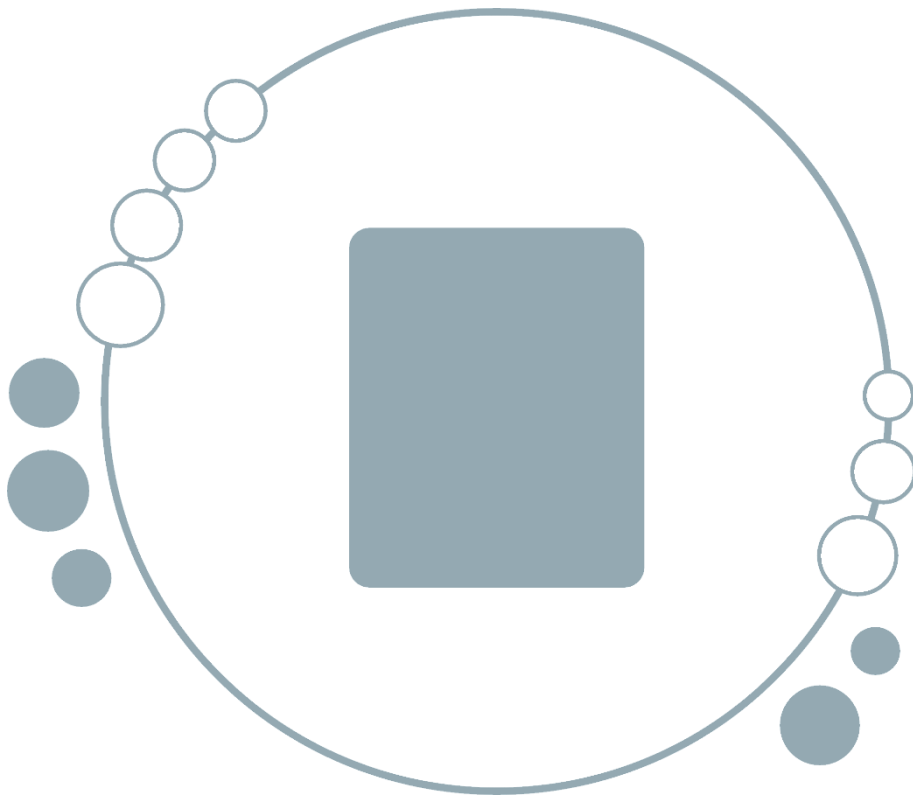




# Accounting for External Conditions within the Home Energy Model

A technical explanation of the methodology

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# 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

The heat loss and heat gains in buildings will be influenced by external factors including external temperature, wind speed and solar radiation.

This paper sets out the methodology for the use of external conditions within the Home Energy Model core engine.

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

*[src/hem\\_core/external\\_conditions.py](#)*

*[src/hem\\_core/input\\_output/read\\_weather\\_file.py](#)*

# Methodology

The Home Energy Model (HEM) core engine requires data on the external conditions of a building. External conditions which the HEM engine requires include the external air temperatures, solar radiation, wind speed and direction, and the latitude and the longitude of the building. This data can be entered into the input file directly but will usually be loaded from a weather file specified by the user.

## 1. Weather Files

The Home Energy Model has been developed to accept two different types of weather file:

- EnergyPlus Weather Format (EPW) files
- CIBSE Test Reference Year (TRY) files.

The EPW file format was chosen as it is easily and freely available for a large range of locations and is sufficiently rich to support the Home Energy Model's treatment of building physics. It is also used within comparable models, facilitating validation of HEM.

The CIBSE format can provide the same data, after some minor modifications which have been automated as part of the data ingestion process (see Table 1). This format was adopted to facilitate the use of the [CIBSE Test Reference Year \(TRY\)](#) scenario data, which offers projected future scenarios based on [Met Office climate projections](#).

The relevant data available in each weather file is shown in Table 1.

| External Factor                     | EPW Weather File | CIBSE Weather File                                               |
|-------------------------------------|------------------|------------------------------------------------------------------|
| External Air Temperature (dry-bulb) | Included in File | Included in File                                                 |
| Wind Speed                          | Included in File | In Knots, converted to m/s                                       |
| Wind Direction                      | Included in File | Included in File                                                 |
| Direct Beam Normal Radiation        | Included in File | Inferred from Global Horizontal and Diffuse Horizontal Radiation |
| Diffuse Irradiation (Horizontal)    | Included in File | Included in File                                                 |
| Latitude                            | Included in File | Included in File                                                 |
| Longitude                           | Included in File | Included in File                                                 |

**Table 1 - Required external condition inputs for the HEM engine and their availability in the weather files.**

## 2. External Temperature

Hourly external air temperature is taken directly from the weather files.

External dry bulb air temperature has several purposes:

- Boundary condition in the fabric heat loss calculation for elements adjacent to the external environment.
- Source temperature for air source heat pumps.
- Supply temperature of air flow due to infiltration and ventilation.
- Used to determine the heating system flow and return temperatures when weather compensation is enabled.
- Used to determine the ductwork losses of mechanical ventilation systems.

## 3. Wind Speed and Direction

Wind speed is taken directly as hourly data from the EPW weather file. The wind speed is provided hourly in Knots within the CIBSE weather file, which is converted to m/s for use in the core HEM engine.

Wind direction is taken directly as hourly data from the weather files.

Wind speed and direction are used to calculate the wind pressure for air flow paths in the infiltration and ventilation calculation.

## 4. Solar Radiation

Diffuse irradiation (horizontal) is taken directly from the weather files.

Direct beam normal radiation is taken directly from the EPW weather file, but for the CIBSE weather file it must be derived from other values. To determine the direct beam normal radiation, the direct beam radiation on the horizontal plane is calculated as the difference between the global horizontal and diffuse horizontal radiation. This value is then divided by the sine of the solar altitude at each timestep to determine the direct beam normal radiation.

Solar radiation is used to calculate:

- Solar gains through transparent elements of a dwelling.
- Solar absorption for opaque elements adjacent to the external environment.

- Electricity produced by PV systems.
- Energy captured by solar thermal systems.

For more information on how solar radiation is treated please see HEM-TP-08 Solar gains and shading.



