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Touchie M, Siegel JA. 2018. Residential HVAC Runtime from Smart Thermostats: Characterization, Comparison, and Impacts. *Indoor Air*, **28**(6), 905-915. DOI: 10.1111/ina.12496.

Abstract

In North America, the majority of homes use forced-air systems for heating and cooling. The proportion of time these systems operate, or runtime, has a significant impact on many building performance parameters. The recent adoption of smart thermostats in many North American homes presents a potential data source for runtime. Smart thermostat data collected from over 7,000 homes were compared with nine other investigations and a runtime estimation method based on exterior temperature. The smart thermostat runtimes have a median of 18% across all homes, but show considerable variation between homes, even at constant exterior temperature conditions suggesting that factors besides climate (e.g. system sizing, user operation) have a significant impact on runtime. Results from other investigations suggest that smart thermostat runtimes are consistent with other measurement approaches. The practical implications of runtime include the impact on central filtration performance. At low to average runtimes, the filter efficiency matters much less for effectiveness because the system does not run enough for a sufficient air volume to pass through the filter and have a substantial impact on particle concentrations. This work illustrates the importance of measuring runtime for a particular home, and the value of data obtained from smart thermostats.

Practical Implications

The results of this analysis suggest that, while heating runtimes in heating-dominated climates tend to be longer than cooling runtimes in cooling-dominated climates, runtimes are highly variable both within and between homes in a particular climate. For example, the spread of the runtimes at any given temperature is larger than the difference between the median values across all homes even for relatively large interior-exterior temperature differences. This being said, exterior temperature alone is not a good predictor of runtime which suggests that building characteristics, and other factors, such as system or user characteristics also significantly impact runtime. Based on the typical runtimes observed in this study, filtration of $PM_{2.5}$ through central HVAC systems that only run to satisfy heating and cooling load (i.e. no fan-only operation) can severely compromise the effectiveness of filters. However, increasing runtimes to improve filtration effectiveness may have significant cost implications related to filter replacement frequency, increased energy use, and fan maintenance.

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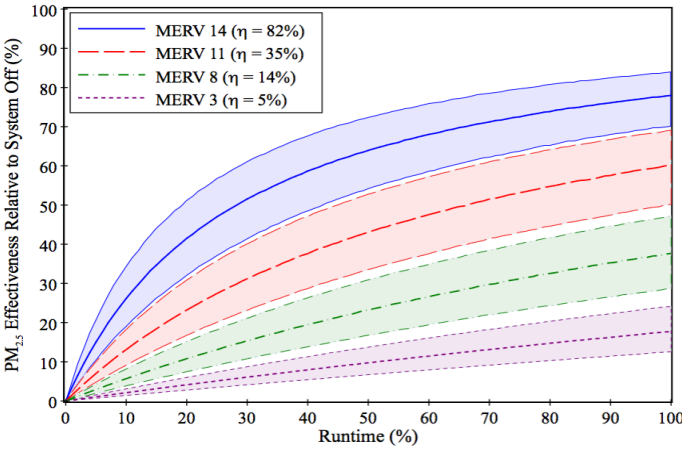

Figure 5 Simulated effectiveness for four filters in a typical North American residential building. Simulation parameters are in Table 2. The shaded areas represent the range that includes the 2nd and 3rd quartiles from the Monte Carlo simulations. MERV = minimum efficiency reporting value.

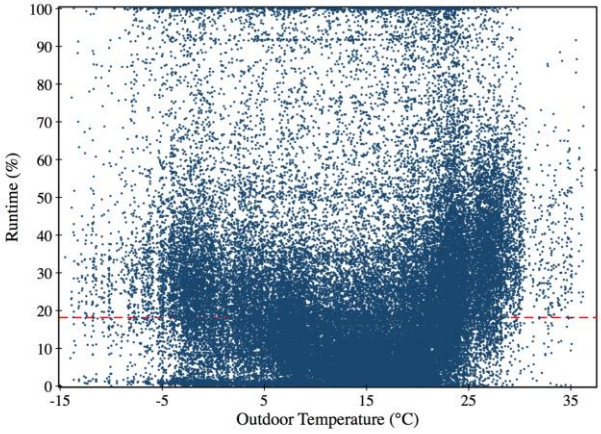

Figure S6 Monthly runtime vs average monthly outdoor temperature from the entire dataset. Red dashed line indicates median.