



Building America Case Study

Technology Solutions for New and Existing Homes

Air-to-Water Heat Pumps With Radiant Delivery in Low Load Homes

Tucson, Arizona and Chico, California

PROJECT INFORMATION

Project Name: Field testing of air-to-water heat pump

Location: Tucson, AZ and Chico, CA

Partners:

La Mirada Homes

www.lamiradahomes.net

Chico Green Builders

Daikin

www.daikinac.com

ARBI

<http://arbi.davisenergy.com/>

Building Component: HVAC, domestic hot water

Application: New, single family

Year Tested: 2011-2012

Applicable Climate Zones: Hot-dry, cold

PERFORMANCE DATA

Cost of Energy Efficiency Measure (including labor): \$6,300

Projected Energy Savings:
3%–31% annual HVAC savings

Projected Energy Cost Savings:
\$13–\$310/year

Space conditioning represents nearly 50% of average residential household energy consumption, highlighting the need to identify alternative cost-effective, energy-efficient cooling and heating strategies. As homes are more tightly built, there is an increasing need for strategies that are particularly well suited for high performance, low load homes. Researchers with the U.S. Department of Energy Building America team Alliance for Residential Building Innovation (ARBI) worked with two test homes in hot-dry climates to evaluate the in-situ performance of air-to-water heat pump (AWHP) systems, an energy-efficient space conditioning solution designed to cost-effectively provide comfort in homes with efficient, safe, and durable operation. This strategy is most effective in tight, insulated homes with high levels of thermal mass (i.e., exposed slab floors).

AWHPs operate on the same mechanical principles as air-to-air heat pumps, but instead of connecting outdoor units to an indoor refrigerant-to-air heat exchanger coil as do split-system air-to-air heat pumps, they employ a refrigerant-to-water heat exchanger and generate hot or chilled water. Heating or cooling is distributed throughout the home by circulating the hot or chilled water through a radiant floor, fan coils, or radiators. The same heat pump can also be used to provide domestic hot water. Efficiency advantages are gained by operating systems during the night in summer and during the day in winter to reduce “thermal lift,” reduce compressor cycling, and improve distribution efficiency.

The mixed-mode distribution strategy consists of hydronic delivery using a small fan coil to provide moisture removal, and radiant distribution to provide sensible heating and cooling. Radiant systems offer comfort advantages to occupants because of more uniform mean radiant temperatures in the home and zoned delivery. Thermal storage provided by the slab allows for off-peak cooling and yields demand response benefits. Insulation at the slab perimeter and underneath the slab improves distribution efficiency.

PACKAGED VERSUS BUILT-UP SYSTEMS



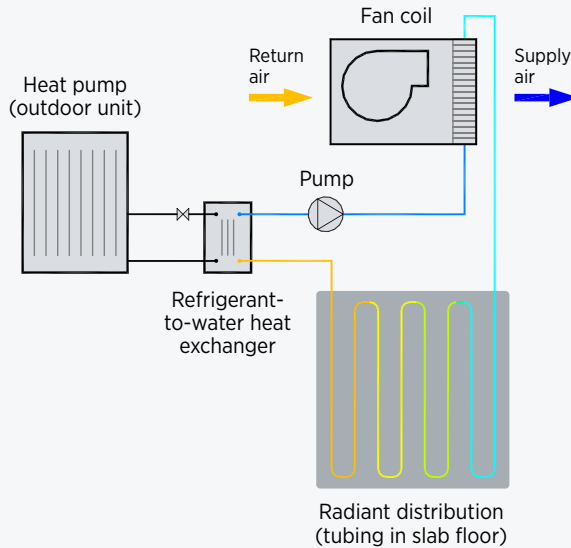
La Mirada Homes of Tucson, AZ, purchased a stand-alone refrigerant-to-water heat exchanger from AquaProducts, which packaged the heat exchanger (mounted underneath) with a standard heat pump. High efficiency heat pumps will increase system operational efficiencies.



Chico Green Builders of Chico, CA, used the Altherma packaged AWHP product from Daikin. This high efficiency product provides hot and chilled water for space conditioning as well as domestic hot water.

For more Information, see Building America report, *Air-To-Water Heat Pumps With Radiant Delivery in Low Load Homes*, at www.buildingamerica.gov

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



This schematic shows the AWHP system in cooling mode with mixed-mode distribution. In cooling mode, the refrigerant-to-water heat exchanger acts as the evaporator. Chilled water first circulates through a fan coil, which supplies latent cooling to the house and raises the temperature of the supply water to the radiant floor. Most sensible cooling is then distributed through tubes embedded in the radiant slab floor.

Lessons Learned

- Proper humidity control is essential to ensure comfort and eliminate chances of condensation in all climates. In very dry climates, spot ventilation is sufficient (i.e., bath and kitchen exhaust fans); otherwise a fan coil or dehumidifier is recommended. Radiant cooling is not recommended in humid climates.
- AWHP savings are up to 31% of annual heating, ventilating, and air-conditioning energy compared with a standard air-to-air heat pump with tight ducts located in the attic, and up to 28% compared to ducts located in conditioned space.
- Air-conditioning pre-cooling can save up to 43% seasonal cooling energy compared with a constant set point strategy. Optimal strategies, which may vary setback temperature and time, are location dependent, even within the range of hot-dry climates.
- Distribution system losses are reduced when delivering energy via radiant floor compared to ductwork. Average measured distribution efficiencies were 94% compared to 76% for a ducted system with tight ducts located in the attic.

Looking Ahead

Further research that focuses on development of packaged AWHPs as well as packaged controls for zoned systems is necessary. This will drive cost reductions, facilitate simplified installation procedures, and ensure consistent levels of quality, resulting in increased market acceptance by contractors and installers. With increased market penetration, system costs are expected to decrease because of increased contractor familiarity and reductions in manufactured equipment costs from volume production.

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

For more information, visit:
www.buildingamerica.gov

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.

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-102013-4045 • November 2013