Estimating Potential Savings from Demand Controlled Pumping Systems

1. Executive Summary

The performance of a **demand controlled pumping system** in a typical residential water heating installation was analyzed. Demand controlled pumping is a method of bringing water quickly to fixtures far from the water heater in order to minimize the waste of water running down the drain while waiting for hot water to arrive. As of January, 2006, there are three companies selling products that do this: ACT Inc., Metlund Systems (www.gothotwater.com), TACO (www.taco-hvac.com) and Uponor Wirsbo (www.wirsbo.com). These products and their application are the subject of this analysis.

An analysis was performed to quantify the potential enhancement of water heater energy factor due to the use of a demand controlled pumping system under a range of conditions expected to be encountered in typical residential settings. A set of linked steady-state energy balance equations was solved in a spreadsheet-based simulation to predict the **energy factor (EF) enhancement** of a 40-gallon gas tank water heater, a 52-gallon electric tank water heater, (the most-commonly-encountered sizes for storage water heaters) and for gas and electric tankless water heaters.

Based on this analysis, it is reasonable to assign the following energy factor enhancement coefficients when using demand controlled pumping systems:

Trunk and Branch
The savings due to a conservative 15% reduction in water consumption results in energy factor enhancement coeffieients ranging from 1.12 to 1.17 for the range of water heaters that were evaluated (See Table 5).

Structured Plumbing
The savings due to a conservative 20% reduction in water consumption plus an additional savings equivalent to another 10% reduction in water use due to insulation, result in energy factor enhancement coefficients ranging from 1.27 to 1.42 for the range of water heaters that were evaluated (See Table 5).

In order to obtain the highest combination of water and energy efficieney, the energy factor enhancement for Structured Plumbing needs to be aligned with the top tier for Hot Water Distribution Systems in LEED-H or similar green building programs.

Retrofitting Existing Recirculation Systems
The savings here are energy, not water related as in the first two applications. Retrofitting a demand controlled pump will reduce the energy needed to operate the pump and keep the circulation loop hot by up to 98 percent (286 therms or 6,388 kWh per year) and is proportional to the run time of the existing system.

Literature Survey

There are four studies that taken together document the energy savings potential of demand pumping systems. In 1999, on behalf of the American Water Works Association Research Foundation (AWWARF)[1], Aquacraft conducted research in many parts of the country as part of the Residential End Uses of Water Study (REUWS). In 2002, Oak Ridge National Laboratory (ORNL)[2] conducted a study in conjunction with the City of Palo Alto that examined the use of demand pumping systems in retrofit applications. In 2003, the Davis Energy Group (DEG)[3] conducted a study as part of their work for the Building America program on new construction that showed that the use of a demand pumping system saves energy compared to standard recirculation techniques. In 2005, the California Energy Commission[4] conducted a study conducted to better understand hot water distribution systems.

Aquacraft's REUWS took data from 1200 homes in 12 metropolitan areas in the U.S. and Canada. Although the vast majority of the effort was focused on total water consumption, in some of these locations hot water use was measured separately. Table 1 shows data from two of these studies and from the REUWS. The range of hot water use in the REUWS is estimated based on the rounded off percentages from the EBMUD and Seattle studies.

Table 1 Estimated Hot Water Consumption in the United States

	EBMUD	Seattle	REUWS
Water Use (gallons/capita/day)			
Hot Water	21.1	25.1	21 to 28
Total Indoor Water	70.9	62.2	69.3
Percent	29.8	39.6	30 to 40
Number of People	2.5	2.6	2.8
Hot Water Use (gallons/household)			
Daily	52.75	65.26	58.8 to 78.4
Monthly	1,582	1,958	1,764 to 2,352
Annually	18,990	23,494	21,168 to 28,224

[1] **Residential End Uses of Water Study (REUWS)**, American Water Works Association Research Foundation, 1999.

[2] **Water and Energy Savings using Demand Hot Water Recirculating Systems in Residential Homes: A Case Study of Five Homes in Palo Alto, California**, Moonis Ally and John Tomlinson, Oak Ridge National Laboratory, September 2002.

[3] **Progress Report on Building America Residential Water Heating Research**, Davis Energy Group, November 2003, cited with permission of David Springer.

[4] **Hot Water Distribution System Research – Phase I Final Report**, Carl Hiller, Applied Energy Technology for the California Energy Commission, March 2005.

Based on the large sample studied, it would appear that typical residential hot water consumption is between 50 and 80 gallons per household per day. A percentage of this is wasted due to inefficient hot water distribution systems.

The ORNL study on five existing homes showed that a demand pumping system saves both water and energy in retrofit. Following typical practice in retrofit, they installed a demand pumping system under a sink in the hot water location furthest from the water heater. Even though there were multiple hot water locations served by the trunk line going to the last fixture, only one activation mechanism was provided for each system. They presented estimates of water and energy savings as shown in Table 2. The daily water savings have been calculated from the annual savings.

Table 2 Water and Energy Savings in Existing Homes

Number of Hot Water Use Points	Daily Water Savings (gallons)	Annual Water Savings (gallons)	Annual Energy Savings (kWh)
1	2.5 to 8.2	900-3,000	200-400
4	10 to 32.8	3,600-12,000	800-1,600

ORNL measured the savings from the one hot water use point that was served by the demand pumping system and projected the savings presented for a house with four hot water use points. ORNL determined that the waste of water and energy were due to both technical and behavioral factors. One very interesting result was that when using the on-demand circulation pump, less water came out of the pipe before water was hot enough to use. They determined empirically that the ratio of water wasted at slow flow to the water wasted at circulation pump flow was 1.29:1.

The Davis Energy Group conducted a study as part of their work for the Building America program on new construction that showed that the use of a demand pumping system saves energy compared to standard recirculation techniques. In this 3080 square foot single story house with a very large recirculation system, DEG tested six combinations of pump and controls to determine which one performed best. Table 3 shows that the demand pumping system (Modes 3 and 4) ran the fewest minutes per gallon of hot water used. It ran one-fifth as long as the next best option and one-seventieth as long as uncontrolled recirculation.

Table 3 Recirculation Pump Operating Time

Parameter	Pump Minutes / Gallon of Hot Water Used
Uncontrolled Recirculation	57.6
Timer control (16 hours/day)	38.4
Mode 1- Wattstopper system	6.4
Mode 2- add return line temp sensor	4.3
Mode 3- Metlund demand system	0.80
Mode 4- "3" w/ 2 sensors shielded	0.88

According to the report, run time could have been reduced by eliminating the false signals, which due to the activation method chosen for the experiment, were 70 percent of the total number of signals sent to the pump. Run times could have been around 0.24 minutes per gallon of hot water used. With improved activation, they estimated that the energy to run the properly configured system would have been 25 therms.

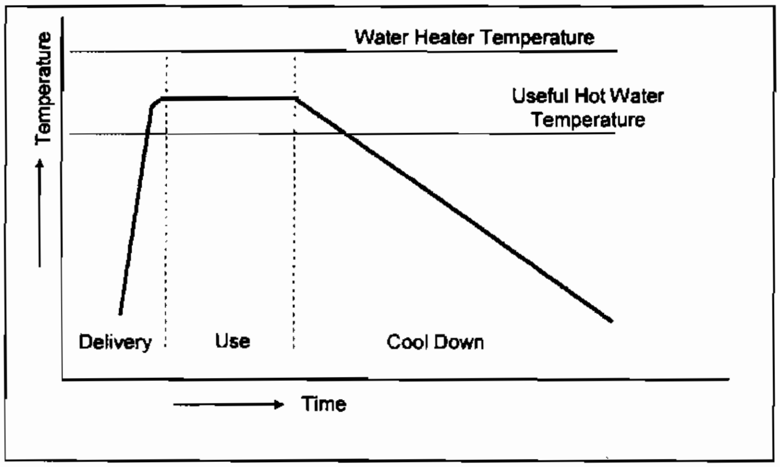
All of the other circulation pump control strategies DEG tested used significantly more energy than that used by the demand controlled system. In addition, all recirculation systems except demand recirculation systems use more energy than is associated with the water running down the drain and therefore are energy inefficient. They have been installed for customer convenience, not energy efficiency.

The energy consumed to operate the demand circulation system in this house with a long, high volume circulation system is comparable to the energy that runs down the drain if only 5 gallons per day is wasted while waiting for hot water to arrive, half that at 10 gallons per day and one fourth at 20 gallons per day. This means that it takes less energy to operate the house with the demand pump than it would to operate it without any circulation system at all. The branch piping in this house was not intentionally configured to minimize the volume of water between the fixtures and the circulation loop. In an intentional Structured Plumbing system it would be possible to reduce the waste and wait by an additional 50 percent, while using no more energy than would have been wasted letting 5 gallons per day run down the drain.

The California Energy Commission study looked at water and energy waste in three parts of a hot water event as shown in Figure 1. They conducted a series of parametric tests in a laboratory on ½ and ¾ inch copper and PEX-A (two layers of cross linked polyethylene with a film of aluminum between them as an oxygen barrier). The tests were done on bare pipe and on pipe with ½ and ¾ wall thickness insulation.

Ideally, the delivery phase is short (seconds), the use phase is however long is required and the cool down phase is what happens between events. The water heater temperature must be hot enough to overcome the losses in the hot water distribution system and provide water that is hot enough to mix with some amount of cold water to get the desired temperature. The useful hot water temperature varies with activity; for example, washing hands may be done at a different temperature than taking a shower.

Figure 1 Typical Hot Water Event



The study found several ways to improve the delivery phase – getting hotter water sooner by minimizing the waste of water, energy and time. These are:

- Reduce the volume of water in the pipe between the source of hot water and the fixture. In practice this means the piping needs to be smaller in diameter, shorter in length or a combination of both.
- Reduce the number of restrictions to flow. These restrictions include fittings, particularly elbows and tees. Restrictions increase the "effective length" of the pipe and can result in 1.5 to 2 times the volume of the water in the pipe coming out of the pipe before hot water gets to fixture. Removing the restrictions can bring the extra volume down to less than 5 percent additional water.
- Insulate the pipes, particularly for low flow rates. The temperature drop over a given distance at flow rates less than 1 gallon per minute is substantially higher than it is at flow rates higher than 2 gallons per minute.
- Increase the flow rate. The temperature drop over a given distance is less as flow rate increases.

The study also found ways to improve the use and cool down phases – increasing the perceived availability of hot water and minimizing the energy waste.

- Insulate the pipes. Insulation reduces heat loss in the pipes, delivering hotter water to the fixtures. This will reduce the amount of hot water needed to get the desired temperature or it will make it possible to lower the temperature of the water heater. Insulation is particularly important with low flow fixtures.
- Insulation on the pipes increases the time it takes for the water in the pipes to cool down to an unusable temperature. R-4 insulation doubles the cool down time for ½ inch diameter piping. It triples the cool down time for ¾ inch piping resulting in as much as a one hour delay for ¾ inch piping when the starting temperature in the pipes was 135F.
- This additional time between hot water events will make it possible for many more hot water use patterns to look like "clustered: use patterns. It will result in less delivery phase waste and increase customer satisfaction.

2. Energy Benefits of Using Demand Controlled Pumping Systems

Demand controlled pumping systems help hot water plumbing installations take advantage of the of these research results. These systems can be installed on trunk and branch systems in both new construction and in retrofit and on Structured Plumbing Systems in new construction or major rehab. Analyzing the benefits of demand controlled pumping systems in these applications in light of their ability to reduce water consumption was the primary focus of this study. The benefits of installing them in retrofit on existing dedicated recirculation systems to reduce pump run time and recirculation loop energy consumption will be discussed later in this report.

Trunk and Branch Plumbing
Trunk and branch plumbing is the most common type of hot water distribution system found in both new and existing single family homes. It is characterized by one main trunk line coming from the water heater that runs towards the furthest fixture. No particular effort is made to optimize the length or volume of the branch lines serving individual fixtures. It is unlikely that the pipes are insulated. Sometimes there are two main lines coming from the water heater serving fixtures in different parts of the house. In this case, there are really two separate hot water distribution systems.

In retrofit and in typical new construction applications, the primary benefit comes in the delivery phase by reducing the waste of water while waiting for hot water to arrive. The energy savings due to the reduction in water waste in these situations come from three things.

1. Less water running down the drain means that less energy has to be used to heat the water.
2. The temperature of the water in the circulation loop that is returned to the water heater is generally warmer than the water coming into the house.
3. Since the on-demand pump moves water at a higher flow rate than typical fixtures, less water is needed to prime the loop than would normally run down the drain.

The reduction in water waste will depend greatly on the configuration of the house, in particular on the volume of water between the water heater and the fixtures, which fixtures are on the same trunk line(s), and the volume in the branch lines off of the trunk line(s). These are the structural variables. There are also behavioral variables such as whether the occupants turn on the water and leave, returning when they think that hot water has arrived at the fixture, and on whether hot water events are clustered together or spread out intermittently throughout the day. This analysis is only looking at the impact of improving the structural waste. Additional savings will accrue from changing behavioral patterns.

From Table1, the average daily hot water use ranges from 60 to 80 gallons per day. From Table 2, the water savings potential ranges from 10-30 gallons per day. Drawing on these two ranges, the average household could save between 12.5% and 50% of its daily hot water consumption by using a demand controlled pumping system. It is useful to note that the waste is greater than the potential savings.

In retrofit applications, it is unlikely that any effort will be made to reconfigure the piping to reroute the trunk lines to minimize the volume in the branch lines. In new construction, the typical installations of trunk and branch plumbing do not consider this either. In both cases, the potential savings is less than would be possible with Structured Plumbing, which is discussed below. A conservative assumption is that the savings from using a demand controlled pumping system on Trunk and Branch plumbing systems is 15% of the daily water use.

Structured Plumbing

Additional energy savings are possible when demand controlled pumping systems are used with Structured Plumbing. Structured Plumbing is a concept that includes:

- A circulation loop as short as practical and with as few hard elbows as possible.
- Fixtures or appliances need to be located within 10 plumbing feet of the circulation loop on branch lines that are no larger than ½ inch diameter.
- All hot water pipes need to be insulated.
- An on-demand pumping system with electronic controls and activation mechanisms placed in key locations throughout the house, generally one per hot water using location.

The circulation loop is intentionally located such that it is both as short as possible and within 10 plumbing feet of every fixture. Except for the friction losses due to its length, it has few other restrictions to flow. Ideally, the only fittings in the circulation loop are the tees for the branch lines feeding each fixture. An on-demand pump, sized to overcome the now reduced losses in the main circulation line will be able to preheat the circulation loop in a relatively short amount of time. The pump is activated shortly before the desired use to "prime the insulated line", after which the electronic controls automatically shut off the pump when they recognize that the water in the circulation loop is hot. The insulation on the piping keeps the water hot for about an hour between uses. The small volume of cold water in each branch line will be replaced with hot water in just a few seconds. Water waste will be minimized, ideally to less than 2 cups per hot water event. Hot water will arrive at each fixture in less than 5 seconds depending on the flow rate at the fixture. Assuming that the average waste is 0.5 to 1 gallon per hot water event in houses without a circulation system, this represents a 75 – 90 percent reduction in water waste. There is a small additional cost of $1-2 per year to operate the demand controlled pump and associated controls.

When demand controlled pumping is used in conjunction with Structured Plumbing systems, the energy savings come primarily from four things – the same three as above and a more efficient hot water distribution system. The more efficient hot water distribution system comes from reducing the restrictions to flow and from insulating the piping.

With more efficient distribution, the water heater does not need to be set as high to overcome these losses. It is very common to find a 5-10F temperature drop from the water heater to the furthest fixtures in a house. For a given flow rate, R-4 insulation will reduce the temperature drop by half. Consumers can take advantage of this in two ways.

1. For a given water heater set point, they will be able to reduce the amount of hot water needed for a desired mixed temperature. This will save some energy. It will also increase the effective capacity of a tank type water heater.
2. They could choose to reduce the set point of the water heater. This will save even more energy, particularly for houses with tank type water heaters. For tank type water heaters,

a reduction of 5F translates into a reduction of 10 percent in standby losses. For tankless water heaters, the reduction in temperature drop translates into both a smaller temperature rise and an effective increase in available hot water capacity.

Installing Structured Plumbing in new construction or major rehab makes it possible to configure the circulation loop to take advantage of the lessons learned from the research. The result will be increased water savings due to the small residual volume of water in the branch lines serving individual fixtures. There will be additional savings due to the insulation on the hot water piping. A conservative assumption is that the water savings from using a demand controlled pumping system on Structured Plumbing systems is 20% of the daily water use with additional savings due to the insulation.

3. Performance Analysis

Trunk and Branch and Structured Plumbing Systems

An analysis was performed to quantify the potential enhancement of water heater energy factor due to the use of a demand controlled pumping system under a range of conditions expected to be encountered in typical residential settings. A set of linked steady-state energy balance equations was solved in a spreadsheet-based simulation to predict the energy factor enhancement of a 40-gallon gas tank water heater, a 52-gallon electric tank water heater, (the most-commonly-encountered sizes for storage water heaters) and for gas and electric tankless water heaters. The enhancement factor does not depend on the size water heater since the effect of that parameter is already "encapsulated" in the value of the GAMA/DOE energy factor. The following ranges of variables were simulated:

DOE Energy Factor (EF) of conventional water heater
(from GAMA Directory or manufacturer's literature)

Table 4 Water Heaters Evaluated in this Study

Fuel	Type	Volume	Energy Factor	Recovery Efficiency
Gas	Tank	40	0.54	0.76
	Tank	40	0.63	0.80
	Tankless	*	0.82	0.84
Electric	Tank	52	0.86	0.98
	Tank	52	0.93	0.98
	Tankless	*	0.98	0.99
* Volume of tankless water heaters is small, generally less than 1 gallon.				

Water Savings as a Percent of Daily Water Consumption

The percent reduction in water heating consumption due to the use of demand controlled circulation or from Structured Plumbing was analyzed over the range of 0-50 percent.

Volume of hot water use per day
(proxy = number of bedrooms)

- 30 gallons of hot water use per day (studio)
- 40 gallons of hot water use per day (1-bedroom)
- 50 gallons of hot water use per day (2-bedrooms)
- 60 gallons of hot water use per day (3-bedrooms)
- 70 gallons of hot water use per day (4-bedrooms)
- 80 gallons of hot water use per day (5-bedrooms)

Water Main Inlet Temperature
(proxy = average annual ambient outdoor air temperature)[5]

The following set of climatic conditions are correlated to **water main inlet temperature**

- 45 F average annual inlet water/average annual ambient temperature - "cold" climate
- 55 F average annual inlet water/average annual ambient temperature - "mixed" climate
- 65 F average annual inlet water/average annual ambient temperature - "mild" climate
- 75 F average annual inlet water/average annual ambient temperature - "hot" climate

Equation 1 shows how to calculate the energy factor enhancement coefficient due to the use of a demand controlled pumping system using the energy factor, the recovery efficiency and percent water savings. The coefficient is independent of water use or incoming water temperature.

The equations used in the analysis were:

1. Calculate Energy Factor Enhancement Coefficient:

$$EFEC = [RE_{DOE} / (RE_{DOE} - S * EF_{DOE})]$$

where:

EFEC = Energy Factor enhancement coefficient
RE_{DOE} = Recovery efficiency of water heater in DOE test
EF_{DOE} = Energy factor of water heater in DOE test
S = Volumetric water savings percentage expressed as a decimal fraction of volume of water (e.g., for a 20% savings this would be 0.2)

The results of this analysis are presented in Table 5. The coefficient is smaller for less efficient water heaters. It is smaller for gas water heaters than for electric water heaters. The coefficient is higher for larger water savings. It is higher for tankless water heaters than for tank type water heaters. Figures 2 and 3 display this information graphically.

[5] A good approximation of **annual average water main temperature** in a particular location is the **average annual ambient air temperature** for that location. See NOAA isotherm map at http://lwf.ncdc.noaa.gov/img/documentlibrary/clim81supp3/tempnormal_hires.jpg A slightly more refined alternative is to use the prior month's average ambient air temperature to estimate the current month's average water main temperature.

Table 5 Energy Factor Enhancement Coefficient

Fuel	Gas			Electric		
Type	NAECA	High-Efficiency	Tankless	NAECA	High-Efficiency	Tankless
Volume (Gallons)	40	40	*	52	52	*
Energy Factor	0.54	0.63	0.82	0.86	0.93	0.98
Recovery Efficiency	0.76	0.80	0.84	0.98	0.98	0.99
Water Savings (%)	Energy Factor Enhancement Coefficient					
0%	1	1	1	1	1	1
5%	1.04	1.04	1.05	1.05	1.05	1.05
10%	1.08	1.09	1.11	1.10	1.10	1.11
15%	1.12	1.13	1.17	1.15	1.17	1.17
20%	1.17	1.19	1.24	1.21	1.23	1.25
25%	1.22	1.25	1.32	1.28	1.31	1.33
30%	1.27	1.31	1.41	1.36	1.40	1.42
35%	1.33	1.38	1.52	1.44	1.50	1.53
40%	1.40	1.46	1.64	1.54	1.61	1.66
45%	1.48	1.55	1.78	1.65	1.75	1.80
50%	1.56	1.65	1.95	1.78	1.90	1.98

* Volume of tankless water heaters is small, generally less than 1 gallon.

Table 6 Enhanced Energy Factor

Fuel	Gas			Electric		
Type	NAECA	High-Efficiency	Tankless	NAECA	High-Efficiency	Tankless
Volume (Gallons)	40	40	*	52	52	*
Energy Factor	0.54	0.63	0.82	0.86	0.93	0.98
Recovery Efficiency	0.76	0.80	0.84	0.98	0.98	0.99
Water Savings (%)	Enhanced Energy Factor					
0%	0.54	0.63	0.82	0.86	0.93	0.98
5%	0.56	0.66	0.86	0.90	0.98	1.03
10%	0.59	0.68	0.91	0.94	1.03	1.09
15%	0.61	0.71	0.96	0.99	1.08	1.15
20%	0.63	0.75	1.02	1.04	1.15	1.22
25%	0.66	0.78	1.08	1.10	1.22	1.30
30%	0.69	0.82	1.16	1.17	1.30	1.39
35%	0.73	0.87	1.25	1.24	1.39	1.50
40%	0.76	0.92	1.35	1.33	1.50	1.62
45%	0.80	0.98	1.46	1.42	1.62	1.77
50%	0.85	1.04	1.60	1.53	1.77	1.94

* Volume of tankless water heaters is small, generally less than 1 gallon.

Figure 2 Energy Factor Enhancement Coefficient for Gas Water Heaters

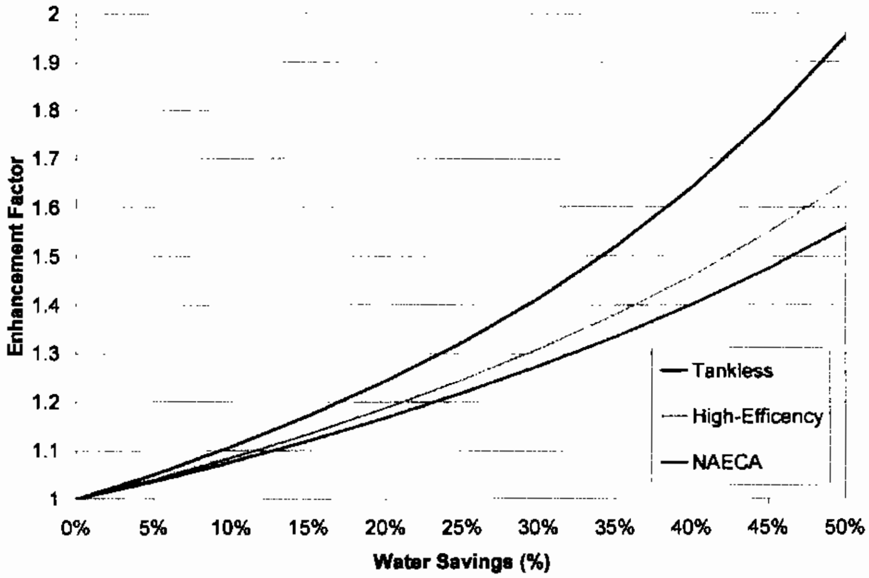
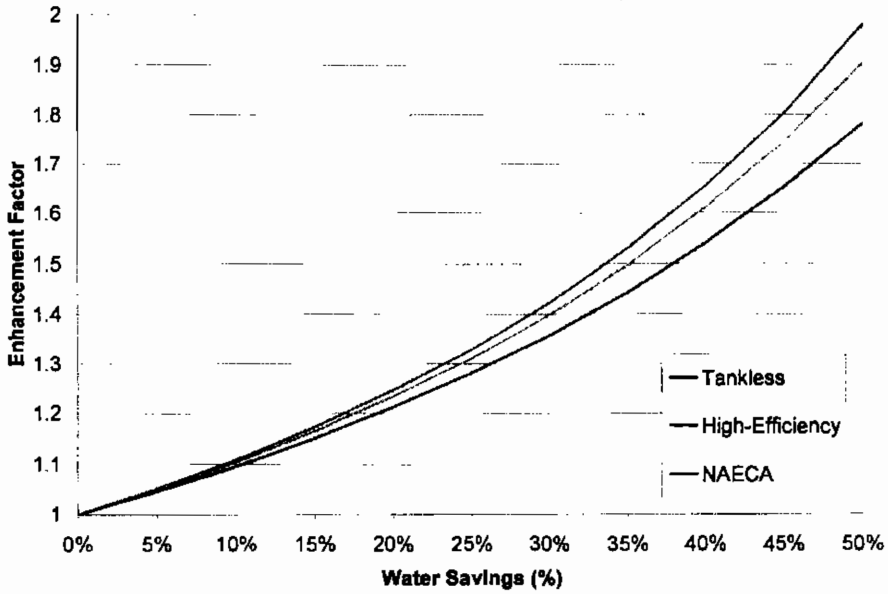


Figure 3 Energy Factor Enhancement Coefficient for Electric Water Heaters



The enhancement coefficient needs to be multiplied by the water heater's EF to determine the enhanced energy factor as shown in Equation 2.

2. Calculate Enhanced Energy Factor

$$EF_{Enhanced} = EFEC * EF_{DOE}$$

The results of this calculation for the water heaters evaluated are shown in Table 6. The most notable observation is that there are many cases where the enhanced energy factor is greater than 1. While this may seem a bit counterintuitive, a large enough reduction in use has the same effect as having a much more efficient water heater.

The impact of the energy factor enhancement coefficient on a HERS rating for a specific house needs to be evaluated in light of the daily volume of hot water and the incoming water temperature (climate). The $EF_{Enhanced}$ number needs to be plugged into REM/Rate or other HERS simulation software in place of normal EF_{DOE}

Retrofitting a Demand Controlled Pump in Homes with an Existing Circulation System

The previous section examined the impact on energy factor when using demand controlled pumping systems on trunk and branch and Structured Plumbing systems. Another application of the technology is to retrofit a demand pumping system on a dedicated recirculation system.

In this application there is a large reduction in energy consumption based on dramatically reduced run times of the pump. According to Davis Energy Group, a demand circulation system will use more than 90% less energy than is consumed by an uncontrolled recirculation pump running 24 hours per day. The savings is a combination of a reduction in the electrical energy used to run the pump and much more importantly a reduction in the heat loss in the loop. The waste of water and the time it takes to get hot water will probably remain the same after the retrofit, since nothing is likely to be done to change the volume of water in the branch lines serving each fixture. The following tables provide a means for estimating the savings.

Table 7 Energy Use for a Circulation System attached to a Gas Water Heater (Therms)

Continuous Pumping at 1 Gallon Per Minute				
	Temperature Drop in °F			
Days	**1**	**5**	**10**	**20**
1	0.16	0.80	1.60	3.20
30	5	24	48	96
365	58	292	584	1,168
Pump Flow Rate in Gallons Per Minute				
1	58	292	584	1,168
5	292	1,460	2,920	5,840
10	584	2,920	5,840	11,680

Table 8 Energy Use for a Circulation System attached to an Electric Water Heater (kWh)

Continuous Pumping at 1 Gallon Per Minute				
	Temperature Drop in °F			
Days	**1**	**5**	**10**	**20**
1	3.50	17.50	35.00	70.00
30	105	525	1,050	2,100
365	1,278	6,388	12,775	25,550
Pump Flow Rate in Gallons Per Minute				
1	1,278	6,388	12,775	25,550
5	6,388	31,938	63,875	127,750
10	12,775	63,875	127,750	255,500

In these tables, the steady state heat transfer efficiency is assumed to be 75% for natural gas and 100% for electric. For most single family circulation systems it is reasonable to assume that the temperature drop is 5°F and that the pump flow rate is 1 gpm. This means that annual energy associated with a circulation system running 24 hours a day is 292 therms or 6,388 kWh. If the flow rate is faster, say 2 gpm or the temperature drop is larger, say 10°F, or both, select the appropriate energy use from the tables. If the system has a timer set for fewer hours, proportion these amounts accordingly.

Savings due to the retrofit of a demand controlled pumping system are proportional to the reduction in hours of operation. The demand controlled pump will move the water faster at closer to 5 gpm, but due to the higher flow rate, the temperature drop will be closer to 1°F. Assuming that the pump operates a relatively long time of 30 minutes as needed over the day, the savings will be 98%, or 286 therms or 6,255 kWh per year.

Conclusions

Based on this analysis, it is reasonable to assign the following first-order energy factor enhancement coefficients when using demand controlled pumping systems:

Trunk and Branch

The savings due to a conservative 15% reduction in water consumption results in energy factor enhancement coefficients ranging from 1.12 to 1.17 for the range of water heaters that were evaluated (See Table 5).

Structured Plumbing

The savings due to a conservative 20% reduction in water consumption plus an additional savings equivalent to another 10% reduction in water use due to insulation, result in energy factor enhancement coefficients ranging from 1.27 to 1.42 for the range of water heaters that were evaluated (See Table 5).

In order to obtain the highest combination of water and energy efficiency, the energy factor enhancement for Structured Plumbing needs to be aligned with the top tier for Hot Water Distribution Systems in LEED-H or similar green building programs.

Retrofitting Existing Recirculation Systems

The savings here are energy, not water related as in the first two applications. Retrofitting a demand controlled pump will reduce the energy needed to operate the pump and keep the circulation loop hot by up to 98 percent (286 therms or 6,388 kWh per year) and is proportional to the run time of the existing system.