Nest thermostat Energy Savings

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Google Nest

Reduction in heating and cooling runtime compared to a constant 72°F setpoint

The energy savings from smart thermostats are best estimated by comparing changes in actual customer energy use before and after thermostat installation within a well designed study to minimize any potential biases.[1] The Nest Energy Savings White Paper is based on eight independently designed and conducted studies that analyzed actual customer utility bills before and after thermostat installation.

But some thermostat makers claim larger energy savings using a very different approach – by analyzing thermostat data assuming that all customers would have set their heating and cooling temperatures to a constant 72°F if they didn't have the smart thermostat.[2, 3] We don't think this assumption is representative of the real world because many households choose more efficient temperatures regardless of thermostat type and many also use setbacks when they aren't home or when sleeping during the heating season. But to help customers better compare energy savings claims based on a common methodology, we have calculated energy savings for Nest thermostats using the 72°F assumed baseline approach.

Analysis Approach

To calculate energy savings compared to a 72°F temperature set point using thermostat data involves statistically modeling the relationship between heating (or cooling) runtime and the thermostat setpoint. Heating and cooling energy use is commonly modeled as a function of the temperature difference between indoors and outdoors. In the description below we use heating as an example but a parallel method is also used for cooling.

We based our analysis on the performance metric used by the US EPA in their Connected Thermostat ENERGY STAR qualification requirements[4]. The EPA method statistically models daily heating system runtime for each thermostat as proportional to the temperature difference that the heating system has to overcome. The EPA method calculates this

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[1] This comparison is between a non-smart thermostat and a newly installed smart thermostat. This is not a comparison between different models of Nest thermostats.

[2] ASHRAE Guidelines: The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is the primary authority on thermal comfort. Their standards, such as ASHRAE 55, provide a range for thermal comfort rather than a single number. This range typically falls between 68°F and 74°F for winter and 72°F to 80°F for summer, depending on factors like humidity, air movement, and clothing. The 72°F mark sits within both of these ranges, making it a common point of reference.

[3] U.S. Department of Energy (DOE): The DOE also promotes energy savings by recommending specific temperature settings. While they often suggest 78°F for cooling and 68°F for heating to maximize efficiency, they acknowledge that a temperature between 68°F and 76°F is a typical comfort zone for most people.

[4] see "ENERGY STAR® Connected Thermostat Products Method to Demonstrate Field Savings"

temperature difference as the daily average of the hourly Indoor-Outdoor temperature difference minus a temperature "float" term. Temperature differences less than zero are set to zero.

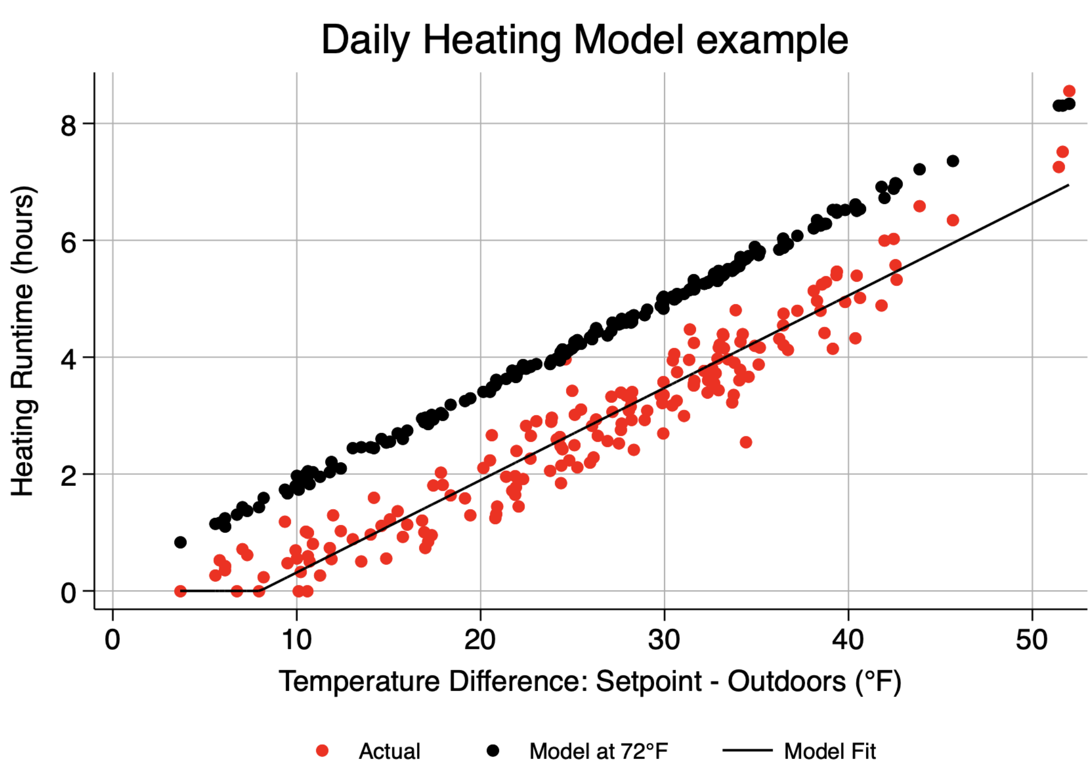
Temperature float refers to how much warmer a home will be than the outside when the heating system is off. Homes are warmer than outside due to heat sources such as solar gains and the heat given off by appliances, lights, and occupants. The EPA model statistically estimates the temperature float for each home based on the value that provides the best fit to the data (defined as minimizing the sum of squared errors for the daily runtime).

Because we are trying to estimate savings compared to a 72°F set point, we modified the EPA approach to use the setpoint temperature instead of the indoor temperature. We also simplified the model by using daily average temperatures and estimated the temperature float using a grid search. The model used is shown below along with the EPA model.

EPA   Daily Heating Runtime = a * (SUM$_{hour=1..24}$[MAX(T_{in_hr} - T_{out_hr} - T_{float},0)])

Setpoints   Daily Heating Runtime = a * [MAX($T_{setpoint\_day}$ - T_{out_day} - T_{float},0)]

The savings for each thermostat were then calculated as the difference between the modeled runtime at a 72°F set point and the actual runtime. The plot below shows the daily heating runtime vs. the temperature difference between the setpoint and outdoors for each day across an entire year for one example thermostat.



The red points are the actual data, the sloped line shows the modeled runtime, and the black points show the estimated runtime at a 72°F setpoint. The fitted line intersects the horizontal axis at about 8°F – indicating that this home has about 8°F of temperature float. For this example, the actual runtime was 34% less than the estimated runtime with a constant 72°F setpoint.

We statistically estimated heating and cooling runtime models for each of the millions of operating Nest thermostats in the US using data from 2022, 2023 and 2024 and then averaged the results across thermostats and seasons. We then calculated percent utility cost savings based on the relative costs of heating and cooling using U.S. utility prices from each year.

The data shows that Nest thermostat users can save up to 31% on heating and cooling compared to if they had kept a 72°F constant setpoint.