

SAP 2009

The Government's Standard Assessment Procedure for Energy Rating of Dwellings

2009 edition

with corrections, May 2010

This document describes SAP 2009 version 9.90, dated March 2010. SAP assessors and other users should ensure that they are using the latest version of the document. Information on this and any updates will be published on the website below.

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BRE
Garston, Watford WD25 9XX
Enquiries to sap2009@bre.co.uk
www.bre.co.uk/sap2009

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SUMMARY

This manual describes the Government's Standard Assessment Procedure (SAP) for assessing the energy performance of dwellings. The indicators of energy performance are energy consumption per unit floor area, an energy cost rating (the SAP rating), an Environmental Impact rating based on CO₂ emissions (the EI rating) and a Dwelling CO₂ Emission Rate (DER).

The SAP rating is based on the energy costs associated with space heating, water heating, ventilation and lighting, less cost savings from energy generation technologies. It is adjusted for floor area so that it is essentially independent of dwelling size for a given built form. The SAP rating is expressed on a scale of 1 to 100, the higher the number the lower the running costs.

The Environmental Impact rating is based on the annual CO₂ emissions associated with space heating, water heating, ventilation and lighting, less the emissions saved by energy generation technologies. It is adjusted for floor area so that it is essentially independent of dwelling size for a given built form. The Environmental Impact rating is expressed on a scale of 1 to 100, the higher the number the better the standard.

The Dwelling CO₂ Emission Rate is a similar indicator to the Environmental Impact rating, which is used for the purposes of compliance with building regulations. It is equal to the annual CO₂ emissions per unit floor area for space heating, water heating, ventilation and lighting, less the emissions saved by energy generation technologies, expressed in kg/m²/year.

The method of calculating the energy performance and the ratings is set out in the form of a worksheet, accompanied by a series of tables. The methodology is compliant with the Energy Performance of Buildings Directive. The calculation should be carried out using a computer program that implements the worksheet and is approved for SAP calculations (BRE approves SAP software on behalf of the Department for Energy and Climate Change; the Department for Communities and Local Government; the Scottish Government; the National Assembly for Wales; and the Department of Finance and Personnel).

INTRODUCTION

The Standard Assessment Procedure (SAP) is adopted by Government as the UK methodology for calculating the energy performance of dwellings.

The calculation is based on the energy balance taking into account a range of factors that contribute to energy efficiency:

- materials used for construction of the dwelling
- thermal insulation of the building fabric
- ventilation characteristics of the dwelling and ventilation equipment
- efficiency and control of the heating system(s)
- solar gains through openings of the dwelling
- the fuel used to provide space and water heating, ventilation and lighting
- energy for space cooling, if applicable
- renewable energy technologies

The calculation is independent of factors related to the individual characteristics of the household occupying the dwelling when the rating is calculated, for example:

- household size and composition;
- ownership and efficiency of particular domestic electrical appliances;
- individual heating patterns and temperatures.

Except where the dwelling has a fixed air conditioning system ratings are not affected by the geographical location.

The procedure used for the calculation is based on the BRE Domestic Energy Model (BREDEM^[1,2,3,4,5]), which provides a framework for the calculation of energy use in dwellings. The procedure is consistent with the standard BS EN ISO 13790.

The Standard Assessment Procedure was first published by the then DOE and BRE in 1993 and in amended form in 1994, and conventions to be used with it were published in 1996 and amended in 1997. Revised versions were published in 1998, 2001 and 2005.

The present edition is SAP 2009 in which:

- space and water heating are calculated on a monthly, instead of an annual, basis
- space cooling is included
- thermal mass of construction elements is explicit rather than implicit
- energy used for domestic hot water has been revised
- weather data has been updated
- CO₂ emissions factors have been updated using the latest available data
- the calculation of boiler efficiency from test data has been amended
- the performance of heat pumps can be based on test data
- internal heat gains have been revised and a reduced level of gains is proposed for design purposes

At present the effect of feed-in tariffs has not been factored into SAP. This is under consideration and the government will consult on proposals at the earliest opportunity.

Reduced Data SAP is not being amended in this revision and RdSAP assessments will continue to use SAP 2005 version 9.83 for the time being. It is anticipated that RdSAP will be revised following the implementation of SAP 2009.

SCOPE OF THE SAP PROCEDURE

The procedure is applicable to self-contained dwellings (of any size and any age).

For flats, it applies to the individual flat and does not include common areas such as access corridors.

Note: Common areas of blocks of flats such as heated access corridors, and other buildings (even though used for residential purposes, e.g. nursing homes) are assessed using procedures for non-domestic buildings.

Where part of an accommodation unit is used for commercial purposes (e.g. as an office or shop), this part should be included as part of the dwelling if the commercial part could revert to domestic use on a change of occupancy. That would be applicable where:

- there is direct access between the commercial part and the remainder of the accommodation, and
- all is contained within the same thermal envelope, and
- the living accommodation occupies a substantial proportion of the whole accommodation unit.

Where a self-contained dwelling is part of a substantially larger building, where the remainder of the building would not be expected to revert to domestic use, the dwelling is assessed by SAP and the remainder by procedures for non-domestic buildings.

SAP is a methodology for calculating energy use and the associated running costs and CO₂ emissions. It does not set any standards or limitations on data.

For SAP calculations dwellings have a standard occupancy and usage pattern, which are typical values of quantities that in practice vary substantially between dwellings of similar size and type. The occupancy assumed for SAP calculations is not suitable for design purposes, for example of hot water systems.

GENERAL PRINCIPLES

Input precision and rounding

Data should be entered into calculation software as accurately as possible, although it is unnecessary to go beyond 3 significant figures (and some product data may only be available to lesser precision).

Input data

Various tables of performance data are provided as part of this document. The tables are used when specific performance information on the product or system is not available. However, when specific performance

information is available for the following items, it should be used in preference to data from the tables, particularly in the new build context.

U-values – walls, floors, roofs

For new build, U-values should be calculated on the basis of the actual construction.

Thermal mass

The Thermal Mass Parameter (TMP) is required for heating and cooling calculations. It is defined as the sum of (area times heat capacity) over all construction elements divided by total floor area. It can be obtained from the actual construction elements of walls, floors and roofs (including party and internal walls, floors and ceilings). For further details see Table 1e.

Linear thermal transmittance (Ψ -values)

Ψ -values are used for thermal bridging. There are three possibilities.

- a) The use of a global factor, which is multiplied by the total exposed surface area, as described in Appendix K.
- b) On the basis of the length of each junction and the default Ψ -values in Table K1.
- c) On the basis of the length of each junction and user-supplied Ψ -values. It is not necessary to supply Ψ -value for each junction type – values from Table K1 can be mixed with user-supplied values.

Window data

Window U-values and g-values (total solar energy transmittance) can be from a certified window energy rating¹ or manufacturers' declaration. Both values are needed (for the calculation of respectively heat loss and solar gain).

Values of light transmittance (g_L) are given in Table 6b for calculation of lighting energy requirements as set out in Appendix L.

For new dwellings and other cases where solar gain provides a significant part of heating requirements the frame factor (representing the glazed fraction of the window) is important in determining solar gain. Frame factors should be assigned per window (or per group of similar windows) particularly where window areas differ on different facades on the dwelling. Default values are given in Table 6c.

Boiler efficiency – gas and oil

Boiler efficiency can be from the Product Characteristics Database (preferably) or from a manufacturer's declaration given in the terms stated in D3 or D6.

Boiler efficiency – solid fuel

Boiler efficiency can be from the Product Characteristics Database (preferably) or from a manufacturer's declaration.

Heat pumps

Data for heat pumps can be obtained from the Products Characteristics Database and applied via the procedures in Appendix N.

Efficiency of gas/oil/solid fuel fires and room heaters

Efficiency can be from a manufacturer's declaration given in terms of E2.

Standing loss – cylinders, thermal stores and CPSUs (includes both gas and electric CPSUs)

The manufacturer's declared loss obtained in terms of the applicable BS and expressed in kWh/day, can be used in place of data from Table 2. (Tables 2a and 2b are applied to declared loss as well as to loss from Table 2).

Pressure test result

The result of a pressure test can be used instead of the default calculations of infiltration. In the case of a dwelling not yet built, a design value of air permeability can be used subject to the requirements of building regulations that apply in the administration where the dwelling will be constructed.

¹ Operated by the British Fenestration Rating Council

Solar collector performance

The zero-loss collector efficiency and the collector's linear heat loss coefficient can be used if obtained from test results.

Specific fan power and ventilation heat exchanger efficiency

Measured values of specific fan power for these mechanical ventilation systems:

- positive input ventilation from outside (not loft)
- mechanical extract
- balanced

and of heat exchanger efficiency for MVHR systems, can be used in place of the default values in Table 4g for those systems that are listed on www.sap-appendixq.org.uk.

Existing properties

The SAP calculation procedure for existing properties follows that for new dwellings. However, some of the data items are usually defaulted or inferred. For further details see Appendix S of SAP 2005 version 9.82.

The calculation is concerned with the assessment of the dwelling itself, as used by standard or typical occupants, and not affected by the way current occupants might use it. Thus, for example, the living room fraction is based on the original design concept and not on the rooms the current occupants heat.

CALCULATION PROCEDURE AND CONVENTIONS

The method of calculating the energy performance is set out in the form of a worksheet, accompanied by a series of tables. A calculation should follow the numbered entries in the worksheet sequentially. Some entries are obtained by carrying forward earlier entries, other entries are obtained, using linear interpolation where appropriate, by reference to Tables 1 to 15 or from user-supplied data. The following notes on calculations and conventions should be read in conjunction with the worksheet.

The worksheet is intended as a form of describing the calculation, to be used for implementing the calculation into computer software, rather than for manual calculations.

1 DWELLING DIMENSIONS

The boundary of the heated space consists of all the building elements separating it from external environment or from adjacent dwellings or unheated spaces. Any internal elements (internal partition walls or intermediate floors within the dwelling) are disregarded for the purposes of establishing areas.

Dimensions refer to the inner surfaces of the elements bounding the dwelling. Thus floor dimensions are obtained by measuring between the inner surfaces of the external or party walls, disregarding the presence of any internal walls.

Storey height is the total height between the ceiling surface of a given storey and the ceiling surface of the storey below. For a single storey dwelling, or the lowest floor of a dwelling with more than one storey, the measurement should be from floor surface to ceiling surface. Where the room height varies, such as in a room-in-roof, the storey height should be an average based on the volume of the space and the internal floor area (plus the thickness of the floor if it is the upper storey of a house).

Floor area should be measured as the actual floor area, i.e. if the height of a room extends to two storeys or more only the actual accessible floor area should be used for the calculations. However, as an exception to this rule in the case of stairs, the floor area should be measured as if there were no stairs but a floor in their place at each level.

In general, rooms and other spaces, such as built-in cupboards, should be included in the calculation of the floor area where these are directly accessible from the occupied area of the dwelling. However unheated spaces clearly divided from the dwelling should not be included. The following provides specific guidance:

Porches:

- *should be included* if heated by fixed heating devices;

- *should not be included* if unheated and external. In this context 'external' means an addition protruding from the line of the external wall of the dwelling;
- *should not be included* if unheated and thermally separated from the dwelling.

Conservatories:

- *should not be included* if they are separated from the dwelling according to the definition in 3.3.3
- *should be included* as part of the dwelling if they are not separated.

Store rooms and utility rooms:

- *should be included* if they are directly accessible from the occupied area of the dwelling, whether heated or not;
- *should not be included* if they are unheated and accessible only via a separate external door.

Basements:

- *should be included* if accessed via a permanent fixed staircase and either:-
 - basement is heated via fixed heat emitters, or
 - basement is open to the rest of the dwelling..

Garages:

- *should be included* if heating is provided within the garage from the main central heating system;
- *should not be included* where the garage is thermally separated from the dwelling and is not heated by the central heating system

Attics:

- *should be included* if accessed by a fixed staircase.

When porches or integral garages are not included in floor area, the door and part of the wall between the dwelling and these structures are adjacent to an unheated space and their U-values should be adjusted where appropriate (see section 3.3).

In flats, if corridors and stairwells are heated, treat walls between the flat and heated corridors/stairwells as non-heat loss walls (i.e. assuming the same temperature on either side of the walls).

No special treatment should be given in cases where a central heating boiler is located in an unheated garage or attic (i.e. the floor area used for the assessment should be the same as if the boiler were in the kitchen or a utility room).

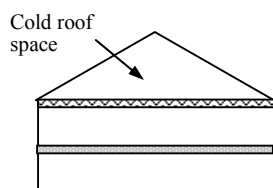
For existing dwellings see additional guidance in Appendix S.

Pitched roofs

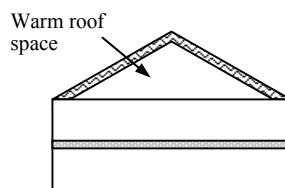
There are three main types of pitched roof construction:

1. pitched roof with insulation at ceiling level, insulated between (and perhaps also above) joists;
2. pitched roof insulated at rafter level (no insulation at ceiling level), insulated between and/or above rafters ("warm roof"), with a non-ventilated loft space but with a ventilated space between the insulation and the roof covering;

3. pitched roof insulated either at ceiling level or at rafter level, with roof space converted into habitable space.

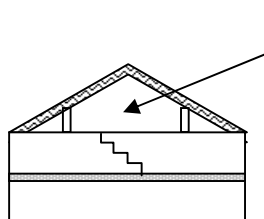


a) Insulation at ceiling level

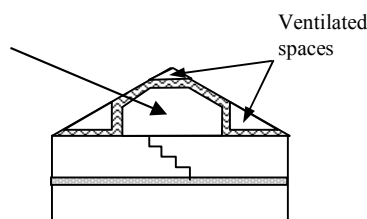


b) Insulation at rafter level

In the cases of a) and b) the roof space should **not** be treated as a separate storey.



c) Room in roof built into a pitched roof insulated at rafter level



d) Room in roof built into a pitched roof insulated at ceiling level

In the cases of c) and d) the floor area of the roof space that is converted into habitable space should be treated as a separate storey.

2 VENTILATION RATE

The ventilation air change rate is the rate at which outside air enters/leaves a building.

SAP requires a reasonable estimate of the air change rate in order to calculate the overall heating requirement. The actual ventilation rate depends on a large number of factors, many of which may not be known precisely (e.g. permeability of materials and inadvertent gaps and openings in the structure) and in most cases cannot be assessed from a site survey or from plans.

The infiltration rate can be assessed either from pressurisation test or, in the absence of pressure test, using the SAP algorithm as defined by (9) to (16) of the worksheet.

Whether or not a pressurisation test has been carried out, the ventilation calculation requires the information on chimneys, fans, open flues and passive vents. Chimneys, fans, open flues and passive vents (blocked off during a pressurisation test but open in practice) should be counted in (6a) to (7b) of the worksheet.

Ventilation rates for chimneys, flues, fans and passive vents, flueless gas fires and passive stack ventilators are given in Table 2.1 below.

Table 2.1 Ventilation rates

Item	Ventilation rate m ³ /hour
Chimney	40
Open flue	20
Intermittent extract fan	10
Passive vent	10
Flueless gas fire	40

2.1 Chimneys and flues

Ventilation rates for chimneys and flues should be counted only when they are unrestricted and suitable for use.

For the purposes of the SAP a chimney is defined as a vertical duct for combustion gases of diameter 200 mm or more (or a rectangular duct of equivalent size). Vertical ducts with diameter less than 200 mm should be counted as flues. The following are also counted as flues:

- a chimney for solid fuel appliances with controlled flow of the air supply;
- a flexible flue liner sealed into a chimney;
- a chimney fitted with a damper;
- a chimney fitted with an open-flue gas fire where the flue products outlet is sealed to the chimney;
- a blocked up fireplace fitted with ventilators (if ventilator area does not exceed 30 000 mm²)

Ventilation rates should be included only for open flues; they should not be included for room-sealed boilers or room heaters. Ventilation rates for specific closed appliances may be introduced.

2.2 Fans and passive vents

Intermittent-running extract fans which exhaust air (typically from the kitchen and bathroom), including cooker hoods and other independent extractor fans, should be included in the 'number of fans' category. For continuously running fans see section 2.6.

Passive stack ventilators (passive vents) are an alternative to extract fans. Such systems comprise extract grilles connected to ridge terminals by ducts. Such systems should be supplied with air bricks or trickle vents for air ingress. It is the number of extract grilles that should be used in the calculation.

Trickle vents or air bricks alone do not count as passive vents and should not be included in the calculation.

2.3 Pressurisation test

A pressurisation test of a dwelling is carried out by installing a fan in the doorway of the principal entrance to the dwelling, sealing all flues and chimneys, and determining the air flow rate required to maintain an excess pressure of 50 pascals (Pa). The pressurisation test should be carried out in accordance with BS EN 13829. The air permeability measured in this way, q_{50} , expressed in cubic metres per hour per square metre of envelope area is divided by 20 for use in the worksheet (to give an estimate of the air change rate at typical pressure differences). In this case (9) to (16) of the worksheet are not used.

2.4 Draught lobby

A draught lobby is an arrangement of two doors that forms an airlock on the main entrance to the dwelling. To be included, the enclosed space should be at least 2 m² (floor area), it should open into a circulation area, and the door arrangement should be such that a person with a push-chair or similar is able to close the outer door before opening the inner door. It may be heated or unheated and may provide access to a cloakroom (but it should not be counted as a draught lobby if it provides access to other parts of the dwelling).

A draught lobby should only be specified if there is a draught lobby to the main entrance of the dwelling. If the main entrance has no draught lobby but, for example, a back door does, then no draught lobby should be specified.

An unheated draught lobby in the form of an external porch should not be counted as part of the area of the dwelling. However, the door between the dwelling and the porch is a 'semi-exposed' element and its U-value should be calculated accordingly (see section 3.3).

² In the case of a new dwelling, subject to the requirements of building regulations that apply in the administration where the dwelling will be constructed, a design value or a specified value of air permeability can be used for the calculation.

Flats with access via an unheated stairwell or corridor should be classified as having a draught lobby.

2.5 Sheltered Sides

A side of a building is sheltered if there are adjacent buildings or tree-height hedges which effectively obstruct the wind on that side of the building. A side should be considered sheltered if all the following apply:

- the obstacle providing the shelter is at least as high as the ceiling of the uppermost storey of the dwelling;
- the distance between the obstacle and the dwelling is less than five times the height of the obstacle;
- the width of the obstacle (or the combined width of several obstacles) is such that it subtends an angle of at least 60° within the central 90° when viewed from the middle of the wall of the dwelling that faces the obstacle - see Figure 1

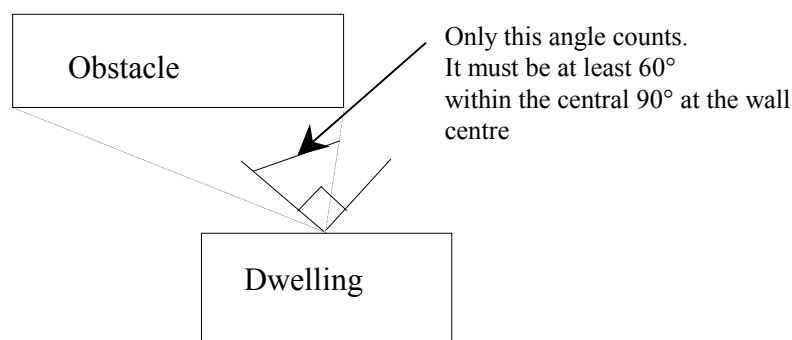


Figure 1 Shelter angle

Two partially sheltered sides should be counted as one sheltered side. Architectural planting does not count as shelter unless it actually exists (even though shown as mature trees on drawings).

Any party wall should be counted as a sheltered side.

For new dwellings it will often be appropriate to assume that two sides of the dwelling are sheltered.

2.6 Mechanical ventilation

Mechanical ventilation systems use continually running fans. They can be input-only, extract-only or balanced (input and extract).

2.6.1 Mechanical ventilation systems

(a) Positive input ventilation (PIV)

Positive input ventilation is a fan driven ventilation system, which often provides ventilation to the dwelling from the loft space. The SAP calculation procedure for systems which use the loft to pre-heat the ventilation air is the same as for natural ventilation, including $20 \text{ m}^3/\text{h}$ ventilation rate equivalent to two extract fans or passive vents. (The energy used by the fan is taken as counterbalancing the effect of using slightly warmer air from the loft space compared with outside).

Some positive input ventilation systems supply the air directly from the outside and the procedure for these systems is the same as for mechanical extract ventilation.

(b) Mechanical extract ventilation (MEV)

MEV is a fan driven ventilation system, which only extracts air from the dwelling. The SAP calculation is based on a throughput of 0.5 air changes per hour through the mechanical system, plus infiltration.

MEV can be either:

- centralised: air is extracted from wet rooms via ducting and expelled by means of a central fan., or
- decentralised: air is extracted by continuously-running fans in each wet room.

(c) Balanced whole house mechanical ventilation

Balanced ventilation provides fresh air to habitable rooms in the dwelling and extracts exhaust air from wet rooms.

A balanced system without heat recovery extracts from wet rooms via ducting and expelled by a central fan. Air is also supplied to habitable rooms, either via ducting and a central fan or by individual supply air fans in each habitable room.

In a balanced system with heat recovery (MVHR) both the extract and supply air are provided via ducting, with a heat exchanger between the outgoing and incoming air.

2.6.2 Data required

Centralised MEV: The system's Specific Fan Power (SFP) and whether the ducting is rigid or flexible.

Decentralised MEV: SFP of each fan together with the fan's ducting arrangements (the fan can be in the ceiling of the room with a duct to the outside, or in a duct, or in a through-wall arrangement with no duct).

Balanced mechanical ventilation without heat recovery. SFP taking account of all fans and whether the ducting is rigid or flexible.

MVHR. SFP as a single value for the system as a whole, the efficiency of the heat exchanger, whether the ducting is rigid or flexible and whether the ducting is insulated (where outside the building's insulated envelope).

For systems that have been tested according to the Appendix Q procedures for mechanical ventilation systems (details at www.sap-appendixq.org.uk) the tested data from the Product Characteristics Database should be used for the calculations. Otherwise the default data in Table 4g is used. Data sheets for each tested system are provided on the Appendix Q website.

2.6.3 In-use factors

In-use factors are applied in all cases to the SFP and, for MVHR systems, heat exchanger efficiency to allow for differences in practical installations compared to the laboratory test conditions that are defined for the Appendix Q methodologies. For SFP, the in-use factor allows for additional lengths and bends compared to the optimal test configuration and for the practicalities of setting the fan speed at the optimal value for the required flow rate. For MVHR efficiency the tested result is the efficiency of the heat exchanger itself and the in-use factor allows for losses from ductwork.

In-use factors are given in Table 4h. Specific fan power and heat exchange efficiency are multiplied by the appropriate in-use factor for the purposes of SAP calculations. The factors will be updated in future as relevant to take account of research results on the practical performance of mechanical ventilation systems, and additional values applicable when the system has been installed under an approved installation scheme for mechanical ventilation if such a scheme is put in place..

2.6.4 Specific fan power – measured data

The specific fan power for centralised MEV systems and MVHR systems is a single value representing the SFP of the whole system. It is multiplied by the appropriate in-use factor for the purposes of SAP calculations.

In the case of decentralised MEV the specific fan power is provided for each fan and an average value is calculated for the purposes of the SAP calculations. There are two types of fan, one for kitchens and one for other wet rooms, and three types of fan location (in room with ducting, in duct, or through wall with no duct). This gives six possible permutations although all would not normally be present in a given installation. The average SFP, including adjustments for the in-use factors, is given by:

$$SFP_{av} = \frac{\sum SFP_j \times FR_j \times IUF_j}{\sum FR_j} \quad (1)$$

where the summation is over all the fans, FR is the flow rate which is 13 l/s for kitchens and 8 l/s for all other wet rooms, and IUF is the applicable in-use factor.

The specific fan power, inclusive of the in-use factor(s), is used to calculate the annual energy use of the fans (Table 4f) and, where applicable, the gains to the dwelling from the fans (Table 5a). Note that electricity consumption of MVHR systems is not added into the gains because their effect is included in the test results for MVHR efficiency.

2.6.5 MEV systems – air throughput and effective air change rate

The throughput is taken as 0.5 air changes per hour.

2.6.6 Balanced mechanical systems – air throughput and effective air change rate

The throughput of balanced mechanical systems, n_{mech} , is taken as having been set to an air change rate of 0.5 ach.

The MVHR efficiency is multiplied by the appropriate in-use factor (Table 4g). The heat recovered is allowed for via an effective air change rate n_{eff} which is

$$n_{\text{eff}} = n_{\text{adj}} + n_{\text{mech}} \times (1 - \eta/100) \quad (2)$$

where n_{adj} is the effective air change rate obtained at worksheet (22b) and η is the MVHR efficiency in % including the in-use factor. η is zero for balanced systems without heat recovery.

2.6.7 Rigid and flexible ducting

Ventilation systems may be tested with rigid ducting, flexible ducting, or both, and the in-use factors for SFP depend on the ducting type. SAP calculations are done using the test data and in-use factors corresponding to the actual duct type. If data for the actual duct type are not available the default values from Table 4g are used.

The data and in-use factors for rigid ductwork may be used only if all the ductwork is rigid, specifically:

- for centralised systems, all ducting is rigid (although occasional flexible ducting to join components together is permitted and allowed for in the in-use factor);
- for decentralised systems, all fans with ducting have rigid ducts.

If the above conditions do not apply, the calculation is done for flexible ductwork.

2.6.8 Two mechanical ventilation systems

Where two systems are used in the same dwelling:

- a) If the two systems are identical, use the data for the system concerned corresponding to half the actual number of wet rooms. If there is an odd number of actual wet rooms, round upwards (e.g. for Kitchen+6 wet rooms use data for Kitchen+3 wet rooms).
- b) If the systems are different, use an average of the data for the two systems, weighted according to the number of wet rooms served by each system. Round SFP to 2 decimal places and efficiency to nearest whole number for entry into SAP software.
- c) If either of the systems are not listed on the SAP Appendix Q website the default data (Table 4g) applies.

3 HEAT TRANSMISSION

The areas of building elements are based on the internal dimensions of surfaces bounding the dwelling.

Window and door area refers to the total area of the openings, including frames. Wall area is the net area of walls after subtracting the area of windows and doors. Roof area is also net of any rooflights or windows set in the roof. Apart from party walls (see section 3.7) losses or gains to spaces in other dwellings or premises that are normally expected to be heated to the same extent and duration as the dwelling concerned are assumed to be zero (and these elements are therefore omitted from the calculation of heat losses).

The calculation should allow for different types of element where their U-values differ (e.g. some windows single glazed and some double glazed, masonry main wall and timber framed wall in an extension, main roof pitched and extension roof flat).

3.1 U-values of opaque elements

When the details of the construction are known, the U-values should be calculated for the floor, walls and roof. This should always be the case for new dwellings being assessed from building plans. For existing dwellings see Appendix S.

U-values for walls and roofs containing repeating thermal bridges, such as timber joists between insulation, etc, should be calculated using methods based on the upper and lower resistance of elements, given in BS EN ISO 6946.

BS EN ISO 6946 gives the calculation that applies to components and elements consisting of thermally homogenous layers (which can include air layer) and is based in the appropriate design thermal conductivity or design thermal resistances of materials and products involved. The standard also gives an approximate method that can be used for inhomogeneous layers, except cases where an insulating layer is bridged by metal.

Thermal conductivity values for common building materials can be obtained from BS EN ISO 10456 or the CIBSE Guide Section A3^[6]. For specific insulation products, data should be obtained from manufacturers.

U-values for ground floors and basements should be calculated using the procedure described in BS EN ISO 13370, in section A3 of the CIBSE Guide A or in the Approved Document 'Basements for dwellings'^[7].

The thickness of loft insulation should be determined by inspection if the loft is accessible. The thickness should be measured at least as accurately as in the following list: 0, 12, 25, 50, 100, 150, 200, 250, 300 mm.

3.2 Window U-values

The U-value for a window should be that for the whole window opening, including the window frame.

Measurements of thermal transmittance in the case of doors and windows should be made according to BS EN ISO 12567-1. Alternatively, U-values of windows and doors may be calculated using BS EN ISO 10077-1 or BS EN ISO 10077-2. In the case of roof windows, unless the measurement or calculation has been done for the actual inclination of the roof window, adjustments as given in Notes 1 and 2 to Table 6e should be applied.

Table 6e gives values that can be used in the absence of test data or calculated values. Use a value from Table 6e which corresponds most closely to the description of the actual window; interpolation should not be used in this table. The table provides default values for windows corresponding to the generic descriptions given in the table. Measured or specifically calculated values can be better than those in the table because of better frame performance, improved spacer bars and other factors.

The effective window or roof window U-value to be used in worksheet (27) and (27a) takes account of the assumed use of curtains; it is calculated using the formula:

$$U_{w,\text{effective}} = \frac{1}{\frac{1}{U_w} + 0.04} \quad (3)$$

where U_w is window U-value calculated or measured without curtains.

3.3 U-values of elements adjacent to an unheated space

The procedure for treatment of U-values of elements adjacent to unheated space is described in BS EN ISO 6946 and BS EN ISO 13789.

The following procedure may be used for typical structures (no measurements are needed of the construction providing an unheated space, just select the appropriate R_u from Tables 3.1 to 3.3 below).

$$U = \frac{1}{\frac{1}{U_0} + R_u} \quad (4)$$

where: U = resultant U-value of element adjacent to unheated space, W/m^2K ;
 U_0 = U-value of the element between heated and unheated spaces calculated as if there were no unheated space adjacent to the element, W/m^2K ;
 R_u = effective thermal resistance of unheated space from the appropriate table below.

R_u for typical unheated structures (including garages, access corridors to flats and rooms in roof) with typical U-values of their elements are given below. These can be used when the precise details on the structure providing an unheated space are not available, or not crucial.

The effect of unheated spaces, however, need not be included if the area of the element covered by the unheated space is small (i.e. less than 10% of the total exposed area of all external walls if the unheated space abuts a wall, or 10% of the total area of all heat-loss floors if the unheated space is below a floor). Consequently a door in an element abutting an unheated space would not need to have its U-value changed (unless it is part of a very small flat where the U-value of the door might make a significant contribution to the result).

3.3.1 Garages

The U-value of elements between the dwelling and an integral garage should be adjusted using R_u from Table 3.1 or Table 3.2. Attached garages (not integral) should be disregarded.

Table 3.1 R_u for integral single garages (single garage is a garage for one car)

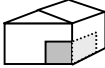
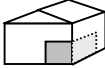
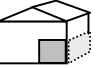

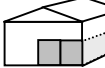
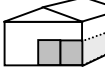


Garage type		Elements between garage and dwelling	R_u for a single garage	
			Inside ¹	Outside ²
Single fully integral		Side wall, end wall and floor	0.68	0.33
Single fully integral		One wall and floor	0.54	0.25
Single, partially integral displaced forward		Side wall, end wall and floor	0.56	0.26

Table 3.2 R_u for integral double garages (double garage is a garage for two cars)

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	0.59	0.28
Double, half integral		Side wall, halves of the garage end wall and floor	0.34	n/a
Double, partially integral displaced forward		Part of the garage side wall, end wall and some floor	0.28	n/a

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

²outside garage – when the walls separating the garage from the dwelling are the external walls

3.3.2 Stairwells and access corridors in flats

Stairwells and access corridors are not regarded as parts of the dwelling. If they are heated they are not included in the calculation. If unheated, the U-value of walls between the dwelling and the unheated space should be modified using the following data for R_u .

Figure 3.1 shows examples of access corridors in flats.

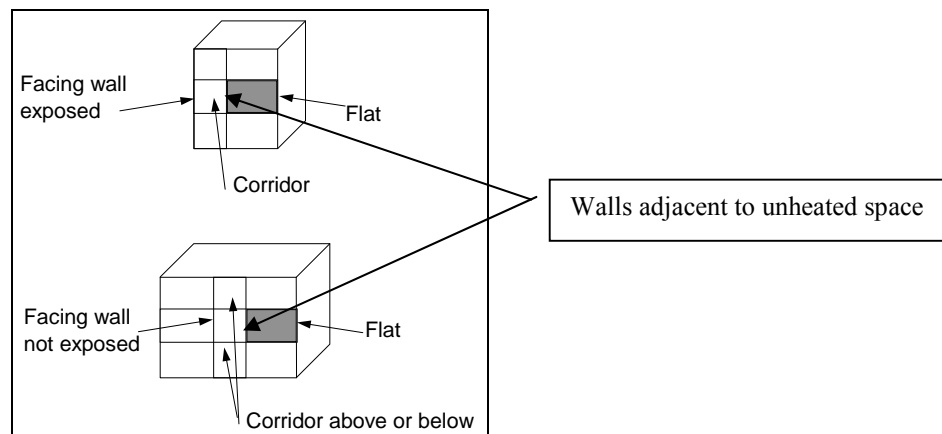


Figure 3.1 Access corridors

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

Table 3.3 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		0.82
Facing wall not exposed		0.90
Access corridors:		
Facing wall exposed, corridors above and below	facing wall, floor and ceiling	0.28
Facing wall exposed, corridor above or below	facing wall, floor or ceiling	0.31
Facing wall not exposed, corridor above and below	floor and ceiling	0.40
Facing wall not exposed, corridor above or below	floor or ceiling	0.43

3.3.3 Conservatories

Since the definition of a conservatory can vary, use the definition and any additional requirements that are appropriate to the building regulations of the administration where the dwelling is situated.

Thermal separation between a dwelling and a conservatory means that they are divided by walls, floors, windows and doors for which

- i) the U-values are similar to, or in the case of a newly-constructed conservatory not greater than, the U-values of the corresponding exposed elements elsewhere in the dwelling;
- ii) in the case of a newly constructed conservatory, windows and doors have similar draught-stripping provisions as the exposed windows and doors elsewhere in the dwelling.

For a conservatory which is thermally separated, the calculation should be undertaken as if it were not present.

3.3.4 Other large glazed areas

Any structure attached to a dwelling that is not a thermally separated conservatory according to the definitions in 3.3.3 should be treated as an integral part of the dwelling. This means that the glazed parts of the structure should be input as if they were any other glazed component (both in the heat loss section, and in the solar gain section according to orientation). See also section 3.2.

3.3.5 Room in roof

An approximate procedure applies in the case of a room-in-roof in an existing dwelling (see Appendix S). The following applies to new dwellings and conversions to create a room-in-roof.

In the case of room-in-roof construction where the insulation follows the shape of the room, the U-value of roof of the room-in-roof construction is calculated using the procedure described in paragraph 3.3 using thermal resistance R_u from Table 3.4. The same applies to the ceiling of the room below.

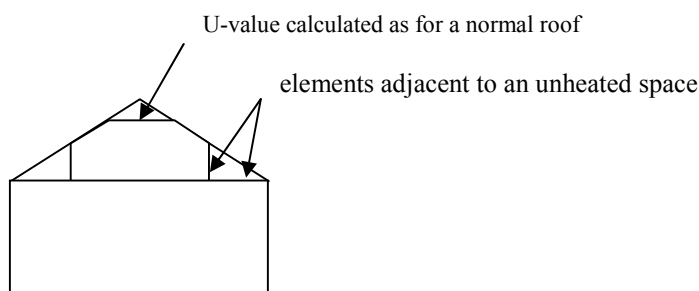


Figure 3.2 Room in roof

Table 3.4 R_u for room in roof adjacent to unheated loft space

Area (figure 3.2)	Element between dwelling and unheated loft space	R_u
Room in roof built into a pitched roof insulated at ceiling level	insulated wall of room in roof	0.50
	or insulated ceiling of room below	0.50

If the insulation follows the slope of the roof, the U-value should be calculated in the plane of the slope. For existing dwellings see Appendix S.

3.3.6 Other cases

In most other cases the effect of an unheated space should be disregarded. Where it needs to be accounted for a general formula for R_u is:

$$R_u = \frac{A_i}{\sum (A_e \times U_e) + 0.33nV} \quad (5)$$

A_i ; A_e = areas of internal and external elements (m^2), excluding any ground floor

U_e = U-values of external elements (W/m^2K)

V = volume of unheated space (m^3)

n = air change rate of unheated space (ach)

Typical values of the air change rate in unheated spaces are given in Table 3.5. A default value of $n = 3$ ach should be used if the airtightness of the unheated space is not known.

Table 3.5 Typical air change rates for unheated spaces

Air tightness type	n (air changes per hour)
No doors or windows, all joints between components well-sealed, no ventilation openings provided	0.1
All joints between components well-sealed, no ventilation openings provided	0.5
All joints well-sealed, small openings provided for ventilation	1.0
Not airtight due to some localised open joints or permanent ventilation openings	3.0
Not airtight due to numerous open joints, or large or numerous permanent ventilation openings	10.0

3.4 Thermal bridging

The SAP calculation takes account of thermal bridging, at junctions between elements and around openings. If linear thermal transmittance values are available for these junctions, they can be multiplied by the length of the junction concerned, and the total added to the transmission heat transfer coefficient.

If specific values for thermal bridges are not known, and the calculation can be done by including an allowance based on the total exposed surface area. Further details are in Appendix K.

3.5 Dwellings that are part of larger premises

In the case of a dwelling that is part of a larger building where the remainder of the building is used for non-domestic purposes, the elements between the dwelling and the remainder of the building are considered:

- to have zero heat loss if the spaces adjacent to the dwelling are normally heated to similar levels as the dwelling, or
- as heat loss elements to an unheated space if the spaces are unheated, heated only intermittently or heated only to a low level, or
- as if they were external elements but with their U-value reduced by a factor of 2 if the spaces are heated to a different pattern to that of the dwelling (e.g. commercial premises).

3.6 Curtain walling

Curtain walling is used sometimes for flats, but it needs a special procedure to get the heat loss and the solar gains correct simultaneously.

The U-value of curtain walling is a U-value is that for the whole façade, i.e. an average value including mullions, transoms, glazing and spandrel panels. SAP calculations should be done by:

- a) entering the façade U-value for the wall U-value, applied to the opaque area;
- b) entering the façade U-value for the window U-value, applied to the glazed area;
- c) assigning a frame factor of 1.0 to the windows.

The façade U-value includes all effects of thermal bridging within the façade. It is therefore permissible to calculate the thermal bridging heat loss with the lengths of window surrounds set to zero. All other junctions are included as normal (as described in Appendix K).

3.7 Party walls

Where of cavity construction a party wall can provide a mechanism for heat loss via air movement within the cavity between lower floors and the loft space. To allow for this party walls should be assigned a U-value as follows (Table 3.6):

Table 3.6 : U-values for party walls

Party wall construction	U-value (W/m²K)
Solid	0.0
Unfilled cavity with no effective edge sealing	0.5
Unfilled cavity with effective sealing around all exposed edges and in line with insulation layers in abutting elements	0.2
Fully filled cavity with effective sealing at all exposed edges and in line with insulation layers in abutting elements	0.0

Where edge sealing is adopted, either on its own or in conjunction with a fully filled cavity, it must be effective in restricting air flow and be aligned with the thermal envelope.

4 DOMESTIC HOT WATER

The demand for hot water is derived from the floor area of the dwelling and is specified in Table 1b. The energy required to produce that amount of hot water is then calculated, taking account of losses in heating and storage. Heat to the dwelling from storage cylinders and distribution pipework is also estimated [‘heat gains from water heating’, (65)] so that it can be taken into account in the calculation of space heating requirements.

Water can be heated by any of the systems in the water heating section of Table 4a which includes systems that provide both space and water heating and systems that provide water heating only.

For systems that recover heat from waste water see Appendix G.

4.1 Distribution loss

A distinction is made between instantaneous water heating, which heats water when it is required, and water heating that relies on storage of hot water in a cylinder, tank or thermal store. ‘Primary’ and ‘cylinder’ losses are not used in the calculation for instantaneous heaters.

‘Single-point’ heaters, which are located at the point of use and serve only one outlet, do not have distribution losses either. Gas multipoint water heaters and instantaneous combi boilers are also instantaneous types but, as they normally serve several outlets, they are assumed to have distribution losses.

4.2 Storage loss

Stored hot water systems can either be served by an electric immersion heater or obtain heat from a boiler or a heat pump through a primary circuit. In both cases, water storage losses are incurred to an extent that depends on how well the water storage is insulated. These losses apply for:

- hot water cylinders;
- the store volume of storage combination boilers (where the boiler efficiency is derived from test data);
- thermal stores;
- combined primary storage units (CPSUs);
- community heating schemes.

Water storage losses are set to zero for other combi boilers and instantaneous water heaters.

For cylinders the preferred way of establishing cylinder losses is from measured data on the cylinder concerned, according to BS 1566.

For thermal stores and CPSUs (including electric CPSUs) the preferred way of establishing heat losses is from measured data on the thermal store or CPSU concerned, according to the WMA Performance Specification for thermal stores.

If measured data is not available, losses from the storage vessel should be estimated by multiplying the loss factor from Table 2 by the volume of the vessel and the volume factor from Table 2a.

In all cases, the loss rate is to be multiplied by a temperature factor from Table 2b. This factor accounts for the average temperature of the cylinder or thermal store under typical operating conditions, compared to its temperature under test.

For combi boilers the storage loss factor is zero if the efficiency is taken from Table 4b. The loss is to be included for a storage combination boiler if its efficiency is the manufacturer's declared value or is obtained from the Product Characteristics Database, using the data in Tables 2, 2a and 2b (its insulation thickness and volume are also to be provided by the manufacturer or obtained from the database).

For boiler systems with separate hot water storage, primary losses are incurred in transferring heat from the boiler to the storage; values for primary losses are obtained from Table 3. For a combi boiler the additional loss in Table 3a is included to allow for the draw-off of water until an adequate temperature at the taps is attained (in the case of combi boiler tested to EN 13203-2 or OPS 26 the additional loss is obtained from the test data using Table 3b or Table 3c).

The efficiency of gas and oil boilers for both space and water heating is reduced by 5% if the boiler is not interlocked for space and water heating (see section 9.3.9).

4.3 Community schemes

Where hot water is provided from a community heating scheme:

- a) If there is a hot water cylinder within the dwelling, its size and the appropriate loss factor should be used (Tables 2 and 2a).
- b) If the DHW is provided from the community scheme via a plate heat exchanger use the volume of the heat exchanger (rounded upwards to the nearest litre) and the insulation of it in Tables 2 and 2a; if there are plate heat exchangers for both space and water heating use the volume of both added together.
- c) If neither of the above applies the calculation should assume a cylinder of 110 litres and loss factor of 0.0152 kWh/litre/day.

Primary circuit loss for insulated pipework and cylinderstat should be included (Table 3).

The efficiency for water heating is incorporated in the price of heat for community schemes in Table 12..

4.4 Solar collector

A solar collector coupled with solar water storage reduces the fuel needed for domestic hot water (see Appendix H). The solar water storage can be either as the lower part of a multi heat source cylinder, or as a separate solar cylinder. For shared systems supplying dwellings with community heating see H2 in Appendix H.

4.5 Alternative DHW heating systems

In most cases the system specified for water heating should be that intended to heat the bulk of the hot water during the course of the year. For example, an immersion heater should be disregarded if provided only for backup where the principal water heating system is from a central heating boiler, as should other devices intended for or capable of heating only limited amounts of hot water. Exceptions are (a) micro-CHP and heat pump packages assessed by Appendix N where the package provides DHW only in the heating season, and (b) solid fuel room heaters with a back boiler where an immersion heater is provided to heat water in the summer (see section 12.4.4).

5 INTERNAL GAINS

Internal gains from lights, appliances, cooking and from the occupants of the dwelling (metabolic gains) are estimated from floor area (Table 5).

Gains from central heating pumps located within the heated space and other items should be added and then included in worksheet (70)_m, using the values given in Table 5a.

Gains from the fans in a whole-dwelling mechanical ventilation system should be included, but no useful gains are assumed from individual extractor fans.

6 SOLAR GAINS AND UTILISATION FACTOR

6.1 Solar gains for openings

The heat gain through windows and glazed doors is calculated as

$$G_{\text{solar}} = 0.9 \times A_w \times S \times g_{\perp} \times \text{FF} \times Z \quad (6)$$

where:

G_{solar} is the average solar gain in watts

0.9 is a factor representing the ratio of typical average transmittance to that at normal incidence

A_w is the area of an opening (a window or a glazed door), m²

S is the solar flux on a surface from Table 6a, W/m²

g_{\perp} is the total solar energy transmittance factor of the glazing at normal incidence (see Table 6b)

FF is the frame factor for windows and doors (fraction of opening that is glazed)

Z is the solar access factor from Table 6d

Frame factors (FF) should be assigned per window (or per group of similar windows) particularly where the areas of the windows differ on different facades on the dwelling. Default values are given in Table 6c.

In the case of a window certified by the British Fenestration Rating Council (BFRC), see www.bfrc.org, the quoted solar factor is g_{window} which is equal to $0.9 \times g_{\perp} \times \text{FF}$. The solar gain for such windows is calculated as

$$G_{\text{solar}} = A_w \times S \times g_{\text{window}} \times Z \quad (7)$$

In the case of 'arrow slit' windows where the width of opening at the external side of the wall is substantially less than the width of the window, this should be taken into account by multiplying FF (or in the case of a BFRC-rated window, g_{window}) by the ratio of the opening width at the external surface of the wall to the width of the window.

Solar gains should be calculated separately for each orientation and for rooflights, and then totalled for use in the calculation. E/W orientation of windows may be assumed if the actual orientation is not known*. The solar access factor describes the extent to which radiation is prevented from entering the building by nearby obstacles. The over-shading categories are dependent on how much the view of the sky through the windows is blocked. The categories are defined in Table 6d in terms of the percentage of sky obscured by obstacles (the 'average' category applies in many cases, and can be used for SAP calculations if the over-shading is not known*).

6.2 Openings for which solar gain is included

Openings should be classified as windows, glazed doors or solid doors according to the percentage of glazed area (the percentage of total area of opening that is glass, i.e. excluding framing, mullions, transoms, solid panels etc.). For SAP calculations definitions in Table 6.1 apply:

Table 6.1 : Classification of openings

Category	Description	Glazing area	Solar gain included
1	Solid door	< 30 %	No
2	Glazed door	30% - 60%	No
3	Window	> 60 %	Yes
4	Roof windows	All cases	Yes

Patio doors which have large glazing areas, generally 70% or more, should be treated as windows and so should take account of solar gain. No allowance should be made for solar gain via doors in categories 1 and

* Subject, in the case of a new dwelling, to any requirements of building regulations that apply in the administration where the dwelling will be constructed.

2 even though they have some glazing. French windows often have high frame factors (around 50%) and are thus classified as glazed doors for which no solar gain is included.

6.3 More than one glazing type

Sometimes a dwelling has more than one type of glazing (e.g. some double glazing and some single glazing). In these cases the gains should be calculated separately for each glazing type, and added in the same manner as (74) to (82), to obtain the entry for (83)_m for each month.

6.4 Utilisation factor

The solar gains are added to the internal gains to give total heat gains. A utilisation factor is then applied to the gains, which has the effect of reducing the contribution of gains where they are large in relation to the heat load. This factor is calculated from the ratio of the total heat gains to the heat loss coefficient of the dwelling and is obtained as described in Table 9a.

6.5 Solar gain in summer

Solar gains in summer (see Appendix P) take account of blinds or curtains that can be drawn to reduce solar gain, and overhangs. These factors are not included in the calculation of solar gains in the winter period.

7 MEAN INTERNAL TEMPERATURE

The calculated mean internal temperature for each month is based on the heating requirement of a typical household, taking account of the extent to which the dwelling is insulated and how well the heating can be controlled. The average temperature is obtained separately for the living area and for the rest of the dwelling and then combined to obtain the mean internal temperature for the dwelling, using the data and equations in Tables 9, 9a and 9b.

The temperature difference between the living area and the rest of the dwelling is obtained from Table 9, using the HLP and the 'Control' column of Table 4e.

7.1 Living area fraction

The living area is the room marked on a plan as the lounge or living room, or the largest public room (irrespective of usage by particular occupants), together with any rooms not separated from the lounge or living room by doors, and including any cupboards directly accessed from the lounge or living room. Living area does not, however, extend over more than one storey, even when stairs enter the living area directly.

The **living area fraction** is the floor area of the living area divided by the total floor area.

8 CLIMATIC DATA

Calculations are based on the climatic data (solar radiation, wind speed and external temperature) provided in Tables 6a, 7 and 8.

9 SPACE HEATING REQUIREMENT

The 'useful' energy required from the heating system each month is calculated from internal and external temperatures and the heat transfer coefficient allowing for internal and solar gains. Totalled over one year this quantity is known as the dwelling's Space Heating Requirement and is calculated at worksheet (98).

The quantity of fuel or electrical energy required to provide that useful energy is then calculated for each month, taking account of the efficiency of the space heating system (obtained from Product Characteristics Database or from Table 4a or 4b).

9.1 Heating systems

It is assumed that the dwelling has heating systems capable of heating the entire dwelling. Calculations are on the basis of a main heating system and secondary heaters as described in Appendix A. The proportion of

heat from the main and secondary systems is as given in Table 11. For cases with more than one main system see A1 in Appendix A.

For a new dwelling that has no heating system specified, it should be assumed that the dwelling will be heated by direct acting electric heaters.

For community heating schemes and combined heat and power, see Appendix C. A heating system supplying more than one dwelling should be regarded as a community scheme. This includes schemes for blocks of flats as well as more extended district schemes.

For an electric CPSU, see Appendix F.

9.2 Heating system efficiency (space and DHW)

9.2.1 Heating systems based on a gas or oil boiler

Boiler efficiency may be obtained from:

- a) The Product Characteristics Database (formerly the Boiler Efficiency Database);
- b) Certified manufacturer's data;
- c) Table 4b of this document.

The preferred source of boiler efficiency is the Product Characteristics Database, which contains boiler efficiency figures intended for use in SAP. If a new boiler is not included in the database, manufacturer's data consisting of a winter seasonal efficiency and a summer seasonal efficiency, certified as explained in section D3 (Appendix D), should be used if available. If there is no entry in the database nor certified manufacturer's data an indicative seasonal efficiency should be taken from Table 4b.

In the Product Characteristics Database, gas and oil boilers that were registered with test results have winter and summer SAP seasonal efficiency values calculated using the procedure in Appendix D. Most other (old/obsolete) boilers have estimated values from SAP Table 4b. The database may be viewed on Internet website www.boilers.org.uk and may also be downloaded to suitable SAP calculation programs. It is updated at the start of every month. SAP calculations should always use the most up to date version of the database.

Separate efficiencies are used for space heating and for water heating.

(1) Space heating

The efficiency is the winter seasonal efficiency η_{winter} (from database record or Table 4b), increased if appropriate by an increment from Table 4c. If only the SEDBUK value as used in SAP 2005 is available, obtain the winter seasonal efficiency by following the procedure in D7 then D2.2 (Appendix D). Where appropriate the space heating efficiency is incremented by the adjustment in Table 4c(1).

(2) Water heating by a boiler for which EN 13203-2 or OPS 26 data are not available

If the boiler provides both space and water heating the efficiency is a combination of winter and summer seasonal efficiencies according to the relative proportion of heat needed from the boiler for space and water heating in the month concerned:

$$\eta_{\text{water}} = \frac{Q_{\text{space}} + Q_{\text{water}}}{\frac{Q_{\text{space}}}{\eta_{\text{winter}}} + \frac{Q_{\text{water}}}{\eta_{\text{summer}}}} \quad (8)$$

where

Q_{space} (kWh/month) is the quantity calculated at (98)_m multiplied by (204) or by (205);

Q_{water} (kWh/month) is the quantity calculated at (64)_m;

η_{winter} and η_{summer} are the winter and summer seasonal efficiencies (from database record or Table 4b).

If only the SEDBUK value as used in SAP 2005 is available, obtain the winter and summer seasonal efficiencies by following the procedure in D7 then D2.2 (Appendix D).

If the boiler provides water heating only, $\eta_{\text{water}} = \eta_{\text{summer}}$ for all months.

(3) Water heating by a gas or oil combi boiler where test data according to EN 13203-2 (gas) or OPS 26 (oil) are available in the database record

If the boiler provides both space and water heating use η_{summer} from the database record for the boiler in equation (8) above. In this case different procedures apply to the calculation of storage loss (for a storage combi boiler) and additional combi loss, see Tables 3b and 3c.

If the boiler provides water heating only, $\eta_{\text{water}} = \eta_{\text{summer}}$ for all months.

9.2.2 Gas or oil boiler with flue gas heat recovery system

A condensing gas or oil boiler may be fitted with a flue gas heat recovery system. The requisite parameters are obtained from the Product Characteristics Database. The amendments to the calculation procedure are described in Appendix G.

9.2.3 Heating systems based on a gas or oil range cooker boiler

For definitions see paragraph B4 (Appendix B). Boiler efficiency may be obtained from:

- a) The Product Characteristics Database;
- b) Certified manufacturer's data;
- c) Table 4b of this document.

For twin burner models the preferred source of efficiency is from the database, which contains the boiler seasonal efficiency values and case heat emission data intended for use in SAP. If a new range cooker boiler is not included in the database, manufacturer's data certified as explained in paragraph D6 (Appendix D) may be used. If there is no entry in the database or certified manufacturer's data is not available or it is not of the twin burner type, indicative seasonal efficiency values should be taken from Table 4b.

Separate efficiencies are used for space heating and for water heating, as described in 9.2.1 above.

9.2.4 Heating systems based on a solid fuel boiler

This applies to independent solid fuel boilers, open fires with a back boiler and roomheaters with a boiler.

Boiler efficiency may be obtained from:

- a) The Product Characteristics Database;
- b) Certified manufacturer's data;
- c) Table 4a of this document.

The preferred source of boiler efficiency is the Product Characteristics Database. If a new boiler is not included in the database, manufacturer's certified data should be used if available. Appendix J defines how the efficiency for calculations is determined from test data. If there is no entry in the database and certified manufacturer's data is not available an indicative seasonal efficiency should be taken from Table 4a.

Table 4a gives two sets of efficiency values for solid fuel appliances:

- (A) the minimum efficiency for HETAS approved appliances;
- (B) default values

Values from column (A) can be used for consideration of a design where it is anticipated that a HETAS-approved appliance will be used: data for the actual appliance should be used to provide certificated energy ratings. Values from column (B) should be used for appliances, particularly those already installed in dwellings, for which efficiency data are not available.

Solid fuel boiler efficiencies for open fires and closed roomheaters with boilers are the sum of the heat to water and heat directly to room. It is the designer's responsibility to ensure that the ratio of these figures is

appropriate to the property being modelled. These systems are assigned a lower responsiveness to allow for limitations on the controllability of heat output to the room.

9.2.5 Direct-acting electric boiler

A direct-acting electric boiler (also known as an electric flow boiler) heats water for space heating radiators as it circulates. Possible tariffs are standard tariff, off-peak 7-hour and off-peak 10-hour. Heating control options are the same as for other radiator systems.

Water heating is usually by an electric immersion. The cylinder can be within the same casing as the boiler or it can be a separate cylinder; the treatment in SAP is the same for both of these cases.

9.2.6 Micro-cogeneration (micro-CHP)

Data are obtained from the Product Characteristics Database and used as described in Appendix N. The data provide the secondary heating fraction based on the micro-cogeneration package output power and the design heat loss of the dwelling.

9.2.7 Heat pumps

Heat pump data may be obtained from:

- a) The Product Characteristics Database;
- b) Table 4a of this document.

Heating control options for heat pumps are given in Group 2 (wet systems) or Group 5 (warm air systems) of Table 4e. A bypass arrangement is usually necessary with TRVs to ensure sufficient water is circulating while the heat pump is operating. Zoning arrangements or TRVs may not be appropriate for small domestic installations for this reason.

The preferred source of data for heat pumps is the Product Characteristics Database and the data are used as described in Appendix N. The factors in Table 4c(4) do not apply when the database is used since the data allow for delivery temperature. The data also provide the secondary heating fraction based on the heat pump output power and the design heat loss of the dwelling, and take account of any proportion of domestic water heating provided by an electric immersion (so an immersion should not be specified for the SAP calculation, and equation (9) below does not apply: the water-heating efficiency derived from the database record incorporates any top-up required).

If a heat pump is not included in the database the appropriate seasonal performance factor (SPF) (given in Table 4a under "Efficiency"), multiplied by a factor from Table 4c(4), is used in (207) and (217). Secondary heating should be specified unless it is known that the heat pump has been sized to meet 100% of the space heating requirement. If the heat pump provides domestic hot water heating an electric immersion should be assumed to operate in conjunction with the heat pump unless it is known that the heat pump can provide 100% of the water heating requirement, using an efficiency for water heating given by:

$$\eta_{\text{water}} = \frac{100}{50 \div \text{SPF} + 0.5} \quad (9)$$

where SPF is the seasonal performance factor from Table 4a.

9.2.8 Room heaters

Where available, manufacturer's declared values should be used for the efficiency of gas, oil and solid fuel room heaters, certified as explained in Appendix E.

Otherwise, and for other types of room heaters, the efficiency should be taken from Table 4a.

Gas fires

The following notes provide guidance for identifying the appropriate entry from the room heater section of Table 4a, for gas fires already installed in a dwelling. (They are not intended to classify gas fires for testing purposes.)

Gas fires can be “open” or “closed” fronted. Open fronted means the fuel bed and combustion gases are not “sealed” from the room in which the gas fire is fitted. Such a fire may or may not have a glass panel in front of the fuel bed, but the glass panel will not be sealed to the front of the fire. Closed fronted means the fuel bed and combustion gases are “sealed” (generally with a glass panel sealed to the front of the fire) from the room in which the gas fire is fitted.

Fuel effect gas fires can be “live fuel effect” (LFE), “inset live fuel effect” (ILFE) or “decorative fuel effect” (DFE). The products of combustion from a DFE pass unrestricted from the fire-bed to the chimney or flue; for the LFE/ILFE the products of combustion are restricted before passing into the chimney or flue. For further clarification of LFE/ILFE/DFE see clauses 3.1.2, 3.1.3 and 3.1.4 and Figure 1 of BS 7977-1:2002.

Room heaters with boilers

Gas, oil and solid fuel room heaters can have a boiler, which may provide either domestic hot water only or both space heating and domestic hot water.

For gas back boilers, separate efficiencies apply to the boiler and to the associated room heater. This means that:

- if the back boiler provides space heating, it should be defined as the main heating system, and the gas fire should be indicated as the secondary heater;
- if the back boiler provides domestic hot water only, the boiler efficiency is used for water heating and the gas fire efficiency for space heating (gas fire as main or as secondary heater).

Gas back boilers are found only behind open-flued gas fires without fan assistance. Note that the fire and the boiler share the same flue.

For oil and solid fuel room heaters with boilers, the efficiency is an overall value (i.e. sum of heat to water and heat to room). This means that:

- if the boiler provides space heating, the combination of boiler and room heater should be defined as the main heating system;
- if the boiler provides domestic hot water only, the overall efficiency should be used as the efficiency both for water heating and for the room heater (room heater as main or as secondary heater).

9.2.9 Other heating systems

For other systems the seasonal efficiency should be taken from Table 4a. For systems not covered by the table guidance should be sought from BRE.

9.3 Heating controls

The type of controls incorporated into the heating system influences the SAP rating. This section gives specifications of the types of controls mentioned in Table 4e.

9.3.1 Room thermostat

A sensing device to measure the air temperature within the building and switch on and off the space heating. A single target temperature may be set by the user.

9.3.2 Time switch

A switch operated by a clock to control either space heating or hot water, but not both. The user chooses one or more “on” periods, usually in a daily or weekly cycle.

9.3.3 Programmer

Two switches operated by a clock to control both space heating and hot water. The user chooses one or more “on” periods, usually in a daily or weekly cycle. A mini-programmer allows space heating and hot water to be on together, or hot water alone, but not heating alone. A standard programmer uses the same time settings for space heating and hot water. A full programmer allows the time settings for space heating and hot water to be fully independent.

9.3.4 Programmable room thermostat

A combined time switch and room thermostat which allows the user to set different periods with different target temperatures for space heating, usually in a daily or weekly cycle.

9.3.5 Delayed start thermostat

A device or feature within a device, to delay the chosen starting time for space heating according to the temperature measured inside or outside the building.

9.3.6 Thermostatic radiator valve (TRV)

A radiator valve with an air temperature sensor, used to control the heat output from the radiator by adjusting water flow.

9.3.7 Cylinder thermostat

A sensing device to measure the temperature of the hot water cylinder and switch on and off the water heating. A single target temperature may be set by the user.

Note: A cylinder thermostat should be assumed to be present when the domestic hot water is obtained from a community scheme, an immersion heater, a thermal store, a combi boiler or a CPSU.

9.3.8 Flow switch

A flow switch is a device, which detects when there is no water flow through the system because the TRVs on all radiators are closed.

9.3.9 Boiler interlock

This is not a physical device but an arrangement of the system controls so as to ensure that the boiler does not fire when there is no demand for heat. In a system with a combi boiler it can be achieved by fitting a room thermostat. In a system with a regular boiler it can be achieved by correct wiring interconnections between the room thermostat, cylinder thermostat, and motorised valve(s). It may also be achieved by a suitable boiler energy manager.

In systems without an interlock the boiler is kept cycling even though no water is being circulated through the main radiators or to the hot water cylinder. This results in a reduction in operating efficiency and for this reason Table 4e specifies that a seasonal efficiency reduction of 5% should be made for such systems. For the purposes of the SAP, an interlocked system is one in which both the space and stored water heating are interlocked. If either is not, the 5% seasonal efficiency reduction is applied to both space and water heating; if both are interlocked no reductions are made.

It is also necessary in the SAP to specify whether a hot water cylinder has a thermostat or not. A cylinder thermostat normally shuts down the primary circuit pump once the demand temperature in the cylinder is met. The cylinder thermostat itself might not switch off the boiler; this is only done if the pump and boiler are interlocked and so the presence of a cylinder thermostat does not in itself signify the presence of an interlock for water heating. If there is no cylinder thermostat, however, there can be no interlock since the system does not know when the demand temperature is reached. A boiler system with no cylinder thermostat must therefore be considered as having no interlock.

A boiler system with no room thermostat (or a device equivalent in this context, such as a flow switch or boiler energy manager) - even if there is a cylinder thermostat - must be considered as having no interlock.

For solid fuel boilers and dry core electric boilers the boiler interlock question is not relevant and the efficiency values in Table 4a allow for normal operation of these appliances. For such systems there is no efficiency reduction for the absence of interlock, except where the system has "No thermostatic control", for which the efficiency reduction of 5% is made to the space and water heating efficiencies.

Note: TRVs alone do not perform the boiler interlock function and require the addition of a separate room thermostat in one room.

9.3.10 Bypass

A fixed bypass is an arrangement of pipes that ensures a minimum flow rate is maintained through the boiler. It is commonly used to ensure a minimum flow rate through a boiler and to limit circulation pressure when alternative water paths are closed (particularly in systems with thermostatic radiator valves).

A fixed bypass is achieved either by ensuring that one radiator stays open or by adding a short pipe with a fixed-position valve between the flow and return pipe. A radiator without a TRV or hand valve is a common form of fixed bypass.

An automatic bypass valve controls the water flow through it according to the water pressure difference across it, typically by spring loading, so that the bypass operates only to the extent needed to maintain a minimum flow rate through the system.

The control type 'TRVs + programmer + bypass' is a non-interlocked system in the absence of other arrangements to provide the interlock function.

9.3.11 Boiler energy manager

Typically a device intended to improve boiler control using a selection of features such as weather compensation, load compensation, start control, night setback, frost protection, anti-cycling control and hot water over-ride. For the purposes of the SAP it is an equivalent to a hard-wired interlock, and if present, weather compensation or load compensation.

9.3.12 Time and temperature zone controls

In order for a system to be specified with time and temperature zone control, it must be possible to program the *heating times* of at least two zones independently, as well as having independent temperature controls. It is not necessary for these zones to correspond exactly with the zone division that defines the living area fraction.

In the case of wet systems this involves separate plumbing circuits, either with its own programmer, or separate channels in the same programmer. (By contrast, TRVs provide only independent temperature control.)

Time and temperature zone control can be obtained for electric systems, including underfloor heating, by providing separate temperature and time controls for different rooms.

9.3.13 Weather compensator

A device, or feature within a device, which maintains the temperature inside the building by sensing and limiting the temperature of the water circulating through the boiler and heat emitters in relation to the temperatures measured outside the building.

9.3.14 Load compensator

A device, or feature within a device, which adjusts the temperature of the water circulating through the heating system according to the temperature measured inside the building.

9.3.15 Enhanced load compensator

A device, or feature within a device, which maintains the temperature inside the building by sensing and limiting the temperature of the water circulating through the boiler and heat emitters in relation to the temperature measured inside the building.

9.3.16 Controls for electric storage heaters

There are three types of control that can be used with electric storage heaters - manual charge control, automatic charge control and CELECT-type control.

Automatic charge control can be achieved using internal thermostat(s) or an external temperature sensor to control the extent of charging of the heaters. Availability of electricity to the heaters may be controlled by the electricity supplier on the basis of daily weather predictions (see 24-hour tariff, 12.4.3); this should be treated as automatic charge control.

A CELECT-type controller has electronic sensors throughout the dwelling linked to a central control device. It monitors the individual room sensors and optimises the charging of all the storage heaters individually (and may select direct acting heaters in preference to storage heaters).

10 SPACE COOLING REQUIREMENT

The space cooling requirement should always be calculated (section 8c of the worksheet). It is included in the DER and ratings if the dwelling has a fixed air conditioning system. This is based on standardised cooling patterns of 6 hours/day operation and cooling of part of or all the dwelling to 24°C. Details are given in Tables 10, 10a and 10b and the associated equations.

11 FABRIC ENERGY EFFICIENCY

Fabric Energy Efficiency is defined as the space heating and cooling requirements per square metre of floor area, obtained at worksheet (109) when calculated under the following conditions:

- natural ventilation with intermittent extract fans
- 2 extract fans for total floor area up to 70 m², 3 for total floor area > 70 m² and up to 100 m², 4 for total floor area > 100 m²
- for calculation of heat gains from the hot water system worksheet (46) to (61) inclusive and (63) are set to zero (equivalent to an instantaneous water heater)
- 100% low energy lights
- column (B) of Table 5 is used for internal gains in the heating calculation
- column (A) of Table 5 is used for internal gains in the cooling calculation
- overshadowing not less than average (i.e. very little is changed to average)
- no heat gains from pumps or fans
- the heating system has responsiveness 1.0 and control type 2, no temperature adjustment
- cooled fraction is 1.0

Other data items are those for the actual dwelling. The above are special conditions for calculation of Fabric Energy Efficiency and do not apply for SAP calculations.

12 TOTAL ENERGY USE AND FUEL COSTS

12.1 Energy use

The annual energy use is calculated for the following items:

- main space heating system;
- secondary space heating;
- space cooling
- domestic hot water heating;
- electricity for pumps and fans (including mechanical ventilation if present);
- electricity for lighting.

12.2 Fuel prices

Fuel costs are calculated using the fuel prices given in Table 12. The fuel prices given are averaged over the previous three years and across regions. Other prices must not be used for calculation of SAP ratings.

Since fuels have to relate to realistic heating systems it is important that practical combinations of fuel types are used.

12.3 Electricity tariff

The electricity tariff is specified as one of:

- standard tariff;
- 7-hour off-peak
- 10-hour off-peak
- 24-hour heating tariff

The 24-hour tariff is used only with specifically-designed electric storage systems (see 12.4.3). Otherwise a dwelling can have standard, 7-hour or 10-hour tariff.

The following systems need an off-peak tariff:

- electric storage heaters (7, 10 or 24 hour)
 - electric underfloor heating if marked "off-peak tariffs" in Table 4a (7 or 10 hour)
 - electric dry core or water storage boiler (7 hour)
 - electric CPSU (10 hour)
 - dual electric immersion (7, 10 or 24 hour)
- and the data is inconsistent if standard tariff is indicated when any of the above are specified.

On the other hand the 7-hour or 10-hour tariff is possible with other systems. See also 12.4.3.

If the dwelling is on a 7-hour or a 10-hour tariff the proportions of electricity applied at the high and low rates are defined in Table 12a.

12.4 Main fuel types

Main space heating systems may use any of the fuel types listed in Table 12 as long as they are relevant to the particular heating system. Specifying the main heating fuel is usually straightforward but the following points should be borne in mind.

12.4.1 Gas systems

The choices are mains gas, bulk LPG and bottled gas. Bottled gas is normally used only with gas room heaters. In dwellings where the main heating system uses mains gas or bulk LPG, any gas-fired secondary system should use the same fuel as the main system.

12.4.2 Oil systems

For appliances using mineral oils, use the data in Table 12 for heating oil.

For appliances that can use either mineral oil or liquid biofuel, the factors (for price, CO₂ emissions or primary energy) correspond to the average UK consumption of these fuels for domestic heating. At present they are the same as those for mineral oil.

For appliances that use specific blends of mineral and liquid biofuels the applicable factor is a weighting of those for the constituent parts. At present the only such fuel is B30K (see Table 12).

12.4.3 Electric systems

SAP provides for four electricity tariffs. The standard tariff is the normal domestic supply.

7-hour off-peak is what would generally be called Economy-7 in England, Wales and Northern Ireland, or Economy White Meter in Scotland. There are two unit prices for electricity, depending on time of day. This tariff should be selected when the low-rate availability is during a single period overnight: the actual duration can be between 7 and 8½ hours. When a dwelling is on the 7-hour off-peak tariff, all electricity is charged at the low rate during the low-rate period and at the high rate at other times. Storage heaters are arranged to be charged only during the low-rate period; for other electricity uses (including secondary heating, pumps and fans, lighting and water heating) see Tables 12a and 13 for proportions of electricity used at the high and low rates. This tariff is used in SAP for between 7 and 9 hours of low-rate electricity per day.

The 10-hour off-peak tariff provides 10 hours of low-rate electricity in three periods (typically one during the night, one in the afternoon and one in the evening). It may be described as Economy-10. When a dwelling is on the 7-hour off-peak tariff, all electricity is charged at the low rate during the low-rate period and at the high rate at other times. Storage heaters are arranged to be charged only during the low-rate period; for other electricity uses (including secondary heating, pumps and fans, lighting and water heating) see Tables 12a and 13 for proportions of electricity used at the high and low rates. This tariff is used in SAP for between 10 and 18 hours of low-rate electricity per day.

The 24-hour tariff is for use with storage based systems where the main heating, secondary heating and water heating are all charged at the 24-hour rate. The storage heaters may be recharged at any time of the day with the recharging being remotely controlled by the electricity company. The 24-hour tariff is used only with whole-dwelling heating systems which are designed for about 60% storage and 40% direct-acting heaters. Lights, appliances etc use standard tariff. It is available only in certain areas.

Integrated storage/direct systems comprise:

- a) electric storage heaters with reduced storage capacity but incorporating a direct-acting radiant heater, designed to provide about 80% of the heat output from storage and about 20% from direct-acting;
- b) underfloor heating designed to take about 80% of the heating needs at off-peak times (low rate) and about 20% at on-peak times (high rate). This heating can be controlled by a "low (off-peak) tariff control" which optimises the timing and extent of the off-peak charge according to outside temperature and the quantity of stored heat. Low tariff control optimises the storage of heat in the floor during the low-rate period, and is modelled by a higher system responsiveness.

A secondary system is always to be specified when the main system is electric storage heaters or off-peak electric underfloor heating (portable electric heaters if no secondary system is identified).

12.4.4 Solid fuel systems

Independent boilers can be fuelled by anthracite or wood; some models are 'multi-fuel' able to use either. For solid fuel open room fires the fuel would generally be house coal, smokeless fuel or wood. For further details see Table 12b. Some pellet boilers and stoves may be room sealed, in which case the flue ventilation loss (see section 2) does not apply.

Independent boilers that provide domestic hot water usually do so throughout the year. With open fire back boilers or closed room heaters with boilers, an alternative system (electric immersion) may be provided for heating water in the summer water heating is provided by the boiler for months October to May and by the alternative system for months June to September.

12.4.5 Smoke controls areas

Outside Smoke Control Areas any fuel can be used subject to the manufacturer's instructions for the appliance concerned.

Within Smoke Control Areas solid fuel may be used if:

- (a) it is an Authorised Smokeless Fuel that has been approved by Parliamentary Statutory Instrument for burning in a Smoke Control Area, or
- (b) it will be used on an Exempted Appliance that has been approved by Parliamentary Statutory Instrument for installation in a Smoke Control Area (the exemption applies to a specific fuel or fuels for the appliance concerned).

Fuel	Limitation
House coal*	Not permitted
Anthracite**	-
Smokeless	Authorised smokeless fuel only
Wood logs, wood chips, wood pellets	Exempted appliance only
Dual fuel*	Not permitted

* The calculation cannot be considered as valid under these conditions
 ** Anthracite is natural smokeless fuel that is permitted in Smoke Control Areas

Information on Smoke Control Areas is provided at www.uksmokecontrolareas.co.uk by local authority area. If it is not known whether it is a Smoke Control Area the applicable statement is qualified by "if the dwelling is in a Smoke Control Area".

12.5 Secondary fuel types

Secondary heating systems are taken from the room heaters section of Table 4a and the fuel options will in practice be determined by the fuel used for the main heating system.

12.6 Water heating fuel types

Water heating may be provided by the main heating system or it may be supplied using an independent water heating system.

Whenever water heating is supplied by a system using off-peak electricity it is assumed that a proportion of the water heating will, nevertheless, take place at on-peak times (and so be charged at the high rate). This proportion is calculated using Table 13 and the percentage is dependent on the total floor area and the cylinder size. This table should be linearly interpolated (in both directions where necessary) for intermediate values. The limits of cylinder size in the table are cut-off points, so that if, for instance, the cylinder size used is 105 litres, the values for 110 litres should be used instead.

12.7 Electricity for pumps and fans

An allowance for the electricity used has to be made for systems that include any of the following:

- central heating pump;
- boiler with fan assisted flue;
- warm air heating system fans;
- whole house mechanical ventilation;
- keep-hot facility (electric) for gas combi boilers

Where there is an off-peak tariff the proportions of electricity at the high and low rates are given in Table 12a. Note that the allowance in this section for fan-assisted flues only applies for a main heating system – fan-assisted flues for secondary heaters should not be counted. Data are given in Table 4f.

12.8 Electricity for lighting

The electricity used for lighting is calculated according to the procedure in Appendix L. The calculation allows for low-energy lighting provided by fixed outlets (both dedicated fittings and compact fluorescent lamps) on the basis of the proportion of the fixed outlets that have low-energy fittings.

13 ENERGY COST RATING

The SAP rating is related to the total energy cost by the equations:

$$\text{ECF} = \text{deflator} \times \text{total cost} / (\text{TFA} + 45) \quad (10)$$

$$\text{if ECF} \geq 3.5, \quad \text{SAP 2009} = 117 - 121 \times \log_{10}(\text{ECF}) \quad (11)$$

$$\text{if ECF} < 3.5, \quad \text{SAP 2009} = 100 - 13.95 \times \text{ECF} \quad (12)$$

where the total cost is calculated at (255) or (355) and TFA is the total floor area of the dwelling at (4).

The SAP rating takes into account energy for lighting, and also energy generated in the dwelling using technologies like micro-CHP or photovoltaics.

The SAP rating scale has been set so that SAP 100 is achieved at zero-ECF. It can rise above 100 if the dwelling is a net exporter of energy. The SAP rating is essentially independent of floor area.

The SAP rating is rounded to the nearest integer. If the result of the calculation is less than 1 the rating should be quoted as 1.

Energy efficiency rating bands are defined by the SAP rating according to Table 14.

14 CARBON DIOXIDE EMISSIONS AND PRIMARY ENERGY

CO₂ emissions attributable to a dwelling are those for space and water heating, ventilation and lighting, less the emissions saved by energy generation technologies.

The calculation should proceed by following the appropriate section of the SAP worksheet, designed for calculating carbon dioxide emissions for:

- a) individual heating systems and community heating without combined heat and power (CHP); or
- b) community heating with CHP or utilising waste heat from power stations.

The Environmental Impact Rating (EI rating) is related to the annual CO₂ emissions by:

$$CF = (\text{CO}_2 \text{ emissions}) / (\text{TFA} + 45) \quad (13)$$

$$\text{if } CF \geq 28.3 \quad \text{EI rating} = 200 - 95 \times \log_{10}(CF) \quad (14)$$

$$\text{if } CF < 28.3 \quad \text{EI rating} = 100 - 1.34 \times CF \quad (15)$$

where the CO₂ emissions are calculated at (271) or (385) and TFA is the total floor area of the dwelling at (4).

The EI rating scale has been set so that EI 100 is achieved at zero net emissions. It can rise above 100 if the dwelling is a net exporter of energy. The EI rating is essentially independent of floor area.

The EI rating is rounded to the nearest integer. If the result of the calculation is less than 1 the rating should be quoted as 1.

Environmental impact rating bands are defined by the EI rating according to Table 14.

Primary energy is calculated in the same way as CO₂ emission using the primary energy factors in Table 12 in place of the CO₂ emission factors.

15 BUILDING REGULATIONS AND DWELLING EMISSIONS RATE (DER)

Building regulations may refer to CO₂ emissions as calculated by the SAP as a method of demonstrating compliance with regulations for the conservation of fuel and power and/or limitation of energy use.

If the applicable regulatory document makes any specific requirements for the calculations (e.g. to specify that reduced internal heat gains are used), these are to be followed for calculations being made to demonstrate compliance with the regulations concerned.

The current requirements of regulations can be checked against documents available at:

England & Wales	www.communities.gov.uk
Scotland	www.scotland.gov.uk/bsd
Northern Ireland	www.buildingregulationsni.gov.uk

Appendix R gives reference values to define a notional dwelling, which may be referred to in building regulations in connection with establishing a target CO₂ emissions rate.

As at the date of this document, building regulations in all three jurisdictions mentioned above place limitations on the permissible annual CO₂ emissions from new dwellings, expressed in kilograms per square metre of floor area (kg/m²). This quantity, when calculated taking account of specific requirements in the applicable regulatory document and expressed in kilograms per unit floor area to two decimal places, is known as the Dwelling Emissions Rate, or DER. The applicable regulatory document may impose specific conditions for the calculation of the DER, which must be followed for DER calculations.

16 CO₂ EMISSIONS ASSOCIATED WITH APPLIANCES AND COOKING AND SITE-WIDE ELECTRICITY GENERATION TECHNOLOGIES

SAP calculations are extended to allow for CO₂ emissions associated with appliances and cooking, and to allow for site-wide electricity generation technologies. This calculation procedure is in support of inter alia (a) Level 6 of the Code for Sustainable Homes, (b) limitation of or exemption from Stamp Duty Land Tax for zero carbon homes as defined in regulations made under sections 58B and 58C of Finance Act 2003 (presently the Stamp Duty Land Tax (Zero-Carbon Homes Relief) Regulations 2007, S.I. 2007 No. 3437)

and (c) rates relief for zero carbon homes as defined in the Rates Relief (Low Carbon Homes Scheme) Regulations (Northern Ireland) 2010, S.R. 2010 No. 66³.

Where the applicable conditions are met the dwelling can be assessed for net CO₂ emissions by the following procedure. Data for this calculation are obtained from the DER calculation worksheet.

		<u>kg/m²/year</u>
DER	(271) or (385) =	<input type="text"/> (ZC1)
CO ₂ emissions from appliances, equation (L14)		<input type="text"/> (ZC2)
CO ₂ emissions from cooking, equation (L16)		<input type="text"/> (ZC3)
Total CO ₂ emissions	(ZC1) + (ZC2) + (ZC3) =	<input type="text"/> (ZC4)
Residual CO ₂ emissions offset from biofuel CHP <i>value at (373) before setting or (373) to zero, where applicable, divided by the total floor area of the dwelling</i>		<input type="text"/> (ZC5)
Additional allowable electricity generation, kWh/m ² /year	<input type="text"/>	(ZC6)
Resulting CO ₂ emissions offset from additional allowable electricity generation	-(ZC6) × EF =	<input type="text"/> (ZC7)
Net CO ₂ emissions	(ZC4) + (ZC5) + (ZC7) =	<input type="text"/> (ZC8)

Concerning (ZC5) see C7 in Appendix C.

EF for the calculation of (ZC7) is the CO₂ emission factor in Table 12 for electricity displaced from grid (kg/kWh).

The entries in (ZC5) and (ZC7) are negative quantities.

Additional allowable electricity generation for (ZC6) includes electricity generated by:

- wind generators
- photovoltaic panels
- hydro-electric generators

where these generators conform with applicable rules and regulations for the purpose of the calculation and not already included at (233) to (235) or (333) to (334). For further details see Appendix M. The electricity generated in kWh/year is divided by the total floor area of buildings on the development to obtain the value for (ZC6).

³ Future legislation may define a zero carbon home or dwelling in a different way and for that reason a definition of zero carbon home is omitted from this document.

References

1. **Anderson B R, A J Clark, R Baldwin and N O Milbank**, *BREDEM The BRE Domestic Energy Model: background, philosophy and description*. BRE Report: BR 66, BRE, Garston, 1985.
2. **Henderson G and L D Shorrock**, *BREDEM - BRE Domestic Energy Model - testing the predictions of a two zone model*, Build. Serv. Eng. Res. Technol., 7(2) 1986, pp87-91.
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7. **Basements for dwellings**. Approved Document, British Cement Association, BCA, Crowthorne, 1997. ISBN 0-7210-1508-5

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List of standards referred to in this document

Reference	Title	Content
BS EN ISO 6946	Building components and building elements – Thermal resistance and thermal transmittance – Calculation method	Calculation of U-values for walls and roofs.
BS EN ISO 13789	Thermal performance of buildings – transmission and ventilation heat transfer coefficients – Calculation method	Heat loss rate from whole building
BS EN ISO 10456	Building materials and products – Hygrothermal properties – Tabulated design values and procedures for determining declared and design thermal values	Lists of thermal data for materials
BS EN ISO 10077-1	Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 1: General	U-values for windows and doors
BS EN ISO 10077-2	Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 2: Numerical method for frames	U-values for window frames
BS EN ISO 12567	Thermal performance of windows and doors – Determination of thermal transmittance by hot box method	U-value measurement for windows and doors
BS EN ISO 13370	Thermal performance of buildings – Heat transfer via the ground – Calculation methods	U-values for floors
BS EN ISO 13790	Energy performance of buildings – Calculation of energy use for space heating and cooling	Energy calculations
BS EN 13203-2	Gas-fired domestic appliances producing hot water – Appliances not exceeding 70 kW heat input and 300 l water storage capacity – Part 2: Assessment of energy consumption	Efficiency of gas combi boilers for DHW heating.
OFTEC Oil Firing Product Standard OPS 26	Guidance for the use of BS EN 13203-2:2006 for liquid fuel fired combination boilers up to 70 kW rated input and with up to 100 litres hot water storage capacity	Efficiency of oil combi boilers for DHW heating.
BS 7977-1	Specification for safety and rational use of energy of domestic gas appliances – Part 1: Radiant/convectors	Gas fires

British Standards are available from:

BSI
 Chiswick High Road
 London
 W4 4AL
 Tel: 020 8996 9001
 Fax: 020 8996 7001
www.bsigroup.com

Appendix A: Main and secondary heating systems

A1 General principles

The **main heating system** is that which heats the largest proportion of dwelling. It is a heating system which is not usually based on individual room heaters (although it can be), and often provides hot water as well as space heating. Main heating systems are either identified via the Product Characteristics Database or are categorised on the basis of the generic types in Tables 4a and 4b.

Occasionally there may be two central heating systems, for example two separate boilers used to heat different parts of the property or a system that utilises more than one heat-raising technology. The total space heating requirement (98) is divided between the two systems in proportion to the amount of heat provided by each system. Unless specified otherwise for particular systems, the proportion of heat provided should be taken as the relative heated floor area served by each system. The calculation of the space heating requirement uses the characteristics (responsiveness and control type) of the system providing the greater proportion of the heat; if equal the system of lower efficiency and if then still equal the system of lower responsiveness. Separate efficiencies, costs and emission factors are then applied for each system.

The **secondary heating system** is based upon a room heater. Secondary heating systems are taken from the room heaters section of Table 4a.

Only fixed secondary heaters are included in a description of the property (e.g. a gas fire, a chimney and hearth capable of supporting an open fire, a wall-mounted electric fire).

Except as mentioned in the next paragraph, portable heaters are not counted for the purposes of SAP assessments: these are characterised by being:

- completely free standing and self supporting on feet, legs or base on the floor, i.e. not wall mounted or specifically designed for a fireplace, and in the case of gas or oil heaters containing a built-in fuel store; and
- readily and easily transferred and relocated from one room to another, in the case of an electric heater having a lead and a plug.

A secondary system is always specified when the main system is electric storage heaters or off-peak electric underfloor heating. If no secondary heater is identified, portable electric heaters are specified.

For detailed selection rules for main and secondary systems see A2 below.

If a fixed secondary heater is not present, a secondary heating system is nevertheless used for the calculation of the energy use and energy ratings where the main system is not sufficient in itself to heat all habitable rooms in the dwelling to the level on which the SAP is based (21°C in the living area and 18°C elsewhere). This should be taken as applicable if there are any habitable rooms without heat emitters associated with the main heating system. See section A4 as regards the calculation routine.

Note that building regulations or other regulations may make additional specifications in relation to secondary heaters, which should be followed in the case of compliance calculations.

The SAP calculation is based on the characteristics of the dwelling and the systems installed and not on the heating practices of the occupying household. That does not preclude further estimates of energy consumption being made to take account of actual usage. Such estimates are not part of SAP but could form the basis of advice given to the occupying household on how to make best use of the systems at their disposal.

A2 Procedure for identifying main and secondary heating systems

A2.1 Identifying the main system

- (1) If there is a central system that provides both space and water heating and it is capable of heating at least 30% of the dwelling, select that system as the main heating system. If there is no system that

provides both space and water heating, then select the system that has the capability of heating the greatest part of the dwelling. For this purpose only habitable rooms should be considered (i.e. ignore heaters in non-habitable rooms).

- (2) If there is still doubt about which system should be selected as the main system, select the system that supplies useful heat to the dwelling at lowest cost (obtained by dividing fuel cost by conversion efficiency).

A2.2 Identifying the secondary system

- (1) Count the number of habitable rooms and the number heated habitable rooms (for the definition of habitable rooms see S9.1 in Appendix S).
- (2) If a fixed secondary heater is found in a habitable room, that heater is the secondary, whether or not there are any unheated habitable rooms.
- (3) If there is an unheated habitable room and no fixed secondary heater in any habitable room, but there is a fixed heater in a non-habitable room, that heater is the secondary.
- (4) If no heater is identified in (2) or (3) there is no fixed secondary heater.

In some cases it may not be immediately clear which of two systems present should be classified as the main system and which as the secondary. In these cases the system which is cheapest to use should be taken as the main system, and if there is still doubt, i.e. if they are both equally cheap to use, select the system that heats the living room. The other system can still be input as a secondary system but it needs to be input as a room heater. A room heater system should be chosen so that its efficiency closely reflects (but does not exceed) that of the actual system (as defined by Table 4a). The chosen room heater should also use the same fuel/tariff as the actual system.

If two types of secondary heater are present, that which heats the greater number of rooms should be specified as the secondary system. If that condition does not resolve the choice, the system which is the cheapest to run should be specified.

A3 Dwellings with inadequate heating systems

A3.1 New dwellings

The SAP assumes that a good standard of heating will be achieved throughout the dwelling. For dwellings in which the heating system is not capable of providing the standard, it should be assumed that the additional heating is provided by electric heaters, using the fraction given in Table 11 (but see also A3.3). For new dwellings that have no heating system specified, it should be assumed that all heat will be provided by electric heaters using electricity at the standard domestic tariff.

A3.2 Existing dwellings

Some existing dwellings have heaters only in a limited number of rooms, generally gas or electric fires. In these cases the usual basis of calculation, that the dwelling is fully heated, still applies. Rooms without heaters are assumed to be heated by electric room heaters. The choice between main and secondary heating for the purposes of the calculation is decided as follows.

- (1) If 25% or less of the habitable rooms are actually heated, and are heated by room heater(s) using a fuel other than electricity, the (assumed) electric system is the main system for the purposes of the calculation and the other fuel is the secondary. This applies only if the identified main heater is a room heater and there is no identified secondary heater, and is subject to A3.3 below. If water heating is from the main system (e.g. the room heater has a back boiler) the water heating becomes from the secondary system for the calculation. A heated room means one with a heat emitter in the room.
- (2) If the number of habitable rooms actually heated is more than 25% but there is no identified secondary heater according to the rules in A2.2, the heaters in these rooms are the main system and the (assumed) electric heaters are the secondary.

- (3) If the number of habitable rooms actually heated is more than 25% and a secondary heater is identified, the procedure for assigning main and secondary heating systems outlined in section A2 applies.

Examples. A house with 6 habitable rooms with one gas fire would be treated as being electrically heated with a gas secondary heater (1 room out of 6). If there were two gas fires (2 rooms out of 6), the gas fires are the main heating and electricity the secondary. If there were 4 habitable rooms, and one gas fire (1 out of 4), the main heating would be electric and the gas fire the secondary.

A3.3 Highly insulated small dwellings

In the case of highly insulated small dwellings, item (1) in A3.2 may not be realistic, for example a 3 kW gas fire could suffice to provide most of the heating needs. Accordingly, if the design heat loss (DHL) is less than 3 kW, the heating in the main room is the main system irrespective of the number of rooms heated. For this purpose, DHL is the annual average heat loss coefficient as calculated at box (37) of the worksheet, multiplied by a design temperature difference of 20 K.

A3.4 Broken heating systems or no heating system

SAP assumes that the installed heating systems are operational and takes no account of whether they are working or not. However, in the case where the main heating unit (e.g. boiler) is missing and thus the dwelling has no installed main heating system, or if there is no heating system present at all, the calculation should be done for main heating as direct electric heaters in all rooms (no secondary heaters).

A4 Description of the dwelling's heating systems and software implementation

A SAP assessor should record, for the purposes of entry into SAP calculation software, the actual heating systems (as found in the dwelling in the case of a site survey or indicated on building plans or associated documentation in the case of new construction), together with the number of habitable rooms and the number of heated habitable rooms. Where case A3.2 (1) applies, the description of the property includes the actual main system. Where a choice has to be made between alternative systems, as described in Section A2, the SAP assessor should make the choice according to the circumstances existing in the property while recording in a separate note any other fixed heaters present.

Software implementing the SAP calculation procedure then applies the remaining rules of this Appendix, namely:

- a) If there is no heating system, assign electric heaters as the main system heating all rooms (no secondary system).
- b) If 25% or less of the habitable rooms are heated and their heating is by a room heater (not electric), assign electric heaters as the main system and the identified room heaters as the secondary system, applying the secondary fraction according to Table 11 for electric room heaters as the main system.
- c) Otherwise if there are any unheated habitable rooms and no secondary system has been identified, undertake the calculation with electric secondary heating.
- d) If any fixed secondary heater has been identified, the calculation proceeds with the identified secondary heater, whether or not there are unheated habitable rooms.
- e) If there are no unheated habitable rooms and no fixed secondary heater in a habitable room, undertake the calculation with no secondary heating.
- f) An assumed heater, where main or secondary, is an electric portable heater. In case of main heating it does not have thermostatic control.

Table 11 gives the fraction of the heating that is assumed to be supplied by the secondary system. The treatment of secondary systems is not affected by any control options for the secondary system.

Appendix B: Gas and oil boiler systems, boilers with a thermal store, and range cooker boilers

B1 Boilers in the database

The Product Characteristics Database (see section 9.2.1) contains, in addition to efficiency, all the boiler parameters relevant to SAP calculations.

B2 Gas and oil boiler systems in Table 4b

General definitions of the various modern boiler types are given in Appendix D. Table 4b gives efficiency values for use when measured data are not available. The following notes give guidance for the categories in Table 4b.

B2.1 Combination boilers

Table 4b does not distinguish between the sub-types of combination boiler, and the values given for 'combi' apply to all sub-types (on/off or modulating, instantaneous or storage).

For definitions of storage combination boilers see D1.10 to D1.12 in Appendix D.

A combination boiler with an internal hot water store may be either:

- primary a primary water store contains mainly water which is common with the space heating circuit.
- secondary a secondary water store contains mainly water which is directly usable as domestic hot water.

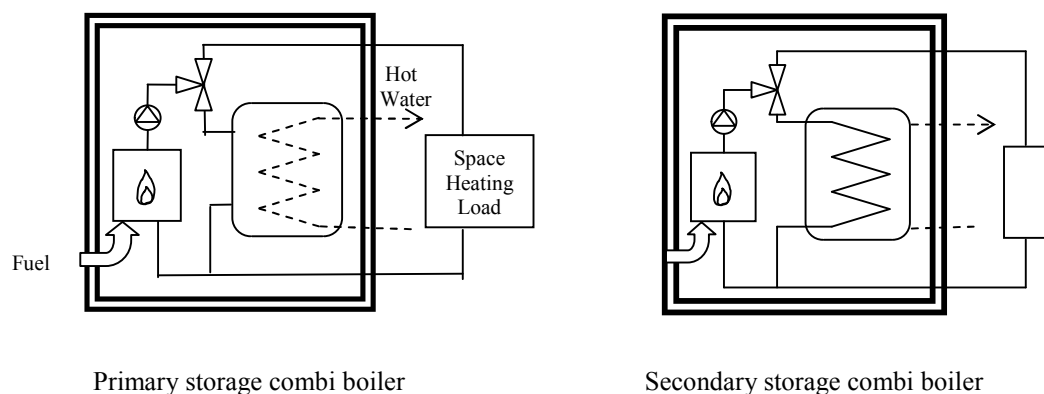


Figure B1 Primary and secondary storage combi boilers

The essential difference between a CPSU (see section B2.5) and a storage combination boiler with a larger primary store is that in the case of a CPSU the feed to the space heating circuit is taken from the store, while in the case of a storage combi with a larger primary store, the store does not feed the space heating circuit.

B2.2 Boilers 1998 or later

If the ignition type is not known, a boiler with a fan-assisted flue may be assumed to have automatic ignition, and one with an open flue to have a permanent pilot light.

B2.3 Boilers with fan-assisted flue

‘Low thermal capacity’ means a boiler either having a copper heat exchanger or having an internal water content not exceeding 5 litres. If the position is uncertain the category of ‘high thermal capacity’ should be used.

B2.4 Boiler selected by date

The date refers to the year of manufacture of the boiler. If this is uncertain the older category should be used.

B2.5 Combined Primary Storage Unit (CPSU)

A CPSU is defined in D1.13 and D1.14. The store must be at least 70 litres - if the store is less than 70 litres, the appliance should be treated as a storage combination boiler. A schematic illustration of a CPSU is shown in Figure B2.

Note: If the store is a different appliance from the boiler (ie contained within a separate overall casing) the system should be treated as a boiler with a thermal store as described in B3.

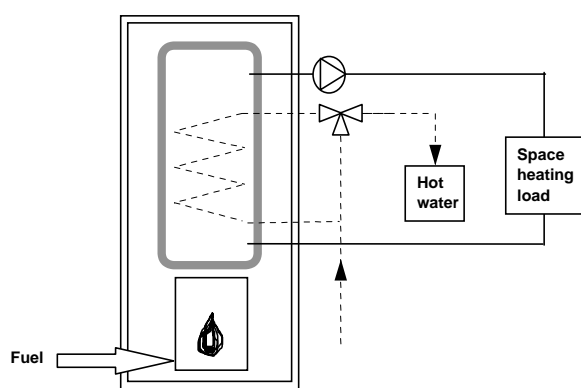


Figure B2 Combined primary storage unit (CPSU)

B3 Boilers with a thermal store

All systems described in this section have hot water stores as a separate appliance from the boiler.

B3.1 Integrated thermal store

An integrated thermal store is designed to store primary hot water, which can be used directly for space heating and indirectly for domestic hot water. The heated primary water is circulated to the space heating (e.g. radiators). The domestic hot water is heated instantaneously by transferring the heat from the stored primary water to the domestic hot water flowing through the heat exchanger. A schematic illustration of an integrated thermal store is shown in Figure B3.

For an appliance to qualify as an integrated thermal store, the specification for integrated thermal stores⁴ must be complied with, and at least 70 litres of the store volume must be available to act as a buffer to the space heating demand. If the WMA specification is not met then the device should be treated like a conventional boiler and hot water cylinder. If only the volume requirement is not met, then the device may be treated as a hot water only thermal store.

⁴ Performance Specification for Thermal Stores, 1999. Obtainable from the Hot Water Association (www.hotwater.org.uk)

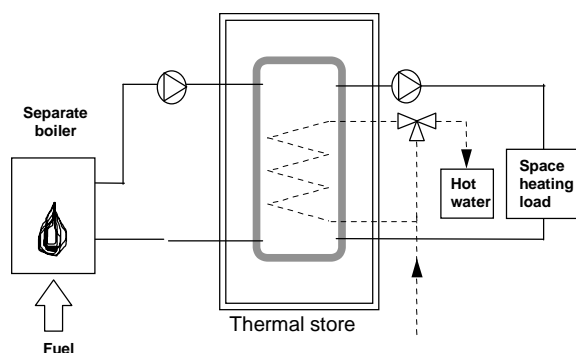


Figure B3 Integrated thermal store

B3.2 Hot water only thermal store

A hot water only thermal store is designed to provide domestic hot water only and is heated by a boiler. The domestic hot water is heated by transferring the heat from the primary stored water to the domestic hot water flowing through the heat exchanger, the space heating demand being met directly by the boiler. A schematic illustration of a hot water only thermal store is shown in Figure B4.

For an appliance to qualify as a hot water only thermal store, the WMA specification for hot water only thermal stores must be complied with. If this requirement is not met then the device should be treated like a conventional boiler and hot water cylinder.

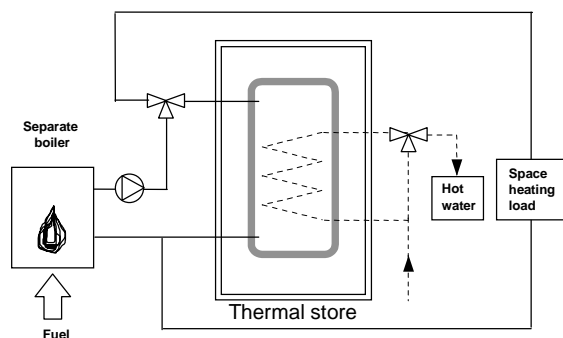


Figure B4 Hot water only thermal store

B4 Range cookers

Range cookers are flued cooking appliances predominantly constructed of cast iron designed to provide some heat from their case into the space in which they are located. There are three types.

B4.1 Range cooker with boiler for space heating

This type provide an independent water heating function for space heating in addition to the cooking function. There are two design variations:

- (i) **Twin burner range cooker/boiler** – an appliance with two independently controlled burners, one for the cooking function, one for the water heating function for space and/or water heating
- (ii) **Single burner range cooker/boiler** – an appliance with a single burner that provides a cooking function and a water heating function for space and/or water heating

For the twin burner type, the efficiency can be can be from the Product Characteristics Database, manufacturer's declaration or Table 4b, as explained in section 9.2.2 of this document.

For the single burner type, the efficiency should be obtained from Table 4b.

B4.2 Single burner range cooker/water heater

This type provides a cooking function and some heating of domestic hot water.

B4.3 Single burner dry heat range cooker

This type is an appliance with a single burner that provides a cooking function. It is not included in SAP calculations.

Appendix C: Community heating, including schemes with Combined Heat and Power (CHP) and schemes that recover heat from power stations

C1 Community heating where heat is produced by centralised unit by dedicated plant

In community schemes, also known as group or district schemes, heat produced centrally serves a number of dwellings or communal areas.

CHP (Combined heat and Power) is defined as the simultaneous generation of heat and power in a single process.

There are two principal ways of producing heat for community heating by a dedicated plant (but see also section C5):

- heat produced by boilers only (Figure C1);
- heat produced by a combination of boilers and CHP units (Figure C2).

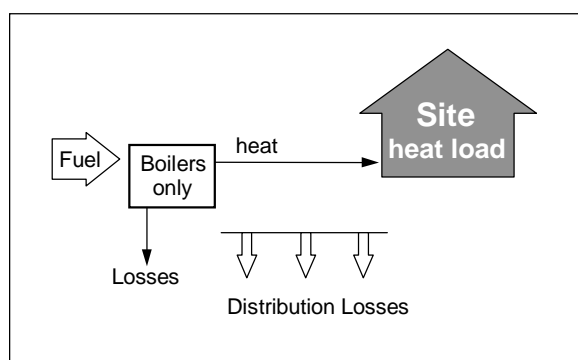


Figure C1 : Community heating with heat supplied by boilers only

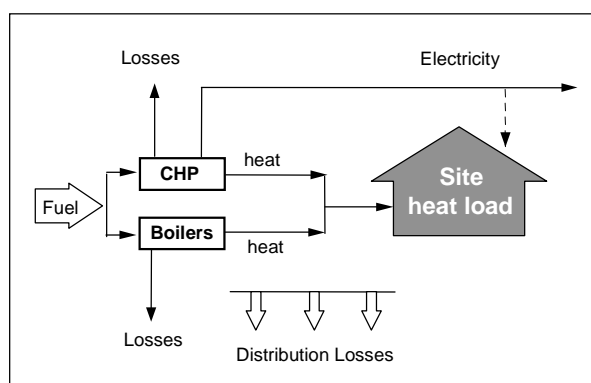


Figure C2 : Community heating with heat supplied by a combination of boilers and CHP

For community heating with CHP, the CHP unit is the primary heat source, and back-up boilers of conventional design are used when the heat output of the CHP plant is insufficient to meet the instantaneous demand. The proportion of heat from CHP and from boilers varies from installation to installation.

The proportions of heat from the CHP and from conventional boilers, and the heat and electrical efficiencies of the CHP for the calculation of CO₂ emissions, should be obtained either on the basis of operational records or in the case of a new scheme on the basis of its design specification. Heat efficiency is defined as the annual useful heat supplied from a CHP scheme divided by the total annual fuel input. The power efficiency is the total annual power output divided by the total annual fuel input. A credit for CO₂

The heat efficiency of the CHP should be based on the useful heat supplied by the CHP to the community heating, excluding any dumped heat (see Figure C3).

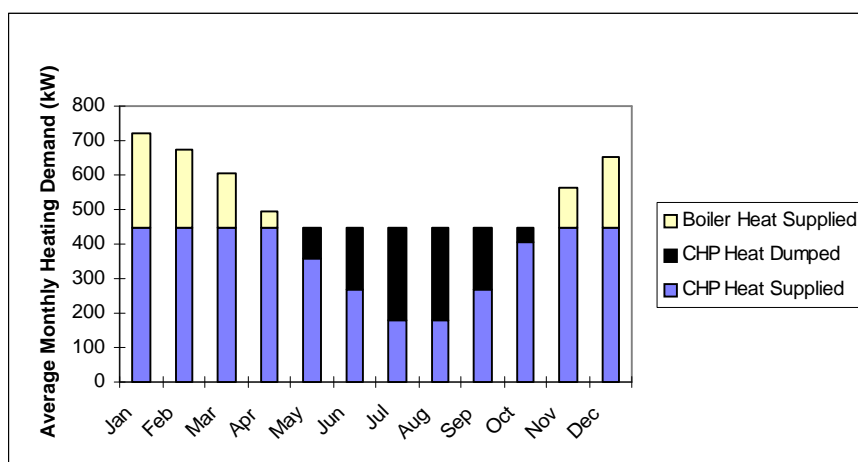


Figure C3 : An example of a heat profile chart

The heat required for space and water heating is calculated using an alternative worksheet, designed for calculating SAP when space and water heating is provided by community heating (with or without CHP). The heat price for community heating is taken from Table 12. This price incorporates bulk rates for buying the fuel used in the plant, operating costs, energy used in pumping the hot water and, in the case of CHP, receipts from the sale of the electricity generated. The factor in Table 4c(3) allows for controls and charging method.

For the calculation of CO₂ emissions, the efficiency to be used is that of the generating plant. A default figure is given in Table 4a for community boilers but, if known, the actual efficiency of the heat generators should be used instead: see C2. For CHP plant, the efficiency can be specified as either (a) the heat efficiency and the electrical efficiency, or (b) the overall efficiency and the heat-to-power ratio.

C2 Boiler efficiency

The efficiency of community boilers is assessed for SAP purposes in the same way as for domestic boilers. The procedures described in Appendix D should be followed, including for boilers with rated output over 400 kW, except that the winter efficiency as calculated in D2.2 is used for all parts of the year (thus a separate summer efficiency need not be calculated or declared).

Where boilers of different efficiency are used in combination the efficiency for SAP purposes is a weighted average:

$$\eta_{\text{average}} = \frac{\sum_{j=1}^n R_j \times \eta_j}{\sum_{j=1}^n R_j}$$

where

n is the number of boilers

R_j is the rated output of boiler j

η_j is the winter efficiency of boiler j calculated as set out in D2.2

C3 Heat distribution

C3.1 Distribution loss

Heat loss in the distribution network is allowed for by increasing the heat to be supplied by the community heating scheme by a 'distribution loss factor'.

The distribution loss factor is taken from Table 12c if any of the following conditions are met:

- 1) The only dwellings connected to any part of the network are flats, or
- 2) The total trench length of the network is no longer than 100 metres, or
- 3) The linear heat density is not less than 2 MWh/year per metre of network.

If conditions 1) or 2) are not satisfied then the linear heat density of the network should be sought from the scheme manager (or designer in the case of a new scheme) to determine whether condition 3) is satisfied.

Linear heat density is defined as the total heat delivered to all premises connected to the distribution network in MWh/year divided by the total length of the whole distribution network ("trench length") in metres.

Where the linear heat density is less than 2 MWh/m/year or is unknown methods that may be employed by the scheme manager or designer to determine the distribution loss factor are:

- (a) if the scheme has full heat metering at all connections to the distribution network, then the total heat supplied to the network from the energy centre(s) divided by the sum of the heat delivered from all the network connections (either to whole buildings or individual apartments), measured over a one year period (the same period for both), or
- (b) by the formula

$$1 + \text{linear loss} \times \text{total length of pipework} \div (\text{total heat supplied} \times 114)$$

where:

'linear loss' is the average heat loss per metre run of pipework in W/m, calculated in accordance with ISO 12241, equations (8) and (9);

'total length of pipework' is the length of the distribution system pipes for the whole scheme in metres;

'total heat supplied' is the heat supplied from the energy centre(s) to the distribution network over a whole year, in MWh/year;

114 converts MWh/year to W.

If the distribution loss factor cannot be calculated from scheme data a value of 1.5 should be used.

C3.2 Energy for pumping

CO₂ emissions associated with the electricity used for pumping water through the distribution system are allowed for by adding electrical energy equal to 1% of the energy required for space and water heating.

C4 Community heating schemes that recover waste heat from power stations

This includes waste heat from power stations rated at more than 10 MW electrical output and with a power efficiency greater than 35%. (Otherwise the system should be considered as CHP.)

For community schemes that recover heat from power stations, the waste heat is the primary heat source, and secondary boilers of conventional design are used when the available waste heat is insufficient to meet the instantaneous demand. The proportions of heat from the power station and from the conventional boilers should be estimated, either on the basis of operational records or in the case of a new scheme on the basis of its design specification.

Note: The applicable emission factor in Table 12 reflects emissions associated with the electricity used for pumping the water from the power station.

C5 Permutations of heat generators

Possible systems for community heating schemes include:

1. A single boiler or set of boilers all using the same fuel. In the case of a set of boilers the average seasonal efficiency for the boilers is used for the calculation (see C2).
2. Two or more boilers or two or more sets of boilers, using different fuels such as mains gas and biomass. In this case the total heat requirement is divided between the boilers or sets of boilers according to the design specification of the overall system. Different average seasonal efficiencies apply to the sets of boilers and the CO₂ emissions are calculated using the emission factors of the respective fuels.
3. CHP plant and boiler(s), calculations according to section C1.

If there are two or more boilers or two or more sets of boilers using different fuels (in addition to the CHP plant) the heat requirement from boilers is divided between the boilers or sets of boilers according to the design specification of the overall system. Different average seasonal efficiencies apply to the sets of boilers and the CO₂ emissions are calculated using the emission factors of the respective fuels.

4. Utilisation of waste heat from a power station topped up by boilers.
5. Geothermal heat topped up by boilers.
6. An electrically driven heat pump with various possibilities as to heat source, such as the ground or waste heat from an industrial process. The calculation is essentially the same as that for boiler systems, with the seasonal performance factor (SPF) for the heat pump system being used in place of boiler efficiency. The SPF should take account of winter and summer operations as appropriate and of the temperature of the heat source.

C6 Community scheme providing DHW only

Some community schemes provide DHW only, with the space heating provided by heaters in each dwelling.

In this case the specification and calculation of space heating is the same as for a dwelling not connected to a community scheme. This includes a main heating system and secondary heaters.

A DHW-only community scheme can be:

- from community boilers;
- from a community heat pump;
- from a community CHP

Data required are:

- fuel used by community scheme (same fuel options as for community scheme providing space and water heating)
- efficiency of community boilers, heat pump or CHP
- if CHP, the heat-to-power ratio
- heat distribution characteristics for the distribution loss factor (Table 12c)
- whether a hot water cylinder is in the dwelling and if so its volume plus either its measured loss factor or its insulation type and insulation thickness.

The water heating calculation follows that for a full community scheme including, if there is not a cylinder in the dwelling, assigning for the purposes of the calculation a 110 litre cylinder with 50 mm factory-applied insulation. The control factor, Table 4c 3), is not applicable and 1.0 should be used for water heating (but allowing for the distribution loss factor from Table 12c). Include one-half of the normal

community standing charge in the calculation of fuel costs unless the space heating is also a community system (see next paragraph).

This also allows for the case where the community system is different for space heating and for water heating. Separate community heating parameters apply to each system including heat distribution characteristics. In this case the total standing charge is the normal community standing charge.

C7 Community biofuel CHP

For community heating with CHP, it is possible for the total CO₂ emissions calculated at (373) to be negative. Once this quantity becomes negative, it becomes advantageous to increase the heating requirements of the dwellings, e.g. by removing insulation. Accordingly (373) should be set to zero unless the specification calling up the SAP calculation states otherwise (usually accompanied by a condition that results in a high standard of insulation).

When (373) has been set to zero, the residual negative amount is carried forward for possible use in consideration of zero carbon homes (see section 16). Unless the specification calling up the SAP calculation states otherwise this is permissible only when:

- (a) the DER is less than or equal to 0; and
- (b) the Heat Loss Parameter (HLP) does not exceed 0.8 W/m²K; and
- (c) the community CHP is fuelled by a biofuel, not a fossil fuel.

Appendix D: Method of determining seasonal efficiency values for gas and oil boilers

Note: The data and equations in this appendix are for manufacturers to calculate seasonal efficiency for declaration purposes. They are not to be used by SAP assessors.

This appendix sets out, in D2 and D4, the method to be used by manufacturers to determine seasonal efficiency for particular gas and oil boilers when test data have been obtained to establish conformity with Council Directive 92/42/EEC⁵. This Directive has been implemented in the UK by the Boiler (Efficiency) Regulations⁶.

Manufacturers' declarations of seasonal efficiency values so calculated should be accompanied by the form of words in D3, and SAP assessors should look for the same form of words in order to ascertain that the efficiency value referred to is appropriate for SAP calculations.

Range cooker boilers with twin burners are covered by D5 and D6.

D1 Definitions

D1.1 Boiler

A gas or liquid fuelled appliance designed to provide hot water for space heating. It may (but need not) be designed to provide domestic hot water as well.

D1.2 Condensing boiler

A boiler designed to make use of the latent heat released by the condensation of water vapour in the combustion flue products. The boiler must allow the condensate to leave the heat exchanger in liquid form by way of a condensate drain. 'Condensing' may only be applied to the definitions D1.3 to D1.14 inclusive. Boilers not so designed, or without the means to remove the condensate in liquid form, are called 'non-condensing'.

D1.3 Regular boiler

A boiler which does not have the capability to provide domestic hot water directly (ie not a combination boiler). It may nevertheless provide domestic hot water indirectly via a separate hot water storage cylinder.

D1.4 On/off regular boiler

A regular boiler without the capability to vary the fuel burning rate whilst maintaining continuous burner firing. This includes those with alternative burning rates set once only at time of installation, referred to as range rating.

D1.5 Modulating regular boiler

A regular boiler with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

D1.6 Combination boiler

A boiler with the capability to provide domestic hot water directly, in some cases containing an internal hot water store.

D1.7 Instantaneous combination boiler

A combination boiler without an internal hot water store, or with an internal hot water store of capacity less than 15 litres.

⁵ Council Directive 92/42/EEC on efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels. Official Journal of the European Communities No L/167/17. 21 May 1992, p. 92.

⁶ The Boiler (Efficiency) Regulations 1993, SI (1993) No 3083, as amended by the Boiler (Efficiency) (Amendment) Regulations 1994, SI (1994) No 3083.

D1.8 On/off instantaneous combination boiler

An instantaneous combination boiler that only has a single fuel burning rate for space heating. This includes appliances with alternative burning rates set once only at time of installation, referred to as range rating.

D1.9 Modulating instantaneous combination boiler

An instantaneous combination boiler with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

D1.10 Storage combination boiler

A combination boiler with an internal hot water store of capacity at least 15 litres but less than 70 litres
OR

a combination boiler with an internal hot water store of capacity at least 70 litres, in which the feed to the space heating circuit is not taken directly from the store. If the store is at least 70 litres and the feed to the space heating circuit is taken directly from the store, treat as a CPSU (D1.13 or D1.14).

D1.11 On/off storage combination boiler

A storage combination boiler that only has a single fuel burning rate for space heating. This includes appliances with alternative burning rates set once only at time of installation, referred to as range rating.

D1.12 Modulating storage combination boiler

A storage combination boiler with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

D1.13 On/off combined primary storage unit (CPSU)

A single appliance designed to provide both space heating and the production of domestic hot water, in which there is a burner that heats a thermal store which contains mainly primary water which is in common with the space heating circuit. The store must have a capacity of at least 70 litres and the feed to the space heating circuit must be taken directly from the store. The appliance does not have the capability to vary the fuel burning rate whilst maintaining continuous burner firing. This includes those with alternative burning rates set once only at time of installation, referred to as range rating.

D1.14 Modulating combined primary storage unit (CPSU)

A single appliance designed to provide both space heating and the production of domestic hot water, in which there is a burner that heats a thermal store which contains mainly primary water which is in common with the space heating circuit. The store must have a capacity of at least 70 litres and the feed to the space heating circuit must be taken directly from the store. The appliance has the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

D1.15 Low temperature boiler

A non-condensing boiler designed as a low temperature boiler and tested as a low temperature boiler as prescribed by the Boiler Efficiency Directive (i.e. the part load test was carried out at average boiler temperature of 40°C).

D1.16 Keep-hot facility

A facility within an instantaneous combination boiler whereby water within the boiler may be kept hot while there is no demand. The water is kept hot either (i) solely by burning fuel, or (ii) by electricity, or (iii) both by burning fuel and by electricity, though not necessarily simultaneously.

D2 Method for calculating Seasonal Efficiencies

The method of calculation is applicable only to boilers for which the full load and the 30% part load efficiency values, obtained by the methods deemed to satisfy Council Directive 92/42/EEC, are available. These are net efficiency values. It is essential that both test results are available and that the tests are appropriate to the type of boiler as defined in the Council Directive, otherwise the calculation cannot proceed.

The efficiencies calculated by this procedure are:

- a) SEDBUK (Seasonal Efficiency of Domestic Boilers in the UK). This is used as a general indicator of efficiency; it is no longer used for SAP calculations.
- b) Winter and summer seasonal efficiencies for SAP calculations. The winter seasonal efficiency is used for space heating, the summer efficiency applies to DHW heating in summer, and DHW heating in winter is a combination of both.

In the calculation method the data are first converted to gross efficiency under test conditions, and then converted to a seasonal efficiency value that applies under typical conditions of use in a dwelling, allowing for standing losses.

In this Appendix, efficiencies are expressed in percent. Intermediate calculations should be done to at least four places of decimals of a percentage, and the final result rounded to one decimal place.

D2.1 SEDBUK(2009)

If the *full-load net efficiency* and *30% part-load net efficiency* test results are available the procedure is as shown below. If they are not available see section D7 to convert a SEDBUK value calculated as specified in SAP 2005.

1. Determine fuel for boiler type

The fuel for boiler type must be one of natural gas, LPG (butane or propane), or oil (kerosene, gas oil or biodiesel). SEDBUK(2009) cannot be calculated for other fuels.

2. Obtain test data

Retrieve the *full-load net efficiency* and *30% part-load net efficiency* test results. Tests must have been carried out using the same fuel as the fuel for boiler type, except as provided in D4.

3. Apply correction to high test results

Apply an adjustment to full-load efficiency greater than 95.5% net and to part-load efficiency greater than 96.6% net to correct for observed bias in test results, according to Table D2.1.

Table D2.1 : Efficiency correction term

Full-load efficiency(h_{FL})		30% Part-load efficiency(h_{PL})	
Correction if $h_{FL} > 95.5\%$	Correction if $h_{FL} \leq 95.5\%$	Correction if $h_{PL} > 96.6\%$	Correction if $h_{PL} \leq 96.6\%$
- 0.673 ($\eta_{FL} - 95.5$)	0	- 0.213 ($\eta_{PL} - 96.6$)	0

4. Reduce to maximum net efficiency values

Table D2.2 gives the maximum values of net efficiency for each fuel that may be used. Reduce any greater value (after adjustment according to Table D2.1) to the appropriate value given in Table D2.2.

Table D2.2 : Maximum net efficiency values (in %)

	Condensing boilers			Non-condensing boilers	
	Natural gas	LPG	Oil	Gas (incl. LPG)	Oil
Full-load	98	98	98	92	92
Part-load	108	106	104	91	93

5. Convert the full and 30% part load efficiencies from net values to gross.

Use the following equation with the appropriate factor from Table D2.3.

$$\eta_{gross} = f \times \eta_{net}$$

Table D2.3 : Efficiency conversion factors

Fuel	Net-to-gross conversion factor, f
Natural gas	0.901
LPG (propane or butane)	0.921
Oil (kerosene or gas oil)	0.937
Oil (biodiesel)	0.937

6. Categorise the boiler

- a) Select the appropriate category for the boiler according to the definitions given in D1.
- b) If a gas or LPG boiler, determine whether it has a permanent pilot light:
 - if it has a permanent pilot light, set $p = 1$
 - if not, set $p = 0$.
- c) In the case of a storage combination boiler (either on/off or modulating) determine from the test report whether the losses from the store were included in the values reported (this depends on whether the store was connected to the boiler during the tests):
 - if the store loss is included, set $b = 1$
 - if not, set $b = 0$.
- d) In the case of a storage combination boiler or a CPSU, obtain the store volume, V_{cs} , in litres from the specification of the device and the standby loss factor, L , using the following equation:

$$\text{if } t < 10 \text{ mm: } L = 0.0945 - 0.0055t$$

$$\text{if } t \geq 10 \text{ mm: } L = 0.394/t$$

where t is the thickness of the insulation of the store in mm.

7. Calculate seasonal efficiency

- a) Use the boiler category and other characteristics as defined in D1 (non-condensing or condensing; gas or LPG or oil; on/off or modulating) to look up the appropriate SEDBUK equation number in Table D2.4. If no equation number is given the calculation cannot proceed. Otherwise, select the appropriate equation from Table D2.5 or Table D2.6.
- b) Substitute the gross full and part load efficiencies (found in step 5) and p , b , V and L (found in step 6). Note the result as η_{annual} for the purpose of D2.2.
- c) Round η_{annual} to one decimal place; i.e. to nearest 0.1%. Note the result as $[x]$ for the purpose of the declaration in D3. The result may also be described as SEDBUK(2009).

Table D2.4 : Boiler category table

SEDBUK Equation numbers for different boiler types	non-condensing (see D1.2)				low-temperature (see D1.15)	condensing (see D1.2)			
	Gas or LPG		Oil			Gas or LPG		Oil	
	on/off (see D1.4, D1.8, D1.11, D1.13)	modulating (see D1.5, D1.9, D1.12, D1.14)	on/off (see D1.4, D1.8, D1.11)	modulating (see D1.5, D1.9, D1.12)		on/off (see D1.4, D1.8, D1.11, D1.13)	modulating (see D1.5, D1.9, D1.12, D1.14)	on/off (see D1.4, D1.8, D1.11)	modulating (see D1.5, D1.9, D1.12)
regular boiler (see D1.4, D1.5)	101	102	201	X	X	101	102	201	X
instantaneous combi boiler (see D1.7, D1.8, D1.9)	103	104	202	X	X	103	104	202	X
storage combi boiler (see D1.10, D1.11, D1.12)	105	106	203	X	X	105	106	203	X
combined primary storage unit (see D1.13, D1.14)	107	107	X	X	X	107	107	X	X

Table D2.5 : Seasonal efficiency (annual), h, for natural gas and LPG boilers

Gas or LPG boiler type	Eq. no.	Equation
D1.4 : On/off regular	101	$\eta = 0.5(\eta_{full} + \eta_{part}) - 2.5 - 4p$
D1.5 : Modulating regular	102	$\eta = 0.5(\eta_{full} + \eta_{part}) - 2.0 - 4p$
D1.8 : On/off instantaneous combination	103	$\eta = 0.5(\eta_{full} + \eta_{part}) - 2.8 - 4p$
D1.9 : Modulating instantaneous combination	104	$\eta = 0.5(\eta_{full} + \eta_{part}) - 2.1 - 4p$
D1.11 : On/off storage combination	105	$\eta = 0.5(\eta_{full} + \eta_{part}) - 2.8 + (0.209 \times b \times L \times V_{cs}) - 4p$
D1.12 : Modulating storage combination	106	$\eta = 0.5(\eta_{full} + \eta_{part}) - 1.7 + (0.209 \times b \times L \times V_{cs}) - 4p$
D1.13 : On/ off combined primary storage unit (condensing and non-condensing)	107	$\eta = 0.5(\eta_{full} + \eta_{part}) - (0.539 \times L \times V_{cs}) - 4p$
D1.14 : Modulating combined primary storage unit (condensing and non-condensing)		

Table D2.6 : Seasonal efficiency (annual), h, for oil boilers

Oil boiler type	Eq. No.	Equation
D1.3 : Regular	201	$\eta = 0.5(\eta_{full} + \eta_{part}) - 1.1$
D1.7 : Instantaneous combination	202	$\eta = 0.5(\eta_{full} + \eta_{part}) - 2.8$
D1.10 : Storage combination	203	$\eta = 0.5(\eta_{full} + \eta_{part}) - 2.8 + (0.209 \times b \times L \times V_{cs})$

D2.2 Seasonal efficiency for SAP

- a) Modify the annual season efficiency η_{annual} obtained at step 7 b) of D2.1 to obtain the winter seasonal efficiency η_{winter} and the summer seasonal efficiency η_{summer} :

$$\eta_{winter} = \eta_{annual} + \Delta\eta_{winter}$$

$$\eta_{summer} = \eta_{annual} + \Delta\eta_{summer}$$

where $\Delta\eta_{\text{winter}}$ and $\Delta\eta_{\text{summer}}$ are given in Table D2.7 according to fuel and boiler type.

- b) Round the results to one decimal place, i.e. to nearest 0.1%. Note the η_{winter} and η_{summer} results as [y] and [z] respectively for the purpose of the declaration in D3.

Table D2.7 : Seasonal efficiency offsets

Fuel and boiler type	Winter offset Dh_{winter}	Summer offset Dh_{summer}
Natural gas or LPG		
D1.4 : On/off regular	+0.9	-9.2
D1.5 : Modulating regular	+1.0	-9.7
D1.8 : On/off instantaneous combi	+0.8	-8.5
D1.9 : Modulating instantaneous combi	+0.9	-9.2
D1.11 : On/off storage combi	+0.7	-7.2
D1.12 : Modulating storage combi	+0.8	-8.3
D1.13 or D1.14 : CPSU	+0.22	-1.64
Oil		
D1.3 : Regular	+1.1	-10.6
D1.7 : Instantaneous combi	+1.0	-8.5
D1.10 : Storage combi	+0.9	-7.2

D3 Declaring values of seasonal efficiency

Manufacturers wishing to declare their products' seasonal efficiencies for the specific purposes of calculating SAP ratings can do so provided that:

- a) they use the SEDBUK calculation procedure given in D2.1 above; and
- b) the necessary boiler test data and the calculations are certified by a Notified Body accredited for the testing of boilers by an EU national accreditation service. The Notified Body must certify that: 'the full load and part load efficiency test results detailed in [*insert reference to report on the efficiency tests*] have been obtained by methods deemed to satisfy the Boiler Efficiency Directive'.

Where a manufacturer declares the SEDBUK(2009) value, it shall be expressed as:

“Seasonal Efficiency SEDBUK(2009) = [x]%
 SAP winter seasonal efficiency = [y]%
 SAP summer seasonal efficiency = [z]%
 These values are used in the UK Government’s Standard Assessment Procedure (SAP) for energy rating of dwellings. The test data from which they have been calculated have been certified by [*insert name and/or identification of Notified Body*].”

Data for several products may be presented in tabulated form, in which case the second paragraph of the declaration should be incorporated as a note to the table.

D4 Method for calculating seasonal efficiency for boilers fuelled by LPG but tested with natural gas

If the fuel for boiler type is LPG but the fuel used to obtain efficiency test results is natural gas then seasonal efficiency may be calculated subject to certain conditions using the procedure given below. The seasonal efficiency will be lower than if the fuel used to obtain the test results had been LPG.

1. Note the restrictions set out at the start of D2, which still apply.
2. Any differences between the boiler fuelled by natural gas (used to obtain full-load and 30% part-load efficiency test results) and the boiler fuelled by LPG (for which seasonal efficiency is required) must be minor. Examples of minor differences are a change of gas injector or adjustment by a single screw on the gas valve.
3. Determine the net heat input on a net calorific value basis for both the natural gas boiler and the LPG boiler. The LPG figure must lie within $\pm 5\%$ of the natural gas figure.
4. Determine by measurement the percentage dry CO₂ by volume at the maximum heat input for both the natural gas boiler and the LPG boiler. From the results calculate the excess air fractions for both boilers. The calculated excess air fraction for the LPG boiler must not exceed that for the natural gas boiler by more than 5% (of the natural gas excess air fraction).
5. Retrieve the *full-load net efficiency* and *30% part-load net efficiency* test results.
6. Apply correction to high test results as in step 3 of D.2.1.
7. If the boiler is a condensing boiler then deduct 2.2 percentage points from the *30% part-load net efficiency* test result.
8. Follow the calculation procedure in D2.1 from step 4 onwards and in D2.2, taking the fuel for boiler type as LPG.

D5 Method for calculating Seasonal Efficiency and Case Emission value of a twin-burner range cooker boiler

1. The method of calculation of the Seasonal Efficiency is applicable only to cooker boilers for which the full load and the 30% part load efficiency values for the boiler function, obtained by the methods deemed to satisfy Council Directive 92/42/EEC, are available.
Note: A range cooker boiler which does not have the capability to provide domestic hot water directly (i.e. is not a combination boiler), but which may nevertheless provide domestic hot water indirectly via a separate hot water storage cylinder exactly matches the definition D1.3 for a Regular Boiler. Consequently the methods deemed to satisfy 92/42/EEC for a Regular Boiler will equally satisfy this requirement for the equivalent type of range cooker boiler.

These efficiencies are for the heat transferred to water and are carried out with the cooker burner turned off.

When undertaking the efficiency test, record

- input power (net) at full load conditions, $\Phi_{\text{input,net}}$, in kW.
- heat transfer to the water under full load conditions, Φ_{water} , in kW
- flue loss (net) under full load conditions, $\Phi_{\text{flue,net}}$, in kW according to the method given in EN 304:1992 + Amendment 1: 1998 or other method assured by the independent test laboratory as providing comparable results for the product under test.

Note: Independent test laboratory is qualified in D6 b).

2. Calculate the seasonal efficiencies according to D2 using the appropriate equation for a regular boiler.
3. Calculate the case heat emission at full load from

$$\Phi_{\text{case}} = \Phi_{\text{input,net}} - \Phi_{\text{water}} - \Phi_{\text{flue,net}}$$

where Φ_{water} is the heat transferred to water under full load conditions;
 $\Phi_{\text{flue,net}}$ is the flue gas loss measured according to BS EN 304.

4. If $\Phi_{\text{case}} < 0.2$ kW and the case temperatures of the range cooker are below 80°C, the case emission may, as an alternative, be derived from measurements of the case temperatures according to Supplement 1 to OFTEC Standard OFS A101, subject to a maximum figure of $\Phi_{\text{case}} = 0.2$ kW.
Note: Supplement 1 to OFTEC Standard OFS A101 (applicable for oil and gas) can be obtained from OFTEC (Oil Firing Technical Association), Tel 0845 6585080, Fax 0845 6585181, e-mail enquiries@oftec.org
5. If Φ_{case} exceeds either of $0.05 \times \Phi_{\text{water}}$ or 1 kW, reduce Φ_{case} to $0.05 \times \Phi_{\text{water}}$ or 1 kW (whichever is the smaller).
6. Provide the values of Φ_{case} and Φ_{water} in kW as part of the test report.

D6 Declaring values of seasonal efficiency and heat emission from the case for twin-burner range cooker boilers

Manufacturers wishing to declare their products' seasonal efficiencies and case emission values for the specific purposes of calculating SAP ratings can do so provided that:

- a) They use the calculation procedure given in D5 above; and
- b) The necessary boiler test data and calculations are certified by an independent Test Laboratory notified under the Council Directive 92/42/EEC on efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels (known as a "Notified Body").

Where a manufacturer declares the seasonal efficiency and the case emission value, it shall be expressed as:

Seasonal Efficiency SEDBUK(2009) = [x]%

SAP winter seasonal efficiency = [y]%

SAP summer seasonal efficiency = [z]%

Case heat emission at full load = [c] kW

Heat transfer to water at full load = [w] kW

The values are used in the UK Government's Standard Assessment Procedure (SAP) for the energy rating of dwellings. The test data from which they have been calculated has been certified by [*insert name and/or identification of Notified Body*].

Data for several products may be presented in tabulated form, in which case the last paragraph of the declaration should be incorporated as a note to the table.

D7 Conversion of SEDBUK values obtained for SAP 2005

Where the *full-load net efficiency* and *30% part-load net efficiency* test results are not available it is possible to derive efficiencies for SAP 2009 from a SEDBUK value calculated as specified in SAP 2005. However, the method is approximate and better results will be obtained from following the procedure in D2.1.

1. Determine fuel for boiler type

The fuel for boiler type must be one of natural gas, LPG (butane or propane), or oil (kerosene or gas oil).

2. Determine boiler type

Determine the boiler type from the first column of Table D7.1, referring to the definitions in D1. If it is not known whether the boiler is on/off or modulating assume that it is on/off. Note the coefficients k_1 and k_2 for the boiler type in Table D7.1.

Table D7.1 : Boiler types and conversion coefficients

Gas or LPG boiler type	k₁	k₂	k₃
D7.1n : On/off regular (non-condensing)	-6.5	3.8	-6.5
D7.1c : On/off regular (condensing)	-2.5	1.45	-2.5
D7.2n : Modulating regular (non-condensing)	-2.0	3.15	-2.0
D7.2c : Modulating regular (condensing)	-2.0	-0.95	-2.0
D7.3n : On/off instantaneous combination (non-condensing)	-6.8	-3.7	-6.8
D7.3c : On/off instantaneous combination (condensing)	-2.8	-5.0	-2.8
D7.4n : Modulating instantaneous combination (non-condensing)	-6.1	4.15	-6.1
D7.4c : Modulating instantaneous combination (condensing)	-2.1	-0.7	-2.1
D7.5n : On/off storage combination (non-condensing)	-6.59	-0.5	-6.59
D7.5c : On/off storage combination (condensing)	-6.59	-0.5	-6.59
D7.6n : Modulating storage combination (non-condensing)	-1.7	3.0	-1.7
D7.6c : Modulating storage combination (condensing)	-1.7	-1.0	-1.7
D7.7n : On/off or modulating combined primary storage unit (non-condensing)	-0.64	-1.25	-0.64
D7.7c : On/off or modulating combined primary storage unit (condensing)	-0.28	-3.15	-0.28
Oil boiler type	k₁	k₂	k₃
D7.8n : Regular (non-condensing)	0	-5.2	-1.1
D7.8c : Regular (condensing)	0	1.1	-1.1
D7.9n : Instantaneous combination (non-condensing)	-2.8	1.45	-2.8
D7.9c : Instantaneous combination (condensing)	-2.8	-0.25	-2.8
D7.10n : Storage combination (non-condensing)	-2.8	-2.8	-2.8
D7.10c : Storage combination (condensing)	-2.8	-0.95	-2.8

3. Calculate notional full-load and part-load net efficiencies

Calculate the notional *full-load net efficiency* and *30% part-load net efficiency* using the equations:

$$\eta_{\text{nfnet}} = (\text{SEDBUK}_{2005} - k_1) \div f + k_2$$

$$\eta_{\text{npnet}} = (\text{SEDBUK}_{2005} - k_1) \div f - k_2$$

where f is the efficiency conversion factor in Table D2.3.

4. Apply correction to high test results

Apply an adjustment to η_{nfnet} if it is greater than 95.5 net and to η_{npnet} if it is greater than 96.6 net, according to Table D7.2.

Table D7.2 : Correction to notional efficiencies

Notional full-load efficiency (η_{nfnet})		Notional part-load efficiency (η_{npnet})	
Correction if $\eta_{\text{nfnet}} > 95.5$	Correction if $\eta_{\text{nfnet}} \leq 95.5$	Correction if $\eta_{\text{npnet}} > 96.6$	Correction if $\eta_{\text{npnet}} \leq 96.6$
- 0.673 ($\eta_{\text{nfnet}} - 95.5$)	0	- 0.213 ($\eta_{\text{npnet}} - 96.6$)	0

5. Reduce to maximum allowable values

Table D7.3 gives the maximum values of η_{nfnet} and η_{npnet} for each fuel that may be used. Reduce any greater value (after adjustment according to Table D7.2) to the appropriate value given in Table D7.3.

Table D7.3 : Maximum allowable values

	Condensing boilers			Non-condensing boilers	
	Natural gas	LPG	Oil	Gas (incl. LPG)	Oil
E _{nflnet}	98	98	98	92	92
E _{nplnet}	108	106	104	91	93

6. Calculate seasonal efficiency

- a) Use the notional *full-load net efficiency* and *30% part-load net efficiency* adjusted as above to calculate annual efficiency from the equation:

$$\eta_{\text{annual}} = 0.5 \times (\eta_{\text{nflnet}} + \eta_{\text{nplnet}}) \times f + k_3$$

where f is the efficiency conversion factor in Table D2.3 and k_3 is the coefficient for the boiler type in Table D7.1.

- b) Round the result to one decimal place; i.e. to nearest 0.1%. Note the result as η_{annual} for the purpose of calculating winter seasonal efficiency and summer seasonal efficiency in D2.2.

Appendix E: Method of determining seasonal efficiency for gas, oil and solid fuel room heaters

Note: The data and equations in this appendix are for manufacturers to calculate seasonal efficiency for declaration purposes. They are not to be used by SAP assessors.

This appendix sets out the method to be used to determine the seasonal efficiency for gas, oil and solid fuel room heaters. It applies to room heaters used as main heating or as secondary heating.

E1 Efficiency determination

Only test results obtained by one of the recognised methods given in Table E1, Table E2 and Table E3 may be used to establish a seasonal efficiency for SAP calculations. The methods give comparable results.

Table E1 : Recognised efficiency test methods for gas room heaters

Reference	Title	Applies to (code in Table 4a or 4b)
BS EN 613:2001	Independent gas-fired convection heaters	609
BS EN 13278:2003	Open-fronted gas-fired independent space heaters	607
BS EN 1266:2002	Independent gas-fired convection heaters incorporating a fan to assist transportation of combustion air and/or flue gases	610
BS 7977-1:2002	Specification for safety and rational use of energy of gas domestic appliances. Part 1: Radiant/Convectors	603, 604, 605, 606
BS 7977-2:2003	Specification for safety and rational use of energy of gas domestic appliances. Part 2: Combined appliances: Gas fire/back boiler	109

Table E2 : Recognised efficiency test method for oil room heaters

Reference	Title	Applies to (code in Table 4a or 4b)
OFS A102:1999	Oil fired room heaters with atomising or vaporising burners with or without boilers, heat output up to 25 kW	131, 132, 621, 622, 623, 624

Table E3 : Recognised efficiency test methods for solid fuel room heaters

Reference	Title	Applies to (code in Table 4a)
BS EN 13229:2001	Inset appliances including open fires fired by solid fuels – Requirements and test methods	156, 631, 632
BS EN 13240:2001	Roomheaters fired by solid fuel - Requirements and test methods	158, 633, 634
BS EN 14785:2006	Residential space heating appliances fired by wood pellets – Requirements and test methods	159, 635, 636

Efficiency test results are normally calculated using the net calorific value of fuel. Before a declaration can be made, conversion to gross must be carried out by multiplying the efficiency by the appropriate conversion factor given in Table E4.

Table E4: Efficiency conversion factors

Fuel	Net-to-gross conversion factor
Natural gas	0.901
LPG (propane or butane)	0.921
Oil (kerosene or gas oil)	0.937
Biodiesel or bioethanol	0.937
House coal	0.97
Anthracite	0.98
Manufactured smokeless fuel	0.98
Wood logs	0.91
Wood chips	0.91
Wood pellets	0.91

E2 Declaring the efficiency of gas, oil and solid fuel room heaters

Manufacturers' declarations so calculated should be accompanied by the following form of words:

"The net efficiency of this appliance has been measured as specified in [*insert appropriate entry from Table E1, Table E2 or Table E3*] and the result after conversion to gross using the appropriate factor from Table E4 of SAP 2009 is [*x*]%. The test data has been certified by [*insert name and/or identification of Notified Body*]. The gross efficiency value may be used in the UK Government's Standard Assessment Procedure (SAP) for energy rating of dwellings."

Appendix F: Electric CPSUs

An electric CPSU is a central heating system providing space and domestic water heating. Primary water heated mainly during low-rate periods to up to 95°C in winter is stored in a thermal store. If the CPSU volume is less than 270 litres, the resulting high-rate fraction can lead to a poor SAP rating.

The procedure in this appendix applies for a 10-hour off-peak tariff providing 3 low-rate periods per day. It is not valid for other tariffs.

The space heating circuit operates in the same way as a wet central heating system, with controls appropriate for "wet" systems. For domestic hot water, secondary water flows directly from the cold mains into a heat exchanger, where it is heated by the hot water in the store before being delivered to the taps.

In the case of an electric CPSU, the high-rate fraction should be calculated (because the procedure is based on a fixed volume).

Note: The treatment of high-rate fraction is different from electric storage heating, because in the case of storage heating the high-rate fraction is fixed (it is achieved by sizing the storage heaters).

The heat losses from the CPSU are calculated, as for other hot water storage vessels, in Section 4 of the calculation, using data from Table 2 or Table 2b.

F1 Procedure for electric CPSUs:

The procedure below applies to the worksheet from box (201) onwards.

1. Calculate the high-rate fraction (for each month) using the following methodology:

- a) Calculate minimum external temperature for which the stored heat can satisfy the demand temperature

$$T_{\min} = \frac{[(39)_m \times (93)_m] - C_{\max} + [1000 \times (45)_m \div (24 \times n_m)] - (95)_m}{(39)_m} \quad (\text{F1})$$

n_m is the number of days in the month. C_{\max} is the low-rate heat available irrespective of power rating of the heating element, calculated using the formula:

$$C_{\max} = 0.1456 \times V_{\text{CS}} \times (T_w - 48) \quad (\text{F2})$$

where V_{CS} is the CPSU capacity in litres and T_w is winter operating temperature in °C.

In equations (F1) to (F4) items written as $(39)_m$ etc. are references to worksheet numbers.

- b) Calculate high-rate energy required

$$\begin{aligned} \text{if } T_{\min} - T_e = 0, \quad E_{\text{on-peak}} &= 0.024 \times (39)_m \times n_m \\ \text{otherwise} \quad E_{\text{on-peak}} &= \frac{0.024 \times (39)_m \times n_m \times (T_{\min} - T_e)}{1 - \exp(-(T_{\min} - T_e))} \end{aligned} \quad (\text{F3})$$

where T_e is the external temperature from Table 8.

2. Calculate the high-rate fraction

$$F = \frac{E_{\text{on-peak}}}{(98)_m + (45)_m} \quad (\text{F4})$$

3. Apply the high-rate price to fraction F of the heating requirement (both space and water) and the low-rate price to fraction $(1 - F)$.
4. Enter 130 in box (230c).

Appendix G: Flue gas heat recovery systems (FGHRS) and Waste water heat recovery systems (WWHRS)

G1 Flue gas heat recovery systems (FGHRS)

When fitted to a condensing boiler a flue gas heat recovery system (FGHRS) recovers heat from the flue products to pre-heat the domestic hot water supply. Passive flue gas heat recovery devices (PFGHRD)⁷ are a subset of FGHRS.

The boiler can be fired by mains gas, LPG or oil. The heat recovered is mostly from condensation of water vapour in the flue products and the application of an FGHRS is restricted to condensing boilers because non-condensing types are not generally adequately protected against the corrosive effects of condensate. For non-condensing boiler they would also alter the buoyancy characteristics of the combustion products posing a potential safety hazard. Where the device has a heat store, energy recovered during space heating production can also be used to later offset the heat required for providing domestic hot water.

Data for FGHRS are brought into SAP calculations via the database. The SAP assessor selects the FGHRS being used from a list offered by the software, identifying the device by means of brand name and model. The software then fetches the parameters needed from the database.

When there is an FGHRS the adjustments to boiler efficiency given in Table 4c for underfloor heating and load/weather compensator are not applied even if selected as there would be double counting if they were.

A FGHRS is an option if:

- main heating is from a boiler fired by mains gas, LPG or oil, and
- the boiler is a condensing type, and
- the fuel to which the FGHRS data applies is the same as the boiler fuel.

It is not relevant if the above conditions do not apply.

Note. The gains from the water heating system (65)_m must be calculated before the calculation of space heating, but if there is an FGHRS the output from the water heater (64)_m must be calculated after calculation of space heating.

If there is also a WWHRS see section G3.

G1.1 FGHRS without an FGHRS heat store

If the FGHRS has no heat store calculate the saving in each month by:

$$S_m = K_{f1} \times K_n \times Q_{hw,m} \quad (G1)$$

where

S_m is the saving in month m due to the FGHRS;

K_{f1} is the useful fraction of heat recovered directly in a hot-water-only test (from database record);

K_n is defined by (G7) below.

G1.2 FGHRS with an FGHRS heat store

The heat store is within the FGHRS. In addition there can be a close-coupled external store (see G1.5) which can be heated also by a PV array (see G1.6).

The energy saving depends on the monthly hot water usage and space heating requirement. A data record for an FGHRS includes two sets of coefficients a , b and c defining a set of equations relating energy saving in kWh to hot water provided by the boiler, $Q_{hw,m}$, for different space heating requirements (typically 6

⁷ A PFGHRD is passive (does not consume electricity) whereas an FGHRS may do; also a PFGHRD is a single component whereas an FGHRS may consist of separate individual components that are not contained within a single package when installed.

equations). One set of applies to instantaneous combi boilers without a keep-hot facility and without an external store, the other applies to all other boiler types (having a heat store within or external to the boiler). If there is also a WWHRS see section G3 below.

If $Q_{hw,m} < 0$ set the saving for month m to zero.

Otherwise the equations, valid in the range $80 \leq Q_{hw,m} \leq 309$, are of the form:

$$S_{0,m} = a \times \ln(Q_{hw,m}) + b \times Q_{hw,m} + c \quad (G2)$$

where

$S_{0,m}$ is the energy saving in month m , in kWh

$Q_{hw,m}$ is the energy content of water heated by the boiler in month m . This is (45)_m less any saving for a WWHRS calculated by equation (G10) and less any solar input calculated by equation (H2) in Appendix H. If there are two boilers each with an FGHRs, for the second set of calculations deduct the savings of the first (see G1.3).

\ln denotes natural logarithm

If $Q_{hw,m} < 80$, use equation (G2) with $Q_{hw,m} = 80$ and multiply the result by $Q_{hw,m} \div 80$

If $Q_{hw,m} > 309$, use equation (G2) with $Q_{hw,m} = 309$.

For each fuel for which the device has been tested there is a database record containing:

- a) whether an internal or external heat store is fitted;
- b) the useful fraction of heat recovered directly in a hot-water-only test, K_{r1} , for use with an instantaneous combi boiler without a keep hot facility and without a close-coupled external store;
- c) the total fraction of heat recovered directly in a hot-water-only test, K_{r2} , for use with all other boiler types;
- d) annual electrical consumption in kWh/year, if any;
- e) first set of coefficients a , b and c for a range of space heating requirements applicable to an instantaneous combi boiler without a keep-hot facility and without a close-coupled external store (assumes the FGHRs reduces the amount of luke-warm water rejected);
- f) second set of coefficient a , b and c for a range of space heating requirements applicable to all other boiler types and combi configurations (assumes no water is rejected).

The procedure is defined by steps 1) to 8).

- 1) Obtain the 12 monthly space heating requirements of the main heating system, $Q_{sp,m}$ (values for the months June to September are zero).

If fitted to the first main heating system:

$$Q_{sp,m} = (98)_m \times (204) \quad (G3)$$

If fitted to the second main heating system:

$$Q_{sp,m} = (98)_m \times (205) \quad (G4)$$

- 2) From the database record, obtain the coefficients a , b and c for the space heating requirement immediately above ($Q_{sp1,m}$) and below ($Q_{sp2,m}$) the actual monthly space heating requirements $Q_{sp,m}$. If the boiler is an instantaneous combi without keep-hot facility and without a close-coupled external store (see G1.5) use the first set coefficients a , b and c ; for any other type of boiler use the second set of coefficients and apply a correction according to the water storage arrangement in step 7). If $Q_{sp,m}$ is exactly equal to a value in the database omit steps 3) and 4) and use the corresponding coefficients to calculate the monthly savings, $S_{0,m}$, according to equation (G2).
- 3) Calculate the estimated monthly saving for the space heating requirements immediately above ($Q_{sp1,m}$) and below ($Q_{sp2,m}$) the actual requirement using equation (G2).

- 4) Using linear interpolation, calculate the monthly saving, $S_{0,m}$, for the each monthly space heating requirement ($Q_{sp,m}$) of the main heating system from the saving for space heating requirements immediately above ($Q_{sp1,m}$) and below ($Q_{sp2,m}$).
- 5) If $S_{0,m}$ is negative set it to zero.
- 6) If $Q_{sp,m}$ is greater than the largest value of space heating requirement in the database record, calculate the saving using the equation for the largest value of space heating requirement in the database record.
- 7) For instantaneous combi boilers without a keep-hot facility and not connected to a close-coupled hot-water store (see G1.5), set $S_m = S_{0,m}$ and omit this step.

Otherwise amend the savings to include the heat recovered while heating the hot-water store according to the water storage arrangement as follows.

- a. In the case of a combi boiler with keep-hot facility,

$$S_m = S_{0,m} + 0.5 \times K_{f2} \times (Q_{c,m} - Q_{ce,m}) \quad (G5)$$

where

- S_m is the saving in month m due to the FGHRs;
- $S_{0,m}$ is the saving calculated at step 4);
- K_{f2} is the total fraction of heat recovered directly in a hot-water-only test;
- $Q_{c,m}$ is the applicable combi loss in month m (Table 3a, 3b or 3c) as at (61)_m;
- $Q_{ce,m}$ is the electrical energy used in month m by the keep-hot (Table 4f), if any;
- 0.5 allows for the lower heat transfer to the FGHRs store compared to heat transfer directly to the cold water feed.

- b. If the boiler is a storage combi, a regular boiler supplying a cylinder or thermal store, a CPSU, or an instantaneous combi connected to a close-coupled external store,

$$S_m = S_{0,m} + 0.5 \times K_{f2} \times [Q_{loss,m} - (1 - K_n) \times Q_{hw,m}] \quad (G6)$$

where

- S_m is the saving in month m due to the FGHRs;
- $S_{0,m}$ is the saving calculated at step 4);
- K_{f2} is the total fraction of heat recovered directly in a hot-water-only test;
- $Q_{loss,m}$ is the storage, primary and combi loss in month m, equal to (56)_m + (59)_m + (61)_m;
- K_n is related to the coincidence of hot-water draw-off and boiler firing and is given by equations (G7).

$$\left. \begin{aligned} K_n &= 0 && \text{if } V_k \geq 144 \\ K_n &= 0.48 - V_k \div 300 && \text{if } 75 \leq V_k < 144 \\ K_n &= 1.1925 - 0.77 V_k \div 60 && \text{if } 15 < V_k < 75 \\ K_n &= 1 && \text{if } V_k \leq 15 \end{aligned} \right\} \quad (G7)$$

where

- V_k is the storage volume in the case of a regular boiler, a secondary storage combi boiler or a close-coupled store;
- V_k is 1.3 times the storage volume in the case of a primary storage combi or a CPSU.

Note. In the case of a close-coupled external store V_k is obtained from the database record for the FGHRs. In other cases V_k is obtained from the database record for the boiler (if applicable) or is supplied by the SAP assessor (e.g. volume of hot-water cylinder used with a regular boiler).

G1.3 FGHRS adjustment to energy requirements for water heating

Deduct S_m from (64)_m.

If there are two boilers each with an FGHRS fitted, carry out the calculations for the first boiler. Then for the second boiler, deduct the savings of the first (S_m) from $Q_{hw,m}$ in equations (G1), (G2) and (G6) and repeat the subsequent steps using the characteristics of the second boiler and system. Deduct from (64)_m the sum of S_m related to each boiler.

G1.4 FGHRS electrical power

Some systems may require electrical power. If that is the case a non-zero value (kWh/year) is included in the database record which is added into (231).

G1.5 FGHRS using a close-coupled external store

An FGHRS for an instantaneous combi boiler without a keep-hot facility may include a close-coupled external store. The store is connected to the boiler by not more than 1.5 m of insulated pipework. In this case the characteristics of the store are used in section 4 of the SAP worksheet and the procedure in G1.2 applies using the volume of the external store (provided in the database record), heat store loss rate (provided in database record) and data from Tables 2b, 3 and 3a, 3b or 3c as indicated for an instantaneous combi with a close-coupled external store.

G1.6 FGHRS using a close-coupled external store and a directly-powered photovoltaic array

The close-coupled store in FGHRS is kept warm by the combi boiler and maintained at 65°C by a separate channel that is controlled by a time clock. Electricity produced by the PV module feeds a low-voltage DC electric immersion heater within the close-coupled store via standard twin and earth mains cable. The store is subject to a maximum temperature of 85°C. There are no additional pumps and no power conversion to 230V AC. The procedure takes account of power loss in the connecting cable.

For these systems the database record includes the fraction of PV power lost in the connecting cable, and user-supplied information is the installed kWp of the PV array and the orientation, tilt and overshadowing of the PV.

G1.6.1 Calculation of solar input

The annual solar input, Q_s , in kWh/year is calculated as follows.

Peak power of PV array		<input type="text"/>	(G1)
Annual solar radiation per m ² from Table H2		<input type="text"/>	(G2)
Overshading factor from Table H4		<input type="text"/>	(G3)
Cable loss (provided in database record)		<input type="text"/>	(G4)
Solar energy available	$0.84 \times (G1) \times (G2) \times (G3) \times [1 - (G4)] =$	<input type="text"/>	(G5)
Solar-to-load ratio	$(G5) \div \sum (45)_m =$	<input type="text"/>	(G6)
Utilisation factor	if $(G6) > 0$, $1 - \exp[-1/(G6)]$, otherwise enter "0" in box (G7)	<input type="text"/>	(G7)
Volume of store, V_k (provided in database record)		<input type="text"/>	(G8)
Effective solar volume, $V_{eff} = 0.76 \times (G8)$		<input type="text"/>	(G9)
Daily hot water demand, $V_{d,average}$, (litres)	$(G10) = (43)$	<input type="text"/>	(G10)
Volume ratio V_{eff}/V_d	$(G9) \div (G10) =$	<input type="text"/>	(G11)
Solar storage volume factor $f(V_{eff}/V_d)$ (not greater than 1.0)	$1 + 0.2 \times \ln(G11) =$	<input type="text"/>	(G12)
Annual solar input Q_s (kWh)	$(G5) \times (G7) \times (G12) =$	<input type="text"/>	(G13)

Note: (43) and (45) are box numbers of the main worksheet

The solar input (in kWh) for month m is

$$Q_{s,m} = -Q_s \times f_m \times n_m / 365 \quad (G8)$$

where f_m is the appropriate month factor from Table H3. These values are carried to (63)_m.

G2 Waste water heat recovery systems (WWHRS)

A waste water heat recovery system uses a heat exchanger to recover heat from waste warm water as it flows through the waste plumbing system to pre-heat the cold water feed of a shower and a combi boiler or hot water cylinder. The energy recovered depends on the temperature of the cold water feed to the dwelling (which varies by month) and the number and type of systems that are installed. The procedure described in this section deals with WWHRS linked to mixer showers (where the shower water is a mixture of cold feed and that from the combi boiler or hot water cylinder). It is applicable only when the output of the heat exchanger is fed to *both* the shower *and* the combi boiler or hot water cylinder.

A WWHRS linked to an instantaneous electric shower (IES) is not covered by this procedure. However any IES present in the dwelling must be included in the total number of showers.

System data for WWHRS are brought into SAP calculations via the database. The SAP assessor selects the WWHRS being used from a list offered by the software, identifying the device by means of brand name and model. More than one brand and model may be installed. The software then fetches the parameters needed from the database for each model and brand identified.

If there is also an FGHRs see section G3.

G2.1 Dwelling-specific data required for WWHRS

The SAP assessor also identifies in rooms without baths the number of showers (IES) and mixer showers fitted by system model, in rooms with baths the number of IES and other showers by system model, and finally the total number of baths and showers irrespective of location or shower type.

Table G1 : Data required

Description of parameter	Symbol
Total number of rooms with bath and/or shower (any type, with or without WWHRS fitted)	N_{bth+sh}
Number of mixer showers fitted with WWHRS ₁ in rooms with a bath	$N_{sh\&bth,1}$
Number of mixer showers fitted with WWHRS ₁ in rooms without a bath	$N_{shxbth,1}$
Number of mixer showers fitted with WWHRS ₂ in rooms with a bath	$N_{sh\&bth,2}$
Number of mixer showers fitted with WWHRS ₂ in rooms without a bath	$N_{shxbth,2}$

G2.2 WWHRS calculation procedure for each month

1. Obtain the utilisation factor (UF) and heat recovery efficiency (η) for mixer showers from the database record for each system installed and calculate the average system effectiveness according to equation (G9).

$$S_{eff} = [\sum (N_{sh\&bth} \times 0.635 \times \eta \times UF)_{1,2} + \sum (N_{shxbth} \times \eta \times UF)_{1,2}] \div N_{bth+sh} \quad (G9)$$

2. Calculate the savings (kWh/month) for mixer showers with WWHRS according to equation (G10).

$$S_m = [N \times A_{w,m} + B_{w,m}] \times S_{eff} \times (35.0 - T_{cold,m}) \times 4.18 \times n_m \times MF_m \div 3600 \quad (G10)$$

$$A_{w,m} = [0.33 \times 25 \times \Delta T_m \div (41 - T_{cold,m})] + 26.1$$

$$B_{w,m} = 0.33 \times 36 \times \Delta T_m \div (41 - T_{cold,m})$$

$T_{cold,m}$ is the temperature of the cold water feed in month m (see Table G2)

n_m is the number of days per month from Table 1a

- MF_m is the monthly hot water use factor from Table 1c
- ΔT_m is the temperature rise of hot water drawn off from Table 1d
- N is the number of occupants as at box (42)

3. Subtract S_m from (64)_m.

Table G2 : Cold water temperatures (°C)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
11.1	10.8	11.8	14.7	16.1	18.2	21.3	19.2	18.8	16.3	13.3	11.8

G2.3 Solar water heating utilisation factor adjustment for WWHRS

WWHRS reduces the hot water demand and hence decreases the solar utilisation factor (H8) in Appendix H. When there is a WWHRS the solar-to-load ratio is as follows:

$$(H8) = (H7) \div [\sum (45)_m - \sum S_m] \tag{G11}$$

G3 Combination of FGHRs, WWHRS and solar water heating

When there is both FGHRs and WWHRS calculate the savings from the FGHRs, WWHRS and solar water heating interact. When two or more of these items are present the calculations must be done in the following order:

1. WWHRS;
2. Solar water heating, allowing for the WWHRS in worksheet (H8) in Appendix H;
3. FGHRs, allowing for the WWHRS saving and the solar input in equations (G1), (G2) and (G6).

Appendix H: Solar water heating

The working principle of solar hot water systems is shown in Figure H1: examples of arrangements are given in Figure H2 (these do not show all possible arrangements and the procedures in this Appendix are applicable to any arrangements that follow the same principles).

Water from the cold supply is either fed (directly or via a cold feed cistern) to the preheat zone where it is heated by solar energy. Then the water passes to the domestic hot storage (separate hot water cylinder or upper part of combined cylinder) which is heated to the required temperature by a boiler or an electric immersion.

There are three main types of solar collector:

- unglazed: the overall performance of unglazed collectors is limited by high thermal losses;
- glazed flat plate: a flat plate absorber (which often has a selective coating) is fixed in a frame between a single or double layer of transparent material (e.g. glass or polymer glazing) and an insulation panel at the back;
- evacuated tube: an absorber with a selective coating is enclosed in a sealed glass vacuum tube.

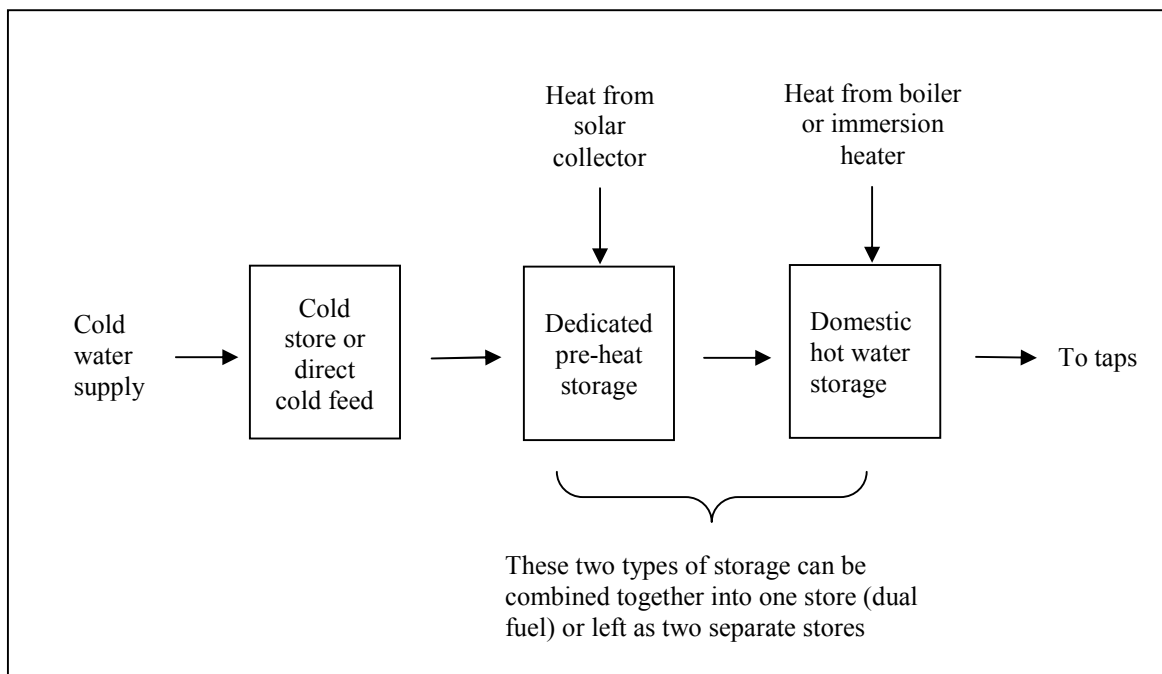
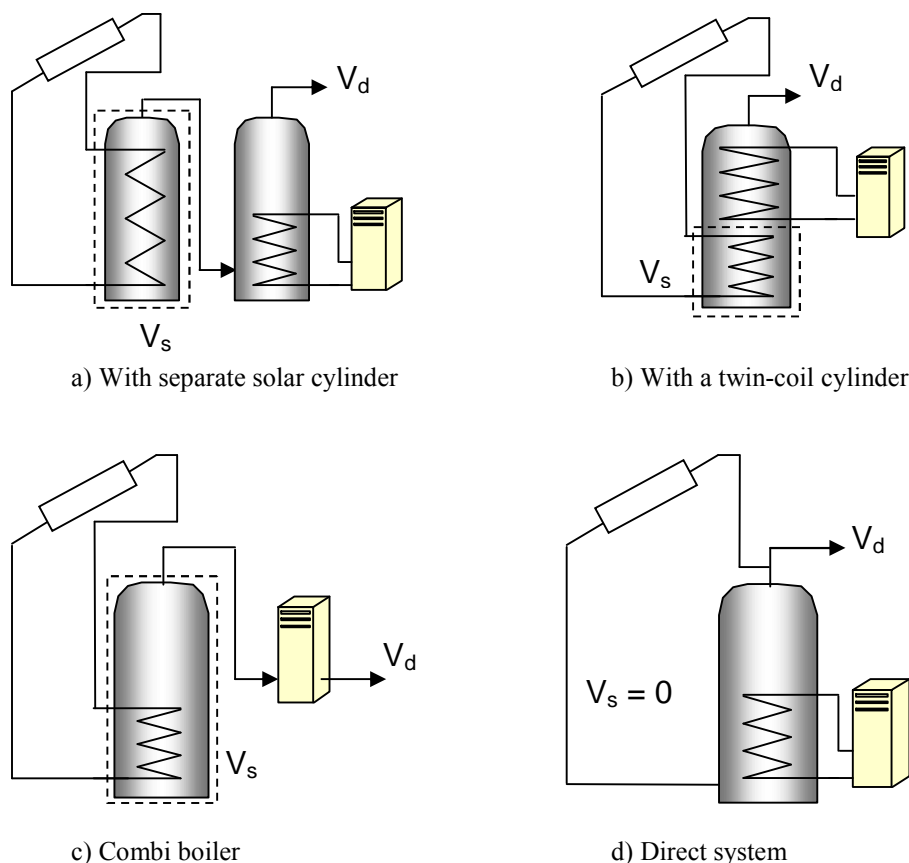


Figure H1: Working principle of solar water heating.



V_s (indicated by the dashed line) is the dedicated solar storage volume. See text below concerning the effective solar volume. V_d is the daily hot water demand. These schematics do not include all possible arrangements and are not intended to show safety measures and devices needed to make the systems safe.

Figure H2: Schematic examples of some arrangements for solar pre-heating

The performance of a solar collector is represented by its zero-loss efficiency (proportion of incident solar radiation absorbed in the absence of thermal loss) and its heat loss coefficient (heat loss from collector to the environment per unit area and unit temperature difference).

The solar contribution to domestic hot water is given by

$$Q_s = S \times Z_{\text{panel}} \times A_{\text{ap}} \times \eta_0 \times UF \times f(a_1/\eta_0) \times f(V_{\text{eff}}/V_d) \quad (\text{H1})$$

where

- Q_s = solar input, kWh/year
- S = total solar radiation on collector, kWh/m²/year
- Z_{panel} = overshadowing factor for the solar panel
- A_{ap} = aperture area of collector, m²
- η_0 = zero-loss collector efficiency
- UF = utilisation factor
- a_1 = linear heat loss coefficient of collector, W/m²K
- $f(a_1/\eta_0)$ = collector performance factor = $0.97 - 0.0367 (a_1/\eta_0) + 0.0006 (a_1/\eta_0)^2$ if $a_1/\eta_0 < 20$
 $= 0.693 - 0.0108 \times a_1/\eta_0$ if $a_1/\eta_0 \geq 20$
- V_{eff} = effective solar volume, litres
- V_d = daily hot water demand, litres
- $f(V_{\text{eff}}/V_d)$ = solar storage volume factor = $1.0 + 0.2 \ln(V_{\text{eff}}/V_d)$ subject to $f(V_{\text{eff}}/V_d) \leq 1.0$

The collector's gross area is the projected area of complete collector (excluding any integral means of mounting and pipework). The aperture area is the opening through which solar radiation is admitted.

The preferred source of performance data for solar collectors is from a test on the collector concerned according to BS EN 12975-2, *Thermal solar systems and components – Solar collectors – Part 2: Test methods*. The aperture area, and the performance characteristics η_0 and a_1 related to aperture area, are obtained from the test certificate. If test data are not available (e.g. for existing installations), the values in Table H1 may be used.

The effective solar volume is:

- in the case of a separate pre-heat tank (such as arrangements a) or c) in Figure H2), the volume of the pre-heat tank;
- in the case of a combined cylinder (such as arrangement b) in Figure H2), the volume of the dedicated solar storage plus 0.3 times the volume of the remainder of the cylinder;
- in the case of a thermal store (hot-water-only or integrated as defined in Appendix B) where the solar coil is within the thermal store, the volume of the dedicated thermal storage.
- in the case of a direct system (such as arrangement d) in Figure H2), 0.3 times the volume of the cylinder.

Note. The overall performance of solar water systems depends on how the hot water system is used, e.g. daily draw-off patterns and the use of other water heating devices such as a boiler or an immersion. The procedure described here is not suitable for detailed design in a particular case. It is intended to give a representative value of the solar contribution to domestic water heating over a range of users.

H1 Calculation of solar input for solar water heating

Aperture area of solar collector, m ²		<input type="text"/>	(H1)
<i>If only the gross area can be established reliably, multiply it by ratio in Table H1</i>			
Zero-loss collector efficiency, η_0 , from test certificate or Table H1		<input type="text"/>	(H2)
Collector heat loss coefficient, a_1 , from test certificate or Table H1		<input type="text"/>	(H3)
Collector performance ratio a_1/η_0	(H3) ÷ (H2) =	<input type="text"/>	(H4)
Annual solar radiation per m ² from Table H2		<input type="text"/>	(H5)
Overshading factor from Table H4		<input type="text"/>	(H6)
Solar energy available	(H1) × (H2) × (H5) × (H6) =	<input type="text"/>	(H7)
Solar-to-load ratio	(H7) ÷ $\Sigma (45)_m$ =	<input type="text"/>	(H8)
<i>if a WWHRS is fitted this becomes (H7) ÷ [$\hat{a} (45)_m - \hat{a}S_m$], see Appendix G</i>			
Utilisation factor	if (H8) > 0, $1 - \exp[-1/(H8)]$, otherwise enter "0" in box (H9)	<input type="text"/>	(H9)
<i>if the cylinder is heated by a boiler and there is no cylinderstat, reduce the utilisation factor by 10%</i>			
Collector performance factor	if (H4) < 20 $0.97 - 0.0367 \times (H4) + 0.0006 \times (H4)^2 =$ else $0.693 - 0.0108 \times (H4) =$	<input type="text"/>	(H10)
Dedicated solar storage volume, V_s , litres		<input type="text"/>	(H11)
<i>volume of pre-heat store, or dedicated solar volume of a combined cylinder</i>			
If combined cylinder, total volume of cylinder, litres		<input type="text"/>	(H12)
Effective solar volume, V_{eff}		<input type="text"/>	(H13)
<i>if separate pre-heat solar storage or a thermal store, (H13) = (H11)</i>			
<i>if combined cylinder, (H13) = (H11) + 0.3 × [(H12) - (H11)]</i>			
Daily hot water demand, $V_{d,average}$, (litres)	(H14) = (43)	<input type="text"/>	(H14)
Volume ratio V_{eff}/V_d	(H13) ÷ (H14) =	<input type="text"/>	(H15)
Solar storage volume factor $f(V_{eff}/V_d)$	$1 + 0.2 \times \ln(H15) =$	<input type="text"/>	(H16)
<i>(not greater than 1.0)</i>			
Annual solar input Q_s (kWh)	(H7) × (H9) × (H10) × (H16) =	<input type="text"/>	(H17)

Note: (43) and (45) are box numbers of the main worksheet

The solar input (in kWh) for month m is

$$Q_{s,m} = -Q_s \times f_m \times n_m / 365 \quad (\text{H2})$$

where f_m is the appropriate factor from Table H3. These values are carried to (63)_m of the main worksheet.

Where the solar-heated water is circulated by a mains-powered pump the electrical energy is included at (230g) or (330g) using data from Table 4f. If the pump is solar-powered by a PV array the energy included in (230g) or (330g) is zero.

H2 Reduction in primary loss

The hot water cylinder does not require additional heating when the solar system had heated it sufficiently. In that case, where the cylinder is heated indirectly by a boiler or other heat generator via a primary circuit and is controlled by a cylinder thermostat, there is a reduction in primary circuit loss. The primary loss (59)_m should be multiplied by the factor from Table H5 when this applies.

Table H1 : Default collector parameters

Collector type	h_0	a_1	Ratio of aperture area to gross area
Evacuated tube	0.6	3	0.72
Flat plate, glazed	0.75	6	0.90
Unglazed	0.9	20	1.00

Table H2 : Annual solar radiation, kWh/m²

Tilt of collector	Orientation of collector				
	South	SE/SW	E/W	NE/NW	North
Horizontal	961				
30°	1073	1027	913	785	730
45°	1054	997	854	686	640
60°	989	927	776	597	500
Vertical	746	705	582	440	371

Table H3 : Ratio of monthly solar radiation to annual average solar radiation

Tilt of collector	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Horizontal	0.24	0.50	0.86	1.37	1.74	1.84	1.78	1.50	1.06	0.63	0.31	0.19
30°	0.35	0.63	0.92	1.30	1.58	1.68	1.62	1.39	1.08	0.74	0.43	0.29
45°	0.39	0.69	0.95	1.27	1.52	1.61	1.55	1.34	1.08	0.79	0.48	0.33
60°	0.44	0.74	0.97	1.24	1.45	1.54	1.48	1.30	1.09	0.84	0.53	0.37
Vertical	0.58	0.92	1.05	1.15	1.25	1.33	1.28	1.15	1.10	0.99	0.69	0.50

Table H4 : Overshading factor

Overshading	% of sky blocked by obstacles.	Overshading factor
Heavy	> 80%	0.5
Significant	> 60% - 80%	0.65
Modest	20% - 60%	0.8
None or very little	< 20%	1.0
<i>Note: Overshading must be assessed separately for solar panels, taking account of the tilt of the collector. Usually there is less overshading of a solar collector compared to overshading of windows for solar gain (Table 6d).</i>		

Table H5 : Primary circuit loss factors with solar water heating

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1.0	1.0	0.94	0.70	0.45	0.44	0.44	0.48	0.76	0.94	1.0	1.0

H3 Community solar DHW

Where solar panels are used in a community heating system, the total collector area and the total dedicated solar store volume should be divided between the dwellings in proportion to the total floor area of the dwellings (these can be rounded to the nearest 0.01 m² and 1 litre).

Example. A block of 24 flats, eight with floor area of 50 m² and 16 with floor area of 60 m². Total aperture area of solar panels is 40 m² and the total solar storage volume is 1000 litres. The smaller flats are each assigned 1.47 m² and 37 litres, and the larger flats 1.76 m² and 44 litres.

The calculation is done as described in H1 for single systems, with the above parameters and the orientation, pitch and overshading of the panels set at values representative of the whole installation. Usually the solar store is separate and the arrangement is equivalent to that of diagram a) in Figure H2.

Appendix I (not used)

Appendix J: Seasonal efficiency for solid fuel boilers from test data

This appendix specifies how to obtain a seasonal efficiency from test data on a solid fuel boiler that is provided in the Product Characteristics Database. A database record for a solid fuel boiler includes:

- SAP seasonal efficiency, %
- Fuel input, heat to water and heat to room from test at full load, kW
- Fuel input, heat to water and heat to room from test at part load, kW

All efficiency values are gross (net-to-gross conversion factors are given in Table E4).

J1 SAP seasonal efficiency is given

If the SAP seasonal efficiency is given, that value is used for both space and water heating, and the other data is disregarded.

J2 SAP seasonal efficiency is not given

If the SAP seasonal efficiency is blank, the appropriate efficiency for use in the calculations is obtained as follows.

J2.1 Part load data is available

The efficiency at full load is obtained from:

$$\eta_{\text{full}} = 100 \times \frac{(\text{heat to water at full load}) + (\text{heat to room at full load})}{\text{fuel input at full load}} \quad (\text{J1})$$

and the efficiency at part load from:

$$\eta_{\text{part}} = 100 \times \frac{(\text{heat to water at part load}) + (\text{heat to room at part load})}{\text{fuel input at part load}} \quad (\text{J2})$$

If the boiler is outside the boundary of the dwelling as defined in section 1, "Dwelling dimensions", the heat to room is omitted from (J1) and (J2).

The seasonal efficiency is then:

$$\text{Seasonal efficiency} = 0.5 (\eta_{\text{full}} + \eta_{\text{part}}) \quad (\text{J3})$$

J2.2 Part load data is not available

If the data for the part load test is blank, the part load efficiency is taken as 95% of the full load efficiency, so that:

$$\text{Seasonal efficiency} = 0.975 \eta_{\text{full}} \quad (\text{J4})$$

where η_{full} is obtained using equation (J1).

J2.3 Rounding

The seasonal efficiency should be rounded to one decimal place before using it in calculations.

J3 Heating type and responsiveness

The heating type and responsiveness is that for the applicable type of appliance given in Table 4a.

Appendix K: Thermal bridging

Thermal bridges that occur at junctions between building elements are included in the calculation of transmission heat losses.

The quantity which describes the heat loss associated with a thermal bridge is its linear thermal transmittance, Ψ . This is a property of a thermal bridge and is the rate of heat flow per degree per unit length of the bridge, that is not accounted for in the U-values of the plane building elements containing the thermal bridge⁸.

The transmission heat transfer coefficient associated with non-repeating thermal bridges is calculated as:

$$H_{TB} = \sum (L \times \Psi) \quad (K1)$$

where L is the length of the thermal bridge, in metres, over which Ψ applies.

If details of the thermal bridges are not known, use

$$H_{TB} = y \sum A_{exp} \quad (K2)$$

where A_{exp} is the total area of external elements calculated at worksheet (31), m², and $y = 0.15$.

There are three possibilities for specifying the thermal bridging:

- 1) All detailing conforms with Accredited Construction Details or another government-approved source involving independent assessment of the construction method. In this case
 - use values from Table K1 for Accredited Construction Details, or
 - use the values provided by the approved source
 in equation (K1) along with the length of each junction.
 Here 'Accredited Construction Details' means:
 - For England & Wales and for Northern Ireland: Accredited Construction Details, as listed on www.planningportal.gov.uk/england/professionals/en/1115314255826.html
 - For Scotland: Accredited Construction Details (Scotland) www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards/publications/pubtech/techacconstrdetails
- 2) Ψ values have been calculated by a person with suitable expertise and experience in accordance with BRE IP 1/06, *Assessing the effects of thermal bridging at junctions and around openings*, and BR 497, *Conventions for calculating linear thermal transmittance and temperature factors*, but have not been subject to independent assessment of the construction method. In this case the Ψ values are increased by 0.02 or 25% (whichever is the larger) and used in equation (K1) along with the length of each junction.
- 3) If neither of the above applies use $y = 0.15$ in equation (K2).

It is possible to use both 1) and 2) together for different junctions within a given calculation, subject to those to which 2) applies being increased by 0.02 or 25% (whichever is the larger).

It is also permissible to use a value of y has been calculated for a particular house design from individual Ψ values⁹, where each Ψ -value has been obtained via 1) or 2) above, and those Ψ values to which 2) applies have been increased by 0.02 or 25% (whichever is the larger). Use this y value in equation (K2).

Documentary evidence as to the calculation of the y value must be available. Such a y value is applicable only to a dwelling of the size, configuration and construction for which it was calculated.

⁸ Repeating thermal bridges that occur throughout a building element, for example timber studs or joists, are taken into account in the U-value of the element and so are not included here.

⁹ A y -value is calculated as the sum of $(L \times \Psi)$ for all junctions divided by the total area of external elements (which includes exposed elements but not party wall).

Table K1 : Values of Ψ for different types of junctions conforming with Accredited Construction Details

	Junction detail	Ψ (W/m²·K)
Junctions with an external wall	Steel lintel with perforated steel base plate	0.50
	Other lintels (including other steel lintels)	0.30
	Sill	0.04
	Jamb	0.05
	Ground floor	0.16
	Intermediate floor within a dwelling	0.07
	Intermediate floor between dwellings (in blocks of flats) ^{a)}	0.07
	Balcony within a dwelling ^{b)}	0.00
	Balcony between dwellings ^{a) b)}	0.02
	Eaves (insulation at ceiling level)	0.06
	Eaves (insulation at rafter level)	0.04
	Gable (insulation at ceiling level)	0.24
	Gable (insulation at rafter level)	0.04
	Flat roof	0.04
	Flat roof with parapet	0.28
	Corner (normal)	0.09
Corner (inverted – internal area greater than external area)	-0.09	
Party wall between dwellings ^{a)}	0.06	
Junctions with a party wall ^{a)}	Ground floor	0.08
	Intermediate floor within a dwelling	0.00
	Intermediate floor between dwellings (in blocks of flats)	0.00
	Roof (insulation at ceiling level)	0.12
	Roof (insulation at rafter level)	0.02

^{a)} Value of Ψ is applied to each dwelling

^{b)} This is an externally supported balcony (the balcony slab is not a continuation of the floor slab) where the wall insulation is continuous and not bridged by the balcony slab

Appendix L: Energy for lighting and electrical appliances

L1 Lighting

The calculation of lighting use is based on the proportion of fixed low energy lighting outlets installed¹⁰, and on the contribution of daylight.

Allowing for fixed low-energy outlets

In UK houses, the average annual energy consumption for lighting if no low-energy lighting is used is:

$$E_B = 59.73 \times (\text{TFA} \times \text{N})^{0.4714} \quad (\text{L1})$$

where TFA is the total floor area in m² and N is the assumed number of occupants.

The SAP calculation takes account of fixed lighting outlets with low-energy lamps, by including a correction factor C₁:

$$C_1 = 1 - 0.50 \times L_{LE}/L \quad (\text{L2})$$

where L_{LE} is the number of fixed low energy lighting outlets (including sockets or complete luminaires capable of taking only low-energy lamps, and also compact fluorescent lamps that fitted into ordinary lighting sockets) and L is the total number of fixed lighting outlets.

Lighting fittings in less frequented areas like cupboards, wardrobes and other storage areas should be omitted from both L and L_{LE}.

Note: In equation (L2), only fixed lighting outlets are included in L_{LE} and L. Movable lamps, which plug into a mains socket, are disregarded for the calculation of C₁ (but are included in the formula for E_B). Equation (L2) is based on two-thirds of the lighting energy consumption being via fixed lighting points, and each fixed low energy lighting point achieving a saving of 75% over a point with a non low energy lamp (2/3 x 3/4 = 0.50).

Daylighting

Analysis of typical house types gives the following approximate correction factor, C₂, for lighting energy use depending on the ratio of glass area to floor area, glass transmittance and light access factor.

$$C_2 = 52.2 G_L^2 - 9.94 G_L + 1.433 \quad \text{if } G_L \leq 0.095 \quad (\text{L3})$$

$$C_2 = 0.96 \quad \text{if } G_L > 0.095 \quad (\text{L4})$$

$$G_L = \frac{\sum 0.9 \times A_w \times g_L \times \text{FF} \times Z_L}{\text{TFA}} \quad (\text{L5})$$

where: FF is the frame factor (fraction of window that is glazed) for the actual window or from Table 6c
 A_w is the area of a window, m²
 TFA is the total floor area, m²
 g_L is the light transmittance factor from Table 6b
 Z_L is the light access factor from Table 6d

If the frame factor (glazed fraction of the window) is not known (i.e. when using BFRC certified data) use FF = 0.7.

The summation allows for different window and rooflight types (the light access factor is different for windows and rooflights).

The initial value of the annual energy used for lighting in the house, E_L, is then

¹⁰ Subject, in the case of DER calculations for a new dwelling, to any requirements of building regulations that apply in the administration where the dwelling will be constructed.

$$E_L = E_B \times C_1 \times C_2 \text{ kWh/year} \quad (\text{L6})$$

The lighting energy use in kWh in month m (January = 1 to December = 12) is

$$E_{L,m} = E_L \times [1 + 0.5 * \cos(2\pi (m - 0.2) / 12)] \times n_m / 365 \quad (\text{L7})$$

Then re-calculate the annual total as the sum of the monthly values:

$$E_L = \sum_{m=1}^{12} E_{L,m} \quad (\text{L8})$$

The associated internal heat gain for each month in watts is

$$G_{L,m} = E_{L,m} \times 0.85 \times 1000 / (24 \times n_m) \quad (\text{L9})$$

where n_m is the number of days in month m. The factor 0.85 is an allowance for 15% of the total lighting usage being external to the dwelling. When reduced internal heat gains are assumed for the calculation the light gains are based on applying equation (L2) to all lighting outlets (fixed and moveable) with 80% power saving compared to standard (GLS) lamps:

$$G_{L,m} = 0.40 \times E_{L,m} \times 0.85 \times 1000 / (24 \times n_m) \quad (\text{L9a})$$

Equation (L8) is used for the annual energy use for lighting. Equation (L9) or (L9a) is used for the heat gain from lighting in each month in Section 5 of the calculation.

L2 Electrical appliances

The initial value of the annual energy use in kWh for electrical appliances is:

$$E_A = 207.8 \times (\text{TFA} \times \text{N})^{0.4714} \quad (\text{L10})$$

where TFA is the total floor area in m² and N is the assumed number of occupants (see Table 1).

The appliances energy use in kWh in month m (January = 1 to December = 12) is

$$E_{A,m} = E_A \times [1 + 0.157 * \cos(2\pi (m - 1.78) / 12)] \times n_m / 365 \text{ kWh} \quad (\text{L11})$$

Then re-calculate the annual total as the sum of the monthly values:

$$E_A = \sum_{m=1}^{12} E_{A,m} \quad (\text{L12})$$

The associated internal heat gain for each month in watts is

$$G_{A,m} = E_{A,m} \times 1000 / (24 \times n_m) \quad (\text{L13})$$

where n_m is the number of days in month m. When reduced internal heat gains are assumed for the calculation the appliance gains are based on efficient cold and wet appliances and below average use of other appliances:

$$G_{A,m} = 0.67 \times E_{A,m} \times 1000 / (24 \times n_m) \quad (\text{L13a})$$

The annual CO₂ emissions in kg/m²/year associated with electrical appliances is

$$E_A \times \text{EF}_{\text{electricity}} / \text{TFA} \quad (\text{L14})$$

where $\text{EF}_{\text{electricity}}$ is the emission factor for electricity (Table 12).

Equation (L13) or (L13a) is used for the heat gain from appliances in each month in Section 5 of the calculation. Equation (L14) is used for the annual emissions for appliances in Section 16 of the calculation (which is applicable only for calculations in relation to Level 6 of the Code for Sustainable Homes and to Stamp Duty Land Tax).

L3 Cooking

Internal heat gains in watts from cooking:

$$G_C = 35 + 7 N \quad (L15)$$

When lower internal heat gains are assumed for the calculation,

$$G_C = 23 + 5 N \quad (L15a)$$

CO₂ emissions in kg/m²/year associated with cooking:

$$(131 + 26 N) / TFA \quad (L16)$$

Equation (L15) or (L15a) is used for the heat gain from cooking in Section 5 of the calculation. Equation (L16) is used for the annual emissions for cooking in Section 16 of the calculation (which is applicable only for calculations in relation to Level 6 of the Code for Sustainable Homes and to Stamp Duty Land Tax).

Appendix M: Energy from Photovoltaic (PV) technology, small and micro wind turbines and small-scale hydro-electric generators

The procedures in this appendix give annual electricity generation, which is added in at the end of the calculation.

This appendix may be extended in future to cover other technologies.

M1 Photovoltaics

Photovoltaic technology converts daylight directly into electricity. It works during daylight hours but more electricity is produced when the sunshine is more intense (a sunny day) and is striking the PV modules directly. Unlike solar systems for heating water, PV technology does not produce heat. Instead, PV produces electricity as a result of interaction of sunlight with semi-conductor materials in the PV cells.

For SAP calculations, the energy produced per year depends on the installed peak power (kW_p) of the PV module (the peak power corresponds to the rate of electricity generation in bright sunlight, formally defined as the output of the module under radiation of 1 kW/m² at 25°C). PV modules are available in a range of types and some produce more electricity per square metre than others, and the peak power depends on the type of module as well as its effective area. In the UK climate, an installation with 1 kW_p typically produces about 850 kWh of electricity per year (at favourable orientation and not overshadowed).

At times of high solar radiation the PV array may generate more electricity than the instantaneous electricity demand within the dwelling. Arrangements must be made for the surplus electricity to be exported to the grid via a dual or two-way electricity meter.

The procedure for PV is as follows.

- 1) Establish the installed peak power of the PV unit (kW_p).
- 2) The electricity produced by the PV module in kWh/year is

$$0.8 \times \text{kW}_p \times S \times Z_{PV} \tag{M1}$$

where S is the annual solar radiation from Table H2 (depending on orientation and tilt), and Z_{PV} is the overshadowing factor from Table H4.

If there are two PV modules, e.g. at different tilt or orientation, apply equation (M1) to each and sum the annual electricity generation.

- 3) The cost saving associated with the generated electricity depends on whether it is used directly within the dwelling or whether it is exported. Electricity used directly within the dwelling is valued at the unit cost for purchased electricity (standard tariff, or the high/low rate proportions given in Table 12a in the case of an off-peak tariff). Electricity exported is valued at the price for electricity sold to the grid. The effective price depends on a factor β, which is in the range 0.0 to 1.0 and is defined as the proportion of the generated electricity that is used directly within the dwelling. The value of β depends on the coincidence of electricity generation and electricity demand within the dwelling. At present the value of β = 0.50 should be used for SAP calculations: this will be reviewed in future if relevant data becomes available.
The fuel price used for calculation of the cost benefit is:
β × normal electricity price + (1 - β) × exported electricity price.
where the normal electricity price is standard tariff, or weighted high and low rates (Table 12a) if an off-peak tariff.
- 4) For calculation of CO₂ emissions, the emissions factor is that for grid-displaced electricity from Table 12. The same factor applies to all electricity generated, whether used within the dwelling or exported.

- 5) Where the PV array is mounted on the building concerned or wholly within its curtilage, and its output is directly connected to the building's electricity supply, the output calculated by (M1) is included in the worksheet at box (233) or (333).

In the case of a building containing more than one dwelling, e.g. a block of flats, then:

- a) if the PV output goes to particular individual flats, the annual output is credited to the flats concerned;
- b) otherwise the total electricity generated is divided amongst all the flats in the block in proportion to their floor area.

In case a) an inverter is needed for each flat with a PV electricity supply. In case b) there will usually be a single inverter for the total PV array and the electricity generated fed to the landlord supply or to the distribution system for the flats (with provision for export of electricity generated in excess of instantaneous demand).

- 6) In other cases the output calculated by (M1) divided by the total floor area of buildings on the development may be entered in (ZC6), see Section 16, when the total net CO₂ emissions are being calculated.

M2 Micro wind turbines on the building or within its curtilage

The procedure given below applies to small wind turbines mounted either on the roof of the dwelling or on a nearby mast within its curtilage. For a wind turbine that serves more than one dwelling see M3.

The performance of wind turbines is very sensitive to the local wind conditions. The procedure given here is based on typical conditions using a formula given by GreenSpec¹¹ and the wind speed correction factors given in MIS 3003¹².

At times of higher wind speeds the wind turbine may generate more electricity than the instantaneous electricity demand within the dwelling. Arrangements must be made for the surplus electricity to be exported to the grid via a dual or two-way electricity meter.

It should be noted that the procedure given in this Appendix is an approximate one and in particular that the correction factors in MIS 3003, while representing the best currently available estimates, are known to be imprecise. Also, it is based on generic turbine technology. It will be revised as better information becomes available.

Meanwhile the procedure is considered as valid for the purposes of calculations by SAP 2009 when:

- no part of the turbine blade dips below the level of the ridge of the roof;
- there are no obstructions significantly larger than the building within a radius of 10 times the building height.

It should not be applied if those conditions are not met.

- 1) The output power P_{wind} of one turbine in watts at a wind speed of s m/s is:

$$P_{\text{wind}} = CP \times A \times PA \times G \times IE \quad (\text{M2})$$

where

CP is the aerodynamic power coefficient (efficiency of the rotor to convert energy)

A is the swept area of the blade

PA is the power density of the wind = 0.6125 s^3

¹¹ www.greenspec.co.uk/html/energy/windturbines.html (accessed 20 September 2007)

¹² Microgeneration Installation Standard MIS 3003, *Requirements for contractors undertaking the supply, design, installation, set to work commissioning and handover of micro and small wind turbine systems*, BRE Certification Ltd, 2007, <http://www.redbooklive.com/page.jsp?id=135> (accessed 20 September 2007)

G is the efficiency of the generator

IE is efficiency of the inverter (allowing for power drawn by the inverter) ¹³.

- 2) The annual energy in kWh/year is related to the output at average wind speed by

$$E_{\text{wind}} = N_{\text{turbines}} \times P_{\text{wind}} \times 1.9 \times 8766 \times 0.001 \quad (\text{M3})$$

where N_{turbines} is the number of wind turbines, 1.9 is a parameter representing the wind speed variation function and 8766 is the number of hours per year.

If there is more than one turbine of differing hub height or blade diameter, apply equation (M3) to each and sum the annual electricity generation.

- 3) The product of CP, G and IE is taken as 0.24.
- 4) The area A is $0.25 \times \pi \times (\text{rotor diameter})^2$.
- 5) The average wind speed is taken as 5.0 m/s multiplied by the appropriate correction factor from Table M1 ¹⁴.
- 6) The total electricity produced as calculated in step 2) above is entered in box (234) of the worksheet.
- 7) For calculation of the cost savings the factor β (see Section M1) is 0.7.
- 8) For calculation of CO₂ emissions, the emissions factor for grid-displaced electricity from Table 12 applies to all electricity generated, whether used within the dwelling or exported.

Table M1 : Wind speed correction factors

Terrain type	Height of turbine hub above ridge of roof (m)*	Correction factor
Dense urban	10	0.56
(city centres with mostly closely spaced buildings of four storeys or higher)	5	0.51
	2	0.40
	0	0.28
	Low rise urban / suburban	6
(town or village situations with other buildings well spaced)	4	0.61
	2	0.53
	0	0.39
	Rural	12
(open country with occasional houses and trees)	7	0.94
	2	0.86
	0	0.82

* must be at least half the rotor diameter

¹³ Equation (M2) differs from that on the GreenSpec website by including IE. The latter is included so as to provide the system output rather than the turbine output.

¹⁴ Factors in Table M1 derived from data in *The Designer's Guide to Wind Loading of Structures*, N.J. Cook, Butterworths, 1986

Use linear interpolation for intermediate values. For hub height higher than the maximum given for the terrain type use the highest for that terrain type (i.e. 0.56, 0.67 or 1.00). This is because of limitations of current knowledge; the table will be revised in future.

As an alternative to the above procedure the total annual output of wind turbines may be estimated using the procedure given in Microgeneration Installation Standard MIS 3003. It is recommended that the wind speed at the intended location is monitored for at least a year in order ascertain the local wind conditions but if that data is not available the wind speed can be estimated from the NOABL database as described in MIS 3003 (this is subject to the limitation in MIS 3003 of a maximum 50 kW rated output at a wind speed of 11 m/s).

M3 Wind turbines associated with more than one dwelling

This refers to wind turbines such as might be installed as part of a housing development. They are not included for the assessment of ratings but can be included in the assessment of an overall CO₂ emission figure inclusive of all energy uses (including appliances and cooking), see Section 16. If not actually on the site they can be included provided that they are connected to the site via private wires. Electricity surplus to the instantaneous electricity demand of the dwellings is fed into the electricity grid.

The total annual output of wind turbines should be estimated using the procedure given in Microgeneration Installation Standard MIS 3003. It is recommended that the wind speed at the intended location is monitored for at least a year in order ascertain the local wind conditions but if that data is not available the wind speed can be estimated from the NOABL database as described in MIS 3003 (this is subject to the limitation in MIS 3003 of a maximum 50 kW rated output at a wind speed of 11 m/s).

The total output from the wind turbines should be apportioned between the dwellings concerned on the basis of their floor area, by multiplying the total annual output by the floor area of the dwelling divided by the total floor area of buildings on the development, and entered in kWh/m² into box (ZC6) in Section 16.

M4 Small-scale hydro-electric generators

Hydro-electric generation is possible only in a small number of situations. Each case is different and detailed calculations of the electricity generated are outside the scope of SAP 2009.

Where small-scale hydro-electric generation is applicable, it may be allowed for in SAP calculations as follows.

- 1) The total electricity generated per year is calculated and signed off by a suitably qualified engineer having adequate competence in the assessment of the technology. In case of doubt guidance should be sought from BRE.
- 2) Where more than one dwelling benefits from the hydro-electric generation, the kWh per year attributable to each dwelling is obtained from the total in step 1) by multiplying the total annual output by the floor area of the dwelling divided by the total floor area of buildings on the development.
- 3) For calculation of the cost savings the factor β (see Section M1) is 0.4.
- 4) For calculation of CO₂ emissions, the emissions factor for grid-displaced electricity from Table 12 applies to all electricity generated, whether used within the dwelling or exported.
- 5) Where the electricity generator is within the curtilage of the building, and its output is directly connected to the building's electricity supply, the output is entered in the worksheet at box (236a).
- 6) In other cases the electricity generated divided by the sum of the floor areas of the buildings concerned may be entered in (ZC6), see Section 16, when the total net CO₂ emissions are being calculated.

Appendix N: Micro-cogeneration (or micro-CHP) and heat pumps

N1 Overview

This appendix deals with heating products whose energy performance is supported by test data and depend critically on the plant size ratio¹⁵. Micro-cogeneration (also known as micro-CHP) and heat pumps are two such products. Products can provide a) heating and hot water throughout the year, b) heating and hot water during the heating season only, c) heating only, or d) hot water only. For heat pumps that are not supported by test data see section 9.2.7.

N1.1 Micro-cogeneration

Micro-cogeneration provides both heat and electricity. It is assumed to be heat-led, meaning that it is allowed to operate only when there is a demand for space heating or hot water. The domestic application of micro-cogeneration is treated as an alternative to a conventional domestic boiler, using mains gas, LPG, oil or solid fuel. It is also assumed that it is connected to the public electricity supply in such a way that all surplus generated electricity is exported. This appendix is not applicable unless these assumptions have been confirmed.

The characteristics of micro-cogeneration are described by data derived from laboratory tests. The test data are used to calculate parameters related to the annual energy performance of the micro-cogeneration “package”. The term “package” refers to a micro-cogeneration unit (such as an engine and generator) in conjunction with a defined set of optional other components (e.g. a boiler or thermal store). The laboratory test data is analysed by an annual performance method to produce results (known as “intermediate results”) that are used for SAP as described in section N2.

Any space heating requirements not met by the micro-cogeneration package is to be provided by secondary heating. If a secondary heating system is not specified assume direct electric heaters. If the package provides domestic hot water it is assumed to provide all water heating needs for the applicable period.

The heat produced by the package and the electrical energy consumed/generated are based on operation during an average year, taking account of its output rating and the design heat loss for the dwelling in which it is installed. The amount of auxiliary heating is determined by the plant size ratio (full output power of the micro-cogeneration package divided by the design heat loss). If the plant size ratio is less than 0.2 then the package cannot be regarded as a main heating system, and the performance data are invalid for SAP.

The electricity consumed/generated will normally be negative, and then represents the net electricity produced by the micro-cogeneration package that is available to offset electricity that would otherwise be taken from the public electricity supply grid or, to the extent that instantaneous generation exceeds instantaneous electricity demand, is exported to the grid.

The thermal efficiency of the micro-cogeneration package is used in the normal way for the calculation of energy requirements for space heating and/or water heating (depending on the services provided by the package). The electricity consumed (or the net electricity generation) is scaled according to the net energy use as obtained in the SAP calculation.

N1.2 Heat pumps

Heat pumps provide space and/or water heating with efficiencies in excess of 100% as they transfer heat from outside the heated envelope of the dwelling, usually from (a) the ground, (b) outside air, (c) exhaust air from mechanical extract ventilation (MEV), (d) exhaust air from balanced mechanical ventilation without or with heat recovery (MVHR) or (e) a mixture of exhaust air from an MEV and outside air.

A heat pump “package” refers to a heat pump unit in conjunction with a defined set of optional other components (e.g. a thermal store or auxiliary heater). Heat pump packages have been categorised by hot water provision, which can be:

- integral hot water store; or

¹⁵ Plant size ratio is the full output power of the heating appliance divided by the design heat loss of the dwelling

- separate cylinder with characteristics specified as part of the package; or
- separate cylinder with characteristics not specified as part of the package; or
- not provided by heat pump package.

In the latter case a water heating system is specified separately for the SAP calculation.

The characteristics of heat pump packages are described by data derived from laboratory tests. The laboratory test data is analysed by an annual performance method to produce results (known as “intermediate results”) that are used for SAP as described in N2. An exhaust air heat pump is tested with a given mechanical ventilation system, and so the exhaust air heat pump system is defined as the mechanical ventilation system *and* the heat pump.

The performance of the heat pump package depends on temperature conditions and running hours, which are affected by output rating and the design heat loss of the dwelling. Any space heating requirements not met by the heat pump package is to be provided by secondary heating. If a secondary heating system is not specified assume direct electric heaters. If the package provides domestic hot water it is assumed to provide all water heating needs for the applicable period (any water heating needs not provided by the heat pump is assumed to be met by an electric immersion heater within the package and is explicitly accounted for in the water heating efficiency in the database record for the heat pump).

The thermal efficiency of the heat pump package is used in the normal way for the calculation of energy requirements for space heating and/or water heating (depending on the services provided by the package).

This appendix is concerned with heat pumps powered solely from electricity (referred to as electric heat pumps) or from fuels including but not limited to natural gas, LPG or oil.

N2 Datasets

The data to be used for SAP calculations are provided by way of the Product Characteristics Database. Each database record consists of the data in Table N1 and a number of sets of intermediate test results (Table N2). The intermediate results from the annual energy performance methods for micro-cogeneration and heat pumps are produced in sets, of which a sub-set of parameters depends on the plant size ratio (PSR). Each sub-set is calculated for a different PSR: values are typically 0.2, 0.5, 1.0, 1.5, 4.0 and 10.0.

The plant size ratio (PSR) for the dwelling is calculated using the maximum nominal output of the package and the design heat loss of the dwelling is taken as the annual average heat loss coefficient, worksheet (39), multiplied by a temperature difference of 24.2 K¹⁶. In the case of a range-rated package, the PSR for the dwelling is calculated assuming that it is set to the top of the range as this was how it was tested.

The intermediate PSR-dependent results applicable to the dwelling are then obtained by linear interpolation¹⁷ between the two datasets whose PSRs enclose that of the actual dwelling. If the PSR for the dwelling is greater than the largest value in the database record or less than the smallest value in the database record the data are invalid for the dwelling concerned. The dwelling-specific values are used in equations (N1) to (N17) to calculate the parameters used in the SAP calculation.

N2.1 Heat pumps

For heat pumps a set of intermediate PSR-dependent results (latter entries of Table N2) is provided for each of up to four emitter types and, in the case of an exhaust air heat pump, for two or three air flow rates at which the combined system was tested. The latter requires an additional linear interpolation of the data based on the air flow rate through the ventilation system in litres per second calculated by equation (N1).

$$\text{throughput (l/s)} = (5) \text{ volume (m}^3\text{)} \times (23a) \text{ system throughput (ach/hour)} \div 3.6 \quad (\text{N1})$$

- If the throughput for the dwelling is greater than the highest value in the database record for the heat pump use the intermediate values at the highest air flow rate in the database record.

¹⁶ This is a change from SAP 2005 that brings the design heat loss into line with sizing methods commonly adopted in the UK

¹⁷ For the efficiency values, the interpolated efficiency is the reciprocal of linear interpolation between the reciprocals of the efficiencies.

- b) If the throughput lies within the range of values in the database record use the intermediate results for the applicable throughput by linear interpolation.
- c) If the throughput is less than the lowest value in the database record calculate a heat pump over-ventilation ratio (R_{hp}) as the lowest rate in the database record in the database record (l/s) divided by the required dwelling rate (l/s); otherwise set the ratio to 1. When the ratio exceeds 2 the data are invalid for the dwelling and when it is above 1 but less than or equal to 2 use the intermediate results for the lowest value in the database record. Further calculations are required using the over-ventilation ratio as set out in N3.1.1.

The interpolation for PSR should be done first, followed by the interpolation for air flow rate.

Table N1: Package general information

Data item	Unit
Package main fuel (see Table 12)	-
For heat pumps, the heat pump source, one of: - ground - water - air - exhaust air MEV - exhaust air MVHR - exhaust air mixed	-
Service provision, one of - space and hot water all year - space and hot water in heating season only - space heating only - water heating only	-
Product index number for MEV/MVHR (for exhaust air MEV, exhaust air MVHR or exhaust air mixed)	-
Hot water vessel, one of - integral to package - separate, specified cylinder - separate but unspecified cylinder - none (DHW not provided by package)	-
Hot water vessel volume (where relevant)	litres
Hot water vessel loss (where relevant)	kWh/day
Hot water vessel volume heat transfer area (where relevant)	m ²

Table N2: Set of intermediate results

Data item (applicable to both heat pumps and micro-generation unless indicated otherwise)	Symbol	Unit
Daily heating duration (24, 16 or 11 ¹⁸ or variable)		hours/day
Effect of weather compensation included in test data (yes/no)		-
Central heating circulator power including in test data (yes/no)		-
Water heating thermal efficiency for test schedule number 2 ¹⁹	$\eta_{hw,2}$	%
Electricity consumed or, if negative, net electricity generated, during test schedule number 2, per unit of heat generated for water heating	$e_{hw,2}$	kWh of electricity per kWh of heat
Water heating thermal efficiency for optional test schedule number 3 ²⁰	$\eta_{hw,3}$	%
Electricity consumed or, if negative, net electricity generated, during optional test schedule number 3, per unit of heat generated for water heating	$e_{hw,3}$	kWh of electricity per kWh of heat
For heat pumps - the emitter type to which the results are applicable, one of: - Radiators (including both radiators and underfloor) - Fan coil units (fan convectors) - Underfloor only - Warm air system		-
For exhaust air heat pumps - the air flow rate for which the PSR dependent results apply.		l/s
PSR dependent results		
Plant size ratio for which the data below apply	PSR	-
Space heating thermal efficiency	η_{space}	%
Electricity consumed for space heating or, if negative, net electricity generated, per unit of heat generated for space heating	e_{space}	kWh of electricity per kWh of heat
For exhaust air or mixed air heat pumps - running hours	h_{hp}	hours per year

N2.1.1 Heat emitters for heat pumps

The performance of heat pumps depends on the delivery temperature which for the purposes of SAP calculations are defined by the emitter type. There are four emitter types: radiators, fan coil units, under-floor heating or warm-air system. There is a separate set of data as given in Table N2 for each emitter type for which the database record is applicable, which take into account the temperature of the emitter. So there is no need to apply additional efficiency adjustments related to emitter type.

¹⁸ 11 hours/day is 9 hours on weekdays and 16 at weekends (standard SAP heating schedule), giving a weekly average of 11 hours/day

¹⁹ This is the results from a hot water test using the draw-off schedule number 2 (defined in Table 3 of EN 13203-2).

²⁰ This is the results from an additional hot water test using the draw-off schedule number 3 (defined in Table 4 of EN 13203-2).

N2.1.2 Mechanical ventilation for exhaust air heat pump

An exhaust air heat pump package includes a mechanical ventilation system which is characterised by the heat exchanger efficiency, if any, and the specific fan power (in W per l/s) which depends on the number of wet rooms and the duct type (rigid or flexible). For an exhaust air heat pump, set the ventilation system to MEV or MVHR as applicable.

In the case of an exhaust air heat pump the product database also contains information on the performance of the mechanical ventilation system which is used to calculate the fan consumption and dwelling air infiltration rate (see section N3.1.1).

N3 Calculation of space and water heating

N3.1 Circulation pump and fan

If the database record indicates that the electricity required by any central heating pump to circulate water through the heat emitters is included in the result, E_{sp} , and the heat gain from it is allowed for in η_{sp} , then no allowance for a central heating pump is included and boxes (70) and (230c) are zero. Warm-air systems, also, do not require a central heating pump. If the package does not include a central heating pump or its contribution was discounted in the database results, the gain from Table 5a is included in box (70) and electricity use from Table 4f is included in box (230c).

The electricity used by any fans within the package (apart from mechanical ventilation fans which are dealt with separately in N3.1.1) is included in data items E_{sp} and E_{sum} for micro-generation and non-electric heat pump packages (see N4.2). For electric only heat pumps the electricity used is included directly in η_{hs} and η_{sum} (see N4.1).

N3.1.1 Exhaust air heat pump

For heat pumps the running hours are limited by need to defrost and included in intermediate set of results dependent on the plant size ratio. With exhaust air heat pumps the heat pump and the mechanical ventilation systems are tested together and so the energy consumption of the central ventilation fan while the heat pump is operating is included in the thermal efficiency but not when the pump is defrosting. Thus for an exhaust air heat pump system a separate calculation, equation (N4), that replaces data from Table 4f is required.

Heat pumps with mechanical ventilation are tested together at two or three different air flow rates as explained in section N2.1. If the required rate for the dwelling [= (23a) × (5)] is less than the lowest air flow rate for which data is provided in the database record for the heat pump, the mechanical ventilation is assumed to operate at the required rate during the non-heat pump operation and at the lowest rate in the database record for the heat pump during heat pump operation hours and hence will change the building infiltration rate calculation (step e below).

- Obtain from the heat pump record the run hours (h_{hp}) applicable to the system exhaust air throughput for the dwelling, after applying linear interpolation based on the plant size ratio and system air throughput.
- Obtain from the MEV/MVHR database record the specific fan power (SFP) for the duct type and number of wet rooms. If data are not listed for the duct type or number of wet rooms use the default values in Table 4g.
- Calculate the heat pump over-ventilation ratio R_{hp} using equation (N2).

If the lowest air flow rate in the heat pump database record (in l/s) is less than the throughput for the dwelling from equation (N1), $R_{hp} = 1$, otherwise:

$$R_{hp} = \text{lowest air flow rate (l/s)} \times 3.6 \div [(23a) \times (5)] \quad (N2)$$

- Calculate the annual fan consumption according to equation (N3) in kWh per year:

$$(230a) = (5) \times \text{SFP} \times \text{Fan in-use factor} \times (23a) \times R_{\text{hp}} \times (8760 - h_{\text{hp}}) \div 3600 \quad (\text{N3})$$

- e) Obtain the mechanical ventilation throughput factor, F_{mv} , from equation (N5) for calculation of box (23b):

$$F_{\text{mv}} = [(8760 - h_{\text{hp}}) + (R_{\text{hp}} \times h_{\text{hp}})] \div 8760 \quad (\text{N4})$$

N3.2 Mean internal temperature

The package, when undersized in relation to the design heat loss of the dwelling, can provide space heating needs on more days of the heating season if it operates for 16 hours per day or continuously. Table N3 shows the days of operation indicated by the parameters $N_{24,16}$, $N_{24,9}$ and $N_{16,9}$ for a nominal heating season length of 238 days (34 weeks) depending on the heating duration defined in the database record and, if duration is variable, on the plant size ratio. For the normal SAP heating schedule, the heating season would comprise 68 weekend days with 16 hours of heating and 170 weekdays with 9 hours of heating (2 hours in the morning and 7 hours in the evening).

Obtain the total number of days per year for each mode of operation from Tables N3 and N4. Allocate these to months in the following order: Jan, Dec, Feb, Mar, Nov, Apr, Oct, May (coldest to the warmest), until all the days $N_{24,16}$, $N_{24,9}$ and $N_{16,9}$ have been allocated. All the days $N_{24,9}$ are allocated first, and then $N_{16,9}$.

Example. Variable heating duration with PSR = 0.2 (first row of Table N4 applies: $N_{24,9} = 143$, $N_{16,9} = 8$ and $N_{24,16} = 57$).

January: $N_{24,16,m=1} = 9$ and $N_{24,9,m=1} = 22$. All weekdays in January have been allocated so $N_{16,9,m=1} = 0$.

The number of days remaining to be allocated is now $N_{24,16} = 48$, $N_{24,9} = 121$ and $N_{16,9} = 8$.

This is continued for Dec, Feb, Mar, Nov, Apr after which the number of days remaining to be allocated is $N_{24,16} = 6$, $N_{24,9} = 13$ and $N_{16,9} = 8$.

For October, $N_{24,16,m=10} = 6$, $N_{24,9,m=10} = 13$ and $N_{16,9,m=10} = 8$.

All days are now allocated so there are none for May.

Table N3 : Additional days at longer heating duration

Heating duration (from database record)	Number of days operating at the number of hours indicated by the first subscript instead of the SAP standard hours indicated by the second subscript		
	$N_{24,16}$	$N_{24,9}$	$N_{16,9}$
24	68	170	0
16	0	0	170
11	0	0	0
Variable	see Table N4	see Table N4	see Table N4

Table N4 Additional days at longer heating duration for variable heating

Plant size ratio	Number of days operating at the hours shown by the first subscript instead of that of the second		
	N _{24,16}	N _{24,9}	N _{16,9}
0.20	57	143	8
0.25	54	135	2
0.30	51	127	10
0.35	40	99	20
0.40	35	88	29
0.45	31	77	40
0.50	26	65	31
0.55	21	54	41
0.60	17	43	30
0.65	8	20	51
0.70	6	15	36
0.75	4	10	40
0.80	3	6	24
0.85	2	4	27
0.90	0	1	15
0.95	0	0	15
1.00	0	0	14
1.05	0	0	7
1.10	0	0	6
1.15	0	0	3
1.20	0	0	2
1.25	0	0	1
1.30 or more	0	0	0

Use linear interpolation for intermediate values of plant size ratio, rounding the result to the nearest whole number of days.

Table N5: Weekend days and weekdays each month

Month:	Jan	Dec	Feb	Mar	Nov	Apr	Oct	May
Number of weekend days, WE _m	9	9	8	9	8	8	9	8
Number of weekdays, WD _m	22	22	20	22	22	22	22	18

Replace step 7 in Table 9c, which is $T = (5 \times T_{\text{weekday}} + 2 \times T_{\text{weekend}}) \div 7$, with:

mean temperature (living room or elsewhere)

$$T = \frac{[(N_{24,16,m} + N_{24,9,m}) \times T_h + (WE_m - N_{24,16,m} + N_{16,9,m}) \times T_{\text{weekend}} + (WD_m - N_{16,9,m} - N_{24,9,m}) \times T_{\text{weekday}}]}{(WE_m + WD_m)} \quad (\text{N8})$$

where T_h is heating temperature for continuous heating for the living area or elsewhere in Table N6.

Table N6: Heating temperatures continuous heating

Living area	Elsewhere	
Temperature T_h (°C)	Heating control (Table 4e)	Temperature T_h °C
21	1	$21 - 0.5 \text{ HLP}$
	2	$21 - \text{HLP} + 0.085 \text{ HLP}^2$
	3	$21 - \text{HLP} + 0.085 \text{ HLP}^2$

N3.3 Thermal efficiency for space heating

For heat pumps the space heating thermal efficiency, box (206), is η_{space} multiplied by 0.95 (0.95 is an in-use factor). The adjustments in Table 4c(4) do not apply: the efficiency data take account of delivery temperature according to the emitter type, and of weather compensation if included in the package.

Note. In reality the space heating efficiency varies through the year according to the source temperature. The value used in this procedure is adjusted to the total annual space heating requirement so as to give the correct total fuel use but the monthly values of fuel use will not be correctly indicated.

For micro-cogeneration packages the in-use factor is 1 because they are based 24-hour tests, so box (206) is equal to η_{space} . If the micro-cogeneration package is a condensing type, the efficiency adjustments in Table 4c(1) apply where relevant to the space heating efficiency.

N3.4 Thermal efficiency for water heating

If the package provides water heating then:

a) If the thermal efficiency for water heating is given in the database record for schedule 2 only obtain the η_{summer} from equation (N9).

$$\eta_{\text{summer}} = \eta_{\text{hw},2} \quad (\text{N9})$$

b) If the thermal efficiency for water heating is given in the database record for schedule 2 and schedule 3 obtain η_{summer} from equation (N10).

$$\eta_{\text{summer}} = \eta_{\text{hw},2} + \frac{\eta_{\text{hw},3} - \eta_{\text{hw},2}}{100} \times \left(\frac{37}{50} \times V_{\text{d,average}} - 100 \right) \quad (\text{N10})$$

Note: 100 in the denominator of equation (N10) is the difference in the daily volume between schedule 2 and schedule 3, the 100 in the numerator is daily volume in litres/day at 50 K rise for schedule 2 and 37 K is average rise in SAP.

N3.4.1 Thermal efficiency for water heating – micro-cogeneration

If the micro-cogeneration package provides both space and hot water heating, calculate the monthly water heating efficiency, η_{water} for box (217)_m according to (N11).

$$\eta_{\text{water}} = \frac{Q_{\text{space}} + Q_{\text{water}}}{\frac{Q_{\text{space}}}{\eta_{\text{space}}} + \frac{Q_{\text{water}}}{\eta_{\text{summer}}}} \quad (\text{N11})$$

where

Q_{space} (kWh/month) is the quantity calculated at (98)_m multiplied by (204);

Q_{water} (kWh/month) is the quantity calculated at (64)_m;

For June, July, August and September and other months when box (98)_m is zero, box (217)_m is η_{summer} .

For micro-cogeneration packages that provide hot water only, η_{water} is η_{summer} for all months.

For micro-cogeneration packages that do not provide hot water in the summer, an alternative water heating system must be specified for June, July, August and September and other months when box (98)_m is zero.

N3.4.2 Thermal efficiency for water heating – heat pumps

If the heat pump provides water heating, in (217)_m use the thermal efficiency η_{summer} for water heating for all the months throughout the year, multiplied by the in-use factor in Table N7; subject to a minimum of 100%. The efficiency adjustments in Table 4c(4) do not apply.

Table N7: In-use factor for water heating efficiency for heat pumps

Description of hot water provision	In-use factor
Integral hot water store	0.95
Separate but specified cylinder	0.95
Separate but specified cylinder but cylinder does not meet the performance criteria specified below this table	0.60
Separate and unspecified cylinder	0.60
Hot water not provided by package	n/a

With a separate but specified cylinder the in-use factor of 0.95 applies when the actual cylinder has performance parameters at least equal to those in the database record, namely:

- cylinder volume not less than that in the database record, and
- heat transfer area not less than that in the database record, and
- heat loss (kWh/day) [either (47) or (50) × (51) × (52)] not greater than that in the database record.

If all these do not apply, or any is unknown, the in-use factor is 0.60.

N3.5 Hot water storage losses

N3.5.1 Micro-cogeneration

If the micro-cogeneration package supplies hot water via an integral store, the heat loss associated with hot water storage is included in the intermediate results and zero is entered for the cylinder loss (55) and the primary loss (58).

Otherwise a cylinder is specified separately and the cylinder loss and primary loss are included in the SAP calculation.

N3.5.2 Heat pumps

If the heat pump package supplies hot water via an integral store enter the daily cylinder loss from the heat pump database record in (47) and the temperature factor (Table 2b) for an indirect cylinder in (48).

If the heat pump provides hot water via a separate cylinder the characteristics of the cylinder are to be supplied separately: if the declared heat loss is available enter this in (47); otherwise enter the volume in (51) and use the insulation type and thickness in Table 2 to calculate (52).

If the heat pump package only provides space heating, the details of the hot water system are to be provided separately.

N3.6 Secondary fraction

Obtain the fraction of the total space heating requirement not provided by the main heating from Table N8. Usually this is assigned to a secondary heating system (room heaters) but can be a second main system if contained within or linked to the package.

Table N8: Secondary fraction

Plant size ratio	Secondary fraction for each daily heating duration			
	24	16	11	Variable
0.20	0.40	0.53	0.64	0.41
0.25	0.28	0.43	0.57	0.30
0.30	0.19	0.34	0.49	0.20
0.35	0.12	0.27	0.42	0.13
0.40	0.06	0.20	0.35	0.07
0.45	0.03	0.14	0.29	0.03
0.50	0.01	0.09	0.24	0.01
0.55	0	0.06	0.19	0
0.60	0	0.03	0.15	0
0.65	0	0.02	0.11	0
0.70	0	0.01	0.09	0
0.75	0	0	0.05	0
0.80	0	0	0.05	0
0.85	0	0	0.03	0
0.90	0	0	0.02	0
0.95	0	0	0.01	0
1.00	0	0	0.01	0
1.05 or more	0	0	0	0

Use linear interpolation for intermediate values of plant size ratio, rounding the result to the nearest 0.001.

Note. In reality the secondary fraction varies through the year according to space heating requirement. The value used in this procedure is adjusted to the total annual space heating requirement so as to give the correct total main and secondary fuel use but the monthly values of fuel use may not be correctly indicated.

N4 Electricity produced/consumed

N4.1 Electric heat pumps

For heat pumps powered solely by electricity, the ancillary electricity consumed is included the space and hot water thermal efficiencies and box (235) is zero.

N4.2 Micro-cogeneration and non-electric heat pumps

If the package provides water heating calculate the electricity produced or consumed daily per heat generated during hot water production, e_{summer} , using equation (N12) or equation (N13). If it does not provide water heating set $e_{\text{summer}} = 0$.

If the water heating test data is provided in the database record for schedule 2 only:

$$e_{\text{summer}} = e_{\text{hw},2} \quad (\text{N12})$$

If the water heating test data is provided in the database record for both schedule 2 and schedule 3:

$$e_{\text{summer}} = e_{\text{hw},2} + \frac{e_{\text{hw},3} - e_{\text{hw},2}}{100} \times \left(\frac{37}{50} \times V_{\text{d,average}} - 100 \right) \quad (\text{N13})$$

Calculate the electricity produced or consumed during the year using equation (N14), (N15), (N16) or (N17) according to the services provided by the package.

- a) Package provides space and hot water heating all year round. The electricity consumed or generated is scaled to the actual annual heat requirement of the dwelling for both heating and hot water according to equation (N14).

$$E^* = (98) \times (204) \times e_{\text{space}} + (64) \times e_{\text{summer}} \quad (\text{N14})$$

- b) Package provides space heating and hot water heating during the heating season only. The electricity consumed or generated is scaled to the actual annual heat requirement of the dwelling for both heating and hot water according to equation (N15).

$$E^* = (98) \times (204) \times e_{\text{space}} + e_{\text{summer}} \times \sum_{(98)_m > 0} (64)_m \quad (\text{N15})$$

in which the summation only applies to the months when the space heating requirement, box (98)_m, is greater than zero.

- c) Package provides space heating only. The electricity consumed or generated is scaled to the actual annual space heating requirement of the dwelling according to equation (N16).

$$E^* = (98) \times (204) \times e_{\text{space}} \quad (\text{N16})$$

- d) Package provides water heating only. The electricity consumed or generated is scaled to the actual annual water heating requirement of the dwelling according to equation (N17).

$$E^* = (64) \times e_{\text{summer}} \quad (\text{N17})$$

If E* is positive, enter E* in box (235) and use the unit price for standard tariff electricity in the calculation of box (96a).

If E* is negative, enter -E* in box (235). The cost saving associated with the net generated electricity depends on whether it is used directly within the dwelling or whether it is exported. Electricity used directly within the dwelling is valued at the unit cost for purchased electricity (usually the standard tariff, or the high rate in the case of an off-peak tariff). Electricity exported is valued at the price in Table 12 for electricity sold to the grid.

The effective price depends on a factor β , which is in the range 0.0 to 1.0 and is defined as the proportion of the generated electricity that is used directly within the dwelling. The value of β depends on the coincidence of electricity generation and electricity demand within the dwelling. At present the value of $\beta = 0.40$ should be used for SAP calculations: this will be reviewed in future if relevant data become available. The fuel price used in the calculation of box (252) is then: $\beta \times \text{normal electricity price} + (1 - \beta) \times \text{exported electricity price}$, using in the case of an off-peak tariff the high-rate fraction for locally generated electricity in Table 12a.

Appendix O (not used)

Appendix P: Assessment of internal temperature in summer

This appendix provides a method for assessing the propensity of a house to have high internal temperature in hot weather. It does not provide an estimate of cooling needs. The procedure is not integral to SAP and does not affect the calculated SAP rating or CO₂ emissions.

The calculation is related to the factors that contribute to internal temperature: solar gain (taking account of orientation, shading and glazing transmission); ventilation (taking account of window opening in hot weather), thermal capacity and mean summer temperature for the location of the dwelling.

Further information about techniques to avoid overheating can be found in 'Reducing overheating– a designer's guide', CE 129, Energy Efficiency Best Practice in Housing, Energy Saving Trust, London (2005).

P1 Assessment procedure

The procedure is undertaken for the months of June, July and August.

1. Obtain a value for the effective air change rate during hot weather. Indicative values based on the procedure in BS 5925²¹ are given in Table P1.

Table P1: Effective air change rate

Window opening	Effective air change rate in ach			
	Trickle vents only	Windows slightly open (50 mm)	Windows open half the time	Windows fully open
Single storey dwelling (bungalow, flat) Cross ventilation possible	0.1	0.8	3	6
Single storey dwelling (bungalow, flat) Cross ventilation not possible	0.1	0.5	2	4
Dwelling of two or more storeys windows open upstairs and downstairs Cross ventilation possible	0.2	1	4	8
Dwelling of two or more storeys windows open upstairs and downstairs Cross ventilation not possible	0.1	0.6	2.5	5

Cross ventilation can be assumed only if the at least half of the storeys in the dwelling have windows on opposite sides and there is a route for the ventilation air. Normally bungalows and two storey houses can be cross ventilated because internal doors can be left open. Three storey houses or other situations with two connected storeys of which one is more than 4.5 m above ground level often have floors which have fire doors onto stairs that prevent cross ventilation.

Slightly open refers to windows that can be securely locked with a gap of about 50 mm. Often this option will not give sufficient ventilation.

Windows on ground floors cannot be left open all night because of security issues. Windows on other floors can. Fully open would refer to dwellings where security is not an issue (e.g. an upper floor flat) or where there is secure night time ventilation (e.g. by means of grilles, shutters with vents or purpose-made ventilators). In most cases where there are ground and upper floor windows 'windows open half

²¹ BS 5925:1991, Code of practice for ventilation principles and design for natural ventilation

the time' would be applicable, which refers principally to night-time ventilation (ground floor evening only, upper floors open all night).

If there is a mechanical ventilation system providing a specified air change rate, that rate can be used instead.

2. Calculate the ventilation heat loss, H_v^{summer} , using the formula:

$$H_v^{\text{summer}} = 0.33 \times n \times V \quad (\text{P1})$$

where:

n = air change rate during hot weather, ach

V = volume of the heated space of the dwelling, m^3

3. Calculate the heat loss coefficient under summer conditions:

$$H = \text{total fabric heat loss} + H_v^{\text{summer}} \quad (\text{P2})$$

The total fabric heat loss is the same as for the heating season (box (37) of the worksheet).

4. Calculate the solar gains for the summer month, $G_{\text{solar}}^{\text{summer}}$, using the solar flux for the appropriate month from Table 10.

$$G_{\text{solar}}^{\text{summer}} = \sum (0.9 \times A_w \times S \times g_{\perp} \times \text{FF} \times Z_{\text{summer}}) \quad (\text{P3})$$

where:

0.9 is a factor representing the ratio of typical average transmittance to that at normal incidence

A_w is the area of an opening (a window, roof window or fully glazed door), m^2

S is the solar flux on a surface during the summer period from Table 6a, W/m^2

g_{\perp} is the total solar energy transmittance factor of the glazing at normal incidence from Table 6b

FF is the frame factor for windows and doors (fraction of opening that is glazed) from Table 6c

Z_{summer} is the summer solar access factor

In the case of a window certified by the British Fenestration Rating Council (BFRC), see www.bfrc.org, the quoted solar factor is g_{window} which is equal to $0.9 \times g_{\perp} \times \text{FF}$. The solar gain for such windows is calculated as

$$G_{\text{solar}}^{\text{summer}} = \sum (A_w \times S \times g_{\text{window}} \times Z_{\text{summer}}) \quad (\text{P4})$$

Solar gains should be calculated separately for each orientation and for rooflights, and totalled according to equation (P3).

For data to calculate Z_{summer} see section P3.

Assume that the summer internal gains (G_i) are equal to the winter internal gains (these are calculated in section 5 of the SAP worksheet), except that where water heating in summer is by a summer-only electric immersion in which case primary loss should not be included in the summer gains, so that the total gains are:

$$G = G_{\text{solar}}^{\text{summer}} + G_i \quad (\text{P5})$$

5. Calculate the summer Gain/Loss ratio:

$$\text{Summer Gain/Loss ratio} = \frac{G}{H} \quad (\text{P6})$$

6. Obtain the mean external temperature for the month, T_e^{summer} , from Table 10.

7. Obtain the threshold internal temperature which is used to estimate likelihood of high internal temperature. This is the mean internal temperature during the summer period plus an increment related to the thermal mass.

$$T_{\text{threshold}} = T_e^{\text{summer}} + \frac{G}{H} + \Delta T_{\text{mass}} \quad (\text{P7})$$

where

$$\Delta T_{\text{mass}} = 2.0 - 0.007 \times \text{TMP} \quad \text{if } \text{TMP} < 285$$

$$\Delta T_{\text{mass}} = 0 \quad \text{if } \text{TMP} \geq 285$$

where TMP is the thermal mass parameter (for further details see Table 1e).

Where night cooling can be employed (window opening at night) ΔT_{mass} is further modified if $\text{TMP} > 285$ by a term $-0.002 \times (\text{TMP} - 285)$. (*to be confirmed*)

8. Use Table P2 to estimate tendency to high internal temperature in hot weather.

Table P2: Levels of threshold temperature corresponding to likelihood of high internal temperature during hot weather

$T_{\text{threshold}}$	Likelihood of high internal temperature during hot weather
< 20.5°C	Not significant
≥ 20.5°C and < 22.0°C	Slight
≥ 22.0°C and < 23.5°C	Medium
≥ 23.5°C	High

P2 Reporting of results

Results should include:

- details of the house design including its thermal mass parameter and specification of any overhangs, together with its orientation and the climatic region assumed;
- for one or more scenarios, the category from Table P2 for the months of June, July and August for stated assumptions on occupant-determined factors (usage of blinds/curtains and window opening).

If the orientation of the dwelling is not known, the assessment should be for the orientation giving the greatest tendency to high internal temperature.

P3 Solar shading

Z_{summer} is given by

$$Z_{\text{summer}} = Z_{\text{blinds}} (Z + Z_{\text{overhangs}} - 1) \quad (\text{P8})$$

subject to

$$Z_{\text{summer}} \geq 0.1 Z_{\text{blinds}} \quad (\text{P9})$$

where

Z_{blinds} is a shading factor for blinds or curtains

Z is the solar access factor from Table 6d

$Z_{\text{overhangs}}$ is a shading factor for overhangs

Table P3 gives values for Z_{blinds} , and Tables P4 and P5 give values for $Z_{\text{overhangs}}$. If there are no overhangs, $Z_{\text{overhangs}} = 1$.

P3.1 Curtains and blinds

Unless specifically included in the design specification a default of dark coloured curtains should be assumed closed during daylight hours ($f = 1$). Shutters with window closed is compatible with windows open half the time in Table P1 as the latter refers to night-time and Table P3 refers to daytime.

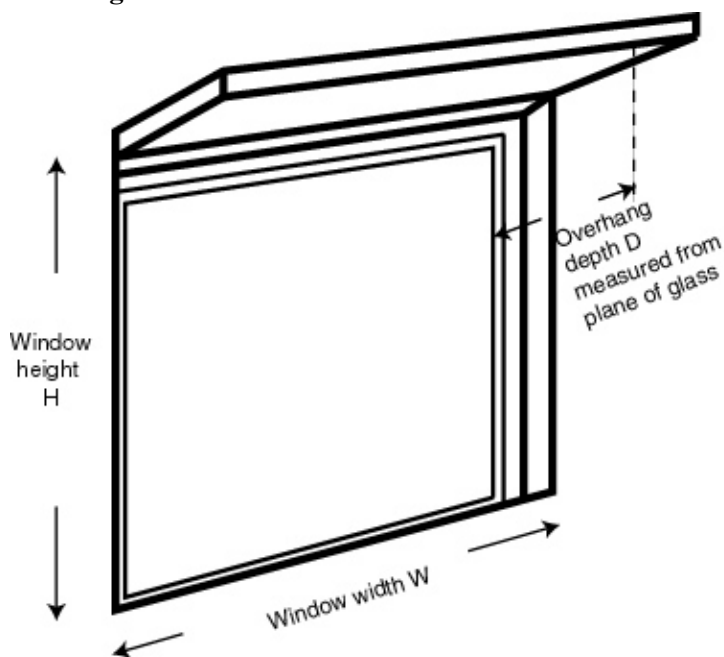
Table P3 : Shading factors for blinds, curtains or external shutters

Blind or curtain type	Z_{blind}
Net curtain (covering whole window)	0.80
Net curtain (covering half window)	0.90
Dark-coloured curtain or roller blind (note 1)	0.85
Light-coloured curtain or roller blind (note 1)	0.60
Dark-coloured venetian blind (note 2)	0.88
Light-coloured venetian blind (note 2)	0.70
Dark-coloured external shutter, window closed (notes 1, 3)	0.27
White external shutter, window closed (notes 1, 3)	0.24
Dark-coloured external shutter, window fully open (notes 1, 3)	0.85
White external shutter, window fully open (notes 1, 3)	0.65

Notes to Table P3

- Factor applies when fully closed. If closed only for a fraction f of the daylight hours or applicable only to a fraction f of the windows use $f \times Z_{\text{blind}} + (1 - f)$.
- Factor applies for venetian blind with slats at 45° against the sun. The same factor can be used if the blind is fully closed. If closed only for a fraction f of the daylight hours or applicable only to a fraction f of the windows use $f \times Z_{\text{blind}} + (1 - f)$.
- External shutters are not applicable to roof windows.

P3.2 Overhangs



Where the overhang is at least twice as wide as the window (e.g. balconies on blocks of flats) use Table P4. In other cases use Table P5. Interpolation may be used between rows of these tables. Use the average overhang depth if it varies. Usually the same value of $Z_{\text{overhangs}}$ can be applied to all the windows on a given façade on the basis of an average depth-to-height ratio.

Table P4: $Z_{\text{overhangs}}$ for wide overhangs

Depth/H	Orientation of window				
	N	NE/NW	E/W	SE/SW	S
0.0	1.00	1.00	1.00	1.00	1.00
0.2	0.92	0.89	0.88	0.83	0.77
0.4	0.85	0.80	0.76	0.67	0.55
0.6	0.79	0.72	0.66	0.54	0.38
0.8	0.73	0.65	0.58	0.43	0.32
1	0.69	0.59	0.51	0.36	0.30
1.2 or more	0.66	0.55	0.46	0.31	0.29

This table is to be used where the overhang is at least twice as wide as the window

Table P5: $Z_{\text{overhangs}}$ for normal overhangs

Depth/H	Orientation of window				
	N	NE/NW	E/W	SE/SW	S
0.0	1.00	1.00	1.00	1.00	1.00
0.2	0.94	0.91	0.89	0.84	0.79
0.4	0.90	0.85	0.79	0.72	0.64
0.6	0.88	0.81	0.72	0.62	0.53
0.8	0.86	0.79	0.66	0.55	0.50
1	0.85	0.77	0.61	0.52	0.49
1.2 or more	0.84	0.76	0.57	0.50	0.48

This table is to be used where the overhang is less than twice as wide as the window

Appendix Q: Special features and specific data

Q1 Special features

This appendix provides a method to enable the SAP calculation to make use of the characteristics of technologies that are not included in the published SAP specification.

This procedure may only be used for technologies whose characteristics have been independently assessed and which are described on the web page www.bre.co.uk/sap2009 or a web page linked to it²². For such systems, this web page will contain details for calculating the data to be used in the SAP calculation.

In general the technology might use additional energy from one fuel while saving energy from another fuel.

Where more than one technology is applicable the procedure is applied for each.

Q1.1 Monthly values

Where the Appendix Q data is provided on an annual basis:

SAP rating:

1. include the amount of energy saved by the technology (kWh/year) in box (236n) or (336n);
2. multiply the amount of saved energy by the unit price of the fuel concerned to obtain box (268n) or (368n);
3. include the amount of energy used by the technology in box (237n);
4. multiply the energy used by the unit price of the fuel concerned and to obtain box (269n) or (369n);
5. include both these items in the calculation of the total energy cost.

In the case of electricity using an off-peak tariff the fractions of electricity at the high and low rates are needed to determine the appropriate price.

CO₂ emissions: the amount of energy saved or used by the technology (kWh/year) is multiplied by the appropriate emission factor and included in the total CO₂ emissions.

In some cases the data may be provided on a monthly basis, in which case they are included at the appropriate point in the worksheet.

Q2 Specific data

A similar mechanism will be used to enable the use of data specific to a technology instead of the data provided in the SAP tables. For applicable data types, the web page mentioned above will give details of the conditions for accepting the data and its applicability within the SAP calculation.

²² One such page is www.sap-appendixq.org.uk

Appendix R: Reference values

This appendix provides a set of reference values for the parameters of a SAP calculation, which are used in connection with establishing a target CO₂ emissions rate for the purposes of demonstrating compliance with regulations for new dwellings. Table R1 is used to define a notional dwelling of the same size and shape as the actual dwelling.

The CO₂ emissions per unit floor area from the notional dwelling are adjusted as specified in the applicable regulatory document to form the target CO₂ emission rate for the actual dwelling.

CO₂ emissions associated with internal lighting should be recorded separately. CO₂ emissions associated with electricity consumption for pumps and fans are included with those for heating and hot water.

Table R1 : Reference values

Element or system	Value
Size and shape	Same as actual dwelling
Opening areas (windows and doors)	25% of total floor area (or, if total exposed façade area is less than 25% of the total floor area, the total exposed façade area) The above includes one opaque door of area 1.85 m ² , any other doors are fully glazed All glazing treated as windows (i.e. no roof windows)
External walls	U = 0.35 W/m ² K
Party walls	U = 0
Floors	U = 0.25 W/m ² K
Roofs	U = 0.16 W/m ² K
Opaque door	U = 2.0 W/m ² K
Windows and glazed doors	U = 2.0 W/m ² K Double glazed, low-E hard coat Frame factor 0.7 Solar energy transmittance 0.72 Light transmittance 0.80
Thermal mass	Medium (TMP = 250 kJ/m ² K)
Living area fraction	Same as actual dwelling
Shading and orientation	All glazing orientated E/W; average overshadowing
Number of sheltered sides	2
Allowance for thermal bridging	0.11 x total exposed surface area (W/K)
Ventilation system	Natural ventilation with intermittent extract fans
Air permeability	10 m ³ /h·m ² at 50 Pa
Chimneys	None
Open flues	None
Extract fans	3 for dwellings with floor area greater than 80 m ² , 2 for smaller dwellings
Main heating fuel (space and water)	Mains gas
Heating system	Boiler and radiators water pump in heated space

Boiler	SEDBUK(2009) 78% room-sealed fanned flue on/off burner control
Heating system controls	Programmer, room thermostat and TRVs boiler interlock
Hot water system	Stored hot water, heated by boiler separate time control for space and water heating
Hot water cylinder	150 litre cylinder insulated with 35 mm of factory applied foam
Primary water heating losses	Primary pipework not insulated cylinder temperature controlled by thermostat
Water use limited to 125 litres per person per day	No
Secondary space heating	10% electric (panel heaters)
Low energy light fittings	30% of fixed outlets
<i>Note: Building regulations can vary between England, Wales, Scotland and Northern Ireland. The data in the table should only be used subject to any qualifications or amendments given in the regulatory documents that apply in the Administration where the dwelling(s) will be constructed.</i>	

Appendix S: Reduced Data SAP for existing dwellings

For the time being Reduced Data SAP assessments are undertaken using SAP 2005 version 9.83. The specification is available at www.bre.co.uk/sap2005.

SAP WORKSHEET (Version 9.90)

1. Overall dwelling dimensions

	Area (m ²)		Average storey height (m)		Volume (m ³)
Basement	<input type="text"/> (1a)	×	<input type="text"/> (2a)	=	<input type="text"/> (3a)
Ground floor	<input type="text"/> (1b)	×	<input type="text"/> (2b)	=	<input type="text"/> (3b)
First floor	<input type="text"/> (1c)	×	<input type="text"/> (2c)	=	<input type="text"/> (3c)
Second floor	<input type="text"/> (1d)	×	<input type="text"/> (2d)	=	<input type="text"/> (3d)
Third floor	<input type="text"/> (1e)	×	<input type="text"/> (2e)	=	<input type="text"/> (3e)
Other floors (repeat as necessary)	<input type="text"/> (1n)	×	<input type="text"/> (2n)	=	<input type="text"/> (3n)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n) =	<input type="text"/> (4)				
Dwelling volume	(3a)+(3b)+(3c)+(3d)+(3e)...(3n) =				<input type="text"/> (5)

2. Ventilation rate

	main heating	secondary heating	other	total		m ³ per hour
Number of chimneys	<input type="text"/>	+	<input type="text"/>	+	<input type="text"/>	= <input type="text"/> × 40 = <input type="text"/> (6a)
Number of open flues	<input type="text"/>	+	<input type="text"/>	+	<input type="text"/>	= <input type="text"/> × 20 = <input type="text"/> (6b)
Number of intermittent fans				<input type="text"/>	×	10 = <input type="text"/> (7a)
Number of passive vents				<input type="text"/>	×	10 = <input type="text"/> (7b)
Number of flueless gas fires				<input type="text"/>	×	40 = <input type="text"/> (7c)
Infiltration due to chimneys, flues, fans, PSVs	(6a)+(6b)+(7a)+(7b)+(7c) = <input type="text"/>				÷ (5) =	<input type="text"/> (8)
<i>If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)</i>						
Number of storeys in the dwelling (n _s)						<input type="text"/> (9)
Additional infiltration	[(9) - 1] × 0.1 =					<input type="text"/> (10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction <i>if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal use 0.35</i>						<input type="text"/> (11)
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0						<input type="text"/> (12)
If no draught lobby, enter 0.05, else enter 0						<input type="text"/> (13)
Percentage of windows and doors draught stripped	<input type="text"/>					(14)
Window infiltration	0.25 - [0.2 × (14) ÷ 100] =					<input type="text"/> (15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =					<input type="text"/> (16)
Air permeability value, q ₅₀ , expressed in cubic metres per hour per square metre of envelope area						<input type="text"/> (17)
If based on air permeability value, then (18) = [(17) ÷ 20] + (8), otherwise (18) = (16)						<input type="text"/> (18)
<i>Air permeability value applies if a pressurisation test has been done, or a design or specified air permeability is being used</i>						
Number of sides on which dwelling is sheltered						<input type="text"/> (19)
Shelter factor	(20) = 1 - [0.075 × (19)] =					<input type="text"/> (20)
Infiltration rate incorporating shelter factor	(21) = (18) × (20) =					<input type="text"/> (21)

Infiltration rate modified for monthly wind speed:

Monthly average wind speed from Table 7

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(22) _m =	(22) ₁	(22) ₂	(22) ₃	(22) ₄	(22) ₅	(22) ₆	(22) ₇	(22) ₈	(22) ₉	(22) ₁₀	(22) ₁₁	(22) ₁₂	
	$\Sigma(22)_{1...12} =$ <input type="text"/>												(22)

Wind Factor $(22a)_m = (22)_m \div 4$

(22a) _m =	(22a) ₁	(22a) ₂	(22a) ₃	(22a) ₄	(22a) ₅	(22a) ₆	(22a) ₇	(22a) ₈	(22a) ₉	(22a) ₁₀	(22a) ₁₁	(22a) ₁₂	
	$\Sigma(22a)_{1...12} =$ <input type="text"/>												(22a)

Adjusted infiltration rate (allowing for shelter and wind speed) = (21) × (22a)_m

(22b) _m =	(22b) ₁	(22b) ₂	(22b) ₃	(22b) ₄	(22b) ₅	(22b) ₆	(22b) ₇	(22b) ₈	(22b) ₉	(22b) ₁₀	(22b) ₁₁	(22b) ₁₂	
	$\Sigma(22b)_{1...12} =$ <input type="text"/>												(22b)

Calculate effective air change rate for the applicable case:

If mechanical ventilation: air change rate through system (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × F_{mv}, (equation (N5)), otherwise (23b) = (23a) (23b)

If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = (23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) $(24a)_m = (22b)_m + (23b) \times [1 - (23c) \div 100]$
 (24a)_m = (24a)

b) If balanced mechanical ventilation without heat recovery (MV) $(24b)_m = (22b)_m + (23b)$
 (24b)_m = (24b)

c) If whole house extract ventilation or positive input ventilation from outside
 if $(22b)_m < 0.5 \times (23b)$, then $(24c) = (23b)$; otherwise $(24c) = (22b)_m + 0.5 \times (23b)$
 (24c)_m = (24c)

d) If natural ventilation or whole house positive input ventilation from loft
 if $(22b)_m \geq 1$, then $(24d)_m = (22b)_m$ otherwise $(24d)_m = 0.5 + [(22b)_m^2 \times 0.5]$
 (24d)_m = (24d)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in box (25)

(25) _m =	(25) ₁	(25) ₂	(25) ₃	(25) ₄	(25) ₅	(25) ₆	(25) ₇	(25) ₈	(25) ₉	(25) ₁₀	(25) ₁₁	(25) ₁₂	(25)
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If Appendix Q applies in relation to air change rate, the effective air change rate is calculated via Appendix Q and use the following instead:

Effective air change rate from Appendix Q calculation sheet:

(25) _m =	(25) ₁	(25) ₂	(25) ₃	(25) ₄	(25) ₅	(25) ₆	(25) ₇	(25) ₈	(25) ₉	(25) ₁₀	(25) ₁₁	(25) ₁₂	(25)
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3. Heat losses and heat loss parameter

Items in the table below are to be expanded as necessary to allow for all different types of element e.g. 4 wall types.
The k-value is the heat capacity per unit area, see Table 1e

Element	Gross area, m ²	Openings m ²	Net area A, m ²	U-value W/m ² K	=	A × U W/K	κ-value kJ/m ² ·K	A × κ kJ/K
Door			<input type="text"/> × <input type="text"/>	<input type="text"/>	=	<input type="text"/>		<input type="text"/> (26)
Window			<input type="text"/> × <input type="text"/>	* below	=	<input type="text"/>		<input type="text"/> (27)
Roof window			<input type="text"/> × <input type="text"/>	* below	=	<input type="text"/>		<input type="text"/> (27a)
Basement floor			<input type="text"/> × <input type="text"/>	<input type="text"/>	=	<input type="text"/>	<input type="text"/>	<input type="text"/> (28)
Ground floor			<input type="text"/> × <input type="text"/>	<input type="text"/>	=	<input type="text"/>	<input type="text"/>	<input type="text"/> (28a)
Exposed floor			<input type="text"/> × <input type="text"/>	<input type="text"/>	=	<input type="text"/>	<input type="text"/>	<input type="text"/> (28b)
Basement wall	<input type="text"/> - <input type="text"/>	=	<input type="text"/> × <input type="text"/>	<input type="text"/>	=	<input type="text"/>	<input type="text"/>	<input type="text"/> (29)
External wall	<input type="text"/> - <input type="text"/>	=	<input type="text"/> × <input type="text"/>	<input type="text"/>	=	<input type="text"/>	<input type="text"/>	<input type="text"/> (29a)
Roof	<input type="text"/> - <input type="text"/>	=	<input type="text"/> × <input type="text"/>	<input type="text"/>	=	<input type="text"/>	<input type="text"/>	<input type="text"/> (30)
Total area of external elements SA, m ²	<input type="text"/> (31)							
Party wall			<input type="text"/> × <input type="text"/>	<input type="text"/>	=	<input type="text"/>	<input type="text"/>	<input type="text"/> (32)
<i>(party wall U-value from Table 3.6, k according to its construction)</i>								
Party floor			<input type="text"/>				<input type="text"/>	<input type="text"/> (32a)
Party ceiling			<input type="text"/>				<input type="text"/>	<input type="text"/> (32b)
Internal wall **			<input type="text"/>				<input type="text"/>	<input type="text"/> (32c)
Internal floor			<input type="text"/>				<input type="text"/>	<input type="text"/> (32d)
Internal ceiling			<input type="text"/>				<input type="text"/>	<input type="text"/> (32e)

* for windows and roof windows, use effective window U-value calculated using formula $1/[(1/U\text{-value})+0.04]$ as given in paragraph 3.2

** include the areas on both sides of internal walls and partitions

Fabric heat loss, W/K = $\Sigma (A \times U)$ (26)...(30) + (32) = (33)

Heat capacity $C_m = \Sigma(A \times \kappa)$ (28)...(30) + (32) + (32a)...(32e) = (34)

Thermal mass parameter (TMP = $C_m \div TFA$) in kJ/m²K = (34) ÷ (4) = (35)

For design assessments where the details of the construction are not known precisely the indicative values of TMP in Table 1f can be used instead of a detailed calculation. Also TMP calculated separately can be used in (35).

Thermal bridges : $\Sigma (L \times \Psi)$ calculated using Appendix K (36)

if details of thermal bridging are not known (36) = 0.15 × (31)

Total fabric heat loss (33) + (36) = (37)

Ventilation heat loss calculated monthly (38)_m = 0.33 × (25)_m × (5)

(38) _m =	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	(38) ₁	(38) ₂	(38) ₃	(38) ₄	(38) ₅	(38) ₆	(38) ₇	(38) ₈	(38) ₉	(38) ₁₀	(38) ₁₁	(38) ₁₂	(38)

Heat transfer coefficient, W/K (39)_m = (37) + (38)_m

(39) _m =	(39) ₁	(39) ₂	(39) ₃	(39) ₄	(39) ₅	(39) ₆	(39) ₇	(39) ₈	(39) ₉	(39) ₁₀	(39) ₁₁	(39) ₁₂	
	Average = $\Sigma(39)_{1...12} / 12 =$ <input type="text"/> (39)												

Heat loss parameter (HLP), W/m²K (40)_m = (39)_m ÷ (4)

(40) _m =	(40) ₁	(40) ₂	(40) ₃	(40) ₄	(40) ₅	(40) ₆	(40) ₇	(40) ₈	(40) ₉	(40) ₁₀	(40) ₁₁	(40) ₁₂	
	Average = $\Sigma(40)_{1...12} / 12 =$ <input type="text"/> (40)												

Number of days in month (Table 1a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(41) _m =	(41) ₁	(41) ₂	(41) ₃	(41) ₄	(41) ₅	(41) ₆	(41) ₇	(41) ₈	(41) ₉	(41) ₁₀	(41) ₁₁	(41) ₁₂	(41)

4. Water heating energy requirement

kWh/year

Assumed occupancy, N (42)

if TFA > 13.9, N = 1 + 1.76 × [1 - exp(-0.000349 × (TFA - 13.9)²)] + 0.0013 × (TFA - 13.9)

if TFA ≤ 13.9, N = 1

Annual average hot water usage in litres per day V_{d,average} = (25 × N) + 36 (43)

Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more than 125 litres per person per day (all water use, hot and cold)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Hot water usage in litres per day for each month V_{d,m} = factor from Table 1c × (43)

(44) _m =	(44) ₁	(44) ₂	(44) ₃	(44) ₄	(44) ₅	(44) ₆	(44) ₇	(44) ₈	(44) ₉	(44) ₁₀	(44) ₁₁	(44) ₁₂	
	Total = Σ(44) _{1...12} = <input type="text"/> (44)												

Energy content of hot water used - calculated monthly = 4.190 × V_{d,m} × n_m × ΔT_m / 3600 kWh/month (see Tables 1b, 1c, 1d)

(45) _m =	(45) ₁	(45) ₂	(45) ₃	(45) ₄	(45) ₅	(45) ₆	(45) ₇	(45) ₈	(45) ₉	(45) ₁₀	(45) ₁₁	(45) ₁₂	
	Total = Σ(45) _{1...12} = <input type="text"/> (45)												

If instantaneous water heating at point of use (no hot water storage), enter "0" in boxes (46) to (61)

For community heating include distribution loss whether or not hot water tank is present

Distribution loss (46)_m = 0.15 × (45)_m

(46) _m =	(46) ₁	(46) ₂	(46) ₃	(46) ₄	(46) ₅	(46) ₆	(46) ₇	(46) ₈	(46) ₉	(46) ₁₀	(46) ₁₁	(46) ₁₂	(46)
---------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	--------------------	--------------------	--------------------	------

Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day): (47)

Temperature factor from Table 2b (48)

Energy lost from water storage, kWh/day (47) × (48) = (49)

b) If manufacturer's declared cylinder loss factor is not known :

Cylinder volume (litres) including any solar storage within same cylinder (50)

If community heating and no tank in dwelling, enter 110 litres in box (50)

Otherwise if no stored hot water (this includes instantaneous combi boilers) enter '0' in box (50)

Hot water storage loss factor from Table 2 (kWh/litre/day) (51)

If community heating see section 4.3

Volume factor from Table 2a (52)

Temperature factor from Table 2b (53)

Energy lost from water storage, kWh/day (50) × (51) × (52) × (53) = (54)

Enter (49) or (54) in (55) (55)

Water storage loss calculated for each month (56)_m = (55) × (41)_m

(56) _m =	(56) ₁	(56) ₂	(56) ₃	(56) ₄	(56) ₅	(56) ₆	(56) ₇	(56) ₈	(56) ₉	(56) ₁₀	(56) ₁₁	(56) ₁₂	(56)
---------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	--------------------	--------------------	--------------------	------

If cylinder contains dedicated solar storage, (57)_m = (56)_m × [(50) - (H11)] ÷ (50), else (57)_m = (56)_m where (H11) is from Appendix H

(57) _m =	(57) ₁	(57) ₂	(57) ₃	(57) ₄	(57) ₅	(57) ₆	(57) ₇	(57) ₈	(57) ₉	(57) ₁₀	(57) ₁₁	(57) ₁₂	(57)
---------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	--------------------	--------------------	--------------------	------

Primary circuit loss (annual) from Table 3 (58)

Primary circuit loss for each month (59)_m = (58) ÷ 365 × (41)_m

(modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)

(59) _m =	(59) ₁	(59) ₂	(59) ₃	(59) ₄	(59) ₅	(59) ₆	(59) ₇	(59) ₈	(59) ₉	(59) ₁₀	(59) ₁₁	(59) ₁₂	(59)
---------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	--------------------	--------------------	--------------------	------

Combi loss for each month from Table 3a, 3b or 3c (enter "0" if not a combi boiler)

(61) _m =	(61) ₁	(61) ₂	(61) ₃	(61) ₃	(61) ₃	(61) ₃	(61) ₃	(61) ₃	(61) ₃	(61) ₃	(61) ₃	(61) ₁₂	(61)
---------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	-------------------	--------------------	------

Total heat required for water heating calculated for each month $(62)_m = 0.85 \times (45)_m + (46)_m + (57)_m + (59)_m + (61)_m$

$(62)_m =$	$(62)_1$	$(62)_2$	$(62)_3$	$(62)_4$	$(62)_5$	$(62)_6$	$(62)_7$	$(62)_8$	$(62)_9$	$(62)_{10}$	$(62)_{11}$	$(62)_{12}$	(62)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

Solar DHW input calculated using Appendix G or Appendix H (negative quantity) (enter "0" if no solar contribution to water heating) (add additional lines if FGHRs and/or WWHRs applies, see Appendix G)

$(63)_m =$	$(63)_1$	$(63)_2$	$(63)_3$	$(63)_4$	$(63)_5$	$(63)_6$	$(63)_7$	$(63)_8$	$(63)_9$	$(63)_{10}$	$(63)_{11}$	$(63)_{12}$	(63)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

Output from water heater for each month, kWh/month $(64)_m = (62)_m + (63)_m$

$(64)_m =$	$(64)_1$	$(64)_2$	$(64)_3$	$(64)_4$	$(64)_5$	$(64)_6$	$(64)_7$	$(64)_8$	$(64)_9$	$(64)_{10}$	$(64)_{11}$	$(64)_{12}$	(64)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

Total per year (kWh/year) = $\Sigma(64)_{1...12} =$

if $(64)_m < 0$ then set to 0

Heat gains from water heating, kWh/month $0.25 \times [0.85 \times (45)_m + (61)_m] + 0.8 \times [(46)_m + (57)_m + (59)_m]$

$(65)_m =$	$(65)_1$	$(65)_2$	$(65)_3$	$(65)_4$	$(65)_5$	$(65)_6$	$(65)_7$	$(65)_8$	$(65)_9$	$(65)_{10}$	$(65)_{11}$	$(65)_{12}$	(65)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

include $(57)_m$ in calculation of $(65)_m$ only if cylinder is in the dwelling or hot water is from community heating

5. Internal gains (see Table 5 and 5a)

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
$(66)_m =$	$(66)_1$	$(66)_2$	$(66)_3$	$(66)_4$	$(66)_5$	$(66)_6$	$(66)_7$	$(66)_8$	$(66)_9$	$(66)_{10}$	$(66)_{11}$	$(66)_{12}$	(66)

Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5

$(67)_m =$	$(67)_1$	$(67)_2$	$(67)_3$	$(67)_4$	$(67)_5$	$(67)_6$	$(67)_7$	$(67)_8$	$(67)_9$	$(67)_{10}$	$(67)_{11}$	$(67)_{12}$	(67)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5

$(68)_m =$	$(68)_1$	$(68)_2$	$(68)_3$	$(68)_4$	$(68)_5$	$(68)_6$	$(68)_7$	$(68)_8$	$(68)_9$	$(68)_{10}$	$(68)_{11}$	$(68)_{12}$	(68)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5

$(69)_m =$	$(69)_1$	$(69)_2$	$(69)_3$	$(69)_4$	$(69)_5$	$(69)_6$	$(69)_7$	$(69)_8$	$(69)_9$	$(69)_{10}$	$(69)_{11}$	$(69)_{12}$	(69)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

Pumps and fans gains (Table 5a)

$(70)_m =$	$(70)_1$	$(70)_2$	$(70)_3$	$(70)_4$	$(70)_5$	$(70)_6$	$(70)_7$	$(70)_8$	$(70)_9$	$(70)_{10}$	$(70)_{11}$	$(70)_{12}$	(70)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

Losses e.g. evaporation (negative values) (Table 5)

$(71)_m =$	$(71)_1$	$(71)_2$	$(71)_3$	$(71)_4$	$(71)_5$	$(71)_6$	$(71)_7$	$(71)_8$	$(71)_9$	$(71)_{10}$	$(71)_{11}$	$(71)_{12}$	(71)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

Water heating gains (Table 5)

$(72)_m =$	$(72)_1$	$(72)_2$	$(72)_3$	$(72)_4$	$(72)_5$	$(72)_6$	$(72)_7$	$(72)_8$	$(72)_9$	$(72)_{10}$	$(72)_{11}$	$(72)_{12}$	(72)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

Total internal gains = $(66)_m + (67)_m + (68)_m + (69)_m + (70)_m + (71)_m + (72)_m$

$(73)_m =$	$(73)_1$	$(73)_2$	$(73)_3$	$(73)_4$	$(73)_5$	$(73)_6$	$(73)_7$	$(73)_8$	$(73)_9$	$(73)_{10}$	$(73)_{11}$	$(73)_{12}$	(73)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

6. Solar gains

Solar gains are calculated using solar flux from Table 6a and associated equations to convert to the applicable orientation. Rows (74) to (82) are used 12 times, one for each month, repeating as needed if there is more than one window type,

	Access factor Table 6d	Area m ²	Solar flux W/m ²	g_{\perp} Specific data or Table 6b	FF Specific data or Table 6c	Gains (W)	
North	<input type="text"/>	<input type="text"/>	<input type="text"/>	$\times 0.9 \times$	<input type="text"/>	<input type="text"/>	(74)
Northeast	<input type="text"/>	<input type="text"/>	<input type="text"/>	$\times 0.9 \times$	<input type="text"/>	<input type="text"/>	(75)
East	<input type="text"/>	<input type="text"/>	<input type="text"/>	$\times 0.9 \times$	<input type="text"/>	<input type="text"/>	(76)
Southeast	<input type="text"/>	<input type="text"/>	<input type="text"/>	$\times 0.9 \times$	<input type="text"/>	<input type="text"/>	(77)
South	<input type="text"/>	<input type="text"/>	<input type="text"/>	$\times 0.9 \times$	<input type="text"/>	<input type="text"/>	(78)
Southwest	<input type="text"/>	<input type="text"/>	<input type="text"/>	$\times 0.9 \times$	<input type="text"/>	<input type="text"/>	(79)
West	<input type="text"/>	<input type="text"/>	<input type="text"/>	$\times 0.9 \times$	<input type="text"/>	<input type="text"/>	(80)
Northwest	<input type="text"/>	<input type="text"/>	<input type="text"/>	$\times 0.9 \times$	<input type="text"/>	<input type="text"/>	(81)
Rooflights	1.0	<input type="text"/>	<input type="text"/>	$\times 0.9 \times$	<input type="text"/>	<input type="text"/>	(82)

Solar gains in watts, calculated for each month $(83)_m = \Sigma(74)_m \dots (82)_m$

$(83)_m =$	$(83)_1$	$(83)_2$	$(83)_3$	$(83)_4$	$(83)_5$	$(83)_6$	$(83)_7$	$(83)_8$	$(83)_9$	$(83)_{10}$	$(83)_{11}$	$(83)_{12}$	(83)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	------

Total gains – internal and solar $(84)_m = (73)_m + (83)_m$, watts

$(84)_m =$	$(84)_1$	$(84)_2$	$(84)_3$	$(84)_4$	$(84)_5$	$(84)_6$	$(84)_7$	$(84)_8$	$(84)_9$	$(84)_{10}$	$(84)_{11}$	$(84)_{12}$	(84)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, T_{h1} (°C) 21 (85)

Utilisation factor for gains for living area, $\eta_{1,m}$ (see Table 9a)

$(86)_m =$	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	(86)
	$(86)_1$	$(86)_2$	$(86)_3$	$(86)_4$	$(86)_5$	$(86)_6$	$(86)_7$	$(86)_8$	$(86)_9$	$(86)_{10}$	$(86)_{11}$	$(86)_{12}$	

Mean internal temperature in living area T_1 (follow steps 3 to 7 in Table 9c)

$(87)_m =$	$(87)_1$	$(87)_2$	$(87)_3$	$(87)_4$	$(87)_5$	$(87)_6$	$(87)_7$	$(87)_8$	$(87)_9$	$(87)_{10}$	$(87)_{11}$	$(87)_{12}$	(87)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

Temperature during heating periods in rest of dwelling from Table 9, T_{h2} (°C)

$(88)_m =$	$(88)_1$	$(88)_2$	$(88)_3$	$(88)_4$	$(88)_5$	$(88)_6$	$(88)_7$	$(88)_8$	$(88)_9$	$(88)_{10}$	$(88)_{11}$	$(88)_{12}$	(88)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

Utilisation factor for gains for rest of dwelling, $\eta_{2,m}$ (see Table 9a)

$(89)_m =$	$(89)_1$	$(89)_2$	$(89)_3$	$(89)_4$	$(89)_5$	$(89)_6$	$(89)_7$	$(89)_8$	$(89)_9$	$(89)_{10}$	$(89)_{11}$	$(89)_{12}$	(89)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

Mean internal temperature in the rest of dwelling T_2 (follow steps 3 to 7 in Table 9c)

$(90)_m =$	$(90)_1$	$(90)_2$	$(90)_3$	$(90)_4$	$(90)_5$	$(90)_6$	$(90)_7$	$(90)_8$	$(90)_9$	$(90)_{10}$	$(90)_{11}$	$(90)_{12}$	(90)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

Living area fraction $f_{LA} = \text{Living area} \div (4) =$ (91)

Mean internal temperature (for the whole dwelling) $= f_{LA} \times T_1 + (1 - f_{LA}) \times T_2$

$(92)_m =$	$(92)_1$	$(92)_2$	$(92)_3$	$(92)_4$	$(92)_5$	$(92)_6$	$(92)_7$	$(92)_8$	$(92)_9$	$(92)_{10}$	$(92)_{11}$	$(92)_{12}$	(92)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

Apply adjustment to the mean internal temperature from Table 4e, where appropriate

$(93)_m =$	$(93)_1$	$(93)_2$	$(93)_3$	$(93)_4$	$(93)_5$	$(93)_6$	$(93)_7$	$(93)_8$	$(93)_9$	$(93)_{10}$	$(93)_{11}$	$(93)_{12}$	(93)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

8. Space heating requirement

Set T_i to the mean internal temperature obtained at step 11 of Table 9b, so that $T_{i,m} = (93)_m$ and re-calculate

the utilisation factor for gains using Table 9a

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Utilisation factor for gains, η_m :

$(94)_m =$	$(94)_1$	$(94)_2$	$(94)_3$	$(94)_4$	$(94)_5$	$(94)_6$	$(94)_7$	$(94)_8$	$(94)_9$	$(94)_{10}$	$(94)_{11}$	$(94)_{12}$	(94)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

Useful gains, $\eta_m G_m$, W $= (94)_m \times (84)_m$

$(95)_m =$	$(95)_1$	$(95)_2$	$(95)_3$	$(95)_4$	$(95)_5$	$(95)_6$	$(95)_7$	$(95)_8$	$(95)_9$	$(95)_{10}$	$(95)_{11}$	$(95)_{12}$	(95)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

Monthly average external temperature from Table 8

$(96)_m =$	$(96)_1$	$(96)_2$	$(96)_3$	$(96)_4$	$(96)_5$	$(96)_6$	$(96)_7$	$(96)_8$	$(96)_9$	$(96)_{10}$	$(96)_{11}$	$(96)_{12}$	(96)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

Heat loss rate for mean internal temperature, L_m , W $= [(39)_m \times ((93)_m - (96)_m)]$

$(97)_m =$	$(97)_1$	$(97)_2$	$(97)_3$	$(97)_4$	$(97)_5$	$(97)_6$	$(97)_7$	$(97)_8$	$(97)_9$	$(97)_{10}$	$(97)_{11}$	$(97)_{12}$	(97)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

Space heating requirement for each month, kWh/month $= 0.024 \times [(97)_m - (95)_m] \times (41)_m$

$(98)_m =$	$(98)_1$	$(98)_2$	$(98)_3$	$(98)_4$	$(98)_5$	$(98)_6$	$(98)_7$	$(98)_8$	$(98)_9$	$(98)_{10}$	$(98)_{11}$	$(98)_{12}$	(98)
------------	----------	----------	----------	----------	----------	----------	----------	----------	----------	-------------	-------------	-------------	--------

Total per year (kWh/year) $= \Sigma(98)_{1...5,9...12} =$ (98)

Space heating requirement in kWh/m²/year $(98) \div (4) =$ (99)

For range cooker boilers where efficiency is obtained from the Boiler Efficiency Database or manufacturer's declared value, multiply the results in $(98)_m$ by $(1 - \Phi_{case}/\Phi_{water})$ where Φ_{case} is the heat emission from the case of the range cooker at full load (in kW); and Φ_{water} is the heat transferred to water at full load (in kW). Φ_{case} and Φ_{water} are obtained from the database record for the range cooker boiler or manufacturer's declared values.

8c. Space cooling requirement

Calculated for June, July and August. See Table 10b

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Heat loss rate L_m (calculated using 24°C internal temperature and external temperature from Table 10)													
$(100)_m =$	0	0	0	0	0	(100) ₆	(100) ₇	(100) ₈	0	0	0	0	(100)
Utilisation factor for loss η_m													
$(101)_m =$	0	0	0	0	0	(101) ₆	(101) ₇	(101) ₈	0	0	0	0	(101)
Useful loss, $\eta_m L_m$ (Watts) = $(100)_m \times (101)_m$													
$(102)_m =$	0	0	0	0	0	(102) ₆	(102) ₇	(102) ₈	0	0	0	0	(102)
Gains (internal gains as for heating except that column (A) of Table 5 is always used; solar gains calculated for applicable weather region based on Table 10, not Table 6a)													
$(103)_m =$	0	0	0	0	0	(103) ₆	(103) ₇	(103) ₈	0	0	0	0	(103)
Space cooling requirement for month, whole dwelling, continuous (kWh) = $0.024 \times [(103)_m - (102)_m] \times (41)_m$ set $(104)_m$ to zero if $(104)_m < 2 \times (98)_m$ with $(98)_m$ calculated using weather data from Table 10													
$(104)_m =$	0	0	0	0	0	(104) ₆	(104) ₇	(104) ₈	0	0	0	0	
	Total = $\Sigma(104)_{6..8} =$											<input type="text"/>	(104)
Cooled fraction	$f_c = \text{cooled area} \div (4) =$											<input type="text"/>	(105)
Intermittency factor (Table 10b)													
$(106)_m =$	0	0	0	0	0	(106) ₆	(106) ₇	(106) ₈	0	0	0	0	
	Total = $\Sigma(106)_{6..8} =$											<input type="text"/>	(106)
Space cooling requirement for month = $(104)_m \times (105) \times (106)_m$													
$(107)_m =$	0	0	0	0	0	(107) ₆	(107) ₇	(107) ₈	0	0	0	0	
	Total = $\Sigma(107)_{6..8} =$											<input type="text"/>	(107)
Space cooling requirement in kWh/m ² /year	$(107) \div (4) =$											<input type="text"/>	(108)

8f. Fabric Energy Efficiency (calculated only under special conditions, see section 11)

Fabric Energy Efficiency	$(99) + (108) =$											<input type="text"/>	(109)
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9a. Energy requirements – Individual heating systems including micro-CHP

For any space heating, space cooling or water heating provided by community heating use the alternative worksheet 9b.

Space heating:

Fraction of space heat from secondary/supplementary system (Table 11) "0" if none (201)

Fraction of space heat from main system(s) $(202) = 1 - (201) =$ (202)

Fraction of main heating from main system 2 *if no second main system enter "0"* (203)

Fraction of total space heat from main system 1 $(204) = (202) \times [1 - (203)] =$ (204)

Fraction of total space heat from main system 2 $(205) = (202) \times (203) =$ (205)

Efficiency of main space heating system 1 (in %) (206)
 (from database or Table 4a/4b, adjusted where appropriate by the amount shown in the 'space efficiency adjustment' column of Table 4c; for gas and oil boilers see 9.2.1)

If there is a second main system complete (207)

Efficiency of main space heating system 2 (in %) (207)
 (from database or Table 4a/4b, adjusted where appropriate by the amount shown in the 'space efficiency adjustment' column of Table 4c; for gas and oil boilers see 9.2.1)

Efficiency of secondary/supplementary heating system, % (from Table 4a or Appendix E) (208)

Cooling System Energy Efficiency Ratio (see Table 10c) (209)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year
Space heating requirement (calculated above)	(98) ₁	(98) ₂	(98) ₃	(98) ₄	(98) ₅	0	0	0	0	(98) ₁₀	(98) ₁₁	(98) ₁₂	

Space heating fuel (main heating system 1), kWh/month

$(211)_m = (98)_m \times (204) \times 100 \div (206)$

(211) _m	(211) ₁	(211) ₂	(211) ₃	(211) ₄	(211) ₅	0	0	0	0	(211) ₁₀	(211) ₁₁	(211) ₁₂	
	Total (kWh/year) = $\Sigma(211)_{1...5,10...12} =$ <input type="text"/> (211)												

Space heating fuel (main heating system 2), kWh/month, omit if no second main heating system

$(213)_m = (98)_m \times (203) \times 100 \div (207)$

(213) _m	(213) ₁	(213) ₂	(213) ₃	(213) ₄	(213) ₅	0	0	0	0	(213) ₁₀	(213) ₁₁	(213) ₁₂	
	Total (kWh/year) = $\Sigma(213)_{1...5,10...12} =$ <input type="text"/> (213)												

Space heating fuel (secondary), kWh/month

$(215)_m = (98)_m \times (201) \times 100 \div (208)$

(215) _m	(215) ₁	(215) ₂	(215) ₃	(215) ₄	(215) ₅	0	0	0	0	(215) ₁₀	(215) ₁₁	(215) ₁₂	
	Total (kWh/year) = $\Sigma(215)_{1...5,10...12} =$ <input type="text"/> (215)												

Water heating

Output from water heater (calculated above)

(64) ₁	(64) ₂	(64) ₃	(64) ₄	(64) ₅	(64) ₆	(64) ₇	(64) ₈	(64) ₉	(64) ₁₀	(64) ₁₁	(64) ₁₂
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Efficiency of water heater (216)

(From database or Table 4a/4b, adjusted where appropriate by the amount shown in the 'DHW efficiency adjustment' column of Table 4c, for gas and oil boilers use the summer efficiency, see 9.2.1)

if water heating by a hot-water-only boiler, (217)_m = value from database record for boiler or Table 4a

otherwise if gas/oil boiler main system used for water heating, (217)_m = value calculated for each month using equation (8) in section 9.2.1

otherwise if separate hot water only heater (including immersion) (217)_m = applicable value from Table 4a

otherwise (other main system 1 or 2 used for water heating) (217)_m = (216)

(217)_m =

(217) ₁	(217) ₂	(217) ₃	(217) ₄	(217) ₅	(217) ₆	(217) ₇	(217) ₈	(217) ₉	(217) ₁₀	(217) ₁₁	(217) ₁₂
--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	---------------------	---------------------	---------------------

 (217)

Fuel for water heating, kWh/month

(219)_m = (64)_m × 100 ÷ (217)_m

(219)_m

(219) ₁	(219) ₂	(219) ₃	(219) ₄	(219) ₅	(219) ₆	(219) ₇	(219) ₈	(219) ₉	(219) ₁₀	(219) ₁₁	(219) ₁₂
--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	--------------------	---------------------	---------------------	---------------------

Total = Σ(219a)_{1...12} = (219)

(for a DHW-only community scheme use (305), (306) and (310a) or (310b), with (304a)=1.0 or (304b)=1.0, instead of (219))

Space cooling

Space cooling fuel, kWh/month

(221)_m = (107)_m ÷ (209)

(221)_m

0	0	0	0	0	(221) ₆	(221) ₇	(221a) ₈	0	0	0	0
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Total = Σ(221)_{6...8} = (221)

Annual totals

	kWh/year	kWh/year
Space heating fuel used, main system 1		(211)
Space heating fuel used, main system 2		(213)
Space heating fuel used, secondary		(215)
Water heating fuel used		(219)
Space cooling fuel used (if there is a fixed cooling system, if not enter 0)		(221)

Electricity for pumps, fans and electric keep-hot (Table 4f):

mechanical ventilation fans - balanced, extract or positive input from outside	<input type="text"/>	(230a)
warm air heating system fans	<input type="text"/>	(230b)
central heating pump	<input type="text"/>	(230c)
oil boiler pump	<input type="text"/>	(230d)
boiler flue fan	<input type="text"/>	(230e)
maintaining electric keep-hot facility for gas combi boiler	<input type="text"/>	(230f)
pump for solar water heating	<input type="text"/>	(230g)
Total electricity for the above, kWh/year	sum of (230a)...(230g) =	<input type="text"/> (231)

Electricity for lighting (calculated in Appendix L) (232)

Energy saving/generation technologies (Appendices M ,N and Q)

Electricity generated by PVs (Appendix M) (negative quantity)	<input type="text"/>	(233)
Electricity generated by wind turbine (Appendix M) (negative quantity)	<input type="text"/>	(234)
Electricity used or net electricity generated by micro-CHP (Appendix N) (negative if net generation)	<input type="text"/>	(235)

Appendix Q items: annual energy (items not already included on a monthly basis)

Appendix Q, <item 1 description>	Fuel	kWh/year
energy saved or generated (enter as negative quantity)	<input type="text"/>	(236a)
energy used (positive quantity)	<input type="text"/>	(237a)

Appendix Q, <item 2 description>

energy saved or generated (enter as negative quantity)

		(236b)
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energy used (positive quantity)

		(237b)
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(continue this list if additional items)

10a. Fuel costs – Individual heating systems including micro-CHP

	Fuel kWh/year		Fuel price (Table 12)		Fuel cost £/year	
Space heating - main system 1	(211)	×	<input type="text"/>	× 0.01 =	<input type="text"/>	(240)
Space heating - main system 2	(213)	×	<input type="text"/>	× 0.01 =	<input type="text"/>	(241)
Space heating - secondary	(215)	×	<input type="text"/>	× 0.01 =	<input type="text"/>	(242)
Water heating (electric off-peak tariff)						
High-rate fraction (Table 13, or Appendix F for electric CPSU)			<input type="text"/>		<input type="text"/>	(243)
Low-rate fraction		1.0 -	(243) =		<input type="text"/>	(244)
High-rate cost	(219) ×	(243) ×	<input type="text"/>	× 0.01 =	<input type="text"/>	(245)
Low-rate cost	(219) ×	(244) ×	<input type="text"/>	× 0.01 =	<input type="text"/>	(246)
Water heating cost (other fuel)	(219)	×	<input type="text"/>	× 0.01 =	<input type="text"/>	(247)
<i>(for a DHW-only community scheme use (342a) or (342b) instead of (247))</i>						
Space cooling	(221)	×	<input type="text"/>	× 0.01 =	<input type="text"/>	(248)
Pumps, fans and electric keep-hot	(231)	×	<input type="text"/>	× 0.01 =	<input type="text"/>	(249)
<i>(if off-peak tariff, list each of (230a) to (230g) separately as applicable and apply fuel price according to Table 12a)</i>						
Energy for lighting	(232)	×	<input type="text"/>	× 0.01 =	<input type="text"/>	(250)
Additional standing charges (Table 12)					<input type="text"/>	(251)
Energy saving/generation technologies	(233) to (235) as applicable, repeat line (252) as needed					
<description>	one of (233) to (235)	×	<input type="text"/>	× 0.01 =	<input type="text"/>	(252)
Appendix Q items:	repeat lines (253) and (254) as needed					
<description>, energy saved	one of (236a) to (236n)	×	<input type="text"/>	× 0.01 =	<input type="text"/>	(253)
<description>, energy used	one of (237a) to (237n)	×	<input type="text"/>	× 0.01 =	<input type="text"/>	(254)
Total energy cost				(245)...(247) + (250)...(260) =	<input type="text"/>	(255)

11a. SAP rating – Individual heating systems including micro-CHP

Energy cost deflator (Table 12):		<input type="text" value="0.47"/>	(256)
Energy cost factor (ECF)	$[(255) \times (256)] \div [(4) + 45.0] =$	<input type="text"/>	(257)
SAP rating (Section 13)		<input type="text"/>	(258)

12a. CO₂ emissions – Individual heating systems including micro-CHP

	Energy kWh/year		Emission factor kg CO ₂ /kWh	=	Emissions kg CO ₂ /year	
Space heating - main system 1	(211)	×	<input type="text"/>	=	<input type="text"/>	(261)
Space heating - main system 2	(213)	×	<input type="text"/>	=	<input type="text"/>	(262)
Space heating - secondary	(215)	×	<input type="text"/>	=	<input type="text"/>	(263)
Energy for water heating <i>(for a DHW-only community scheme use (361) to (373) instead of (264))</i>	(219)	×	<input type="text"/>	=	<input type="text"/>	(264)
Space and water heating	(261) + (262) + (263) + (264)			=	<input type="text"/>	(265)
Space cooling	(221)	×	<input type="text"/>	=	<input type="text"/>	(266)
Electricity for pumps, fans and electric keep-hot	(231)	×	<input type="text"/>	=	<input type="text"/>	(267)
Electricity for lighting	(232)	×	<input type="text"/>	=	<input type="text"/>	(268)
Energy saving/generation technologies	(233) to (235) as applicable, repeat line (269) as needed					
<description>	one of (233) to (235)	×	<input type="text"/>	=	<input type="text"/>	(269)
Appendix Q items	repeat lines (270) and (271) as needed					
<description>, energy saved	one of (237a) to (236n)	×	<input type="text"/>	=	<input type="text"/>	(270)
<description>, energy used	one of (237a) to (237n)	×	<input type="text"/>	=	<input type="text"/>	(271)
Total CO ₂ , kg/year				sum of	(261)...(271)	= <input type="text"/> (272)
Dwelling CO ₂ Emission Rate				(272) ÷ (4)	=	<input type="text"/> (273)
EI rating (section 14)					<input type="text"/>	(274)

13a. Primary energy – Individual heating systems including micro-CHP

Same as 12a using primary energy factor instead of CO₂ emission factor to give primary energy in kWh/year

Community heating

9b. Energy requirements – Community heating scheme

This part is used for space heating, space cooling or water heating provided by a community scheme.

Fraction of space heat from secondary/supplementary heating (Table 11) "0" if none (301)
 Fraction of space heat from community system $1 - (301) =$ (302)

The community scheme may obtain heat from several sources. The procedure allows for CHP and up to four other heat sources; the latter includes boilers, heat pumps, geothermal and waste heat from power stations. See Appendix C.

Fraction of heat from community CHP (303a)
 Fraction of community heat from heat source 2 (fractions obtained from operational records or plant design specification; omit line if not applicable) (303b)
 Fraction of community heat from heat source 3 (303c)
 Fraction of community heat from heat source 4 (303d)
 Fraction of community heat from heat source 5 (303e)

Fraction of total space heat from community CHP $(302) \times (303a) =$ (304a)

=
 Fraction of total space heat from community heat source 2 <description> $(302) \times (303b) =$ (304b)

Fraction of total space heat from community heat source 3 <description> $(302) \times (303c) =$ (304c)

Fraction of total space heat from community heat source 4 <description> $(302) \times (303d) =$ (304d)

Fraction of total space heat from community heat source 5 <description> $(302) \times (303e) =$ (304e)

Factor for control and charging method (Table 4c(3)) for community space heating (305)

Factor for control and charging method (Table 4c(3)) for community water heating (305a)

Distribution loss factor (Table 12c) for community heating system (306)

Space heating

		kWh/year
Annual space heating requirement		<input type="text"/> (98)
Space heat from CHP	$(98) \times (304a) \times (305) \times (306) =$	<input type="text"/> (307a)
Space heat from heat source 2	$(98) \times (304b) \times (305) \times (306) =$	<input type="text"/> (307b)
Space heat from heat source 3	$(98) \times (304c) \times (305) \times (306) =$	<input type="text"/> (307c)
Space heat from heat source 4	$(98) \times (304d) \times (305) \times (306) =$	<input type="text"/> (307d)
Space heat from heat source 5	$(98) \times (304e) \times (305) \times (306) =$	<input type="text"/> (307e)
Efficiency of secondary/supplementary heating system in % (from Table 4a or Appendix E)	<input type="text"/>	(308)
Space heating fuel for secondary/supplementary system	$(98) \times (301) \times 100 \div (308) =$	<input type="text"/> (309)

Water heating

Annual water heating requirement		<input type="text"/> (64)
If DHW from community scheme:		
Water heat from CHP	$(64) \times (303a) \times (305a) \times (306) =$	<input type="text"/> (310a)
Water heat from heat source 2	$(64) \times (303b) \times (305a) \times (306) =$	<input type="text"/> (310b)
Water heat from heat source 3	$(64) \times (303c) \times (305a) \times (306) =$	<input type="text"/> (310c)
Water heat from heat source 4	$(64) \times (303d) \times (305a) \times (306) =$	<input type="text"/> (310d)
Water heat from heat source 5	$(64) \times (303e) \times (305a) \times (306) =$	<input type="text"/> (310e)
If DHW by immersion or instantaneous heater within dwelling:		
Efficiency of water heater	<input type="text"/>	(311)
Water heated by immersion or instantaneous heater	$(64) \times 100 \div (311) =$	<input type="text"/> (312)
Electricity used for heat distribution	$0.01 \times [(307a)...(307e) + (310a)...(310e)] =$	<input type="text"/> (313)
Cooling System Energy Efficiency Ratio	<input type="text"/>	(314)
Space cooling (if there is a fixed cooling system, if not enter 0)	$= (107) \div (314) =$	<input type="text"/> (315)
Electricity for pumps and fans within dwelling (Table 4f):		
mechanical ventilation - balanced, extract or positive input from outside	<input type="text"/>	(330a)

warm air heating system fans	<input type="text"/>	(330b)
pump for solar water heating	<input type="text"/>	(330g)
Total electricity for the above, kWh/year	$(330a) + (330b) + (330g) =$ <input type="text"/>	(331)
Energy for lighting (calculated in Appendix L)	<input type="text"/>	(332)
Energy saving/generation technologies (Appendices M and Q)		
Electricity generated by PVs (Appendix M) (negative quantity)	<input type="text"/>	(333)
Electricity generated by wind turbine (Appendix M) (negative quantity)	<input type="text"/>	(334)
Appendix Q items: annual energy (items not already included on a monthly basis)	Fuel	kWh/year
Appendix Q, <item 1 description>		
energy saved or generated (enter as negative quantity)	<input type="text"/>	<input type="text"/> (336a)
energy used (positive quantity)	<input type="text"/>	<input type="text"/> (337a)
Appendix Q, <item 2 description>		
energy saved or generated (enter as negative quantity)	<input type="text"/>	<input type="text"/> (336b)
energy used (positive quantity)	<input type="text"/>	<input type="text"/> (337b)
<i>(continue this list if additional items)</i>		

10b. Fuel costs – Community heating scheme

	Heat or fuel required kWh/year		Fuel price (Table 12)		Fuel cost £/year
Space heating from CHP	(307a)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (340a)
Space heating from heat source 2	(307b)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (340b)
Space heating from heat source 3	(307c)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (340c)
Space heating from heat source 4	(307d)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (340d)
Space heating from heat source 5	(307e)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (340e)
Space heating (secondary)	(309)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (341)
Water heating from CHP	(310a)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (342a)
Water heating from heat source 2	(310b)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (342b)
Water heating from heat source 3	(310c)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (342c)
Water heating from heat source 4	(310d)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (342d)
Water heating from heat source 5	(310e)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (342e)
If water heated by immersion heater:					
High-rate fraction (Table 13)			<input type="text"/>		(343)
Low-rate fraction		1.0 -	(343) =	<input type="text"/>	(344)
			Fuel price		
High-rate cost, or cost for single immersion	(312) ×	(343) ×	<input type="text"/>	× 0.01 =	<input type="text"/> (345)
Low-rate cost	(312) ×	(344) ×	<input type="text"/>	× 0.01 =	<input type="text"/> (346)
If water heated by instantaneous water heater	(312)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (347)
Space cooling (community cooling system)	(315)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (348)
Pumps and fans	(331)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (349)
<i>(if off-peak tariff, list each of (330a) to (330g) separately as applicable and apply fuel price according to Table 12a)</i>					
Electricity for lighting	(332)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (350)
Additional standing charges (Table 12)					<input type="text"/> (351)
Energy saving/generation technologies	(333) to (334) as applicable, repeat line (352) as needed				
<description>	one of (333) to (334)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (352)
Appendix Q items: repeat lines (253) and (259) as needed					
<description>, energy saved	one of (336a) to (336n)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (353)
<description>, energy used	one of (337a) to (337n)	×	<input type="text"/>	× 0.01 =	<input type="text"/> (354)
Total energy cost		=	(340a)...(342e) + (345)...(354) =		<input type="text"/> (355)

11b. SAP rating – Community heating scheme

Energy cost deflator (Table 12):		0.47	(356)
Energy cost factor (ECF)	[(355) × (356)] ÷ [(4) + 45.0] =		(357)
SAP rating (Section 13)			(358)

12b. CO₂ Emissions – Community heating scheme

CO₂ from CHP (space and water heating) Omit (361) to (366) if no CHP

Electrical efficiency of CHP unit (e.g. 25%) from operational records or design spec.			(361)
Heat efficiency of CHP unit (e.g. 50%) from operational records or design specification			(362)

		Energy used kWh/year	×	Emission factor kgCO ₂ /kWh	=	CO ₂ emission kgCO ₂ /year	
Space heating from CHP	(307a) × 100 ÷ (362) =		×	Note A	=		(363)
less credit emissions for electricity	-(307a) × (361) ÷ (362) =		×	Note B	=		(364)
Water heated by CHP	(310a) × 100 ÷ (362) =		×	Note A	=		(365)
less credit emissions for electricity	-(310a) × (361) ÷ (362) =		×	Note B	=		(366)

Note A: factor for CHP fuel. Note B: factor for electricity generated by CHP

CO₂ from other sources of space and water heating (not CHP)

Efficiency of heat source 2 (%)		If there is CHP using two fuels repeat (363) to (366) for the second fuel		(367b)		
Efficiency of heat source 3 (%)				(367c)		
Efficiency of heat source 4 (%)				(367d)		
Efficiency of heat source 5 (%)				(367e)		
CO ₂ associated with heat source 2	[(307b)+(310b)] × 100 ÷ (367b) ×		=		(368)	
CO ₂ associated with heat source 3	[(307c)+(310c)] × 100 ÷ (367c) ×		=		(369)	
CO ₂ associated with heat source 4	[(307d)+(310d)] × 100 ÷ (367d) ×		=		(370)	
CO ₂ associated with heat source 5	[(307e)+(310e)] × 100 ÷ (367e) ×		=		(371)	
Electrical energy for heat distribution		(313) ×		=		(372)
Total CO ₂ associated with community systems		(363)...(366) + (368)...(372)	=		(373)	
<i>if it is negative set (373) to zero (unless specified otherwise, see C7 in Appendix C)</i>				=		(373)
Space heating (secondary)		(309) ×		=		(374)
Water heating by immersion heater or instantaneous heater		(312) ×		=		(375)
Total CO ₂ associated with space and water heating		(373) + (374) + (375)	=		(376)	
Space cooling		(315) ×		=		(377)
Electricity for pumps and fans within dwelling		(331) ×		=		(378)
Electricity for lighting		(332) ×		=		(379)
Energy saving/generation technologies	(333) to (334) as applicable, repeat line (380) as needed					
<description>	one of (333) to (334)	×		=		(380)
Appendix Q items	repeat lines (381) and (382) as needed					
<description>, energy saved	one of (336a) to (336n)	×		=		(381)
<description>, energy used	one of (337a) to (337n)	×		=		(382)
Total CO ₂ , kg/year		sum of (376)...(382) =				(383)
Dwelling CO ₂ Emission Rate		(383) ÷ (4) =				(384)
EI rating (section 14)						(385)

13b. Primary energy – Community heating scheme

Same as 12b using primary energy factor instead of CO₂ emission factor to give primary energy in kWh/year

FORMULAE AND TABLES

Table 1a: Number of days in month, n_m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
m	1	2	3	4	5	6	7	8	9	10	11	12
$n_m =$	31	28	31	30	31	30	31	31	30	31	30	31

Table 1b: Occupancy and domestic hot water usage

<p>Assumed number of occupants</p> <p>if TFA > 13.9: $N = 1 + 1.76 \times [1 - \exp(-0.000349 \times (TFA - 13.9)^2)] + 0.0013 \times (TFA - 13.9)$ if TFA ≤ 13.9: $N = 1$</p> <p>N is the assumed number of occupants, TFA is the total floor area of the dwelling.</p>
<p>Domestic hot water usage</p> <p>(a) Annual average hot water usage in litres per day $V_{d,average} = (25 \times N) + 36$ (b) Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more than 125 litres per person per day (all water use, hot and cold) (c) For each month, multiply $V_{d,average}$ by the factor from Table 1c to obtain the daily volume in the month $V_{d,m}$ (d) The energy content of water used is $4.190 \times V_{d,m} \times n_m \times \Delta T_m / 3600$ kWh/month where ΔT_m is the temperature rise for month m from Table 1d. (e) Distribution loss is 0.15 times energy content calculated in (d).</p>

Table 1c: Monthly factors for hot water use

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	annual
1.10	1.06	1.02	0.98	0.94	0.90	0.90	0.94	0.98	1.02	1.06	1.10	1.00

Table 1d: Temperature rise of hot water drawn off (ΔT_m , in K)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	annual
41.2	41.4	40.1	37.6	36.4	33.9	30.4	33.4	33.5	36.3	39.4	39.9	37.0

Table 1e: Heat capacities for some common constructions

Heat capacity per unit area, κ in $\text{kJ/m}^2\text{K}$, for a construction element can be calculated from:²³

$$\kappa = 10^{-6} \times \Sigma (d_j \rho_j c_j)$$

where:

the summation is over all layers in the element, starting at the inside surface and stopping at whichever of these conditions occurs first (which may mean part way through a layer):

- half way through the element;
- an insulation layer (thermal conductivity $\leq 0.08 \text{ W/m}\cdot\text{K}$);
- total thickness of 100 mm.

d_j is the thickness of layer (mm)

ρ_j is density of layer (kg/m^3)

c_j is specific heat capacity of layer ($\text{J/kg}\cdot\text{K}$)

The elements to be included are walls, floors and roofs (windows and doors have negligible capacity), including all internal and party walls and floors. In the case of internal walls and floors, the capacity is needed for each side of the element.

The table gives some typical values.

Construction	Heat capacity κ ($\text{kJ/m}^2\text{K}$)
Ground floors	
Suspended timber, insulation between joists	20
Slab on ground, screed over insulation	110
Suspended concrete floor, carpeted	75
Exposed floors	
Timber exposed floor, insulation between joists	20
External walls - masonry, solid, external insulation	
Solid wall: dense plaster, 200 mm dense block, insulated externally	190
Solid wall: plasterboard on dabs or battens, 200 mm dense block, insulated externally	150
Solid wall: dense plaster, 210 mm brick, insulated externally	135
Solid wall: plasterboard on dabs or battens, 210 mm brick, insulated externally	110
External walls - masonry, solid, internal insulation	
Solid wall: dense plaster, insulation, any outside structure	17
Solid wall: plasterboard on dabs or battens, insulation, any outside structure	9
External walls - cavity masonry walls, full or partial cavity fill	
Cavity wall: dense plaster, dense block, filled cavity, any outside structure	190
Cavity wall: dense plaster, AAC block, filled cavity, any outside structure	70
Cavity wall: plasterboard on dabs or battens, dense block, filled cavity, any outside structure	150
Cavity wall: plasterboard on dabs or battens, AAC block, filled cavity, any outside structure	60
External walls – timber or steel frame	
Timber framed wall (one layer of plasterboard)	9
Timber framed wall (two layers of plasterboard)	18
Steel frame wall (warm frame or hybrid construction)	14
Roofs	
Plasterboard, insulated at ceiling level	9
Plasterboard, insulated slope	9
Plasterboard, insulated flat roof	9
Party walls	
Dense plaster both sides, dense blocks, cavity (E-WM-1 or E-WM-2)*	180
Single plasterboard on dabs on both sides, dense blocks, cavity	70

²³ This simplified calculation is acceptable for SAP calculations. A detailed method is given in ISO 13786, Thermal performance of building components – Dynamic thermal characteristics – Calculation methods.

Construction	Heat capacity k (kJ/m ² K)
(E-WM-3 or E-WM-4)*	
Plaster on dabs and single plasterboard on both sides, dense cellular blocks, cavity (E-WM-5)*	70
Plasterboard on dabs mounted on cement render on both sides, AAC blocks, cavity (E-WM-6 or E-WM-7)*	45
Double plasterboard on both sides, twin timber frame with/without sheathing board (E-WT-1 or E-WT-2)*	20
Steel frame (E-WS-1 to E-WS-3)*	20
Party floors (k from above / k from below)	
Precast concrete planks floor, screed, carpeted (E-FC-1)*	40 / 30
Concrete floor slab, carpeted (E-FC-2)*	80 / 100
Precast concrete plank floor (screed laid on insulation), carpeted (E-FC-3)*	40 / 30
Precast concrete plank floor (screed laid on rubber), carpeted (E-FC-4)*	70 / 30
In-situ concrete slab supported by profiled metal deck, carpeted (E-FS-1)*	64 / 90
Timber I-joists, carpeted (E-FT-1)*	30 / 20
Internal partitions	
Plasterboard on timber frame	9
Dense block, dense plaster	100
Dense block, plasterboard on dabs	75
Ceiling/floor between floors in a house (k from above / k from below)	
Plasterboard ceiling, carpeted chipboard floor	18 / 9

* Reference in the Robust Details for Part E “Resistance to the passage of sound”

Table 1f: Thermal mass parameter

The κ values are used to calculate the TMP variable (Thermal Mass Parameter), worksheet (35), which is used to characterise the thermal mass of the building. It is:

$$TMP = \frac{\sum \kappa \times A}{TFA}$$

where the summation is over all walls, floors and roofs bounding the dwelling (including party walls and floors/ceilings) together with both sides of all internal walls and floors/ceilings.

Indicative values of TMP are:

Thermal mass	TMP (kJ/m ² K)
Low	100
Medium	250
High	450

Table 2: Hot water storage loss factor (kWh/litre/day)

If the manufacturer's declared loss is available, see Table 2b.

In the absence of manufacturer's declared cylinder loss, the loss factor L from Table 2 is multiplied by the cylinder volume in litres, by the volume factor from Table 2a, and by the appropriate temperature factor from Table 2b, to obtain the loss rate. These data apply to cylinders heated by gas, oil and solid fuel boilers and by electric immersion, and to stores within combi boilers not tested to EN 13203-2 or OPS 26.

For community heating systems with no cylinder in the dwelling, use loss factor for 50 mm factory insulation and a cylinder size of 110 litres. For community systems using a plate heat exchanger apply the data in the table to the insulation on the heat exchanger.

In the case of a combination boiler:

- the storage loss factor is zero if the efficiency is taken from Table 4b;
- the loss is to be included for a storage combination boiler if its efficiency is the manufacturer's declared value or is obtained from the Boiler Database (in which case its insulation thickness and volume are also to be provided by the manufacturer or obtained from the Database), using the loss factor for a factory insulated cylinder.

Insulation thickness, mm	Cylinder loss factor (L) kWh/litre/day	
	Factory insulated cylinder thermal store store in combi boiler	Loose cylinder jacket
0	0.1425	0.1425
12	0.0394	0.0760
25	0.0240	0.0516
35	0.0191	0.0418
38	0.0181	0.0396
50	0.0152	0.0330
80	0.0115	0.0240
120	0.0094	0.0183
160	0.0084	0.0152

Notes:

- Alternatively the heat loss factor, L , may be calculated for insulation thickness of t mm as follows:
Cylinder, loose jacket: $L = 0.005 + 1.76/(t + 12.8)$
Cylinder, factory insulated: $L = 0.005 + 0.55/(t + 4.0)$
- The data for factory insulated cylinder apply to all cases other than an electric CPSU where the insulation is applied in the course of manufacture irrespective of the insulation material used, e.g. the water store in a storage combi or a gas CPSU.
- For an electric CPSU, the loss is 0.022 kWh/litre/day.

Table 2a: Volume factor for cylinders and storage combis

Volume V_c	Volume Factor VF	Volume V_c	Volume Factor VF
40	1.442	180	0.874
60	1.259	200	0.843
80	1.145	220	0.817
100	1.063	240	0.794
120	1.00	260	0.773
140	0.950	280	0.754
160	0.908	300	0.737

Notes:

- When using the data in Table 2, the loss is to be multiplied by the volume factor.
- Alternatively, the volume factor can be calculated using the equation $VF = (120 / V_c)^{1/3}$

Table 2b: Factors applied to losses for cylinders, thermal stores and CPSUs, and to storage combi boilers not tested to EN 13203-2 or OPS 26

Type of water storage	Temperature Factor	
	for manufacturer's declared loss	for loss from Table 2
Cylinder, electric immersion	0.60	0.60
Cylinder, indirect	0.60 ^{a) b)}	0.60 ^{a) b)}
Storage combi boiler, primary store	n/a	Store volume \geq 115 litres: 0.82 Store volume $<$ 115 litres: $0.82 + 0.0022 \times (115 - V_c)$
Storage combi boiler, secondary store	n/a	Store volume \geq 115 litres: 0.60 Store volume $<$ 115 litres: $0.60 + 0.0016 \times (115 - V_c)$
Instantaneous combi boiler with close-coupled external store (Appendix G)	0.60 ^{a) b)}	0.60 ^{a) b)}
Hot water only thermal store	0.89 ^{c) d)}	1.08 ^{c) d)}
Integrated thermal store and gas-fired CPSU	0.89 ^{c) d)}	1.08 ^{c) d)}
Electric CPSU: for winter operating temperature T_w ($^{\circ}\text{C}$)	$1.09 + (T_w - 85)$	1.00
Plate heat exchanger in a community system	1.0	1.0

Notes:

^{a)} Multiply Temperature Factor by 1.3 if a cylinder thermostat is absent.

^{b)} Multiply Temperature Factor by 0.9 if there is separate time control of domestic hot water (boiler systems and heat pump systems)

^{c)} Multiply Temperature Factor by 0.81 if the thermal store or CPSU has separate timer for heating the store

^{d)} Multiply Temperature Factor by 1.1 if the thermal store or CPSU is not in an airing cupboard

If a storage combi boiler has been tested to EN 13203-2 or OPS 26 see Tables 3b and 3c.

Table 3: Primary circuit losses

System type	kWh/year
Electric immersion heater	0
Heat generator connected to cylinder by uninsulated primary pipework ^{a)} and no cylinder thermostat	1220
Heat generator connected to cylinder by insulated primary pipework ^{a)} and no cylinder thermostat	610
Heat generator connected to cylinder by uninsulated primary pipework ^{a)} and cylinder thermostat	610 ^{c)}
Heat generator connected to cylinder by insulated primary pipework ^{a)} and cylinder thermostat	360 ^{c)}
Combi boiler	0
CPSU (including electric CPSU)	0
Boiler and thermal store ^{b)} within a single casing	0
Separate boiler and thermal store ^{b)} connected by no more than 1.5 m of insulated pipework	0 ^{d)}
Separate boiler and thermal store ^{b)} connected by:	
- uninsulated primary pipework	470 ^{d)}
- more than 1.5 m of insulated primary pipework	280
Community heating	360

Notes:

^{a)} 'Primary pipework' means the pipes between the heat generator (e.g. boiler) and a hot water tank

^{b)} Thermal stores have a cylinder thermostat.

^{c)} Reduce if there is solar water heating, see H2 in Appendix H.

^{d)} Apply these values in the case of a combi boiler with a close-coupled external store (Appendix G).

Table 3a: Additional losses for combi boilers not tested to EN 13203-2 or OPS 26

Combi type	kWh/month
Instantaneous, without keep-hot facility [*]	$600 \times f_u \times n_m / 365$
Instantaneous, with keep-hot facility controlled by time clock	$600 \times n_m / 365$
Instantaneous, with keep-hot facility not controlled by time clock	$900 \times n_m / 365$
Storage combi boiler ^{**} , store volume $V_c \geq 55$ litres	0
Storage combi boiler ^{**} , store volume $V_c < 55$ litres	$[600 - (V_c - 15) \times 15] \times f_u \times n_m / 365$

For n_m see Table 1a

If the daily hot water usage, $V_{d,m}$, is less than 100 litres/day, $f_u = V_{d,m} / 100$, otherwise $f_u = 1.0$

Notes:

^{*} "keep-hot facility" is defined in Appendix D, section D1.16. The facility to keep water hot may have an on/off switch for the user, or it may be controlled by a time clock. If the store is 15 litres or more, the boiler is a storage combination boiler.

In the case of keep-hot:

- 1) If the keep-hot facility is maintained hot solely by burning fuel, use the appropriate loss for combi boiler from Table 3a and proceed with the calculation as normal.
- 2) If the keep-hot facility is maintained by electricity:
 - a) include appropriate combi loss from Table 3a in box (61)_m.

b) calculate energy required for water heating as $[(64)_m - (61)_m] \times 100$, $(217)_m$ and enter in box $(219)_m$.

See also Table 4f.

3) In the case of an electrically powered keep-hot facility where the power rating of the keep-hot heater is obtained from the Boiler Efficiency database, the electric part of the total combi loss should be taken as:

$$LE = 8.76 \times P \text{ (kWh/year) (subject to maximum of the value from Table 3a, 3b or 3c)}$$

where P is the power rating of the heater in watts

with the remainder (either $600 - LE$ or $900 - LE$) provided by the fuel.

** "storage combi boilers" are defined in Appendix D, section D1.10. Apply these values in the case of a combi boiler with a close-coupled external store with V_c as the volume of the close-coupled store (Appendix G).

Table 3b: Losses for combi boilers tested to EN 13203-2 or OPS 26, schedule 2 only

Combi type	Storage loss $(56)_m$, kWh/month	Additional loss $(61)_m$, kWh/month
Instantaneous without FGHRs	0	$[(45)_m \times r \times f_u] + [F_1 \times n_m]$
Instantaneous with FGHRs not fitted with a close-coupled store	0	$[F_1 \times n_m]$
Instantaneous with FGHRs fitted with a close-coupled store	(temperature factor from Table 2b) \times (store loss from database record for the FGHRs) $\times n_m$	$[F_1 \times n_m]$
Storage combi without FGHRs	$F_1 \times n_m$	$(45)_m \times r \times f_u$
Storage combi with FGHRs	$F_1 \times n_m$	0

These values are obtained from the database record for the boiler:
 rejected energy proportion, r
 loss factor F_1

For n_m see Table 1a

If the daily hot water usage, $V_{d,m}$, is less than 100 litres/day, $f_u = V_{d,m} / 100$, otherwise $f_u = 1.0$

See notes below Table 3a
 See Appendix G for FGHRs

Table 3c: Losses for combi boilers tested to EN 13203-2 or OPS 26, schedule 2 plus schedule 1 or 3

Combi type	Storage loss (56) _m , kWh/month	Additional loss (61) _m , kWh/month
Instantaneous without FGHRs	0	$(45)_m \times [r + \{100.2 - V_{d,m}\} \times F_3] \times f_u + [F_2 \times n_m]$
Instantaneous with FGHRs not fitted with a close-coupled store	0	$[F_2 \times n_m]$
Instantaneous with FGHRs fitted with a close-coupled store	(temperature factor from Table 2b) \times (store loss from database record for the FGHRs) $\times n_m$	$[F_2 \times n_m]$
Storage combi without FGHRs	$F_2 \times n_m$	$(45)_m \times [r + \{100.2 - V_{d,m}\} \times F_3] \times f_u$
Storage combi with FGHRs	$F_2 \times n_m$	0

These values are obtained from the database record for the boiler:
 rejected energy proportion, r
 loss factors F_2 and F_3

For n_m see Table 1a

If the daily hot water usage, $V_{d,m}$, is less than 100 litres/day, $f_u = V_{d,m} / 100$, otherwise $f_u = 1.0$

See notes below Table 3a

See Appendix G for FGHRs

Table 4a: Heating systems (space and water)

1. The table shows space heating efficiency. The same efficiency applies for water heating when hot water is supplied from a boiler system.
2. For independent water heaters see section at the end of table.
3. Responsiveness (R) is used to calculate mean internal temperature (Table 9b).
4. Systems marked "rd" in the right-hand column are part of the reduced data set (see S10 in Appendix S)
5. Heating systems, heating controls and fuels are assigned a code number for identification purposes

	Efficiency %	Heating type	Respon- siveness (R)	Code	Rd SAP
NO HEATING SYSTEM PRESENT					
<i>Refer to Group 0 in Table 4e for control options and temperature adjustments due to control</i>					
Electric heaters (assumed)	100	1	1.0	699	rd
CENTRAL HEATING SYSTEMS WITH RADIATORS OR UNDERFLOOR HEATING					
Gas boilers and oil boilers					
<i>For efficiency, use boiler database (www.boilers.org.uk) if possible, otherwise use efficiency from Table 4b.</i>					
<i>Use Table 4c for efficiency adjustments.</i>					
<i>Use Table 4d for heating type and responsiveness.</i>					
<i>Refer to Group 1 in Table 4e for control options and temperature adjustments due to control.</i>					
Micro-cogeneration (micro-CHP)					
<i>See Appendix N. Performance data to be obtained from boiler database (www.boilers.org.uk).</i>					
<i>Refer to Group 1 in Table 4e for control options and temperature adjustments due to control.</i>					
Solid fuel boilers					
<i>For efficiency, use boiler database if possible, otherwise use efficiency from this table. Column (A) gives minimum values for HETAS approved appliances, use column (B) for other appliances (see section 9.2.4). For open fires with back boilers and closed roomheaters with boilers the efficiencies are the sum of heat to water and heat to room. See Table 12b for fuel options.</i>					
<i>Refer to Group 1 in Table 4e for control options</i>					
	(A)	(B)			
Manual feed independent boiler in heated space ^{a)}	65	60	2	0.75	151 rd
Manual feed independent boiler in unheated space ^{a)}	60	55	2	0.75	152
Auto (gravity) feed independent boiler in heated space ^{a)}	70	65	2	0.75	153
Auto (gravity) feed independent boiler in unheated space ^{a)}	65	60	2	0.75	154 rd
Wood chip/pellet independent boiler	65	63	2	0.75	155
Open fire with back boiler to radiators	63	55	3	0.50	156 rd
Closed roomheater with boiler to radiators	67	65	3	0.50	158 rd
Stove (pellet-fired) with boiler to radiators	65	63	2	0.75	159
Range cooker boiler (integral oven and boiler)	50	45	3	0.50	160 rd
Range cooker boiler (independent oven and boiler)	60	55	3	0.50	161
^{a)} Heated space means within the boundary of the dwelling as defined in section 1, "Dwelling dimensions"					
Electric boilers					
<i>Refer to Group 1 in Table 4e for control options</i>					
Direct acting electric boiler	100	1	1.0	191	rd
Electric CPSU in heated space ^{a)} – radiators or underfloor	100	2	0.75	192	rd
Electric dry core storage boiler in heated space ^{a) b)}	100	2	0.75	193	rd
Electric dry core storage boiler in unheated space ^{a) b)}	85	2	0.75	194	
Electric water storage boiler in heated space ^{a) b)}	100	2	0.75	195	rd
Electric water storage boiler in unheated space ^{a) b)}	85	2	0.75	196	
^{a)} Heated space means within the boundary of the dwelling as defined in section 1, "Dwelling dimensions"					
^{b)} Store within boiler capable of meeting all space heating needs					

	Efficiency %	Heating type	Respon- siveness (R)	Code	Rd SAP
Heat pumps (see also warm air systems)					
<i>Refer to Group 2 in Table 4e for control options</i>					
<i>The efficiency values shown apply only for heat pumps that cannot be located in the database</i>					
Ground-to-water heat pump (electric)	320	From Table 4d		201	rd
Ground-to-water heat pump with auxiliary heater (electric)	300	From Table 4d		202	rd
Water-to-water heat pump (electric)	300	From Table 4d		203	rd
Air-to-water heat pump (electric)	250	From Table 4d		204	rd
Gas-fired, ground source	120	From Table 4d		205	
Gas-fired, water source	120	From Table 4d		206	
Gas-fired, air source	110	From Table 4d		207	
COMMUNITY HEATING SCHEMES					
<i>Multiply the energy use by the factor for controls and charging method in Table 4c</i>					
<i>For calculation of CO₂ emissions: if known, use manufacturer's declared efficiency instead of value from this table.</i>					
<i>Refer to Group 3 in Table 4e for control options.</i>					
<i>Check Table 4c for efficiency adjustment due to controls.</i>					
<i>Allow for distribution loss (see Table 12c).</i>					
Community boilers	75	1	1.0	306	rd
Community CHP	75	1	1.0	307	rd
Community waste heat from power station	100	1	1.0	308	
Community heat pump	300	1	1.0	309	
Community geothermal heat source	100	1	1.0	310	
ELECTRIC STORAGE SYSTEMS					
<i>Refer to Group 4 in Table 4e for control options.</i>					
<i>Off-peak tariffs:</i>					
Old (large volume) storage heaters	100	5	0.0	401	rd
Modern (slimline) storage heaters	100	4	0.25	402	rd
Convactor storage heaters	100	4	0.25	403	
Fan storage heaters	100	3	0.5	404	rd
Modern (slimline) storage heaters with Celect-type control	100	3	0.5	405	
Convactor storage heaters with Celect-type control	100	3	0.5	406	
Fan storage heaters with Celect-type control	100	2	0.75	407	
Integrated storage+direct-acting heater	100	2	0.75	408	rd
<i>24-hour heating tariff:</i>					
Modern (slimline) storage heaters	100	3	0.5	402	rd
Convactor storage heaters	100	3	0.5	403	
Fan storage heaters	100	3	0.5	404	rd
Modern (slimline) storage heaters with Celect-type control	100	2	0.75	405	
Convactor storage heaters with Celect-type control	100	2	0.75	406	
Fan storage heaters with Celect-type control	100	2	0.75	407	
ELECTRIC UNDERFLOOR HEATING					
<i>Refer to Group 7 in Table 4e for control options.</i>					
<i>Off-peak tariffs:</i>					
In concrete slab (off-peak only)	100	5	0.0	421	rd
Integrated (storage+direct-acting)	100	4	0.25	422	rd
Integrated (storage+direct-acting) with low (off-peak) tariff control	100	3	0.50	423	
<i>Standard or off-peak tariff:</i>					
In screed above insulation	100	2	0.75	424	rd

	Efficiency %	Heating type	Respon- siveness (R)	Code	Rd SAP
In timber floor, or immediately below floor covering	100	1	1	425	

WARM AIR SYSTEMS

Refer to Group 5 in Table 4e for control options.

Gas-fired warm air with fan-assisted flue

Ducted, on-off control, pre 1998	70	1	1.0	501	
Ducted, on-off control, 1998 or later	76	1	1.0	502	rd
Ducted, modulating control, pre 1998	72	1	1.0	503	
Ducted, modulating control, 1998 or later	78	1	1.0	504	
Roomheater with in-floor ducts	69	1	1.0	505	

Gas fired warm air with balanced or open flue

Ducted or stub-ducted, on-off control, pre 1998	70	1	1.0	506	rd
Ducted or stub-ducted, on-off control, 1998 or later	76	1	1.0	507	
Ducted or stub-ducted, modulating control, pre 1998	72	1	1.0	508	
Ducted or stub-ducted, modulating control, 1998 or later	78	1	1.0	509	
Ducted or stub-ducted with flue heat recovery	85	1	1.0	510	rd
Condensing	81	1	1.0	511	rd

Oil-fired warm air

Ducted output (on/off control)	70	1	1.0	512	rd
Ducted output (modulating control)	72	1	1.0	513	
Stub duct system	70	1	1.0	514	

Electric warm air

Electricaire system	100	2	0.75	515	rd
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Heat pumps

The efficiency values shown apply only for heat pumps that cannot be located in the database

Ground-to-air heat pump (electric)	320	1	1.0	521	rd
Ground-to-air heat pump with auxiliary heater (electric)	300	1	1.0	522	rd
Water-to-air heat pump (electric)	300	1	1.0	523	rd
Air-to-air heat pump (electric)	250	1	1.0	524	rd
Gas-fired, ground source	120	1	1.0	525	
Gas-fired, water source	120	1	1.0	526	
Gas-fired, air source	110	1	1.0	527	

ROOM HEATERS

Refer to Group 6 in Table 4e for control options.

If declared efficiency is available (see Appendix E) use instead of value from table.

The normal flue type is indicated as OF (open), BF (balanced) or C (chimney)

Gas (including LPG) room heaters:

Column (A) gives efficiency values for mains gas, column (B) for LPG

	Flue	(A)	(B)				
Gas fire, open flue, pre-1980 (open fronted)	OF	50	50	1	1.0	601	rd
Gas fire, open flue, pre-1980 (open fronted), with back boiler unit	OF	50	50	1	1.0	602	rd
Gas fire, open flue, 1980 or later (open fronted), sitting proud of, and sealed to, fireplace opening	OF	63	64	1	1.0	603	rd
Gas fire, open flue, 1980 or later (open fronted), sitting proud of, and sealed to, fireplace opening, with back boiler unit	OF	63	64	1	1.0	604	rd
Flush fitting Live Fuel Effect gas fire (open fronted), sealed to fireplace opening	OF	40	41	1	1.0	605	rd
Flush fitting Live Fuel Effect gas fire (open fronted), sealed to fireplace opening, with back boiler unit	OF	40	41	1	1.0	606	rd

		Efficiency %		Heating type	Respon- siveness (R)	Code	Rd SAP
Flush fitting Live Fuel Effect gas fire (open fronted), fan assisted, sealed to fireplace opening	OF	45	46	1	1.0	607	rd
Gas fire or wall heater, balanced flue	BF	58	60	1	1.0	609	rd
Gas fire, closed fronted, fan assisted	BF	72	73	1	1.0	610	rd
Condensing gas fire	BF	85	85	1	1.0	611	rd
Decorative Fuel Effect gas fire, open to chimney	C	20	20	1	1.0	612	rd
Flueless gas fire, secondary heating only (add additional ventilation requirements in box (9a))	none	90	92	1	1.0	613	rd

Oil room heaters:

	Flue						
Room heater, pre 2000	OF	55		1	1.0	621	rd
Room heater, pre 2000, with boiler (no radiators)	OF	65		1	1.0	622	rd
Room heater, 2000 or later	OF	60		1	1.0	623	rd
Room heater, 2000 or later with boiler (no radiators)	OF	70		1	1.0	624	rd

Solid fuel room heaters

Column (A) gives minimum values for HETAS approved appliances, use column (B) for other appliances (see section 9.2.3).

	Flue	(A)	(B)				
Open fire in grate	C	37	32	3	0.50	631	rd
Open fire with back boiler (no radiators)	C	50	50	3	0.50	632	rd
Closed room heater	OF*	65	60	3	0.50	633	rd
Closed room heater with boiler (no radiators)	OF*	67	65	3	0.50	634	rd
Stove (pellet fired)	OF*	65	63	2	0.75	635	
Stove (pellet fired) with boiler (no radiators)	OF*	65	63	2	0.75	636	

* some wood-burning appliances have a room-sealed flue

Electric (direct acting) room heaters:

Panel, convector or radiant heaters		100		1	1.0	691	rd
Water- or oil-filled radiators		100		1	1.0	694	
Fan heaters		100		1	1.0	692	
Portable electric heaters		100		1	1.0	693	rd

OTHER SPACE HEATING SYSTEMS

Refer to Group 7 in Table 4e for control options.

Electric ceiling heating		100		2	0.75	701	rd
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Table 4a (continued)

	Efficiency %	Code	Rd SAP
HOT WATER SYSTEMS			
No hot water system present - electric immersion assumed	100	999	rd
From main heating system			
Back boiler (hot water only), gas*	65	901	rd
Circulator built into a gas warm air system, pre 1998	65		
Circulator built into a gas warm air system, 1998 or later	73		
From second main system		914	
		efficiency of second main system, exceptions as above	
From secondary system		902	rd
Back boiler (hot water only), gas*	65		
Electric immersion	100	903	rd
Single-point gas water heater (instantaneous at point of use)	70	907	rd
Multi-point gas water heater (instantaneous serving several taps)	65	908	rd
Electric instantaneous at point of use	100	909	rd
Gas boiler/circulator for water heating only*	65	911	
Oil boiler/circulator for water heating only*	70	912	
Solid fuel boiler/circulator for water heating only	55	913	
Range cooker with boiler for water heating only:*			
Gas, single burner with permanent pilot	46	921	
Gas, single burner with automatic ignition	50	922	
Gas, twin burner with permanent pilot pre 1998	60	923	
Gas, twin burner with automatic ignition pre 1998	65	924	
Gas, twin burner with permanent pilot 1998 or later	65	925	
Gas, twin burner with automatic ignition 1998 or later	70	926	
Oil, single burner	60	927	
Oil, twin burner pre 1998	70	928	
Oil, twin burner 1998 or later	75	929	
Solid fuel, integral oven and boiler	45	930	
Solid fuel, independent oven and boiler	55	931	
Hot-water only community scheme - boilers	75	950	
Hot-water only community scheme - CHP	75	951	
Hot-water only community scheme - heat pump	300	952	

* If available use data from the boiler database instead of the values in this table

Table 4b: Seasonal efficiency for gas and oil boilers

1. This table is to be used only for gas and oil boilers which cannot be located in the database.
2. See section 9.2.1 for application of the efficiency values in this table.
3. See Appendix B for guidance on boiler classification.
4. Apply efficiency adjustments in Table 4c if appropriate.
5. See Table 4d for heating type and responsiveness.
6. Systems marked "rd" in the right-hand column are part of the reduced data set (see S10 in Appendix S)

Boiler	Efficiency, %		Code	Rd SAP
	Winter	Summer		
Gas boilers (including LPG) 1998 or later				
Regular non-condensing with automatic ignition	74	64	101	rd
Regular condensing with automatic ignition	84	74	102	rd
Non-condensing combi with automatic ignition	74	65	103	rd
Condensing combi with automatic ignition	84	75	104	rd
Regular non-condensing with permanent pilot light	70	60	105	rd
Regular condensing with permanent pilot light	80	70	106	
Non-condensing combi with permanent pilot light	70	61	107	rd
Condensing combi with permanent pilot light	80	71	108	
Back boiler to radiators (select gas fire as secondary heater, see section 9.2.8)	66	56	109	rd
Gas boilers (including LPG) pre-1998, with fan-assisted flue				
Low thermal capacity	73	63	110	
High or unknown thermal capacity	69	59	111	rd
Combi	71	62	112	rd
Condensing combi	84	75	113	rd
Condensing	84	74	114	rd
Gas boilers (including LPG) pre-1998, with balanced or open flue				
Wall mounted	66	56	115	rd
Floor mounted, pre 1979	56	46	116	rd
Floor mounted, 1979 to 1997	66	56	117	rd
Combi	66	57	118	rd
Back boiler to radiators (select gas fire as secondary heater, see section 9.2.8)	66	56	119	rd
Combined Primary Storage Units (CPSU) (mains gas and LPG)				
With automatic ignition (non-condensing)	74	72	120	rd
With automatic ignition (condensing)	83	81	121	rd
With permanent pilot (non-condensing)	70	68	122	
With permanent pilot (condensing)	79	77	123	
Oil boilers				
Standard oil boiler pre-1985	66	54	124	
Standard oil boiler 1985 to 1997	71	59	125	rd
Standard oil boiler, 1998 or later	80	68	126	rd
Condensing	84	72	127	rd
Combi, pre-1998	71	62	128	rd
Combi, 1998 or later	77	68	129	rd
Condensing combi	82	73	130	rd
Oil room heater with boiler to radiators, pre 2000	66	54	131	rd
Oil room heater with boiler to radiators, 2000 or later	71	59	132	rd
Range cooker boilers (mains gas and LPG)				
Single burner with permanent pilot	47	37	133	rd
Single burner with automatic ignition	51	41	134	rd
Twin burner with permanent pilot (non-condensing) pre 1998	61	51	135	
Twin burner with automatic ignition (non-condensing) pre 1998	66	56	136	rd
Twin burner with permanent pilot (non-condensing) 1998 or later	66	56	137	
Twin burner with automatic ignition (non-condensing) 1998 or later	71	61	138	

Range cooker boilers (oil)

Single burner	61	49	139	rd
Twin burner (non-condensing) pre 1998	71	59	140	rd
Twin burner (non-condensing) 1998 or later	76	64	141	

Table 4c: Efficiency adjustments

Heating system	Efficiency adjustment, %			
----------------	--------------------------	--	--	--

Gas or oil boiler systems with radiators or underfloor heating:

The adjustments are to be applied to the space and water heating seasonal efficiency for both tested efficiency values and efficiency values from Table 4b.

(1) Efficiency adjustment due to lower temperature of distribution system:	---- Space ----		---- DHW ----	
	Mains gas	Oil or LPG	Mains gas	Oil or LPG
Condensing boiler with load compensator	0	0	0	0
Condensing boiler with enhanced load compensator ^{a)}	+3	+1.5	0	0
Condensing boiler with weather compensator ^{a)}	+3	+1.5	0	0
Condensing boiler with under-floor heating ^{a) b)}	+3	+2	0	0
Condensing boiler with thermal store ^{a)}	0	0	0	0
(2) Efficiency adjustment due to control system				
No thermostatic control of room temperature – regular boiler ^{c)}			-5	-5
No thermostatic control of room temperature – combi ^{c)}			-5	0
No boiler interlock – regular boiler ^{c)}			-5	-5
No boiler interlock - combi ^{c)}			-5	0

Community heating systems:

(3) Factor for controls and charging method (control code as defined in Table 4e)	Multiply energy use by:	
	Space	DHW
2301 Flat rate charging ^{d)} , no thermostatic control of room temperature	1.10	1.05
2302 Flat rate charging, programmer, no room thermostat	1.10	1.05
2303 Flat rate charging, room thermostat only	1.05	1.05
2304 Flat rate charging, programmer and room thermostat	1.05	1.05
2307 Flat rate charging, TRVs	1.05	1.05
2305 Flat rate charging, programmer and TRVs	1.05	1.05
2308 Charging system linked to use of community heating, room thermostat only	1.05	1.0
2309 Charging system linked to use of community heating, programmer and room thermostat	1.05	1.0
2310 Charging system linked to use of community heating, TRVs	1.0	1.0
2306 Charging system linked to use of community heating, programmer and TRVs	1.0	1.0
Community DHW-only system, flat rate charging	-	1.05
Community DHW-only system, charging linked to use	-	1.0

Heat pumps:

(4) Efficiency adjustment due to temperature of heat supplied where the efficiency is from Table 4a (not applied if from database)	Multiply efficiency by:	
	Space	DHW
Heat pump with underfloor heating only	1.0	
Heat pump with radiators without weather or enhanced load compensator ^{e)}	0.7	
Heat pump with fan coil units	0.85	
Heat pump with radiators and weather or enhanced load compensator ^{e)}	0.75	
Warm-air heat pump	1.0	
Heat pump supplying all DHW		0.7
Heat pump supplying 50% DHW		1.0

Notes to Table 4e:

- a) These are mutually exclusive and therefore do not accumulate; if more than one applies, the highest applicable efficiency adjustment is to be used. Also, these efficiency adjustments are not applied if there is a flue gas heat recovery device/system.
- b) Adjustment is applicable if the boiler supplies only the underfloor heating, and not if it also feeds radiators or supplies hot water.
- c) These do not accumulate as no thermostatic control or presence of a bypass means that there is no boiler interlock.
- d) 'Flat rate charging' means that households pay for the heat according to a fixed monthly or annual amount, not depending on the amount of heat actually used. If the charges vary within a scheme for other reasons, for example according to dwelling size, it is still classified as flat rate. 'Charging system linked to use of community heating' refers to a system in which the charges are substantially related to the amount of heat used.
- e) Based on maximum heat distribution temperature of 50°C.

Table 4d: Heating type and responsiveness for wet systems depending on heat emitter

Heat emitter	Heating type	Responsiveness (R)
Systems with radiators:	1	1.0
Underfloor heating (wet system):		
pipes in insulated timber floor	1	1.0
pipes in screed above insulation	2	0.75
pipes in concrete slab	4	0.25
Underfloor heating and radiators		
pipes in insulated timber floor	1	1.0
pipes in screed above insulation	2	0.75
pipes in concrete slab	4	0.25
Warm air via fan coil units	1	1.0

Table 4e: Heating system controls

1. Use Table 4a to select appropriate Group in this table.
2. 'Control' indicates the appropriate column to use in Table 9.
3. The 'Temperature adjustment' modifies the mean internal temperature and is added to worksheet (92)_m.
4. Controls marked "rd" in the right-hand column are part of the reduced data set (see S10 in Appendix S)

Type of control	Control	Temperature adjustment, °C	Reference to other possible adjustments	Code	rd SAP
GROUP 0: NO HEATING SYSTEM PRESENT					
None	2	+0.3	n/a	2699	rd
GROUP 1: BOILER SYSTEMS WITH RADIATORS OR UNDERFLOOR HEATING					
No time or thermostatic control of room temperature	1	+0.6	Table 4c(2)	2101	rd
Programmer, no room thermostat	1	+0.6	Table 4c(2)	2102	rd
Room thermostat only	1	0	Table 4c(2)	2103	rd
Programmer and room thermostat	1	0	Table 4c(2)	2104	rd
Programmer and at least two room thermostats	2	0	Table 4c(2)	2105	rd
Programmer, room thermostat and TRVs	2	0	Table 4c(2)	2106	rd
TRVs and bypass	2	0	Table 4c(2)	2111	
Programmer, TRVs and bypass	2	0	Table 4c(2)	2107	rd
Programmer, TRVs and flow switch	2	0	Table 4c(2)	2108	
Programmer, TRVs and boiler energy manager	2	0	Table 4c(2)	2109	rd
Time and temperature zone control	3	0	Table 4c(2)	2110	rd
Adjustments for features of control systems: (applicable to any control option above and in addition to the adjustments selected above)					
Delayed start thermostat	one of the above	-0.15	n/a		
Load or weather compensation	one of the above	0	Table 4c(1)		
Temperature control of water heating (cylinderstat)	n/a	n/a	Tables 2b and 3		rd
Time control of water heating (separate programming)	n/a	n/a	Table 2b		
Adjustments for features other than controls:					
Temperature adjustment for CPSU or integrated thermal store	n/a	-0.1	n/a		rd
Underfloor heating	n/a	n/a	Table 4c(1)		rd
GROUP 2: HEAT PUMPS WITH RADIATORS OR UNDERFLOOR HEATING					
No time or thermostatic control of room temperature	1	+0.3	Table 4c(4)	2201	rd
Programmer, no room thermostat	1	+0.3	Table 4c(4)	2202	rd
Room thermostat only	1	0	Table 4c(4)	2203	rd
Programmer and room thermostat	1	0	Table 4c(4)	2204	rd
Programmer and at least two room thermostats	2	0	Table 4c(4)	2205	rd
Programmer, TRVs and bypass	2	0	Table 4c(4)	2206	rd
Time and temperature zone control	3	0	Table 4c(4)	2207	rd
Adjustments for features of control systems: (applicable to any control option above and in addition to the adjustments selected above)					
Load or weather compensation	one of the above	0	Table 4c(4)		
Temperature control of water heating (cylinderstat)	n/a	n/a	Tables 2b and 3		rd
Time control of water heating (separate programming)	n/a	n/a	Table 2b		
Adjustments for features other than controls:					
Temperature adjustment for integrated thermal store	n/a	-0.1	n/a		rd

Table 4e continued

Type of control	Control	Temperature adjustment, °C	Reference to other possible adjustments	Code	Rd SAP
GROUP 3: COMMUNITY HEATING SCHEMES					
Flat rate charging*, no thermostatic control of room temperature	1	+0.3	Table 4c(3)	2301	rd
Flat rate charging*, programmer, no room thermostat	1	+0.3	Table 4c(3)	2302	rd
Flat rate charging*, room thermostat only	1	0	Table 4c(3)	2303	rd
Flat rate charging*, programmer and room thermostat	1	0	Table 4c(3)	2304	rd
Flat rate charging*, TRVs	2	0	Table 4c(3)	2307	
Flat rate charging*, programmer and TRVs	2	0	Table 4c(3)	2305	rd
Charging system linked to use of community heating, room thermostat only	2	0	Table 4c(3)	2308	
Charging system linked to use of community heating, programmer and room thermostat	2	0	Table 4c(3)	2309	
Charging system linked to use of community heating, TRVs	3	0	Table 4c(3)	2310	
Charging system linked to use of community heating, programmer and TRVs	3	0	Table 4c(3)	2306	rd
* 'Flat rate charging' means that households pay for the heat according to a fixed monthly or annual amount, not depending on the amount of heat actually used. If the charges vary within a scheme for other reasons, for example according to dwelling size, it is still classified as flat rate. Other entries refer to a system in which the charges are substantially related to the amount of heat used.					
GROUP 4: ELECTRIC STORAGE SYSTEMS					
Manual charge control	3	+0.3	n/a	2401	rd
Automatic charge control	3	0	n/a	2402	rd
Ceect-type controls	3	0	n/a	2403	
GROUP 5: WARM AIR SYSTEMS (including heat pumps with warm air distribution)					
No thermostatic control of room temperature	1	+0.3	n/a	2501	rd
Programmer, no room thermostat	1	+0.3	n/a	2502	rd
Room thermostat only	1	0	n/a	2503	rd
Programmer and room thermostat	1	0	n/a	2504	rd
Programmer and at least two room thermostats	2	0	n/a	2505	rd
Time and temperature zone control	3	0	n/a	2506	rd
GROUP 6: ROOM HEATER SYSTEMS					
No thermostatic control of room temperature	2	+0.3	n/a	2601	rd
Appliance thermostats	3	0	n/a	2602	rd
Programmer and appliance thermostats	3	0	n/a	2603	rd
Room thermostats only	3	0	n/a	2604	rd
Programmer and room thermostats	3	0	n/a	2605	rd
GROUP 7: OTHER SYSTEMS					
No thermostatic control of room temperature	1	+0.3	n/a	2701	rd
Programmer, no room thermostat	1	+0.3	n/a	2702	rd
Room thermostat only	1	0	n/a	2703	rd
Programmer and room thermostat	1	0	n/a	2704	rd
Temperature zone control	2	0	n/a	2705	rd
Time and temperature zone control	3	0	n/a	2706	rd

Table 4f: Electricity for fans and pumps and electric keep-hot facility

Equipment	kWh/year
Heating system:	
Central heating pump (supplying hot water to radiators or underfloor system)	130 ^{a)}
Oil boiler ^{b)} - pump (supplying oil to boiler and flue fan) ^{c)}	100 ^{a)}
Gas boiler - flue fan (if fan assisted flue)	45
Gas-fired heat pump - flue fan (if fan assisted flue)	45
Warm air heating system fans ^{d)}	$0.6 \times V$
Keep-hot facility of a combi boiler:	
Electricity for maintaining keep-hot facility ^{e) f)}	
- keep-hot facility, controlled by time clock	600
- keep-hot facility, not controlled by time clock	900
Ventilation system:	
Mechanical extract ventilation ^{g)}	$SFP \times 1.22 \times V$
Balanced whole house mechanical ventilation fans ^{g)}	$SFP \times 2.44 \times n_{mech} \times V$
Positive input ventilation (from loft space)	0
Positive input ventilation (from outside) ^{g)}	$SFP \times 1.22 \times V$
Solar water heating pump:	
Solar water heating pump, electrically powered	75
Solar water heating pump, PV powered	0

Notes:

- ^{a)} Multiply by a factor of 1.3 if room thermostat is absent.
- ^{b)} Applies to all oil boilers that provide main heating, but not if boiler provides hot water only.
- ^{c)} The same motor operates both the pump and the flue fan.
- ^{d)} If the heating system is a warm air unit and there is balanced whole house mechanical ventilation, the electricity for warm air circulation should not be included in addition to the electricity for mechanical ventilation. However it is included for a warm air system and MEV or PIV from outside. V is the volume of the dwelling in m^3 .
- ^{e)} See notes to Table 3a for the definition of keep-hot facility.
- ^{f)} In the case of an electrically powered keep-hot facility where the power rating of the keep-hot heater is obtained from the Boiler Efficiency database, the electric part of the total combi loss should be taken as:
 $LE = 8.76 \times P$ (kWh/year) (subject to maximum of the value from Table 3a, 3b or 3c)
where P is the power rating of the heater in watts
with the remainder (either 600 – LE or 900 – LE) provided by the fuel.
- ^{g)} SFP is specific fan power in W/(litre/sec) including the applicable in-use factor, see paragraph 2.6 and Tables 4g and 4h, V is volume of the dwelling in m^3 . n_{mech} is the throughput of the MVHR system, see paragraph 2.6.

Table 4g: Default specific fan power for mechanical ventilation systems and heat recovery efficiency for MVHR systems

1. The data in Table 4g are used only where values via database or Appendix Q for the specific product are not available.
2. The SFP values apply to both rigid and flexible ducting.
3. Values of specific fan power and heat recovery efficiency are to be multiplied by the appropriate in-use factor for default data (Table 4h).

Type of mechanical ventilation	SFP, W/(litre/sec)	Heat recovery efficiency
Mechanical extract ventilation (centralised or decentralised), or positive input ventilation from outside	0.8	-
Balanced whole house mechanical ventilation, without heat recovery	2.0	-
Balanced whole house mechanical ventilation, with heat recovery	2.0	66%

Table 4h: In-use factors for mechanical ventilation systems

In-use factors are applied to the data for mechanical ventilation systems in all cases

Type of mechanical ventilation	Approved installation scheme	In-use factor for Specific fan power			In-use factor for Efficiency	
		Flexible duct	Rigid duct	No duct	Uninsulated ducts	Insulated ducts ^{c)}
Mechanical extract ventilation or positive input ventilation from outside, centralised ^{a)}	No	1.70	1.40	-	-	-
	Yes	*	*	-	-	-
Mechanical extract ventilation or positive input ventilation from outside, decentralised ^{a)}	No	1.45	1.30	1.15	-	-
	Yes	*	*	*	-	-
Balanced whole house mechanical ventilation, without heat recovery ^{a)}	No	1.70	1.40	-	-	-
	Yes	*	*	-	-	-
Balanced whole house mechanical ventilation, with heat recovery ^{a)}	No	1.70	1.40	-	0.70	0.85
	Yes	*	*	-	*	*
Default data from Table 4g (all types) ^{b)}		2.5			0.70	

* Additional values may be added if an approved installation scheme for mechanical ventilation systems is put in place.

^{a)} Use these values for data from the database or from data sheets obtained from www.sap-appendixq.org.uk

^{b)} Use these values for data from Table 4g.

^{c)} This column applies when all ductwork is within the insulated envelope of the building even though ductwork is not itself insulated.

Table 5: Internal heat gains (in watts)

Source	(A) Typical gains	(B) Reduced gains
Metabolic	$60 \times N$	$50 \times N$
Lighting	equation (L9) in Appendix L	equation (L9a) in Appendix L
Appliances	equation (L13) in Appendix L	equation (L13a) in Appendix L
Cooking	$35 + 7 \times N$	$23 + 5 \times N$
Water heating	$1000 \times (65)_m \div (n_m \times 24)$	$1000 \times (65)_m \div (n_m \times 24)$
Losses	$-40 \times N$	$-40 \times N$
Pumps and fans	Table 5a	Table 5a

Notes:

1. N is the assumed number of occupants, based on floor area.
2. Losses comprise heat to incoming cold water and evaporation.
3. Column (B) applies to the calculation of the space heating requirements for the DER and TER for new dwellings. Column (A) applies in all other cases (including the calculation of space cooling requirements and overheating assessments).

Table 5a: Gains from pumps and fans

Function	Gains (W)
Central heating pump in heated space ^{a)}	10
Oil boiler pump, inside dwelling ^{b)}	10
Warm air heating system fans ^{a) c)}	$0.06 \times V$
Fans for positive input ventilation from outside ^{d)}	$SFP \times 0.12 \times V$
Fans for balanced whole house mechanical ventilation without heat recovery ^{d)}	$SFP \times 0.06 \times V$

Notes:

- ^{a)} Does not apply to community heating
- ^{b)} Only for boiler providing main heating. In addition to central heating pump, but not if oil pump is outside dwelling.
- ^{c)} If the heating system is a warm air unit and there is balanced whole house mechanical ventilation, the gains for the warm air system should not be included.
- ^{d)} SPF includes the applicable in-use factor (Table 4h).

V is the volume of the dwelling.

Gains are not added in for MVHR systems (because their effect is included in the MVHR efficiency), nor for MEV systems.

Table 6a: Mean global solar irradiation on a horizontal plane (latitude 53.4°N) and solar declination, and conversions to vertical surfaces

Solar radiation on the horizontal (W/m ²)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
26	54	94	150	190	201	194	164	116	68	33	21
Solar declination (°)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
-20.7	-12.8	-1.8	9.8	18.8	23.1	21.2	13.7	2.9	-8.7	-18.4	-23.0

Solar radiation on vertical surfaces for solar gain through windows and roof windows

Solar radiation is obtained from the data in Table 6a as follows.

$$F_{x_i}(m) = R_{\text{htov}}(\theta) S_h \quad \text{where} \quad R_{\text{htov}}(\theta) = A + B \cos(\theta) + C \cos(2\theta)$$

$$A = 0.702 - 0.0119 (\phi - \delta) + 0.000204 (\phi - \delta)^2$$

$$B = -0.107 + 0.0081 (\phi - \delta) - 0.000218 (\phi - \delta)^2$$

$$C = 0.117 - 0.0098 (\phi - \delta) + 0.000143 (\phi - \delta)^2$$

and

$F_{x_i}(m)$ is the vertical solar flux for an element in month m with orientation θ (W/m^2)

$R_{\text{htov}}(\theta)$ is the factor for converting from horizontal to vertical solar flux

θ is the orientation of the opening measured eastwards from North (e.g. East = 90°) ($^\circ$)

ϕ is the latitude of the site ($^\circ$), = 53.4°N for heating calculations or Table 10 for summer calculations

δ is the solar declination for month m ($^\circ$) (Table 6a)

S_h is the horizontal solar flux (W/m^2) (Table 6a or Table 10)

For roof windows

- if orientated within $\pm 30^\circ$ of North, the value for a North-facing vertical surface
- otherwise the value for a horizontal surface (i.e. as tabulated in Table 6a or Table 10)

Angles may need to be converted to radians depending on the software implementation of the cosine function.

Table 6b: Transmittance factors for glazing

Type of glazing	Total solar energy transmittance, g^* (for calculation of solar gains in section 6 of the worksheet)	Light transmittance, g_L (for calculation of lighting requirement in Appendix L)
Single glazed	0.85	0.90
Double glazed (air or argon filled)	0.76	} 0.80
Double glazed (low-E, hard-coat)	0.72	
Double glazed (low-E, soft-coat)	0.63	
Window with secondary glazing	0.76	0.80
Triple glazed (air or argon filled)	0.68	} 0.70
Triple glazed (low-E, hard-coat)	0.64	
Triple glazed (low-E, soft-coat)	0.57	

Notes:

1. The values are for normal incidence of solar radiation and they are multiplied by 0.9 (both solar and light transmittance) in calculations.
2. When the window U-value is declared by the manufacturer (rather than from Table 6e) the solar transmittance should also be obtained from the manufacturer. In this case, ascertain whether the solar transmittance is related to the glazing only or to the whole window: see section 6.1.
3. Light transmittance should always be taken from Table 6b, irrespective of the source of the U-value and solar transmittance.

Table 6c: Frame factors for windows and glazed doors

Frame type	Frame factor (proportion of opening that is glazed)
Wood	0.7
Metal	0.8
Metal, thermal break	0.8
PVC-U	0.7

Note: If known, the actual frame factor should be used instead of the data in Table 6c. Frame factors can be assigned per window (or per group of similar windows) or as an average for each façade of the dwelling.

Table 6d: Solar and light access factors

Overshading	% of sky blocked by obstacles.	Winter solar access factor (for calculation of solar gains for heating)	Summer solar access factor (for calculation of solar gains for cooling and summer temperatures in Appendix P)	Light access factor (for calculation of lighting requirement in Appendix L)
Heavy	> 80%	0.3	0.5	0.5
More than average	>60% - 80%	0.54	0.7	0.67
Average or unknown	20% - 60%	0.77	0.9	0.83
Very little	< 20%	1.0	1.0	1.0

Notes

1. The overshading category of "very little" is not appropriate for new dwellings.
2. A solar access factor of 1.0 and a light access factor of 1.0 should be used for roof windows.

Table 6e: Default U-values (W/m²K) for windows, doors and roof windows

The values apply to the entire area of the window opening, including both frame and glass, and take account of the proportion of the area occupied by the frame and the heat conducted through it. Unless known otherwise, double and triple glazing should be taken as air-filled without low-E coating. If the U-value of the components of the window (glazed unit and frame) are known, window U-values may alternatively be taken from the tables in Annex F of BS EN ISO 10077-1, using the tables for 20% frame for metal-framed windows and those for 30% frame for wood or PVC-U framed windows.

When available, the manufacturer's certified U-values for windows or doors should be used in preference to the data in this table. Adjustments for roof windows as in Notes 1 and 2 to the table should be applied to manufacturer's window U-values unless the manufacturer provides a U-value specifically for a roof window.

	Type of frame					
	Window with wood or PVC-U frame (for roof windows use adjustment in Note 1)			Window with metal frame with 4mm thermal break (use adjustments in Note 1 and Note 2)		
	6 mm gap	12 mm gap	16 or more mm gap	6 mm gap	12 mm gap	16 or more mm gap
double-glazed, air filled	3.1	2.8	2.7	3.7	3.4	3.3
double-glazed, air filled (low-E, ε _n = 0.2, hard coat)	2.7	2.3	2.1	3.3	2.8	2.6
double-glazed, air filled (low-E, ε _n = 0.15, hard coat)	2.7	2.2	2.0	3.3	2.7	2.5
double-glazed, air filled (low-E, ε _n = 0.1, soft coat)	2.6	2.1	1.9	3.2	2.6	2.4
double-glazed, air filled (low-E, ε _n = 0.05, soft coat)	2.6	2.0	1.8	3.2	2.5	2.3
double-glazed, argon filled	2.9	2.7	2.6	3.5	3.3	3.2
double-glazed, argon filled (low-E, ε _n = 0.2, hard coat)	2.5	2.1	2.0	3.0	2.6	2.5
double-glazed, argon filled (low-E, ε _n = 0.15, hard coat)	2.4	2.0	1.9	3.0	2.5	2.4
double-glazed, argon filled (low-E, ε _n = 0.1, soft coat)	2.3	1.9	1.8	2.9	2.4	2.3
double-glazed, argon filled (low-E, ε _n = 0.05, soft coat)	2.3	1.8	1.7	2.8	2.2	2.1
triple glazed, air filled	2.4	2.1	2.0	2.9	2.6	2.5
triple-glazed, air filled (low-E, ε _n = 0.2, hard coat)	2.1	1.7	1.6	2.6	2.1	2.0
triple-glazed, air filled (low-E, ε _n = 0.15, hard coat)	2.1	1.7	1.6	2.5	2.1	2.0
triple-glazed, air filled (low-E, ε _n = 0.1, soft coat)	2.0	1.6	1.5	2.5	2.0	1.9
triple-glazed, air filled (low-E, ε _n = 0.05, soft coat)	1.9	1.5	1.4	2.4	1.9	1.8
triple-glazed, argon filled	2.2	2.0	1.9	2.8	2.5	2.4
triple-glazed, argon filled (low-E, ε _n = 0.2, hard coat)	1.9	1.6	1.5	2.3	2.0	1.9
triple-glazed, argon filled (low-E, ε _n = 0.15, hard coat)	1.8	1.5	1.4	2.3	1.9	1.8
triple-glazed, argon filled (low-E, ε _n = 0.1, soft coat)	1.8	1.5	1.4	2.2	1.9	1.8
triple-glazed, argon filled (low-E, ε _n = 0.05, soft coat)	1.7	1.4	1.3	2.2	1.8	1.7

Windows and doors, single-glazed	4.8	5.7
Window with secondary glazing	2.4	
Solid wooden door to outside	3.0	
Solid wooden door to unheated corridor	1.4	

Notes:

1. For roof windows apply the following adjustments to U-values:

All frame types	U-value adjustment for roof window, W/m^2K
Single glazed	+0.5
Double glazed or secondary glazing	+0.3
Triple glazed	+0.2

2. For windows or roof windows with metal frames apply the following adjustments to U-values:

Metal frames	U-value adjustment, W/m^2K Window or roof window
Metal frame, no thermal break	+0.3
Metal frame, thermal break 4 mm	0
Metal frame, thermal break 8 mm	-0.1
Metal frame, thermal break 12 mm	-0.2
Metal frame, thermal break 20 mm	-0.3
Metal frame, thermal break 32 mm	-0.4

3. For doors which are half-glazed (approximately) the U-value of the door is the average of the appropriate window U-value and that of the non-glazed part of the door (e.g. solid wooden door [U-value of $3.0 W/m^2K$] half-glazed with double glazing [low-E, hard coat, argon filled, 6 mm gap, U-value of $2.5 W/m^2K$] has a resultant U-value of $0.5(3.0+2.5) = 2.75 W/m^2K$).

Table 7: Wind speed (in m/s) for calculation of infiltration rate

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
5.4	5.1	5.1	4.5	4.1	3.9	3.7	3.7	4.2	4.5	4.8	5.1

Table 8: Mean external temperature (°C)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
4.5	5.0	6.8	8.7	11.7	14.6	16.9	16.9	14.3	10.8	7.0	4.9

Calculation of mean internal temperature

Calculation of mean internal temperature is based on the heating patterns defined in Table 9.

Table 9: Heating periods and heating temperatures

Living area		Elsewhere		
Temperature T_{h1} (°C)	Hours of heating off t_{off}	Heating control (Table 4e)	Temperature T_{h2} °C	Hours of heating off t_{off}
21	Weekday: 7 and 8 ^a Weekend: 0 and 8 ^b	1	21 – 0.5 HLP	Weekday: 7 and 8 ^a Weekend: 0 and 8 ^b
		2	21 – HLP + 0.085 HLP ²	Weekday: 7 and 8 ^a Weekend: 0 and 8 ^b
	3	21 – HLP + 0.085 HLP ²	All days: 9 and 8 ^c	
^a heating 0700-0900 and 1600-2300 ^b heating 0700-2300 ^c heating 0700-0900 and 1800-2300 If HLP > 6.0 use HLP = 6.0 for calculation of T_{h2}				

During heating periods the temperature is as given in Table 9 and at other times it falls towards the temperature that would apply without heating (T_{sc} as defined in Table 9b). The calculation is done separately for the living area and for elsewhere and the two values combined in proportion to the respective floor areas.

Table 9a: Utilisation factor for heating

<p>H = heat transfer coefficient, (39)_m</p> <p>G = total gains, (84)_m</p> <p>T_i = internal temperature</p> <p>T_e = external temperature, (96)_m</p> <p>TMP = Thermal Mass Parameter, (35), in kJ/m²K (= C_m for building / total floor area)</p> <p>HLP = Heat Loss Parameter, (40)_m, in W/m²K</p> <p>τ = time constant</p> <p>η = utilisation factor</p>
<p>$\tau = \text{TMP} / (3.6 \times \text{HLP})$</p> <p>$a = 1 + \tau / 15$</p> <p>$L = H (T_i - T_e)$</p> <p>$\gamma = G / L$</p> <p>if $\gamma > 0$ and $g \neq 1$: $\eta = \frac{1 - \gamma^a}{1 - \gamma^{a+1}}$</p> <p>if $g = 1$: $\eta = \frac{a}{a + 1}$</p> <p>if $g \leq 0$: $\eta = 1$</p>

Table 9b: Temperature reduction when heating is off

<p>τ = time constant (from Table 9a)</p> <p>t_{off} = number of hours that heating is off</p> <p>T_h = temperature during heating period (Table 9)</p> <p>T_{sc} = internal temperature without heating</p> <p>R = responsiveness of main heating system (Table 4a or Table 4d) or where there are two main systems R is a weighted average of R for the two systems: $R = (203) \times R_{\text{system2}} + [1 - (203)] \times R_{\text{system1}}$</p>
<p>$t_c = 4 + 0.25 \tau$</p> <p>$T_{\text{sc}} = (1 - R) \times (T_h - 2.0) + R (T_e + \eta G / H)$</p> <p>if $t_{\text{off}} \leq t_c$ $u = 0.5 t_{\text{off}}^2 \times (T_h - T_{\text{sc}}) / (24 \times t_c)$</p> <p>if $t_{\text{off}} > t_c$ $u = (T_h - T_{\text{sc}}) \times (t_{\text{off}} - 0.5 t_c) / 24$</p>

Table 9c: Heating requirement

<p>The following is done using data for the applicable month.</p> <p><u>Living area</u></p> <ol style="list-style-type: none"> Set T_i to the temperature for the living area during heating periods (Table 9) Calculate the utilisation factor (Table 9a) Calculate the temperature reduction (Table 9b) for each off period (Table 9), u_1 and u_2, for weekdays $T_{\text{weekday}} = T_h - (u_1 + u_2)$ Calculate the temperature reduction (Table 9b) for each off period (Table 9), u_1 and u_2, for weekends $T_{\text{weekend}} = T_h - (u_1 + u_2)$ Mean temperature (living area) $T_1 = (5 T_{\text{weekday}} + 2 T_{\text{weekend}}) / 7$ <p><u>Rest of dwelling</u></p> <ol style="list-style-type: none"> Set T_i to the temperature for elsewhere during heating periods (Table 9) Repeat steps 2 to 7 above to obtain the mean temperature (rest of dwelling), T_2 Mean internal temperature = $f_{\text{LA}} \times T_1 + (1 - f_{\text{LA}}) \times T_2$ f_{LA} is the living area fraction, (91) Apply adjustment to the mean internal temperature from Table 4e, where appropriate Set T_i to the mean internal temperature obtained at step 11 and re-calculate the utilisation factor Heat requirement for month in kWh is $Q_{\text{heat}} = 0.024 \times (L_m - \eta_m G_m) \times n_m$ n_m is the number of days in the month <p>Set Q_{heat} to 0 if negative.</p> <p>Include the heating requirement for each month from October to May (disregarding June to September).</p>

When there are two main heating systems the procedure is adapted as follows, depending on whether both systems serve the whole house or each system serves different parts.

1. Both systems heat whole house

When both systems heat all the house (or at least all those rooms with heat emitters connected to the systems), the fraction of main heat from main system 2, worksheet (203), is provided as part of the specification of the systems. The heating controls are the same for both systems, and the control type concerned is used in Table 9 for the calculation of MIT in rest of dwelling, worksheet (89)_m and (90)_m, and for the calculation of MIT for the whole dwelling, worksheet (93)_m.

2. The two systems heat different parts of the house

When the systems heat different parts of the house they are treated as being separate. The fraction of main heat from main system 2, worksheet (203), is in the absence of specific information the fraction of the total floor area heated by main system 2. Main system 1 is that which provides heat to the living area, and heating controls for each system are specified according to those fitted to each system (and so can be different).

Calculate the mean internal temperature (MIT) for the living area according to SAP 2009 Tables 9, 9a, 9b and 9c (this is the same as if there were only one main system).

Calculate the MIT for the rest of the dwelling twice, once for the heating control specified for main system 1 and once for the heating control specified for main system 2. Obtain the average of these two temperatures with weighting factors

$(203) / [1 - (91)]$ for the temperature calculated for the controls on main system 1;

$[1 - (203) - (91)] / [1 - (91)]$ for the temperature calculated for the controls on main system 2;

and use that average as T_2 for the calculation of worksheet (92)_m. This step can be omitted if the heating control type (1, 2 or 3 from Table 4e) is the same for both systems.

In the calculation of MIT for the whole dwelling, worksheet (93)_m, use the temperature adjustment from Table 4e for the heating controls on main system 1.

Calculation of cooling requirements

Table 10: Mean global solar irradiation on a horizontal plane and mean external temperature in summer

Region	Representative latitude (°N)	Solar radiation on the horizontal (W/m ²)			Mean external temperature (°C)		
		Jun	Jul	Aug	Jun	Jul	Aug
Thames	51.5	214	204	177	15.4	17.8	17.8
South East England	51.0	225	213	186	15.2	17.6	17.8
Southern England	50.8	225	213	190	15.2	17.4	17.6
South West England	50.6	218	208	186	14.7	16.8	17.0
Severn	51.5	218	208	184	15.2	17.4	17.3
Midlands	52.7	204	194	168	14.9	17.2	17.1
West Pennines	53.4	196	186	159	14.5	16.6	16.5
North West England / South West Scotland	54.8	192	187	156	13.5	15.5	15.4
Borders	55.5	186	178	149	13.4	15.5	15.4
North East England	54.5	188	183	154	14.0	16.2	16.1
East Pennines	53.4	201	194	164	14.6	16.9	16.9
East Anglia	52.3	212	203	173	15.0	17.5	17.6
Wales	52.5	209	198	172	14.3	16.4	16.3
West Scotland	55.8	186	183	154	13.1	14.9	14.8
East Scotland	56.4	187	177	146	13.2	15.2	15.0
North East Scotland	57.2	187	170	142	12.8	14.9	14.7
Highland	57.5	181	163	140	12.5	14.5	14.4
Western Isles	58.0	189	175	147	11.7	13.7	13.7
Orkney	59.0	199	178	141	11.2	13.3	13.6
Shetland	60.2	183	163	138	10.6	12.7	13.0
Northern Ireland	54.7	188	175	152	13.4	15.4	15.2

(See map on next page)

Convert data in Table 10 to the radiation on vertical surfaces using the procedure below Table 6a.



Table 10a: Utilisation factor for cooling

<p>H = heat transfer coefficient, (39)_m</p> <p>G = total gains, (103)_m</p> <p>T_i = internal temperature = 24°C</p> <p>T_e = external temperature, for the region and month concerned from Table 10</p> <p>TMP = Thermal Mass Parameter, (35), in kJ/m²K (= C_m for building / total floor area)</p> <p>HLP = Heat Loss Parameter, (40)_m, in W/m²K</p> <p>τ = time constant</p> <p>η = utilisation factor</p>
<p>τ = TMP / (3.6 × HLP)</p> <p>a = 1 + τ / 15</p> <p>L = H (T_i - T_e)</p> <p>γ = G / L</p> <p>if γ > 0 and g ≠ 1: $\eta = \frac{1 - \gamma^{-a}}{1 - \gamma^{-(a+1)}}$</p> <p>if g = 1: $\eta = \frac{a}{a + 1}$</p> <p>if g ≤ 0: η = 1</p>

Table 10b: Cooling requirement

If the heat exchanger in an MVHR unit has a summer by-pass, calculate without heat recovery, i.e. for the summer months set (23c)_m = 0.

<ol style="list-style-type: none"> Cooling requirement for continuous cooling of whole house for month in kWh is $0.024 \times (G_m - \eta_m L_m) \times n_m$ n_m is the number of days in the month Set the cooling requirement to zero if less than twice the heating requirement for the same month, i.e. (104)_m < 2 × (98)_m, where the heating requirement is also calculated using external temperature and solar radiation from Table 10 (i.e. same weather data as for the cooling calculation). Multiply by the fraction of the total floor area that is cooled, f_{cool}. Multiply by an intermittency factor, f_{intermittent}, where f_{intermittent} = 0.25 (based on 6 hours/day operation). The cooling requirement for the part of the dwelling that is cooled allowing for standard hours of operation is: $Q_{cool} = 0.024 \times (G_m - \eta_m L_m) \times n_m \times f_{cool} \times f_{intermittent}$ Set Q_{cool} to zero if negative. Divide by the System Energy Efficiency Ratio (SEER), see Table 10c. <p>Include the cooling requirements for each month from June to August (disregarding September to May). The fuel cost, CO₂ emission factor and primary emission factor are those for electricity in Table 12. The energy for cooling is included in the FEE in all cases and in the DER and ratings when there is a fixed cooling system.</p>

Table 10c: Energy Efficiency Ratio (EER) and System Energy Efficiency Ratio (SEER)

Energy label class	Default EER	
	Split and Multi-split systems	Packaged systems
A	3.2	3.0
B	3.0	2.8
C	2.8	2.6
D	2.6	2.4
E	2.4	2.2
F	2.2	2.0
G	2.0	1.8

The energy label class is that applied to the product in terms of the Energy Information (Household Air Conditioners) (No. 2) Regulations 2005 (SI 2005 No. 1726). If unknown class G is assumed.

Alternatively the EER measured in accordance with BS EN 14511:2004 Parts 1-4 *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling* by an independent accredited laboratory at conditions T1 'moderate', may be used.

The SEER is:

for systems with on/off control	$SEER = 1.25 \times EER$
for systems with variable speed compressors	$SEER = 1.35 \times EER$

Note: If the air conditioner is reversible so as to provide heating it should be assessed as a heat pump in heating mode.

Table 11: Fraction of heat supplied by secondary heating systems

Main heating system	Secondary system	Fraction from secondary
All gas, oil and solid fuel systems	all secondary systems	0.10
Micro-cogeneration	all secondary systems	see Appendix N
Heat pump, data from database	all secondary systems	see Appendix N
Heat pump, data from Table 4a	all secondary systems	0.10
Electric storage heaters (not integrated)	all secondary systems	
- not fan-assisted		0.15
- fan-assisted		0.10
Integrated storage/direct-acting electric systems	all secondary systems	0.10
Electric CPSU	all secondary systems	0.10
Electric room heaters	all secondary systems	0.20
Other electric systems	all secondary systems	0.10
Community heating	all secondary systems	0.10

Notes:

1. *See also Appendix A.*

2. *If an off-peak tariff is present, see Table 12a for proportions at the high and low rates*

Table 12: Fuel prices, additional standing charges, emission factors and primary energy factors

Fuel	Additional standing charge, £ ^(a)	Unit price p/kWh	Emissions kg CO ₂ per kWh	Primary energy factor	Fuel code
Gas:					
mains gas	106	3.10	0.198	1.02	1
LNG	106	3.10	0.198	1.02	8
bulk LPG	70	5.73	0.245	1.06	2
bottled LPG		8.34	0.245	1.06	3
LPG subject to Special Condition 18 ^(b)	106	3.10	0.245	1.06	9
Oil:					
heating oil		4.06	0.274	1.06	4
biodiesel from any biomass source ^(c)		5.7	0.047	1.30	71
biodiesel from used cooking oil only ^(d)		5.7	0.004	1.08	72
rapeseed oil		5.7	0.009	1.12	73
appliances able to use mineral oil or liquid biofuel B30K ^(e)		4.06	0.274	1.06	74
B30K ^(e)		4.6	0.193	1.06	75
bioethanol from any biomass source		42.0	0.064	1.34	76
Solid fuel: ^(f)					
house coal		2.97	0.301	1.02	11
anthracite		2.86	0.318	1.02	15
manufactured smokeless fuel		3.73	0.347	1.08	12
wood logs		3.42	0.008	1.05	20
wood pellets (in bags for secondary heating)		5.45	0.028	1.20	22
wood pellets (bulk supply for main heating)		4.93	0.028	1.20	23
wood chips		2.49	0.009	1.07	21
dual fuel appliance (mineral and wood)		3.21	0.206	1.04	10
Electricity:					
standard tariff		11.46	0.517	2.92	30
7-hour tariff (high rate) ^(g)		12.82	0.517	2.92	32
7-hour tariff (low rate) ^(g)	27	4.78	0.517	2.92	31
10-hour tariff (high rate) ^(g)		11.83	0.517	2.92	34
10-hour tariff (low rate) ^(g)	18	6.17	0.517	2.92	33
24-hour heating tariff	57	4.64	0.517	2.92	35
electricity sold to grid		11.46 ^(h)			36
electricity displaced from grid			0.529 ^(h)	2.92 ^(h)	37
electricity, unspecified tariff ⁽ⁱ⁾					39
Community heating schemes: ⁽ⁱ⁾					
heat from boilers – mains gas	106 ^(k)	3.78	0.198	1.02	51
heat from boilers – LPG		3.78	0.245	1.06	52
heat from boilers – oil		3.78	0.297 ^(l)	1.06	53
heat from boilers – B30D ^(e)		3.78	0.199	1.06	55
heat from boilers – coal		3.78	0.350 ^(m)	1.02	54
heat from electric heat pump		3.78	0.517	2.92	41
heat from boilers – waste combustion		3.78	0.040	1.28	42
heat from boilers – biomass		3.78	0.013 ⁽ⁿ⁾	1.07	43
heat from boilers – biogas (landfill or sewage gas)		3.78	0.018	1.10	44
waste heat from power station		2.65	0.058 ^(o)	1.20	45
geothermal heat source		2.65	0.036	1.16	46
heat from CHP		2.65	as above ^(p)	as above ^(p)	48
electricity generated by CHP			0.529 ^(h)	2.92 ^(h)	49
electricity for pumping in distribution network			0.517	2.92	50

Energy Cost Deflator ^(q) = 0.47
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Notes to Table 12:

- (a) *The standing charge given for electricity is extra amount for the off-peak tariffs, over and above the amount for the standard domestic tariff, as it is assumed that the dwelling has a supply of electricity for reasons other than space and water heating. The standing charge for off-peak electricity is added to space and water heating costs where either main heating or hot water uses off-peak electricity. The standing charge for gas is added to space and water heating costs where gas is used for space heating (main or secondary) or for water heating.*
- (b) www.ofgem.gov.uk/networks/gasdistr/otherwork/Documents1/7940-Independentnetworksopenletter.pdf
- (c) *For appliances that specifically use biodiesel (FAME) and fuel verified as wholly derived from biomass sources*
- (d) *For appliances that specifically use biodiesel (FAME) and fuel verified as wholly derived from used cooking oil*
- (e) *For appliances that specifically use a blend of 30% biodiesel from cooking oil and 70% kerosene (B30K) or 70% fuel oil (B30D)*
- (f) *The specific fuel should be assumed for those appliances that can only burn the particular fuel (including Exempted Appliances within Smoke Control Areas).
Where a main heating appliance is classed as dual fuel (i.e mineral and wood), the data for dual fuel should be used, except where the dwelling is in a Smoke Control Area, when the data for solid mineral fuel should be used.
Wood should be specified as fuel for a main heating system only if there is adequate provision (at least 1.5 m³) for storage of the fuel.
Outside Smoke Control Areas an open fire should be considered as dual fuel, and a closed room heater without boiler if capable of burning wood as burning wood logs.*
- (g) *With certain appliances using an off-peak tariff, some of the consumption is at the low rate and some at the high rate. The high-rate fractions to be used are given in Table 12a, the remainder being provided at the low rate.*
- (h) *Deducted from costs, emissions or primary energy*
- (i) *This code is used to define the fuel for any electric system. Other codes for electricity are to provide cost data, depending on the applicable electricity tariff.*
- (j) *Cost is per unit of heat supplied, emission and primary factors are per unit of fuel used*
- (k) *Include half this value if the community scheme is for DHW only*
- (l) *Based on the mix of petroleum products used to generate heat in the UK (predominantly gas oil).*
- (m) *Value for non-domestic coal*
- (n) *Based on the mix of biomass sources used to generate heat in the UK.*
- (o) *Takes account of the reduction in electricity generation that occurs where heat is produced at a high enough temperature to provide community heating.*
- (p) *Use factor for community heat from boilers according to fuel used.*
- (q) *An energy cost deflator term is applied before the rating is calculated. It will vary with the weighted average price of heating fuels in future so that the SAP rating is not affected by the general rate of fuel price inflation. However, individual SAP ratings are affected by relative changes in the price of particular heating fuels.*

Table 12a: High-rate fractions for systems using 7-hour and 10-hour tariffs

This table is used for electric space and water heating systems which take electricity at both high and the low rates. Use an electricity price weighted between the high-rate and low-rate unit price using the fraction from the table. Secondary heating with fraction according to Table 11 is applied as well.

System	Tariff	Fraction at high rate	
		Space heating	Water heating
Integrated (storage+direct-acting) systems (applies to storage heaters 408 and underfloor heating 422 and 423)	7-hour	0.20	-
Direct-acting electric boiler ^(a)	7-hour	0.90	-
	10-hour	0.50	-
Electric CPSU	10-hour	Fraction from Appendix F	Fraction from Appendix F
Underfloor heating (in screed above insulation, in timber floor or immediately below floor covering)	7-hour	0.90	-
	10-hour	0.50	-
Ground/water source heat pump:			
water heating calculated by Appendix N	7-hour or 10-hour	-	0.70
water heating with off-peak immersion	7-hour or 10-hour	-	0.17
water heating without immersion heater	7-hour or 10-hour	-	0.70
space heating with on-peak auxiliary	7-hour	0.80	-
do.	10-hour	0.60	-
space heating without auxiliary	7-hour	0.70	-
do.	10-hour	0.60	-
Air source heat pump:			
space heating	7-hour	0.90	-
do.	10-hour	0.60	-
water heating calculated by Appendix N	7-hour or 10-hour	-	0.70
water heating with off-peak immersion	7-hour or 10-hour	-	0.17
water heating without immersion heater	7-hour or 10-hour	-	0.70
Other direct-acting electric heating (including electric secondary heating)	7-hour	1.00	-
	10-hour	0.50	-
Immersion water heater	7-hour or 10-hour	-	Fraction from Table 13

Note

(a) An electric boiler can provide space heating only, with a separate cylinder and immersion heater for DHW, or the DHW cylinder can be within the boiler casing. The calculation is the same for both cases.

Other electricity uses	Tariff	Fraction at high rate
Fans for mechanical ventilation systems	7-hour	0.71
	10-hour	0.58
All other, and locally generated electricity	7-hour	0.90
	10-hour	0.80

Table 12b: Solid Fuels

The table shows the fuels that can normally be used on the different types of solid fuel appliance. It should be regarded as only indicative: it is always necessary to follow the appliance manufacturer's instructions. See also section 12.4.5 and note (f) to Table 12 as regards fuel selection for SAP calculations.

Appliance	Possible fuels	
	Within Smoke Control Area	Outside Smoke Control Area
Auto (gravity) feed boiler	Anthracite grains and beans	Anthracite grains and beans
Manual feed boiler	Anthracite nuts	Anthracite nuts
	Authorised Smokeless	Smokeless
		Wood logs
Wood chip boiler	Wood chips if Exempted Appliance	Wood chips
Wood pellet boiler	Wood pellets if Exempted Appliance	Wood pellets
Open fire (with or without back boiler)	Authorised Smokeless	House coal
		Smokeless
		Wood logs
Closed room heater (with or without boiler)	Anthracite nuts	House coal
	Authorised Smokeless	Anthracite nuts
	Wood logs if Exempted Appliance	Smokeless
		Wood logs
Pellet-fired stove	Wood pellets if Exempted Appliance	Wood pellets
Range cooker boiler	Anthracite	Anthracite
		Wood logs

Table 12c: Distribution loss factor for group and community heating schemes

The following factors are used when one of the conditions stated in section C3.1 in Appendix C apply. Otherwise the factor is calculated as described in section C3.1.

Heat distribution system	Factor
Mains piping system installed in 1990 or earlier, not pre-insulated medium or high temperature distribution (120-140°C), full flow system	1.20
Pre-insulated mains piping system installed in 1990 or earlier, low temperature distribution (100°C or below), full flow system.	1.10
Modern higher temperature system (up to 120°C), using pre-insulated mains installed in 1991 or later, variable flow system.	1.10
Modern pre-insulated piping system operating at 100°C or below, full control system installed in 1991 or later, variable flow system	1.05

Note:

A full flow system is one in which the hot water is pumped through the distribution pipe work at a fixed rate irrespective of the heat demand (usually there is a bypass arrangement to control the heat delivered to heat emitters). A variable flow system is one in which the hot water pumped through the distribution pipe work varies according to the demand for heat.

Table 13: High-rate fraction for electric DHW heating

Dwelling total floor area, m ²	Cylinder size, litres										
	7-hour tariff						10-hour tariff				
	110		160		210	245	110		160		210
	Immersion (dual/single)						Immersion (dual/single)				
	dual	single	dual	single	dual	dual	dual	single	dual	single	dual
20	0.11	0.55	0.06	0.16	0.01	0	0.05	0.14	0	0	0
40	0.12	0.56	0.07	0.18	0.02	0	0.06	0.16	0	0	0
60	0.15	0.58	0.09	0.21	0.03	0	0.08	0.19	0	0	0
80	0.17	0.60	0.10	0.24	0.04	0	0.09	0.21	0	0	0
100	0.18	0.61	0.11	0.25	0.04	0	0.10	0.23	0	0	0
120	0.18	0.61	0.11	0.26	0.04	0	0.11	0.23	0	0	0
140	0.18	0.61	0.11	0.26	0.04	0	0.11	0.24	0	0	0
160	0.19	0.61	0.12	0.26	0.04	0	0.11	0.24	0	0.01	0
180	0.19	0.61	0.12	0.26	0.05	0	0.11	0.24	0	0.01	0
200	0.19	0.61	0.12	0.27	0.05	0	0.11	0.24	0	0.01	0
220	0.19	0.61	0.12	0.27	0.05	0	0.11	0.24	0	0.01	0
240	0.19	0.61	0.12	0.27	0.05	0	0.11	0.24	0	0.01	0
260	0.19	0.62	0.12	0.27	0.05	0	0.11	0.25	0	0.02	0
more than 260	use formulae below										

Notes:

- 1) Table 13 shows fractions of electricity required at the high rate for cylinders with dual and single immersion heaters, for tariffs providing at least 7 hours of heating per day at the low rate and for tariffs providing at least 10 hours of heating per day at the low rate.
- 2) Alternatively, the fraction may be calculated (for V between 110 and 245 litres) from the following equations:
tariffs providing at least 7 hours of heating per day at the low rate
Dual immersion: $[(6.8 - 0.024V)N + 14 - 0.07V]/100$
Single immersion: $[(14530 - 762N)/V - 80 + 10N]/100$

tariffs providing at least 10 hours of heating per day at the low rate
Dual immersion: $[(6.8 - 0.036V)N + 14 - 0.105V]/100$
Single immersion: $[(14530 - 762N)/(1.5V) - 80 + 10N]/100$

where V is the cylinder volume and N is as defined in Table 1b. (If these formulae give a value less than zero, set the high-rate fraction to zero; if greater than one, set to one.)
- 3) Do not use this table to obtain the high-rate fraction for an electric CPSU. Calculate the high-rate fraction using the procedure described in Appendix F.
- 4) Do not use this table for the high-rate fraction for domestic hot water heated by a heat pump. Use the high-rate fraction given in Table 12a.

Table 14 : Rating bands

The rating is assigned to a rating band according to the following table. It applies to both the SAP rating and the Environmental Impact rating.

Rating	Band
1 to 20	G
21 to 38	F
39 to 54	E
55 to 68	D
69 to 80	C
81 to 91	B
92 or more	A

Table 15 : Relationship between SAP 2005 ratings and SAP 2009 ratings

Where possible, SAP ratings previously calculated using SAP 2005 should be re-calculated using SAP 2009. The table indicates typical differences between the ratings.

SAP 2005	SAP 2009 for main heating fuel as:					
	Mains gas	LPG	Oil	Electricity	Solid mineral	Biomass
1	1	10	1	6	12	9
10	9	20	9	16	21	18
20	19	31	19	26	31	28
30	29	41	29	37	41	37
40	39	50	39	46	50	47
50	48	59	50	56	59	56
60	58	68	60	65	68	65
70	67	76	70	74	77	74
80	76	84	80	82	85	83
90	85	92	90	91	93	92
100	94	99	100	99	100	100

Table 16 : Relationship between Environmental Impact ratings SAP 2005 and Environmental Impact ratings SAP 2009

Where possible, Environmental Impact ratings previously calculated using SAP 2005 should be re-calculated using SAP 2009. The table indicates typical differences between the ratings.

EI Rating SAP 2005	EI Rating SAP 2009 for main heating fuel as:	
	all except electricity	electricity
1	1	1
10	10	3
20	20	14
30	30	24
40	40	35
50	50	45
60	60	55
70	70	66
80	80	76
90	90	87
100	100	97