HEM – Module 1 - Theory

Elmhurst Energy

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Housekeeping

- **Video and Audio**
- **Discussions**
- **Timekeeping**
  - Aim to finish at 4
  - Regular breaks
- **Slides and CPD certificates will be provided after the course**

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Agenda

- **Home Energy Model Background**
- **HEM Delivery Model**
- **Elmhurst Design HEM update**
- **HEM Calculation Methodology & FHS inputs**
- **Q + A**

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Aims of the day

- To start understanding the new data fields in HEM:FHS assessments.
- To discuss impacts on flow of information between assessors and clients.
- To help us identify areas of uncertainty for future conventions.
- Lots of discussion.

HOME ENERGY MODEL BACKGROUND

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Evolution of SAP

2006

SAP 2005 (9.8)

Introduced thermal bridging

Lighting energy added

Overheating risk added

2008

SAP 2005 9.81

EPCs introduced

Added MV from PCDB

Added wind and hydro turbines

2010

SAP 2009 (9.9)

Introduced party wall heat loss

Space cooling added

Thermal mass added

2013

SAP 2012 (9.92)

New R junctions

Pipework heat loss options added

2022

SAP 10

Thermal mass changes

PV diverters and batteries added

PV, Lighting & Hot water calculation changes

Why replace SAP?

- SAP has been used since 2002 for demonstrating compliance with Part L.
- *"The government recognises that there are longstanding issues with SAP, which are not conducive to the delivery of our housing and climate change objectives." DESNZ Home Energy Model Consultation (2023).*
- SAP is very simple compared to the modern industry standards.
- SAP is limited in its ability to model modern dwellings and technologies.
- Many industry bodies have recommended updating SAP such as the Climate Change Committee (CCC), SAP Industry Forum and 2023 Mission Zero Review.

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Government Response

- In 2021 Etude were commissioned by BEIS to complete a ‘scoping study’ on improving the next version SAP methodology.
- Elmhurst contributed to their work giving our opinions on the implementation of SAP 10 and other areas of concern.
- Etude published “Making SAP fit for Net Zero” report in 2021 with 25 recommendations including;
  - *Alignment between SAP and strategic objectives*
  - *Improvements to the methodology*
  - *Improvements to SAP for net zero*
  - *A better evaluation of energy use*
  - *Support decarbonisation of heat and electricity*
- Following this Government appointed BRE and other experts to carry out a multi-year project to develop a replacement for SAP.

Introducing the Home Energy Model

- Replacement for SAP.
- Previously known as "SAP 11".
- Originally created by BRE.
- A complete rebuild of the methodology.
- To be used to assess compliance for the FHS.

HEM Consultations

HEM Consultation

- Closed 27th March 2024.
- Covers the reasons for replacement of the SAP methodology and new approach taken by the HEM.

HEM: Future Homes Standard assessment Consultation

- Closed 27th March 2024.
- Covers the parts of the HEM methodology specific to demonstrating compliance with the FHS aka the ‘wrapper’.

Supporting documents

HEM

- 18 supporting documents
- Covering core HEM approach
- Areas such as ventilation, PV, space heating, shading, hot water demand covered.
- https://www.gov.uk/government/publications/home-energy-model-technical-documentation

HEM: Future Homes Standard

- 6 supporting documents
- Covering assumptions, fuel factors etc. used in the FHS wrapper
- https://www.gov.uk/government/publications/home-energy-model-future-homes-standard-assessment-technical-documentation

Home Energy Model Consultation

- Home Energy Model consultation responses published 2nd October 2025;
  - Provided further details around the open source repositories and energy calculations as a service (ECaaS) facility.
  - Confirmed revised PCDB and Appendix Q process underway.
  - Confirmed increase in time resolution likely to be half hour timesteps.
  - Confirmed standards to be used in the core model including space heating, water heating, ventilation, self generated electricity etc.
  - Further details on validation of the model provided.

- HEM:FHS consultation responses will come later.

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Future Homes Standard

- Consultation on the Future Homes Standard closed March 2024.
- Heat pump led notional dwelling.
- Labour have supported PV on new homes but notional dwelling amount likely to differ from consultation.
- Proposed to retain Primary Energy, Carbon and Fabric Energy Efficiency metrics.
- New standards for material change of use.
- Transitional arrangements same as previous i.e. one year to commence.
- Still awaiting responses.

SAP 10.3

- On 14th May 2025 Government announced both SAP and HEM could be used for demonstrating compliance with the Future Homes Standard.

- SAP 10.3 will use existing SAP 10 methodology with two changes;
  - A new notional dwelling to assess compliance with the Future Homes Standard.
  - New carbon and primary energy factors for fuels.

- Government recently confirmed work started in SAP 10.3 would be able to be completed in SAP 10.3

- As HEM is still under development SAP 10.3 will provide a smoother transition to the Future Homes Standard.

Discussion

HEM Delivery Model

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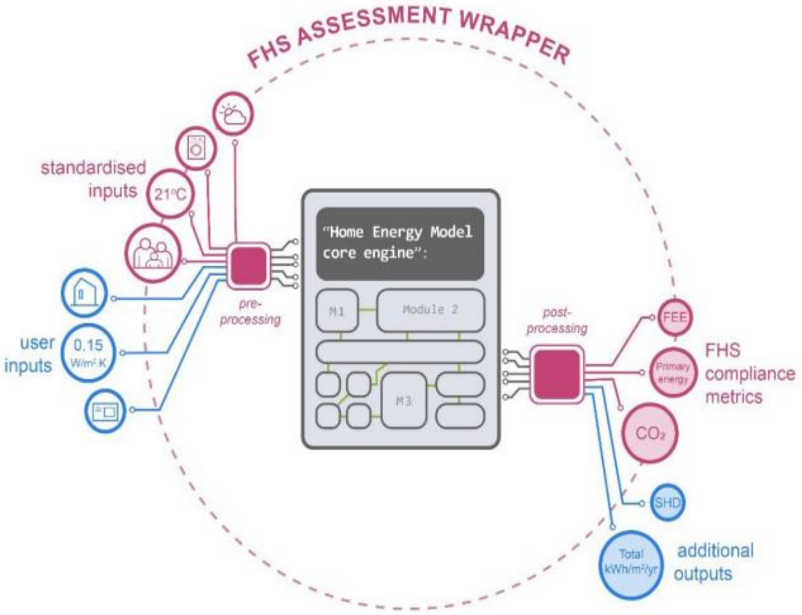
Open Source Methodology

- One aim for HEM was to increase the transparency of the methodology.
- Government/BRE have published the code base of the HEM.
- Changes now shown in the open source code.
- Should improve transparency and allow peer review of the methodology.
- This may remove the need for a specification document as used for SAP previously.
- May result in more users of the HEM which will feed into the official versions used.

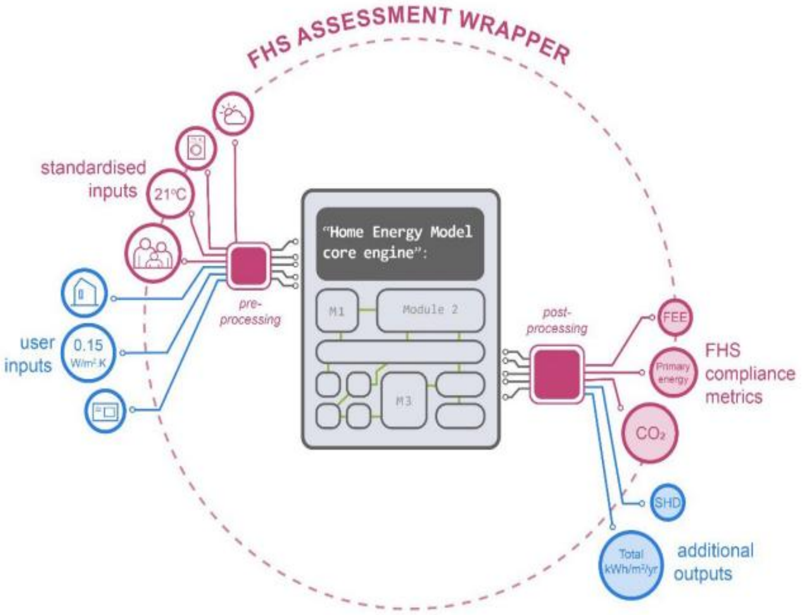
Wrappers

- To distinguish between different purposes when using the HEM, ‘wrappers’ will be created.
- A wrapper controls the user inputs, standardized inputs and outputs from the HEM for a specific purpose.
- The only wrapper currently available is for assessing compliance to the Future Homes Standard.
- **The use of HEM + FHS wrapper = HEM:FHS**
- Future wrappers may include PAS 2035 assessments, existing dwelling EPCs etc.



FHS:HEM Outputs

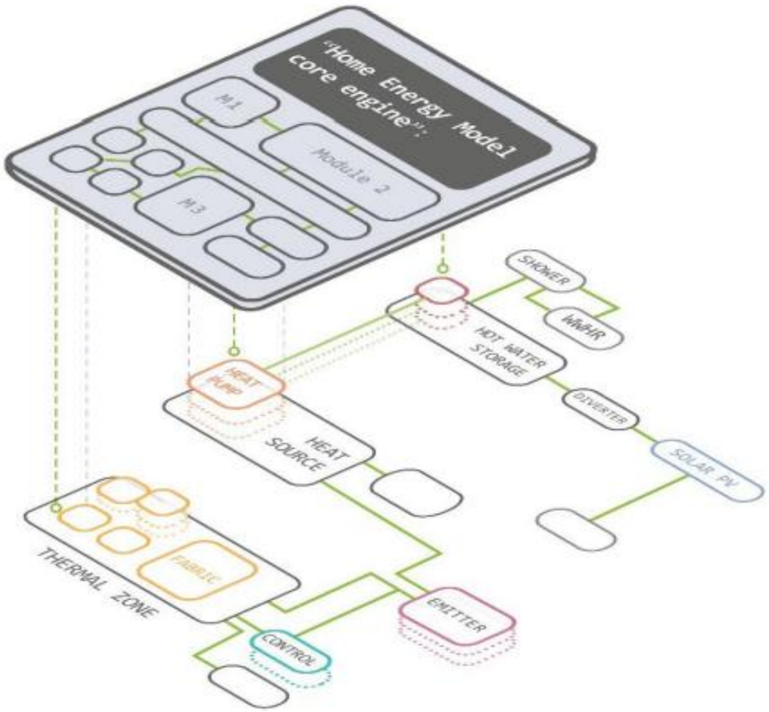
- As well as compliance metrics the following are shown on the consultation tool;
  - Space heating demand (kWh/m²/yr)
  - Space cooling demand (kWh/m²/yr)
  - Space energy use
    - total energy use (kWh/m²/yr)
    - energy use by use type (kWh/m²/yr)
    - energy use by fuel type (kWh/m²/yr)
  - Heat transfer coefficient (W/K and W/m².K)
  - On-site electricity generation
    - exported (kWh/yr)
    - used on-site (kWh/yr)
  - Peak half-hour electricity draw (kWh)



- Also detailed results can be downloaded to CSV files.

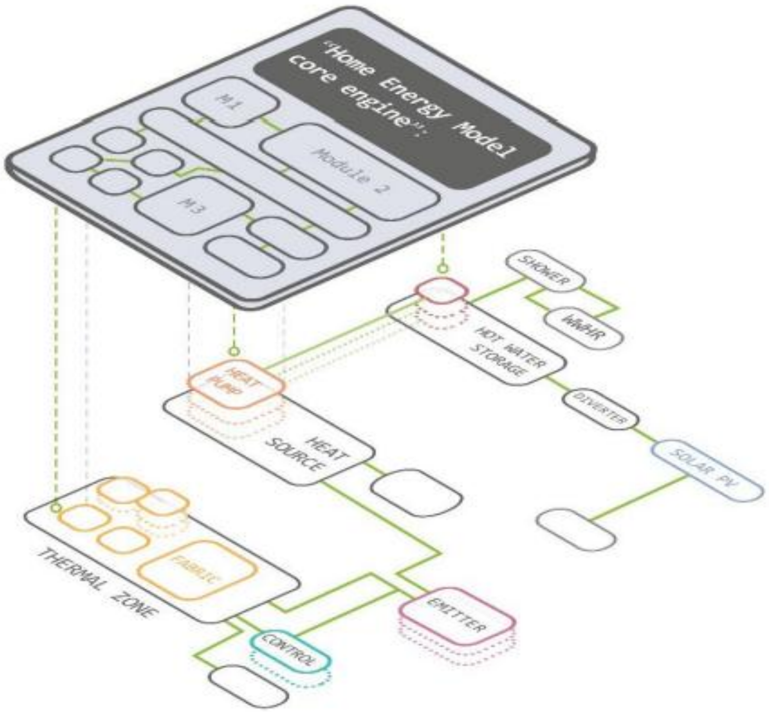
Energy Calculations as a Service (ECaaS)

- Previously software providers have had to create a calculation engine based on the SAP specification.
- This was then checked against BRE supplied 'test cases' for accuracy.
- Issues included inconsistent results, speed of changes and accountability for delivering results.
- For SAP 10 test cases were delivered late, with numerous errors.
- A number of test cases were deferred, with a phased approval process implemented.
- Some technologies were not benchmarked against a test case e.g. PV diverters.



Energy Calculations as a Service (ECaaS)

- Going forwards the HEM engine will be centralised and cloud based.
- This will be controlled by MHCLG and known as 'Energy Calculations as a Service'.
- Rewritten Python code into RUST code resulting in much faster calculations ~ 1 second.
- Only accreditation schemes can use ECaaS via their front end applications.
- First official purpose will be calculation of FHS compliance results.
- Expected to be used for calculation of EPCs in future.



ECaaS Analysis

Opportunities	Issues
• Consistency of results regardless of software package used. • Quicker deployment of fixes/amendments. • Software providers may be able to focus more resource on user interfaces. • No delays in PCDB being implemented.	• Will it be ready/reliable? • May not be able to see ‘under the bonnet’ like current engine. • How will changes to the engine be deployed? • Downtime – no calculation possible? • Potential charge for the service?

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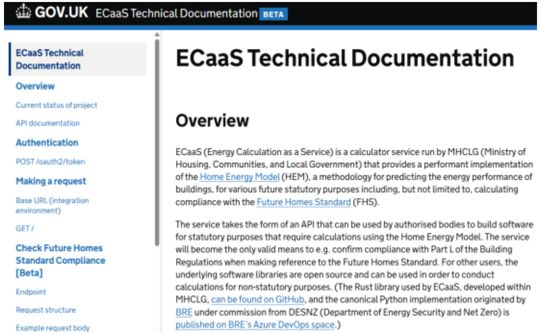
Energy Calculations as a Service (ECaaS)

MHCLG will host the HEM calculation engine

Known as Energy Calculation As A Service (ECaaS)


GOV.UK ECaaS Technical Documentation BETA

ECaaS Technical Documentation
Overview
Current status of project
API documentation
Authentication
POST /oauth2/token
Making a request
Base URL (integration environment)
GET /
Check Future Homes Standard Compliance [Beta]
Endpoint
Request structure
Example request body

ECaaS Technical Documentation

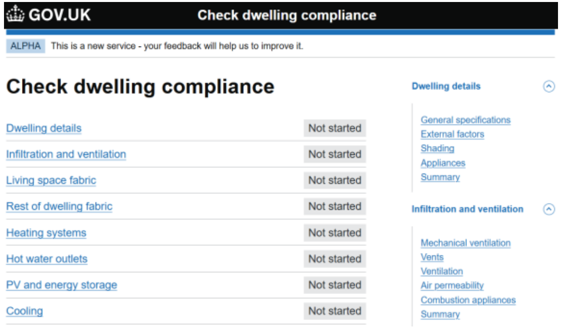
Overview

ECaaS (Energy Calculation as a Service) is a calculator service run by MHCLG (Ministry of Housing, Communities, and Local Government) that provides a performant implementation of the Home Energy Model (HEM), a methodology for predicting the energy performance of buildings, for various future statutory purposes including, but not limited to, calculating compliance with the Future Homes Standard (FHS).

The service takes the form of an API that can be used by authorised bodies to build software for statutory purposes that require calculations using the Home Energy Model. The service will become the only valid means to e.g. confirm compliance with Part L of the Building Regulations when making reference to the Future Homes Standard. For other users, the underlying software libraries are open source and can be used in order to conduct calculations for non-statutory purposes. (The Rust library used by ECaaS, developed within MHCLG, can be found on GitHub, and the canonical Python implementation originated by BRE under commission from DESNZ (Department of Energy Security and Net Zero) is published on BRE's Azure DevOps space.)

First version released November 2024

Elmhurst are already interacting with the service to generate results, understand inputs etc.


GOV.UK Check dwelling compliance

ALPHA This is a new service - your feedback will help us to improve it.

Check dwelling compliance

Dwelling details	Not started
Infiltration and ventilation	Not started
Living space fabric	Not started
Rest of dwelling fabric	Not started
Heating systems	Not started
Hot water outlets	Not started
PV and energy storage	Not started
Cooling	Not started

Dwelling details
General specifications
External factors
Shading
Appliances
Summary

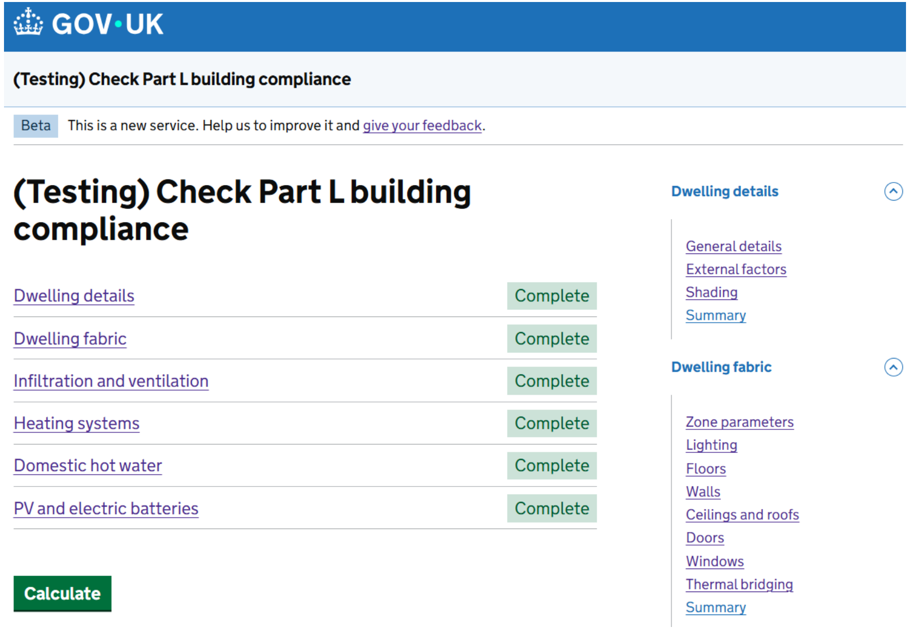
Infiltration and ventilation
Mechanical ventilation
Vents
Ventilation
Air permeability
Combustion appliances
Summary

Ongoing development

ECaaS still being developed. MHCLG expect a front end to be ready with launch of FHS.

Home Energy Model Interface

- On 6th August 2025 the first version of the HEM:FHS interface was released by MHCLG.
- Free to use and open to all Elmhurst members.
- This was communicated to Elmhurst members via Notification Centre on Access Elmhurst.
- Allows user to get familiar with look and feel of MHCLG interface and report bugs.



BREL Reports

- Currently provided by a plugin to SAP 10 software from BRE.
- Report is not able to be digitally signed via Adobe.
- Expected that for FHS the BREL will be supplied via ECaaS to schemes.
- Elmhurst have had meetings with MHCLG to highlight the current issues with the BREL.
- New BREL will be needed for SAP 10.3 as well.

Building Regulations England Part L (BREL) Compliance Report

Approved Document L1 2021 Edition, England assessed by Array SAP 10 program, Array

Date: Thu 09 Mar 2023 14:18:25

Project Information			
Assessed By	Catherine Newbuild	Building Type	House, Detached
OCDEA Registration	EES/090010	Assessment Date	2023-03-09

Dwelling Details			
Assessment Type	As built	Total Floor Area	50 m^2
Site Reference	Plot 3_Copy	Plot Reference	00001_Copy_Copy_Copy
Address	Elmhurst Energy, Unit 16 St Johns Business Park, Lutterworth, LE17 4HB		

Client Details	
Name	Name
Company	Company
Address	AddressLine1, Town, Postcode

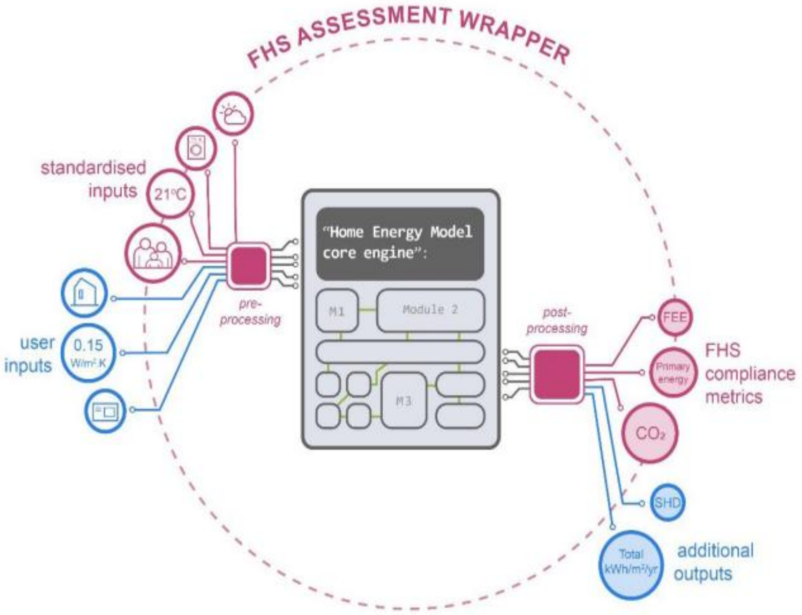
This report covers items included within the SAP calculations. It is not a complete report of regulations compliance.

1a Target emission rate and dwelling emission rate		
Fuel for main heating system	Mains gas	
Target carbon dioxide emission rate	*10.41 $kgCO_2/m^2$*	
Dwelling carbon dioxide emission rate	10.11 $kgCO_2/m^2$	OK
1b Target primary energy rate and dwelling primary energy		
Target primary energy	*55.6 kWh_{PE}/m^2*	
Dwelling primary energy	57.62 kWh_{PE}/m^2	FAIL
1c Target fabric energy efficiency and dwelling fabric energy efficiency		
Target fabric energy efficiency	*32.7 kWh/m^2*	
Dwelling fabric energy efficiency	41.5 kWh/m^2	FAIL

2a Fabric U-values				
Element	*Maximum permitted average U-Value [W/m^2K]*	Dwelling average U-Value [W/m^2K]	Element with highest individual U-Value	
External walls	*0.26*	0.2	Walls (1) (0.2)	OK
Party walls	*0.2*	N/A	N/A	N/A
Curtain walls	*1.6*	N/A	N/A	N/A
Floors	*0.18*	0.1	Heatloss Floor 1 (0.1)	OK
Roofs	*0.16*	0.1	Roof (1) (0.1)	OK
Windows, doors, and roof windows	*1.6*	1.6	Opening (3)	OK
Rooflights	*2.2*	N/A	N/A	N/A

EPCs?

- A separate wrapper is needed for EPCs.
- Expected to be consulted on in 2026.
- EPC production via HEM may be on a separate timeline to Building Regulations.
- Recent EPC Reform consultation proposed changing the metrics on EPCs which HEM will need to provide.



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Timeline

Dec 2023

FHS & HEM Consultations

Consultations launched.

BRE HEM:FHS Consultation tool available.

Mar 2024

Consultations close

FHS & HEM consultations close after 3 week extension.

Nov 2024

ECaaS launched

First version of ECaaS launched to schemes.

Based on HEM v30.

Feb 2025

ECaaS updated

ECaaS updated to HEM v32.

Apr 2025

ECaaS updated

ECaaS updated to HEM v34.

Mid 2025

MHCLG HEM:FHS Tool launched

MHCLG HEM:FHS tool launched to industry.

Early 2026

FHS released

SAP 10.3 available.

MHCLG HEM:FHS tool updated.

Early 2027

FHS commences

FHS commences within Building Regulations.

Transitional arrangements commence.

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Design (HEM) Update

- Elmhurst are authorized to use the ECaaS facility.
- We commenced development of our HEM:FHS application at the start of 2025.
- Interacting with ECaaS to understand user inputs.
- Has been difficult due to changing HEM versions/inputs.
- No timeline available for release but intent to release as soon as possible.

Key design decisions

- Platform will remain browser based.
- Calculation of results using ECaaS controlled by user.
- Saving data now controlled by user.
- Navigation through sections remains on left side of assessment.
- Results displayed vertically on right side of assessment.

HEM Methodology & FHS Inputs

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New standards

- HEM uses many different calculation standards compared to SAP.
- Based on established international standards to ensure HEM is an up to date methodology.
- Significantly more complex than SAP.
- The HEM:FHS wrapper sees an increase in data input fields for assessors.

Calculation Time Resolution

- SAP 10 calculates energy use monthly.
- Struggles with new technologies, time of use tariffs, loadshifting etc.
- HEM:FHS will calculate on 30 minute intervals as per BS EN ISO 52016-1:2017.
- Will ensure it is more suited to new innovations, flexible energy demand and weather profiles.
- In the BRE FHS:HEM consultation tool the calculation of results were very slow, often up to 10 minutes.

HEM Time Resolution

Fewer constraints

Heat Pump modelling improvements

Smart technologies and storage

Support different use cases

Validation improvements

HEM Calculation Structure

- The core HEM model includes;
  - Calculation of infiltration rates and ventilation energy use.
  - Calculation of space heating/cooling demand and energy use.
  - Calculation of hot water demand and energy use.
  - Calculation of electricity generation, self-consumption, and storage.
  - Additional calculations for systems providing multiple services.
- One iteration of each per time step.
- Modular structure to maximize flexibility.

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Weather Location

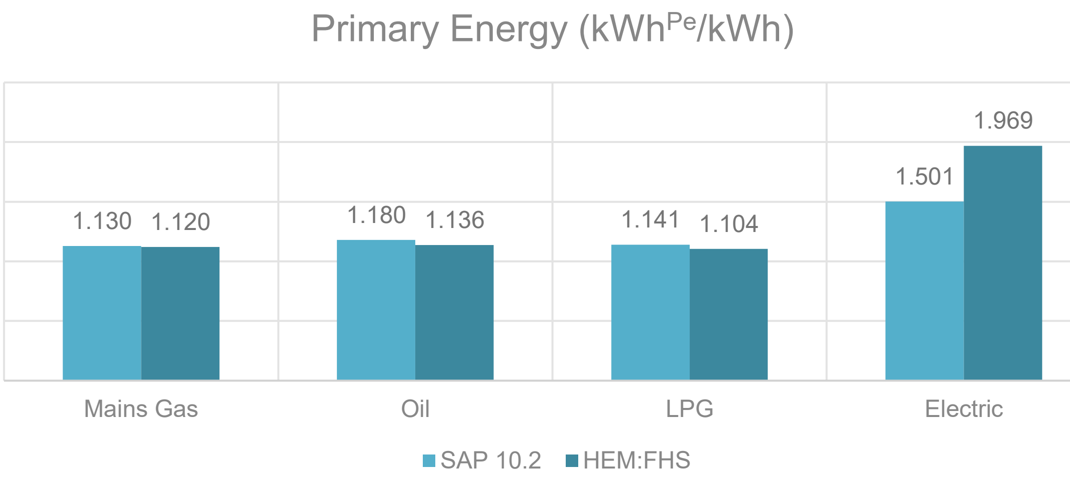
- FHS will use regional weather data rather than UK average for compliance metrics.
- Weather data will be standardized in the FHS wrapper.
- Ten weather locations were available in the HEM:FHS consultation tool.
- Based on CIBSE's test reference year and future projections.
- Will ensure that new homes are assessed against the more relevant circumstances for their lifetime.

(a) SAP 10.2

(b) Home Energy Model: FHS assessment Consultation Tool

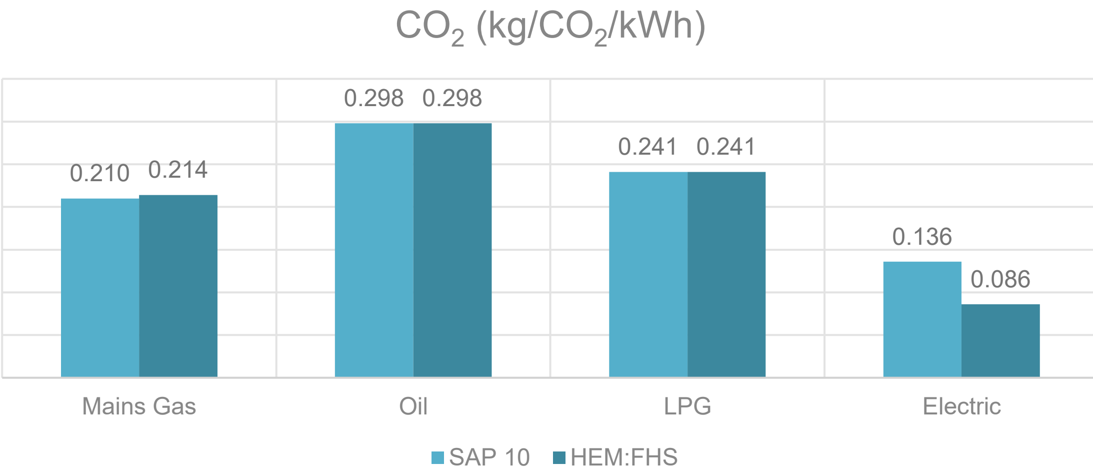
Primary Energy Factors – HEM:FHS

Fuel	SAP 10.2	HEM:FHS
Mains Gas	1.130	1.120
Oil	1.180	1.136
LPG	1.141	1.104
Electricity	1.501	1.969



Carbon Factors - HEM:FHS

Fuel	SAP 10.2	HEM:FHS
Mains Gas	0.210	0.214
Oil	0.298	0.298
LPG	0.241	0.241
Electricity	0.136	0.086



HEM:FHS Inputs

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Property Configuration Fields

Field	Description
Property Type	House or Flat
Number of stories	Number of heated, habitable stories in the dwelling
Which floor?	For flats only, which floor of the building the flat is sited on
Number of bedrooms	Number of bedrooms
Number of wet rooms	Number of wet rooms as per AD F definition
Part G Compliant?	Compliant with Part G of the Building Regulations – affects hot water demand
Number of tapped rooms	Number of rooms with hot water taps in
Number of utility rooms	Number of utility rooms as per AD F definition
Number of bathrooms	Number of bathrooms as per AD F definition
Number of sanitary accommodations	Number of sanitary accommodation rooms as per AD F definition
Number of habitable rooms	Number of habitable rooms as per AD F definition

Definitions

- House is defined as "*a standalone residential building surrounded by open space or terraced or semi terraced buildings*".
- Flats are defined as "*a self contained unit within a multi unit structure sharing common walls and areas*".

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Part F Definitions

- Wet room - A room used for domestic activities (such as cooking, clothes washing and bathing) that produce significant amounts of airborne moisture, e.g. a kitchen, utility room or bathroom.
- Utility Rooms - A room containing a sink or other feature or equipment that may reasonably be expected to produce significant quantities of water vapour.
- Bathrooms - A room that contains a bath or shower and which can also include sanitary accommodation
- Sanitary accommodation - A space containing one or more flush toilets (WCs) or urinals. Sanitary accommodation containing one or more cubicles counts as one space if there is free circulation of air throughout the space.
- Habitable rooms - A room used for dwelling purposes but which is not solely a kitchen, utility room, bathroom, cellar or sanitary accommodation

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Occupancy

- FHS calculates energy use and carbon emissions of a dwelling under a standardised usage pattern.
- HEM:FHS occupancy based on recent data from the English Housing Survey and uses floor area and number of bedrooms to calculate occupancy.
- The ADs refer frequently to requirements for ‘bedrooms’ but there is no statutory definition of what a bedroom is.
- In the English Housing Survey the number of bedrooms includes bedsitting rooms, but not bedrooms converted to other uses unless they have been denoted as bedrooms by the household.

Lighting

- Lighting details similar to SAP 10.
- Power (W), efficacy (l/w) and number of bulbs needed.
- Lighting energy use based on performance data and solar gains into the dwelling.
- Internal heat gains from lighting also included in calculation.

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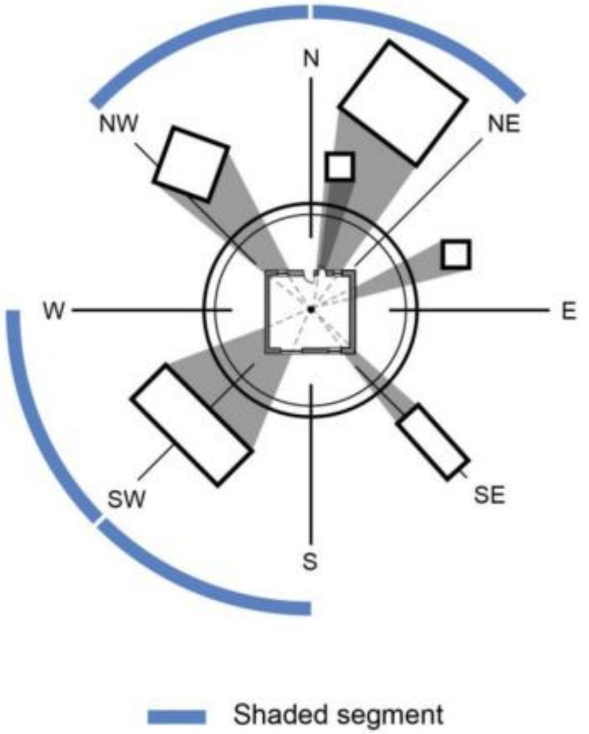
Appliances

- HEM:FHS wrapper includes non regulated energy consumption from appliances.
- Appliances include;
  - Dishwasher
  - Washing machine/dryer
  - Fridge/freezer
  - Oven
  - Kettle
  - Microwave
  - Hob
- Due to increased time resolution in HEM individual events can now be modelled. Appliances with load shifting capability can also be accounted for.
- To be determined if these will be included in FHS compliance results.

DISTANT SHADING

Distant Shading

- SAP applied shading to opening based on '% of sky obscured by obstacles'.
- Vast majority of new homes classed as 'average' in SAP.
- HEM makes a much more detailed analysis of distant shading.
- Shading from surrounding objects now needs to be recorded.
- This influences as solar irradiance and therefore solar gains and PV output.
- Shading from nearby objects e.g. overhangs and reveals only applies to openings.



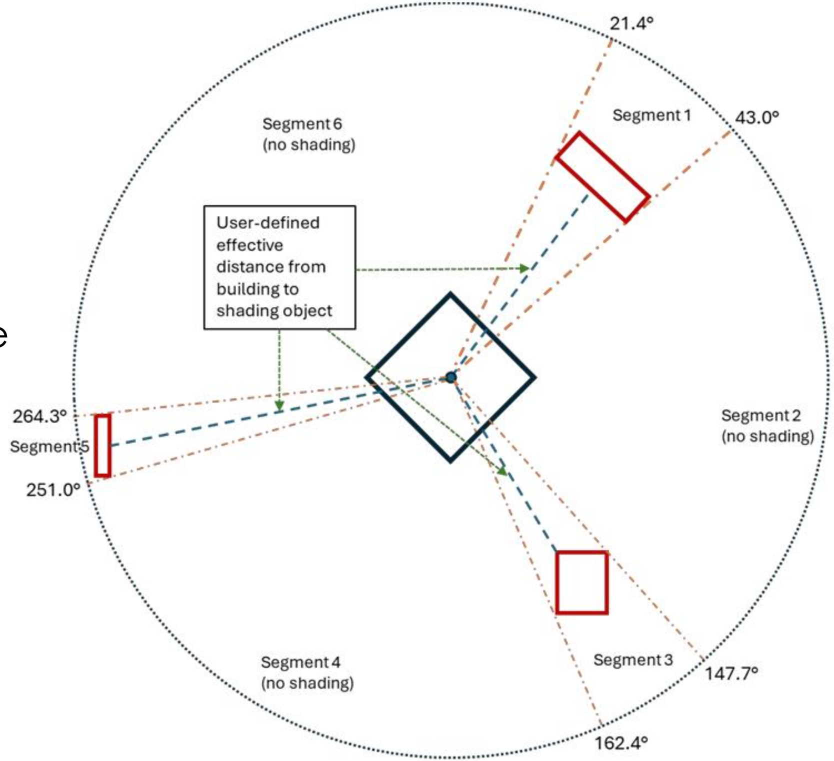
Distant Shading

- Distant shading is defined by splitting the ground plane is into segments, and shading objects surrounding the building are assigned to the relevant segments.
- For each segment with a shading object the following is required;

Field	Description	Unit
Orientation	Absolute start angle from compass North (0°) of the segment	Degrees
Orientation	Absolute end angle from compass North (0°) of the segment clockwise from the start angle.	Degrees
Shading Type	Obstacle or Overhang	N/A
Height	Height to the top of the obstacle/bottom of the overhang from ground level	m
Distance	Distance of the obstacle from the shaded surface measured between their central points	m

Distant Shading Rules

- An obstacle ends at a certain height above ground level e.g. a neighboring building.
- An overhang starts at a certain height above ground level e.g. a roof or balcony.
- There is no limit on the distance an object can be from the surface, however it must be in sight of the surface.
- If other parts of a connected building (such as courtyard block of flats) shade the dwelling these should be accounted for.
- Where a dwelling shades itself (e.g. an L-shaped dwelling) this should not be included.



Distant Shading – Impacts?

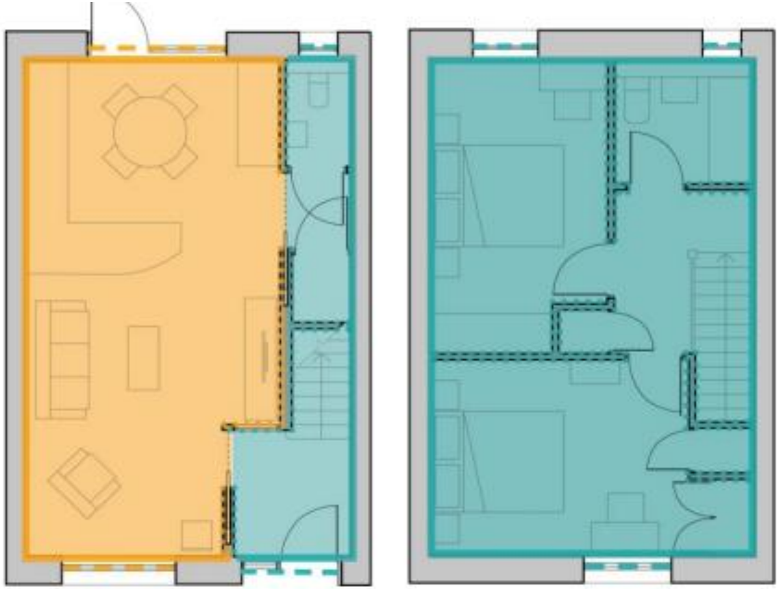
- Significant additional time needed to measure and enter shading details.
- Detailed site plans will be required.
- No conventions yet;
  - Will make type approval difficult. Can we find a worse case approach?
  - If information is not available what happens?
  - Is this based on date the dwelling is completed, or assumption that all plots on the site will be built?

Discussion

MEASUREMENTS

Measurements - Building Zones

- HEM has the ability to split a home into many zones.
- Each zone's heat fabric loss is then assessed individually at half hour intervals.
- However the FHS wrapper is restricted to a **single zone** - similar to SAP.



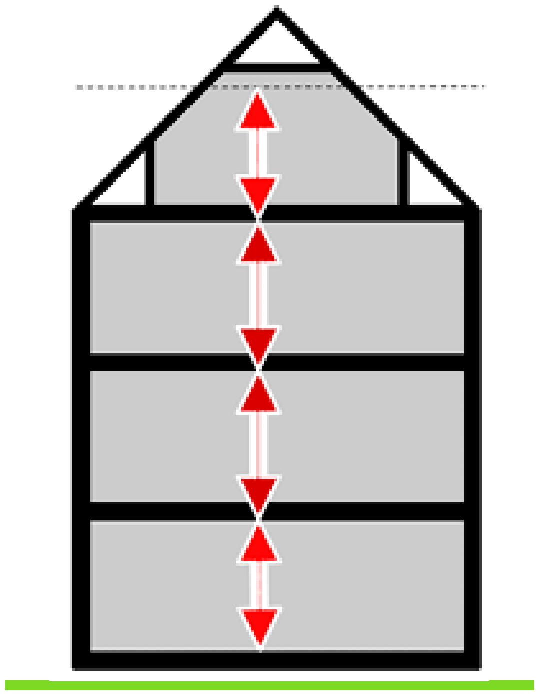
Measurement Fields

Field	Description	Unit
Total Ground Floor Area	Area of entire ground floor	m^2
Building Length	The maximum horizontal distance across the building footprint	m
Building Width	The maximum horizontal distance perpendicular to the building length	m
Volume	Volume of the dwelling	m^3
Living room area	Area of living room/lounge	m^2
Rest of dwelling area	Area of the remainder of the dwelling – excluding the living area	m^2

Wall Heights

- **Same approach as SAP;**

- **For houses ground floor walls are measured floor surface to underside of ceiling.**
- **For houses mid/top floor walls are measured underside of ceiling to underside of ceiling.**
- **In a single storey flat wall height is measured from floor surface to underside of ceiling.**



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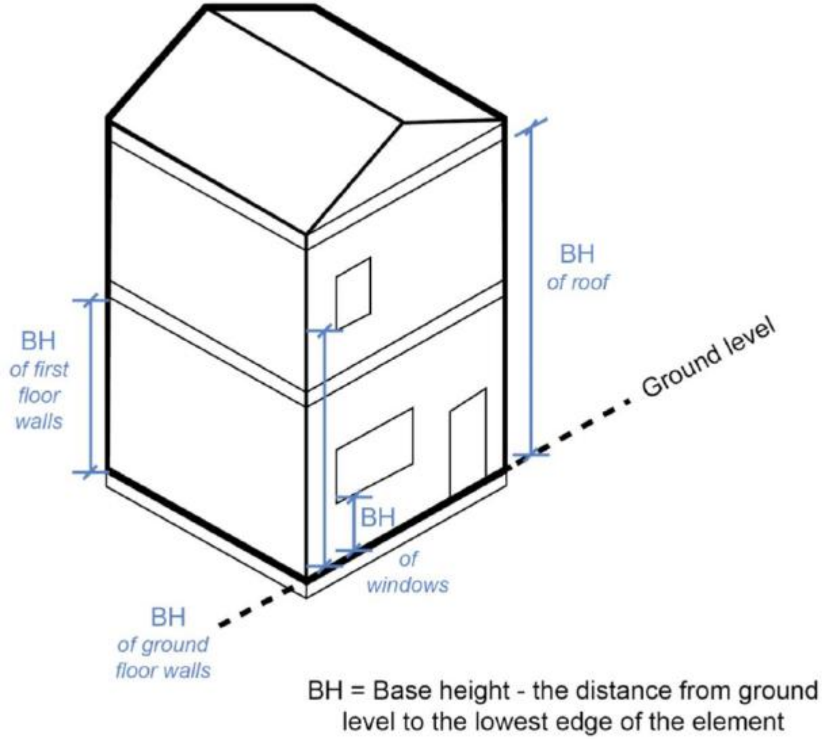
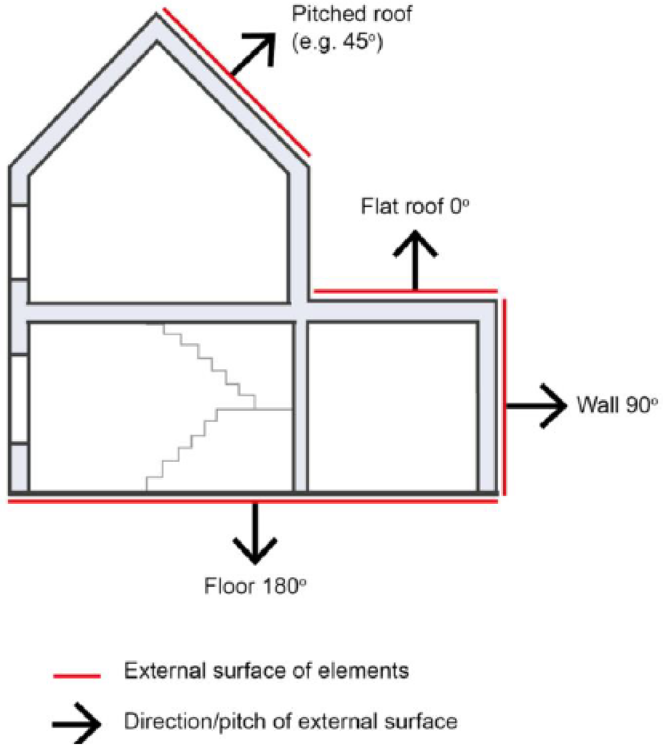
Base Heights

- For all elements we now need to enter 'Base Height'.
- Defined as 'distance between the ground and the lowest edge of the element'.
- For example;
  - In a two storey house the base height of the first floor is the height from ground level to the ceiling of the ground floor.
  - Base height of the roof is the height from ground level to ceiling of highest floor.
  - In flats the base height is from the ground level to the floor level of the flat (as opposed to the ceiling level of the flat below).
- Used to determine shading effect on solar gains/absorption.



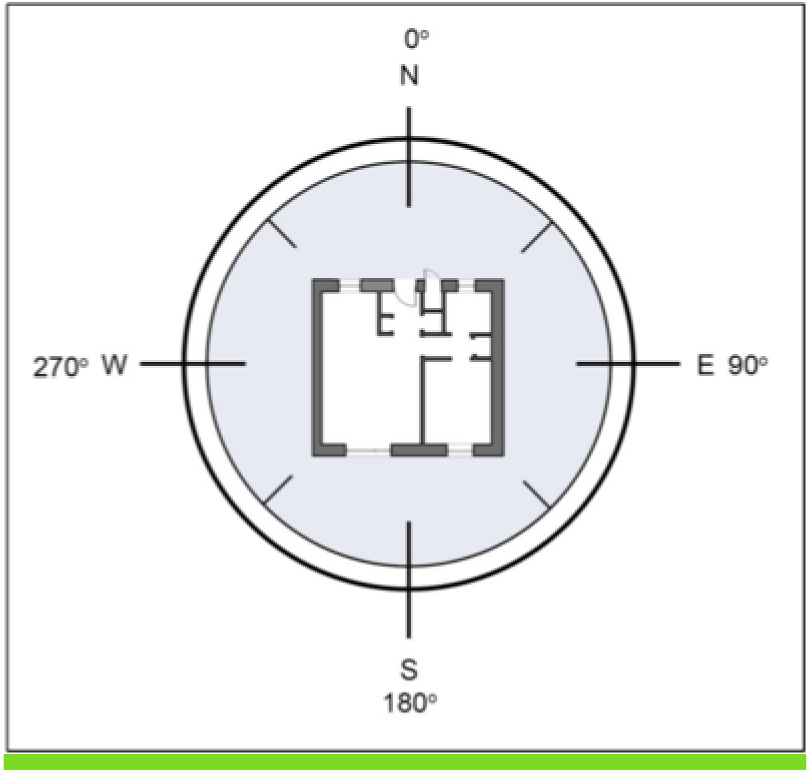
Pitch

- For all elements we need to enter 'Pitch'.
- Pitch is defined as;
  - 'Tilt angle of the external surface from horizontal, in degrees between 0°and 180°
- 0° represents a flat surface facing directly upwards i.e. flat roofs.
- 90° represents a vertical surface i.e. walls, windows and doors.
- 180° represents a flat surface facing directly downwards i.e. floors.



Orientation

- For external walls, roofs and openings we need to enter 'Orientation'.
- Defined as "*The compass orientation angle of the building component, from 0-360*".
- Currently a free text entry expressed in degrees.
- North = 0, South = 180



WALLS, ROOFS AND FLOORS

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Walls, Roofs, and Floors

- Increased data entry compared to SAP.
- The same wall or roof type facing different orientations must be entered separately.
- New fields to assess thermal mass and solar absorption coefficient of elements.

External Wall Data Fields

Field	Description	Unit
Name	Your name for the wall	N/A
U-value	U-value	W/m^2K
Pitch	Pitch of the external surface of the wall. Typically this will be 90°	Degrees
Orientation	The compass orientation angle of the building component, from 0-360	Degrees
Colour	The colour of the external surface of the wall, used to calculate solar absorption coefficient.	N/A
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Base Height	Height of the bottom of the wall above the ground level	m
Height	Height of the top of the wall (starting from base height)	m
Length	Length of the wall	m
Nett Area	Nett surface area of the wall	m^2

Thermal Mass in HEM

- Thermal mass in SAP 10 was limited.
- In HEM thermal mass of building components is dealt with in the core heat balance equations, as described in BS EN ISO 52016-1:2017.
- Kappa values have been replaced with 'Areal Heat Capacity'.
- Additionally we have to indicate where the thermal mass is located within each element.
- Thermal mass of transparent elements (openings) is still ignored.

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Areal Heat Capacity

- SAP 10 calculates thermal mass using the internal effective heat capacities – kappa values.
- Only accounts for the innermost 100 mm of elements.
- In HEM this has been replaced with 'Areal Heat Capacity'
- Takes account of all construction layers.
- Some default options available derived from Table B.14 of BS EN ISO 52016-1:2017.

Areal heat capacity

This is the sum of the heat capacities of all the construction layers, also known as effective areal heat capacity or kappa value

▸ Help with this input

○ Very light
e.g. Light board of plastic

○ Light
e.g. 5-10 cm lightweight brick or concrete

○ Medium
e.g. 10-20 cm lightweight brick or concrete

○ Heavy
e.g. 7-12 cm solid brick or heavyweight concrete

○ Very heavy
e.g. More than 12 cm solid brick or heavyweight concrete

Areal Heat Capacity Options

Value	Example
Very light	Thin plastic composite panels; Thin plywood or hardboard; Fabric or thin membranes; Single glazing; Lightweight suspended ceilings
Light	Aerated concrete blocks (5-10 cm thick); Lightweight timber frame wall with thin sheathing; Thicker layer of less dense insulation board (e.g. 8cm EPS).
Medium	15 cm lightweight concrete block wall; 12 cm timber frame wall with some internal dense layers; 10 cm of standard concrete screed.
Heavy	10 cm solid brick wall; 8 cm heavyweight concrete slab; Stone flooring (for example 2cm) on a thicker concrete subfloor (for example 10 cm).
Very Heavy	20 cm solid brick wall; 15 cm or thicker heavyweight concrete slab; Thick stone or masonry walls (for example 15 cm of limestone).

Mass Distribution Class

- Also to account for heat storage, the location of the mass in the element is categorised.
- Five options available.
- Further guidance in BS EN ISO 52016 1:2017 6.5.7.2 Opaque components Table A.13.

Mass distribution class

This is the distribution of mass in the building element

▶ Help with this input

- ○ 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

Mass Distribution Class Options

Field	Description	Example
Mass concentrated on inner side	Construction with external thermal insulation (main mass component near inside surface), or equivalent	Solid wall, external insulation
Mass concentrated on external side	Construction with internal thermal insulation (main mass component near outside surface), or equivalent	Timber Frame, Solid wall, internal insulation
Mass divided over internal and external side	Construction with thermal insulation in between two main mass components, or equivalent	Cavity wall
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	Uninsulated solid wall
Mass concentrated inside	Main mass component concentrated near centre of construction), or equivalent	Solid wall with both external and internal insulation

Mass Distribution Class Options

	External	Inside			Internal
	Nodes				
Mass fraction/8	1	2	3	4	5
1					
2					
3					
4					
5					
6					
7					
8					

Figure 1 – Mass concentrated on internal side

Mass concentrated on external side: E

	External	Inside			Internal
	Nodes				
Mass fraction/8	1	2	3	4	5
1					
2					
3					
4					
5					
6					
7					
8					

Figure 2 – Mass concentrated on external side

Mass divided over internal and external side: IE

	External	Inside			Internal
	Nodes				
Mass fraction/8	1	2	3	4	5
1					
2					
3					
4					
5					
6					
7					
8					

Figure 3 – Mass divided over internal and external side

Mass Distribution Class Options

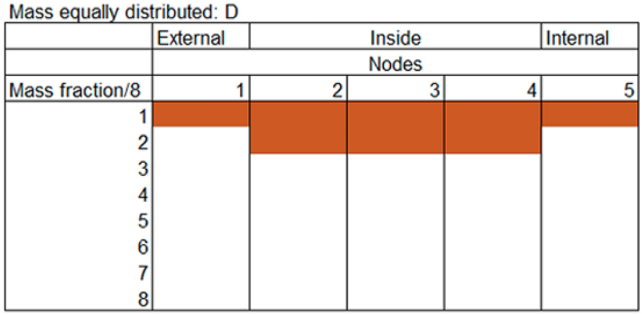


Figure 4 – Mass equally distributed

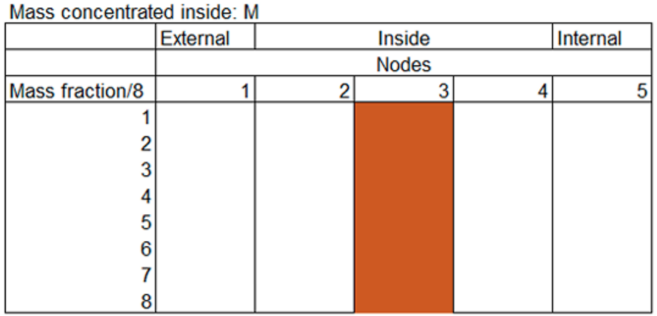


Figure 5 – Mass concentrated inside

Solar Absoprtion Coefficient

- Solar energy absorbed at the external surface of an element will have the effect of reducing heat transfer through the fabric element by reducing the temperature difference between the internal and external surfaces.

- For walls and roofs this is taken into consideration by the ‘Colour’ field.

Colour of external surface

- ○ Light
- ○ Medium
- ○ Dark

Colour Options

Field	Description	Example
Light	White surfaces, Light colour	Paint, Light grey, cream render
Intermediate	Medium colour	Bricks, light timber cladding, clay tile cladding
Dark	Dark colour, Black surfaces	Dark timber cladding, dark grey metal cladding, grey render

Wall to Unheated Space Data Fields

Field	Description	Unit
Name	Your name for the wall	N/A
Shelter Factor	The effective thermal resistance of the unheated space	$(m^2k)/W$
U-value	U-value	W/m^2K
Pitch	Pitch of the external surface of the wall. Typically this will be 90°	Degrees
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Nett Area	Nett surface area of the wall	m^2

Shelter Factors

- Shelter factors can still be applied to elements adjacent to unheated internal spaces.
- Same scenarios as SAP…

Shelter Factors

Table 1 – R_u for integral single garages (single garage is a garage for one car, assuming n = 3ach, U-value of internal walls = $0.3\ W/(m^2K)$, U-value of external walls = $1.6\ W/(m^2K)$)

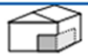
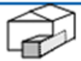
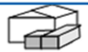
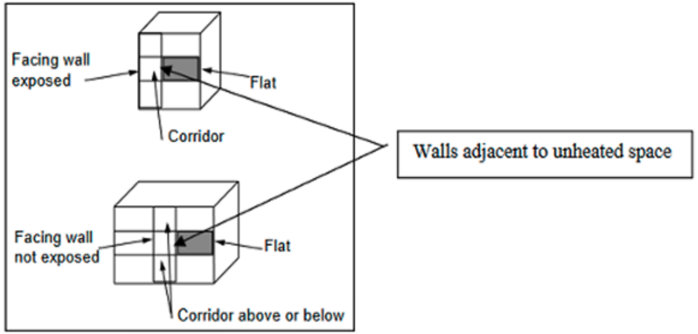
Garage type		Elements between garage and dwelling	R_u for a single garage	
			Inside[1]	*Outside*[2]
Single fully integral		Side wall, end wall and floor	0.70	0.35
Single fully integral		One wall and floor	0.55	0.25
Single, partially integral, displaced forward		Side wall, end wall and floor	0.60	0.30

Table 2 - R_u for integral double garages (double garage is a garage for two cars, assuming n = 3ach, U-value of internal walls = $0.3\ W/(m^2K)$, U-value of external walls = $1.6\ W/(m^2K)$)

Garage type		Element between garage and dwelling	R_u for a double garage	
			Inside[1]	Outside[2]
Double garage fully integral		Side wall, end wall and floor	0.60	0.35
Double, half integral		Side wall, halves of the garage end wall and floor	0.35	0.25
Double, partially integral displaced forward		Part of the garage side wall, end wall and some floor	0.30	0.25

[1]inside garage – when the insulated envelope of the dwelling goes round the outside of the garage

Shelter Factors



The following table gives recommended values of R_u for common configurations of access corridors and stairwells.

Table 3 - R_u for common configurations of stairwells and access corridors.

Elements between stairwell/corridor and dwelling	Heat loss from corridor through:	R_u
Stairwells:		
Facing wall exposed		2.1
Facing wall not exposed		2.5
Access corridors:		
Facing wall exposed, corridors above and below	facing wall, floor and ceiling	0.6
Facing wall exposed, corridor above or below	facing wall, floor or ceiling	0.5
Facing wall not exposed, corridor above and below	floor and ceiling	0.9
Facing wall not exposed, corridor above or below	floor or ceiling	0.7

The figures in Table 3 were derived using the following assumptions:

- $n = 1$ ach
- Storey height = 2.6 m
- Footprint (floor area)
  - Stairwells: 2.4 m by 10 m
  - Corridors: 3 m by 25 m
- Window area:
  - Corridors with facing wall exposed: 20% of exposed wall area
  - Corridors with facing wall not exposed: 15% of the end walls
- U-values:
  - Exposed wall = 0.3 $W/(m^2K)$
  - Floor/roof = 0.25 $W/(m^2K)$
  - Window = 2 $W/(m^2K)$

Shelter Factors

Room in roof

In the case of room-in-roof construction where the insulation follows the shape of the room, use values of R_u from Table 4. The same applies to the ceiling of the room below.

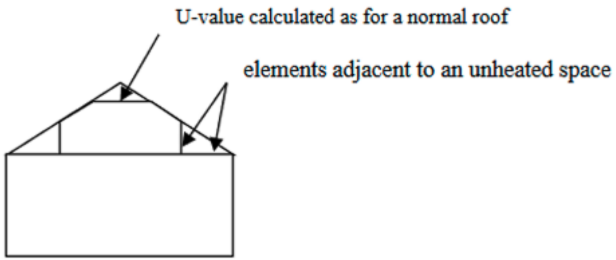


Table 4 - R_u for room in roof adjacent to unheated loft space

Area (figure 3.2)	Element between dwelling and unheated loft space	R_u
	insulated wall of room in roof	0.5
Room in roof built into a pitched roof insulated at ceiling level	or insulated ceiling of room below	0.5

Party Wall Data Fields

Field	Description	Unit
Name	Your name for the wall	N/A
U-value	U-value, typically 0	W/m^2K
Pitch	Pitch of the external surface of the wall. Typically this will be 90° (unless a mansard wall)	Degrees
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Nett Area	Nett surface area of the wall	m^2

Party Walls

- Draft FHS Consultation document showed;

Construction	HEM Condition
Solid	No heat loss
Unfilled cavity with no effective edge sealing	Heat loss
Unfilled cavity with effective sealing around all exposed edges and in alignment with insulation layers in abutting elements	Heat loss
Unfilled cavity with effective sealing around all exposed edges and in alignment with insulation layers in abutting elements for a concrete frame construction in a building containing flats	No heat loss
A fully filled cavity with effective sealing at all exposed edges and in alignment with insulation layers in abutting elements	No heat loss

Internal Walls Data Fields

Field	Description	Unit
Name	Your name for the wall	N/A
Pitch	Pitch of the external surface of the wall. Typically this will be 90°	Degrees
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Nett Area	Nett surface area of the wall	m^2

- Internal elements only influence thermal mass
- They can be grouped together if they have the same areal heat capacity so internal floors, internal walls and internal ceilings only need to be defined once.
- The net surface area should only be for one side of the wall, not both.

Roof Data Fields

Field	Description	Unit
Name	Your name for the roof	N/A
Roof type	Type of roof	Flat roof, Pitched roof insulated at rafter, Pitched roof insulated at joist
U-value	U-value	W/m^2K
Pitch	Pitch of the external surface of the roof. This would typically be 30°, 45° for a pitched roof and 0° for a flat roof	Degrees
Orientation	The compass orientation angle of the building component, from 0-360	Degrees
Colour	The colour of the external surface of the roof, used to calculate solar absorption coefficient.	N/A
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A

Roof Data Fields - Dimensions

Field	Description	Unit
Base Height	Height of the bottom of the roof above the ground level	m
Length	Height of the top of the roof starting from bottom of the roof (base height)	m
Width	Width of the roof	m
Nett Area	Nett surface area of the roof	m^2

Ceiling to Unheated Space Data Fields

Field	Description	Unit
Name	Your name for the wall	N/A
Shelter Factor	The effective thermal resistance of the unheated space	$(m^2k)/W$
U-value	U-value	W/m^2K
Pitch	Pitch of the external surface of the ceiling. Typically this will be 0°	Degrees
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Nett Area	Nett surface area of the ceiling	m^2

Party Ceiling Data Fields

Field	Description	Unit
Name	Your name for the ceiling	N/A
Pitch	Pitch of the external surface of the ceiling. Typically this will be 0°	Degrees
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Nett Area	Nett surface area of the ceiling	m^2

Internal Ceiling Data Fields

Field	Description	Unit
Name	Your name for the ceiling	N/A
Pitch	Pitch of the external surface of the ceiling. Typically this will be 0°	Degrees
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Nett Area	Nett surface area of the ceiling	m^2

- Internal elements only influence thermal mass
- They can be grouped together if they have the same areal heat capacity so internal floors, internal walls and internal ceilings only need to be defined once.

Floor Data Fields

Field	Description	Unit
Name	Your name for the floor	N/A
Type	Type of floor	Slab edge insulation, Slab no edge insulation, Suspended floor, Heated basement, Unheated basement
U-value	U-value	W/m^2K
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Thermal resistance of floor	Total thermal resistance of the floor construction (excluding the ground). Can be found on u-value reports	m^2k/W
Wall to floor psi value	Psi value of the wall to floor junction	W/mK

Floor Data Fields - Dimensions

Field	Description	Unit
Wall thickness	Thickness of walls	m
Ground floor perimeter	Heat loss perimeter of the floor	m
Nett Area	Nett surface area of the floor	m^2
Total area across of all floors	Total area of all floor constructions	m^2

Floor Data Fields – Edge Insulation

- Only needed if floor type is ‘slab edge insulation’;

Field	Description	Unit
Type	Type of edge insulation	Horizontal, Vertical
Width	Width of the edge insulation	mm
Edge Insulation Thermal Resistance	Thermal resistance of the edge insulation	m^2k/W

Floor Data Fields – Suspended floors

- Only needed if floor type is 'suspended floor';

Field	Description	Unit
Upper surface height	Height of top surface of ground floor above external ground level	m
Wall thermal transmittance	U-value of walls above ground level	W/m^2K
Area of perimeter vents	Area of perimeter vents per m of wall. Typically this is 1500 mm^2/m	mm^2/m
Shield factor location	Exposure level of the dwelling. Used to calculate airflow through the floor void	Sheltered, Average, Exposed
Wall thickness	Thickness of walls at perimeter of floor	mm
Insulation thermal resistance	Thermal resistance of the insulation installed at the base of the underfloor space	m^2k/W

Floor Data Fields – Basement floors

- Only needed if floor type is ‘heated basement’;

Field	Description	Unit
Wall thickness	Thickness of walls at perimeter of floor	mm
Basement floor depth	Depth of basement floor surface below external ground level	m
Wall thermal transmittance	U-value of basement walls	W/m^2K

- Only needed if floor type is ‘unheated basement’;

Field	Description	Unit
Basement wall height	Height of basement walls	m
Basement floor thermal transmittance	U-value of basement floor	W/m^2K
Wall thermal transmittance	U-value of basement walls	W/m^2K

Floors to Unheated Space Data Fields

Field	Description	Unit
Name	Your name for the wall	N/A
Shelter Factor	The effective thermal resistance of the unheated space	$(m^2k)/W$
U-value	U-value	W/m^2K
Pitch	Pitch of the external surface of the floor. Typically this will be 180°	Degrees
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Nett Area	Nett surface area of the floor	m^2

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Party Floor Data Fields

Field	Description	Unit
Name	Your name for the floor	N/A
Pitch	Pitch of the external surface of the floor. Typically this will be 180°	Degrees
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Nett Area	Nett surface area of the floor	m^2

Internal Floor Data Fields

Field	Description	Unit
Name	Your name for the floor	N/A
Pitch	Pitch of the external surface of the floor. Typically this will be 180°	Degrees
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Nett Area	Nett surface area of the floor	m^2

- Internal elements only influence thermal mass
- They can be grouped together if they have the same areal heat capacity so internal floors, internal walls and internal ceilings only need to be defined once.

OPENINGS

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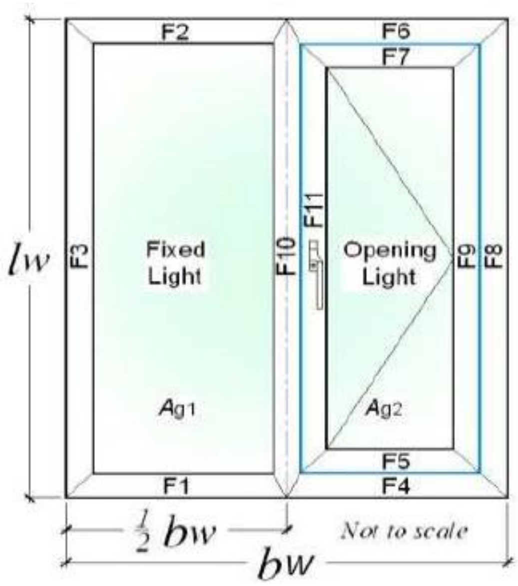
Openings

- Each opening must be entered individually with its respective performance data and dimensions.
- Must be assigned to a wall/roof type.
- For windows, openable parts must be defined.
- Shading must also be added where relevant.



Sample Style:

Casement

Fixed Light / Side Hung

Blue line illustrates opening light length (air leakage)

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Doors Data Fields

Field	Description	Unit
Name	Your name for the opening	N/A
Type	Type of opening	Glazed door, Unglazed door, Internal door
Mass Distribution Class	Distribution of thermal mass in building component	N/A
Areal Heat Capacity	The heat capacity of the full thickness of the construction component (wall, roof, floor)	N/A
Base Height	Height of the bottom of the opening above the ground level	m
Height	Height of the top of the opening starting from base height	m
Width	Width of the opening	m
Nett Area	Nett area of the opening – needed for non square/rectangle openings	m^2
U-value	U-value	W/m^2K

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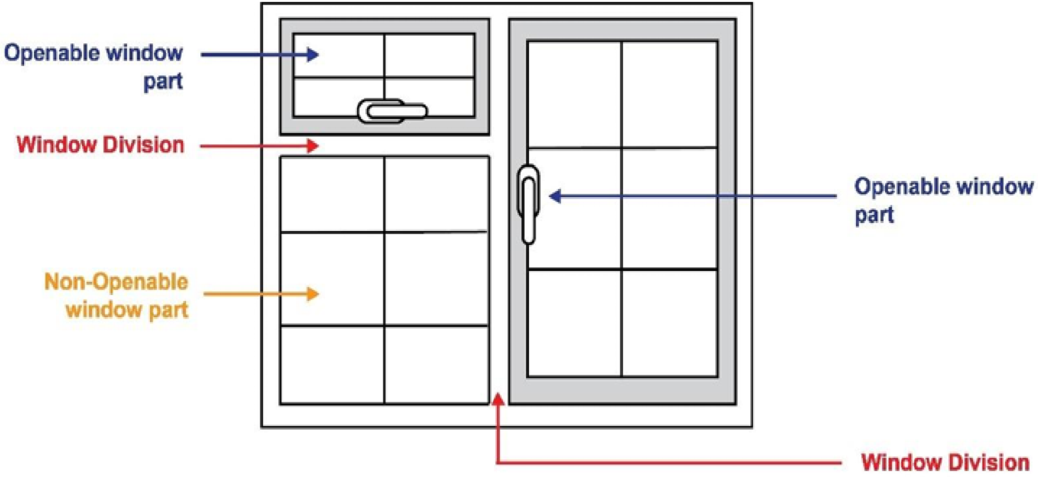
Windows Data Fields

Field	Description	Unit
Name	Your name for the opening	N/A
Orientation	The compass orientation angle of the building component, from 0-360	Degrees
Pitch	Pitch of the external surface of the wall. Typically this will be 90° for doors and windows. Roof windows/lights will typically be the pitch of the roof element they are located within.	Degrees
Base Height	Height of the bottom of the opening above the ground level	m
Height	Height of the top of the opening starting from base height	m
Width	Width of the opening	m
Maximum openable area	The total area of the window that can be opened	m^2
Nett Area	Nett area of the opening – needed for non square/rectangle openings	m^2
U-value	U-value	W/m^2K
G-value	Solar energy transmittance, the fraction of solar energy that the **glazing** transmits into the dwelling	Decimal 0-1
Opening to frame ratio	The proportion of the total opening area taken up by the frame.	Decimal 0-1

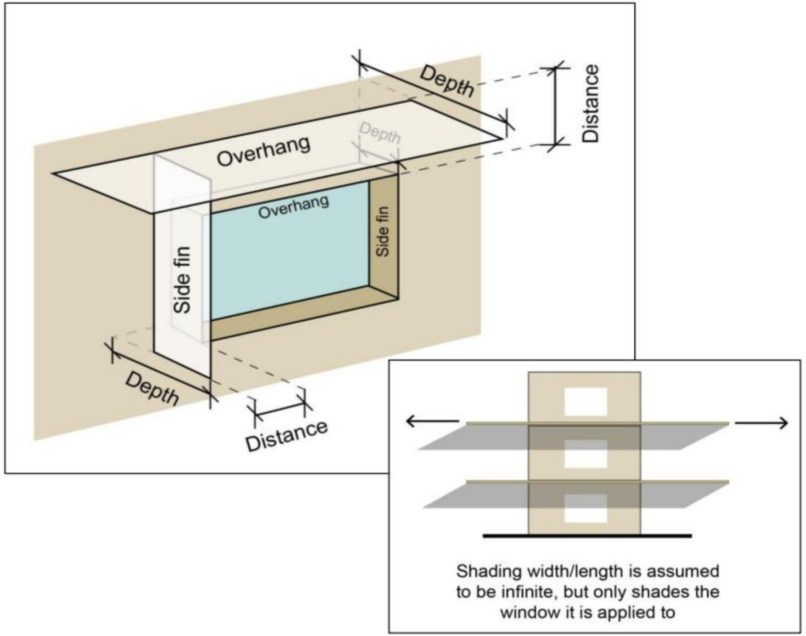
Openings – Openable parts

Field	Description	Unit
Number of openable parts	Number of openable parts of each opening	
Mid Height Air Flow Path	The height from the ground to the midpoint of the window	m
Openable area height	The vertical measurement of the section of the window that can be opened	m
Openable parts mid height	the height from the ground to the midpoint of the openable section of the window	m



Window Shading

- Any sidefins or overhangs should be modelled as shading.
- Window reveals are classed as overhangs and sidefins so also must be entered.
- Curtains and blinds can also be entered.



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Opening Shading Data Fields

Field	Description	Unit
Shading Type	Type of shading structure – overhang, side fin	N/A
Depth	Depth away from the transparent element	mm
Distance	Distance of the closest edge of the shading from the glass, not to window frame	mm

Field	Description	Unit
Type	Type of internal shading	Curtains, Blinds
Controls	Control type for the curtain or blind	Auto motorized, Manual
Resistance increase	Increase in thermal resistance of the opening from the curtain or blind	m^2k/W
Solar transmittance reduction	Reduction in g-value from curtain or blind	

THERMAL BRIDGING

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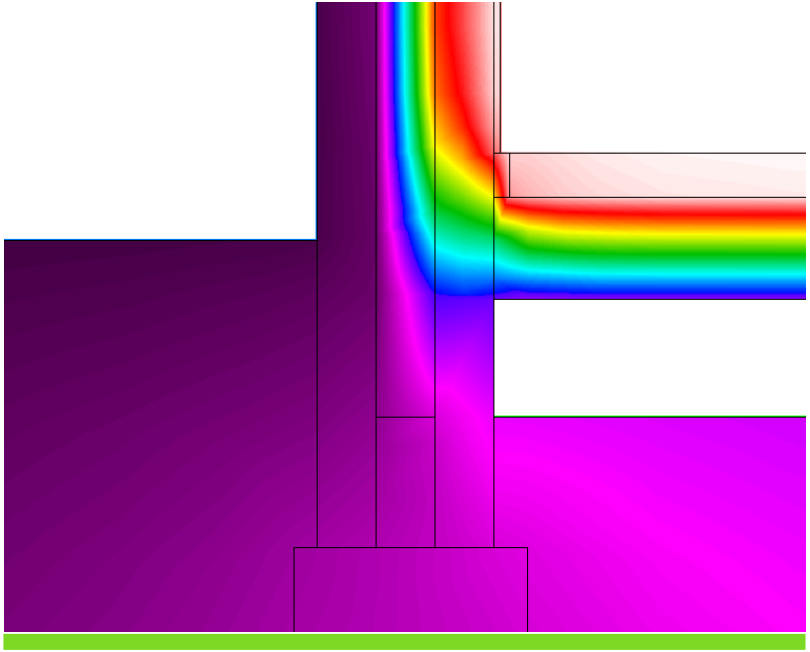
Thermal Bridging

- Very similar to SAP 10.
- Proposed that direct entry of a y-value is not permitted – junctions must always be measured.
- SAP 10 default psi values will still be allowed.



Thermal Bridging Data Fields

Field	Description	Unit
Thermal Bridge Type	‘Linear ‘or ‘Point’ thermal bridge	N/A
Junction Type	Same types as recognized in SAP 10 e.g. E1, P4, R4	N/A
Length	Length of the junction	m
Psi value	Heat loss of the junction	W/mK
Reference	User reference for the junction	
Heat Transfer Coefficient	For point thermal bridges only - the heat transfer coefficient of the bridge	W/K

Discussion

INFILTRATION & VENTILATION

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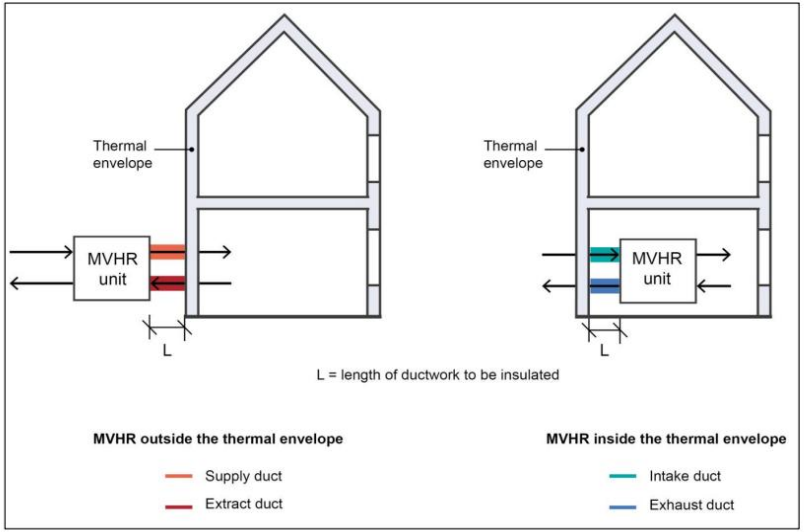
Infiltration & Ventilation

- Based on BS EN ISO 16798-7
- Much more detail than SAP.
- More inputs needed to establish infiltration of the home.
- Vents, air terminal devices etc. must be entered.
- More inputs needed to establish the performance of the ventilation system.
- Much more information on ductwork needed.



Infiltration Data Fields

Field	Description	Unit
Cross ventilation factor	Is cross ventilation possible in the dwelling?	Yes/No
Type of exposure	The level of shielding or protection a dwelling will have against external environmental factors such as wind, noise, or outdoor pollutants	Open, Normal, Shielded
Terrain type	Terrain class helps determine how external conditions, such as wind speed and turbulence, will impact ventilation and airflow around a building	Open water, Open field, Suburban, Urban
Altitude	Meters the dwelling is above sea level	m
Base Height	Height of the bottom of the dwelling above the ground level	m
Noise nuisance?	Is there environmental noise from the surrounding area, which can influence whether occupants keep windows closed?	Yes/No

Noise

3.2 In locations where external noise may be an issue (for example, where the local planning authority considered external noise to be an issue at the planning stage), the overheating mitigation strategy should take account of the likelihood that windows will be closed during sleeping hours (11pm to 7am).

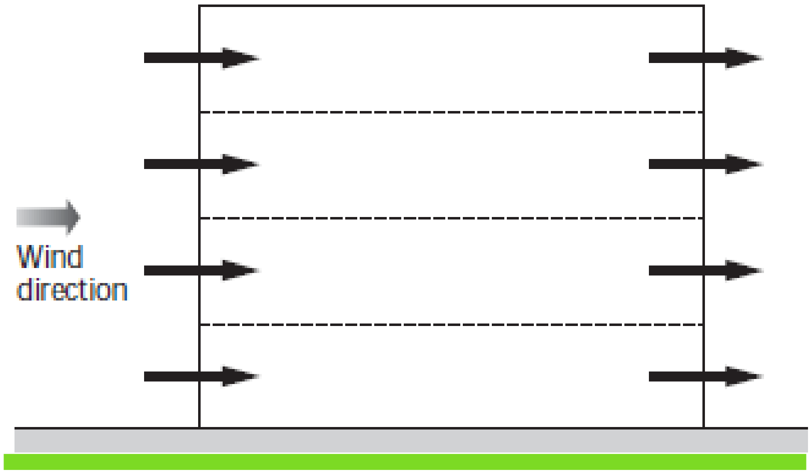
3.3 Windows are likely to be closed during sleeping hours if noise within bedrooms exceeds the following limits.

a. 40dB $L_{Aeq,T}$, averaged over 8 hours (between 11pm and 7am).

b. 55dB L_{AFmax}, more than 10 times a night (between 11pm and 7am).

Shield Class Definitions

- Similar to sheltered sides in SAP.
- Used to calculate uncontrolled infiltration.
- Each type is defined as;
  - Open – Highly exposed location with minimal natural or artificial barriers e.g. rural house in open land.
  - Normal – Typical suburban or urban setting with average levels of protection e.g. residential neighbourhood.
  - Shielded – Well protected by dense surroundings like trees, hills, or buildings e.g building surrounded by taller structures.



Terrain type Definitions

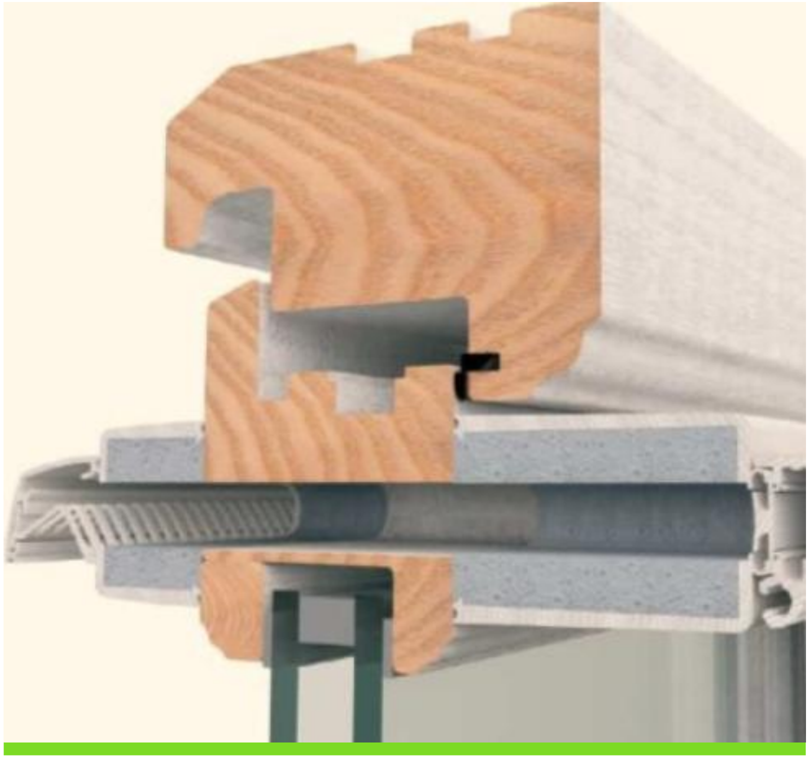
- Each type is defined as;
  - Open water – Large, flat surface of water with no obstructions to airflow e.g. coastal areas, lakeside properties.
  - Open field – Flat, unobstructed land with little to no buildings or trees e.g. farmland.
  - Suburban – Mixed development with houses, gardens, and moderate vegetation e.g. residential neighbourhoods with spaced housing
  - Urban - Dense development with closely packed buildings and limited vegetation e.g. city centres, high rise residential zones.

Vents Data Fields

Field	Description	Unit
Area	Effective area of vent opening. The actual area through which air can flow, accounting for obstructions like grilles or mesh. Standard window trickle vent 40-80 cm^2, Wall mounted air brick 50-200 cm^2	cm^2
Mid height Airflow path	Mid height of the dwelling	m
Orientation	Orientation angle of the surface the vent is located on	Degrees
Pitch	Pitch of the external surface of the vent. Typically this will be 90° for airbricks and trickle vents	Degrees

Area types?

- AD O Effective area = *"The area through which air flows after the resistance of airflow has been taken into account."*
- AD F Equivalent area = *"A measure of the aerodynamic performance of a ventilator. It is the area of a sharp edged circular orifice through which air would pass at the same volume flow rate, under an identical applied pressure difference, as through the opening under consideration. The equivalent area of a background ventilator is determined at 1Pa pressure difference in accordance with Table 1.7."*
- AD O Free area = *"The geometric open area of a ventilation opening. This area assumes a clear sharp-edged orifice that would have a coefficient of discharge (Cd) of 0.62."*



Examples

	Invisivent® AIR		
	Light	Basic	High
Airflow			
Airflow Q at 1 Pa	10.6 l/s/m	10.6 l/s/m	8.9 l/s/m
	38.1 m³/h/m	38.0 m³/h/m	32.2 m³/h/m
Airflow Q at 2 Pa	17.2 l/s/m	17.2 l/s/m	12.1 l/s/m
	62.0 m³/h/m	62.0 m³/h/m	43.4 m³/h/m
Airflow Q at 10 Pa	16.4 l/s/m	17.6 l/s/m	11.9 l/s/m
Airflow Q at 20 Pa	19.2 l/s/m	17.3 l/s/m	14.3 l/s/m
Equivalent Area	13,479 mm²/m	13,429 mm²/m	11,364 mm²/m

Performance and dimensions

Product	Ventilation equivalent area	Geometric free area	Slot size (height x width)	Length	Sound reduction up to
TVES4dB	3815mm²	4000mm²	2no x 13 x 162.5mm	420mm	39dB Dn,e,w

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Pressure Test Fields

Field	Description	Unit
Test Type	To set the equipment type used to conduct the airtightness test	4 Pa (Pulse) or 50 Pa (Blower Door)
Design airtightness result	The airtightness rate used for design stage assessments	$m^3/m^2/hr$ @4/50 Pa
As built airtightness result	The airtightness rate used for as built stage assessments	$m^3/m^2/hr$ @4/50 Pa
Dwelling Envelope area	Total envelope area for the whole dwelling	m^2
Ventilation zone height	Used for ventilation calculations. Measured from the lowest finished floor level in the dwelling to the highest of part of the dwelling that is ventilated.	m

Mechanical Ventilation Data Fields

Field	Description	Unit
Energy Supply	Energy supply to the system, likely to be Electricity	N/A
Design Outdoor Air Flow Rate	The required design air flow rate to be supplied to or extracted from the ventilation zone by the system	m^3/hr
System Type	The type of ventilation system	Intermittent MEV, Centralised continuous MEV, Decentralised continuous MEV, MVHR
Specific Fan Power	Specific fan power, inclusive of any in use factors	W/l/s
SFP in use factor	Adjustment factor to be applied to SFP to account for e.g. type of ducting. Typical range 1 - 2.5	
Measured Air Flow Rate	The air flow rate of the system when measured on site	l/s
Measured Fan Power	The specific fan power of the system when measured on site	W/l/s
MVHR Efficiency	Heat recovery efficiency allowing for in use factors	0-1
MVHR location	Whether the MVHR unit is located inside or outside the thermal envelope	Inside, Outside
Supply air flow rate control type	Control for the supply airflow	Outdoor air, Load
Supply air temperature control type	Controls to manage the air temperature of air supplied	Constant, No control, Load comp

Design Outdoor Air Flow Rate Guidance

- Whole house system (MVHR) 150-300 m^3/hr.
- Intermittent MEV – 30-60 m^3/hr per fan.
- Centralised MEV – 60-150 m^3/hr.
- Decentralised MEV – 10-40 m^3/hr per fan.

Measured Air Flow Rate Guidance

- Whole house system (MVHR) 42-83 l/s.
- Intermittent MEV – 8-17 l/s per fan.
- Centralised MEV – 17-42 l/s.
- Decentralised MEV – 3-11 l/s per fan.

MVHR Intake/Exhaust Position Fields

Field	Description	Unit
Air flow path mid height	Mid height of the dwelling	m
Orientation	Orientation angle of the surface the intake/exhaust is located on	Degrees
Pitch	Pitch of the external surface the intake/exhaust is located on	Degrees

Mechanical Ventilation Duct Data Fields

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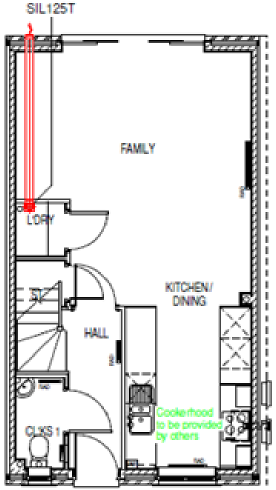
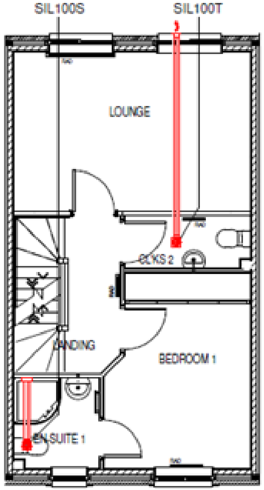
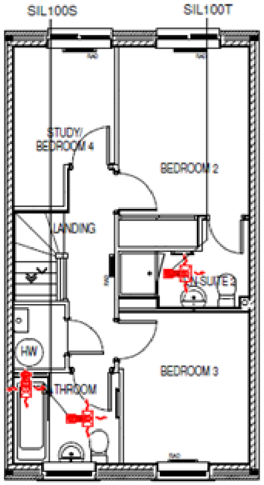
Field	Description	Unit
Ductwork Cross Section Shape	Cross sectional shape of ductwork	Circular, Rectangular
Ductwork type	Type of ductwork	Intake, Supply, Extract, Exhaust
Duct Internal Diameter	Internal diameter of duct, typically 100-150 mm (Ø)	mm
Duct External Diameter	External diameter of duct, typically 125-160 mm (Ø)	mm
Length of duct	Length of the ductwork	m
Duct insulation thermal conductivity	Thermal conductivity of the duct insulation	λ – w/m·k
Duct insulation thickness	Thickness of duct insulation, typically 25-50 mm	mm
MVHR Reflective Insulation?	Is the surface of the duct reflective?	Reflective, Not Reflective



GROUND FLOOR



FIRST FLOOR



SECOND FLOOR

Minimum Flow Rates	
Room	Boost Rate
Laundry	30.0 L/s
En-Suite 1	15.0 L/s
Bathroom	15.0 L/s
En-Suite 2	15.0 L/s
Cloaks 2	6.0 L/s

ADDITIONAL NOTES:

1) 100/125mm dia uninsulated flexible duct to be used within floor voids.
2) 100/125mm dia insulated flexible duct to be used within uninsulated areas.
3) 100/125mm dia & 204x60mm flat rigid duct to be used through external walls.
4) In a room with no openable window, the intermittent extract fan should have a 15 minute overrun.
5) Minimum trickle ventilation required to meet 2010 Building Regs Part F – 55,000 sq. mm

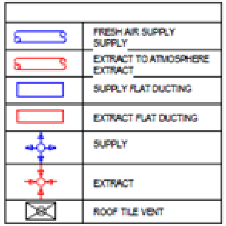
Total Floor Area: 114.9sqm

Notes:

THIS SYSTEM HAS BEEN DESIGNED TO COMPLY WITH THE 2010 BUILDING REGULATIONS PART F - MEANS OF VENTILATION.

AS SUCH THE SYSTEM MUST BE INSTALLED AND COMMISSIONED AS PER THE DESIGN SPECIFICATION TO ENSURE COMPLIANCE WITH THE ABOVE MENTIONED.

ADDITIONALLY THE COMMISSIONED SYSTEM MUST COMPLY WITH THE 17th EDITION IEE BS7671 PART 6 (ADDITIONAL WORKS).



F

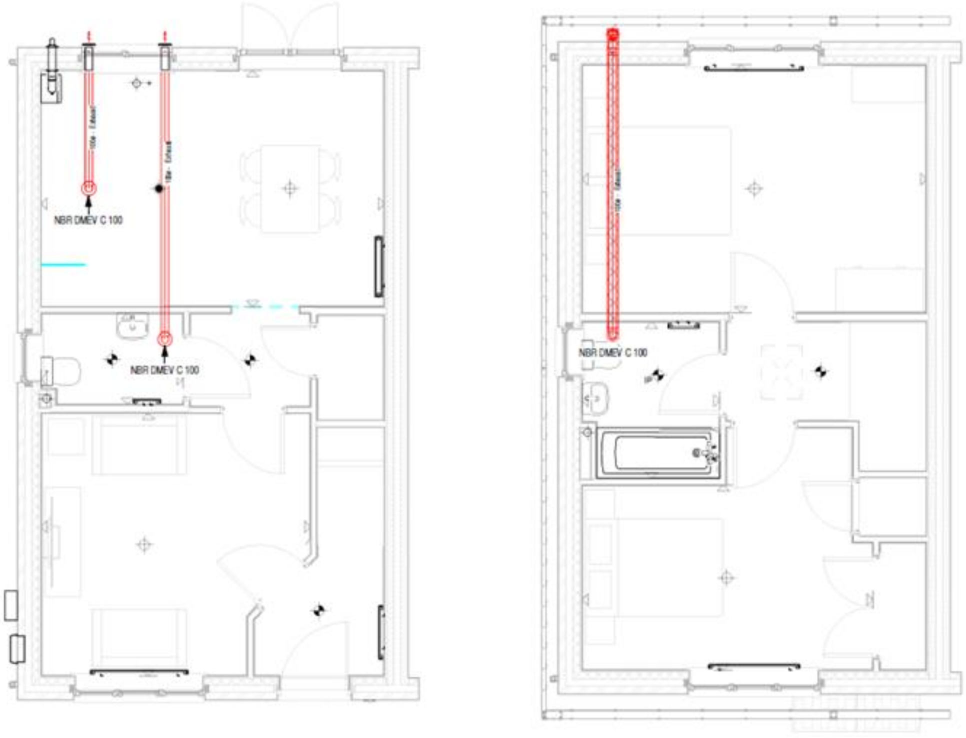
E

Date	Scale	Paper Size
15/02/2018	1 : 75	A3

COMMISSIONING TABLE (l/s)

Extract	Fan Boost Setting	Fan Trickle Setting
Kitchen	13.0	9.0
WC	12.0	8.0
Bathroom	12.0	8.0
	37.0	25.0

(Minimum flow rates to Doc F Building Regs 2021 Edition)



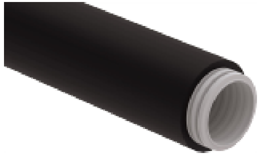
LEGEND

	NBR dMEV C 100 Reference Number - 498095
	NBR dMEV C 125 Reference Number - 498097
	100/125mmØ Round Ducting (Pre-Insulated in Roof Space)

*DRAWING ONLY TO BE USED FOR THE PURPOSE OF VENTILATION INSTALLATION

Zehnder ComfoTube Therm insulated ø 90mm, 20m roll

Article number: 990 328 030



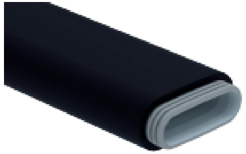
Technical Specification

Material - Ductwork	High-quality food-grade plastic polyethylene (PE)
Material - Insulation	Cellular rubber
Operating temperature range	-25 to +60°C
Thermal conductivity at 0°C	0.033 W/mK
Thermal conductivity at 20°C	0.035 W/mK
10 m Temperature loss @ 40 m^3hr (40/20°C)	7.1 K
10 m Temperature loss @ 40 m^3hr (16/25°C)	-5.3 K
Maximum recommended air volume per tube	13.8 l/s (50 m^3/h)
Minimum bending radius	1 x D
Buoyancy in concrete	190 N/m
Outside diameter	108 mm
Inside diameter	74.5 mm
Insulation thickness	9 mm

Examples

Zehnder ComfoTube Therm insulated Flat 51, 138 x 51mm, 10m roll

Article number: 990 328 032



Technical Specification

Material - Ductwork	High-quality food-grade polyethylene (PE)
Material - Insulation	Cellular rubber
Operating temperature range	-25 to +60°C
Thermal conductivity at 0°C	0.033 W/mK
Thermal conductivity at 20°C	0.035 W/mK
10 m Temperature loss @ 40 m^3hr (40/20°C)	7.1 K
10 m Temperature loss @ 40 m^3hr (16/25°C)	-5.3 K
Maximum recommended air volume per tube	13 l/s (47 m^3/h)
Minimum bending radius	207 mm and 468 mm
Buoyancy in concrete	150 N/m
Outside diameter (W/H)	157 mm x 69 mm
Inside diameter (W/H)	127 mm x 39 mm
Insulation thickness	9 mm

Cooling

- HEM will calculate internal cooling demand based on a setpoint of 24°C.
- It will assume windows will be opened first to address high temperatures.
- If this is not sufficient mechanical (active) cooling will then be used creating a cooling demand.
- If cooling system has insufficient capacity to meet demand, unmet demand is calculated.

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Cooling Fields

Field	Description	Unit
Part O Cooling required?	Is active cooling needed for Part O?	
System type	Currently only 'Air Conditioning'	
Cooling Capacity	Maximum cooling capacity of the system	kW
Efficiency	Seasonal Energy Efficiency Ratio	
Convection fraction	The proportion of the system's sensible cooling output that is delivered through air movement as opposed to radiant cooling. Typically this is 1 as all cooling is by convection.	0-1
Advanced start	Advanced Start control is a feature designed to pre-cool a space before the scheduled time to ensure the desired temperature is reached exactly when needed	Y/N
Setback temperature	Setback temperature refers to a deliberate adjustment to a less energy-intensive temperature during periods when cooling demand is lower e.g. when a home is unoccupied	Degrees

Discussion

SPACE HEATING

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Space Heating Introduction

- In SAP the space heating system has the one of the largest influence on results.
- Fuel type will vary results significantly due to carbon/Primary energy factors.
- Likely FHS notional dwelling will be based on a heat pump.
- Modelling of systems such as heat pumps and batteries now much more accurate in HEM due to half hour timestep.

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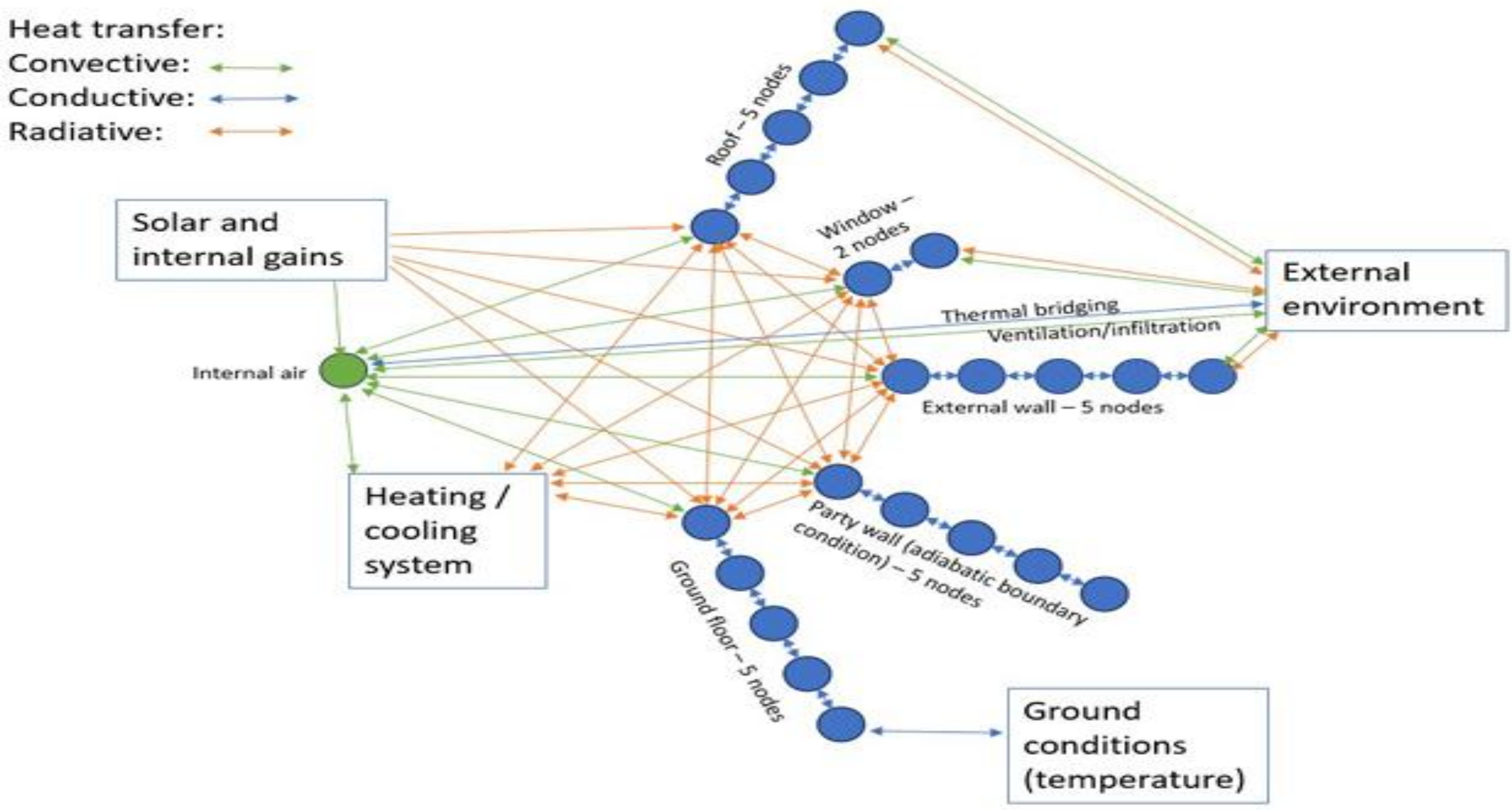
HEM Space Heating Calculation

- Based on BS EN ISO 52016-1:2017.

- Each zone in the building is modeled as a heat flow network, where:
  - The internal air is represented by a central node.
  - This node connects to internal surface nodes of building elements, which are also connected to each other to model radiative heat transfer.
  - Internal surface nodes link to additional nodes representing layers within each building element:
    - Transparent elements have two nodes (internal and external surfaces).
    - Other elements have five nodes.
  - Each node has a heat capacity, and each connection has a heat transfer coefficient.
  - External surface nodes have boundary conditions based on what the element borders (ground, outdoor air, conditioned, or unconditioned space).

HEM Space Heating Calculation

- For each timestep;
  - Heat capacity of each node (Thermal mass).
  - Heat transfer coefficient between each pair of connected nodes and at the external boundary of the dwelling.
  - Ventilation heat transfer coefficient based on flow rate and temperature of supply air (Ventilation and infiltration).
  - Thermal bridging heat transfer coefficient (sum over all thermal bridges).
  - Internal gains, made up of metabolic gains, appliance gains, lighting gains, cooking gains, hot water distribution, storage and pipework gains and ventilation fan gains.
  - Solar gains.
  - Heating/cooling system output.
  - Boundary conditions at external surfaces (e.g., for an external wall: external air temperature, solar radiation absorbed).



Heat transfer:
Convective:
Conductive:
Radiative:
Roof – 5 nodes
Solar and internal gains
Window – 2 nodes
External environment
Thermal bridging
Ventilation/infiltration
Internal air
External wall – 5 nodes
Heating / cooling system
Party wall (adiabatic boundary condition) – 5 nodes
Ground floor – 5 nodes
Ground conditions (temperature)

HEM Space Heating Calculation

- HEM calculates space heating demand by comparing internal temperature without heating to a setpoint temperature.
- HEM: FHS wrapper sets living area temperature is 21°C, rest of home is 20°C.
- Where internal heat gains do not meet the setpoints, space heat demand is created.
- If the heating system meets the demand within the timestep, its output is reported. If not, the shortfall is calculated.
- Any remaining shortfall is reported as ‘unmet demand’.

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Unmet demand

- If the heating system cannot provide enough energy to reach the setpoint in a timestep, this is recorded as "unmet demand"
- The HEM:FHS wrapper will then apply emission and primary energy factors to this energy shortfall;
  - Carbon = 0.172 $kgCO_2/kWh$
  - Primary energy = 3.938 kWh^{Pe}/kWh
- The sizing and controls for heating and cooling systems will have a significant effect on the unmet demand.

PCDB

- PCDB is currently maintained by BRE. It is updated monthly which is then incorporated into SAP applications.
- The current PCDB used in SAP is incompatible with HEM.
- New PCDB being developed, using existing PCDB data and Appendix Q technologies.
- Expected to be ready once final MHCLG HEM tool released.
- Due to the large increase in space heating details, especially for heat pumps, this is vital.

HEM PCDB

- The HEM PCDB will contain;
  - Air powered showers (App Q in SAP)
  - Fan coil emitters
  - Gas boilers
  - Heat batteries
  - Heating controls
  - HIUs
  - Heat Networks
  - Heat pumps
  - Hybrid heat pumps
  - WWHRS
  - Mechanical ventilation
  - Radiators
  - Smart air bricks (App Q in SAP)
  - Smart hot water tanks (App Q in SAP)
  - Storage heaters
  - Underfloor heating
- Will also contain 'generic' system types.

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Space Heating Fields - General

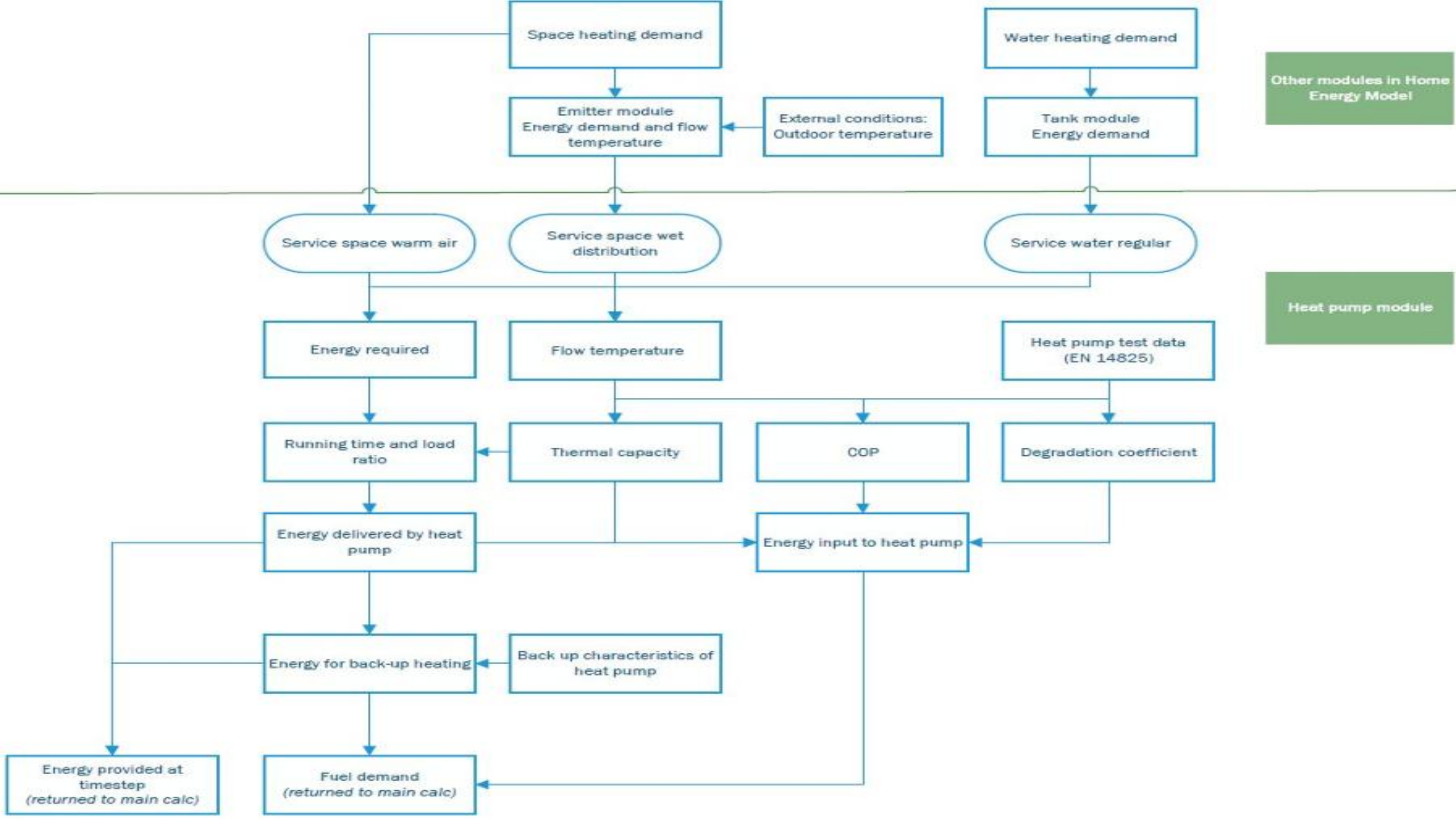
Data Field	Description	Unit
System type	Type of space heating system	Heat Pump, Boiler, Heat Battery, HIU, Storage Heaters, Direct Electric
Energy supply	Space heating system fuel	Mains elec, Mains gas, Unmet demand, Custom, Bulk LPG, LPG bottled, LPG condition 11F, Heat network
System Location	Is the system located inside or outside the heated envelope?	Internal, External

Space Heating Fields - Boilers

Data Field	Description	Unit
Full load efficiency	Efficiency of a boiler when it is operating at its maximum rated capacity in accordance with EN 15502-1	%
Part load efficiency	Efficiency of a boiler when it is operating at 30% of maximum rated capacity in accordance with EN 15502-1	%
Circulation pump electricity	Power of the circulation pump	W
Full load electricity	Measured electrical power consumed while the boiler is firing under full load	W
Part load electricity	Measured electrical power consumed while the boiler is firing under part load	W
Standby electricity	Measured electrical power consumed while the boiler is not firing (standby conditions)	W
Modulation load	The actual load (or demand) that the boiler is currently meeting through this variable output	W
Rated power	The maximum amount of thermal energy a boiler can produce under standard operating conditions	kW

Heat Pumps

- *"EN 14825 test data is used in combination with calculations from EN 15316-4-2 to calculate the performance of the heat pump."*
  - *1. HEM will provide the energy requirements for the required service and the required flow temperature during the operational hours.*
  - *2. Calculate the performance (COP, thermal capacity and degradation coefficient) for the calculation interval conditions using the flow temperature weighted average of the EN 14825 test data.*
  - *3. Calculate the running time and load ratio of the heat pump in different operation modes.*
  - *4. Calculate the energy delivered by the heat pump system and energy input to deliver that energy depending on climatic conditions and energy requirements.*
  - *5. Calculate energy for any back–up heating, if required.*
  - *6. Calculate ancillary energy and auxiliary energy.*



Space heating demand
Water heating demand
Other modules in Home Energy Model
Emitter module
Energy demand and flow temperature
External conditions:
Outdoor temperature
Tank module
Energy demand
Service space warm air
Service space wet distribution
Service water regular
Heat pump module
Energy required
Flow temperature
Heat pump test data (EN 14825)
Running time and load ratio
Thermal capacity
COP
Degradation coefficient
Energy delivered by heat pump
Energy input to heat pump
Energy for back-up heating
Back up characteristics of heat pump
Energy provided at timestep
(returned to main calc)
Fuel demand
(returned to main calc)

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Space Heating Fields - Heat Pump

Data Field	Description	Unit
Sink type	Method used to transfer heat to heat emitters	Water, Air, Glycol 25
Heat pump type	Type of heat pump	Ground, Outside air, Exhaust air MEV/MVHR/Mixed, Ground/surface water, Heat Network
Buffer tank loss	Buffer tank standing heat loss	kWh/day
Buffer fixed flow rate	Fixed water flow rate under testing to EN 14825	L/min
Buffer pump power	Power of the buffer tank pump	W
Buffer tank volume	Volume of buffer tank	L
Backup control type	Controls used to manage the activation of the backup heating source	None, Topup, Substitute

Space Heating Fields - Heat Pump

Data Field	Description	Unit
Minimum flow/return temperature difference	Minimum flow/return temperature difference for the heat pump to operate	
Modulating control		
Crankcase heater power		
Heating circulation pump power		
Backup delay time		
Variable flow temp control during test		

Space Heating Fields - Heat Pump

Data Field	Description	Unit
Off power		
Source circulation pump power		
Standby power		
Lower operating limit temperature		
Return feed max temperature		
Test data EN14825		
On off operation time constant		

Space Heating Fields – Direct Electric heating

Data Field	Description	Unit
Rated Power	Maximum power consumption of heater	kW
Convective Fraction	Proportion of heat transferred through convection. 1 = all heat convective	0-1
Advanced start	Advanced Start control is a feature designed to pre-heat a space before the scheduled time to ensure the desired temperature is reached exactly when needed	Y/N
Setback temperature	Setback temperature refers to a deliberate adjustment to a less energy-intensive temperature during periods when heating demand is lower e.g. when a home is unoccupied	Degrees

Space Heating Fields – Storage heating

Data Field	Description	Unit
Number of units	Number of units in the zone	
Control charger	The system or device that manages the charging process of electric storage heaters	
Maximum output	Maximum output of the heater during discharge periods	kW
Minimum output	Minimum output of the heater during discharge periods	kW
Air flow type	Damper only relies on natural convection to distribute the heat.	Fan assisted, Damper only
Control		
Fan power	Electrical power consumed by the fan(s) to circulate warm air during discharge periods	kW
Convective Fraction	Proportion of heat transferred through convection. 1 = all heat convective	0-1

Space Heating Fields – Storage heating

Data Field	Description	Unit
Power in	The electrical power input to the heater during the charging (storage) phase	W/hr
Rated power instant	Rated power of the instant backup	kW
Storage capacity	Maximum heat storage capacity in kWh	kWh
Advanced start	Advanced Start control is a feature designed to pre-heat a space before the scheduled time to ensure the desired temperature is reached exactly when needed	Y/N
Setback temperature	Setback temperature refers to a deliberate adjustment to a less energy-intensive temperature during periods when heating demand is lower e.g. when a home is unoccupied	Degrees
Room temperature charging cutoff	The room temperature above which if sensed during a charging hour the heater won't charge (storage heaters only)	Degrees

Convective Fraction Guidance

- *Air heating convectors/fan coils = 0.95*
- *Radiators/radiant panels = 0.7*
- *Low temperature radiant tube heaters, luminous heaters = 0.5*
- *Radiant ceiling panels = 0.35*
- *Radiant ceiling electric heating = 0.2*

- *Allows different types of electric heating to be reflected.*
- *Will allow infrared heaters to be entered accurately?*

Heat Batteries

- Heat batteries store/release thermal energy by heating a storage medium with a heat transfer fluid passing through a coil or heat exchanger.
- Examples include Sunamp, Tepeo Zeb, Fischer Aquafficient
- Technologies that are not properly accounted for in SAP 10.

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Heat Batteries

- Due to half hour calculations outputs from heat batteries can be modelled more accurately in HEM.
- For each timestep heat battery modelling is based on;
  - System initialization
  - Electric charging for conversion to stored heat
  - Energy output
  - Auxiliary energy consumption
- Potential to add to HEM PCDB.
- Types/configurations of heat battery not yet recognised may be added to the Home Energy Model in future.

Space Heating Fields – Heat Batteries

Data Field	Description	Unit
Number of units	Number of heat battery units	
A		
B		
Control charge	The system or device that manages the charging process of the heat battery	
Capillary diameter	The diameter of small channels or pores in the phase change material	m
Circulation pump electricity	Power of the circulation pump	W
Standby electricity	Measured electrical power consumed while the system is not providing heat	W
Flow rate		l/min
Heat exchanger surface area	Surface area of the heat exchanger	m^2
Charge rated power		kW

Space Heating Fields – Heat Batteries

Data Field	Description	Unit
Heat storage zone material above phase transition		kJ/K
Heat storage zone material below phase transition		kJ/K
Heat storage zone material during phase transition		kJ/K
Maximum rated losses		W
Maximum temperature		Degrees
Transition phase maximum temperature		Degrees
Transition phase lower temperature		Degrees
Simultaneous charging and discharging		Y/N
Velocity in HEX tube		

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Example

Zero Emission Boiler ZEB-40R_03			
Electrical	Rated input power (@230V)	9	kW
	Rated current (@230V)	41.5	A
	Max current draw (inc FCU)	46.3	A
	Nominal voltage (*48 - 52Hz*)	230	VAC
	Onboard power & frequency monitoring	Class B	
Heating	Thermal storage capacity (usable)	40	kWh
	Time to full charge (from empty)	4.5	hour
	Heat output (at >50% Charge)	15	kW
	Modulation range	0-100%	%
	Output temperature range	35-80	°C
	Recommended ΔT across boiler	10 - 20	°C
	Maximum operating pressure	6	bar
	Typical flow rate	10	l/min
	Minimum flow rate	3.5	l/min
	Standing heat loss (at 50% charge)	280	W
Physical	Dimensions (W x D x H)	598 x 660 x 980*	mm
	Weight	375	kg
	Max sound power level	58	dB
Environment	Ambient temperature	5 - 40	°C
	Storage temperature	-20 - 55	°C
	Operating humidity	10 - 85	%
	Storage humidity	5 - 90	%

Space Heating Emitters

- In SAP 10 heat emitters were always deemed to be appropriately sized and had a responsiveness factor.
- In HEM heat output is determined by the emitter characteristics and the temperature difference between the emitters and the surrounding air.
- Responsiveness is dependent on the thermal mass of the emitter system.
- Had a significant impact on results in the BRE HEM:FHS consultation version.

Wet distribution

Name

Provide a name for this element so that it can be identified later

Heat source

Select the relevant heat source that has been added previously

○ Heat pump

Thermal mass

Enter the thermal mass of the entire wet distribution system including pipework. Typically between 0.1 and 0.5 kWh/K.

kWh/K

Design temperature difference across the emitters

The temperature difference between the flow and return water temperatures at each emitter. Typically between 5 and 15°C.

°C

Space Heating Emitter Fields

Data Field	Description	Unit
Emitter type	The type of emitter for the heating system	Radiators, UFH, Fan coil
Number of radiators	The number of radiators in this wet distribution system	
Design flow temperature	The temperature at which water is delivered to the heating system during the coldest expected conditions. Typically between 35 and 55 °C	Degrees
Thermal mass of emitter circuit	The thermal mass of the entire wet distribution system including pipework. Typically between 0.1-0.5 kWh/K	kWh/K
Design Flow Rate	Enter the volume of water flowing through the heater	l/m
Design Temperature Difference across Emitters	The difference between the water floor temperature and the room air temperature at the point where the heating is being emitted. Typically between 5 and 15 °C	Degrees

Space Heating Emitter Fields

Data Field	Description	Unit
Temperature Setback	Setback temperature refers to a deliberate adjustment to a less energy-intensive temperature during periods when heating demand is lower e.g. when a home is unoccupied	Degrees
Advanced Start	Advanced Start control is a feature designed to pre-heat a space before the scheduled time to ensure the desired temperature is reached exactly when needed	Y/N
Convective Fraction	Proportion of heat transferred through convection. 1 = all heat convective Air heating convectors/fan coils = 0.95 Radiators = 0.6-0.8 Underfloor heating = 0.2-0.4 Radiant ceiling panels = 0.35 Radiant ceiling electric heating = 0.2	0-1
Ecodesign control class	The Ecodesign class of any control used	Class I-VIII

Ecodesign Class Definitions

Class	Description
Class I	**On/off Room Thermostat**: A room thermostat that controls the on/off operation of a heater. Performance parameters, including switching differential and room temperature control accuracy, are determined by the thermostat's mechanical construction.
Class II	**Weather compensator control**, for use with modulating heaters: A heater flow temperature control that varies the set point of the flow temperature of water leaving the heater dependent upon prevailing outside temperature and selected weather compensation curve. Control is achieved by modulating the output of the heater. **e.g. Ideal OS2**
Class III	**Weather compensator control, for use with on/off output heaters**: A heater flow temperature control that varies the set point of the flow temperature of water leaving the heater dependent upon prevailing outside temperature and selected weather compensation curve. Heater flow temperature is varied by controlling the on/off operation of the heater. **e.g. Worcester Weather Sensor**
Class IV	**TPI (time proportional and integral) room thermostat**, for use with on/off output heaters: An electronic room thermostat that controls both thermostat cycle rate and in-cycle on/off ratio of the heater proportional to room temperature. TPI control strategy reduces mean water temperature, improves room temperature control accuracy and enhances system efficiency. **e.g. Myson Unisenza Plus Electronic Thermostatic Head**
Class V	**Modulating room thermostat, for use with modulating heaters**: An electronic room thermostat that varies the flow temperature of the water leaving the heater dependent upon measured room temperature deviation from room thermostat set point. Control is achieved by modulating the output of the heater. **e.g. Viessmann,ViCare Thermostat**

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Ecodesign Class Definitions

Class	Description
Class VI	**Weather compensator and room sensor, for use with modulating heaters**: A heater flow temperature control that varies the flow temperature of water leaving the heater dependent upon prevailing outside temperature and selected weather compensation curve. A room temperature sensor monitors room temperature and adjusts the compensation curve parallel displacement to improve room comfort. Control is achieved by modulating the output of the heater. **e.g**. **Alpha Smartech Plus Thermostat**
Class VII	**Weather compensator and room sensor, for use with on/off output heaters**: A heater flow temperature control that varies the flow temperature of water leaving the heater dependent upon prevailing outside temperature and selected weather compensation curve. A room temperature sensor monitors room temperature and adjusts the compensation curve parallel displacement to improve room comfort. Heater flow temperature is varied by controlling the on/off operation of the heater. **e.g**. **Drayton Wiser TTZC**
Class VIII	**Multi-sensor room temperature control, for use with modulating heaters**: An electronic control, equipped with 3 or more room sensors that varies the flow temperature of the water leaving the heater dependent upon the aggregated measured room temperature deviation from room sensor set points. Control is achieved by modulating the output of the heater. **e.g**. **Radbot,2R**

Secondary Heating

- Secondary heating details still needed.
- Currently only shown to influence infiltration rates.
- We expect more fields such as efficiency to be added in future.

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Secondary Heating Fields

Data Field	Description	Unit
Type	Type of appliance	Open fireplace, Closed fire with fan, Open gas flue balancer, Open gas kitchen stove, Open gas fire, Closed fire
Fuel type	Type of fuel	Wood, Oil, Gas, Coal
Air supply	Air supply to appliance	Room air, Outside
Exhaust method	Exhaust method from appliance	Into room, Into separate duct, Into mechanical vent

Discussion

DOMESTIC HOT WATER

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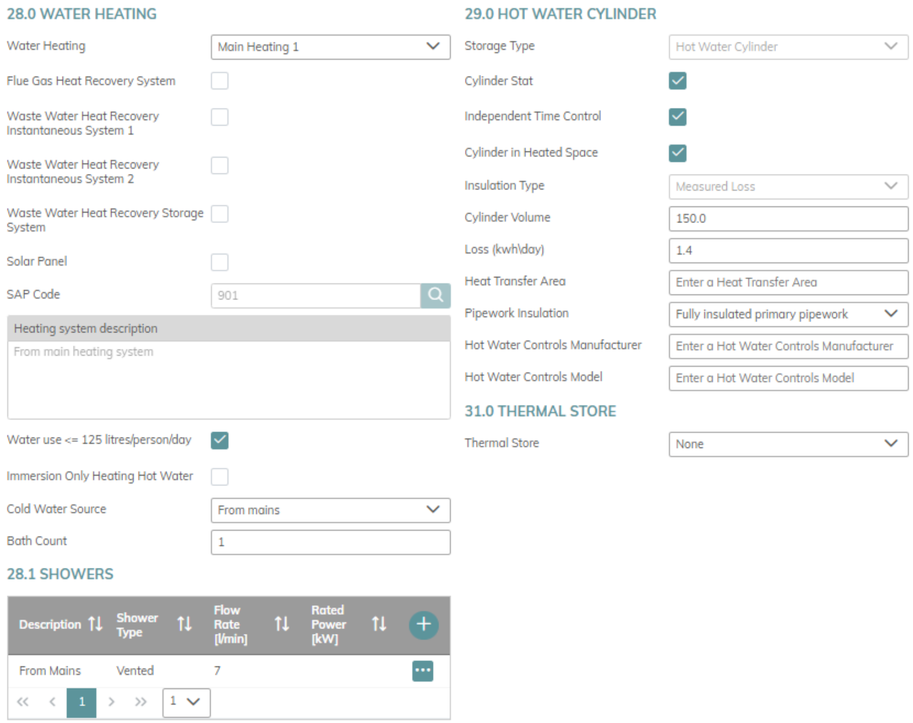
Domestic Hot Water and SAP

- SAP 10 uses a fixed formula to calculate hot water demand.
- This is based on floor area as a proxy for calculating occupancy, with assumptions for water use per person.
- Type of water storage, shower flow rates, number of baths, PV diverters, solar hot water panels and WWHRs also influence hot water demand.
- Limited in regards to smart controls and time of use tariffs etc.
- Assumes 15% heat loss from pipework.



Domestic Hot Water and HEM

- HEM introduces more granular dynamic modeling of hot water demand.
- With half hourly timesteps HEM can calculate demand based on actual length and frequency of hot water events.
- Improved modelling of water storage systems based on number of hot water events.
- Seasonal variation of mains cold water also accounted for.
- Pipework losses now modelled fully.

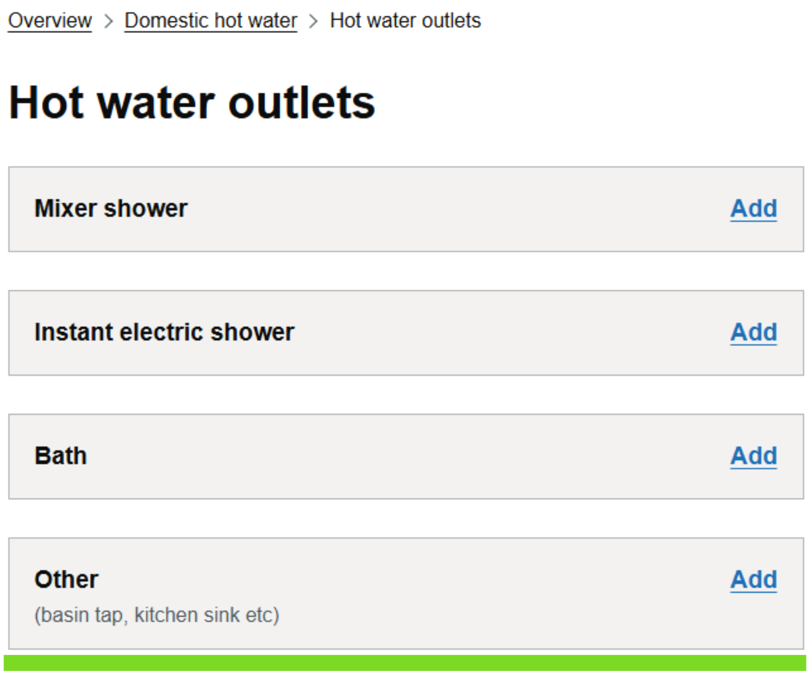
Domestic hot water

Water heating	In progress
Hot water outlets	Not started
Pipework	Not started

Return to overview | View summary

Hot Water Outlets

- Hot water outlets are needed to calculate the Hot Water Demand.
- Similar to SAP 10 but contains more details for baths and other outlets.
- Hot water demand is calculated based on these details in every half hourly timestep in the model.



Hot Water Outlets

Field	Description	Unit
Cold water source	Source of cold water for the outlet	Mains, Header tank
Shower type	Type of shower	Mixer Shower, Instant Electric
Mixer shower flow rate	Flow rate of the shower	l/min
Mixer shower connected to WWHRS	Is the shower connected to a WWHRS?	
Electric shower rated power	Rated power of the shower	kW
Bath volume	Volume of the bath	L
Other hot water outlets flow rate	Flow rate of other hot water outlets - taps	l/min

Hot Water Cylinders

- Modelled in HEM against BS EN 15316-5:2017.
- SAP standing loss replaced by 'Daily Energy Loss'.
- HEM allows definition of a setpoint temperature – temperature the water is heated to.
- In the HEM:FHS wrapper consultation this was set at 60 °C.
- 'Smart hot water tanks' now distinguished from normal cylinders.

Hot Water Cylinders

Field	Description	Unit
Volume	Total volume of water storage	l
Daily Energy Loss	Daily energy loss encompasses all energy used to heat the water, including the energy to replace heat lost through standing losses and the energy used for hot water draw-offs. Note that this is not standing heat loss, which refers to the heat lost from the cylinder to the surrounding environment over a specific period, typically measured over a 24-hour period.	kWh
Hot Water Cylinder Controls	Type of controls	On off time control, On off cost minimizing time control, Setpoint time control, ToU charge control
Heat Exchanger Area	Area of heat exchanger	m^2

Hot Water Cylinders Controls

Field	Description
On off time control	Control to determine if the system if on or off
Setpoint time control	Heats only during scheduled times where below setpoint temperature
ToU charge control	Same as on off time control except sets a schedule of charge levels
On off cost minimizing time control	Uses a schedule for desired number of hours per day on and sets these at the lowest cost times of the day

Smart Hot Water Tanks

Field	Description	Unit
Volume	Total volume of water storage	l
Daily Energy Loss	Daily energy loss of water storage	kWh
Hot Water Cylinder Controls	Type of controls	On off time control, On off cost minimizing time control, Setpoint time control, ToU charge control
Minimum Temperature	Minimum temperature required for domestic hot water	°C
Maximum Setpoint Temperature	The maximum temperature the system is programmed to maintain	°C
Useable temperature	The portion of the tank's hot water that is available and suitable for use at the desired temperature	°C
Pump energy supply	Energy supply to the pump, normally electricity	
Pump power	The power of the built in circulation pump	kW
Pump max flow rate	The maximum volume of water the built-in circulation pump can move per unit of time	l/min

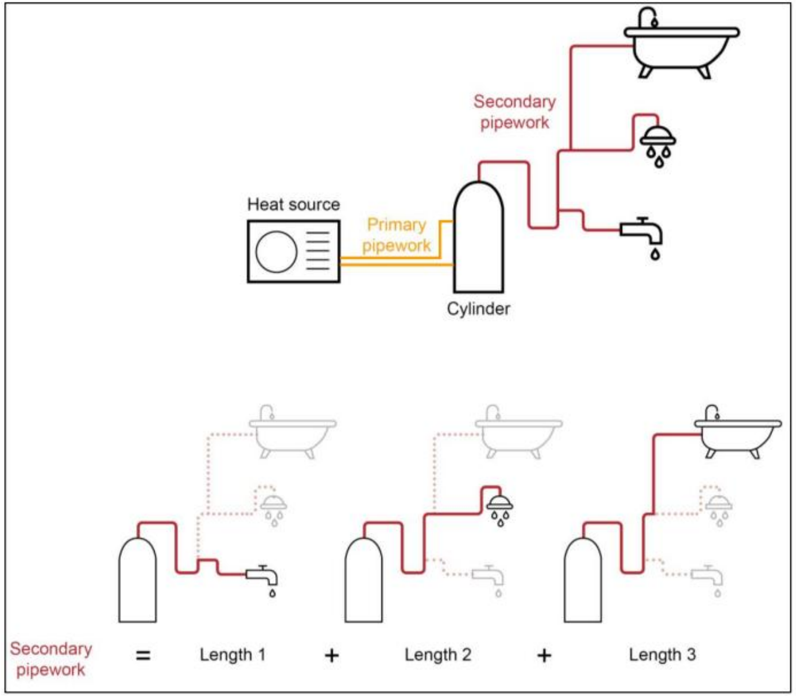
WWHRS

Field	Description	Unit
Outlet	Which outlet is the WWHRS connected to?	
WWHRS Type	Is the WWHRS System A, B or C?	
Flow Rate	The cold water flow rate	l/min
Efficiency	The efficiency of the WWHRS	%
Utilisation factor	The ratio of time the WWHRS is in use to the total time that it could be in use. % expressed in decimal form.	0-1

- System A – Output of the heat exchanger is fed to both the shower and the combi boiler or hot water system.
- System B – Output of the heat exchanger is fed to the shower only.
- System C - Output of the heat exchanger is fed to the combi boiler of hot water system but not to the shower.

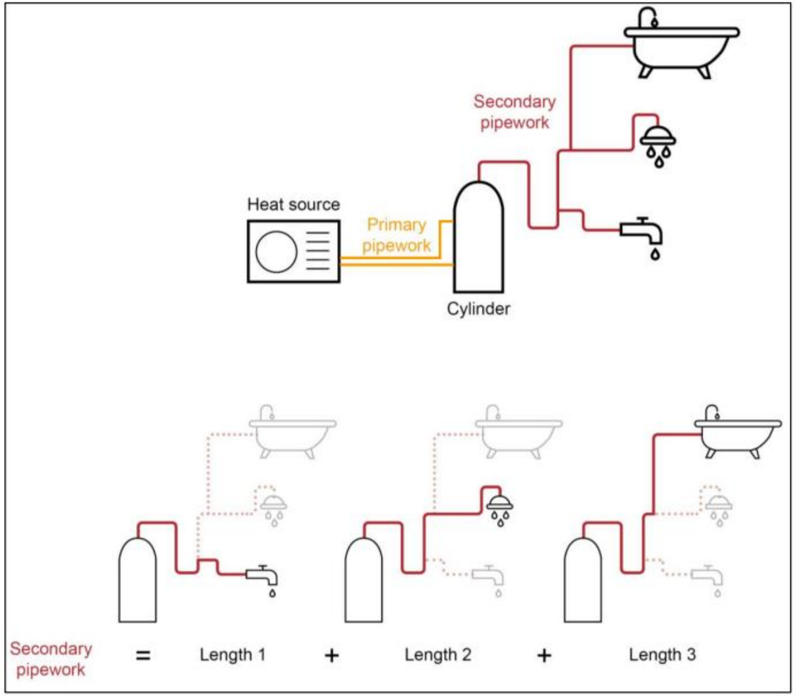
DHW Pipework

- In HEM there is a much more detailed assessment of DHW pipework heat loss.
- Calculated to BS EN ISO 12241:2022.
- Information for 'Primary' and 'Secondary' DHW pipework must be entered.
- HEM takes account of properties of the pipework such as the volume, length and level of insulation.
- Heat losses are based on the temperature differential between the water within the pipe and the surrounding air, as well as the duration of the tapping event.
- The main component of pipework losses is from hot water left standing in the pipework once DHW demand is met.



DHW Pipework

- Primary pipework length measured from the heat source to hot water storage. Both primary flow and return lengths should be included.
- Secondary pipework is pipes from the hot water storage to outlets e.g. taps, showers.
- We need an approach for planning/design stage work.



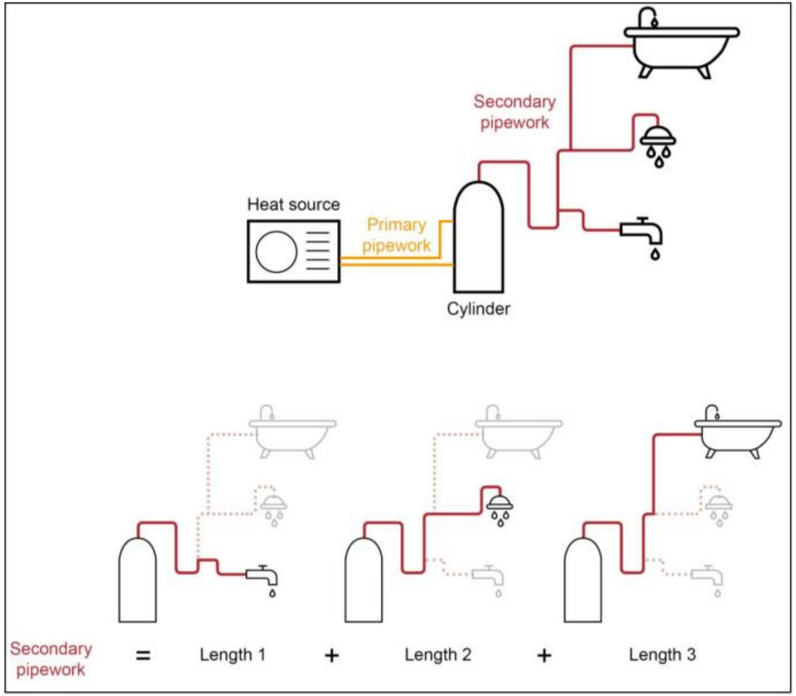
Primary Pipework

Field	Description	Unit
Primary Pipework Length	Length of pipework measured from the heat source to storage tank. Both primary flow and return lengths should be included	m
Primary Pipework Internal Diameter	Internal diameter of pipework (Ø)	mm
Primary Pipework External Diameter	External diameter of pipework (Ø)	mm
Insulation Thickness	Thickness of the pipework insulation	mm
Insulation Conductivity	Thermal conductivity of the pipework insulation	λ – w/m ·k
Pipework Location	Is the pipework inside or outside the heated envelope	Internal or External
Pipe Contents	Contents of the pipework	Water or glycol 25
Surface Reflectivity	Is the surface of the pipework reflective?	Y/N

Primary Pipework guidance

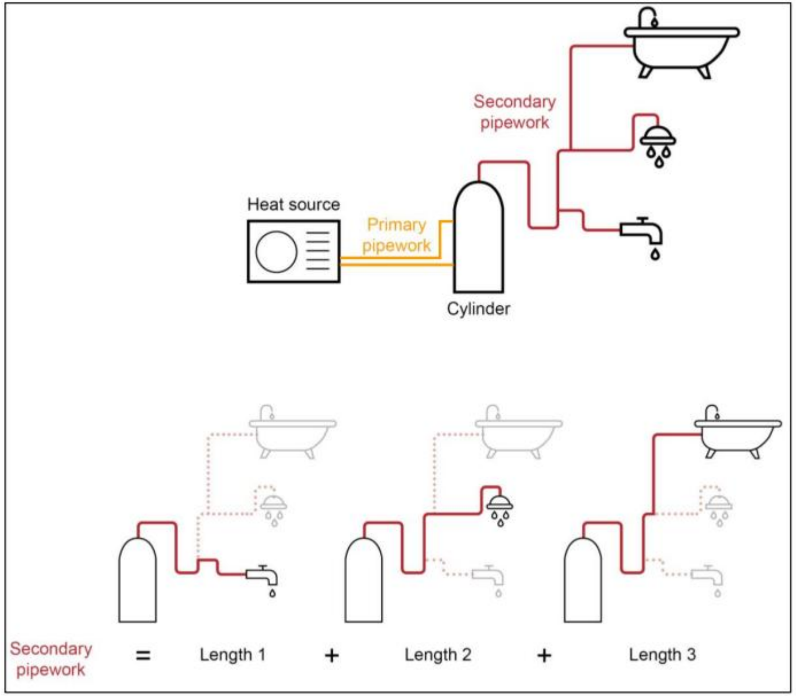
- For internal diameter;
  - Generally 15-28 mm for space and water heating
  - 15 mm for small radiators/taps
  - 22 mm for main distribution
  - 28 mm for high flow systems

- For external diameter;
  - 15 mm internal = 22 mm external
  - 22 mm internal = 28 mm external



Primary Pipework guidance cont.

- For length;
  - 5-20 m for small apartment
  - 20-50 m for large house
  - Higher value for complex layouts or multiple zones
- For thermal conductivity;
  - Mineral wool – 0.035-0.045 W/m·k
  - Polyethylene foam – 0.035-0.04 W/m·k
  - Elastomeric foam/Armaflex– 0.033-0.04 W/m·k
- For thickness;
  - 9 mm minimal insulation
  - 13-25 mm recommended
  - 32 mm for higher performance/external pipework

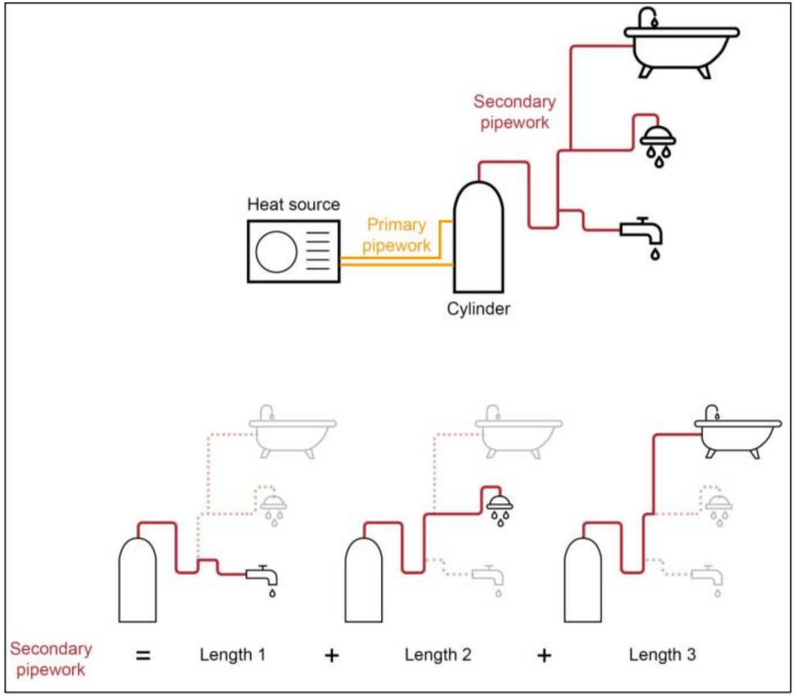


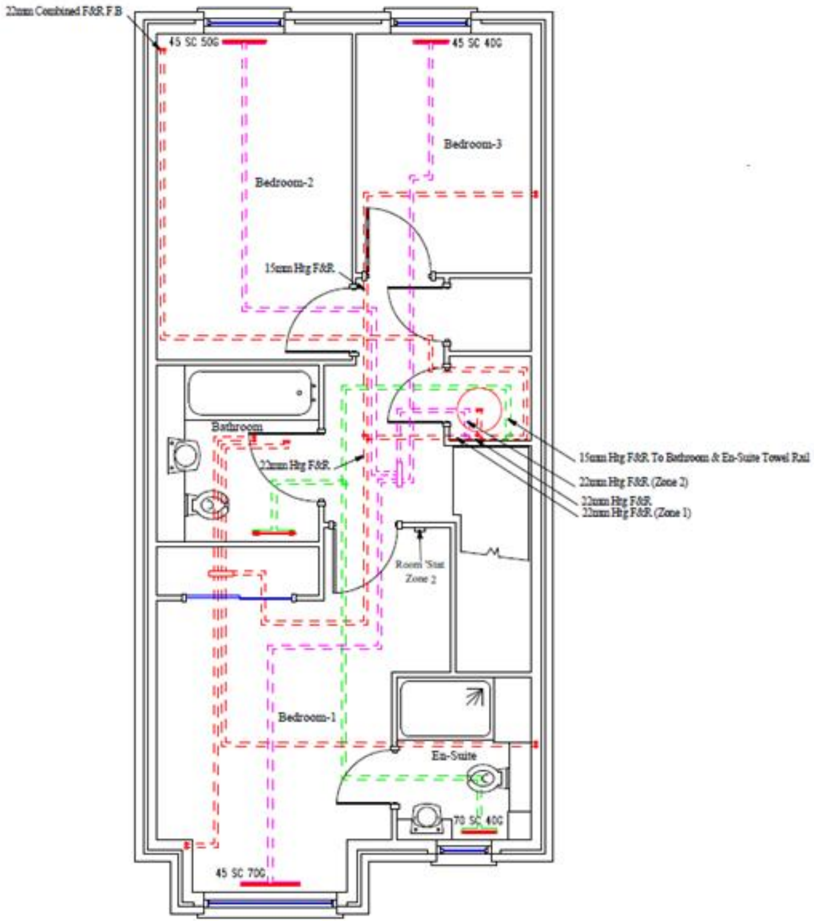
Secondary Pipework

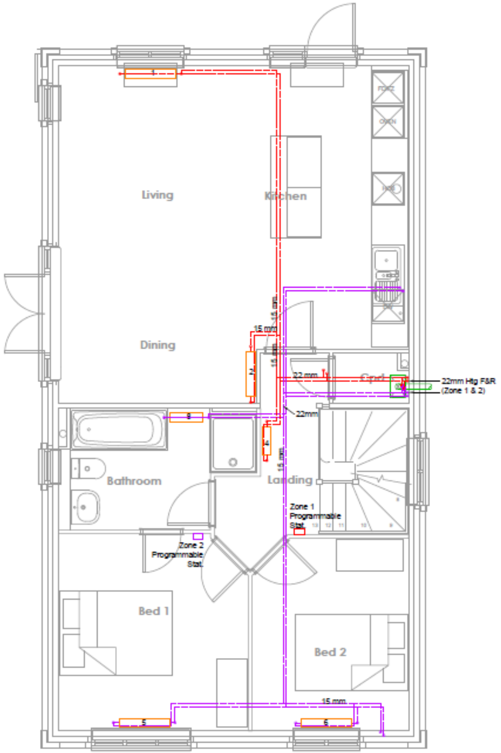
Field	Description	Unit
Secondary Pipework Length	Length of pipework measured from the storage tank to tapping points. pipework serving multiple tapping points should be counted once for each tapping point.	m
Secondary Pipework Internal Diameter	Internal diameter of pipework (Ø)	mm
Secondary Pipework External Diameter	External diameter of pipework (Ø)	mm
Insulation Thickness	Thickness of the pipework insulation	mm
Insulation Conductivity	Thermal conductivity of the pipework insulation	λ – w/m·k
Pipework Location	Is the pipework inside or outside the heated envelope	Internal or External
Pipe Contents	Contents of the pipework	Water or glycol 25
Surface Reflectivity	Is the surface of the pipework reflective?	

Secondary Pipework guidance

- For internal diameter;
  - 10-22 mm depending on use
  - 10-15 mm for individual outlets e.g. taps or showers
  - 15-22 mm for main hot water distribution pipes
- For length;
  - 5-15 m for small apartment or compact layout
  - 15-30 m for standard house with multiple outlets
  - >30 m for larger homes with complex pipe runs







BUILDING NOTES

All plumbing fitting and outlets must be fitted in accordance with manufactures instructions and have isolating flow rate and pressure reducing valves as required. The installation must be in accordance with all relevant regulations.

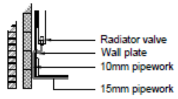
The first meter of pipework from the boiler to be copper all pipework in airing cupboard to be copper all exposed pipework to be copper

System to be balanced to achieve 55°C flow 45°C return with 10°C temperature drop across the boiler and radiators

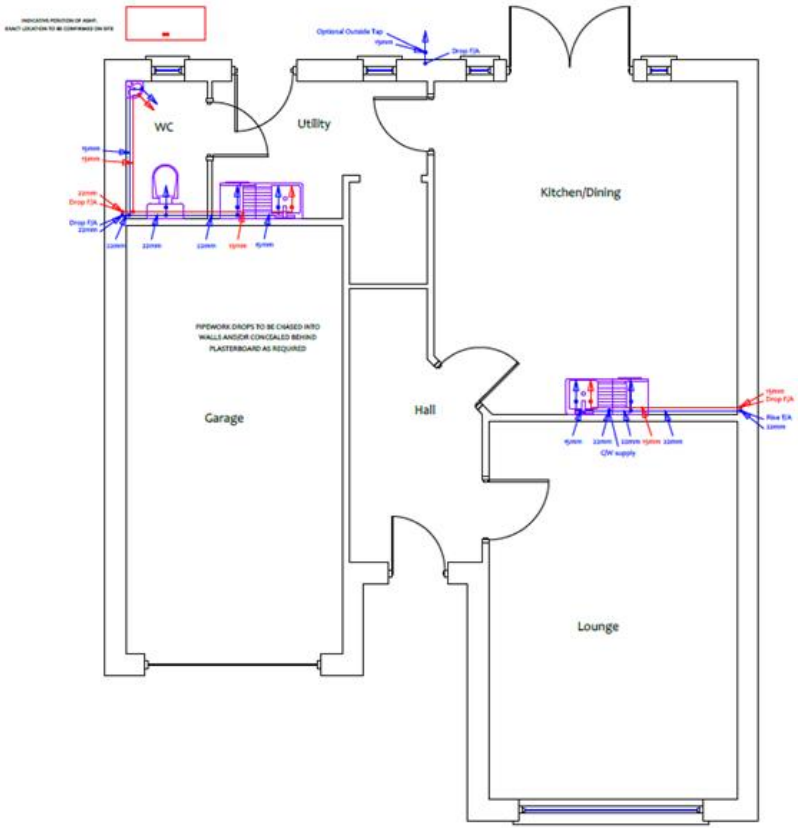
Flow and Return	F&R
To Above	T/A
To Below	T/B
To Ceiling Void	T/CV
From Above	F/A
From Below	F/B
From Ceiling Void	F/CV
Zone 1 F&R Pipes	-
Zone 2 F&R Pipes	-
Pipes in Floor Space	-
Pipes at Low Level	-
Pipes at High Level	-
Pipes in Roof Space	-

All pipework to radiators to be run in continuous lengths with formed bends at changes of direction with minimum number of elbows and fittings.

PIPEWORK ROUTES SHOULD BE CONFIRMED AS BEING



Typical detail showing pipework connection to radiator



NOTES

Primary pipework, first & second fix pipework and all underfloor heating system pipework & fittings must be installed to sizes confirmed by Myson design department & Daikin technical installation guide.

All pipework in cylinder cupboard to be copper.

All final pipework to radiators to be 15mm diameter or above for all radiators, as detailed on relevant Myson heating system designs.

All products specified within this drawing must be fitted in accordance with all of the manufacturers installation instruction manuals.

DESIGN VALID FOR 12 MONTHS - CONTACT REDD IF START DATE ON SITE EXTENDS PAST DATE SHOWN ON THIS DRAWING.

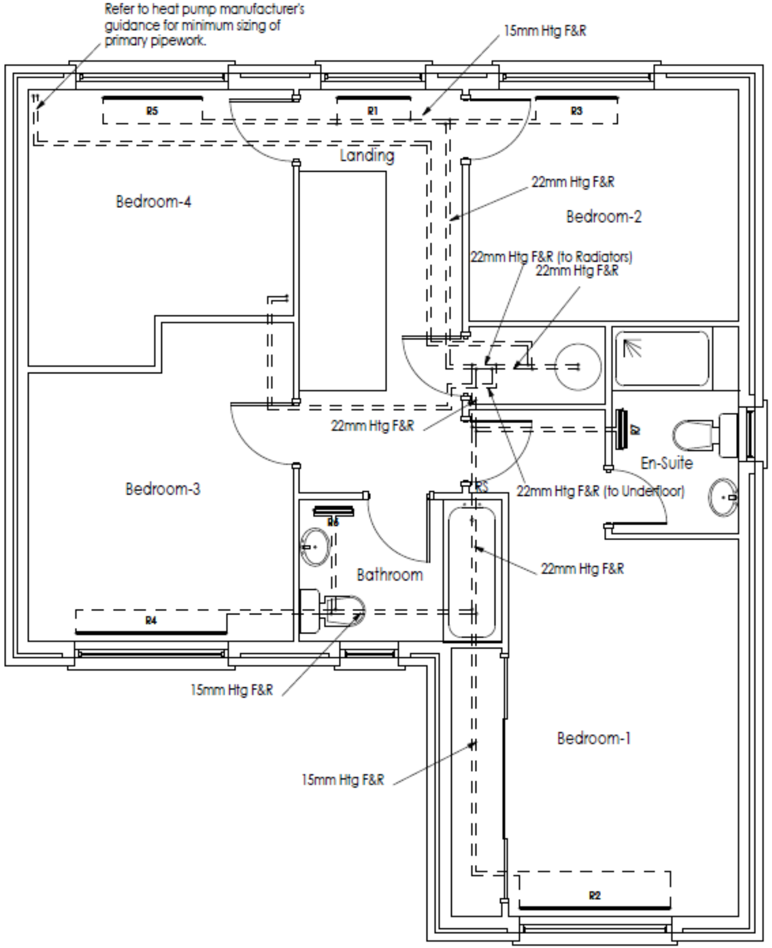
All drawings are not to scale and should be treated as diagrammatic.
Any discrepancies must be reported to designer prior to installation.

KEY

Wall Mounted Thermostat for Zone 1
Wall Mounted Thermostat for Zone 2
Programmable Wall Mounted Thermostat for Zone 1
Programmable Wall Mounted Thermostat for Zone 2

Flow and Return - F & R
Hot Water Supply - HWS
Cold Water Supply - CWS
Mains Cold Water - MCW
Pipework Rise To Above - T/A
Pipework Drop To Below - T/B
Pipework Drop From Above - F/A
Pipework Rise From Below - F/B

Zone 1 Heating System Pipework
Zone 2 Heating System Pipework
Domestic Hot Water Supply
Domestic Cold Water Supply
Pipework at Low Level
Pipework in Floor Void
Pipework in Roof or Ceiling Void


Refer to heat pump manufacturer's guidance for minimum sizing of primary pipework.
15mm Htg F&R
R5
R1
R3
Landing
22mm Htg F&R
Bedroom-4
Bedroom-2
22mm Htg F&R (to Radiators)
22mm Htg F&R
22mm Htg F&R
En-Suite
Bedroom-3
22mm Htg F&R (to Underfloor)
Bathroom
22mm Htg F&R
R4
15mm Htg F&R
Bedroom-1
15mm Htg F&R
R2

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Discussion

RENEWABLES

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Solar PV

- PV likely to be required for FHS.
- For PV HEM uses calculation procedures in BS EN 15316-4-3:2017.
- Half hourly timestep allows a more comprehensive calculation of PV output.
- Distant shading will directly influence PV output.
- More details of the PV panels and supporting infrastructure needed.

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Generation Priorities

- Where electricity is generated it will be allocated in the following priority;

1. Instantaneous demand from the dwelling (heating, cooling, ventilation & appliances)
2. Battery storage
3. PV diverter
4. Grid export

Demand Priorities

- Electricity demand within the home is met in the following priority order;

1. Self generated electricity
2. Battery storage
3. Mains electricity (Grid import)

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Solar PV

Field	Description	Unit
Peak Power	The electrical power of a photovoltaic system with a given area and a for a solar irradiance of 1 kW/m²	kWp
Inverter Type	Type of PV inverter	String, Optimised
Is Inverter Inside?	Is the inverter inside the thermal envelope?	Y/N
Inverter Peak Power AC	The maximum amount of alternating current (AC) power the inverter can output at a given time under ideal conditions	kW
Inverter Peak Power DC	The maximum amount of direct current (DC) power the inverter can handle from the solar panel array	kW
Pitch	The tilt angle (inclination) of the PV panel from horizontal measured upwards facing, 0 to 90. 0 = horizontal surface, 90 = vertical surface	Degrees
Orientation	Orientation of the panels	Degrees
Base Height	The distance between the ground and the lowest edge of the PV panel	m
Array Ventilation	Ventilation strategy of the panels	Unventilated, Moderately ventilated, Strong/forced ventilated, Rear surface free
Panel Length	Length of the panel	m
Panel Width	Width of the panel	m

PV Ventilation Options

Field	Description	Example
Unventilated	The PV module is installed without airflow behind it, leading to higher operating temperatures and reduced efficiency. Suitable for building integrated systems (e.g., PV panels embedded in roofs or facades)	
Moderately ventilated	Limited airflow is present behind the PV module, allowing some cooling but still leading to moderate temperature increases. Common in rooftop installations with a small gap between the panel and the surface.	
Strong/forced ventilated	Active airflow (natural or mechanical) is used to cool the PV module, reducing temperature and improving efficiency. Often used in large-scale solar farms or setups with cooling fans.	
Rear surface free	The back of the PV module is completely open to airflow, maximising natural cooling. Typically seen in ground-mounted systems or open-rack installations.	

PV Shading

Field	Description	Unit
Shading Type	Type of shading structure	Reveal, Obstacle, Overhang, Sidefin Left/Right
Depth	Depth away from the PV array	m
Distance	Distance of the closest edge of the shading from the edge of the array	m
Height	If shading type is obstacle, the height of the obstacle above the PV array	m
Transparency	If shading type is obstacle, the transparency where 100% is transparent	%

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Example PV Design

Batteries

Field	Description	Unit
Capacity	Maximum capacity of the battery	kWh
Battery Charge/Discharge Efficiency	The percentage of energy retained during charging and discharging. Where 1 is no energy loss.	0-1
Minimum Charge Rate One Way	The lowest power at which the battery can be charged during a single one-way trip	kW
Maximum Charge Rate One Way	The maximum charge rate the battery allows during a single charging session or one-way trip	kW
Maximum Discharge Rate One Way	The highest power at which the battery can discharge energy during a single one-way trip	kW
Battery Location	Is the battery located inside or outside the heated envelope?	Inside, Outside
Grid charging possible?	Can the battery be charged from grid electricity?	Y/N

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PV Diverters

Field	Description	Unit
Energy diverted to heat generation?	Which heat generator is being sent energy by the diverter?	
Energy diverted to storage tank?	Which storage tank which is being sent energy by the diverter?	

Solar Thermal

Field	Description	Unit
Location	Location of the main part of the solar thermal collector loop piping	Outside, Heated space, Non heated space
Module Area	Area of one collector module	m^2
Number of modules	Number of modules	N/A
Peak collector efficiency	Peak collector efficiency	0-1
Incidence angle modifier	Modifier for off angle performance	K(θ)
1st Order HLC	Represents linear thermal losses as a function of temperature difference	W/m^2k
2nd Order HLC	Represents non linear thermal losses as a function of temperature difference	W/m^2k^2
Collector mass flow rate	Mass flow rate through the collector	L/hr
Pump power	Electrical power of the pump	W
Pump power control	Electrical power of the pump control	W
Pump energy supply	Energy supply for the pump, likely to be electricity	N/A
Pitch	The tilt angle (inclination) of the panels from horizontal measured upwards facing, 0 to 90. 0 = horizontal surface, 90 = vertical surface	Degrees
Orientation	Orientation of the panels	Degrees
Solar loop piping HLC	Heat loss coefficient for solar loop piping	W/mK

Discussion

Remaining areas

- HEM and the FHS wrapper remain under development.

- In order for HEM to be used for FHS we believe the following are required;
  - Stable, locked set of user inputs/wrapper
  - Stable, locked HEM engine
  - Complete PCDB
  - All current SAP technologies available in HEM
  - Conventions group set up and conventions issued
  - Trained, competent assessors

Unavailable Technologies

- Wind Turbines
- Hydroelectric generation
- Heat networks
- PIV
- FGHRS

Final Thoughts

- HEM is a significant change for the industry.

  New methodology, delivery model, data inputs and results generation.

- Increased accuracy but complex

  Half hourly timestep, shading, pipework, ventilation, space heating etc.

- There is a lot of work to do

  Finalising HEM version, wrapper, input fields, conventions, PCDB, all technologies.

Discussion