An evaluation of the Home Energy Model and Future Homes Standard assessment wrapper

Assessment of consultation versions against success criteria established in 2022

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Acknowledgements

Quality assurance for the Home Energy Model project has been undertaken by a consortium led by Etude, including Levitt Bernstein, Julie Godefroy Sustainability, and UCL.

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Background

What are the Home Energy Model and Future Homes Standard assessment wrapper?

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

The Home Energy Model: Future Homes Standard assessment is a methodology designed to assess compliance with the 2025 Future Homes Standard ("FHS"). The Home Energy Model and FHS assessment wrapper together make up the Home Energy Model: FHS assessment.

$$Home\ Energy\ Model + \ FHS\ assessment\ wrapper = Home\ Energy\ Model{:}\ FHS\ assessment$$

The Home Energy Model and FHS assessment wrapper are still under development and will be implemented alongside the FHS in 2025. We are publishing information about the methodologies while they are still at a formative stage to enable industry to participate in the ongoing development process.

Model development and quality assurance

In 2021, the government appointed a consortium of experts led by the BRE[1] to carry out a multi-year project to develop a replacement for SAP. Given the importance and duration of this project, the government additionally appointed a consortium led by Etude[2] to quality assure the work undertaken (the "QA team").

The purpose of the QA process has been to ensure that:

- Issues with the current SAP methodologies are identified and clearly defined.
- Evidence for suggested improvements is thorough.
- Validation processes are robust.
- The decision-making process is clear, robust, and documented.
- Project governance is working effectively, with government, key user groups, and technical experts associated with key decisions.

The Home Energy Model has been a joint project between government, the BRE team, and the QA team, and has undergone several stages of work since its inception in 2021.

[1] Project team: BRE, AECOM, Sustenic, University of Strathclyde, Loughborough University, Kiwa, Zensar, John Tebbit, Chris Martin
[2] Project team: Levitt Bernstein, UCL, Julie Godefroy Sustainability, and Etude.

Evaluation

For the consultations, the QA team has produced an evaluation of the methodologies, which is presented in this document. This evaluation presents an assessment of the project's progress to date and will be used to plan the next phase of model development, alongside the consultation responses.

Please note that the QA team has not reviewed aspects of the FHS assessment wrapper which are being consulted on as part of the FHS consultation (e.g. the proposed FHS performance targets, notional dwelling approach, use of regional weather data etc.).

The following tables list some of the success criteria identified by government, the BRE project team, and the QA team in July-August 2022. The ambition is to achieve these success criteria ahead of implementation in 2025. Therefore, any success criteria which have been assessed as *C* or *D* will be prioritised as key areas of focus for the next phase of development. Quality assurance is an ongoing process, and we will continue to quality assure the work undertaken and assess our progress against success criteria going forwards.

High-level overview

Table 1 (p. 5) provides a high-level overview of the QA team's evaluation, using the following letter code to summarise the current status of performance:

A	Success criterion already achieved or on track for delivery in final product
B	Success criterion partially achieved, with a clear path to completion
C	Success criterion partially achieved, with further decisions and development planned for the next phase of the project.
D	Success criterion not yet achieved, and therefore a key area of focus for the next phase of development.
-	Success criterion not relevant or not applicable

*Note that the letter codes reflect the current position of project development, which is ongoing.

Summary evaluation

Table 2 (p. 6-12) expands on Table 1 to provide a more detailed summary of how the consultation versions of the Home Energy Model and the FHS assessment wrapper perform against each of the success criteria.

Table 1: High-level overview of the QA team's evaluation

	Key success criteria	Home Energy Model	FHS assessment wrapper
1	A methodology which is suitable for regulatory purposes (e.g. Part L of the Building Regulations)	*A*	*A*
2	A methodology able to better predict annual energy use of homes	*B*	*C*
3	A methodology suitable for the assessment of ultra-low energy and Net Zero homes	*B*	*B*
4	A methodology which can assess space heating, space cooling and DHW demand more accurately	*C*	*D*
5	An improved assessment of ventilation and infiltration	*C*	-
6	A methodology which can assess the energy flexibility potential of a dwelling	*A*	-
7	A better estimate of energy use from white goods and appliances	-	*C*
8	A better estimate of solar PV energy generation and self-consumption	*A*	*A*
9	A methodology which can predict total carbon emissions from a dwelling	-	*A*
10	A model able to calculate and output a number of key metrics	*A*	*A*
11	A well-integrated products database, storing performance data for a wide variety of technologies	*D*	-
12	An open-source model and well documented methodology ready for continuous improvement	*B*	*B*
13	Validation processes for the methodology and the model are scientifically rigorous and agreed	*C*	*C*

Table 2: Summary evaluation of the Home Energy Model and FHS assessment wrapper

	Key success criteria	Home Energy Model summary evaluation		FHS assessment wrapper summary evaluation	
1	A methodology which is suitable for regulatory purposes (e.g. Part L of the Building Regulations)	*A*	The new architecture of the Home Energy Model with its wrappers helps to clarify and differentiate the model's different purposes, including regulatory ones. The FHS assessment wrapper has been developed and is the subject of a specific consultation. Other wrappers will enable the Home Energy Model to be used for other regulatory purposes (e.g. EPCs) and non-regulatory purposes. In addition, the intent to replace the SAP specification by reference code will ensure a higher level of quality and consistency of regulatory calculations.	*A*	The FHS assessment wrapper has been developed specifically to enable a standardised compliance assessment of new dwellings with Building Regulations. This has facilitated the development of assumptions which are relevant and appropriate to new dwellings, instead of the housing stock as a whole.
2	A methodology able to better predict annual energy use of homes	*B*	This objective has been a key focus of the development and validation processes, with a clear ambition to seek for the model to simulate building energy use as realistically as possible. The calibrated comparisons of the Home Energy Model against other energy modelling tools (i.e. PHPP and ESP-r) and in-use energy data constitute the evidence that the core engine is a satisfactory building physics model. However, more work, particularly on shading, infiltration and ventilation, as well as on existing homes, will be necessary to demonstrate that this aim has been fully achieved.	*C*	The non-calibrated comparisons of the Home Energy Model: FHS assessment with other energy modelling tools (i.e. PHPP and ESP-r) indicate that the new methodology is able to better predict annual energy use of new homes, as compared to SAP 10.2. However, the assessment of internal gains, space heating demand and energy use from appliances and cooking are three areas where further improvement is likely to be required. In addition, the ability of wrappers to use more localised weather data, and

			In addition, the ability of wrappers to use more localised weather data, and therefore take into account regional differences in temperatures and solar radiation, is very positive. Using more localised weather data would enable a more accurate assessment of energy use and renewable energy generation than when a single weather file is used (as in SAP, previously).		therefore to take into account regional differences in temperatures and solar radiation, is very positive. Using more localised weather data would enable a more accurate assessment of energy use and renewable energy generation than using UK average weather data (as in SAP, previously).
3	A methodology suitable for the assessment of ultra-low energy and Net Zero homes	*B*	Alongside a more accurate building physics model, the Home Energy Model is able to better represent the impact of key features and technologies associated with low energy and Net Zero homes, in particular MVHR, heat pumps and solar PVs. In addition, the ability to model the interaction between environmental systems and the building fabric within the Home Energy Model at a half hourly time step provides the potential to assess the effects of dedicated energy storage devices and the intrinsic energy storage in the building fabric. Homes in the future are expected to use dedicated thermal and electrical energy storage devices in response to price signals from the energy system. Further work intended in 2023-24 will help to validate the assessment of heat pumps in order to ensure that their performance is accurately modelled. In addition, there is an intention for further validation with field trial data from low energy and Net Zero homes in future.	*B*	The ability of wrappers to use more localised weather data instead of UK average weather is very positive. Using more localised weather data would positively affect both sides of the energy balance: the assessment of energy use and of renewable energy generation. Further validation with field trial data from low energy and Net Zero homes will also benefit the FHS assessment wrapper.

4	A methodology which can assess space heating, space cooling and Domestic Hot Water (DHW) demand more accurately	*C*	Significant work has been undertaken to validate the Home Energy Model's assessment of space heating, space cooling and DHW. Validation through the inter-model comparison of three housing archetypes with ESP-r and PHPP has driven significant improvements. Validation with in-use energy data from a limited number of case studies also assisted development. A significant data resource on actual DHW demand in existing dwellings was also identified and used thoroughly. However, quality concerns remain about how infiltration and ventilation are being modelled, and in particular natural ventilation with intermittent extract and background ventilators. Further work on ventilation and infiltration is intended to be undertaken in future. Field information on space cooling demand and use in the UK is also limited and could be an area for further investigation in future.	*D*	Although the Home Energy Model has given satisfactory results as a building physics model, a number of assumptions built in the FHS assessment wrapper have led to a level of space heating demand which does not represent a significant improvement over SAP 10.2. According to the latest validation results, there is a risk that the Home Energy Model: FHS assessment underestimates space heating demand. This appears to be due to the heating patterns (particularly how the calculations deal with intermittency), and internal gains (potentially too high) assumed by the FHS assessment wrapper. The intention is to carry out further testing of these variations during and following the consultation period.
5	An improved assessment of ventilation and infiltration	*C*	The methodology used in the Home Energy Model to assess infiltration and its impact has been partially improved compared with SAP 10.2. Dwelling types in locations with different levels of shelter now result in different infiltration rates, which is a significant improvement. The assessment of mechanical ventilation has also been improved both for continuous mechanical extract with background ventilators (MEV) and for mechanical	-	The FHS assessment wrapper does not include any specific calculation in addition to those undertaken by the core engine. Therefore this success criterion is not relevant.

			ventilation with heat recovery (MVHR), and now considers the length of intake/exhaust ducts on heat losses. However, the assessment of intermittent mechanical extract with background ventilators is largely unchanged compared with SAP 10.2 and includes optimistic assumptions regarding the behaviour of occupants at high infiltration rates. The consultation asks for feedback on this approach and notes the intention for further research and development work in future.		
6	A methodology which can assess the energy flexibility potential of a dwelling	*A*	The move towards a half-hourly time step enables the assessment of energy flexibility potential in a variety of ways. This represents a significant new feature of the Home Energy Model.	-	The FHS compliance metrics are part of the FHS consultation and are therefore not assessed here.
7	A better estimate of energy use from white goods and appliances	-	This estimate is produced in the relevant wrappers, rather than within the core engine itself.	*C*	The FHS assessment wrapper is based on a 'top down' calculation based on the Energy Follow Up Survey (EFUS) 2017. This represents a substantial update and improvement on SAP 10.2 which used EFUS 1998. However, it may be that the FHS assessment wrapper over-estimates the amount of energy used by appliances and cooking for a new build home due to the age/efficiency of appliances and cooking systems which formed part of the EFUS 2017 analysis. Only limited validation

					against in-use energy data, and supplier data has been possible at this stage. Calculation of energy use from white goods and appliances on a 'bottom-up' basis and by equipment type is not yet possible in the FHS assessment wrapper. Preliminary work has been undertaken but has not yet been implemented. This is being considered as area for further development in 2023-24, in addition to generating a more realistic event profile.
8	A better estimate of solar PV energy generation and self-consumption	*A*	The Home Energy Model estimates the energy output of solar PV systems using the hourly procedure method described in BS EN 15316-4-3:2017. A particularly significant improvement is the ability to assess self-consumption (i.e. the amount of self-generation used within the home) at a higher time resolution (half-hourly, compared to monthly in SAP 10.2). The Home Energy Model can also model different scenarios for the use of surplus energy, for example electrical storage in a battery or thermal storage in a hot water tank. This will require further validation in 2023-24.	*A*	The ability of wrappers to use more localised weather data instead of UK average weather is very positive. Using more localised weather data would positively affect the assessment of renewable energy generation.
9	A methodology which can predict total emissions from a dwelling	-	Not applicable: The Home Energy Model core engine does not predict total emissions from a dwelling. Different approaches will be adopted in the wrappers depending on the application (i.e. Future Homes	*A*	A detailed review of the different options for assessing electricity emission factors has been undertaken as part of Home Energy Model development.

			Standard, EPC, etc.) to suit different purposes and policy objectives.		A short-term prediction of electricity greenhouse gas emission factors has been selected for the FHS assessment wrapper, i.e. 2025-2029.
10	A model able to calculate and output a number of key metrics	*A*	The Home Energy Model is able to output a wide selection of metrics, including energy use and space heating demand, both in kWh/m2.yr. The dynamic nature of the model also means that additional metrics are now obtainable, such as hours of over- and under-heating, peak temperatures, and renewable energy contribution to demand. Different wrappers (e.g. FHS assessment wrapper, EPC wrapper) will specify the regulatory metrics but will still provide access to a wide range of metrics.	*A*	The FHS assessment wrapper provides an emphasis on the regulatory metrics (i.e. those which are used to check compliance with the Future Homes Standard), but the intention is for a wider selection of outputs to be made available to the user.
11	A well-integrated products database, storing performance data for a wide variety of technologies	*D*	A new products database is in the process of being created. This area of development has not progressed significantly in 2022/23 and will be a key development area in 2023/24.	-	Not applicable
12	An open-source model and well documented methodology ready for continuous improvement	*B*	The Home Energy Model codebase and methodology papers have been made publicly available as part of the consultation in order to enable future improvement with additional evidence and feedback. Some areas of the calculation need to be further documented (e.g. heat networks, electric batteries).	*B*	The Home Energy Model: FHS assessment codebase and methodology papers have been made publicly available as part of the consultation in order to enable future improvement with additional evidence and feedback.

13	Validation processes for the methodology and the model are scientifically rigorous and agreed	*C*	There have been three types of validation processes for the Home Energy Model: - comparison with other building energy models (i.e. PHPP, ESP-r) - comparison with in-use data from actual buildings (i.e. Building for 2050 Marmalade Lane, Annex 58, Camden Passivhaus) - comparisons with laboratory tests (e.g. heat pumps). A sensitivity analysis was also undertaken to assess the relative impact of several parameters. Each of these activities has been independently quality assured and is summarised in publicly accessible documents for further scrutiny. However, due to ongoing improvements to the Home Energy Model, the validation processes have been limited to a small sample of home archetypes and case studies. More validation is planned for the next phase of development, particularly to test whether the Home Energy Model is capable of accurately modelling a wider range of buildings and specifications, both at a stock and individual building level. These validation processes will continue to be quality assured.	*C*	Additional validation processes have taken place for the FHS assessment wrapper as part of the comparison with other building energy models and the sensitivity analysis. These activities have been independently quality assured and are summarised in publicly accessible documents for further scrutiny. However, due to ongoing improvements to the FHS assessment wrapper and the limited time available, the validation processes have been limited to a small sample of home archetypes. More validation is planned for the next phase of development, and will continue to be quality assured