Certification of ENERGY STAR Smart Thermostats

From Field Data to Performance Metrics

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What's an EPA Poster Doing at a BTO Review?

BTO is providing technical assistance to EPA's smart thermostat program.

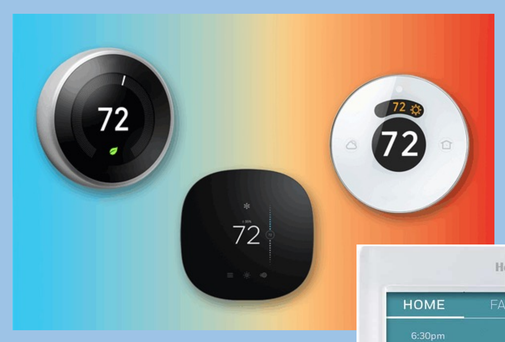
EPA wants to introduce building scientists to the knotty problems in evaluating thermostats (controls) from field data and Software as a Service in general

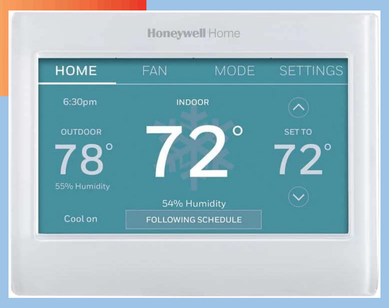
All of these thermostats report the home's indoor temperatures and HVAC runtimes to the cloud at least every 15 minutes. They may receive instructions, too.

How Do Smart Thermostats Save Heating and Cooling Energy?

Smart thermostats rely on improved user interfaces, local sensors, computation, and increasingly sophisticated algorithms to save energy. Methods include:

- Reduce/increase temperatures according to schedule
- Guide users through, or automate, schedule creation and adjustment
- Optimize recovery times (especially important for heat pumps)
- Detect occupancy
- Accept remote control and proximity sensing
- Use multiple temperature sensors
- Maintain a thermal model of each unit in the cloud
- Use weather prediction (including sun and wind in some cases)





EPA's policy question for building scientists:
Which vendors' algorithms and technologies save the most energy?

Unique Aspects of the ENERGY STAR Smart Thermostat Program

The certification process is unique because it relies on field data from user installations, which both reflects the complex interaction of product features and user behavior, and tests the full product (hardware + software/service). Most appliance certifications are based on laboratory tests of a few units and often do not take into account the full impact of controls.

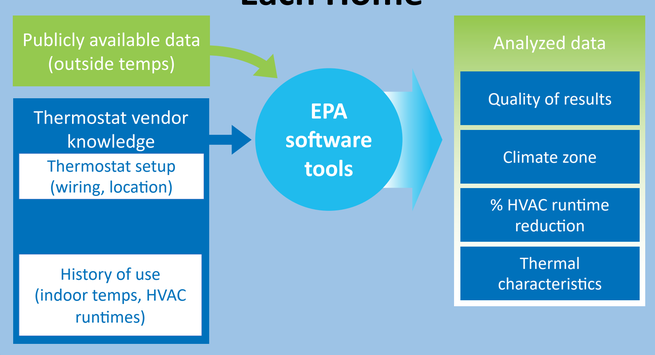
Vendors must collect hourly data from HUNDREDS of operating thermostats for one year, including:

- ❖ **HVAC runtimes.**
- ❖ **Temperatures (settings, indoor, outdoor).**

- Vendors calculate the EPA performance metric (% savings in HVAC runtime) using an EPA-supplied software tool.
  - HVAC % runtime reduction is estimated against a constant temperature setting, derived from the history of indoor temperatures for that thermostat.
  - Vendors run the EPA software tool on their own computers to protect customer privacy and vendor's technical IP.
- Submitted results represent metered performance information from MILLIONS of thermostats.

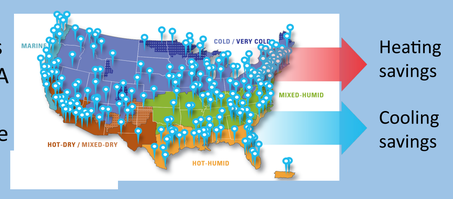
Smartphones and smart speakers provide new user interface options for smart thermostats, and are growing in popularity.

Calculating the Savings Metric for Each Home

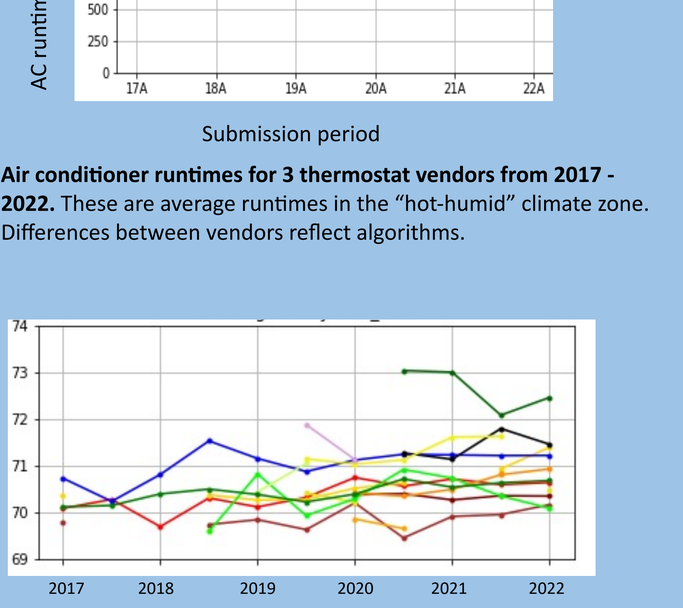


ENERGY STAR Certification

1. Thermostat meets sensor accuracy requirements
2. Thermostat product (hardware + service) demonstrates basic capability (e.g. scheduling)
3. Vendor demonstrates field savings using EPA software tools to analyze and aggregate data from hundreds of US homes



Sample Data



Air conditioner runtimes for 3 thermostat vendors from 2017 - 2022. These are average runtimes in the "hot-humid" climate zone. Differences between vendors reflect algorithms.

What temperatures do people heat their homes? Each line is a different thermostat vendor. These data reflect recorded temperatures, taken every 15 minutes, in millions of American homes located in cold and very-cold climate zones.

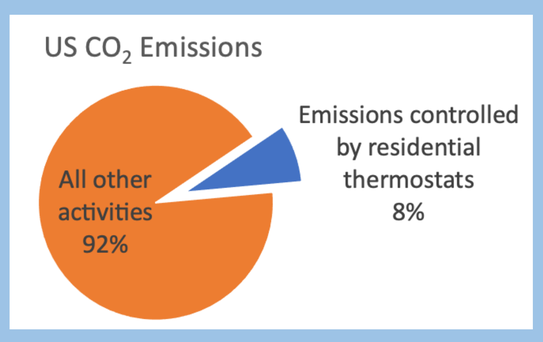
Technical Challenges for Future Thermostat Certification

EPA needs input from building scientists, data scientists, psychologists and other experts to keep its certification credible. Here are (just a few) technical challenges:

- Using a history of field data requires products to enter the market without ENERGY STAR certification, competing with products that are certified.
- Simulation models often implement abstractions that make it difficult to capture behaviors of smart thermostats.
- HVAC runtime not a useful metric for variable-speed heat pumps; what should replace it?
- Method captures savings only from set-back and set-up; how can we capture additional savings?
- Avoiding uncertainties introduced by self-referential baseline.
- How to assess algorithms and Software as a Service?
- Inclusion of grid services.
- Control of dual fuel installations.

Factoids

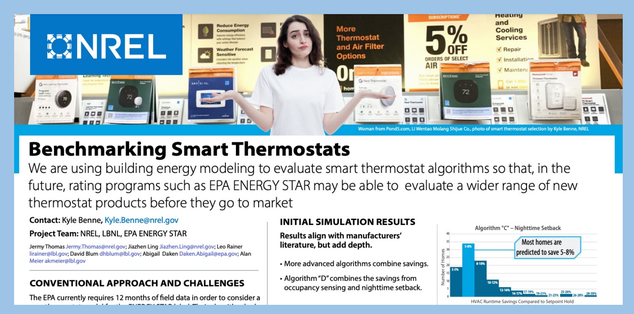
Thermostats "control" about 8% of US carbon emissions (so it's important to get them right)



At least 15 million homes have smart thermostats (and growing by millions/year).

At least 30% of thermostats are set to "long-term hold"; how do we improve usability so that consumers switch to more energy-saving modes?

Check out the related poster "Benchmarking Smart Thermostats" using BOPTEST.



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Talk to us to learn more about building science tasks related to certifying the next generation of thermostats, controls, heat pumps

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