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

Final Report

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Table of Contents

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Technical Advisory Group

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

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Executive Summary

Introduction

Energy Management and Information Systems (EMIS) are software tools that store, analyze, and display energy use or building systems data. A wide variety of EMIS is available, and they have shown promise for supporting nonresidential utility energy efficiency programs. One major barrier to adoption has been a general lack of transparency in the embedded analytical capabilities, which makes it harder to validate EMIS performance. For most potential EMIS users, it is challenging just to keep up with the ever-increasing number of EMIS entering the market and the evolution of existing tools.

To assist its Pacific Northwest utility stakeholders, the Northwest Energy Efficiency Alliance (NEEA) contracted with Portland Energy Conservation, Inc. (PECI) to help provide clarity on the range of EMIS available and their respective feature sets. The output of this work is an EMIS inventory that details the functionality of fourteen EMIS. The overarching objective of the inventory is to document EMIS features that can support utility programs and financial transactions for energy efficiency.

Stakeholder Needs Assessment

The project team conducted a series of guided interviews with representatives of Northwest utilities to better understand: past, current, and planned EMIS-related activities; the most desirable features that EMIS could provide; and recommendations for specific tools to evaluate for the EMIS inventory. These interviews indicated that Northwest utilities' current approaches to EMIS cover a wide range, from monitoring EMIS developments and responding to customer inquiries to implementing program pilots. Many EMIS pilots are in progress across the region, with a few of the larger utilities taking the lead. Utility representatives expressed strong and widespread interest in future use of EMIS for applications including portfolio screening, opportunity identification, occupant engagement, and measurement and verification (M&V). Many respondents saw potential benefits for the use of EMIS in M&V but noted a need for more visibility, understanding, and documentation of the tools' M&V approaches. In addition, the manner in which the tools can be integrated into programs remains unclear to utility representatives, and they are uncertain regarding program cost-effectiveness.

EMIS Inventory

Building on the needs assessment, PECI's past research, and recent literature on EMIS, PECI developed a draft inventory design, which it then refined based on feedback received from the project's Technical Advisory Group (TAG). The final inventory is comprised of twenty-four columns, divided into the following five groups:

- **Product Information:** EMIS name, vendor, website
- **General Features:** Data security protocol, end-user audience
- **M&V Features:** Details defining M&V methodology
- **Technical Features:** Other features offered in addition to M&V
- **Applications:** Information on pilots/programs and installations

PECI carefully documented the feature definition and data entry requirements for each of the columns in the inventory spreadsheet to ensure consistency and to enable comparisons across EMIS.

PECI developed an initial target list of fifty-one EMIS for consideration, including tools suggested by NEEA stakeholders and other tools known to the project team or reported in recent literature. For EMIS to qualify for inclusion in the inventory, PECI set minimum criteria for M&V capabilities and market presence. Screening the target list against the minimum criteria reduced the list to approximately twenty tools. Several more tools were removed from the inventory after the software demonstration showed that the tools did not sufficiently meet the minimum criteria for inclusion in the inventory.

Findings

The final inventory is populated with fourteen EMIS, which are shown in the table 1.

Table 1. EMIS Included in the Inventory

Vendor	EMIS	Data Input Frequency	M&V	Opportunity Identification	Project Tracking
Cascade Energy	Sensei	< Hourly	Option C[i]		Advanced
Elster EnergyICT	EIServer Platform	< Hourly	Option C		Advanced
Energent	Energent	< Hourly	Option C		Advanced
EnergyCAP	EnergyCAP Enterprise	Monthly	Option C		Basic
EnergyRM	DeltaMeter	Monthly	Option D[ii]		
EnerNOC	Efficiency Smart Insight	< Hourly	Option C	Yes	Basic
eSight Energy	eSight Energy	< Hourly	Option C		Basic
FirstFuel	Rapid Building Assessment	< Hourly	Option C	Yes	Basic
Johnson Controls	Energy Performance Monitor	< Hourly	Option C		Basic
MACH Energy	MACH Asset Manager	< Hourly	Option C		Basic
Noesis	Noesis	Monthly	Option C		Advanced
NorthWrite	Energy Worksite	< Hourly	Option C		Advanced
Pulse	Energy Manager	< Hourly	Option C		Basic
Retroficiency	Virtual Energy Assessment (VEA) Automated Energy Audit (AEA)	< Hourly	Option D	Yes	

Notes: i. International Performance Measurement and Verification Protocol (IPMVP), Option C: Actual vs. normalized/adjusted baseline -- ii. IPMVP Option D: Calibrated simulation

The project team's research on meter-level EMIS found that EMIS technology has progressed markedly compared to its capabilities of even a few years ago. The process of identifying, screening, and populating the inventory with tools yielded several findings and themes, including the following.

Advanced M&V Features Are Aligning with Utility Needs

The stakeholder needs assessment identified a need for clear visibility into the tools' M&V algorithms. Two-thirds of the EMIS vendors reported that model equations or model specifications can be viewed and downloaded by the user. Most of the tools reported statistical metrics for "model fit" (i.e., how well the theoretical energy model matched actual energy use) to tool users.

Almost all of the EMIS in the inventory support an International Performance Measurement and Verification Protocol (IPMVP) Option C approach to M&V, under which the actual post-implementation energy usage is compared to an adjusted baseline ("avoided energy use" approach). This approach typically requires twelve months of post-implementation data to report on annual savings. However, five of the tools in the inventory reported an ability to perform "normalized" savings analyses in which the model estimates annual savings using less than a year of post-implementation energy use data. In addition, seven of the meter-level EMIS vendors in this inventory reported that they are starting to include methods for accounting for non-project effects, such as occupancy changes.

Just two of the tools in the inventory support IPMVP Option D calibrated simulation; these tools implement whole-building simulations informed by meter data. One key benefit of simulations is that the tools may be used to calculate energy savings for individual measures or end uses.

The inventory includes three examples of EMIS that provide advanced M&V capabilities using monthly data. One drawback of using monthly data is that the method is not well-suited to projects with relatively low savings (less than ten percent of whole-building energy use). Since higher resolution interval data is not available for many commercial buildings, PECI considered it essential to include monthly tools in the inventory.

EMIS Products and Offerings Continue to Evolve

EMIS have evolved significantly over the previous few years, and this evolution is expected to continue. As part of this evolution, many EMIS in the inventory now share a common set of basic features and capabilities, especially around data visualization and benchmarking. Beyond those basic features, tools in the inventory are differentiating in two key ways. First, the level of automation and user expertise required varies among tools. Second, an increasing number of EMIS are offering project tracking capabilities and some ability to disaggregate energy use and to identify measure opportunities.

Conclusions

The state of the art in EMIS technology has progressed markedly when compared to capabilities of a few years ago. Utilities have a number of options for EMIS that can support program M&V (even if smart metering infrastructure is not in place), and that offer other beneficial features in addition to the software's M&V capabilities.

The recent evolution of advanced M&V capabilities presents utilities an opportunity to determine appropriate methods for validating the tools for program applications. This is not simply a case of validating new tools that can replicate existing programmatic methods; capitalizing on the

M&V capabilities of EMIS requires the development of whole-building programmatic approaches that can satisfy the needs of building owners, utilities, and regulators. If meter-level EMIS features are proven to be robust and the programmatic approaches are cost-effective, this opens the way for rapid growth of whole-building approaches to energy efficiency.

1. Introduction

Energy Management and Information Systems (EMIS) are software tools that store, analyze, and display energy use or building system 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 use 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 have shown interest in using EMIS to expedite energy efficiency projects, reduce costs, and improve customer engagement, with the ultimate goal of increasing energy savings. While the potential for these tools to support energy efficiency programs is substantial, utilities in the US are currently in the pilot or early program phase of development, with no defined program best practices. Utilities face challenges in finding an effective method for comparing and evaluating EMIS options given the number and complexity of the offerings available on the market.

To assist its Pacific Northwest utility stakeholders, the Northwest Energy Efficiency Alliance (NEEA) contracted with Portland Energy Conservation, Inc. (PECI) to develop an EMIS inventory. The objective of the inventory is to document EMIS features that could support future utility programs and energy efficiency financial transactions. The focus is on EMIS with the ability to measure and verify 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 and reliable.

The key tasks under this project were:

- A needs assessment to understand NEEA stakeholder perspectives on requirements and opportunities related to use of EMIS
- Design of an EMIS inventory (in the form of a spreadsheet) that captured desirable and essential EMIS features as determined through the needs assessment
- Population of the EMIS inventory, based on the project team's research and web-based demonstrations of EMIS

This report documents the EMIS inventory development process and summarizes the key findings from the research. The report concludes with recommendations for how NEEA might further advance the use of EMIS to support Northwest energy efficiency programs and energy efficiency transactions.

1.1. Background

The Sixth Northwest Conservation and Electric Power Plan (Sixth Power Plan) calls for meeting eighty-five percent of new energy needs through improved energy efficiency (Northwest Power and Conservation Council 2010). This aggressive goal is driving utilities to explore more comprehensive energy efficiency program approaches to achieve deeper savings. Currently, commercial energy efficiency programs typically apply a “widget-based” approach, wherein savings are counted for each new piece of efficient technology installed (such as higher efficiency lighting). While these programs have produced lasting savings, they usually consist of a single intervention as opposed to a comprehensive whole-building approach, and reporting of project benefits is rarely based on actual energy measurements. Existing building commissioning (EBCx) or energy audit programs use a comprehensive approach, but identifying, quantifying, and verifying energy efficiency opportunities requires considerable time and expense.

For utilities to successfully deploy projects with comprehensive savings on a large scale cost-effectively, they need technically robust, low-cost and scalable methods for enabling, estimating, and quantifying project savings. Using monthly data analysis to quantify savings has been manually applied on projects with high savings (typically more than ten percent). However, quantifying savings from lower-impact approaches such as operational and maintenance (O&M) and behavior-based approaches requires higher-resolution data (such as hourly or daily interval meter data). Research has shown that utilities can detect whole-building savings of around five percent by using data at intervals of one hour or less to create the energy regressions.[1] Higher-resolution data can also reduce the length of time required to develop annualized savings estimates (at least nine, but ideally twelve months of post-implementation energy use data is needed to achieve reasonable accuracy using monthly data).

While analyzing whole-building meter data has the potential to facilitate quantifying project savings, successful manual interval data analysis is a relatively rare skill that is both time-consuming and subject to different applications by different analysts. Leveraging EMIS for whole-building analysis represents a largely untapped opportunity to automate data analysis, reduce variations in the calculation methodologies, and at the same time reduce costs.

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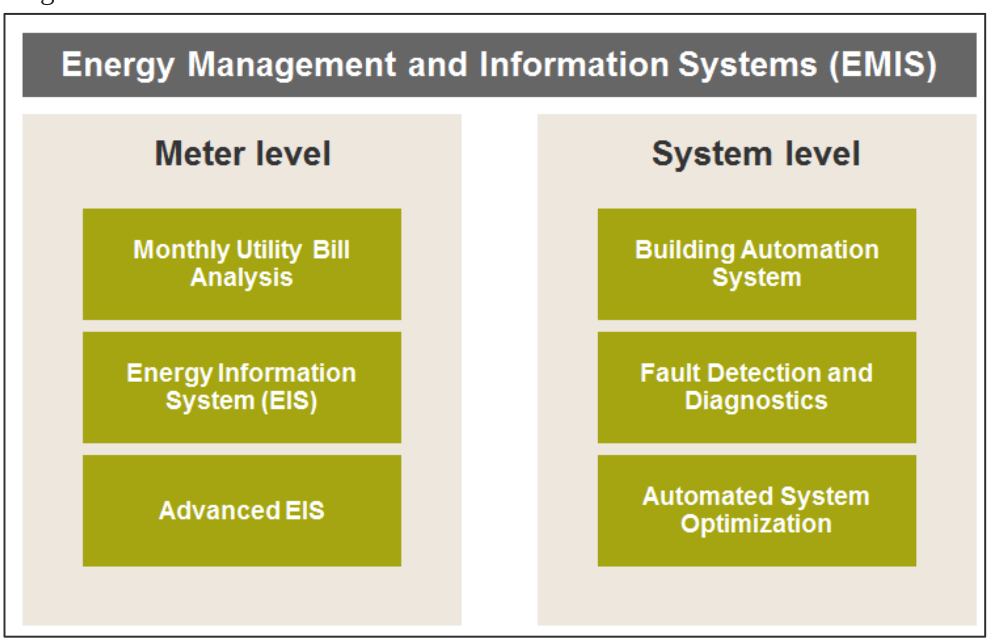
[1] Several resources document the relationship between data resolution and savings magnitude that can be identified at the whole building level, including Effinger, Effinger, and Friedman 2012; Jump 2008; Katipamula, Reddy, and Claridge 1995; and Katipamula, Reddy, and Claridge 1994.

1.2. EMIS Defined

EMIS are enabling tools that support users' efforts to improve the energy efficiency of their buildings by providing better access to energy and system data and by applying analytics to these data. Energy efficiency experts have developed several research reports and guides over the last five years to characterize EMIS features and to develop an overall terminology framework; these efforts are ongoing (Friedman et al. 2011, Granderson et al. 2011, Granderson et al. 2009). Where possible, the terminology and feature classifications used in this report align with other industry efforts.

EMIS use either meter-level data to track energy use or equipment-level data to track system performance as shown below. System-level EMIS functionalities include building automation system (BAS) trending and monitoring capabilities, fault detection and diagnostic (FDD) tools, and automated system optimization software that involves dynamic changes to BAS settings. This project focuses on meter-level EMIS that perform M&V at the whole-building level. While system-level tools have rich features, as a group they are oriented more toward optimizing system performance rather than whole-building M&V.

Figure 1. Classification of EMIS **T**ools



Vendors predominantly offer meter-level EMIS as cloud-based "software as a service" (SaaS), allowing the user to view and analyze energy data online. They offer a variety of functions and features that are driven by their respective target users, typically building owners, property managers, operators, and in some cases, electric and gas utilities. However, certain core features are nearly universal. Such core features of meter-level EMIS include:

- **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 use profiles over time in a graphical format. Many tools have additional more 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.

- **Benchmarking:** The ability to compare energy use across a portfolio of buildings to determine the best and worst performers.

- **Energy cost estimation:** At a minimum this includes the ability to estimate energy costs using an average cost per kWh or cost per therm.

The meter-level column defines three subcategories of EMIS: Monthly utility bill analysis, Energy Information Systems (EIS), and Advanced EIS. Each of these categories includes the core features of meter-level EMIS discussed above; they differ in the granularity of data they support and in the complexity of additional features they provide. Monthly utility bill analysis tools are primarily distinguished from the other two categories by their use of monthly data, whereas EIS and Advanced EIS use more granular interval data.

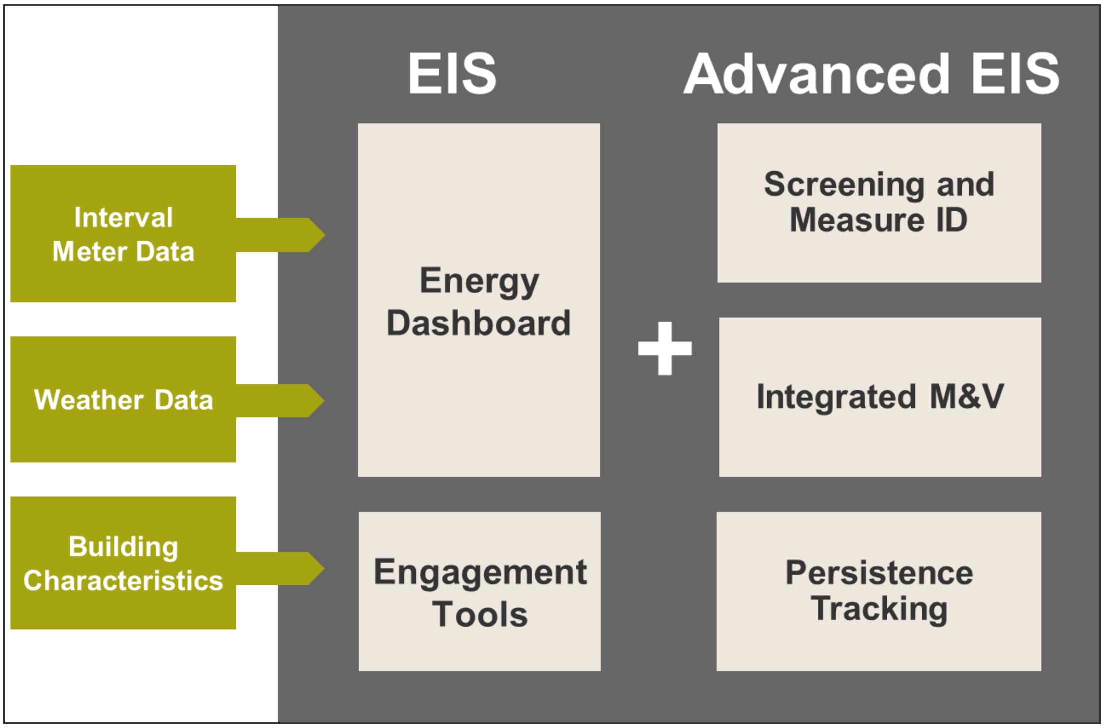
- **Monthly Utility Bill Analysis:** Monthly data is used for high-level analysis of large opportunities that may be detected in monthly data (such as high gas use during summer months).

- **EIS:** Provides the capability for the user to analyze energy consumption patterns using a variety of standard charts and metrics (often called a “dashboard”). EIS enables a trained user to identify problems more easily and quickly than does monthly utility bill analysis software.

- **Advanced EIS:** Includes the capabilities of EIS plus one or more advanced functions, such as load disaggregation and end-use benchmarking, energy efficiency opportunity identification, and integrated M&V. Advanced EIS may also be able to track ongoing building performance in comparison with historical baseline models and automatically alert users when energy use is higher than expected.

Figure 2 illustrates the distinction between EIS and Advanced EIS, showing the typical features associated with EIS tools and the features that are considered advanced.

Figure 2. Features Distinguishing EIS from Advanced EIS



Acquiring and analyzing energy data for a meter-level EMIS requires metering hardware, data storage, and communication devices. Meeting this infrastructure requirement involves either utility interval meters and a meter data management system or a separate metering and communication system installed at the site.

1.3. Meter-Level EMIS Applications

The EIS and Advanced EIS features discussed in the previous section meet the needs of various target markets. Figure 3 illustrates six target markets and the applications potentially served by EMIS within each market. Each of these market actors has a critical need to manage the risks involved with investing in energy efficiency; EMIS offer the potential to better monitor and manage energy use and hence to reduce investment risks.

Figure 3. Market Actors and Their Potential Meter Level EMIS Uses

Notes: ESCO = Energy Service Company; EM&V = Evaluation, Measurement and Verification

EMIS, particularly Advanced EIS, have many features and capabilities with the potential to change and streamline key elements of traditional utility programs. Some of the potential applications of Advanced EIS features are shown in Table 2.

Table 2. Potential Applications of EMIS Features

Capability	Potential Application
Opportunity Identification	Analysis at the whole-building meter level can be used to focus an on-site investigation in two ways: benchmarking buildings to identify the buildings with the greatest potential (some tools offer end-use level benchmarking as well as whole building), and identifying opportunities for O&M improvements or retrofits in a building.
M&V	Using a whole-building approach to verifying savings can quantify savings from comprehensive approaches that combine retrofits, O&M improvements, and behavior-driven improvements. Whole-building M&V approaches typically are able to quantify uncertainty in the savings and inherently account for interactions among systems or multiple measures, capabilities often not found with custom calculation approaches. This approach may provide improved savings accuracy and lower cost when compared with custom calculations for each individual measure.
Persistence Tracking	Continuously tracking energy use after measure implementation can verify that savings are persisting over time, reducing uncertainty associated with estimated measure life.

These Advanced EIS features alone do not result in energy savings – building managers must take actions based on the information. In order to achieve energy savings, EMIS need to be paired with a program design that integrates the EMIS to reduce cost, capture energy savings potential, and improve customer engagement. Utility programs that incorporate EMIS typically fall into five general program designs:

- **Strategic Energy Management (SEM) Programs**: Support for improved energy management within a company's standard operating practices. Savings may result from a combination of retrofit, O&M, and behavior.
- **Existing Building Commissioning, O&M, or Tune-up Programs**: Improve the operation of existing systems, often focused on control strategy improvements.
- **Behavior-Based Programs:** Occupants change their energy-consuming behaviors. Often paired with energy-saving competitions or as the occupant engagement portion of more comprehensive program approaches.
- **Comprehensive Retrofit Programs:** Auditing the whole building to identify and implement retrofits in heating, ventilation and air conditioning (HVAC); lighting; and control systems.

- **Marketing-Only Programs**: The intent is to engage customers and funnel projects into existing programs.

The Consortium for Energy Efficiency (CEE) has documented whole-building performance programs and pilot activities by utilities across the country (CEE 2012). The past three years have seen a stark increase in EMIS-enabled whole-building pilots and programs.

2. Northwest EMIS Needs Assessment

To complete this project, PECI first contacted NEEA members to understand their needs related to meter-level EMIS products and to document existing uses of such products. Early in 2013, PECI conducted interviews of eleven stakeholders in Northwest energy efficiency programs from eight NEEA member organizations.

These phone interviews lasted between thirty minutes and one hour. Respondents' backgrounds included planning/EM&V (six), engineering (four), and program management (one). They represented three investor-owned utilities, three other regional energy efficiency organizations, and two public utilities.

Several themes emerged from the interviews:

- Respondents' current approaches to EMIS cover a wide range, from monitoring EMIS developments and responding to customer inquiries to proactive piloting.
- Many EMIS pilots are in progress across the region, with a handful of larger utilities and energy efficiency providers taking the lead.
- Respondents expressed strong and universal interest in future use of EMIS for applications including portfolio screening, opportunity identification, occupant engagement, and M&V.
- While many respondents see potential benefits for the use of EMIS in M&V, they generally see a need for more visibility, understanding, and documentation of the tools' M&V approaches.

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 framework. The interview guide (Appendix A) covered the following topic areas:

- **Past and current EMIS programs or pilots:** A discussion of each interviewee's organization's experience using EMIS in programs or pilots. Those with such experience discussed the EMIS tool(s) used, how it was used, the end-user of the tool, and any lessons learned from the experience.
- **Other EMIS knowledge and experience:** Some respondents had experience with EMIS beyond specific pilots and programs operated by their organizations. For example, some

had conducted their own market research to identify available tools. PECI asked for their insights into both the specific tools and the EMIS market in general.

- **Incorporating EMIS in future plans:** This typically constituted the longest and most wide-ranging part of the discussion, during which respondents were asked if they had plans to use EMIS in the future, and if so, how. Respondents discussed both programs and markets in which EMIS could be used as well as EMIS capabilities that might serve them.

- **Important questions to answer:** Respondents identified key issues that needed to be resolved relative to EMIS. For example, interviewers asked them to identify specific EMIS tools about which they wanted to know more, and specific EMIS capabilities that they wanted to understand.

2.2. Needs Assessment Findings

These interviews directly informed the following assessment of current approaches and future plans for meter-level EMIS.

2.2.1. Current Approaches

The larger utilities and energy efficiency providers are actively testing multiple EMIS products and pursuing pilots. Smaller entities reported constraints that prevent them from actively pursuing EMIS-based approaches, principally limited staff and budget resources and the capabilities of their metering infrastructure.

Three utilities indicated that their current metering infrastructure did not provide the interval data necessary for EIS or Advanced EIS, but that it would in five or ten years. They are meanwhile following industry developments, but are only implementing projects in response to customer requests. All respondents seemed very conscious of the need to demonstrate cost-effective applications before going beyond pilot-scale deployments of EMIS.

2.2.2. Meter-Level EMIS Pilots in Progress

Utilities are piloting the use of meter-level EMIS as an enabling tool for energy efficiency and demand management programs across the Northwest. Pilots involve between one and one hundred sites and feature different applications of meter-level EMIS with varying degrees of reliance on the EMIS. Specific pilots described by stakeholders are outlined below:

- Avista worked with the University of Idaho to install an EMIS created by Resource Associates International to view five-minute resolution energy use data for sixty-five buildings.

- The Bonneville Power Administration (BPA) is supporting an emerging technology study that has installed Catalyst, a sophisticated rooftop HVAC controller with EMIS features, at forty-three sites.
- With BPA's support, Snohomish Public Utility District (PUD) conducted a behavior-based pilot with ten Starbucks stores that used the Lucid Design EMIS to present energy information to drive behavior change.
- BPA and Seattle City Light are using data center-focused EMIS products at three sites in the Seattle area.
- The Energy Trust of Oregon (ETO) has engaged Northwrite/Air Advice and Kite & Lightning in EMIS-enabled pilots for small and medium business customers.
- Snohomish PUD deployed the Pulse Energy EMIS for one of the school districts in its resource conservation management program.
- Northwrite's EMIS is being used in the hospitals program managed by NEEA.
- PacifiCorp reports piloting Advanced EIS products at three sites (industrial, light manufacturing, and large commercial) both to identify opportunities and for M&V.

Utilities mentioned additional pilots underway that are protected by non-disclosure agreements. The variety of approaches being explored is indicative of the region's strong interest in using EMIS.

2.2.3. M&V Capability

All interviewees saw some role for EMIS in supporting M&V for energy efficiency programs. They also expressed strong senses of potential challenges, most frequently citing clear visibility into and validation of a tool's M&V algorithms to understand the approach and limits of application. One interviewee from the EM&V perspective stated, "I have to know exactly what's being calculated and how… there has to be transparency in how it is being done." Two other interviewees noted the necessity for program managers and customers of clearly stating the uncertainty in energy savings estimates.

2.2.4. Future Interests

Overall, interviewees expressed cautious optimism about the future of EMIS in the region. They identified many ways that EMIS could help, including portfolio tracking and screening, occupant engagement, identification of opportunities, M&V, and persistence. No single feature or strategy emerged from the interviews as most interesting or promising. This may reflect the interviewees' uncertainty about EMIS capabilities, the small sample size, or perhaps the fact that many tools are now reporting many features and benefits. Many interviewees expressed considerable uncertainty regarding how and where the use of EMIS could be cost-effective.

2.2.5. Tool Recommendations

In addition to their feedback above, the interviewees recommended inclusion of a number of meter-level EMIS. PECI added these tools to the initial list of tools considered for inclusion in the EMIS inventory.

3. Meter-Level EMIS Inventory

PECI next designed an inventory framework to capture information about meter-level EMIS M&V capabilities and other features identified as important through the needs assessment. Once the framework was established, PECI identified, screened, and documented EMIS in the inventory.

3.1. Framework Design Process

PECI intended the inventory design process to deliver a framework that would support a clear and objective snapshot of EMIS features based on self-reported information from vendors and web-based demonstrations. To design the inventory, the project team leveraged existing research and conducted a review of the most recent literature, including:

- **PECI Emerging Technology Research –** PECI's internal Emerging Technology research group has evaluated over eighty EMIS tools across the Residential, Grocery, Commercial, and Industrial markets. The classifications and standard data collection fields served as the starting point for the NEEA inventory.

- **California Energy Commission Research –** A recent project funded by the California Energy Commission's Public Interest Energy Research (PIER) Program studied how energy and system information is being used to improve building operations. The project identified current industry best practices in performance tracking. The work concluded with the development of a practical handbook for selecting the best-fit building performance tracking management strategy and supporting technology category (Friedman et al. 2011). This handbook served as the basis for the taxonomy of EMIS used in this project.

- **Recent Literature –** The project team also reviewed recent literature from Pacific Gas & Electric (Summers, Chan, and Hilger 2013), Lawrence Berkeley National Laboratory (Granderson et al. 2009), and the Consortium for Energy Efficiency (CEE 2012, CEE 2011). The team used this literature to identify features and functions to evaluate during the design of the inventory, to identify possible EMIS tools to include in the inventory, and also to identify various pilots and programs across the US that are utilizing EMIS.

Through this process, PECI expanded a preliminary feature set identified by stakeholders during the needs assessment, and refined it into categories consistent with the growing body of research on EMIS. The project team presented the inventory features to the TAG for review.

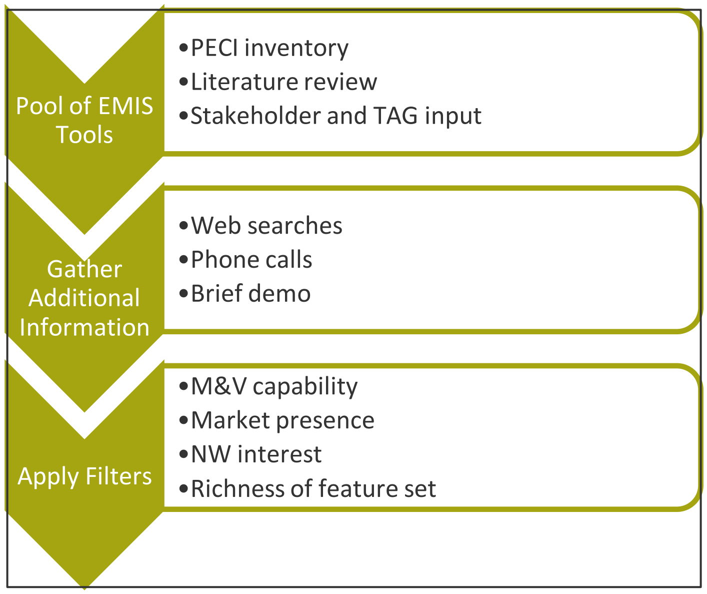
3.2. Meter-Level EMIS Research

The following section describes the process PECI employed to identify, screen, and evaluate meter-level EMIS to populate the inventory. It outlines the tools included in the pool, why some tools were eliminated, and the tools ultimately included in the inventory.

3.2.1. Screening

Given the large number of meter-level EMIS available, PECI employed a screening process to identify the software most likely to meet stakeholder needs, with an emphasis on M&V. The screening process is shown in Figure 4.

Figure 4. EMIS Screening Process



As the first step, the project team established a pool of meter-level EMIS by utilizing PECI's previous research, recently published literature, and the recommendations made by stakeholders during the needs assessment. This process yielded a pool of fifty-one tools. Not all of the utilities in the Northwest have interval meters installed, so the pool included those that require interval meter data as well as some meter-level EMIS that have rigorous M&V algorithms but utilize monthly billing data. The team included this range of EMIS to render the inventory relevant to a wider range of NEEA stakeholders, regardless of whether they have interval meters installed.

The second step of the screening process involved gathering additional information about each of the fifty-one tools in the pool to determine which tools met the minimum criteria. Focusing on capabilities relating to project M&V constituted the most important criterion. The International Performance Measurement and Verification Protocol (IPMVP) describes several techniques to calculate energy savings.[2] Aside from benchmarking annual energy use against reference values, meter-level EMIS supports two M&V approaches:

- **IPMVP Option C Whole Facility:** Uses whole-building energy data and drivers of building energy use, such as temperature, schedule, occupancy, and day of week, to construct an empirical model (such as regression, bin analysis, or neural network) of the building's baseline energy use.
- **IPMVP Option D Calibrated Simulation:** Uses building simulation software to create a computer model that predicts building energy performance. Building simulation models represent the thermodynamic flow of energy through building systems. Energy modeling requires skilled users to provide numerous inputs about the characteristics of building systems and operations, and to then calibrate the model to confirm that its energy use estimations align with actual energy use.

As this project was not intended to provide a comprehensive inventory of all meter-level EMIS, the inventory focused on capturing information about tools that go beyond the basic M&V capability of benchmarking annual energy use against reference values. Therefore, PECI set a minimum M&V capability for a tool to be included in the inventory. The team used the following screening criteria to determine which tools to review and include in the inventory:

- **Advanced M&V:** The ability to create a predictive model (with at least weather normalization, but preferably including other independent variables) using either interval or monthly meter data, or the ability to perform calibrated simulations.
- **Market presence**: Tools with a significant number of installations (i.e., those that aren't brand-new to the market).
- **Regional interest**: Tools being used by Northwest utilities either with a significant Northwest presence or specifically recommended by NEEA's stakeholders.
- **Richness of feature set**: Tools that include features in which NEEA's stakeholders are interested (in addition to M&V capabilities).

The team applied advanced M&V capability as the most important criterion.

3.2.2. Demonstrations

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[2] IPMVP also describes two types of savings estimates: 1. Avoided Energy Use, which retrospectively measures energy use as the difference between a baseline model and actual performance, and 2. Normalized Savings, which can be used to estimate future savings using assumed future values of the independent variables, such as typical meteorological year (TMY) weather data. PECI did not use these two types of savings estimates in the screening process, but are identified in the inventory.

To aid in populating the inventory with the fourteen tools, the project team engaged in in-depth conversations with each vendor and received live web-based demonstrations of each EMIS. These demonstrations focused on collecting the information needed to report on each feature in the inventory. Each demonstration lasted about an hour and often included follow-up questions via email to clarify PECI's understanding from the demonstration.

Given that the commercial EMIS market is rapidly evolving with new product offerings and additional features being continuously released, this inventory should be viewed as a snapshot of current features; it does not report on features the vendors are developing, testing, or have on their roadmaps for future development.

3.3. Results

The final EMIS inventory (Appendix C) is a Microsoft® Excel® workbook comprising two worksheets. A "Descriptions" worksheet shows all the inventory features included in the inventory, with the type of input expected for each feature and a definition of the feature. The "Inventory" worksheet presents the data collected for each EMIS. Each EMIS feature is presented in one column and each EMIS is displayed in one row.

3.3.1. Feature List and Descriptions

The final list of twenty-two features is organized into four sections: general features, technical features, M&V features, and applications. The inventory structure is shown in Table 3.

Some of the feature columns in the inventory have open data fields, while others have pre-defined lists of options from which to select. Appendix B provides more detailed descriptions of options for each feature.

Table 3. Inventory Columns and Brief Descriptions

	COLUMN HEADING	DEFINITION / NOTES
GENERAL	Current End-User Audience	What user group does the EMIS target?
GENERAL	Data Input Frequency	Finest resolution of data that can be integrated into and processed by the EMIS.
TECHNICAL FEATURES	Portfolio Analysis	Does the EMIS offer the ability to analyze a portfolio of buildings?
TECHNICAL FEATURES	Benchmarking	How does the tool benchmark the building being analyzed to other similar buildings?
TECHNICAL FEATURES	End-use Disaggregation	Does the EMIS disaggregate whole building interval data into end uses?
TECHNICAL FEATURES	Opportunity Identification Included?	Does the EMIS identify specific deficiencies and/or measures using their analytics?
TECHNICAL FEATURES	Opportunity Identification Type?	If the answer to the above is "yes", what types of deficiencies/measures are identified by the EMIS?
TECHNICAL FEATURES	Cost Savings	How does the EMIS calculate cost savings from energy efficiency improvements?
TECHNICAL FEATURES	Demand Savings	Does the tool calculate monthly peak demand savings in addition to energy savings?
M&V	Highest Resolution Data Input	Finest resolution of data frequency that can be used in the EMIS's models.
M&V	Data Acquisition	How energy use data is delivered to the EMIS
M&V	Project Tracking & Management	Does the EMIS have a way for tracking efficiency project information such as implementation dates, verification items, project schedules/budget, etc.
M&V	Savings Method	**Supports Option C: Actual vs. baseline (comparative)**: tool compares energy use in the post period to the energy use in the pre period. Baseline (or pre) conditions not normalized or adjusted for post conditions. **Supports Option C: Actual vs. normalized/adjusted baseline (avoided savings)**: the baseline created with pre-data is adjusted or normalized to post conditions. Actual usage is compared with adjusted/normalized baseline to determine savings. **Supports Option C: Annualized (normalized):** The tool does actual vs. normalized/adjusted baseline as well as projects annualized savings based on less than 1 year of post data. **Supports Option D: Calibrated simulation**
M&V	Annualized Savings Estimates	Identifies whether the EMIS can estimate energy savings for the entire year.
M&V	Required User Expertise	How familiar the user needs to be with M&V principles and the software to use the EMIS for verifying savings.
M&V	Statistics Reported	What statistics are available and reported?
M&V	Model Equations/Specification Reported?	Are the model equations/specification reported?
M&V	Ongoing Energy Monitoring	Brief description of how the tool conducts ongoing energy monitoring
APPLICATIONS	Number of Utility Pilots and Programs	# of pilots and programs. Includes completed and in-progress pilots/programs
APPLICATIONS	Total Number of Installations (can include non-utility applications)	# of buildings the EMIS has been used in/on
APPLICATIONS	Other Uses	Brief description of non-energy uses such as building security applications, maintenance management, etc.
APPLICATIONS	Utility Program Management Support Tool	Brief description of any features the EMIS has to support utility program management activities such as power purchase agreements, aggregating energy savings across a whole program portfolio, etc.

3.3.2. Final List of EMIS Included in the Inventory

Nineteen tools met the primary M&V screening criteria. Five of those tools' vendors did not respond to repeated attempts to collect information for the inventory and to schedule a demonstration. The fourteen remaining tools all satisfied one or more of the additional screening criteria and were selected for the inventory.

The project team populated the inventory using the information collected during the demonstrations. The fully-populated inventory is shown in Appendix C and is also available as a Microsoft Excel spreadsheet.

4. Findings

The final inventory is populated with fourteen EMIS, which are shown below.

Table 4. EMIS Included in the Inventory

Vendor	EMIS	Data Input Frequency	M&V	Opportunity Identifi-cation	Project Tracking
Cascade Energy	Sensei	< Hourly	Option C[i]		Advanced
Elster EnergyICT	EIServer Platform	< Hourly	Option C		Advanced
Energent	Energent	< Hourly	Option C		Advanced
EnergyCAP	EnergyCAP Enterprise	Monthly	Option C		Basic
EnergyRM	DeltaMeter	Monthly	Option D[ii]		
EnerNOC	Efficiency Smart Insight	< Hourly	Option C	Yes	Basic
eSight Energy	eSight Energy	< Hourly	Option C		Basic
FirstFuel	Rapid Building Assessment	< Hourly	Option C	Yes	Basic
Johnson Controls	Energy Performance Monitor	< Hourly	Option C		Basic
MACH Energy	MACH Asset Manager	< Hourly	Option C		Basic
Noesis	Noesis	Monthly	Option C		Advanced
NorthWrite	Energy Worksite	< Hourly	Option C		Advanced
Pulse	Energy Manager	< Hourly	Option C		Basic
Retroficiency	Virtual Energy Assessment (VEA) Automated Energy Audit (AEA)	< Hourly	Option D	Yes	

Notes: **i. International Performance Measurement and Verification Protocol (IPMVP), Option C: Actual vs. normalized/adjusted baseline**. ii. IPMVP Option D: Calibrated simulation

Half of the EMIS in this inventory have several (three or more) utility pilots. Vendors of tools with active utility pilots tended to identify utilities as their primary target market (Pulse, Retroficiency, and FirstFuel), or their tools were developed by energy efficiency professionals who sought to introduce analytical capabilities (EnerNOC and Cascade Energy). Other vendors who had originally targeted building owners/managers now report actively pursuing utility pilots. This focus on the utility market has resulted in the development of EMIS features to potentially meet utilities' needs. In particular, the M&V methodologies are becoming more transparent, some EMIS can calculate annualized savings, and vendors now recognize the need to account for building-specific changes unrelated to energy projects. In addition, new features are opening up new possibilities for utility program applications. These findings and others are discussed below.

4.1. M&V Methodologies Becoming More Transparent

Utilities have been wary of using the integrated M&V functionality of EMIS tools due to the "black box" (i.e., proprietary) nature of their analysis algorithms. Northwest stakeholders plainly stated a need for clear visibility into the tools' M&V methodology during the needs assessment. The inventory shows an unexpected shift in the outlook of the vendors regarding this topic. In the past, vendors had been reluctant to share information about their M&V methodologies. For the inventory, eight of fourteen (57%) vendors reported that the model equations or model specifications can be viewed and downloaded by the user within their tools. Two additional vendors reported that while they don't automatically provide their model specifications, they would be willing to do so for a client who wanted it.

In addition to transparency about their algorithms, many of the EMIS provide some information regarding how well their models represent actual building energy use. While consistency is lacking across the tools, most of the tools inventoried report some statistical metric showing how well their model performs. Table 5 illustrates the range of statistics reported by the EMIS in the inventory.

Table 5. Range of Statistics Reported by EMIS

Vendor	EMIS	Statistics Reported
EnergyRM	DeltaMeter	R^2
Elster EnergyICT	EIServer Platform	R^2
EnergyCAP	EnergyCAP Enterprise	R^2
Energent	Energent	R^2, Coefficient of Variation of the Root Mean Square Error (CVRMSE), and other error metrics
Johnson Controls, Inc.	Energy Performance Monitor	R^2, Coefficient of Variation of the Root Mean Square Error (CVRMSE), and other error metrics
eSight Energy	eSight Energy	R^2, Coefficient of Variation of the Root Mean Square Error (CVRMSE), and other error metrics
FirstFuel	Rapid Building Assessment	R^2, Coefficient of Variation of the Root Mean Square Error (CVRMSE), and other error metrics
NorthWrite	Energy Worksite	R^2, Coefficient of Variation of the Root Mean Square Error (CVRMSE), and other error metrics
Pulse	Energy Manager	R^2, Coefficient of Variation of the Root Mean Square Error (CVRMSE), and other error metrics
Cascade Energy	Sensei	R^2, Coefficient of Variation of the Root Mean Square Error (CVRMSE), and other error metrics
Noesis	Noesis	R^2, t-stats, CVRMSE, Coefficient of variation of the standard deviation (CVSTD), Net Determination Bias (NDB)

This type of statistical reporting gives utilities an opportunity to more easily validate the EMIS tools' M&V algorithms. Validating the M&V capabilities of these EMIS is critical because while it appears these capabilities are well developed, they are relatively unproven; small or self-reported implementation case studies are the norm.

4.2. Some Options Available for Calculating Annual Savings

Almost all of the meter-level EMIS included in the inventory support an avoided energy use approach whereby the actual post-project energy usage is compared to a normalized or adjusted baseline. While the automation introduced by the avoided energy use approach can reduce program costs, it calculates savings retrospectively and therefore requires a full year of post-project monitoring to calculate annual savings. Alternatively, an EMIS could project annualized savings using less than one year of data and predictions of future independent variables, such as typical meteorological year (TMY) weather data. IPMVP refers to this as the normalized savings approach. Five of the tools (Retroficiency, Sensei, EIServer Platform, EnergyCAP Enterprise, and Energent) reported an ability to perform normalized savings analysis.

4.3. Accounting for Changes

The use of buildings is dynamic – tenants move in and out, floor area is added, and space use changes. These changes occurring in parallel with an energy efficiency project can make it challenging to distinguish the energy impacts of the project from the non-project changes when looking at whole-building energy use. Recognizing this, seven of the EMIS vendors in the inventory reported that their tools offer some functionality for accounting for these types of changes. These methods range from manual adjustment by an expert user to more straightforward modifications of schedule, occupancy, or square footage inputs by a user, which are interpreted by the tool's M&V algorithms to adjust a baseline model. For example, MACH Asset Manager allows users to input monthly percent occupancy, and the energy modeling algorithms can then account for the influence of the occupancy variable. Accounting for these types of changes is a challenge in M&V, and requires further study in order to understand the most appropriate methods for accounting for changes.

4.4. Few Calibrated Simulation Approaches

The majority of the tools in the inventory support an IPMVP Option C approach to M&V; two tools support Option D calibrated simulation – Retroficiency's AEA and EnergyRM's DeltaMeter. DeltaMeter uses a thermodynamic simulation to model equipment characteristics and AEA uses whole-building simulation, similar to that of eQuest or Energy Plus but with a simplified set of inputs. Both DeltaMeter and AEA calibrate the model to actual energy consumption, and determine savings by comparing calibrated post-implementation simulations to calibrated pre-implementation simulations.

The use of simulations presents some unique opportunities. Simulations allow for pre-implementation estimates of measure-level energy savings during the audit phase. Such estimates can be used to construct a business case for implementing an energy efficiency project. Simulations can also be used to predict the impact of changes in the building use by modeling those changes within the simulation, which can facilitate non-routine adjustments to baseline models against which energy savings are estimated. As a result of these opportunities afforded by simulations, meter-level EMIS using Option D have the potential to support different programmatic approaches than do the other meter-level EMIS tools.

4.5. Several Options Available for Utilities without Interval Meters

The inventory includes three meter-level EMIS tools that require only monthly input data and still offer advanced M&V features – DeltaMeter, Noesis, and EnergyCAP Enterprise. These tools may be well-suited for utilities without interval meters. Due to the low resolution of monthly billing data, whole-building M&V approaches have typically been applicable only in cases in which savings were high (greater than ten percent of whole-building energy use).

4.6. EMIS Products and Offerings Continue to Evolve

The original draft EMIS framework included several columns to confirm the capabilities of the tools. As the inventory was populated, the team found the following features to be common to all tools, and thus they were removed from the inventory spreadsheet:

- **Web-based**: Vendor hosts service "in the cloud," meaning data is sent to the vendor's servers and users access their data online. All EMIS tools in the inventory are web-based except for EnergyRM's DeltaMeter, which is a Microsoft Excel-based tool.
- **Customizable Interface**: User can at a minimum create unique graphs and tables. All web-based EMIS tools in the inventory could be customized to this minimum degree, and many had significant customization potential.
- **Import/Export**: Data in a table format can be uploaded to the EMIS or downloaded from the EMIS either by the user or manually at the request of the EMIS vendor.
- **Predicted Values Download**: Predicted energy use data can be downloaded from the tool in a table format.

While all of the EMIS vendors discussed features either planned or in development, this project represents a snapshot in time of current features. EMIS vendors continue to develop tool capabilities as they work to improve acceptance by various end-users. A few of the newer capabilities featured in this inventory are project tracking, end-use disaggregation, opportunity identification, and advanced M&V.

- **Project tracking:** Pulse Energy Manager, eSight Energy, Efficiency Smart Insight, and MACH Asset Manager have basic project tracking features that allow insertion of simple notes or a point on time-series charts to indicate times of actions taken. Some vendors recognize that energy managers need a place to more closely track their actions, and have developed for their tools (Sensei, Energent, and Energy Worksite) advanced project tracking features through which users can assign tasks, track progress, calculate ROI/payback, send reminders, and generally support efficiency project management. These project tracking features have the potential to address the utilities' needs to document actions so that savings can be attributed to program-related efforts.
- **End use disaggregation and opportunity identification**: Retroficiency, FirstFuel, EnergyRM, and Energent have algorithms to disaggregate meter-level data into discrete end uses, such as lighting, HVAC, and plug loads. By comparing the disaggregated end uses to other buildings' performance levels (such as in a portfolio or in a commercial building survey), EMIS users can gain insights into areas of potential efficiency improvements. They can also identify additional opportunities through automated load shape analysis and regression analysis against occupancy and weather data. This functionality has the potential to streamline programs seeking to achieve deeper and more comprehensive savings. Several pilots of the measure identification functionality are

complete or underway (Summers et al. 2013) and some research has been published on the accuracy of the tools' energy disaggregation algorithms.[3]

- **Advanced M&V:** The EMIS included in this inventory use multivariate analysis, typically including weather, day/time, and a daily schedule derived from the load profile as inputs into their analytics. They can also include other variables such as schedule or occupancy if that data is available. Adding other driving variables to further improve model results, as well as automating more of the analysis, will continue to contribute to the evolution of the EMIS market.

Beyond the data visualization or dashboard capabilities, many of the tools now have similar features and capabilities especially around portfolio analysis, benchmarking, and cost savings. The tools differ in how they execute these capabilities. Some tools are designed for minimal user input, meaning users can log in to access a wide range of reports and charts using simple menus and checkboxes; other tools are designed more for an expert analyst, in which each graph, screen, and the underlying analytics driving them are shaped by a highly-engaged user who customizes the interface. In addition to the available features, this variation in the level of required user experience is also likely to be an important criterion for potential users of EMIS.

[3] Reports documenting the accuracy of FirstFuel's disaggregation algorithms can be found at: http://www.firstfuel.com/how-it-works

5. Conclusions and Recommendations

The state of the art in EMIS technology has progressed markedly compared to capabilities of a few years ago. Not only do several tools on the market offer advanced M&V features, but many of the tools have functionality to support additional aspects of utility program implementation. When meter-level EMIS entered the market over ten years ago, the tools with the most advanced data visualization or dashboard capabilities led the market. Today, those features are more standard and are required for entry into the market. Utilities have a number of options for EMIS that can support program M&V (even if they don't have smart metering infrastructure in place), and will receive many other attractive features alongside M&V capabilities.

The recent evolution of advanced M&V capabilities presents utilities an opportunity to determine appropriate methods for validating the tools for program applications. This is not simply a case of validating new tools that can replicate existing programmatic methods; capitalizing on the M&V capabilities of EMIS also requires the development of whole-building programmatic approaches that can satisfy the needs of building owners, utilities, and regulators. If meter-level EMIS features are proven to be robust and the programmatic approaches are cost-effective, this opens the way for rapid growth of whole-building approaches to energy efficiency.

As noted earlier, the EMIS analytics documented in the inventory have not been independently evaluated for accuracy except in a relatively small number of pilot projects. In the absence of industry standards for EMIS performance, PECI recommends due diligence to ensure that EMIS meet specific utility requirements. Depending on the type of tool and the programmatic approach being proposed, software validation could follow multiple paths built around some core components:

- **Define the accepted method that will be compared to the EMIS analytics:** For instance, stakeholders could compare the EMIS end-use disaggregation to a detailed energy audit in the building. M&V could use multivariate regressions that take into account weather and occupied/unoccupied schedule as an accepted method; however, using this method requires careful monitoring for acceptable accuracy (for example, buildings with frequent tenant changes in the baseline period may not be modeled easily).

- **Determine how close the EMIS analytics results must be to the accepted method:** Setting the bar is a risk-management decision around the acceptable level of confidence and uncertainty in the savings estimates.

- **Define the number of sites required for validation:** While a large number of sites may be required to validate the software for many building types or climate zones, even small pilots will add to the collective knowledge across the country.

If EMIS validation protocols and program pilots can show that meter-level EMIS features are robust and that the programmatic approaches are cost-effective, they may open the way for rapid growth of whole-building approaches to energy efficiency.

The meter-level EMIS and the descriptions of their features in the inventory represent a snapshot in time of a fast-evolving market. Even after screening for M&V capabilities, PECI finds an emerging, competitive market. The meter-level EMIS inventoried are now deployed in numerous buildings. The more widely deployed meter-level EMIS began by marketing their product directly to owners of large building portfolios, and the market is moving quickly towards utility-supported deployments.

NEEA can facilitate this process and help to unlock the potential of meter-level EMIS for the Northwest market. Enabling information-sharing about pilot results provides one means of doing so; where such information-sharing identifies gaps in understanding, NEEA can work with members and meter-level EMIS vendors to see that those gaps are filled, either by additional Northwest pilots or by sharing information with other regions. For example, this study found that few tools offer systematic approaches to making non-routine adjustments to baseline models – a capability identified as important by both stakeholders and TAG members. NEEA might first survey its members to determine whether any of the recent pilots have tackled this issue, and then work with Northwest stakeholders to design and pilot a standard approach for making non-routine adjustments in meter-level EMIS-aided M&V approaches. Doing so would give program designers and EM&V professionals a shared understanding of how to meet this need, and it would also provide guidance to meter-level EMIS vendors regarding areas of focus for future development.

In reviewing the existing features of meter-level EMIS tools, this study found a number of available tools aligned with the interests of Northwest stakeholders. Some program models can be piloted, proven and scaled up now based on these existing features. Even as this happens, the growth and evolution of meter-level EMIS tools and their capabilities will continue, as will the smart metering infrastructure that many tools leverage. That growth will reveal new opportunities for using those tools to reduce costs and to increase the benefits of energy efficiency projects and programs.

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APPENDIX A – Needs Assessment Interview Guide

Goal

Understand the EMIS needs of NEEA's utility stakeholders and their existing use of the tools.

Participants

Summary of Approach

1. Call participants to explain the project and ask if they're willing to participate. If so, schedule interview.
2. PECI staff conducts 1-hr interview following guide below.

Interview Guide

<u>EMIS Introduction</u>

1. Definition: 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 building energy data. The energy data is supplied by utility meters and in some cases by custom-installed metering.
2. Background: 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.
3. Address any questions.

<u>Past and Present Activities</u>

4. Have you brought EMIS into any programs or pilots?
    a. If yes:
        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?
        iv. Who uses the tool (end-user)?
        v. How has it worked out? Any lessons learned that you can share?
5. Do you have any other EMIS experience?
    a. If yes:
        i. What tool?
        ii. How was it used?
        iii. Strengths/weaknesses?

<u>Future Interests</u>

6. Are you interested in using EMIS more in the future?
7. For the inventory, are there any specific tools you'd like us to look at?
    a. Why are you interested in these particular tools?
8. Are there specific things that you want to know about tools?
    a. 'Must-have' features?
    b. Desirable features?
    c. What do you think is the biggest hurdle EMIS need to overcome?
9. Are there specific types of programs or target markets where you think EMIS would be most useful?
10. What types of applications do you see for EMIS in the future?
    a. Customer engagement?
    b. Opportunity identification?
    c. M&V: Many EMIS not only collect the data (such as weather and interval data) needed for M&V but also have built-in algorithms to conduct Measurement and Verification of savings. Are you interested in using an EMIS with built-in savings quantification algorithms to conduct M&V? ?
        i. EMIS M&V approaches tend to follow IPMVP Option C or D – Option C is whole building quantification of savings and Option D uses a calibrated simulation model – do you have a preference for either of these, or some other approach?
        ii. Does the tool need to be compatible with smart meter data (hourly or sub-hourly interval data)?
        iii. One advantage of using EMIS for M&V is that they can quantify the level of uncertainty in savings estimates. An example of uncertainty is: a project saves 100 kWh ± 5%. The ±5% is the uncertainty. What level of uncertainty is considered acceptable for your organization?
    d. Persistence? For example, automated alerts or reports.

<u>Closing</u>

11. Address any remaining questions
12. Leave contact information for additional input, as desired by interviewee

APPENDIX B – Inventory Features Defined

	COLUMN HEADING	OPTIONS	DEFINITION / NOTES
GENERAL	Current End-User Audience	Utilities, Owner/Property mgr, Tenants, Service providers, Building engineers, ESCOs, Lenders	What user group does the EMIS target?
	Data Input Frequency	Monthly, Daily, Hourly, < Hourly	Finest resolution of data that can be integrated into and processed by the EMIS.
TECHNICAL FEATURES	Portfolio Analysis	Yes, No	Does the EMIS offer the ability to analyze a portfolio of buildings? (e.g.. view energy use of many buildings to identify ones that are worse performers)
	Benchmarking	Energy Star, CBECS (Commercial Building Energy Consumption Survey), Portfolio, Other, None	How does the tool benchmark the building being analyzed to other similar buildings? Portfolio means a group of buildings for a particular client. "Other" may refer to benchmarking Energy Usage Intensity (EUI) against another public dataset.
	End-use Disaggregation	Yes, No	Does the EMIS disaggregate whole building interval data into end uses?
	Opportunity ID Included	Yes, No	Does the EMIS identify specific deficiencies and/or measures using their analytics?
	Opportunity ID Type	O&M, Retrofit, O&M & Retrofit, None	If the answer to the above is "yes", what types of deficiencies/measures are identified by the EMIS?
	Cost Savings	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	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

	COLUMN HEADING	OPTIONS	DEFINITION / NOTES
M&V	Model Data Frequency	Monthly, Daily, Hourly, < Hourly	Finest resolution of data frequency that can be used in the EMIS's models. This applies to the analyzed dataset itself, not to the frequency at which data is uploaded. For example, if data files are uploaded to the EMIS on a daily basis, and the dataset used in the models is hourly electric demand, then the entry here would be "hourly".
	Data Acquisition	MDMS (Meter Data Management System) connection, Direct from meter/submeter, BAS connection, Other periodic file transfer, Manual input	How energy use data is delivered to the EMIS
	Project Tracking & Management	Basic, Advanced, No [open data entry]	Whether the EMIS had a way for tracking efficiency project information such as implementation dates, verification items, project schedules/budget, etc. Basic: identifying when projects are implemented Advanced: tracking projects from definition through completion.
	Savings Method	Supports Option C: Actual vs. baseline (comparative), Supports Option C: Actual vs. normalized/adjusted baseline (avoided), Supports Option C: Annualized (normalized), Supports Option D: Calibrated simulation	**Supports Option C: Actual vs. baseline (comparative)**: tool compares energy use in the post period to the energy use in the pre period. Example is bar graph for each month. Baseline (or pre) conditions not normalized or adjusted for post conditions. **Supports Option C: Actual vs. normalized/adjusted baseline (avoided savings)**: the baseline created with pre-data is adjusted or normalized to post conditions. Actual usage is compared with adjusted/normalized baseline to determine savings. **Supports Option C: Annualized (normalized):** The tool does actual vs. normalized/adjusted baseline as well as projects annualized savings based on less than 1 year of post data. **Supports Option D: Calibrated simulation**
	Annualized Savings Estimates	Yes, No	Identifies whether the EMIS can estimate energy savings for the entire year. IPMVP refers to this as normalized savings estimates.
	Required User Expertise	Low, Medium, High	Representation of how well or familiar the user needs to be with M&V principles and the software itself to use the savings features . **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	None, R2, CV, Other error metrics, Confidence interval	What statistics are available and reported? (Examples of Other Error Metrics: Mean Absolute Percentage Error, Mean Bias Error, etc.)
	Model Equations/Specification Reportec	Yes, No	Are the model equations/specification reported? (Example: for linear regression: y = mx + b are the m and b reported?)
	Ongoing Energy Monitoring	[open data entry field]	Brief description of how the tool conducts ongoing energy monitoring (ongoing data feed, Expected (modeled) vs. actual, (with alerts), cumulative summation (CUSUM) analysis, actual vs. budget, automatic reports)
APPLICATIONS	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 buildings the EMIS has been used in/on
	Other Uses	[open data entry field]	Brief description of any non-energy uses such as building security applications, financial analysis, maintenance management, etc.
	Utility Program Management Support To	[open data entry field]	Brief description of any features the EMIS has to support utility program management activities such as power purchase agreements, aggregating energy savings across a whole program portfolio, etc.

APPENDIX C – EMIS Inventory Workbook

Click here to open the EMIS Inventory Workbook