U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building America Case Study

Technology Solutions for New and Existing Homes

Energy-Efficient Management of Mechanical Ventilation and Relative Humidity in Hot-Humid Climates

Cocoa, Florida

PROJECT INFORMATION

Project Name: Energy-Efficient Management of Mechanical Ventilation and Relative Humidity in Hot-Humid Climates

Location: Cocoa, FL

Partners:

Building America Partnership for Improved Residential Construction, *ba-pirc.org*

Building Component: Heating, Ventilating, and Air Conditioning

Application: New and/or retrofit; single- and/or multifamily

Year Tested: 2014

Applicable Climate Zone: Hot-humid

PERFORMANCE DATA

Cost of energy-efficiency measure: Added cost of mini-split offset by ability to opt for reduced central system efficiency and no dehumidifier

Projected energy savings: 20% of space-conditioning energy for a typical summer day

Projected peak power savings: 25% of space-conditioning power for a typical summer day

Building America U.S. Department of Energy

Building codes such as International Energy Conservation Code 2012 require mechanical ventilation, which during warm and humid weather conditions increases the potential for higher indoor relative humidity (RH). In hot and humid climates, it is challenging to maintain indoor RH at acceptable levels in an energy-efficient manner, particularly in high-performance homes that have low cooling loads.

The fundamental problem with solely relying on "properly sized" fixed-capacity central cooling systems to manage RH during periods that have low sensible loads is that they are oversized for cooler periods of the year. Dehumidifiers are commonly suggested for supplemental RH control. During the cooling season in hot and humid climates, a dehumidifier is not an energy-efficient method of controlling humidity, because much of the added energy use results from the addition of condenser refrigeration heat back into the living space.

The U.S. Department of Energy's research team Building America Partnership for Improved Residential Construction set out to determine the impact of utilizing a high-efficiency (SEER 21.5) ductless mini-split (DMS) for RH control instead of a dehumidifier. The DMS is also capable of providing the bulk of a home's sensible cooling needs, and it is backed up by a centrally ducted heat pump for peak loads and distribution effectiveness. The influence of both fixed-capacity (SEER 13) and variable-capacity (SEER 22) centrally ducted heat pumps was tested utilizing the attic duct system available in the Florida Solar Energy Center's Manufactured Housing Laboratory. To maintain acceptable thermal distribution, the central systems were operated on an air-circulation schedule set to 20 minutes of fan operation if a central cooling or fan circulation cycle had not occurred for 20 minutes. Central fan circulation was delayed 20 minutes after a cooling cycle to allow most of the water on the coil to drain for better humidity control. The average temperature difference between the bedrooms and the central area was approximately 1.6°F, and the peak difference was below 2.5°F during the hottest time on hot summer days.

Experimental Setup

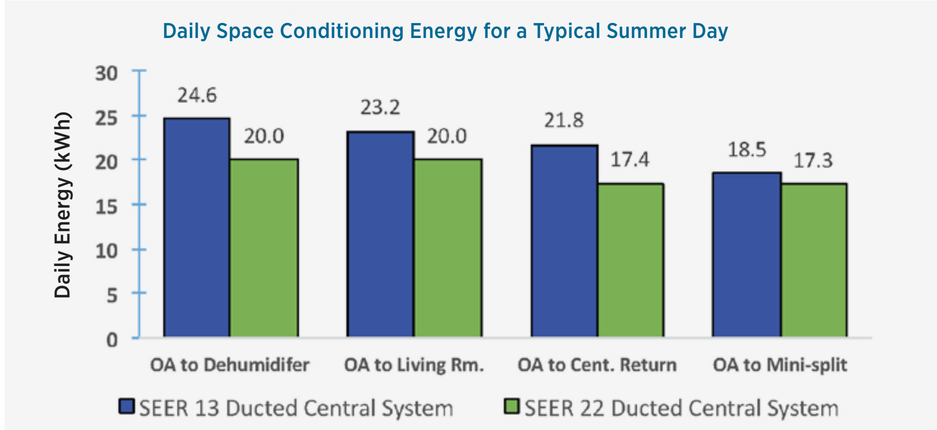
Experiments were conducted with simulated occupancy in Florida Solar Energy Center's Manufactured Housing Laboratory.

The space-conditioning performance of an efficient DMS (above) was compared to ducted central systems using a dehumidifier for supplemental dehumidification.

The influence of using a fixed-capacity (SEER 13) heat pump compared to a variable-capacity heat pump (SEER 22) as part of the system was tested.

For more information see the Building America report *Energy-Efficient Management of Mechanical Ventilation and Relative Humidity in Hot-Humid Climates* at *buildingamerica.gov*.

Image credit: All images were created by the Building America Partnership for Improved Residential Construction team.



Experiments were conducted with outdoor air (OA) delivered to the intake of the dehumidifier, the living room, the return of the central heat pumps, or the return of the DMS. The first three sets of tests above had a dehumidifier enabled and the DMS off. The last set had the DMS on and the dehumidifier disabled.

Lessons Learned

- Tests with the DMS used the least energy compared to tests with central ducted systems and RH control by dehumidifier. The greatest proportion of savings resulted from shifting most of the cooling load from the lower-efficiency SEER 13 system to the SEER 21.5 DMS as well as reducing cooling load from the attic duct system. Cost savings from reducing central system operation and eliminating a suboptimal dehumidifier control design can offset the cost of the DMS and pay back added costs in approximately 5 years.
- Dehumidifier energy of an optimal control design averaged less than 1% of total daily space-conditioning use on hot and humid days and approximately 9% on days that had low cooling loads. However, these results represent a best-case scenario for dehumidifiers using a remote dehumidistat in the central living space. The dehumidifier use could be approximately 12 times greater if RH control was within a confined space, such as a closet, where OA is delivered.
- RH control was evaluated based on holding indoor RH below 60%. The dehumidifier tests did well, except when OA was delivered near the central returns in the utility room. The utility room exceeded 60% RH 15% of the time, and this was most likely to occur overnight.
- The DMS maintained reasonable RH control on hot and humid days, but it exceeded 60% RH for 65% of the hours during low load conditions in standard mode. The RH control mode reduced the frequency to 15%.

Looking Ahead

The RH control of variable-capacity cooling equipment could be improved with modifications to existing control designs. Enhanced OA control may further improve indoor RH control and energy conservation.

U.S. DEPARTMENT OF
ENERGY
Energy Efficiency & Renewable Energy

For more information visit
buildingamerica.gov

The U.S. Department of Energy's Building America program is engineering the American home for energy performance, durability, quality, affordability, and comfort.

DOE/GO-102017-4767 • January 2017