Improving Water Heating Efficiency in the Residential Performance Code

Rationale

The efficiency of water heating in Florida residences has remained static for more than fifty years, being dominated by electric resistance water heating. Although modest improvements have been made—perhaps improvements of 10% due to better tank insulation, water heating remains a very large energy end use in Florida—second only to space cooling in Florida homes. With the recent advent of reliable, inexpensive and very efficient heat pump water heaters (HPWH) the potential now exists to cut household energy use for heating hot water by more than 60%. This technology has particular attributes that make it uniquely ideal for application in Florida's climate. The technology works exceedingly well in in Florida's warm climate and offers the potential of free cooling & dehumidication when units are located inside in utility rooms. By establishing HPWH as the baseline water heater, it not only improves the energy efficiency of the code, but provide a convenient way for builders to obtain "free" credit by locating HPWH inside the building rather than the default garage location. The energy conservation code will need a strategy to provide HPWH for the appropriate baseline for a reference home.

Overview

The performance method (R405) is the most popular compliance method in Florida. The method requires a software vendor to virtually create a baseline reference home the same size as the home to be permitted and insulate and equip it to a set of parameters spelled out in Table R405.5.2.1. This table follows the federal minimum that specifies a standard electric resistance water heater storage tank of 55 gallons or less have an efficiency of 0.96-(0.0003*V) so for 40 gallons EF=0.948 while specifying EF of 2.057– (0.0013*V) for systems over 55 gallons which equates to an EF of 1.979 for a 60 gallon electric system. Unfortunately as this is rated per unit, houses with larger loads may be installing multiple smaller less efficient electric resistance water heaters instead a of a single more efficient heat pump water heater. Heat pump water heaters have been shown to save significant water heating energy.

1. Average residential energy use in Florida single family homes is approximately 2,100 kWh/year. Several studies, point out that this can be cut by more than 65% to an average of about 750 kWh through the use of HPWH. This is a savings of around 1,700 kWh/year typically and a reduction in whole house energy reduction by more than 10%-- a very significant improvement.
2. FSEC has conducted the most relevant study of the free cooling from HPWH which showed a 3-6% reduction in space cooling from interior or ducted HPWH. In a typical home this will reduce space cooling by 100 – 400 kWh/year.

Figure 1Heat pump water heater saved 70% of water heating energy use when it replaced electric resistance unit at "site #8" of recent DOE/FPL funded retrofit study

3. The incremental installed cost of HPWH over standard electric resistance tanks is now only about $1000. As typical savings are nearly $200 per year (without cooling interactions), these systems are highly cost effective for Florida consumers—and potentially even more cost effective when HVAC interactions are considered.
4. The study will determine where a reference home HPWH should be located. If outside the conditioned space, the proposed home that might locate the HPWH in an interior utility room could be associated with a "free" reduction in cooling that would help to achieve code compliance.
5. The change in the reference baseline system would obviously not preclude using alternative means to heat hot water efficiently including desuperheater or solar water heaters. Electric resistance systems can also be used so long as other tradeoffs are made to make up the difference.

Scope of Work

Task 1a: Literature review of HPWH performance and cost in Florida. Literature review will at a minimum include searching databases of FSEC, NREL, LBNL, ASHRAE, DOE Building America for data on HPWH and performance in warm climates. Particular attention will be given to newer studies. This study will also compare the costs of HPWH installation vs. standard electric resistance tanks to ensure that the reference system is indeed cost effective.

Task 1b: Literature and simulation review of studies of interactions of the HPWH with space heating and cooling. However, these results will be compared with simulation results of the interaction as estimated within EnergyGauge USA to ensure that the code related credits are appropriately estimated across Florida climate zones, considering both heating and cooling interactions for the relevant cases.

Task 1c: Based on the literature and simulation evaluation, develop draft rules. Draft rules will be of a form that can fit into the code document. The rules will describe how to treat the proposed home as well as the standard reference home.

Task 1d: Test draft rules in a simulation program. EnergyGauge USA will be used for this as it already has the ability to accurately simulate HPWH as well as to potentially evaluate interactions with heating and cooling. The test will allow Florida energy code comparisons to results without HPWH. A study will also be made on how the performance code can still be met

by a) using alternative water heating technologies such as solar or desuperheaters or, b) of improving other building and equipment related items in the building to make up for continuing to use an electric resistance water heater.

Task 1f. Write report to include the literature review, final recommendations for code changes, and expected impact for example homes. Recommended code language required to implement changes will be included.

Expected Outcome and Impact on the Code:

Performance modeling rules for HPWH will be developed. The impact of adding HPWH to the building baseline for all homes will be explored. It is expected that the changing to the HPWH in the baseline for all homes will have two beneficial impacts for Floridians: a) improve energy efficiency of new Florida code by a significant amount (amounting to 1,700 kWh per year), while preserving flexibility to meet the code and b) allow easier qualification of meeting code compliance in cases where the HPWH can be located on an interior utility room to reduce cooling energy use.

Budget:

$15,000