CLEAResult®

GUIDE TO

SMART thermostats

We change the way people use energy™

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Glossary

Here's a list of definitions to give you a high-level understanding of terms used in this paper.

Communicating thermostats are devices that control the cooling and heating equipment through a user and equipment interface. These devices are often programmable, though they tend to offer more options to operate auxiliary devices than other programmable thermostats. They also reduce the required number of conductor wires between the user interface and the indoor unit, which can be ideal for retrofit applications. Not all communicating thermostats are smart thermostats, though.

Connected thermostat: See Wi-Fi thermostat and smart thermostat below.

Demand reduction, or demand response (kW), is when an electric utility customer reduces their power consumption to better match the demand for power with the supply. To get people to reduce electricity use in peak periods, many utilities will offer price incentives for reducing power consumption in peak periods. The implication of this is that it can prevent customers from paying "surge" unit prices, whether directly or factored into general rates. Demand reduction is a great solution to the problem, since there are limits to what can be achieved on the supply side in a timely manner.

Energy savings, or energy conservation (kWh), is when someone reduces energy consumption by using less electricity. An example of how to achieve this could be shutting off a HVAC system with a smart thermostat or changing the setpoint of the thermostat, while the home is unoccupied or the occupants are asleep.

Geofencing is a virtual perimeter for a real-world geographical area. You can dynamically generate a geofence, around something like a home. When someone enters this area, it could trigger an alert to the device's user or geofence operator. This information could be used for something like triggering a thermostat to heat or cool the home prior to the occupant arriving home.

Heating, ventilation and air conditioning, or HVAC, refers to heating and cooling equipment and sometimes the duct system attached to such a system. Thermostats are typically used to control the operation of these devices.

Home energy management systems, or HEMS, refer to any hardware or software system that monitors and provides feedback about a home's energy usage and/or enables advanced control of energy-using systems and devices in the home.

In-home display, or IHD, is a screen or dashboard physically present in the home. Most often IHD is used to describe a dashboard that monitors or controls several energy-using systems in the home (sometimes referred to as a "command center").

Internet of things, or IoT, is any physical device that's connected to the Internet and inside a home or business that can control the device.

Learning algorithms are built by learning thermostats and thermostat optimization to improve the HVAC system performance.

Learning thermostats can automatically learn when the house is likely to be occupied or empty. This allows it to automatically pre-heat or pre-cool the house, to make it comfortable when a resident arrives. Even if a resident's lifestyle changes, the smart thermostat will gradually adjust the schedule to maintain both energy savings and comfort. A well-known example is the Nest thermostat.

Low-voltage thermostat senses a home's temperature to maintain the system's temperature near a desired setpoint. The thermostat does this by switching heating or cooling devices on or off, maintaining the correct temperature. Most thermostats are low voltage, whether they're smart, communicating or programmable thermostats.

Occupancy sensor is an energy-saving heating or cooling control device that detects the occupancy of a space and automatically turns the HVAC system on or off accordingly. These sensors use infrared, ultrasonic, microwave or other technology.

Programmable thermostats electronically control heating and cooling equipment to deliver pre-set indoor conditions at established times. This doesn't automatically make it a smart or communicating thermostat, though.

Setback is when a thermostat is adjusted from the setpoint, while the home is unoccupied or the occupants are asleep. This is an energy-saving strategy made possible by the creation of smart. Appropriate setbacks vary by system type. Gas furnaces have larger capacities than other HVAC systems, so larger setbacks are appropriate. Heat pumps have small capacities, so setbacks should be small to prevent the use of electric strip heat.

Smart thermostats allow users to control the temperature of your home using a schedule. Its heating settings can be controlled from Internet-connected devices, like smartphones, computers and tablets—making it easy to switch off the heating or air conditioning when the house is empty. Smart thermostats can save more energy than Wi-Fi thermostats because of their occupancy or proximity-sensing technology feature.

Thermostat optimization compares historical energy usage data from a connected thermostat or device to real-time weather data. After it determines how a home responds to specific weather conditions, weather optimization is performed to the timing of the thermostat's setpoint schedule. Occupants still control the settings and manage the thermostat schedule by altering the timing of when the system should use energy to meet that temperature.

Wi-Fi thermostat, also known as a connected, programmable communicating thermostat, or PCT, controls a HVAC system from an Internet-connected device. All smart thermostats are wireless, connected and PCTs, but not all PCTs are smart.

Zone thermostats control the temperature of individual rooms instead of the entire home. This can increase energy savings.

Introduction

To truly understand smart thermostats, you have to understand where they came from.

It all started with the smart grid, which has been evolving since the late 20th century. The technology, devices and software that allow us to capitalize on the promises of smart grid infrastructure began to appear in the last several years, and in 2016, they are now ready for widespread use.

The first official definition of the smart grid came from the Energy Independence and Security Act of 2007, in which the U.S. Congress envisioned a "reliable and secure electricity infrastructure that can meet future demand growth." In the efficiency industry, the smart grid meant that potential advances in energy tracking and data analysis might improve our ability to offer energy efficiency upgrades to buildings and homes. With the energy consumption data from the smart grid available at more frequent intervals, we could have much greater insight into how any given home uses energy. This could allow us to detect faults in equipment, replace inefficient equipment and determine which of our behaviors are costing us the most energy.

CLEAResult believes strongly in the potential of smart grid technologies to yield these insights and ultimately facilitate more cost-effective energy efficiency and demand response programs.

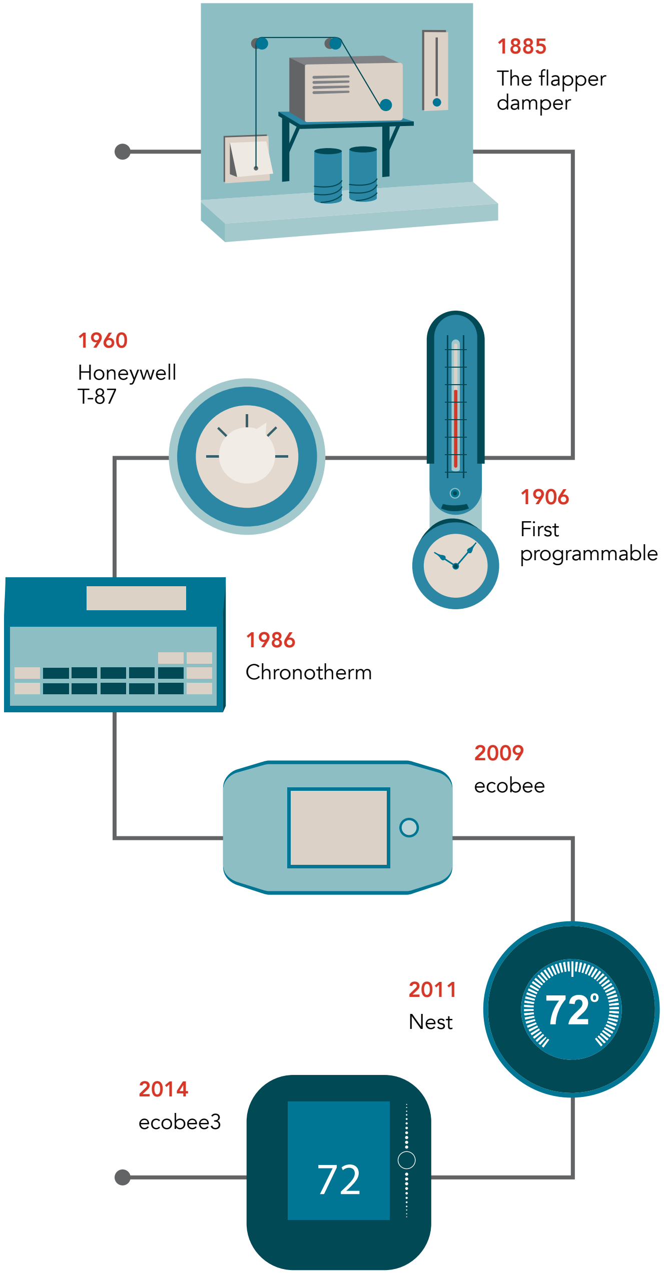
CLEAResult believes strongly in the potential of smart grid technologies to yield these insights and ultimately facilitate more cost-effective energy efficiency and demand response, or DR, programs. In houses, this technology is often referred to as smart home products, or Home Energy Management Systems, or HEMS. According to the Northeast Energy Efficiency Partnership's, or NEEP, HEMS Working Group, HEMS refer to "any hardware and/or software system that can: monitor and provide feedback about a home's energy usage, and/or also enable advanced control of energy-using systems and devices in the home." Smart home devices and ecosystems began to show up in the consumer market over a decade ago, in connected products like remote-controlled window coverings, Wi-Fi enabled sound systems, outlet level plug-load controls and—the focus of this paper—smart thermostats.

CLEAResult has been tracking the growth of the smart grid and HEMS products for several years, particularly with respect to how they may affect our residential programs. Smart home platforms are an exciting technology that have the potential to not only help homeowners save energy, but also improve health, safety, security and even water efficiency through advanced monitoring and wireless control technology. We see this potential most clearly in the category of smart thermostats, which have truly captured the attention of American and international consumers and have opened the door to other smart products. For those of us in the energy industry, the opportunity to save energy in millions of new and existing dwellings—using a product that consumers are clamoring for—is too good to pass up.

We want you to be able to maneuver this current ecosystem of smart thermostats.

That's why this paper outlines available products and services and shares the collective expertise of CLEAResult's energy analysts, building science consultants and program managers who have first-hand knowledge of how smart thermostats work and how they can help save energy.

The pages you're about to read include actual user experiences, product functionality, characteristics, prominent manufacturers, interoperability, evaluated results, savings potential, implementation efforts and recommendations going forward. In other words, it justifies why we refer to this paper as a guide and should answer most, if not all, of your questions.



History of thermostats

Humans have always strived for comfort in their homes. Thermostats achieved that goal on a whole new level.

The timeline and images presented here depict milestones in the evolution of HVAC controls, going back to the 19th century. You can see how far HVAC controls have come since the very first attempt to control a coal furnace.

1592 Cornelius Drebbel invented the first thermostat, using a mixture of mercury and alcohol to raise and lower a piston that regulates an air damper. He called it the “magic oven.” Others accused him of witchcraft.

1883 Warren Johnson invented the first bimetal thermostat. Johnson was a mechanical engineering professor who grew tired of notifying the janitor that his classroom was too cold. His first thermostat simply rang a bell that notified the janitor to open the damper or add more coal. It was later modified to control airflow and the coal feed. He went on to found the Johnson Control Company.

1885 Albert Butz invented the flapper damper to regulate the control of air to a boiler. The way it worked is when a room cooled below a predetermined temperature, a thermostat closed the circuit and energized an armature. This pulled the stop from the motor gears, allowing a crank attached to the main motor shaft to turn one-half revolution. A chain connected to the crank opened the furnace’s air damper to let in air. This made the fire burn hotter. When the temperature rose to the preset level, the thermostat signaled the motor to turn another half revolution, closing the damper and damping the fire. The temperature correction was automatic. Over the years, many Honeywell products have been based upon similar, but more complicated, closed-loop systems. His invention was eventually acquired by Honeywell.

1906 Honeywell created the first programmable thermostat, the Jewell. It was a setback clock thermostat called “Jewell.”

1960 The Honeywell T-87 was created, which is now in the Smithsonian Museum for its design.

2011 Nest released its first generation learning thermostat, making many Americans aware of smart thermostats.

What is a smart thermostat?

Smart thermostats have all of the features of ordinary programmable thermostats—and then some.

Programmable thermostats can electronically control heating and cooling equipment to deliver preset indoor conditions. Though some newer programmable thermostats have internet capabilities (referred to as programmable communicating thermostats), many don't. Adding this Internet connectivity has really expanded the capabilities and ranges of products to control indoor conditions, increase system efficiency, improve comfort, share data and even inform homeowners of operating conditions of equipment.

But what makes smart thermostats "smart" is generally characterized by two unique features: the ability to communicate, typically through a Wi-Fi connection that lets users control the unit remotely; and algorithms or functionalities that allow the unit to control the HVAC system based on user inputs and previous behavior.

We also support that, in order for a thermostat to be "smart," it must have the ability to recognize if users are occupying conditioned space and be capable of programming (automatically or not) the HVAC system based on the location of the user.

Smart thermostats can provide unprecedented levels of control on heating and cooling systems.

Benefits and challenges

As with any emerging technology, there are many potential benefits and some perceived challenges to smart thermostats.

One of the biggest benefits of smart thermostats is that they can provide unprecedented levels of control on heating and cooling systems. With a house's HVAC system representing on average the largest energy consumption category in a household, every bit of control a user can have to save energy is huge.

The ease of use is another big advantage of smart thermostats over standard programmable thermostats, which require greater attention to manuals and instructions and are often not set up properly. With clear and well-designed user interfaces, smart thermostats engage customers more easily. At a utility portfolio level, the unprecedented amounts of data that can be gathered by smart thermostats could allow utilities and programs to easily identify DR events or deliver energy savings as a more reliable resource.

A smart thermostat can also solve the problem of a user not setting their thermostat back when they leave the home. Its occupancy and/or proximity sensors can "see" if an occupant has left for an extended period of time. Wireless apps or dashboards give the user remote control capabilities to save even more energy when they're not at home or asleep.

But there are also several challenges to implementing smart thermostats in energy programs, since the technology is actively being developed and refined. Smart thermostats are not completely compatible with ductless systems and rely on software and firmware updates to stay current. Also, if a software/firmware update doesn't take place, it is possible that the thermostat could stop working or not function properly. Smart thermostats collect more user data than their predecessors, causing some consumers to be hesitant to adopt a technology that knows so much about them. ■

Markets

Since 2011, smart thermostat sales have continued to grow each year, with sales increasing globally by 123 percent in 2015 and the U.S. market owning 70 percent of the market share. Today, the leaders in the smart thermostat space include Nest, ecobee and Honeywell. In 2017, smart thermostats are expected to take more than 50 percent of the thermostat market share in the U.S. And if the future's not already looking bright enough, a recently updated market research report by Navigant Research predicts that global revenue for smart thermostats and associated software and services will grow from $1.1 billion in 2016 to $4.4 billion in 2025.

The market was clearly ready for smart thermostat programs. According to a study by the Shelton Group, 84 percent of people said they expect to be able to control something in their homes via smart devices in 2016, while 39 percent of Americans said they prioritize smart thermostats as something they would try if given the chance. Of the people who have smart thermostats, 66 percent said they are seeing the savings they expected.

NEEP also thinks smart thermostats have "great potential to impact energy programs," according to its report published in September 2015. NEEP described smart thermostats as primarily control-based devices for space heating and air conditioning energy end-uses, with potential energy savings in the overall HVAC category of about 2–22 percent—a proposed range that's largely due to variations in behavior and the functionality of the devices. The report also implied smart thermostats can help manage summer and winter peak demand events, which are increasing in climate zones across the country. It also stated that the opportunity to use smart thermostats as a demand management tool or hub for other demand response control devices, may have an even bigger impact driving energy efficiency programs.

In other words, smart thermostats could be a game changer for energy programs. ■

Global revenue for smart thermostats and associated software and services will grow from $1.1 billion in 2016 to $4.4 billion in 2025.

Product functionality and specifications

The majority of the thermostats in this report are low-voltage controls applied to systems that heat or cool, based on the control of that centrally located thermostat. However, the thermostats we discuss could also apply to line-voltage systems or individually operated zonal systems. They could also use multi-temperature or humidity-sensing devices to control a central system.

Smart thermostats—with the help of occupancy sensors, proximity sensors, local weather data and smart algorithms—can determine the heating and cooling needs in a more efficient manner than simply setting temperature setpoints and letting the HVAC system run. In this section, we will discuss prominent characteristics and functionality of smart thermostats, as well as best practices for choosing a smart thermostat.

Compare the thermostats

Programmable thermostats	Occupants set schedules and setbacks to match their lifestyle; programmable thermostats do not have occupancy or proximity sensors
	Ability to maintain comfortable temperatures in a structure
	Displays temperatures and operating modes
Wi-Fi thermostats	Wi-Fi enabled
	Online dashboard and/or mobile app connected to the user account
	Intuitive user interface, or UI, that may include touchscreen or buttons
Smart thermostats	Occupancy sensing that directly detects occupants by internal sensor and adjusts the thermostat accordingly
	Proximity sensing that indirectly detects occupants by external device, like a smart phone, and adjusts thermostat accordingly
	Algorithms that learn occupant behavior to improve schedules and learn characteristics of the structure to improve performance of the system
	Basic demand response capabilities that allow remote connection with utilities, who can adjust thermostat settings during peak demand periods (optional)

Smart thermostat functionality

Let's look at each of the functions of a smart thermostat in a more specific way.

	Honeywell Lyric Round™	Nest "Learning" Thermostat (3rd Gen)	Schneider Electric Wiser Air®	ecobee3
MSRP	$199	$249	$239	$249
Voltage compatibility	Most 24 V heating and cooling systems	Most 24 V heating and cooling systems	Most 24 V heating and cooling systems	Most 24 V heating and cooling systems
Key feature	Geofence	Occupancy sensors and "learning"	Eco IQ (learning)	Remote sensors
System compatibility	Gas and electric furnaces, heat pumps, air conditioner	Gas and electric furnaces, heat pumps, air conditioner	Gas and electric furnaces, heat pumps, air conditioner	Gas and electric furnaces, heat pumps, air conditioner
Touchscreen	No	No	Yes	Yes
Heat stages Cool stages	3 2	3 2	3 2	3 2

Applicability to different HVAC system types

The most prominent smart thermostats available on the market today are designed for central forced-air heating and/or cooling systems, which represent the majority of systems in American homes. These include single- and multi-stage heating and cooling systems, air-source or ground-source heat pumps with air handlers and heating-only or cooling-only systems.

By and large, smart thermostats do not address zonal heating or cooling systems, such as baseboard heaters, room air conditioners or ductless heat pump systems (mini-splits). While more traditional zonal HVAC systems, like baseboard heaters, are themselves good targets for efficiency upgrades, smart products capable of controlling zonal systems are only starting to emerge, and may eventually be a factor in increasing uptake of high-efficiency HVAC systems, like mini-splits.

Control-based

As described in the NEEP HEMS Research Report, smart thermostat functionality falls into the category of "control-based" devices (as opposed to "information-based"). This means that they rely very little on consumer behavior to work properly. Characteristics of control-based devices that apply to smart thermostats include remote control, rule-based, scheduling and optimization. These characteristics distinguish smart thermostats from their predecessors.

Communication protocols and Wi-Fi

There are many Wi-Fi enabled thermostats coming from HVAC manufacturers like Trane® and Lennox® and stand-alone manufacturers like ecobee, Honeywell and Nest Labs. All of these thermostats are web-enabled, allowing user control through online dashboards and applications access via computer or smartphone apps. This gives the user options for scheduling setpoints and lets them fine-tune the thermostat algorithms to determine the needed amount for efficiency or comfort.

Occupancy and proximity sensing

Some smart thermostats have occupancy sensing functionality. This uses built-in motion detection to enable the thermostat to determine when a user is regularly home, allowing the thermostat to learn and adjust to their schedule. Programing can still be set to desired times and temperatures, but as the thermostat learns a user's behavior, it adjusts automatically. Weather data can also be used in the algorithm to help determine current and future heating and cooling needs. Humidity sensors can help to determine the amount of cooling needed to maintain comfort.

Some varieties of smart thermostats use geofencing in lieu of occupancy sensors, detecting a user's proximity to their home. These thermostats connect the home's Wi-Fi to a user's account(s) and enable "location services" on their smartphone(s). If geofencing is not enabled, the thermostats use the setpoints a user entered and continually monitor weather data, indoor temperature and indoor humidity to fine-tune the HVAC system through the thermostat's built-in programming. This all achieves optimal performance, and often, energy efficiency.

Learning

Learning, or adaptive control, describes the algorithms that enable smart thermostats to optimize HVAC functionality based on certain conditions. These thermostats can "learn" when the house is likely to be occupied or empty using data it collects about occupant habits. This allows it to automatically pre-heat or pre-cool the house to a comfortable temperature when a user is home. The adjustment even occurs if their lifestyle changes.

The learning capability also builds an algorithm of the amount of heat or cooling a home needs at different outdoor temperatures. This ensures more precise control of the indoor temperature and is extremely helpful in controlling the use of strip heat on heat pump systems.

Smart thermostats rely very little on consumer behavior to work properly.

Wiring

Wiring a smart thermostat is just like wiring any other thermostat. The only difference is that it usually needs what is called a "C" wire. The C wire gives constant voltage to a smart thermostat to maintain Wi-Fi connectivity and display functionality. Some smart thermostats can use a technology called "power stealing" to power the display and Wi-Fi connectivity. But if the C wire is not connected, the power may drop the Wi-Fi and display to charge the battery. This typically occurs when the thermostat determines a user is away or sleeping, and there is no demand on the heating or cooling system.

Some occupants have complained about this type of wiring scheme. There is always the option of getting an adapter that enables an always-on C wire with slight modifications at the wire connections. However, these adapters are only needed if the thermostat wire between the furnace and the thermostat do not have enough conductors within the wire sheath. Heat pump systems typically have more wires and wire connections.

Here are common uses for wire colors:

- Blue or Black, **C**: a common wire that enables continuous power flow to the thermostat *(CLEAResult recommends using a C wire as a best practice if at all possible.)*
- Red, **R**: 24VAC power from the system's transformer
- Red, **Rh**: 24VAC (dedicated to heat call)
- Red, **Rc**: 24VAC (dedicated to cooling call)
- Green, **G**: fan
- White, **W**: heat
- Yellow, **Y**: air conditioner

National specifications

Below are a number of national entities that have created smart thermostat specifications or guidelines.

ENERGY STAR®

The ENERGY STAR specification for programmable thermostats was suspended on Dec. 31, 2009 and the ENERGY STAR label is no longer available for this category. Manufacturers were required to cease using the ENERGY STAR name and mark in association with all products manufactured on or after Dec. 31, 2009.

Connected thermostats specification v1.0

ENERGY STAR is, however, due to have a specification publicized by the end of this year. On June 9, 2014, the U.S. Environmental Protection Agency, or EPA, announced a new approach where residential HVAC controls will be recognized as ENERGY STAR, based on their ability to save energy measured by the total data collected from homes using the Building America Best Practices guidelines. A test specification will also be required.

Consequently, the EPA has renamed the forthcoming product category, "Connected Thermostat Product." Data will need to be provided by thermostat manufacturers to the EPA every six months. A product will not be considered new if the thermostat is receiving significantly different software features through software updates via the Web.

CEE

Though not much information has been made available on this specification, we do know initially there will be two pathways. The first is a feature-based pathway, which should be of interest to utilities. This pathway allows a user to pick and choose qualifying product lists of thermostats, including products that have the features that fit specific goals. The second pathway is a performance-based specification similar to ENERGY STAR. The specification will be a tiered system based on heating and cooling degree days. ■

Manufacturers

Here are some of the leaders in the smart thermostat space and details on their products.

Smart thermostat manufacturer	Product	Wi-Fi enabled	"Learning" capability	Occupancy sensing	Geofencing	Local weather	DR capable
ecobee	ecobee3	✓	✓	✓		✓	✓
Nest	Nest "Learning" Thermostat	✓	✓	✓		✓	✓
Honeywell	Lyric Round	✓			✓	✓	✓
Schneider Electric	Wiser Air	✓	✓	✓		✓	✓

ecobee

Since launching the world's first Wi-Fi enabled smart thermostat technology in 2009, ecobee has developed residential and small and medium commercial solutions that deliver meaningful savings, improve comfort, provide superior customer service and offer insight into customer behavior. ecobee also enables utilities to enhance engagement with their customers while managing, tailoring and tracking energy efficiency and demand response events.

The flagship thermostat, the ecobee3 is designed for easy and quick self- or pro-installation including auto-wire detection for quick, initial setup. The ecobee3 has an integrated occupancy sensor and works with up to 32 wireless remote sensors to track occupancy and temperature in every room in which they are placed. This combined occupancy detection design makes it easy for the thermostat to automatically adjust to deliver comfort when residents are home and savings when they are away.

Overall, the ecobee3 provides many advanced features including full seven-day programming, vacation events and optimum start time for recovery from setback or set-forwards using weather and home performance. Other features include high and low temperature alerts by email, service reminders and a three-year warranty.

In the web portal, customers have access to HomeIQ with personalized reports about how the home's heating and cooling equipment is performing each month as well as runtime reports. ecobee3 users have lifetime access to the mobile app (iOS/Android) and web portal.

For a commercial application, ecobee's EMS Si is perfect where a simple thermostat just isn't enough. The EMS Si is easy-to-use, Wi-Fi enabled for remote web and mobile access, supports DR and smart meter integration, and features adaptive algorithms to maximize energy savings. The EMS Si supports a wide variety of equipment including conventional forced air systems, heat pumps, boilers, humidifiers, dehumidifiers, ventilators fresh air dampers, economizer control, as well as automation and Load Control Devices. The ecobee EMS Si supports up to two dry contact inputs or 10K resistive sensors for additional building automation features, such as temperature monitoring in freezers, motion detection, etc. The ecobee EMS Si also reduces costly on-site service calls as it is easy to log in and assess from off-site.

All of ecobee's thermostats are Wi-Fi enabled in combination with their programmable communicating thermostat (PCT) functionality. All ecobee users can remotely monitor and control their thermostats using either their ecobee customer web portals or mobile applications for iOS and Android. All ecobee thermostats are fully upgradable Over-the-Air, so customers will enjoy improvements to the firmware, web portal and new enhancements to the mobile applications. In addition, as customers' requirements evolve, custom applications (using our OpenAPIs) can enable ecobee thermostats to provide a true future-proof platform. ecobee is already integrated with Amazon Echo, Apple HomeKit, Samsung SmartThings, IFTTT and Wink, among others.

Nest

Nest focuses on simple and delightful hardware, software and services. They have a mission of comfortable products and saving energy. They've helped people achieve those goals all over, by selling products in the U.S., U.K., Canada, France, Belgium, Ireland and the Netherlands that are installed in more than 190 countries.

The **Nest Learning Thermostat**, for example, learns from a user's habits and adapts to their schedule to save energy and eliminate confusing programming. Its remote control allows a user to change the temperature from a phone, tablet or laptop. The device lets them know when they've chosen a temperature that conserves energy. It learns how the home warms up and keeps an eye on the weather, so the temperature will be just right when they walk in the door. It can spot occupants across the room and light up the display to show the temperature or the time.

To date, the Nest Learning Thermostat has helped save approximately $7 billion in kWh of energy and has reduced household heating and cooling energy consumption by an average of 10–12 percent. With numbers like that, the Nest "Learning" Thermostat pays for itself over time.

Honeywell

Honeywell's focus is on making products that are easy to install, easy to use and important to them.

The **Lyric Round** thermostat introduced new features that combine ease of use with smart control, inluding geofencing and fine-tuning. These features offer simple, customizable comfort control, allowing a user to control indoor temperature and humidity, as well as outdoor temperature. In other words, 72 degrees in the home will really feel like 72.

Honeywell has the widest selection of Wi-Fi thermostats, including the Wi-Fi 9000, which helps save a user money during times of high demand. Programming options, like utility scheduling, allow homeowners in areas with variable rate electricity prices to schedule their thermostat so that it doesn't turn on as much during the more expensive peak periods. The Wi-Fi 9000 is also capable of demand response, allowing a user to save energy and money due to the utility limiting the amount of time the air conditioning runs during high-demand periods.

Honeywell also offers a number of useful apps, like the Total Connect Comfort Thermostat app. This app allows a user to connect their RedLINK™ and Wi-Fi thermostats into one app and monitor or make changes remotely from a smartphone. The Lyric™ app works with the Lyric family of products, including the Lyric Round thermostat and Lyric Water Leak and Freeze Detector. Both solutions enable a user to make temperature changes when they're home or away and keep them updated on system operatives.

Schneider Electric

Schneider Electric is a global specialist in energy management and automation. With 170,000 employees serving customers in over 100 countries, the company's technology, software and services have reshaped the industry and transformed cities and lives.

In late 2015, Schneider Electric released the **Wiser Air** smart thermostat. The thermostat's state-of-the-art technology gives a user control of comfort and savings by using a learning algorithm called Eco IQ™. This algorithm learns their heating and cooling preferences over time, allowing them to define their comfort level by how warm or cold they are. Eco IQ also works efficiently and intelligently, taking the following factors into account: lifestyle patterns, thermal model, weather forecast and energy usage. Additional unique features for even more comfort and savings include our patented comfort boost feature, Humidity Balance, and Schneider Weather Alerts. Wiser Air is also equipped with Wi-Fi and Zigbee radio. ■

Other device manufacturers

CLEAResult is regularly evaluating new Wi-Fi thermostats to determine if they meet the definition of "smart" and can qualify for our smart thermostat programs. Some notable products are described in the table below.

Manufacturer	Model	Type of HVAC system controlled	Functionality (beyond Wi-Fi & smartphone app)	Cost (MSRP)
Allure Energy	Eversense® Thermostat	Central forced air heating and/or cooling systems	Geofencing, built-in audio speakers	$249.00
tado°	Smart AC Control	Remote-controlled A/C or ductless heat pumps	Geofencing	$179.00
Emerson	Sensi™ Wi-Fi Thermostat	Central forced air heating and/or cooling systems	Does not require a Cwire	$129.00
Radio Thermostat	Wi-Fi Thermostat	Central forced air heating and/or cooling systems	Geofencing	$149.95–$199.95
Mitsubishi Electric	kumo cloud™	Mitsubishi-only zonal systems (e.g., ductless)	Check filter status	App add-on to existing controls
Zen	Zen Thermostat™	Central forced air heating and/or cooling systems	Cwire optional	$199.00

Thermostat optimization

Smart thermostats and Wi-Fi thermostats offer the opportunity for web-based optimization. Here are some of the providers in the small market of thermostat optimization.

WeatherBug

WeatherBug operates the largest network of 10,000 professional grade weather stations, updating every two seconds. This quality-controlled data powers WeatherBug Home® models and algorithms, as well as outage models for utilities.

A thermodynamic model of each home indicates how the home will respond to certain weather patterns to optimize the timing of setpoints with the weather forecast. The model performance improves over time and repetition.

WeatherBug Home combines the power of big weather data, proprietary algorithms, connected device input and meter or billing data to deliver unmatched performance in peak load reduction for utilities and energy savings for customers. It's an innovative (and patent pending) use of big weather data, smart meters and two-way thermostats that seamlessly boosts energy efficiency through weather optimization.

Other services—like thermodynamic modeling, DR, energy efficiency, energy scorecards and mobile/digital engagement—are available to over 10 million WeatherBug app users through partnerships.

EnergyHub®

EnergyHub is a cloud-based platform developed for utilities and energy efficiency and demand service providers to interface with the connected home. The company works with over 20 utilities across North America to help deliver smart thermostat-based demand response and energy-saving programs.

EnergyHub offers a DR program called Bring Your Own Thermostat® , or BYOT. In this program, they work with utilities to reduce demand during peak periods, relieving utilities of the need to ramp up production to meet peak demand. The EnergyHub proprietary DR software, Mercury™, works with a wide variety of Wi-Fi thermostats. Utilities and service providers can use existing connected thermostats or deploy new connected thermostats to interface with this software through the Wi-Fi connection to support their load control programs.

By working with many different service providers and connected home technology partners, EnergyHub has an opportunity to rapidly move from DR to energy conservation and optimization. Their current offerings and solutions provide load verification, DR event optimization, administrative support and customer interface.

Overall, EnergyHub's techniques and software provided 60 percent better load shedding than traditional by using techniques like pre-cooling, event monitoring and scheduling, temperature ceiling settings and customer notifications.

EcoFactor®

EcoFactor's web-based platform provides utilities and energy service providers with program support for three residential HVAC-based products: Proactive Energy Efficiency, Optimized DR and HVAC Performance Monitoring. These products minimize HVAC energy usage by running algorithms on Wi-Fi thermostat data that shows a home's heating and cooling needs, comfort demands and occupant preference.

EcoFactor's algorithm also provides pre-cooling prior to a demand event, which monitors and predicts load events to help a user remain comfortable in their home while shedding load. HVAC performance monitoring is also available, a service that uses pattern recognition of the HVAC system performance to identify issues and send automated signals and notifications to the consumer and service partners for repair.

Powerley

Powerley is a utility-led, home energy management company focused on bridging the Smart Grid to the Smart Home. Through a turnkey hardware and software solution, Powerley is partnering with energy companies to help their customers optimize energy consumption as part of a unified home automation experience.

By connecting to the smart meter, the Powerley solution provides real-time visibility into the home's consumption, including energy management insights for the HVAC system as well as other appliances. Through the mobile app, the user can remotely control the Powerley Thermostat, leveraging advanced analytics to optimize the HVAC system's use. The solution improves upon the demand response experience by allowing the customer to choose whether or not to participate in the event via push notifications.

Powerley is helping homeowners achieve greater efficiency and savings while providing utilities with a solution they can brand as their own. Through the platform, energy companies can boost customer satisfaction, elevate energy efficiency and enable the advancement of the connected home. ■

Works with...

The Internet of Things, or IoT, allows different devices to interface with each other seamlessly in ways they were never able to before. By leveraging other device capabilities, this enables the devices to become more effective and dynamic in their applications. This allows smart thermostats to offer even more benefits and functionality.

There are two primary ways a smart thermostat can become a part of a larger IoT ecosystem:

1. External manufacturer's devices, as well as complementary internal Original Equipment Manufacturer devices, can be incorporated into an OEM ecosystem.
2. OEM devices can be integrated into external IoT-based ecosystems, such as HEMS, smart home interfaces, utility energy efficiency, DR platforms and even urban infrastructure systems.

The logic driving these processes is that either the smart thermostat is adding value to devices that are allowing it to integrate into its ecosystem, or the external ecosystem is adding value to the smart thermostat. Added value may include more dynamic functionality, increased customization, better return on investment, increased customer convenience or integration availability into big-picture applications.

These ecosystems start at the individual home level, with various HEMS and user interfaces. HEMS and user interfaces provide the ability to control several smart home devices from a single point of access, increasing convenience. Many of the HEMS also provide the added value of creating routines for a user's smart home that contour to the their daily routines.

IoT ecosystems can also incorporate smart thermostats into giant utility scale networks. Thermostat optimization platforms are often used to increase the responsiveness of these utility demand-side management, or DSM, and DR networks. These platforms allow customers to bring their own smart thermostats to utility DSM and DR programs.

This benefits everyone: utilities, consumers and product manufacturers. The utility is able to aggregate the energy efficiency and demand response impacts of thousands of consumers to impact their bottom line. Consumers are able to enjoy more choices, while still participating in utility incentive programs. And manufacturers can leverage utility incentive programs to help increase their product sales.

These platforms are also leveraging analytic-based approaches to add further value along multiple vectors. Some of these approaches are designed to optimize user comfort, while still saving energy. Other approaches are focused on grid benefits by optimizing energy usage to have a positive impact on grid constraints, such as transmission and delivery congestion. ■

Leading smart thermostats

	Honeywell Lyric Round	Nest Learning Thermostat (3^{rd} Gen)	ecobee3
Amazon Echo	✓	✓	✓
Control4	✓	✓	✓
Lutron Caseta®	✓	✓	✓
NEEO	✓	✓	
Samsung SmartThings	✓		✓
Vera™ Smart Home Control		✓	✓
Wink Hub		✓	✓

User experiences

To ensure the best possible user experience, we had six technically inclined CLEAResult employees try out four different smart thermostats. Their feedback was based on physical installation, initial setup and Wi-Fi connection—and just flat-out living and interacting with these thermostats. The findings take into account a wide range of skill levels. The installation each employee completed may differ from what each manufacturer may recommend or communicate. Those results are below.

Installation

Physical installation of all units was very easy, requiring little skill due to multiple baseplates and mounting hardware included.

Since many existing thermostats are battery-powered, a C wire is not in use to power the unit from the control board in the air handler. By nature, smart thermostats have a respectable power draw and their internal batteries need charging from an external source. At times, there is an extra conductor not being used in the existing thermostat wire sheath. Unfortunately, this is not always the case, which then requires running a new wire through the wall. A few manufactures do, however, provide a device that allows a wire-sharing technology to power the display and Wi-Fi connectivity. The wire-sharing device requires some amount of technical skill and may not be compatible for do-it-yourself, or DIY, markets.

Some manufacturers have a workaround by a technology commonly called power stealing. This has some drawbacks. If the thermostat is a heat or cool-only thermostat, this may not allow the air handler to run in fan-only mode for air circulation. This technology will only allow the thermostat to charge its internal battery when the heat and cool cycles are off. If the thermostat wire has an unused conductor that can be repurposed as a C wire, this usually requires the C wire to be connected to the new thermostat and control panel in the air handler cabinet, where it's unlikely for a homeowner to feel comfortable making the connection.

Here are the results of the six installations we documented: One new wire had to be run. Three went smoothly by repurposing a C wire, but required making connections in the air handler cabinet. Two had issues of either losing fan-only mode or blown fuses. This feedback suggests that, in order to have a fully functional system, most installations would either require the expertise of a contractor incurring associated costs or homeowners to be comfortable using tools inside of equipment. The latter may require spending time with chosen products online or phone support staff, which some DIY studies demonstrate do work.

Setup

Like many connected devices, connecting a smart thermostat to Wi-Fi takes some degree of patience and technical skill. Thankfully, each manufacturer has a helpful Frequently Asked Questions page and tech support that helps solve most issues.

Once Wi-Fi is connected, the thermostat must be configured to the installed space conditioning equipment and layout of the house. This process went very smoothly with all documented installations. The thermostat can sense this from the wire connection, at times even warning the installer if something is wired incorrectly. In order to access all features of the thermostat and have the ability to control it with a smartphone, an online account must be created and an app must be downloaded. Users found that controlling their thermostat with a smartphone was easier, which works out well since smartphone interfaces seem to be favored by manufacturers.

Interactions

Our users enjoyed the thermostat being able to sense when occupants are in the home. One user, though, noted that units using geofencing for occupancy sensing caused a drag on smartphone battery life. Since this type of occupancy sensor bases the heating or cooling status on locations of smartphones, occupants without smartphones could not be tracked properly, thus, not adjusting the temperature automatically. Units with motion sensors built into the dial worked well as long as the thermostat was located in a central area where it could easily pick up activity in the home. If occupancy sensors were not triggered for a while, the thermostat tended to turn the HVAC system to a more efficient setback, whether the occupants wanted it to or not.

Learning thermostats offered the next-level experience. Users entered basic information into the thermostat, such as “Away” and “Home” temperatures, and began to adjust the thermostat manually. Between motion sensing and user adjustments, within three weeks, the thermostat began to “learn” behavior and predict patterns. One user, however, reported unusual multistage gas furnace behavior as the thermostat became accustomed to system behavior and the time it took to reach setpoint.

At times, learning algorithms engages space conditioning out of sync with the normal routine, like in the middle of the night. When this happens, this “false” behavior data can be deleted from its algorithm to true-up its learning. The thermostat will eventually learn this on its own as well.

Overall, experiences suggest that smart thermostats are very intuitive and helpful devices that allow users of all skill levels to interact as they wish. Our test users could “set it and forget it,” or adjust the setpoint manually and know that the smart thermostat will take care of it if they forgot.

Smart thermostats have helped manage the space conditioning of the home, and each user rated the “coolness” factor pretty high. Features range from being able to monitor the conditions in a user’s home to checking the local weather from the dial. It’s easy to admit that smart thermostats are cool. ■

Overall, experiences suggest that smart thermostats are very intuitive and helpful devices that allow users of all skill levels to interact as they wish.

Education and training

Smart thermostats present no new challenges to the well-trained HVAC technician. But what about everyone else?

One of the ways that smart thermostat manufacturers have disrupted the market is by focusing on creating products and a DIY help ecosystem that makes it possible for non-contractors to successfully install their products. This ecosystem includes extensive web and telephone support. Manufacturer call centers can even view how the thermostat is wired in real time, once the device has been paired with the homeowner's Wi-Fi system.

The smart thermostat is now at an evolutionary phase where the manufacturers are offering strong online help. Training and homeowner education are also far easier than with previous thermostats, due to the improved user interfaces in smart thermostats. For thermostats that are WI-Fi enabled with energy-saving algorithms controlled by remote servers, ease of use is less important. However, the look and feel of the device is still critical to many homeowners and should not be discounted.

The training of contractors for participation in utility programs can depend on the level of expertise of the technicians and the program requirements. Many states require licensed HVAC technicians or electricians to install these devices. Training technicians in areas where licenses are not required is essential. Most thermostat manufactures have been eager to assist in these trainings. These trainings are beneficial in setting expectations before the first thermostat of a program is installed. ■

The smart thermostat is now at an evolutionary phase where the manufacturers are offering strong online help.

QA/QC with smart thermostats

Imagine using smart thermostats as a quality management, or QM, tool. Since smart thermostats are essentially data collection devices that happen to control HVAC systems, their data can be used to determine installation quality and how they are configured. CLEAResult did this by using smart thermostat data to determine if the installing-contractor was successfully configuring the thermostat to minimize the use of strip heat in a heat pump pilot program. The ability to conduct online quality control, or QC, sessions instead of in-person visits is a major cost-saver.

The data stream can also be analyzed to find underperforming HVAC equipment and help programs both target homes and conduct remote checkups on newly installed systems. Smart thermostat manufacturers that operate DR programs currently use their data in a manner that helps them identify the best homes for a DR event and determine how to best optimize the event for both the utility and the homeowner. Targeting poorly performing systems is an obvious extension of this capability. Utilizing this data could lead to many different targeted QA/QC implementations and result in lower program costs. Targeted programs could be developed to serve homes with higher energy use per size or other metric. The utilization of this data to create new programs that target low-performing homes has yet to be tested, but seems like a logical next step to explore.

Another potential use of smart thermostats is calibrating modeling software. The manufacturers of smart thermostats collect runtime data for heating and cooling use. In the case of heat pumps, they also collect runtime of the strip heat required for space heating modes. Where equipment size is known, comparison of modeling predications to actual usage could be easily analyzed. ■

Evaluations

Evaluated results from pilots and programs using smart thermostats have been consistently favorable. These evaluations demonstrate that smart thermostats can be equally effective at reducing demand during peak events and saving energy in heating (gas and electric) and cooling modes. Measurable savings were observed in hot and cold climates and covered most regions of the U.S..

Evaluated energy savings

- ~13 percent average heating load reduction (gas)
- ~10–12 percent average heating load reduction (electric)
- ~15 percent cooling load reduction

Evaluated demand savings

- .60–1.2 kW reduction per thermostat

Below is a summary of completed published smart thermostat evaluations.

Entity	Program objective (energy efficiency, demand reduction)	Year	Participants/ thermostats	Brand	Average demand savings	Average energy savings (gas)	Average energy savings (electric)	Evaluator	Find online
Centerpoint Energy	DR	Summer 2012	280 thermostats	Radio Thermostat	1.2 kW/T-Stat	N/A	N/A	Earth Networks	
CPS Energy	DR	Summer 2014	800 thermostats	Nest	.75 kW/ T-Stat	N/A	N/A	Nexant	
Energy Trust of Oregon	EE	Fall 2013–Spring 2014	185 Nest thermostats	Nest	N/A	N/A	12% heating load, 5% total (on heat pumps only)	Apex Analytics	
Minnesota Valley Electric Cooperative	DR	Summer 2013	115 participants	Unknown	.67–.86 kW	N/A	N/A	Power System Engineering	
National Grid	EE	2011	86 homes, 123 thermostats	ecobee	N/A	.1	.16	Cadmus	
Northern Indiana Public Service Company (NIPSCO)	EE	2013–2014	400 thermostats	Nest	N/A	13% heating load, 11% total	16% cooling, 4% total	Cadmus	
NV Energy	EE + DR	Summer 2013	5000–8000 thermostats	EcoFactor	2.37 kW potential	18 therms (potential)	585 kWh (potential)	ADM Associates	
San Diego Gas & Electric	DR	Summer 2014	~4000 participants	ecobee Si	.62–72 kW	N/A	N/A	Iton	
Southern California Edison (SCE)	DR	Summer 2013, Summer 2014	3994 thermostats	Nest and EnergyHub	.68 kW	N/A	N/A	Nexant	
Vectren	EE	2013–2014	300 thermostats	Nest	N/A	13% heating load, 9% total	14% cooling, 4% total	Cadmus	

Energy savings and demand reduction

Savings for smart thermostats depend primarily on the device's ability to reduce HVAC system runtime in a home. This is done in a variety of ways depending on the thermostat's available features. But according to how we define smart thermostats in this paper, smart thermostats save energy by detecting homeowner occupancy to determine the most efficient HVAC system settings and setbacks.

Reducing HVAC system runtimes through controlling setbacks is not a new concept. Programmable thermostats have provided homeowners the ability to manually program heating and cooling schedules for a while now. However, according to a paper by Washington State University, "Studies indicate that only about 50% of programmable thermostat users actively use programmed schedules." Smart thermostats try to address and remove the behavioral barrier by automating this control as much as it can.

ACEEE estimates that electricity savings from smart thermostats are 12% at the average level, 15% at the high level and 8% at the low level.

With respect to the results of published evaluations of smart thermostat programs and pilots, there appears to be two primary ways automated control is accomplished: through occupancy sensors or geofencing. An occupancy sensor is either built into the thermostat device or the thermostat comes with the compatibility to hook up to remote motion sensors. Geofencing utilizes the occupant's smartphone to detect occupant location in order to determine if the thermostat should be in "away" or "home" settings. Some of the smart thermostats currently available also rely on learning algorithms, which predict homeowner schedules and desired setbacks, which maximize the balance of efficiency and homeowner comfort.

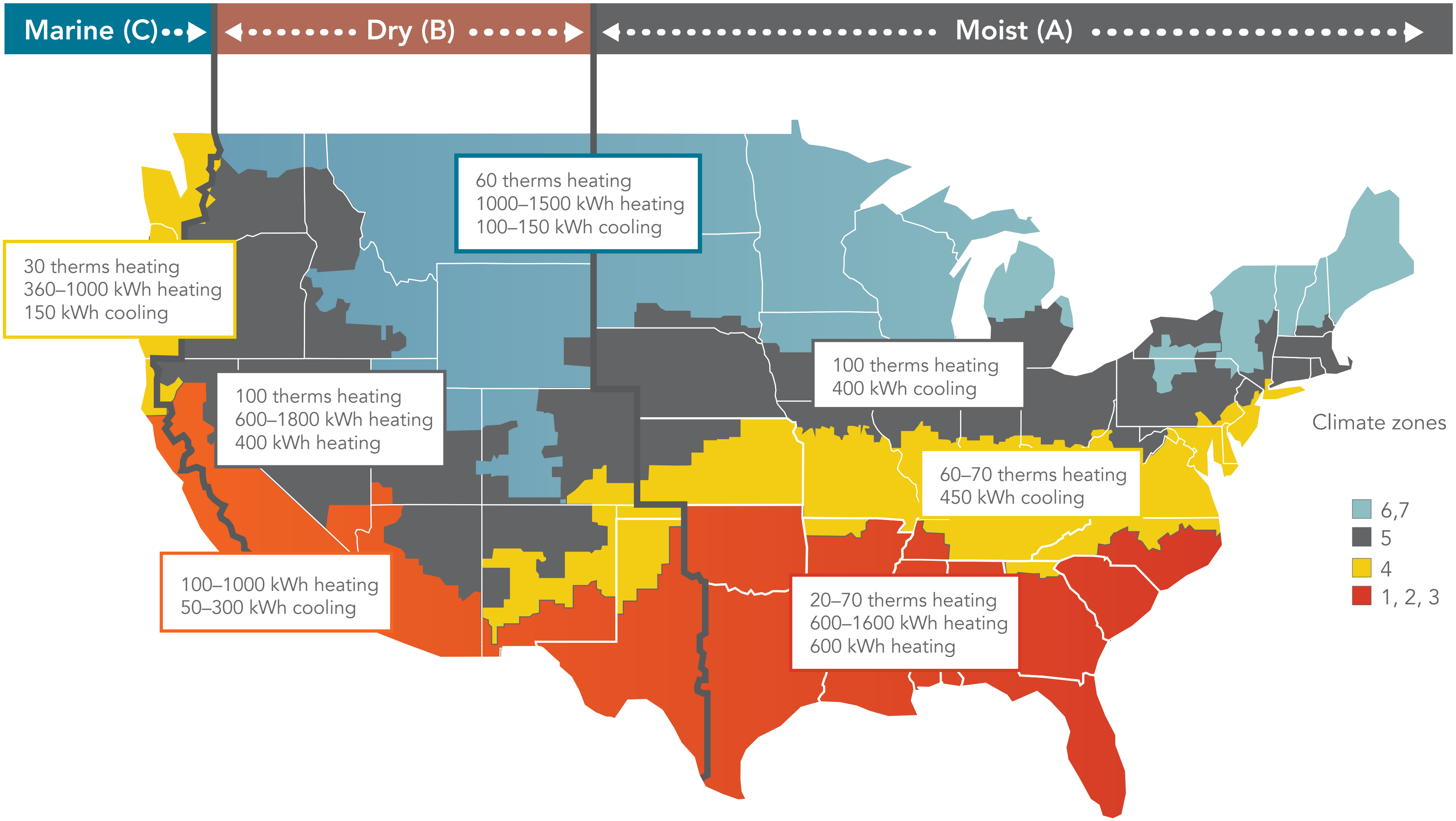
Several of the devices on the market now also provide additional saving opportunities for heat pump systems through advanced backup heat lockout controls. Heat pump systems primarily use the heat pump for heating, but most systems require backup heat sources (usually electric resistance coils) for very cold temperatures. Electric resistance coils are able to provide heat independent of the outside temperature (unlike heat pumps), but do so in a much more energy-intensive manner, making them not as efficient. Many existing systems are not set up with a lockout control for this backup heat source, and the less efficient, electric resistance coils end up turning on in scenarios when the heat pump is still able to adequately provide heat.

Traditionally, in order to set up a backup heat lockout control, a contractor would have to install a physical outdoor temperature sensor. With the prevalent feature of Wi-Fi connection on devices, a few of the smart thermostats available are able to bypass this barrier by gathering local weather station or Internet temperature information. Some of these devices are then able to provide a lockout setting or better control when the backup heat turns on.

Existing smart thermostat programs and currently available evaluations and pilot studies show a range of savings: 10–13 percent for gas savings; 14–18 percent for electric cooling savings; and 6–13 percent for electric heating savings. In fact, according to a 2015 ACEEE report, "Midrange estimate of electricity savings from smart thermostats assumes 12% average savings; for our high estimate we use 15% and for our low estimate we use 8%. These values represent likely potential savings based on early experiences with smart thermostats."

The following graphic summarizes research that CLEAResult has conducted on smart thermostats, using published evaluations and extrapolated and modeled estimations.

Ranges of savings achieved by smart thermostats in existing homes by IECC climate zone



User impact on energy savings

Based on CLEAResult's user experiences, we have observed that energy savings could vary depending on the existing (baseline) thermostat, heating/cooling system type and amount of interaction the occupants had with the old thermostat.

If a homeowner had fine-tuned an existing programmable thermostat to meet their regular schedule, they would likely not see much savings with a new smart thermostat, unless the inhabitants deviate from their schedule. An occupant who manually adjusts the heating setpoint on a gas furnace consistently, may see more usage with a new smart thermostat. Though Nest thermostats can predict behavior and slowly ramp up the temperature to reach a setpoint that maximizes compressor use over strip heat, a homeowner may manually set back the temperature to a point that encourages copious amounts of strip heat. Having that access to local weather data can enable the occupant to set a strip heat lock out.

Demand response

DR provides utilities with a key lever for managing peak load issues.

Many of the smart thermostats currently on the market provide utilities a seamless entryway into DR with their two-way communication abilities. Many of these devices are capable of connecting to smart meters or other DR platforms like OpenADR, allowing utilities direct communication with the thermostat and real-time deployment and response. Homeowners are typically given opt-in or opt-out options to participate in the current event from the utility. BYOT or device DR programs are popping up at utilities, thanks to the standardized communication protocols that allow the utility to interface with a variety of branded devices.

Manufacturers are also building utility-specific portals that allow utilities to directly communicate with homeowners and access data collected on the HVAC system, such as runtimes, setpoints and indoor and outdoor temperatures. Evaluation results show that DR programs save between 0.6 to 1.2 kW per thermostat.

In addition to utility-prompted DR, some manufacturers are establishing and proposing other novel features and programs to reduce HVAC consumption. A certain smart thermostat manufacturer has set up an optional feature to automatically perform small, incremental temperature setback adjustments in the household or schedule setup. This feature is only available to customers who have a utility that is participating. ■

Looking through the gas program lens

Additional gas products are rising up with smart thermostats and HEMS, expanding the opportunities for homes with gas.

The most immediate way to save with smart thermostats in gas-heated homes is to shut off the furnace when the setpoint is met, including setbacks when the home is not occupied. These savings are most commonly found in single-stage, central-gas furnaces. For these system types, a wide variety of smart thermostats will be capable of delivering savings. For homes with multistage or modulating furnaces, many smart thermostats may work, but should be matched according to manufacturer specifications in order to garner the full savings potential.

With zoned gas furnaces or gas boiler heating systems, many manufacturers, such as tado and ecobee, are developing zoning options and applications. In many cases, additional sensor and equipment may need to be purchased.

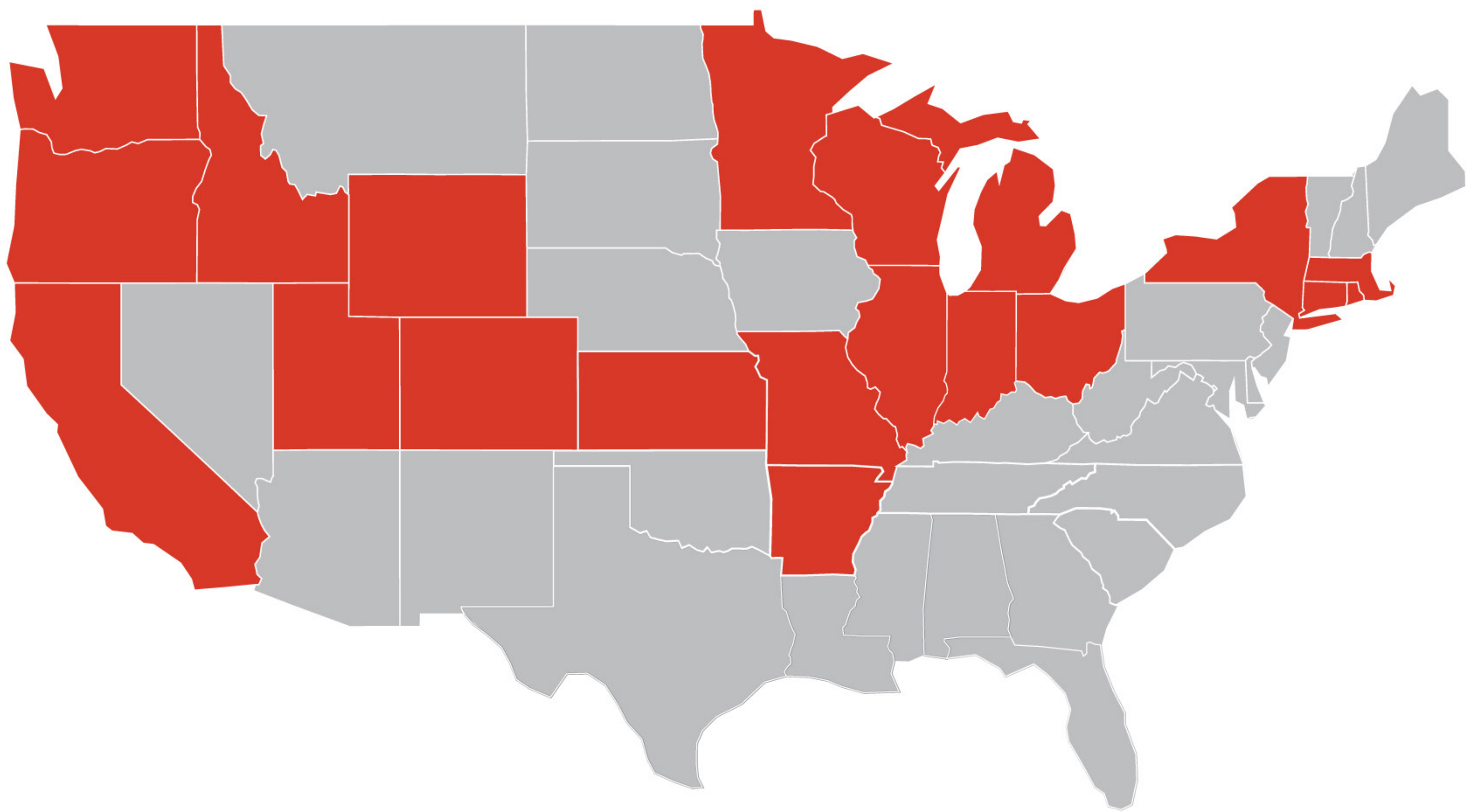
Gas fireplaces with electronic ignition may also work with a smart thermostat, but unless they are the primary heating system, it may not be cost-effective. A few fireplace manufacturers are even developing their own remote control thermostats with added features. But as of the writing of this paper, most smart thermostats can't control both central heating systems and secondary/ambiance systems.

In the U.S. market, Nest and competitors do not yet control gas tank water heaters. According to a recent article, Aquanta is planning to enter the market with a system designed to provide smart thermostat operational tasks similar to heating system smart thermostats. ■

Existing CLEAResult programs

CLEAResult has many smart thermostat programs, ranging from smart thermostat-driven DR pilots to weatherization and HVAC retrofit offering incentives toward smart thermostat installations. We currently manage over 15 programs or pilots. They all offer smart thermostats as a measure, either bundled with other measures or as a stand-alone tool for exploring energy savings and/or demand response options. These programs and pilots provide reliable savings and demand reduction estimates for program planning purposes to leverage evaluation results, technical reference manual deemed savings and CLEAResult engineering analysis. ■

The areas in red below indicate CLEAResult's current smart thermostat program coverage.



Summary and recommendations

How to use smart thermostats as a measure for savings, tool for data collection or a means of customer engagement in energy programs, pilots and projects.

Design and implementation

CLEAResult can assist utilities in the design and implementation of a customized smart thermostat program to fit the ever-shifting needs of complex energy efficiency and DR networks. To do this, we recommend a deliberate approach to understanding whether smart thermostats would be a valuable addition to a portfolio of energy efficiency and/or demand savings strategies. Program administrators who wish to incorporate smart thermostats should consider any or all of the following:

- **Location and weather:** The overall climate zone of the territory being considered is a primary factor in considering whether smart thermostats would be cost effective. However, localized weather conditions and recent climate trends should also be considered. For instance, although historical typical meteorological year weather data is useful in weather normalization during savings calibration, the average temperature of the entire planet has been rising steadily since 2000, NASA reported. Therefore, using smart thermostats in a climate zone with more heating degree days than cooling degree days will reliably yield savings during the heating season, but may be a source of cooling savings in the near future, as well.
- **Fuel sources and equipment:** The breakdown of fuel sources for heating equipment in the territory should be understood in order to make sound assumptions on savings potential. Furthermore, an understanding of the types of heating and cooling equipment in existing homes and buildings in the territory is fundamental to launching a program with smart thermostats. For example, smart thermostats may be an attractive savings option in a colder climate zone due to the estimated heating savings, but it may not be a viable solution as a measure on its own if a majority of dwellings in a certain location currently use baseboard heating.
- **Channel and distribution:** According to the NEEP HEMS Research Report, there are three primary channels for distribution of smart thermostats, outlined in the chart on the next page.
- **Customer engagement plan:** As noted in the “User experiences” and “Education and training” sections, smart thermostats are in many ways easier to use than their predecessors. However, if program administrators wish to ensure integrity and persistence of savings in energy efficiency programs, QA/QC and customer surveys should be conducted to ensure both proper installation and continued use of smart thermostats. Furthermore, to achieve demand savings in an energy efficiency program, attention to customer messaging and feedback is necessary.

CLEAResult can assist utilities in the design and implementation of a customized smart thermostat program to fit the ever-shifting needs of complex energy efficiency and DR networks.

Potential for smart thermostat adoption through program types, channels and dwellings identified in NEEP HEMS research paper

Program type	Channel	Dwelling type	Potential for smart thermostat adoption via program
DIY/customer self-install	Retail/big box	▪ Existing single-family homes ▪ Existing manufactured homes	**High:** Big box retail and online portals have seen the most sales of smart thermostats to date. Programs which have already successfully utilized e-commerce portals would see significant traffic with the addition of smart thermostats.
	Online e-commerce portal	▪ Existing single-family homes ▪ Existing multifamily dwellings	
Licensed contractor/ qualified installer	Builder	▪ New single-family home construction ▪ New multifamily construction	**Medium:** Programs have seen mixed results with the distribution of smart thermostats through builder and contractor channels. Many builders recognize that smart thermostats are increasing in popularity and have offered them in new homes as a sales tool. On the other hand, many builders and contractors prefer certain brands of HVAC equipment with proprietary thermostats and are predisposed to use those controls, rather than smart thermostats. Home performance contractors represent a larger opportunity to engage directly with homeowners using program incentives and mechanisms, and they may also see increased uptake by bundling smart thermostats with upgraded HVAC equipment.
	Manufacturer	▪ New manufactured homes	
	Home performance contractor/trade ally	▪ Existing single-family homes ▪ Existing multifamily dwellings ▪ Existing manufactured homes ▪ Low-income	
In-home service providers	Cable/Internet service providers	▪ New single-family home construction ▪ New multifamily construction ▪ Existing single-family homes ▪ Existing multifamily dwellings ▪ Existing manufactured homes	**Medium:** Some large in-home service providers are already offering smart thermostats to customers via add-ons to home automation packages that are sold primarily as entertainment or security packages. With notable exceptions, it is difficult for energy programs to reach customers in this space without a strong partnership with the in-home service provider at a strategic level. However, if programs can make that connection, the potential is large.
	Home security systems	▪ New single-family home construction ▪ New multifamily construction ▪ Existing single-family homes ▪ Existing multifamily dwellings ▪ Existing manufactured homes	

Potential for advanced M&V

Energy programs are at a crossroads when it comes to proving cost-effective savings to state and local regulators. Building and residential code improvements across the country, along with the full implementation of the Energy Independence and Security Act in 2007, mean that baselines are shifting upwards. Utilities and program administrators are seeking new ways to drive down costs and are taking advantage of the data unlocked by smart home products.

The potential benefits of advanced measurement and verification, or M&V, have been discussed by the Home Performance Coalition, NEEP's EM&V Forum and the Lawrence Berkeley National Lab, or LBNL. The general premise of advanced M&V is the notion that more data can help streamline or refine the M&V of energy programs. The smart grid, as it was envisioned, could enable advanced M&V at an individual home or building all the way up to a program portfolio level. However, due to lack of or evolving data standards, programs have not yet been able to take full advantage of the possibilities of advanced M&V.

With smart thermostats, programs may have a tool that could enable advanced M&V of a single measure or an entire end-use category. Although most smart thermostat manufacturers will not divulge exactly how many data points their devices collect, it is assumed that each of them collect basic information about the systems that they control. It's also assumed that they'll collect manually-entered or programmed setpoints; energy quantities required to achieve those setpoints; and information about the amount of energy not used when their algorithms set back the smart thermostat with no occupants present. Coupled with baseline or pre-installation billing history information that could be provided by utilities, programs may have enough tools to conduct M&V quicker and more cost-effectively. And when placed in context with the QA/QC strategies outlined earlier, an M&V plan that uses data from smart thermostats could lead to continuous savings calibration and program improvement.

CLEAResult has conducted test analysis of advanced M&V strategies with interval data, using methodologies put forth by LBNL, with promising results. Below is a brief list of some of the data points recommended for collection by CLEAResult in the event that a program wishes to pursue advanced M&V using the smart thermostat as an enabling device:

- Installation date
- Zip code location of residence
- Location of thermostat within residence
- HVAC system type and size
- HVAC system manufacturer and model
- HVAC system age

Helping customers choose the best smart thermostat option through thoughtful program design can help your utility meet its goals and ensure that your customer's user experience is a positive one.

Conclusion

In the second half of 2016, we see smart thermostats as unique products with a lot of potential. They are at the leading edge of an emerging category of smart devices that have given consumers new reasons to reinvest in their home. And, with their advanced control and data-gathering capabilities, they provide many opportunities to optimize HVAC systems and enhance energy programs in ways that are cost-effective for both utilities and homeowners.

That said, smart thermostats are not a "one size fits all" commodity. They all have different attributes and functionalities. These attributes may help utilities meet efficiency and customer engagement goals, or on the other end, disrupt them.

Ignoring the disruptive effects of smart thermostats is not in a utility's best interests. Helping customers choose the best smart thermostat option through thoughtful program design can help your utility meet its goals and ensure that your customer's user experience is a positive one.

CLEAResult can help you chart a path to success. With the qualifications, experiences, best practices and savings outlined in this paper, we recommend using smart thermostats in a variety of existing program types to drive customer engagement and refine data collection. While we can't predict the future, we believe that smart thermostats will continue to evolve into even better products for consumers, and—if utilized thoughtfully—could supply value to energy programs for years to come. ■

If you have questions about this publication,
please contact **info@clearesult.com**.

CLEAResult®