Energy efficiency of HVAC equipment suffers due to poor installation

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Without proper installation, air conditioning and heating equipment will perform significantly below rated energy-efficiency levels, according to a new NIST study. Credit: NIST

The push for more efficient air conditioners and heat pumps aims to trim the 30 percent share of residential electrical energy use devoted to cooling and heating. But the benefits of improved energy efficiency ratings can go for naught if the equipment is not installed properly, as verified in a recent study from the National Institute of Standards and Technology (NIST).

The NIST research report is the first to quantify efficiency losses due to common installation errors documented in field surveys.

"Our measurements indicate that improper installation could increase household energy use for space heating and cooling on the order of 30 percent over what it should be," says Piotr Domanski, who leads NIST research on the performance of HVAC (heating, ventilation, and air conditioning) and refrigeration equipment.

Domanski, Hugh Henderson of CDH Energy Corp., and NIST mechanical engineer Vance Payne undertook their three-year measurement and modeling study in response to surveys and other field evidence indicating that, as "typically installed," HVAC equipment may waste considerable energy. Commonly reported installation errors—or faults—include leaky ducts, improper refrigerant charge, oversizing of systems, and restricted air flow.

In surveys reviewed by the team, the majority of air-conditioning equipment evaluated in the field performed below rated energy-efficiency levels due to one or more installation faults. "Degraded equipment performance was commonly found in air conditioners, heat pumps, and related equipment," Domanski explains. "But most studies did not measure the increase in energy consumption due to a particular fault or combination of faults, which can be difficult to do in the field."

Under controlled environmental conditions, the team characterized the

performance of a heat pump while operating with any one of seven commonly encountered faults. After determining how much each fault affected energy consumption in the laboratory, the researchers investigated how these same errors might impact energy use in two types of houses—one with a basement, the other built on a concrete slab—and in five different climate zones. This part of the analysis was conducted with a simulation tool developed by CDH Energy Corp.

Leaky air ducts emerged as the "dominant fault." Refrigerant undercharge and incorrect indoor airflow due to improperly sized ductwork followed as the most significant cause of increased energy use. Other findings include:

For six of the seven faults studied, associated increases in energy use are similar for slab-on-grade and basement houses. However, leaky air ducts installed in unconditioned attic space can cause the greatest increase in energy use in slab-on-grade houses.

In hot and humid climates, duct leakage substantially increases indoor relative humidity, reducing human comfort. Occupants will typically lower the thermostat to compensate, which significantly increases energy use.

With a few exceptions, simultaneous faults have additive effects on energy consumption.

The bottom line: Sizing, selecting, and installing HVAC equipment according to industry-recognized procedures is critical to ensuring energy efficiency.

This NIST report constitutes the U.S. contribution to the recently completed Annex 36 Quality Installation/Quality Maintenance Sensitivity Analysis of the International Energy Agency and is the first

of its kind to quantify the effects of improper installation. The report will serve as the scientific basis for guiding training requirements for equipment installers.

More information: P.A. Domanski, H.I. Henderson and W. Payne. "Sensitivity Analysis of Installation Faults on Heat Pump Performance," NIST Technical Note 1848, October 2014.
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