Calculating water heating energy demand within the Home Energy Model

A technical explanation of the methodology

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Acknowledgements

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Contents

Background to the Home Energy Model

What is the Home Energy Model?

The Home Energy Model (HEM) is a calculation methodology designed to assess the energy performance of homes, which will replace the government's Standard Assessment Procedure (SAP).

The Home Energy Model is still under development and its first version will be implemented alongside the Future Homes Standard (FHS) in 2025. We are publishing information about the model while it is still at a formative stage to enable industry to participate in the ongoing development process.

Where can I find more information?

This document is part of a wider package of material relating to the Home Energy Model:

Home Energy Model technical documentation (e.g. this document)

What: This document is one of a suite of technical documents, which go into further detail on the methodology and the validation exercises that have been carried out. We intend to update and produce further technical documentation throughout the model development process.

Audience: The technical documentation will be of interest to those who want to understand the detail of how the Home Energy Model works and how different technologies are treated.

The Home Energy Model consultation

What: The Home Energy Model consultation, which explains the overhaul to the SAP methodology and seeks views on the approach taken by the new Home Energy Model.

Audience: The Home Energy Model consultation will be of interest to those who want to understand the proposed changes to the SAP methodology and wider SAP landscape.

The Home Energy Model reference code

What: The full Python source code for the Home Energy Model and the Home Energy Model: FHS assessment has been published as a Git repository. This code is identical to that sitting behind the consultation tool. We are currently considering whether the open-source code could serve as the approved methodology for regulatory uses of the Home Energy Model.

Audience: The reference code will be of interest to those who want to understand how the model has been implemented in code, and those wishing to fully clarify their understanding of the new methodology. It will also be of interest to any potential contributors to the Home Energy Model.

Related content

This document provides an overall description of the calculation of energy demand for water heating in the core Home Energy Model. For information on how the list of hot water draw-off events is constructed within the FHS assessment wrapper, see HEMFHS-TP-03 FHS domestic hot water assumptions.

To understand how this methodology has been implemented in computer code, please see:

src/core/project.py

src/core/water_heating_demand/shower.py

src/core/water_heating_demand/bath.py

src/core/water_heating_demand/other_hot_water_uses.py

src/core/heating_system/point_of_use.py

src/core/heating_system/storage_tank.py

src/core/heating_system/wwhrs.py

Methodology

1. Hot water demand

The calculation of the energy required to heat domestic hot water can be described as a series of steps:

1. A list of hot water draw-off events for each tapping point is provided to the core Home Energy Model (HEM) as part of the input data; these events may be user-specified or come from a schedule defined in a wrapper. Tapping points are divided into showers, baths and other tapping points. Each event specifies the demand for hot water at the tapping point, with the desired output temperature:
    a. for showers, the desired temperature and duration,
    b. for baths, the desired temperature and volume
    c. for other events, the desired temperature and duration.
2. Hot water use for showers is calculated, based on temperature and duration of shower events in events schedule input.
    a. For mixer showers, a constant flow rate is assumed (this is part of the shower specification in the inputs) to calculate the volume of warm water and then the volume of hot water required. The hot water use is added to the total hot water demand, accounting for any saving due to instantaneous waste water heat recovery. Losses from water flowing through distribution pipework are also added to the hot water demand.
    b. For instantaneous electric showers, a constant power output is assumed and the flow rate is adjusted so that water flows at the desired temperature. No additional demand is added to the total hot water demand because it does not have to be satisfied by the main water heating system. Instead, the electricity consumption of the electric shower is calculated and added to the total electricity demand.
3. Hot water use for baths is calculated, based on bath size and temperature requirements from the events schedule input. Losses from water flowing through distribution pipework while the bath is being filled are also added to the hot water demand.
4. Hot water use for other tapping points is calculated, based on the flow rate of the tapping point and the temperature and duration of draw-off events in the events schedule input. Losses from water flowing through distribution pipework are also added to the hot water demand.
5. Losses due to hot water left standing in distribution pipework are then calculated and added to the total hot water demand and the total internal gains. It is assumed that all

the energy left in the distribution pipework is lost between draw-off events. See HEM-TP-10 Ductwork and pipework losses.

6. The total hot water demand calculated is then an input to the calculation of the energy provided by and used by the water heating system. This calculation will differ completely depending on the type of system providing hot water.

2. Water heating system

At present, the HEM is limited to having a single water heating system (plus instantaneous electric showers), although this can have several components (e.g., hot water cylinder heated by multiple heat sources). If instantaneous point of use water heaters are used then it is currently assumed they are used throughout the dwelling and all have the same efficiency.

Where an instantaneous water heating system is used (i.e., no tank) draw-offs are assumed to be provided directly by the heat generator. If instantaneous point of use water heaters are used then no distribution pipework should be entered into the model.

If a hot water tank is used to accumulate hot water, draw-offs are taken from the top layer of the hot water tank (or sequentially from lower layers if the top layer contains insufficient energy). The same volume of cold water is added to the lowest layer. The temperature of each layer is recalculated at each time step using the logic described in Method A from BS EN 15316-5:2017. See HEM-TP-11 Hot water storage tanks for further details on the storage tank inputs and methodology. Where hot water tanks are used there are several additional factors:

- Standing losses from the tank (based on daily loss from standard lab test as specified in the inputs).
- Where applicable, primary pipework losses are calculated and added to the required energy output from the heat generator to heat the tank.
- Where present, heat from a solar thermal system and/or PV diverter is added to the tank. See HEM-TP-18 PV generation and self-consumption for an explanation of diverters.

Taking into consideration the draw-offs, losses and heat input from other sources described above, the amount of energy required from the heat generator to reheat the tank is calculated. If the controls (e.g., timer) allow, the heat generator is assumed to output this amount of heat, subject to its maximum power output (domestic hot water production is assumed to take priority over space heating).

The efficiency of the heat generator is applied to the heat output required from it to calculate the amount of fuel used for water heating. The total hot water energy or fuel requirement for each time-step is summed to give the relevant totals required and written to the output files.

Future changes

The model is currently limited to a single water heating system (plus instantaneous electric showers), but future development effort could be put into allowing the model to handle more than one system. This would most likely require individual tapping points (showers, baths etc.) to be assigned to specific water heating systems in the user inputs.

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This publication is available from: https://www.gov.uk/government/publications/home-energy-model-technical-documentation