FSC'S LAW & ECONOMICS INSIGHTS

Issue 00-6 **Fisher, Sheehan & Colton, Public Finance and General Economics** **Nov/Dec 2000**

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HOT WATER USAGE BY PUBLIC HOUSING TENANTS

Hot water usage probably doesn't rank high on the list of everyday legal problems facing low-income advocates. But to tenants of public and subsidized housing, the appropriate calculation of hot water consumption could mean the difference of hundreds of dollars a year in utility allowances.

Hot water is one of the major sources of energy consumption in a low-income household. According to the U.S. Department of Energy, energy for hot water consumption is generally about 15 percent of a household's total home energy consumption.

Several factors are of particular importance in establishing an appropriate hot water energy allowance for public and assisted housing, including: (1) hot water temperature to be maintained in the water tank; and (2) daily hot water consumption per person.

In a recent report for the Equal Justice Foundation, of Dover (OH), Fisher, Sheehan & Colton, Public Finance and General Economics (FSC) explained the hot water consumption of public housing tenants of the Gallia (OH) Metropolitan Housing Authority (GMHA).

Water Temperature in the Water Tank

To appropriately determine the hot water energy consumption for public housing tenants, it is necessary to consider both the hot water temperature to be maintained in the hot water tank as well as the hot water temperature to be maintained at the point of usage. FSC disputed the use of a 120E hot water tank temperature for tenants of GMHA public housing.

The water temperature to be maintained in a hot water heater tank is different from the water temperature delivered at the outlet. An "outlet" is the fixture at the point of use: a faucet, a showerhead, and the like. The water temperature at the outlet is driven by the mixed temperature of hot and cold water. FSC cited the American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE), a national standard-setting body, which states: "Where multiple temperature requirements are met by a single system, the system temperature is determined by the *maximum* temperature needed. Lower temperatures can be obtained by mixing hot and cold water." FSC further noted that the American Society of Plumbing Engineers (ASPE) agrees. ASPE states: "To inhibit the growth of bacteria in a hot-water system, a temperature of about 140E F or higher is recommended. *If a lower temperature is required at a fixture, it can be obtained by mixing water at this temperature with cold water at the fixture.*"

Tank Temperatures and Energy Conservation

An argument is often advanced that a lower water temperature in the tank will result in energy savings. As a result, the argument goes, use of a lower water temperature is appropriate under the "energy conservative household" standard for setting public utility allowances. Superficially, the argument makes sense: if you need to heat water to a lower temperature, it might seem that you would use less energy in doing so. In fact, FSC said, that superficial answer is wrong because it confuses water temperature at the tank with water temperature at the outlet.

Total hot water energy consumption is a function of *two* factors: (1) the temperature to which the water is heated; *and* (2) the amount of hot water that is used. These two factors are inversely related to each other. Given the fact that the hot hot water delivered at an outlet is a mix of hot water from the tank with cold inlet water, it mathematically follows that as the hot water temperature in the tank goes up, the amount of hot water (in gallons) needed to obtain a specified mixed water temperature at the outlet goes down. Conversely, it also mathematically follows that the amount of hot water (in gallons) needed to obtain a specified mixed water temperature at the outlet goes down as the hot water temperature in the tank goes up.

Because of this truism, total hot water energy consumption is driven not by the hot water temperature in the tank, but rather by the hot water temperature at the outlet. If, in other words, a person uses a 110E temperature for showers, it does not matter from an energy use perspective whether the 110E is obtained by a 50%/50% hot-to-cold water mix (with the tank water temperature set at a higher temperature) or by a 85%/15% hot-to-cold water mix (with the tank temperature set at a lower temperature). The factor driving the energy use is the temperature of the shower, not the temperature in the tank.

In sum, the energy consumption associated with hot water use is driven by the water temperature at the water outlet (*e.g.*, the faucet, the showerhead), *not* by the water temperature in the hot water tank. Given otherwise identical hot water uses in a home, the energy consumption associated with 135E tank temperatures and 120E tank temperatures will be identical.

The Problems with Low Tank Temperatures

Two reasons exist, FSC said, why a lower tank temperature cannot be used consistent with the utility allowance guidelines established by the U.S. Department of Housing and Urban Development (HUD).

First, given reasonable hot/cold water mixes at the outlet, a lower tank temperature will not provide sufficient hot water at the outlet to perform typical household functions.

FSC illustrated by taking the water inlet temperature used in its calculation of GMHA utility allowances (65E) and the hot water temperature in the tank of 120E (used by GMHA). The FSC illustration used a typical water mix at the outlet of 50% hot water and 50%

cold water. Given this information, FSC demonstrated that GMHA could not provide hot water at the tap at the temperatures used for common household purposes.

FSC cited the American Society of Plumbing Engineers (ASPE) which reports typical hot water temperatures for common household uses to be:

Lavatory (sinks)	105E F
Showers and baths	110E F

Calculating the mixed water temperature involves calculating the weighted average temperature using the percent of hot water and the percent of cold water involved with the mix. Using the three pieces of information identified immediately above (inlet temperature, tank temperature, hot-to-cold water mix) thus yields the following:

	Cold	Hot
Water Temperature:	65E	120E
Mixture:	50%	50%
Weighted Temperature: 33E	60E	
Mixed Water Temperature:		93E

(Weighted cold water temperature + weighted hot water temperature = mixed water temperature)

FSC concluded that a hot water tank temperature of 120E does not provide the water temperatures needed for typical residential uses. The mixed water temperature (93E) resulting from a 120E tank temperature is less than the typical hot water temperature used for handwashing in a bathroom sink (105E). The temperature does not even approach that normally used in showers (110E).

Hot Water and Safety

There will be times, FSC said, when a local housing authority will argue that a 120E F tank temperature is needed for safety reasons. According to these arguments, consumers will be placed in danger of serious scalding should hot water temperatures be permitted to reach greater than 120E F. Given the acknowledged consumer need of temperatures, other than for laundry and dishwashing, of less than 120E F, this argument has some intuitive appeal. On closer examination, however, the argument fails.

The danger arising from hot water can be assessed in terms of first degree burns. A first degree burn is the least serious type of burn and causes no irreversible damage. According to research at the Harvard Medical School, relied upon by the American Society of Plumbing Engineers (APSE):

> it takes a 3-second exposure to 140EF (60EC) water to produce a first-degree burn. At 130EF (54EC), it takes approximately 20 seconds, and at 120EF (40EC), it takes 8 minutes to produce a first degree burn.

The normal threshold for pain, however, is approximately 118EF. A person exposed to 120EF water would "immediately experience discomfort," APSE notes. Nonetheless, a person would need to expose themselves to 130E water for nearly 20 seconds to experience a first degree burn.

In 1988, APSE released its two year study of "temperatures limits in service hot water systems." In recommending a hot water tank temperature of either 135E or 140E, the APSE study observed that the potential for scalding, while a not insignificant concern, should not govern the hot water tank temperatures. It should be noted, APSE said, "that virtually all severe burns and scalding deaths occur as the result of immersion in hot water in a bathtub rather than as a result of being sprayed by hot water in a shower." Moreover, APSE noted, the greater

vulnerability to such injuries involves the elderly, young children, and "especially patients in health care facilities." According to APSE, the danger of scalding from a 135E water tank temperature "can be minimized and practically eliminated by the selection of thermostatic or pressure balancing mixing valves at bath/shower facilities. It is also important that a maximum temperature limit stop be incorporated in these mixing valves."

Controlling temperature at the outlet is the safety mechanism recommended by Housing Authority Insurance Company, as well. Housing Authority Insurance is an insurance company serving local housing authorities nationwide. Housing Authority Insurance released its recommendations on controlling the risk of "tap water scald injuries" in 1996. According to this insurance carrier:

> Research shows that children left unsupervised tend to be at higher risk of scald injuries. The children are also more likely to live in multi-family residential buildings where the boiler is set at a high temperature to meet the larger demand for hot water. The water in the lower level units is often extremely hot because of the close proximity to the boiler.
>
> Since that type of problem cannot be eliminated, it had been hoped that turning down the hot water service to 120E F would be an attractive and simple method of achieving anti-scald protection. However, a study of families showed that 80% abandoned the trial because they either ran out of hot water or the water was not hot enough to meet all of their needs.

Stating that "prevention techniques are necessary" to respond to potential scald injuries in multi-family buildings, Housing Authority Insurance then considered a variety of mechanisms to control the exposure of local housing authority tenants to tap water scald injuries. The company ultimately recommended:

> A thermostatic mixing valve is a device that reduces or shuts off the supply of hot water if the temperature of the hot and cold mix exceeds a certain level. The temperature limit is set by a qualified installer and usually the adjustment can be locked to avoid tampering. Thermostatic mixing valves are either situated close to the hot water heater, near the individual outlets, or integrated into the mixer tap. Temperature Actuated Flow Reduction Valves (TAFRs) are simple to install devices. TAFRs can be installed by staff maintenance personnel as a retro-fit accessory. They fit into individual plumbing fixtures, such as shower heads, bath and utility faucets, and sink and lavatory faucets. They are temperature-sensitive, not pressure sensitive. TAFRs do not mix or adjust the water temperature, but reduce water flow to a trickle of less than 1/4 gallon per minute when the water temperature exceeds 120E F at the point of discharge. These devices can be activated by too much hot water being used or the cold water pressure dropping. They resume full flow when the temperature reaches a safe level of approximately 98E F.

In sum, several important pieces of information have been added by the recommendations made by Housing Authority Insurance Company:

1. The risk of scalding due to high temperature water is primarily associated with multi-family buildings, where hot water temperatures are kept higher in order to serve the hot water demand in units further away from the central hot water tank.

2. A test of reducing water temperatures in housing authority tanks to 120E resulted in 80% of the households dropping out of the test because they either ran out of hot water or the water was not hot enough to meet all of their needs.

3. Temperature-controlled "thermostatic mixing devices" can be installed to protect against scald injuries. They are easy to install, can be "locked" to prevent tampering, and are effective at controlling dangerous exposure to hot water temperatures.

Hot Water Use Per Person

FSC also challenged the utility allowance calculation that GMHA public housing tenants would use roughly 10 gallons of hot water per person per day. FSC noted that according to the Gas Appliance Manufacturers Association (GAMA), a typical household's hot water consumption is as follows:

End Use	Gallons of Hot Water Per Use
Shower	20
Shaving	2
Hands and Face Washing	4
Hand Dishwashing	4
Food Preparation	5

Given these typical consumption figures, FSC said, it is impossible to limit individual hot water consumption to only 10 gallons per person per day.

It is possible also, FSC said, to gain a reasonable estimate of daily per occupant hot water consumption by looking at measured results from other authoritative studies. FSC cited ASHRAE's recent work on hot water consumption issues. ASHRAE has determined that specific demographic characteristics correlate to different levels of hot water consumption: high, medium and low. ASHRAE's categorization follows:

Demographic Characteristics
Correlation to DHW Consumption
(ASHRAE 1996)

Characteristics Associated with High Usage

No occupants work
Public assistance and low income (mix)
Family and single-parent households (mix)
High percentage of children
Low income

Characteristics Associated with Medium Usage

Families
Public assistance
Singles
Single-parent households
Couples

Characteristics Associated with Low Usage

Higher population density
Middle income
Seniors
One person works, one stays homes
All occupants work

(The demographics are listed in order from highest consumption to lowest consumption.)

According to ASHRAE, a low-income housing project will generally fall somewhere between the "low income" and "no occupants work" categories of high-volume water consumption. ASHRAE then set national standards for sizing hot water equipment for multi-family buildings. According to ASHRAE, the average daily per person usage to be assumed for purposes of sizing a hot water heater would be as follows:

National Hot Water Sizing Guidelines
(Low-Medium-High)
(ASHRAE 1996)

Average Hot Water Usage Per Person Per Day

Low	14 gallons
Medium	30 gallons
High	54 gallons

These data, ASHRAE said, are for centrally fired units. Consumption for individually metered are likely to be somewhat lower.

ASPE has adopted these ASHRAE guidelines, as well, for its standards regarding the proper sizing of domestic hot water systems as well.

Hot Water Leaks

Finally, FSC said, high hot water consumption is often driven by leaks, particularly in low-income households. According to the American Housing Survey, performed by the Census Bureau and the U.S. Department of Housing and Urban Development (HUD), while only 13 percent of all occupied units in the country were occupied by households living below the Poverty Level, nearly 20 percent of all households with leaking pipes were in low-income homes.

In addition, the AHS reports, nearly one-quarter of all leaks that were "unreported" but discovered upon inspection of the housing being surveyed were in homes occupied by households living below the Poverty Level.

Overall, nearly one in six low-income households (16%) had water leaks. The AHS reports that 22 percent of the occupied households experiencing "severe" physical problems with their plumbing were low-income households, while in addition, 34 percent of the occupied households experiencing "moderate" physical problems with their plumbing were low-income households.

Persons interested in obtaining a copy of FSC's report prepared for the Equal Justice Foundation can write:

publications@fsconline.com

Persons interested in obtaining help with documenting and presenting requests for appropriate adjustments to utility allowances for local public housing authorities may contact the following e-mail address to request assistance:

roger@fsconline.com

Fisher, Sheehan and Colton, Public Finance and General Economics (FSC) is a research and consulting firm with offices in Belmont (MA), Scappoose (OR), and Iowa City (IA).

FSC specializes in providing economic, financial and regulatory consulting. The areas in which *FSC* has worked include infrastructure financing, public enterprise planning and development, natural resource economics, community economic development, telecommunications, public sector labor economics, planning and zoning, regulatory economics, energy law and economics, fair housing, and public welfare policy.

Fisher, Sheehan & Colton
Public Finance and General Economics
34 Warwick Road, Belmont, MA 02478-2841
617-484-0597 *** 617-484-0594 (fax)
editor@fsconline.com (e-mail)
http://www.fsconline.com