Intelligent Efficiency and Utility Programs

Reports from the Midwest

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MEEA
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MEEA's Role

MEEA is a collaborative network advancing energy efficiency in the Midwest for sustainable economic development and environmental stewardship. MEEA seeks to keep its members and the public informed about important trends, facilitate meaningful dialogue and serve as a catalyst for market transformation through collaborative pilots. With this paper, MEEA hopes to encourage an ongoing conversation on how intelligent efficiency is changing the way energy savings are identified, captured and measured in the Midwest. While this report only highlights a few regional examples, MEEA looks forward to featuring new efforts in future reports.

Executive Summary

Recent advances across a wide-ranging spectrum of technology are creating significant new opportunities in the energy efficiency landscape. The Midwest Energy Efficiency Alliance (MEEA) expects this evolution to rapidly and fundamentally change the ways energy efficiency is identified, achieved and measured in the Midwest. The term intelligent efficiency, while broad, refers to the growing number of products, software applications, services and systems that are enabling not only the collection and analysis of large quantities of data, but also the remote or automated control of energy-consuming devices and processes. By leveraging information and control technologies to create networks of sensors and connected devices, intelligent efficiency solutions enable more system-level savings, greater end user engagement, the creation of dynamic baselines, real-time savings measurement and the continuous commissioning of equipment.

A key aspect of intelligent efficiency solutions is their ability to create multiple value streams for both energy consumers and efficiency program managers. Non-energy benefits such as production efficiencies, deeper insights into building systems, enhanced safety, automated control, convenience and even status may be leading drivers of market adoption. While this creates some complexity for efficiency program efforts, it also offers the opportunity to leverage these benefits to enhance energy efficiency. Similarly, intelligent efficiency solutions can streamline efforts at the utility or municipal level to increase efficiency and capture new savings.

MEEA has been prompted by its network of members to provide insights into regional intelligent efficiency trends. While it is difficult to discuss the full extent of these trends in one report, MEEA hopes to encourage an ongoing discussion on the opportunities and challenges associated with intelligent efficiency and identify ways Midwest efficiency stakeholders can more effectively collaborate on market transformation goals. A number of Midwest utilities and municipalities are pursuing innovative program models based on intelligent efficiency technologies and are already capturing deeper savings as a result. At the same time, there is ample opportunity for regional energy efficiency stakeholders to lead in this area; for example, the Midwest's unique position as a national manufacturing hub lends great potential for the advancement of smart manufacturing techniques as a strategy for not only capturing previously unattainable levels of industrial energy efficiency, but also promoting cost competitiveness and production benefits.

For this report, MEEA surveyed Midwest energy efficiency programs and initiatives promoting or utilizing a range of emerging technologies, conducted a literature review and held interviews with over 20 representatives from utilities, program implementers, manufacturers, solution providers and other relevant stakeholders. This report provides a brief overview of several major areas of intelligent efficiency at the residential, commercial, industrial and municipal levels and highlights notable efforts across the region. The report also synthesizes from interviews the main market barriers to these solutions and offers a number of general recommendations for the Midwest energy efficiency community.

Introduction

Energy efficiency stakeholders across the country are grappling with a wave of new products and platforms, and the accompanying flood of data and new capabilities is poised to change the Midwest efficiency program landscape. To better understand these trends, the Midwest Energy Efficiency Alliance (MEEA) conducted a literature review, surveyed Midwestern energy efficiency programs at the utility, state and local levels and held over twenty targeted interviews with representatives from energy utilities, manufacturers, program implementers, research organizations and local government.

What is Intelligent Efficiency?

In recent years, a groundswell of technology innovation has permeated energy efficiency markets and begun to change how programs and services are structured, implemented and evaluated. New products embedded with data collection, communication and anticipatory or learning capabilities hold the potential to revolutionize energy efficiency efforts across all building types and customer segments. Recently, the American Council for an Energy-Efficient Economy (ACEEE), Northeast Energy Efficiency Partnerships (NEEP) and others have helped define this relatively nascent industry niche and provide spaces for utility representatives, product manufacturers, program managers and service providers to discuss the latest innovations and their implications for efficiency.[1,2]

> *The chief advantage of these solutions is that they enable multiple value streams and a more holistic approach to energy savings.*

In short, intelligent efficiency "takes the friction out of implementing energy efficiency," and enables a more systems-based approach to identifying, achieving and measuring energy savings.[3] This approach relies on modern information and control technologies to collect and interpret large amounts of data in order to improve upon energy-consuming processes.[4] In practice, this can take many shapes. For example, it can be a residential device that automates the control of heating and cooling systems, or an advanced data analytics platform that allows a utility to improve customer engagement and satisfaction. It can also be a network of machines on a factory floor that continually optimizes output and energy consumption while providing production managers with timely updates of equipment status.

Beyond helping us achieve deeper energy savings, the chief advantage of these solutions is that they enable multiple value streams and a more holistic approach to energy savings. In many

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[1] American Council for an Energy-Efficient Economy (ACEEE) website. *Intelligent Efficiency*. www.aceee.org/topics/intelligent-efficiency
[2] Northeast Energy Efficiency Partnerships (NEEP) website. *Home Energy Management Systems*. www.neep.org/initiatives/high-efficiency-products/home-energy-management-systems
[3] Ethan Rogers, 2016 ACEEE Intelligent Efficiency Conference (oral presentation)
[4] Rogers, E. et al. 2013. *Intelligent Efficiency: Opportunities, Barriers, and Solutions*. ACEEE. Report No. E13J.

cases, energy efficiency is not the leading driver of adoption, and the same is often true for the utility or program administrator. MEEA interviewed a utility program manager who saw current trends in intelligent efficiency as beneficial beyond device-level energy savings: "These new technologies and systems are so much more than a new program measure... they can serve as critical gateways for a utility into a customer's home or business." A utility could use this kind of insight for much more than helping a customer save energy. A different representative added that "the most valuable utility infrastructure of the future won't be poles or wires, but data."

> *"The most valuable utility infrastructure of the future won't be poles or wires, but data."*

The term intelligent efficiency does not imply existing efficiency efforts are not intelligent. Rather, intelligence as used here refers to efficiency solutions that are "adaptive, anticipatory and networked."[5] Such solutions use real- or near-time data and communication to provide deeper feedback, more timely information, tighter control of energy-using devices or systems and smarter automation. For example, an advanced building management system relying on an integrated system of thousands of sensors can achieve continuous commissioning by simultaneously measuring performance at all building points, reporting faults to operators, making recommendations for improvement and automatically calculating energy and cost savings.

Intelligent efficiency also does not imply artificial intelligence. For most of these solutions, humans are still the essential element, but technology has enabled them to make better and faster decisions. One solution provider noted that "these new technologies will not replace smart people, but will make smart people a lot more effective at identifying and achieving energy savings."

Finally, while some intelligent efficiency products and solutions have successfully entered the market without the influence of the energy efficiency community, many emerging technologies will require dedicated market transformation efforts. As one technology expert said: "Rather than change the energy efficiency landscape overnight, most solutions will undergo a slow and incremental evolution." As this report will discuss, many solutions face significant market barriers. The good news is the energy efficiency industry is well versed in market intervention techniques. Unsurprisingly, the industry leaders interviewed for this project were eager and equipped with creative strategies for overcoming the inertia of the status quo.

Reports from Midwestern Programs

The following section provides an overview and examples of Midwestern intelligent efficiency efforts in five technology areas: Home Energy Management Systems, Commercial Advanced Lighting Controls, Energy Management Information Systems, Smart Manufacturing and Smart Cities.

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[5] Elliott, N., Molina, M. & Trombley, D. 2012. *A Defining Framework for Intelligent Efficiency*. ACEEE. Report No. E125.

Home Energy Management Systems

The term Home Energy Management Systems (HEMS) has recently emerged as a popular term for this discrete residential technology group. The HEMS Working Group, a collaborative of program managers and manufacturers led by NEEP and the Home Performance Council, defines HEMS as "any hardware and/or software system that can monitor and provide feedback about a home's energy usage, and/or enable advanced control of energy-using systems and devices in the home."[6]

Many utility HEMS efforts are still emerging and currently focus on promoting devices that offer basic feedback, better HVAC system management and access to demand response programs. However, the appeal of HEMS to energy efficiency practitioners should go well beyond their relative capacity to save energy. An intelligent efficiency device or system can serve not just as a data collection tool and a window into a customer's home, but also as a critical two-way linkage between the utility and their customers. Many of the interviewed program managers described their current efforts as "step one" and were eager to begin piloting various alternative HEMS use cases. The following graphic illustrates the range of potential future use cases for HEMS devices and platforms. As the range of uses expands, the value to the utility, customer and grid could increase. [7]

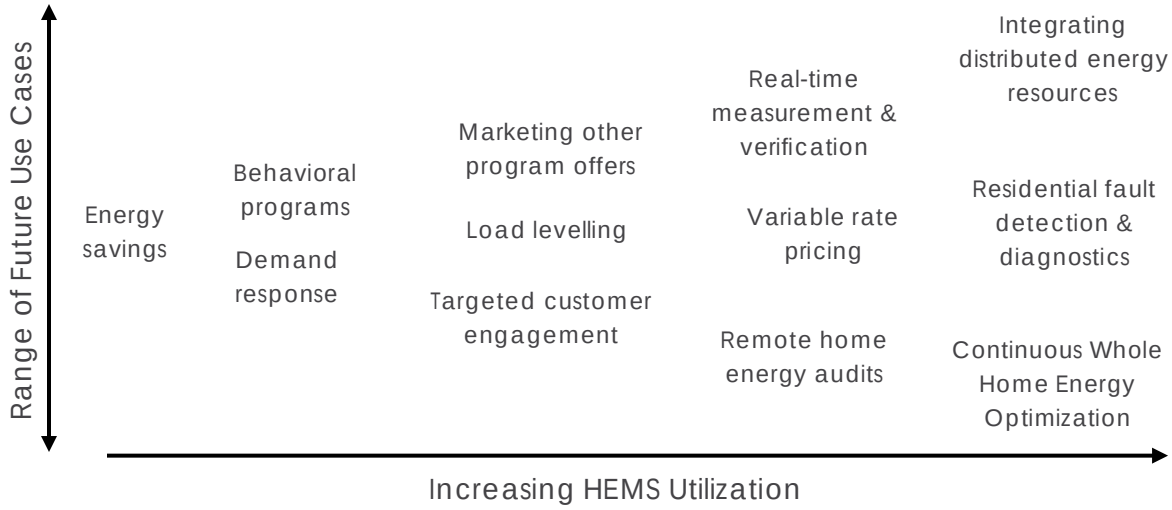

Figure 1: Potential Future Utility HEMS Use Cases

Currently, among the many types of products and solutions in HEMS, at least two-thirds of consumers are aware of smart thermostats and smart lighting, but awareness is very low for a host of other smart household devices. Ownership rates are much lower and are concentrated

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[6] NEEP. 2015. *Opportunities for Home Energy Management Systems (HEMS) in Advancing Residential Energy Efficiency Programs*.

[7] Use cases from MEEA interviews and [U.S. Department of Energy. 2016. *Overview of Existing and Future Use Cases for Connected Thermostats*. Prepared by Energetics Inc. & Vermont Energy Investment Corporation.]

in higher-income urban areas, but this varies by device type.[8] Complicating utility program efforts is the fact that energy savings are not always the leading value proposition for consumers, even for energy-related devices. Convenience, security, novelty and status remain priorities for many early adopters, and the vast majority of HEMS products sold to date have been purchased through online or brick-and-mortar retail channels or bundled with security packages, not through utility or energy services.[9] These trends, combined with the rapid pace of new product innovation, have created a confusing landscape for energy efficiency program stakeholders. While some new products and services will require calculated market lift efforts (push strategies), other product types have already passed early adopter stages and can be leveraged to create energy savings opportunities as homeowners bring them into their homes (pull strategies).[10]

Convenience, security, novelty and status remain priorities for many early adopters.

Despite the visibility of smart thermostats, most HEMS solutions have yet to gain traction in the Midwest. For example, several representatives from the technology firms MEEA interviewed noted the promise of smart water heaters, but currently consumer awareness is very low. With this emerging technology group, energy savings are realized through tighter control of setbacks, usage prediction and learning capabilities, user-friendly mobile interfaces and holistic integration with smart thermostats and other HEMS devices. This should interest energy efficiency program managers for two reasons. First, although electric water heaters present many opportunities, water heating represents a common gas savings opportunity in a field of solutions aimed primarily at intelligent control of electric devices. Second, like smart thermostats, smart electric water heating is well suited to serve as the point of integration between energy efficiency and demand response programs. Manufacturers such as Rheem and Whirlpool currently have smart water heaters in production, while other companies such as Aquanta and General Electric offer intelligent control systems that can be added onto existing water heaters.

Another area of interest is residential smart lighting. Efficiency Vermont recently released the results of a pilot that suggests homeowners may dim lights more often if given the chance with smart lighting products.[11] This is an unexpected energy saving opportunity that could be incorporated into energy efficiency or even demand response programs in the near future. Another important finding is that study participants were generally satisfied with the products and were able to install and configure them largely on their own. Technology firms interviewed for this report indicated that smart lighting products currently requiring a communications hub

[8] Miziolek, C. 2016. *The Smart Energy Home: Strategies to Transform the Region*. NEEP.
[9] Strother, N. 2016. *Smart Home Products Resonate with Consumers*. Navigant Research. navigantresearch.com/blog/smart-home-products-resonate-with-consumers-and-utilities-should-take-note
[10] Miziolek, C. 2016. *The Smart Energy Home: Strategies to Transform the Region*. NEEP.
[11] Note: The dimming results were not statistically significant. Reference: Bonn, L. & Rivest, J. 2016. *Smart Lighting & Smart Hub DIY Install: Does it Yield?.* Efficiency Vermont.

are likely to be phased out in 2017 in favor of hubless systems where bulbs communicate directly with each other and the user via Bluetooth and/or Wi-Fi.

KCP&L Residential Thermostat Program

Kansas City Power and Light (KCP&L), with over 800,000 customers in 47 northwest Missouri and eastern Kansas counties, has been a regional leader in thermostat-centric energy efficiency programs for a number of years. Recently, they began strategically integrating their energy efficiency and demand response program portfolios for residential and commercial customers in the hope of multiplying demand side management impacts and customer satisfaction.
These efforts began in 2005 with Energy Optimizer, a residential and commercial direct load control program that utilized Honeywell programmable thermostats capable of receiving one-way signals from the utility in order to remotely curtail space conditioning energy use. The program expanded and evolved through the years, adding two-way programmable thermostats in 2013 for a total of 75,000 installed devices by 2015 under a new name, the "KCP&L Programmable Thermostat Program."[12] After a 2015 pilot with the Electric Power Research Institute (EPRI) confirmed the ability of a new generation of smart thermostats to reduce both summer peak demand and household energy consumption, KCP&L announced a new partnership with Nest and CLEAResult.[13]

With this new program, KCP&L will purchase and install 23,000 Nest Learning Thermostats over three years at no cost to the customer. To make early distribution and program enrollment easier, they are marketing the new program first to customers with programmable thermostats installed under previous iterations of the program. Participants can choose between a free installation, a $50 incentive for do-it-yourself installation (DIY), or a "Bring Your Own Thermostat" (BYOT) option, where customers can enroll their own Nest Learning Thermostat and earn a $100 incentive. All participants receive a $25 annual incentive for continued enrollment and 24/7 device maintenance and customer support.
Participants are then enrolled in Rush Hour Rewards, Nest's residential demand response program, which fine-tunes heating and cooling set points during peak events to trim power needs by an estimated 1.2 kW per thermostat. This translates to an estimated 55% cooling load reduction. Also, over 450 kWh are expected to be saved annually through more automated set point control during non-peak times.[14]

The DIY and BYOT options are exciting innovations in the Midwest HEMS space; a limited number of utilities across the country have experimented with these strategies to date.[15] These features not only reduce program implementation costs by 40% and substantially increase the speed of

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[12] Brown, T. 2016. *Smart Thermostats: The Newest, Latest, and Next in Program Strategy*. KCP&L. aceee.org/sites/default/files/pdf/conferences/mt/2016/Brown_MT16_SessionC2_3.21.16.pdf
[13] KCP&L website. *Receive a Free Nest Learning Thermostat*. www.kcpl.com/save-energy-and-money/for-home/upgrade-your-home/thermostat/receive-a-free-nest-learning-thermostat
[14] Brown, T. 2016. *Smart Thermostats: The Newest, Latest, and Next in Program Strategy*. KCP&L. aceee.org/sites/default/files/pdf/conferences/mt/2016/Brown_MT16_SessionC2_3.21.16.pdf
[15] Tweed, K. 2013. *SCE Rolls Out Bring-Your-Own-Thermostat Concept*. Greentech Media. www.greentechmedia.com/articles/read/sce-rolls-out-bring-your-own-thermostat

participant enrollment, but also expand the pool of potential participants to include customers that already have a device or would prefer to purchase on their own through a different retail channel. Combined with a strong marketing campaign and an exceptionally lucrative basic offer ($249 value plus free installation), these options have accelerated program enrollment so quickly that KCP&L is now considering ways to either control growth or revise program goals. Proving DIY options is a valuable lesson for HEMS program managers, especially as new, smart devices gain popularity largely outside of the efficiency program landscape.

This program is also innovative in its integration of energy efficiency savings and demand response capabilities. Nest, ecobee, Honeywell, Schneider Electric and several other companies offer smart thermostats that facilitate this synergy. After years of program experimentation with thermostats, KCP&L recognizes that these devices can be more than energy saving measures. In fact, they can catalyze a transformation of the utility-customer relationship, provide critical customer insights and help link together a portfolio of programs for the benefit of both the customer and utility.[16]

ComEd Million Thermostats

The Million Thermostats program, launched in late 2015, is a collaborative effort of Commonwealth Edison Company (ComEd), Nicor Gas, Peoples Gas, North Shore Gas, several thermostat manufacturers and several industry advocates. The program aspires to deploy one million smart thermostats by 2020, and even with approximately 3.8 million ComEd customers across northern Illinois, the program's volume alone makes it worthy of recognition.

The Environmental Law & Policy Center (ELPC) played a key role in convening the large stakeholder group responsible for the initiative, including utilities, program implementers and the Illinois Citizens Utility Board. ComEd and partners then took on the challenge with a high level of executive support and involvement. In 2015, the utility was incentivizing around 2,000 mostly programmable thermostats annually. As they were already an early innovator in demand response and dynamic pricing, they were eager to enter more fully into the HEMS space. ComEd representatives have noted an increasingly urgent need to identify new sources of residential energy savings as the pool of potential savings associated with lighting measures is depleted.[17] The new program was originally expected to save 300 kWh per home annually.

After one year, this is ComEd's fastest moving program, with over 41,000 customers participating.[18] A notable departure from the KCP&L model, this program incentivizes a range of devices on a qualified products list that includes the Nest Learning Thermostat, ecobee3,

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[16] Walton, R. 2016. *'The house becomes a battery': Inside KCP&L's thermostat program*. Industry Dive. www.utilitydive.com/news/the-house-becomes-a-battery-inside-kcpls-thermostat-program/431289/
[17] Savenije, D. 2015. *ComEd targets 1M smart thermostats by 2020.* Utility Dive. www.utilitydive.com/news/comed-targets-1m-smart-thermostats-by-2020/407083/. This was also mentioned during interviews.
[18] Tweed, K. 2015. *Illinois Aims for 1 Million Smart Thermostats.* Greentech Media. www.greentechmedia.com/articles/read/illinois-aims-for-one-million-smart-thermostats

Honeywell Lyric, LUX/GEO and others. These devices rely on a variety of strategies to optimize occupant comfort while reducing energy consumption such as geofencing, wireless remote sensors or learning to anticipate occupant schedules.[19] The standard rebate offer for all devices is $100, but the ecobee3 can be obtained for $150 with a free installation when bundled with a home energy assessment. Customers can then receive up to an additional $40 if they enroll in ComEd's AC Cycling program (Nest Rush Hour Rewards).

As with all smart thermostat utility programs, it is likely that marketing efforts have, to some extent, been buoyed by growing general awareness of the devices. Although region-specific data was not available, in 2015 approximately 45% of national smart thermostat sales took place through retail channels, compared to15% via utilities.[20] However, integration with other program offerings, such as home energy assessments, has contributed.

The utility of the future may serve as a one-stop shop for a range of HEMS devices and solutions.

ComEd's new online Marketplace (currently in a beta version), a product of their recent partnership with Simple Energy, may also prove effective in promoting HEMS devices, although it is currently managed outside the energy efficiency portfolio. Via the Marketplace, ComEd customers can purchase energy-saving smart home products such as smart thermostats, advanced power strips and connected lights, and also products with no obvious energy efficiency benefit such as smart locks, security cameras and connected carbon monoxide alarms.[21] This model as the utility as a one-stop shop for a range of smart home products, including products not directly related to energy savings, is a novel idea in the Midwest but seems to fit within ComEd's strategic plan to become a more holistic customer service platform, an integrator for third party providers and an overall smart grid facilitator.[22]

DTE Insight

In 2011, Detroit-based DTE Energy reassessed their energy efficiency portfolio and found their customers increasingly likely to take advantage of third-party energy management services and applications. They felt these interactions could lead to numerous energy efficiency actions being taken outside of utility programs, resulting in missed opportunities in program participation and utility-customer experience. Wanting to stay relevant to customers comfortable with modern technology and take advantage of the opportunities this presented, DTE Energy partnered with Vectorform to develop a utility-specific HEMS application. The DTE Insight app

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[19] Geofencing uses GPS or RFID signals to define a geographic boundary and alert a device when your phone crosses in or out of such boundary. Please see http://whatis.techtarget.com/definition/geofencing.
[20] Parks Associates. 2015. *Over 40% of thermostats sold in 2015 will be smart thermostats*. www.parksassociates.com/blog/article/pr0715-smart-thermostats
[21] Unger, D. 2016. *Utilities embrace e-commerce in bid to boost efficiency*. Midwest Energy News. midwestenergynews.com/2016/12/02/utilities-embrace-e-commerce-in-bid-to-boost-efficiency/
[22] Bade, G. 2016. *Chicago's REV: How ComEd is reinventing itself as a smart energy platform*. Industry Dive. www.utilitydive.com/news/chicagos-rev-how-comed-is-reinventing-itself-as-a-smart-energy-platform/416623/

was launched in 2014 and found quick success. As of late 2016, the app had over 200,000 downloads, 100,000 unique users and an active user retention rate of 65%. For reference, the average app user retention rate across all industries in 2015 has been reported to be 25%.[23]

The app is essentially a mobile-friendly energy dashboard customized for DTE Energy residential customers with a smart meter. It can display energy use in a variety of formats, including electricity and gas (for customers with an AMI-enabled gas meter) consumption in daily, weekly, monthly and yearly formats. Through the app, customers can request a free, optional hardware device called an Energy Bridge that will connect the app to their smart meter and display real-time, whole-building power consumption data. The app features efficiency tips, ENERGY STAR® product comparisons and several gamification components like points-based challenges, rewards and personal goalsetting meant to nudge users to take conservation actions or utilize product rebates and other DTE Energy programs.[24] Also included is the PowerScan tool, which allows iPhone users to scan the power cord of electrical appliances and estimate monthly operating costs.

The DTE Insight app has been found to yield 1% electric and 2% gas savings, but it also contributes significantly to participation in other energy saving programs such as Home Energy Surveys and Appliance Recycling.[25,26] Although the Energy Bridge is an optional add-on, the access to real-time energy data it enables can lead to increased user engagement and more energy-saving behaviors. A recent evaluation found the average incremental energy savings associated with the Energy Bridge to be 3.2%.[27]

The development of the app offers insights into the tradeoff between building a custom solution or buying a third-party service. Creating the app required a large amount of resources at DTE Energy and the ongoing technical support needed to maintain a highly integrated platform called for dedicated IT teams and substantial investment. Although DTE Energy now feels they have a vital HEMS offering tailor-made to their customer base, they also recognize that this may not be the desired route for other utilities. In response, they created Powerley, an independent company that will help utilities implement the Insight app as a HEMS platform. Central to this new third-party effort is the Powerley Energy Bridge which goes beyond DTE Insight to act as a hub for many different smart home products, facilitate the disaggregation of whole-home energy usage data and provide deeper insights that foster more pro-efficiency and conservation behaviors.[28] In short, Powerley aims to bundle DTE Energy's lessons learned over several years of app

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[23] Perro, J. 2016. *Mobile Apps: What's A Good Retention Rate?* Localytics. http://info.localytics.com/blog/mobile-apps-whats-a-good-retention-rate
[24] DTE Insight website. 2016. www2.dteenergy.com/wps/portal/splashpage/DTE%20Insight/
[25] Navigant. 2015. *DTE Insight Smartphone App*. www.michigan.gov/documents/mpsc/DTE_Insight_MEMD_White_Paper_06012015_491804_7.pdf
[26] Navigant. 2016. *DTE Insight: App Gas Savings*. www.michigan.gov/documents/mpsc/DTE_Insight_Gas_App_522661_7.pdf
[27] Navigant. 2016. *DTE Insight: Energy Bridge Electric Savings*. Prepared for DTE Energy. www.michigan.gov/documents/mpsc/DTE_Insight_Electric_Energy_Bridge_522660_7.pdf
[28] Powerley website. 2016. www.powerley.com/

development, hardware troubleshooting, marketing and program implementation with new HEMS capabilities and replicate the Insight program cost-effectively across the country.

Commercial Advanced Lighting Controls

National market growth of light emitting diode (LED) lighting in residential, commercial and outdoor applications has been strong for many years, and will likely continue. However, a substantial amount of attention at the utility program level is shifting to lighting controls so as to further reduce energy consumption and maximize occupant benefits. This area of technology, called Advanced Lighting Controls (ALC) or Networked Lighting Controls (NLC), is experiencing the greatest uptake in commercial applications. Although similar products have emerged for residential use, namely connected lighting devices that can be programmed, remotely controlled, color shifted or have sensing or reactive components, the most progress in terms of energy savings and program integration has been made with commercial ALC.

> *More intelligent lighting control is needed to realize the full extent of energy savings available.*

Similar to the concept of zone control in space conditioning, the basic purpose of ALC is to match lighting output (and thus energy use) to lighting need and curtail or eliminate all other output. Common control capabilities include occupancy sensing, daylight accommodation, personal control and task tuning, lumen maintenance, high-end trimming and reduced lighting power density at full output. In recent years, control systems have grown in capability, complexity and availability, and energy savings no longer represent the sole value proposition; for some building managers, the ability to provide the right type and level of light for specific applications, or enable remote control through sophisticated user interfaces, or integrate their building with utility-driven demand response programs are more valuable than energy savings.

More intelligent lighting control is critical to realizing the full extent of energy savings available. Lighting in the U.S. commercial sector consumes approximately 350 TWh annually, and the U.S. Department of Energy (US DOE) estimates that 100 TWh—or $10.4 billion annually—would be saved by ALC installed in all commercial buildings.[29] Substantial energy savings are possible even when controls are added to highly efficient fixtures. For example, an analysis of the Sacramento Municipal Utility District's (SMUD) Advanced Lighting Controls Program in 2013 attributed 55% of the total savings associated with LED/ALC retrofits to lighting upgrades, and 45% to controls.[30] Similarly, another recent demonstration of wireless ALC yielded 54% overall energy savings when controls were added to existing fluorescent lamps with dimmable ballasts, and 78% energy savings when ALC was paired with new LED fixtures.[31]

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[29] U.S. Department of Energy. 2016. *Commercial Advanced Lighting Control Demonstration and Deployment*. http://energy.gov/sites/prod/files/2016/04/f30/22299_Arnold_040616-1605.pdf
[30] Bisbee, D. 2014. *Advanced Lighting Controls Winners and Losers*. Sacramento Municipal Utility District (SMUD). www.mwalliance.org/conference/sites/default/files/pdf/MES_2014_presentations_Bisbee.pdf
[31] General Services Administration website. *Wireless Advanced Lighting Controls*. www.gsa.gov/portal/content/227563

Despite this potential, US DOE describes ALC as an "underutilized technology" experiencing "low market penetration."[32] They list the largest market barriers as a lack of familiarity among potential customers, installation and operational complexity, lack of standardization, high cost and lack of effective energy efficiency program designs.[33] Many of these market barriers are not unique to ALC, but proven programmatic solutions for combatting them have been slow to appear. Only a quarter of commercial buildings have some type of non-manual lighting control strategy (e.g., occupancy sensors, dimming), only 1-2% have some type of advanced or networked controls and the utilization rate of ALC in existing energy efficiency programs is less than 1%.[34] Another potential barrier is that many would-be early adopters may have also been first movers with LED retrofits unlikely to undertake another lighting upgrade soon.

In an effort to overcome these barriers, the DesignLights Consortium (DLC), an initiative of NEEP, created the Networked Lighting Controls (NLC) Program. This project seeks to increase market adoption of ALC by establishing an official technology specification, a Qualified Products List (QPL), a savings calculator, access to case studies and other resources for program managers, manufacturers and distributors. The new specification and QPL are likely to serve an important role in helping utility program managers across the country "understand, evaluate and compare Networked Lighting Control Systems," as well as take a substantial amount of guesswork out of designing cost-effective, high-quality programs centered on these products.[35]

AEP Ohio Advanced Lighting Controls Program

Several Midwestern electric utilities have taken steps to integrate ALC into their lighting programs. AEP Ohio has experimented with several program strategies and recently launched a new program encouraging lighting retrofits that include both LEDs and control packages. This effort began in 2013 with stakeholder consensus that demand for ALC was growing and lighting and control product manufacturers were able to meet the demand in Ohio. Early efforts were stymied, however, by a lack of contractor technical knowledge and fears over installation complexity. Many contractors provided inflated quotes to interested customers in order to hedge against increased uncertainty and risk.

To overcome this barrier, AEP Ohio shifted the incentive in 2015 for controls from final energy savings to facility square footage, drastically increasing the predictability of incentive amounts. This simplified the program, attracted new customers and contractors, and increased overall program cost-effectiveness. In 2016, incentive levels were adjusted down to compensate for

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[32] Arnold, G. 2015. *Commercial Advanced Lighting Control Demonstration and Deployment*. U.S. Department of Energy. www.energy.gov/sites/prod/files/2015/05/f22/cbi55_Arnold_041415.pdf
[33] Ibid.
[34] Arnold, G. & McCullough, J. 2016. *Commercial Advanced Lighting Control Demonstration and Deployment*. U.S. Department of Energy.
[35] DesignLights Consortium website. *Networked Lighting Controls QPL*. www.designlights.org/content/CALC/SpecificationAndQPL

recent price drops in LEDs, but participation has remained strong. Participants have reported 80-90% lighting energy savings associated with LED fixtures and advanced control retrofit packages, and in 2015, projects representing nearly two million square feet of buildings yielded over five million kWh in savings.

Program managers attribute a large part of their success to open and frequent communication between ALC manufacturers and trade allies. Throughout the process, AEP Ohio has leveraged a robust stakeholder network in order to evolve the program. Manufacturers, distributors and contractors in the AEP Ohio Solution Provider network have been invited to the table to share insight, concerns and suggestions through live webinars and in-person meetings.

One programmatic advantage offered by ALC and many other intelligent efficiency products is the ability to measure energy consumption in real time, which also enables faster calculation or modeling of energy savings. During the ALC pilot phase, AEP Ohio calculated actual energy savings from each project rather than make estimates based on industry data. Program managers hope to eventually use this data to shift ALCs entirely to a deemed savings system with a QPL, as making the program entirely prescriptive would reduce administration costs and customer reporting burden.

Energy Management Information Systems

Energy Management and Information Systems (EMIS) is a term applied to a "broad family of tools... [that] store, analyze and display energy use or building system data."[36] EMIS tools cater to different levels of building management; some focus on whole-building data useful for utility bill analysis or benchmarking (such as Energy Information Systems or EIS), while others focus on specific building components or groups of systems, such as with Building Automation Systems (BAS) or fault/anomaly detection systems. After a recent Nicor Gas pilot, a small commercial end user reported the greatest benefits of their EMIS to be remote access to building controls, more feedback from occupants, more rapid problem solving by service technicians and access to insights that could lead to energy savings.[37] The US DOE recently launched the Smart Energy Analytics Campaign to promote the adoption of EMIS technologies in commercial buildings and unite public and private stakeholders around market transformation strategies.[38] The following graphic adapted from a US DOE resource shows the taxonomy of various types of EMIS.

Performance monitoring or EIS seek to inform building owners and operators of overall energy patterns in ways that allow them to take efficiency or preventative maintenance actions. Much of the recent growth in EIS is a result of increased availability of low-cost sensors, the spread of building benchmarking requirements and performance reporting requirements at the federal, state and local level. A basic EIS typically offers straightforward meter data visualization and user

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[36] U.S. Department of Energy. 2016. *Smart Energy Analytics Campaign Glossary*. https://smart-energy-analytics.org/glossary/emis-energy-management-and-information
[37] Nicor Gas. 2016. *Small Commercial Building Public Project Report*. Emerging Technology Program.
[38] Smart Energy Analytics Campaign website. 2016. https://smart-energy-analytics.org/

interaction through dashboards, while newer "Advanced EIS" can layer in energy use models that account for weather and occupancy and measure savings from efficiency interventions. The median annual building portfolio savings enabled by EIS is estimated to be around 8%, enough to quickly recoup metering, sensor installation and software licensing fees.[39]

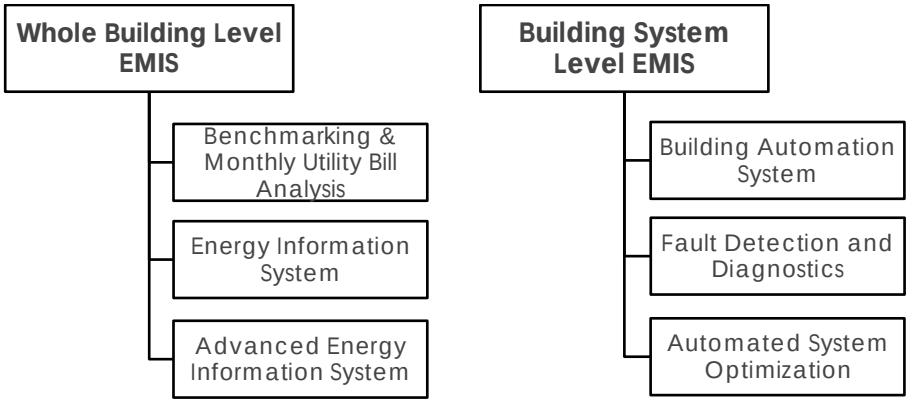

Figure 2: Energy Management Information Systems (EMIS)[40]

A step beyond the collection and presentation of energy data is the control of building systems such as HVAC, lighting, security and other critical building components. BAS is a mature technology group that relies on sensors, actuators and controllers with robust communications protocols in order to maintain occupant comfort, monitor safety systems and track key system performance metrics. Although BAS require greater investment in initial infrastructure and calibration, average reported energy savings range from 10% to 15% and significant maintenance cost savings are also common.[41]

Recent developments in intelligent building control technology such as fully wireless hardware, cloud integration, open communications protocols and more powerful analytics capabilities have begun to disrupt the maturing BAS market and cause major vendors to evolve their core offerings.[42] There are many incumbent service providers innovating in this space, but a few with a strong Midwestern presence are Schneider Electric, Johnson Controls, Honeywell, Siemens and Trane. These newer EMIS seek to deliver on the promise of instinctive, continuous commissioning of building energy systems through intelligent algorithms and learning strategies. However, even as the analytical, automation and prediction capabilities of these systems steadily improve, they are still "90% about the people and 10% about the technology."[43]

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[39] Ibid.
[40] Graphic adapted from a slide in the U.S. Department of Energy's *EMIS Crash Course* (2016). gaia.lbl.gov/EMIS/Crash%20Course/CrashCourse%20Recording/CrashCourse/lib/playback.html
[41] Ibid.
[42] Navigant Research. 2016. *Commercial Building Automation Systems.* www.navigantresearch.com/research/commercial-building-automation-systems
[43] Consortium for Energy Efficiency (CEE). 2016. *Summary of Commercial Whole Building Performance Programs.*

It is important to note that although energy cost savings have served as the primary value driver behind market adoption of commercial EMIS, this may be changing just like with HEMS and ALC. The range of use cases for EMIS is growing quickly as it becomes easier to integrate energy, water, fire and security systems into one user-friendly platform or to maximize occupant comfort, safety and engagement. Across the country, and particularly in the Midwest, few utility energy efficiency programs are aimed specifically at EMIS. Instead, several utilities accept building control solutions in custom rebate programs for industrial or large commercial customers. In the Midwest, this includes AEP Ohio, Alliant Energy, DTE Energy, Duke Energy and potentially others; meanwhile, Xcel Energy and ComEd maintain standalone incentive programs.[44]

The latest EMIS seek to deliver on the promise of instinctive, continuous commissioning of building energy systems through intelligent algorithms and learning strategies.

Xcel Energy Efficiency Controls Program

The Xcel Energy Efficiency Controls Program provides incentives to commercial customers for a wide range of building control systems or the installation of additional points (metering or control devices) on an existing BAS. Targeted building systems include lighting, heating and cooling, ventilation and equipment scheduling, and incentives start at $400/kW and $5 per dekatherm.[45] The program does not provide rebates for EMIS or demand response-enabled systems, but encourages their use and expects to move in this direction soon. Xcel's approach is a hybrid between a prescriptive and a custom program, where the customer must receive pre-approval and rebates are calculated based on energy savings for each project, but stock savings calculations are used for each type of equipment. In Minnesota, this program had 2016 goals of 10 GWh and 180,000 dekatherms, but these may adjusted down slightly in coming years due to saturation. A strong trade ally network helps Xcel Energy recruit sufficient participants and hit their savings goals each year with minimal utility marketing.

A process evaluation for a similar Xcel Energy program in Colorado (Energy Management Systems) interviewed staff from comparable programs nationwide and reported strong interest in evolving programs solely focused on BAS. These administrators predicted future programs will take a more holistic approach and will aim to fully outfit their customers' facilities with EMIS and a new generation of monitoring and control technologies that tie together many building systems into one intelligent platform.[46] Xcel Energy is currently conducting an Energy Information Systems pilot where customers can receive assistance installing additional monitoring points in order to receive more detailed building analytics. Although still in pilot phase, the utility sees this type of program as promising way to driver commercial behavioral savings in the near future.

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[44] Xcel Energy. 2015. *2014 Comprehensive Evaluation: Colorado Energy Management Systems*.
[45] Xcel Energy. *Efficiency Controls program Information Sheet*. www.xcelenergy.com/staticfiles/xe/Marketing/MN-Trade-Efficiency-Controls-Info-Sheet.pdf
[46] Xcel Energy. 2015. *2014 Comprehensive Evaluation: Colorado Energy Management Systems*.

Smart Manufacturing

Manufacturing is a fundamental part of the Midwestern identity and a critical contributor to regional economic prosperity. Over a third of national manufacturing productivity comes from the Midwest and most states in the region are among the highest ranked for share of total workforce employed in manufacturing.[47] These economic benefits do not come without costs, however. The Midwest industrial sector is responsible for 33% of the region's total energy consumption, and unsurprisingly, 40% of the nation's energy efficiency potential exists in this sector.[48] With the help of federal, state and utility efficiency programs and resources, many Midwest manufacturers have dramatically reduced energy use through process improvements, equipment upgrades, retrocommissioning efforts and strategic energy management planning. But recent technology developments promise to accelerate this work and capture even more of this sector's energy savings potential.

Today, many manufacturers already utilize a number of sophisticated data collection and automation strategies that assist or expedite parts of the production process, such as equipment sensors, data loggers and programmable logic controllers. Data is often passed to human operators using supervisory control and data acquisition (SCADA) systems or human-machine interfaces. Over the last 10-15 years, the price of microprocessors, sensors, wireless internet and other enabling components have steadily declined, making the acquisition of important energy or production data and the networking of systems of devices significantly cheaper. Schneider Electric, a regional leader in industrial automation, projects massive growth of connected devices globally, with over seven billion devices in use by 2025.[49] The resulting volume and velocity of data hold great potential to increase efficiency and production speed, but also present unique challenges to plant operators seeking to harness it.

> *"Tomorrow's machines will be trained by humans and will have intelligent, adaptive capabilities."*

Smart manufacturing is a broad term used to describe this unfolding technology evolution, generally characterized by an increasing reliance on connected devices, data collection, advanced analytics and automation to maximize productivity on the factory floor while minimizing waste, energy use and equipment downtimes.[50] With a network of constant machine-to-machine communication and a backbone of predictive analytics software, a plant manager could monitor all aspects of production in real-time, continuously commission

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[47] National Association of Manufacturers. 2016. *Manufacturing Employment by State.* www.nam.org/Data-and-Reports/State-Manufacturing-Data

[48] Midwest Energy Efficiency Alliance. 2016. *Industrial Energy Efficiency. www.mwalliance.org/sites/default/files/uploads/advokit/MEEA-Advokit_2016_IEE_Factsheet_v1.1.pdf*

[49] Beudert, R., Juergensen L., and J. Weiland. 2015. *Understanding Smart Machines: How They Will Shape the Future*. Schneider Electric white paper.

[50] Other popular terms include "Industrial Internet of Things" and "Industry 4.0" (frequently used in Europe)

equipment and automatically optimize processes for a number of variables relevant to efficiency stakeholders such as total energy use, peak demand or utility price signals.

Adaptability and automatic optimization is what sets this "Fourth Industrial Revolution" apart from previous generations of industrial advances. As one manufacturing representative noted, "today's machines seem advanced, but they are merely programmed to perform tasks and respond to stimuli. Tomorrow's machines will be *trained* by humans and will have intelligent, adaptive capabilities." Coupled with cloud computing and new production techniques like additive manufacturing (3-D printing), this melding of the digital and the physical will enable several types efficiencies at many points in the supply chain, production process and distribution network.[51]

Companies active in the Midwest such as Schneider Electric, General Electric, Honeywell, 3M, Bosch and Rockwell Automation are currently vying for smart manufacturing market share with comprehensive digitization, monitoring and control platforms. For example, General Electric's (GE) Predix platform is only a few years old but is already providing many high-profile firms with a suite of powerful tools to analyze their production, customer and facility data.[52] Called "Brilliant Factories," these operations are using GE platforms to "link design, engineering, manufacturing, supply chain, distribution and services" and streamline dozens of processes.[53]

Holistic, connected solutions like these could lead to a 20% average reduction in overall energy consumption per industrial facility, or $15 billion saved on manufacturers' electricity bills by 2035.[54] Despite this potential, productivity improvement, better working conditions, safety and quality control are likely to remain the primary drivers behind most smart manufacturing efforts.[55] However, an increase in productivity for an operation likely decreases average per-unit energy intensity, creating indirect efficiencies worth noting and possibly measuring.

Outside of a few custom incentive projects, there are not many instances where smart manufacturing is being actively promoted by energy efficiency programs in the Midwest. Although this is a major area of opportunity for energy savings, it remains to be seen how utility programs will support technology adoption and lower barriers to entry. A lack of awareness, complexity, technological uncertainty and the lack of one-size-fits-all solutions are among the chief market barriers to smart manufacturing, and energy efficiency stakeholders should work hand-in-hand with researchers to identify opportunities for market transformation.

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[51] Schwab, K. 2016. *The Fourth Industrial Revolution: what it means, how to respond*. World Economic Forum.
[52] Leonard, D. and Clough, R. 2016. *How GE Exorcised the Ghost of Jack Welch...Startup*. Bloomberg.
[53] General Electric website. *Brilliant Manufacturing*. www.ge.com/digital/brilliant-manufacturing
[54] Rogers, E. 2014. *The Energy Savings Potential of Smart Manufacturing*. ACEEE.
[55] Conner, C. 2016. *Improving worker safety with wearables*. IBM. www.ibm.com/blogs/internet-of-things/worker-safety-and-wearables/

Manufacturing USA

In 2013, President Obama called for a rigorous, national focus on advanced manufacturing as a means of creating next-generation jobs, increasing productivity and reducing energy consumption in industry.[56] The resulting initiative, called Manufacturing USA (formerly called the Nationwide Network for Manufacturing Innovation), has so far established nine institutes across the country dedicated to accelerating advanced manufacturing technologies. These institutes will surely yield important innovations with energy efficiency implications over the next decade. Three of them are based in the Midwest: The Digital Manufacturing and Design Innovation Institute in Chicago, Illinois; the National Additive Manufacturing Innovation Institute in Youngstown, Ohio; and the Lightweight Materials Manufacturing Innovation Institute in Detroit, Michigan. Most recently, the Smart Manufacturing Innovation Institute, which will focus exclusively on industrial energy efficiency, was launched by the Smart Manufacturing Leadership Coalition in Los Angeles, California.[57]

Smart Cities

Smart cities are commonly defined by the U.S. government as "communities that are building an infrastructure to continuously improve the collection, aggregation and use of data to improve the lives of their residents."[58] This can be realized through low-cost sensors deployed on streets, in buildings and in city vehicles, through research collaborations between local universities and private businesses or by deploying new technologies that synthesize data and intelligently optimize traffic patterns, energy use, grid reliability, citizen safety and more. Energy efficiency industry professionals should watch regional smart city developments closely as typical first steps include advanced lighting controls, LED street lighting, building benchmarking mandates, intelligent building controls, large-scale demand response efforts, electric vehicle infrastructure and widespread Internet of Things (IoT) deployment.

Data of many types provide the backbone of any smart city effort.

Data of many types provide the backbone of any smart city effort. In theory, real-time information about the environment, infrastructure and human activity in a given area could be used to curtail energy-consuming devices and processes, optimize traffic patterns and provide useful services to residents. In practice, at least on a large scale in the Midwest, this concept is still under development. Generally speaking, the smart city concept represents a massive area of technology innovation and this report only summarizes a few notable Midwest initiatives. Important, large-scale collaborations to watch include the US DOE Better Communities Alliance,

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[56] Manufacturing.gov. Manufacturing USA. December 2016. Webpage: https://www.manufacturing.gov/nnmi/

[57] The White House. 2016. *FACT SHEET: President Obama Announces Winner of New Smart Manufacturing Innovation Institute and New Manufacturing Hub Competitions*. Webpage: www.whitehouse.gov/the-press-office/2016/06/20/fact-sheet-president-obama-announces-winner-new-smart-manufacturing

[58] The White House. 2015. *Administration Announces New "Smart Cities" Initiative*. Factsheet. www.whitehouse.gov/the-press-office/2015/09/14/fact-sheet-administration-announces-new-smart-cities-initiative-help

Rockefeller Foundation's 100 Resilient Cities Challenge, C40 Cities Climate Leadership Group, the Sustainable Cities Institute, Open & Agile Smart Cities and the MetroLab Network.

U.S. Smart City Challenge

In order to help transform smart city concepts into reality, the U.S. Department of Transportation (DOT) recently launched the Smart City Challenge, a competition with a single $40 million prize. The competition generated a substantial amount of interest and resulted in 78 applications representing nearly every mid-size city in the nation, including 16 from the Midwest.[59] In mid-2016, the DOT announced Columbus, Ohio as the overall winner; the city had a winning plan and an additional $90 million in private funding.

The Columbus plan is mostly focused on decarbonizing local transportation and proposes to build an all-electric, self-driving public transportation system, expand electric vehicle charging infrastructure and use advanced data analytics to provide transit services to low-income neighborhoods. The city also plans to leverage AEP Ohio's existing program portfolio and recruit city business and residents to take advantage of offerings such as product rebates, audits and technical assistance. AEP Ohio has also committed to working closely with the city to support their electric vehicle goals. Surely this city-utility partnership contributed to Columbus' success with the Smart City Challenge.

Columbus is not the only Midwestern city moving forward with smart city plans. Another example is Kansas City, Missouri, which launched the Smart City Corridor initiative in early 2016 with $15 million in funding leveraged through a unique public-private partnership.[60] The collaboration, which includes Cisco, Sprint and Think Big Partners, will cover 50 city blocks with free public Wi-Fi and upgrade a popular downtown corridor with smart streetlights that automatically adjust for occupancy to save energy, smart traffic signals that optimize traffic flow and interactive kiosks that connect residents and visitors to local information and services.

Chicago Smart Lighting Project

The Chicago Smart Lighting Project (which MEEA is involved with) is a major municipal effort seeking to upgrade more than 270,000 high-pressure sodium street lights to high-efficiency LED fixtures and embed them in a citywide networked outdoor lighting control system. This control system is expected to enable some of the following capabilities (the project is still under development): remote monitoring and control, potential integration with utility meters and improved asset management through real-time data collection. The city's vision is outdoor lighting infrastructure that eventually serves as a foundational platform for many smart city applications that could improve public safety, communicate timely neighborhood information to residents, improve parking and public transit, increase access to affordable internet and

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[59] U.S. Department of Transportation. 2016. *DOT Announces Columbus as Winner of...*. www.transportation.gov/briefing-room/us-department-transportation-announces-columbus-winner-unprecedented-40-million-smart

[60] Kansas City smart city initiative website. http://kcmo.gov/smartcity/

provide other critical services. This initiative is also linked to the Array of Things project, as sensor packages are intended to be anchored to light poles across the city.

The Array of Things

Another Midwestern project of interest is the Array of Things, an "urban sensing project" in Chicago, Illinois coordinated jointly by Argonne National Laboratory and the University of Chicago.[61] Initially, the project will consist of 500 sensor packages dispersed throughout the city attached to streetlights and traffic signal poles. These "nodes" will collect data related to the weather, air quality, traffic and pedestrian activity, and then broadcast to the public via an online open data platform. The hope is that this freely available platform spurs individuals and companies to access this data and create innovative, useful applications that reduce energy, protect public health and safety, increase transportation efficiency and serve other public needs. The open, online platform featuring data from the first 50 nodes was launched in late 2016.[62]

Summary of Barriers

While the growing number of devices, systems and solutions facilitating intelligent efficiency offer great promise, many face significant barriers to market adoption. The following section synthesizes insights gained during MEEA's interviews with industry leaders and outlines the most frequently mentioned challenges faced by consumers, solution providers and program managers.

Higher upfront cost

There is a substantial price differential between some connected devices and their non-connected predecessors. Furthermore, many intelligent efficiency solutions represent entirely new product categories and are thus initially limited to early adopters with higher levels of disposable income. In the HEMS space, this also raises the potential for equity issues, as many devices are not necessary components of a household and may thus require additional effort to ensure equal access and prevent free ridership.[63] Incentive programs such as those designed by the utilities highlighted earlier offer useful examples of how this barrier can be mitigated.

Lack of awareness

Lack of awareness of new technologies slows market adoption and limits a product's potential in energy efficiency programs. Awareness of intelligent efficiency solutions varies widely, but there has been steady progress recently with some HEMS devices.[64] In the Midwest, commercial building operators and facility managers are demanding information on intelligent controls and Energy Management Information Systems.[65] Production managers and similar professionals lack knowledge about the full potential of the Internet of Things and are largely unprepared for

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[61] Array of Things website. https://arrayofthings.github.io/index.html#
[62] Plenar.io website. http://plenar.io/
[63] Miziolek, C. 2016. *The Smart Energy Home: Strategies to Transform the Region*. NEEP.
[64] Ibid.
[65] MEEA-administered Building Operator Certification training program surveys

technological advancements in smart manufacturing.[66] Although awareness for many solutions may grow naturally over time, targeted marketing efforts by energy efficiency stakeholders could accelerate this process.

Data availability, integrity and access

Data is a fundamental component of all intelligent efficiency solutions. Thus, poor data availability or quality is a major hindrance to the effectiveness of certain applications. Specifically, access to interval data is critical for many strategies involving end user feedback; although any type of interval data can be used for feedback, efficacy increases as intervals decrease.[67] Also, data integrity must be maintained in order to be used by some applications; one solution provider called poor data quality their "biggest, most common issue."

> *One solution provider called poor data quality their "biggest, most common issue."*

In terms of availability, the Midwest is a patchwork of advanced metering infrastructure (AMI), hindering the deployment of certain devices and programs in some areas and potentially preventing the creation of some types of regional programs. This may become less of a barrier over time, as the number of smart meters nationally is expected to increase from 70 million in 2016 to 90 million by 2020.[68] If a utility has already deployed smart meters, some HEMS solutions could help them leverage their investment to its fullest potential by enabling new types of programs and third party interventions. Fortunately, many intelligent efficiency applications can operate independently of smart meters or access to granular energy data. In these cases, they can serve as an important source of proxy data in the absence of AMI (e.g. HVAC system run time and occupancy schedules as proxies for whole-building energy data).[69]

Access to customer data remains a significant barrier to many intelligent efficiency software and analytics platforms and the development of new and innovative data-driven efficiency solutions. Allowing third party access to customer data while maintaining security and dispelling privacy fears is a top concern for many Midwest utilities and regulatory commissions. The Green Button Initiative, launched in 2012, has served an important role as a straightforward way for customers to opt-in to sharing their energy data with third party applications, but the growing volume of data and range of possible solutions is necessitating more consistent access.[70] ComEd's new Anonymous Data program is a promising step in this direction. Through this initiative, intelligent efficiency solution providers are able to request de-identified, 30-minute

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[66] Leathers, M. 2016. *How to Prepare Your Workforce for Smart Manufacturing*. IndustryWeek. www.industryweek.com/education-training/how-prepare-your-workforce-smart-manufacturing
[67] Minnesota Department of Commerce. 2015. *Energy Efficiency Behavioral Programs: Literature Review, Benchmarking Analysis, and Evaluation Guidelines.*
[68] St. John, J. 2016. *US Smart Meter Deployments to Hit 70M in 2016, 90M in 2020.* www.greentechmedia.com/articles/read/US-Smart-Meter-Deployments-to-Hit-70M-in-2016-90M-in-2020
[69] NEEP. 2015. *Opportunities for Home Energy Management Systems (HEMS) in Advancing Residential Energy Efficiency Programs.*
[70] U.S. Department of Energy Green Button website. 2017. https://energy.gov/data/green-button

interval energy data from everywhere the utility has installed smart meters.[71] More utility efforts like this are needed to encourage the development of next-generation efficiency solutions.

Perceived risk – complexity and product-specific challenges

With unfamiliar technology, awareness is a prerequisite but not a predictor of adoption. When faced with many unfamiliar options or heightened complexity, a wait-and-see approach may seem like the best course of action. Perceived complexity may deter consumer adoption among older or less tech-savvy individuals or cause program administrators to rely on lengthy pilot projects to determine program fit. Intelligent controls in the commercial or industrial sectors that require detailed operator training may not be attractive to building owners or production managers facing high personnel turnover or a shortage of dedicated energy management staff. Other related issues that vary from product to product could include a device's applicability to only a narrow market segment, perceived aesthetic issues or the need for frequent troubleshooting.

Perceived risk – energy savings

Intelligent efficiency products and solutions lacking a large body of evidence proving cost effectiveness may not find their way quickly into efficiency programs. Also, although many solutions are undoubtedly cost effective over a short time period, system-level savings can be hard to measure and connected devices that are not saving energy, but rather controlling energy-using equipment or systems, are harder to evaluate than discreet measures.[72] An example of an important development concerning the HEMS space is the ENERGY STAR® Connected Thermostats Specification, which seeks to establish a means of comparison between different thermostats using common baselines with the end goal of producing a qualified products list.[73] This in turn should increase confidence in the technology among utilities and public utility commissions and facilitate the adoption of deemed savings metrics.

Interviews with representatives from the natural gas efficiency space signaled an additional lack of confidence in some intelligent efficiency applications or at least felt that the vast majority of related emerging technology was focused narrowly on electric savings. This is perhaps not surprising, considering that the vast majority of smart thermostat studies reviewed by the US DOE focused on electricity savings while only 46% also looked at natural gas savings, despite 80% of studies primarily analyzing the "energy savings due to automatic HVAC controls".[74] Clearly there are ample opportunities for gas savings with many of the solutions discussed in this report, but

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[71] ComEd. 2017. *Anonymous Data Service.* www.comed.com/SmartEnergy/InnovationTechnology/Pages/AnonymousDataService.aspx

[72] There is a growing body of evidence on the efficacy and cost effectiveness of various solutions. For examples, see www.buildingefficiencyinitiative.org/sites/default/files/intelligent-efficiency_issue-brief.pdf, https://nest.com/downloads/press/documents/energy-savings-white-paper.pdf or http://aceee.org/files/proceedings/2016/data/papers/2_1172.pdf

[73] ENERGY STAR. Connected Thermostats Specification V1.0. www.energystar.gov/products/spec/connected_thermostats_specification_v1_0_pd

[74] U.S. Department of Energy. 2016. *Overview of Existing and Future Use Cases for Connected Thermostats.* Prepared by Energetics Inc. and Vermont Energy Investment Corporation.

there appears to have been an initial emphasis on applications (not just with smart thermostats) concerning space cooling, motor control, ventilation, plug load, and other electric-centric opportunities. One leader in this area is the Gas Technology Institute, which partners with utilities and manufacturers to verify gas savings for a range of new technologies.[75]

Perceived risk – security/privacy

Security remains a top concern for both efficiency program administrators and consumers. Surveys have shown that many consumers are worried about the vulnerability of connected devices and the Internet of Things to hacking, and interviews with product manufacturers showed this is an internal priority being given serious attention.[76] Also, as all intelligent efficiency solutions generate large amounts of building, process or behavior-specific data, each solution raises questions over data ownership and appropriate use. One solution provider described how utility sensitivity regarding customer data slows program development: "It's not uncommon for setting up a data link with a utility to take months. Compare this to linking to and making a transaction with a financial institution today. In the future, we might need to be more like that."

Communication protocols and interoperability

A device enabling intelligent efficiency is typically nested in a communicating network of other devices. Many protocols are currently in use allowing devices to talk to each other, to nearby control hubs, to the cloud or to off-site servers. Popular protocols include Wi-Fi, ZigBee, Bluetooth and cellular, but many more are in development and the market has yet to coalesce around one set.

> *"Fragmentation is the enemy of the Internet of Things."*

Further complicating this is different products' inability to communicate with one another. A frequently-mentioned concept during MEEA's interviews was that "fragmentation is the enemy of the Internet of Things."[77] While some manufacturers may view this as a strategy to lock in consumers on a specific brand, a lack of interoperability can impede technology adoption and complicate program design. More attention and support is needed for public-private partnerships looking to solve this issue. A number of initiatives have been launched that involve major information technology companies, device manufacturers and advocacy groups.[78]

Structural program changes

Many utility energy efficiency programs rely on a prescriptive, single-component-based approach to energy savings. Intelligent efficiency relies on a network of connected components that enable deeper, system-wide energy savings. As most of these components (sensors,

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[75] Nicor Gas. 2015. *1022: Home Energy Management System Utilizing a Smart Thermostat – Final Public Project Report*. Prepared by Gas Technology Institute.
[76] Deloitte. 2016. *Switch on to the connected home*. UK Consumer Review Report. Also: Bell, S. 2016. *What do consumers think about IoT?* IoT Security Foundation.
[77] Qualcomm. 2016. *Fragmentation is the enemy of the Internet of Things*. www.qualcomm.com/news/onq/2016/02/19/fragmentation-enemy-internet-things
[78] Consortium for Energy Efficiency (CEE) and Electric Power Research Institute (EPRI) coordinate notable smart thermostat-related efforts.

dashboards and software) do not directly save energy, programs will need to adapt to new methods of savings measurement and find novel ways to encourage investment in such systems. As it is unclear how some solutions will be adapted to fit within Technical Reference Manual frameworks, attention will be needed not just at the program level, but also at the evaluation and regulatory levels.

Asset tag issue and utility investment barriers

Many intelligent efficiency solutions lean on cloud computing or turnkey software-as-a-service applications. When an on-site, physical asset is replaced with a digital asset, will commercial or industrial customers be able to smoothly transition the expense from capital to operational? Likewise, many regulated utilities earning a rate of return only on capital expenses and physical assets face obstacles when investing in newer, more nimble data analytics tools and platforms that are cloud-based. Under the current accounting paradigm in most states, such investments are considered operating expenses and may not qualify for a rate of return. This may discourage utilities from taking advantage of important cloud-based services and innovative, third party program solutions.

The chasm of pilots

Several manufacturers and service providers pointed to a phenomenon they called "death by a thousand pilots" or "the chasm of pilots."[79] When it comes to incorporating new technology into a utility program, whether as a new measure or as a new program management tool, a detailed pilot process is standard procedure. However, technology innovation in the intelligent efficiency space is moving fast enough to render some common approaches to piloting too slow to take full advantage of its benefits. Several utility representatives recounted that by the time they had finished piloting and evaluating a new energy-saving connected device, the market had moved beyond and the product was already in later iterations. Similarly, manufacturers expressed some concern over the need to pilot the same products across several utility territories simultaneously.

Recommendations

MEEA synthesized the insights from industry interviews into the following list of recommendations for Midwest energy efficiency stakeholders. These considerations should assist efficiency program administrators and solution providers in better understanding emerging intelligent efficiency opportunities and how to work together to create effective program strategies that take advantage of their exciting potential.

Leverage non-energy benefits to increase energy savings and technology adoption

As has been stated, intelligent efficiency solutions can create significant value streams outside of energy savings. For many HEMS devices, ALC systems, BAS, or smart manufacturing applications, cost savings through energy reduction is a secondary or only minor driver of market adoption.

[79] Lacey, S. 2013. *Tendril CEO Adrian Tuck: 'How I Almost Killed My Company'*. Greentech Media.

Many homeowners and building managers are purchasing these products and solutions to enable exciting new capabilities, to increase productivity or data quality or for reasons that are harder to measure like convenience, status and novelty. Although these are ancillary benefits to an energy efficiency stakeholder, they could be leveraged to increase the adoption of energy-saving technologies. Similar to how a home performance program might promote enhanced comfort alongside energy savings, utilities and program administrators should consider using non-energy benefits as a hook that increases customer interest. For example, it is possible that a utility that facilitates residential customers' transition to a range of smart home technologies (energy related and non-energy related) could result in greater adoption of energy savings solutions. Or a program administrator that helps industrial customers better understand smart manufacturing's production benefits could open up a deep well of new energy efficiency opportunities.

Look beyond consumer benefits to leverage program efficiencies

Intelligent efficiency solutions not only capture additional savings and open up new value streams for consumers, but they also present new programmatic opportunities for program administrators. For example, one utility representative said "a smart device can be so much more than a measure; it can be a gateway for the utility into a home or business, and it will allow for program recruitment like no one has seen yet." Many HEMS devices hold the potential to integrate efficiency and demand response efforts, expand behavioral strategies, convey program offering information to customers at precise times, calculate ongoing energy savings, enable real-time measurement and verification or remotely audit homes for inclusion in home performance programs.[80] Similarly, many auxiliary program benefits could be realized through intelligent efficiency solutions in the commercial and industrial sectors.

Recognize the product development push-pull effect between utilities and manufacturers

While not all intelligent efficiency products are designed with efficiency incentives and programs in mind, every manufacturer interviewed expressed a strong desire for utilities to more clearly articulate the features they are looking for in new products. Some utility representatives were surprised to hear that they potentially had a "pull" effect on product development, while others confirmed this and said they frequently interact with manufacturers and solution providers during the design process.

Step up research and piloting interactions between utilities, manufacturers, solution providers and program implementation experts…

Several manufacturers saw utilities as critical allies in reducing the perceived risk associated with a given new technology. For a product or service with low consumer awareness, inclusion in a utility program can be a powerful endorsement and legitimizing factor. However, few Midwestern utilities see themselves as the holistic test bench these manufacturers are looking for,

[80] Building America. *Moisture Managed High-R Envelopes*. www.energy.gov/eere/buildings/building-america-moisture-managed-high-r-envelopes#fraunhofer

and even less have a dedicated initiative for testing new products and solutions. Instead, most utilities interviewed suggested implementation contractors were the better vehicle for surveying and experimenting. The implementers who were interviewed largely agreed. These companies actively seek out best practices and emerging opportunities in order to improve their ability to manage effective efficiency programs and should broadcast more clearly to manufacturers and solution providers their willingness to consider piloting new technologies, particularly in areas where utilities are taking a wait-and-see approach.

State policy can also have a dramatic effect on bringing new technologies to market. In some Midwest states with energy efficiency resource standards, regulated utilities can dedicate a portion of overall program spending for research and development that leads to new measures and greater efficiencies in program recruitment and administration. For example, Nicor Gas maintains an Emerging Technology Program aimed at identifying, piloting and evaluating new products, strategies and equipment that hold the potential to reduce gas consumption and augment their existing energySMART program portfolio. The importance of a dedicated focus on testing emerging technologies at the utility level was consistently emphasized throughout MEEA's interviews. One utility representative explained that even though such a focus will inevitably help new products find a path to market, for the utility such efforts are actually more of an operational imperative: "Program managers live in an increasingly constrained world where every year the easiest savings go away. Each year we have to use the same dollars to go farther and faster than before. Intelligent efficiency solutions and the more productive use of big data discovered through dedicated research processes are critical to find new savings and program operational improvements."

"Program managers live in an increasingly constrained world where every year the easiest savings go away."

... but acknowledge that intelligent efficiency may be moving too fast for traditional approaches to piloting

The rapid pace of innovation in these markets has created an urgent need for more regional collaboration among energy efficiency stakeholders. Utilities and implementers must increase the amount of data and lesson sharing they currently engage in. Similar to how lighting programs have had to update incentive levels on an increasingly more frequent basis to appropriately respond to falling LED prices, utilities and program administrators must, as one utility representative put it, "develop new ways to more rapidly test emerging program concepts and manufacturer claims while considering in real-time what savings, incentives and program management would look like." Newly developed tactics should be shared as openly as possible using existing forums and Regional Energy Efficiency Organizations (such as MEEA), industry advocates and federal agencies should facilitate this exchange and create new channels for collaboration between utilities, implementers, manufacturers, trade allies and consumer advocates. Regional efforts which aggregate funding and consolidate research and piloting efforts could reduce repetition, increase sample size and disseminate best practices more quickly.

Consider how connected devices can unite and streamline energy efficiency and demand response programs

As discussed in this paper, some intelligent efficiency solutions integrate energy efficiency and demand response efforts into a single platform. This can not only streamline the enrollment process and day-to-day experience for customers, but also increase program cost effectiveness for administrators. Ensuring that new products incorporate high efficiency with demand response capabilities should be a priority for energy efficiency program stakeholders.

> *The rapid pace of innovation in these markets has created an urgent need for more regional collaboration among energy efficiency stakeholders.*

Inc*rease programmatic attention on product support, technical assistance and troubleshooting*

Efficiency programs centered on intelligent efficiency solutions are naturally going to involve devices, software platforms and datasets that are more complex or extensive than before. Thus, these programs will need to devote additional focus to customer support. Particularly when devices rely on internet connections or need to be regularly updated, programs will need to provide ongoing assistance with troubleshooting that lowers the complexity barrier for all types of customers. For many specialized applications, utilities and program administrators will need to lean on third-party, niche solution providers with deep experience in the technology.

Encourage updated regulatory treatments of cloud-based solutions

The utility regulatory investment barrier mentioned earlier discourages utilities from adopting some cloud-based, Software-as-a-Service solutions that may enable large-scale intelligent efficiency. At a recent meeting of the National Association of Regulatory Utility Commissioners (NARUC), a resolution was passed encouraging regulators to consider allowing utilities to treat these expenses as capital expenses, potentially enabling a rate of return. If adopted in the Midwest, this change in the accounting framework could open up more utilities to working with innovative third-party providers of intelligent efficiency solutions.[81]

Prevent lost opportunities by including connected devices in existing programs

In the residential sector, smart appliances are rapidly gaining market share and seem poised to increase dramatically in the near future. The spread of these devices present new opportunities for both energy efficiency and demand response programs. Programs currently incentivizing efficient products and appliances that lack intelligent or communicative capabilities could delay their ability to take advantage of these opportunities in the coming years. One issue is that manufacturers currently include such capabilities only on higher-end models, largely due to lack

[81] Buckley, B. 2016. NARUC Resolution Tips Hat to SaaS Investments. NEEP. www.neep.org/blog/naruc-resolution-tips-hat-software-service-investments-new-york-rev

of consumer demand.[82] Program administrators could play a big role by partnering more closely with manufacturers and by more explicitly defining desired product specifications.

Pilot new measurement and verification strategies as well as performance-based programs

Intelligent efficiency promises greater access to operational and system-wide energy savings, but the measurement of these savings could be more difficult than measuring savings associated with more traditional programs. Embedded in many solutions are extensive data collection capabilities, and new and advanced approaches to data analytics offer the ability to correlate constantly changing factors such as equipment performance and occupant behavior with energy consumption. The creation of a "dynamic baseline" – a baseline for comparison that constantly and automatically reflects business-as-usual conditions – enables the real-time measurement of savings associated with a given intervention.[83] This ability may lead to program administrators piloting more performance-based approaches to incentivizing efficiency efforts. In such a program, an advanced EMIS, smart thermostat or similar intelligent efficiency solution would assist program administrators in establishing a dynamic baseline and comparing post-measure energy consumption to generate a custom savings estimate. Such an approach may also have the potential to enhance behavior-based program strategies. Stakeholders should look for leadership from several firms currently active in the Midwest in real-time measurement and verification and real-time data analytics, including EnergySavvy, FirstFuel, Agentis, Itron, Cadmus, Navigant, and others.

Invest in cross-industry intelligent efficiency collaborations

Successful technology deployment and program design will require collaboration between a wide range of non-traditional stakeholders, including major names in software, telecommunications, cloud computing, security, robotics and online retailers. Many technology industry players may not be aware of the role energy efficiency programs could play in market adoption or the ancillary benefits their products could provide, and the burden is on efficiency stakeholders to make these connections clear. Midwest utilities, program administrators and solution providers participate in several groups that seek to increase collaboration, guide the development of standards and better understand the potential for intelligent efficiency, including the Commercial Advanced Lighting Controls Project, Midwest LUMEN, Smart Manufacturing Leadership Coalition, Connected Devices Alliance, Emerging Technologies Coordinating Council, and the HEMS Working Group coordinated by NEEP and the Home Performance Coalition.[84]

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[82] Miziolek, C. 2016. *The Smart Energy Home: Strategies to Transform the Region*. NEEP.
[83] Rogers, et al. 2015. *How Information and Communications Technologies Will Change the Evaluation, Measurement, and Verification of Energy Efficiency Programs*. ACEEE.
[84] These are just the groups that were mentioned during interviews.

Develop partnerships with Manufacturing USA institutes and Industrial Internet of Things service providers to better understand smart manufacturing opportunities

The Manufacturing USA institutes represent an important opportunity for utilities and industrial energy efficiency program administrators to better understand smart manufacturing and potentially participate in working groups or pilots. The three institutes in the Midwest, each representing massive collaborations between government, academia, and hundreds of manufacturing and technology firms, should be primary targets for utilities and program implementers seeking guidance on this growing industry. Also, the recently-commissioned Smart Manufacturing Innovation Institute will be looking to partner in 2017 with the energy efficiency community specifically to further its mission of dramatically improving the efficiency of industrial processes. Meanwhile, in the private sector, prominent Industrial Internet of Things companies are in intense competition to design the smart manufacturing platform of the future. Utilities and energy efficiency stakeholders risk being left out of the conversation if more effort is not made to collaborate and get a seat at the table.