Water and Energy Savings, and Greenhouse Gas Emission Reductions Resulting from a Change to the Connecticut Plumbing Fixture Efficiency Standards

The Alliance for Water Efficiency was asked to generate a summary of water and energy savings, and greenhouse gas emission reductions, associated with an update to state plumbing fixture efficiency standards. Water and energy savings estimates are provided herein under two scenarios, the first with the current federal standards and second with fixture standards that align with WaterSense. The primary difference in the scenarios is driven by residential and non-residential toilets, and urinals in the commercial, industrial and institutional (CII) sector. The reader may note the customer-side energy savings and greenhouse gas emission reductions are the same for both scenarios. Those savings are derived from federal clothes washer and showerhead efficiency standards. Clothes washer efficiency will not change with an update to the Connecticut state plumbing fixture efficiency standards, and showerheads were not modified for this analysis.[1] Utility energy savings are generated by treating and delivering less water. These savings were calculated using the Alliance for Water Efficiency's Water Conservation Tracking Tool. The year 2019 was used as the start year, as it is the most recent year with population and housing unit estimates from the U.S. Census Bureau. A population forecast was included from the University of Connecticut's Connecticut State Data Center.[2] Dwelling units were projected based on population growth. Table 1 displays the population and dwelling unit forecast, and Table 2 shows the demographic data inputs used for this analysis. Energy savings and CO_2 equivalent greenhouse gas emission reductions are based on the assumption that it takes 2,673 kilowatt hours (kWh) per million gallons of water treated and delivered, and 1,284 kWh per million gallons for wastewater collection and treatment. These energy intensity estimates were generated using the AWE Tracking Tool's built-in calculator and it was assumed 82 percent of local water supplies are surface water and 18 percent are groundwater. The surface to groundwater ratio was based on data from the USGS's report, *Estimated Use of Water in the United States in 2015*.[3]

Population & Housing	2019	2020	2025	2030	2035	2040	2045	2050
Population	3,602,343	3,604,603	3,618,763	3,633,994	3,645,370	3,654,015	3,662,660	3,671,305
Single Family Dwelling Units	889,358	889,916	893,412	897,172	899,981	902,115	904,249	906,384
Multi Family Dwelling Units	635,601	636,000	638,498	641,186	643,193	644,718	646,243	647,769

Table 1: Population and Dwelling Unit Forecast

[1] The 2016 Residential End Uses of Water Study found a nominal difference in shower water use despite a change in flow rate. While savings will likely occur, a change from 2.5 gpm to 2.0 gpm is arguably imprudent to estimate savings for. https://www.waterrf.org/research/projects/residential-end-uses-water-version-2

[2] University of Connecticut's Connecticut State Data Center. https://ctsdc.uconn.edu/2015-to-2040-population-projections-state-level/

[3] United States Geological Survey. (2017). Estimated Use of Water in the United States in 2015. https://pubs.usgs.gov/circ/1441/circ1441.pdf

U.S. Census Data	Single Family	Multi Family
Persons per household	2.73	2.10
Full Baths/Dwelling Unit	1.57	1.06
Half Baths/Dwelling Unit	0.58	0.12
Dwelling Units in 1992	696,394	585,653
Population in 1990	3,287,116	

Table 2: Demographic Data Inputs Used in the Analysis

Table 3 shows an estimate of the additional water and energy savings that will be generated from updating the Connecticut plumbing fixture efficiency standards to match the efficiency levels of WaterSense. By 2050, an additional 1.98 billion gallons of water will be saved per year. This will reduce energy use by an additional 7.85 gigawatt hours per year by 2050 and total annual CO_2 equivalent emissions by an additional 4,258 tons. By 2050, passive water savings can be increased by 27 percent. Utility energy savings resulting from treating and delivering less water and treating less wastewater can be increased by 27 percent, as can utility-side greenhouse gas emission reductions.

Additional Water Savings from WaterSense Standards by Customer Class								
	Units	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Single Family	MG	63	326	517	649	736	788	814
Multi Family	MG	43	220	349	438	496	532	549
CII	MG	34	187	312	414	496	564	620
Total	MG	140	733	1,177	1,500	1,729	1,884	1,983
Additional Energy Savings by Source for WaterSense Standards								
		2020	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Utility-Side Energy Savings	MWh	553	2,902	4,658	5,936	6,840	7,455	7,847
Customer-Side Electricity	MWh	-	-	-	-	-	-	-
Customer-Side Natural Gas	Thou. Therm	-	-	-	-	-	-	-
Additional Emission Reductions from WaterSense Standards - Carbon Dioxide Equivalent								
		2020	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Utility-Side Reductions	Tons	300	1,575	2,527	3,221	3,711	4,045	4,258
Customer-Side Reductions	Tons	-	-	-	-	-	-	-
Total CO_2-Equivalent Reductions	Tons	300	1,575	2,527	3,221	3,711	4,045	4,258
Cumulative Reduction	Tons	300	5,769	16,615	31,422	49,069	68,683	89,590

Table 3: Estimated Additional Water and Energy Savings, and Greenhouse Gas Emission Reductions Achieved with a WaterSense Standard

Table 4 shows the estimated savings based on current plumbing fixture efficiency standards, and Table 5 contains the savings estimates for WaterSense-based efficiency standards.

Forecast of Water Savings from Plumbing Fixture/Appliance National Standards by Customer Class								
	Units	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Single Family	MG	236	1,276	2,110	2,782	3,332	3,788	4,170
Multi Family	MG	134	728	1,216	1,619	1,955	2,238	2,479
CII	MG	39	215	360	477	573	651	716
Total	MG	409	2,219	3,685	4,878	5,859	6,677	7,364
Estimated Energy Savings by Source of Savings from Plumbing Fixture/Appliance National Standards								
		2020	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Utility-Side Energy Savings	MWh	1,618	8,780	14,582	19,302	23,185	26,420	29,139
Customer-Side Electricity	MWh	3,802	18,828	28,720	35,247	39,614	42,604	44,681
Customer-Side Natural Gas	Thou. Therm	180	898	1,361	1,659	1,854	1,985	2,075
Estimated Emission Reductions from Plumbing Fixture/Appliance National Standards - Carbon Dioxide Equivalent								
		2020	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Utility-Side Reductions	Tons	878	4,764	7,913	10,474	12,581	14,337	15,812
Customer-Side Reductions	Tons	3,129	15,529	23,640	28,945	32,468	34,866	36,523
Total CO_2-Equivalent Reductions	Tons	4,007	20,293	31,552	39,419	45,049	49,202	52,335
Cumulative Reduction	Tons	4,007	75,222	212,098	394,520	609,215	847,406	1,103,153

Table 4: Estimated Water and Energy Savings, and Greenhouse Gas Emission Reductions Achieved with Current Standard (Equal to National EPAct Standard)

Forecast of Water Savings from WaterSense Plumbing Fixture/Appliance Standards by Customer Class								
	Units	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Single Family	MG	299	1,602	2,626	3,431	4,067	4,576	4,984
Multi Family	MG	176	948	1,564	2,056	2,451	2,770	3,028
CII	MG	74	402	672	891	1,070	1,216	1,336
Total	MG	549	2,952	4,862	6,378	7,588	8,561	9,347
Estimated Energy Savings by Source of Savings from WaterSense Plumbing Fixture/Appliance Standards								
		2020	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Utility-Side Energy Savings	MWh	2,171	11,682	19,239	25,238	30,024	33,875	36,986
Customer-Side Electricity	MWh	3,802	18,828	28,720	35,247	39,614	42,604	44,681
Customer-Side Natural Gas	Thou. Therm	180	898	1,361	1,659	1,854	1,985	2,075
Estimated Emission Reductions from WaterSense Plumbing Fixture/Appliance Standards - Carbon Dioxide Equivalent								
		2020	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Utility-Side Reductions	Tons	1,178	6,339	10,440	13,695	16,292	18,382	20,070
Customer-Side Reductions	Tons	3,129	15,529	23,640	28,945	32,468	34,866	36,523
Total CO_2-Equivalent Reductions	Tons	4,307	21,868	34,080	42,640	48,761	53,248	56,593
Cumulative Reduction	Tons	4,307	80,990	228,713	425,942	658,284	916,088	1,192,744

Table 5: Estimated Water and Energy Savings, and Greenhouse Gas Emission Reductions Achieved with a WaterSense Standard

Analysis Assumptions

This section summarizes the assumptions that were used to generate the estimates presented herein.

The Alliance for Water Efficiency's Water Conservation Tracking Tool was used to calculate the water savings, energy savings, and greenhouse gas emission reduction estimates. Two scenarios were created to reflect different paths forward.

1) Current Connecticut plumbing fixture efficiency standards
2) Changing the Connecticut plumbing fixture efficiency standards to reflect efficiency levels that align with WaterSense

First, demographic data were entered into the Tracking Tool. This included a population and housing forecast and additional data including persons per household, number of full and half baths per household, housing units built before 1992, and the population in 1990.

Population & Housing	2019	2020	2025	2030	2035	2040	2045	2050
Population	3,602,343	3,604,603	3,618,763	3,633,994	3,645,370	3,654,015	3,662,660	3,671,305
Single Family Dwelling Units	889,358	889,916	893,412	897,172	899,981	902,115	904,249	906,384
Multi Family Dwelling Units	635,601	636,000	638,498	641,186	643,193	644,718	646,243	647,769

Table 6: Population and Dwelling Unit Forecast

The population forecast was obtained from the University of Connecticut's Connecticut State Data Center. The dwelling unit forecast was projected based on the 2019 population and dwelling unit ratios.

Additional demographic data inputs were obtained and derived from the U.S. Census Bureau and American Housing Survey.

U.S. Census Data	Single Family	Multi Family
Persons per household	2.73	2.10
Full Baths/Dwelling Unit	1.57	1.06
Half Baths/Dwelling Unit	0.58	0.12
Dwelling Units in 1992	696,394	585,653
Population in 1990	3,287,116	

Table 7: Demographic Data Inputs Used in the Analysis

This generated a base-year (2019) fixture and appliance stock. All except the residential toilets stock were auto-generated by the Tracking Tool. The residential toilet stock was adjusted to reflect findings of the 2019 Plumbing Manufacturers International *2019 U.S. WaterSense Market Penetration* report.[4] The 2019 toilet inventory for both scenarios is displayed in Table 8.

Residential Toilet Inventory in 2019		
Flush Volume	**Single Family**	**Multi Family**
3.5+ Gallons per Flush	315,500	123,752
1.6 Gallons per Flush	1,300,241	510,006
1.28 Gallons per Flush	296,379	116,251

Table 8: Residential Toilet Inventory in 2019

The fixture flush volumes and flow rates are included in Table 9. The scenario for the current standards assumes 48% of new and replaced toilets will be 1.28 gpf. This is based on the 2019 Plumbing Manufacturers International *2019 U.S. WaterSense Market Penetration* report that states, "During 2007-2018, a total of 118.126 million tank-type toilets were sold and installed in homes throughout the United States. Based on our research, 56.212 million WaterSense toilets or those which met the WaterSense specification of not flushing more than 1.28 gallons per flush were sold (pg. 21)." This is equal to 48 percent of toilets sold.

Fixture/Appliance	Current Standards Scenario	CT Standards Update Scenario
Residential Toilets	New and replaced toilets - 48% 1.28 gpf/52% 1.6 gpf	All new and replaced toilets 1.28 gpf
Showerheads	Same for both scenarios.	
CII Toilets	1.6 gpf	1.28 gpf
CII Urinals	Not included, but 1.0 gpf assumed.	0.5 gpf
Residential Clothes Washers	Same for both scenarios.	
Residential Dishwashers	Same for both scenarios.	

Table 9: Scenario Differences for Future Fixture/Appliance Installations

[4] Plumbing Manufacturers International. (2019). 2019 U.S. WaterSense Market Penetration. https://www.safeplumbing.org/files/safeplumbing.org/documents/misc/2019-WaterSense-market-penetration-study.pdf

Energy and Greenhouse Gas Emission Data Inputs

Key to estimating energy savings and greenhouse gas emission reductions is the energy intensity of water and wastewater. That is, the amount of energy it takes to pump, treat, and deliver potable water and the energy required to treat wastewater. Because no such estimates currently exist for the state of Connecticut, the energy intensity of treated and delivered water and wastewater was estimated using the Tracking Tool's built-in calculator. Tables 10 through 13 include the assumptions made for energy and greenhouse gas emission related data inputs.

Greenhouse Gas	eGRID Factors (lb/MWh)
Carbon Dioxide CO_2	1,079.73
Methane CH_4	0.068
Nitrous Oxide N_2O	0.013

Table 10: Average Emission Factors for eGRID Region NEWE

Local Water Supply Sources	KWh/MG	% of Local Supply
Surface Water	683	82%
Groundwater	1,915	18%
Average Energy Intensity of Local Water Supply	904	N/A

Table 11: Connecticut Water Supply Sources Characterization and Energy Intensity

Average Energy Intensity of Delivered Water	KWh/MG
Supply	904
Treatment	251
Distribution	1,519
Total	2,673

Table 12: Average Energy Intensity of Delivered Water

Wastewater Collection and Treatment Energy Intensity	KWh/MG
Wastewater Collection Pumps	229
Treatment	1,055
Total	1,284

Table 13: Wastewater Collection and Treatment Energy Intensity