ILLUME

PROJECT:

Load Shaping Research:

Case Studies
FINAL

PROJECT SPONSOR:

Focus on Energy

ACKNOWLEDGMENTS

ILLUME Advising, LLC is a forward-thinking consulting company at the rare intersection of insight and execution. Founded in 2013 by industry thought-leaders Anne Dougherty and Sara Conzemius, the company has quickly grown to include a deep bench of quantitative and qualitative research experts. ILLUME uses cutting edge research strategies to help build a resilient energy future to enrich lives, improve global health, and ensure a more secure and sustainable future.

For this effort, we would like to acknowledge, first and foremost, Focus on Energy.

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EXECUTIVE SUMMARY

As the need for load shaping and controllable technologies and interventions increases, Focus on Energy (Focus) has the potential to build from the current energy efficiency (EE) landscape in Wisconsin to expand opportunities for saving energy at critical times in the future. ILLUME Advising, LLC (ILLUME), together with Focus, researched the load shaping market to explore which behavioral and technology-based solutions could supplement existing program offerings and provide the greatest opportunity for Wisconsin.

This report represents the culmination of ILLUME's load shaping research with Focus, in which we present four case studies, provide findings and potential next steps, and identify future research opportunities. In the Appendix sections, we document interim results from previous stages of research, including an initial list of over 40 load shaping measures and market and measure characterizations of ten promising load shaping measures.

METHODOLOGY

Per the Focus on Energy Policy Manual, "Load Shifting is not eligible for Focus incentives since in most cases it simply shifts load from peak to off-peak with no resulting energy savings. Under Focus, load shifting has remained a utility function." As such, the objective of this project was to provide a broad view into where and how load shaping opportunities intersect and/or can build upon current and emerging energy efficiency opportunities in Wisconsin. In this project, ILLUME and the Focus team used a staged approach to enable this view, conducting deeper research on a narrower list of measures at each consecutive stage. The stages were as follows: (1) identify a set of potential measures to research; (2) select ten measures for ILLUME to characterize (e.g., documenting savings, relevant Wisconsin policies, and market indicators); and (3) identify four measures for ILLUME to develop into case studies. At each stage, ILLUME provided a recommended list of measures, and the Focus team collected stakeholder feedback with which the team made final selections.

ILLUME reviewed industry literature, program documentation, and our team's experience to examine the technological potential, current market (maturity, channels, actors, and barriers), and program design considerations for each of the final four selected measures. To further build out the case study for each, we considered each measure's "fit" into the Focus portfolio and identified what Focus might be able to achieve from piloting or offering such a measure.

KEY FINDINGS AND RECOMMENDATIONS

In this section, we present the key findings and recommendations culminating from this research effort in total. For the four case studies, we present considerations and potential next steps for Focus as the final section of each of the case studies presented in this report.

- Focus has been and continues to provide incentives for EE measures that save energy at typical peak summer times in Wisconsin. For example, this research indicates that energy recovery ventilators, variable frequency drives, compressed air nozzles, certain efficient kitchen equipment, and other readily available measures in Focus's portfolio save coincident summer demand.

- *Recommendation: Provide stakeholders with information related to existing Focus programs that are already providing demand savings, and information identifying which technologies are achieving this (such as those included in the initial measure list of over 40 measures).*

- **In other states, such as Massachusetts, Vermont and California, regulators and utilities are using EE programs to support initiatives beyond EE (e.g., residential customer sited battery storage and beneficial electrification).** EE programs are well suited to administer these directives because EE programs and program staff have the infrastructure and market knowledge to prioritize technologies, affect adoption rates, and monitor their progress.
  - *Recommendation: Focus and their stakeholders should consider options by which Focus can support targeted initiatives driven by utilities or other entities, such as non-wires alternatives, beneficial electrification, or customer sited battery storage. Focus could collect this type of feedback through utility, regulator and other stakeholder interviews or focus groups, which ILLUME describes in more detail in section 8.*
- **Smart thermostats currently represent the most immediate and least risky opportunity to administer an integrated EE and demand response (DR) measure.** There are examples of programs currently supporting smart thermostats as an integrated EE and DR measure, and Xcel Energy's DR program in Wisconsin already channels their customers to combine DR rebates with Focus's EE rebates.
  - *Recommendation: Focus should develop a strawman proposal and seek feedback from potential utility partners on how to administer an integrated EE and DR smart thermostat measure in Wisconsin. Focus could collect this type of feedback through utility, regulator and other stakeholder interviews or focus groups, which ILLUME describes in more detail in section 8.*
- **There is an opportunity for Wisconsinites, where Wisconsin customers could yield greater benefits from some EE measures already supported by Focus with supplemental funding, education, coordination, and/or support from utilities or entities interested in demand savings.** Strategic energy management (SEM) program staff indicated that some facilities are interested in help with their demand charges, but Focus is limited to support energy savings. Similarly, customers getting smart thermostats installed through Focus may be unaware of the DR opportunities from their utility, and combining these initiatives could help drive participation in both EE and DR programs.
  - *Recommendation: Pending feedback from utility partners, regulators, and other stakeholders around potential opportunities for Focus to enhance their programs to achieve greater demand savings, Focus could consider research to better understand the value in achieving greater demand savings. This research could include summarizing Wisconsin demand issues and characterizing the demand for utility partners—or estimating the cost-of-acquisition for specific initiatives to increase demand savings. ILLUME describes these potential research tasks in more detail in section 8.*
  - *Recommendation: Pending the progress of an integrated EE and DR smart thermostat measure and stakeholder feedback on potential demand-based offerings, Focus should revisit the market readiness of other opportunities no later than the end of 2021 or beginning of 2022. These offerings could include HPWH, customer sited battery storage, and SEM, or Focus could expand or refine their list of potential demand-based offerings by implementing certain research tasks described in section 8 (e.g., prioritizing measures with winter demand savings, fully reviewing the Spectrum database for measures with high summer demand savings, or reviewing and revising demand and coincident demand savings for certain measures).*

TABLE 1. SUMMARY OF NEXT STEPS BY MEASURE

MEASURE	RECOMMENDATION	NEXT STEPS FOR FOCUS
Smart thermostats	Use smart thermostats as a learning experience and test case for enhancing Focus's programs to achieve greater demand impacts.	Develop a strawman proposal and seek feedback from potential utility partners on how to administer an integrated EE and DR smart thermostat measure in Wisconsin.
Residential heat pump water heaters	Monitor the progress of integrating EE and DR for smart thermostats before integrating EE and DR for this measure. Monitor any discussions or initiatives around beneficial electrification.	Include this measure in future market research in late 2021 or 2022 related to achieving greater demand savings. Include this measure for consideration in any future beneficial electrification research.
SEM for water and wastewater treatment plants	Monitor the progress of integrating EE and DR for smart thermostats before integrating EE and DR for this measure.	Include this measure in future market research in late 2021 or 2022 related to achieving greater demand savings.
Residential customer sited battery storage	Monitor the progress of integrating EE and DR for smart thermostats and wait to better understand stakeholder perspectives before driving forward a battery storage offering.	When collecting stakeholder feedback around smart thermostats, consider also collecting any initial reactions to battery storage offerings, as exemplified in other states (e.g., Massachusetts and Vermont).

POTENTIAL FUTURE RESEARCH

The findings resulting from this research effort indicate that there is potential to enhance Focus's current EE offerings to yield greater benefits to Wisconsinites via supplemental marketing, funding, coordination, and support from utilities and/or entities interested in demand savings. However, additional research could provide an enhanced understanding of the path toward these opportunities. Together with the Focus team, ILLUME identified three key areas of targeted future research; (1) assessing different strategies for enhancing programs to achieve greater demand savings, (2) better understanding the value of achieving additional demand savings, and (3) expanding the list of potential demand saving opportunities. Bulleted below, we present seven potential research studies designed to help address these target areas of research and to help the Focus team continue to enhance EE offerings for Wisconsinites. We describe these research studies in more detail in the final section of this report.

- Utility, regulator, and other stakeholder interviews or focus groups
- Wisconsin customer survey on awareness and knowledge of demand issues and savings
- Summary of Wisconsin and utility partner demand issues
- Cost of acquisition for demand savings

- Full database review of Spectrum
- Prioritized EE measure list for winter demand savings opportunities
- Reviewed and revised demand and coincident demand savings for key measures

1. INTRODUCTION

While traditional EE programs help manage peak demand through efficiency measures, there may be a larger role for EE programs to mitigate demand at critical times in the future. This shift is due to a variety of factors, including increased penetration of intermittent renewable generation, improved technology, and improved markets and understanding of managing demand. In practice, EE programs are increasingly delivering load mitigation through **non-wires alternative** projects,[1] refining methods to account for the dynamic **time- and locational-value of efficiency**,[2] and in partnership with DR programs (i.e., integrated EE/DR) to implement **shape, shift, shed, and shimmy**.[3]

In Wisconsin, Focus has the potential to build on their current EE offerings to increase their demand impacts. These demand impacts could help their utility partners and reduce demand charges for Wisconsin rate payers. ILLUME, together with Focus, researched the load shaping market to explore potential opportunities to supplement Focus's existing program offerings and provide the greatest opportunity for Wisconsin.

This report represents the culmination of ILLUME's load shaping research with Focus, where we lay out four case studies, provide findings and potential next steps, and identify future research opportunities. In the Appendix sections, we document interim results, including an initial list of over 40 load shaping measures and our market and measure characterization of ten promising load shaping measures. Each of the appendices also includes the methodology and data sources ILLUME used.

[1] E4TheFuture, Peak Load Management Alliance (PLMA), and Smart Electric Power Alliance (SEPA). "Non-Wires Alternatives Case Studies from Leading U.S. Projects," 2018, https://sepapower.org/resource/non-wires-alternatives-case-studies-from-leading-u-s-projects/

[2] Berkley Labs, Electricity Markets and Value. "Time- and Locational-Sensitive Value," accessed September 2020, https://emp.lbl.gov/projects/time-value-efficiency

[3] Peter Alstone, Jennifer Potter, Mary Ann Piette, Peter Schwartz, Michael A. Berger, Laurel N. Dunn, Sarah J. Smith, Michael D. Sohn, Arian Aghajanzadeh, Sofia Stensson, Julia Szinai, and Travis Walter. "2015 California Demand Response Potential Study," November 14, 2016, http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442451541

2. METHODOLOGY

In this project, ILLUME and the Focus team used a staged approach with deeper research on a narrower list of measures at each stage.

As the first task of this research effort, ILLUME and the Focus team reviewed measures associated with common load mitigation strategies and selected measures that best meet the specific needs of Focus. To initiate this process, ILLUME provided a list of over 40 measures that are commonly part of load mitigation strategies as well as measures currently included in the Focus on Energy TRM with substantial coincident demand savings. We include this original list as Appendix B.

Reviewing this list of measures, ILLUME and the Focus team discussed the priorities and limitations of this research effort, which included prioritizing:

- Measures that save annual energy as well as energy at key times
- Measures that are already included in the Wisconsin TRM
- Technology-based interventions over behavioral interventions
- Measures with a mix of applicable sectors, including commercial, industrial, single family (SF) residential, and multifamily (MF) residential
- Measures with a mix of value propositions
- Measures with a mix of uptake in Wisconsin (i.e., measures that demonstrate where Focus can help utilities manage load through existing EE programs, measures that have been delivering load mitigation value yet where benefits could be extended, measures that may be worth further investigation for Focus as a potential future priority or offering)

ILLUME and the Focus team then sought stakeholder input on the measures, reviewed recent participation data, and ultimately selected ten measures for measure characterizations. In Appendix C, we include our memo characterizing these ten measures, their load shaping value proposition, potential, and our recommended list of measures for which to develop case studies.

To identify the list of measures to develop into case studies, ILLUME used the following criteria:

- The measure represents moderate or high demand savings potential.
- The measure represents a program design outside of Focus's typical operations, and as such, represents an opportunity for Focus to learn from other EE programs' successes and challenges.
- The selected set of measures represent a meaningful cross section of the various load shaping value propositions, customer segments, and end-uses.
- Reports, program design descriptions, and other information necessary for a case study are readily available.

The Focus team and their stakeholders supported these priorities and together agreed to have ILLUME create case studies for the following set of measures:

- **Smart thermostats** as a measure to provide integrated energy efficiency (EE) and demand response (DR) in Wisconsin, where Focus could support adoption of smart thermostats (delivering annual energy savings) and enable utility programs to deliver load shifting with the newly adopted smart thermostats
- **Heat pump water heaters (HPWH)** as a measure to deliver integrated EE/DR (but that is less mature than smart thermostats), to deliver coincident demand savings, and with potential to provide load management for an electrifying end-use
- **Strategic energy management (SEM) for water and wastewater treatment plants** as a measure to deliver integrated EE/DR and coincident demand savings
- **Customer sited battery storage** as a potential future offering to deliver demand savings at key times.[4]

We present the details of this decision in Appendix A and the full case studies in the sections below.

[4] It is important to note that Focus on Energy is limited in its current ability to support incentives for batteries, as batteries do not provide annual energy savings. However, the team includes a case study for customer sited batteries to demonstrate what a statewide offering may look like in practice. As noted in the Focus on Energy Policy Manual for frequently asked policy questions, in Section 1.5 states "Load Shifting is not eligible for Focus incentives since in most cases it simply shifts load from peak to off-peak with no resulting energy savings. Under Focus, load shifting has remained a utility function." "Focus on Energy Policy Manual", 2019, https://www.focusonenergy.com/sites/default/files/inline-files/2019_Focus_on_Energy_Policy_Manual.pdf

3. SMART THERMOSTATS

3.1 SUMMARY

Smart thermostats represent an important case study for Focus, because they provide the most immediate opportunity for Focus to coordinate with utilities to deliver an integrated EE and DR offering in Wisconsin. One of the greatest implementation challenges for integrated EE and DR is coordination between the two program administrators, even when those groups are in the same organization, such as two distinct departments within a utility. This could be particularly challenging for Focus, given that the Focus Policy Manual explicitly prohibits Focus from providing DR, necessitating that Focus coordinate with utility DR programs to realize the benefits of integrated EE and DR. In this case study, ILLUME highlights findings from our research that can inform Focus's conversations with utilities to facilitate integrated EE and DR in Wisconsin.

3.2 MEASURE CHARACTERIZATION

ILLUME summarizes our measure characterization research for smart thermostats in Table 2. Our research indicates that smart thermostats provide moderate energy savings and moderate DR event-based savings for residential customers in Wisconsin or comparable climates.

TABLE 2. SMART THERMOSTAT MEASURE CHARACTERIZATION

CATEGORY	MEASURE DETAILS
Measure Summary	
Description	Standard programmable thermostats allow customers to adjust temperatures at different times of the day, changing temperatures during unoccupied periods to allow for energy savings. Communicating thermostats provide this base level of functionality but can be programmed remotely through various communication protocols, including Wi-Fi. Smart thermostats provide additional functionality, having several automatic features to increase energy savings.[1] Smart thermostats can be used to control a growing number of residential HVAC types, although performance standards for some products, notably line-voltage electronic thermostats, are lacking in both Canada and the U.S.[2].
Segment	Residential
End Use	HVAC system
Load Shaping Value Proposition	Integrated EE/DR partnership with utilities
Relevance for Load Shaping	*Recurring:* Documented annual energy savings without demand savings in the Focus TRM 2020, but other sources indicate potential demand savings
	Event-based: Strong opportunity for event-based savings with integrated EE and DR
Measure Performance	
Focus Program Data Energy Savings per Unit (kWh/yr)	Median: 440 Range: 233-440 (varies by SF/MF)

Focus Program Data Demand Reduction (kW)	Median: 0 Range: 0-0 (the IL TRM documents savings of about 0.084-0.122 kW for advanced thermostats, and recent evaluations indicated positive summer daytime savings)[3,4]
Average Load Shifting Savings	0.46-0.54 kW per unit per event for thermostat setbacks[5] 0.31-0.59 kW per unit per event depending on setback and strategy[6]

1. "Wisconsin Focus on Energy 2020 Technical Reference Manual," The Cadmus Group, 2020, https://focusonenergy.com/sites/default/files/Focus_on_Energy_2020_TRM.pdf
2. A Report of BPA's Emerging Technologies Initiative https://www.bpa.gov/EE/Technology/EE-emerging-technologies/Projects-Reports-Archives/Documents/LVCT_FINAL.PDF
3. IL TRM: https://ilsag.s3.amazonaws.com/IL-TRM_Effective_01-01-20_v8.0_Vol_3_Res_10-17-19_Final.pdf
4. Recent IL evaluation study: https://ilsag.s3.amazonaws.com/ComEd-Adv-Thermostat-Research-Report-Final-2020-11-10.pdf
5. Evaluation results for Xcel Energy Colorado: https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/Regulatory%20Filings/CO-Smart-Thermostat-Pilot-Evaluation.PDF
6. Evaluation results for National Grid in Rhode Island: http://www.ripuc.ri.gov/eventsactions/docket/4.%202017%20NGrid%20DR%20Eval%20Final%20Report%20-%202018-03-30.pdf

3.3 MARKET CHARACTERIZATION

ILLUME summarizes our market characterization research for smart thermostats in the subsections below.

DELIVERY CHANNELS

EE programs largely distribute smart thermostats through brick-and-mortar retail, online retail or utility e-marketplaces. On the other hand, smart thermostat DR programs typically reach customers through one of three channels: through the device or its associated account (for customers who already own smart thermostats), through utility marketing targeted at customers who received EE rebates for smart thermostats, or at the point of sale. In our research, we only uncovered examples of integrated EE and DR for the latter two DR delivery channels (additional details provided in Section 3.4).

MARKET ACTORS

Focus and their utility partners should anticipate working with the following market actors should they pursue an integrated EE and DR smart thermostat offering:

- E-marketplace vendors (e.g., Focus's online marketplace[5])
- DR providers with experience administering "Bring-Your-Own" Thermostat DR programs

However, it is becoming more common that program implementers can provide both of these services (e.g., Uplight).

[5] Focus on Energy. Online Marketplace, 2020, https://www.focusonenergy.com/residential/marketplace

ADOPTION AND SATURATION

Smart thermostat adoption is in a period of growth, with adoption increasing exponentially over the past few years. The Focus program estimates that they have rebated over 40,000 smart thermostats since 2016, which based on program data, indicates a cumulative annual growth rate of over 200% between 2016 to 2019. The data omits Wisconsin residents who may be purchasing smart thermostats without Focus rebates, suggesting there are yet more smart thermostats installed in customer homes. That said, considering that there are nearly three million dwelling units in the state, a rough estimate assuming there is one smart thermostat-controlled HVAC system per home indicates these devises may be installed in 1 to 2% of Wisconsin homes.[6]

Smart thermostat load shifting is also growing rapidly. A 2016 report projected that the number of U.S. customers enrolled in BYOT programs would grow from 50,000 in 2016 to 20 million customers in 2020, a 347% cumulative annual growth rate.[7,8]

Given the rapid growth to date and other factors, ILLUME cannot provide a reliable estimate for when smart thermostats may begin to reach market saturation. As a potential comparison point, in 2009, the Energy Information Agency (EIA) estimated that 45% of households had programmable thermostats, a product that became widely available in the 1980s.[9,10] However, given that smart thermostats became widely available in 2011 and their market potential is high, saturation is likely still a few years out.[11]

MARKET BARRIERS

The primary market barriers for the adoption of smart thermostats include cost, privacy concerns, and HVAC system compatibility.

The 2020 Focus on Energy TRM estimates an incremental cost of about $174 for a smart thermostat, and roughly $91 for a basic communicating thermostat. Many customers may not see the value in purchasing a new thermostat with an incremental cost of between $100 and $200 dollars. Additionally, for many customers, their current thermostats are working as designed, and customers may not feel an impetus to purchase a new thermostat, let alone for a higher-priced product. Smart thermostat vendors, however, are

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[6] United States Census Bureau. "Quick Facts Wisconsin," accessed November 30, 2020, https://www.census.gov/quickfacts/WI

[7] Navigant Research. "Bring Your Own Thermostat Demand Response from Navigant," January 5, 2016, www.navigantresearch.com/research/bring-your-own-thermostat-demand-response

[8] PLMA. "The Future of Utility Bring Your Own Thermostat Programs," March 2018, https://www.peakload.org/assets/Groupsdocs/PractitionerPerspectives-UtilityBYOTPrograms-March2018.pdf

[9] State Brief from EIA. "Household Energy Use in Wisconsin," 2009, https://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/wi.pdf

[10] Laura Bourland. "The History of Thermostats and Their Evolution to Smart," May 2020, https://getmysa.com/blog/thermostat-talk/the-history-of-thermostats-and-their-evolution-to-smart/

[11] Wikipedia. "Nest Learning Thermostat," accessed November 28, 2020, https://en.wikipedia.org/wiki/Nest_Learning_Thermostat

bringing cheaper products to market to reach a wider customer base, which may help mitigate this market barrier.[12, 13]

As the adoption of smart devices continues to accelerate, it is unclear the extent to which privacy concerns remain a barrier for smart thermostats. On one hand, smart phones have reached wide adoption. On the other hand, there are numerous examples of customers sharing privacy concerns around smart thermostats and other smart home products, which seem to suggest that adoption has remained most successful with the cohort of customers who are pro-technology, and that less technology-centric customers have not fully overcome this barrier.[14, 15, 16, 17]

Finally, performance standards are lacking for smart thermostats that control some types of residential HVAC systems. For example, ENERGY STAR does not currently offer a specification for the connected version of line voltage thermostats, thermostats used to control electric baseboard heating.[18]

3.4 PROGRAM DESIGN CONSIDERATIONS

Our smart thermostat research centers on the dynamics of integrated EE and DR. In the subsections below, we summarize our findings regarding program design considerations for smart thermostats across four geographies where program administrators offer smart thermostats as an integrated EE and DR measure.

INCENTIVES AND MARKETING

In Table 3 and the program highlights below, we present incentive and marketing information for programs that offer smart thermostats as an integrated EE and DR measure. Two common elements include (1) using an implementer that can manage both the DR implementation and e-marketplace for the EE program, and (2) having the DR marketing effort piggyback on the e-marketplace managed and paid for by the EE program.

XCEL ENERGY'S DEMAND RESPONSE PROGRAM IN WISCONSIN PROMOTES FOCUS'S EE PROGRAM

The website for Xcel's DR program (AC Rewards) advertises to customers in Wisconsin "Additional thermostat rebate available through Focus on Energy with 60% matching rebate from us." This marketing essentially supports smart thermostats as an integrated EE and DR measure in the Xcel service territory,

[12] Product Information from Google. "Nest Thermostat E," accessed November 12, 2020, https://store.google.com/us/product/nest_thermostat_e

[13] Product Information from Ecobee. "ecobee3 lite," accessed November 12, 2020, https://www.ecobee.com/en-us/smart-thermostats/smart-wifi-thermostat/

[14] Parks Associates. "Smart Home Devices" presentation, 2018. Parks Associated Connections Conference.

[15] Marlene Motyka, Suzanna Sanborn, Andrew Slaughter, and Scott Smith. "Energy Management: Most consumers and Businesses Push for Cleaner Energy: Deloitte Resources 2018 Study," 2018.

[16] Pia S. de Boer, Alexander J.A.M. van Deursen, and Thomas J.L. van Rompay. "Accepting the Internet-of-Things in our homes: The role of user skills," Telematics and Informatics, 36(2019):147-156, DOI:10.1016/j.tele.2018.12.004.

[17] Chankook Park, Yangsoo Kim, and Min Jeong. "Influencing factors on risk perception of IoT based home energy management services," Telematics and Informatics, 35 no.8 (2018) DOI:10.1016/j.tele.2018.10.005.

[18] ENERGY STAR. "Connected Thermostats Version 1.0 Final Draft Specification" January 2017.

although providing access to the rebates within Focus's e-marketplace may have a larger impact on adoption and enrollment.

GEORGIA POWER COMPANY AND XCEL ENERGY IN MINNESOTA COMBINE EE AND DR INCENTIVES ON THEIR E-MARKETPLACES

Georgia Power Company and Xcel Energy in Minnesota offer both instant DR and EE rebates at the point of purchase on their e-marketplaces. The DR components of these programs also enroll customers through a "Bring Your Own Device" (BYOD) type model. BYOD programs are a shift from the popular Bring Your Own Thermostat program design, expanding the concept to encourage customers to enroll a broader selection of customer-owned (and qualifying) devices into DR or energy efficiency programs managed through the utility, energy supplier or third-party systems integrator.

PGE'S DR PROGRAM CROSS-PROMOTES ENERGY TRUST OF OREGON'S EE REBATES FOR SMART THERMOSTATS

Similar to Xcel Energy's DR program in Wisconsin, PGE's program advertises EE rebates from the Energy Trust of Oregon for their customers. PGE's DR program provides two channels to their customers: on-going rewards and up-front rewards. PGE markets the smart thermostat EE rebates available to Oregon customers in their on-going rewards channel. PGE's up-front rewards channel supports customers with the upfront cost and installation for smart thermostats (e.g., with virtual installation help from a professional). Our research did not uncover what support, if any, Energy Trust provides specifically for PGE's up-front rewards.

COMED'S E-MARKETPLACE ADVERTISES THEIR TIME-OF-USE AND CRITICAL PEAK PRICING RATES FOR CERTAIN SMART THERMOSTAT MODELS

For certain smart thermostat models, ComEd's e-marketplace shares information about rate-based load shaping programs in a section called "Related Programs." In this section, ComEd references their critical peak pricing program (i.e., "Peak Time Savings") and their time-of-use rate (i.e., "Hourly Pricing").

TABLE 3. INCENTIVE AND MARKETING FOR SMART THERMOSTAT EE/DR OFFERINGS

STATE	EE PROGRAM	DR PROGRAM	NOTABLE EE AND DR INTERPLAY
Program Administrators			
Wisconsin	Focus on Energy	MGE	
Wisconsin	Focus on Energy	Xcel Energy[1]	
Georgia	Georgia Power	Georgia Power	
Oregon	Energy Trust	PGE	
Illinois	ComEd	ComEd	
Minnesota	Xcel Energy	Xcel Energy	
Incentives and Marketing			
Wisconsin[2,3]	$50	$25 for enrollment and $25 for each completed summer season	No
Wisconsin[4]	$50	$25 every year of participation	Somewhat
Georgia[5,6]	Up to $75	One-time $50 for participation	Yes

Oregon[7,8]	$100	"Up-front rewards:" One-time rebate and installation support **-or-** "Ongoing rewards:" $25 for program enrollment, and $25 per season of participation	Somewhat
Minnesota[9,10,11]	$50	$75 bill credit for enrollment, and $25 per year	Yes
Illinois[12,13]	Up to $75	On bill credits dependent on savings, estimated at $4-12 for a 4° change in setpoint.	Somewhat

1. Xcel Energy AC Rewards: https://www.xcelenergy.com/programs_and_rebates/residential_programs_and_rebates/heating_and_cooling/ac_rewards_smart_thermostat_program
2. Focus on Energy program information: https://www.focusonenergy.com/residential/marketplace
3. MGE Connect: https://www.mge.com/saving-energy/for-homes/heating-and-cooling/mge-connect
4. Xcel Energy AC Rewards: https://www.xcelenergy.com/programs_and_rebates/residential_programs_and_rebates/heating_and_cooling/ac_rewards_smart_thermostat_program
5. Georgia Power DR program information: https://georgiapowermarketplace.com/programs/content_drpe_info.html
6. Product information on Georgia Power e-marketplace: https://georgiapowermarketplace.com/google-nest-learning-thermostat/P-NST3RDGEN.html
7. Energy Trust program information for smart thermostats: https://www.energytrust.org/incentives/smart-thermostats/
8. PGE DR program information: https://www.portlandgeneral.com/residential/energy-savings/thermostats/smart-thermostat-programs
9. Xcel Energy e-marketplace: https://www.xcelenergystore.com/
10. Xcel Energy AC Rewards Program information: https://www.xcelenergystore.com/pages/ac-rewards-program
11. ComEd's e-marketplace: https://secure.comed.com/marketplace/category/comed_smart_thermostats
12. Product information on ComEd's e-marketplace: https://secure.comed.com/marketplace/product/google-nest-learning-thermostat
13. ComEd Peak Time Savings: https://www.comed.com/WaysToSave/ForYourHome/Pages/PeakTimeSavings.aspx

ELIGIBILITY CONSIDERATIONS

Program eligibility requirements for the EE and DR components of integrated EE and DR offerings can be identical or be specific to the offering. For example, Georgia Power customers with central AC or heat pumps are eligible for the EE smart thermostat rebate, but only customers with heat pumps are eligible for the DR rebate. In cases where eligibility requirements differ by offer, care should be taken to avoid increased administrative burden and potential customer satisfaction issues.

BARRIERS TO IMPLEMENTATION

One of the largest barriers to the implementation of an integrated EE and DR smart thermostat offering may be the "evaluation risk" posed by the variation in energy savings these devices achieve. While smart thermostats are a part of almost every EE program portfolio, evaluation results are somewhat mixed, and deemed smart thermostat savings are subject to change over time. This uncertainty or risk could affect the cost of acquisition for smart thermostats. To date, the variation in evaluated savings from smart thermostats has tended to impact the role and magnitude of these devices in EE portfolios, rather than

whether or not they are included in EE programs. It remains to be seen whether additional evaluation results of smart thermostat offerings further impact the role these devices play in EE programs.

Smart thermostats are well suited for DR implementation as they control one of the largest energy users in residential customer homes and do not require site visits for enrollment, installation, or evaluation. However, the largest barrier for DR implementation might be smart thermostat manufacturers' willingness to work with utilities. Smart thermostat manufacturers are protective of their customer relationships and customers' data. While they enable easily dispatchable load shifting in 2020, there is some risk for future interoperability challenges. For example, some thermostat manufacturers, such as ecobee and Google, are now offering thermostat optimization services to all customers on their own, ceasing their partnerships with utilities (e.g., Eco+ and Seasonal Savings).[19] This shift was relatively abrupt and left some program implementers and administrators struggling to meet future savings goals. As another example, EE programs and researchers have pursued opportunities to use smart thermostat data to support HVAC maintenance or upgrade programs, but these efforts have largely stalled in part due to data access issues.[20, 21, 22]

Attribution of impacts, while not necessarily a barrier, is another important program design consideration for an integrated EE and DR smart thermostat offering. In a common design we have seen, the EE program receives energy savings (and potentially some small coincident demand savings), and the DR program receives demand savings during events in excess of the coincident demand savings from the device itself. In our experience, the cost benefits of energy savings for integrated EE and DR offerings may exceed the DR savings, and as such, the DR program leverages as much of the EE program's administrative infrastructure as possible (e.g., by marketing for the DR program on the EE program's website).[23]

3.5 CONSIDERATIONS AND POTENTIAL NEXT STEPS

Our research indicates that smart thermostats:

- Provide moderate energy and DR event-based savings
- Have a large market potential, with nearly three million dwelling units in Wisconsin[24]

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[19] Zoe Schiffer. "Google is making Seasonal Savings free for all Nest thermostat owners," The Verge, June 30, 2020, https://www.theverge.com/2020/6/30/21308606/google-nest-seasonal-savings-free-thermostat-owners

[20] Michael Zeifman and Kurt Roth. "Residential remote energy performance assessment: Estimation of Building Thermal parameters using interval energy consumption data," 2016, https://www.aceee.org/files/proceedings/2016/data/papers/12_127.pdf

[21] Michael Zeifman, Amine Larzak, and Kurt Roth. "Residential retrofits at scale: Opportunity identification, saving estimation, and personalized messaging based on communicating thermostat data," Energy Efficiency 13, 3939-405(2020), http://publica.fraunhofer.de/documents/N-558972.html

[22] Ethan Goldman, Nick Lange, Jake Jurmain, Greg Fanslow, and Rebecca Foster. "Are Thermostats the New Energy Audits?," January 29, 2014, https://www.efficiencyvermont.com/Media/Default/docs/white-papers/efficiency-vermont-are-thermostats-new-energy-audits-white-paper.pdf

[23] Slipstream webinar, "Load shifting: the market potential for carbon and energy savings," accessed November 30, 2020, https://slipstreaminc.org/about/events/load-shifting-market-potential-carbon-and-energy-savings

[24] United States Census Bureau. "Quick Facts Wisconsin," accessed November 30, 2020, https://www.census.gov/quickfacts/WI

- Are in a period of growth, with adoption rates increasing exponentially over the past few years
- Have remaining market barriers, including cost, privacy concerns, and compatibility with the HVAC system
- Are commonly sold through EE program e-marketplaces
- Are currently being offered with some components of integrated EE and DR in areas with similar climates to Wisconsin through e-marketplaces
- Can be offered as an integrated EE and DR measure with the same or different EE and DR eligibility requirements
- Allow for EE and DR programs to combine incentives and marketing power to increase adoption and enrollment in DR programs when offered as an integrated EE and DR measure
- May create risk due to variability in achieved energy savings and shifts in manufacturer willingness to share data and work with utility programs

Focus and their utility partners are well set up for an integrated EE and DR smart thermostat measure, because Focus provides an e-marketplace and offers EE incentives for utilities who offer smart thermostat DR. Additionally, an integrated offering could reduce the upfront cost of smart thermostats (a current barrier to adoption) for Wisconsin residents without Focus having to increase incentives.

While one of the main benefits for integrated EE and DR is driving adoption, smart thermostat adoption in Wisconsin is already moderate to high and growing. Instead, ILLUME suggests that Focus view an integrated EE and DR smart thermostat offering as a learning experience and test case for similar future endeavors. Such an experience may facilitate future opportunities for integrated EE and DR where adoption or enrollment are more of a concern (e.g., HPWHs).

Specific research questions that could be answered with an integrated EE and DR pilot for smart thermostats might include:

- What are the challenges of an integrated EE and DR offering (e.g., added staff demands, reduced program flexibility)?
- Could an integrated EE and DR offering enable Focus's smaller utility partners to offer their customers DR?
- Does the additional incentive change the participant demographics for smart thermostats?

As a next step, Focus should consider whether an integrated EE and DR smart thermostat offering aligns with Focus's near-term strategy and consider whether starting conversations with Madison Gas and Electric and Xcel Energy would be worthwhile. If a deeper understanding of program design considerations, such as cost-effectiveness, or lessons learned from an in-flight EE and DR smart thermostat offering would enhance these conversations, Focus could consider first connecting with program managers at Georgia Power or Energy Trust of Oregon.

4. HEAT PUMP WATER HEATERS

4.1 SUMMARY

Heat pump water heaters (HPWH) represent an important case study for Focus, because they:

- Save coincident demand and energy over electric resistance water heaters

- Provide a potential opportunity for Focus to coordinate with utilities and deliver an integrated EE and DR offering (although a less mature opportunity than for smart thermostats)
- Potentially mitigate grid impacts for an electrifying end-use

However, there are barriers for each of these value propositions. Focus's current program offers HPWH incentives but is experiencing low participation. Historically, part of the low participation was due to the relatively low proportion of electric versus gas water heaters in Wisconsin. However, even with recent changes to enable some degree of fuel switching, participation is still low. Similarly, Focus's ability to support HPWH as an integrated EE and DR measure is limited by the lack of active HPWH DR programs in Wisconsin. Finally, while Focus has recently expanded their offering to include HPWHs for customers switching from natural gas fired water heaters, there is not yet a dedicated beneficial electrification (BE) initiative in Wisconsin, which might enable Focus to better support HPWH as an electrification measure rather than simply an EE measure.

In this case study, ILLUME highlights findings related to incentives, marketing efforts, and current utility initiatives designed to facilitate HPWH as an integrated EE and DR measure. We also include findings from current utility initiatives that support HPWH directly as a fuel switching or BE measure.

4.2 MEASURE CHARACTERIZATION

ILLUME summarizes our measure characterization research for heat pump water heaters in Table 4. Our research indicates that heat pump water heaters provide relatively high electric energy savings and coincident demand savings but provide moderate DR savings.

TABLE 4. HEAT PUMP WATER HEATER MEASURE CHARACTERIZATION

CATEGORY	MEASURE DETAILS
Measure Summary	
Description	In addition to using electricity, HPWHs pull heat from the surrounding air, making them more efficient than traditional electric resistance heating.
Segment	Residential (SF)
End Use	Domestic hot water
Load Shaping Value Proposition	Traditional EE measure with potential demand savings Potential for integrated EE/DR partnership with utilities Opportunity to pilot load management for electrifying end-uses
Relevance for Load Shaping	*Recurring:* Established recurring energy and demand savings
	Event-based: Potential savings with connected HPWH[1] but the greater EE of HPWH means they provide less benefit to peak demand mitigation and energy shifting.[2]
Measure Performance	
Focus Program Data Energy Savings per Unit[3] (kWh/yr)	Median: 1,660 Range: 1,660 – 1,660
Focus Program Data Demand Reduction (kW)	Median: 0.079 Range: 0.079 – 0.079
Average Load Shifting Savings[4]	Typically, 0.1-0.3 kW per unit per event, but vary by implementation strategy (e.g., pre-heating and time of day)

1. PNNL paper: https://www.iepec.org/wp-content/uploads/2019/08/4A-Not-Your-Fathers-Water-Heater-Demand-Response-Program-%E2%80%93-Cheryn-Metzger_Pacific-Northwest-National-Laboratory.pdf

2. BPA report: https://www.bpa.gov/EE/Technology/demand-response/Documents/Demand%20Response%20-%20FINAL%20REPORT%20110918.pdf
3. Focus on Energy TRM: https://www.focusonenergy.com/sites/default/files/Focus_on_Energy_2020_TRM.pdf
4. BPA report: https://www.bpa.gov/EE/Technology/demand-response/Documents/20181118_CTA-2045_Final_Report.pdf

4.3 MARKET CHARACTERIZATION

ILLUME summarizes our market characterization research for HPWH in the subsections below.

DELIVERY CHANNELS

EE programs typically offer incentives for HPWH through trade allies (e.g., plumbers and HVAC contractors) or direct-to-customer rebates for do-it-yourself (DIY) installation. Because the installation of residential HPWH is more complex than other DIY EE measures (such as LEDs or thermostats), the dominant delivery channel is through trade allies.

MARKET ACTORS

The key actors in the HPWH market include:

- Trade allies: Plumbers, Electricians, and HVAC Contractors
- Retail stores and their online marketplaces (e.g., Home Depot and Lowe's)
- E-marketplace vendors (e.g., Focus's online marketplace[25])
- Distributors (for mid-stream programs)

For an integrated EE and DR approach for HPWH, Focus and utility partners should anticipate working with the following additional market actors.

- Manufacturers of DR-enabled water heaters and/or after-market water heater DR controllers
- DR system service providers (e.g., Autogrid, Shifted Energy)

ADOPTION AND SATURATION

Nationally, HPWHs make up just 1% of all electric water heaters sold in the residential sector.[26] Adoption rates for HPWH in Wisconsin are also low. In the 2019 Focus evaluation report, builders noted that adoption of HPWHs is not widespread.[27] In fact, Focus has only had 44 participants for this measure from 2017 through 2019.

[25] Focus on Energy. Online Marketplace, 2020, https://www.focusonenergy.com/residential/marketplace

[26] Josh Butzbaugh, Linda Sandahl, Michael Baechler. "US HPWH Market Transformation: Where We've Been and Where to Go Next," Pacific Northwest National Laboratory, 2017, https://rpsc.energy.gov/tech-solutions/sites/default/files/resources/attachments/ECEEE_EEDAL_Paper-159_US-HPWH-Mkt-Transformation_7-21-2017%5B1%5D.pdf

[27] Public Service Commission of Wisconsin. "Focus on Energy Calendar Year 2019 Evaluation Report," June 2, 2020, https://focusonenergy.com/sites/default/files/Annual_Report-CY_2019_Volume_II_0.pdf

MARKET BARRIERS

The key barriers to the adoption of residential HPWHs include the following:

Cost. The purchase and installation of a HPWH is 2-3 times more expensive relative to a conventional water heater. If upgrades to the service panel are required, due to capacity, lack of space for new breakers and/or code compliance, this can contribute significantly to installation costs.

Customer awareness. Customers generally lack awareness of HPWHs as a purchase option, their value proposition and what to do to facilitate a HPWH installation.

Predominance of natural gas fired residential water heaters. Electric water heaters are less common than natural gas water heaters in Wisconsin, and customers often replace equipment as like-for-like. However, the market potential for HPWH increases significantly when pursuing HPWH as a BE measure for replacing natural gas water heaters.

Availability. Because most residential water heater upgrade decisions are made as a result of the failure of the existing water heater, the lack of HPWHs being 'on the truck' or readily availability via trade allies can create a barrier to adoption.

Installer expertise. Trade allies still lack sufficient training and engagement with HPWHs. This includes understanding HPWH sizing to meet household hot water needs, climate suitability and understanding the use cases and value proposition necessary to promote HPWHs to consumers. Some installers also remain unconvinced of the efficient performance of HPWHs and point to parasitic losses to heating systems and reduced performance in colder climates as arguments against promoting these devices.

Installation constraints. In some homes, the location of the current water heater does not include space sufficient to accommodate a HPWH. In addition to size, some homes do not have the ability to accommodate the ventilation, ducting, and/or condensate drainage requirements of HPWHs.

Customer experience. Some customers have expressed dissatisfaction with hot water delivery when these appliances are in in heat pump mode. Customers have also articulated displeasure with the compressor noise level and cool air exhaust HPWHs produce while in operation.

4.4 PROGRAM DESIGN CONSIDERATIONS

ILLUME summarizes program design considerations for HPWH in the subsections below. Our HPWH research centers on the dynamics of integrated EE and DR, BE, and potential opportunities to increase adoption.

INCENTIVES AND MARKETING

In Table 4 and the program highlights below, we present incentive and marketing information for programs that offer HPWHs as an integrated EE and DR measure as well as for programs providing HPWH incentives as part of BE efforts. We also provide a summary of a market transformation initiative occurring in the Pacific Northwest.

THE CITY OF SAN JOSE OFFERS HPWH REBATES UP TO TEN TIMES THAT OF OTHER PROGRAMS TO MEET THEIR CLIMATE GOALS

The City of San Jose offers a program called Electrify San Jose, where the program pays for HPWH installations up to $4,500 for residents when the HPWH requires a panel upgrade. The goal of their program is to "…help homes switch from fossil-fuel based energy sources to electricity, helping reach our Climate Smart San José goals for zero net carbon (ZNC) building and citywide greenhouse gas reduction to improve public health, environment and economy."[28]

CALIFORNIA ESTABLISHES STATEWIDE PROGRAMS TO JUMPSTART THE MARKET FOR LOW-EMISSIONS SPACE AND WATER-HEATING TECHNOLOGIES

In September 2018, the California Legislature passed SB 1477 which funds efforts to promote "low-emissions buildings and sources of heat energy." SB 1477 established two new statewide programs: Technology and Equipment for Clean Heating (TECH) and Building Initiative for Low Emissions Development (BUILD). TECH aims to jumpstart the market for low-emissions space and water-heating technologies (including HPWHs) in the state via three main efforts (1) working directly with manufacturers, distributors, and vendors (2) consumer education, and (3) contractor training. Over the next four years, TECH will receive $120 million from natural gas utility carbon-allowance proceeds in the state's cap-and-trade program. Implementation is scheduled to begin in 2021. BUILD will be primarily focused on creating new all-electric housing for low-income families. [29]

BPA CONSIDERS MARKET TRANSFORMATION TO DR-READY WATER HEATERS

Bonneville and other northwest utilities have conducted research, developed a business case and a market transformation plan to increase adoption of DR-ready water heaters that use the CTA 2045 communication interface.[30] Part of the market transformation initiative could include a component making HPWHs that are not DR-ready ineligible for EE rebates or eligible for a reduced rebate.[31]

TABLE 5. INCENTIVE, MARKETING AND FUEL SWITCHING ELIGIBILITY FOR HPWH OFFERINGS

STATE/REGION	EE PROGRAM	DR PROGRAM	EE REBATES ELIGIBLE FOR FUEL SWITCHING
Program Administrators			
Wisconsin	Focus on Energy	-	

[28] City of San Jose. "Electrify San Jose Rebates," accessed November 30, 2020, https://www.sanjoseca.gov/your-government/departments-offices/environmental-services/climate-smart-san-jos/electrify-san-jos

[29] Steven Nadel, ACEEE. "Programs to Electrify Space Heating in Homes and Buildings," June 2020, https://www.aceee.org/sites/default/files/pdfs/programs_to_electrify_space_heating_brief_final_6-23-20.pdf

[30] Bonneville Power Administration (BPA). "TIP 336: Scaled Deployment and Demonstration of Demand Response using Water Heaters with CEA 2045 Technology," September, 2018, https://www.bpa.gov/EE/Technology/EE-emerging-technologies/Projects-Reports-Archives/Documents/TIP%20336%20Scaled%20Deployment%20and%20Demonstration%20of%20Demand%20Response%20using%20Water%20Heaters%20with%20CEA%202045%20Technology.pdf

[31] BPA. "Regional Study of CTA-2045 Enabled Water Heaters," accessed November 30, 2020, https://www.bpa.gov/EE/Technology/demand-response/Pages/CTA2045-DataShare.aspx

Northwest	Seattle City Light (w/ BPA)	BPA	
Minnesota	Minnesota Power	-	
Vermont	Efficiency Vermont	WEC	
Massachusetts	Mass Save	-	
California	PG&E		
California	Electrify San Jose	-	
California	SMUD	SMUD	
Incentives and Marketing			
Wisconsin[1]	$300	-	No
Northwest[2,3,4]	$500	Pilot study, with challenging recruitment	No
Minnesota[5]	$400	-	No
Vermont[6,7,8]	$300-$600 discount from your utility or Efficiency Vermont, plus of additional rebates for income-eligible Vermonters, up to $1k from Burlington Electric Department & $250 bill credit from Vermont Electric CO-OP	$5/month bill credit throughout pilot	Yes
Massachusetts[9]	Up to $600	-	Yes
California[10]	$300	-	No
California[11]	Full cost, up to $2,000 and up to $4,500 with Panel replacement. Additional rebates available for income-qualified customers.	-	Yes
California[12]	$150	$2 for each month of the pilot	Yes

1. Focus on Energy program information: https://focusonenergy.com/sites/default/files/Application_PDFs/2017%20HP%20Heating%20and%20Cooling%20Application_01.05.2017.pdf
2. Seattle City Light (BPA customer) program information: https://energysolutions.seattle.gov/your-home/water-heaters/
3. BPA DR study: https://www.bpa.gov/EE/Technology/demand-response/Documents/20181118_CTA-2045_Final_Report.pdf
4. Seattle City Light (BPA customer) eligibility: https://formstack.io/0595A
5. Minnesota Power program information: https://www.mnpower.com/ProgramsRebates/WaterHeaterRebateForm
6. Efficiency Vermont program information: https://www.efficiencyvermont.com/rebates/list/heat-pump-water-heaters
7. Burlington Electric program information: https://burlingtonelectric.com/waterheaters
8. WEC PowerShift pilot information: https://www.efficiencyvermont.com/powershift
9. Mass Save program information: https://www.masssave.com/saving/residential-rebates/electric-heat-pump-water-heaters
10. PG&E and program information: https://www.pge.com/pge_global/common/pdfs/save-energy-money/savings-solutions-and-rebates/rebates-by-product/ee_residential_rebate_catalog.pdf
11. Electrify San Jose: https://www.sanjoseca.gov/your-government/departments-offices/environmental-services/climate-smart-san-jos/electrify-san-jos
12. SMUD PowerMinder integrated program information: https://www.smud.org/powerminder?_ga=2.189171051.1782180992.1589836566-745043934.1580862712

ELIGIBILITY CONSIDERATIONS

Notable eligibility considerations for HPWH offerings include specified performance requirements (e.g., uniform energy factor) and the requirement of a self-install or program-eligible plumbing contractor. It is also notable that EE program eligibility could be a component of a market transformation initiative to DR-ready water heaters. Lastly, as noted in Table 5, programs vary in whether the EE rebates are available for customers with natural gas, propane, or oil water heaters.

BARRIERS TO IMPLEMENTATION

The largest barrier to the implementation of an integrated EE and DR HPWH offering results from the low customer demand for and adoption of these appliances. Many EE programs require that HPWHs replace electric resistance water heaters, reducing the potential market size. Recently, Focus has expanded their offering allowing customers to receive discounted HPWHs even where they are replacing gas-fired water heaters. This is important as most existing residential water heaters in Wisconsin use natural gas. That said, adoption rates remain low, and on the DR side, this could limit the ability to run a Bring Your Own Device (BYOD) type program for HPWHs in Wisconsin.

The market for HPWH DR is less mature than for smart thermostats, posing another barrier to the implementation of an EE and DR offering for these appliances. While vendors of HPWH DR controls and software are increasing in number, gaining experience, and improving their products, some products remain largely untested at scale. For example, recent pilots show that Wi-Fi connectivity can have a significant impact on the ability for DR-enabled units to receive and respond to DR events. In a 2019 pilot of 70 residential DR-enabled HPWHs, Wi-Fi connectivity issues diminished winter shed savings between 6-25%.[32] Notably, manufacturers are continuing to explore and offer devices that leverage a range of communication protocols, such as Bluetooth and cellular, as a way to improve connectivity and responsiveness to events.

Finally, there is no dedicated BE initiative in Wisconsin that could enable Focus to better support HPWH as an electrification measure rather than, or in addition to, an EE measure. Opening program eligibility to customers with natural gas, propane, or oil water heaters greatly increases the market potential in Wisconsin, but a BE initiative, at the state level for example, could potentially secure funding to offer elevated incentive levels, enhanced contractor training and targeted customer education. Such efforts would be likely to create a more substantial impact on adoption rates. Additionally, the lack of a BE policy may, in turn, create the absence of appropriate mechanisms for Focus to claim the benefits of BE.

Throughout the country, however, policies regarding EE and BE, and how utilities are allowed or not allowed to promote or get credit for BE are mostly lacking. California has led the way with new legislation that allowed utilities to use EE funds for BE. However, while the California Public Utilities Commission (CPUC) has had a policy to nominally allow fuel switching in the EE portfolio for several years, many details of this policy were unclear, specifically those that would have enabled EE program administrators to readily include fuel-switching measures in their programs. As a result, little fuel-switching activity took place. In

[32] ILLUME Advising. "Water Heater Demand Response Pilot: Final Evaluation Report" November 22, 2019.

August 2019, the CPUC issued a revised policy to attempt to resolve the lack of clarity, but the impact of these revisions remain to be seen.[33]

4.5 CONSIDERATIONS AND POTENTIAL NEXT STEPS

Our research indicates that HPWHs:

- Provide relatively high electric energy savings and coincident demand savings and moderate DR savings
- Potentially mitigate grid impacts for an electrifying end-use
- Have low customer adoption and low to moderate market potential in the absence of BE efforts
- When considered for a DR offering, may create risk due to technological immaturity
- An integrated residential HPWH offering could increase customer and contractor awareness of these appliances, as well as reduce upfront costs, all current barriers to adoption

As a next step, Focus should consider HPWH as a good test case for BE in Wisconsin, whether at the state level or for engaging with interested cities or utility partners. While the creation of a BE initiative in the state could enable Focus to justify higher incentives for HPWH and increased contractor training and customer education, as well as create a mechanism through which Focus could claim the benefits of BE, there is not yet sufficient data to identify the optimal playbook for successful BE policy. Instead, having specific measures in mind (such as residential HPWHs) can inform conversations in Wisconsin about BE. Furthermore, Focus could conduct research on current HPWH participants who are fuel switching, should Focus and other stakeholders want to test a BE offering before developing generalized policies or protocols. Similarly, HPWH represent a potential BE offering should Focus develop a system to enable interested cities or utility partners in Wisconsin to leverage Focus's infrastructure and market knowledge to launch a BE initiative.

With regards to HPWH as an integrated EE and DR offering, Focus should consider whether an integrated EE and DR HPWH offering aligns with Focus's long-term strategy. If so, Focus should consider limiting eligibility for the EE rebates to models that meet DR needs and should monitor the progress, successes, and failures for any smart thermostat integrated EE and DR offering. This strategy should create: (1) greater penetration of DR-ready HPWH; (2) time for Focus and their stakeholders to develop better procedures around integrated EE and DR in Wisconsin; (3) time for HPWH DR technologies and vendors to continue improving; and (4) time for any potential BE initiatives to take shape, which could empower Focus to better support HPWH.

Specific research questions for piloting HPWH as a BE offering might include the following, in reference to switching from a natural gas water heater to a HPWH:

- What are the customer economics?
- How is the customer experience different?
- How is the installation process and experience different?
- What are the non-energy benefits, if any?
- What are the emissions impacts?

[33] Pierre Delforge and Merrian Borgeson. "2019 Set the Stage for Cleaner and Healthier Buildings" January 5, 2020.

Specific research questions for piloting HPWH as an integrated EE and DR offering might include:

- What are the DR savings?
- How do the DR savings change over the seasons and throughout the day?
- What is the customer experience with DR events, and how frequently and long could they be run?
- Does the combination of EE and DR incentives impact participation rates?

5. SEM FOR WATER AND WASTEWATER TREATMENT

5.1 SUMMARY

Strategic energy management (SEM) for water and wastewater treatment plants represents an important case study for Focus as an example of a potential integrated EE and DR offering outside of the residential sector. Unlike other integrated EE and DR opportunities, SEM programs could achieve greater coincident demand savings on a *recurring* basis by including demand saving behavioral adjustments as well as energy savings adjustments in trainings, program recommendations, incentives, and evaluations. As with DR, Focus may have to coordinate with utility partners or other entities interested in demand savings in order to incorporate demand saving adjustments into their SEM program offering.

Two of the greatest implementation challenges for these types of offerings include overcoming barriers to participation and empowering Focus to emphasize demand savings as well as energy savings in their SEM offering. In this case study, ILLUME explores these barriers to help Focus better understand the interventions required to make an integrated EE and DR offering via SEM in wastewater treatment plants viable. Notably, many of our findings are relevant to SEM projects in other industrial facilities.

5.2 MEASURE CHARACTERIZATION

ILLUME summarizes our measure characterization research for SEM for water and wastewater treatment plants in Table 6. Our research indicates that this intervention provides moderate energy savings and moderate to high DR event-based savings.

TABLE 6. SEM FOR WATER AND WASTEWATER TREATMENT PLANT MEASURE CHARACTERIZATION

CATEGORY	MEASURE DETAILS
Measure Summary	
Description	SEM can be defined as taking a holistic approach to managing energy use in order to continuously improve energy performance, by achieving persistent energy and cost savings over the long term.[1] Water and wastewater treatment plants represent facilities with both energy efficiency and load shifting opportunities, which are complex, and as a result, well suited for SEM.[2]
Segment	Industrial
End Use	Controls

Load Shaping Value Proposition	Traditional EE measure with potential demand savings Potential for integrated EE/DR partnership with utilities
Relevance for Load Shaping	*Recurring:* Established recurring energy savings
	Event-based: Opportunity for event-based savings with integrated EE and DR
Measure Performance	
Focus Program Data[3] Energy Savings per Unit (kWh/yr)	Estimates of about 1-5% annual savings
Focus Program Data Demand Reduction (kW)	Estimates not currently available
Average Load Shifting Savings	Varies substantially by application, but 4-20% of demand or demand charges for case studies with capital investments (e.g., controllable VFD or solar powered mixers) and up to 30% for emergency shut-down DR scenarios[2]

1. CEE paper on elements of SEM programs: https://library.cee1.org/system/files/library/11283/SEM_Minimum_Elements.pdf
2. LBL paper on SEM potential for wastewater treatment: https://industrialapplications.lbl.gov/sites/default/files/lbnl-2572e.pdf
3. Program team estimates of savings for active projects in 2020

5.3 MARKET CHARACTERIZATION

ILLUME summarizes our market characterization research for SEM for water and wastewater treatment plants in the subsections below. Because SEM offerings extend beyond energy efficient equipment to include staff behavioral changes and optimized operations and maintenance (O&M) procedures, this section is structured slightly different than the other three case studies included in this report.

DELIVERY CHANNELS

SEM offerings are delivered through SEM program implementers. SEM programs commonly include three program components: (1) customer commitment, (2) planning and implementation, and (3) energy use measurement. SEM program implementers work directly with participants and also rely on peer-to-peer exchange (or a cohort approach) throughout the SEM engagement period. SEM programs can also include trainings and/or co-funding on-site staff who are responsible for identifying savings opportunities.[34]

MARKET ACTORS

Key actors in the energy management of water and wastewater treatment plants include plant facility managers and staff, water solution providers (the private firms sometimes affiliated with the management of these facilities), and the engineering community the plant uses for capital improvement projects.

[34] Northeast Energy Efficiency Partnerships (NEEP). "Opportunities for Strategic Energy Management in the Municipal Water Sector," March 2018, https://neep.org/sites/default/files/resources/Opps%20for%20SEM%20in%20Muni%20Water%20Sector.pdf

PARTICIPATION

SEM participation among water and wastewater treatment facilities in Wisconsin is low. The Focus SEM program is currently working with three wastewater treatment facilities, while resources indicate that Wisconsin has nearly 90 major municipal wastewater treatment plants.[35]

BARRIERS TO PARTICIPATION

The greatest barriers for water and wastewater participation in SEM offerings generally include limited available capital, limited staff availability, and a strong emphasis on regulatory compliance and water quality.

Municipalities and other water utilities are known to have constrained budgets and potential capital needs for upgrades related to water quality or regulatory compliance. As such, investing in EE upgrades is often a low priority. Similarly, our communication with Focus program staff identified that funding is limited at participating wastewater facilities in Wisconsin, which essentially eliminates capital measures and drives the program to focus on low or no cost improvements (e.g., pumping sequence, blower setpoints, and compressed air optimization).

Rightfully so, water and wastewater treatment facilities strongly emphasize regulatory compliance as a top priority. Accordingly, staff and decision makers are very risk averse, wary of behavior or equipment changes that could negatively affect water quality and pay little attention to anything unrelated to water quality. Similarly, this mindset often leads to oversized equipment to account for future population growth and running equipment even when it is not needed.[36]

5.4 PROGRAM DESIGN CONSIDERATIONS

ILLUME summarizes program design considerations for SEM in water and wastewater treatment plants in the subsections below.

INCENTIVES AND MARKETING

In Table 7, we present incentive and marketing information for programs that offer SEM in water and wastewater treatment plants. While we uncovered research describing the opportunity for both EE and DR at water and wastewater facilities, we did not find any strong SEM program designs that enabled integrated EE and DR operations at these facilities.

TABLE 7. INCENTIVE AND MARKETING FOR SEM IN W&WW TREATMENT PLANT OFFERINGS

STATE/REGION	EE PROGRAM

[35] Steven Verburg. “Wisconsin case shows how sewage plants spread unregulated toxins across landscape,” January 27, 2019, https://madison.com/wsj/news/local/govt-and-politics/wisconsin-case-shows-how-sewage-plants-spread-unregulated-toxins-across-landscape/article_e9e50bb6-85b8-5377-95ab-736541129386.html#:~:text=Wisconsin%20has%20about%2090%20major,municipal%20and%20industrial%20treatment%20plants

[36] NEEP. “Opportunities for Strategic Energy Management in the Municipal Water Sector,” March 2018, https://neep.org/sites/default/files/resources/Opps%20for%20SEM%20in%20Muni%20Water%20Sector.pdf

Program Administrators	
Wisconsin	Focus on Energy
Massachusetts	Mass Save
Oregon	Energy trust of Oregon
Incentives and Marketing	
Wisconsin[1]	$0.02/kWh
Illinois[2]	$0.01/kWh for wastewater treatment, but $0.02/kWh for certain cohorts
Oregon[3]	Energy savings—Energy Trust offers cash incentives for electric savings in Portland General Electric and Pacific Power territories ($0.02/annual kilowatt hour saved) and natural gas savings ($0.20/annual therm saved) in NW Natural, Cascade Natural Gas and Avista territories through SEM improvements. Milestones—A $1,000 incentive for each SEM milestones that you reach. Interns—Energy Trust offers up to $10,000 to help cover the cost of hiring an intern who works on SEM-related activities for a minimum of 80 hours during the 12 – 15-month SEM enrollment period.

1. Focus on Energy program communication
2. ComEd program: https://ilsag.s3.amazonaws.com/ComEd-SEM-CY2019-Impact-Evaluation-Report-2020-04-29-Final.pdf
3. Energy Trust of Oregon: https://energytrust.org/commercial/strategic-energy-management/

ELIGIBILITY CONSIDERATIONS

As SEM program savings are typically tied to or corroborated with measured performance, the primary eligibility requirement is customer size and interest. However, SEM programs can cost effectively reach smaller customers using a cohort model.

BARRIERS TO IMPLEMENTATION

The largest barrier to implementing integrated EE and DR SEM in wastewater treatment plants is the lack of alignment in motivation and goals that would allow Focus to encourage DR and participating facilities to identify load reduction goals as a part of the SEM program. This issue is not unique to Focus but was confirmed by program staff. Focus program staff indicated that some facilities are interested in reducing demand and their demand charges, but with Focus's incentives tied to energy savings, the Focus teams target energy savings. On the demand side, program staff indicated that there currently is no entity within the SEM process that is responsible for coordinating or funding efforts to reduce demand.

While our research did not identify program designs that exemplify solutions to overcome this barrier, we did find resources documenting some potential solutions. For example, the Association of Energy Professionals (AESP) indicates that incorporating demand savings into SEM programs includes many of the same market actors as for EE savings. The processes to achieve demand savings could mirror the same SEM processes for EE savings, there are a variety of demand saving opportunities to consider, and incorporating demand savings could help increase participation and the cost-effectiveness for participants to engage with SEM programs. Similar to EE savings, programs could develop demand or DR assessments with SEM facilitators, utility employees, and engineering firms. These assessments could include pricing options, scheduling changes, and equipment curtailment processes and levels. SEM programs could also build in an initial phase for participants to define strategic objectives, including potential demand and DR objectives.

Whether through different utility rates or specific DR programs, the SEM process could help participants realize demand saving benefits in addition to energy savings.[37]

5.5 CONSIDERATIONS AND NEXT STEPS

Our research indicates that:

- Participation is low in the existing Focus SEM offering for water and wastewater facilities
- Water and wastewater treatment facilities represent moderate energy savings, and moderate to high demand savings potential
- Participant water and wastewater facilities in Wisconsin have limited capital, which reduces the options for energy savings
- Regulatory compliance and water quality are a top priority for water and wastewater facilities, and as a result, these facilities tend to be risk averse and apprehensive about operational or equipment changes that could negatively affect water quality
- Focus's program does not prioritize demand savings, as Focus's SEM incentives are tied to energy savings
- There is currently no single point of contact to facilitate additional funding for demand savings within Focus's SEM operations

While our research indicates that there is a potential opportunity for SEM at water and wastewater treatment plants to provide an integrated EE and DR offering, we suggest Focus consider more ready opportunities to pilot integrated EE and DR for other measures (e.g., smart thermostats). As a parallel effort, Focus might consider beginning to engage utility partners to better understand their appetite for aligning on goals and expanding the SEM offering to include DR and demand specific savings. This might be particularly relevant for municipal utilities that handle both electricity and water supply.

Given the limited availability of funding for EE and DR upgrades at wastewater treatment plants, another potential path for Focus might include finding a willing utility partner who is interested in large scale demand reduction (e.g., for non-wires alternatives, or NWA). While we did not uncover an example of this program design, Focus could conceivably pair their relationships with these facilities and their SEM incentives with a utility administered competitive bidding process for demand reduction. Earlier research identified electric utilities using dynamic resource auctions as a part of NWA projects. For this use case, the utility could seek competitive bids from energy service companies and industrial SEM firms to pursue demand savings opportunities at these facilities while leveraging Focus incentives (e.g., for VFD or with SEM incentives of $0.02/kW). If Focus was interested in the potential of this design, however, ILLUME suggests additional research, such as interviews with utilities, energy service companies, and industrial engineering firms in Wisconsin to better understand their reactions to and feedback for this idea.

[37] Julie Blackwell. "Integrating Demand Response into Strategic Energy Management" March 2017. https://www.aesp.org/page/IntegratingDRArtic

6. RESIDENTIAL CUSTOMER SITED BATTERY STORAGE

6.1 SUMMARY

Residential customer sited battery storage represents an important case study for Focus to better understand the technology and related multi-utility program designs. Through this research, Focus would be better prepared should Wisconsin policy makers empower Focus to support customer sited battery storage. It is important to note that Focus is limited in its current ability to support incentives for battery storage, as batteries do not provide annual energy savings. In this case study, ILLUME highlights findings to help demonstrate what a statewide offering may look like in practice.

6.2 MEASURE CHARACTERIZATION

ILLUME summarizes our measure characterization research for residential customer sited battery storage in Table 8 Our research indicates that customer sited battery storage does not create energy savings but do offer the potential to shift loads on a recurring and event basis.

TABLE 8. RESIDENTIAL CUSTOMER SITED BATTERY STORAGE MEASURE CHARACTERIZATION

CATEGORY	MEASURE DETAILS
Measure Summary	
Description	Demand side management programs are beginning to leverage customer sited battery storage to provide grid services, such as load shifting.
Segment	Residential
End Use	Storage
Load Shaping Value Proposition	Potential future offering warranting further research and monitoring
Relevance for Load Shaping	*Recurring:* While not saving energy, batteries can shift load on a recurring basis (e.g., daily)
	Event-based: Strong opportunity for event-based savings
Measure Performance	
Focus Program Data Energy Savings per Unit (kWh/yr)	-
Focus Program Data Demand Reduction (kW)	-
Average Load Shifting Savings	2-hour events saved an average of 5.5 kW/unit[1]

1. National Grid and Until residential storage evaluation: https://ma-eeac.org/wp-content/uploads/MA19DR02-E-Storage_Res-Storage-Summer-Eval_wInfographic_2020-02-10-final.pdf

6.3 MARKET CHARACTERIZATION

ILLUME summarizes our market characterization research for residential customer sited battery storage in the subsections below.

DELIVERY CHANNELS

Initially, residential customers purchased battery storage directly from energy storage and solar back up equipment suppliers. In recent years, solar installers, including some of the nation's largest (Tesla, Sunrun and SunPower) are providing battery storage for sale or lease to residential customers.[38] Online marketplaces, like EnergySage, are increasingly becoming a channel that links residential customers to solar and storage installation contractors and providers.

Some utilities and electric co-ops have also begun to offer community storage to residential customers. Similar to community solar projects, community storage offerings allow customers to buy or lease a portion of the total storage provided.[39] Finally, some utilities have begun to move toward a vertically integrated business model with solar and storage companies as a way to drive costs down.

MARKET ACTORS

Focus and utility partners should anticipate working with the following market actors should they pursue offering a residential customer sited battery storage measure.

- Solar installation contractors and/or battery storage manufacturers (e.g., Generac PWRCell, SolarEdge, Sonnen, Sunverge, and Tesla)
- Lending partners
- Trade allies including enrollment service providers and performance data providers

ADOPTION AND SATURATION

The adoption of residential customer sited battery storage is low but growing. Between 2013 and 2016, total U.S. residential energy storage deployments remained under ten MW annually. Starting in 2017, however, growth nearly doubled quarterly, beating commercial and almost outpacing utility-scale storage deployments.[40] Current estimates indicate that residential storage will reach between 1000 to 2000 MW of deployment in the U.S. annually from 2023 to 2025.[41]

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[38] Paul Dailey. "Three signs that battery storage is mainstream today" May 20,2020. PV Magazine. https://pv-magazine-usa.com/2020/05/20/three-signs-that-battery-energy-storage-is-mainstream-today/

[39] Joseph Petta and Erica McConnell. "Community energy storage: What is it: where is it: how does it work?" Mary 7, 2018. Utility Dive. https://www.utilitydive.com/news/community-energy-storage-what-is-it-where-is-it-how-does-it-work/518540/

[40] Julian Specto. "Residential Batteries Almost Beat Out Utility-Scale Deployments Last Quarter," Green Tech Media, June 6, 2018, https://www.greentechmedia.com/articles/read/residential-batteries-almost-beat-utility-scale-deployments-last-quarter

[41] Wood Mackenzie. "U.S. Energy storage monitor: Q3 2020" September 2020.

At the state and local level, adoption rates vary depending on the influence of natural disasters, regulatory push (or pull), utility interests, local energy costs, and local state incentives. Industry experts suggest that the increasing opportunity to integrate residential storage with residential solar and electric vehicle offerings, the emergence of community storage programs, and the increase in desire for resiliency (resulting from increased fires and outages) will likely increase the demand for and adoption of customer sited battery storage.[42] The conditions created by COVID-19 may further increase energy resiliency as a motivation for the adoption of battery storage, given the increased amount of time customers are in their homes.

Finally, net metering and evolving rate designs are increasingly making the business case for residential energy storage strong. This is particularly true where customers experience time-of-use rates or tariffs, critical peak pricing programs or residential demand charges, allowing customer to use battery storage to offset or reduce energy consumption and thereby costs.[43]

MARKET BARRIERS

The primary market barriers for the adoption of solar plus storage systems include cost, awareness and misconceptions of technological capabilities, and permitting and regulation.

Cost. Customer research indicates that cost is one of the largest barriers to the adoption of battery storage. In addition to the inability to pay the up-front installation costs, customers report concern that their return-on-investment (ROI) may not be realized through electricity bill savings.[44] There are also a number of "soft costs", ranging from permitting to connection fees, that increase the up-front investment for residential customers. While equipment prices have fallen steadily over the last several years, these soft costs have largely remained stagnant.[45]

Awareness and misconceptions of technological capabilities. Our research with residential customers indicates that customers generally do not understand what battery storage can power in their homes and for how long.[46] Interviewees attributed some of these misconceptions to the lack of a reliable information center that educates the general public about the performance of battery storage. Without a trusted source for information, potential customers are left searching through sources that often contain industry jargon and can be alienating to the laymen interested in exploring these options.[47]

Permitting and regulation. While residential battery development has increased, there is still a lack of uniformity in national interconnection and permitting requirements. In their 2018 report, the National Renewable Energy Laboratory found that:

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[42] ILLUME Advising, "Solar + Storage Literature Review" January 2019.

[43] Owen Zinaman, Thomas Bowen, and Alexandra Aznar. "An Overview of Behind-The-Meter Solar-Plus-Storage Regulatory Design. March 2020.

[44] DNV GL. "Here Comes the Sun, Maybe?", 2018.

[45] Jeni Hall, "Benchmarking Solar Soft Costs 2014 Survey Analysis," Energy Trust, October 23, 2015,https://www.energytrust.org/wp-content/uploads/2015/10/Benchmarking_Solar_Soft_Costs_2014.pdf.

[46] ILLUME Advising. "Solar + Storage Customer Research: Overall Research Findings" July 2019.

[47] ILLUME Advising, "Solar + Storage Literature Review" January 2019.

"Persistent challenges with local permitting of PV-plus-storage systems, because timelines and costs differ across AHJs and often reflect a lack of local familiarity with such systems. Several industry stakeholders reported the need to educate permitting officials about storage technology during the permitting process. The pervasive unfamiliarity with storage introduces additional regulatory uncertainty and poses a barrier to widespread PV-plus-storage growth. Many industry experts have pointed to the market for solar plus storage systems in the United States and compared it to the standalone PV market 10 or 15 years ago. Some of the permitting and regulatory challenges are similar."[48]

6.4 PROGRAM DESIGN CONSIDERATIONS

ILLUME summarizes program design considerations for residential customer sited battery storage in the subsections below. Our customer sited battery storage research centers on statewide offerings. As such, we summarize our findings across three states, Massachusetts, Oregon and Vermont.

INCENTIVES AND MARKETING

In Table 9 and the program highlights below, we present incentive, design, eligibility and marketing information for programs that support customer sited battery storage. This research indicates that both utility and statewide programs are providing different degrees of support for battery storage, whether directly administering a program, providing incentives for standalone storage devices, supporting battery storage indirectly using solar rebates, or with marketing.

MASS SAVE DIRECTLY ADMINISTERS BATTERY STORAGE REBATES FOR MULTIPLE UTILITIES

Mass Save offers incentives to residential and small business customers across Massachusetts for the installation of a battery storage system with a new solar panel system, the addition of a battery storage system to an existing solar panel system, or the installation of a stand-alone battery storage system. In exchange, the program is allowed to draw energy from the battery during peak periods of up to 60 times per summer and five times per winter, with each event lasting a maximum of three hours. The incentive amount is set at $225 per kilowatt (kW) for a participant's average contribution during summer events and $50 per kW during winter events. For a typical battery capable of a 5-kW continuous contribution during these events, the program would pay $1,375 per year of participation. Customers are also eligible to apply for a 0% loan to cover the cost of the battery system.

In addition to being a National Grid or Eversource customer and paying into the energy efficiency fund, the only program requirement is to have a battery storage system controlled by an approved inverter manufacturer, some of which are specified for specific participating utilities to ensure compatibility.[49] The battery integrators are responsible for communicating the need for a demand response event and sending the customer's battery storage systems discharge rate and state-of-charge to the customers' program administrator.

To allow customers the ability to use their battery storage for resiliency, if the weather forecast calls for an extreme weather event, the program will not call a winter event, allowing participants to keep charged

[48] NREL. "Q&A with Kristen Ardani: From Research to Rooftops," August 31, 2018. Accessed January 10, 2019, https://www.nrel.gov/news/program/2018/q-and-a-kristen-ardani.html

[49] Mass Save is funded, in part, via the energy efficiency fund. This fund is supported via a charge on customers' energy bills.

batteries in preparation for a possible outage event. Finally, participants may also co-participate in and receive net metering credits.

GREEN MOUNTAIN ENERGY OFFERS A BYOD BATTERY PROGRAM

In partnership with Renewable Energy Vermont, Green Mountain Power (GMP) provides up to $10,500 toward a qualifying home battery purchase for residential and small business customers. Participants receive $850 per kW enrolled for three-hour discharge, $950 for four-hour discharge, and batteries in areas of the state where extra storage is needed most can get an extra payment of $100 per kW enrolled. Events can happen five to eight times per month and last three to six hours. GPM alerts participating customers via smartphone app or other electronic method at least four hours in advance. Similar to the Mass Save program, if a weather event is expected to bring outages to the area, GPM takes steps to help participants still have access to their stored energy.

In addition to a qualifying battery system, participants need to maintain Wi-Fi connection and cannot use the battery system for any controls other than providing backup power for the home. GMP provides a specifies inverter and charges a monthly communicating fee of $6.67

GREEN MOUNTAIN ENERGY (GMP) ALLOWS CUSTOMERS TO LEASE BATTERY STORAGE

GMP also offers a Tesla Powerwall pilot program wherein participants can lease up to two Tesla Powerwall systems for their home. Similar to their BYOD program described above, GMP can draw energy from these leased batteries during peak events.

ENERGY TRUST OF OREGON SUPPORTS STORAGE WHEN INSTALLED WITH SOLAR BY MAXIMIZING SOLAR INCENTIVES

Energy Trust of Oregon (Energy Trust) indirectly supports battery storage when installed with solar by linking customers to multiple avenues of solar rebates. For example, their webpage for solar plus battery storage links customers to state, federal, and Energy Trust program rebates for solar installations, which could be enough to increase access to storage for Energy Trust customers.

TABLE 9. INCENTIVE AND MARKETING FOR RESIDENTIAL CUSTOMER SITED BATTERY STORAGE OFFERINGS

STATE/REGION	EE PROGRAM	MULTI-UTILITY
Program Administrators		
Massachusetts	Mass Save	
Oregon	Energy trust of Oregon	
Vermont	Efficiency Vermont	
Vermont	Green Mountain Power BYOD	
Vermont	Green Mountain Power Powerwall II	
Incentives and Marketing		
Massachusetts [1]	$225 per kilowatt (kW) for your battery's average contribution during summer events and $50 per kW for your battery's average contribution during winter events, or a typical value of $1,375 per year of participation.	Yes
Oregon[2]	Energy Trust provides rebates for solar, and thus can support solar plus storage installations. More specifically, they point customers to solar rebates from the state, Energy Trust, and fed tax credits, which can offset as much as 50% of the solar installation costs.	Yes

	Energy Trust also provides a link to a quote/bid tool for solar plus storage installations.	
Vermont[3]	Efficiency Vermont points customers to utilities' battery programs through their website.	Yes
Vermont[4]	GMP incentive is $850 per kW enrolled for three-hour discharge, $950 for four-hour discharge. Batteries in areas of the state where extra storage is needed most can get an extra payment of $100 per kW enrolled. For residential and small business customers. EV chargers: GMP will give you a monthly credit of $10.	No
Vermont[5]	GMP offers two different leasing payment options: monthly payments of $55 for ten years, or an upfront payment of $5,500. Either way, because this is a lease, GMP owns and maintains the battery throughout the lease agreement	No

1. Mass Save program: https://www.masssave.com/saving/residential-rebates/connectedsolutions-batteries
2. Energy Trust of Oregon: https://www.energytrust.org/solar-storage/
3. Efficiency VT: https://www.efficiencyvermont.com/blog/our-insights/why-does-it-matter-what-time-of-day-you-use-power
4. Green Mountain Power BYOD: https://greenmountainpower.com/rebates-programs/home-energy-storage/bring-your-own-device/
5. Green Mountain Power Tesla Powerwall I (full for 2020): https://www.energysage.com/local-data/storage-rebates-incentives/vt/#:~:text=Backup%20mode%20incentive%3A%20if%20you,this%20means%20up%20to%20%243%2C825

ELIGIBILITY CONSIDERATIONS

Common program eligibility considerations for residential customer sited battery storage offerings include qualifying battery storage systems and qualified inverters, approved interconnection applications (with the participating utility or co-op) and the use of program participating trade allies.

BARRIERS TO IMPLEMENTATION

The fact that battery storage does not produce energy savings can be a barrier to their inclusion in EE programs.

Where utilities and other organizations are able to promote and provide funding for battery storage, the primary barrier to implementation involves overcoming the customer barriers of technological awareness and misconceptions. Utilities should undertake advanced planning around education, messaging and marketing to avoid potential customer satisfaction issues.

6.5 CONSIDERATIONS AND NEXT STEPS

Our research indicates that:

- Current adoption of residential customer sited battery storage is low, but it is a rapidly growing market
- Based on earlier research presented in Appendix B, utility-side battery storage may be considered for NWA initiatives

- While battery storage does not yield energy savings, several states use statewide EE agencies to administer, support and/or provide marketing for utilities' customer sited battery storage programs
- Cost, interconnection rules, and customer awareness are barriers to adoption

Our research indicates that there is a potential opportunity for Wisconsinites to benefit from a residential battery storage offering. While we suggest Focus consider more ready opportunities to pilot load shaping (e.g., an EE and DR smart thermostat offering), ILLUME recommends that Focus, their utility partners, and other stakeholders consider various potential roles for Focus with regards to battery storage using the examples identified in this research. For example, if utility partners create battery storage offerings, Focus could channel customers toward these utility-administered battery storage programs. Similarly, as noted in Appendix B, Focus can make utility partners aware of battery storage as a potential component for any NWA initiatives.

7. FINDINGS

ILLUME identifies the following key findings culminating from this research effort in total. For the four case studies, we present considerations and potential next steps for Focus as the final section of each of the case studies presented in this report.

- **Focus has been and continues to provide incentives for EE measures that save energy at typical peak summer times in Wisconsin.** For example, this research indicates that energy recovery ventilators, variable frequency drives, compressed air nozzles, certain efficient kitchen equipment, and other readily available measures in Focus's portfolio save coincident summer demand.
- **In other states, such as Massachusetts, Oregon and Vermont, regulators and utilities are using EE programs to support initiatives beyond EE (e.g., residential customer sited battery storage and beneficial electrification).** EE programs are well suited to administer these directives because EE programs and program staff have the infrastructure and market knowledge to prioritize technologies, affect adoption rates, and monitor their progress.
- **Smart thermostats currently represent the most immediate and least risky opportunity to administer an integrated EE and DR measure.** There are examples of programs currently supporting smart thermostats as an integrated EE and DR measure, and Xcel Energy's DR program in Wisconsin already channels their customers to combine DR rebates with Focus's EE rebates.
- **There is an opportunity for Wisconsinites, where Wisconsin customers could yield greater benefits from some EE measures already supported by Focus with supplemental funding, education, coordination, and/or support from utilities or entities interested in demand savings.** Strategic energy management (SEM) program staff indicated that some facilities are interested in help with their demand charges, but Focus is limited to support energy savings. Similarly, customers getting smart thermostats installed through Focus may be unaware of the DR opportunities from their utility, and combining these initiatives could help drive participation in both EE and DR programs.

8. POTENTIAL FUTURE RESEARCH OPPORTUNITIES

The findings resulting from this research effort indicate that there is potential to enhance Focus's current EE offerings to yield greater benefits to Wisconsinites via supplemental marketing, funding, coordination, and support from utilities and/or entities interested in demand savings. However, these opportunities will likely require an adjustment to Focus's current operations, and Focus might first benefit from targeted research in the following three areas; (1) assessing different strategies for enhancing programs to achieve greater demand savings, (2) better understanding the value of achieving additional demand savings, and (3) expanding the list of potential demand saving opportunities.

ILLUME identifies the following seven potential research studies designed to help address these target areas of research and to help the Focus team continue to enhance EE offerings for Wisconsinites.

UTILITY, REGULATOR AND OTHER STAKEHOLDER INTERVIEWS OR FOCUS GROUPS

Focus could conduct interviews or focus groups to assess different strategies for enhancing their offerings to generate greater demand savings. ILLUME recommends that Focus prepare for the interviews or focus groups by developing an interview guide and developing one or more strawman proposals of *how* Focus might adjust their current offerings to deliver greater demand savings. For example, through this research, Focus could collect feedback from utilities and stakeholders on their interest and ability to benefit from targeted reporting on "kW-emphasis" measures (e.g., those found in Appendix B). This research would be invaluable in ensuring Focus navigates this new space with awareness of their stakeholders' needs, concerns, and challenges. Furthermore, this research could be extended to culminate in the development of a roadmap for Focus to provide enhanced demand services.

Objectives: inform assessment of load shifting program designs, processes, and strategies for Wisconsin

WISCONSIN CUSTOMER SURVEY ON AWARENESS AND KNOWLEDGE OF DEMAND ISSUES AND SAVINGS

Focus could survey Wisconsin's residential, small business, commercial, and industrial customers to better understand the general awareness and knowledge of demand issues and savings, and ultimately to assess different strategies for enhancing their offerings to generate greater demand savings. ILLUME recommends that Focus prepare for the survey by developing a survey instrument and survey plan and making room in the timeline to collect stakeholder feedback and agreement on the survey before delivering it. Many utility customers around the U.S. are unaware of demand issues, which can lead to customer dissatisfaction without the appropriate program design.

Objectives: inform assessment of load shifting program designs, processes, and strategies for Wisconsin

SUMMARIZE WISCONSIN DEMAND ISSUES AND CHARACTERIZE UTILITY PARTNERS

Focus could leverage publicly available data on the Mid-Continent Independent System Operator (MISO) and utility customers to summarize current demand needs in Wisconsin and characterize Focus's utility partners. Through this research, Focus would have a better understanding of their utility partners' demand issues, would be better prepared to assess different strategies for enhancing their offerings to generate greater demand savings, and would better understand the value of adjusting their offerings to achieve greater demand savings. Identifying energy and demand savings opportunities depend on a lot of factors, including climate, typical end-uses, building codes, and economic development. However, identifying demand savings opportunities introduces another dimension: time. Focus has substantial resources around energy savings, which translate to demand savings in certain cases, but not with regards to the timing of demand constraints at a grid level. With 107 utility partners, Focus's partners may have winter demand constraints, summer demand constraints, both, or other demand issues depending on their customer base, local conditions, and generation mix. Once Focus understands their utility partners' demand constraints, Focus could extend this research and attempt to develop utility-specific load shaping recommendations as a proof of concept.

Objectives: inform assessment of load shifting program designs, processes, and strategies for Wisconsin; and assess load shaping value for Wisconsin

COST OF ACQUISITION FOR DEMAND SAVINGS

Focus could conduct research for the cost of acquisition in terms of demand savings, rather than energy savings. Through this research, Focus would have a better understanding for the value of adjusting their offerings to achieve greater demand savings. This research could specifically target supplemental demand

savings in excess of current program offerings, where costs would reflect an implementation strategy that builds off of Focus's current programs rather than new disparate offerings.
Objectives: assess load shaping value for Wisconsin

FULL DATABASE REVIEW OF SPECTRUM

Focus could leverage Spectrum's full data base to assess summer coincident demand savings by program, measure, year, end-use, and partner utility. This research could reveal traditional energy efficiency measures that yield promising summer coincident demand savings beyond those presented in this report. Furthermore, Focus could provide the utility-specific results to their partners to further demonstrate their current and past successes helping their utility partners manage summer peak demand. This research represents an opportunity to expand Focus's list of measures with promising demand savings.
Objectives: expand the list of potential demand saving opportunities

PRIORITIZE EE MEASURES WITH WINTER DEMAND SAVINGS OPPORTUNITIES

Focus could conduct research to identify and prioritize measures that reduce winter peak demand. Some of Focus's 107 utility partners may have winter peaks. This research would better prepare Focus to coordinate with these utility partners to help reduce their winter peaks.
Objectives: expand the list of potential demand saving opportunities

REVIEW AND REVISE DEMAND AND COINCIDENT DEMAND SAVINGS

Focus could conduct research to review and revise common load shaping measures, such as those included in Appendix B. This research would include refining coincident demand saving estimates for these measures (specific to Wisconsin), potentially developing other demand saving estimates (e.g., for winter savings or with hourly load shapes), or potentially developing Wisconsin specific active load shifting savings estimates (i.e., estimates of demand savings for events). This research could help Focus more accurately prioritize potential load shaping measures and more accurately track their impact.
Objectives: expand the list of potential demand saving opportunities

9. APPENDIX

Appendix A. SELECTING MEASURES

In this project, ILLUME and the Focus on Energy team prioritized measures at two stages: selecting measures for ILLUME to characterize (e.g., documenting savings, relevant Wisconsin policies, and market indicators); and selecting measures for ILLUME to develop into case studies. At each stage, ILLUME provided recommendations and the Focus on Energy team collected stakeholder feedback with which the team made final selections.

MEASURE AND MARKET CHARACTERIZATION

In an earlier task for this work, ILLUME and the Focus on Energy team reviewed measures associated with common load mitigation strategies and selected measures that best meet the specific needs of Focus on Energy. To start this process, ILLUME provided a list of measures that are commonly part of load mitigation strategies as well as measures currently included in the Focus on Energy TRM with substantial coincident demand savings. ILLUME and the Focus on Energy team discussed the priorities and limitations for Focus on Energy and highlighted promising measures. ILLUME and the Focus on Energy then sought stakeholder input on the measures, reviewed recent participation data, and ultimately selected ten measures for measure characterizations, which are documented in this memo. The priorities and limitations for Focus on Energy are detailed below:

- Prioritize measures that save annual energy as well as energy at key times
- Prioritize measures that are already included in the Wisconsin TRM
- Prioritize technology-based interventions over behavioral interventions
- Provide measures with a mix of applicable sectors, including commercial, industrial, single family (SF) residential, and multifamily (MF) residential
- Provide measures with a mix of value propositions
- Provide measures with a mix of uptake in Wisconsin (i.e., measures that demonstrate where Focus on Energy can help utilities manage load through existing EE programs, measures that have been delivering load mitigation value yet where benefits could be extended, measures that may be worth further investigation for Focus as a potential future priority or offering)

CASE STUDIES

To select measures for case studies, ILLUME provided Focus on Energy and their stakeholders measure and market characterizations for the ten measures listed in Table 10.

TABLE 10. RECOMMENDED MEASURE POTENTIAL AND PRIORITY FOR FUTURE RESEARCH

MEASURE	LOAD SHAPING VALUE PROPOSITION	POTENTIAL	SELECT FOR CASE STUDY
Smart Thermostats	Integrated EE/DR partnership with utilities	High	Yes
Heat Pump Water Heater (HPWH)	Traditional EE measure with potential demand savings	Moderate/High	Yes

	Potential for integrated EE/DR partnership with utilities Opportunity to pilot load management for electrifying end-uses		
Strategic Energy Management (SEM) for Water and Wastewater Treatment Plants	Traditional EE measure with potential demand savings Potential for integrated EE/DR partnership with utilities	Moderate/High	Yes
Customer Sited Battery Storage	Potential future offering warranting further research and monitoring	Moderate	Yes
Energy Recovery Ventilator	Traditional EE measure with high deemed demand savings	High	No
Variable Frequency Drive High Speed Ventilation/ Circulation Fan	Traditional EE measure with high deemed demand savings Potential future opportunity for integrated EE/DR partnership with utilities	High	No
Efficient Compressed Air Nozzles	Traditional EE measure with high deemed demand savings	Moderate	No
Efficient Clothes Washers	Traditional EE measure with moderate deemed demand savings Potential future opportunity for integrated EE/DR partnership with utilities	Moderate	No
High Frequency (HF) Battery Chargers for Lift-Trucks	Opportunity to pilot load management for electrifying end-uses	Low	No
Energy Management Information Systems (EMIS)	Emerging EE measure with demand savings potential Potential future opportunity for integrated EE/DR partnership with utilities	Moderate	NA – see other concurrent Focus on Energy research

The ILLUME team recommended four measures for case study development based on the following priorities:

- The measure represents moderate or high demand savings potential.
- The measure represents a program design outside of Focus on Energy's typical operations, and as such, represents an opportunity for Focus on Energy to learn from other EE programs' successes and challenges.
- The selected measures represent a meaningful cross section of the various load shaping value propositions, customer segments, and end-uses.
- Reports, program design descriptions, and other information necessary for a case study are readily available.

The Focus on Energy team and their stakeholders supported these priorities and ILLUME's recommended measures. Stakeholders expressed interest in how integrated EE/DR partnerships work for smart thermostats and how to handle customer-level energy storage (e.g., with batteries). Stakeholders also provided potential resources

to better understand current SEM for water treatment activity in Wisconsin and additional information about smart thermostat participation in the state.

However, stakeholders were curious why ILLUME did not recommend case studies for energy recovery ventilators and variable frequency drives, which ILLUME marked as having high potential for load shaping in Wisconsin. In summary, while these measures have high potential for load shaping in Wisconsin, our measure characterization indicated that these two measures and their program delivery are better understood than some of the other measures with moderate/high potential for load shaping, perhaps excluding smart thermostats. As such, ILLUME believes providing case studies for other measures may provide a greater learning opportunity for Wisconsin. ILLUME recommended creating a case study for smart thermostats as it is currently the most viable measure to explore integrated EE/DR.

Appendix B. INITIAL LIST OF MEASURES

Energy efficiency programs have helped manage peak demand for decades, where evaluations, cost-effectiveness analyses, and technical reference manuals (TRM) regularly document and assign increased monetary value for saving energy at times when the electric grid will likely peak. However, due to a variety of factors, there may be a larger role for EE programs to mitigate demand at critical times in the future. These factors include increased penetration of intermittent renewable generation, improved technology, and improved markets and understanding of managing demand.

In practice, EE programs are increasingly delivering load mitigation through **non-wires alternative (NWA)** projects,[50] refining methods to account for the dynamic **time- and locational-value of efficiency**,[51] and in partnership with demand response (DR) programs (i.e., integrated EE/DR) to implement **shape, shift, shed, and shimmy**.[52] In Table 11 and Table 12, ILLUME provides the Focus on Energy team basic measure information, examples, and references for an initial and full list of measures that span these strategies.

[50] E4TheFuture, PLMA, and SEPA. "Non-Wires Alternatives Case Studies from Leading U.S. Projects," 2018, https://sepapower.org/resource/non-wires-alternatives-case-studies-from-leading-u-s-projects/

[51] Berkley Labs, Electricity Markets and Value. "Time- and Locational-Sensitive Value," accessed September 2020, https://emp.lbl.gov/projects/time-value-efficiency

[52] Peter Alstone, Jennifer Potter, Mary Ann Piette, Peter Schwartz, Michael A. Berger, Laurel N. Dunn, Sarah J. Smith, Michael D. Sohn, Arian Aghajanzadeh, Sofia Stensson, Julia Szinai, and Travis Walter. "2015 California Demand Response Potential Study," November 14, 2016, http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=6442451541

TABLE 11. BASIC MEASURE INFORMATION FOR INITIAL AND FULL LIST OF MEASURES

ID	TECH. VS BEHAVIOR	TOP SELECTION	INTERVENTION TYPE	SEGMENT	MEASURE AREA DESCRIPTION	ACTIVE/ PASSIVE SHAPING	EVENT OR RECURRING SAVINGS	RELATED TRM MEASURE	EXISTING PROGRAM	POSSIBLE COIN. KW SAVINGS	EMERGING TECH	FLEXIBLE FOR RENEWABLE INTEGRATION
1	Tech	Y	Customer Generation	All	Distributed energy storage (e.g., batteries)	Active	Either	N		Yes	No	Yes
2	Tech	Y	Connected Equipment	C&I	Energy Management Systems	Either, both	Either, both	Y, with controls		Yes	No, but some evolution	Yes
3	Tech	Y	Transportation	C&I	Vehicle charging (e.g., forklifts, carts, buses)	Either, both	Either, both	Y, Industrial High Frequency Battery Chargers		Possible	No, but some evolution	Yes
4	Tech	Y	Traditional Efficiency	C&I, Food Service	ENERGY STAR Commercial Combination Ovens	Passive	Recurring Savings	Y		Yes	No	No
5	Tech	Y	Traditional Efficiency	C&I, Food Service	Steamer, ENERGY STAR	Passive	Recurring Savings	Y		Yes	No	No
6	Tech	Y	Traditional Efficiency	C&I, Process	Compressed Air Nozzles, Air Entraining	Passive	Recurring Savings	Y		Yes	No	No
7	Tech	Y	Efficient, Connected Equipment	Res	Heat pump and/or connected water heaters	Either, both	Either, both	Y		Yes	No, but some evolution	Possible
8	Tech	Y	Efficient, Connected Equipment	Res	Smart Thermostats	Either, both	Either, both	Y		Yes	No	Possible
9	Behavior	Y	Rates	Res	Time-of-use	N/A	Recurring Savings	N	Y	Yes	No	Yes
10	Tech	Y	Traditional Efficiency	Res, C&I	Efficient HVAC, such as heat pumps and Energy Recovery Ventilators	Passive	Recurring Savings	Y		Yes	No	No
11	Behavior	Y	Energy Reports	Res, SMB	Energy reports to influence daily energy-use routines	N/A	Recurring Savings	N		Yes	No, but some evolution	Possible
12	Behavior	maybe	Energy Water Nexus	Agriculture	Shifting agricultural pumping schedules	N/A	Recurring Savings	Y, efficient pumps are available in the TRM		Possible	No	Yes
13	Behavior	maybe	Customer Coaching	C&I	Identify opportunities to shift equipment schedules	N/A	Recurring Savings	Y, DEET behavioral savings		Possible	No	No
14	Tech	maybe	Utility Side Efficiency	N/A	Voltage optimization	Active	Event Based	N		Possible	No	Yes
15	Tech	maybe	Utility Side Efficiency	N/A	Dynamic Resource Auction	Either, both	Either, both	N		Possible	No	Yes
16	Tech	maybe	Traditional Efficiency	Res	Plumbed dehumidifiers	Passive	Recurring Savings	N		Possible	No	No

ID	TECH. VS BEHAVIOR	TOP SELECTION	INTERVENTION TYPE	SEGMENT	MEASURE AREA DESCRIPTION	ACTIVE/ PASSIVE SHAPING	EVENT OR RECURRING SAVINGS	RELATED TRM MEASURE	EXISTING PROGRAM	POSSIBLE COIN. KW SAVINGS	EMERGING TECH	FLEXIBLE FOR RENEWABLE INTEGRATION
17	Tech	maybe	Efficient, Connected Equipment	Res	Pool pumps	Either, both	Either, both	Y		Yes	No	Possible
18	Behavior	maybe	Contractor training	Res	Pool pump technician training	N/A	Recurring Savings	N		Yes	No	Yes
19	Behavior	maybe	Customer Education	Res	For EV owners	N/A	Either	N		Possible	No, but some evolution	Possible
20	Tech	No - too little energy savings	Customer Generation	C&I	Efficient back-up generators	N/A	N/A	N		Possible	No, but some evolution	Yes
21	Tech	No - too little energy savings	Demand Response	C&I	Commercial Refrigeration Energy Storage, or Ice Storage	Active	Either, both	N		Possible	No, but some evolution	Possible
22	Tech	No - too little energy savings	Connected Equipment	Res	Smart home, home energy management systems	Active	Either, both	N		Possible	No	Possible
23	Tech	No - too little energy savings	Connected Equipment	Res	Smart plugs and breakers	Active	Either, both	Y, if applicable to smart strips		Possible	Yes	Possible
24	Tech	No - too little energy savings	Transportation	Res, SMB	Customer owned EVs	Either, both	Either, both	N		Possible	Yes	Possible
25	Behavior	No - too event-based	Rates	C&I	Interruptible Rider	N/A	Event Based	N	Y	-	No	Yes
26	Behavior	No - too event-based	Rates	Res	Critical Peak Rates	N/A	Event Based	N	Y	Yes	No	Yes
27	Tech	No - too event-based	Demand Response	Res, C&I	Saver's Switch, Direct Load Control (DLC)	Active	Event Based	N	Y	-	No	Yes
28	Behavior	No - too event-based	Energy Reports	Res, SMB	Event style DR messages	N/A	Event Based	N		Possible	Yes	Yes
29	Tech	No - tech doesn't seem ready	Demand Response	C&I	Automated DR (ADR)	Active	Either, both	N		Possible	Yes	Yes
30	Tech	No - not scalable enough	Traditional Efficiency	C&I, Process	Pressure Screen Rotor	Passive	Recurring Savings	Y		Yes	No	No
31	Tech	No - not scalable enough	Traditional Efficiency	Res, C&I	Ground Source Heat Pump, Residential, Natural Gas and Electric Backup	Passive	Recurring Savings	Y		Yes	No	No
32	Tech	No - not scalable (not mature enough)	Customer Generation	C&I	Fuel cell	Active	Either, both	N		Yes	Yes	Yes
33	Tech	No - more applicable for utilities than Focus	Utility Side Efficiency	N/A	Utility energy storage	Active	Either, both	N		Yes	No, but some evolution	Yes
34	Behavioral, Tech	No - more applicable for utilities than Focus	Energy Water Nexus	Municipal	Shift energy use for municipal water and wastewater treatment.	Either, both	Recurring Savings	N		Possible	Yes	Possible

ID	TECH. VS BEHAVIOR	TOP SELECTION	INTERVENTION TYPE	SEGMENT	MEASURE AREA DESCRIPTION	ACTIVE/ PASSIVE SHAPING	EVENT OR RECURRING SAVINGS	RELATED TRM MEASURE	EXISTING PROGRAM	POSSIBLE COIN. KW SAVINGS	EMERGING TECH	FLEXIBLE FOR RENEWABLE INTEGRATION
35	Behavior	No - may not be scalable	Customer Education	All	Community oriented messaging/programs (i.e., "how your community can help reduce new emissions" targeted for certain customers)	N/A	Either	Y, DEET behavioral savings		Yes	No, but some evolution	Possible
36	Tech	No - in TRM with 0 kW savings	Traditional Efficiency	Agriculture	Efficient grain drying	Passive	Recurring Savings	Y		No	No	No
37	Behavior	No – too behavioral	Customer Coaching	All, not res	Specific customer coaching using account managers, similar to Strategic Energy Management	N/A	Recurring Savings	N		Possible	No	Possible
38	Tech	No - limited research need	Customer Generation	All	Solar (PV)	Passive	Recurring Savings	Y		Yes	No	N/A
39	Tech	No - limited research need	Traditional Efficiency	Commercial	Direct install program	Passive	Recurring Savings	N, specific measures require additional research		Yes	No	No
40	Tech	No - limited research need	Traditional Efficiency	Res	Weatherization	Passive	Recurring Savings	Y		Yes	No	No
41	Tech	No - limited research need	Traditional Efficiency	Res MF	MF EE Program	Passive	Recurring Savings	Y, e.g., lighting, HVAC, boilers, VFDs		Yes	No	No
42	Tech	No - limited research need	Efficient, Connected Equipment	Res, C&I	Lighting	Either, both	Either, both	Y		Yes	No	No
43	Tech	No - CHP is more appropriate for reducing winter peak	Customer Generation	C&I	Combined heat and power	Passive	Recurring Savings	N		No	No	No

TABLE 12. EXAMPLES AND REFERENCES FOR INITIAL AND FULL LIST OF MEASURES

ID	MEASURE AREA DESCRIPTION	EXAMPLES, SOURCES
1	Distributed energy storage (e.g., batteries)	ConEd BQDM, https://www.utilitydive.com/news/bqdm-program-demonstrates-benefits-of-non-traditional-utility-investments/550110/
2	Energy Management Systems	This category includes Slipstream's suggested Smart Building technology.
3	Vehicle charging (e.g., forklifts, carts, buses)	
4	ENERGY STAR Commercial Combination Ovens	WI TRM 2020, https://www.focusonenergy.com/sites/default/files/Focus_on_Energy_2020_TRM.pdf
5	Steamer, ENERGY STAR	WI TRM 2020, https://www.focusonenergy.com/sites/default/files/Focus_on_Energy_2020_TRM.pdf
6	Compressed Air Nozzles, Air Entraining	WI TRM 2020, https://www.focusonenergy.com/sites/default/files/Focus_on_Energy_2020_TRM.pdf
7	Heat pump and/or connected water heaters	
8	Smart Thermostats	
9	Time-of-use	Madison Gas & Electric customers with peak loads over 20 kW are defaulted onto the company's time-of-use rate, for which 1-6 P.M. weekday consumption incurs higher prices, especially in the summer, and 9 P.M. to 10 A.M. usage (as well as all consumption during weekends and holidays) is cheapest. Commercial and industrial customers can also take advantage of Alliant's Time of Day Pricing rate if they can divert load away from peak hours (11 A.M. to 7 P.M., June through August, and 5-9 P.M., December through February) and toward off-peak times (11 P.M. to 6 A.M. on weekdays, as well as all hours on weekends and holidays)
10	Efficient HVAC, such as heat pumps and Energy Recovery Ventilators	Y
11	Energy reports to influence daily energy-use routines	Typical Home Energy Report (HER) programs yield coincidence peak savings. Our team could investigate modifying current HER with further emphasis on load shaping behavior.
12	Shifting agricultural pumping schedules	https://www.bpa.gov/EE/Technology/demand-response/Documents/180319_BPA_DR_Potential_Assessment.pdf
13	Identify opportunities to shift equipment schedules	Power Take Off and Uplight are vendors who provide this service.
14	Voltage optimization	ConEd BQDM, https://www.utilitydive.com/news/bqdm-program-demonstrates-benefits-of-non-traditional-utility-investments/550110/
15	Dynamic Resource Auction	ConEd BQDM (e.g., DR aggregators), or including pay-for-performance
16	Plumbed dehumidifiers	
17	Pool pumps	
18	Pool pump technician training	Other EE programs have attempted to train pool contractors to set pump schedules to off peak times.
19	For EV owners	
20	Efficient back-up generators	
21	Commercial Refrigeration Energy Storage, or Ice Storage	ConEd BQDM, https://www.utilitydive.com/news/bqdm-program-demonstrates-benefits-of-non-traditional-utility-investments/550110/
22	Smart home, home energy management systems	
23	Smart plugs and breakers	This technology could be applied to window AC units or electric dryers. https://www.amazon.com/CNZJSC-Wifi-Smart-Circuit-Breakers/dp/B07HQ515P2
24	Customer owned EV's	
25	Interruptible Rider	Wisconsin Public Service Corp. (WPSC) offers: Participants contract for a 200 kW or greater load reduction (with curtailability up to 600 hours/yr.) subject to WPSC's determination of either economic or emergency conditions on the grid. In exchange, the customer receives reduced rates for its monthly peak demand Alliant Energy/Wisconsin P&L offer: offers customers discounts for their willingness to reduce their power consumption to a firm level (by at least 200 kW) with one hour's notice. MGE also offers customers with at least 75 kW of curtailable demand an interruptible rate; there is a more generous interruptible option for customers that can curtail 500 kW or more.
26	Critical Peak Rates	https://accel.wisconsinpublicservice.com/home/response_rewards.aspx Existing Xcel Energy program in the state:

ID	MEASURE AREA DESCRIPTION	EXAMPLES, SOURCES
		reduced demand charges for peak demand reduction at commercial and industrial facilities that can cut load by 50 kW or more during peak periods, primarily in the summer (though customers can be called on to reduce anytime during the year). Participating customers receive a per-kW discount on controllable demand every month, but in exchange must commit to reducing their load to a pre-determined level, usually for four to eight hours.
27	Saver's Switch, Direct Load Control (DLC)	Existing Xcel Energy program in the state offers program participants a year-round bill discount of $3 per kW of enrolled air conditioning in exchange for allowing the utility to cycle their air conditioners on and off for 15 to 20-minute intervals during periods of peak electric demand in the summer. Wisconsin Public Service Corp. (WPSC) offers to place control switches on equipment ranging from lights to motors and pumps, and shut them off periodically during high demand periods in exchange for bill credits. Shut-off options range from just summer- and winter-only cycling to year-round load-shedding capability (up to 8 hours per day and 100 per year). Remuneration depends on the particular option, but ranges between $4.35/kW to $6.50/kW per month of participation.
28	Event style DR messages	Oracle provided a similar service in Vermont. It was not continued, but could be improved (e.g., with better norming groups)
29	Automated DR (ADR)	ADR can include dimming or turning off non-critical lights, changing zone temperature set points and turning off non-critical equipment. It differs from EMS in that it is intended to drive automatic load reductions. It differs from DLC in that is intended to lead to small, hard-to-notice reductions in demand.
30	Pressure Screen Rotor	WI TRM 2020, https://www.focusonenergy.com/sites/default/files/Focus_on_Energy_2020_TRM.pdf
31	Ground Source Heat Pump, Residential, Natural Gas and Electric Backup	WI TRM 2020, https://www.focusonenergy.com/sites/default/files/Focus_on_Energy_2020_TRM.pdf
32	Fuel cell	ConEd BQDM, https://www.utilitydive.com/news/bqdm-program-demonstrates-benefits-of-non-traditional-utility-investments/550110/
33	Utility energy storage	
34	Shift energy use for municipal water and wastewater treatment.	https://ieeexplore.ieee.org/document/7280267 https://www.aceee.org/files/proceedings/2005/data/papers/SS05_Panel05_Paper05.pdf https://www.epa.gov/sites/production/files/2015-08/documents/wastewater-guide.pdf
35	Community oriented messaging/programs (i.e., "how your community can help reduce new emissions" targeted for certain customers)	10 or 15 years ago Wisconsin launched successful EE campaigns targeted for two specific communities to overcome specific transmission upgrades
36	Efficient grain drying	WI TRM 2020, https://www.focusonenergy.com/sites/default/files/Focus_on_Energy_2020_TRM.pdf
37	Specific customer coaching using account managers, similar to Strategic Energy Management	This approach could apply to: * Agricultural groups (e.g., with pump schedules) * Vehicle charging for fleets, forklifts, buses * Advanced MNF and healthcare facilities * Municipal water treatment https://www.aesp.org/page/IntegratingDRArtic
38	Solar (PV)	
39	Direct install program	ConEd BQDM, https://www.utilitydive.com/news/bqdm-program-demonstrates-benefits-of-non-traditional-utility-investments/550110/
40	Weatherization	
41	MF EE Program	ConEd BQDM, https://www.utilitydive.com/news/bqdm-program-demonstrates-benefits-of-non-traditional-utility-investments/550110/ https://www.coned.com/-/media/files/coned/documents/save-energy-money/rebates-incentives-tax-credits/rebates-incentives-for-multifamily-customers/mf-bldg-app.pdf
42	Lighting	
43	Combined heat and power	ConEd BQDM, https://www.utilitydive.com/news/bqdm-program-demonstrates-benefits-of-non-traditional-utility-investments/550110/

Appendix C. MARKET AND MEASURE CHARACTERIZATION MEMO

ILLUME developed market and measure characterizations for ten promising load shaping measures as an interim deliverable for this research. The corresponding memo begins on the following page.

MEMO

LOAD SHAPING MEASURE AND MARKET CHARACTERIZATION

PREPARED FOR: Focus on Energy
PREPARED BY: ILLUME
DATE: October 2, 2020

As the need for load shaping and controllable technologies and interventions increases, Focus on Energy has the potential to build from the current energy efficiency (EE) landscape in Wisconsin to expand demand mitigation opportunities in the future. ILLUME Advising, LLC (ILLUME), together with Focus on Energy, is researching the load shaping market to explore which behavioral and technology-based solutions supplement existing program offerings and provide the greatest opportunity for Wisconsin. This memo characterizes and ranks ten promising load shaping measures for Wisconsin, as well as provides the methodology used to conduct this work. Finally, this memo provides a recommendation for the four measures for which ILLUME will develop case studies, the final task of this research.

LOAD SHAPING LANDSCAPE

Energy efficiency programs have helped manage peak demand for decades, where evaluations, cost-effectiveness analyses, and technical reference manuals (TRM) regularly document and assign increased monetary value for saving energy at times when the electric grid will likely peak. However, due to a variety of factors, there may be a larger role for EE programs to mitigate demand at critical times in the future. These factors include increased penetration of intermittent renewable generation, improved technology, and improved markets and understanding of managing demand.

In practice, EE programs are increasingly delivering load mitigation through **non-wires alternative (NWA)** projects,[1] refining methods to account for the dynamic **time- and locational-value of efficiency**,[2] and in partnership with demand response (DR) programs (i.e., integrated EE/DR) to implement **shape, shift, shed, and shimmy**.[3] As a part of an earlier task for this work, ILLUME provided the Focus on Energy team a workbook of measures that span these strategies.

SELECTING LOAD SHAPING MEASURES FOR WISCONSIN

In an earlier task for this work, ILLUME and the Focus on Energy team reviewed measures associated with common load mitigation strategies and selected measures that best meet the specific needs of Focus on Energy. To start this process, ILLUME provided a list of measures that are commonly part of load mitigation strategies as well as measures currently included in the Focus on Energy TRM with substantial coincident demand savings. ILLUME and the Focus on Energy team discussed the priorities and limitations for Focus on Energy and highlighted promising measures. ILLUME and the Focus on Energy then sought stakeholder input on the measures, reviewed recent participation data, and ultimately selected ten measures for measure characterizations, which are documented in this memo. The priorities and limitations for Focus on Energy are detailed below:

- Prioritize measures that save annual energy as well as energy at key times

- Prioritize measures that are already included in the Wisconsin TRM
- Prioritize technology-based interventions over behavioral interventions
- Provide measures with a mix of applicable sectors, including commercial, industrial, single family (SF) residential, and multifamily (MF) residential
- Provide measures with a mix of value propositions
- Provide measures with a mix of uptake in Wisconsin (i.e., measures that demonstrate where Focus on Energy can help utilities manage load through existing EE programs, measures that have been delivering load mitigation value yet where benefits could be extended, measures that may be worth further investigation for Focus as a potential future priority or offering)

HIGH POTENTIAL MEASURES

In Table 1, ILLUME lists the ten load shaping measures characterized in this memo, their load shaping value proposition, potential, and our recommended priority for consideration in future tasks of this research. The measures in the table below are listed in order of draft potential, which ILLUME defines in the Methodology section below. ILLUME provides specific justifications for these ratings within each measure characterization section.

The fourth column of this table indicates ILLUME's draft designation for which of the ten measures to include in the final tasks of this research, including case study development. The ILLUME team believes that there are valuable reports and data available for these four measures, these measures represent opportunities for Focus on Energy to understand how other EE programs are evolving, and they represent a meaningful cross section of the various load shaping value propositions, customer segments, and end-uses. While ILLUME identified energy recovery ventilators (ERV) and variable frequency drives (VFD) as having high potential for load shaping in Wisconsin, our measure characterization indicated that these two measures and their program delivery are better understood than some of the other measures with moderate/high potential for load shaping, perhaps excluding smart thermostats. As such, ILLUME believes providing case studies for other measures than ERV and VFD may provide a greater learning opportunity for Wisconsin. ILLUME recommended creating a case study for smart thermostats as it is currently the most viable measure to explore integrated EE/DR. Finally, it is important to note that Focus on Energy is limited in its current ability to support incentives for batteries, as batteries do not provide annual energy savings. However, the team includes a case study for customer sited batteries to demonstrate what a statewide offering may look like in practice. ILLUME will work with Focus on Energy to finalize this list.

TABLE 1. RECOMMENDED MEASURE POTENTIAL AND PRIORITY FOR FUTURE RESEARCH

MEASURE	LOAD SHAPING VALUE PROPOSITION	POTENTIAL	SELECT FOR CASE STUDY
Smart Thermostats	Integrated EE/DR partnership with utilities	High	Yes
Energy Recovery Ventilator (ERV)	Traditional EE measure with high deemed demand savings	High	No
Variable Frequency Drive (VFD) High Speed Ventilation/ Circulation Fan	Traditional EE measure with high deemed demand savings Potential future opportunity for integrated EE/DR partnership with utilities	High	No

Heat Pump Water Heater (HPWH)	Traditional EE measure with potential demand savings Potential for integrated EE/DR partnership with utilities Opportunity to pilot load management for electrifying end-uses	Moderate/High	Yes
Strategic Energy Management (SEM) for Water and Wastewater Treatment Plants	Traditional EE measure with potential demand savings Potential for integrated EE/DR partnership with utilities	Moderate/High	Yes
Energy Management Information Systems (EMIS)	Emerging EE measure with demand savings potential Potential future opportunity for integrated EE/DR partnership with utilities	Moderate	NA – see other Focus on Energy research
Efficient Compressed Air Nozzles	Traditional EE measure with high deemed demand savings	Moderate	No
Customer Sited Battery Storage	Potential future offering warranting further research and monitoring	Moderate	Yes
Efficient Clothes Washers	Traditional EE measure with moderate deemed demand savings Potential future opportunity for integrated EE/DR partnership with utilities	Moderate	No
High Frequency (HF) Battery Chargers for Lift-Trucks	Opportunity to pilot load management for electrifying end-uses	Low	No

METHODOLOGY

CHARACTERIZATION

ILLUME conducted secondary research and a review of Wisconsin load shaping tactics and policies to date to create high-level market and measure characterizations for the ten candidate measures. To characterize the selected measures and their markets, the ILLUME team reviewed and synthesized information from the following sources:

- Focus on Energy program data
- Wisconsin Technical Reference Manual (TRM)
- Illinois TRM
- Publicly available evaluation and annual reports
- Publicly available market assessments
- Publicly available studies (e.g., NREL and EIA data on residential appliances)
- Conference proceedings

- Industry experts (e.g., Slipstream)
- Commercial building studies
- Recent EE evaluation filings
- Recent EE planning documents

IDENTIFYING MEASURE POTENTIAL

ILLUME identified measure potential by reviewing current and potential strategies in the context of the Wisconsin market and existing offerings. For this task, ILLUME defined potential as measures that have the highest potential to reduce summer peak demand for both residential and commercial customers in Wisconsin. More specifically, ILLUME considered the following characteristics:

- Market size
- Potential uptake
- Potential demand savings
- Market need for Focus on Energy intervention
- Robustness of the solution for different peak load issues

INTRODUCTION TO MEASURE CHARACTERIZATIONS

The remainder of this memo summarizes key details for each of the ten measures reviewed, including:

- Key Finding
- Measure Description
- Program and Savings Details
- Considerations for Future Measure Potential.

We provide details on sources at the end of the document.

SMART THERMOSTAT

KEY FINDING

Smart thermostats represent the premier opportunity for integrated EE/DR in Wisconsin, where Focus on Energy could support adoption of smart thermostats (delivering annual energy savings) and enable utility programs to deliver load shifting with the newly adopted smart thermostats. Focus on Energy could partner with utilities by combining EE and DR incentives at the time of sale and by sharing with utilities which of their customers have received rebated smart thermostats and thus may be eligible for utility-run DR.

MEASURE DESCRIPTION

CATEGORY	MEASURE DETAILS
Description	Standard programable thermostats allow customers to adjust temperatures at different times of the day, changing temperatures during unoccupied periods to allow for energy savings. Communicating thermostats provide this base level of functionality but can be programmed remotely through various communication protocols, including Wi-Fi. Compared to standard programmable thermostats, smart thermostats provide additional functionality, having several automatic features to increase energy savings. Smart thermostats can be installed with a furnace/air conditioner or with an existing air source heat pump.[4]
Segment	Residential
Load Shaping Value Proposition	Integrated EE/DR partnership with utilities
Relevance for Load Shaping	*Recurring:* Documented annual energy savings without demand savings in the Focus TRM 2020, but other sources indicate potential demand savings
	Event-based: Strong opportunity for event-based savings with integrated EE/DR
Priority Level	High – deemed energy savings with successful examples of integrated EE/DR and high adoption in Wisconsin

PROGRAM AND SAVINGS DETAILS

METRIC	INSTALLED WITH FURNACE AND AIR CONDITIONER	INSTALLED WITH EXISTING AIR SOURCE HEAT PUMP
Program Years	2019 through June 2020	
Measure Unit	Per thermostat	
Energy & Demand Savings		

Program Data Energy Savings per Unit (kWh/yr)	Median: 420 Range: 420-420	Median: 440 Range: 233-440 (varies by SF/MF)
Program Data Demand Reduction (kW)	Median: 0 Range: 0-0.103 (values greater than 0 represent legacy savings from the 2018 TRM)	Median: 0 Range: 0-0
Context Outside of WI	• The Focus TRM 2020 estimates an Energy Savings Factor for cooling of 20.5%, while other research in the region indicates the value may be closer to 3-15%[5,6] • The Focus TRM 2020 estimates 0 kW savings, however, other research in the region estimates moderate coincident demand savings[7,8]	
Current Program Performance		
Participation by Program	• HPwES: 2,494 • Trade Ally Solutions: 1,729	• Business/Industry: 40 (1 project) • Direct to Consumer: 109 • HPwES: 10 • Multifamily Energy Savings: 5 • Retail Lighting & Appliance: 235 • Direct to Consumer: 109 • HPwES: 10 • Multifamily Energy Savings: 5 • Retail Lighting & Appliance: 235 • Trade All Solutions: 4
Total Claimed Demand Savings (kW)	1.545	0
Measure Costs and Useful Life		
Effective Useful Life (years)	10	
Typical Average Cost ($/unit)	$213	
Program Data Incremental Cost ($/unit)	$174-$250	
TRM 2020 Incremental Cost ($/unit)	$173.89	
Non-Energy Benefits		
Notable Non-Energy Benefits	• Increased thermal comfort and convenience • Potential future access to services (e.g., for HVAC maintenance)	

CONSIDERATIONS FOR FUTURE MEASURE POTENTIAL

TRENDS AND CHALLENGES IN THE INDUSTRY

Smart thermostats exemplify an opportunity for EE programs to work with load shifting programs (i.e., integrated EE/DR). In this framework, EE programs can drive market adoption of DR-ready smart thermostats – EE programs

save annual energy while building a population of readily available customers for DR programs. In some cases, DR programs also provide incentives at the point of purchase to help further increase market adoption and improve the cost-effectiveness of the EE programs.[9]

Smart thermostat manufacturers are protective of their customer relationships and customers' data. While they enable easily dispatchable load shifting in 2020, there is some risk for future interoperability challenges. For example, some thermostat manufacturers, such as ecobee and Google, are now offering thermostat optimization services to all customers on their own, ceasing their partnerships with utilities (e.g. Eco+ and Seasonal Savings).[10] This shift was abrupt and left program implementers and administrators struggling to meet 2020 savings goals. As another example, EE programs and researchers have pursued opportunities to use smart thermostat data to support HVAC maintenance or upgrade programs,[11,12,13] but these efforts have largely stalled due to data access issues.

MARKET ACTORS AND PLAYERS

Programs largely distribute smart thermostats through brick-and-mortar retail and through online retail or utility e-marketplaces. The top selling household thermostats according to Amazon are:[14]

- Google Nest Learning Smart Thermostat
- Emerson Sensi Smart Thermostat
- Honeywell Home five 2-day programmable thermostat
- Emerson Sensi Touch Wi-Fi Smart Thermostat
- Honeywell Home Wi-Fi thermostat
- Honeywell Home T9 Wi-Fi Smart Thermostat
- ecobee3 Lite Smart Thermostat with two room sensors

In Focus on Energy's program (2019 – 2020), Honeywell, Lennox, and Carrier are the leading smart thermostats (see Table 2 for more details).

TABLE 2. TOP SMART THERMOSTAT MANUFACTURERS FOR FOCUS ON ENERGY

MANUFACTURER	UNITS INSTALLED (2019 – 2020)
Honeywell	1073
Lennox	980
Carrier	878
ecobee	463
Bryant	434
Nest	298
Trane	276

MARKET PENETRATION

Moderate and rapidly growing.

The smart thermostat market is growing rapidly. From 2016 through mid-2020, Focus on Energy rebated a total 8,525 smart thermostats across four thermostat measures, and over 40,000 smart thermostats in total. This growth represents a 250% cumulative annual growth rate from 2016 through 2019.

Smart thermostat load shifting is also growing rapidly. A 2016 report projected that the number of U.S. customers enrolled in BYOT programs would grow from 50,000 in 2016 to 20 million customers in 2020, a 347% cumulative annual growth rate.[15,16]

POTENTIAL FOR ADOPTION

High

While smart thermostats have been gaining market share, it is still relatively small compared to the number of thermostats currently in use. For example, Focus on Energy rebated roughly 8,500 smart thermostats across four measures 2016 through mid-2020, which represents a small fraction of eligible thermostats in Wisconsin.

POLICY CONSIDERATIONS

Connected devices represent an opportunity for Focus on Energy to help increase market penetration for DR-ready appliances while saving energy. However, this approach touches on a gray area regarding Focus on Energy's policy manual. Focus on Energy is prohibited from directly supporting DR.[17]

OTHER RELEVANT PROGRAMS

The following Wisconsin utilities offer smart thermostat DR programs,[18] which represent integrated EE/DR opportunities for Focus on Energy:

- Madison Gas & Electric
- Xcel Energy

ENERGY RECOVERY VENTILATOR

KEY FINDING

Energy recovery ventilators (ERVs) represent significant savings potential and have become more commonly available. While there are cases of operational issues in practice, these issues can be easily identified by staff that are trained to understand ERVs and assess their operation.

MEASURE DESCRIPTION

CATEGORY	MEASURE DETAILS
Description	This measure is installing an ERV on an HVAC system that provides both heating and cooling to occupied space. ERV systems exchange heat (often both sensible heat and water vapor) between outgoing exhaust air and incoming ventilation air. Under appropriate conditions, this allows for reducing the capacity of the HVAC system, which creates energy savings. Heat and energy recovery wheels are the most applied ERV systems.
Segment	Commercial
Load Shaping Value Proposition	Traditional EE measure with high deemed demand savings
Relevance for Load Shaping	*Recurring:* Demonstrated potential for recurring savings with high coincident demand savings
	Event-based: No current opportunity for event-based savings
Priority Level	High – established efficiency measure suitable for retrofits with high demand savings

PROGRAM AND SAVINGS DETAILS

METRIC	DETAILS
Program Years	2019 through June 2020
Measure Unit	Per unit
Energy and Demand Savings	
Program Data Energy Savings per Unit (kWh/yr)	Median: -460 (ERV, as heat exchangers, cause negative electric savings annually in Wisconsin, because in heating mode, their savings are realized as natural gas savings and they increase static pressure or friction loss in ducts, which increases fan consumption) Range: -11,779 - 4,009 (varies by installation conditions, air flow, and heating fuel)
Program Data Demand Reduction (kW)	Median: 1.030 (9.43 kW in TRM when installed for a system with cooling and a 7,200 CFM supply fan)

	Range: 0 – 34.160 (varies by installation conditions and air flow)
Context Outside of WI	Although the IL TRM breaks out ERV savings by building type and ERV technology, it suggests savings on the order of magnitude of 10 kW per ERV for a system with a 7,200 CFM supply fan.[31]
Current Program Performance	
Participation by Program	• Agriculture, Schools & Government: 32 • Business Incentives: 39 • Large Energy User: 5 • Business New Construction: 17 • Business & Industry: 8 • Schools & Government: 5 • Multifamily Energy Savings: 1 • Small Business V2: 1
Total Claimed Demand Savings (kW)	• Agriculture, Schools & Government: 162.25 • Business Incentives: 37.51 • Large Energy User: 33.3 • Business New Construction: 29.51 • Business & Industry: 26.22 • Schools & Government: 16.44 • Multifamily Energy Savings: 0.75 • Small Business V2: 0.59
Measure Costs and Useful Life	
Focus TRM 2020 Effective Useful Life (years)	15
Typical Average Cost ($/unit)	Costs vary by quality, capacity, controls, efficiency, and type
Program Data Incremental Cost ($/unit)	$995 – $212,160 (varies by capacity, efficiency, and HOU)
Focus TRM 2020 Incremental Cost ($/unit)	$6.63/CFM
Non-Energy Benefits	
Notable Non-Energy Benefits	• Improved thermal comfort • Improved ventilation, humidity control, and air quality[19,20]

CONSIDERATIONS FOR FUTURE MEASURE POTENTIAL

TRENDS AND CHALLENGES IN THE INDUSTRY

In the past 20 years, ERVs have become more common in commercial and institutional buildings because of their potential for cost-effective EE benefits. While ERVs can achieve savings of up to 80% of the ventilation air heating load, steps must be taken to ensure that units are installed and operated according to specification to reach performance expectations.[21]

MARKET ACTORS AND PLAYERS

ERVs are generally distributed through HVAC distributors. Top selling manufacturers include:[19]

- Airxchange
- American Aldes Ventilation Corp.
- Fantech
- Greenheck
- Johnson Controls
- Nortek Air
- PuriFresh Ventilation Products
- RenewAire
- Ruskin Rooftop Systems
- Zehnder

MARKET PENETRATION

Moderate, as far as our research indicates.

Focus on Energy rebated 491 ERV's between 2014 and mid-year 2020.

In a review of 402 commercial and institutional ERVs installed in Minnesota (across 134 different buildings), 31% of ERVs were found in commercial buildings. Most installations found in institutional buildings were in K-12 schools (51%) followed by higher education (22%), with municipal facilities making up the balance. While information on space use was only available from some of the data, it suggests that energy recovery systems are distributed among a variety of different types of commercial facilities that have larger than average ventilation loads including casinos, manufacturing and auto shops, assisted living, labs, and sports or gym facilities.[21]

POTENTIAL FOR ADOPTION

Moderate

In a 2017 report, CEE found that a general lack of understanding around ERV performance has resulted in negative experiences with the measure, leading to negative perceptions and diminished expectations. Specifically, 75% of the lost energy recovery results from mistakes related to part failures, operator overrides, and installation. Such mistakes persist due to unfamiliarity among operations staff and controls technicians and the absence of system feedback from poorly functioning ERVs. A Public Buildings Enhanced Energy Efficiency Program (PBEEEP) assessment found that roughly 25% of the 81 ERVs installed in Minnesota public buildings were not performing optimally.[21]

Fortunately, these mistakes can be easily corrected by commissioning new units to ensure that they function properly from the start. Problems with existing ERV systems can be easily identified by staff that are trained to understand ERVs and assess their operation. [21]

POLICY CONSIDERATIONS

Our research did not uncover any noteworthy policy considerations for ERV.

VFD HIGH SPEED VENTILATION/ CIRCULATION FAN

KEY FINDING

Variable frequency drive (VFD) motors for high-speed ventilation and circulation fans in agricultural applications represent a measure with steadily increasing participation and operation that often overlaps with system peaks. Additionally, when installed in combination with automated demand response (ADR), such as with OpenADR, they may be able to play an important role in load mitigation in Wisconsin.[22]

MEASURE DESCRIPTION

CATEGORY	MEASURE DETAILS
Description	VFD control motor systems in high-speed ventilation/circulation fan applications by physically slowing the motors' driving fans to achieve reduced flow rates at considerable energy savings. For agriculture ventilation/circulation fans, VFDs can reduce fan energy used for ventilating greenhouses or other enclosed spaces during hot summer conditions, which often occur at system peaks.
Segment	Agriculture
Load Shaping Value Proposition	Traditional EE measure with high deemed demand savings Potential future opportunity for integrated EE/DR partnership with utilities
Relevance for Load Shaping	*Recurring:* Established recurring energy and demand savings
	Event-based: Currently limited, but potential future opportunity for event-based savings with integrated EE/DR for VFD installed with ADR
Priority Level	High – an established efficiency measure, VFD are applicable for a variety of segments, and adoption has been good for this application of VFD

PROGRAM AND SAVINGS DETAILS

METRIC	HIGH SPEED VENTILATION/CIRCULATION FAN
Program Years	2019 through June 2020
Measure Unit	Per horsepower
Energy and Demand Savings	
Program Data Energy Savings per Unit (kWh/yr)	Median: 4,392 Range: 665 – 122,635 (varies by horsepower, efficiency, and fan load)

Program Data Demand Reduction (kW)	Median: 0.51 Range: 0.097 – 9.39
Context Outside of WI	Our research did not uncover any noteworthy findings related to savings outside of Wisconsin.
Current Program Performance	
Participation by Program	• Business & Industry: 618 (41 projects) • Agribusiness: 647 (48 projects) • Agriculture, Schools & Government: 1
Total Claimed Demand Savings (kW)	• Business & Industry - Rural: 579 • Agribusiness: 266 • Agriculture, Schools & Government: 3
Measure Costs and Useful Life	
Focus TRM 2020 Effective Useful Life (years)	15
Typical Average Cost ($/unit)	Varies
Program Data Incremental Cost ($/unit)	$130.00 – $4,210.40
Focus TRM 2020 Incremental Cost ($/unit)	$210.52
Non-Energy Benefits	
Notable Non-Energy Benefits	• Minimizing maintenance costs • Improved process control • Improved quality • Decreased noise • Reduced wear. VFDs start motors slowly by ramping up the voltage rather than slamming motors with full line voltage to start.[23] • Reduced emissions • Offset oversizing. Fans can be oversized to account for various uncertainties. VFD systems minimize energy wasted by oversized motors that may never run at full speed.[23]

CONSIDERATIONS FOR FUTURE MEASURE POTENTIAL

TRENDS AND CHALLENGES IN THE INDUSTRY

VFD have been experiencing an increase in demand,[24] which will likely continue as they constitute an important component of advanced controls. The functionality of VFD allows for full automation technology to maintain customer comfort levels and limit disruption to operations.[25] Also, these technologies can be installed with commercial HVAC units and agricultural pumps.[4] In other words, VFD can be used to save energy and provide other benefits in a wide variety of applications, including as a component of advanced control systems.

VFD may also provide grid services (i.e., with load shifting), but costs for VFD enabled with ADR is roughly $349/kW installed. Also, to provide load shimmy service to the bulk power system, the system costs for the advanced telemetry and communications will be an additional $1,290- $2,080 per site.[25]

MARKET ACTORS AND PLAYERS

Some of the prominent manufacturers in the variable frequency drive market include:[26,27]

- Johnson Controls, Inc.
- Honeywell International, Inc.
- ABB Limited
- Emerson Electric Co.
- Siemens AG
- Schneider Electric,
- CG Power and Industrial Solutions Limited
- Mitsubishi Electric
- Eaton Corporation
- Fuji Electric Co. Ltd.
- Rockwell Automation
- WEG Electric Corporation
- Yaskawa Electric Corporation
- Hiconics Eco-energy Technology Co.
- Danfoss
- Hitachi
- Yaskawa Electric Corporation

MARKET PENETRATION

Low to moderate

From 2016 through mid-2020, Focus on Energy rebated almost 2,000 VFD high speed ventilation/circulation agricultural fans.

POTENTIAL FOR ADOPTION

High

Participation in this measure has increased year over year since 2016, indicating the program is successfully administering this measure. Similarly, the functionality of the VFD allows for full automation technology to maintain customer comfort levels, limit disruption to operations, and can provide load shaping opportunity services to the grid.[25] Focus on Energy can continue supporting this measure in the market and consider potential future opportunities with advanced controls for VFD or for VFD in other applications.

POLICY CONSIDERATIONS

Our research did not uncover any noteworthy policy considerations for VFD.

HEAT PUMP WATER HEATER

KEY FINDING

Heat pump water heaters (HPWH) represent an opportunity to save energy over standard electric resistance water heaters and models are available from major manufacturers. However, gas water heaters are more common than electric water heaters in the Midwest and market adoption for HPWH has been low. Furthermore, HPWH are more efficient than standard electric resistance water heaters, which limits the cost-effectiveness for administering a load shifting program with HPWH.

Perhaps the most promising role for Focus on Energy would be to incentivize uptake of HPWH in Wisconsin in single family applications, which could become more valuable with any Wisconsin initiatives that open Focus on Energy to beneficial electrification.

MEASURE DESCRIPTION

CATEGORY	MEASURE DETAILS
Description	In addition to using electricity, HPWHs pull heat from the surrounding air, making them more efficient than traditional electric resistance heating.
Segment	Residential (SF)
Load Shaping Value Proposition	Traditional EE measure with potential demand savings Potential for integrated EE/DR partnership with utilities Opportunity to pilot load management for electrifying end-uses
Relevance for Load Shaping	*Recurring:* Established recurring energy and demand savings
	Event-based: Potential savings with connected HPWH[28] but the greater EE of HPWH means they provide less benefit to peak demand mitigation and energy shifting.[29]
Priority Level	Moderate/High – relatively high demand savings potential and emerging end-use for integrated EE/DR

PROGRAM AND SAVINGS DETAILS

METRIC	ELECTRIC HPWH
Program Years	2017 – 2019
Measure Unit	Per heater
Energy and Demand Savings	
Program Data Energy Savings per Unit (kWh/yr)	Median: 1,660 Range: 1,660 – 1,660

Program Data Demand Reduction (kW)	Median: 0.079 Range: 0.079 – 0.079
Context Outside of WI	Savings outside of WI support the Focus TRM. HPWHs can permanently reduce peak loads for water heating by up to 50%, compared to homes with conventional electric resistance water heaters,[30] which as indicated in the IL TRM, can represent 1,861 kWh/yr and 0.088 kW savings.[31]
Current Program Performance	
Participation by Program	• Home Performance – Flood Relief: 2 • Home Performance with Energy Star V3: 42
Total Claimed Demand Savings (kW)	• Home Performance – Flood Relief: 0.158 • Home Performance with Energy Star V3: 3.318
Measure Costs and Useful Life	
Focus TRM 2020 Effective Useful Life (years)	13
Typical Average Cost ($/unit)	Installed cost of a HPWH ranges from $1,500 to $3,500 (depending on the model and installation circumstances)[32]
Program Data Incremental Cost ($/unit)	$1,000 (data is only available for 2019)
Focus TRM 2020 Incremental Cost ($/unit)	$1,030 - $1,199
Non-Energy Benefits	
Notable Non-Energy Benefits	Reduced emissions if switching from gas heater[33]

CONSIDERATIONS FOR FUTURE MEASURE POTENTIAL

TRENDS AND CHALLENGES IN THE INDUSTRY

While HPWH are widely commercially available, market adoption has been low. In 2017, for example, there were more than 180 HPWH models in the U.S. market offered by major manufacturers, but HPWH only make up about 1% of the annual U.S. electric water heater sales, and considerably less than 1% of the installed base.[32] Without increases in adoption, it is possible that major water heater manufacturers will decrease investment in their HPWH product lines and eventually discontinue their HPWH models.[32]

MARKET ACTORS AND PLAYERS

Major manufacturers of HPWH include:[32]

- GE
- A.O. Smith
- Stieble Eltron
- Rheem
- Air Generate

- Bradford White

MARKET PENETRATION

Low

HPWH consume 50% less energy than conventional electric-resistance water heaters. Yet, HPWH make up just 1% of all electric water heaters sold in the residential sector, where electric water heaters are less common than gas water heaters in Wisconsin.[32]

The 2019 Focus on Energy evaluation report aligns with these national trends with builders reporting that use of HPWH (in addition to other measures) is not widespread.[34] Furthermore, Focus on Energy has only had 44 participants for this measure from 2017 through 2019.

POTENTIAL FOR ADOPTION

Low

Focus on Energy has only had 44 participants for this measure from 2017 through 2019 and has experienced declining participation for this measure year over year. Since 2017, the program reaches about 50% fewer participants each year or less.

Barriers to HPWH adoption are summarized below:[32]

Cost. Consumers encounter "sticker shock" when discovering the purchase and installation of a HPWH is 2-3 times more expensive relative to a convention water heater.

Awareness. Lack of awareness of HPWH as a purchase option, its value proposition and what to do to facilitate a HPWH installation.

Availability. Lack of consumer access to HPWH, particularly when replacement results from failure of the existing water heater.

Installer Expertise. Lack of trained and engaged installers, understanding of HPWH sizing to meet household hot water needs, understanding or desire to promote HPWH to consumers and resolve installation barriers.

Performance. Confusion over climate suitability and parasitic losses to heating systems. Dissatisfaction with hot water delivery in heat pump mode. Displeasure with the compressor noise level and cool air exhaust.

Installation Constraints. Insufficient space of the current water heater footprint to accommodate a HPWH and inability to accommodate ventilation requirements, ducting and/or condensate drainage.

POLICY CONSIDERATIONS

Some states are opening their energy efficiency programs to beneficial electrification to reduce carbon emissions.[35] Similarly, the Focus on Energy policy manual allows fuel switching in cases that meet certain criteria.[36] As such, Focus on Energy could pursue HPWH to help manage load growth if Wisconsin chose to incentivize electrification.

SEM FOR WATER & WASTEWATER TREATMENT PLANTS

KEY FINDING

Rather than ask facilities staff to access and manage EE, demand charges, and load shifting through separate channels, strategic energy management (SEM) at water and wastewater treatment facilities represents an opportunity for integrated EE/DR, where Focus on Energy can partner with utility programs to help these facilities save energy, reduce demand charges, and actively shift demand at critical times. Furthermore, climate change may be affecting investment plans for these facilities, which could increase energy use and may mark an important time for Focus on Energy to engage with these facilities.

MEASURE DESCRIPTION

CATEGORY	MEASURE DETAILS
Description	SEM can be defined as taking a holistic approach to managing energy use in order to continuously improve energy performance, by achieving persistent energy and cost savings over the long term.[37] Water and wastewater treatment plants represent facilities with both energy efficiency and load shifting opportunities,[38] which are complex, and as a result, well suited for SEM.
Segment	Industrial
Load Shaping Value Proposition	Traditional EE measure with potential demand savings Potential for integrated EE/DR partnership with utilities
Relevance for Load Shaping	*Recurring:* Established recurring energy and demand savings
	Event-based: Opportunity for event-based savings with integrated EE/DR
Priority Level (high/low)	Moderate/High – high potential savings and potential for integrated EE/DR, but adoption could be a challenge and the market size in WI may be small

PROGRAM AND SAVINGS DETAILS

While Focus on Energy has provided SEM and provides incentives for water and wastewater treatment,[39] we did not uncover any SEM efforts specifically related to water and wastewater treatment. To estimate potential impacts, we reference a Minnesota study of 107 wastewater facilities, which treat 300,000 to 10,000,000 gallons per day. These facilities represent 53% of Minnesota's mechanical facilities and account for 33% of the estimated energy use in the sector, approximately 127,000,000 kWh/yr. Based on previous EE work with wastewater treatment plants, it is estimated there is a 25% average energy saving opportunity per plant. This represents nearly 32,000,000 kWh/yr of energy conservation opportunity or nearly 300,000 kWh per site on average.[40] Similarly, wastewater

treatment facilities often have centralized control systems, which makes them well-suited to shift or shed electrical loads in response to financial incentives, utility bill savings, and/or opportunities to enhance reliability.[38]

These facilities are also often well suited for SEM. SEM programs often provide facility-specific recommendations, because many industrial and large commercial facilities have unique characteristics, making group analysis problematic. For example, wastewater treatment plants, food processors, and hospitals have very different outputs, production processes, and energy-consumption characteristics. These differences make regression modeling for groups of different facilities difficult.

NYSERDA identifies the following non-energy benefits of SEM at water and wastewater treatment plants:[41]

- Control. Improve control and operation of water treatment processes.
- Reduce risk. Ensure a reliable and consistent effluent quality reducing likelihood of violating discharge permits.
- Prolong equipment life. Extend infrastructure and equipment life spans with lower demand.
- Risk mitigation. Identify operational issues ahead of time to avoid costly break-fix scenarios or service issues.
- Carbon Footprint Reduction. Contribute to a cleaner environment.

CONSIDERATIONS FOR FUTURE MEASURE POTENTIAL

TRENDS AND CHALLENGES IN THE INDUSTRY

Two key trends affecting SEM at water and wastewater treatment facilities are climate change and the emerging opportunity for integrated EE/DR at these facilities.

Climate change considerations, like extreme weather events, are causing municipalities to implement resiliency plans through the protection of equipment and relocation of key process components. Additional pumping to higher ground surface elevations may be necessary to avoid flooding but introduces additional use of energy, furthering the case for SEM.[42,43] Similarly, wildfires are driving water treatment facilities to change water management practices to ensure residents have adequate access to healthy drinking water.[44] These practices could ultimately lead to investments in additional water treatment equipment, which could also increase energy use.

Successful case studies are emerging for integrated EE/DR for water and wastewater treatment.[38]

MARKET ACTORS AND PLAYERS

Key market actors include facility managers who manage water and wastewater treatment plants and water solution providers (the private firms affiliated with the management of those facilities).

MARKET PENETRATION

Low

SEM for water treatment is not a part of every utility EE portfolio but using SEM practices in water and wastewater treatment plants is becoming more prevalent. This is an emerging EE program with relatively few examples across the country. Since these facilities generally have similar features in their operation and are in a non-competitive industry, a cohort model may help maximize the impact of these programs.[40]

POTENTIAL FOR ADOPTION

Low to moderate

Treatment facilities can be hard to engage in EE and load shifting. However, some innovative program designs may enhance program participation. A Minnesota study proposes to use a cohort training model for Wastewater Treatment Plants (WWTP). This model aims to help utilities reach high-energy using customers that are geographically spread-out, who may otherwise remain unengaged. A statewide offering would maximize the number of eligible WWTP along with the energy savings potential and could be a model for other sector-focused programs.[40]

POLICY CONSIDERATIONS

The DOE launched a Superior Energy Performance (SEP) program to improve energy performance at water and wastewater treatment facilities across the county, which can improve energy performance by up to 30% over three years.[45, 46] Focus on Energy could consider whether participation in SEP is occurring in Wisconsin and whether Focus on Energy can partner with SEP to better serve facilities in Wisconsin.

Also, SEM at water and wastewater treatment facilities represents an integrated EE/DR opportunity, where Focus on Energy could partner with utilities to consolidate support for EE, demand reduction, and load shifting through one point of contact or one channel. However, this approach touches on a gray area regarding Focus on Energy's policy manual. Focus on Energy is prohibited from directly supporting DR.[17]

ENERGY MANAGEMENT INFORMATION SYSTEMS

KEY FINDING

Energy management information systems (EMIS) represent an emerging opportunity to save energy and demand, provide event-based savings, and provide grid flexibility as load constraints change. However, EMIS is an emerging technology, and as such, there are barriers for adoption and a few cases where savings varied beyond the expected range.

MEASURE DESCRIPTION

CATEGORY	MEASURE DETAILS
Description	An EMIS tool is a software tool that collects, stores, analyzes, and displays a facility's energy consumption data. It can be the first step a company takes when adopting intelligent energy management and efficiency. EMIS are also compatible with many continuous improvement practices such as continuous commissioning and SEM and can help automate the data collection and analysis required by such practices.[47]
Segment	Commercial
Load Shaping Value Proposition	Emerging EE measure with demand savings potential Potential future opportunity for integrated EE/DR partnership with utilities
Relevance for Load Shaping	*Recurring:* Demonstrated potential for recurring savings
	Event-based: Demonstrated potential for event-based application[48]
Priority Level (high/low)	Moderate – technology is still emerging, and current vendors are best suited for larger facilities, but there are promising savings results where available

PROGRAM AND SAVINGS DETAILS

To provide perspective on energy and demand savings from EMIS, we reference research from ACEEE, the Lawrence Berkeley National Lab (LBNL), and a Focus on Energy pilot. EMIS services are relatively new, but the early evidence suggests that energy savings may vary between 10 – 20%, and 21% demand savings may be possible with load shifting.

A 2019 ACEEE paper on EMIS programs found three programs with positive savings results, and one program with low savings (Table 3).[49] A LBNL researcher (Granderson) often reports EMIS savings between 10% to 20%.[50,51,52] Microsoft, with the largest contiguous corporate campus in the U.S., deployed a fault detection and diagnostics

(FDD) system for building-level HVAC operations, and saved over 18% in electricity consumption at their Puget Sound campus with rapid payback.[53] Lastly, we provide a list of savings by building type in Table 4.

TABLE 3. SUMMARY OF EMIS SAVINGS FROM 2019 ACEEE PAPER

UTILITY	EMIS PROGRAM DETAILS	REPORTED SAVINGS
Efficiency Nova Scotia	Program launched in 2015 and as of 2018, a total of seven participants have benefited from the program	In 2016, participating customers saved 2.02 GWh, and net program cumulative savings reached 4.66 GWh[49]
Xcel Energy Colorado	In 2016 the program achieved 100% of its electric energy savings target and came in under budget	Exact savings values were not provided
NYSERDA	Real Time Energy Management program launched in 2016	NYSERDA's Real Time Energy Management program claims customers can achieve energy savings of 15–30% per year[54]
BC Hydro	The program was deemed ineffective and discontinued after 2016	Saved an average of 2% of annual natural gas consumption

TABLE 4. EMIS SAVINGS BY BUILDING TYPE

BUILDING DESCRIPTION	SAVINGS
Office Building	12% reduction in electricity use in 11 months[55]
University	14% reduction in summer electricity usage[56]
Office Building	12% lighting electricity savings in a week[57]
University	30% reduction in average daily gas use[58]
Refrigerated/Dry Warehouses	18% reduction in portfolio energy use in 3 years[58] 36% reduction in whole-building energy use at a single site in 3 years[58]
University	30% reduction in daily whole-building energy use[58]
Retail	$35,000/year avoided costs[58]

Regarding load shifting savings, Focus on Energy supported an 18-month Madison Gas and Electric pilot program, On Demand Savings (ODS), which provided commercial and industrial (C&I) customers with a real-time energy dashboard, demand limiting strategies, and financial incentives to help control summertime on-peak demand. The goal of the program was to help C&I customers manage their electrical load profile during critical on-peak periods through operational and behavioral modifications via their existing energy management systems and the customized energy dashboard. Preliminary findings from a very small sample set show customers reduced their on-peak demand by an average of 21%. These preliminary savings were achieved primarily through programming changes to the energy management system that shifted HVAC cooling away from the peak demand periods.[59] While this pilot may exemplify a simplified EMIS, these load shifting savings provide a valuable planning estimate.

CONSIDERATIONS FOR FUTURE MEASURE POTENTIAL

TRENDS AND CHALLENGES IN THE INDUSTRY

While EMIS adoption is growing, sustainable market growth still requires support from EE programs, even in developed markets like Illinois. This is driven in part by the cost and complexity of these systems. Specific barriers to EMIS adoption include:[51]

1. High cost
2. Data security
3. Coordination across departments or stakeholders (e.g., IT, facilities maintenance, managers and decision-makers, investors)
4. Interoperability and legacy systems
5. Non-standardized building typologies
6. Misaligned priorities (e.g., where Focus on Energy may target savings, facilities maintenance might prefer to avoid complaints and the business might prefer to optimize employee productivity)

Some of the primary technology advancements include interoperability (e.g., with openADR[22]) and pairing energy benefits with non-energy benefits (e.g., comfort and productivity).

MARKET ACTORS AND PLAYERS

Primary market actors, as identified through ILLUME's conversations with Slipstream, include:

- Obvius: Building Manager Online
- SkyFoundry: Skyspark
- Lucid: BuildingOS
- Noveda: Energy Flow Monitoring
- BuildingIQ
- IBIS Networks: WattIQ
- EnerNOC EfficiencySmart
- Schneider Energy Operation: Ecostruxure
- JCI Panoptix
- EFT Energy Manager
- eSight Enterprise

MARKET PENETRATION

Low, but growing

At the beginning of 2018, there were 31 program administrators that offer 13 SEM-only, 11 EMIS-only, and 19 SEM-with-EMIS-option programs in North America.[49] While market penetration is low, this technology is beginning to ramp up in terms of adoption.[47,60]

POTENTIAL FOR ADOPTION

Low to moderate

In the ILLUME team's conversation with SlipStream, they stressed that technical, financial, and awareness barriers still exist. This is particularly true for small and medium businesses as they tend to not have much automation in buildings to leverage. Additionally, cost remains a barrier to adoption. Granderson and Lin (2016) reported that median up-front cost of EIS software is $23,000, and median annual costs being $16,000.[52] SlipStream also noted that subscription payment models is another barrier for adoption.

POLICY CONSIDERATIONS

EMIS represent an integrated EE/DR opportunity, where Focus on Energy could increase adoption of a DR-ready service while saving energy. However, this approach touches on a gray area regarding Focus on Energy's policy manual, where Focus on Energy is prohibited from directly supporting DR.[17]

EFFICIENT COMPRESSED AIR NOZZLES

KEY FINDING

Efficient compressed air nozzles in commercial and industrial applications represent a traditional EE offering that is applicable to many manufacturing and processing facilities. However, the program has experienced low participation, which may be due to stringent program requirements (i.e., only facilities with usage of 2,000 hours or more per year qualify).

MEASURE DESCRIPTION

CATEGORY	MEASURE DETAILS
Description	Engineered nozzles, also known as air entraining nozzles, reduce the amount of compressed air required for cleaning, cooling, drying, and blowoff applications. These nozzles use the coandă effect to pull in free air and accomplish tasks with up to 70% less compressed air.[4]
Segment	Commercial and Industrial
Load Shaping Value Proposition	Traditional EE measure with high deemed demand savings
Relevance for Load Shaping	*Recurring:* Documented recurring energy and demand savings in Focus TRM 2020
	Event-based: No current opportunity for event-based savings
Priority Level (high/low)	Moderate – established efficiency measure, but adoption has been low, which may be the result of eligibility requirements (i.e., 2,000 hours of use per year)

PROGRAM AND SAVINGS DETAILS

METRIC	AIR ENTRAINING
Program Years	2019 through June 2020
Measure Unit	Nozzle
Energy and Demand Savings	
Program Data Energy Savings per Unit (kWh/yr)	Median: 4,800 Range: 4,800 – 4,800
Program Data Demand Reduction (kW)	Median: 1.8 Range: 1.8 – 1.8

Context Outside of WI	The IL TRM estimates savings of 50% rather than the roughly 70% estimated in the Focus TRM.[31] Similarly, the IL TRM provides default assumptions that the nozzles are in use 416 hours per year at a facility with continual (24 hour/day) operation and 99 hours per year for a single shift facility, where Focus on Energy only offers rebates for nozzles in use 2,000 hours per year or more.
Current Program Performance	
Participation by Program	Business & Industry: 4 (1 project) Business Incentives: 30 (1 project)
Total Claimed Demand Savings (kW)	• Business & Industry: 7.2 • Business Incentives: 54
Measure Costs and Useful Life	
Focus TRM 2020 Effective Useful Life (years)	15
Typical Average Cost ($/unit)	Varies by size and material[61]
Program Data Incremental Cost ($/unit)	$35.49
Focus TRM 2020 Incremental Cost ($/unit)	$35.49
Non-Energy Benefits	
Notable Non-Energy Benefits	• Reduced noise due to laminar air flow. • Potential safety benefits due to the elimination of potential skin contact with high pressure air.

CONSIDERATIONS FOR FUTURE MEASURE POTENTIAL

TRENDS AND CHALLENGES IN THE INDUSTRY

Technological developments have enabled compressor controllers to be connected via mobile systems, allowing equipment monitoring remotely over a secure network. Connected compressors allow operators to track key parameters like pressure and flow. If needed, these parameters can be manually adjusted by customers to meet varying production demands of the facility, significantly improving the compressed air EE. Production and maintenance staff can use this data to analyze the energy consumption of the compressed air in their facilities.[62]

Air compressor manufacturers are working on transforming this technology from manual to fully automated. Research is being conducted to develop air compressors that can track and make process improvements autonomously. Currently, predictive maintenance is the most applicable use case of connected air compressors.[62]

MARKET ACTORS AND PLAYERS

Some of the key players operating in the global compressed air nozzles market include the following manufacturers:[63]

- KJN Enterprises
- EXAIR Corporation
- Euspray
- Technical Products and Services Inc.
- H.Ikeuchi & Co., LTD.
- Lechler Inc.
- SMC Corporation
- Nex Flow Air Products Corp.
- Pneumadyne
- Ikeuchi USA, INC.
- John Brooks Company
- Knight Pneumatics.

MARKET PENETRATION

Low

We were unable to determine market penetration for air entraining nozzles in Wisconsin or a similar state or region. However, the information from the IL TRM implies that the market size for nozzles that operate over 2,000 hours per year may be small. For instance, the IL TRM estimates that facilities in continual operation use compressed air nozzles for 416 hours per year.

POTENTIAL FOR ADOPTION

Low

A 2001 market characterization report identified that the major barriers to market transformation of compressed air systems include lack of awareness about costs and savings potential, perceived long payback times, and reluctance to interrupt continuous operations.[64] These findings were corroborated by DOE interviews with compressed air system efficiency consultants who repeatedly stressed that the major barrier to increased demand for compressed air efficiency services is lack of customer understanding of potential benefits: energy savings and improved control over production processes.[64]

Other barriers mentioned included:[64]

- Lack of time. Maintenance and facilities engineering staff tend to prioritize issues that impact short-term production needs.
- Lack of communication. There tends to be a lack of communication and shared goals between the maintenance department—which typically is responsible for system operation— and plant engineers, who are focused on meeting the needs of production departments.
- Lack of awareness of payback times. There is a misconception among customers that payback times are too long. However, compressed air system experts suggest this is a misguided concern. Much of the savings available from compressed air upgrades can be achieved without capital investment, or with investments

that pay for themselves less than two years. If true, the real barrier is not actually long payback times but a lack of education about opportunities, their low cost, and their fast payback time.

POLICY CONSIDERATIONS

Our research did not uncover any noteworthy policy considerations for efficient compressed air nozzles.

CUSTOMER SITED BATTERY STORAGE

KEY FINDING

Customer sited battery storage represents a reliable and predictable load shifting opportunity. While this measure does not save energy, utilities are beginning to engage with customer sited batteries and the market, thanks in large part to key market actor, Tesla, is growing. That said, initial cost, awareness and misconceptions of technological capabilities and permitting requirements may create moderate to significant barriers to the adoption of this technology in the residential sector.

MEASURE DESCRIPTION

CATEGORY	MEASURE DETAILS
Description	Demand side management programs are beginning to leverage customer sited battery storage to provide grid services, such as load shifting.
Segment	Residential
Load Shaping Value Proposition	Potential future offering warranting further research and monitoring
Relevance for Load Shaping	*Recurring:* While not saving energy, batteries can shift load on a recurring basis (e.g., daily)
	Event-based: Strong opportunity for event-based savings
Priority Level (high/low)	Moderate – high potential demand savings per installation, but would require changes to policy manual

PROGRAM AND SAVINGS DETAILS

Focus on Energy does not currently provide an offering for customer sited battery storage, and as such, this memo references savings from studies in Vermont and Massachusetts to provide context. Batteries do not save energy but demonstrate stable and predictable load shifting. Furthermore, early programs in the U.S. are finding willing participants. National Grid's "Bring your own battery" program saved 139 kW per event on average, including 126 kW during the 2019 ISO-NE Peak Hour. Batteries that successfully participated in 2-hour events saved an average of 5.5 kW/unit.[65] Green Mountain Power (GMP) reported it saved ratepayers $500,000 by reducing peak demand during a heat wave in July 2019 by calling on about 500 Powerwall batteries.[66]

CONSIDERATIONS FOR FUTURE MEASURE POTENTIAL

TRENDS AND CHALLENGES IN THE INDUSTRY

The battery market is growing quickly, but barriers exist, including regulatory uncertainty and costs. The solar plus storage market is emerging across the country with great variance depending on influence of natural disasters,

regulatory push (or pull), utility interests, local energy costs, and local state incentives.[67] In the emerging market, residential battery deployment outpaced utility battery deployment in Q1 2018.[68] While residential battery development has increased, there is still a lack of uniformity in national interconnection and permitting requirements.[69] There is also significant regulatory uncertainty in the energy storage industry, which is consistently cited as one of the primary barriers to increasing energy storage deployment.[70]

Some of the most notable utility programs for customer sited battery storage have successfully acquired participants and seem to be continuing. National Grid's DR program manager said that after a slow start in 2018, the "Bring-your-own-battery" program gained some traction with customers responding to an average of 40 events through the season.[71] Furthermore, the program is expanding and continuing in Massachusetts.[72] In Vermont, GMP has 13 to 14 MW of distributed, small-scale residential batteries on its grid, and about 100 MW of peaking facilities.[73]

MARKET ACTORS AND PLAYERS

Some key market actors include the following manufacturers and vendors:[74]

- Tesla
- Sonnen
- OutBack Power
- SunPower
- Sunnova

MARKET PENETRATION

Low, but growing

Residential storage deployments grew through Q2 2020 and estimates 1000 to 2000 MW of deployment in the U.S. annually from 2023 to 2025.[75]

In 2019, Green Mountain Power had 2,000 customers install Powerwalls (Tesla Powerwall program) and another 500 batteries were installed through their Resilient Home Pilot. The pilot is testing the effectiveness of batteries as an advanced metering tool, and a "bring-your-own-device" pilot. The BYOD program incorporates other energy storage brands as well (e.g., Sonnen and LG Chem).[76]

POTENTIAL FOR ADOPTION

Moderate to high

Battery storage is particularly salient during the conditions created by COVID-19 as energy resiliency gains more prominence with people spending time at home. Given the marked increase in people working from home, having reliable electricity with a battery backup is becoming increasingly important.[73]

A 2018 Energy Management study conducted by Deloitte demonstrated that 49% of residential customers who did not already have solar panels on their homes would be interested in installing rooftop solar and battery storage, and this number is growing.[77]

However, the cost of battery storage may still be prohibitive. For instance, GMP customers pay $5,500 for two Powerwall batteries or $55 per month for ten years.[73]

POLICY CONSIDERATIONS

Other states are supporting the battery storage market in different ways, which may inform Wisconsin's approach moving forward. Massachusetts utilities will begin offering EE performance incentives for behind-the-meter active demand reduction measures, including battery storage, which may provide a valuable case study for the final task of this research.[72] And as of June 2020, National Grid was seeking regulatory approval to use customer-sited batteries and inverters to help manage local grid problems or serve as non-wires alternatives to distribution grid investments. It has received approval to allow batteries to export power to the grid, rather than simply zero out home energy usage, boosting their value as demand-response assets.[71] California initiated a solar mandate that "requires all new homes under three stories install solar panels — a first for the nation — the codes help to incentivize energy storage and include a host of EE upgrades that will collectively slash energy use in new homes..." [78] While California may not be generalizable to Wisconsin, this notable policy may facilitate driving down technology costs, helping drive adoption in other states.

The applicability of these programs and regulations to Wisconsin may depend on Wisconsin's current interconnection rules and permits, which vary across the country.

EFFICIENT CLOTHES WASHERS

KEY FINDING

Efficient clothes washers provide proven energy savings, in addition to providing non-energy benefits such as water savings. Manufacturers may begin to offer connected efficient clothes washers, which could represent an opportunity for integrated EE/DR, where Focus on Energy could support annual energy savings for connected-and-efficient clothes washers and utility programs could deliver load shifting with the newly adopted clothes washers. However, the technology and market for integrated EE/DR with connected-and-efficient clothes washers is emerging and behind that of smart thermostats and water heaters.

MEASURE DESCRIPTION

CATEGORY	MEASURE DETAILS
Description	Energy efficient clothes washers save energy within the appliance and by reducing dryer needs. Furthermore, efficient models may increasingly include connectivity and associated functionality, where connected clothes washers can receive, interpret, and respond to signals (customer or utility) by automatically adjusting its operation depending on both the signal's contents and settings from consumers.[79]
Segment	Residential
Load Shaping Value Proposition	Traditional EE measure with moderate deemed demand savings Potential future opportunity for integrated EE/DR partnership with utilities
Relevance for Load Shaping	*Recurring:* Established recurring energy savings with moderate demand savings
	Event-based: Currently limited, but potential future opportunity for event-based savings with integrated EE/DR for connected clothes washers
Priority Level (high/low)	Moderate – small market size for installations in common areas, but lower savings in SF applications and the technology and market for integrated EE/DR with clothes washers is behind that of smart thermostats and water heaters

PROGRAM AND SAVINGS DETAILS

METRIC	MULTIFAMILY COMMON AREA, ELECTRIC, ENERGY STAR
Program Years	2014 through 2017
Measure Unit	Per clothes washer
Energy & Demand Savings	
Program Data Energy Savings per Unit (kWh/yr)	Median: 1971

	Range: 1971 - 1971
Program Data Demand Reduction (kW)	Median: 0.071 Range: 0.071 - 0.071
Context Outside of WI	The IL TRM estimates a maximum coincident demand savings of 0.03 kW for their SF application of this measure. As more efficient clothes washer models become connected, savings may become more closely tied to consumer behaviors, rather than the technologies themselves.[80]
Current Program Performance	
Participation by Program	• Multifamily New Construction: 5 • Multifamily Energy Savings: 31
Total Claimed Demand Savings (kW)	Multifamily New Construction: 0.355 Multifamily Energy Savings: 2.201
Measure Costs and Useful Life	
Focus TRM 2020 Effective Useful Life (years)[4]	11
Typical Average Cost ($/unit)	Varies: typical cost of $940[81]
Focus TRM 2020 Incremental Cost ($/unit)	$325.40
Non-Energy Benefits	
Notable Non-Energy Benefits	• Time savings. Less drying time required when using high spin wash cycles. • Water savings. ENERGY STAR certified clothes washers use 33% less water than conventional clothes washers.[82] • Connected devices add convenience. Washer can send notifications when laundry is done. Washer can occasionally tumble clothes to prevent clothes from smelling of mildew (when end user is away and forgot to remove clothes from laundry). Some washers offer remote and/or delayed start cycles.

CONSIDERATIONS FOR FUTURE MEASURE POTENTIAL

TRENDS AND CHALLENGES IN THE INDUSTRY

Efficiency of clothes washers has steadily increased, with current washers saving 5% and 7% for front loading and top loading models respectively.[80]

Manufacturers may be pursuing “smart” or “connected” appliances in combination with efficiency.

MARKET ACTORS AND PLAYERS

Clothes washers make and model information were not available in the Focus on Energy program data provided to ILLUME. However, ENERGY STAR reports that the most efficient clothes washers in 2020 are made by the following brands: 1) Electrolux, 2) Kenmore, 3) LG, and 4) Samsung.[81]

Major retailers will play an important role in selling clothes washers. In 2013, 68% of major appliance sales were by Sears, Lowes, Home Depot, and Best Buy.[83]

MARKET PENETRATION

High for efficient clothes washers, but low for connected washers

ENERGY STAR washing machines have high market share in the U.S., with 66% market penetration in 2013. Despite significant market penetration, sales of ENERGY STAR front loading washers decreased to 30% of machines sold in 2014.[80]

POTENTIAL FOR ADOPTION

Low to moderate for efficient clothes washers and for connected clothes washers

The market may largely be transformed for efficient clothes washers, meaning rebates from Focus on Energy may have diminishing impact on the market. In other words, customers who could be persuaded with a rebate to buy an efficient clothes washer may buy one without the rebate. That said, Focus on Energy could pursue adoption among other customers through innovative marketing efforts. For example, while high efficiency washers have become more common, some consumer misconceptions persist. One common misconception is that older model clothes washers that use more water do a better job cleaning. Consumer preference has also been a challenge. Despite being less efficient, many consumers still prefer top-loading units because clothes washers were historically top-loading.[80]

Barriers to adoption of efficient front-loading washers include:

- Longer cycle times. Most of the high scoring high efficiency top-loaders tested took 60 to 90 minutes to do an 8-pound load while front-loaders took 75 to 100 minutes to do the same[84]
- Access. Loading a front-loading clothes washer requires a lot of bending and thus a barrier to adoption for some customers, and front-load washers may not allow for mid-cycle access[85]
- Cost. Front-loaders cost $100-$200 more than high-efficiency top-loaders[80]
- Mold. Mold can form around the front-loading gasket[86]

On the other hand, for connected washers, the barriers for adoption may represent the typical barriers for emerging technologies (e.g., unclear value proposition and cost). Focus on Energy could potentially spur the market for connected water heaters.

POLICY CONSIDERATIONS

Connected devices represent an opportunity for Focus on Energy to help increase market penetration for DR-ready appliances while saving energy. However, this approach touches on a gray area regarding Focus on Energy's policy manual. Focus on Energy is prohibited from directly supporting DR.[17] Furthermore, in our research, we were not

able to uncover strong examples demonstrating successful interoperability of dispatchable DR and clothes washer software, although some protocols exist to facilitate interoperability.[79,87]

With regards to efficient clothes washers, the Department of Energy (DOE) recently proposed to establish a separate product class for top-loading residential clothes washers that offer cycle times for a normal cycle of less than 45 minutes.[88] If approved, this policy change would essentially exclude top-loading clothes washers from EE or water use standards, and as a result, EE programs could fill the void and discourage customers from purchasing inefficient washers.[89]

HIGH FREQUENCY BATTERY CHARGERS FOR LIFT-TRUCKS

KEY FINDING

High frequency (HF) battery chargers represent an opportunity for Focus on Energy to use EE to help manage the load of an electrifying end-use. Businesses across the U.S. are adopting electric lift-trucks where applicable over gas or diesel lift-trucks, because electric lift-trucks provide long term financial benefits due to reduced maintenance and fuel costs, safer work environments (i.e., reduced noise and air pollutants), reduced carbon emissions, and better maneuverability.[90,91] Each electric lift-truck adds load to the grid, and where possible, EE programs can minimize the additional load with efficient charging. At a minimum, this measure could provide a research opportunity for Focus on Energy to better understand how EE can interplay with electrification in Wisconsin, where fuel switching is authorized within the Focus on Energy Policy Manual.

MEASURE DESCRIPTION

CATEGORY	MEASURE DETAILS
Description	HF battery chargers are used for portable industrial equipment like lift-trucks, forklifts, fork trucks, and airport transport equipment in factories, warehouses, and similar facilities.
Segment	Industrial
Load Shaping Value Proposition	Opportunity to pilot load management for electrifying end-uses
Relevance for Load Shaping	*Recurring:* Documented annual energy savings without demand savings in the Focus TRM 2020
	Event-based: Limited, but potential may exist for event-based savings in certain applications
Priority Level (high/low)	Low – mixed savings results in Midwest study and no deemed demand savings

PROGRAM AND SAVINGS DETAILS

METRIC	DETAILS
Program Years	2019 through June 2020
Measure Unit	Per kWh of battery charger capacity
Energy and Demand Savings	
Program Data Energy Savings per Unit (kWh/yr)	Median: 1,292 Range: 554 – 1,860 (varies by battery capacity, efficiency, and HOU)

Program Data Demand Reduction (kW)	0
Context Outside of WI	• The IL TRM suggests that efficient battery chargers save coincident demand in certain applications, specifically for 3 and 4 shift operations (i.e., 24 hour/ day operations).[31] • A MN CARD study found variable energy savings for efficient battery chargers.[92]
Current Program Performance	
Participation by Program	• Business and Industry: 1 • Large Energy User: 19 (2 projects)
Total Claimed Demand Savings (kW)	0
Measure Costs and Useful Life	
Focus TRM 2020 Effective Useful Life (years)	15
Typical Average Cost ($/unit)	$2,800[93]
Program Data Incremental Cost ($/unit)	$400
Focus TRM 2020 Incremental Cost ($/unit)	$400
Non-Energy Benefits	
Notable Non-Energy Benefits	• Increased productivity and reduced labor costs. With HF chargers, batteries do not have to be changed between shifts or at the end of the day.[92] • Improved safety. Reduced risk of injury associated with battery change-outs, and reduced risk of vehicle collisions in battery changing areas.[92] • Parts and maintenance savings. Better part protection and reduction of extra battery purchases.[92] • Battery and part protection. Batteries are less likely to go below 20% of charge capacity, which can damage batteries, brushes, and connection points.[92]

CONSIDERATIONS FOR FUTURE MEASURE POTENTIAL

TRENDS AND CHALLENGES IN THE INDUSTRY

Electric lift-trucks are gaining market share, which may be driven in part by economics, worker safety, and environmental regulations.[94,95]

However, it is unclear whether HF chargers are well-suited for applications in the northern Midwest or whether other efficient charging technology may emerge that is better suited for the northern Midwest. For example, the

operating hours for lift-trucks in the northern Midwest may be more sporadic than in other regions of the country, which could affect HF charger savings.[92]

MARKET ACTORS AND PLAYERS

Leaders in HF battery chargers include:[95]

- Crown Equipment Corporation
- ABB
- Raymond Handling Concepts Corporation
- Douglas Battery
- GS Yuasa International Ltd.
- ENERSYS
- AMETEK, Inc
- Hitachi Ltd
- SEVCON (BorgWarner Inc.)
- Storage Battery Systems, LLC
- Lester Electrical

MARKET PENETRATION

Moderate and growing.

A 2009 assessment report estimated that HF chargers were about 10% of California's charging stock and increasing.[93]

POTENTIAL FOR ADOPTION

Moderate

Demand for chargers for electric lift-trucks is growing, but it is unclear whether HF chargers or other technology represents the best opportunity for EE programs.

POLICY CONSIDERATIONS

HF battery chargers could provide both an opportunity to use EE to help manage the load of an electrifying end-use and a research opportunity for Focus on Energy to better understand how EE can interplay with electrification in Wisconsin. Both opportunities touch on a sensitive area for most EE programs – fuel switching. While the Focus on Energy policy manual allows fuel switching in cases that meet certain criteria,[36] Focus on Energy should coordinate with stakeholders around any efforts that touch on fuel switching.

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