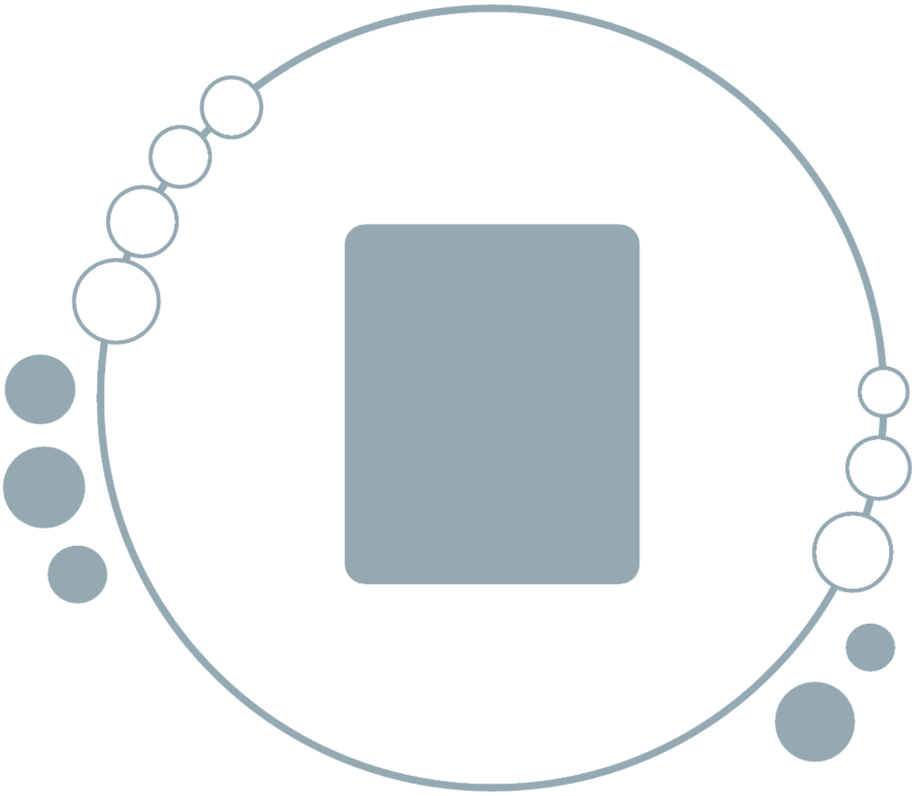

Modelling electric storage heaters and dry core heat batteries within the Home Energy Model

A technical explanation of the methodology

January 2026

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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).

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 explain the calculation methodology in detail. New documents will be added, and the content amended, when necessary to ensure documentation is sufficiently comprehensive. This will usually, but not always, occur alongside the release of a new version of HEM.

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 and government response

What: The Home Energy Model consultation introduces the overhaul to the SAP methodology and sought views on the approach taken by the new Home Energy Model. The Home Energy Model consultation summarises the feedback to the consultation and the actions taken subsequently in development, ahead of the initial release of HEM.

Audience: The Home Energy Model consultation will be of interest to those seeking a general introduction to HEM and its role in government policy on domestic energy performance.

The Home Energy Model reference code

What: The full Python source code for the Home Energy Model core engine has been published as a Git repository. Note the reference code for official HEM wrappers is published separately.

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 or those wishing to use it within their own projects.

Related content

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

src/hem_core/heating_systems/elec_storage_heater.py

src/hem_core/heating_systems/heat_battery_drycore.py

src/hem_core/heating_systems/heat_battery_pcm.py

Overview

Electric storage heaters are room heaters which typically use off-peak electricity to heat up a high thermal mass core, then release this heat later when space heating is required. Their use is long-established in the UK, and they have historically been a helpful technology in terms of smoothing the load on the national grid.

Similarly, dry core heat batteries contain a solid, high thermal mass core which retains thermal energy. However, rather than directly releasing heat during discharge, they contain an integrated heat exchange mechanism for transferring that energy to a separate working fluid. Such heat batteries act as a central heating system and can fulfil both space and water heating demand.

In either case, the main factors determining their performance are their storage capacity, their heat output, their ability to retain heat, and their ability to determine the correct amount of heat to store each night relative to the next day’s requirement. The Home Energy Model therefore uses a unified model for the heat output of both technologies (which we refer to as dry core thermal stores from here on). The additional complexities of the heat battery model are inherited from the phase change heat battery model.

This paper sets out the methodology used to determine the energy performance of dry core thermal storages and dry core heat batteries within the Home Energy Model core engine. It is simple compared to other areas of methodology, using a primarily empirical approach to model heat output.

Methodology

The Home Energy Model's (HEM's) electric dry core thermal storage model is now[1] based primarily on empirical performance data describing how heat output varies with charge level. This data is derived from standardised laboratory tests[2] conducted under controlled conditions during which heat output and energy input is measured for various states of charge.

The objective of this model is to predict the overall electricity input and heat output of a dry core thermal store under various conditions such as room temperature, stored energy level and heating requirement.

An empirical approach was chosen on the basis that the output of storage heaters is determined by air movement within/through the unit, which is difficult to model, but is implicitly captured in the data generated during the existing standard laboratory test methodology for assessing the performance of storage heaters. Similar testing can assess the performance of dry core heat batteries and avoids the requirement to model the integrated air-to-water heat exchanger. Consideration was given to the methods described in the BS EN 15316-1-2017, 15316-2-2017 and 15500-1-2017, but these did not provide methods to determine the output of dry core thermal stores.

Heat output

In HEM, dry core thermal stores are assumed to operate in one of two modes:

- Active Mode: Intentionally releasing stored heat.
- Inactive Mode: Retaining stored heat, with passive losses.

Dry core thermal stores retain heat imperfectly and therefore release a non-negligible amount of heat when inactive. When in active mode the rate at which they can provide heat (i.e. their power output) varies depending on how fully charged they are. Therefore, a key step in the calculation process is to determine the minimum and maximum energy output possible at any given time. In practice, for storage heaters, this is related to the temperature of the core/storage material relative to ambient air temperature; but to avoid modelling component temperatures directly, HEM bases output capability on the current charge level. By calculating the state of charge of dry core thermal storages each time heat is added or removed from the dry core thermal storage the minimum and maximum outputs can be determined directly from the empirical data sets.

[1] The more complicated method for storage heaters in place at the time of the HEM v0.28 consultation involved explicitly modelling the temperature and heat flows for component parts.
[2] BS EN 60531:2000+A11:2019

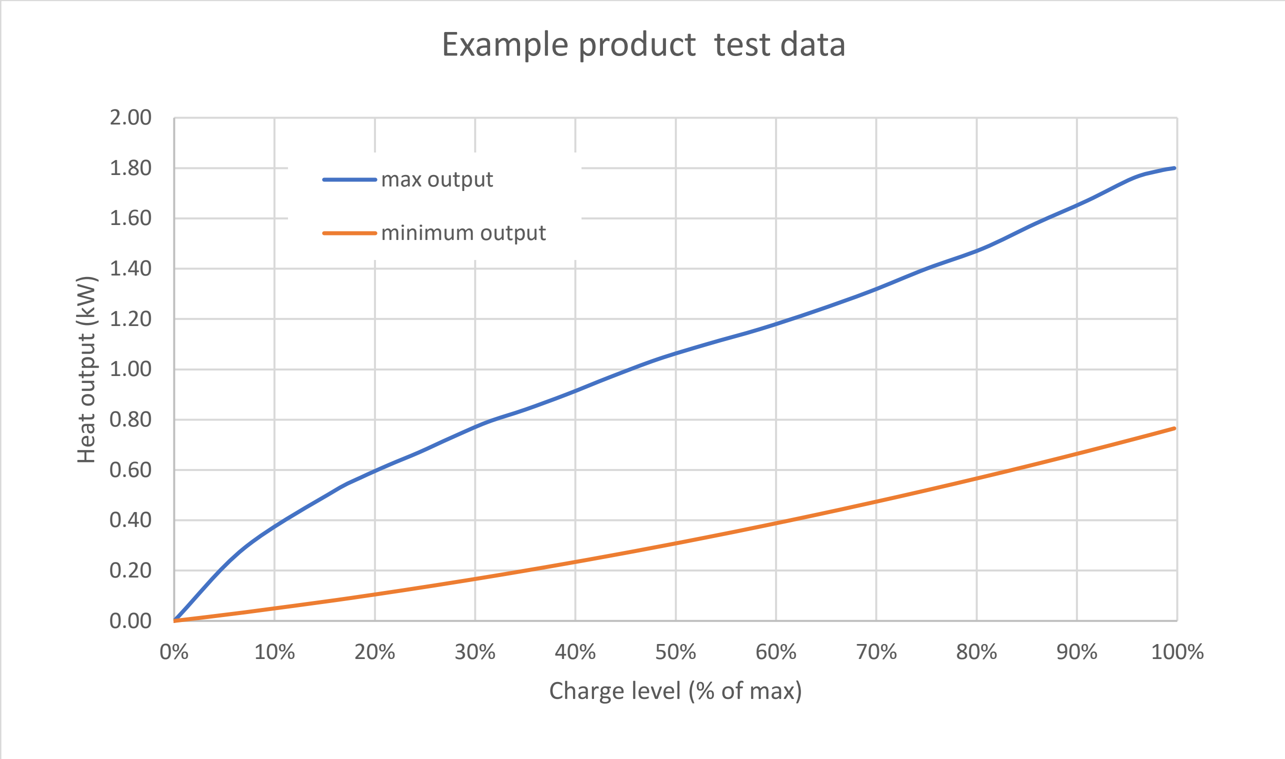

Figure 1: Plot of example heat output test data when the unit is in active (max output) and inactive (min output) mode

The above figure shows an example plot of the kind of test data that will be held in HEM's product data base for each dry core thermal storage model. The data will be stored as a series of x,y points – interpolation is applied in the HEM dry core thermal storage code to impute between data points. If the instantaneous heat requirement is between these two figures it can be met exactly; whereas, if the requirement is outside this range it cannot be exactly met from storage alone[3].

A solver function is used to integrate the amount of energy deliverable during each timestep taking into account the constantly changing charge level and min/max outputs. This integrates the system's energy output across the timestep. This procedure is essential because the state of charge and associated heat outputs are not static over a single timestep (e.g. 30 minutes) but dynamically evolve as heat is delivered to the space.

Heat Distribution from dry core heat batteries

Dry core heat batteries are a form of central heating and are therefore utilised to provide space heating via wet distribution systems, instantaneous hot water or hot water via a storage cylinder. HEM utilises the same operational logic as the model of phase change heat batteries to provide these connections. This is detailed in section 1.7 of HEM-TP-15.

[3] In many cases there will be a direct electric top-up heating element able to make up the shortfall, avoiding 'unmet demand'. However, if the heat requirement is less than the minimum output, over-provision is inevitable.

Electrical energy input

An important factor affecting the energy consumption of dry core thermal storage systems is how well the level they are charged to overnight matches the amount of heat that will be required the next day. If charged too little, more (on-peak) top-up heating will be required. If charged too much, a proportion of the excess will be delivered to the home unnecessarily.

The electrical energy input to (i.e. charging of) dry core thermal stores is determined by the control system logic, limited by the following constraints:

- Rated power: Limits the maximum instantaneous charging power to the system's rated input.
- Charging time-window: Charging is restricted to the charging hours specified in the input file, which would typically reflect the hours of off-peak electricity tariffs.[4]
- Residual heat and maximum charge capacity: Any residual heat remaining in the dry core thermal storage is subtracted from the available capacity to prevent the addition of charge that would take the amount stored over the unit's maximum capacity.
- Control Logic: Manual, automatic, and predictive controls determine the target charge level, influencing the charging behaviour – see below.

Four forms of control logic have been implemented for electric storage heaters:

- **Manual control** assumes dry core thermal storages are charged to a level (between 0 and 100%) determined in the input file, which can vary over the year. It is therefore largely up to the user how to set this[5]. In practice householders would be likely to adjust this infrequently, meaning a mixture of over and under-charging relative the next day's load.
- **Automatic control** assumes charging is cut when a threshold internal room temperature is reached during the charging cycle, so that in warmer weather the unit will charge for a shorter time[6]. This cut-off temperature is set in the input file and can be varied across the year, if desired.
- **CELECT control** is a variant of an automatic control able to react to radio signals. While this can be entered as a distinct control type in HEM, it is currently treated no differently to a normal automatic control. In future, this may be updated[7].

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[4] However, if the unit has a built in top-up element, this is assumed to be available at any time of day. The same outcome could alternatively be achieved with a separate secondary direct electric heater.
[5] However, this will often be set in the policy wrapper being used, rather than being a free input for the model user.
[6] If the room temperature were later to drop again, it could once more fall below the threshold temperature and charging could resume. This is in practice unlikely because heaters output a non-negligible amount of heat when they are inactive.
[7] This control type is present in SAP, but it is not believed to be in active use at this time so has not been prioritised to include in HEM.

Predictive control[8] is where a prediction is made of the heat expected to be required over the next 24 hours, to determine the appropriate level of energy input. This prediction can either be backward looking only (based on the previous day's heat demand) or also forward looking (based on predicted weather for the following day). In version 1.0 only the forward-looking method has been implemented. This works by calculating the heating degree-hours for the previous day (from the weather data file) and comparing this with the heat output that was required. The heating degree-hours for the following day are then calculated and used to predict the following day's heat requirement on a proportional basis, after subtracting any heat left in the dry core thermal storages at the start of the charging period. This is recalculated on a rolling 24-hour basis. An additional parameter 'temp_charge_cut' can be used to further limit that charge by preventing further charging once the room temperature reaches a threshold point specified in the input file.

The options above make the approach consistent with BS EN 15500-1-2017 Section 5.2.4.4, which states that 'the storage of the heat can be controlled by indoor temperature and/or by the precalculated demand according to the outdoor temperature'. The standard does not specify a method for modelling the control.

The dry core heat battery has only one control option at present:

- **Heat Battery**. This is functionally the same as the 'Predictive control' described above for use with storage heaters, the only difference being that the 'temp_charge_cut' input is not used, since this is only relevant to room heaters.

[8] This control type is currently referred to as control type 'HHRSH' in the storage heaters code, since it has primarily been used with high heat retention storage heaters to date, but it could in theory be paired with other dry core thermal storage types, so this may be renamed in a future update.

Future development

Further refinement of control options is anticipated, including for controls capable of responding to the availability of renewable energy generated on site (e.g. PV), as well as the backward looking predictive control method mentioned above.

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