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Bathing and the Environment

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Bathing and the Environment

Executive Summary

There are two significant environmental aspects of bathing: consumption of water and consumption of energy. In 40 of the 50 states, governments are concerned about future shortages of fresh water, and therefore are seeking strategies for reducing consumption. In addition, many citizens and governmental leaders are apprehensive about rising levels of atmospheric carbon, and are looking for ways to either reduce energy consumption and/or transition away from fossil-fueled energy production.

Individual consumers have the power to contribute to reduction of both water and energy use in bathing. Using less water can reduce energy use, since energy is used at every step in water purification and distribution, and in heating water to bathing temperatures. Things that consumers can do to reduce water and energy consumption include use of showers rather than bathtubs, replacement of high-flow shower heads in older homes, installation of lower flow shower heads than mandated by law, taking shorter showers, using only the quantity of bathwater needed to clean up when using a bathtub, and giving careful thought to consequences before purchasing large volume and whirlpool bathtubs. Hot tub purchases deserve even greater consideration prior to acquisition.

This report examines environmental implications of bathing facilities and habits. Alternatives for minimizing impacts are identified.

Current Trends and Their Significance

A clear trend in upscale homes is toward larger, luxurious bathrooms. As part of this trend, bathtubs are often considerably larger than the 'standard' models that have long typified American homes and they are often whirlpool-style tubs. Bathrooms, moreover, are also being pitched by designers as places of rest and relaxation, with sound systems and mood lighting, suggesting longer periods in the bath and shower. Similar trends are emerging in remodeling projects.

In evaluating whether going with the newest trends might be for you, one thing to consider is what the environmental impact of that new or remodeled bathroom might be. With respect to bathing facilities, there are two primary determinants of impact: the volume of water used per bath cycle, and the temperature of the hot water which supplies the bath.

The Evolving Bathtub

What is still considered a standard bathtub in the U.S. typically uses 25-40 gallons (95-150 liters) per bath cycle. A larger, and more recent addition to the standard tub is a foot longer, and a half-foot both wider and deeper. The effect of adding width, length, and depth comes at an environmental price: the largest standard model requires about twice the volume of water (50-80 gallons or 189-303 liters) per bath cycle, while whirlpool tubs are typically at the upper end of this range (80 gallons). Some of the bathtubs now on the market require as much as 100-110 gallons (379-416 liters) per fill.

The quantity of water used in taking a bath is obviously dependent upon the depth of water drawn, and therefore within the control of the bather. From an environmental perspective it makes sense to use as little water as needed to bathe. However, when the bathroom becomes a haven for relaxation, use of a quantity of water for near complete immersion becomes more likely. This is especially true when using whirlpool or soaking-style tubs.

Environmental impacts related to water consumption primarily depend upon the quantity of *hot* water used. The larger the bath, the greater the consumption of both fresh water and energy. The effect of large tubs on hot water use is reflected in a number of articles explaining the need for investment in larger water heaters as part of large tub installations.[1] Some articles advise installation of a second water heater to handle hot water demand.

A Focus on Showers

The past decade or so has seen a trend toward bathrooms with a spacious walk-in shower and no bathtub. Now, however, many designers and realtors are cautioning against this practice because of the potential impact on resale – especially when the prospective buyer has small children.

The focus on a showers-only trend has been driven, in part at least, by oft repeated reports that showering consumes significantly less water than bathing.[2] Even when a standard bathtub is used, showering often uses less water than that used in the tub. In 1994, the federal government mandated that new shower heads sold in the U.S. be 2.5 gallons (9.5 liters) per minute (GPM) or less. So, in comparison to a bathtub filled with 40 gallons (151 liters) of water, it would take 16 minutes in the shower to use an equivalent amount of water. Some states and jurisdictions mandate even lower flow showers. California, for instance, now requires a flow rate of 1.8 GPM (6.8 liters per minute), while Colorado and New York City mandate 2.0 GPM (7.6 liters per minute) or less. Minnesota-based Xcel Energy recently began promoting 1.5 gpm showerheads throughout the eight state area where it operates.

One disadvantage of showers from the standpoint of water use is that most people wait until water is brought to the desired temperature before beginning to shower. This often means a minute or two of running water before sufficient hot water is available – and to the loss of 3-5 gallons (11-19 liters) of water down the drain before showering begins. Energy is also wasted in the process. At the conclusion of showering, hot water left in the pipes cools off. As the next shower begins, the cooled off water in the pipes is allowed to

[1] Del Grande (2010), Saltzman (2011)
[2] Arrington (2015), Tessaly (2011), U.S. Geological Survey (2019), watercalculator.org (2017)

run down the drain while again waiting for hot water. As reported by Lutz[3] "Not only has the energy used to heat this water been wasted, but the water itself is thrown away. This is water that must be treated twice, once at the water treatment plant and again as wastewater, but it does not provide the consumer with any useful service."

To combat water and energy loss linked to delays in hot water delivery to shower spigots, demand hot water recirculating systems have been developed. These systems utilize recirculating pumps which rapidly pull hot water from a water heater, while at the same time sending cool water from the hot water lines back to the water heater for reheating and reuse. Demand systems can be controlled by the push of a button, a timer, or motion sensor. Other systems operate continuously.[4] Scientific assessment of these systems has shown that while some systems (push button operated or motion sensor activated) have the potential to save both water and energy, many or most of the systems that are installed operate continuously or on a timer. These systems have, unfortunately, been demonstrated to actually increase both energy and water consumption, with the increase in overall water consumption due to the increase in energy demand.[5]

As with bathtubs, water use is within the control of the person involved, with the length of showering the determining factor. The good news here is that most showers fall well short of that 16-minute example cited earlier. A 1999 study of water consumption, which involved sampling of individual homes in six states and one Canadian province, found an average shower length of 8.2 minutes and an average shower volume of 17.2 gallons (65 liters).[6] A 2011 study of water use in seven U.S. states found an average shower flow rate of 2.0 GPM, a duration of 8 minutes, and water use of 15.9 gallons (60 liters).[7] A 2016 follow-up to the 2011 study[8] found slight reductions in average shower length (7.8 minutes) and flow rate (1.9 GPM).

Environmental Impacts of Water Consumption

According to a 2014 U.S. Government Accountability Office (GAO) report, 40 out of 50 state water managers expect water shortages under average conditions in at least some portion of their states over the next decade. In view of the fact that each American uses an average of 83-88 gallons (314-333 liters) of water a day at home,[9] and that water conservation is important to reducing the likelihood of future water shortages, taking steps to reducing daily water consumption is important.

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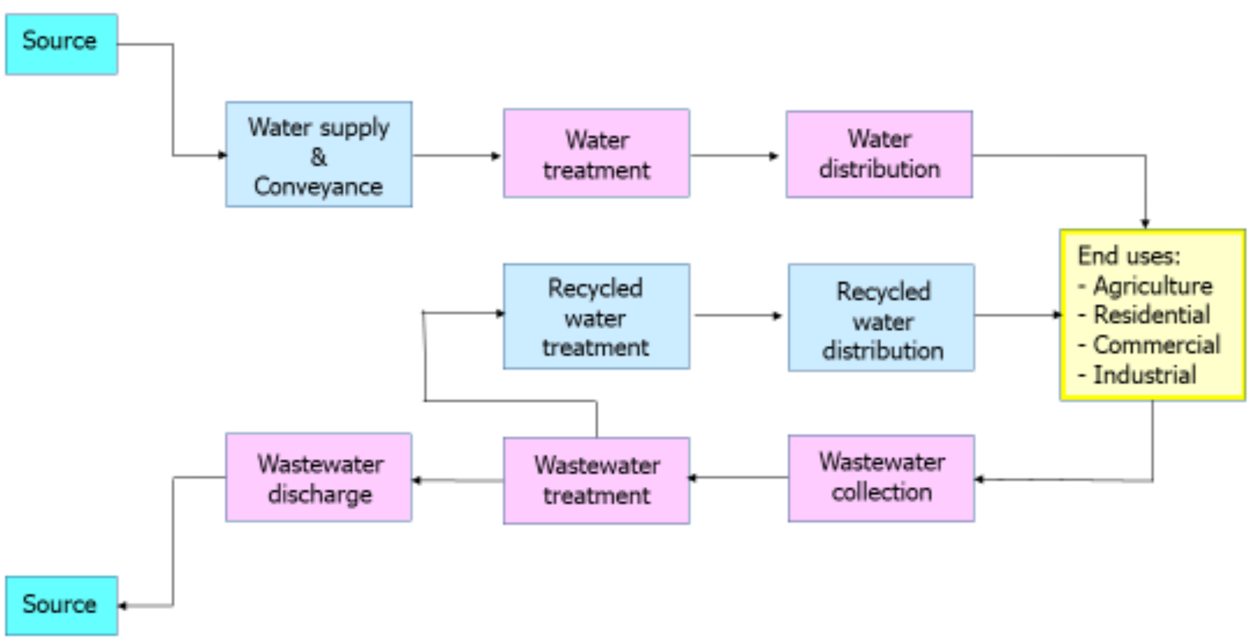
[3] Lutz, Lawrence Berkeley National Laboratory (2005)
[4] ENERGY STAR (2019)
[5] Ally et. Al. (2002), Brazeau and Edwards (2013)
[6] Mayer et al. (1999). Involved sampling of homes in Arizona, California, Colorado Florida, Oregon, Washington, and Ontario, Canada.
[7] DeOreo (2011). States in which data was collected were Arizona, California, Colorado, Florida, Nevada, Oregon, and Utah.
[8] DeOreo, et al. (2016)
[9] Walton (2017), USEPA (2019c)

Beyond the matter of water consumption is the energy used in providing clean water and, in heating of water for uses such as bathing. Municipalities that have centralized sewer systems serve about 90 percent of U.S. households. The rest obtain their water from private wells.[10] In areas served by centralized systems, water which flows from home faucets gets pumped from its source, goes through a water treatment facility, is checked and rechecked for quality, and is then delivered through a network of municipal pipes to individual homes. After use, water travels from sink, shower, and bathtub drains into another network of pipes to wastewater treatment plants where it is filtered and disinfected. Much of this is used in landscape watering and irrigation. In some commercial applications, water is released back to the source (such as a river) after treatment (Figure 1).

Energy is expended at every step. Water and wastewater treatment facilities account for 35% of typical U.S. municipal energy budgets, and the cost of electricity used in processing and distributing fresh water for household use typically accounts for a major portion of a water utilities budget .[11] A great deal of energy is consumed in treating wastewater and moving it to where it will be used. For a family of four, and assuming consumption of 88 gallons (333 liters) per person per day, delivering fresh water to the home would require an average of 337 kWh (1,213 MJ) of electricity and result in CO_2 emissions of approximately 0.24 metric tons.[12]

Figure 1
Water Treatment and Distribution



Source: Griffiths-Sattenspiel and Wilson. (2009). The Carbon Footprint of Water. River Network.

10 USEPA (2019b), Statista (2019)
11 USEPA (2013)
12 Griffiths-Sattenspiel and Wilson (2009)

In comparison to energy required to recycle water and deliver it to the home, far greater quantities of energy are expended in heating water. Data from the U.S. Energy Information Administration (EIA, 2018), shows that water heating accounted for 19% of U.S. residential energy consumption in 2015.[13]

Returning to the example of water use by an average family of four, if each took a daily 7.8 minute shower using a 2.0 GPM flow head which consumed 15.6 gallons (59 liters), 437 gallons (1,654 liters) of water would be used each week, 22,724 gallons (86,020 liters) per year. Heating that water would require about 235,000 Btu (248 MJ) /week or 12.3 million Btu (12,935 MJ)/year.[14] This level of energy consumption would generate about 1,434 pounds (650 kg) of carbon dioxide equivalent (CO_2e) emissions annually if heating water with natural gas, or 2,510 pounds (1,139 kg) if heated by coal-fired electricity.[15] Were a higher-flow flow shower head used, or if time in the shower were increased, these numbers would obviously be higher (Table 1). For instance, in comparison to 7.8 minute showers with a 2.0 GPM shower head, the effect of using a 2.5 GPM shower head (common in many older North American homes), and showering slightly more than 2 minutes longer would increase energy consumption and related emissions by 60%.

Table 1
Impact of Shower Head Flow Rate and Time in Shower
on Water and Energy Use for Family of Four

	Water flow rate	Annual water consumption*	Energy consumed annually in heating water*	Annual CO_2e emissions linked to water heating
Daily showers (7.8 minutes for each family member)	2.0 GPM	22,724 gallons (86,020 liters)	12.3 million Btu (12,935 MJ)	1,434-2,510 pounds (650-1,139 kg)
	2.5 GPM	28,405 gallons (107,525 liters)	15.3 million Btu (16,169 MJ)	1,793-3,138 pounds (813-1,424 kg)
Daily showers (10 minutes for each family member	2.5 GPM	36,417 gallons (137,853 liters)	19.6 million Btu (20,729 MJ)	2,299-4,023 pounds (1,042-1,826 kg)

* Values do not include volume of water wasted while waiting for water to warm to desired temperature or energy required in processing waste water and delivering to household.

Reducing Bathing Impacts

Despite efforts by the building industry to offer more green and efficient products, the luxury market continues to demand tubs and showers that have high water and energy use

[13] U.S. Energy Information Administration (2018)
[14] Calculations based on assumption that beginning water temperature is 55F and is heated to 120F.
[15] USEPA (2019a)

demands. A number of manufacturers are currently marketing tubs with water capacities of over 200 gallons (757 liters). Such tubs will consume prodigious quantities of water and energy through the life of the appliance. It is an unfortunate trend at a time when developments very much need to be going in the other direction.

Luxury market trends notwithstanding, there are many things that individual consumers can do to reduce both water and energy consumption in bathing.

- Avoid the temptation to purchase bathing appliances that require or encourage use of large quantities of water.
- Take showers rather than using the bathtub.
- Install lower flow shower heads than mandated by law.
- Limit the time spent in the shower.
- When using a bathtub, fill only to the level needed to get clean.
- Install a high efficiency water heater, easily identified by the USEPA's ENERGY STAR label.

Hot Tubs

While not intended for bathing, some vendors cite efficiencies over standard or whirlpool bathtubs, noting that bathtubs are drained after every use whereas water is retained in hot tubs for many months before water is changed. They note that this frequent change of water in whirlpool tubs requires 16 times as much water over a given time span as hot tubs.

The problem with comparison of hot tub water consumption over that in bath tubs is that hot tubs are not intended for bathing. In fact, many websites advise hot tub users to shower both before and after use. Consequently, whatever the water consumption in a given hot tub is, that consumption is above and beyond the quantity of water used for household bathing.

Still, the volume of water used in a hot tub is relatively small. With capacity of most hot tubs at 400-450 gallons (1500-1700 liters), and assuming three months between draining and refilling, and no loss of water from the tub during this period, water consumption on a daily basis would be about 4-5 gallons (15-19 liters) per day. Water losses must also be taken into account in calculating daily water use. When a tub is in use, water is lost as users climb in and out, taking water with them in their bathing suits, and hair. Evaporation losses can also be significant during use. Water loss of 6-8 gallons (23-30 liters) with each use is common. When a tub is not in use and covered, water losses of ¼" a day are commonly reported, an amount that translates to about a gallon daily. Assuming use of a tub twice weekly, and considering periodic refilling and water lost along the way, daily water consumption associated with a leak-free hot tub is in the 7-8 gallon (25-30 liter) per day range.

As with bathtubs, the greatest environmental impacts of a hot tub come not from the quantity of water used, or the energy and materials consumed in producing the tub, but rather from ongoing energy consumption to heat water. Heating water, and maintaining temperature until the water is used, is a major consumer of energy. Hot tubs typically use electric energy to heat and continuously circulate water, with most of the energy consumed in heating. As reported by the Western Area Power Association (WAPA), more than 75% of energy consumption occurs during the 95% of the time when hot tubs are covered and not in use. WAPA also noted that heat loss occurs continuously, but when tubs are in use, heat losses increase six-fold or more, and more rapidly when jets are activated. Average annual energy consumption of hot tubs nationwide was reportedly found by the National Pool and Spa Institute to be 2,514 kWh (9,050 MJ), translating to $335 at 2019 average electricity costs in the US. This number would be significantly higher in northern cold climates, and lower in the warmest climates.

It is worth thinking very hard about environmental consequences of a hot tub prior to purchase, and if already a hot-tub owner, taking steps to minimize energy consumption. Recommendations include:

- When purchasing a hot tub look for low wattage, small pumps, and the smallest water capacity that will fit your needs.
- Install a tight-fitting cover that has features to minimize evaporation loss.
- Install a timer to allow running often enough to keep the tub and water in good condition, but to prevent the use of continuous power.
- Reduce temperature to the lowest possible level during long periods of no use.
- Keep well maintained and monitor often for leaks.
- Create a wind break to protect from prevailing wind.

Summary

There is widespread interest today in finding ways to conserve both water and energy. One way that individual consumers can contribute to a goal of using less of both is through bathing habits. Individual consumers have the power to contribute to reduction of both water and energy use in bathing. Use of showers rather than bathtubs, installation of low flow shower heads, shortening time in the shower, filling to less than full capacity of a bathtub, and avoiding purchase of large volume bathtubs are all steps that individuals can take to reduce the environmental impacts of their bathing. The same mindset should apply to the purchase and/or maintenance of hot tubs.

Sources of Information

Ally, M., Tomlinson, J. and Ward, B. 2002. Water and Energy Savings using Demand Hot Water Recirculating Systems in Residential Homes: A Case Study of Five Homes in Palo Alto, California. Oak Ridge National Laboratory, Report ORNL/TM-2002/245. (https://info.ornl.gov/sites/publications/Files/Pub57428.pdf)

Ames, D. 2012. Hot Tub's Ready to Go, Using Power All Winter. Home Energy Pros Forum. (https://homeenergypros.org/profiles/blogs/energy-audit-and-5-hot-tub-energy-saving-tips-for-winter)

Anonymous. 2009. Waiting for Hot Water. Building Green. (https://www.buildinggreen.com/blog/waiting-hot-water)

Arrington, D. 2015. Showers vs. Baths: Which Use Less Water? Sacramento Bee, Feb. 13. (https://www.sacbee.com/news/state/california/water-and-drought/article2591077.html)

Brazeau, R. and Edwards, M. 2013. Water and Energy Savings from On-Demand and Hot Water Recirculating Systems. Journal of Green Building 8(1):75-89. (https://www.researchgate.net/publication/270068632_Water_and_energy_savings_from_on-demand_and_hot_water_recirculating_systems)

Del Grande, E. 2010. Big Tubs Need Big Water Heaters. Seattle Times, July 23. (https://www.seattletimes.com/life/lifestyle/big-tubs-need-big-water-heaters/)

DeOreo, W. 2011. Analysis of Water Use in New Single Family Homes. Salt Lake City Corporation and U.S. Environmental Protection Agency. (http://www.aquacraft.com/wp-content/uploads/2015/10/Analysis-of-Water-Use-in-New-Single-Family-Homes.pdf)

DeOreo, W., Mayer, P., Dziegielewski, B. and Kiefer, J. 2016. Residential End Uses of Water, Version 2, Executive Report. Water Research Foundation. (http://www.waterrf.org/PublicReportLibrary/4309A.pdf)

ENERGY STAR. 2019. Demand Hot Water Recirculating System. (https://www.energystar.gov/products/water_heaters/demand_hot_water_recirculating_system)

Griffiths-Sattenspiel, B. and Wilson, W. 2009. The Carbon Footprint of Water. River Network. (https://www.rivernetwork.org/wp-content/uploads/2015/10/The-Carbon-Footprint-of-Water-River-Network-2009.pdf)

Higgins, C. 2019. Capacity of the Average Bathtub. (https://www.hunker.com/13400924/capacity-of-the-average-bathtub)

Lutz, J. 2005. Estimating Energy and Water Losses in Residential Hot Water Distribution Systems. Lawrence Berkeley National Laboratory, Report LBNL 57199. (file:///C:/Users/Owner/Downloads/Lutz,%20J.%20(2005)%20Estimating%20Energy%20and%20Water%20Losses%20-%20Residential%20Hot%20Water%20Distribution.pdf)

Mayer, P., DeOreo, W., Opitz, E., Kiefer, J., Davis, W., Dziegielewski, B., and Nelson, J. 1999. Residential End Uses of Water. AWWA Research Foundation. (https://www.waterdm.com/sites/default/files/WRF%20(1999)%20Residential%20End%20Uses%20of%20Water.pdf)

Saltzman, R. 2011. Is Your Water Heater Large Enough for Your Bathtub? Structure Tech, Oct. 4. (https://structuretech1.com/is-your-water-heater-large-enough-for-your-bathtub/)

Statista. 2019. U.S. Number of Households: 1960-2018. (https://www.statista.com/statistics/183635/number-of-households-in-the-us/)

Tessaly, J. 2011. Shower or Bath?: Essential Answer. Stanford Magazine, March/April. (https://stanfordmag.org/contents/shower-or-bath-essential-answer)

U.S. Energy Information Administration. 2018. Space Heating and Water Heating Account for Nearly Two Thirds of U.S. Home Energy Use. (https://www.eia.gov/todayinenergy/detail.php?id=37433)

U.S. Environmental Protection Agency. 2013. Energy Efficiency in Water and Wastewater Facilities: A Guide to Developing and Implementing Greenhouse Gas Reduction Programs. (https://www.epa.gov/sites/production/files/2015-08/documents/wastewater-guide.pdf)

U.S. Environmental Protection Agency. 2019a. Greenhouse Gas Equivalencies Calculator. (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator)

U.S. Environmental Protection Agency. 2019b. Private Drinking Water Wells. (epa.gov/privatewells)

U.S. Environmental Protection Agency. 2019b. Water Sense, Statistics and Facts. (https://www.epa.gov/watersense/statistics-and-facts)

U.S. Geological Survey. 2019. How Much Water Does an Average Person Use At Home Per Day? (https://water.usgs.gov/edu/qa-home-percapita.html)

U.S. Government Accountability Office (GAO). 2014. Freshwater: Supply Concerns Continue, and Uncertainties Complicate Planning. (https://www.gao.gov/products/GAO-14-430)

Walton, B. 2017. U.S. Household Water Use Continues to Decline. Water News, Nov. 8. (https://www.circleofblue.org/2017/world/u-s-household-water-use-continues-decline/)

Watercalculator.org. 2017. Shower & Bath. August 2. (https://www.watercalculator.org/save-water/shower-bath/)

Western Area Power Administration. 2009. What Goes into an Energy-Efficient Spa or Hot Tub? Energy Services. Hot Tubs Fact Sheet. (https://www.wapa.gov/EnergyServices/Documents/HotTubs.pdf)