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The Role of Energy Management Information Systems in Wisconsin's Focus on Energy Program

slipstream

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Leidos
Madison Gas and Electric
National Renewable Energy Lab
Nexant
Niagara
NYSERDA
Phaidra
Prescriptive Data
SCS Engineers
Sky Foundry
Switch Automation
Trane
Xcel Energy

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1 INTRODUCTION

From September 2020 to June 2021, Slipstream performed research into energy management information systems (EMIS) to create a foundation for Focus on Energy to begin ramping up EMIS offerings. We began by investigating best practices and best available products for EMIS-based efficiency and demand response around the country. This was combined with modeling, stakeholder discussions, and interviews focused on the Wisconsin context. This research was then used to develop program recommendations for Focus on Energy.

1.1 DEFINING EMIS

Energy management information systems (EMIS) are software tools which collect and process data gathered about a building or campus to recommend, prioritize, or implement controls changes, repairs, capital improvements, or other changes to reduce energy usage, manage demand, or improve occupant comfort and productivity.

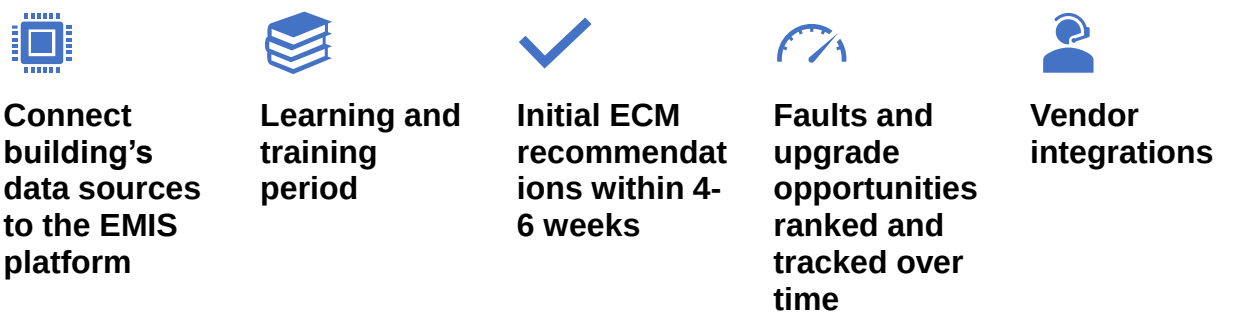

Figure 1. EMIS product lifecycle

1.2 ORGANIZATION OF THIS REPORT

This report is divided into six sections. Following this introduction, Section 2 discusses EMIS products currently available on the market, their features, plans for features expected to be available in the near term.

In Section 3 we provide a detailed review of programs currently offered by Focus on Energy that relate to EMIS, as well as programs outside of Wisconsin that incorporate EMIS.

Section 4 covers the methodology and results of our grid-scale model of the potential for EMIS in Wisconsin, including economic potential, utility bill savings, wholesale market savings, and carbon emissions reductions.

To understand how EMIS is currently being used in the state, we looked for sites in Wisconsin that are currently using EMIS. Due to the short timeframe of this project and COVID-19

restrictions we only identified a handful of sites. Details of these sites and our conversations with stakeholders are in Section 5.

Finally, Section 6 contains our program recommendations for Focus on Energy, including an analysis of existing programs, potential pathways for a new program, and near-term possibilities for integrating EMIS into existing programs.

1.3 NOTE ON CONFIDENTIAL DATA

During our research, we spoke to several vendors, service providers, and program implementers. Details of these conversations have been kept confidential for use by Focus on Energy staff only. Any data considered confidential has not been included in this report and is instead included in confidential appendices provided to Focus on Energy with this report.

2 PRODUCT REVIEW

Energy management information systems (EMIS) collect data from building systems and analyze the data to recommend and/or implement controls changes and energy conversation measures to reduce energy usage, reduce operating costs, and improve occupant comfort. Most EMIS can accept data from a variety of sources including building automation systems (BAS), utility meters (gas and electric), submeters, and lighting systems. The typical EMIS product cycle involves installation and collection, a brief “learning period,” an implementation period where the software or an engineering team reviewing the data make high value, low-cost recommendations, followed by an observation period (see Figure 1). Implementation and observation can occur simultaneously depending on which interventions are being implemented.

Slipstream performed a product review of EMIS platforms, adding to previous work we have done in this area. In this section we characterize the market, describing functionality, integration mechanisms, and business models. To conduct this research, we used publicly available data in research and marketing materials, and conducted in-depth interviews with developers, controls vendors, and engineering firms. In speaking to vendors, we also asked about near-term plans for new products from major developers.

In our initial scope of work, we anticipated narrowing a list of preferred EMIS platforms for Focus on Energy. However, our research indicates that the market for EMIS platforms is growing rapidly with diverse offerings, each with unique specialties. Furthermore, the advent of demand reduction and load shedding functionality in these tools is still new; existing products are slowly adding it and a few new offerings have come out specializing in it. At this point we believe that limiting EMIS programs in Wisconsin to a smaller number of vendors is not advised.

In addition to interviewing EMIS vendors and installers, we also spoke to retrocommissioning (RCx) and strategic energy management (SEM) service providers to understand how they are using EMIS tools, and how R&D testing of new tools could best aid them[1].

[1] Details of these conversations are included in the confidential appendices.

Finally, in all our conversations we asked about recent and future EMIS installations in Wisconsin, to identify potential buildings to observe – a summary of our findings is provided in Section 4.

2.1 EMIS MARKET CHARACTERIZATION

Nearly all the vendors we spoke to work primarily in the commercial, education, healthcare, and government markets. Some vendors also work in a limited capacity in the industrial or manufacturing sectors – activities in this area are typically limited to demand management. A few also work in the retail sector, primarily with large portfolio owners.

The primary function of the EMIS systems offered by vendors we spoke to is reading building information from a building automation system to perform AFDD – automated fault detection and diagnostics. This information is combined with electric meter data (at least at building level, including submeter data if available) to determine the energy impact of faults which have been detected. Faults are then characterized and ranked to provide feedback to engineering professionals (either a contractor or building staff) of specific steps to take to mitigate the highest priority faults. Vendors specialize in the ease of setup, types of buildings or systems they work with, and the types of actionable recommendations they can provide.

Monitoring HVAC systems and recommending upgrades and changes in operations is the key role of most EMIS platforms. Certain vendors specialize in particular markets – certain healthcare and industrial clients have specific ventilation needs, government vendors have high data security needs, and retail clients seek low-cost solutions that work in their “cookie cutter” portfolios.

Buildings (or portfolios of buildings) typically procure EMIS tools through a software-as-a-service model. There is an up-front cost for equipment and engineering required to set up the system, then a monthly or annual fee which covers use of the software and a set number of engineering hours to support in analyzing and acting on findings. From our conversations with vendors, prices (both for setup and annual services) were typically based on gross floor area, though the rates in some cases scaled based on building and sensor complexity (buildings like hospitals, or those with a high density of data points, might cost more). These prices ranged from $\$0.04/ft^2$ for simpler systems, up to $\$0.13/ft^2$ for a more advanced EMIS, or in more complicated buildings. Up-front costs were either fixed (estimates ranged from $15,000 to $60,000), or based on square footage, usually using the same rate as the annual fee. Additional details on costs and payback periods are included in Section 2.4.

The product may be purchased directly from the software vendor, or through a reseller program, typically operated by a controls vendor or engineering firm. To scale their services, several EMIS vendors partner or contract with local engineering firms. Either the vendor will maintain a contract with building(s) and a subcontract with the engineering form, or the engineering firm will serve as a preferred reseller of the EMIS system, securing a lower-cost license of the software in exchange for driving business to the EMIS vendor.

2.2 EMIS CAPABILITY OVERVIEW

Like an RCx program, EMIS platforms provide data analysis of how an HVAC system operates over time to determine the lowest cost and highest value energy conservation measures (ECM) that a building could implement. Given time constraints, typical RCx programs focus on collecting a few weeks to a few months (at most) of data from a few pieces of equipment, then performing an analysis once data has been collected. EMIS goes beyond this by collecting a more comprehensive set of data continuously. While initial recommendations from an RCx program may be comparable to EMIS, an EMIS by default will compare data and recommendations to a broader array of similar buildings, based on similarities in the data and usage (rather than just building or system type and size). Additionally, the EMIS will be permanently installed, able to provide on-going recommendations and measurement and verification of measures that have been implemented. This ability of an EMIS to provide recommendations with a high probably of success is powered by various machine-learning algorithms that are trained by the vast sets of data which each vendor collects from their clients – the ability of the system to quickly provide valuable recommendations improves with each new client that is connected to the system.

EMIS platforms may additionally offer cost projections, measurement and verification (M&V), charting dashboards, demand management, work order dispatch, and ASO. EMIS has the potential to support existing RCx contractors by quickly sifting through data and pinpointing problems which require further investigation. However, the setup, integration, and training of an EMIS system can be complicated for older buildings with an inadequate or poorly maintained BAS.

Whereas data analysis in RCx is an intense manual process and depends on the skill set of the analyst, EMIS follows a trained or rules-based approach which provides the same or better results in much less time. EMIS also leverages the ability to infer seasonal issues with a limited dataset (based on learned patterns from other similar buildings) where RCx would require more data to identify these issues. Some EMIS platforms implement customizable rules, others offer a standard set, and others allow some combination of the two.

In EMIS, data can be pulled into the software platform in near real time with integration to the BAS controllers or an integration of the BAS' historical databases. Data is typically transported to the cloud through proprietary hardware provided by the EMIS vendor, though some can work with a building's existing hardware. Analysis of data is performed in a cloud computing application, and feedback may be provided to the data through a web-based dashboard, e-mail alerts, or some combination of the two.

While those vendors with a powerful dashboard were often enthusiastic to demonstrate these capabilities, most confirmed that building staff rarely utilize these systems. Instead, engineering time from a dedicated team (either the vendor, a subcontractor, or the reseller) is included in the monthly or annual service cost, and this team reviews the data to provide targeted recommendations to the building. Typically, this engineering team would meet with building staff on a regular basis in the first year of the contract, scheduling meetings as needed in subsequent years. Some vendors do not even give building staff access to their platform, as they find the overhead of supporting additional users outweighs the benefit gained from providing this access.

In addition to RCx programs, EMIS can also work well within MBCx (monitoring-based commissioning), VCx (virtual commissioning), and SEM (strategic energy managements) programs. As a tool, EMIS can surface the data needed to participate in MBCx. Some EMIS systems focus on analysis of monthly bills, energy meters, or submeters, and provide higher-level data in a package often referred to as EIS – energy information systems. This level of analysis can be utilized by utility staff or trade allies in a SEM program, or by building staff or vendors in a VCx program.

2.3 NEAR-TERM PLANS FOR NEW FEATURES

Automated System Optimization (ASO) is a more recent development for EMIS. With ASO, the EMIS can implement changes to the building through the BAS, starting with simple set-point adjustments, up to more advanced interventions such as outdoor air resets, schedule changes, chiller sequencing, etc.

Some EMIS platforms are developing turnkey demand response (DR) features for utility providers with a complete platform on the utility side to communication DR signals to EMIS systems installed in buildings to trigger DR events.

2.4 EMIS COSTS AND PAYBACK

The Department of Energy's Smart Energy Analytics Campaign, performed by Lawrence Berkeley National Laboratory, recently released a comprehensive report[2] on EMIS systems based on analysis of 6,500 buildings under 104 owners, totaling over 500 million square feet. Details from this report, along with related research, are included in Table 1.

Table 1. Energy savings potential of EMIS from previous research

Source	Annual Energy Savings Potential
Kramer, H., Lin, G., Curtin, C., Crowe, E., and Granderson, J. "Proving the Business Case for Building Analytics." Lawrence Berkeley National Laboratory, October 2020. https://doi.org/10.20357/B7G022	3% median ($0.03/ft^2) (EIS only) 9% median ($0.24/ft^2) (EIS + AFDD) (Whole building level, all fuels)
Granderson, J., and G. Lin. "Building Energy Information Systems: Synthesis of Costs, Savings, and Best-practice Uses." 2016. https://www.osti.gov/pages/servlets/purl/1363638	Ranges from 10-26% Average 18.4%
Meiman, A., et. al. "Monitoring-Based Commissioning: Tracking the Evolution and Adoption of a Paradigm-Shifting Approach to Retro-Commissioning." 2012. https://aceee.org/files/proceedings/2012/data/papers/0193-000137.pdf	8% energy savings / 4-year simple payback
Mills, E., and P. Mathew. 2009. "Monitoring-based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects." Lawrence Berkeley National Laboratory: Berkeley, California. Report No. LBNL 1972E. Available at: https://buildings.lbl.gov/publications/monitoring-based-commissioning	$0.25 cost savings per ft^2 per year, median 2.5-year simple payback

[2] Kramer 2020

3 PROGRAM REVIEW

We conducted a review of current program offerings in the country for EMIS as well as dynamic and automated forms of load shaping, shifting, and shedding. We paid specific attention to finding program offerings with similar regulatory context to Wisconsin. A review of current Focus on Energy offerings was also conducted to form a basis of comparison.

3.1 CURRENT PROGRAM OFFERINGS IN FOCUS ON ENERGY

3.1.1 Retrocommissioning (RCx)

Focus on Energy has offered RCx for several years and recently updated the program to reflect the change to a focus on energy use intensity (EUI) improvements and total MMBtu savings, as opposed to kWh or therm savings metrics. Additional changes to be implemented include streamlining the process for clients, improving cost effectiveness of program implementation, and providing more holistic results.

Using the Spectrum database, we identified service providers in Wisconsin which have been highly active in the RCx program. Findings from these interviews, as well as conversations with out of state providers for other programs, are included in this section[3].

3.1.1.1 Feedback from vendors

The service providers we spoke to about the Focus on Energy RCx program provided a few pieces of feedback. In general, they expressed frustration with what they perceived as a lack of flexibility and strict program requirements. They were hopeful that the redesigned program would bring more flexible requirements, higher and more predictable incentives, and a focus on increasing participation. They also indicated a need to streamline the process of becoming a trade ally.

3.1.2 Strategic Energy Management (SEM)

Focus on Energy has also offered SEM for several years. We spoke to staff at the SEM implementer in Wisconsin. While there is some potential for EMIS to be used as a tool in SEM programs, SEM in Wisconsin has been most successful in the industrial sector, an area where EMIS is just beginning to gain traction. SEM program staff mentioned installations of EMIS on a couple of industrial projects, with main barrier being the cost and complexity of implementation, and a general concern that more information will not lead to better outcomes for facilities that already have more information than they are able to process for energy efficiency gains.

3.1.3 Building Automation System (BAS) upgrades

Focus on Energy's offerings around BAS implementations, upgrades, and programming are currently limited to two areas, the first of which is within the RCx program. In addition, there is a pathway for upgrading from pneumatic controls to digital controls. However, as indicated by our

[3] Additional interview details are included in the confidential appendices.

research for program pathways, summarized in Table 7, adoption of these programs has been limited.

3.2 BEST PRACTICE PROGRAM OFFERINGS OUTSIDE OF WISCONSIN

Table 2. Three categories of EMIS programs and examples

Program type	Structure	Risks and benefits	Examples
Real time energy management (RTEM)	• Cost offset based on spec, building size • ECMs incentivized elsewhere	• Does not directly incentivize savings • Strong growth sector	• NYSERDA – 30% of cost, 5-year contract • BC Hydro – $0.05 to $0.10/ft^2
Monitoring-based commissioning (MBCx)	• Cost offset based on spec, building size • Some restriction on ECM incentives	• Improved savings and persistence vs RCx • High realization rate	• ComEd – $0.10 to $0.25/ft^2, tiered (previously based on kWh saved)
Pay for performance (P4P)	• Not specific to EMIS, but a good fit • Targets buildings implementing suites of interactive measures • Incentive estimated up-front based on engineering calcs • Final incentive calculated after observation	• Final incentive calculated/paid after M&V period • Capture savings that would be hard to track elsewhere	• DCSEU – pilot stage currently. Incentives range from $0.03/kWh saved up to $100,000 per site depending on total pilot budget

In interviews with EMIS vendors, a common refrain was that while EMIS products are a clear choice for large portfolio, campus, or institutional owners, the greatest indicator of a successful market is the strength of utility or state energy efficiency program offerings. Programs with incentives covering a significant portion of up-front costs, or predictable post-implementation incentives, were cited by several vendors. Upfront costs can make EMIS challenging for some clients, but are less important to vendors, who rely primarily on annual fees (see Section 2.1 for an overview of typical EMIS pricing schemes). Incentive programs designed to offset upfront costs make EMIS more attractive to building owners, and programs with predictable post-implementation incentives make the programs more attractive to vendors. Vendors active in these programs typically present the opportunity in their outreach efforts, though in most cases the utilities and/or state programs also participate in outreach. Participation is usually only client-

led in cases where a client may utilize EMIS at other properties they own or manage, and are interested in adding them to properties within the territory of the program.

In addition to talking to vendors working in these markets, we also spoke to staff at a number of these programs. Details of key programs are also provided below,[4] and summarized in Table 2.

3.2.1 British Columbia, Canada: BC Hydro Real Time Energy Management

BC Hydro's Real Time Energy Management is one program offering under their Continuous Optimization program, developed to meet customer service and energy savings goals. The Continuous Optimization program provides funding for an approved service provider to work with an approved software provider to install specialized energy management information software as part of the recommissioning process to assess the building. An early iteration of the program focused on providing whole-building data directly to EMIS vendors, but ultimately this did not prove successful – the program has shifted to a model focused on ASO (automated system optimization) and AFDD (automated fault detection and diagnostics). Program incentives are currently paid on a $/ft^2 basis, ranging from $0.05 to $0.10 depending on the specific attributes of the system implemented. BC Hydro works directly with EMIS vendors who then market the program to eligible buildings.

3.2.2 Illinois: ComEd Monitoring-based Commissioning

ComEd's RCx program includes a monitoring-based commissioning (MBCx) option for facilities over 150,000 square feet. The program covers the costs of EMIS software and engineering services for one year, following a maximum of 60 days for the EMIS calibration period (also known as the learning period). The facility is responsible for any additional costs related to updating the BAS or adding additional meters or sensors, and for continuing the EMIS contract after the first year. ComEd certifies service providers who are eligible to offer MBCx, then pays the incentive directly to these service providers. This structure reduces overhead that ComEd needs to spend on recruitment. The program design has evolved over time, with ComEd increasing the incentives to EMIS vendors. The vendors we spoke to who are most active in the MBCx program indicate that ComEd's motivation for developing and growing this program is the ability to identify, implement, and verify permanent savings opportunities, with typical buildings realizing 10 to 15% annual energy savings. For the 12-month program year from June 2016 to December 2017 (the latest year for which MBCx evaluation data is available), the program had an average realization rate of 120% across 79 sites, with individual rates varying from negative values at a handful of sites, to over 200% in over a dozen sites[5]. Currently, cost-effectiveness data is not available.

3.2.3 New York: NYSERDA Real Time Energy Management

The NYSERDA program offers an up-front cost-share incentive up to 30% for RTEM project expenses. These include hardware, installation, and five years of ongoing support from energy experts. Service providers and EMIS vendors must apply to the program to qualify for incentives, then market their offerings to eligible buildings. This vendor-driven approach has led to innovation and evolution in the program – from an initial focus on commercial real estate,

[4] Additional interview details are included in the confidential appendices.
[5] ComEd 2018.

recent strong growth has been seen in the residential multi-family sector. The program was developed to meet NYSERDA's goals of decarbonizing the buildings sector in New York state, with the primary path being improving energy efficiency of large buildings, and a secondary path of incorporating technology that enables load shaping, flexibility, and demand response.

3.2.4 Washington, DC: DCSEU Pay for Performance

The DC Sustainable Energy Utility launched a pay for performance study in 2018, followed by a pilot in 2019. Development of the program was inspired by a shift in DCSEU's goals to include fuel-neutral energy savings and a greenhouse gas emissions reduction target. Initial results also indicated that establishing an EMIS was lower cost than a full BAS upgrade, but still consistently demonstrated savings above 5%, generally closer to 10% (there are other ways besides EMIS to participate in the program, but this has been the most successful). A full program was planned for 2020, but launch was delayed due to COVID-19 and the need for verification data from fully occupied buildings. However, there are currently 20 projects going through the program. The program is flexible, intended to serve customers implementing measures or suites of measures for which savings could be hard to quantify under existing programs. By basing incentives on actual energy saved, the program allows clients to apply after only meeting a minimal set of pre-requisites (such as building size, type, and lack of eligibility for other standard programs). The focus on measurement and verification makes the program a natural fit for EMIS vendors and implementers, as well as more traditional RCx vendors. At enrollment, approved EMIS vendors estimate the savings they expect for a given project. DCSEU will review the analysis and offer an incentive at a minimum rate of $30 per MWh saved for a more conservative estimate, essentially setting a minimum incentive for the project. If the project results in greater savings the incentive may increase if the program has sufficient budget.

3.3 WISCONSIN DEMAND RESPONSE INITIATIVES AND PLANS

We spoke to Xcel Energy and Madison Gas and Electric (MG&E) about their current and future demand response (DR) offerings in Wisconsin. Both utilities currently offer DR programs, but due to the limited number of events, an expectation that MISO (the system operator) intends to increase testing stringency, and limited financial incentives, enrollment is not significant. While both utilities are interested in how EMIS could facilitate broader, lower-cost implementation of DR programs, this was not seen as an immediate need.

4 POTENTIAL MODELING

To quantify the potential impact of EMIS in Wisconsin, we developed a model incorporating EMIS load shapes for individual buildings, the commercial building stock in Wisconsin, and a model of the state's electric grid. In this section we will describe the modeling methodology and results.

4.1 METHODOLOGY

Potential modeling involved six steps, discussed in the rest of this section.

1. Identify building types reflective of the potential EMIS market in Wisconsin
2. Estimate participation rates of buildings in Wisconsin
3. Select measures that best represent EMIS
4. Scale measures to Wisconsin building stock and achievable potential
5. Calculate impact of measures statewide
6. Apply cost and emissions data for 2020 and 2030

4.1.1 Building types and participation rates

We first referenced data from the Smart Energy Analytics Campaign[6] to understand the primary markets for EMIS. In the campaign, three building types represented 82% of participating buildings: offices, higher education, and healthcare (see Figure 2). In our interviews with 12 vendors and eight service providers we confirmed that these three building types were key customers, both in terms of existing contracts and future growth efforts.

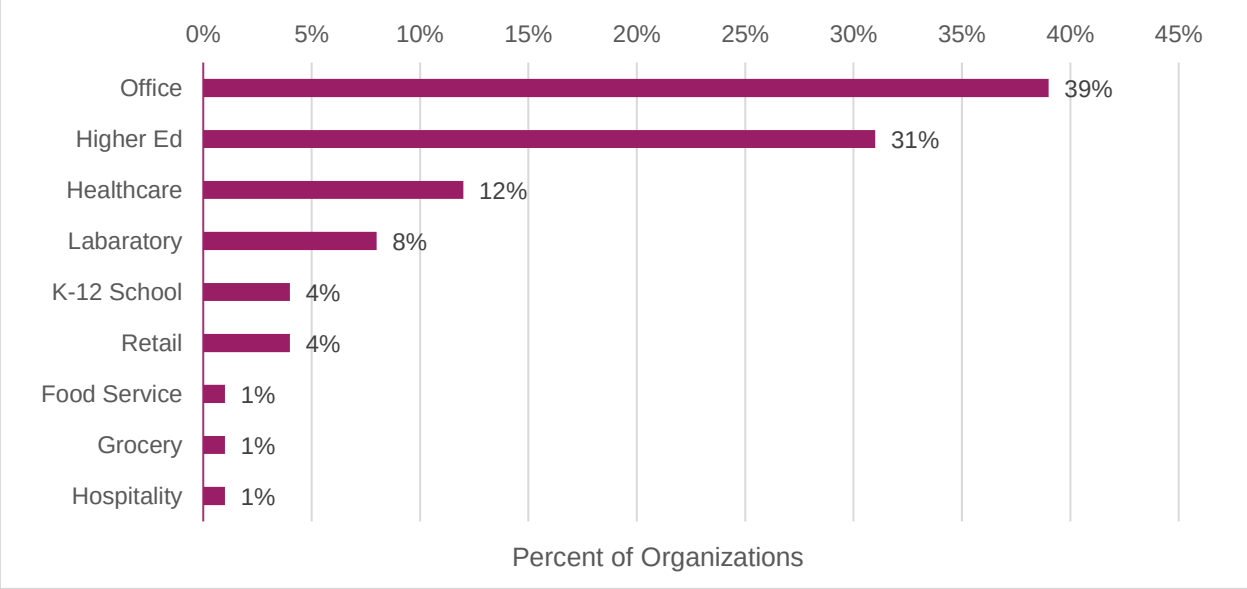

Figure 2. Smart Energy Analytics Campaign participants by sector[7]

Next, these three categories were adapted to building types included in the Department of Energy commercial building prototype models.[8] Office is represented by large and medium offices (vendor interviews indicated that small offices are not currently a significant measure sector). Healthcare was divided into hospital and outpatient healthcare. Higher education is not a category in the DOE prototypes, so secondary school was used instead. While K-12 schools were less well represented in the Smart Energy Analytics Campaign, several mitigating factors indicate this substitution is an appropriate choice. First, to have the broadest reach, the campaign worked with large portfolio owners, meaning that colleges and universities with large campuses are likely over-represented compared to K-12 schools. Second, data from the Focus

[6] Kramer 2020
[7] Kramer 2020
[8] DOE 2020

on Energy Spectrum database indicates that K-12 schools actively participate in state-wide energy efficiency programs (see Table 3), meaning they would be a good candidate for any future EMIS program.

The next step was to estimate the rate at which these building would participate in an EMIS program. The total building counts were derived from EIA's commercial building stock data from CBECS.[9] Then, we used the Focus on Energy Spectrum database to determine how many of each building type had participated in any one of a suite of measures from April 2014 through March 2021 (the extent of data available in Spectrum). Participants in the SEM and/or RCx programs were first selected, as these two programs have obvious parallels to EMIS.

We also looked at participants in other Focus on Energy programs, with a few criteria:

- Total incentive (across measures) of at least $1,000
- Individual incentives (per measure) of at least $200
- Measures through one of the following programs: Business & Industry, Midstream, or Schools & Government
- Measures in one of the following groups: HVAC, Boilers and Burners, Lighting, Other, Compressed Air & Vacuum Pumps, Lighting, Process
- Envelope and lighting retrofit measures (aside from controls) were excluded

These criteria are not intended to represent an EMIS client – rather, they are intended to identify the type of client for whom an EMIS program might have represented a cost-effective solution, to approximate potential enrollment in a future EMIS program. The final modeled participation rate is provided in Table 3. Further details of EMIS-enabled measures and participation rates are included with the program recommendations in Table 7.

Table 3. Participation rate in Focus on Energy programs (2012 to 2014) and modeled participation rate

Building type	Quantity in Wisconsin	SEM and/or RCx participants	EMIS-enabled measure participants	Modeled participation rate
Medium Office	1406	19	30	**3%**
Large Office	96			**3%**
Hospital	123	58	14	**59%**
Outpatient Healthcare	510	28	11	**8%**
Secondary School	822	88	163	**31%**

4.1.2 Measure development and scaling

Results from the Smart Energy Analytics campaign were again used to select and scale measures. Figure 2 shows the rate at which various types of measures were implemented as part of the campaign. We looked at those measures with a rate of participation over 15%.

[9] EIA 2016

Measures were then grouped and matched to a set of measures for which data was readily available, either in NREL's ComStock, or through eQuest modeling (the resources which were used to develop load shapes).

In addition to using these participation rates to select measures, we also applied these participation rates as measure factors, to scale down the effect of each measure across the building stock (since not all buildings will implement all measures). Note that while these participation rates reduce the impact of individual measures, we did not consider interactive effects between measures applied in the same building, due to the complexity of this task. This omission would tend to over-estimate savings from the suite of measures, an outcome which is mitigated by the fact that not all energy-saving measures were included in the analysis.

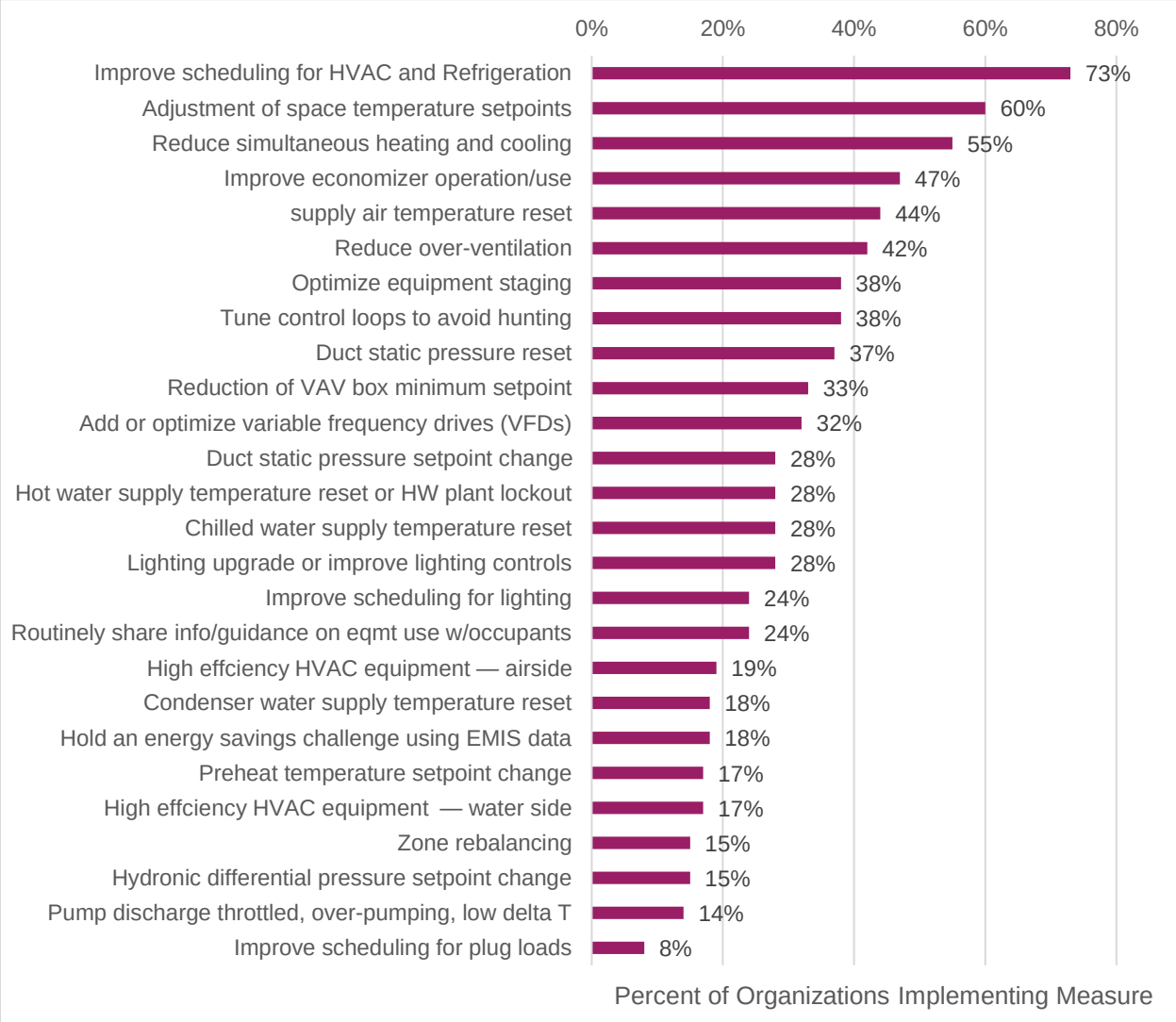

Figure 3. Rate of measure implementation in the Smart Energy Analytics Campaign[10]

The table below lists the measures included in the model, which source they came from, and applicable current measures offered by Focus on Energy. A matching measure (or measures)

[10] Kramer 2020

from Focus on Energy was identified to demonstrate the applicability of an EMIS program within the state. The following sections describe how each source was used to develop load profiles.

Table 4. Measures included for potential modeling

Measure	Source	Existing Focus on Energy measures
RTU VFD and controls improvements	ComStock	VFD – HVAC fan; Advanced Rooftop Unit Controller.
Upgrade RTU DX air conditioner	ComStock	A/C Split or Packaged System – High Efficiency
Upgrade boilers	ComStock	Several boiler upgrade, replacement, and controls measures
Add heat recovery	ComStock	Energy recovery ventilator; Exhaust air heat recovery system; Heat recover (not otherwise specified).
Demand controlled ventilation	ComStock	Several demand-controlled ventilation measures
Adjust thermostat setpoints	ComStock	HVAC controls – scheduling/setpoint optimization
Daylighting controls	ComStock	Daylighting controls
Add economizer	eQuest	Several economizer upgrade and controls measures
Reset chilled water supply temperature	eQuest	Chiller plant chilled water setpoint adjustment
Reset hot water temperature	eQuest	Hot water supply reset
Reset supply air temperature	eQuest	Supply air temperature reset

Examples of the final load electric shapes for each building type are shown in Figure 4 – in the model, full year annual data (i.e., 8760 data) was used.

4.1.2.1 ComStock measures

ComStock[11] is an analysis tool provided by the National Renewable Energy Lab (NREL), currently in a beta release. The tool combines a state-level representation of the commercial building stock, DOE prototype building energy models[12] for a suite of energy conservation measures, and calibrated measure data collected from around the U.S. The tool provides both analysis and details of the building stock, and energy information about the impacts of the various measures as applied to that building stock. We chose to use ComStock for this project

[11] NREL 2021
[12] DOE 2020

as it provides hourly energy use by fuel type (electricity and natural gas) for the major categories of buildings we are considering.

NREL graciously provided Slipstream with beta access to the tool and guided us in selection of the appropriate measures to use for this research, as they continue the process of calibrating and refining the data.

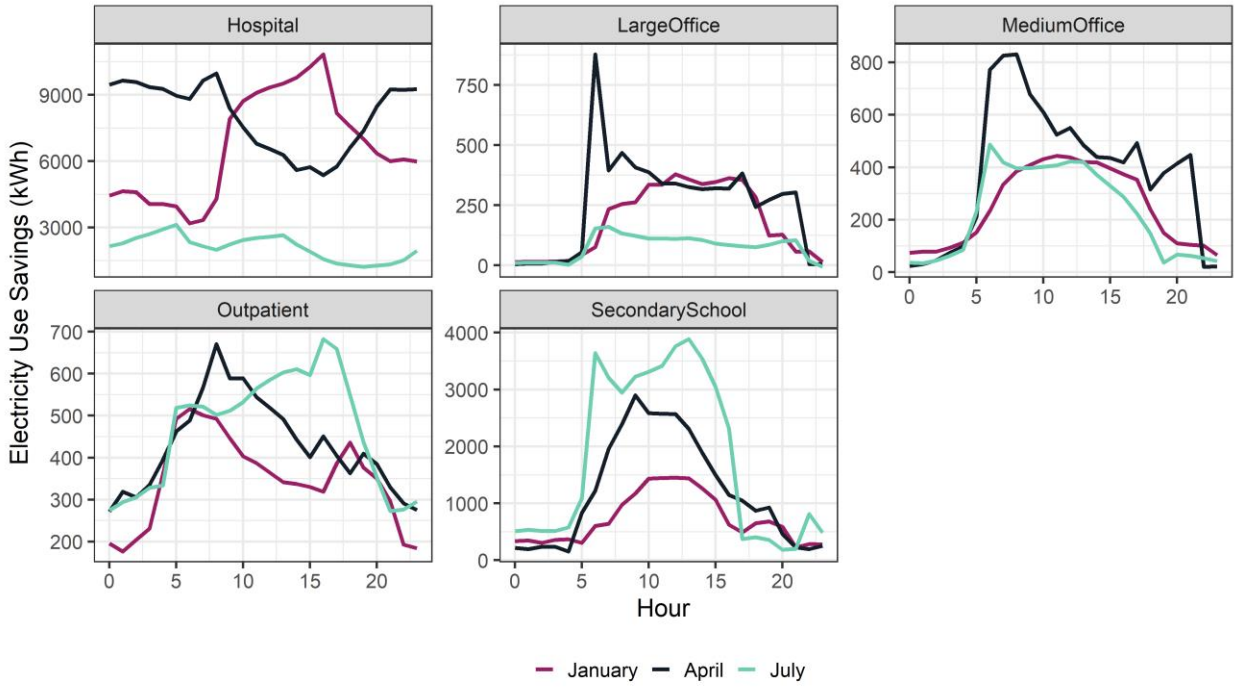

Figure 4. Total electricity savings by building type (includes measure factors)

4.1.2.2 eQuest measures

The four eQuest measures were modeled using prototype building models that Slipstream has developed for use across research projects. These prototypes are designed to reflect the DOE Commercial Prototype Building Models. The DOE prototype models are built in EnergyPlus, while Slipstream's research versions are built in eQuest which allows for faster prototyping and analysis.

Baseline models for large office, medium office, outpatient, hospital, and secondary school were used as the starting point. Weather data from Wittman Regional Airport, near Oshkosh, WI was used for the modeling, as this most closely represents the population-weighted geographical center of the state.

The modeling methodology was adapted from prior Slipstream efforts, combined with the ComStock prototype methodology for these measures. Although ComStock data for these measures is not available yet, the modeling methodology itself has gone through a detailed review process so we felt it represented the most accurate approach to modeling these measures.

Baseline values for the four measures were based on Slipstream's research on retrocommissioning persistence in ComEd service territory in Chicago and surrounding areas[13].

4.1.3 Grid modeling

To quantify the emissions and cost impact from load shifting measures, we developed hourly annual models (i.e., 8760 models) of costs and emissions for both 2020 and 2030.

4.1.3.1 Avoided Cost and Emissions Data Collection

The availability of cost and emissions data varies by timeframe, requiring the use of several sources for current day and future day data. Table 5 provides an overview of the sources used in this analysis.

Table 5. Summary of hourly emissions and cost data sources by timeframe

Data Type	Timeframe	Costs	Emissions
Retail Rates	2020	Average of WI IOU rates from the U.S. Utility Rate Database[14]	*Not applicable*
Retail Rates	2030	EIA rates[15]	*Not applicable*
Wholesale	2020	MISO Market Data[16] + Cambium	MISO marginal plant data + Cambium
Wholesale	2030	Cambium forecasts	Cambium forecasts

The cost data included retail rate data for the major investor-owned utilities in Wisconsin and wholesale cost data from both the Midcontinent Independent System Operator (MISO)'s market data and NREL's Cambium tool.[17] The emissions data used includes both MISO's market data and NREL's Cambium data.

The electricity rates shown in Table 2 outline the costs seen by business owners and include both the energy charge and the demand charge rates. For 2020, we calculated a blended rate using the current rates of the major investor-owned utilities in the state. For 2030, we relied on Energy Information Administration's forecasted prices. Additional details are provided in Section 8.

[13] Gunasingh 2018
[14] Zimny-Schmitt 2020
[15] This analysis combined EIA's Short Term Energy Outlook and Annual Energy Outlook.
[16] MISO 2021
[17] NREL 2020. NREL's Cambium tool models the future expansion of power plants across the United States and the expected dispatch of those plants for future years. It reports on marginal wholesale energy and capacity costs for a variety of scenarios.

Table 2. Summary of average current electricity rates by top Wisconsin IOU's

Utility	Tera-Watt Hours	Average $/kW	Average $/kWh
MG&E	2.211	13.57	0.101
Wisconsin Electric Power Co.	8.839	8.79	0.094
Wisconsin Power and Light Co.	2.395	6.31	0.071
Wisconsin Public Services Corps	4.011	6.63	0.051
Northern States Power Co.	2.821	8.60	0.068
Statewide Total/Averages	**20.278**	**8.57**	**0.080**

The wholesale cost savings represent costs seen by utilities. NREL's Cambium data is forecasted data that represents a business-as-usual case while the MISO market data is historical data. We utilized Wisconsin-specific price data in both cases. For wholesale capacity cost savings, we utilized Cambium data which represents the cost saved by deferring or delaying the need for a new power plant. These costs only exist in the roughly 60 to 70 hours of the year when the system is near peak capacity.

The emissions data represents marginal emissions, or the generation mix that would be influenced through a change in demand. The MISO emissions data reflects short-term marginal emissions, which only considers plants that are currently on the grid. The Cambium data reflect long-term marginal emissions, which considers the addition (or removal) of plants to meet a change in demand. Figure 5 shows capacity forecasts by fuel for the 2020 and 2030 Cambium scenarios.

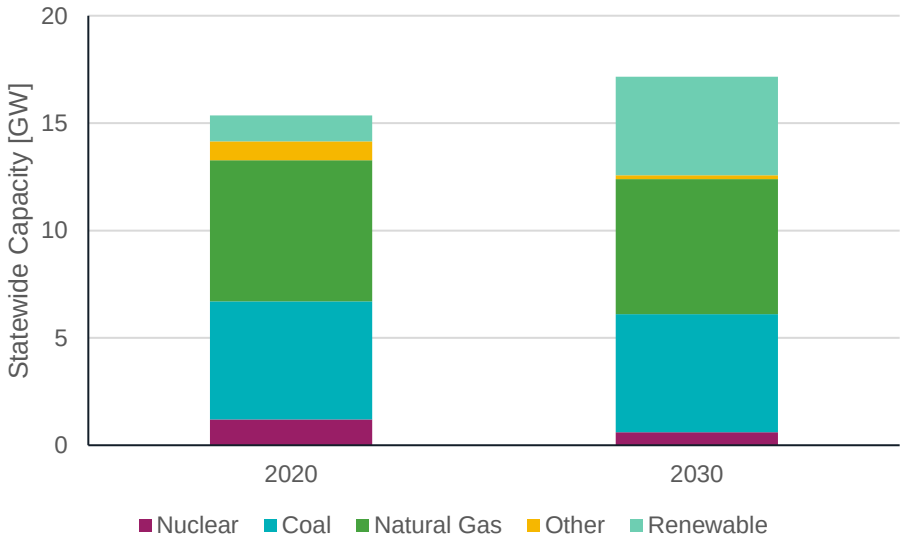

Figure 5. Wisconsin grid capacity by source, 2020 and 2030

4.1.3.2 *Quantifying Cost and Emissions Impacts*

To analyze the results, we combined the measure data and cost and emissions data to estimate annual energy costs, annual emissions, and annual capacity costs savings.

To estimate annual value for energy costs and emissions, hourly measure load shapes were multiplied by annual cost and emissions data from each source. Summing hourly values across the year and across building type generated annual point values for savings by building type.

This method was also applied for 2020 and 2030 wholesale capacity cost savings using the Cambium data. However, to estimate the demand charge savings for 2020, we found the maximum demand for each month in the baseline period and the maximum demand after EMIS is implemented. Using the relevant rate based on time-of-day and season, we then calculated what the demand charge would be before and after implementation of EMIS. The difference in the demand charges represented the demand charge savings.

4.2 MODELING RESULTS

Building-level modeling results are shown in Table 6. Results comparing 2020 wholesale savings, bill savings, and carbon emissions are shown in Figure 6 through Figure 9. Detailed results are provided in additional tables and figures in Section 8.

Table 6. Building level savings results, 2020

Building Type	Energy savings					Utility bill savings			
	kWh	Therm	MMBtu	%	kBtu/ft²	Energy	Demand	Total	$/ft²
Hospital	716,960	14,532	1,663	19%	5.9	$57,820	$8,075	$65,985	$0.23
Large Office	517,368	7,569	908	14%	2.6	$41,995	$4,605	$46,600	$0.13
Medium Office	53,493	1,752	191	17%	2.8	$4,800	$930	$5,730	$0.08
Outpatient	95,605	2,897	318	13%	3.4	$8,275	$1,685	$9,960	$0.11
Secondary School	46,760	4,877	501	17%	5.2	$5,985	$1,780	$7,760	$0.08
Total	**71,260,040**	**2,492,000**	**270,085**	**17%**	**5.1**	**$6,349,540**	**$1,152,290**	**$7,501,830**	**$0.12**

A few key findings to highlight from the results:

- The greatest savings, both in total dollars and $/ft², are for hospitals. This is a result of their larger size and higher energy density.
- While medium offices show a higher rate of energy savings, large offices show a higher rate of bill savings, due to the lower relative fraction of natural gas use, and higher relative demand charges.
- Total energy savings are within the ranges expected based on previous studies.
- Total bill savings for all modeled buildings in the state is $7.5 million, including $1.2 million in demand charge reductions.

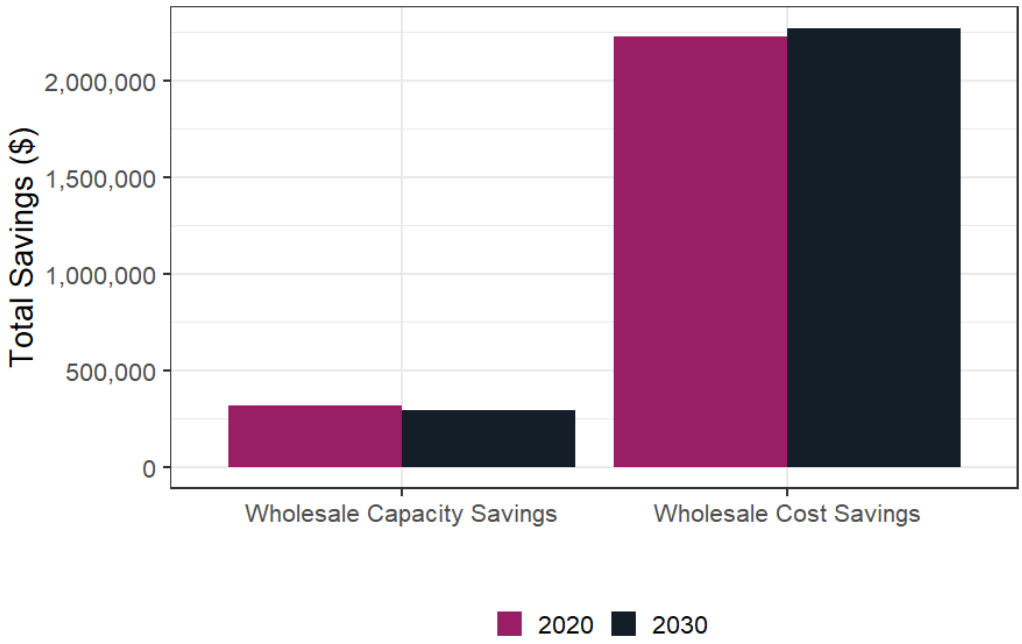

Figure 6. Statewide wholesale cost savings, 2020 and 2030

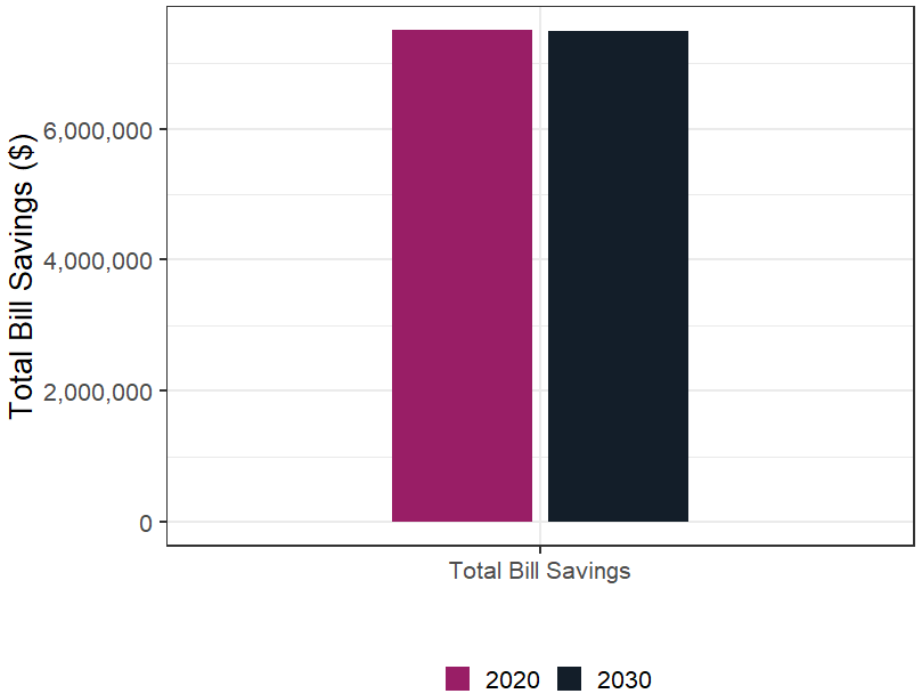

Figure 7. Statewide bill savings, 2020 and 2030

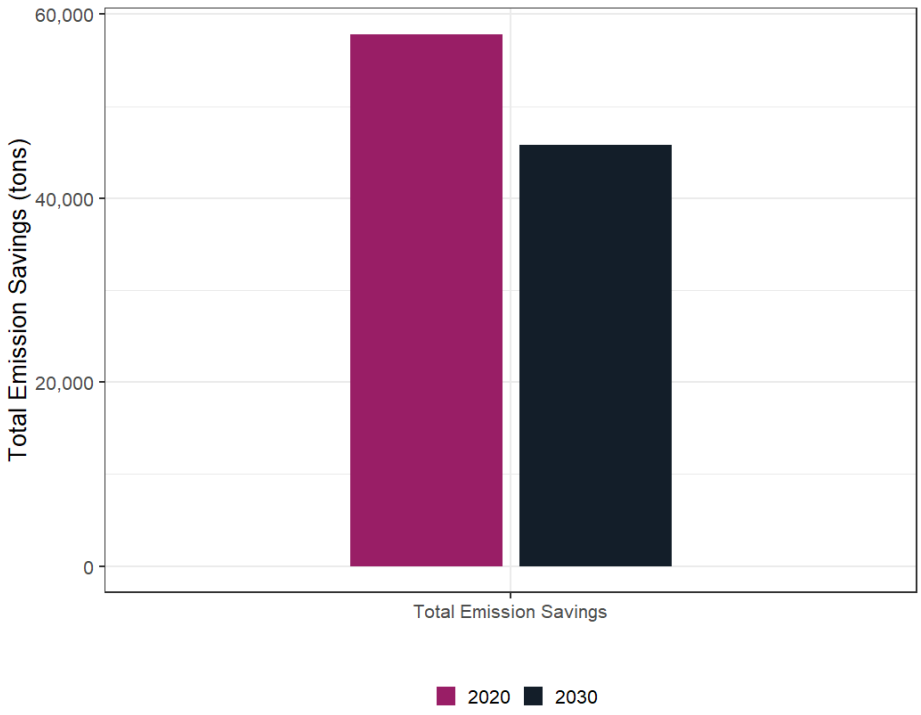

Figure 8. Total Statewide emissions savings, 2020 and 2030

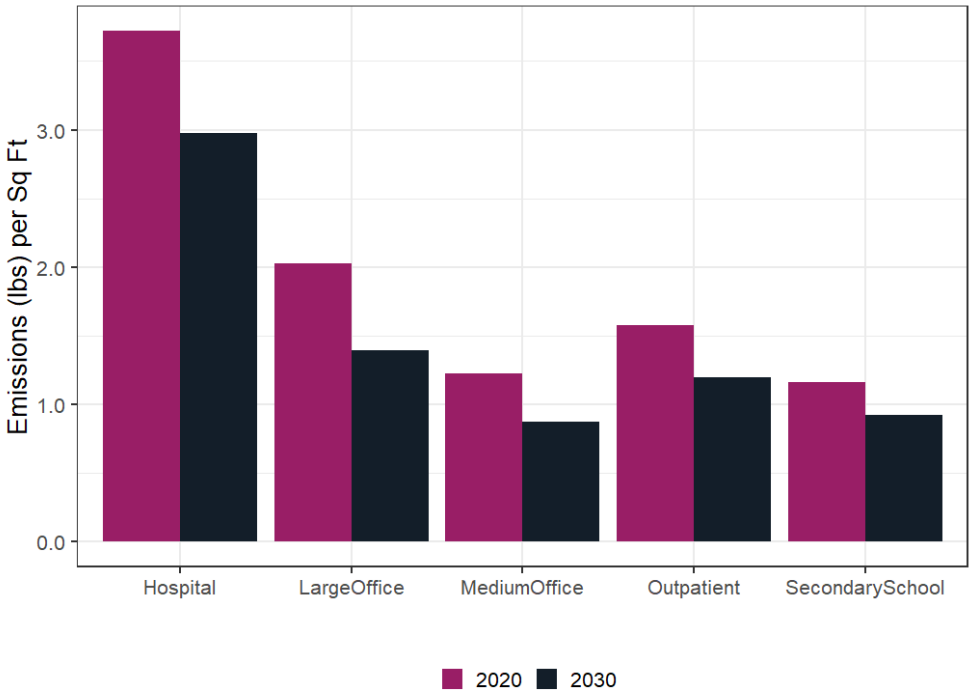

Figure 9. Statewide emissions savings by building type, 2020 and 2030.

5 SITE OBSERVATIONS

During the project, we identified four sites in Wisconsin with active EMIS systems[18]:

- A big box retail chain
- A food processing facility
- A large office building
- A public high school

We spoke to a vendor who supplies EMIS for a big box retailer with three locations in Wisconsin. They have a contract to implement EMIS each time a new store is built and are also working on retrofitting the system into existing stores. The packaged solution they provide interfaces with the RTUs and lighting controls at each store, where it serves to provide centralized energy management for the chain's head office, and AFDD information that is analyzed by the vendor. According to the vendor, a new store with EMIS saves 20 to 25% in energy costs per square foot compared to an existing store without the system. When the system is retrofit into an existing store, the addition of controls alone is responsible for a savings of 12 to 15%. This vendor is currently not working with Focus on Energy on an ongoing basis, though in some cases the contractor responsible for an individual store may work with the Focus on Energy program.

Another vendor described a project where they performed retrocommissioning of a food processing facility and implemented EMIS. The RCx project was performed through the Focus on Energy program. Measures implemented through RCx included AHU and space scheduling, various temperature resets, and terminal unit flow adjustments. The vendor recommended EMIS to the client to monitor and ensure persistence of these measures, while also providing FDD.

We were also able to speak directly to the head of facilities for a Wisconsin-based company with several offices in the state that is in the process of implementing EMIS across their facilities. Their motivation for implementing EMIS was to obtain FDD capabilities. Despite having a sophisticated facilities staff, they found themselves often responding to problems, trying to implement quick fixes and control the fallout. They sought EMIS to get ahead of these challenges. They started with a pilot project in 2019, implementing an EMIS system in their headquarters facility. Early in the project they encountered some challenges due to the diversity of systems which existed in the building, which had resulted in inconsistencies in how points within each system were named. This delayed the mapping and data validation process, which was not wrapped up until early 2020, just before the start of COVID-19 lockdowns. Additionally, they found that EMIS capabilities were somewhat limited for their built-up systems, where it may have provided more detailed insights for packaged systems. Today, the facilities staff regularly interacts with the system to track the eleven measures which they have identified and are in the process of implementing. The EMIS enables them to plan for measure implementation, verify measures, and ensure persistence of each measure. Despite the implementation challenges at this facility, the company does intend to pursue additional EMIS projects, though at this time they are planning to focus first on new construction, as they anticipate that changes to a hybrid

[18] Details of these projects are included in the confidential appendices.

in-person/remote workforce may result in changes to their building portfolio which may obviate the need for EMIS.

Due to time and budget constraints, we were unable to speak to parties familiar with the high school project.

6 PROGRAM PLAN

Considering the product review, program review, and modeling results, this section provides an analysis of the potential for an EMIS program in Wisconsin, and recommended program paths.

6.1 CURRENT STRENGTHS OF FOCUS ON ENERGY PROGRAMS

Table 7. Count of sites by category where EMIS-enabled measures were implemented, 2014 to 2021

Building Type	Lighting controls	All other controls	Other	Total
Agriculture	0	1	442	**443**
Education	19	48	513	**580**
Food sales and service	0	204	247	**451**
Healthcare	4	1	87	**92**
Housing and lodging	1	18	90	**109**
Manufacturing	35	62	751	**848**
Office	5	20	67	**92**
Public assembly and religious worship	4	19	101	**124**
Public order and safety	1	10	66	**77**
Retail	14	80	110	**204**
Warehouse	8	2	34	**44**
Other	8	15	274	**297**
Total	**99**	**480**	**2,782**	**3,361**

Our review of sites and measures implemented by Focus on Energy programs indicates that there is significant potential for an EMIS program – from April 2014 to March 2021, 3,361 sites implemented the types of measures that are typically discoverable by EMIS (see Table 7). These include:

- HVAC measures, such as
    - Upgrades of air conditioning, heat pumps, boilers, etc.;
    - Implementation of economizers, connected thermostats, heat recovery;

    - Controls adjustments, such as temperature resets or demand controlled ventilation;
    - Upgrades of motors and drives to VSD, VFD, ECM, etc.
- Controller upgrades, such as advanced RTU controls, or guest room energy management systems for hotels and motels.
- Lighting controls, such as bi-level controls, or networked lighting systems.

However, only 14% of these sites implemented the controls-based measures that represent the most cost-effective measures which EMIS typically discovers. This is a primary indicator that there are clients willing to implement these types of changes, a significant quantity of measures to be implemented, and significant savings to be gained from these measures, but that current Focus on Energy programs are not capturing. These are typically low-cost, high-impact measures. Currently, the RCx program is the main pathway for implementation of controls measures, and while there has been some success, an EMIS program (either stand-alone or within the RCx program) could build on this success and achieve additional energy savings impacts.

One of the key benefits of an EMIS is identifying measures that are not always visible to traditional programs, such as missed opportunities in controls settings, or repairs to minor equipment malfunctions (stuck valves, broken dampers, etc.). Even when discovered, several of these more operations-focused measures can be challenging to capture for energy efficiency programs that target equipment upgrades. By leveraging EMIS, programs can capture these savings more readily. Where these savings are identified for systems that have already received program funding, EMIS ensures savings persistence. Promoting EMIS installations is a program strategy that could identify additional measures at sites that are already participating in Focus on Energy programs like RCx and SEM, and could also be a way of enrolling additional sites with energy savings opportunities.

6.2 EMIS PROGRAM PATHWAYS

Taking the review of programs outside of Wisconsin as a roadmap (see Section 3.2), three program pathways are presented in Table 8, and discussed in more detail in the following sections.

Table 8. Three possible EMIS program pathways

Program type	Benefits	Risks	Solutions
Real time energy management (RTEM)	• Clear incentive structure enables robust vendor outreach • Broad appeal across sectors • Enables creative use of EMIS	• Up-front incentive could lead to attrition • Less guarantee of robust savings	• Require evidence of multi-year contract with vendor with application
Monitoring-based commissioning (MBCx)	• Can build on success and active development of RCx program • Increase savings and persistence of RCx	• May not reach client types outside of traditional RCx programs	• Offer an “RCx lite” pathway, perhaps using EIS
Pay for performance (P4P)	• Capture highly specific and interactive measures that are hard to track elsewhere • Verified savings	• Unknown incentive amount • Incentive paid after M&V period	• Provide a portion of incentive up-front • Verify some savings seasonally rather than annually

6.2.1 Pay for performance

In this model, EMIS is used as a platform to collect pre- and post- measure implementation data for calculating savings, which is used as the basis for an incentive. This would serve as a complement to existing measure incentive programs that are focused on upgrades and improvements to existing infrastructure.

One of the key challenges with the pay for performance model is that participants need to wait until after the M&V period to receive an incentive payment, and in many cases it can be difficult to accurately predict the incentive amount ahead of time. This lack of information can make it difficult for some clients to justify the up-front cost and can serve as an enrollment barrier. There are a few approaches which can be used to avoid this challenge:

- Pay a fixed incentive up front based on engineering calculations, system cost, building size/type, or some other standard metric, with a bonus based on actual performance paid after the evaluation period.
- If measures allow, use shorter M&V periods to reduce the amount of time between implementation and incentive payment. For instance, lighting controls measures or domestic hot water measures can be de-coupled from the weather, while improvements to seasonal equipment (such as some air conditioning systems) would only require a few months of data to verify savings.

While pay for performance would be a different approach than most existing programs in Wisconsin, new program design could build on Focus on Energy's current success in SEM engagement, as well as the learnings which contributed to the recent re-design of the retrocommissioning program. Additionally, several utilities in the state are active in helping their clients retrieve and make use of the data the utilities collect about their buildings and could serve as allies in recruiting clients.

A program could be modeled after the experiences of the DCSEU in designing their pay for performance pilot.

6.2.2 As a new retrocommissioning offering

The next two program pathways both relate closely to conventional retrocommissioning offerings. Monitoring based commissioning is essentially EMIS-enabled continuous commissioning and expands on the incentive and M&V structure built into existing RCx programs.

Real time energy management is a simplification of retrocommissioning programs, removing some of the detailed program requirements in favor of an up-front incentive for EMIS installation, then relying on other existing program pathways to provide further incentive for measures enabled by the EMIS.

6.2.2.1 Monitoring based commissioning

In this model, EMIS is implemented as part of an advanced retrocommissioning program with a higher level of technical assistance and incentive than typical RCx options. Measures are supported and paid through a combination of the RCx program and existing prescriptive/custom rebates.

One of the prime motivations for an MBCx program is to achieve and track persistent savings, which an EMIS is designed to enable due to its always-on functionality.

A program could be modeled after the best practices established by ComEd.

6.2.2.2 Real time energy management

In this model, EMIS is used as an advanced energy management tool. Clients are provided with technical assistance and an up-front incentive to implement EMIS. Subsequently, any measures which are implemented through use of the EMIS would only be incentivized if they qualified for an existing program. However, the program should be designed such that follow-up data is collected after two to five years and compared to baseline data, to quantify the savings attributable to the program.

RTEM programs are typically structured around the software service, rather than the ECMs that are enabled. The program takes as a given that EMIS results in energy savings (which is well supported by the research) and provides an incentive to clients to cover the up-front installation costs, as well as the data needed to identify additional ECMs for which incentives may be available.

A program could be modeled after the best practices established by NYSERDA or BC Hydro.

6.3 ADDITIONAL CONSIDERATIONS FOR EMIS PROGRAM DESIGN

In addition to the three broad program pathways mentioned above, there are a few additional pathways (or pathway add-ons) that should be considered. Figure 10 gives a brief explanation of these, with more detail in the following sections.

Tie-in to SEM	Energy Information Systems	Demand response
• Hand-off from SEM to EMIS • EMIS reports for SEM follow-up	• Lower cost, lower savings entry point • Use utilities' own data to identify candidates • Could also be a part of SEM	• Demand charge savings of $1.2M • Total demand reduction of 8.1 MW • Reduction of 7.1 MW during 61 system peak hours

Figure 10. Summary of additional EMIS program design options

6.3.1 Strategic Energy Management

Given the strength of Focus on Energy's existing SEM program, one option would be to integrate EMIS as a measure within SEM, effectively integrating the EMIS and SEM offerings. Some SEM customers have been interested in a more sophisticated energy management platform, though certainly not all.

This could also include a default hand-off of each SEM cohort into the EMIS program. In subsequent follow-up work, SEM implementers could then review EMIS reports when checking in with past SEM program participants.

Program tie-in could be modeled after the best practices established by ComEd, which is currently active in creating strong connections between related programs, such as connecting buildings completing new construction offerings, to their monitoring-based commissioning program.

6.3.2 Energy Information Systems

In this report we have focused on the AFDD functions of EMIS, that integrates closely with a building's BAS. An "entry-level" product class (in many cases offered by the same vendors) that integrates only building-level energy information is Energy Information Systems (or EIS, as opposed to EMIS). EIS can still provide valuable recommendations for potential ECMs, though with less granularity. For instance, using interval meter data from the gas and electric utilities, many EIS can predict, with reasonable accuracy, when a building may be conditioning spaces during un-occupied hours, or if scheduled lighting controls do not match building occupancy schedules. But they cannot identify more granular measures like a supply air temperature reset, for example, and so the savings are proportionally smaller (see detail from the LBNL study in Table 1). But due to the lower up-front cost, EIS installations face fewer barriers to implementation than EMIS systems with more advanced AFDD features. A low-cost EIS offering

could serve as a complement or on-ramp to a more intensive EMIS program with full functionality. Additionally, An EIS program offering could provide an opportunity to experiment with a pay-for-performance approach within the Focus on Energy program.

A program could be modeled after the best practices established by ComEd in their virtual commissioning program. While we did not collect extensive data on this program, it was created by ComEd as a pathway for buildings that are interested in monitoring-based commissioning but do not qualify for that program. Similarly, Xcel Energy has an EIS path in Minnesota that recently transitioned out of pilot phase.

6.3.3 Demand management

Another function that EMIS platforms can support is better demand management and demand response. As indicated in Section 4.2, EMIS has the potential to result in $1.2 million in demand charge reductions in Wisconsin, ranging from $1,000 to $9,000 in savings per site per year. This can additionally translate into demand reduction at the grid level. While our model did not target peak demand reduction, it does indicate a potential demand reduction of 7.1 MW during the 61 system peak hours just through standard EMIS measures. Currently, several vendors are working to implement demand response capabilities in their EMIS offerings.

As the capacity of intermittent renewables increases on the grid, there will be a greater need for load flexibility in Wisconsin. Increasing penetration of EMIS within the state will lay the groundwork for several demand management strategies that could be available to utilities and Focus on Energy, such as event-based load shed, peak demand reduction, and load shifting.

Driven by California's Rule 21, the utility industry is working towards widespread adoption of protocols such as OpenADR and IEEE 2030.5 which enable buildings and utilities to communicate data around demand response needs and capacity. This is a space which several EMIS vendors also indicated they are exploring; some have already enabled OpenADR capability. This indicates that soon, EMIS could serve as a platform both for Focus on Energy to implement energy-saving programs, but also for utilities to implement or expand demand response programs. There may be many benefits in Focus on Energy and the utilities collaborating on in this way, including faster adoption and better cost-effectiveness for new technology in both program areas.

6.4 CONCLUSIONS

One key question emerged during this research project: What benefit would there be to Focus on Energy in developing an EMIS program, in additional to continuing to run the existing programs that already offer support and incentives for the measures that EMIS enables? There are three key benefits and three challenges which we have identified. These are listed in Figure 11, then further described below.

Opportunities	Challenges
• Realize increased savings from controls-based measures • Capture additional measures • Empower clients to discover and implement measures	• EMIS is proven tech, but still new • Upfront costs and unpredictable incentives limit adoption • Client engagement required for long-term success

Figure 11. EMIS opportunities and challenges

6.4.1 Benefits

Realize increased savings from controls-based measures. While Focus on Energy currently offers some incentives around controls-based measures, there remains significant opportunity to expand implementation of such measures. An EMIS program can create an umbrella to capture these savings without needing to develop programs or rules for myriad individual controls-based measures.

Increase the ability to discover additional measures for enrolled clients. EMIS assists customers in identifying savings opportunities such as broken equipment and small mistakes in controls programming which would not easily fit into an equipment rebate program but would be covered by an EMIS program focused on holistic savings.

Increase client capacity to discover and implement their own measures. Often, clients who implement an EMIS are already aware of some of the measures that need to be implemented. However, EMIS enables them to prioritize these measures, and then discover additional savings opportunities that may not have been apparent previously.

6.4.2 Challenges

EMIS is still new. While the prior research discussed in Section 2.4 provides a robust business case for EMIS, it is still a new and growing technology which many stakeholders may be wary of. This creates an opportunity for energy efficiency programs to spur adoption.

Upfront costs limit adoption. Due to a lack of familiarity with EMIS and its benefits, many potential clients are turned off by what are perceived as high up-front costs, a factor which many vendors identified as a barrier to adoption. A well-designed incentive program can reduce this barrier.

Long-term success requires client engagement. While a typical EMIS identifies ECMs within one or two months, the greatest benefit comes from long-term engagement with the system. As the market matures, vendors are working to develop reporting structures that keep clients engaged over the long term. Engagement by energy efficiency program staff can be another means to ensure this engagement and continued savings.

7 REFERENCES AND FURTHER READING

"Commercial Prototype Building Models." 2020. U.S. Department of Energy (DOE). https://www.energycodes.gov/development/commercial/prototype_models.

Crowe, Eliot, Hannah Kramer, and Jessica Granderson. 2020. "EMIS Applications Showcase." https://doi.org/10.20357/B7G022.

Dean, Jesse, and James Dice. n.d. "Energy Management Information System Powers NREL's Intelligent Campus," 4. https://www.nrel.gov/docs/fy21osti/77462.pdf

Granderson, Jessica, and Guanjing Lin. 2016. "Building Energy Information Systems: Synthesis of Costs, Savings, and Best-Practice Uses." *Energy Efficiency* 9 (6). https://doi.org/10.1007/s12053-016-9428-9.

Granderson, Jessica, Rupam Singla, Ebony Mayhorn, Paul Ehrlich, Draguna Vrabie, and Stephen Frank. n.d. "Characterization and Survey of Automated Fault Detection and Diagnostic Tools," 29. https://eta.lbl.gov/publications/characterization-survey-automated

Gunasingh, Saranya, Joe Zhou, and Scott Hackel. 2018. "Persistence of Savings from Retro-Commissioning Measures: A Field Study of Past ComEd Retro-Commissioning Projects." Slipstream (Formerly Seventhwave). https://ilsag.s3.amazonaws.com/ComEd_Retrocommissioning_Persistence_Study_Oct-2018_FINAL.pdf.

Higgins, Paul, and Mack Shaughnessy. 2018. "ComEd Energy Advisor Monitoring-Based Commissioning Program Impact Evaluation ReportEnergy Efficiency / Demand Response Plan: Plan Year 9 (PY9)." Commonwealth Edison Company (ComEd). https://ilsag.s3.amazonaws.com/ComEd_PY9_Energy_Advisor_MBCx_Evaluation_Report_2018-06-18_Final.pdf.

Hooke, James H., David Hart, and Byron J. Landry. 2004. *Energy Management Information Systems: Achieving Improved Energy Efficiency: A Handbook for Managers, Engineers and Operational Staff*. [Ottawa: Published by the Office of Energy Efficiency of Natural Resources Canada].

Kramer, Hannah, Guanjing Lin, Claire Curtin, Eliot Crowe, and Jessica Granderson. 2020. "Proving the Business Case for Building Analytics." https://doi.org/10.20357/B7G022.

Lin, Guanjing, Rupam Singla, and Jessica Granderson. 2017. "Using EMIS to Identify Top Opportunities for Commercial Building Efficiency." LBNL-1007250. Lawrence Berkeley National Lab. (LBNL), Berkeley, CA (United States). https://www.osti.gov/biblio/1350976.

McLaren, Joyce, Pieter Gagnon, Daniel Zimny-Schmitt, Michael DeMinco, and Eric Wilson. 2017. "Maximum Demand Charge Rates for Commercial and Industrial Electricity Tariffs in the United States." National Renewable Energy Laboratory - Data (NREL-DATA), Golden, CO (United States); National Renewable Energy Laboratory. https://www.osti.gov/servlets/purl/1392982/.

Meiman, Andrew, Mike Anderson, and Karl Brown. n.d. "Monitoring-Based Commissioning: Tracking the Evolution and Adoption of a Paradigm-Shifting Approach to Retro-Commissioning," 15. https://escholarship.org/uc/item/3052f752

Mills, Evan, and Paul Mathew. n.d. “Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects,” 46. https://buildings.lbl.gov/publications/monitoring-based-commissioning

MISO. 2021. “Markets and Operations.” 2021. https://www.misoenergy.org/markets-and-operations/.

National Renewable Energy Lab (NREL). 2020. *Cambium*. https://cambium.nrel.gov/.

———. 2021. *ComStock*. https://comstock.nrel.gov/.

Szinai, Julia. 2017. “Putting Your Money Where Your Meter Is: A Study of Pay-for-Performance Energy Efficiency Programs in the United States.” R: 16-09-A. Natural Resources Defense Council. https://www.nrdc.org/sites/default/files/pay-for-performance-efficiency-report.pdf.

U.S. Department of Energy. 2020. “EMIS Specification and Procurement Support Materials.” Better Buildings Initiative. November 12, 2020. https://betterbuildingssolutioncenter.energy.gov/resources/emis-specification-and-procurement-support-materials.

U.S. Energy Information Administration (EIA). “Commercial Buildings Energy Consumption Survey Commercial Buildings Energy Consumption and Expenditures.” Washington, DC: The Administration: U.S. G.P.O., Supt. of Docs. [distributor], 2016. Available: https://www.eia.gov/consumption/commercial/data/2012/

U.S. Energy Information Administration (EIA). 2021. “Short-Term Energy Outlook.” June 8, 2021. https://www.eia.gov/outlooks/steo/.

U.S. Energy Information Administration (EIA). 2021. “Annual Energy Outlook 2021.” February 3, 2021. https://www.eia.gov/outlooks/aeo/.

Zimny-Schmitt, Daniel. 2020. “Utility Rate Database.” National Renewable Energy Lab (NREL). https://openei.org/wiki/Utility_Rate_Database.

8 APPENDIX – ADDITIONAL MODELING DATA AND RESULTS

Table 9. Size and quantity of buildings included in modeling results

Summary statistics	Statewide sq ft	Statewide count	Avg sq ft	Modeled building rate	Modeled qty	Modeled sq ft
Medium Office	96,787,500	1,406	68,839	3%	49	3,373,110
Hospital	34,600,000	123	281,301	59%	72	20,253,670
Large Office	33,600,000	96	350,000	3%	3	1,050,000
Outpatient	48,262,500	510	94,632	8%	39	3,690,650
Secondary School	79,992,500	822	97,314	31%	251	24,425,815
Total	**293,242,500**	**2,957**	**892,087**	**14%**	**414**	**52,793,245**

Table 10. 2020 energy use rates, $/kWh[19]

Utility	TWh Sales	Off-peak	Winter/Spring (January-May)			Summer (Jun-Sep)			Fall (Oct-Dec)			
			Morning	Afternoon	Evening	Morning	Afternoon	Evening	Morning	Afternoon	Evening	Average
Madison Gas & Electric	2.211	0.05	0.11	0.11	0.11	0.12	0.13	0.12	0.11	0.11	0.11	**0.11**
Wisconsin Electric Power	8.839	0.07	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	**0.10**
Wisconsin Power & Light	2.395	0.06	0.07	0.07	0.07	0.07	0.09	0.07	0.07	0.07	0.07	**0.07**
Wisconsin Public Service	4.011	0.04	0.06	0.04	0.06	0.06	0.06	0.04	0.06	0.04	0.06	**0.05**
Northern States Power	2.821	0.06	0.07	0.07	0.07	0.06	0.06	0.06	0.07	0.07	0.07	**0.07**
	Average	**0.06**	**0.09**	**0.08**	**0.09**	**0.09**	**0.09**	**0.08**	**0.09**	**0.08**	**0.09**	**0.08**

Table 11. 2020 demand charge rates, $/kW[20]

Utility	TWh Sales	Off-peak	Winter/Spring (January-May)			Summer (Jun-Sep)			Fall (Oct-Dec)			
			Morning	Afternoon	Evening	Morning	Afternoon	Evening	Morning	Afternoon	Evening	Average
Madison Gas & Electric	2.211	12.99	12.99	12.99	12.99	15.12	15.12	15.12	12.99	12.99	12.99	**13.63**
Wisconsin Electric Power	8.839	1.94	10.32	10.32	10.32	10.32	10.32	10.32	10.32	10.32	10.32	**9.48**
Wisconsin Power & Light	2.395	2.06	2.06	9.86	9.86	2.06	9.86	9.86	2.06	9.86	9.86	**6.74**
Wisconsin Public Service	4.011	1.73	9.20	1.73	9.20	13.74	13.74	1.73	9.20	1.73	9.20	**7.12**
Northern States Power	2.821	4.43	8.95	8.95	8.95	10.67	10.67	10.67	8.95	8.95	8.95	**9.01**
	Average	**3.47**	**9.22**	**8.66**	**10.14**	**10.59**	**11.51**	**9.14**	**9.22**	**8.66**	**10.14**	**9.08**

[19] Off: 9pm-8am; Morning: 9am-12pm; Afternoon: 1pm-5pm; Evening: 6pm-8pm
[20] Off: 9pm-8am; Morning: 9am-12pm; Afternoon: 1pm-5pm; Evening: 6pm-8pm

Table 12. 2020 grid level savings results

Building Type	Wholesale Cost Savings	Whole Capacity Cost Savings	Long-term Electricity Emission Savings (tons)	Natural Gas Emission Savings (tons)	Total Emission Savings (tons)
Hospital	$1,574,531	$127,695	31,547	6,121	37,668
Large Office	$50,485	$4,674	932	133	1,065
Medium Office	$86,194	$22,780	1,567	502	2,069
Outpatient	$120,140	$30,754	2,249	661	2,910
Secondary School	$394,358	$178,879	6,977	7,161	14,139
Total	**$2,225,708**	**$364,782**	**43,273**	**14,578**	**57,851**

Table 13. 2030 grid level savings results

Building Type	Wholesale Cost Savings	Whole Capacity Cost Savings	Long-term Electricity Emission Savings (tons)	Natural Gas Emission Savings (tons)	Total Emission Savings (tons)
Hospital	$1,632,166	$121,550	24,047	6,121	30,168
Large Office	$49,744	$4,822	597	133	730
Medium Office	$84,264	$17,658	969	502	1,471
Outpatient	$123,809	$32,510	1,551	661	2,212
Secondary School	$383,097	$115,357	4,098	7,161	11,259
Total	**$2,273,079**	**$291,897**	**31,262**	**14,578**	**45,841**

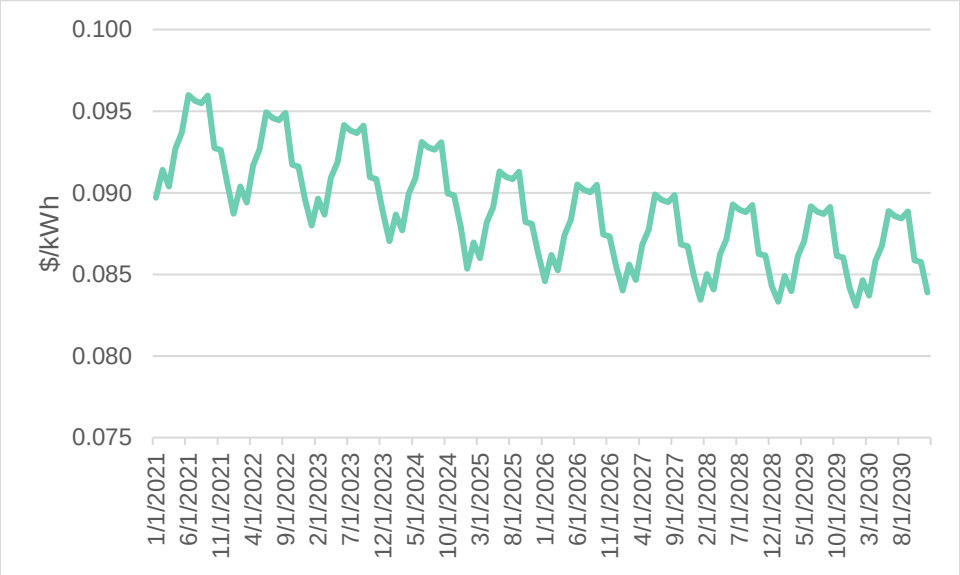

Figure 12. Wisconsin electric rate forecast, 2021 to 2030

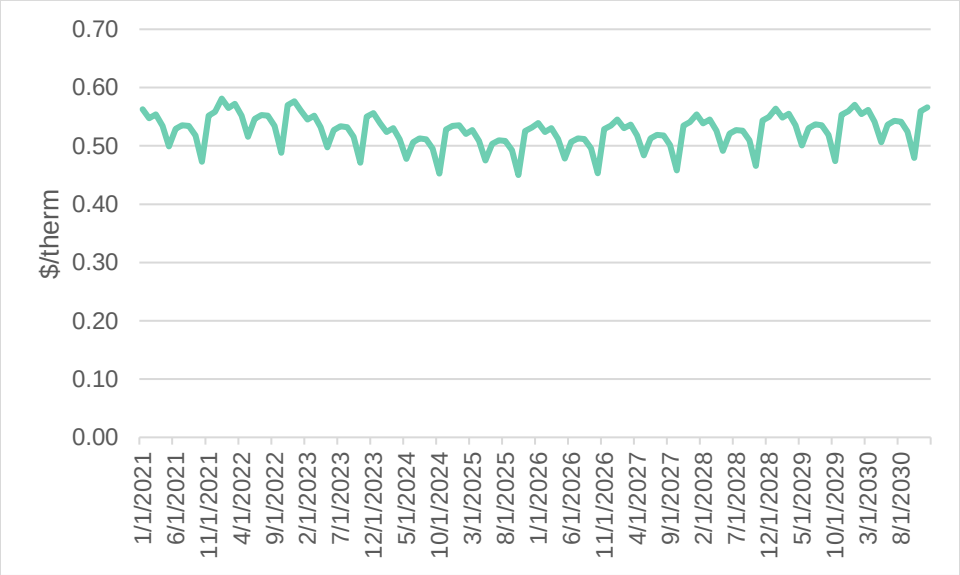

Figure 13. Wisconsin natural gas rate forecast, 2021 to 2030