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

Building America Case Study
Technology Solutions for New and Existing Homes

Heat Pump Water Heater Ducting Strategies with Encapsulated Attics in Climate Zones 2 and 4

LaFayette, Georgia (CZ 4)
Savannah, Georgia (CZ 2)

PROJECT INFORMATION

Project Name: Ducted HPWHs

Locations: LaFayette, GA; and Savannah, GA

Partners:

LaFayette Housing Authority, Housing Department of the City of Savannah, A.O. Smith

Partnership for Home Innovation, *homeinnovation.org*

Southface Energy Institute, *southface.org*

Building Component: Water heating

Application: New or retrofit; single- or multifamily

Year Tested: 2014

Applicable Climate Zones: Hot and mixed humid (CZ 2 and CZ 4)

PERFORMANCE DATA

Cost of energy-efficiency measure (including labor): $2,000

Projected energy savings: 70%–72%*

Projected energy cost savings: $267–$329/year*

*Based on modeling results compared to a standard electric storage water heater

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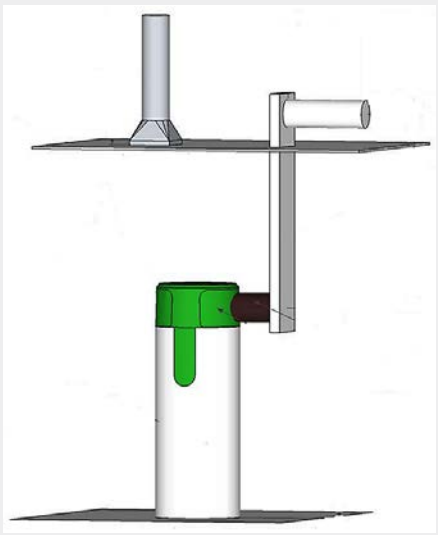
Heat pump water heaters (HPWHs) decrease water heating energy consumption by up to 62% compared to standard electric storage water heaters by using a refrigeration cycle to transfer energy from the air to water in the tank. HPWH performance is largely dependent upon intake air temperature, which requires HPWH installations to be in areas with at least 750 ft^3 of free air to prevent recirculation of cool exhaust air. Ducting HPWHs enables installation in confined spaces that usually would not provide enough air volume for sufficient energy transfer.

The U.S. Department of Energy's Building America research team Partnership for Home Innovation examined the effect of ducting HPWH air streams to and/or from attics encapsulated with open-cell spray polyurethane foam. Four ducted HPWHs installed in small mechanical closets were monitored in LaFayette, Georgia, under different ducting configurations. In Savannah, Georgia, a ducted HPWH in a sealed attic with an exhaust duct terminating at the other side of the attic was also monitored and compared to attic conditions of a nearly identical neighboring house. The plumber installed the HPWH, and the heating, ventilating, and air-conditioning (HVAC) contractor installed the duct. It was the first HPWH installation for both trades at both sites. The plumber's and the HVAC contractor's only training was a 30-minute instructional video provided by A.O. Smith. Measured ducted HPWH coefficient of performance (COP) values ranged between 1.9 and 3.1 and were comparable to other unducted field studies not in confined areas. COP values (and energy savings) were dependent upon many variables—most prominently intake air temperature and humidity.

In addition to HPWH performance, the impact on total HVAC loads was also studied. The space conditioning provided by the HPWH did not have a noticeable impact on HVAC cooling or heating loads when the HPWH air streams were ducted to and from the sealed attic within the building envelope. Temperature and humidity changes of the living zone were not detected. Attic temperature and humidity were reduced during HPWH operation but returned to pre-existing conditions shortly after the heat pump cycle. Peak moisture loads in the attic were reduced only if the heat pump operated during the morning hours.

Ducted HPWH



Schematic of HPWH installation inside a small utility closet of a building with a sealed attic. A transfer duct in the ceiling provides intake air from the sealed attic, while the HPWH's exhaust is directly ducted to the attic. The distance between the ducts' terminals must be a minimum of 5 feet, and the different orientations of the ducts are to prevent recirculation of cool exhaust air.

HPWH installed in a small mechanical closet with intake (left) and exhaust (right) ducts installed; the ducts connect air streams to a spray-foam-encapsulated attic.

For more Information see the Building America measure guideline report *Heat Pump Water Heater Ducting Strategies with Encapsulated Attics in Climate Zones 2 and 4* at *buildingamerica.gov*.

Image credit: All images were created by the Partnership for Home Innovation team.

Unit	Location	Period 1 8/26–9/16	Period 1 Average Daily COP	Period 2 9/18–10/19	Period 2 Average Daily COP
A	Intake		2.5	✓	2.5
	Exhaust	✓		✓	
B	Intake		1.8	✓	1.8
	Exhaust	✓			
C	Intake		2.3		2.3
	Exhaust	✓		✓	

Ducting configurations were varied during the monitoring period in LaFayette. Initially (Period 1); all units had exhaust ducted to a sealed attic and a transfer duct across the attic floor for supply air (schematic, left). During Period 2, Unit A had both supply and exhaust ducted to the attic, Unit B had only supply ducted from the attic, and Unit C remained unchanged with supply through the transfer grille and exhaust ducted to the attic. The average daily COP values of all units did not change from Period 1 to Period 2.

Lessons Learned

- HPWH performance was not affected by ducting configuration and performed comparably to unducted installations in unconfined spaces. Performance was largely dependent upon intake air temperature and humidity conditions, inlet water temperature, number of heat pump operation events, total hot water demand, and tank set point temperature.
- Exhaust ducts should be insulated to avoid exterior condensation; however, this imposes a risk of interior duct condensation near the HPWH because of the large variation of temperatures between the compressor and the duct and the presence of bulk moisture around the condenser.
- HPWHs are not fit to serve as dehumidifiers in sealed attics, because peak moisture loads were reduced only if the heat pumps operated during the morning.
- HPWH's air-conditioning impact on HVAC loads is minimal when ducted to a sealed attic and not the living space.

Looking Ahead

Ducting air streams to and from the living space and the outside could provide further energy savings by increasing the intake air temperature and humidity and directly conditioning the living space. Further research is needed to identify smart damper controls to provide multiple intake and exhaust air locations for maximum savings. Ducted HPWHs operating to meet domestic hot water loads only are not appropriate replacements for ventilation or dehumidification equipment.

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DOE/GO-102017-4754 • February 2017