Residential Energy Management Systems: Market Trends and Future Growth

Hannah Bastian, Guidehouse Insights
William Hughes, Guidehouse Insights

ABSTRACT

Demand for residential energy management systems (REMS) is expected to grow substantially over the next decade as both residents and utilities seek to leverage new technologies to better manage residential energy use. There are a wide variety of REMS on the market today ranging from systems that monitor and manage a single end-use application to grid-scale systems that manage a portfolio of residential distributed energy resources. Similarly, there are many different types of companies that offer REMS products and services, including long-standing original equipment manufacturers to start-ups that have yet to launch their first products. The market for REMS is rapidly changing each year as technologies evolve and more companies enter the market with their own REMS products and services.

This paper will share findings from a recent report on the current and future state of the REMS market. It will provide an overview of the different types of REMS available today and expectations for how systems are likely to evolve over time to meet the needs of their consumers. It will also share insights from interviews with a variety of REMS manufacturers and feature case studies from real-world applications of leveraging REMS solutions to reach and serve low- and moderate-income customers.

Introduction

Residential energy management systems (REMS) are devices and services that monitor and manage one or more home energy end-uses. There are many different types of REMS on the market ranging from smart home devices that control a single end-use to grid-based systems that manage a portfolio of residential distributed energy resources (DER). While each REMS uses a unique approach for managing home energy use, they all ultimately strive to improve how homes use energy to provide benefits for their end-users.

Today, there are two customer segments for REMS: residents and utilities (Bastian 2023). Residents purchase REMS for a variety of reasons including gaining better control of their home, reducing their energy costs, acting on their interest in smart devices and home automation, and desiring to have a greener or more resilient home. Utilities invest in REMS to gain better insights and control over residential energy use for a variety of reasons including meeting demand side management regulations, providing enhanced customer service, and reducing grid operation and upgrade costs.

This paper will provide an overview of the different types of REMS on the market and how they serve both of these key customer segments. It will provide a discussion of how these systems have evolved over time and include case studies of current applications of REMS with an emphasis on reaching and serving low to moderate-income customers.

Technology Landscape

The REMS technology landscape is diverse and constantly evolving. In general, REMS can be categorized into two main groups based on the key customer segments in this market: in-home REMS and grid-based REMS. The following sections provide an overview of these two primary product categories and discuss how they have advanced over time and are likely to develop in the near future.

In-Home REMS

In-home REMS, which may also be referred to as behind-the-meter technologies, are devices and systems installed in the home that track and communicate information about the home's energy systems. Today, most in-home REMS are associated with particular building systems like heating, cooling, and ventilation (HVAC) equipment, solar photovoltaic (PV) systems, battery storage, electric vehicle (EV) charging equipment, smart plugs, and smart appliances. Home energy management systems (HEMS) are another type of REMS that offer a single platform that integrates multiple separate REMS within the home and provides a single interface for users to access their energy systems. The distinction between HEMS and REMS is that HEMS provide a whole-home perspective while REMS focuses one or more associated end-uses.

In-home REMS are generally a part of the broader smart home technology market, which is comprised of four primary application segments: security and access control, convenience and automation, health and safety, and energy management, show in Figure 1 below.

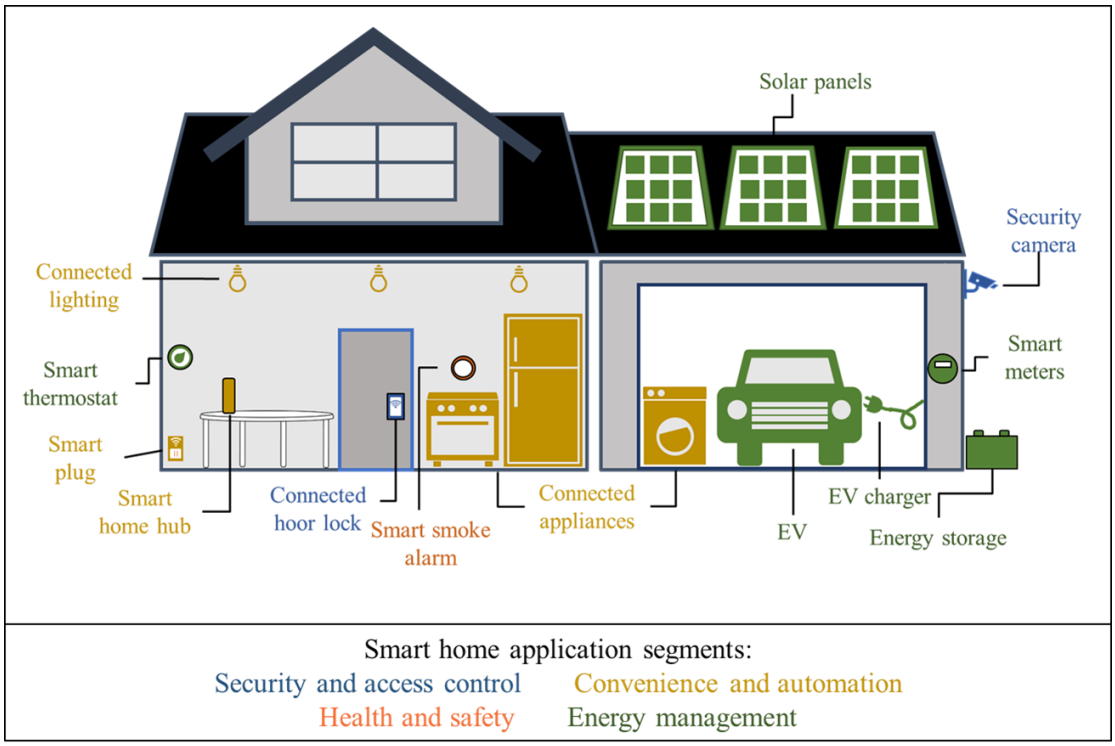


Figure 1. Primary Smart Home Application Segments

The application segments not directly involved with energy management can act as drivers for REMS adoption. For example, convenience and automation technologies like connected lighting and smart plugs can include features for energy management, potentially resulting in more households having REMS who may otherwise have been uninterested in energy management technologies. Even smart home technologies that may not directly relate to energy end-uses in the home can still contribute to energy management when integrated with REMS. For example, security cameras and door locks can provide occupancy data to REMS that can then adjust energy consumption up or down depending on when the home is occupied or when an occupant's smartphone is getting close to the residence.

Technology Evolution

In-home REMS technologies have evolved greatly over time, generally following broader trends in technology development like the widespread use of digital interfaces, cloud computing, occupancy sensing, and now artificial intelligence (AI). Smart thermostats offer a clear example of how home energy management has evolved alongside technological innovation, as described in Figure 2.

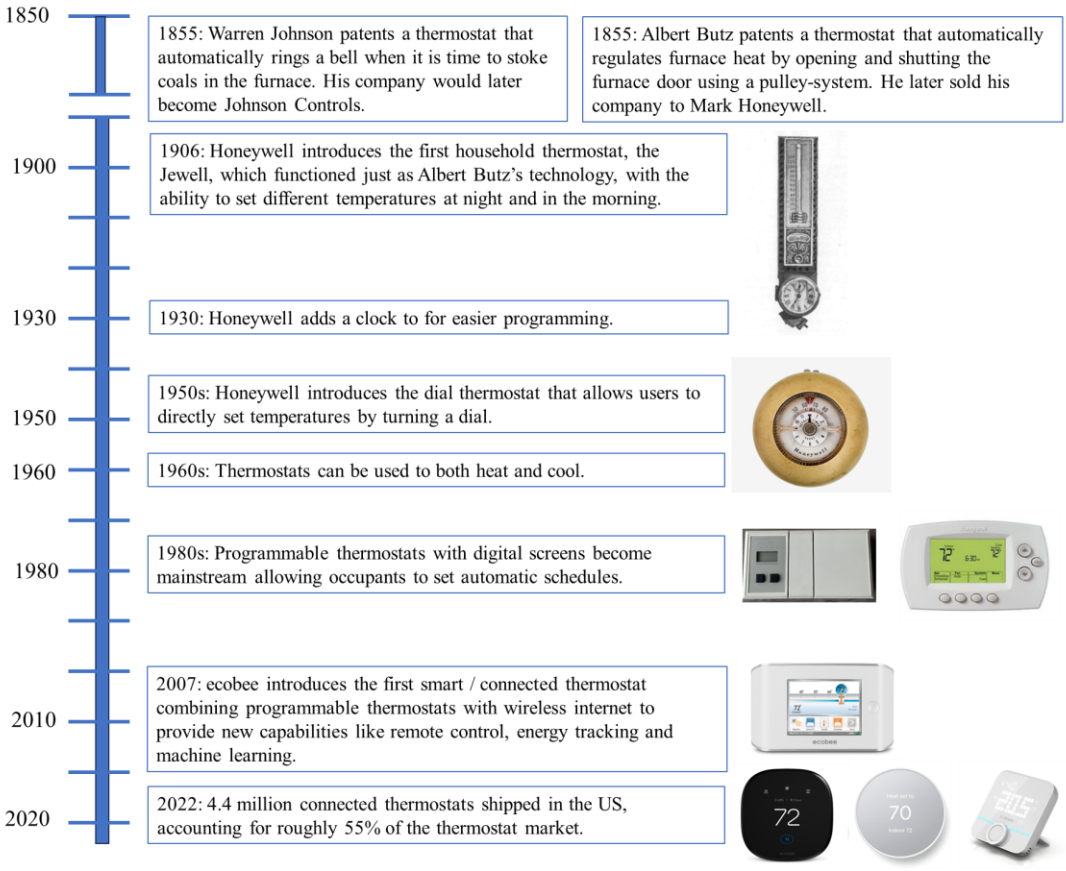


Figure 2. Evolution of Thermostat Technology. *Sources*: MYSA, 2020; ENERGY STAR®, 2022; NMAH, 2024; Hagley Digital Archives, 2024; Western Hardware, 2024; Home Depot, 2024.

Smart thermostats are emblematic of similar technological transformations happening across many types of residential energy equipment and devices. Technology innovations are moving energy management from an active and physical process initiated by users to passive and digital experiences that need little to no user intervention. The smart thermostat perfectly captures this transformation – the first thermostats reduced the physical burden of stoking furnace coals by using a pulley system to automatically open furnace doors, up through today, in which smart thermostats remove the need for occupants to interact with their thermostats at all.

Furthermore, today's REMS offers the promise of being able to manage energy use better than occupants by leveraging machine learning can rapidly consider multiple data streams. For example, smart thermostats can incorporate local time-of-use rate information to automatically adjust heating and cooling loads according to hourly electricity prices, ensuring the home maximizes cost savings while maintaining comfortable temperatures.

Emerging Technology Trends in In-Home REMS

A few trends appear to be growing throughout the in-home REMS market. The first is the development of mobile applications (apps) with an emphasis on user interfaces that make energy management simple for users. Most REMS manufacturers have developed their own mobile apps that allow consumers to have greater control over their products. These apps are continuously adding new features that are moving beyond simplified and streamlined operations of their associated equipment. For example, in 2023, Mitsubishi Electric Trane announced a new feature in their app that allows consumers to directly connect with contractors for maintenance and service requests (Mitsubishi Electric Trane 2023).

System integration is another trend that is becoming common amongst REMS manufacturers. While REMS manufacturers are developing systems to optimize use of their proprietary devices, they also recognize the importance of offering consumers the ability to seamlessly integrate all of the REMS in their home, even those sold by competitors. Nearly all smart home platform providers include information about their partners on their website, highlighting the importance of system integration. Furthermore, broad manufacturer support of communication standards like Matter, Zigbee, and Z-wave also serve as evidence of the importance of system integration in REMS technology development.

Beyond streamlined integration between REMS, companies are also pursuing partnerships to unlock synergies capabilities, or benefits that would be otherwise unattainable without integrated systems. For example, Ford and Resideo announced a partnership to explore ways that customers could "use energy stored in their EVs to heat and cool their homes" (Tuohy 2023). Likewise, Maxeon Solar Technologies and Samsung announced a partnership to integrate their products so that homeowners can "increase their energy independence, save money, and contribute to a cleaner environment" (Maxeon 2023). One of the new features available through this partnership will allow homeowners to maximize the use of their solar generation by integrating generation data from the Maxeon system into Samsungs SmartThings platform, which can then adjust HVAC schedules to pre-heat or cool the home during times of high generation.

Grid-Based REMS

Grid-based REMS are products and services that enable utilities to monitor and manage residential energy use. These systems typically revolve around software solutions that integrate and analyze data from a variety of sources including advanced metering infrastructure (AMI), proprietary meters and monitors, and utility systems. Using the latest technology available, grid-based REMS providers integrate these various data streams to provide utilities greater visibility into residential energy use in their territory and solutions to engage with customers to change their energy consumption habits.

One of the most prevalent types of grid-based REMS on the market are AMI-based HEMS providers. AMI-based HEMS use advanced data analytics to disaggregate whole-home energy consumption data, typically from smart meters, into information about individual loads. These systems then use this data to create a variety of products and solutions for utility clients including home energy reports, customer web portals, and back-end systems for customer engagement and grid visibility.

Technology Evolution

Over the last 15 years, AMI-based HEMS solutions have evolved to meet the ever-changing needs of utilities by continuously improving their software and products. One such product, home energy reports (HERs), provide a clear example of how AMI-based HEMS solutions have evolved to provide new solutions for residential energy management to both utilities and their customers, shown in greater detail in Figure 3.

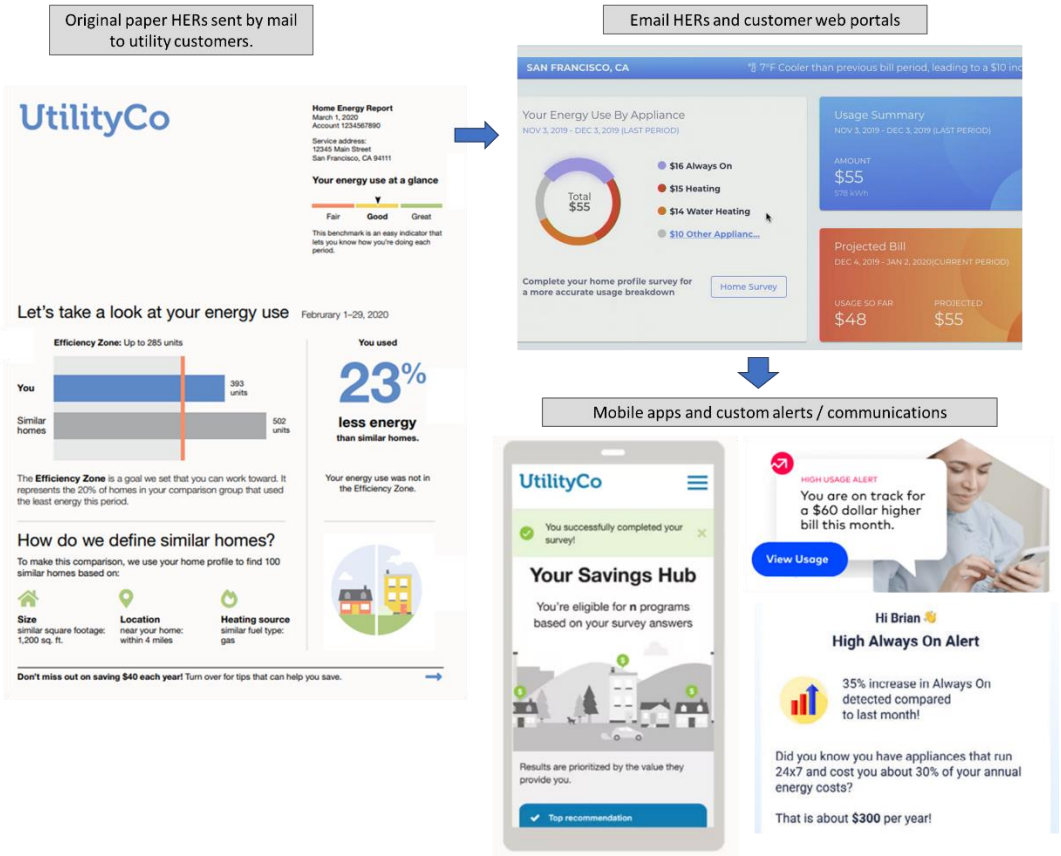


Figure 3. Evolution of Home Energy Reports *Sources*: Oracle 2020, Bidgely 2024c, Oracle 2024b, Uplight 2024, Bidgely 2020.

Overall, AMI-based HEMS solution providers have generally evolved their REMS products and services in the same way that any technology company approaches product development. This includes iterative design updates for core products, like the original paper HERs, and the introduction of new features and products. These developments typically involve a combination of user-research, product evaluations, and incorporation of new technologies like machine learning and AI.

Emerging Technology Trends in Grid-based REMS

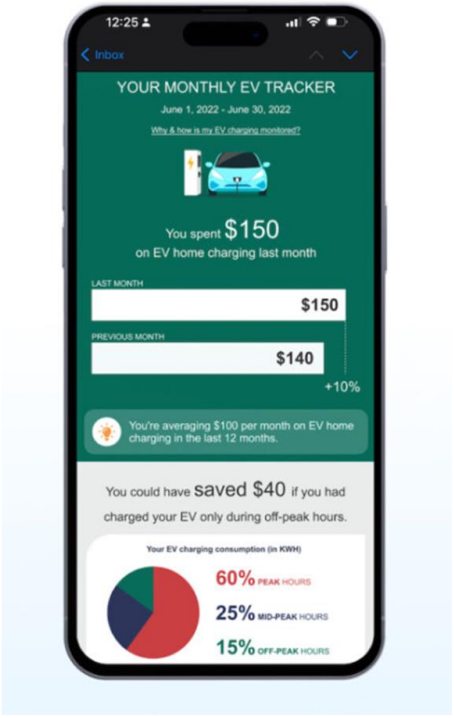
Looking ahead, there are many emerging trends in how AMI-based HEMS are likely to develop in the near future. The first is a continued focus on customized products and communications to each utility customer through the use of AI. While this has been a core part of AMI-based HEMS offerings for many years, the systems continue to become more advanced in their data analytics capabilities to create custom solutions and strategies for each customer. For example, Bidgely's Next Best Interaction engine leverages data from customer account profiles, information about the utility's objectives, and external data like weather forecasts to determine the best time and mode of communication for engaging with each individual customer. For

instance, if the utility has a goal of reducing peak loads in the summer, Bidgely's system can identify customers with the highest cooling demand and send them a custom alert explaining that they use more energy for cooling than similar homes and recommend that they consider upgrading their HVAC system with links to local contractors and incentive programs.

More recently, these systems are leveraging real-time energy use data to provide more immediate feedback to utility customers around their energy consumption. For example, Uplight's AMI alerts send communications to utility customers that explain deviations in their typical energy use as they occur. For example, the alerts can let customers know they are using more energy than they did the previous month and provide insights as to why their usage has gone up including higher outdoor temperatures, more people in the home, and changes in occupant schedules. Almost all major AMI-based HEMS providers leverage real-time data, including Uplight, Bidgely, Oracle's Opower.

Another trend is the development of products for emerging utility needs like improving visibility of customer-installed DER, tracking, and managing home electrification, and enrolling customers in time-of-use rates. These solutions may include back-end platforms that provide data dashboards around these specific needs, as well as solutions for customer engagement like specific email communications and webpages. Figure 4 includes examples of recently developed products and services that meet some of these needs.

Oracle's Rate Coach provides customers feedback on their time-of-use rates and how it relates to their energy use.



Bidgley's EV management solution provides customers information about their EV charging and recommends best times to change their cars to reduce their energy bills.

Figure 4. Examples of AMI-based HEMS solutions for specific utility needs *Sources*. *Source*: Oracle 2024a, Bidgely 2024b

Future Capabilities for REMS

In addition to the trends that are noted earlier, there are many important capabilities that REMS technologies enable that will revolutionize the way people consume power and get service from their respective power utilities. Some examples include:

- **Integration with other Smart Home Systems:** Today, REMS systems can optimize the performance of one or two energy uses. Energy usage and the performance of other smart home systems can be further improved by sharing information among smart home application segments. For example, a security system can more accurately detect the presence of an intruder by detecting the additional HVAC needs associated with the opening of a window or turning on of lights when no authorized user is present.
- **Enhanced Smart Thermostats:** The first generation of smart thermostats can offer significant energy use reductions when compared to single-set and programable thermostats by leaning occupancy patterns of the residents. The next generation of smart thermostats will further increase savings by using cellular geofencing and testing the effectiveness of deeper temperature setbacks. Experience has shown that many smart thermostat users are too tentative in trying setbacks, which reduces the impact of energy reductions. In addition, next generation thermostats will have insight into weather fronts and anticipate changing conditions so that it does not need to heat or cool the residence unnecessarily.
- **Performance Monitoring of Residential Systems**: REMS can identify changes in energy use over time for each appliance. This kind of information can offer advanced warning of an imminent failure in addition to any performance degradation suggesting the need to routine maintenance.
- **Tracking Usage Data**: Human nature is that, when a homeowner gets a new appliance, they tend to change their usage patterns and use the new appliance more frequently. This is called the "rebound effect." REMS systems can track usage patterns and show homeowners how their usage patterns affect their expected energy savings.
- **Financial Analysis of Energy Efficiency Upgrades:** A homeowner has many options on ways to increase energy savings. This can include replacing older equipment within the house or improving the building envelope. Accurate REMS information enables the homeowner to calculate the savings associated with a variety of these options so the homeowner can make the tradeoffs that best meeting their needs.

There are just some of the ways that the various elements of smart homes can more effectively use information to produce more efficient energy outcomes and greater homeowner satisfaction, with little to no impact on comfort or convenience.

REMS Applications for Reaching Underserved Customers

Both in-home and grid-based REMS can offer benefits for low-income and historically underserved customer segments, which will only become more important as grid modernization efforts continue throughout the U.S. With the federal government committing nearly $7.5 billion

towards grid modernization projects through 2025, it is critical that these communities have equitable access to REMS so that they can also reap the benefits of a modernized grid. For example, as more utilities move towards time-of-use rates, it is important that these communities are included in education and enrollment solutions provided by grid-based REMs providers and have in-home REMS like smart thermostats or grid-connected water heaters that can automatically adjust their energy use. The following sections provide an overview of successful applications of REMS technologies to serve these communities.

Customer Segmentation, Tailored Outreach, and Customized Interfaces

Grid-based REMS can be extremely useful tools for identifying and engaging hard-to-reach and underserved customer segments. This is largely due to the ability of these systems to integrate many different data streams to identify key customer segments more accurately. These data streams may include census data, customer-provided data, energy use data, and proprietary data sets (O'Keefe 2023). These systems are often able to leverage more advanced technology and staff expertise to incorporate these different data streams than what utilities are able to do in-house. For example, one utility worked with Oracle's Opower to identify low-income customers eligible for their income-based programs and the Opower system was able to identify 78% more eligible customers than the utility was able to identify through their usual processes (O'Keefe 2023). Several grid-based REMS providers offer dashboards that allow utilities to more easily identify and segment key customer groups including low-income and underserved customers, as show in Figure 5.

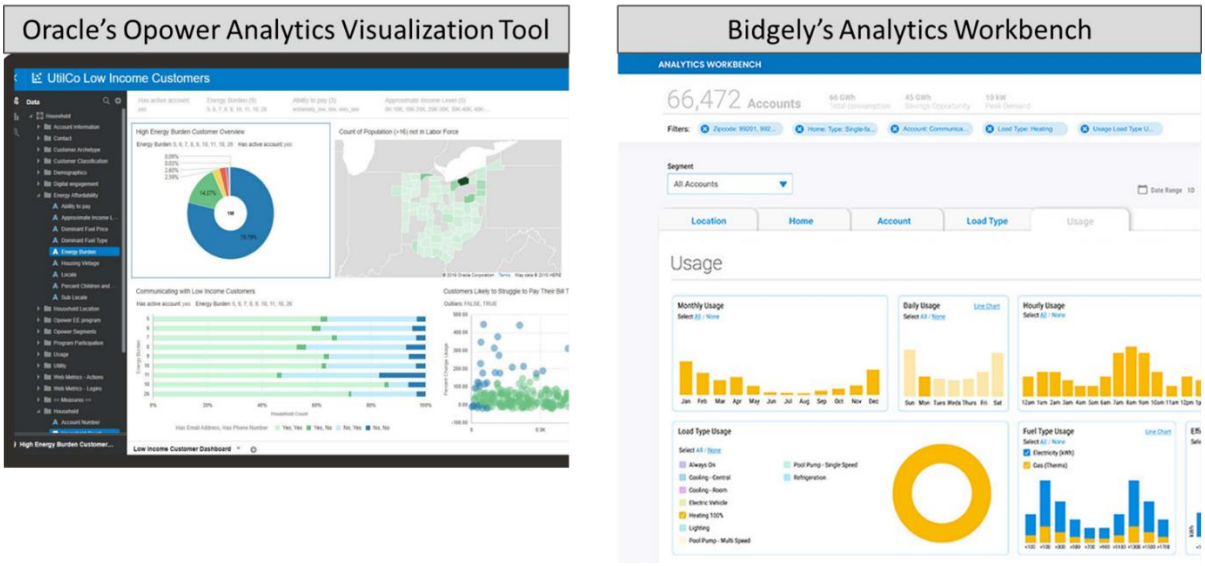


Figure 5. Examples of dashboards for identifying key customer segments *Sources*: Belyeu and Klausmeier 2023, Bidgely 2024a

Beyond identifying underserved customer segments, grid-based REMS technology providers are also able to leverage AI and machine learning to develop specific communications for reaching these customers. This can include identifying the messages that are most effective

for resonating with each customer, recognizing and automatically translating communications into a customer's preferred language, and automatically qualifying customers for programs so that they do not have to wade through program requirements before applying. Grid-based REMS providers can also develop unique solutions and interfaces for these customer segments, one of which is described in more detail in the subsection below.

Case Study: Uplight's Giveaway Hub

Uplight developed a solution for reaching low-to-moderate income customers called Giveaway Hubs. To utility customers, these hubs look like traditional utility marketplaces with rebate-qualified products, except the Giveaway Hubs feature free-to-order products to qualified customers. The hubs make it easy for income-qualified customers to see the products that are available to them through utility programs and instantly apply to receive them without having to enter payment information. The solution also offers the capability of streamlining the participant qualification process by having customers enter their address and account number, as well as answer any questions the utility wants to include to verify their program eligibility.

In 2021, Sacramento Municipal Utility District worked with Oracle to offer a Giveaway Hub that provided income-eligible customers free ENERGY STAR certified Christmas lights. The solution was so effective that the program reached its rebate cap in less than 48 hours after the promotion was launched (Uplight 2021). This case study illustrates the value that grid-based REMS can provide when designing solutions to reach underserved customer segments at a meaningful scale. These solutions can combine customer segmentation, unique interfaces, and tailored engagement strategies to provide programs that more effectively reach these customer segments.

Access to Demand Flexibility Compensation

In general, more utilities are moving towards programs and rate structures that incorporate demand flexibility. These typically are designed to encourage customers to shift their energy use to times when demand on the grid is low and reduce peak-demand spikes. This will only become more necessary as home electrification and EV adoption contribute to higher peaks. Both grid-based and in-home based REMS will be critical for customers to actively participate in these programs and rates, highlighting the need for low-income customers to have equitable access to both of these solution types. The case study below illustrates the benefits that low-income and underserved customers can receive when programs provide access to both types of REMS.

Case Study: Shifted Energy and Hawaiian Electric Smart Water Heater Program

Hawaiian Electric partnered with Shifted Energy to install over 3,000 grid-connected water heater control modules in homes throughout Oahu and Maui, with approximately 90% of these installations in the homes of hard-to-reach customers including lower-income, multifamily residents, and renters (Hanley 2023). Shifted Energy's virtual power plant software platform is able to communicate with these modules to heat water at the most cost-effective and beneficial times for both occupants and the grid. Participants in the smart water heater program have received over $215,000 in bill credits, with an estimated monthly savings of $75 to $125 for participants (Coules 2023). Shifted Energy's system is also able to detect leaks or broken parts

and inform customers of these issues, resulting in better performance of their equipment and potential cost savings. This program illustrates the value that a combination of in-home and grid-based REMS can provide to low-income customers and underscores the need for these customer segments to have equitable access to both solution types so that they are able to access the benefits of demand flexibility programs.

Conclusion

REMS technology will continue to advance over the next decade and become an increasingly important part of our homes and electrical grid. Technology has advanced to a point that these systems are more affordable than ever, and grid modernization efforts are creating an environment where these systems can deliver real value to customers, utilities, and grid operators. It is critical that underserved communities gain equitable access to these systems so that they are not excluded from the benefits of a more modernized grid. While the case studies in this report illustrate the value of REMS programs designed specifically for these customer segments, these efforts need to be considerably scaled over the next few years in order to ensure widespread and equitable access to REMS technologies and their future benefits.

References

Bastian, Hannah, 2023. Residential Energy Management Systems. Boulder, CO: Guidehouse Insights. https://guidehouseinsights.com/reports/residential-energy-management-systems

Bidgely, 2020. *AI-Powered Home Energy Reports for Behavioral Energy Efficiency*. Los Altos, CA: Bidgely. https://www.bidgely.com/resources/ai-powered-home-energy-reports-for-behavioral-energy-efficiency/

Bidgely, 2024a. *Equitably Engaging All Low-to-Moderate Income (LMI) Customers.* Los Altos, CA: Bidgely. https://www.bidgely.com/resources/equitably-engaging-all-low-to-moderate-income-lmi-customers/

———. 2024b. "Get Shift Done." Accessed February 29. https://www.bidgely.com/solutions/ev/

———. 2024c. "UtilityAI In-Depth: Introduction to the Bidgely Demo Portal." Accessed February 29. https://www.youtube.com/watch?v=yuWUa01PBHA&t=22s

Belyeu, Jameela and Klausmeier, Ryan Irwan, 2023. 'Opower's Approach to Energy Affordability". *Presented at Oracle Energy and Water Customer Edge Conference.* https://www.oracle.com/a/ocom/docs/opower-customer-centric-approach-affordability.pdf

Coules, Ryann, 2023. "Hawai'i's Sustainability Heroes: Shifted Energy." *Hawaii Business Magazine,* September 18. https://www.hawaiibusiness.com/hawaii-sustainability-hero-shifted-energy/

ENERGY STAR, 2022. *ENERGY STAR Unit Shipment and Market Penetration Report Calendar Year 2022 Summary*, Washington, DC: ENERGY STAR.

https://www.energystar.gov/sites/default/files/2022%20Unit%20Shipment%20Data%20Summary%20Report.pdf

Hagley Digital Archives, 2024. "The Jewell Automatic Temperature Controller Makes the House Comfortable. Accessed February 29. https://digital.hagley.org/08058379_jewell

Hanely, S, 2023. "Shifted Energy Uses Energy Control Strategies to Stabilize the Grid in Hawaii." *Clean Technica*, March 3. https://cleantechnica.com/2023/03/07/shifted-energy-uses-energy-control-strategies-to-stabilize-the-grid-in-hawaii/

Home Depot, 2024. "Smart Thermostats." Accessed February. https://www.homedepot.com/b/Smart-Home-Smart-Devices-Smart-Thermostats/N-5yc1vZc7cl

Maxeon, 2023. "Maxeon Solar Technologies and Samsung Join Forces on Smart Home Energy Management Solutions." *Press Release,* June 24. https://mediaroom.maxeon.com/2023-06-14-Maxeon-Solar-Technologies-and-Samsung-Join-Forces-on-Smart-Home-Energy-Management-Solutions

Mitsubishi Electric Trane, 2023. "New smart feature connects HVAC contractors and homeowners with app for enhanced service." *Press Releases,* June 23. https://metahvac.com/news-and-press-room/entry/new-smart-feature-connects-hvac-contractors-and-homeowners-within-app-for-enhanced-service

MYSA, 2020. "The History of Thermostats and Their Evolution to Smart." *Home Automation Blog*, May 29. https://getmysa.com/blogs/home-automation/the-history-of-thermostats-and-their-evolution-to-smart

National Museum of American History (NMAH), 2024. "Honeywell T832 Round Thermostat." Accessed February 29. https://americanhistory.si.edu/collections/nmah_1392753

O'Keefe, Matt, 2023. "Alleviating the Energy Affordability Crisis in America." *Utility Dive,* July 11. https://www.utilitydive.com/spons/alleviating-the-energy-affordability-crisis-in-america/685584/

Oracle, 2020. "Welcome to the Future of Home Energy Reports, Today." Accessed February. https://www.oracle.com/a/ocom/docs/industries/utilities/utilities-opower-home-energy-reports.pdf

———. 2024a. "Customer Experience: TOU Rate Coach Emails." Accessed February 29. https://docs.oracle.com/en/industries/energy-water/behaviorial-load-shaping/behavioral-load-shaping-overview/Content/BLS_TOU_Coach_Customer_Experience.htm

———. 2024b. "Easily enroll your LMI customers in energy assistance programs." Accessed February 29. https://www.oracle.com/utilities/products/opower-limited-income/#rc30p3

Tuohy, Jennifer Pattison, 2023. “Ford is partnering with smart thermostat maker Resideo to use energy stored in your EV to heat and cool your home.” *The Verge,* December 7. https://www.theverge.com/2023/12/7/23992267/ford-resideo-ev-home-power-partnership-bidirectional-charging

Uplight, 2021. *SMUD’s Giveaway Hub Serving Low-to-Moderate Income Customers.* Boulder, CO: Uplight. https://uplight.com/resources/smuds-giveaway-hub-serving-low-to-moderate-income-customers/

———. 2024. “Changing to a New Rate.” Accessed February 29. https://uplight.com/customer-journeys/

Western Hardware, 2024. “Honeywell Wi-fi Programmable Thermostat.” Accessed February 29. https://westhardware.com/p/wi-fi-programmable-thermostat-085267771955

Disclaimer: Companies and products mentioned throughout this paper do not constitute endorsement by Guidehouse