Hot Water Code Calculation Proposal

Background

Code calculations for hot water use and energy consumption are overly simplistic. Current calculations do not consider plumbing design, which typically engenders significant hot water waste. They also assume that the same quantity of hot water is used by homes regardless of the time of the year and regardless of climate location. Further, hot water recirculation systems that are gaining popularity can cause significant increases in hot water energy consumption if adequate controls are no employed. None of these hot water energy impacts are currently considered by Florida's Energy Codes.

Hot Water Waste

Research indicates that conventional residential plumbing designs waste 20-25% of hot water use in homes (Lutz 2005, Klein 2012, Henderson and Wade 2014) yet energy codes provide no mechanism to account for this hot water waste. The quantity of hot-water waste that a hot water distribution system experiences is dependent on three principle factors:

- The length and diameter of the hot-water piping between the hot-water heater and the point of hot-water use (i.e., the volume of hot water that can be left in the piping)
- The amount of insulation on the hot-water piping
- The elapsed time between multiple hot-water events that use the same piping

Improved piping layout and plumbing design using insulated piping can significantly reduce hot water waste. However, at present, there is no incentive in Florida's Energy code that would encourage better piping layout and plumbing design.

Hot Water Use Quantity

In addition to the hot water waste engendered by distribution system design, the quantity of hot water used in residences is also influenced by the mains water temperature entering the home. The research shows that approximately 50% of the hot water used in homes is for showering (Henderson and Wade 2014) and that the mean hot water system delivery temperature is approximately 125 ^{o}F (Lutz and Melody 2012, Parker 2002). Showering does not occur at 125 ^{o}F so it is reasonable to assume that there is a "useful" mixed water temperature at which showering does occur. Some quantity of water at the mains water temperature must be mixed with the hot water to achieve the useful mixed water temperature. As a result, the temperature of the mains water entering the residence is a significant determinant of the quantity of hot water necessary to attain the useful mixed water temperature for at least 50% of the hot water used in homes (i.e. for showering).

The National Renewable Energy Laboratory has conducted research to determine typical mains water temperatures based on climatic data (Burch and Christensen 2007) and found that mains water temperature is relatively well correlated to the average air temperatures and that it fluctuates over the course of the year as a sinusoidal function. On an annual average basis, the average mains water temperature is approximately equal to the annual average air temperature plus 6.4 ^{o}F. Thus, in Tallahassee, Florida, the annual average mains water temperature is 73.2 ^{o}F (66.8 + 6.4) and in Miami, Florida, the annual average mains water temperature is 82.5 ^{o}F (76.1 + 6.4) a difference of 9.3 ^{o}F. If one assumes that the useful mixed water temperature for showering is 105 ^{o}F, the impact of these mains water temperatures can be calculated. The fraction of hot water at 125 ^{o}F needed to achieve the mixed water temperature of 105 ^{o}F is calculated as follows:

$$\text{Hot Water Fraction} = (105 - T_{mains}) / (125 - T_{mains}) \qquad \text{Eq. 1}$$

Thus, for Tallahassee the hot water fraction is 0.614 and for Miami the hot water fraction is 0.529. The research has also shown that the typical shower lasts about 8.3 minutes at about 2.7 gallons per minute, using approximately 22 gallons of mixed water. Thus, in Tallahassee, the typical shower would use 13.5 gallons of hot water but in Miami that same shower would use only 11.6 gallons of hot water, or about 2 gallons less. If one assumes that there are approximately 2 showers per day in the typical household, the difference in daily hot water use between Tallahassee and Miami would be about 4 gallons per day – or approximately 1,460 gallons per year. The approximate energy implications of this difference in hot water use can also be calculated. If one assumes minimum standard electric water heater efficiency of 0.95 and the temperature difference between the mains water temperature in Tallahassee (73.2 ^{o}F) and a hot water delivery temperature of 125 ^{o}F, the energy use for this additional 1,460 gallons of hot water is 1460*8.3*(125-73.2)/0.95/3412 =194 kWh per year.

While bathing is the largest single user of hot water in the home, this same mixed water temperature issue exists for all of the fixtures in the home where skin contact with hot water occurs, meaning that the difference in total hot water use between a Tallahassee home and a Miami home will actually be greater than 1,460 gallons per year.

Hot Water Recirculation Systems

Hot water recirculation systems are becoming increasingly more widespread. Hot water recirculation system pumps and retrofit materials are advertised and sold in DIY outlets like Home Depot and Lowes as devices that will reduce wait times for hot water at the tap or shower. These hot water recirculation systems can be very large energy waste, increasing hot water energy consumption by as much a 200% or more. Where they are incorporated in new homes, the Florida Energy code should account for this potential increase in hot water energy consumption.

Proposed Research

The proposed research will characterize hot water waste sources, characterize the implications of the climatic differences on hot water use and characterize the energy impacts of hot water recirculation systems and controls with respect to energy consumption in Florida homes and recommend Florida-specific methods that can be employed in the Florida Energy code for residential hot water use and energy consumption calculations.

Deliverables

A literature review, research report and recommendations suitable for consideration by the Florida Building Commission in determining the most appropriate Florida-specific methods, procedures and calculations for determining the energy use effectiveness, including the hot water distribution system effectiveness, of domestic hot water systems in the Florida Energy Code for Residential Buildings.

Budget

The estimated budget for completion of the project is $20,728.

References

Burch, J., and C. Christensen. 2007. Towards development of an algorithm for mains water temperature. Proceedings of the 2007 ASES Annual Conference. OH: Cleveland.

Lutz, J. 2005. Estimating energy and water losses in residential hot water distribution systems. LBNL-57199. Berkeley, CA: Lawrence Berkeley National Laboratory.

Lutz, J and M. Melody. 2012. “Typical Hot Water Draw Patters Based on Field Data.” Environmental Energy Technologies Division, Lawrence Berkeley National laboratory, Berkeley, CA.

Klein, Gary, 2012. Affordable Comfort Conference, Baltimore, MD. Personal communication.

Henderson, H., and J.Wade. 2014. Disaggregating hot water use and predicting hot water waste in five test homes. NewYork: Aries Collaborative.

Parker, D.S., 2002. Research highlights from a large scale residential monitoring study in a hot climate. Proceeding of International Symposium on Highly Efficient Use of Energy and Reduction of its Environmental Impact 108–16, Japan Society for the Promotion of Science Research for the Future Program, JPS-RFTF97P01002. Osaka, Japan.

PROPOSAL TITLE: Hot Water Code Calculation Proposal

Period of Performance: 09/01/15 TO 05/31/16

ver.101614

LABOR COST	FB Rate	BASE HOURLY RATE	HOURS	SALARY & WAGES	FRINGE BENEFITS	TOTAL COSTS	FSEC Cost Share	Agency Funding Requested
Program Manager/Professor	Fac/Staff	$73.88	40	$2,955	$845	$3,800	$0	$3,800
Sr. Research Engr-Scientist/Ass't Prof.	Fac/Staff	$39.41	104	$4,099	$1,172	$5,271	$0	$5,271
Research Engr-Scientist	Fac/Staff	$34.95	191	$6,675	$1,909	$8,585	$0	$8,585
Associate Research Engr-Scientist	Fac/Staff	$29.05	0	$0	$0	$0	$0	$0
Subtotal Labor Costs:				**$13,729**	**$3,927**	**$17,656**	**$0**	**$17,656**

TRAVEL	TOTAL COSTS	FSEC Cost Share	Agency Funding Requested
Travel (out of state)	$0	$0	$0
Travel (in-state)	$938	$0	$938
Travel (foreign)	$0	$0	$0
Subtotal Travel:	**$938**	**$0**	**$938**
OTHER EXPENSE:			
Materials & Supplies (specify below)	$0	$0	$0
Printing/photocopying of project reports and related delilverable documents & materials	$250	$0	$250
Overnight mail & postage for project reports and related deliverable docs & materials	$0	$0	$0
Computer Charges (monitoring, database mgmt.)	$0	$0	$0
Tuition and fees	$0	$0	$0
Other (specify)	$0	$0	$0
Other (specify)	$0	$0	$0
Other (specify)	$0	$0	$0
Subtotal Other Expense:	**$250**	**$0**	**$250**
EQUIPMENT:			
--	$0	$0	$0
--	$0	$0	$0
--	$0	$0	$0
Subtotal Equipment:	**$0**	**$0**	**$0**
TOTAL DIRECT COSTS:	**$18,843**	**$0**	**$18,843**
O/H Rate: 10.0%			
Base for Indirect Costs	$18,843	$0	$18,843
INDIRECT COSTS:	**$1,884**	**$0**	**$1,884**
TOTAL PROPOSED COSTS:	**$20,728**	**$0**	**$20,728**
		Cost Share:	**0.0%**

Details of Materials and Supplies:

--	$0
--	$0
--	$0
--	$0
Total Materials & Supplies	**$0**