Department for
Business, Energy
& Industrial Strategy

# TECHNICAL APPENDIX TO THE HEAT NETWORK (METERING AND BILLING) REGULATIONS 2014

# PROPOSED AMENDMENTS

## Additional information on the draft metering cost-effectiveness assessment tool

December 2019

Any enquiries regarding this publication should be sent to us at:
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# Contents

# Content and purpose of this technical appendix to the consultation

*This section outlines the purpose of this technical appendix in the context of the consultation and explains how information about the draft metering cost-effectiveness assessment tool is presented.*

Stakeholders have asked for additional information about the draft metering cost-effectiveness assessment tool to support their response to the consultation on the proposed amendments to the Heat Network (Metering and Billing) Regulations 2014.

The draft tool is in the process of being tested and may be amended following the consultation. It is therefore not possible to publish a draft version of the tool at this stage.

This technical appendix provides information in the form of an extract from the draft user guide of the tool. It contains a significant amount of detail on the proposed user inputs, assumptions made, and the core calculations used to generate the final outputs.

While the tool and user guide are in draft form and subject to consultation outcomes, it is important to emphasise that the requirement to carry out the assessment of cost-effectiveness at building level cannot be amended.

This document should be read together with the consultation and be considered as a description of the draft tool, implementing the proposed amendments to the cost-effectiveness methodology.

We would be grateful if you could integrate your comments into your response to the consultation.

# Draft User Guide

# Introduction to the [draft] tool

*The purpose of the [draft] tool is to enable existing communal and district heat networks to consistently assess whether it is considered cost-effective to install consumption heat meters or heat cost allocators in buildings in line with the requirements of the Energy Efficiency Directive (2012/27/EU).*

A Microsoft Excel tool (the tool) has been developed to enable the assessment of the cost/benefit of the installation of heat meters, or failing that, heat cost allocators within specific buildings that fall within the definition of communal or district heating networks. The tool has been developed to materially adhere to the European Commission's 2016 "*Guidelines on good practice in cost-effective cost allocation and billing of individual consumption of heating, cooling and domestic hot water in multi-apartment and multi-purpose buildings*"[1].

The underlying assumption of metering is that consumption patterns will change when heat customers are aware of how much heat they consume and are billed based on consumption. The cost of the fuel saved as a result of reduced energy consumption is taken as the benefit of installing heat meters, a benefit that should accrue to the customer. The assumptions on energy savings of 20% for domestic and 10% for non-domestic customers have been retained from the original tool.[2]

However, installing heat meters or heat cost allocators will incur costs to a heat supplier. The discounted costs to the heat supplier are weighed against the discounted benefit to the customer over a 10-year period, the assumed lifetime of the meter.

If the present value of the benefits is greater than the present value of the estimated cost of installing and managing heat meters for a given building then the tool will indicate that it is cost-effective to install heat meters in each such building.

If the present value of the costs is greater than or equal to the discounted benefits then the tool assesses if the present value of the benefits outweighs the present value of the costs associated with installing heat cost allocators. If they do, then the tool will indicate that it is cost-effective to install heat cost allocators for all such buildings.

[1] Empirica GmbH (2016) 'Guidelines on good practice in cost-effective cost allocation and billing of individual consumption of heating, cooling and domestic hot water in multi-apartment and multi-purpose buildings' (available at: https://ec.europa.eu/energy/sites/ener/files/documents/mbic_guidelines20170123_en.pdf)

[2] As above.

# User Inputs

*The numbered references in brackets relate to the excel tool and are shown in the screen prints in relevant sections below. Inputs in the building section are prefaced with "A", in plant section with "B", and unit type section with "C".*

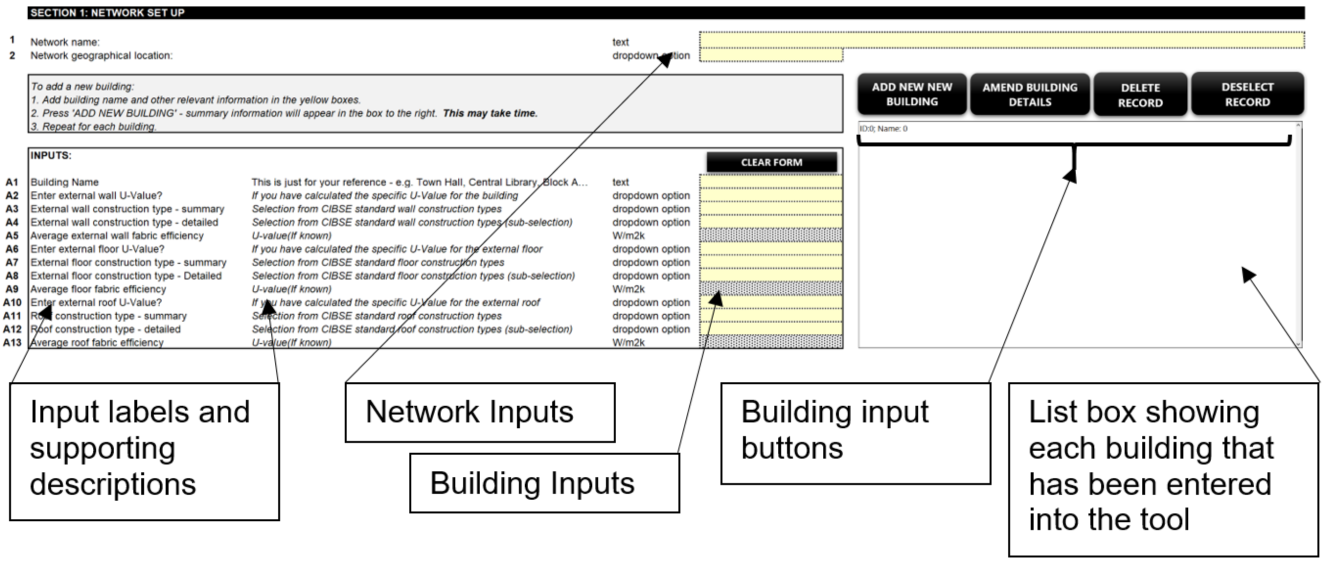
*At least one entry is required in each section.*

## Overview

The user input sheet is intended to allow the user to separately describe each building on their network and not impose a one-size fits all. Buildings are added by the user and against each building the user sets out the heat and / or cooling plant used to supply energy to the building's individual units which are also entered by the user. In this way the user can better tailor the assessment to their actual network buildings.

All user inputs are labelled with a reference number in Column B of the user input sheet of the tool. The calculations section below explains how each user input is used in order to derive key values to establish the cost/benefit analysis for the installation of heat meters or heat cost allocators.

## Network and Building Setup




### Network Inputs

#### Network Name [1] (mandatory)

The network name is a mandatory field and should be a name that the user readily associates with the network (communal or district) that is being assessed. A building cannot be entered into the tool unless this field is populated.

### Network geographical location [2] (mandatory)

The network's geographical location is a mandatory field and requires the user to select the region of the UK that the network is located in. In the unlikely event that a network spans across more than one UK region please select the region where most customers are located.

## Building Inputs

### Overview

The tool has been designed much like a database. The user input form is the user's means of entering data into a standardised table. The listbox in the user input form shows which buildings have already been entered. Clicking on a building in the listbox will retrieve the data stored allowing the user to update the building information.

The black macro buttons are fundamentally the means to allow the user to clear the form, enter new buildings, amend existing buildings and delete buildings.

### Building Name [A1] (mandatory)

This should be the name of one of the buildings that is to be assessed for the installation of either heat meters or heat cost allocators. For example, imagine a district heat network of 10 buildings is being assessed. Each of the 10 buildings would be entered into the tool (see "Add New Building" section below) and a separate name for each of the 10 buildings would be provided in this field upon entry of each building.

### Enter external wall U-value [A2] (mandatory)

If the user intends to enter his/her self-calculated U-Value for the external wall construction type, rather than rely on industry standards for the wall construction type, then the user should select "TRUE". On selecting "TRUE" [A5] will no longer be hashed out and the user will be required to enter a U-Value. On selecting "FALSE" [A5] will remain hashed and the user need not make an entry.

### External wall construction type - summary [A3] (mandatory)

The external wall construction type allows the user to select the type of external wall construction that is used in the building. Evidently different construction types and insulation used will impact the wall's thermal conductivity (the extent to which heat will pass through it to the outside). This selection only impacts the calculation of heat/cooling demand in the event that the user does not specify the average U-value for the building's external wall ([A5]).

This is a mandatory field, even when a self-calculated U-Value for external wall is being provided. This is because we reserve the right to compare the U-Value provided to the industry benchmark for the External Wall Construction type selected.

The list of external wall construction types corresponds to CIBSE (2015), *Guide A*, Table 3.48.[3]

| External wall construction type - summary |
|---|
| 1. Stone walls |

[3] CIBSE (2015): *Guide A: Environmental design* (London: The Chartered Institution of Building Services Engineers)

| |
|---|
| 2. No fines concrete walls |
| 3. Solid brick walls |
| 4. Dense concrete walls |
| 5. Precast concrete panel walls |
| 6. Brick/brick cavity walls |
| 7. Brick/dense concrete block cavity walls |
| 8. Brick/lightweight aggregate concrete block cavity walls |
| 9. Brick/autoclaved aerated concrete block cavity walls |
| 10. Timber frame walls |

### External wall construction type - detailed [A4]

The dropdown list for [A4] is only populated when the user makes a selection for the summary external wall type. The detailed sub-list for each summary external wall construction type with accompanying U-Values and wall thicknesses can be found in the appendix.

### Average external wall fabric efficiency [A5]

The average external wall fabric efficiency or U-value reflects the W/m2K (Watt per meter squared Kelvin) thermal conductance of the external wall. The U-value provides the combined thermal conductivity of all the separate components of the external wall (e.g. brick, cavity, internal plaster etc.) as well as the convection of the internal and external surfaces.

It is not expected that all users will know the average U-value for a given building's external walls. For this reason, industry average U-values are stored in the tool (refer to [A4]). For each building material used in the external wall, the K-value (thermal conductivity) should be sourced from either the original supplier or an equivalent supplier as supporting evidence for the U-value calculation. Internal and external surface resistance should be sourced from CIBSE (2015), *Guide A*.

### Enter external floor U-value [A6] (mandatory)

If the user intends to enter his/her self-calculated U-Value for the external floor construction type, rather than rely on industry standards for the floor construction type, then the user should select "TRUE". On selecting "TRUE" [A9] will no longer be hashed out and the user will be required to enter a U-Value. On selecting "FALSE" [A9] will remain hashed and the user need not make an entry.

### External floor construction type - summary [A7] (mandatory)

The external floor construction type allows the user to select the type of floor construction that is used in the building where it is in contact with the ground. Evidently different construction types and insulation used will impact the floor's thermal conductivity (the extent to which heat will pass through it to the outside). This selection only impacts the calculation of heat/cooling demand in the event that the user does not specify the average U-value for the building's floor that is in contact with the ground ([A9]).

This is a mandatory field, even when a self-calculated U-Value for the external floor is being provided. This is because we reserve the right to compare the U-Value provided to the industry benchmark for the external floor construction type selected.

The list of external floor construction types corresponds to CIBSE (2015), *Guide A*, Tables 3.52 – 3.54.

| External floor construction type - summary |
| --- |
| 1. Ground contact solid concrete floors |
| 2. Ground contact suspended timber floors |
| 3. Outside air contact floors |

## External floor construction type - detailed [A8]

The dropdown list for [A8] is only populated when the user makes a selection for the summary external floor type. The detailed sub-list for each summary external floor construction type with accompanying U-Values can be found in the appendix.

## Average floor fabric efficiency [A9]

The average external floor fabric efficiency or U-value reflects the W/m2K (Watt per meter squared Kelvin) thermal conductance of the building's floors that are in contact with the ground. The U-value provides the combined thermal conductivity of all the separate components of the external floor (e.g. carpet, floorboards, air cavity, concrete etc.) as well as the convection of the internal and external surfaces (where appropriate).

It is not expected that all users will know the average U-value for a given building's floors. For this reason, industry average U-values are stored in the tool. For each building material used in the external floor, the K-value (thermal conductivity) should be sourced from either the original supplier or an equivalent supplier as supporting evidence for the U-value calculation.

## Enter external floor U-value [A10] (mandatory)

If the user intends to enter his/her self-calculated U-Value for the external roof construction type, rather than rely on industry standards for the roof construction type, then the user should select "TRUE". On selecting "TRUE" [A13] will no longer be hashed out and the user will be required to enter a U-Value. On selecting "FALSE" [A13] will remain hashed and the user need not make an entry.

## Roof construction type – summary [A11] (mandatory)

The roof construction type allows the user to select the type of roof construction that is used in the building. Evidently different construction types and insulation used will impact the roof's thermal conductivity (the extent to which heat will pass through it to the outside). This selection only impacts the calculation of heat/cooling demand in the event that the user does not specify the average U-value for the building's roof ([A8]).

This is a mandatory field, even when a self-calculated U-Value for the external roof is being provided. This is because we reserve the right to compare the U-Value provided to the industry benchmark for the external roof construction type selected.

The list of external roof construction types corresponds to CIBSE (2015), *Guide A*, Table 3.49.

| Roof construction type - summary |
| --- |
| 1. Flat concrete roofs |
| 2. Flat timber roofs |
| 3. Pitched roofs (insulated at ceiling level) |
| 4. Pitched roofs (insulated at rafter level) |
| 5. Sheet metal construction |

## External roof construction type - detailed [A12]

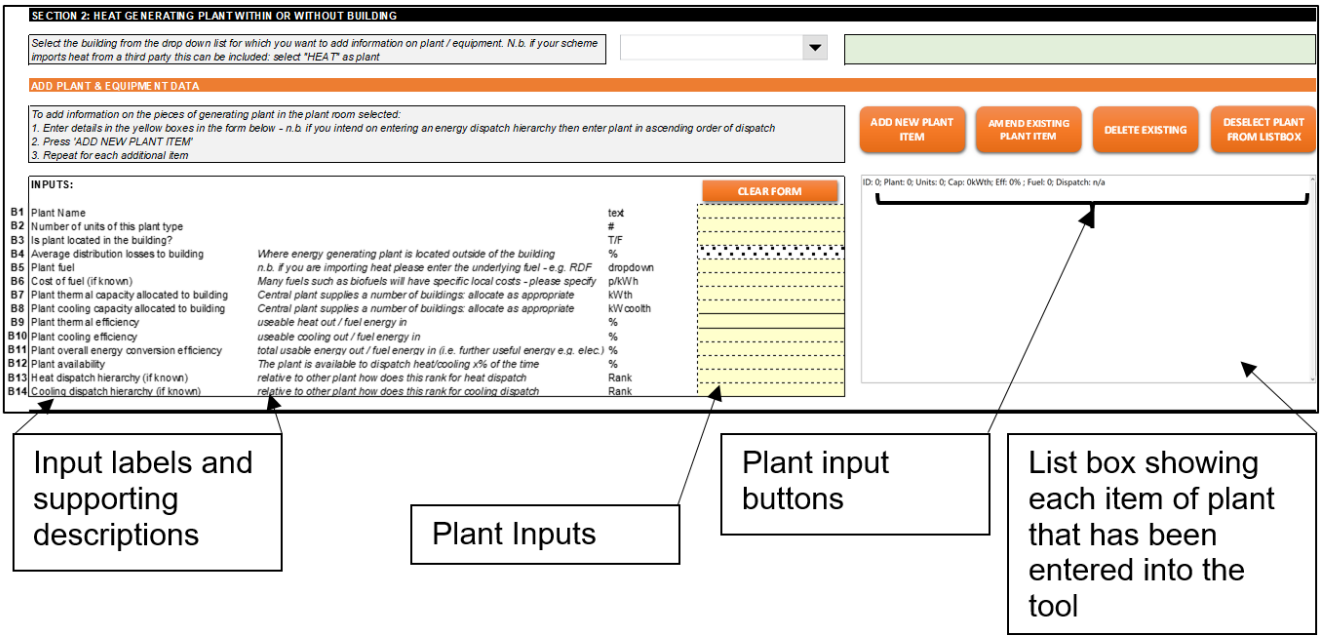
The dropdown list for [A12] is only populated when the user makes a selection for the summary external roof type. The detailed sub-list for each summary external roof construction type with accompanying U-Values can be found in the appendix.

## Average roof fabric efficiency [A13]

The average roof fabric efficiency or U-value reflects the W/m2K (Watt per meter squared Kelvin) thermal conductance of the building's roof. The U-value provides the combined thermal conductivity of all the separate components of the roof (e.g. plaster, wood, loft insulation, loft cavity, tiles, felt etc.) as well as the convection of the internal and external surfaces.

It is not expected that all users will know the average U-value for a given building's roof. For this reason, industry average U-values are stored in the tool. For each building material used in the roof construction, the K-value (thermal conductivity) should be sourced from either the original supplier or an equivalent supplier as supporting evidence for the U-value calculation.

# Heat generating plant within or external to the building




## Plant Inputs

### Overview

The aim of the plant entry section is to build a picture of the mix of energy generating plant for the supply of heat and / or cooling to a given building. Plant items that do not contribute to the generation of heat or cooling should not be entered into the tool. For example, it is not necessary to enter plate heat exchangers, electric pumps, ventilation equipment etc., rather assessment should be made on the impact of such plant on the overall conversion efficiency of the core heat and / or cooling generating plant for a given building.

**It should be noted that as an allocation of the heat and / or cooling capacity (kW) of the plant needs to be made for each building within a network, where heat and / or cooling plant is used to supply energy to multiple buildings. The combined heat and / or cooling capacity of the plant allocated to each building, when added across all buildings, must sum to the actual capacity of that plant**.

### Plant Name [B1] (mandatory)

The plant name should be a short title allowing the user to easily differentiate the plant entered from other plant items relating to the supply of heat and / or cooling to a given building.

### Number of units of this plant type [B2] (mandatory)

Where similar plant items are present in a given energy centre, building basement etc. then the user need not enter them multiple times rather enter here the number of plant items of this type are present.

### Is the plant located in the building [B3] (mandatory)

Where the plant is located outside of the building (e.g. in an energy centre) there will be distribution losses from the central generation point up to the bulk supply connection to the building. These losses will need to be captured when estimating fuel requirements.

### Average distribution losses to the building [B4] (mandatory if B3 is set to FALSE)

When plant is located outside of the building it is necessary to include the distribution losses that will arise on supplying heat / cooling from the central point to that building. The percentage entered should be a **percentage loss of supply not of demand**. For example, if heat losses across a distribution network are estimated to be 5% this should reflect 5% of the supply into that network not 5% of the demand from that network.

### Plant Fuel [B5] (mandatory)

The user can select the following fuel types for converting to heat and / or cooling:

| Fuel type | Further description where required |
|---|---|
| Biofuel | Primarily this will relate to biomethane sourced from anaerobic digestion. |
| Biomass | This should relate to solid biomass such as woodchips or wood pellets. |
| Coal | |
| Electricity | |
| Gas | |
| LPG | |
| Oil | |
| RDF | Refuse Derived Fuel – where the primary heat source is from an Energy from Waste (EFW) plant. |
| Waste heat | Heat recovered that otherwise would have been lost. This should not include heat recovered from a facility where there is an impact on other energy generation. For example, heat recovered from an EFW will likely have a direct impact on electricity generated by that plant with knock on impacts on the wider electricity grid. |

In the event that the heat network imports heat / cooling from another party the primary fuel for the generation of that heat source should be used.

### Cost of fuel [B6] (mandatory if not a BEIS published commodity type)

For the cost of fuels for Coal, Electricity, Gas and Oil the BEIS published prices are used.[4] For all other fuels the user must enter a p/kWh cost of that fuel. Where there is both a fixed and variable charge associated with the fuel the user should convert the fixed charge into a p/kWh value. This can be done by taking the average annual fuel consumption (kWh) and divide the

[4] *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal, Data Tables 1-19: supporting the toolkit and the guidance* (available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal), tables 4-8.

total annual cost (expressed in pence) by this value. This can then be added to the variable (p/kWh) charge of the fuel type.

If the fuel type consumption is quoted in units other than kWh then the most recent published conversion rates should be used[5].

## Plant thermal capacity allocated to building [B7] (mandatory)

The thermal capacity allocated to the building should reflect the kWth capacity of the plant that is available for the building that has been selected. For example, if a gas boiler of 10,000kWth is peaking plant for heat supply to 10 buildings of equal size then the allocation might be 1,000kWth entered on the basis of 1/10 allocation. Another method may be to add the estimated diversified peak heating demand of each customer within a given building to establish the capacity allocation to that building.

The sum of capacities allocated across different buildings must not exceed the plant's actual heat generating capacity.

Where the plant supplies only cooling the value entered should be 0.

## Plant cooling capacity allocated to building [B8] (mandatory)

The cooling capacity allocated to the building should reflect the kWcoolth capacity of the plant that is available for the building that has been selected. For example, if an electric chiller 10,000kWcoolth is supplying cooling to 10 buildings of equal size then the allocation might be 1,000kWcoolth entered on the basis of 1/10 allocation. Another method may be to add the estimated diversified peak cooling demand of each customer within a given building to establish the capacity allocation to that building.

The sum of capacities allocated across different buildings must not exceed the plant's actual cooling generating capacity.

Where the plant supplies only heating the value entered should be 0.

## Plant thermal efficiency [B9] (mandatory)

The plant's thermal efficiency should reflect the heat capacity (kWth) out divided by the fuel supplied to the plant (kW) to enable that capacity output. For example, if a Combined Heat and Power (CHP) engine has a thermal capacity of 1,000kWth and has a total gas fuel requirement of 2,325kW then the thermal efficiency entered would be 43% (1000/2325).

If no heat is being supplied then enter 0%.

## Plant cooling efficiency [B10] (mandatory)

The plant's cooling efficiency should reflect the cooling capacity (kWcoolth) out divided by the fuel supplied to the plant (kW) to enable that capacity output. For example, if an electric chiller has a cooling capacity of 1,000kWcoolth and has a total electricity input requirement of 222kW then the thermal efficiency entered would be 450% (1000/222).

If no cooling is being supplied then enter 0%.

[5] *Government emission conversion factors for greenhouse gas company reporting* (available at: https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting)

## Plant overall energy conversion efficiency [B11] (mandatory)

The overall energy conversion efficiency reflects the possibility that the plant may be generating useful energy other than heat or cooling. Namely this will be electricity. For example, a CHP may have a thermal efficiency of 43% but an overall conversion efficiency of 82% when taking both heat and electricity into account.

The overall energy conversion efficiency should typically be the same as the sum of the cooling and heating efficiencies, but it should never be less.

## Plant availability [B12] (mandatory)

The plant availability reflects the % of total hours in the year that the plant can operate at its stated capacity. For example, if the plant will only operate over the winter period then the availability entered would be the number of hours in the winter when it may supply heat divided by the total number of hours in the year (8760).

## Heat dispatch hierarchy (if known) [B13]

The heat dispatch hierarchy reflects the relative order of dispatch of heat. For example, if a heat network has a watersource heat pump (WSHP), a small gas CHP engine and a back-up gas boiler the dispatch hierarchy may be that the WSHP will be the primary supply of heat to the extent that it is available, the CHP as the secondary plant and the gas boiler held in reserve (third).

If the dispatch hierarchy is not known then this can be left blank and the tool will determine the dispatch hierarchy (see calculations section).

Values entered must be sequential starting from 1. As such, using the example above, if the user were to first enter the gas boiler it would not be possible to enter 3 as 1 & 2 would not have been entered into the tool at that point. The user would need to store the gas boiler leaving the heat dispatch hierarchy blank. When all other plant items had been added then the gas boiler’s dispatch hierarchy could be updated to 3.

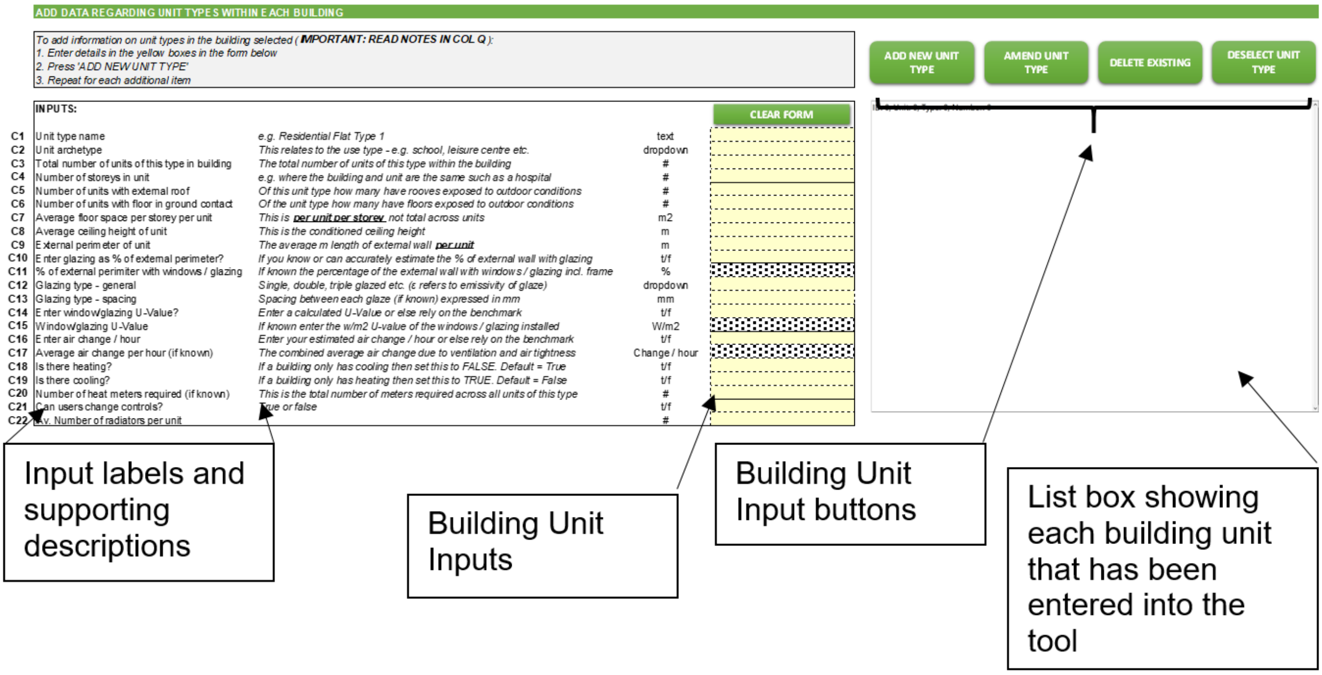
In the event that a plant item is deleted, and the plant item has a dispatch hierarchy lower than the plant item deleted, then the tool will automatically adjust the hierarchy down by 1. Taking the example above, were the CHP engine deleted from the tool the gas boiler’s heat dispatch hierarchy would be adjusted down to 2.

## Cooling dispatch hierarchy (if known) [B14]

This is the same logic as for heat dispatch (see section above) only with regards the dispatch of cooling.

**It should be noted that cooling dispatch and heating dispatch are treated completely separately within the tool.**

# Unit types within each building




## Overview

Each building will require at least one unit type to be entered and to be allocated to the building. All unit types allocated to a building will provide additional information for estimating heat demand and costs for that particular building. If the building only contains one unit, one unit should be entered.

A unit type reflects the different types of heat / cooling customers within a given building. For example, a residential tower block may have two commercial units on the ground floor, 20 Type A flats and 20 Type B flats. In this case four entries might be made into the tool for the building unit types (2 commercial units, Type A flats and Type B flats). Were the commercial units essentially the same then this could be reduced to three entries.

## Building Unit Inputs

### Unit type name [C1] (mandatory)

The unit type name should be a title that is understood by the user to identify the unit or units within a building being appraised. For example, this could be a flat type (e.g. Type 1A) or it could be a commercial unit (e.g. Commercial Unit 1), or any other collection of occupied spaces with similar characteristics. A key objective is to consolidate as many building units into a single entry such that it does not require the user to enter every single connected customer's individual occupied space.

### Unit archetype [C2] (mandatory)

The unit archetype allows the user to select the type of unit within a building that best describes the use of that unit by its occupiers. The archetypes permissible within the tool are a compressed version of the building archetypes that can be found in CIBSE (2008), *TM46: Energy benchmarks* and are as follows:

| Unit occupant archetype | Occupancy classification | Air Change per hour[6] | Glazing to wall ratio[7] |
|---|---|---|---|
| Cold store | Industrial | 0.3 | 5% |
| Cultural activities | Commercial | 0.45 | 10% |
| Dry sports | Commercial | 0.45 | 10% |
| Emergency serv | Commercial | 0.45 | 30% |
| General retail | Commercial | 0.55 | 60% |
| Hospital | Commercial | 0.45 | 30% |
| Hotel | Commercial | 0.60 | 50% |
| Large food store | Commercial | 0.30 | 10% |
| Office (naturally ventilated 100–3000 m2) | Commercial | 0.55 | 60% |
| Office (naturally ventilated 500–4000 m2) | Commercial | 0.55 | 60% |
| Office (air conditioned 2000–8000 m2) | Commercial | 0.60 | 60% |
| Office (air-conditioned HQ type) | Commercial | 0.65 | 70% |
| Public building / light usage | Commercial | 0.60 | 30% |
| Residential: <=1995 | Residential | 1.60 | 30% |
| Residential: 1995-2000 | Residential | 0.80 | 30% |
| Residential: 2000-2005 | Residential | 0.55 | 30% |

[6] CIBSE (2015), *Guide A*, Tables 4.16 to 4.24
[7] There is no published guidance (that we are aware of) that provides an average ratio of glazing to external wall surface area and we have therefore applied our estimate of what the ratio may on average be. However, the user can enter his/her own estimate of the glazing to wall ratio [C11].

| | | | |
|---|---|---|---|
| Residential: 2005-2010 | Residential | 0.40 | 30% |
| Residential: 2010-present | Residential | 0.25 | 30% |
| Schools / seasonal public buildings | Commercial | 0.45 | 30% |
| Swimming pool | Commercial | 0.45 | 10% |
| University | Commercial | 0.45 | 60% |

The selection impacts three key aspects of the tool's estimate of annual demand:

- Degree days associated with that unit's archetype;
- The air change rate per hour of building units within that building archetype when the user has not specified his/her own estimate of average air change rate per hour ([C9]); and
- The glazing to wall ratio if the user has not specified his/her own estimate of the average ratio of glazing to wall fabric ([C11])

### Total number of units of this type in building [C3] (mandatory)

Continuing the example presented in the overview above for the Type A flat the value entered would be 20. This is an important part of the section as it allows the user to avoid having to enter every single unit of a given type.

### Number of storeys in unit [C4] (mandatory)

Some units may be split across several floors. The user should enter the number of floors that a given unit covers.

### Number of units with external roof [C5] (mandatory)

Of the total number of units entered ([C3]) how many of these have external roofs? For example, if the block of flats was a high-rise then perhaps only 4 of the 20 units had external roofs. Alternatively, if the Building Units entered was a low-rise block of flats then perhaps 10 of the Type A flats have external roofs.

This entry is important for the calculation of heat losses through roofs (see calculation section).

### Number of units with floor in ground contact [C6] (mandatory)

Of the total number of units entered ([C3]) how many of these have floors that are in contact with the ground? For example, if the block of flats was a high-rise then perhaps only 2 of the 20 units had contact with the ground. Alternatively, if the Building Units entered was a low-rise block of flats then perhaps 10 of the Type A flats have ground contact.

This entry is important for the calculation of heat losses through floors (see calculation section).

### Average floor space per storey per unit [C7] (mandatory)

This is the average m2 floor space per storey of the building unit type being entered. Continuing the example, if the Type A flat typically had a floor space of 50m2 on a single storey then 50 would be entered. If there were two storeys then the user might enter 25m2 (2 x 25 = 50m2). What would **not** be entered would be 50 x 20 units.

### Average ceiling height of unit [C8] (mandatory)

The average ceiling height is the number of meters that the ceiling is above the floor for the building unit type being entered. For simplicity, the ceiling should be taken as the visible ceiling – i.e. the ceiling of the conditioned internal space. Where suspending ceilings are used it is not necessary to enter the cavity above the suspending ceiling.

### External perimeter of unit [C9] (mandatory)

The external wall length should be the average length, in meters, of wall that is in contact with outside conditions on a per unit. Continuing with the example, if the average Type A flat had total external walls of 8 meter length (the remaining walls being in contact with other flats and common parts) then 8 would be entered here. What would **not** be entered would be 8 x 20 units. If the unit was split over two storeys 8 would still be entered here.

### Enter glazing as % of external perimeter? [C10] (mandatory)

If the user wishes to enter his/her own estimate of the ratio of external glazing to external wall surface area then the user should select “TRUE”. On selecting “TRUE” [C11] will become unhashed. If the user does not wish to enter his/her own estimate the user should select “FALSE”. Please refer to [A2] above for the standing assumptions for glazing to external wall surface area ratios.

### % of external perimeter with windows/glazing [C11]

The ratio can be calculated as the total m2 of glazing (including frames) divided by the total external wall surface area m2 (including glazing and frames).

### Glazing type - general [C12] (mandatory)

The tool uses CIBSE (2015), *Guide A* classifications for glazing types as reflected in Table 3.29. For simplicity sake where the glazing uses a coating to reduce emissivity the tool assumes an emissivity of 0.1.

| Glazing type – general |
|---|
| 1. Double glazed air filled |
| 2. Double-glazed, air filled, low-E |
| 3. Double-glazed, argon filled |
| 4. Double-glazed, argon filled, low-E |
| 5. Triple-glazed, air filled |
| 6. Triple-glazed, air filled, low-E |

| |
|---|
| 7. Triple-glazed, argon filled |
| 8. Triple-glazed, argon filled, low-E |
| 9. Single glazed |
| 10. Window with secondary glazing |

### Glazing type - spacing [C13] (mandatory)

The detailed selection allows the user to specify the spacing between each panel within the window: 6, 12 and 16mm. If the user does not know they can select “Don’t know”.

Where the user has calculated his/her own estimate of the U-Value of the glazing used in the building this can be entered manually [C15].

### Enter window/glazing U-Value? [C14] (mandatory)

If the user intends to enter his/her self-calculated U-Value for the glazing type, rather than rely on industry standards for the glazing construction type, then the user should select “TRUE”. On selecting “TRUE” [A15] will no longer be hashed out and the user will be required to enter a U-Value. On selecting “FALSE” [A15] will remain hashed and the user need not make an entry.

### Window/glazing U-Value [C15]

The average window glazing efficiency or U-value reflects the W/m2K (Watt per meter squared Kelvin) thermal conductance of the building’s glazing (including frames). The U-value provides the combined thermal conductivity of all the separate components of the window (e.g. each panel, the spacing between – argon filled, air filled etc.) as well as the convection of the internal and external surfaces.

It is not expected that all users will know the average U-value for a given building’s glazing. For this reason, industry average U-values are stored in the tool. For each building material used in the glazing’s construction, the K-value (thermal conductivity) should be sourced from either the original supplier or an equivalent supplier as supporting evidence for the U-value calculation.

### Enter air change / hour? [C16] (mandatory)

If the user intends to enter his/her self-calculated air change per hour for the unit type, rather than rely on industry standards for the unit archetype selected, then the user should select “TRUE”. On selecting “TRUE” [C17] will no longer be hashed out and the user will be required to enter an air change per hour assumption. On selecting “FALSE” [C17] will remain hashed and the user need not make an entry.

### Average air change per hour [C17]

This is not a mandatory field and may be something that the user does not know. If the user is unaware of the average air change per hour arising due to the combination of mechanical ventilation and air infiltration, the tool will use an appropriate assumption based on industry standards for the unit archetype selected ([C2]).

If the air change per hour is known then this should be entered as a positive value. Where the user enters his/her own air change per hour value then the calculations and evidence to support this assumption should be retained with the completed tool in the event that this is queried by the regulator.

### Is there heating? [C18] (mandatory)

It is likely that this will always be set to TRUE; however, there may be instances where only cooling is provided say to certain types of commercial or industrial units. In such cases this would be set to FALSE.

For calculation purpose this entry relates to whether the unit type is supplied heat.

### Is there cooling? [C19] (mandatory)

It is likely that this will be set to FALSE as there are few district or communal cooling networks.

For calculation purpose this entry relates to whether the unit type is supplied cooling.

### Number of heat meters required (if known) [C20]

The tool’s presumption is that there is a 1-to-1 relationship between the number of heat meters required and the units in a building to calculate the total meters required for the building. If the ratio is other than this (e.g. due to internal pipework configurations for some but not all of the building units) then the user can enter the number of meters estimated. Where the ratio is other than 1-to-1 the user should retain supporting evidence of how this estimate was made.

### Can users change controls? [C21] (mandatory)

This relates to the presence of temperature controls and thermostatic radiator valves (TRV) that can be operated by the occupiers of building units. If they are not present then this should be set to FALSE.

Evidently if users are unable to change the way they heat internal spaces then the presumption of energy savings on installation of heat meters or heat cost allocators would be undermined. For this reason for schemes that would require temperature controls (with heat meters) or TRVs (with HCAs) to be installed this cost needs to be included in the cost/benefit analysis.

### Av. Number of radiators per unit [C22] (mandatory)

This represents the average number of radiators within the unit type being entered. To continue the example: if the average number of radiators in the Type A flat is 5 then 5 would be entered here. What would **not** be entered would be 5 x 20 units.

# Tool Outputs

## Integrity Check

The tool provides the user with some integrity checks to better ensure that the data entered by the user is internally consistent and complete. At the top of the user input sheet cell F3 shows whether all integrity checks have been met:

| | | |
|---|---|---|
| **HEAT METER VIABILITY ASSESSMENT TOOL** | | |
| **USER INPUT FORM** | | |
| **Tool integrity checks:** | *If errors are present please refer to "OUTP; Integrity"* | OK |

If they have not been met when the user believes that all necessary entries have been made, then the user should refer to the separate integrity tab within the tool:

| Integrity Checks | | | | n/a | | n/a | |
|---|---|---|---|---|---|---|---|
| # | Description | Check | Decision | Heating Demand | Max Heat Supply | Cooling Demand | Max Cooling Supply |
| | | | | kWh | kWh | kWh | kWh |
| 1 | Has a network name been provided? | OK | | | | | |
| 2 | Has the location of the network been selected? | OK | | | | | |
| 3 | Has at least one building been entered? | OK | | | | | |
| 4 | Has at least one plant item been entered? | OK | | | | | |
| 5 | Has at least one unit been entered? | OK | | | | | |
| 6 | Has heating been selected? | | TRUE | | | | |
| 7 | Is the heat generating capacity sufficient to meet all demand with availability assumptions? | OK | | - | - | | |
| 8 | Has cooling been selected? | | FALSE | | | | |
| 9 | Is the cooling generating capacity sufficient to meet all demand with availability assumptions? | OK | | | | - | - |
| 10 | Has at least one energy type been entered in the tool? | OK | | | | | |
| | **Total tool integrity checks:** | OK | | | | | |

### Has a network name been provided?

This refers to entry [1] in the user inputs. A network name must be provided in the tool.

### Has the location of the network been selected?

This refers to entry [2] in the user inputs. A network location must be provided in the tool.

### Has at least one building been entered?

At least one building must be entered into the tool for appraisal purposes. If this fails then the user has not entered a building into the tool. This could arise where the user completes the entry cells but does not press the “Add New Building” macro button (see “Add New Building”).

### Has at least one plant item been entered?

At least one energy generating plant item must be entered into the tool for appraisal purposes. If this fails then the user has not entered a single plant item into the tool. This could arise where the user completes the entry cells in the plant section but does not press the “Add New Plant” macro button (see “Add New Plant”).

### Has at least one unit been entered?

At least one building unit must be entered into the tool for appraisal purposes at building level. If this fails then the user has not entered a single building unit into the tool. This could arise where the user completes the entry cells in the building unit section but does not press the “Add New Unit Type” macro button.

### Has heating been selected?

If the user has selected that heating is supplied to at least one building unit type ([C10]) then:

### Is the heat generating capacity sufficient to meet all demand with availability assumptions?

This checks whether total heating demand for a given building is met by total heat supply. If it does not then cell G3 (on image above: “n/a” above heating demand) will provide the building name entered by the user of the building where the heat supplied by the plant entered is not sufficient to meet the demand estimated by the tool. In the columns below the building name the tool provides the total heating demand estimated across all the units within the building (integrity check #7, G12) and the maximum annual heating supply that the plant entered by the user could supply (integrity check #7, H12). Fundamentally this is the plant’s thermal capacity allocated to the building ([B7]) multiplied by the plant’s availability ([B12]) multiplied by the number of hours in the year (8760). If this is less than the demand then it either suggests that there has been an error in the spatial values of the building units entered or else that the plant values have been incorrectly entered (e.g. MWth instead of the required kWth plant capacity).

### Has cooling been selected?

If the user has selected that cooling is supplied to at least one building unit type ([C18]) then:

### Is the cooling generating capacity sufficient to meet all demand with availability assumptions?

This checks whether total cooling demand for a given building is met by total heat supply. If it does not then cell J3 (on image above: “n/a” above cooling demand) will provide the building name entered by the user of the building where the cooling supplied by the plant entered is not sufficient to meet the demand estimated by the tool. In the columns below the building name the tool provides the total cooling demand estimated across all the units within the building (integrity check #9, J14) and the maximum annual cooling supply that the plant entered by the user could supply (integrity check #9, K14). Fundamentally this is the plant’s cooling capacity allocated to the building ([B8]) multiplied by the plant’s availability ([B12]) multiplied by the number of hours in the year (8760). If this is less than demand then it either suggests that there has been an error in the spatial values of the building units entered or else that the plant values have been incorrectly entered (e.g. MWcoolth instead of the required kWcoolth plant capacity).

### Has at least one energy type been entered in the tool?

The tool must have at least either heating or cooling assessed in at least one building unit.

## Appraisal

Having entered all of the network’s buildings, heat/cooling generating plant and building unit types for each building and confirmed that all integrity checks have been met, the Appraisal tab provides the user with the assessment of whether a) heat meters should be installed; and failing that whether b) heat cost allocators should be installed.

All information (input at building, plant, and unit level) is aggregated at building level. The appraisal is on a building by building basis, not a whole network basis. For each building entered into the tool a corresponding line entry is provided:

| Newtork 1 | Meter Assessment | | Heat Cost Allocator | |
|---|---|---|---|---|
| | £ NPV / (£NPC) | Meters required? | £ NPV / (£NPC) | HCA required? |
| Building 1 | (22,867) | FALSE | 3,128 | TRUE |

The tool first assesses whether a net present benefit arises on installing heat meters over a 10-year assessment period.

A value in brackets represents a negative value for the NPV calculation. In the example above, this means that it is not assessed to be cost-effective to install meters in Building 1 (also reflected by the red cell showing "FALSE"). However, the above example indicates, under the Regulations, the installation of heat cost allocators would be required in Building 1 (also reflected by the green cell showing "TRUE").

Accompanying each building some key outputs from the calculations are provided to allow the user to assess whether the values calculated are within the user's expectations:

| Newtork 1 | Meter Assessment | | Heat Cost Allocator | | Total Heat demand | Total Cooling demand | Total Fuel consumed | Heat Meters | Data Monitoring | HCAs | Water Meters |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | £ NPV / (£NPC) | Meters required? | £ NPV / (£NPC) | HCA required? | kWh/Y | kWh/Y | kWh/Y | # | # | # | # |
| Building 1 | (22,867) | FALSE | 3,128 | TRUE | 118,800 | - | 40,340 | - | - | 100 | 1 |

In the event that the heat/cooling demand and fuel consumption is at odds with expectations this may be a cause to return to the values entered for the network and the building.

# Core Calculations

## Underlying principles

### Establishing demand

The tool is intended to provide a sufficient level of detail such that reasonable estimates for heat demand, relating to the provision of space heating, and the associated cost of metering can be made without placing too great a burden on the user of the tool.

The user is able to add buildings and unit types within each building such that an accurate representation of the buildings and the units within them can be captured. From this information heat demand estimates are established using the principles of:

- Fabric losses through external walls, roofs, glazing and floors in contact with the ground; and
- Ventilation / air infiltration air change rate per hour.

Heat / cooling demand is then established based on the heat/cooling degree days for the unit archetype in the UK region where the heat network is located. Where users do not specify their own estimates for fabric efficiencies and air change rates the tool uses averages of published CIBSE[8] values by fabric type and unit archetype.

It should be noted that the tool does make simplifications with regards to common parts and thermal bridges in that it discounts these from the calculation. This is a simplification in the favour of the operator in that unheated common parts and thermal bridges would be expected to increase overall heating and cooling demand.

Other factors that will influence heating demand, such as solar irradiance through windows, thermal bridges and domestic hot water supply are not included. This is because the tool is intended to find a balance between simplicity whilst still being able to approximate a network tailored estimate for heat/cooling demand.

### Cost assumptions

The actual cost of installing heat meters or heat cost allocators (HCA) will vary depending on specific building characteristics. For this reason a range of buildings with technical impediments to installing heat meters or HCAs (proposed ‘Exempt’ class) do to not have to undertake the cost-effectiveness assessment.

For all other buildings with heat supplied by either a communal heat network or a district heat network the costs for installing, maintaining and monitoring heat meters and heat cost allocators and data gathering equipment are assumed as follows:

| Heat Meter Cost Items | Units | Domestic | Non-Domestic |
|---|---|---|---|
| **Meter cost and installation** | £/meter | £372 | £1,457 |

[8] CIBSE (2015), *Guide A*

| | | | |
|---|---|---|---|
| **Annual meter operational costs (includes meter reading, data processing, billing)** | £/meter/year | £81 | £81 |
| **Cost of data gathering equipment**[9] | £/building units | £160 | £160 |

| Heat Cost Allocator Cost Items | Unit | Domestic | Non-Domestic |
|---|---|---|---|
| **Heat Cost Allocator cost and installation** | £/HCA | £46 | £46 |
| **Hot water meter cost and installation** | £/building unit | £155 | £155 |
| **Annual HCA operational costs (includes meter reading, data processing, billing)** | £/building unit/year | £81 | £81 |
| **Cost of data gathering equipment**[10] | £/units | £160 | £160 |

| User Controls | Unit | Domestic | Non-Domestic |
|---|---|---|---|
| **Temperature control devices cost and installation** | £/unit | £50 | £50 |
| **Thermostatic radiator valves cost and installation** | £/radiator | £50 | £50 |

# Detailed Energy Calculations

## Energy Demand

### Fabric heat loss coefficient

The fabric heat loss coefficient reflects the total thermal conductance of all the external walls, ceilings, glazing and floors of the building and unit types entered by the user into the tool. In order to establish the total thermal conductance it is necessary to establish the area of external wall (fabric & glazing), floor or ceiling (m2) and the U-value (thermal transmittance) of the wall,

9 Reflects the combined costs of data gathering system supply and installation proposed in the consultation (table 4).
10 As above.

glazing, ceiling or floor construction type. Simply put it estimates how much energy will be transferred at a given point in time between the internal and external environment.

For a given building, entered into the tool, the fabric heat loss coefficient (W/K) is determined by adding the external wall, glazing, roof and floor fabric heat loss coefficients (see sections above).

### External wall fabric heat loss coefficient

The tool establishes the total external wall area (m2) by taking the external wall perimeter length by building unit type [C9] multiplied by the average ceiling height [C8] multiplied by the number of units of that type within the building [C3] multiplied by the number of storeys in a given unit [C4]. The glazing area is established by multiplying the total surface area by either the user specified % [C11] or the tool's stored value for the unit archetype. The difference between the total surface area and the glazing is the fabric surface area.

If the user has provided his/her own fabric efficiency assumption (W/m2 K) [A5] then this is used in the calculation. If no value has been provided or if the value provided is 0 then the fabric efficiency is sourced from CIBSE (2015), *Guide A* average fabric efficiency for the external wall construction type selected by the user [A3, A4] (for values see appendix). This logic also applies to the glazing U-Value [C14, C15].

The external wall fabric heat loss coefficient (W/K) is calculated by multiplying the external wall fabric area by the fabric efficiency value plus the glazing area multiplied by the glazing U-Value.

### Roof fabric heat loss coefficient

The roof area (m2) is determined by the average floor space for the building unit type [C7] multiplied by the number of units of that building type that have an external roof [C5] – i.e. excluding building units that have ceilings in direct contact with the floor of the building unit above where the tool assumes the same temperature and hence no thermal transfer.

The determination of the roof fabric efficiency is the same as with the external wall with the exception that in the absence of a value provided by the user [A13] the tool looks up the CIBSE (2015), *Part A* average fabric efficiency for the roof construction type selected by the user [A11, A12] (for values see appendix).

The roof fabric heat loss coefficient (W/K) is calculated by multiplying the roof area by the fabric efficiency value.

### Floor fabric heat loss coefficient

The floor area (m2) is determined by the average floor space for the building unit type [C7] multiplied by the number of units of that building type that are in contact with the ground [C6] – i.e. excluding building units that have floors in direct contact with the ceiling of the building unit below where the tool assumes the same temperature and hence no thermal transfer.

The determination of the floor fabric efficiency, before ground contact adjustments, is the same as with the external wall with the exception that in the absence of a value provided by the user [A9] the tool looks up the CIBSE (2015) *Part A* average fabric efficiency for the floor construction type selected by the user [A8] (for values see appendix).

If the floor type is in direct contact with the ground, as opposed to being suspended and in contact with the air, then the calculation for thermal conductivity is not linear through the floor fabric. CIBSE (2015), *Guide A* sections 3.20 to 3.23 set out the methodology for estimating the ground contact adjusted W/m2 K conductivity of the floor. These calculations are applied to establish:

- The characteristic dimension of the floor (B'); and
- The equivalent thickness of the floor (d*ef*);

The floor fabric heat loss coefficient (W/K) is calculated by multiplying the floor area by the ground adjusted (if applicable) U-Value of the floor.

## Ventilation / infiltration heat loss coefficient

The ventilation / infiltration heat loss coefficient reflects the energy required to heat the air that circulates within a given building unit. Essentially the more frequently the external air replaces the internal air, the greater amount of energy is required to elevate the external air temperature to the desired internal air temperature. Air change occurs primarily due to two reasons:

- Mechanical ventilation takes internal air and exchanges it with external air. This is important for avoiding internal condensation among other things;
- Air tightness – cracks under doors, windows etc. as well as the pores within building fabric mean that air will circulate in the absence of mechanical ventilation.

In order to calculate the ventilation / infiltration heat loss coefficient it necessary to know the internal volume of the building unit (m3), the number of times that the air changes per hour (change / hour) and the energy required to raise one cubic meter of air by one degree kelvin which is an empirically established value of 0.33 Wh/m3K.

The internal volume of a given building unit type entered into the tool is established by multiplying the total number of building units of that type in the building [C3] by the average floor space per unit [C7] by the average building unit ceiling height [C8].

The ventilation / infiltration heat loss coefficient (W/K) is calculated by multiplying the internal volume by 0.33 (the volume-based heat capacity of air) by the number of air changes per hour.

## Heat / Cooling Demand at the building unit level

The user will have selected the geographical location in section 1 of the input sheet [1] as well as the unit archetype [C2]. For each archetype and geographical location heating and cooling degree day values are stored in the tool.

The degree day values have been established as follows:

- Met Office hourly average temperatures for each UK region were obtained for the period 01/01/2014 – 31/12/2018;
- For each unit archetype an assumption was made for the hourly heating and cooling regimes over weekdays and weekends, in line with CIBSE guidance[11];
- A heating event is assessed to occur in the event that the hourly temperature in a given region was below the base temperature for that building (typically assumed to be 15.5 Degrees Celsius) **and** the hour in which the event occurred was set as part of the

[11] CIBSE (2008), *TM46: Energy Benchmarks*

heating regime. The heating degree days for that hour would be calculated to be the difference between the base temperature and the outdoor temperature divided by 24.

- A cooling event is assessed to occur in the event that the hourly temperature in a given region was above the base temperature **and** the hour in which the event occurred was set as part of the cooling regime. The cooling degree days for that hour would be calculated to be the difference between the outdoor temperature and the base temperature for cooling.

Degree days are an important part of the heat / cooling demand calculation as they represent the temperature differential (Delta-T) that needs to be overcome in order to keep the dwelling at the target internal temperature.

Heat/cooling demand (kWh) is calculated by multiplying the sum of the fabric and ventilation / air infiltration heat loss coefficients by the heating/cooling degrees days[12]. If the user has selected that heat [C18] or cooling [C19] is **not** supplied to that building unit (e.g. there is no air conditioning) then no demand for that building unit will be calculated.

### Heat / Cooling Demand at the building level

The tool aggregates all the calculated heat and cooling demand by building such that a total heat and cooling demand by building is established and presented in annual kWh values.

# Energy Supply Calculations

## Overview

A core part of the cost/benefit analysis is the cost of fuel that is assumed to be saved by heat/cooling customers. In order to establish this it is necessary to first understand the heating/cooling demand of each building supplied by the heat network. Having established this (see section above) it is then necessary to estimate the fuel required to supply that heat/cooling to customers.

In order to do this the tool gathers information on the heat/cooling plant that is available to the network. A key challenge for establishing fuel consumption is that more complex schemes will have a variety of plant capable of delivering heat or cooling. For example, a district heat network may have a water-source heat pump that operates throughout the year. In peak winter periods further plant, such as gas boilers, may be used to top up the heat requirement. The heat pump may be an electric heat pump meaning that for much of the heat supplied a reduction in heat would mean that electricity consumption is reduced. However, for some of the supply when the gas boilers are being operated, a heat reduction would result in lower gas costs also.

The tool attempts to address the hierarchy of heat / cooling dispatch as follows:

- The user can enter the dispatch ranking of the heat / cooling plant entered into the tool for a given building; or

[12] As the heat loss coefficient is expressed in W/K it is necessary to divide by 1000 in order to express the demand in kWh values.

- If the user is unsure then the tool will establish a dispatch hierarchy on the basis that the plant is operated with lowest carbon impact in mind.

## Energy dispatch hierarchy not provided by user

If the user does not provide a relative ranking for heat / cooling dispatch then the tool will rank any unranked plant on the basis of carbon equivalent emissions. It does this as follows:

- Some plant will also produce electricity. As such when the plant is used to provide heat and potentially cooling there is a potential benefit of displacing other forms of electricity generation. As the carbon content of electricity on the national grid reduces this benefit diminishes. The electricity generating efficiency of the plant is established by taking the total plant efficiency entered by the user [B11] less the heat [B9] and cooling [B10] generating efficiencies entered by the user. The plant's capacity (kWe) to displace electricity is established from this and the carbon offsetting potential of the plant is calculated by multiplying the electricity generating capacity with the long run marginal average commercial / public sector kgCO2e of electricity consumption;

- The fuel type for the plant is selected by the user [B5]. The carbon content (kgCO2e/kWh) of the fuel type selected is stored within the tool and is sourced from published guidance[13]. This is adjusted to reflect the thermal or cooling conversion efficiency of the plant;

- Any emissions relating to displaced electricity are subtracted from the fuel consumption emissions;

- The emissions are then ranked from lowest emissions to highest. Where there are **duplicates** then the ranking follows the user's input sequence with plant entered first being ranked higher than those entered last;

- Having calculated separate dispatch hierarchies for heat and cooling supply the user's dispatch hierarchies for heat [B13] and cooling [B14] are overlaid such that the tool's determined hierarchies come after the dispatch hierarchy entered by the user.

  For example, if the user entered a CHP engine as primary dispatch and separately entered a water-source heat pump and 2 gas boilers with no dispatch assumptions; the tool would rank the water-source heat pump (WSHP) as first and the gas boilers as second for heat dispatch. It would then set the CHP as the first heat dispatch, the WSHP as second and the gas boilers as third.

## Heat / cooling supply

Having determined the plant dispatch hierarchy for both heating and cooling for a given building, the tool then determines the heat supplied by different plant types entered up to the point that the heat / cooling demand calculated has been met. Where plant is not located in the building, distribution losses are calculated based on the user's input [B4], and the heat supply value is amended to reflect both the distribution losses plus the demand.

[13] HMT *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal* (available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal)

The plant's availability [B12] is an important part of the calculation as while a plant item may have the capacity to deliver heat or cooling it may not be available to do so. For example, some plant may only be operated in winter/summer periods. The calculation of heat supply by plant type is therefore the plant's capacity multiplied by its availability (hours in the year) limited by the amount of heat / cooling demand not already allocated a supply by the tool.

### Fuel consumption

Having determined the heat / cooling supply by each plant type entered by the user, the tool calculates the fuel consumption by dividing the annual heat / cooling supply (kWh) by the plant's conversion efficiency. Where plant or a plant configuration supplies both heat and cooling, the tool allocates the fuel consumption to heat and cooling generation in proportion to the relative efficiency of heat and cooling conversion efficiencies entered by the user.

### Fuel Cost

For heating oil, gas, coal and electricity fuel types, BEIS publishes their typical retail prices. On the basis that communal and district schemes should be able to source energy prices at rates lower than individual domestic customers the published "Commercial/ Public sector" central retail price for gas, electricity, coal and oil[14] are stored in the tool. For all other fuel types the price will vary substantially. As such the user is required to enter the price they pay for their fuel on a p/kWh basis [B6].

The p/kWh cost of fuel is then multiplied by the fuel consumption (kWh) value determined by plant item to give the cost of fuel. For gas, electricity, coal and oil the cost over the appraisal period is escalated in line with the real price inflation assumptions for those commodities within the published forward curves. For all other fuel types the user's input value is held constant over the 10-year period.

## Cost / Benefit Analysis

### Overview

The cost / benefit analysis (CBA) assesses whether the benefit of the fuel estimated to be saved by the heat / cooling customer when a heat meter or heat cost allocators are installed does or does not outweigh the cost of their installation, maintenance and monitoring over the assessment period.

### Methodology

The CBA is calculated on a building by building basis.  The assessment for heat meters can be summarised as follows:

| Cash Flow | Unit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Energy Saved** | £ | + | + | + | + | + | + | + | + | + | + |

[14] Fuel oil is published on a p/litre basis. As such this is converted to p/kWh value for the tool using the published *Greenhouse gas reporting: conversion factors 2019* (available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Meter installation** | £ | - | | | | | | | | | |
| **Data gathering equipment** | £ | - | | | | | | | | | |
| **Meter operational costs** | £ | - | - | - | - | - | - | - | - | - | - |
| **Installation of user controls** | £ | - | | | | | | | | | |
| **Net Cash Flow** | £ | - | + | + | + | + | + | + | + | + | + |

The net cash flow is discounted using a discount rate of 3.5% to establish the net present value (NPV) of the cash flows attributable to a given building entered into the tool.

If the NPV of the cash flows is positive for a given building then the tool would determine that that building would, under the regulations be required to retrospectively install heat meters. If the NPV is less than or equal to zero then a CBA assessment is made for the installation of heat cost allocators (HCA). The cash flows assessed for HCAs is as follows:

| Cash Flow | Unit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Energy Saved** | £ | + | + | + | + | + | + | + | + | + | + |
| **HCA installation** | £ | - | | | | | | | | | |
| **Hot Water meter** | £ | - | | | | | | | | | |
| **Data gathering equipment** | £ | - | | | | | | | | | |
| **HCA operational costs** | £ | - | - | - | - | - | - | - | - | - | - |
| **Installation of user controls** | £ | - | | | | | | | | | |
| **Net Cash Flow** | £ | - | + | + | + | + | + | + | + | + | + |

If the NPV of the cash flows is positive for a given building then the tool would determine that that building would, under the regulations be required to retrospectively install heat cost allocators and hot water meters.

## Energy Saved

Energy saved on installation of a heat meter or HCA is assumed to be 20% for domestic customers and 10% for non-domestic customers. However, it is acknowledged that the transition would not be instantaneous. For this reason, in the first year it is assumed that only 50% of fuel cost savings would be made. For all other periods of the 10-year assessment it is assumed that the savings are made on the fuel costs calculated (see fuel cost section above).

## Meter installation

The number of meters required for a given building are assumed to be a 1:1 ratio with the number of building units within a given building. To determine the total number of domestic and non-domestic meters the number of building units [C3] entered by the user are sorted by domestic or non-domestic (retail / industrial) units in line with the user selection [C2]. However, if the user has entered the number of meters required [C20] then this value would be used. It may be necessary that more than one meter is required per building unit – this is the means for allowing the user to reflect some of the additional costs such a configuration would entail.

The cost for domestic meters (see cost assumption section above) is multiplied by the number of domestic meters required for the building. The same approach is taken for non-domestic meters.

## Data gathering equipment

This is the annual cost per building unit of gathering data for invoicing purposes from either heat meters or HCAs. It includes the supply and installation of the equipment. The total cost is the number of units per building multiplied by the cost of data gathering equipment per unit.

## Operational costs for meters and HCAs

The annual operational cost is per meter or per building unit, in the case of HCAs, and includes meter reading, data processing and billing information. The total cost is the number of units per building multiplied by the annual cost, unless a different number of meters has been provided for the building.

## Installation of user controls

For any building unit type that the user has selected that the occupant is unable to control their heat demand (e.g. in the absence of controls or thermostatic valves on radiators) [C21], the number of controls required to be installed for that building unit is:

- one per unit for heat meters or
- the number of radiators in each unit of that type [C22] where HCA are installed.

The cost of controls is the number of controls multiplied by the cost of controls (£/control) – see cost assumptions section.

## HCA Installation

The number of HCAs required per dwelling is assessed to be the number of radiators [C22] within the dwelling.

The cost of HCAs is the cost per HCA multiplied by the number of HCAs required.

## Hot water meter installation

In order to allow metering with HCAs it is necessary to also install a hot water meter. The number of hot water meters required is equivalent to the number of building units within the building.

The cost of water meter installation is the number water meters required multiplied by the cost of each meter (domestic and non-domestic).

# Appendix 1: CIBSE values and averages

The specific U-values for construction or glazing types in the tables below have either been taken from or are averages based on values in the publication CIBSE (2015): *Guide A: Environmental design* (London: The Chartered Institution of Building Services Engineers). The respective CIBSE source tables are referenced in each section.

The U-Values in the tables below for the "Don't know" option indicate that they represent averages of the specific CIBSE values provided.

## External Walls

The U-values for external wall construction types have been taken from CIBSE (2015) *Guide A*, Table 3.48 (Thermal properties of typical wall constructions).

### 1. Stone Walls

| Wall construction type | U-Value (W/m2 K) | Wall thickness (m) |
|---|---|---|
| Don't Know | 1.05 (average of below) | 0.68 (average of below) |
| (a) 600 mm stone, 50 mm airspace, 25 mm dense plaster on laths | 1.38 | 0.68 |
| (b) 600 mm stone, 50 mm airspace/timber battens, 25 mm EPS insulation, 12.5 mm plasterboard | 0.72 | 0.69 |

### 2. No fines concrete walls

| Wall construction type | U-Value (W/m2 K) | Wall thickness (m) |
|---|---|---|
| Don't Know | 0.94 (average of below) | 0.32 (average of below) |
| (a) 19 mm render, 220 mm no fines concrete, 50 mm airspace/ timber battens, 12.5 mm plasterboard | 1.63 | 0.3 |
| (b) 19 mm render, 220 mm no fines concrete, 50 mm mineral fibre insulation between battens, 12.5 mm plasterboard | 0.67 | 0.3 |
| (c) 19 mm render, 50 mm mineral wool insulation between | 0.52 | 0.35 |

| | | |
|---|---|---|
| battens, 220 mm no fines concrete, 50 mm airspace/battens, 12.5 mm | | |

## 3. Solid brick walls

| Wall construction type | U-Value (W/m2 K) | Wall thickness (m) |
|---|---|---|
| Don't Know | 1.17 (average of below) | 0.28 (average of below) |
| (a) 220 mm solid brick, 13 mm dense plaster | 2.09 | 0.23 |
| (b) 220 mm solid brick, 50 mm airspace/battens, 12.5 mm plasterboard | 1.41 | 0.28 |
| (c) 220 mm solid brick, 50 mm mineral wool insulation between battens, 12.5 mm plasterboard | 0.63 | 0.28 |
| (d) 19 mm render, 50 mm EPS insulation, 220 mm solid brick, 13 mm dense plaster | 0.54 | 0.3 |

## 4. Dense concrete walls

| Wall construction type | U-Value (W/m2 K) | Wall thickness (m) |
|---|---|---|
| Don't know | 1.6 (average of below) | 0.26 (average of below) |
| (a) 19 mm render, 200 mm dense concrete block, 13 mm dense plaster | 3.02 | 0.23 |
| (b) 19 mm render, 200 mm dense concrete block, 50 mm airspace/battens, 12.5 mm plasterboard | 1.78 | 0.28 |
| (c) 19 mm render, 200 mm dense concrete block, 25 mm polyurethane insulation between battens, 12.5 mm plasterboard | 0.9 | 0.26 |
| (d) 19 mm render, 50 mm mineral wool between battens, 200 | 0.7 | 0.28 |

| | | |
|---|---|---|
| mm dense concrete block, 13 mm dense plaster | | |

## 5. Precast concrete panel walls

| Wall construction type | U-Value (W/m2 K) | Wall thickness (m) |
|---|---|---|
| Don't know | 0.78 (average of below) | 0.25 (average of below) |
| (a) 80 mm dense concrete, 25 mm EPS insulation, 100 mm dense concrete, 13 mm dense plaster | 1.07 | 0.22 |
| (b) 80 mm dense concrete, 25 mm EPS insulation, 100 mm dense concrete, 50 mm airspace/battens, 12.5 mm plasterboard | 0.85 | 0.27 |
| (c) 80 mm dense concrete, 50 mm EPS insulation, 100 mm dense concrete, 12.5 mm plasterboard | 0.56 | 0.24 |
| (d) 19 mm render, 80 mm dense concrete, 50 mm EPS insulation, 100 mm dense concrete, 13 mm dense plaster | 0.63 | 0.26 |

## 6. Brick/brick cavity walls

| Wall construction type | U-Value (W/m2 K) | Wall thickness (m) |
|---|---|---|
| Don't know | 0.93 (average of below) | 0.28 (average of below) |
| (a) 105 mm brick, 50 mm airspace, 105 mm brick, 13 mm dense plaster | 1.44 | 0.27 |
| (b) 105 mm brick, 50 mm airspace, 105 mm brick, 13 mm lightweight plaster | 1.34 | 0.27 |
| (c) 105 mm brick, 50 mm UF foam insulation, 105 mm brick, 13 mm dense plaster | 0.59 | 0.27 |

| | | |
|---|---|---|
| (d) 105 mm brick, 50 mm blown wool insulation, 105 mm brick, 13 mm dense plaster | 0.59 | 0.27 |
| (e) 105 mm brick, 50 mm cavity, 25 mm EPS insulation, 105 mm brick, 22 mm airspace/battens, 12.5 mm plasterboard | 0.67 | 0.32 |

## 7. Brick/dense concrete block cavity walls

| Wall construction type | U-Value (W/m2 K) | Wall thickness (m) |
|---|---|---|
| Don't know | 0.92 (average of below) | 0.27 (average of below) |
| (a) 105 mm brick, 50 mm airspace, 100 mm dense concrete block, 13 mm dense plaster | 1.77 | 0.27 |
| (b) 105 mm brick, 50 mm UF foam insulation, 100 mm dense concrete block, 13 mm dense plaster | 0.63 | 0.27 |
| (c) 105 mm brick, 50 mm blown fibre insulation, 100 mm dense concrete block, 13 mm dense plaster | 0.63 | 0.27 |
| (d) 105 mm brick, 50 mm EPS insulation, 100 mm dense concrete block, 13 mm dense plaster | 0.64 | 0.27 |

## 8. Brick/lightweight aggregate concrete block cavity walls

| Wall construction type | U-Value (W/m2 K) | Wall thickness (m) |
|---|---|---|
| Don't know | 0.6 (average of below) | 0.28 (average of below) |
| (a) 105 mm brick, 50 mm airspace, 100 mm lightweight aggregate concrete block, 13 mm dense plaster | 1.06 | 0.27 |
| (b) 105 mm brick, 50 mm UF foam insulation, 100 mm lightweight aggregate concrete block, 13 mm dense plaster | 0.52 | 0.27 |

| | | |
|---|---|---|
| (c) 105 mm brick, 50 mm blown fibre insulation, 100 mm lightweight aggregate concrete block, 13 mm dense plaster | 0.52 | 0.27 |
| (d) 105 mm brick, 100 mm blown fibre insulation, 100 mm lightweight aggregate concrete block, 13 mm dense plaster | 0.33 | 0.32 |
| (e) 105 mm brick, 50 mm EPS insulation, 100 mm lightweight aggregate concrete block, 13 mm dense plaster | 0.52 | 0.27 |
| (f) 105 mm brick, 25 mm airspace, 25 mm EPS insulation, 100 mm lightweight aggregate concrete block, 13 mm dense plaster | 0.66 | 0.27 |

## 9. Brick/autoclaved aerated concrete block cavity walls

| Wall construction type | U-Value (W/m2 K) | Wall thickness (m) |
|---|---|---|
| Don't know | 0.3 (average of below) | 0.37 (average of below) |
| (a) 105 mm brick, 50 mm airspace, 100 mm autoclaved aerated concrete block (density 700 kg/m3), 13 mm lightweight plaster | 0.27 | 0.28 |
| (b) 105 mm brick, 50 mm airspace, 150 mm autoclaved aerated concrete block (density 500 kg/m3), 13 mm lightweight plaster | 0.32 | 0.38 |
| (c) 105 mm brick, 25 mm airspace, 25 mm EPS insulation, 150 mm autoclaved aerated concrete block (density 500 kg/m3), 13 mm | 0.32 | 0.47 |

## 10. Timber frame walls

| Wall construction type | U-Value (W/m2 K) | Wall thickness (m) |
|---|---|---|
| Don't know | 0.61 (average of below) | 0.37 (average of below) |

| | | |
|---|---|---|
| (a) 105 mm brick, 50 mm airspace, 19 mm plywood sheathing, 95 mm studding, 12.5 mm plasterboard | 1.14 | 0.28 |
| (b) 105 mm brick, 50 mm airspace, 19 mm plywood sheathing, 95 mm studding, 95 mm mineral wool insulation between studs, 12.5 mm | 0.39 | 0.38 |
| (c) 105 mm brick, 50 mm airspace, 19 mm plywood sheathing, 140 mm studding, 140 mm mineral wool insulation between studs, 12.5 mm | 0.29 | 0.47 |

# External Floors

The values in CIBSE (2015), *Guide A,* Tables 3.52-3.54 have been used for external floor U-values.

## 1. Ground contact solid concrete floors

| Floor type | U-Value (W/m2 K)[15] | Ground contact adjustment requirement[16] |
|---|---|---|
| Don't Know | 1.46 (average of below) | TRUE |
| (a) Vinyl floor covering, 75 mm screed, 150 mm cast concrete | 2.39 | TRUE |
| (b) 10 mm carpet/underlay, 75 mm screed, 150 mm cast concrete | 2.37 | TRUE |
| (c) Vinyl floor covering, 75 mm screed, 50 mm extruded polystyrene insulation, 150 mm cast concrete | 0.54 | TRUE |
| (d) Vinyl floor covering, 19 mm timber or chipboard, 50 mm extruded polystyrene insulation, 150 mm cast concrete | 0.55 | TRUE |

## 2. Ground contact suspended timber floors

| Floor type | U-Value (W/m2 K) | Ground contact adjustment requirement |
|---|---|---|
| Don't Know | 1.75 (average of below) | TRUE |
| (a) Vinyl floor covering, 19 mm timber or chipboard on 100 mm joists, ventilated underfloor cavity | 3.15 | TRUE |
| (b) Vinyl floor covering, 19 mm timber or chipboard on 100 mm joists, 100 mm mineral fibre between joists, ventilated underfloor cavity | 0.37 | TRUE |

[15] The values for ground contact floors were derived from resistance values published in CIBSE (2015), *Guide A,* Table 3.46 combined with surface resistance values provided in the same guide.
[16] Heat losses through floors in direct contact with the ground do not follow standard conduction calculations. Where it assessed the floor type is in direct contact with the ground ("TRUE") then the calculations incorporate CIBSE (2015), *Guide A*, Tables 3.20-3.23

| | | |
|---|---|---|
| (c) 10 mm carpet/underlay, 19 mm timber or chipboard on 100 mm joists, ventilated underfloor cavity | 3.1 | TRUE |
| (d) 10 mm carpet/underlay, 19 mm timber or chipboard on 100 mm joists, 100 mm mineral fibre between joists, ventilated underfloor cavity | 0.37 | TRUE |

## 3. Outside air contact floors

| Floor type | U-Value (W/m2 K) | Ground contact adjustment requirement |
|---|---|---|
| Don’t Know | 0.85 (average of below) | FALSE |
| (a) Vinyl floor covering, 50 mm screed, 150 mm cast concrete | 2.26 | FALSE |
| (b) Vinyl floor covering, 50 mm screed, 150 mm cast concrete, 50 mm mineral fibre insulation between battens, 12 mm cementitious building board on underside | 0.63 | FALSE |
| (c) Vinyl floor covering, 50 mm screed, 150 mm cast concrete, 100 mm mineral fibre insulation between battens, 12 mm cementitious building board on underside | 0.38 | FALSE |
| (d) 10 mm carpet/underlay, 50 mm screed, 150 mm cast concrete, 100 mm mineral fibre insulation between battens, 12 mm cementitious building board on underside | 0.36 | FALSE |
| (e) Vinyl floor covering, 19 mm timber or chipboard on 100 mm joists, 12 mm cementitious building board on underside | 1.59 | FALSE |
| (f) Vinyl floor covering, 19 mm timber or chipboard on 100 mm joists, 100 mm mineral fibre insulation between joists, 12 mm cementitious building board on underside | 0.39 | FALSE |

| | | |
|---|---|---|
| (g) 10 mm carpet/underlay, 19 mm timber or chipboard on 100 mm joists, 100 mm mineral fibre insulation between joists, 12 mm cementitious building board on underside | 0.37 | FALSE |

## External Roofs

The U-values for external roof construction types have been taken from CIBSE (2015) *Guide A*, “Table 3.49 Thermal properties of typical roof constructions”.

### 1. Flat concrete roofs

| Roof construction type | U-Value (W/m2 K) |
|---|---|
| Don’t Know | 0.68 (average of below) |
| (a) Waterproof covering, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster | 2.19 |
| (b) Waterproof roof covering, 35 mm polyurethane insulation, vapour control layer, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster | 0.54 |
| (c) Waterproof roof covering, 100 mm polyurethane insulation, vapour control layer, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster | 0.25 |
| (d) Waterproof roof covering, 200 mm polyurethane insulation, vapour control layer, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster | 0.12 |
| (e) Ballast (chips or paving slab), 50 mm extruded polystyrene insulation, waterproof roof covering, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster | 0.59 |
| (f) Ballast (chips or paving slab), 100 mm extruded polystyrene insulation, waterproof roof covering, 75 mm screed, 150 mm cast concrete, 13 mm dense plaster | 0.39 |

### 2. Flat timber roofs

| Roof construction type | U-Value (W/m2 K) |
|---|---|

| | |
|---|---|
| Don't Know | 0.78 (average of below) |
| (a) Waterproof roof covering, 19 mm timber decking, ventilated airspace, vapour control layer, 12.5 mm plasterboard | 2.35 |
| (b) Waterproof roof covering, 19 mm timber decking, ventilated airspace, 50 mm mineral fibre insulation, vapour control layer, 12.5 mm plasterboard | 0.64 |
| (c) Waterproof roof covering, 35 mm polyurethane insulation, vapour control layer, 19 mm timber decking, unventilated airspace, 12.5 mm plasterboard | 0.53 |
| (d) Waterproof roof covering, 100 mm polyurethane insulation, vapour control layer, 19 mm timber decking, unventilated airspace, 12.5 mm plasterboard | 0.23 |
| (e) Waterproof roof covering, 200 mm polyurethane insulation, vapour control layer, 19 mm timber decking, unventilated airspace, 12.5 mm plasterboard | 0.13 |

## 3. Pitched roofs (insulated at ceiling level)

| Roof construction type | U-Value (W/m2 K) |
|---|---|
| Don't Know | 0.74 (average of below) |
| (a) 12.5 mm plasterboard, no insulation, roof space, tiling | 2.3 |
| (b) 12.5 mm plasterboard, 25 mm mineral wool quilt between ceiling joists, roof space, tiling | 1.1 |
| (c) 12.5 mm plasterboard, 50 mm mineral wool quilt between ceiling joists, roof space, tiling | 0.71 |
| (d) 12.5 mm plasterboard, 100 mm mineral wool quilt between ceiling joists, roof space, tiling | 0.42 |
| (e) 12.5 mm plasterboard, 100 mm mineral wool quilt between ceiling joists, 50 mm mineral wool quilt over joists, roof space, tiling | 0.28 |
| (f) 12.5 mm plasterboard, 100 mm mineral wool quilt between ceiling joists, 100 mm mineral wool quilt over joists, roof space, tiling | 0.21 |

| | |
|---|---|
| (g) 12.5 mm plasterboard, 100 mm mineral wool quilt between ceiling joists, 150 mm mineral wool quilt over joists, roof space, tiling | 0.17. |
| (h) 12.5 mm plasterboard, 100 mm mineral wool quilt between ceiling joists, 200 mm mineral wool quilt over joists, roof space, tiling | 0.14 |

## 4. Pitched roofs (insulated at rafter level)

| Roof construction type | U-Value (W/m2 K) |
|---|---|
| Don't Know | 0.44 (average of below) |
| (a) 12.5 mm plasterboard, 25 mm PU insulation between rafters, ventilated airspace, roofing felt, 25 mm ventilated airspace, clay tiles | 0.95 |
| b) 12.5 mm plasterboard, 50 mm PU insulation between rafters, ventilated airspace, roofing felt, 25 mm ventilated airspace, clay tiles | 0.56 |
| (c) 12.5 mm plasterboard, 100 mm PU insulation between rafters, ventilated airspace, roofing felt, 25 mm ventilated airspace, clay tiles | 0.31 |
| (d) 12.5 mm plasterboard, 150 mm PU insulation between rafters, ventilated airspace, roofing felt, 25 mm ventilated airspace, clay tiles | 0.22 |
| (e) 12.5 mm plasterboard, 150 mm PU insulation between rafters and 50 mm over rafters, ventilated airspace, roofing felt, 25 mm ventilated airspace, clay tiles | 0.15 |

## 5. Sheet metal construction

| Roof construction type | U-Value (W/m2 K) |
|---|---|
| Don't Know | 0.35 (average of below) |
| (a) 0.4 mm inner sheet, 150 mm Z-spacer with MW insulation, 0.7 mm outer sheet | 0.35 |

| | |
|---|---|
| (b) 0.4 mm inner sheet, 85 mm MW insulation, 40 mm MW insulation between rails, 0.7 mm profiles outer sheet | 0.35 |

# Glazing types

The U-values for different glazing types are averages based on values provided in CIBSE (2015) *Guide A*, Table 3.29 (“U-values for windows”).

## 1. Double glazed, air filled

| Glazing type spacing | U-Value (W/m2 K) |
|---|---|
| Don’t Know | 2.87 |
| 6 mm gap | 3.10 |
| 12 mm gap | 2.80 |
| 16 mm or greater gap | 2.70 |

## 2. Double glazed, air filled, low-E

| Glazing type spacing | U-Value (W/m2 K) |
|---|---|
| Don’t Know | 2.20 |
| 6 mm gap | 2.60 |
| 12 mm gap | 2.10 |
| 16 mm or greater gap | 1.90 |

## 3. Double glazed, argon filled

| Glazing type spacing | U-Value (W/m2 K) |
|---|---|
| Don’t Know | 2.73 |
| 6 mm gap | 2.90 |

| | |
|---|---|
| 12 mm gap | 2.70 |
| 16 mm or greater gap | 2.60 |

## 4. Double glazed, argon filled, low-E

| Glazing type spacing | U-Value (W/m2 K) |
|---|---|
| Don't Know | 2.00 |
| 6 mm gap | 2.30 |
| 12 mm gap | 1.90 |
| 16 mm or greater gap | 1.80 |

## 5. Triple glazed, air filled

| Glazing type spacing | U-Value (W/m2 K) |
|---|---|
| Don't Know | 2.17 |
| 6 mm gap | 2.40 |
| 12 mm gap | 2.10 |
| 16 mm or greater gap | 2.00 |

## 6. Triple glazed, air filled, low-E

| Glazing type spacing | U-Value (W/m2 K) |
|---|---|
| Don't Know | 1.70 |
| 6 mm gap | 2.00 |
| 12 mm gap | 1.60 |
| 16 mm or greater gap | 1.50 |

## 7. Triple glazed, argon filled

| Glazing type spacing | U-Value (W/m2 K) |
|---|---|
| Don’t Know | 2.03 |
| 6 mm gap | 2.20 |
| 12 mm gap | 2.00 |
| 16 mm or greater gap | 1.90 |

## 8. Triple glazed, argon filled, low-E

| Glazing type spacing | U-Value (W/m2 K) |
|---|---|
| Don’t Know | 1.57 |
| 6 mm gap | 1.80 |
| 12 mm gap | 1.50 |
| 16 mm or greater gap | 1.40 |

## 9. Single glazed

| Glazing type | U-Value (W/m2 K) |
|---|---|
| Single glazed | 4.80 |

## 10. With secondary glazing

| Glazing type | U-Value (W/m2 K) |
|---|---|
| With secondary glazing | 2.40 |

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