Calculations for Water Heating Life Cycle Costs

This document explains the calculations used in the State of Hawaii Department of Business, Economic Development, and Tourism's "Water Heating Life Cycle Cost Comparison" worksheet.

The spreadsheet cells with formulae cannot be edited. Most of the inputs can be edited. Please note that although the "Lookup Tables" (see tab at bottom of LCCC worksheet) inputs can be modified, all modifications to the lookup table data must be stated on the LCCC worksheet in the "Comments" section at the bottom of page 2, and accompanied by:
(1) An explanation of the reason for the modification, and
(2) The source of the new data. All sources must be current at the time of submission and publicly available.

Please put the above explanation and sources in the "Comments" box near the bottom of page 2 of the LCCC worksheet.

The basic formula for annualized fixed cost is:
(equipment cost – rebates and tax credits) / equipment life

The basic formula for annual operating costs is: amount of energy needed to heat water*cost of energy. The amount of water is determined by the number of people in the household. The amount of energy needed to heat water accounts for efficiencies in energy transfer for electricity and gas in the input, as calculated by the Department of Energy (see link in spreadsheet). The operating cost calculation also utilizes solar fraction calculations for solar water heating, and the Heat Pump COP for heat pump calculations when appropriate. The operating cost for solar water heating accounts for maintenance.

Variable list

Variable	Cell reference
Number of people in household	B15
Island	selective box located at cell B16
Installation cost (dollars) for solar water heater	B18
30% federal income tax credit (dollars) for solar water heater, if eligible	B19
Energy Factor (percent)	B20
Estimated life (years) of the solar water heater	B21
Solar Savings Fraction (percent)	B22
Requested variance technology	selective box located at cell B23
Installation cost (dollars) for requested variance technology (dollars)	B24
Rebates and tax credits (dollars) for requested variance technology, if any	B25
Energy Factor (percent) for requested variance technology	B26
Estimated life (years) for requested variance technology	B27
COP (Coefficient of Performance) (percent) (heat pump only)	B28

Water Heater Costs Calculations (annualized)

Outputs:	**Formulae:**
Solar	
Solar Fixed Cost	(Installation Cost, Solar Water Heater – tax credit, Solar Water Heater, if eligible) / Estimated Technology Life, Solar
Solar Operating Cost	[Estimated Annual Hot Water Use, Number of People * Energy to heat water, Electric * (1 – Solar Savings Fraction) * Energy Rate kWh, island specific] / Solar Energy Factor + [(Installation Costs, Solar Water Heater * .10) / Estimated Technology Life, Solar]
Total Solar Cost	Solar Fixed Cost + Solar Operating Cost
Heat Pump	
Heat Pump Fixed Cost	(Installation Cost, Heat Pump – rebate and tax credits, Heat Pump) / Estimated Technology Life, Heat Pump
Heat Pump Operating Cost	Estimated Annual Hot Water Use, Number of People * Energy to heat water, Electric * (Energy Rate per kWh, island-specific / Heat Pump Energy Factor / Heat Pump COP)
Total Heat Pump Cost	Heat Pump Fixed Costs + Heat Pump Operating Cost
Gas with Tank	
Gas with Tank Fixed Cost	(Installation Costs, gas with tank – rebate and tax credits, gas with tank) / Estimated Technology Life, gas with tank
Gas with Tank Operating Cost	Estimated Annual Hot Water Use, Number of People * Energy to heat water, Gas * Energy Rate in Therm, island-specific / Energy Factor
Total Gas with Tank Cost	Gas with Tank Fixed Costs + Gas with Tank Operating Cost
Gas Tankless	
Gas Tankless Fixed Cost	(Installation Cost, gas tankless – rebate and tax credits, gas tankless) / Estimated Technology Life, gas tankless
Gas Tankless Operating Cost	Estimated Annual Hot Water Use, Number of People * Energy to heat water, gas tankless * Energy Rate in Therm, island-specific/Energy Factor
Total Gas Tankless Cost	Gas Tankless Fixed Costs + Gas Tankless Operating Costs
Electric Resistance Water Heater	
Electric RWH Fixed Cost	(Installation Costs, electric resistance water heater – rebate and tax credits, electric resistance water heater) / Estimated Technology Life, electric resistance water heater
Electric RWH Operating Cost	Estimated Annual Hot Water Use, Number of People * Energy to heat water, Electric * Energy Rate per kWh, island-specific / Energy Factor
Total Electric RWH Cost	Electric RWH Fixed Costs + Electric RWH Operating Costs

Water Heating Life Cycle Cost Comparison (LCCC), Annualized

For use if Option #1 or #3 is selected on the form for a variance (exemption) from mandated solar water heater installation on a new single-family dwelling.

Option #1 is selected if the installation of a solar water heater is impracticable due to poor solar resource; and/or installation is cost-prohibitive based upon a life cycle cost-benefit analysis that incorporates the average residential utility bill and the cost of the new solar water heater system with a life cycle that does not exceed 15 years (Hawaii Revised Statutes, §196-6.5).

Option #3 is for installation of a demand water heater device approved by Underwriters Laboratories, Inc., provided that at least one other gas appliance is installed in the dwelling. For the purposes of this paragraph, "demand water heater" means a gas-tankless instantaneous water heater that provides hot water only as it is needed (Hawaii Revised Statutes §196-6.5).

For a solar water heater variance request to be approved, this LCCC must be completed by a Hawaii licensed mechanical engineer or architect and show that the total annualized water heater cost of a solar water heater is more than the device (listed below) that you want to install.

Instructions:

Step 1: Fill out the bold red box below with (1) Household information; (2) Island; (3) Cost of a solar water heater and applicable 30 percent federal income tax credit (total cost of SWH installation x .3), Energy Factor, estimated life, and Solar Savings Fraction of dwelling location; and (4) Requested technology type, installation cost, tax credit and rebate (if any), Energy Factor, and estimated life of the water heater device that you want to install. If you are comparing a heat pump to a solar water heater, please also enter the heat pump Coefficient of Performance (COP)(300 percent for State of Hawaii). **The State Energy Office may ask for verification of price quotes for installation and rebate costs.**

Optional: Default values of the relevant variables are from the "Lookup Tables" tab below. Any modifications to the default values will affect Outputs listed on page 2. Modifications must be explained in the Comments box on page 2, along with the source of the new data. All sources must be current and publicly available.

Step 2: Complete the identifying information on page 2.

Step 3: Submit PDF or print of the signed and stamped analysis with the variance request.

Inputs:

	Entered values	Default values
Number of people in household	4	
Island	Hawaii	
Solar Water Heater:		
Installation cost (dollars)		
30% fed. income tax credit (dollars)		0
Energy Factor (percent)		92%
Estimated life (years)		15
Solar Savings Fraction (percent)		90%
Requested Variance Technology	Heat Pump	
Installation cost (dollars)		
Rebate/tax credit (if any, dollars)	-	
Energy Factor (percent)		92%
Estimated life (years):		15
COP (percent)(heat pump only)	300%	300%

Outputs:

Water heater costs (annualized):

Solar Water Heater	
Annual fixed cost (dollars)	#DIV/0!
Annual operating cost (dollars)	#DIV/0!
Annual total cost (dollars)	#DIV/0!
Electric Resistance water heater	
Annual fixed cost (dollars)	$ -
Annual operating cost (dollars)	$ -
Annual total cost (dollars)	$ -
Gas with tank water heater	
Annual fixed cost (dollars)	$ -
Annual operating cost (dollars)	$ -
Annual total cost (dollars)	$ -
Gas Tankless water heater	
Annual fixed cost (dollars)	$ -
Annual operating cost (dollars)	$ -
Annual total cost (dollars)	$ -
Heat Pump water heater	
Annual fixed cost (dollars)	#DIV/0!
Annual operating cost (dollars)	#DIV/0!
Annual total cost (dollars)	#DIV/0!

Identifying Information:

Analysis performed FOR (Name): _____

Address of Home: _____

Tax Map Key: _____

County Bldg. Permit Appl. No.: _____

Date: _____

Analysis* performed BY (Name): _____

Signature: _____

Business Address: _____

Phone: _____

**Analysis must be performed by an engineer or architect licensed under HRS Chapter 464*

Comments:

(Professional Stamp)

Lookup Tables

Estimated Hot Water Use

Number of people	gallons/year*
1	5,475
2	10,950
3	16,425
4	20,075
5	23,725
6	27,375
7	31,025
8	34,675
9	38,325
10	41,975
11	45,625
12	49,275
13	52,925
14	56,575
15	60,225
16	63,875

Island	Energy Rates	
	dollar/kWh	dollar/therm
Hawaii	0.317	4.73
Kauai	0.350	4.74
Lanai	0.339	5.07
Maui	0.286	3.88
Molokai	0.336	4.38
Oahu	0.268	4.70

Technology	Estimated Technology Life (years)	Energy Factor (%)	Solar Savings Fraction (%)	Coefficient of Performance (COP) (%)
Electric Resistance	12	92%		
Gas with Tank	12	61%		
Gas Tankless	12	82%		
Heat Pump	15	92%		300%
Solar	15	92%	90%	

Parameters for calculations

Estimated Hot Water Use (gallons/year)	20,075
Energy Rates	
Electric (dollar/kWh)	0.317
Gas (dollar/therm)	4.73
Energy to heat water:	
Electric (kWh/gallon)	0.142
Gas (therm/gallon)	0.00485

Notes: 1. According to USDOE, 12.03 kWh or 0.41045 therms are needed to heat 64.3 gallons of water from 58F to 135F. Thus, 0.187 kWh or 0.00638 therms are needed to heat 1 gallon of water. <https://www.energy.gov/energysaver/estimating-costs-and-efficiency-storage-demand-and-heat-pump-water-heaters>. Hawaii's groundwater temperature ranges from 68.36F to 84.56F, i.e., the mean value is 76.5F. The energy needed to heat 1 gallon water is 76% of the numbers above: 0.187x 0.76 = 0.142 kWh; 0.00638x0.76 = 0.00485 therms. <https://pubs.er.usgs.gov/publication/ofr20181147>. **2. Energy Factor** is based on the amount of hot water produced per unit of fuel consumed. Default values are from <https://www.energy.gov/eere/femp/energy-cost-calculator-electric-and-gas-water-heaters-0>.
3. Solar Savings Fraction is energy savings from solar water heating. 90% was used in the previous version of the model, but can be modified by the applicant.
4. The **coefficient of performance (COP)** is the ratio of the heating or cooling output to the energy input to run the heat pump. According to a Pierre Delforge study in 2017, Hawaii's COP is 3.0. In this LCCC, the COP is converted to a percentage (300 percent). <https://aceee.org/sites/default/files/pdf/conferences/hwf/2017/Delforge_Session4B_HWF17_2.28.17.pdf>.

* "Gallons per Year" from Hawaii Energy's "Solar Water Heating Program Handbook"

June 1, 2019