

User Guide

Heat Pump Program Impact Excel Tool

By Taylor Briglio, Lily Eunhee Lee, Erica Petrofsky, Cooper
Tamayo, and Symphony Yu and advised by Mark Buntaine, PhD
Bren School of Environmental Science & Management, University of
California, Santa Barbara | June 2018

www.ccetoolkit.weebly.com



Table of Contents

Tool Overview	3
Using the Tool	3
Worksheet Details	3
Interface	4
Inputs	4
Outputs	5
References	7

Tool Overview

This is a tool meant to help Community Choice Energy agencies predict impacts of increasing the adoption of residential heat pumps. It does not have the consumer demand prediction power of the other tools in this toolkit, so users will need to estimate the number of heat pump installations or use this tool to evaluate the success of completed programs. Based on a variety of program and agency specifications, the model predicts the associated (GHG) emissions reductions, health impacts, and changes to agency revenue from installing heat pumps.

Using the Tool

To use the tool, users will interact with the Interface worksheet, which contains all of the user inputs and resulting outputs. At a minimum, users will need to enter values into the Basic Agency and Program Information section and the agency's energy mix. The Basic Agency and Program Information section includes: retail electricity generation rate, percent net revenue from electricity sales, expected number of heat pumps installed, the agency's financial discount rate, the societal discount rate. There are a variety of additional inputs that allow users to add further program specifications as appropriate. A detailed explanation of all available input options is included in the Interface section of this user guide.

Once the user has filled in the appropriate inputs and run the model, the Primary Outputs section of the Interface will display a summary of model predictions. These include: annual net revenue from electricity sales, net present value of revenue from electricity sales, total lifetime anthropogenic GHG emissions avoided, total lifetime biogenic GHG emissions avoided, societal net present value of GHG emissions avoided, and health benefits. A detailed explanation of all outputs is included under the Outputs heading in the Interface section of this user guide.

The number of heat pumps installed is used to calculate the benefits associated with the program. GHG and pollutant emissions from these devices are compared to the emissions from a typical residential natural gas fired furnace. This difference in emissions is then converted into GHG and health impacts and reported in the model outputs.

Worksheet Details

The tool contains three worksheets: Interface, Calculations, and Data.

Interface: This is the worksheet with which users interact to use the tool.

Calculations: This worksheet contains all of the calculations determining the quantity of emissions, their societal impacts, and changes in net revenue to the agency.

Data: This worksheet contains the background data that the model uses to determine emission impacts. It includes:

- GHG emission factors of different electricity sources
- Criteria pollutant emission factors of different electricity sources
- Estimates of the value of reducing criteria pollutants
- NOx standards
- Unit conversions used throughout the model

Interface

To use the tool, at minimum users will need to enter the relevant information in the Basic Agency and Program Information section and the Energy Mix, detailed below. This will produce predicted results based on the user's Primary Inputs and the model's default values for all remaining input categories.

Additional inputs are organized into Additional Agency, Energy, and Program Information section. These are provided with default values, but can be altered to suit the needs of the user. The following Inputs section details all available inputs and their uses.

Model outputs are organized into two categories: Monetized Values and GHG and Health Effects. The Outputs section contains a detailed explanation of the outputs.

Inputs

Basic Energy and Program Information

These inputs represent the minimum amount of information necessary to use the tool.

- **Retail electricity generation rate (\$/kWh):** Electricity rate the agency charges its customers.
- **Percent net revenue from electricity sales (%):** The percentage of electricity sales that goes to revenues.
- **Expected heat pumps installed:** The number of heat pumps expected to be installed as the result of the program. If using the tool as a post-impact analysis tool, input the actual number of heat pumps installed.
- **Agency's discount rate:** The agency's discount rate when making investment decisions.
- **Societal discount rate:** Discount rate societies apply to future environmental and health benefits. A default value of 5% is used.

Energy mix

These inputs are also required to run the tool. They specify the composition of the energy mix that is used to power heat pumps, and are used to calculate criteria pollutants, anthropogenic GHG emissions and biogenic GHG emissions.

Additional Agency, Energy, and Program Information

These inputs represent additional information used to calculate the benefits and impacts from running the heat pump program. All of these inputs have recommended defaults. They can be changed as appropriate based on agency specific information.

- **Transmission losses:** This input accounts for electricity losses during transmission from the electricity source to the vehicle. The default value is set at 4.23%, representing the California average transmission losses, according to the USEPA (USEPA, 2018).

- **Cost of Carbon:** The monetary value given to an avoided ton of CO_{2e} emissions. The default value is \$13/ton, based on the 2016 California market trading rate for CO_{2e}.
- **Rebound effect:** This input accounts for the tendency for individuals to increase their usage of more efficient appliances. The default value is set at 0% because the default energy used per heat pump is based on actual total energy use and already incorporates any rebound effect. A rebound effect should be considered if the default energy usage is changed to manufacturer estimated energy use. Studies have shown that rebound effects can be as high as 20% (Gram-Hanssen et al. 2012).
- **Average space heating requirement (BTU/yr):** The amount of heating the typical residence uses over a year. A default of 23,590,814 BTU/yr is used based on the average heating load that natural gas furnaces provide in California homes from the 2009 Residential Energy Consumption Survey (RECS 2009).
- **Average annual heat pump energy usage (kWh/yr):** The annual quantity of electricity heat pumps use in kWh/yr. A default of 1,986 kWh/yr is used based on the average heat pump energy usage in California from the 2009 Residential Energy Consumption Survey (RECS 2009).
- **Expected Heat Pump Lifetime:** The expected useful lifetime of the installed heat pump, in years. A default of 15 is used based on current averages recommended by manufacturers. The tool can accommodate values between 1 and 30.
- **Emission limit of gas furnaces replaced:** The emission rating of the replaced natural gas furnace. The user may select between 40 ng/J or 14 ng/J. We recommend users use the 40 ng/J limit because California residential natural gas furnaces historically had to meet the 40 ng/J emission limit. South Coast Air Quality Management District and San Joaquin Valley Air Management District have decreased the limits to 14 ng/J over the past couple of years. It is unlikely that these newer units will be replaced through an agency's heat pump program; therefore, it is recommended to stay with the 40 ng/J limit.
- **Average heat content of natural gas (BTU/cf):** The quality of natural gas supplied to California in BTU/cf. 1,035 is used as a default based on the 2016 average from the US Energy Information Administration (USEIA 2018).
- **Health impact level:** Users can select High, Mid, or Low which adjusts the level of impact from the criteria pollutants. The default is set to the middle value. We recommend that highly urbanized areas use a high impact to reflect the impact caused to more people. We recommend that more rural agencies use the low impact.

Outputs

Monetized Values

These include a summary of the main results of the model's calculations that relate to financial impacts to the agency from running the program.

- **Annual net revenue from electricity sales (\$):** The net revenue generated each year from additional electricity sales associated by running heat pumps.

- **Net present value of revenue from additional electricity sales (\$):** The present value of net revenue generated from additional electricity sales associated by running the heat pumps over the expected useful lifetime of the equipment.

GHG and Health Impacts

These include a summary of the main results of the model's calculations that relate to public benefits of running the program.

- **Total Anthropogenic Lifetime GHG emissions avoided:** Predicted anthropogenic GHG emissions avoided by the program over the expected lifetime of the heat pumps, in tons of CO₂e.
- **Total Biogenic Lifetime GHG emission:** If the agency uses biomass in its electricity mix, this reports the quantity of biogenic CO₂e emissions from powering the heat pumps.
- **Present value of GHG emission reductions (\$):** Predicted present value in societal benefits from reducing GHG emissions associated with running heat pumps instead of natural gas furnaces over the lifetime of the equipment.
- **Present value of Health improvements (\$):** Predicted present value in changes to public health from the change in criteria pollutants associated with running heat pumps instead of natural gas furnaces over the lifetime of the equipment. Note that biomass in an agency's electricity mix will likely make this negative due to the high quantity of particulate matter generated from biomass burning relative to other sources.

References

Residential Energy Consumer Survey (RECS). 2009 RECS Survey Data. (2013). Retrieved February 20, 2018, from

<https://www.eia.gov/consumption/residential/data/2009/index.php?view=consumption>

Gram-Hanssen, K., Christensen, T. H., & Petersen, P. E. (2012). Air-to-air heat pumps in real-life use: Are potential savings achieved or are they transformed into increased comfort?. *Energy and Buildings*, 53, 64-73.

USEIA. (2018). Heat Content of Natural Gas Delivered to Consumers. Retrieved from

https://www.eia.gov/dnav/ng/ng_cons_heat_a_EPG0_VGTH_btucf_a.htm

USEPA. (2018, March 13). Emissions & Generation Resource Integrated Database (eGRID).

Retrieved from <https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid>