Space heating and cooling assumptions within the Home Energy Model: FHS assessment

A technical explanation of the methodology

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Background to the Home Energy Model: Future Homes Standard assessment

What is the Home Energy Model: Future Homes Standard assessment?

The Home Energy Model: Future Homes Standard assessment is a calculation methodology designed to assess compliance with the 2025 Future Homes Standard (FHS).It builds on the government's Home Energy Model, which will replace the government's Standard Assessment Procedure (SAP).

The Home Energy Model: FHS assessment is still under development and its first version will be implemented alongside the 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: FHS assessment technical documentation (e.g. this document)

What: This document is one of a suite of technical documents, which go into further detail on the assumptions 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 justifications and evidence base behind the assumptions used in the model.

The Home Energy Model: Future Homes Standard assessment consultation

What: The Home Energy Model: Future Homes Standard (FHS) assessment consultation seeks views on the proposed methodology for demonstrating compliance with the FHS.

Audience: The Home Energy Model: FHS assessment consultation will be of interest to those who want to understand the proposed standardised assumptions around occupancy, energy demand etc. to be used when assessing compliance with the FHS, as well as the methodology for the calculation of the proposed FHS compliance metrics.

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 legal approved methodology for demonstrating whether new homes comply with energy performance standards in the Building Regulations.

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

The core Home Energy Model (HEM) can be used with a variety of heating and cooling periods and temperature settings. This note relates only to the way the HEM is intended to be used for the Future Homes Standard assessment. For more information on space heating and cooling demand calculations in the core methodology, see the following technical papers:

- HEM-TP-04 Space heating and cooling demand
- HEM-TP-17 Controls

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

src/wrappers/future_homes_standard/future_homes_standard.py

Methodology

Space heating and cooling demand is the amount of thermal energy that needs to be provided to the space (heating demand) or removed from the space (cooling demand) in order to achieve a desired temperature. The space heating and cooling demand calculated by the model is highly dependent on the external conditions, internal heat gains, setpoint temperatures, heating/cooling times and other control settings of the heating/cooling system.

1. Internal gains

The FHS assessment wrapper specifies heat gains from occupant metabolism, appliances, cooking and lighting, as well as losses to incoming cold water and evaporation, which necessarily affect the energy demand for space heating. More information on these can be found in HEMFHS-TP-01 FHS occupancy assumptions (for metabolic gains) and HEMFHS-TP-04 FHS appliances assumptions (for gains from appliances, cooking and lighting, and losses to incoming cold water and evaporation).

Other sources of internal gains (e.g., ventilation fans) are handled in the core model and are therefore not defined in the FHS assessment wrapper.

2. External conditions (weather)

Details of the data on external conditions required by the Home Energy Model (HEM) can be found in HEM-TP-03 External conditions. For details of the specific proposed weather data to be used for the Home Energy Model: FHS assessment, see the Home Energy Model: FHS assessment consultation document.

3. Unmet demand

Note that if the heating system cannot provide enough energy to reach the setpoint in a given timestep, then the energy shortfall will be recorded as "unmet demand" (see HEM-TP-04 Space heating and cooling demand). The FHS assessment wrapper will then apply emission and primary energy factors (see HEMFHS-TP-05 FHS fuel factors) to this energy shortfall to avoid the FHS assessment providing an advantage to systems which do not adequately heat the dwelling. The same also applies if a cooling system has insufficient cooling capacity. The sizing and controls for heating and cooling systems will have a significant effect on the unmet demand which will need to be considered when specifying the system (see following sections).

4. Space heating demand

The core model requires a control schedule to be defined for each zone's heating system (see HEM-TP-17 Controls for description of SetpointTimeControl), which defines a setpoint (in terms of operative temperature) for each timestep in the simulation. As the FHS specifies that the simulation should run for one year with a half-hourly timestep, this means that when running with the FHS assessment wrapper a setpoint needs to be defined for each half-hour of the year.

The FHS assessment wrapper therefore specifies a schedule of operative temperature set points. In order to do this, the FHS assessment wrapper needs an additional input for the overall zonal time and temperature control; there are two broad control types[1] currently defined:

- Separate temperature control in each zone (e.g., room thermostat and TRVs)
- Separate time and temperature control in each zone

See the following sub-section on times of heating demand for how this affects the setpoint schedule generated by the FHS assessment wrapper.

4.1 Demand temperature setpoints

The assumed operative temperature set point in the zone containing the living room (zone 1) is 21°C on the basis that this was the 75th percentile reported thermostat setting in the 2017 Energy Follow Up Survey[2] (EFUS). The mean and median setpoints were 20.4 and 20.0°C respectively, but it is known that some homes are underheated[3], so the 75th percentile was chosen.

In setting an assumed setpoint for the zone not containing the living room (zone 2), there are three issues that need to be considered together:

- **Nominal setpoint temperatures**: the temperatures to which different parts of the dwelling are intended to be heated.
- **Inter-zone heat transfer:** this effect is currently ignored in HEM but in reality may lead to significantly higher heat loss from zone 2 than would be modelled when ignoring this heat transfer. If one part of the dwelling is heated to a higher setpoint that another adjacent part, then there will be heat transfer from the warmer zone to the cooler zone, which may mean that the cooler zone spends much of its time at a temperature above its nominal setpoint. For a dwelling with lower overall heat loss, this effect would be

[1] These correspond to control types 2 and 3 in SAP 10.2 Table 4e.
[2] From the Heating Patterns and Occupancy report: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1018727/efus-heating-patterns-occupancy.pdf
[3] As compared with the occupants' preferences, if their home's fabric and heating system were good enough that they could afford it.

expected to lead to a greater increase in the temperature of the cooler zone than would occur in a dwelling with higher overall heat loss.

- **Control arrangements:** In practice in UK homes there is often not a specific setpoint in other rooms with supply of heat to rooms being determined by the living room thermostat. In such a system arrangement, the temperature achieved in the other rooms is determined by the heat output of the emitters in the other zone relative to the heat output of the emitters in the zone containing the living room; this relative output will be determined by the system design/sizing. The temperature in other rooms may be limited further by the presence of separate temperature controls such as room thermostats or TRVs.

We note that guidance on design setpoint temperatures differs. For example:

- BS EN 16798-1:2019 Table B.2 suggests a design value of 20°C for the "medium expectation" scenario (category II in table) for both living rooms and bedrooms, and 21°C for the “high expectation” scenario (category I in table). The high expectation scenario is intended for occupants with special needs (e.g., elderly).
- The CIPHE Domestic Heating Design Guide (2021) states that new (well-insulated) buildings should generally use a design temperature of 21°C everywhere except for bathrooms, which should use 22°C.

Considering the above, for the Future Homes Standard assessment a setpoint temperature of 20°C is assumed in zone 2. At present, the model cannot differentiate between scenarios where there is or is not separate temperature control (e.g., via additional room thermostats or TRVs) in zone 2. Therefore, the zone 2 setpoint currently assumed is for the case where there is separate temperature control. The relatively small difference (1°C) between the zone 1 and zone 2 setpoints assumed means that the calculation error arising from the lack of consideration of inter-zone heat transfer should be relatively small.

4.2 Times of heating demand

According to the 2017 EFUS the most common heating pattern on a weekday is a bi-modal one with the hours 07:00-09:30 and 16:30-22:00. The most common heating pattern at the weekend is a single ‘all-day’ period of 08:30-22:30. It is also possible to heat living and non-living rooms at different times where separate time and temperature controls have been installed. In this case we assume that there is a two-hour delay to the start of the evening heating period (i.e. it is 18:30-22:00) on bi-modal days for zone 2. See Table 1 for a summary of these heating patterns.

	Weekday	**Weekday (zone 2, when separate time and temperature controls are installed)**	**Weekend**
Heating period 1	07:00-09:30	07:00-09:30	08:30-22:00

Heating period 2	16:30-22:00	18:30-22:00	N/A

Table 1 – Heating periods within the FHS assessment wrapper

We note that the EFUS 2017 data covers more dwellings heated by gas boilers that any other system type, as this is representative of the current building stock. Research[4] suggests that while the bimodal and daytime heating patterns are typical of gas boiler use, for heat pumps daytime or continuous heating strategies are more common. In order to produce a fair comparison between different heating systems, the FHS assessment wrapper specifies the same heating periods regardless of the characteristics of the system, However, these heating periods merely specify when the FHS assessment wrapper requires the setpoint temperature to be reached, and the wrapper does not forbid the system from running outside these times (see section 4.3).

4.3 Setback temperatures, advanced start periods and continuous heating

Some heating systems, particularly those with a low capacity and/or a high degree of thermal inertia, may work more efficiently with a heating schedule that is more continuous rather than intermittent. The FHS assessment wrapper therefore allows the user to specify a setback temperature and/or an “advanced start” period if the system controls have been configured in this way, to allow the system to run outside of the FHS heating hours. See HEM-TP-17 Controls for details on how the setback temperatures and advanced start periods affect the setpoint schedule.

If a setback or advanced start period are specified, then the heating system will attempt to meet the target temperature outside of the FHS heating hours but if it cannot do so then no unmet demand will be recorded (i.e., unmet space heating demand is only recorded within the heating periods specified by the FHS assessment wrapper).

A continuous heating pattern can be specified by setting the setback temperature for each zone to be equal to the setpoint temperature. Note that setting a continuous heating pattern, setback temperatures or advanced start periods can be expected to increase overall space heating demand, because the dwelling will be heated to a higher temperature for longer than it otherwise would be (i.e., the mean internal temperature over the simulation period will be higher), therefore increasing overall heat loss. There is therefore a trade-off between any increase in system efficiency or reduction in unmet demand achieved and the increase in overall space heating demand that results.

Consideration was given to fixing the setback and/or advanced start period for all systems in the FHS assessment wrapper. However, it was decided not to do this to enable the user to specify their own setback temperature and ensure that it is suitable for the combined

[4] S.D. Watson, K.J. Lomas, R.A. Buswell, How will heat pumps alter national half-hourly heat demands? Empirical modelling based on GB field trials, Energy & Buildings 238 (2021) 110777, https://doi.org/10.1016/j.enbuild.2021.110777

characteristics of the heating system (capacity, responsiveness) and the dwelling (heat loss rate, thermal mass).

5. Space cooling demand

As for space heating demand, the FHS assessment wrapper specifies a schedule of operative temperature set points for cooling. In addition to active cooling (if present), it is also assumed that occupants will open windows to avoid overheating (see HEM-TP-04 Space heating and cooling demand for how this is handled in the core calculation) and a setpoint schedule is also required for this.

5.1 Demand temperature

For active cooling systems, a cooling setpoint of 24°C is assumed. This is the central figure in the range 23-25°C given for habitable rooms in CIBSE Guide A. It is noted, however, that BS EN 16798-1:2019 Table B.2 suggests 26°C for the "medium expectation" scenario. Given the relative rarity of active cooling systems in the UK, evidence as to how they are used in practice is sparse.

It is assumed that occupants will open/close windows in an attempt to keep the temperature at 22°C, which is the temperature at which windows in occupied rooms are assumed to be fully closed but above which they start to open according to Approved Document O, 2021 edition.

5.2 Times of cooling demand

In the zone containing the living room the hours of active cooling are set to 07:00-09:30 and 18:30-22:00 on weekdays and 08:30-22:30 at weekends. The hours that windows are openable are assumed to be 09:00-22:00.

In the zone not containing the living room the hours of active cooling are set to the bedroom cooling hours from TM59 (22:00 – 07:00) and the hours that windows are openable are assumed to be 08:00-23:00.

6. Initial temperatures

The calculation for each timestep depends on the temperatures achieved for the previous timestep, which means that an assumption has to be made for the temperature at the start of the calculation. See HEM-TP-04 Space heating and cooling demand for details of the temperature initialisation. For the FHS assessment, zone 1 is initialised to an operative temperature of 21°C and zone 2 is initialised to an operative temperature of 20°C (i.e. both zones start the calculation at their setpoint temperature).

Future development

At present, the model cannot differentiate between scenarios where there is or is not separate temperature control (e.g., via additional room thermostats or TRVs) in zone 2. This may be added in future, most likely by assuming a higher zone 2 setpoint in the absence of such controls.

Assumptions on setpoints and heating/cooling periods may be revised as new evidence or guidance becomes available.

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