Energy Consumption and Green House Gas Emission Reduction Opportunities Available by Increasing the Efficiency of Residential Water Heaters

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Summary: With approximately 100 million residential water heaters installed throughout the United States, upgrading to higher-efficiency models promises to have a major impact on energy consumption and carbon dioxide emissions. Depending upon the technologies chosen, annual savings could be as high as a 30 percent reduction in natural gas usage, a nearly 68 percent reduction in the amount of electricity needed, and a reduction of more than 56 percent in carbon dioxide emissions.

According to a number of authoritative sources, water heating represents the second-largest consumer of energy in the typical American home behind heating and air conditioning equipment. Current estimates indicate there is an installed base of approximately 100 million residential water heaters in the United States. Given that sizeable number of units, any increase in the efficiency of an individual water heater would conceivably result in a reduction in energy consumption as well as having a potentially significant beneficial effect on both national energy usage and green house gases (GHG) emissions in this country.

To understand the magnitude of these positive effects, let us consider three replacement scenarios: the first two involve the impact of changing all existing water heaters to the most efficient models that are currently available (best available technology or BAT); the third measures the impact of changing all existing water heaters to the most efficient technology that could be developed (maximum feasible technology or MaxTech).

Water heating as it exists today

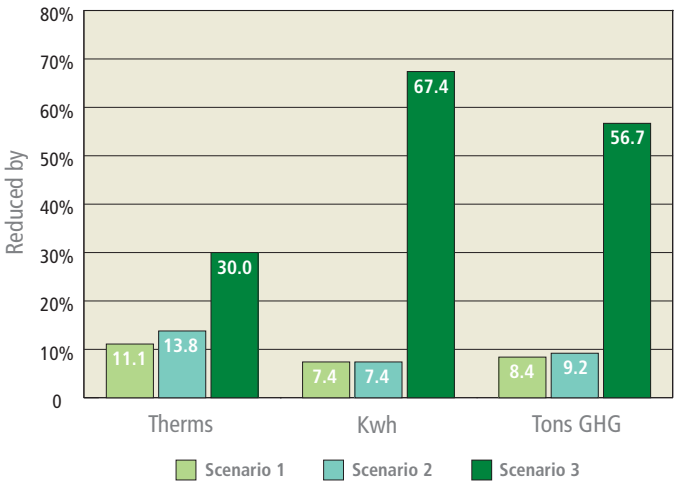
Before considering these scenarios, it is necessary to understand the baseline condition of the 100 million heaters that are installed throughout the country. Some terminology, physical factors, and assumptions need to be established – specifically:

- The same sources of demographic data that give us the 100 million installed units tell us that approximately half of these residential water heaters are gas-fired and half are powered by electricity.
- The energy input of gas water heaters is rated in British thermal units per hour (Btu/h), with larger amounts of consumption frequently report in therms (1 therm = 100,000 Btu's).
- The energy consumption of electric heaters is rated in kilowatt-hours (kwh).
- U.S. Dept. of Energy (DOE) and Environmental Protection Agency (EPA) literature states that 11.70 pounds of GHG are emitted per therm of natural gas burned; and 1.37 pounds of GHG are emitted per kwh of electricity generated (GHG expressed in terms of carbon dioxide, or CO_2).
- The "kwh generated" distinction is important, since there are losses in the transmission of electrical power from the power generation station to the point of use in a home or business. Literature indicates that these losses range from 8 to 15 percent of the power transmitted, so for the purpose of this analysis, we will use a power loss of 12 percent. Therefore, if one kilowatt is used by an installed heater, 1.14 kilowatts must be generated at the power plant to supply it (1.14 x (100%-12%) = 1.0).
- An overwhelming number of residential water heaters are covered under National Appliance Energy Conservation Act (NAECA) regulations of the DOE, and their efficiency is defined in terms of Energy Factor or "EF." NAECA specifies both the test method used and the calculations performed to determine the EF of a heater. This value is based on average usage patterns and conditions specified in the regulations, so that an equal basis of comparison exists for different types of water heaters.
- The NAECA calculations provide a method to relate EF to annual energy consumption in terms of either Btu/yr or kwh/yr, as appropriate to gas or electric units.
- Based on historical EF information, including minimums required by NAECA, we can reasonably assume that the installed base has an average EF of .56 for gas heaters and .88 for electric heaters.

Using this information and assumptions, we can determine that the installed base of ***.56 EF gas*** and ***.88 EF electric*** water heaters in the U. S.:

- Consume 13,376,272,321 therms of natural gas per year.
- Require the generation of 283,506,585,744 kwh of electricity per year.
- Emit 272,453,204 tons of GHG (CO_2) per year. This figure includes both emissions from individual gas water heaters and emissions from the coal-fired or gas-fired power plants that provide the electric power to the electric water heaters.

Annual Energy Reduction Potential



Using either proven technology improvements to gas and electric residential water heaters or maximum feasible technologies has the potential to save substantial amounts of natural gas or electricity each year. In addition, employing these enhanced technologies could also mean significant reductions in greenhouse gas emissions.

SCENARIO ONE: Best Available Technology (BAT)

In using this scenario, we will assume that proven technology improvements to gas-fired and electric residential water heaters will enhance the energy efficiency of these units. Specifically,

- An appropriate value to use for electric water heaters is .95 EF, based on the most optimized designs currently available.

- An appropriate value to use for gas water heaters is .65 EF, if we consider just power-vented heaters, .63 EF if limited to atmospherically vented gas units. (Note: More than 90 percent of the installed base of residential gas water heaters are atmospherically vented. Replacing an atmospheric unit with a power-vented heater in a residential application requires providing electricity to the unit to power the blower and changing the existing vent pipe. Consequently, the less costly change-out is atmospheric to atmospheric.)

If all 100 million U. S. water heaters are replaced using atmospherically vented gas water heaters at ***.63 EF***, and ***.95 EF for electrics***, the results are:

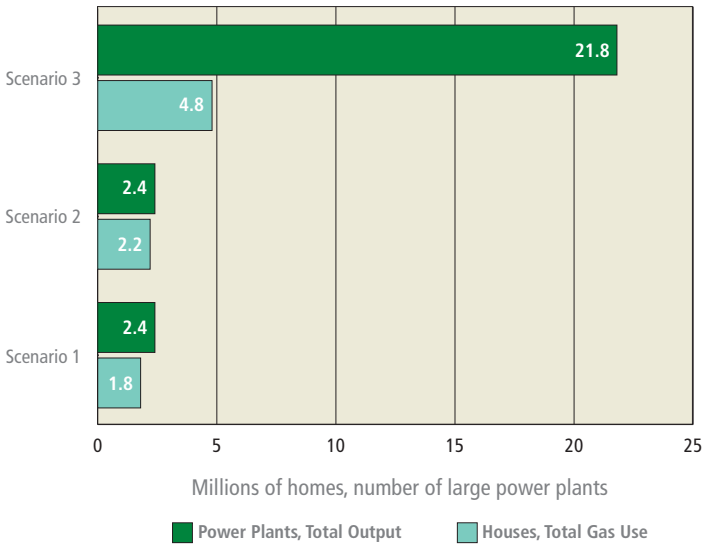
- Consumption of 11,890,019,841 therms of natural gas per year – a reduction of 1,486,252,480 therms per year, or 11.1 percent – ***equivalent to the average gas usage of 1.8 million homes***.
- The generation of 262,616,626,794 kwh of electricity per year – a reduction of 20,889,958,950 kwh/yr, or 7.4 percent – ***equivalent to the average electricity usage of 2.0 million homes, or the output of 2.4 large power plants***.
- Emissions of 249,449,005 tons of GHG per year – a reduction of 23,004,199 tons per year, or 8.4 percent – ***equivalent to the emissions of 3.8 million cars, the energy use of 1.8 million homes, or 4.5 coal-fired power plants***.

SCENARIO TWO:

Alternatively, using power-vented gas water heaters at ***.65 EF***, and the same ***.95 EF for electrics***, the results are:

- The water heaters would consume 11,524,173,077 therms of natural gas per year – a reduction of 1,852,099,245 therms per year, or 13.8 percent – ***equivalent to the average gas usage of 2.2 million homes***.
- They would require the generation of 262,616,626,794 kwh of electricity per year – a reduction of 20,889,958,950 kwh/yr, or 7.4 percent – ***equivalent to the average electricity usage of 2.0 million homes, or the output of 2.4 large power plants*** (same conditions as above).
- This would mean total emissions of 247,308,802 tons of GHG per year – a reduction of 25,144,402 tons per year, or 9.2 percent – ***equivalent to the emissions of 4.2 million cars, the energy use of 2.0 million homes, or 4.9 coal-fired power plants***.

Energy Reduction Equivalents



Another way of looking at the potential savings of switching to more efficient water heating solutions is by evaluating the impact in terms of the energy usage of the average American home or power plant output requirements. Savings are based on upgrading all existing U. S. water heaters to more energy efficient models.

SCENARIO THREE:
Maximum Feasible Technologies (MaxTech)

This scenario involves using several emerging technologies to replace the conventional water heaters now marketed in the U. S. Electric heaters will make the transition from resistance elements to using a heat pump cycle, in which efficiency is frequently stated as a coefficient of performance (COP). Due to standby losses inherent in a water heater, the EF of a heat pump water heater will be somewhat less than the COP. An appropriate value to use for a heat pump water heater is a COP of 3.0, for an EF of approximately 2.7. Gas water heaters will be redesigned as condensing models, which have combustion efficiencies in the mid-90 percent range. An appropriate value to use for such a condensing water heater is .80 EF.

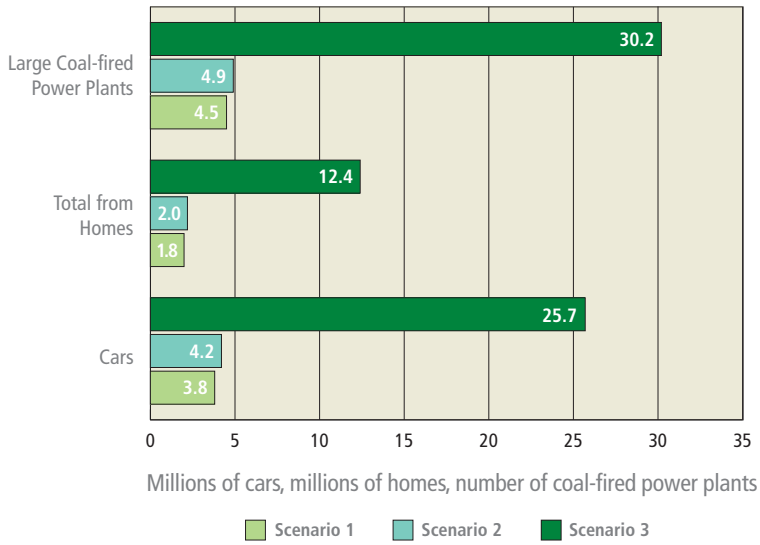
Once again, if we replace all 100 million U. S. installed water heaters, using ***electric heat pump heaters at 2.7 EF*** and ***gas condensing heaters at .80 EF***, the results are:

- These more efficient products would consume 9,363,390,625 therms of natural gas per year – a reduction of 4,012,881,696 therms per year, or 30.0 percent – ***equivalent to the average gas usage of 4.8 million homes***.
- They would require the generation of 92,402,146,465 kwh of electricity per year – a reduction of 191,104,439,279 kwh/yr, or 67.4 percent – ***equivalent to the average electricity usage of 18.7 million homes, or the output of 21.8 large power plants***.
- These units would emit 118,071,305 tons of GHG per year – a reduction of 154,381,899 tons per year, or 56.7 percent – ***equivalent to the emissions of 25.7 million cars, the energy use of 12.4 million homes, or 30.2 coal-fired power plants***.

Conclusion

While it would be impractical to replace every water heater in the United States in one year's time, historical data show that roughly 10 percent of households replace their water heaters in any given year. Upgrading those units to the best available technology on the market would clearly have a positive impact on energy consumption as well as reducing carbon dioxide emissions. Making the leap to maximum feasible technologies results in impressive savings in both energy consumption and emissions. As high energy prices and growing environmental concerns weigh on consumers' minds, they will almost certainly become more interested in high efficiency water heating solutions in the years to come.

Greenhouse Gas Reduction Equivalents



More efficient gas and electric residential water heaters also have the potential to make a positive impact in terms of greenhouse gas emissions (primarily carbon dioxide). One way of looking at the greenhouse gas impact is by translating the reductions into the emissions produced by automobiles, homes, or coal-fired power plants.

Sources

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