Home Energy Model

Friends of the Earth England, Wales and Northern Ireland Consultation Response

26 March 2024

Introduction

This document is Friends of the Earth's response to the Home Energy Model consultation issued by the Department for Energy Security and Net Zero (DESNZ) in December 2023. Overall we very much welcome the Home Energy Model initiative and believe it has potential to help address the challenge of ensuring the UK has warm homes as we transition to net zero.

We are currently involved, with two other organisations, in a legal challenge over the government's climate action plan. We are nonetheless very pleased to be supportive of the Home Energy Model (HEM) initiative.

Friends of the Earth has been campaigning on environmental issues since 1971. Our 'Big Ask' campaign in 2007 calling for a new climate change law attracted the support of hundreds of thousands of people. It was followed by the introduction of the Climate Change Act in 2008.

Summary of comments

We have commented positively on the following specific aspects of the HEM initiative:

- **Model name:** We are supportive of the name 'Home Energy Model'. It concisely reflects the model's focus. It will be evident to all stakeholders what kind of data and functionality HEM provides, and that it models home energy. This will promote understanding of the model's scope. This in turn will help maintainability over the long term by keeping the model focused on this scope.

- **Open source and community approaches:** We believe these have the potential to encourage development of an ecosystem of high quality open source software based around HEM, and to contribute positively to the development of HEM itself.

- **Centralised, cloud-based approach:** We would welcome the approach and we agree with the assessment of the advantages identified in the consultation document.

Although we have a very positive overall view, there are two areas where we have concerns. Much of our response is devoted to identifying and explaining these concerns. **This does not detract in any way from our overall supportive view.** We very much hope that the HEM initiative will succeed.

The areas where we have concerns are:

- **Ultimate legal reference:** The approach of using the open source code as the ultimate legal reference for the HEM methodology would, if adopted, have a number of drawbacks. These are detailed in the answer to Question 4. We believe that the legal reference should continue to be a HEM Specification document that is accessible to and understandable by all stakeholders.
- **Wrappers for the Home Energy Model:** We believe that under the current approach there is potential for duplication of effort and for inconsistencies between data and functionality in different wrappers. The concern is detailed in the answer to Question 3 along with a suggestion for how to modify the approach to deal with the concern.

In addition to identifying the areas where we are supportive and where we have concerns, we have also commented on the following topics in the answer to Question 4:

- Other documentation and utilities
- Document/artefact precedence
- Treatment of bugs and associated change control
- Unified Modeling Language (UML)
- Automated documentation.

The remainder of this document gives our answers to specific questions in the consultation document. We have answered questions **1, 3, 4, 5, 6, 7, 14 and 28.** We have left the other questions unanswered as we have less knowledge in these areas.

Q1. What are your views on the choice of name for the new model? Please provide your reasoning and any supporting evidence.

The name 'Home Energy Model' is a substantial improvement over 'Standard Assessment Procedure'. It concisely reflects the model's focus. It will be evident to all stakeholders what kind of data and functionality the model provides, and that it deals with home energy. This will promote understanding of the model's scope. This in turn will help maintainability over the long term by keeping the model focused on this scope.

Q3. What are your views on the potential implications of this proposed name change? Please provide your reasoning and any supporting evidence.

The name makes the model's focus clear: Adopting the name Home Energy Model indicates that its focus is home energy. It will be evident to all stakeholders what kind of data and functionality the model provides, and that it deals with home energy.

A clear focus scope will help intelligibility and long term maintenance: The technical documentation (HEM-TP-01) describes the scope of the Home Energy Model core as:

> A core calculation component which models heat transfer in the building, demand on heating, cooling and hot water systems and the resulting energy demand for electricity, mains gas etc.

Maintaining a clear focus on this scope will help to ensure that the model grows in a coherent way. If new data and functionality are needed and they fall within this overall scope they are suitable for inclusion in the Home Energy Model core. If they fall outside this scope then they would be better located elsewhere.

This approach will help to keep the model intelligible as it grows and this in turn will help with long term maintenance of the model.

It should be noted that the HEM scope does not include carbon emissions, primary energy usage or costs. We do not see this as a problem, but it has implications which are discussed below.

Thick wrappers and multiple instances of non-core data and functionality: The FHS Wrapper that has been released with the Home Energy Model calculates both carbon emissions and primary energy usage. These metrics are not available from the HEM core. The FHS Wrapper includes data and functionality that enable them to be calculated. This keeps the scope of the HEM core clear, but also has the following consequences:

- **The FHS wrapper is 'thicker' than it could be:** It includes more than it would if emissions and primary energy were available through its interface with a core component available to wrappers.

- **Duplication of effort - other wrappers may need similar data and functionality:** For example, the EPC wrapper may need to support emissions calculations. To do this it will need to include data on the emissions intensity of various types of energy, as well as functions to convert energy use to emissions.

- **Potential for inconsistencies between wrappers:** Different wrapper developers may implement such features in different ways, leading to the possibility of inconsistencies between wrappers. The inconsistencies may be due to different wrappers using different data structures to store carbon intensity data, differences in the carbon intensity data itself, or differences

in the algorithms used to calculate emissions. Some of these differences may be intentional due to different requirements for different wrappers. But in most cases they will be simply because different wrappers were developed differently, often by different people. Ideally the emissions calculation data structures, the data itself, and the calculation functionality would be the same in each wrapper, based on a single (possibly centralised) source.

As more wrappers are added there could be more of them with similar data and functionality requirements. Some of these may involve emissions and / or primary energy as in the example above. But there may also be more categories of data / functionality needed by wrappers that go beyond the scope of the HEM core. For example, the EPC Wrapper may need data and functionality to support financial cost calculations for various heating and insulation options. As the HEM ecosystem grows there will be more instances of potentially inconsistent data and functionality between wrappers, and they may become more complex as time goes on. This will adversely affect the long-term maintenance of HEM and the associated wrappers.

Options for location of non-core data and functionality: Two basic options can be identified for effective management of non-core data and functionality:

- **Add to the core:** In this approach the new data and functionality would be added to the core. There would be only one version, available to all wrappers. This avoids the possibility of inconsistencies between similar but different versions. The FHS Wrapper could become 'thinner'. However, the core would now have begun to diverge from its home energy focus (e.g. it may now include data and functionality for emissions and primary energy). Either its name would need to change, or the divergence would need to be accepted. The statement of the scope of HEM would need to include new areas such as emissions and the model would no longer be purely about home energy
- **Extend outside the HEM core:** In this approach the additional data and functionality could be made available alongside but outside the HEM core.

In our view extending beyond the core is preferable. The HEM core would retain its focus on home energy, unnecessary divergence between wrappers with similar but different data and functionality would be avoided, and wrappers would be thinner.

Given the open source nature of the project, some of this extended functionality can (and probably will) be provided by third parties who lie beyond the scope of the core HEM project and its governance.

Sufficiency of core functions: The functions provided for wrappers by the HEM core and the extended core should be sufficient for the needs of most wrapper requirements that can be reasonably anticipated. This applies regardless of whether or not HEM is cloud based.

Q4. What are your views on using the open-source code as the approved methodology for regulatory uses of the Home Energy Model? Please provide your reasoning and any supporting evidence.

Note on interpretation of the question: In answering this question we have assumed that comments and 'documentation strings' embedded in the code would not be part of the legal reference. However, if the intention were to take the code, comments and documentation strings together as the legal reference, our view would not change substantially.

Friends of the Earth is supportive of the open-source approach and so the HEM initiative is very welcome. The benefits are well documented, for example in the government's Technology Code of Practice. Our support extends to all uses of the Home Energy Model, including regulatory uses.

We also support the vision of the development of a "community of users who can adapt the Home Energy Model for their own purposes, and some of whose contributions may ultimately form part of the official version as used by government".

We believe that the open source and community approaches together have the potential to encourage development of an ecosystem of high quality open-source software based around HEM, and to contribute positively to the development, acceptance and adoption of HEM itself.

However, we have serious concerns about the approach under consideration in which HEM code would act as the ultimate legal reference for the HEM methodology and would replace the SAP specification.

Concerns

Our concerns about making the codebase the ultimate legal reference can be summarised as follows:

- Ultimate legal reference understandable only to programmers
- Risk of embedding program bugs in a legal reference
- Program code is not the best methodology specification language
- A software system and its legal reference may need different structures
- The complete methodology includes data as well as code
- Equations and graphics could not be part of the (text only) codebase.

In our opinion these drawbacks would be very serious. We believe that the legal reference should continue to be a document (probably including equations and graphics) that is accessible to and understandable by all stakeholders.

We also have an associated concern that reliance on expensive and legally encumbered standards documentation reduces access and openness.

The following paragraphs give more detail on each of the concerns.

Ultimate legal reference understandable only to programmers: Using the HEM

code as the ultimate legal reference for the methodology would mean that only Python programmers would be able to read and understand it. This would exclude most stakeholders. We understand that they would have access to other project documents, such as the technical documents that have been published. However, these would not be a definitive statement of the methodology.

Risk of embedding program bugs in a legal reference: All large programs include bugs / errors. Making the code the ultimate legal reference risks giving such bugs a legal significance. It is true that specification documents can also include errors which would need to be corrected through a change control process (see below). However, in the case of a specification document, errors would be visible to all stakeholders, and therefore more likely to be noticed. In the case of the program code being the legal reference, only a minority of stakeholders (Python programmers) would have sufficient understanding to be able to identify errors.

Program code is not the best methodology specification language: The primary purpose of a piece of code is to *automate* some logic. Ideally, code should be as understandable as possible to human readers. In practice textual comments and documentation strings are needed to *explain* the code. This illustrates the limitations of program code as a specification language.

A software system and its legal reference may need different structures: In many cases it may be possible for the HEM methodology reference to have the same structure as the HEM code and its associated data structure. Friends of the Earth would welcome this. However it might not be possible in all cases. For example, there may be elements of the methodology that are best stated as a single paragraph, but which require consistent and coordinated behaviour across a range of components of the system. Or there might be general requirements that apply across the whole methodology and do not apply to a particular section of code. An example of this is the General Principles section in the SAP specification. Model performance (e.g. run time) requirements are another example. Attempting to force these two structures (legal reference and software system) together could be sub-optimal from both perspectives.

The complete methodology includes data as well as code: The SAP methodology includes many data tables and values, for example default U-values used in heat loss calculations. The Home Energy Model also needs similar data. Such data is as much a part of the methodology as the code. It is typically considered good practice for the system to load data tables from files or a database rather than holding them directly in the code. Under the former approach the code alone could not be regarded as the entirety of the methodology.

Equations and graphics could not be part of the legal reference: The SAP specification includes many equations and graphics. Similar content is also relevant in the legal reference for the Home Energy Model. However, the special typesetting used for mathematics would not be available in Python, and none but the crudest graphics embedded in Python code would not be possible.

Reliance on expensive and legally encumbered standards documentation reduces access and openness: The provision of the technical documentation is

welcome as useful explanatory material for the methodology. However, it includes a number of references to standards documents with substantial prices. For example:

- HEM-TP-04 refers to BS EN ISO 52016-1:2017 and the CIBSE Guide
- HEM-TP-05 refers to BS EN ISO 13789:2017 and BS EN ISO 13370:2017 (BS EN ISO 13789:2017 lists a number of other normative references such as ISO 6946)

The current (March 2024) online price for ISO 52016-1:2017 is 216 Swiss Francs (about £190). Such costs reduce access and openness by presenting a substantial barrier to potential contributors of the HEM project. This is particularly so given that many open source contributors operate on a limited budget.

Additional considerations on documentation

The following additional considerations are discussed further below:

- A HEM specification is needed to replace the SAP specification
- HEM core interface documentation is needed
- A range of other documentation and utilities are needed
- Document/artefact precedence, bugs and change control
- Automating documentation using code files may have benefits.

The paragraphs below provide further detail on these topics.

A HEM specification is needed to replace the SAP specification: As indicated above, we do not believe it is appropriate to take the HEM program code as the ultimate legal reference for the methodology. It follows that a separate specification document will be needed to take the place of the SAP specification.

We have found the SAP specification on the whole to be accessible and understandable, despite its size (200+ pages). However, it would be worth exploring techniques for the HEM specification that may not have been in common use for specifications when when SAP was originally developed.

One such technique could be **conceptual data modelling**. Analysis of the HEM code shows that Building Element is an important class of objects represented in the methodology. It is also important in the SAP methodology, despite appearing relatively few times in the text (key heat loss calculations in the SAP worksheet are linked to building elements).

Conceptual data modelling can help to identify such important concepts and the relationships between them. In addition, developing a conceptual data model as part of (or alongside) the HEM specification will also help provide a **standard project vocabulary** for all stakeholders.

Some relevant references on this topic can be found at https://www.sciencedirect.com/topics/computer-science/conceptual-data-model

HEM core interface documentation is needed: In order to adapt the Home Energy Model as envisaged, community users will need to be able to provide it

with input. We understand that this is currently done using input data in JSON (JavaScript Object Notation) format. Friends of the Earth has experimented with some of the JSON input files provided with the HEM code (e.g. demo.json). The layout and keywords used (e.g. `"Infiltration"`, `"storeys_in_building"` etc.) are intuitive. However, details of the valid keywords and allowed data values are not evident without close inspection of the program code. Documentation of this JSON interface would assist users wishing to adapt the model, and this in turn would help development of the community.

The JSON interface can be considered to be an *Application Programming Interface (API)* for the HEM core engine. API documentation is typically required on many projects. For example, Linux provides API documentation for its kernel.

Other documents and utilities: A range of other items will be needed for various purposes. Examples may include:

- High level system architecture and design
- Technical architecture specification including hardware and system software environment (e.g. operating system version)
- User interface specification
- Program module specifications
- A comprehensive test suite with robust acceptance testing and validation procedures

Unified Modeling Language (UML) may be considered for producing some of these documents, as well as for the HEM Specification. However, any use should be judicious and in a way that adds value to the documentation. No UML diagram should be produced simply because UML includes a convention for drawing that type of diagram.

In keeping with the open source approach, all project documents should be open licensed.

Document/artefact precedence, bugs and change control: Documents and the program code are *artefacts*. Each artefact has a primary purpose. As has been noted, the primary purpose of a piece of code is to automate some logic. The primary purpose of the HEM Specification is to provide a definitive statement of the methodology, including how heat transfer and the resulting energy demand are modelled.

Any artefact may include errors, either in a document or in program code. This applies regardless of whether or not the artefact is acting as the legal reference for the methodology. As part of identifying the correction needed, other artefacts may be relevant, even on topics for which they are not the primary reference. For example, in the case of the HEM program code acting as the legal reference, if an error were noticed it would be relevant to refer to the HEM technical documents to determine what the code is expected to do. Similarly, in the case of a HEM Specification document acting as the legal reference it may be relevant look at other technical documents or at the program code.

To handle such cases a change control procedure will be needed to manage the

process of changing the artefact (whether code or a document). The change control procedure would also apply in the case of system modifications or extensions that were not the result of an error.

Automating documentation using code files may have benefits: Although we do not support making the HEM code the legal reference, we do support use of automated documentation approaches that use the program code and documentation strings embedded in it. This may help in keeping the legal reference up to date and in sync with code changes.

To test the concept of documentation automation in the HEM context, Friends of the Earth has imported the HEM code into Doxygen, an open source utility for producing software-based documentation. We can see that the HEM code includes many useful documentation strings, and these appear at appropriate places in documentation that is automatically generated. This is not to say that Doxygen is the best tool for the job - there may be others that are more suitable. But we do welcome the use of documentation strings in the source code, and would support their use in generating automated documentation.

Other considerations

The following identifies a number of topics we recognise as being important. We have not discussed them in any detail, but believe that it will be useful for them to be considered in the next stage of the project:

- How to build a strong and active community (needs to take account of the legislative significance of HEM)
- Licensing for software and documentation produced by the community
- Process for incorporation of contributed code into the HEM core
- Who will have commit rights to the HEM core and how will those maintainers be appointed?
- Open data.

Q5. What forms of collaboration would you be interested in for future development of the Home Energy Model codebase? Please provide further details.

In principle, Friends of the Earth would be interested in collaborating but the resources we can commit are very limited. We are interested as we are exploring how the model might enable us to develop a tool or tools to help inform our supporters and others on insulation and heating options. It may be useful to look at potential for synergies in this area. The person leading our work (Chris Gordon-Smith) has a wide knowledge of IT including modelling and simulation and would be our point of contact for collaboration.

Q6. What are your views on our assessment of issues with the current SAP delivery model? Please provide your reasoning and any supporting evidence.

We agree with the assessment, and make the following observations:

- **Inconsistencies in results:** These are almost inevitable in a situation where there are multiple software implementations.

- **Inertia:** We saw in 2018 that the SAP methodology is slow to change when doing modelling work on heating systems. We wanted to use the SAP figure for the carbon intensity of electricity (SAP 2012 specification version 9.92, page 225). We did not use it because the figure was out of date and more than double the true figure. In the period since then the SAP specification has not changed, and so the figure is even more out of date.

  Such inertia leads more widely to a lack of flexibility and extensibility which may result in unnecessary delay to important decarbonisation measures.

- **Lack of accountability:** This is another factor likely to lead to inconsistencies.

Q7. What are your views on the concept of a centralised, cloud-based version of the Home Energy Model, to be used for regulatory purposes? Please provide your reasoning and any supporting evidence.

We would welcome the approach and agree with the assessment of the advantages identified in the consultation document under 'Possible changes to the delivery model'.

We have commented under Question 4 that comprehensive documentation of the interface to the core engine would be needed (as well as other documentation). This applies in the case of cloud-based delivery as much as in any other form of delivery.

Q14. What are your suggestions for other wrappers that could be developed for the Home Energy Model in future? Please provide your reasoning and any supporting evidence.

As noted under Question 5, we are exploring how the Home Energy Model might enable us to develop a tool or tools to help inform our supporters and others on insulation and heating options. This kind of tool may have some overlap with the self assessment wrapper mentioned in the consultation document as a possible future development.

Q28. What suggestions do you have for further validation exercises that could be undertaken to refine the Home Energy Model? Please make suggestions, explaining your reasoning, and providing any supporting evidence.

Building a functioning community would be likely to be helpful in supplementing formalised validation. The diverse use cases that arise and the wide ranging discussions can be powerful drivers in identifying unforeseen issues.

Acknowledgement

We would like to thank Robbie Morrison of the Open Energy Modelling Initiative for discussing a number of topics on the openmod forum and by email. These discussions have enriched our understanding in a number of areas and improved the quality of our response to this consultation.

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