Explanation of Calculations for Water Heating Life Cycle Costs
(REVISED 3-13-2013)

1. Formulae for calculations

These formulae are embedded in the spreadsheet ("SWH LCC Comparison templ") provided to compare life cycle costs of various methods of water heating in Hawaii. The spreadsheet is intended for use with requests for variances from the mandated installation of solar water heaters on new residences. It can, however, be used by any consumer who wishes to compare life cycle costs prior to investing in a water heater.

For those users who have Excel software, the values will compute automatically as you fill in the green cells; this explanation is not needed to complete the LCC. However, for users who do not use a computer and instead print out the spreadsheet to perform the calculations manually, this explanation of the formulae will assist in the accurate computation of the life cycle costs.

Each formula is identified by the cell in which it appears; for instance, cell A1 would be the cell located in column A and row 1.

Assumptions

G15, "Total gallons of hot water needed per day" =G13*G14
G23, "Equivalent non-utility gas cost, $/therm" = G22/0.96

Solar Water Heater

E30, "solar savings fraction, %" = G16: The default value is 90, as a properly oriented and sized solar water heater in Hawaii, which is exposed to sunshine from 9 a.m. to 3 p.m., is assumed to be able to provide an average of 90% of the hot water used by the household. A "solar day" is 9 a.m. to 3 p.m.; shading outside of those hours is assumed not to affect the solar water heater's functioning, since very little heat is acquired in the early morning or late afternoon hours. If your building experiences shading, the number entered in this cell should reflect the amount of shading. For instance, if your solar collector will be shaded 20% of the time between 9 a.m. and 3 p.m., enter 72 instead of 90 (20% of 90 is 18; subtract 18 from 90 to get 72). In another example, if your solar collector will be shaded 50% of the hours between 9 a.m. and 3 p.m., enter 45 (half of 90). Shading could be caused by trees, neighboring structures, or mountains. Do not try to account for cloud cover as "shading." Cloud cover is taken into account when your system is sized.

E31, "electricity consumption, kWh/yr" = G17*(100-E30)/100
E32, "residential electric utility rate, $/kWh" = G20 [filled in by user with current rate]
E33, "annual electricity cost, $/year" = E31*E32
E35, "lifetime electricity cost, $" = E33*E34
E36, "total gallons of hot water needed per day" = G15 [filled in by user]
E41, "applicable federal tax credit, $" = 0.3*E38
E42, "total initial installed cost of solar water heater, $" = E38-E39-E40-E41
E43, "Maintenance at 10%, $" = E38*0.1
E44, "lifetime solar water heater cost, $" = E42+E43
E45, "Total Life Cycle Costs (LCC), $" = E44+E35

Heat Pump Water Heater

E52, "electricity consumption, kWh/year" = G17-(G17*0.3)
E53, "residential electric utility rate, $/kWh" = G20 [filled in by user]
E54, "annual electricity cost, $/year" = E52*E53

E56, “lifetime electricity cost, $” = E54*E55
E61, “total initial installed cost of heater, $” = E58+E59-E60
E62, “inflation rate” = G19 [filled in by user]
E63, “replace heat pump unit at 8 years, $” = E61*POWER(1+E62,8)
E64, “replace electric water heater once, $” = E58*POWER(1+E62,12)
E65, “lifetime water heater cost, $” = E61+E63+E64
E66, “Total Life Cycle Costs (LCC), $” =E65+E56

Electric Resistance Water Heater
E72, “electricity consumption, kWh/year” = G17 [filled in by user]
E73, “residential electric utility rate, $/kWh” = G20 [filled in by user]
E74, “annual electricity cost, $/year” = E72*E73
E76, “lifetime electricity cost, yr” = E74*E75
E80, “total initial installed cost of water heater, $” = E78-E79
E81, “inflation rate” = G19 [filled in by user]
E82, “replace water heater once, $” = E78*POWER(1+E81,12)
E83, “lifetime electric heater cost, $” = E82+E80
E84, “Total Life Cycle Costs (LCC), $” = E83+E76

Gas Water Heater
E92, “gas consumption, therms/year” = G18 [filled in by user]
E93, “gas utility rate, $/therm” = G21 [filled in by user]
E94, “gas non-utility cost, $/therm” = G23 [filled in by user]
E96, “annual gas cost, $/year” = E92*E95
E98, “lifetime gas cost, $” = E96*E97
E104, “installed cost of water heater, $” = E100+E101+E102-E103 [NOTE: read comment to adjust if this is not a new installation; connection charges will vary]
E105, “inflation rate” = G19 [filled in by user]
E106, “replace water heater once, $” = (E104-E100-200)*POWER(1+E105,12)
E107, “lifetime gas heater cost, $” = E106+E104
E108, “Total Life Cycle Costs (LCC), $” = E107+E98

2. Comments on Specified Cells

Users who print out the spreadsheet instead of opening it on a computer with Excel software will not be able to access the pop-up comments on specific cells. Those comments are reproduced here for the convenience of users who are doing the calculations manually.

For those using Excel, the cells with comments are marked with small, red triangles. Pointing to those cells with the cursor will open the comment.

Assumptions:
E14: Hot water use ranges from 15-25 gallons per person today in Hawaii. Source: ""A Home-Owner's Guide to Solar Water Heating with Oahu Sunshine Map," published by DBEDT.
E 16: A properly sized solar water heating system can provide 90% of a household's estimated annual hot water demand. Source: "A Home-Owner's Guide to Solar Water Heating with Oahu Sunshine Map," published by DBEDT.
E 17: A conventional electric water heater in a four-person household uses an estimated 260 kWh/mo, or 3120 kWh/yr. Source: "Energy Tips & Choices," published by HECO.

E 18: Typical 4-person household may use approximately 10 therms per month to heat water. Source: Gas Company Customer Services, 2/09

E 19: Annual Hawaii inflation rate (CPI-U) for 2008 was estimated to be 4.2%, according to DBEDT statistics. To obtain current forecasts of inflation (CPI), go to the quarterly statistical and economic reports on DBEDT's website: http://hawaii.gov/dbedt/info/economic/data_reports/info/economic/data_reports/qser/outlook-economy

E 20: The amount paid by utility customers for electricity varies with the fuel adjustment, and in 2008 ranged from roughly $0.25 to $0.50 per kWh depending on the island. Check with your utility for current figures.

E 21: Gas utility residential rates per therm as of 2/6/09: Oahu--$2.89, Big Island--$3.88, Maui--$3.11, Kauai--$3.54. Source: The Gas Company.

E 22: Propane cost in Hilo in January 2009 was appx. $4.25/gal.

E 23: One gallon of propane contains 0.96 therms of energy (a therm is 100,000 Btu)

E 26: Heat pump dealers have found that simple maintenance, such as washing or replacing the inexpensive filter on the heat pump, will extend the life of the heat pump well beyond 8 years, to approximately the same as the tank or longer. Also, tank life can be affected by installation location (it will rust sooner in an exposed outdoor location.) Source: AirCond Hawaii, 2/09.

Solar water heater:

E31: HECO estimates that solar water heaters that are well designed and properly sized can reduce water heating costs by 80-90% (Source "Energy Tips & Choices"); the estimated energy use for solar water heating for a family of 4 is 26 kWh/mo, or 312 kWh/yr.

E37: Solar water heating tanks typically come in 80 gallon and 120 gallon sizes. Storage tanks should be larger than daily use to carry through nights and cloudy days. Round the number given in the line above up to either 80 or 120. A larger tank is advisable for cloudier areas and families with heavy hot water use. A tank which is too small will result in higher electricity costs for back-up. Tank size will affect system price. In Feb. 2009, an 80-gallon system for a 4-person family might run $5-6,000; a 120-gallon system for the same family might run $6-7,000. Source: InterIsland Solar Supply 2/09.

E38: Enter a quote from a solar water heating dealer/installer. It's a good idea to get quotes from three licensed solar businesses. The cost will reflect the size of the system (collectors and tank), and installation costs which may be specific to your home. $5,500 is a median figure for a system with an 80 gallon tank in Hawaii.

E39: No rebates apply to mandated solar water heaters on new construction

E40: No state tax credits apply to mandated solar water heaters on new construction

E41: Federal tax credits do apply to mandated solar water heaters. The federal residential tax credit is 30% of the installed cost without a cap. The equipment must meet certain standards. Please get details from the IRS.

Heat pump water heater:

E51: DBEDT recommends a heat pump with a coefficient of performance (COP) of 2.7 or higher. Source: "Hawaii Homeowner's Guide to Energy, Comfort & Value," published by DBEDT. Heat pumps accepted by the utilities' residential efficient water heating program had COPs above 3.

E52: Heat pump water heaters can reduce water heating costs by approximately 30%. The estimated energy use for a heat pump used by a family of 4 is 180 kWh/mo. Source: "Energy Tips and Choices," published by HECO.

E57: According to HECO, water heaters should be sized as follows:

1-2 people--40-52 gal
3-4 people--50-66 gal
5 people--66-82 gal
6-8 people--82-120 gal

The price will vary with the size. Source: HECO Residential Efficient Water Heating Program "Heat Pump Water Heater Guidelines for Participation."

E58: At least one heat pump company feels that a high-efficiency electric resistance water heater is not necessary for heat pump hot water storage, and installation costs are included with the heat pump installation. Source: AirCond Hawaii 2/09. Another heat pump company recommends a large (70-80 gallon) electric water heater tank to accommodate the heat pump, since it produces heat more slowly; the cost might be $1000 without installation. Source: HECO, 2/09. It is recommended that you obtain 3 quotes from licensed dealers/installers.

E59: An E-Tech R106K5 heat pump, COP 3.2, costs about $2100, and labor to install the heat pump (alone or with the electric resistance heater tank) is about $300. Source: AirCond Hawaii, 2/09. An alternative quote on Oahu was $1500 for heat pump equipment, not including installation. Source: HECO 2/09. It is recommended that you obtain 3 quotes from licensed dealers/installers.

Electric resistance water heater:

E77: According to HECO, water heaters should be sized as follows:

1-2 people--40-52 gal
3-4 people--50-66 gal
5 people--66-82 gal
6-8 people--82-120 gal

The price will vary with the size. Source: HECO Residential Efficient Water Heating Program "Heat Pump Water Heater Guidelines for Participation."

E78: Price will vary. A 50-gallon water heater with an efficiency factor of 0.91 might cost $450. A 50-gallon water heater with an efficiency factor of 0.94 might cost $525 but will save electricity costs because it is more efficient. Installation in new construction might be approximately $400. Source: InterIsland Solar Supply, 2/09.

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