Building America Case Study

Long-Term Monitoring of Mini-Split Ductless Heat Pumps in the Northeast

Devens and Easthampton, Massachusetts

PROJECT INFORMATION

Construction: New construction

Type: Single-family

Partners:

Builder: Transformations, Inc., *transformations-inc.com*

Building Science Corporation, *buildingscience.com*

Size: 1,100 ft²–2,300 ft² houses

Climate Zone: Cold (5A)

Transformations, Inc., has extensive experience building high-performance homes—production and custom—in a variety of Massachusetts locations and uses mini-split heat pumps (MSHPs) for space conditioning in most of its homes. The use of MSHPs for simplified space-conditioning distribution provides significant first-cost savings, which offsets the increased investment in the building enclosure.

In this project, the U.S. Department of Energy Building America team Building Science Corporation (BSC) evaluated the long-term performance of MSHPs in 8 homes during a period of 3 years. The work examined electrical use of MSHPs, distributions of interior temperatures and humidity when using simplified (two-point) heating systems in high-performance housing, and the impact of open-door/closed-door status on temperature distributions.

Overall, this research demonstrates that MSHPs can work well in many houses (including simplified space-conditioning distribution). However, designers should be aware of potential failures and that occupant operation can negatively affect performance.

One such occupant operation effect is the impact of heating set point on interior temperatures and energy use. If a constant set point is used, MSHPs will modulate their output up and down in response to the load from outdoor temperature, which is its most efficient operating state. When MSHPs are running at maximum output (instead of part load), they are at their least efficient state. In addition, using a constant set point results in the most even temperature distributions throughout the house when using simplified heating and cooling. Most of the test houses were run using a constant set point; however, one homeowner controlled the MSHP by turning the unit on and off in response to perceived comfort and occupancy of a given space (first or second floor). This allowed for a comparison of energy use and interior temperatures.

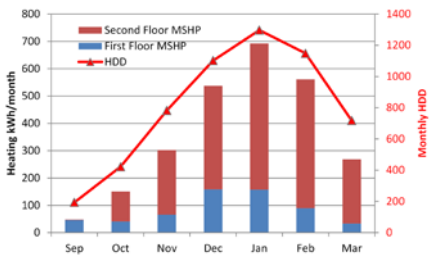
Energy Performance with On-Off MSHP Operation

Homeowners often turn heating and cooling systems on and off in an effort to save energy and costs. However, in high-performance housing the use of setbacks makes less sense because high insulation levels and low air leakage reduce the rate of heat loss to outside.

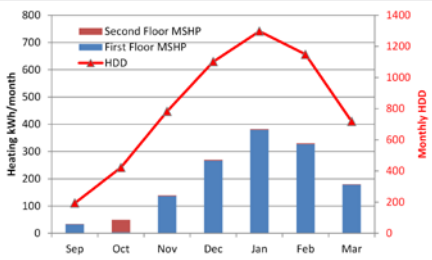
BSC compared the heating electrical use for the on-off and constant set point houses; the graphs below show first- and second-floor MSHP electrical use and monthly heating degree days (HDD).

The on-off operation clearly results in greater energy use. The constant set point house showed roughly half the consumption (54%) of the on-off house.

Similar figures were also seen when comparing the on-off house to others in terms of normalized square footage energy use.



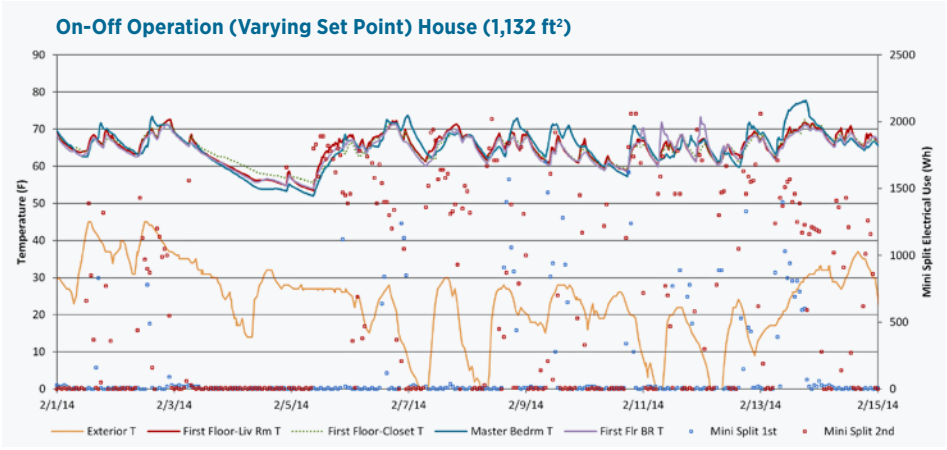
On-off operation house

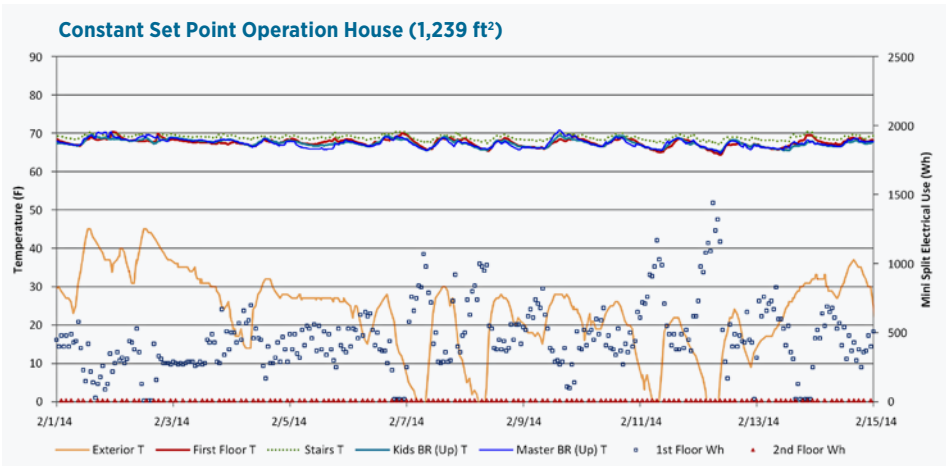


Constant set point house

For more information see the Building America research report *Long-Term Monitoring of Mini-Split Ductless Heat Pumps in the Northeast* at *buildingamerica.gov*.

Image credit: All images were created by the BSC team.





Graphs comparing the on-off operation house and constant set point house, which are comparable in size and occupancy. Indoor and outdoor temperatures (left-hand axis) and hourly MSHP power use (right-hand axis) are shown for 2 weeks in February 2014.

In the constant set point house, the first-floor MSHP ramps up and down in output in response to outdoor temperatures. Interior temperatures are very close to each other with a small variation (65°F–70°F range typical).

In the on-off operation house, interior temperatures vary from the low 50s to high 70s, with most temperatures in the 60°F–70°F range. The MSHPs were turned on, resulting in a spike in temperature, followed by turning the unit off and a drop in temperature. There are greater temperature variations between interior spaces when using the on-off control strategy (e.g., as shown by a comparison of the first-floor bedroom to the first-floor living room).

During the temperature spikes, the MSHP has very high electrical draw (often ~2000 W, the maximum capacity of the unit). In comparison, in the constant set point house, the unit ramps up and down, with only rare peaks above 1,000 W draw.

The energy impacts of these two operation states are shown in the sidebar.

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Energy Efficiency & Renewable Energy

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