Optimizing Today's Residential Energy and Automation Systems

W e've all become familiar with smart appliances around the house. From my perspective, the smart-home revolution was launched by smart lighting. Admittingly, I am biased. Today, there's so many smart lighting products to choose from, the selection feels a bit overwhelming. The array of products seems endless when I start to consider all the other smart appliances available for my home—refrigerators, hot water heaters, thermostats, doorbells, even toilets. I don't yet own an electric vehicle or have solar power on my roof. Where I live, these technologies are not as mainstream as they are in other parts of the country. The logistics don't quite work, but someday. Someday soon.

AUTHOR

CORI JACKSON

This leads me to consider how one household would even begin to manage all this smart technology. It should be connected. Wouldn't that be ideal? One central hub to monitor, track and control all the smart, connected appliances in our homes, plus our photovoltaic (PV) panels, our electric vehicles and even battery storage? Well, I am happy to report that such an ideal solution may already exist. In the not-too-distant future, maybe even right now, the centralized residential energy and automation (REA) system is a reality. Note, I've coined this term myself, as no industry accepted term yet exists, to my knowledge. What is a REA system? How do they work? What can they do? How much do they cost? Some people are starting to ask these questions right now with an eye toward making a purchase at some point, or helping others to make the right choice. The answers don't yet exist, but they will soon.

T he California Lighting Technology Center at UC Davis, in collaboration with California's statewide electric emerging technologies program—CalNEXT[1]—is considering research to address these questions and more for this new suite of residential products. REA systems combine home-energy monitoring features with automated appliance management and control of distributed energy resources (DER) such as electric vehicle (EV) chargers, rooftop solar panels and stationary battery energy storage (BES). A REA system is typically a single device coupled with an app and, in some cases, one or more secondary components, which brings residential energy generation, storage and use under one integrated appliance. These new systems have significant potential to advance residential energy efficiency and peak demand reductions. Other benefits include residential load flexibility in the form of complete islanding for single family homes, which can remove significant load from the grid, and discharging of stationary and mobile BES (via bi-directional chargers), which can add capacity back. In addition, these new systems can make homes more resilient during grid outages by automatically switching loads to local BES when the grid is unavailable.

REA products are the next step in the smart-home technology evolution. They build on, but are fundamentally different from, some important technologies that are also still relatively new to the residential market. Google Nest, for example, is a well-known line of smart-home

automation devices that include cameras, touch screens, gaming devices, smart thermostats and a host of others. Alternatives include complete product lines as well as software solutions like the SmartThings app from Samsung, which allows you to connect and control devices from multiple vendors. Honeywell Home is another example, which offers smart air filters and humidifiers in addition to the doorbells and thermostats. Its products can also be controlled through SmartThings. However, these products gener-

ally neglect electric vehicles, battery storage and PV; three of the most important components of your home's energy infrastructure. REA systems do not.

REA systems are currently under development by multiple companies, and a few are marketing REA technology today. Of the systems already being promoted, each has different functionality, system configurations and EV charging options. Currently available product options include a stationary battery-based system from Panasonic called EverVolt

Battery Storage as well as the r16 product from Dcbel that relies on DC charging standards for its EV communication including combined charging system (CCS) or CHAdeMO connectors. These are compatible with the Nissan LEAF (**Figure 1**). Other manufacturers offering REA products include Flex Power Control[2] and SolarEdge.[3]

There is limited information available on these systems, which is pushing the need for publicly accessible research and testing. CLTC's goal is to validate technology perfor-

Figure 1. Commercially available residential energy and automation products: Dcbel r16 (left), Panasonic EverVolt (right).

First Spec

In June 2021, ENERGY STAR issued its first specification for Smart Home Energy Management Systems (SHEMS). At a minimum, an ENERGY STAR-certified SHEM system must include the following devices in addition to meeting other program requirements: one ENERGY STAR-certified smart thermostat, two connected lighting devices, and one plug-load control or home-energy submetering device. This past January, Baltimore Gas and Electric (BGE) became the first company to secure the ENERGY STAR SHEMS rating for a suite of smart-home technologies called the BGE Smart Home Solution. The SHEM boundary does not extend beyond the home living space, however, which means it does not yet address EV charging supply equipment, battery energy storage or rooftop PV panels.

mance against manufacturers' claims and in comparison to more traditional home-energy and smart-appliance technology. Its research will quantify the incremental difference in energy, economic and environmental performance between business-as-usual and emerging per kWh basis. Demand and carbon reduction benefits can be achieved by combining appliance control systems, enabling two-way grid communications, and leveraging EV batteries as load-flexible energy storage when EVs are connected to the system. Researchers are also

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REA systems based on currently available market data. In addition, REA systems can potentially provide customers with extended energy management and storage at a lower cost than stationary storage on a dollar considering development of regionally specific use cases for energy-efficiency improvements and carbon reduction potential considering hourly emissions factors for different state regions.

Market barriers do exist such as first cost, lack of consumer education, the existence of site-specific design needs, lack of EV adoption, EV interoperability and utility interconnection. Additionally, the lack of home-energy management to date means there is a lack of well-defined and validated sequence of operations for residential whole-building control strategies. Additionally, there have been very few interconnections with bi-directional charging stations. The requirements for interconnection are still in development in some areas and the process is still largely undefined, which will continue to be a barrier as products come to market. However, the research questions and studies are beginning, and manufacturers can expect increased interest over the next several years. I look forward to seeing the results from CLTC's first study. I am sure it will not be the last for this technology. ⊚

THE AUTHOR | Cori Jackson is the program director at CLTC. Her research focuses on building design optimization, workforce training program development, and codes and standards enhancement activities.

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