**Building Science Education Solution Center – Introduction to Heat Pump Water Heaters**

Proficiency Level 3: Apply

**Learning Objective 3.1:**

* Compute calculations for energy savings from HPWHs

**Lecture Notes 3.1:**

# References:

ENERGY STAR. *Energy Star Ask Experts: When Should You Replace Your Water Heater*. n.d. 2022. <https://www.energystar.gov/products/ask-the-experts/when-should-you-replace-your-water-heater>.

**How to Calculate Yearly Operational Costs**  
In order to determine the economic benefits of installing a HPWH, the average annual operating cost should be considered. When comparing the average annual cost of operating a water heater, prospective buyers should consider two things: the energy factor of the water heater and the fuel source cost powering the water heater. The higher the energy factor displayed on the yellow label is, the more efficient the water heater is. Additionally, customers should consider size and first hour rating. To estimate the yearly cost of operating a unit, the Uniform Energy factor (displayed on the yellow energy label) is multiplied by the fuel type and current price rates (this information can be provided by local utility providers). Then the total cost should be extrapolated for the entirety of a year (365 days) to understand the annual cost. A simplified form of how to determine the yearly operating cost is found in Equation 1.

Equation 1 :

**Calculation Examples**  
Below are three examples. These examples include gas or oil water heaters, conventional electric water heaters, and heat pump water heaters. The energy usage per day in the below equations is based on the DOE test procedure for water heaters, which assumes an incoming water temperature of 58 °F, hot water temperature of 135 °F, and total hot water production of 64.3 gallons per day, which is the average usage for a household size of three people. This corresponds to and average energy us of ~41,000BTU/day (0.4 therms/day, or 12.03 kWh)

Other items to consider as well include rebates from utility suppliers and tax-based incentives from local, state, and federal government sources. Additional research based on individual local is needed for the consumer to identify potential rebates from incentives program.

**FOR CONVENTIONAL GAS AND OIL WATER HEATERS**

You need to know the unit cost of fuel[[1]](#footnote-2)

Example: A natural gas water heater with a UEF of 0.58 and a fuel cost of $1.82/therm 2

(The cost of natural gas on the Energy Label) = **$470 per year**

**FOR CONVENTIONAL ELECTRIC WATER HEATERS**

You need to know or convert the unit cost of electricity by kilowatt-hour (kWh)\*.

Example: A conventional electric water heater with a UEF of 1.0 and an electricity cost of $0.168/kWh 2

(This is the latest cost of electricity used on the Energy Label) = **$738 per year**

**FOR HEAT PUMP WATER HEATERS**

You need to know or convert the unit cost of electricity by kilowatt-hour (kWh).

Example: A heat pump water heater with a UEF of 4.0 and an electricity cost of

$0. /kWh 2

(This is the latest cost of electricity used on the Energy Label) = **$184 per year**

Assuming an initial purchase cost distribution of $500 for the conventional gas and oil water heater, $500 for the conventional electric water heater, and $1,500 for the HPWH, we can extend the total cost of each option over the course of 10 years of operation. An example is shown in Table 1.

**Initial Cost, and Yearly operation cost for different types of water heaters**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Conv. Gas and Oil | Conv. Electric | HPWH |
| Initial Cost ($) | 500 | 500 | 1500 |
| 1 Year | 970 | 1238 | 1684 |
| 5 Years | 2848 | 4188 | 2422 |
| 10 Years | 5196 | 7877 | 3344 |

Table 1: Initial Cost is the cost of purchase. 1 Year is the Initial Cost plus 1 Year of operation. 5 Years is Initial cost plus 5 years of operation. 10 Years is Initial cost plus 10 years of operation.

Problem Set 3.1

1. Calculate the estimated annual operational cost of a HPWH with a Uniform Energy Factor of 4.5. Assume a daily power usage of 13 kWh/day and an average electricity cost of 0.20 $/kWh.

1. *kWh = 3412.14 BTU - 12.03 kWh is an estimate energy usage per household*

   *therm = 100,000 BTU – 0.4105 therm is an estimated fuel usage per household*

   2 *Electricity cost and Fuel cost are the US National average costs for January 2023.* [Average energy prices for the United States, regions, census divisions, and selected metropolitan areas : Midwest Information Office : U.S. Bureau of Labor Statistics (bls.gov)](https://www.bls.gov/regions/midwest/data/averageenergyprices_selectedareas_table.htm) [↑](#footnote-ref-2)