Improving Water Heaters for Sustainability

THE UNIVERSITY OF UTAH

Nicholas Malinowski
University of Utah

Dr. Amanda D. Smith
University of Utah

I. Introduction

Buildings use about 40% of the total U.S. energy demand. Water heaters provide hot water for a variety of building uses including sinks, showers, dishwashers, washing machines, and space heating. Water heaters are the second most energy intensive appliances in a common household. Typically a home water heater's energy source is natural gas. There are other types of tank water heaters include ultra low NO_x, and electric resistance. Figure 1 displays the differences in water heater types. Electric resistance water heaters use electrical grid power. Building owners burden the cost of water heating through the initial water heater cost, energy bills, and the communal air pollution they breathe. Burning and extracting non-renewable fuels including natural gas leads to climate change. Water heaters noticeably attribute air pollution to winter inversions have adverse affects on human health. Combusted air pollutants include Carbon Dioxide (CO_2), Nitrogen oxides (NO_x), and Sulfur oxides (SO_x). Pushing towards the future Salt Lake City has set a goal to reduce 80% of green house gases emissions by the year 2040 setting a demand for water heater emissions reduction.

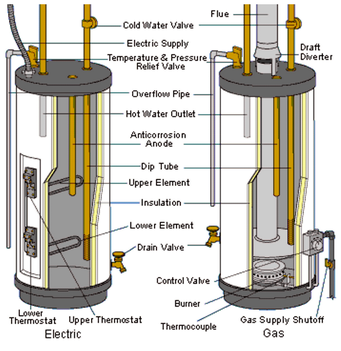


Figure 1 – Electric Resistance and Natural Gas Water Heaters

II. Methods

This research aims to quantify energy and emissions effects for various water heaters. EnergyPlus a building modeling software utilizes a comprehensive building information file and location specific weather file to perform an annual energy demand simulation for a buildings hot water usage delivered by a water heating system. Modelkit software was used to perform multiple EnergyPlus calculations at once with modified variables for water heater fuel source type, and thermal efficiency. Matlab coding software inputs the water heater energy demand data to numerically and graphically analyze energy usage, and emissions on various time scales.

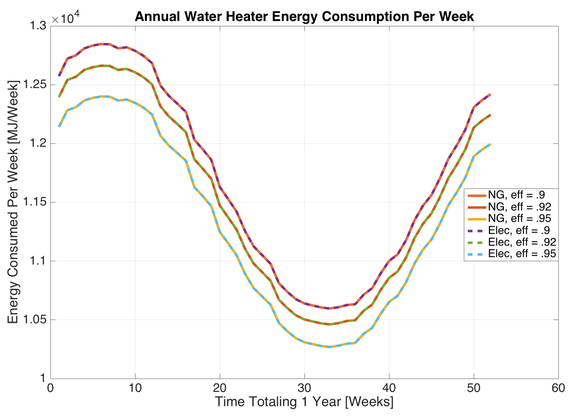
III. Results

The results in figure 2 and 3 show annual water heater energy consumption and savings per week for water heaters with efficiencies ranging from 90 to 95%. All trends display the matching water heater efficiency delivering the same amount of energy to the water. Week 6 during winter is the highest demand for water heating during the year and week 34 in the summer is the lowest demand for water heating. Figure 4 and 5 display annual water heater emissions and savings per week for water heaters with efficiencies ranging from 90 to 95%. The CO_2 emissions are the dominating trends for both water heater types. The electric water heaters generate more CO_2 with the current Salt Lake City electricity grid. Emissions for NO_x, and SO_x appear in small amounts at the bottom of the graphs.

Table 1 – Water Heater Values

500 Gallon 95% Efficient Water Heater System Values for a Small Hotel in Salt Lake City			
Water Heater Type	Water Heater Output	Value	Unit
Natural Gas	Annual Energy Consumption	577.095	MBTU
Resistance Electric	Annual Energy Consumption	577.095	MBTU
Natural Gas	Annual Emitted CO_2	65,473	lbs
Resistance Electric	Annual Emitted CO_2	137,903	lbs
Natural Gas	Annual Emitted NO_x	1.23	lbs
Resistance Electric	Annual Emitted NO_x	235	lbs
Natural Gas	Annual Emitted SO_x	0.34	lbs
Resistance Electric	Annual Emitted SO_x	193	lbs
Natural Gas	Annual Energy Consumption Savings Comparing Efficiencies 95% and 90%	19.028	MBTU
Resistance Electric	Annual Energy Consumption Savings Comparing Efficiencies 95% and 90%	19.028	MBTU
Natural Gas	Annual Emitted CO_2 Savings Comparing Efficiencies 95% and 90%	2225.80	lbs
Resistance Electric	Annual Emitted CO_2 Savings Comparing Efficiencies 95% and 90%	4580.21	lbs
Natural Gas	Annual Emitted NO_x Savings Comparing Efficiencies 95% and 90%	0.042	lbs
Resistance Electric	Annual Emitted NO_x Savings Comparing Efficiencies 95% and 90%	7.79	lbs
Natural Gas	Annual Emitted SO_x Savings Comparing Efficiencies 95% and 90%	0.011	lbs
Resistance Electric	Annual Emitted SO_x Savings Comparing Efficiencies 95% and 90%	6.38	lbs

Figure 2 & 3 – Annual Water Heater Energy Consumption and Savings Per Week



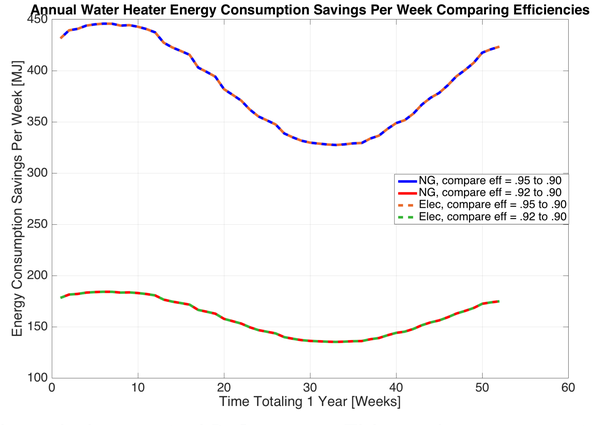
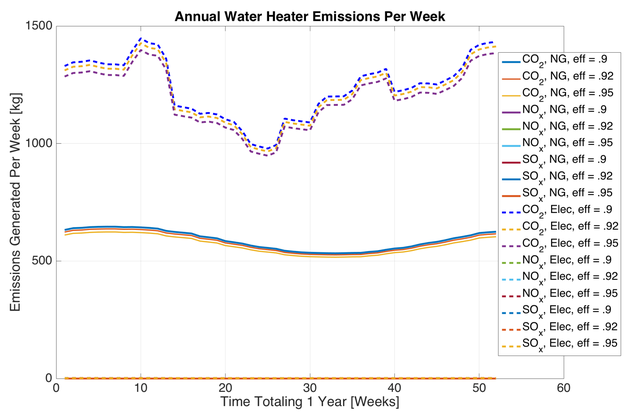
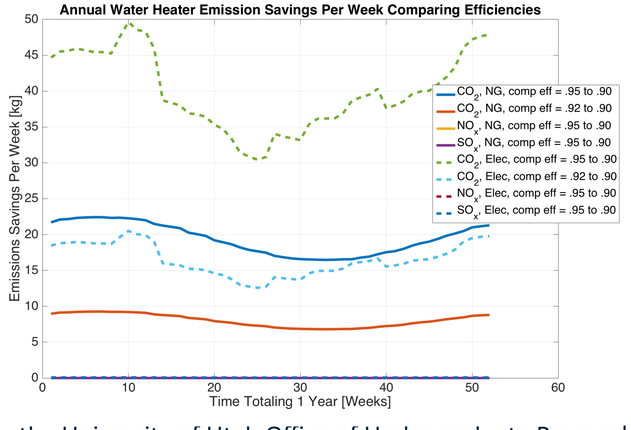


Figure 4 & 5 – Annual Water Heater Emissions Generated and Saved Per Week





IV. Conclusions

A case-by-case basis is the best way to correctly size the right equipment for a buildings hot water demand. The graphs demonstrate for both water heater fuel sources types an increase of thermal efficiency, decreases the energy consumption, decreases the emissions, and increases the energy and emission savings. The water heaters CO_2 emissions are relatively high compared to NO_x, and SO_x emissions. Electric resistance water heaters produce more CO_2 with the current electricity grid. Increasing the efficiency of an electric resistance water heater has a larger effect of reducing CO_2 emissions compared to a natural gas. Electric water heaters give the option for building electrification.

V. Future Work

Model hybrid tank water heater equipment with EnergyPlus. Utilize real building water heater energy usage to perform calculations for estimate implications of water heater choices.

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Nicholas Malinowski
University of Utah
Mechanical Engineering
malinowski.nicholas@gmail.com