Hot Water Recirculation System White Paper

Energy and Water Cost Calculations

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Hot water recirculation loops are a system whereby hot water from the water heater is mechanically circulated through the house in a dedicated hot water loop which passes as near as possible to all plumbing fixtures which draw hot water. (Building code in Monterey County, CA requires that the hot water loop be no more than 6 ft. from the fixture.) In residential applications, the loop is typically 3/4" copper piping and the fixtures are connected to the loop with 1/2" copper piping. The intention is to minimize wasting water waiting for the water to get hot and thereby having a water delivery system that is better for the environment, i.e. a green system. This paper investigates the claim by calculating the cost benefit of 4 different configurations of this type of installation.

1. Cost of the system without a hot water recirculation loop.
2. Cost of the system with a hot water loop that has a pump which runs 24/7.
3. Cost of the system with a hot water loop and a timer controlled pump that runs 8 hours a day, 7 days a week.
4. Cost of the system with a hot water look and a pump that is on a demand-initiated pump that runs 10 times a day, for 3 minutes at a time.

The calculation is based on the length of copper piping that makes up the recirculation loop as that will determine the amount of water in the loop that is wasted waiting for a system with no pump to get hot and the loss of heat to the environment when hot water is circulating. Because the values are dependent on a number of assumptions, a spreadsheet was created that allows the values to be changed so that different scenarios can be compared.

Starting with the assumption that an average home has 125 feet of 3/4" pipe[(1)] and it is type M copper pipe with 1/2" insulation. From this information the amount of water that is wasted annually without a recirculation system is estimated. The cost of the water and sewer is determined. Then the cost of running a recirculation pump 24/7, 8 hours per day and demand-initiated is estimated. The results of these calculations are then compared, the cost of a demand recirculation pump is estimated at roughly $300 and conclusions are drawn.

How much water is wasted waiting for water to warm up?

Assuming type M copper piping where the inner diameter is 0.811 inches[(2)], this holds 3.35 gallons of water. $V = \pi r^2 h = 3.14 \times (0.811/2 \text{ in})^2 \times 125 \text{ ft} \times 12 \text{ in}/1 \text{ ft} \times 0.0043290 \text{ gal/in}^3 = 3.35 \text{ gal}$.

Assuming hot water is used 10 times per day and assuming that on average the fixture is halfway between the water heater and the end of the hot water loop, 33.5/2 or 16.75 gallons of water is wasted daily running water at the faucet or shower waiting for the water to get hot. In a year, this equals 6,114 gallons of water. Most municipalities measure water in billing units where 1 billing unit is 100 cubic feet of water which is approximately 748 gallons[(3)]. So this would be 8.17 billing units per year.

To figure out the cost of this we need to know the cost of the water as well as the cost of the sewer as it

1. http://www.premierh2o.com/blogs/news/37679553-how-much-water-is-wasted-waiting-for-water-to-warm-up
2. http://www.petersenproducts.com/Specifications/Pipe_Copper.aspx
3. http://www.lbwater.org/understanding-your-billrates

is dependent upon the amount of water used. Using numbers from the Long Beach Water Department[1] 12 units of water would cost $43.90 which would be $3.65/unit and 10 units of sewer would cost $24.49 which would be $2.45/unit. Multiplying each of these numbers by 8.17 units/year gives the cost of the water that is run down the drain as:

8.17 units/year x $3.65/unit = $29.89/year for the water
8.17 units/year x $2.45/unit = $20.02/year for sewer

The Total Estimated Annual Cost of Water and Sewer without a Recirculation System: $49.91/year

This amount must be compared against the cost of operating a hot water recirculation system.

The only additional cost of installing a recirculation system vs not installing one in new construction is the cost of the pump which we assume to be roughly $300.00. The plumbing cost difference is minimal since a line needs to be run to each fixture anyway and many times this is done with a 3/4" main pipe and 1/2" tee's coming off the main pipe. The only additional piping is running from the end of the 3/4" line back to the water heater. While this certainly does cost something, it is insignificant when compared to the cost of the plumbing installation as a whole and is ignored in these calculations. The bigger cost is the ongoing cost of running the recirculation system, in particular the cost for running the electric pump and the cost of keeping the recirculation loop hot. It is these two latter costs that are analyzed in this white paper.

How much energy is used maintaining a recirculation loop hot?

The calculation will initially be performed assuming the pump is running 24/7. Then the final values can be calculated based on the actual amount of time the pump is being run when using a timer-based recirculation pump and then demand-initiated recirculation pump.

Pump energy cost calculation:
Most pumps are 1/25 hp which is 30 watts and would use 263 kWh/year (30W x 24 hours/day x 365 days = 263kWh)

Heat loss from the pipe as the hot water is circulated:
I will assume 3/4" copper piping with 1/2" insulation as is building code in CA. I will assume a 68 deg F ambient temperature, indoor installation and a water temperature of 118 deg F to give a temperature difference of 50 F deg. which works out to be roughly 2.7 W/ft[2] and converting to BTU/hr where 1 W/ft = 3.41 BTU/hr-ft, 2.7 W/ft = 9.2 BTU/hr-ft x 125 ft = 1,150 BTU/hr. And converting this to therms (common unit of measure for natural gas) 1 therm = 100,000 BTU so 1,150 BTU/hr x 1 therm/100,000 BTU = 0.0115 therm/hr. So annually this would equal 0.0115 therm/hr x 365 days x 24 hr/1 day = 101 therm/year that is lost running the recirculation pump 24/7.

What does this cost?

Pump energy cost calculation:
The national average cost of a kWh is $0.12[3] therefore the cost of running the pump is:
263 kWh x $0.12/kWh = $31.56 annually.

1. http://www.lbwater.org/understanding-your-billrates
2. http://www.engineeringtoolbox.com/heat-loss-insulated-pipes-d_1152.html
3. http://www.npr.org/sections/money/2011/10/27/141766341/the-price-of-electricity-in-your-state

Cost of heat loss from the pipe as the hot water is circulated:
The national average cost of a therm of natural gas is $0.942[1] therefore the heat cost is:
101 therm/year x $0.942/therm = $95.14 per year.

The total average cost of running a recirculation pump 24/7 is $31.56 + $95.14 = **$126.70/year**.

Looking at the cost of water and sewer for one year which was calculated to be $49.91/year, it makes no financial sense to install a hot water recirculation system and have the pump run 24/7. Based on these calculations the initial cost of the pump would never be recouped.

If a timer were used instead of running the pump 24/7 the the amount of time that the pump runs could be cut down. If we were to assume that the timer would run the pump only 4 hours in the morning and 4 hours in the evening for a total of 8 hours a day, this would cut the cost down to 1/3 of the cost of running the pump 24/7 or **$42.23/year**. While this is a small savings over simply running the water down the drain, it would still be a very long time before the investment in a recirculation system would be recouped. At $49.91 - $42.23 = $7.68/year in savings it would take 39 years to recoup the cost of the pump assuming the pump and timer cost $300.

If a demand-initiated recirculation pump were used instead of a timer and it is assumed that the pump is activated 10 times a day and runs for 3 minutes each time resulting in 0.5 hour/day of pump run time This would cut the cost down to 1/48 of the cost of running it 24/7 or **$2.64/year**. The savings would be $49.91 - $2.64 = $47.27/year in savings. Assuming the same cost of $300 for the pump and controller would mean the demand-initiated recirculation system would pay for itself in 6.3 years.

Of course if you live in a location where gas and electricity are more expensive, like San Francisco where the cost of a therm is $1.574 and a kWh of electricity is $0.233[2] the expense of running a recirculation system 24/7 would be:

263 kWh/year x $0.233/kWh = $61.28
101 therm/year x $1.574/therm = $158.97
Total = **$220.25/year**.

Which makes even less sense to install a recirculation system. And even if a timer were used to cut the costs by 1/3 the cost ($220.25/3 = **$73.42/year**) would be higher than the cost of just running the water down the drain ($49.91).

However, the energy cost of a demand-initiated recirculation system ($220.25/48 = **$4.59/year**) is still significantly less than the cost of running the water down the drain ($49.91) and while it would extend the time required to recoup the investment, it would still be worthwhile. $49.91 - $4.59 = $45.32/year in savings. Assuming the same cost of $300 for the installation of the system would mean the demand-initiated recirculation system would pay for itself in 6.6 years.

So you can see that a demand-initiated controller for a recirculation pump can have significant savings over running the water down the drain.

And what is the savings of retrofitting a 24/7 or a timer-based recirculation system? We already

1. http://www.bls.gov/regions/west/news-release/averageenergyprices_sanfrancisco.htm
2. http://www.bls.gov/regions/west/news-release/averageenergyprices_sanfrancisco.htm

calculated the cost of running a pump 24/7 at the national average cost ($126.70/year) and at the San Francisco cost ($220.25/year) and the cost of running them on a timer which is 1/3 of this cost ($42.23/year at national average prices and $73.42/year at San Francisco prices).

National Average

Pump runs 24/7:	$126.70 - $2.64 = $124.06/year savings!
Pump on Timer:	$42.23 - $2.64 = $39.59/year savings!

San Francisco

Pump runs 24/7:	$220.25 - $4.59 = $215.66/year savings!
Pump on Timer:	$73.42 - $4.59 = $68.83/year savings!

Based on these calculations, if the cost of the demand-initiated controller were $200.00, the worst case scenario for recouping the cost of the controller would be 5 years and the best case scenario would be under 1 year!

So it is obvious that a demand-initiated recirculation system is the only way to install a recirculation system and that even retrofitting an outdated timer-based recirculation system would be hugely beneficial to the environment and your wallet. And being demand-initiated, hot water is always at your fingertips so it is much more convenient for the home owner.