Calculating thermal mass within the Home Energy Model

A technical explanation of the methodology

December 2023

Acknowledgements

This methodology has been developed for the Department for Energy Security & Net Zero by a consortium led by the Building Research Establishment (BRE), including AECOM, Sustenic, University of Strathclyde's Energy Systems Research Unit, Kiwa Ltd., Loughborough University Enterprises Limited, Chris Martin and John Tebbit.

Quality assurance has been undertaken by a consortium led by Etude, including Levitt Bernstein, Julie Godefroy Sustainability, and UCL.

Document reference: HEM-TP-07

Document version: v1.0

Issue date: 13/12/23

Home Energy Model version: HEM v0.24

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 paper sets out the methodology for calculating thermal mass within the Home Energy Model core engine.

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

src/core/space_heat_demand/building_element.py

Methodology

1. Thermal mass of building elements in main calculation

The thermal mass of building components is dealt with in the core heat balance equations, as described in BS EN ISO 52016-1:2017. In accordance with this standard, the areal heat capacity[1] (in J/(m2.K)) of each element is input along with one of 5 mass distribution classes describing in general terms the position of the mass (from internal to external) relative to the thermal resistance:

- Mass concentrated on internal side – Construction with external thermal insulation (main mass component near inside surface), or equivalent
- Mass concentrated on external side – Construction with internal thermal insulation (main mass component near outside surface), or equivalent
- Mass divided over internal and external side – Construction with thermal insulation in between two main mass components, or equivalent
- Mass equally distributed – Uninsulated construction (e.g. solid or hollow bricks, heavy or lightweight concrete, or lightweight construction with negligible mass (e.g. steel sandwich panel), or equivalent
- Mass concentrated inside – Construction with both internal and external insulation (main mass component concentrated near centre of construction), or equivalent

The standard also includes typical default values for areal heat capacity with a set of default construction type classes, varying from “very light” to “very heavy”. These construction types can be found in BS EN ISO 52016-1:2017 Table B.14. Table 1 below is a summary of the construction of these default classes.

Default class	Example of construction type
Very light	Light board or plastic
Light	5 to 10 cm lightweight brick/concrete
Medium	10 to 20 cm lightweight brick/concrete
Heavy	7 to 12 cm solid brick or heavyweight concrete
Very heavy	More than 12 cm solid brick or heavyweight concrete

Table 1 – Examples of construction type for each default class

Each opaque building element is modelled as five heat balance nodes and the areal heat capacity is distributed among these nodes according to the mass distribution class (the

[1] Note: that the thermal mass includes the entire thickness of the building element. A monthly method such as the Standard Assessment Procedure would instead use the kappa value, which includes only the thickness of the construction active in thermal storage for the internal surface.

procedure is described in BS EN ISO 52016-1:2017 section 6.5.7). The five nodes are then included in the overall network for the zone in the model. The heat balance equations for all the nodes in the zone are then solved simultaneously using a linear algebra solver.

Thermal mass of transparent building elements is ignored.

The thermal mass is either distributed as a whole unit, or divided up in fractions of a half, a quarter or one-eighth. The distribution amongst the nodes is shown graphically below, where the thermal mass distribution is represented by the brown area.

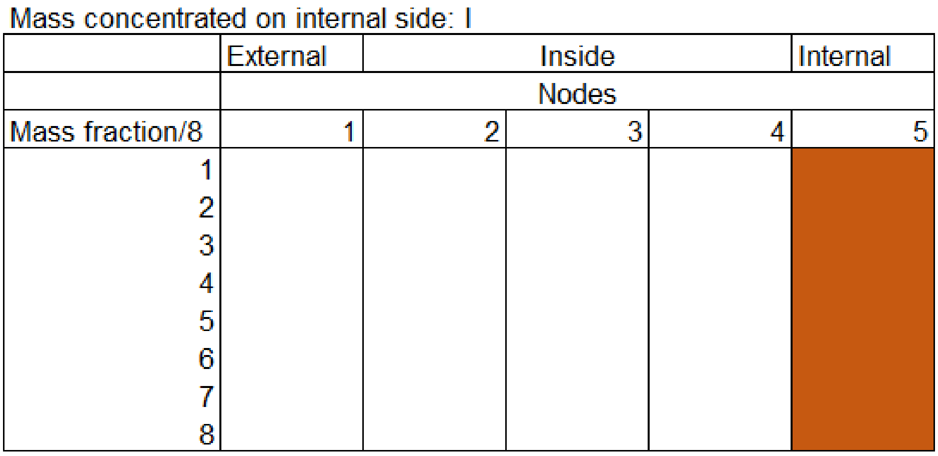

Figure 1 – Mass concentrated on internal side

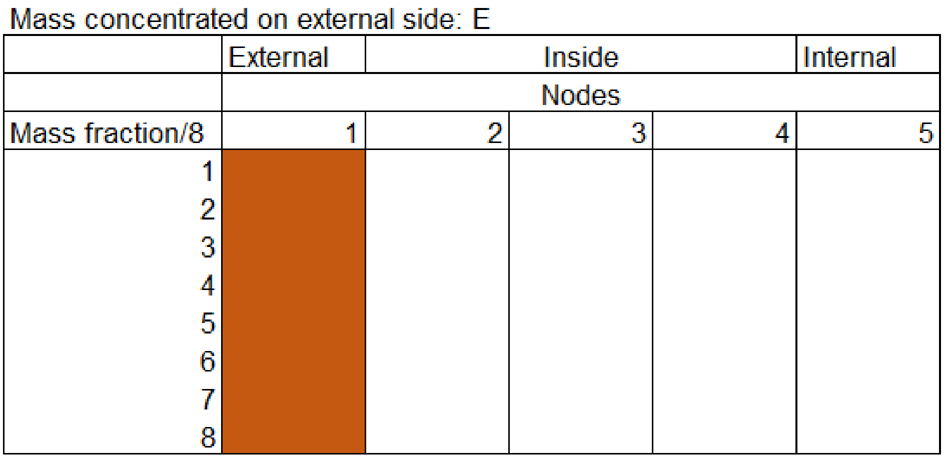

Figure 2 – Mass concentrated on external side

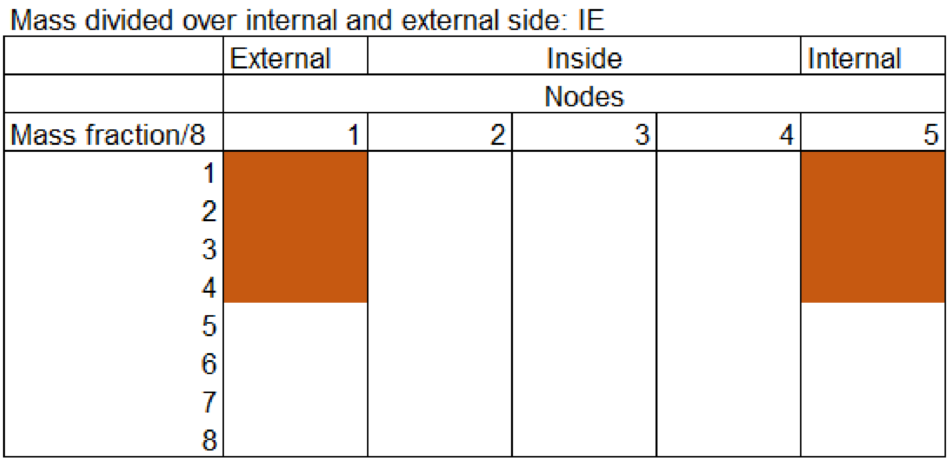

Figure 3 – Mass divided over internal and external side

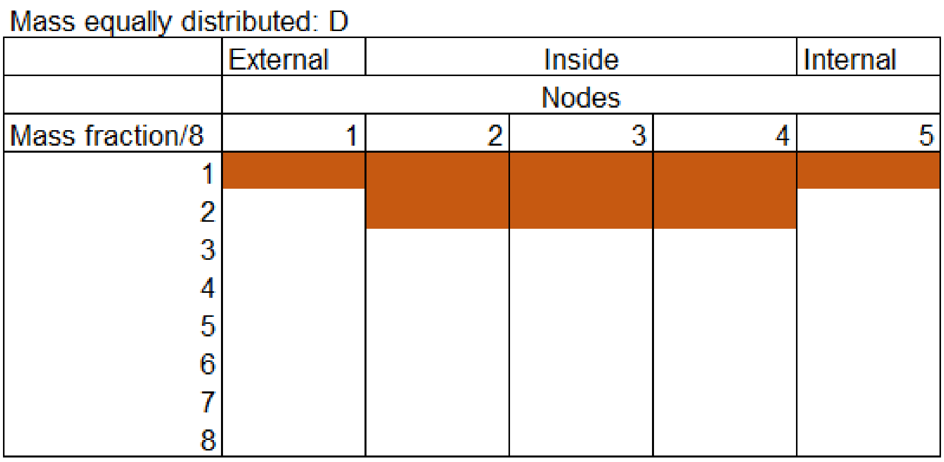

Figure 4 – Mass equally distributed

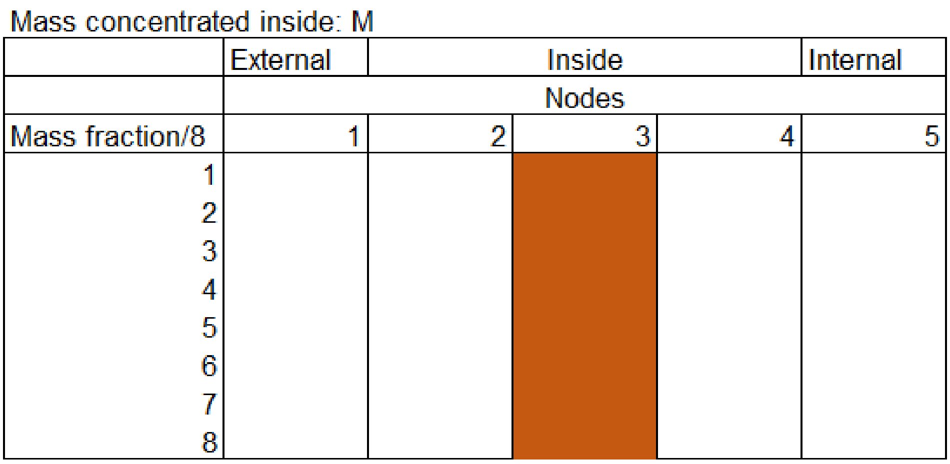

Figure 5 – Mass concentrated inside

2. Thermal mass of air and furniture in main calculation

The thermal mass of the air in the zone is assumed to be 10,000 J/K per m2 of floor area, as per the suggested default in BS EN ISO 52016-1:2017 Table B.17, which also assumes the presence of furniture.

3. Static calculation for reporting

Although not used in the main heat balance calculation, for comparison purposes, a single heat capacity figure for the dwelling is also calculated. This is called the Heat Capacity Parameter (HCP) and is calculated by summing the heat capacity of all building elements in all zones and dividing by the total floor area. That is,

$$HCP = \frac{\sum heat\ capacities\ of\ building\ elements}{total\ floor\ area}$$

4. Limitations in the consultation version

The thermal mass distribution classes are an approximation of the thermal mass distribution in a real construction. They may be appropriate where there are simple layers, such as solid brick wall, cavity wall, solid wall internally insulated, or solid wall externally insulated. However, other constructions might not be so well represented. For example, a solid brick wall could be insulated internally using insulated plasterboard. In this case, the thermal mass of the plasterboard would not be represented in the internal node, if the wall is assigned to the mass distribution class “Mass concentrated on external side” or “E”.

For some construction types, it is not obvious to which mass distribution class they should belong. This may in some cases lead to incorrect choices of mass distribution classes.

Future development

The selection of mass distribution class could be made easier with a tool that determines the most appropriate class. This might be included with a related tool such as a U-value calculator.

The mass distribution classes could be amended to better handle a wider range of construction types. Note this may involve a divergence from the standards, or for a request to BSI for the update of BS EN ISO 52016-1:2017.

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