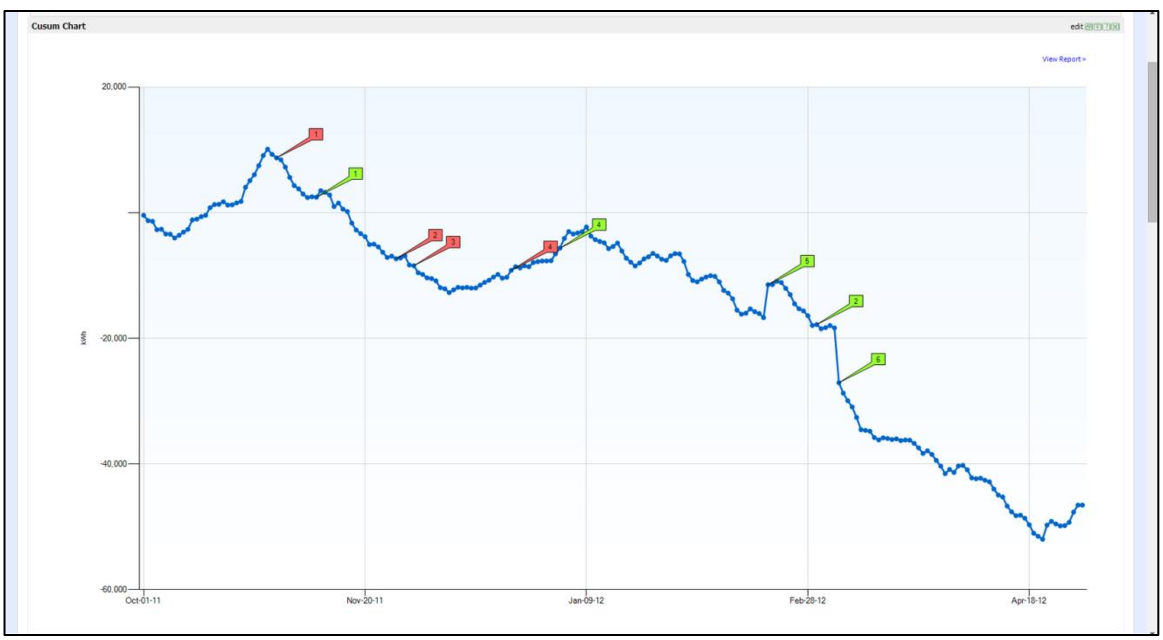


Figure 5. Screenshot from SENSEI by Cascade Energy