Methodology and Assumptions for Estimating WaterSense® Annual Accomplishments (Updated June 2020)

Each year the U.S. Environmental Protection Agency (EPA) collects product shipment data for WaterSense labeled products from its manufacturer partners. This data set is then aggregated and entered into the National Water Savings (NWS) model to measure the impact on the market and estimate annual water savings attributable to WaterSense labeled products. The annual water savings data, in turn, is used to calculate associated energy, carbon dioxide, and dollar savings. WaterSense strives to provide the full methodology in technical papers (referenced below) for those interested in the details of the approach. This document is provided as a summary for stakeholders that would like a high-level overview of the inputs and data points but do not wish to review a full technical paper. Unlike the NWS model, which is updated every year, this document is only updated when there are major changes to the underlying data, assumptions, or methodology. For annual values, WaterSense has provided the numbers used for 2019, the most current year at time of writing.

Water Savings

The NWS model was developed to estimate the national water savings attributable to WaterSense labeled products. The model uses market penetration data of WaterSense labeled products in both existing and new construction combined with an accounting analysis of water-using equipment and of building stock to replicate the likely usage of products.

Calculating the total gallons of water WaterSense labeled products save nationwide involves comparing two scenarios. First, the model uses the data from multiple sources[1] pertaining to the baseline national water use of typical fixtures, fittings, and appliances that existed prior to the program's inception in 2006, as well as trends in efficiency for water-using products to establish a business-as-usual scenario (i.e., the market if the WaterSense program did not exist). Next, the NWS model uses product shipment data, as reported by WaterSense partners, to create a program scenario that estimates the overall efficiency of the stock in use today (as it is influenced by WaterSense). The NWS model then compares the business-as-usual scenario with the program scenario to calculate total gallons saved by the WaterSense program.

Based on the calculations in the model, WaterSense can project a timeline of water savings attributable to labeled products. Each year, new products shipped with the WaterSense label are added to the model's stock accounting, while older products that have reached the end of their projected life are retired. This provides a realistic picture of the savings attributable to WaterSense both on an annual and cumulative basis.

Energy Savings

There are two types of energy savings associated with the reduction in water used by WaterSense labeled products. All water delivered from a public supply system requires energy for conveyance and treatment. Based on publicly available data, WaterSense estimates that it

[1] Schein, J., P. Chan, Y. Chen, C. Dunham, H. Fuchs, V. Letschert, M. McNeil, M. Melody, S. Price, H. Stratton, and A. Williams. 2019. "Methodology for the National Water Savings models—indoor residential and commercial/institutional products, and outdoor residential products." *Water Supply* 19(3): 879–890.

takes 2.1 kilowatt hours of electricity to supply 1,000 gallons of water to households from the public supply. This includes energy required for pumping raw water, water filtration, treatment, and distribution. Many products generate wastewater as well, and WaterSense estimates that it takes an additional 2.5 kilowatt hours of electricity to treat 1,000 gallons of residential wastewater at a treatment plant.[2] Therefore, the embedded energy footprint of water from the public supply is 4.6 kilowatt hours of electricity per thousand gallons supplied for products that create wastewater.

Abated Water Heating

There are additional savings realized by WaterSense labeled products that reduce hot water use. By reducing the amount of hot water used, a portion of the energy (commonly electricity or natural gas depending on heating type) is abated. A full accounting of this energy and costs savings requires several inputs.[3] Table 1 summarizes the needed data points and the source of data utilized by WaterSense.

Table 1. Required Data Points and Source Data Used by WaterSense

Data Point	Influenced by	Source data	Notes
Water use	Installed fixtures/appliances	NWS model	The NWS model is discussed above.
	Hot water piping configurations		
	Household occupancy		
	Occupant behavior		
	Occupant ages		
Water heater energy use	Fuel source	American Housing Survey (AHS)	The stock accounting process of water heaters is discussed below.
	Inlet water temperature	Residential Energy Consumption (RECS) analysis	
	Average efficiency of stock water heaters	Stock accounting from Air-Conditioning, Heating, and Refrigeration Institute (AHRI) shipment data and U.S. Department of Energy (DOE) requirements	
	Water heater set point	American National Standards Institute (ANSI)/Residential Energy Services Network (RESNET)/International Code Council (ICC) Standard 301	

[2] EPRI, 2013. Electricity Use and Management in the Municipal Water Supply and Wastewater Industries, Electric Power Research Institute, Palo Alto, California, November 2013 Report 3002001433.
[3] Chen, Y., H. Fuchs, J. Schein, V. Franco, H. Stratton, and C. Dunham. "Estimating the Hot Water Portion of Residential Bathroom Faucet & Showerhead Water Use." LBNL Report, 2020.

Data Point	Influenced by	Source data	Notes
Mix of hot and cold water at point of use	Water heater set point	ANSI/RESNET/ICC Standard 301	ANSI/RESNET/ICC 301 provides the necessary relationship to express the results as a percentage.
	Inlet water/cold side water temperature	RECS analysis	
	Warm water target temperature	ANSI/RESNET/ICC Standard 301	
Cost of energy	N/A	Energy Information Administration (EIA) Short Term Energy Outlook (STEO)	The cost of energy is influenced by various factors represented in the STEO.
Carbon impact of abated energy	N/A	EPA greenhouse gas equivalencies	The carbon impact of abated energy is influenced by various factors represented in the EPA greenhouse gas equivalencies.

Beginning with the 2019 annual accomplishments report, WaterSense introduced a major update to how abated energy use from residential water heating is calculated to more completely address the factors listed above. Overall, this reduced the estimated energy saved by roughly 5 percent. WaterSense is applying this update retroactively to be as accurate, representative, and consistent as possible.

Prior Assumptions

Prior to the 2019 annual accomplishments report, WaterSense used the best available data with the assumptions below:

- Heating water is 100 percent efficient for an electric hot water heater.
- Heating water is 75 percent efficient for a natural gas water heater.
- Incoming water temperature is raised 75ºF by a hot water heater.[4]
- Water used at the lavatory faucet and from showerheads is, on average, approximately 73 percent hot water and 27 percent cold water.[5]
- Water used by commercial pre-rinse spray valves is 100 percent hot water.

While the assumptions WaterSense used prior to 2019 represent the best available data at the time, WaterSense recognized that the limited geographic scope and sample size of many of the underlying studies may not be nationally representative. This is particularly true given the regional variation and seasonality observed in water heating. Additionally, as the WaterSense program is now tracking over a decade of savings, representing changes to the distribution of the population by region—as well as the stock of water heaters in use—has become more important to the accuracy of these estimates. While flat numbers applied to all years of savings

[4] DOE, 2012. Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Residential Clothes Washers. Office of Energy Efficiency and Renewable Energy, Building Technologies Program, Appliances and Commercial Equipment Standards, p. 7-1. April 2012. www.regulations.gov/document?D=EERE-2008-BT-STD-0019-0047

[5] Mayer, Peter W. and William B. DeOreo. *The End Uses of Hot Water in Single-Family Homes From Flow Trace Analysis*. Aquacraft, Inc.

may have been appropriate in the past, this may no longer be the case. The revised estimates apply to residential hot water-using products (showerheads and faucets/faucet accessories) which represent most of the energy hot water energy savings attributable to WaterSense labeled products.

Inlet Water Temperature and Temperature Rise

The revised estimates for energy savings use ANSI/RESNET/ICC Standard 301[6] and groundwater temperature and housing data from the 2015 Residential Energy Consumption Survey (RECS) microdata. This approach estimates a weighted national average for inlet water temperature (the average annual temperature of water entering a home) from groundwater temperature. This value is in turn used to estimate the mix of hot and cold water used for both showerheads and faucets.[7] WaterSense will update this input for future years using the most recent version of RECS to create a unique estimate for each year. The following estimates are used in the revised approach:

- Average inlet water temperature is 60.5º F.
- Average water heater set point is 125º F.
- The target warm water temperature at fixtures is 105º F.
- Showerhead water use is 67.8 percent hot and 32.2 percent cold.
- Faucet water use is 60.7 percent hot and 39.3 percent cold.

Water Heater Efficiency

WaterSense estimates the efficiencies of the stock of water heaters in use using shipment data from AHRI,[8] estimated life expectancy, and DOE appliance standards for Energy Factors (EFs). WaterSense conducts a stock accounting analysis annually to estimate EFs for water heaters in use. The estimated EF for stock water heaters is applied to abated hot water use for the year in which the water was saved.

Table 2. Estimated EFs for Water Heaters Based on Shipment Year[9]

Fuel Source	Pre-2004	2005-2014	2015-Present
Natural Gas	0.544	0.594	0.62
Electric	0.877	0.917	0.95

Additionally, WaterSense monitors Unit Shipment Data from ENERGY STAR® to determine when high-efficiency water heaters increase in market share to the point where the above estimates should be revised. Failing to do so could underestimate the efficiency of stock water heaters and overestimate the impact of WaterSense labeled products.

[6] ANSI/RESNET/ICC, 2019. *ANSI/RESNET/ICC 301-2019 Standard for the Calculation and Labeling of the Energy Performance of Dwelling and Sleeping Units using an Energy Rating Index.*
[7] Chen et. al, 2020. Op cit.
[8] AHRI. "Residential Automatic Storage Water Heaters Historical Data." Accessed May 22, 2020. www.ahrinet.org/Resources/Statistics/Historical-Data/Residential-Storage-Water-Heaters-Historical-Data
[9] DOE, 2010. ENERGY STAR Water Heater Market Profile. September 2010. www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/Water_Heater_Market_Profile_2010.pdf

At the same time, WaterSense acknowledges it likely overestimates stock water heater efficiency and underestimates savings by assuming water heaters prior to 1990 meet the 1990 DOE standard, assuming 100 percent retirement after 20 years, and that no degradation in performance occurs over the life the water heater. WaterSense has left these assumptions in place due to a lack of available data, and because WaterSense prefers a conservative approach.

The retirement of water heaters is estimated by a triangular distribution with set points of 6, 13, and 20 years.[10] Table A-1 in Appendix A shows the survival probability of residential water heaters using this approach. Table A-2 shows the estimated stock EF for water heaters using this approach. For 2019, the estimated EF for natural gas water heaters was 0.602 and the estimated EF for electric water heaters was 0.931.

Calculating Kilowatt Hours of Electricity and Cubic Feet of Natural Gas Saved

Using the specific heat of water (equal to 1.0 British thermal units [BTU] per 1.0 pound of water raised one degree Fahrenheit), WaterSense uses the data above to estimate the energy used to heat water. For 2019, that heating of water requires approximately 0.17 kilowatt hours of electricity per gallon of hot water for an electric-powered water heater, or approximately 0.87 cubic feet of natural gas per gallon of hot water for a natural gas-fired water heater. Table A-3 in Appendix A shows the estimated energy consumed per gallon of water heated for years 2007 through 2019.

These numbers are updated annually along with the rest of the model, and the energy consumption is applied for the year in which water savings occurred. For the purposes of reporting in a single unit, WaterSense converts natural gas savings to the equivalent units of kilowatt hours using the following conversion factors:

1 therm = 29.3 kWh

1 Mcf of natural gas = 10.307 therms

WaterSense uses data collected by the American Housing Survey to estimate the percentage of households that heat with either electricity or natural gas. WaterSense assumes that the stock of WaterSense labeled products in service are distributed according to these percentages for the purpose of estimating the amount of energy saved. Other methods of heating hot water are not considered in this calculation. However, households using electricity or natural gas to heat water currently account for more than 95 percent of all occupied households in the United States.

Carbon Dioxide Savings

Once the associated energy savings are calculated, WaterSense uses the best available estimates for the equivalent amount of carbon dioxide that has been eliminated from abating this energy use:

[10] DOE, 2009. *Technical Support Document: Energy Conservation Program for Consumer Products: Energy Conservation Standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters.* November 23, 2009. www.regulations.gov/document?D=EERE-2006-STD-0129-0170

67.07×10^{-4} metric tons of carbon dioxide per kWh

0.005302 metric tons of carbon dioxide per therm

These figures are publicly available on the EPA's Greenhouse Gases Equivalencies Calculator page.

Cost Savings

Much like the energy savings, consumers save money on their utility bills in two ways: reduction in water bills (drinking water and wastewater) and reduction in energy bills (electricity and/or natural gas) used to heat water.

The cost savings attributable to reduction in water bills is calculated by the NWS model using an analysis of rate information reported in the American Water Works Association's (AWWA) Rate Survey. For years when the survey is not available, the average cost is updated using the Gross Domestic Product (GDP) deflator for water from the U.S. Department of Commerce Bureau of Economic Analysis. The average cost of water and wastewater in the year that the savings occurred is applied to the total water savings, and the total is then discounted to the current year.

The cost savings attributable to reduce energy bills are calculated for each type of hot water heating units are calculated by applying the average cost of energy supplied by the U.S. Energy Information Agency's Short-Term Energy Outlook to the total amount of hot water saved. Only products that typically are supplied with hot water are taken into account for the savings attributed to reduced energy costs. Energy that is saved as a result of total water savings but not associated with heating water (e.g., the energy embedded in water that is publicly supplied and treated) is not added to the cost savings.

WaterSense represents dollar values adjusted with the GDP Deflator to the current year and continually reviews the available data, as well as the methodology used in its savings calculations to improve accuracy. As a result, comparisons of the data in the WaterSense annual reports from one year to the next cannot be used in direct calculations to estimate cumulative savings. WaterSense will continue to publish updated cumulative savings numbers as they become available.

Appendix A: Summary Tables

Table A-1 shows the survival probability of residential water heaters used as part of EPA's methodology.

Table A-1. Survival Probability of Residential Water Heaters

Years Old	Percent Survival
1	100
2	100
3	100
4	100
5	100
6	100
7	100
8	98
9	94
10	88
11	80
12	69
13	57
14	43
15	31
16	20
17	12
18	6
19	2
20	0

Table A-2 shows the estimated stock EF for water heaters used as part of EPA's methodology.

Table A-2. Estimated EF of Stock Residential Water Heaters

Year	Average EF for Natural Gas Water Heaters	Average EF for Electric Water Heaters
2007	0.560	0.891
2008	0.564	0.894
2009	0.568	0.897
2010	0.572	0.900
2011	0.575	0.903
2012	0.579	0.906
2013	0.583	0.909
2014	0.586	0.911
2015	0.591	0.916
2016	0.595	0.920
2017	0.599	0.924
2018	0.602	0.927
2019	0.605	0.931

Table A-3 shows the estimated energy consumed per gallon of water heated for years 2007 through 2019.

Table A-3. Estimated Energy per Gallon Water Heated

Year	mcf/gallon	kWh/gallon
2007	0.0009321	0.177023531
2008	0.0009260	0.176399776
2009	0.0009200	0.175810915
2010	0.0009138	0.175226524
2011	0.0009078	0.174657460
2012	0.0009020	0.174117444
2013	0.0008965	0.173610652
2014	0.0008917	0.173158349
2015	0.0008844	0.172283115
2016	0.0008781	0.171505907

Year	mcf/gallon	kWh/gallon
2017	0.0008727	0.170782658
2018	0.0008679	0.170117778
2019	0.0008638	0.169514222