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

**2005 edition,
revision 3**

This document describes SAP 2005 version 9.81/9.83, dated June 2009. 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 BRE website below.

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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 the energy performance are energy consumption per unit floor area, an energy cost rating (the SAP rating), an Environmental Impact rating based on CO$_2$ emissions (the EI rating) and a Dwelling CO$_2$ 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 CO_2 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 CO_2 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 CO_2 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 of Energy and Climate Change; the Department for Communities and Local Government; the Scottish Government; the Welsh Assembly Government; 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
- 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.

Ratings are not affected by the geographical location, so that a given dwelling has the same rating in all parts of the UK.

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 European standards BS EN 832 and BS EN ISO 13790.

The Standard Assessment Procedure was first published by the DOE (now the Department of Energy and Climate Change, DECC) 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. A consolidated edition was published as SAP 1998, and a revised version was published in 2001 (SAP 2001).

The present edition is SAP 2005 in which:
- The SAP scale has been revised to 1 to 100, where 100 now represents zero energy cost. It can be above 100 for dwellings that are net exporters.
- The dwelling CO_2 Emission Rate (DER) together with an Environmental Impact rating replace the Carbon Index.
- Energy for lighting is included.
- Solar water heating has been revised.
- Cylinder loss has been revised; manufacturer's data for heat loss becomes the preferred source of cylinder loss.

- The effect of thermal bridging is taken into account.
- It incorporates additional renewable and energy saving technologies.
- It provides a method for estimating a tendency to high internal temperature in summer;
- Data tables have been updated (fuel costs, CO_2 emissions, boiler efficiency and heating controls, etc).
- The measure of energy is now kWh rather than GJ.

The 9.81 revision to SAP 2005 dated January 2008:
- Described the procedure for handling tested data on mechanical ventilation systems (previously done through Appendix Q).
- Introduced some additional heating and hot water systems and additional control options.
- Provided additional options for community heating (two boiler types; hot-water-only systems).
- Added "in-screed" to the underfloor heating options for wet systems.
- Amended the kWh/kWp for photovoltaics to 800.
- Amended the electricity export price in Table 12 to 5.7 p/kWh.
- Included treatment of curtain walling.
- Provided a routine for micro wind turbines and allows small scale hydro-electric generation.
- Provided the means for assessing a "net zero carbon home" for the purposes of Stamp Duty Land Tax
- Included some clarifications.

9.81 also consolidated the amendments to Reduced Data SAP (Appendix A and Appendix S) published in March 2007 but introduced no further changes to Reduced Data SAP.

9.82 made some amendments to Reduced Data SAP (Appendix S) but introduced no changes to SAP. For a dwelling assessed by SAP the version number remained 9.81.

9.83 clarifies some conventions for data collection when using Reduced Data SAP (Appendix S) but introduces no changes to SAP. For a dwelling assessed by SAP the version number remains 9.81.

SAP version	SAP version status	RdSAP version	RdSAP version status
9.80	Superseded by 9.81 but may be needed for re-assessment of dwellings originally assessed by 9.80	9.80	From August 2007 Uses 9.80 for the SAP calculations Superseded by 9.82 in September 2008
9.81	Current	not applicable	
		9.82	From September 2008 Uses 9.81 for the SAP calculations Superseded by 9.83 in October 2009
		9.83	From October 2009 (additional conventions added to Appendix S, March 2010) Uses 9.81 for the SAP calculations

SCOPE OF THE SAP PROCEDURE

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

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.

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.

Admittances
A list of admittance values (used for calculation of thermal mass required for assessment of summer overheating) is provided in Appendix P, which are suitable for most cases. However, other values can be used if appropriate.

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 rating[*] or manufacturers' declaration. Both values are needed.

The light transmittance factor (g_L) is used for calculation of lighting requirement in Appendix L. Only the values in Table 6b are to be used for light transmittance..

Normally the frame factors (representing the glazed fraction of the window) in Table 6c are used. However, manufacturer's values are permitted provided they are representative of the actual windows.

Boiler efficiency – gas and oil
Boiler efficiency can be from the boiler efficiency database (preferably) or from a manufacturer's declaration given in the terms stated in D3.

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[*] Operated by the British Fenestration Rating Council

<u>Boiler efficiency – solid fuel</u>
Boiler efficiency can be from the boiler efficiency database (preferably) or from a manufacturer's declaration.

<u>Efficiency of gas/oil/solid fuel fires and room heaters</u>
Efficiency can be from a manufacturer's declaration given in terms of E2.

<u>Standing loss – cylinders, thermal stores and CPSUs (includes both gas and electric CPSUs)</u>
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).

<u>Pressure test result</u>
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.

<u>Solar collector performance</u>
The zero-loss collector efficiency and the collector's linear heat loss coefficient can be used if obtained from test results.

<u>Specific fan power and ventilation heat exchanger efficiency</u>
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.

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 the floor area.

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.

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 / roof rooms:
- *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.
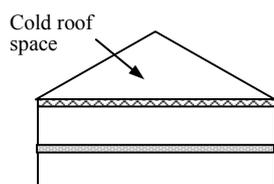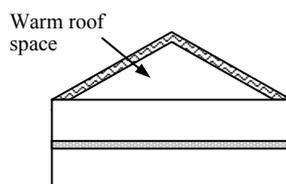
a) Insulation at ceiling level   b) Insulation at rafter level

In the cases of a) and b) the roof space should **not** be treated as a separate storey.
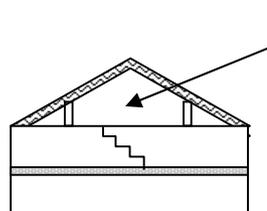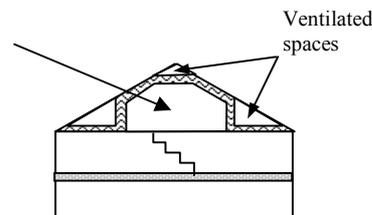
c) Room in roof built into a   d) Room in roof built into a
    pitched roof insulated at rafter level   pitched roof insulated at ceiling level

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 boxes (11) to (18) 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 boxes (7) to (9a) 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.

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Table 2.1 Ventilation rates

Item	Ventilation rate m^3/hour
Chimney	40
Open flue	20
Fan	10
Passive vent	10
Flueless gas fire	40

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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 boxes (11) to (18) 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 m^2 (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).

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[*] 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.

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).

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
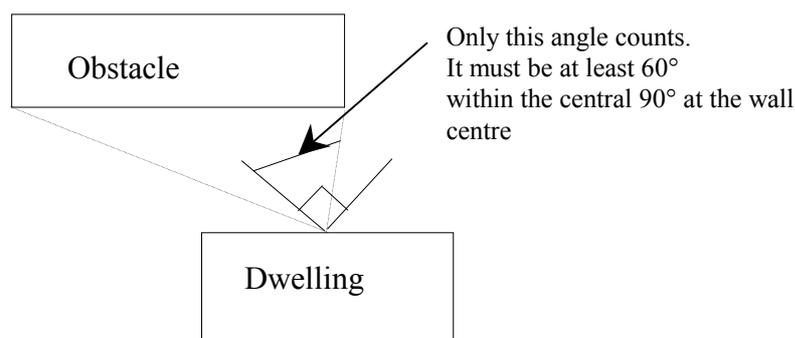
Figure 1 Shelter angle

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 m³/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 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 is 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.

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:

$$SFP_{av} = \frac{\sum SFP_j \times FR_j \times IUF_j}{\sum FR_j}$$

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. For effective air change rate see worksheet (23b).

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 give an average air change rate of 0.5 ach with an allowance for air infiltration. The allowance is 0.20 ach for single-storey dwellings and 0.15 ach for multi-storey dwellings, so that n_{nech} is 0.30 ach for single-storey dwellings and 0.35 ach for multi-storey dwellings. However if the dwelling is very airtight such that the total air change rate, i.e. n_{mech} plus the adjusted infiltration at worksheet (22), is less than 0.5, n_{mech} is set so as to give a total of 0.5 ach.

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

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

where n_{adj} is the adjusted air change rate obtained at worksheet (22) and η is the MVHR efficiency in % including the in-use factor. η is zero for balanced systems without heat recovery. n_{eff} is then the value for worksheet (25).

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.

3 HEAT LOSSES

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. Losses or gains through party walls and floors 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 12524 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 U-value to be used in boxes (27), (27a) and (27b) takes account of the assumed use of curtains; it is calculated using the formula:

$$U_{w,\text{effective}} = \cfrac{1}{\cfrac{1}{U_w} + 0.04}$$

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).

$$U = \cfrac{1}{\cfrac{1}{U_o} + R_u}$$

where: U = resultant U-value of element adjacent to unheated space, W/m^2K;

U_o = 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 the dwelling). 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)
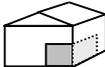
Garage type		Elements between garage and dwelling	R_u for a single garage	
			Inside[1]	Outside[2]
Single fully integral		Side wall, end wall and floor	0.68	0.33
Single fully integral		One wall and floor	0.54	0.25
Single, partially integral displaced forward		Side wall, end wall and floor	0.56	0.26
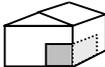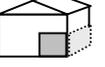
Table 3.2 R_u for integral double garages (double garage is a garage for two cars)

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
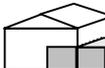
[1]*inside garage* – when the insulated envelope of the dwelling goes round the outside of the garage
[2]*outside garage* – when the walls separating the garage from the dwelling are the external walls

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.
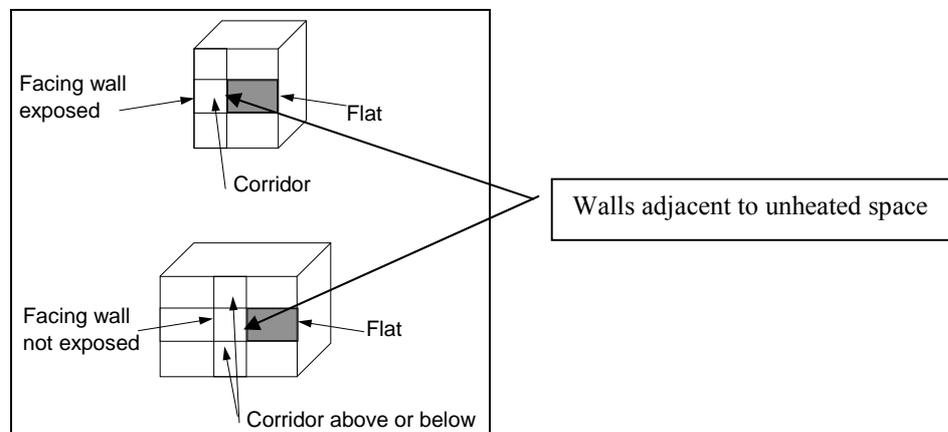
Figure 3.1 Access corridors

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

A conservatory is usually defined in building regulations as an extension attached to a dwelling which has not less than three-quarters of the area of its roof and one half of the area of its external walls made of translucent material. 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.

U-value calculated as for a normal roof

elements adjacent to an unheated space
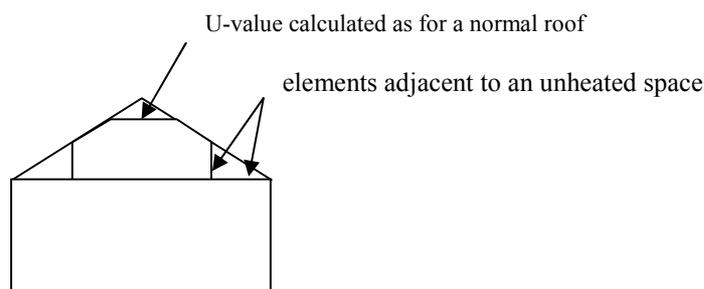
Figure 3.2 Room in roof

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 for elements
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:

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

A_i; A_e = areas of internal and external elements (m²), excluding any ground floor
U_e = U-values of external elements (W/m²K)
V = volume of unheated space (m³)
n = air change rate of unheated space (ach)

3.4 Thermal bridging

The SAP calculation now 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.

Usually, however, 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).

4 DOMESTIC HOT WATER

The demand for hot water is derived from the floor area of the dwelling and is given in Table 1. The energy required to produce that amount of hot water is then calculated, taking account of losses in heating, storage and distribution. Heat to the dwelling from storage cylinders and distribution pipe work is also estimated ['heat gains from water heating', box (52)] so that it can be taken into account in the calculation of space heating requirements.

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 Boiler 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 combi boilers the additional losses in Table 3a are included to allow for the draw-off of water until an adequate temperature at the taps is attained. The data in Table 3a are provisional pending the availability of test results according to the standards to be written under EU Mandate 324.

The efficiency for both space and water heating is reduced by 5% if the boiler is not interlocked for both 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, and 100% (adjusted where appropriate by the amount in the "efficiency adjustment" column of Table 4c) is used in box (82*) in these cases.

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.

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) heat pump systems where an immersion is provided to operate in conjunction with the heat pump as described in

Appendix G, and (b) solid fuel room heaters with a back boiler where an immersion heater is provided to heat water in the summer (see section 10.4.3).

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). The internal gains are obtained by interpolating the data in Table 5 or by using the formula provided after Table 5. A reduction in gains is applied for low-energy lights, as calculated in Appendix L.

Gains from central heating pumps located within the heated space and other items should be added and then included in box (53b), 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

$$G_{solar} = 0.9 \times A_w \times S \times g_\perp \times FF \times Z$$

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) (see Table 6c)
Z is the solar access factor from Table 6d

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 $0.9 \times g_\perp \times FF$. The solar gain for such windows is calculated as

$$G_{solar} = A_w \times S \times g_{window} \times Z$$

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 [*]).

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[*] 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.

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 the following definitions apply:

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 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 boxes (56) - (64), to obtain the entry for box (65).

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 from Table 7.

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 is based on the heating requirements 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 of the living area is obtained from Table 8, using the 'Heat loss parameter' (HLP), obtained from box (38) in the worksheet, and the type of heating system, obtained from the 'Heating type' column of Table 4a or 4d. The temperature is adjusted to take account of the level of heat gains previously calculated in sections 5 and 6 of the worksheet and also for certain control options as indicated in Table 4e.

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 DEGREE-DAYS

The degree-days depend on the 'base' temperature, which is calculated by adjusting the mean internal temperature to take account of the heat provided by gains. Degree-days for different base temperatures are obtained from Table 10, using linear interpolation for intermediate values.

9 SPACE HEATING REQUIREMENT

The 'useful' energy required from the heating system is calculated from degree-days and the heat loss coefficient allowing for internal and solar gains. This quantity is known as the dwelling's Space Heating Requirement and is calculated at worksheet (81).

The quantity of fuel or electrical energy required to provide that useful energy is then calculated, taking account of the efficiency of the space heating system (obtained from Boiler 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 a new dwelling that has no heating system specified, it should be assumed that the dwelling will be heated by direct acting electric heaters (at standard tariff).

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.
For heat pumps, see Appendix G.

9.2 Heating system efficiency

9.2.1 Heating systems based on a gas or oil boiler

Boiler efficiency may be obtained from:
a)   The Government's Boiler Efficiency Database;
b)   Certified manufacturer's data;
c)   Table 4b of this document.

The preferred source of boiler efficiency is the Government's Boiler Efficiency Database, which contains boiler efficiency figures intended for use in SAP. If a new boiler is not included in the database, manufacturer's data certified as explained in paragraph D3 (Appendix D) should be used if available. 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 4b.

In the Boiler Efficiency Database, gas and oil boilers that are currently in production are normally shown with SAP seasonal efficiency calculated from test results by the SEDBUK method. SEDBUK stands for Seasonal Efficiency of Domestic Boilers in the UK. 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.

9.2.2 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 Government's Boiler Efficiency 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 figure and case heat emission figure 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, an indicative seasonal efficiency should be taken from Table 4b.

9.2.3 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 Government's Boiler Efficiency Database;
b) Certified manufacturer's data;
c) Table 4a of this document.

The preferred source of boiler efficiency is the Government's Boiler Efficiency 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.

9.2.4 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 10-hour and off-peak 7-hour. Heat 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.

9.2.5 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).

9.2.6 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 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 adjusts the temperature of the water circulating through the heating system according to the temperature 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 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, 10.4.2).

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 TOTAL ENERGY USE AND FUEL COSTS

10.1 Energy use

The annual energy use is calculated for the following items:

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

10.2 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 the purpose of this calculation.

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

10.3 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 10.4.2). 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 (those 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 10.4.2.

10.4 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.

10.4.1 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.

10.4.2 Electric systems

7-hour off-peak is what would generally be called Economy-7 in England, Wales and Northern Ireland, or Economy White Meter in Scotland. This tariff should be selected when the off-peak availability is during a single period overnight: the actual duration can be between 7 and 8½ hours. When the main system is 7-hour off-peak electricity, any systems that use electricity outside the low tariff times are charged at the on-peak rate (i.e. pumps and fans, lighting, electric secondary heating and a percentage of the water heating). For proportions of electricity used at the on-peak and off-peak rates see Tables 12a and 13.

10-hour off-peak provides 10 hours of off-peak electricity in three periods (typically 5 hours during the night, 3 hours in the afternoon and 2 hours in the evening) but for main space heating and water heating only; pumps and fans, lighting, electric secondary heating appliances etc. use standard tariff. For proportions of electricity used at the on-peak and off-peak rates see Tables 12a and 13. The 10-hour off-peak tariff is available only in certain areas.

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 and about 20% at on-peak times. 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 off-peak 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).

10.4.3 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 roomheaters with boilers, an alternative system (electric immersion) may be provided for heating water in the summer. In that case a fraction N/365 of the annual water heating is provided by the boiler and 1-N/365 by the alternative system where N is the length of the heating season. For SAP 2005, N = 238 days.

10.4.4 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).

For new-build assessments, if solid fuel is specified for any appliance, software should ask whether the property is in a Smoke Control Area.

If it is not in a Smoke Control Area, no action is needed.

If it is, then software should include a statement on the screen, and also in the printout of the input data to the calculation, according to the fuel.

Fuel	Statement
House coal*	Not permitted
Anthracite**	(no statement needed)
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".

10.5 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.

10.6 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 on-peak rates). 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.

10.7 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

The tariff at which this electricity is charged is the on-peak rate if the heating and/or hot water uses the 7-hour off-peak tariff, otherwise it is the standard tariff. Note that the allowance in this section for fan-assisted flues only applies for boilers - fan assisted flues for gas fires should not be counted. Data are given in Table 4f.

10.8 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.

The tariff at which electricity for lighting is charged is the on-peak rate if the heating and/or hot water uses the 7-hour off-peak tariff, otherwise it is the standard tariff.

11 ENERGY COST RATING

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

$$\text{if ECF} \geq 3.4, \qquad \text{SAP } 2005 = 111 - 110 \times \log_{10}(\text{ECF}) \qquad (1)$$
$$\text{if ECF} < 3.4, \qquad \text{SAP } 2005 = 100 - 13.96 \times \text{ECF} \qquad (2)$$

where ECF = Energy cost factor, calculated in box (99) or (99*).

SAP ratings can also be obtained by using Table 14.

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

The SAP rating scale (1-100) 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 15.

12 CARBON DIOXIDE EMISSIONS AND PRIMARY ENERGY

CO_2 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 CO_2 emissions by:

$$CF = (CO_2 \text{ emissions})/(TFA + 45) \tag{3}$$

| if CF >= 28.3 | EI rating $= 200 - 95 \times \log_{10}(CF)$ | (4) |
| if CF < 28.3 | EI rating $= 100 - 1.34 \times CF$ | (5) |

where the CO_2 emissions are calculated in box (112) or box (119*) and TFA is the total floor area of the dwelling as in box (5).

The EI rating scale (1-100) 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 15.

The total primary energy can also be calculated using the primary energy factors in Table 12 in place of the CO_2 emission factors.

13 BUILDING REGULATIONS AND DWELLING EMISSIONS RATE (DER)

Building regulations may refer to CO_2 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 a certain proportion of low-energy lighting), 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.sbsa.gov.uk
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 CO_2 emissions rate.

As at the date of this document, building regulations in all three jurisdictions mentioned above place limitations on the permissible annual CO_2 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, e.g. on secondary heating or low energy lighting, which must be followed for DER calculations.

14 CO$_2$ EMISSIONS ASSOCIATED WITH APPLIANCES AND COOKING AND SITE-WIDE ELECTRICITY GENERATION TECHNOLOGIES

SAP calculations may be extended to allow for CO$_2$ emissions associated with appliances and cooking, and to allow for site-wide electricity generation technologies[*].

Where the DER for the dwelling is ≤ 0.00 the dwelling can be assessed for net CO$_2$ emissions by the following procedure.

kg/m²/year

DER	(113) or (120*) =	(ZC1)
CO$_2$ emissions from appliances and cooking		(ZC2)
Total CO$_2$ emissions	(ZC1) + (ZC2) =	(ZC3)
CO$_2$ saving from additional low-energy lights and omission of secondary heating (where applicable)		(ZC4)
Residual CO$_2$ emissions offset from biomass CHP value at (107) or (115*) before setting (107) or (115*) to zero, where applicable, divided by the total floor area of the dwelling		(ZC5)
Additional allowable electricity generation, kWh/m²/year		(ZC6)
Resulting CO$_2$ emissions offset from additional allowable electricity generation	-(ZC6) × EF =	(ZC7)
Net CO$_2$ emissions	(ZC3) + (ZC4) + (ZC5) + (ZC7) =	(ZC8)

Box (ZC2) is calculated as [99.9 × (TFA × N)$^{0.4714}$ – 3.267 × TFA + 32.23 × N + 72.65]/TFA where:

  TFA is the total floor area as in box (5);
  if TFA < 43, N = 1.464;
  if TFA ≥ 43, N = 2.844 × (1 – exp (–0.000391 × TFA²)).

Box (ZC4) is the difference between the CO$_2$ emission rate at (113) or (120*) for the DER calculation (following the rules for compliance with building regulations) and for the SAP calculation. This adjusts the CO$_2$ emission rate to that applying with low-energy lights as specified for the dwelling and without secondary heating if no secondary heater is specified. Note that assessment of the DER must first be done with low-energy lights and secondary heating as specified for the DER calculation and without any residual offset for biomass CHP.

Concerning (ZC5) see C5 in Appendix C.

EF for the calculation of (ZC7) is the CO$_2$ emission factor in Table 12 for electricity displaced from grid (kg/kWh).

The entries in (ZC4), (ZC5) and (ZC7) are negative quantities.

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

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[*] The introduction of this calculation procedure is in support of 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). 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.

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 (95) or (95*). 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).

REFERENCES

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3. **Shorrock L D and Anderson B R,** *A guide to the development of BREDEM.* BRE Information Paper IP 4/95, BRE, Garston, 1995.

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6. **CIBSE Guide A3,** The Chartered Institution of Building Services Engineers, CIBSE, London, 1999.

7. **Basements for dwellings.** Approved Document, British Cement Association, BCA, Crowthorne, 1997. ISBN 0-7210-1508-5

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 heat loss coefficient - Calculation method	Heat loss rate from whole building
BS EN 12524**	Building materials and products - Hydrothermal properties - Tabulated design values	List of thermal conductivity values
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

* new 2007 edition to be published soon
** being subsumed into ISO 10456

The standards are available from:

BSI
Chiswick High Road
London
W4 4AL
Tel: 020 8996 9001
Fax: 020 8996 7001
www.bsonline.bsi-global.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 boiler efficiency 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. In this case the calculation should be undertaken using the system that heats the largest part of the property.

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 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

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, the rules in A3.2 should be followed.

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 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.

b) Otherwise if there are any unheated habitable rooms and no secondary system has been identified, undertake the calculation with electric secondary heating.

c) If any fixed secondary heater has been identified, the calculation proceeds with the identified secondary heater, whether or not there are unheated habitable rooms.

d) If there are no unheated habitable rooms and no fixed secondary heater in a habitable room, undertake the calculation with no secondary heating.

e) 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 boiler 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 the SEDBUK value is not available. The following notes give guidance for the categories in Table 2 and 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.

Primary storage combi boiler   Secondary storage combi boiler
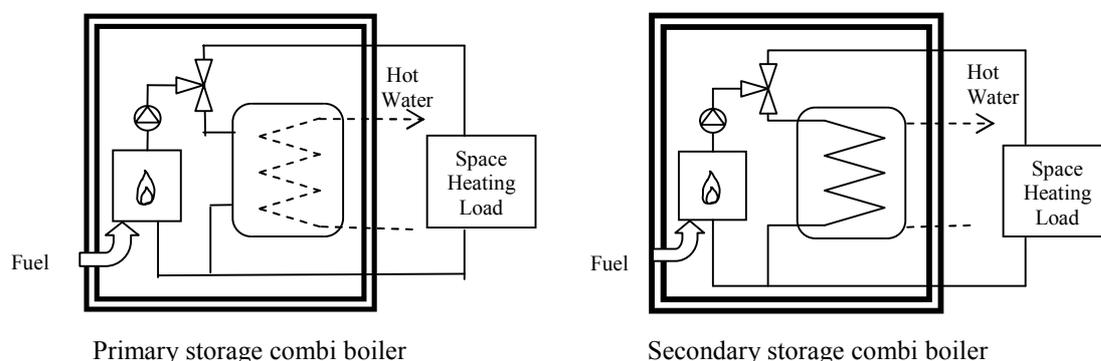
Figure B1 Primary and secondary storage combi boilers

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 D 1.13. 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.
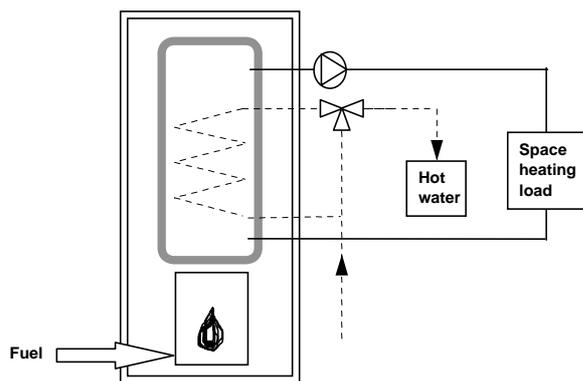
Figure B2 Combined primary storage unit (CPSU)

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 stores[*] 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.

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[*] **Performance Specification for Thermal Stores**, 1999. Obtainable from the Hot Water Association (www.hotwater.org.uk)
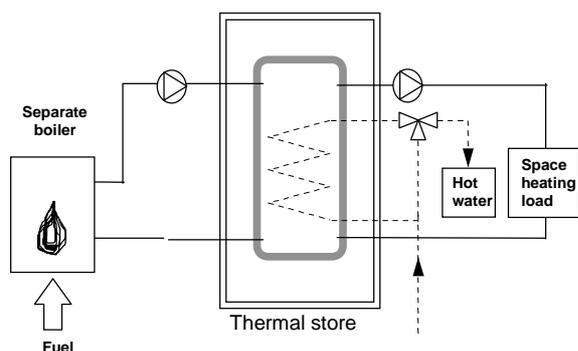
Figure B3 Integrated thermal store

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.
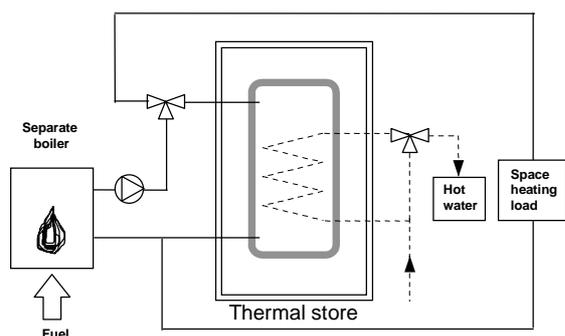
Figure B4 Hot water only thermal store

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 heating, or for space and 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 heating, or for space and water heating

For the twin burner type, the efficiency can be can be from the boiler efficiency 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 ranger 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 C3):

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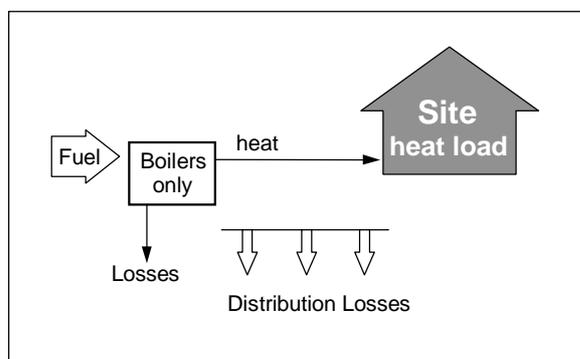
Figure C1 Community heating with heat supplied by boilers only
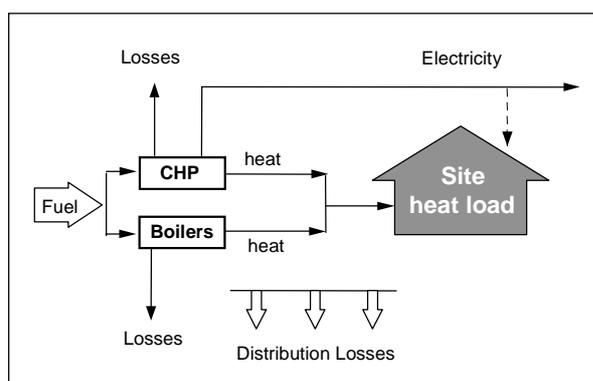
Figure C2 Community heating with heat supplied by a combination of boilers and CHP

For community heating with CHP Schemes, 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 CO_2 emissions, 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. 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.

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).
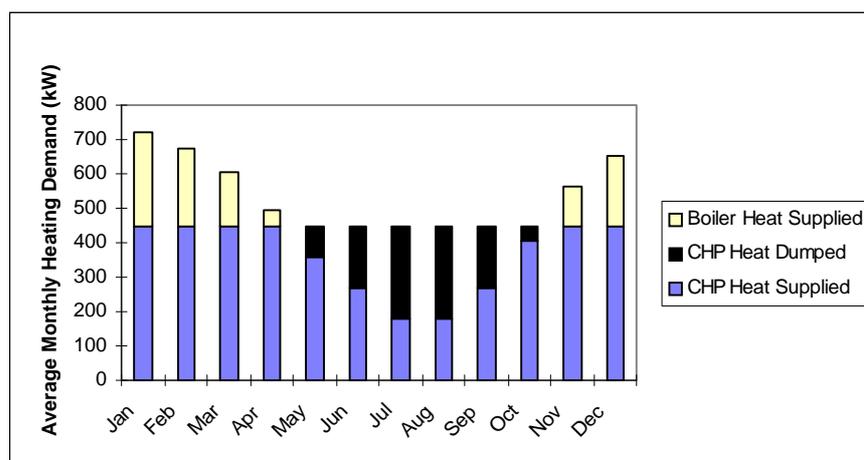
Figure C3 An example of a heat profile chart

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 efficiency to be used in the calculation of the SAP rating is 100% less the adjustment given in Table 4c(3) for controls and charging method.

For the calculation of CO_2 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 boilers should be used instead. 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.

Note: In the case of community heating with CHP, both heat and electricity are produced and the CO_2 emissions associated with the fuel burnt have to be apportioned to the two forms of energy. In the SAP calculation the electricity generated by CHP is taken as having a CO_2 emissions factor equivalent to the average of that for electricity generated by new gas fired power stations and that of marginal existing plant, and the remaining CO_2 is assigned to the heat produced. For the current SAP version that average is 0.568 kg/kWh.

C2   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.

The overall efficiency of the heating plant is 100% minus the amount shown in the "efficiency adjustment" column of Table 4c(3).

The CO_2 emissions are calculated using the following procedure:
a)   use the procedure for calculating community heating with CHP or schemes that recover heat from power stations;
b)   boxes (101*) to (106*) are zero;
c)   the emission factor for waste heat from power stations (Table 12) applies in box (107*) and the calculation is then completed as normal.

The fraction of heat in box (83*) is the fraction of useful heat, i.e.

$$\frac{\text{waste heat}}{\text{waste heat } + \text{ boiler output}}$$

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

C3   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.

2. Two boilers or two sets of boilers, using two different fuels such as mains gas and biomass. In this case the total heat requirement is divided between the two boilers or sets of boilers according to the design specification of the overall system. Different average seasonal efficiencies apply to the two sets of boilers and the CO_2 emissions are calculated using the emission factors of the respective fuels.

    The calculation proceeds as for a community scheme without CHP, i.e. worksheet sections 9b, 10b, 11b and 12a.

    Use (83*) for the fraction of heat from boiler type 2 and (84*) for the fraction of heat from boiler type 1. Similarly (86*) to (87b*) are used for the two boiler types. For CO_2 emissions and primary energy, (104) to (106) are used twice, multiplying each (104) and (105) by the applicable fraction of heat.

3. CHP plant and boiler(s), calculations according to section C1.

4. Utilisation of waste heat from a power station topped up by boilers, calculations according to section C2.

5. Geothermal heat topped up by boilers. The calculation is the same as that described in C2 for waste heat from power stations.

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.

C4   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 efficiency, Table 4c 3), is not applicable and 100% should be used for water heating (but allowing for the distribution loss factor from Table 12b). 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.

C5   Community biomass CHP

For community heating with CHP, it is possible for the total CO_2 emissions calculated at (115*), or at (107) in the case of a DHW-only community scheme, to be negative. In such cases the negative value is replaced by zero. The reason is that, once this quantity becomes negative, it becomes advantageous to increase the heating requirements of the dwellings, e.g. by removing insulation.

However, in the case of a CHP plant fuelled by biomass, the residual negative amount is carried forward for possible use in consideration of zero carbon homes (see section 14 of the SAP specification). In this way the full benefit of biomass CHP can be taken into account. 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, thus ensuring that a high standard of insulation is provided; and
(c)   the community CHP is fuelled by biomass, not a fossil fuel.

If all these conditions are not met the residual is set to 0.

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

Note: The data and equations in this appendix 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 the Seasonal Efficiency of Domestic Boilers in the UK (SEDBUK) for particular gas and oil boilers when test data have been obtained to establish conformity with Council Directive 92/42/EEC[*]. This Directive has been implemented in the UK by the Boiler (Efficiency) Regulations[**].

Manufacturers' declarations of SEDBUK 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.

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[*] 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

[**] 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 <u>instantaneous combination boiler</u> 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 <u>instantaneous combination boiler</u> with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

D1.10   Storage combination boiler

A <u>combination boiler</u> with an internal hot water store of capacity at least 15 litres but less than 70 litres, OR
a <u>combination boiler</u> 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 <u>storage combination boiler</u> 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 <u>storage combination boiler</u> 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 <u>non-condensing boiler</u> designed as a low temperature boiler and tested as a low temperature boiler as prescribed by the Boiler Efficiency Directive (ie; the part load test was carried out at average boiler temperature of 40°C).

D1.16   Keep-hot facility

A facility within an <u>instantaneous combination boiler</u> 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 the Seasonal Efficiency of Domestic Boilers in the UK (SEDBUK)

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 Council Directive, otherwise the calculation cannot proceed.

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.

The procedure to be adopted by manufacturers is as follows:

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). SEDBUK 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. Reduce to maximum net efficiency values
Table D2.1 gives the maximum values of net efficiency for each fuel that may be used for the purposes of the SAP. Reduce any greater test value to the appropriate value given in Table D2.1.

Table D2.1 : Maximum net efficiency values (in %)

Condensing boilers		Non-condensing boilers	
Full load	30% part load	Full load	30% part load
101.0	107.0	92.0	91.0

4. Convert the full and 30% part load efficiencies from net values to gross.
Use the following equation with the appropriate factor from Table D2.2.

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

Table D2.2 : 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

5. 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:

        if t < 10 mm: L = 0.0945 – 0.0055t
        if t ≥ 10 mm: L = 0.394/t
        where t is the thickness of the insulation of the store in mm.

6. 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 D2.3. If no equation number is given the calculation cannot proceed. Otherwise, select the appropriate equation from Table D2.4 or Table D2.5.

b) Substitute the gross full and part load efficiencies (found in step 4) and p, b, V and L (found in step 5). Round the result to one decimal place; ie, to nearest 0.1%. Note the result as [x] for the purpose of the declaration in D3.

<div align="center">Table D2.3 : Boiler category table</div>

SEDBUK Equation numbers for different boiler types	non-condensing *(see D1.2)*				low-temperature *(seeD1.15)*	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 D2.4 : Seasonal efficiency, *E*, for natural gas and LPG boilers

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

Table D2.5 : Seasonal efficiency, *E*, for oil boilers

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

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 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, it shall be expressed as:

> "Seasonal Efficiency (SEDBUK) = [x]%
> The value is used in the UK Government's Standard Assessment
> Procedure (SAP) for energy rating of dwellings. The test data from
> which it has 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 the SEDBUK 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 SEDBUK may be calculated subject to certain conditions using the procedure given below. The value of SEDBUK 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 the SEDBUK 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 ± 5% of the natural gas figure.

4. Determine by measurement the percentage dry CO_2 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. If the boiler is a condensing boiler then deduct 2.2 percentage points from the *30% part-load net efficiency* test result.

6. Follow the calculation procedure in D2 from step 3 onwards, 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, $\Phi_{input,net}$, in kW.
- heat transfer to the water under full load conditions, Φ_{water}, in kW
- flue loss (net) under full load conditions, $\Phi_{flue,net}$, 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 SEDBUK according to D2 using the appropriate equation for a regular boiler.

3. Calculate the case heat emission at full load from

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

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

4. If $\Phi_{case} < 0.2$ 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 $\Phi_{case} = 0.2$ 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 $0.05 \times \Phi_{water}$ or 1 kW, reduce Φ_{case} to $0.05 \times \Phi_{water}$ 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) = [x]%
        Case heat emission at full load = [y] kW
        Heat transfer to water at full load = [z] 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.

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

Note: The data in this appendix 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.

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
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 efficiency of this appliance has been measured as specified in [*insert appropriate entry from Table E1, Table E2 or Table E3*] and the result is *[x]%*. The gross calorific value of the fuel has been used for this efficiency calculation. The test data from which it has been calculated has been certified by [*insert name and/or identification of Notified Body*]. The 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 off-peak times to up to 95°C in winter is stored in a thermal store. If the CPSU volume is less than 270 litres, the on-peak fraction can become high leading to a poor SAP rating.

The procedure in this appendix applies for a 10-hour off-peak tariff providing 3 off-peak 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 on-peak fraction should be calculated (because the procedure is based on a fixed volume).

Note: The treatment of on-peak fraction is different from electric storage heating, because in the case of storage heating the on-peak 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 worksheet, using data from Table 2 or Table 2b.

F1   Procedure for electric CPSUs:

The procedure below applies to the worksheet from box (82) onwards.

1. Calculate the on-peak fraction using the following methodology:

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

    $$T_{min} = \frac{[(37)\times(77)] - C_{max} + [(39)\div 8.76] - (69)}{(37)}$$
    (F1)

    C_{max} is off-peak heat available irrespective of power rating of the heating element, calculated using the formula:

    $$C_{max} = 0.1456 \times V_{cs} \times (T_w - 48)$$
    (F2)
    where:
    V_{cs} is the CPSU capacity, litres
    T_w is winter operating temperature, °C

    b) Find the degree-days (DD) from Table 10 for base temperature T_{min} calculated above.

    c) Calculate on-peak energy required
    $$E_{on-peak} = 0.024 \times (37) \times DD \text{ kWh/year}$$
    (F3)

2. Calculate on-peak fraction

    $$F = \frac{E_{on-peak}}{(81) + (39)} \text{ and enter in boxes (82) and (90)}$$

3.   Enter 130 in box (87a) and follow the normal worksheet calculation.

Note: In the SAP worksheet box (82) is normally used for entry of a fraction from secondary heating but for the purpose of electric CPSU only, this box is used for CPSU on-peak fraction.

Appendix G: Heat pumps

A heat pump is a device which takes heat energy from a low temperature source and upgrades it to a higher temperature at which it can be usefully employed for heating. There are a number of heat pump techniques by which this can be achieved. The ratio of heat energy released to the energy consumed can be substantially greater than one. Heat pump systems operate most efficiently when the source temperature is as high as possible and the heat distribution temperature is as low as possible.

Heat pump systems are categorised by the low temperature heat source used (e.g. air, water, ground) and the seasonal performance factors (SPF) given in Table 4a under "Efficiency" are assumed to apply for all systems using that source. This is a simplified approach especially for ground source heat pumps where energy may be collected from the ground in a variety of ways, e.g. using surface water from lakes or ponds, using ground water from wells, using fluid (either refrigerant or a water/antifreeze mixture) circulated in closed pipe loops buried horizontally in shallow trenches or vertically in boreholes.

At the time of publication, the SPF to be used for SAP calculations is the appropriate entry in Table 4a. A system of appliance-specific performance factors may be introduced (see Appendix Q).

Heat pumps can also be used in community schemes. That does not affect the calculation of the SAP rating but the SPF of the heat pump should be used in box (104) for the calculation of CO_2 emissions.

G1   Domestic hot water (DHW)

G1.1   DHW heated by heat pump with immersion heater
The heat pump raises the water temperature to a maximum of about 40°C, and an immersion heater is then used to raise the water temperature to the required delivery temperature. For the purpose of the SAP calculation it is assumed that 50% of domestic hot water heating is by the heat pump and 50% by the immersion heater.

The average efficiency for water heating, box (86), is:

$$\frac{100}{[50 \div SPF] + 0.5} \qquad\qquad (G1)$$

where SPF is the seasonal performance factor for the heat pump, %, given under "Efficiency" in Table 4a. (The SPF is an overall figure, taking account of all the energy required to operate the heat pump, including primary circulation pumps and an auxiliary heater if present). In the case of a ground or water source heat pump using an off-peak tariff the fraction of electricity at the on-peak rate is given in Table 12a with the remainder charged at the off-peak rate.

G1.2   DHW heated by heat pump without immersion heater
The heat pump supplies all domestic hot water without supplementary immersion heater. In the case of a ground or water source heat pump using an off-peak tariff, the on-peak fraction is given in Table 12a. The SPF of the heat pump for water heating is to be multiplied by the factor given in Table 4c.

G1.3   DHW heated by immersion only
An immersion heater is used, either standard or off-peak electric tariff.

G2   Space heating requirement

G2.1   Ground or water source heat pump
A ground source heat pump system (when the main heating system) may consist of either a ground source heat pump sized to meet all space heating requirements, or a combination of a ground source heat pump and a direct acting electric heater (auxiliary heater). A ground source heat pump system which includes an auxiliary heater to help meet the maximum demands has a lower SPF than one without an auxiliary heater. Use the appropriate SPF given in Table 4a under "Efficiency".

G2.2   Air source heat pump

A heat pump using ambient air as the source is subject to frost build up on the external coil and is very likely to have an integral electric heater to provide space heating while the external coil is being defrosted. The use of this heater is allowed for in the SPF.

G2.3   Delivery temperature

If the heat pump supplies heat to radiators (as opposed to underfloor heating) the heat pump efficiency for space heating is to be multiplied by the appropriate factor given in Table 4c.

G2.4   Electricity tariff

Electric heat pumps can operate on the standard electricity tariff or on an off-peak tariff. When using an off-peak tariff, the fraction of the electricity used for space heating at the on-peak rate is given in Table 12a with the remainder charged at off-peak rate.

G2.5   Heating controls

Control options for heat pumps are given in Group 2 of Table 4e. Note that a bypass arrangement is usually necessary with TRVs to ensure sufficient circulating thermal mass while the heat pump is operating. Zoning arrangements or TRVs may not be appropriate for small domestic installations for this reason.

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 glass and an insulation panel at the back;
- evacuated tube: an absorber with a selective coating is enclosed in a sealed glass vacuum tube.
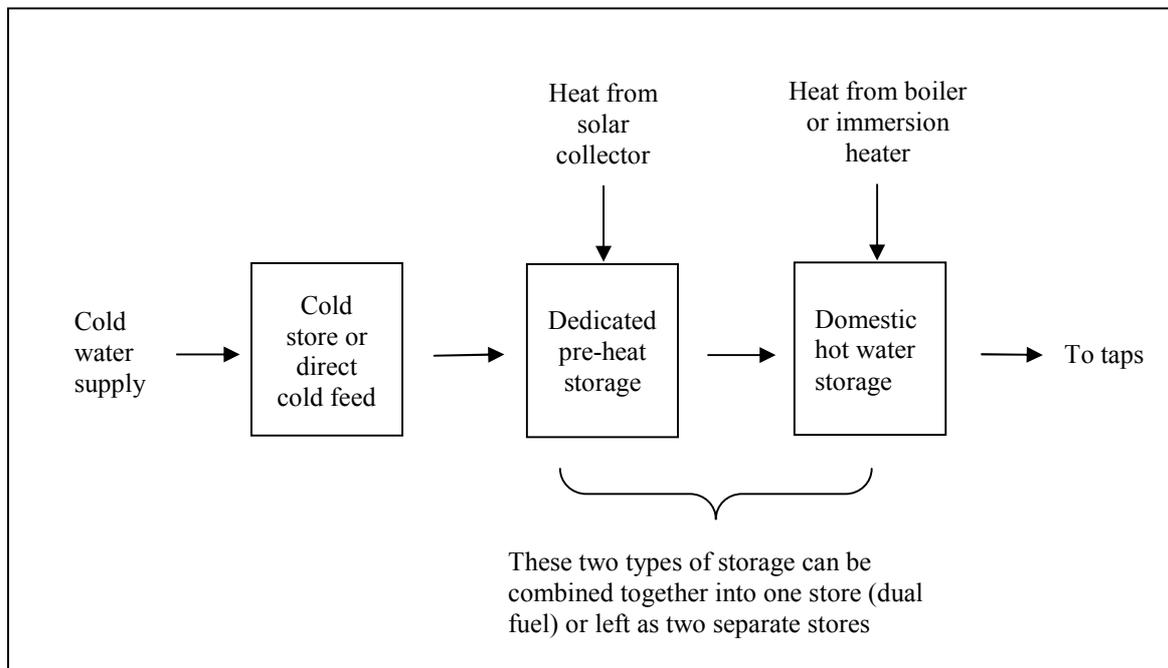
Figure H1: Working principle of solar water heating.

a) With separate solar cylinder

b) With a twin-coil cylinder

c) Combi boiler

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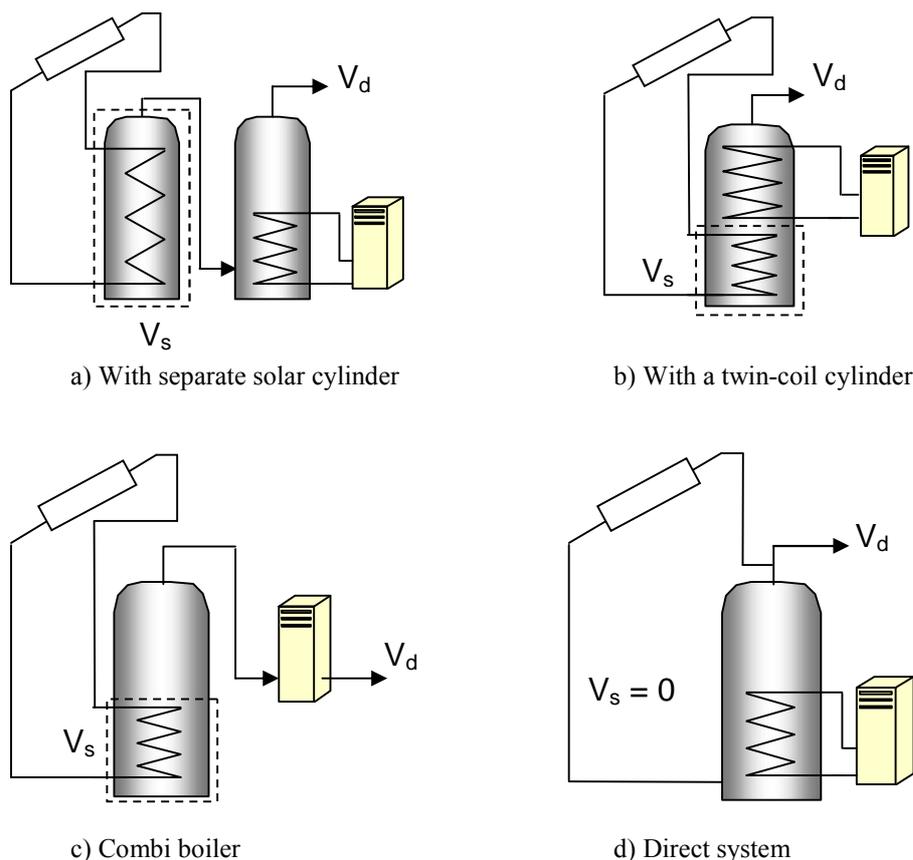
V_s (indicated by the dashed line) is the dedicated solar storage volume. See text below concerning the effective solar volume. V_d is the daily hot water demand. These schematics are not intended to show safety measures and devices needed to make the systems safe.

Figure H2: Schematic examples of 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

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

where

Q_s = solar input, kWh/year
S = total solar radiation on collector, kWh/m²/year
Z_{panel} = overshading 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 = $0.87 - 0.034 (a_1/\eta_0) + 0.0006 (a_1/\eta_0)^2$
V_{eff} = effective solar volume, litres
V_d = daily hot water demand, litres
$f(V_{eff}/V_d)$ = solar storage volume factor = $1.0 + 0.2 \ln(V_{eff}/V_d)$ subject to $f(V_{eff}/V_d) <= 1.0$

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, m² (H1)
    If only the gross area can be established reliably, multiply it by ratio in Table H1

Zero-loss collector efficiency, η_0, from test certificate or Table H1 (H2)

Collector heat loss coefficient, a_1, from test certificate or Table H1 (H3)

Collector performance ratio a_1/η_0 (H3) ÷ (H2)= (H4)

Annual solar radiation per m² from Table H2 (H5)

Overshading factor from Table H3 (H6)

Solar energy available   (H1) × (H2) × (H5) × (H6) = (H7)

Solar-to-load ratio   (H7) ÷ [(39) + (40)] = (H8)

Utilisation factor   if (H8) > 0, 1 - exp[-1/(H8)], otherwise enter "0" in box (H9) (H9)
    if the cylinder is heated by a boiler and there is no cylinderstat, reduce the utilisation factor by 10%

Collector performance factor   if (H4) < 20   0.87 - 0.034 × (H4) + 0.0006 × (H4)² =
                      else   0.604 – 0.0087 × (H4) = (H10)

Dedicated solar storage volume, V_s, litres (H11)
    volume of pre-heat store, or dedicated solar volume of a combined cylinder

If combined cylinder, total volume of cylinder, litres (H12)

Effective solar volume, V_{eff} (H13)
    if separate pre-heat solar storage or a thermal store, (H13) = (H11)
    if combined cylinder, (H13) = (H11) + 0.3 ´ [(H12) – (H11)]

Daily hot water demand, V_d, (litres) from Table 1 (H14)

Volume ratio V_{eff}/V_d (H13) ÷ (H14) = (H15)

Solar storage volume factor $f(V_{eff}/V_d)$ 1 + 0.2 × ln(H15) = (H16)
    (not greater than 1.0)

Solar input Q_s (H7) × (H9) × (H10) × (H16) = (H17)

Note: (39) and (40) are box numbers of the main worksheet

Enter (H17) in (50) of main worksheet. If separate figures for solar input are required for the heating season (8 months) and summer (4 months) take 50% of Q_s as applying during the heating season and 50% during the summer.

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	933				
30°	1042	997	886	762	709
45°	1023	968	829	666	621
60°	960	900	753	580	485
Vertical	724	684	565	427	360

Table H3 : 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
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).		

H2   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 small 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)

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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 boiler 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

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:

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

and the efficiency at part load from:

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

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:

$$\text{Seasonal efficiency} = 0.5 \, (E_{full} + E_{part}) \tag{J3}$$

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:

$$\text{Seasonal efficiency} = 0.975 \, E_{full} \tag{J4}$$

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 bridge[*].

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

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

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

If details of the thermal bridges are not known, use

$$H_{TB} = y \sum A_{exp} \tag{K2}$$

where A_{exp} is the total area of exposed elements, m^2.

The value y = 0.08 applies for new dwellings whose details conform with *Accredited Construction Details*[†] (or are otherwise shown to be equivalent), and a default value of y = 0.15 applies otherwise.

Alternatively values of Ψ can be determined from the results of numerical modelling, or they can be derived from measurement.

Values of Ψ for particular cases should be calculated 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*.

If the junction detail is as recommended in *Accredited Construction Details*, the Ψ-value associated with that junction can be taken from Table K1.

There are four possibilities for specifying the thermal bridging:
1) No information on thermal bridging. Use y = 0.15 in equation (K2).
2) All detailing conforms with Accredited Construction Details. Use y = 0.08 in equation (K2).
3) A value of y has been calculated for a particular house design from individual Ψ values. Use this value in equation (K2). Documentary evidence as to its calculation must be available.
4) Ψ values are known for each junction type. Use equation (K1) with the total length of each junction type. In this case values may be taken from Table K1 for conformant details or they may be calculated according to BR 497. All junction types must be included.

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[*] 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.

[†] For England & Wales and for Northern Ireland: Accredited Construction Details, see www.planningportal.gov.uk/england/professionals/en/1115314255826.html

For Scotland: Accredited Construction Details (Scotland) www.sbsa.gov.uk

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

Junction detail in external wall	Ψ (W/m·K)
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 [a]	0.14
Balcony within a dwelling [b]	0.00
Balcony between dwellings [a] [b]	0.04
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
Corner (normal)	0.09
Corner (inverted)	-0.09
Party wall between dwellings [a]	0.06

[a] For these junctions, half the 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

The calculation of lighting use is based on the proportion of fixed low energy lighting outlets installed[*], and on the contribution of daylight.

Allowing for fixed low-energy outlets
In UK houses, the average energy consumption for lighting is taken as 9.3 kWh/m² annually if no low-energy lighting is used.

$$E_B = 9.3 \text{ kWh/m}^2 \qquad \text{(L1)}$$

The SAP calculation takes account of fixed lighting outlets with low-energy lamps, by including a correction factor C_1:

$$C_1 = 1 - 0.50 \times N_{LE}/N \qquad \text{(L2)}$$

where N_{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 N is the total number of fixed lighting outlets (only the ratio N_{LE}/N is needed).

Note: In Equation (L2), only fixed lighting outlets are included in N_{LE} and N. Movable lamps, which plug into a mains socket, are disregarded. The equation 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, C_2, for lighting energy use depending on the ratio of glass area to floor area, glass transmittance and light access factor.

$$C_2 = 52.2 \, G_L^2 - 9.94 \, G_L + 1.433 \qquad \text{if } G_L \leq 0.095 \qquad \text{(L3)}$$
$$C_2 = 0.96 \qquad \text{if } G_L > 0.095 \qquad \text{(L4)}$$

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

where: FF is the frame factor 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 (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 annual energy used for lighting in the house, E_L, is then
$$E_L = E_B \times TFA \times C_1 \times C_2 \quad \text{kWh/year} \qquad \text{(L6)}$$

where:
$E_B = 9.3$ kWh/m²
TFA is the total floor area, m²
C_1 and C_2 are defined above

Gains from lighting
The reduction in lighting energy use due to low energy lights is:

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[*] 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.

$$\Delta E_L = E_B \times TFA \times (1 - C_1) \times C_2 \text{ (kWh/year)} \tag{L7}$$

To allow for this the quantity

$$\Delta gains = 0.15 \, \Delta E_L \tag{L8}$$

should be deducted from the internal heat gains obtained from Table 5. The factor 0.15 in equation (L8) is based on 75% of the annual lighting energy being used during the months October to April when there is a significant heating need.

Appendix M: Energy from Photovoltaic (PV) technology, small and micro wind turbines and small-scale hydro-electric generators

This appendix may be extended in future to cover other technologies.

M1   Photovoltaics

Photovoltaic technology converts sunlight 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 (kWp) 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 (the range for currently available types is from about 30 to 125 watts peak per m²), and the peak power depends on the type of module as well as its effective area. In the UK climate, an installation with 1 kWp typically produces about 800 kWh of electricity per year (at favourable orientation and not overshaded).

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 (kWp).

2)   The electricity produced by the PV module in kWh/year is

$$0.8 \times kWp \times S \times Z_{PV} \tag{M1}$$

where S is the annual solar radiation from Table H2 (depending on orientation and pitch), and Z_{PV} is the overshading factor from Table H3.

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 (usually the standard tariff, or the day rate 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 in the calculation of box (95a) is:
β × normal electricity price + (1 - β) × exported electricity price.

4)   For calculation of CO_2 emissions, the emissions factor for grid-displaced electricity from Table 12 is used in the calculation of box (110). 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 (95).

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 14, when the total net CO_2 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 other cases see M3.

The performance of wind turbines is very sensitive to the local wind conditions. The procedure is based on typical conditions using a formula given by GreenSpec [*] and the wind speed correction factors given in MIS 3003 [†].

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 2005 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:

$$P_{wind} = CP \times A \times PA \times G \times IE \tag{M2}$$

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
G is the efficiency of the generator
IE is efficiency of the inverter (allowing for power drawn by the inverter) [‡].

2)   The annual energy in kWh/year is related to the output at average wind speed by

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[*] www.greenspec.co.uk/html/energy/windturbines.html (accessed 20 September 2007)
[†] 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)
[‡] 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.

$$E_{wind} = N_{turbines} \times P_{wind} \times 1.9 \times 8766 \times 0.001 \qquad\qquad (M3)$$

where $N_{turbines}$ is the number of wind turbines, 1.9 is a parameter representing the wind speed variation function and 8766 is the average 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 $0.25 \times \pi \times$ (rotor diameter)².

5)   The average wind speed is taken as 5.0 m/s multiplied by the appropriate correction factor from Table M1 [*].

6)   The total electricity produced as calculated in step 2) above is entered in box (95) of the worksheet.

7)   For calculation of the cost savings the factor β (see Section M1) is 0.7.

8)   For calculation of CO_2 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	0.67
(town or village situations with other buildings well spaced)	4	0.61
	2	0.53
	0	0.39
Rural	12	1.00
(open country with occasional houses and trees)	7	0.94
	2	0.86
	0	0.82

* must be at least half the rotor diameter

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.

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[*] Factors in Table M1 derived from data in *The Designer's Guide to Wind Loading of Structures*, N.J. Cook, Butterworths, 1986

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 CO_2 emission figure inclusive of energy uses (including appliances and cooking), see Section 14. 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 output from the wind turbines should be apportioned between the dwellings concerned on the basis of their floor area, by dividing the total annual output by the total floor area of buildings on the development, and entered in kWh/m² into box (ZC6) in Section 14.

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 2005.

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) apportioned to each dwelling according to the total floor area of the dwelling.

3)   For calculation of the cost savings the factor β (see Section M1) is 0.4.

4)   For calculation of CO_2 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 (95).

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 14, when the total net CO_2 emissions are being calculated.

Appendix N: Micro-cogeneration (also known as micro-CHP)

N1   Overview

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. It provides space heating throughout the heating season, and hot water service for either (a) the whole of the year, or (b) none of the year.

The characteristics of micro-cogeneration are described by data derived from laboratory tests. The test data is used to calculate parameters related to the annual energy performance of the micro-cogeneration package. Results (known as "intermediate results") from the annual energy performance method are used for SAP as described in N2.

Any space heating requirements not met by the micro-cogeneration package are assumed to be provided by secondary heating appliances (if provided) or by electric room heaters. If the package provides domestic hot water it is assumed to provide all water heating needs.

The heat produced by the package and the electrical energy consumed/generated are based on operation during an average year, taking account of the output rating of the appliance and the design heat loss for the dwelling into 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 0.5 then the package cannot be regarded as the primary heating system, and the performance data are not valid for SAP.

The electricity consumed/generated will normally be negative, and then represents the net electricity provided 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, if supplied by the micro-cogeneration package, water heating. The electricity consumed (or the net electricity generation) is scaled according to the net energy use as obtained in the SAP calculation.

N2   Interpolation of result sets

The intermediate results from the annual energy performance method are produced in sets, with each set calculated for a different plant size ratio (e.g. 0.5, 1.0, 1.5 and 4.0). The plant size ratio is defined as the maximum heat output of the micro-cogeneration package divided by the design heat loss of the dwelling. Each set of results contains the data in Table N1. The data to be used for SAP calculations are provided by way of the boiler database, each database record for a micro-cogeneration package containing the output power of the package and a number of sets of intermediate results.

Table N1: Set of intermediate results from the annual energy performance method

Data item	Symbol	Unit
Plant size ratio for which data apply	PSR	-
Annual heat generated for space heating	Q_{sp}	kWh
Annual heat generated for domestic hot water, if any	Q_{hw}	kWh
Annual auxiliary heating requirement	Q_{aux}	kWh
Heating season[*] thermal efficiency	η_{hs}	-
Summer season thermal efficiency	η_{sum}	-
The electricity consumed or, if negative, net electricity generated, during the heating season	$E_{mc,hs}$	kWh
The electricity consumed or, if negative, net electricity generated., during the summer season	$E_{mc,sum}$	kWh
Number of days operating for 16 hours instead of 9	$N_{16,9}$	days
Number of days operating for 24 hours instead of 9	$N_{24,9}$	days
Number of days operating for 24 hours instead of 16	$N_{24,16}$	days

The plant size ratio (PSR) for the dwelling is calculated using the maximum output of the micro-cogeneration package and the design heat loss of the dwelling taken as the heat loss coefficient, box (37) of the worksheet, multiplied by a temperature difference of 20 K. 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. The intermediate results applicable to the dwelling are then obtained by linear interpolation between the intermediate results[†] for the two sets of data whose PSRs enclose that of the actual dwelling. The dwelling-specific result sets are used in equations (N1) to (N4) to calculate the parameters used in the SAP calculation.

N3   Calculation of space and water heating, and electricity produced

The electricity used by any fans within the package is included in $E_{mc,hs}$ and $E_{mc,sum}$ and is not included separately in the SAP calculation, thus box (87b) is zero.

If the micro-cogeneration package includes a central heating system pump to circulate water through the heat emitters the electricity for it is included in $E_{mc,hs}$ and the heat gain from it is allowed for in η_{sp}. In that case no allowance for a central heating pump is included in box (53b) and box (87a) is zero. If the package does not include a central heating pump, it is provided separately outside the package, and the gain from Table 5a is included in box (53b) and electricity use from Table 4f is included in box (87a).

Mean internal temperature
The micro-cogeneration package, when undersized in relation to the dwelling's design heat loss, can provide space heating needs on more days of the heating season if it operates for 16 hours per day or continuously. The seasonal thermal efficiency and electricity generated in the intermediate results are based on the hours of operation indicated by the parameters $N_{16,9}$, $N_{24,9}$ and $N_{24,16}$ for a total heating season length of 238 days (34 weeks). For the normal SAP heating schedule, this would comprise 68 weekend days with

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[*] The heating season and summer season together comprise a whole year.
[†] For the efficiency values, the interpolated efficiency is the reciprocal of linear interpolation between the reciprocals of the efficiencies. Round $N_{16,9}$, $N_{24,9}$ and $N_{24,16}$ to the nearest integer.

16 hours of heating and 170 weekdays with 9 hours of heating (2 hours in the morning and 7 hours in the evening). The mean internal temperature in the living area for the heating season is

$$\text{MIT} = [\ (N_{24,16} + N_{24,9})\ T_{24} + (68 - N_{24,16} + N_{16,9})\ T_{16} + (170 - N_{16,9} - N_{24,9})\ T_9\ ]\ /\ 238 \qquad (N1)$$

where T_{24}, T_{16} and T_9 are the mean temperatures for 24, 16 and 9 hours of heating, given in Table N2. MIT from equation (N1) is used instead of a value obtained from the data in Table 8.

Table N2: Internal temperature of living area for different hours of operation
HLP is item (38) in the worksheet

HLP	T_{24} continuous	T_{16} 16 hours/day	T_9 9 hours/day
1.0 (or lower)	21.00	19.63	18.58
1.5	21.00	19.63	18.58
2.0	21.00	19.61	18.55
2.5	21.00	19.58	18.50
3.0	21.00	19.53	18.40
3.5	21.00	19.45	18.26
4.0	21.00	19.36	18.11
4.5	21.00	19.27	17.94
5.0	21.00	19.16	17.75
5.5	21.00	19.04	17.54
6.0 (or higher)	21.00	18.93	17.32

Efficiency
Use the heat efficiency η_{hs} in box (83) for space heating.

If the micro-cogeneration package provides both space and hot water heating, use the heat efficiency η_{hs} for water heating in the heating season (238 days) and and η_{sum} for water heating in summer (127 days).

If the package only provides space heating specify a separate hot water system such as an electric immersion heater.

If the package is a condensing type, the efficiency adjustments in Table 4c(1) apply where relevant to efficiency in the heating season.

Hot water storage losses
If the micro-cogeneration package contains within it a storage vessel for domestic hot water that was included in the energy performance tests, heat losses associated with hot water storage are included in the intermediate results and zero is entered for the cylinder loss (46) and the primary loss (48). The distribution loss (40) is included as normal.

If the package does not contain a storage vessel for domestic hot water, a cylinder is specified separately and the cylinder loss and primary loss are included in the SAP calculation.

Secondary heating
The auxiliary heating requirement Q_{aux} is provided by a secondary heating system (any system from the room heater section of Table 4a). The secondary fraction is calculated from

$$\text{SF} = \frac{Q_{aux}}{Q_{sp} + Q_{aux}} \qquad (N2)$$

Electricity

If the package provides both space and hot water heating, the electricity consumed or generated is scaled to the actual heat requirement of the dwelling for both heating and hot water:

$$E^* = \frac{[\text{box }(81)]\times(1-SF)+[0.66\times\text{box }(51)]}{Q_{sp}+0.66\times Q_{hw}}\times E_{mc,hs} + \frac{\text{box}(51)}{Q_{hw}}\times E_{mc,sum} \qquad \text{(N3)}$$

(0.66 is the heating season as a fraction of a year).

If the package provides space heating only, the electricity consumed or generated is scaled to the actual space heating requirement of the dwelling:

$$E^* = \frac{\text{box}(81)\times(1-SF)}{Q_{sp}}\times E_{mc,hs} \qquad \text{(N4)}$$

If E^* is positive, enter E^* in box (96) and use the unit price for standard tariff electricity in the calculation of box (96a).

If E^* is negative, enter E^* in box (95). 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 day 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 (95a) is then:

β x normal electricity price + (1 - β) x exported electricity price.

If E^* is positive, the emission factor used in the calculation of box (111) is that for grid-supplied electricity from Table 12.

If E^* is negative, the emission factor used in the calculation of box (110) is that for grid-displaced electricity from Table 12.

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 CO_2 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

1. Obtain a value for the effective air change rate during hot weather. Indicative values based on the procedure in BS 5925[*] 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 the time' would be applicable, which refers principally to night-time ventilation (ground floor evening only, upper floors open all night).

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[*] BS 5925:1991, Code of practice for ventilation principles and design for natural ventilation

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:

$$H_v^{summer} = 0.33 \times n \times V \tag{P1}$$

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:

$$H = \text{total fabric heat loss} + H_v^{summer} \tag{P2}$$

The total fabric heat loss is the same as for the heating season (box (35) of the worksheet).

4. Calculate the total solar gains for the summer period , G_{solar}^{summer}, using the solar flux for the summer period from Table 6a.

$$G_{solar}^{summer} = \sum \left(0.9 \times A_w \times S \times g_{\perp} \times FF \times Z_{summer} \right) \tag{P3}$$

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), m²
   S is the solar flux on a surface during the summer period from Table 6a, W/m²
   $g_{\perp}$ 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 $0.9 \times g_{\perp} \times FF$. The solar gain for such windows is calculated as

$$G_{solar}^{summer} = \sum \left(A_w \times S \times g_{window} \times Z_{summer} \right) \tag{P4}$$

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:

$$G = G_{solar}^{summer} + G_i \tag{P5}$$

5. Calculate the summer Gain/Loss ratio:

$$\text{Summer Gain/Loss ratio} = \frac{G}{H} \tag{P6}$$

6. Obtain the summer mean external temperature, T_e^{summer}, from Table P2.

Table P2: Summer mean external temperature

Region	Mean external temperature, T_e^{summer}, used for estimating mean internal temperature in summer
Thames valley	17
Severn valley; South, South East, South West England	16
Midlands; East Anglia; East Pennines; West Pennines	15.5
North West, North East England; Borders	14
Wales, Northern Ireland, East, West Scotland	14
North East Scotland; Highland; Western Isles	13
Orkney	12
Shetland	11

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.

$$T_{threshold} = T_e^{summer} + \frac{G}{H} + \Delta T_{mass} \qquad (P7)$$

where

$\Delta T_{mass} = 2.0 - 0.2 \times TMP$ if TMP < 10
$\Delta T_{mass} = 0$ if TMP ≥ 10

TMP typically varies between 5 for lightweight construction to 20 for heavy construction. For further details see section P4.

8. Use Table P3 to estimate tendency to high internal temperature in hot weather.

Table P3: Levels of threshold temperature corresponding to likelihood of high internal temperature during hot weather

$T_{threshold}$	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 P3 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

$$Z_{summer} = Z_{blinds} (Z + Z_{overhangs} - 1) \qquad \text{(P8)}$$

subject to

$$Z_{summer} \geq 0.1 \, Z_{blinds} \qquad \text{(P9)}$$

where
 Z_{blinds} is a shading factor for blinds or curtains
 Z is the solar access factor from Table 6d
 $Z_{overhangs}$ is a shading factor for overhangs

Table P4 gives values for Z_{blinds}, and Tables P5 and P6 give values for $Z_{overhangs}$. If there are no overhangs, $Z_{overhangs} = 1$.

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 P4 refers to daytime.

Table P4 : 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 (note 3)	0.24
White external shutter, window closed (note 3)	0.27
Dark-coloured external shutter, window fully open (note 3)	0.85
White external shutter, window fully open (note 3)	0.65

Notes to Table P4
1. Factor applies when fully closed. If closed only for a fraction f of the daylight hours use
   $f \times Z_{blind} + (1 - f)$.
2. 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 use
   $f \times Z_{blind} + (1 - f)$.
3. External shutters are not applicable to roof windows.

P3.2   P3.2 Overhangs
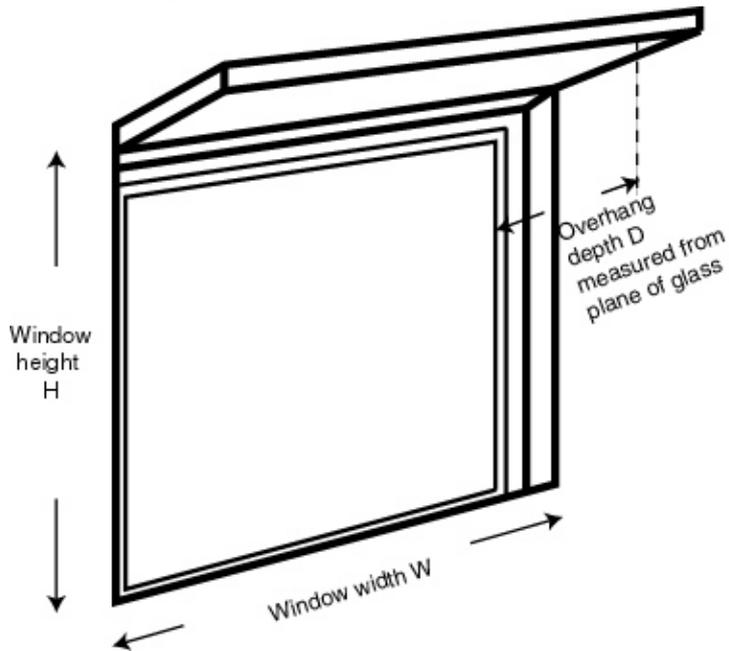
Where the overhang is at least twice as wide as the window (e.g. balconies on blocks of flats) use Table P5. In other cases use Table P6. Interpolation may be used between rows of these tables. Usually the same value of $Z_{overhangs}$ can be applied to all the windows on a given façade on the basis of an average depth-to-height ratio.

Table P5: $Z_{overhangs}$ 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 P6: $Z_{overhangs}$ 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					

P4 Thermal mass

The thermal mass of a building is represented by the thermal mass parameter (TMP). Table P7 gives some indicative values of TMP based on the characteristics of the construction elements. For this purpose the mass of an element is low for admittance less than 2 W/m²K, medium 2 to 3.5 W/m²K and high over 3.5 W/m²K (see Table P8). Note that the threshold temperature is not affected by any increase in TMP above 10.

Table P7: Indicative values of thermal mass parameter

Mass of construction elements					
Ground floor	External walls	Separating walls	Internal partitions	Illustrative construction	TMP W/m²K
low	low	low	low	suspended timber floor, timber/steel frame walls, plasterboard on timber/steel stud internal partitions	5
medium	low	low	low	solid floor, timber/steel frame walls, plasterboard on timber/steel stud internal partitions	6
medium	low	medium	low	solid floor, masonry external walls (internal insulation), masonry separating walls with plasterboard on dabs, plasterboard on timber/steel stud internal partitions	7
medium	medium	medium	low	solid floor, masonry external walls (cavity fill or external insulation) with plasterboard on dabs, masonry separating walls with plasterboard on dabs, plasterboard on timber/steel stud internal partitions	8
medium	medium	high	low	solid floor, masonry external walls (cavity fill or external insulation) with plasterboard on dabs, masonry separating walls dense plaster, plasterboard on timber/steel stud internal partitions	9

Mass of construction elements					
Ground floor	External walls	Separating walls	Internal partitions	Illustrative construction	TMP W/m²K
medium	high	medium	low	solid floor, masonry external walls (cavity fill or external insulation) with dense plaster, masonry separating walls with plasterboard on dabs, plasterboard on timber/steel stud internal partitions	10
medium	low	medium	medium	solid floor, masonry external walls (internal insulation), masonry separating walls with plasterboard on dabs, masonry internal partitions with plasterboard on dabs	11
medium	high	high	low	solid floor, masonry external walls (cavity fill or external insulation) with dense plaster, masonry separating walls with dense plaster, plasterboard on timber/steel stud internal partitions	11
medium	medium	medium	medium	solid floor, masonry external walls (cavity fill or external insulation) with plasterboard on dabs, masonry separating walls plasterboard on dabs, masonry internal partitions with plasterboard on dabs	12
medium	medium	high	high	solid floor, masonry external walls (cavity fill or external insulation) with plasterboard on dabs, masonry separating walls dense plaster, masonry internal walls with dense plaster	17
medium	high	high	high	solid floor, masonry external walls (cavity fill or external insulation) with dense plaster, masonry separating walls with dense plaster, masonry internal walls with dense plaster	19

Alternatively, TMP can be calculated from the admittances of the elements comprising the structure of the dwelling. It is defined as

$$TMP = \frac{\sum AY}{TFA} \tag{P9}$$

where A and Y are the areas and admittance of each element of the construction and TFA is the total floor area of the dwelling.

Thin elements like windows and doors are omitted from the calculation of $\Sigma\,AY$ but, unlike the calculation of $\Sigma\,AU$ for heat loss calculations, the sum includes all internal partitions, intermediate floors and party walls and floors. The area of an internal partition includes both sides of the partition. The admittance of a building element is determined primarily by the properties of the layers adjacent to the room. Values for some common constructions are given in Table P8.

Table P8: Y-values for common constructions

Construction (external elements insulated to typical new-build levels)	Admittance Y (W/m²K)
Ground floors	
Suspended timber, carpeted	1.4
Suspended timber, laminated	1.7
Slab on ground (insulation above or below slab, screed on top, carpeted	3.2
Slab on ground (insulation above or below slab, screed on top, laminated	3.4
Suspended concrete floor, carpeted	3.0
Suspended concrete floor, laminated	3.2
Exposed floors	
Timber exposed floor, carpeted	1.2
Timber exposed floor, laminated	1.5
External walls - masonry, solid, external insulation	
Solid wall: dense plaster, 200 mm dense block, insulated externally	4.8
Solid wall: plasterboard on dabs, 200 mm dense block, insulated externally	2.5
Solid wall: dense plaster, 210 mm brick, insulated externally	4.1
Solid wall: plasterboard on dabs, 210 mm brick, insulated externally	2.3
External walls - masonry, solid, internal insulation	
Solid wall: dense plaster, insulation, dense block or brick, rendered	1.3
Solid wall: plasterboard on dabs, insulation, dense block or brick, rendered	0.7
External walls - cavity masonry walls, full or partial cavity fill	
Cavity wall: dense plaster, dense block, filled cavity, dense block or brick	5.2
Cavity wall: dense plaster, AAC block, filled cavity, AAC block	3.0
Cavity wall: plasterboard on dabs, dense block, filled cavity, dense block or brick	2.6
Cavity wall: plasterboard on dabs, AAC block, filled cavity, AAC block	2.0
External walls – concrete panel construction (precast or in-situ)	
Plasterboard directly fixed, concrete panel construction	4.5
Plasterboard directly fixed with 5 mm air gap, concrete panel construction	3.1
Plasterboard, internal insulation board, concrete panel construction	0.9
External walls – timber or steel frame	
Timber framed wall (one layer of plasterboard)	0.8
Timber framed wall (two layers of plasterboard)	1.3
Steel frame wall (warm frame construction)	2.0
Steel frame wall (hybrid construction)	1.1
Roofs	
Insulated at ceiling level	0.7
Insulated slope	0.7
Insulated flat roof	0.7
Separating walls	
Dense plaster both sides, dense blocks, cavity (E-WM-1 or E-WM-2)*	5.0
Single plasterboard on dabs on both sides, dense blocks, cavity (E-WM-3 or E-WM-4)*	2.5
Plaster on dabs and single plasterboard on both sides, dense cellular blocks, cavity (E-WM-5)*	2.5
Plasterboard on dabs mounted on cement render on both sides, AAC blocks, cavity (E-WM-6 or E-WM-7)*	2.2
Double plasterboard on both sides, twin timber frame with/without sheathing board (E-WT-1 or E-WT-2)*	1.4
Steel frame (E-WS-1 to E-WS-3)*	1.4
Separating floors (Y from above /Y from below)	
Precast concrete planks floor, screed, carpeted (E-FC-1)*	1.9/1.9
Concrete floor slab, carpeted (E-FC-2)*	2.0/2.7
Precast concrete plank floor (screed laid on insulation), carpeted (E-FC-3)*	2.3/1.9
Precast concrete plank floor (screed laid on rubber), carpeted (E-FC-4)*	2.7/1.9
In-situ concrete slab supported by profiled metal deck, carpeted (E-FS-1)*	1.9/2.7

Construction (external elements insulated to typical new-build levels)	Admittance Y (W/m^{2}K)
Timber I-joists, carpeted (E-FT-1)*	1.7/1.4
Internal partitions	
Plasterboard on timber frame	0.8
Dense block, dense plaster	4.6
Dense block, plasterboard on dabs	2.6
Ceiling/floor between floors in a house (Y from above/Y from below)	
Plasterboard ceiling, carpeted chipboard floor	0.9/1.0

 * Reference in the Robust Details for Part E "Resistance to the passage of sound"

Appendix Q: Special features and specific data

Q1   Special features

This section provides a method to allow for the benefits of new energy-saving 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 recognised as part of SAP by being described on the web page www.bre.co.uk/sap2005 (or a web page linked to it[*]). For recognised systems, this web page will contain details for calculating the data to be entered into the worksheet.

In general, a technology may use one form of energy to achieve savings in another form of energy.

Example. If whole-house mechanical ventilation with heat recovery were to be assessed in this way for an oil-heated house:
- *the web page would contain the routine for calculating the heat recovered (and so the energy saved), together with a routine to calculate the energy used by fans;*
- *the energy saved would be applied with the cost and CO_2 emission factors for oil;*
- *the electricity used for fans would be applied with the cost and CO_2 factors for electricity.*

In the worksheet:

SAP rating:
1. include the amount of energy saved by the technology (kWh/year) in box (95);
2. multiply the amount of saved energy by the unit price of the fuel concerned to obtain box (95a);
3. include the amount of energy used by the technology in box (96);
4. multiply the energy used by the unit price of the fuel concerned and to obtain box (96a);
5. include both these items in the calculation of the total energy cost in box (97).

CO_2 Emissions:
1. the amount of energy saved by the technology (kWh/year) in box (94) is multiplied by the appropriate emission factor and subtracted from the total CO_2 emissions;
2. the amount of energy used by the technology (kWh/year) in box (95) is multiplied by the appropriate emission factor and added to the total CO_2 emissions.

Q2   Specific data

A similar mechanism will be used, if appropriate, to permit the use of data specific to a technology instead of the data provided in the SAP tables. For recognised data types, the web page mentioned above will give details of the conditions for accepting the data and its applicability within the SAP calculation.

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[*] 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 CO_2 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 CO_2 emissions per unit floor area from the notional dwelling are adjusted as specified in the applicable regulatory document to form the target CO_2 emission rate for the actual dwelling.

CO_2 emissions associated with internal lighting should be recorded separately. CO_2 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 m², any other doors are fully glazed All glazing treated as windows (i.e. no roof windows)
Walls	U = 0.35 W/m²K
Floors	U = 0.25 W/m²K
Roofs	U = 0.16 W/m²K
Opaque door	U = 2.0 W/m²K
Windows and glazed doors	U = 2.0 W/m²K Double glazed, low-E hard coat Frame factor 0.7 Solar energy transmittance 0.72 Light transmittance 0.80
Living area fraction	Same as actual dwelling
Shading and orientation	All glazing orientated E/W; average overshading
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 m³/h·m² at 50 Pa
Chimneys	None
Open flues	None
Extract fans	3 for dwellings with floor area greater than 80 m², 2 for smaller dwellings
Main heating fuel (space and water)	Mains gas
Heating system	Boiler and radiators water pump in heated space
Boiler	SEDBUK 78% room-sealed fanned flue

Heating system controls	Programmer + room thermostat + 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
Secondary space heating	10% electric
Low energy light fittings	30% of fixed outlets
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.	

Appendix S: Reduced Data SAP for existing dwellings

Reduced Data SAP has been developed by government for use in existing dwellings based on a site survey of the property, when the complete data set for a SAP calculation is not available. It consists of a system of data collection (defined in Table S19) together with defaults and inference procedures, as defined by the rules given in this Appendix, that generate a complete set of input data for the SAP calculation. For any item not mentioned in this Appendix, the procedures and data given elsewhere in this document apply.

The calculation starting from reduced data is done in two stages. First the reduced data set is expanded into a full data set, and then the SAP calculation is undertaken using the expanded data set. The actual SAP calculation is therefore identical, whether starting from a reduced data set or a full data set.

This Appendix forms part of SAP 2005 and provides a methodology for existing dwellings that is compliant with the Energy Performance of Buildings Directive. It is not appropriate for new dwellings for which all data for the calculation should be acquired related to the dwelling concerned.

This Appendix contains the data and rules for expanding the data collected in a Reduced Data survey into the data required for the SAP calculation. Information in shaded boxes is primarily concerned with data collection and is addressed to energy assessors.

S1   Dwelling types

Dwellings are classified as one of
  – house
  – bungalow
  – flat
  – maisonette

and one of
  – detached
  – semi-detached
  – mid-terrace
  – end-terrace
  – enclosed mid-terrace
  – enclosed end-terrace

Reduced Data SAP is for existing dwellings only. Any new dwelling, including dwellings created by change of use, must be assessed using SAP.

A house or bungalow has a complete heat loss ground floor and a completely exposed roof. A dwelling without a heat loss floor cannot be a house and must be treated as a flat or maisonette. A flat or maisonette does not have both a heat loss ground floor and a heat loss roof.

RdSAP makes no distinction between a flat and a maisonette as regards calculations; it is acceptable to select either type as definitions vary across the UK.

"Enclosed" is typically applicable for "back-to-back" terraces and has the following meaning:
  – mid-terrace has external walls on two opposite sides;
  – enclosed mid terrace has an external wall on one side only;
  – end-terrace has three external walls;
  – enclosed end-terrace has two adjacent external walls.

Many dwellings have an extension either added onto the main part, or built at the same time but of different construction or insulation. In these cases, dimensions and constructional details of the main part of the dwelling and the extension are recorded separately, to allow the assignment of different U-values to the original and to the extension. Occasionally there may be two extensions whose details need each to be recorded separately. In addition, dwellings can have a different construction for some parts of the walls (for example, a timber framed bay window in otherwise masonry construction). These are recorded as a separate constructional element, termed 'alternative wall'. If the area of the alternative wall is less than 10% of the total wall area it can be disregarded.

S2 Age bands

A set of age bands is defined according to Table S1 for the purposes of assigning U-values and other data.

Table S1 : Age bands

Age band	Years of construction		
	England & Wales	**Scotland**	**Northern Ireland**
A	before 1900	before 1919	before 1919
B	1900-1929	1919-1929	1919-1929
C	1930-1949	1930-1949	1930-1949
D	1950-1966	1950-1964	1950-1973
E	1967-1975	1965-1975	1974-1977
F	1976-1982	1976-1983	1978-1985
G	1983-1990	1984-1991	1986-1991
H	1991-1995	1992-1998	1992-1999
I	1996-2002	1999-2002	2000-2006
J	2003-2006	2003-2007	(not applicable)
K	2007 onwards	2008 onwards	2007 onwards

From the 1960s, constructional changes have been caused primarily by amendments to building regulations for the conservation of fuel and power, which have called for increasing levels of thermal insulation. The dates in Table S1 are generally one year after a change in regulations, to allow for completion of dwellings approved under the previous regulations.

For a conversion which was a change of use (e.g. barn converted to dwelling) enter conversion date as the age of construction.

For a conversion where a dwelling is sub-divided (e.g. house to flats) use the original construction date, unless there is documentary evidence that all thermal elements have been upgraded to the building regulation standards applicable at the conversion date.

S3 Areas

Areas are determined separately for the main part of the dwelling and any extension. Horizontal dimensions can be measured either internally or externally.

The measurements required are the floor area, exposed perimeter and room height on each storey. Exposed perimeter includes the wall between the dwelling and an unheated garage or a separated conservatory and, in the case of a flat or maisonette, the wall between the dwelling and an unheated corridor.

Internal dimensions are permissible in all cases. In the case of a house or bungalow external dimensions for area and perimeter are usually more convenient, except where access to all sides of the building is not possible or where there are differing wall thicknesses or other aspects that would make the dimensional conversion unreliable. When using external measurements for a dwelling joined onto another dwelling (semi-detached and terraced houses) the measurement is to the mid-point of the party wall. Flats and maisonettes are usually measured internally (although it is not a requirement of the specification that internal measurements are always used and if measured externally the measurement is to the mid-point of the party wall). Whichever is chosen the same basis must be used for all parts of the dwelling.

Measure all perturbations (e.g. bay windows) but disregard chimney breasts unless assessor considers significant e.g. large inglenook.

Vertical dimensions (room heights) are always measured internally within the room. Also, the floor area of room(s)-in-roof are always measured internally (irrespective of the dimensions basis for other storeys).

Measure lengths to one decimal place (0.1 m) or better. Retain higher precision when that has been measured (especially room heights).

If there is an alternative wall, it is identified as being part of the external wall of main dwelling or of one of the extensions. When calculating the area of alternative wall exclude the area of any windows and doors contained within it.

S3.1   Definition of the extent of the dwelling

Generally rooms and other spaces, such as built-in cupboards, are included as part of the dwelling where these are directly accessible from the occupied area of the dwelling, whereas unheated spaces clearly divided from the dwelling are not.

Basements

Include when accessed via a permanent fixed staircase such that one is able to walk downwards facing forwards and either:-
- basement is heated via fixed heat emitters, or
- basement is open to the rest of the dwelling.
A basement does not necessarily contain habitable rooms.

Attics and roof rooms

Include when accessed via a permanent fixed staircase such that one is able to walk downwards facing forwards. Does not necessarily contain habitable rooms.

For a roof room to be classed as such and not a separate storey, the height of the common wall must be less than 1.8 m for at least 50% of the common wall (excluding gable ends or party walls). The common wall is a vertical continuation of the external wall of the storey below.

There is no explicit allowance for dormer windows except to include in the floor area of the roof rooms.

See Figures S1 and S2 (next page).

Rooms within a Mansard roof

A storey having non-vertical walls of at least 70° pitch constitutes a separate storey; it is not treated as roof rooms. Use alternative wall if appropriate.

Whole dwelling within roof

When property is a single storey entirely located within a roof, enter it as:
- lowest occupied level
- timber frame construction of appropriate age band
- room height 2.2 m
- include area and perimeter measurements as a normal storey.

If there are two storeys within roof, enter the lower storey as above and the upper storey as rooms-in-roof.

Mezzanine floor

Enter the part of the property above and below the mezzanine deck as a two storey extension Treat the remaining part as a single level with the full floor to ceiling/roof height.

If the mezzanine is located such that it has no heat loss perimeter then assign a nominal 1 m perimeter and deduct 1 m from an actual heat loss perimeter.

> Porches
> If heated always include (separated or not).
> If external and not heated, disregard.
> If internal, not heated and thermally separated, disregard.
> ('external' means an addition protruding from the line of the external wall of the dwelling)

S3.2   Illustrations of roof rooms

The following are all classified as roof rooms:
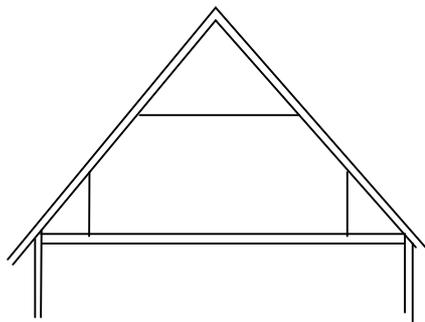
Basic roof room
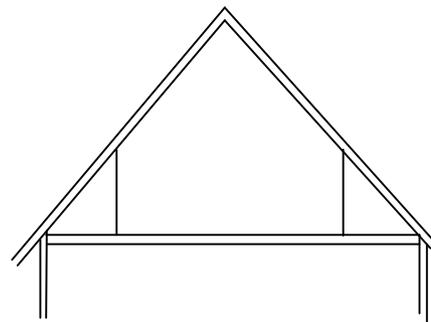
Roof room with
vaulted ceiling
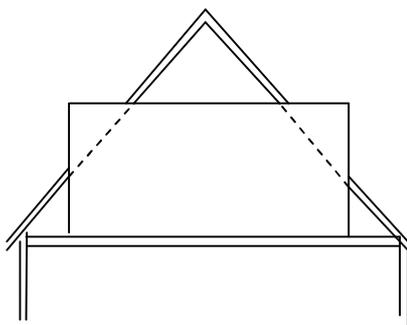
Roof room with
dormer windows
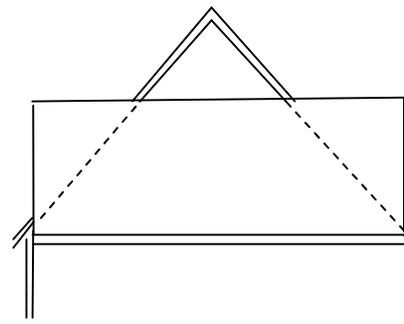
Roof room with large
dormer windows
(chalet style)

Figure S1 : Roof rooms

Where there is a common wall it is:
- a roof room if the height of the common wall in the upper storey is less than 1.8 m;
- a separate storey if greater or equal to 1.8 m:
as illustrated in Figure S2.

Roof room

Separate storey, not roof room
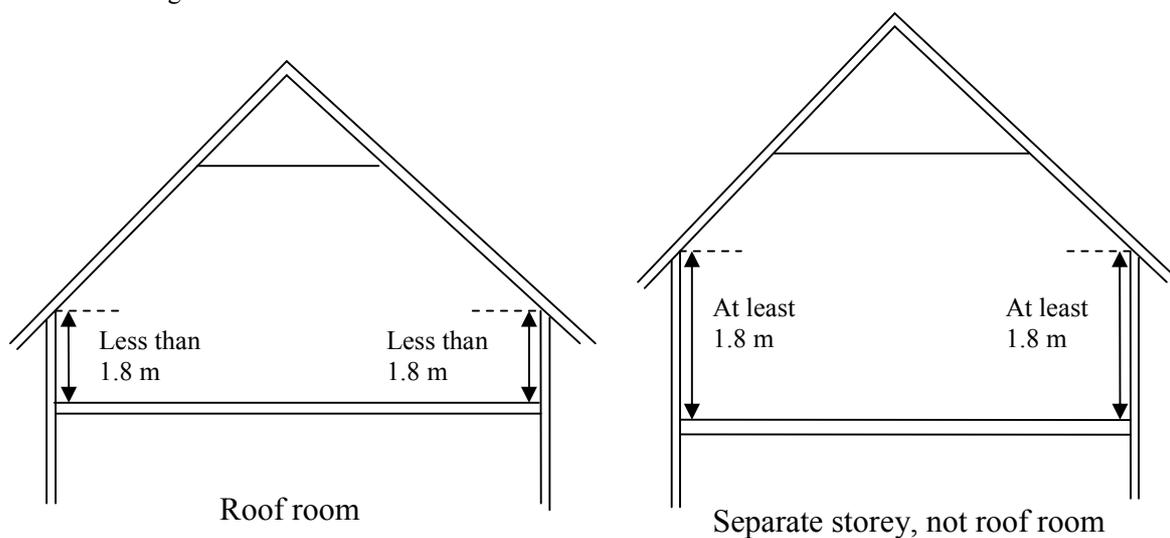
Figure S2 : Upper storey with common wall

S3.3   Extensions and alternative wall

Provision is made for the main dwelling and up to two extensions, each with their own age band, dimensions and other characteristics. Also there is an additional wall type, 'alternative wall', which is part of the external walls of either the main dwelling or one of the extensions.

<u>More than two extensions</u>

Add together floor areas and exposed perimeters of extensions (or add extension to main dwelling) to reduce to two extensions. Combine parts having the most similar age bands (see **Table S6**, **Table S7** or **Table S8** for U-values of relevant constructions). Use alternative wall where appropriate.

<u>Vertical extensions</u>
Use one of:

1) Enter new upper floor as an extension

2) Make of use alternative wall for the new upper storey

Reasons for decision to be recorded in site notes.

<u>Alternative wall</u>

Disregard when less than 10% of total exposed wall area of the whole dwelling (including windows and doors). When entering alternative wall area into software exclude the area of any windows and doors contained in the alternative wall.

Consolidate walls of same type.

If there are two areas of external wall of different construction types that should be regarded as alternative wall, use the one with the larger area.

S3.4   Conversion to internal dimensions

If horizontal dimensions are measured externally, they are converted to overall internal dimensions for use in SAP calculations by application of the appropriate equations in Table S2, using the appropriate wall thickness from Table S3. The equations are applied on a storey-by-storey basis, for the whole dwelling (i.e. inclusive of any extension).

Table S2 : Conversion of dimensions

Dwelling type	Equations
Detached	$P_{int} = P_{ext} - 8\,w$ $A_{int} = A_{ext} - w\,P_{int} - 4\,w^2$
Semi-detached or End-terrace	If $P_{ext}^2 > 8\,A_{ext}$: $\qquad P_{int} = P_{ext} - 5\,w$ $\qquad a = 0.5\left(P_{ext} - \sqrt{P_{ext}^2 - 8\,A_{ext}} \right)$ $\qquad A_{int} = A_{ext} - w\,(P_{ext} + 0.5\,a) + 3\,w^2$ otherwise $\qquad P_{int} = P_{ext} - 3\,w$ $\qquad A_{int} = A_{ext} - w\,P_{ext} + 3\,w^2$
Mid-terrace	$P_{int} = P_{ext} - 2\,w$ $A_{int} = A_{ext} - w\,(P_{ext} + 2\,A_{ext}/P_{ext}) + 2\,w^2$
Enclosed end-terrace	$P_{int} = P_{ext} - 3\,w$ $A_{int} = A_{ext} - 1.5\,w\,P_{ext} + 2.25\,w^2$
Enclosed mid-terrace	$P_{int} = P_{ext} - w$ $A_{int} = A_{ext} - w\,(A_{ext}/P_{ext} + 1.5\,P_{ext}) + 1.5\,w^2$
All types	Perimeter ratio = P_{int}/P_{ext} Area ratio = A_{int}/A_{ext}

Notes:
1. P_{ext} and A_{ext} are the measured external perimeter and area (of whole dwelling)
2. P_{int} and A_{int} are the calculated internal perimeter and area
3. w is the wall thickness of the main dwelling
4. After obtaining the perimeter ratio and area ratio for the whole dwelling, multiply separately the measured perimeters and areas of (a) the main part of the dwelling and (b) any extension, by these ratios.

Table S3 : Wall thickness (m)

Age band	A	B	C	D	E	F	G	H	I, J, K
Wall type									
Stone as built*	0.50	0.50	0.50	0.50	0.45	0.42	0.42	0.42	0.45
Stone with internal or external insulation*	0.57	0.57	0.57	0.57	0.52	0.49	0.49	0.49	0.52
Solid Brick as built	0.22	0.22	0.22	0.22	0.24	0.25	0.27	0.27	0.30
Solid brick with internal or external insulation	0.29	0.29	0.29	0.29	0.31	0.32	0.34	0.34	0.37
Cavity**	0.25	0.25	0.25	0.25	0.25	0.26	0.27	0.27	0.30
Timber Frame	0.15	0.15	0.15	0.25	0.27	0.27	0.27	0.27	0.30
Cob	0.54	0.54	0.54	0.54	0.54	0.54	0.56	0.56	0.59
Cob with internal or external insulation	0.59	0.59	0.59	0.59	0.59	0.59	0.61	0.61	0.64
System Build	0.25	0.25	0.25	0.25	0.25	0.30	0.30	0.30	0.30
System build with internal or external insulation	0.32	0.32	0.32	0.32	0.32	0.37	0.37	0.37	0.37

* If in Scotland add 0.20 m for bands A and B, and 0.10 for other bands
** If in Scotland add 0.05 m

S3.5 Heights and exposed wall areas

Heights are measured internally within each room, and 0.25 m is added by software to each room height except for the lowest storey of the dwelling, to obtain the storey height. Façade areas are obtained from the product of heat loss perimeter (after conversion to internal dimensions if relevant) and storey height, summed over all storeys.

For the main dwelling and any extension(s), window and door areas are deducted from the façade areas to obtain the net wall areas for the heat loss calculations, except for the door of a flat/maisonette to an unheated stair or corridor which is deducted from the sheltered wall area.

If an alternative wall is present, the area of the alternative wall is recorded net of any openings in it and the alternative wall is identified as part of the main wall or extension wall, so that it may be subtracted from that wall area prior to the calculation of wall heat losses.

S3.6 Door and window areas

The area of an external door is taken as 1.85 m². The number of external doors is:
- flat/maisonette with heated corridor: 0
- flat/maisonette with unheated corridor or no corridor: 1
- house/bungalow, enclosed mid-terrace or enclosed end-terrace: 1
- house/bungalow, not enclosed type: 2

External doors are taken as being in the main part of the dwelling.

> In RdSAP the definition of what is a window and what is a door is defined by the area of glazing in relation to the area of the whole opening, i.e. door and frame. To be classed as a window a glazed door and frame must contain glazing amounting to 60% or more or its surface area.

Total window area is assessed as being typical, more than typical, much more than typical, less than typical, or much less than typical.

Window area typical, more than typical or less than typical
Window areas are obtained by application of the appropriate equation from Table S4. The equation used is chosen according to the age band of the main part of the dwelling, with the resulting total window area apportioned between main part and extension(s) pro rata to their floor areas. If the window area of any part

of the dwelling (main, extension, 2nd extension) is greater than 90% of the exposed façade area of that part, after deducting doors and alternative wall area if applicable to that part, the window area is set equal to 90%.

Table S4 : Window area (m²)

Age band of main dwelling	House or Bungalow	Flat or Maisonette
A, B ,C	WA = 0.1220 TFA + 6.875	WA = 0.0801 TFA + 5.580
D	WA = 0.1294 TFA + 5.515	WA = 0.0341 TFA + 8.562
E	WA = 0.1239 TFA + 7.332	WA = 0.0717 TFA + 6.560
F	WA = 0.1252 TFA + 5.520	WA = 0.1199 TFA + 1.975
G	WA = 0.1356 TFA + 5.242	WA = 0.0510 TFA + 4.554
H	WA = 0.0948 TFA + 6.534	WA = 0.0813 TFA + 3.744
I	WA = 0.1382 TFA – 0.027	WA = 0.1148 TFA + 0.392
J, K	WA = 0.1435 TFA – 0.403	WA = 0.1148 TFA + 0.392
WA = window area TFA = total floor area of main part plus any extension		

This does not include conservatories, which are treated separately: see S6.

The window areas calculated using Table S4 are to be reduced by 25% if it is assessed as being less than typical for the age and type of property, and increased by 25% if assessed as being more than typical for the age and type of property.

When assessing window area consider the whole dwelling (windows, glazed doors and roof lights), including any extensions (**but not conservatories**).

Typical applies if the surface area of the glazing in the dwelling is essentially as would be expected of a typical property of that age, type, size and character. Even if there is slightly more or less glazing than would be expected, up to 10% more or less.

More than typical applies if there is significantly more surface area of glazing than would be expected (15%-30% more), perhaps because there is a large sun room or numerous patio doors have been added.

Less than typical applies if there is significantly less glazing than would be expected. This is rare as homeowners tend not to take out windows, but a property may have an unusual design with few windows.

Much more than typical and **Much less than typical** should be used for those dwellings with very unusual amounts of glazing; such as a glass walled penthouse flat or a Huff Haus. Due to this option allowing measurements of each window to be accounted for, it can also be used if a dwelling has a mixture of glazing types e.g. single, double and triple.

Two types of window are allowed for, single and multiple glazed. Multiple glazing can be double glazed units installed before 2002[*], double glazed units installed during/after 2002*, secondary glazing or triple glazing.

If more than one of type of multiple glazing is present, the assessor selects the type according to what is the most prevalent in the dwelling.

If secondary glazing has been removed in summer, enter as secondary glazing only if assessor can confirm that the panels exist and can be re-fitted. Evidence to be recorded on site notes.

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[*] 2002 in England & Wales, 2003 in Scotland, 2006 in Northern Ireland

The window area of each part of the dwelling (main, extension 1, extension 2) is divided into two areas, single and multiple, according to the assessor's estimate of the multiple-glazed percentage. The same percentage is used in main dwelling and each extension.

<u>Window area much more or much less than typical</u>
If window area is assessed as much greater than typical or as much less than typical, the total window area should be obtained from measurements of each individual window. In this case the area of each window in the main part of the dwelling and in any extension are recorded separately (along with whether single glazed, double glazed before or during/after 2002*, secondary glazing or triple glazed, and whether window or roof window) and Table S4 is not used. In this case there can be up to five types of window (although all types in one property is unlikely). The multiple-glazed percentage is calculated on the basis of the area and type of each window or roof window.

S3.7   Roof area

Roof area is the greatest of the floor areas on each level, calculated separately for main dwelling and any extension.

S3.8   Room in roof

The following procedure is applied to main dwelling and separately to any extension with roof rooms as applicable.

If there are roof rooms, with a total floor area of F_{rr} (measured internally), then:
(1) Area F_{rr} is deducted from the roof area determined at S3.4.
(2) A separate heat-loss roof of area $A_{rr} = F_{rr}$ is defined.
(3) A separate heat-loss wall of area A_{rw} is defined , where

$$A_{rw} = 11.0 \sqrt{F_{rr} / 1.5}$$ where the roof rooms are exposed on four sides, or

$$A_{rw} = 8.25 \sqrt{F_{rr} / 1.5}$$ where the roof rooms are adjacent to another part of the dwelling.

The roof rooms are adjacent to another part if there is another part of the dwelling at the same level as the roof room (where the main dwelling, extension 1 and extension 2 are considered as separate parts). This means the other building part has the same number of storeys and a roof room, or the other building part has more storeys than the current one (excluding roof rooms from the storey count for this purpose).

The areas A_{rr} and A_{rw} are based on a rectangular room-in-roof area of average height 2.2 m, and A_{rw} includes the walls of the roof rooms and the sloping parts their roof. The storey height for the room-in-roof is (2.2 + 0.25) = 2.45 m.

The default U-values for A_{rr} and A_{rw} are those for the appropriate age band for the construction of the roof rooms (see Table S10).

Where the thickness of insulation on the flat ceiling of the roof room can be determined, the U-value U_{rr} associated with A_{rr} is the lower of the U-value from Table S9 for the insulation thickness concerned and the and the U-value from Table S10 for the age band of the roof room.

Where the walls and sloping parts of the roof are known to be insulated, the U-value U_{rw} associated with A_{rw} is the lower of 0.68 W/m²K and the U-value from Table S10 for the age band of the roof room. U_{rr} is the value from Table S9 for the insulation thickness on the flat ceiling, except for a vaulted roof when the insulation of the flat ceiling is marked as "not applicable" and for the purposes of the calculation $U_{rr} = U_{rw}$.

The residual area (area of roof determined at S3.7 less the floor area of room(s)-in-roof) has a U-value according to its insulation thickness if at least half the area concerned is accessible, otherwise it is the default for the age band of the original property or extension.

Roof rooms constitute an additional storey.

S3.9   Heat loss floor area

The lowest floor of a dwelling can be a basement, a ground floor, an exposed floor (e.g. over a passageway) or a semi-exposed floor (e.g. over an integral garage) or not a heat loss floor (flats/maisonettes).

If it is a basement it is treated as if it were a ground floor for heat loss purposes.

S3.10   Heat loss floor area for houses and bungalows

The area of the lowest occupied floor is a ground floor. If the area of any upper floor is greater than that of the floor below, the difference in these areas is an exposed or semi-exposed floor. This can occur particularly when there is an integral garage. When external dimensions are being used, however, the method of dimensional conversion can result in a small, but spurious, exposed floor area. To avoid that situation., the area of exposed floor on any level cannot be greater than the difference between the area of the current floor and the floor below measured using external dimensions. This rule is implemented as follows:

1. Calculate the exposed floor area before converting dimensions, call this A_1
2. Convert dimensions
3. Calculate exposed floor area from the internal areas, call this A_2
4. If $A_2 \leq A_1$ the exposed floor area is A_2
5. If $A_2 > A_1$ the exposed floor area is A_1
6. Repeat for all levels if dwelling has more than two storeys, and obtain the total exposed floor area.

When dimensions have been measured internally, the exposed floor area is simply the difference in area between the current floor and the floor below.

Semi-exposed floors are treated as if they were fully exposed.

The ground floor area of the main dwelling and that of any extension are treated separately as they can have different U-values. The lowest floor of an extension is treated as a ground floor irrespective of the actual configuration.

S3.11   Heat loss floor area for flats and maisonettes

There is no heat loss through the floor if there is another flat below. Otherwise the floor area of the flat, or the lower floor of the maisonette, is:
- an exposed floor if there is an open space below;
- a semi-exposed floor if there are unheated premises below it (e.g. an enclosed garage);
- above a partially heated space if there are non-domestic premises below (heated, but at different times).

Semi exposed floors are treated as if they were fully exposed.

S3.12   Semi-exposed walls for flats and maisonettes

If the flat or maisonette is adjacent to an unheated corridor or stairwell, the area of wall between the dwelling and the corridor or stairwell is treated as a semi-exposed wall, see S5.2. Semi exposed walls in houses and bungalows are treated as if they were fully exposed.

> The length of wall between the dwelling and the unheated corridor or stairwell is included in the exposed perimeter.

S4   Parameters for ventilation rate

The parameters for calculation of the ventilation rate are obtained from Table S5.

Table S5 : Ventilation parameters

Parameter	Value
Chimneys	Number of open fireplaces
Flues	Number of open flues (main and secondary heating systems)
Ventilation system	Natural with intermittent extract fans, unless mechanical system clearly identified
Extract fans	Age bands A to E all cases 0 Age bands F to G all cases 1 Age bands H to K up to 2 habitable rooms 1 " 3 to 5 habitable rooms 2 " 6 to 8 habitable rooms 3 " more than 8 habitable rooms 4
Wall infiltration	According to the largest area of wall, system build treated as masonry, and infiltration according to masonry if equal. Net wall area after deduction of openings is used for this purpose, walls of roof rooms are not included.
Floor infiltration (suspended timber floor only)	Age band of main dwelling A to E: unsealed Age band of main dwelling F to K: sealed
Draught lobby	House or bungalow: no Flat or maisonette: yes if heated or unheated corridor
Percent of doors and windows draughtstripped	Windows draughtstripped equal to percentage of triple, double or secondary glazing (glazing in a non-separated conservatory is included in the calculation of the percentage) doors not draughtstripped
Number of storeys	Greater of the number of storeys in the main part of the dwelling and in any extension
Sheltered sides	4 for flat/maisonette up to third storey above ground level 2 in other cases
Age bands in this table relate to the age of the main dwelling and not to any extension. The number of rooms is as defined in S9.	

Include all open chimneys/fireplaces in the fireplace count (both downstairs and upstairs). The definition is a vertical duct with a flue diameter of at least 200 mm or its equivalent. The following are <u>not</u> counted as open fireplaces:

- Any open flue that is less than 200 mm diameter
- A permanently blocked up fireplace, even if fitted with an airbrick
- Any heating appliance with controlled flow of air supply i.e. appliance has closing doors
- A flexible gas flue liner sealed into the chimney (because the diameter is less than 200 mm)
- A chimney fitted with a damper enabling the flue to be mechanically closed when not in use

Temporary means of blocking a flue, e.g. cardboard, newspaper bungs and similar, are not a permanent means of controlling ventilation and therefore the chimney is counted as an open fireplace.

Note that this relates only to the number of open fireplaces (it affects the ventilation rate assumed for the calculation). Other rules apply when considering the choice of main or secondary heating systems.

If a mechanical ventilation system, it is treated as mechanical extract ventilation (MEV) if an extract-only system, and as mechanical ventilation with heat recovery (MVHR) if a balanced system, using the following data:

    MEV: specific fan power 0.8 W/(litre/sec)

    MVHR: specific fan power 2.0 W/(litre/sec), heat recovery efficiency 66%

S5   Constructional types and U-values

Reduced data SAP assigns default insulation on the basis of the age band of the part of the property concerned (main dwelling, extension, room in roof). Except for loft insulation which should be measured wherever possible, in most cases the construction elements will be indicated as "as-built" or "unknown insulation".

> Where it can be established that a building element has insulation beyond what would normally be assumed for the age band, this can be indicated if adequate evidence exists. Evidence can be:
> - what is observed in the site inspection (e.g. loft insulation, rafter insulation, cavity wall insulation), and/or
> - on the basis of documentary evidence.
>
> Acceptable documentary evidence includes certificates, warranties, guarantees, building regulation submissions and official letters from the applicable Registered Social Landlord (RSL). The assessor must be confident, and able to demonstrate, that any documentation relates to the actual property being assessed and that there is no physical evidence to the contrary.

> Walls
>
> If the dwelling has a wall type that does not correspond closely with one of the available options, select the nearest equivalent taking account of the U-values in the tables below and include addendum 1 (see S12).
>
> Where a cavity wall has been identified, enter as such irrespective of the width of the cavity.
>
> If there is a system built wall that has evidence of retro cavity fill, record as system build with internal insulation.
>
> Do not use the "unknown" option for wall insulation inappropriately as this automatically suppresses any insulation recommendation; assume as-built if no evidence of retro-fitted insulation.
>
> "Unknown" should be used only in exceptional circumstances, e.g. when there is conflicting evidence (inspection and/or documentary) of added insulation whose presence cannot be ascertained conclusively. In these cases clarification must be provided in site notes.

> Loft insulation
>
> If joist and rafter insulation are both present record joist insulation only
>
> If loft is fully boarded enter unknown unless householder has documentary evidence (maximum thickness is depth of joists) or is prepared to lift the boards
>
> If the property has modern foil or foam insulation at joists the depth of the insulation is entered as double its actual thickness.
>
> If varying levels, apply an area-weighted average. However if there is an area with no insulation the dwelling should be split to give different roof scenarios.

Table S19 indicates the options used for collection of data on site in respect of additional insulation of elements. These are:
- insulated floor
- cavity filled wall
- internal or external wall insulation
- measured thickness of loft insulation
- rafter insulation
- flat roof insulation
- insulation of roof rooms

A U-value is assigned to an insulated loft according to the measured thickness. In other cases the U-value is based on 50 mm of insulation of the mineral wool type. Additional roof insulation (at joists or rafters) should be indicated in the data collection only where it provides comparable thermal resistance.

Within software U-values of construction elements are determined from the constructional type and date of construction according to the tables below. U-values are assessed separately for the main part of the dwelling and for any extension. If the insulation status is unknown, the relevant value for "as built" is used.

S5.1   U-values of walls

Table S6 : Wall U-values – England and Wales

Age band Wall type	A	B	C	D	E	F	G	H	I	J	K
Stone: granite or whin (as built)	2.4	2.4	2.4	2.4	1.7	1.0	0.60	0.60	0.45	0.35	0.30
Stone: sandstone (as built)	2.1	2.1	2.1	2.1	1.7	1.0	0.60	0.60	0.45	0.35	0.30
Solid brick (as built)	2.1	2.1	2.1	2.1	1.7	1.0	0.60	0.60	0.45	0.35	0.30
Stone/solid brick (external insulation)	0.60	0.60	0.60	0.60	0.55	0.45*	0.35*	0.35*	0.30*	0.25*	0.21*
Stone/solid brick (internal insulation)	0.60	0.60	0.60	0.60	0.55	0.45*	0.35*	0.35*	0.30*	0.25*	0.21*
Cob (as built)	0.80	0.80	0.80	0.80	0.80	0.80	0.60	0.60	0.45	0.35	0.30
Cob (external insulation)	0.40	0.40	0.40	0.40	0.40	0.40	0.35*	0.35*	0.30*	0.25*	0.21*
Cob (internal insulation)	0.40	0.40	0.40	0.40	0.40	0.40	0.35*	0.35*	0.30*	0.25*	0.21*
Cavity (as built)	2.1	1.6	1.6	1.6	1.6	1.0	0.60	0.60	0.45	0.35	0.30
Filled cavity[+]	0.50	0.50	0.50	0.50	0.50	0.40	0.35	0.35	0.45[†]	0.35[†]	0.30[†]
Timber frame	2.5	1.9	1.9	1.0	0.80	0.45	0.40	0.40	0.40	0.35	0.30
System build (as built)	2.0	2.0	2.0	2.0	1.7	1.0	0.60	0.60	0.45	0.35	0.30
System build (external insulation)	0.60	0.60	0.60	0.60	0.55	0.45	0.35*	0.35*	0.30*	0.25*	0.21*
System build (internal insulation)	0.60	0.60	0.60	0.60	0.55	0.45	0.35*	0.35*	0.30*	0.25*	0.21*

* wall may have had internal or external insulation when originally built; this applies only if insulation is known to have been increased subsequently (otherwise "as built" applies)

[+] cavity wall with internal or external insulation to be treated as filled cavity wall for the purposes of the SAP calculation.

[†] assumed as built

Table S7 : Wall U-values – Scotland

Age band	A	B	C	D	E	F	G	H	I	J	K
Wall type											
Stone: granite or whin (as built)	1.7	1.7	1.7	1.7	1.7	1.0	0.60	0.45	0.45	0.30	0.25
Stone: sandstone (as built)	1.5	1.5	1.5	1.5	1.5	1.0	0.60	0.45	0.45	0.30	0.25
Solid brick (as built)	2.1	2.1	2.1	2.1	1.7	1.0	0.60	0.45	0.45	0.30	0.25
Stone/solid brick (external insulation)	0.60	0.60	0.60	0.60	0.55	0.45*	0.35*	0.30*	0.30*	0.21*	0.19*
Stone/solid brick (internal insulation)	0.60	0.60	0.60	0.60	0.55	0.45*	0.35*	0.30*	0.30*	0.21*	0.19*
Cob (as built)	0.80	0.80	0.80	0.80	0.80	0.80	0.60	0.60	0.45	0.30	0.25
Cob (external insulation)	0.40	0.40	0.40	0.40	0.40	0.40	0.35*	0.35*	0.30*	0.21*	0.19*
Cob (internal insulation)	0.40	0.40	0.40	0.40	0.40	0.40	0.35*	0.35*	0.30*	0.21*	0.19*
Cavity (as built)	2.1	1.6	1.6	1.6	1.6	1.0	0.60	0.45	0.45	0.30	0.25
Filled cavity$^+$	0.50	0.50	0.50	0.50	0.50	0.40	0.35	0.45†	0.45†	0.30†	0.25
Timber frame	2.5	1.9	1.9	1.0	0.80	0.45	0.40	0.40	0.40	0.30	0.25
System build (as built)	2.0	2.0	2.0	2.0	1.7	1.0	0.60	0.45	0.45	0.30	0.25
System build (external insulation)	0.60	0.60	0.60	0.60	0.55	0.45	0.35*	0.30*	0.30*	0.21*	0.19*
System build (internal insulation)	0.60	0.60	0.60	0.60	0.55	0.45	0.35*	0.30*	0.30*	0.21*	0.19*

* wall may have had internal or external insulation when originally built; this applies only if insulation is known to have been increased subsequently (otherwise "as built" applies)

$^+$ cavity wall with internal or external insulation to be treated as filled cavity wall for the purposes of the SAP calculation.

† assumed as built

Table S8 : Wall U-values – Northern Ireland

Age band	A	B	C	D	E	F	G	H	I	J	K
Wall type											
Stone: granite or whin (as built)	2.4	2.4	2.4	2.4	1.7	1.0	0.60	0.45	0.45	-	0.30
Stone: sandstone (as built)	2.1	2.1	2.1	2.1	1.7	1.0	0.60	0.45	0.45	-	0.30
Solid brick (as built)	2.1	2.1	2.1	2.1	1.7	1.0	0.60	0.45	0.45	-	0.30
Stone/solid brick (external insulation)	0.60	0.60	0.60	0.60	0.55	0.45*	0.35*	0.30*	0.30*	-	0.21*
Stone/solid brick (internal insulation)	0.60	0.60	0.60	0.60	0.55	0.45*	0.35*	0.30*	0.30*	-	0.21*
Cob (as built)	0.80	0.80	0.80	0.80	0.80	0.80	0.60	0.60	0.45	-	0.30
Cob (external insulation)	0.40	0.40	0.40	0.40	0.40	0.40	0.35*	0.35*	0.30*	-	0.21*
Cob (internal insulation)	0.40	0.40	0.40	0.40	0.40	0.40	0.35*	0.35*	0.30*	-	0.21*
Cavity (as built)	2.1	1.6	1.6	1.6	1.5	1.0	0.60	0.45	0.45	-	0.30
Filled cavity$^+$	0.50	0.50	0.50	0.50	0.50	0.40	0.35	0.45†	0.45†	-	0.30†
Timber frame (as built)	2.5	1.9	1.9	1.0	0.80	0.45	0.40	0.40	0.40	-	0.30
System build (as built)	2.0	2.0	2.0	2.0	1.7	1.0	0.60	0.45	0.45	-	0.30
System build (external insulation)	0.60	0.60	0.60	0.60	0.55	0.45	0.35*	0.30*	0.30*	-	0.21*
System build (internal insulation)	0.60	0.60	0.60	0.60	0.55	0.45	0.35*	0.30*	0.30*	-	0.21*

* wall may have had internal or external insulation when originally built; this applies only if insulation is known to have been increased subsequently (otherwise "as built" applies)

$^+$ cavity wall with internal or external insulation to be treated as filled cavity wall for the purposes of the SAP calculation.

† assumed as built

S5.2 U-values of semi-exposed walls

For semi-exposed walls of flats and maisonettes, the U-value for the applicable wall area is taken as that of the external walls of the dwelling adjusted as described in Section 3.3 using $R_u = 0.4$ m²K/W.

S5.3 U-values of roofs

The U-value assumed for a pitched roof with an insulated ceiling should, where possible, be based on the observed thickness of the loft insulation according to Table S9.

Table S9 : Roof U-values when loft insulation thickness at joists is known
(for insulation between joists including insulation at flat ceiling of a roof room)

Insulation thickness at joists (mm)	Assumed roof U-value (W/m²K)	
	Slates or tiles	**Thatched roof**
None	2.3	0.35
12	1.5	0.32
25	1.0	0.30
50	0.68	0.25
75	0.50	0.22
100	0.40	0.20
150	0.29	0.16
200	0.20	0.13
250	0.16	0.11
>= 300	0.13	0.10

Note: These U-values take account of joists. The insulation is taken as being between joists only up to 150 mm, and between and over joists for 200 mm or more.

If the insulation thickness is not known, the U-value should be taken from Table S10. For a pitched roof with no access, use the column for "between joists".

<div align="center">

Table S10 : Assumed U-values when the roof insulation thickness is unknown
(this includes all cases of insulation between rafters)

</div>

Age band	Assumed Roof U-value (W/m²K)					
	Pitched, slates or tiles, insulation between joists	Pitched, slates or tiles, insulation between rafters	Flat roof	Room-in-roof, slates or tiles	Thatched roof	Thatched roof, room-in-roof
A, B, C, D	2.3 (none) [1]	2.3 [1]	2.3 [1]	2.3 [1]	0.35	0.25
E	1.5 (12 mm) [1]	1.5 [1]	1.5 [1]	1.5 [1]	0.35	0.25
F	0.68 (50 mm)	0.68	0.68	0.80 [1]	0.35	0.25
G	0.40 (100 mm)	0.40	0.40	0.50	0.35	0.25
H	0.29 (150 mm)	0.35	0.35	0.35	0.35	0.25
I	0.26 (150 mm)	0.35	0.35	0.35	0.35	0.25
J	0.16 (250 mm)	0.20	0.25	0.30	0.30	0.25
K	0.16 (250 mm)	0.20	0.25 [2]	0.25 [2]	0.25 [2]	0.25 [2]

[1] If the roof is known to have more insulation than would normally be expected for the age band, either observed or on the basis of documentary evidence, use U = 0.68 W/m²K in these cases.

[2] 0.20 W/m²K in Scotland

Note: These U-values take account of joists. They may differ from Elemental U-values in regulations applicable at the time of construction, where the Elemental U-values in regulations (up to age band H) were set on the basis of ignoring joists in U-value calculations.

S5.4 U-values of floors next to the ground

The floor U-value is calculated according to BS EN ISO 13370 using its area (A) and exposed perimeter (P), and rounded to two decimal places. Floor U-values are obtained separately for the main dwelling and for any extension, using the applicable area, exposed perimeter and wall thickness. The following parameters are used:
– wall thickness (w) from Table S3
– soil type clay (thermal conductivity $\lambda_g = 1.5$ W/m·K)
– $R_{si} = 0.17$ m²K/W
– $R_{se} = 0.04$ m²K/W
– floor construction as specified by assessor, or from Table S11 if unknown
– all-over floor insulation of thickness from Table S11 with thermal conductivity 0.035 W/m·K
  ($R_f = 0.001*d_{ins}/0.035$ where d_{ins} if the insulation thickness in mm)

A non-separated conservatory has an uninsulated solid ground floor with wall thickness 300 mm.

<u>For solid ground floors</u>

    1. $d_t = w + \lambda_g \times (R_{si} + R_f + R_{se})$

    2. $B = 2 \times A/P$

    3. if $d_t < B$, $U = 2 \times \lambda_g \times \ln(\pi \times B/d_t + 1)/(\pi \times B + d_t)$

    4. if $d_t >= B$, $U = \lambda_g / (0.457 \times B + d_t)$

<u>For suspended floors:</u>
– thermal resistance of floor deck 0.2 m²K/W
– height above external ground level h = 0.3 m
– average wind speed at 10 m height v = 5 m/s
– wind shielding factor $f_w = 0.05$

– ventilation openings per m exposed perimeter ε = 0.003 m²/m
– U-value of walls to underflow space U_w = 1.5 W/m²K

1. $d_g = w + \lambda_g \times (R_{si} + R_{se})$

2. $B = 2 \times A/P$

3. $U_g = 2 \times \lambda_g \times \ln(\pi \times B/d_g + 1)/(\pi \times B + d_g)$

4. $U_x = 2 \times h \times U_w/B + 1450 \times \varepsilon \times v \times f_w/B$

5. $U = 1 / (2 \times R_{si} + R_f + 0.2 + 1/(U_g + U_x))$

Table S11 : Basis for floor U-value calculation

Age band	Floor construction[1]	All-over floor insulation[2]		
		England & Wales	Scotland	Northern Ireland
A, B	suspended timber [3]	none	none	none
C to G	solid	none	none	none
H	solid	none	25 mm	25 mm
I	solid	25 mm	50 mm	50 mm
J	solid	75 mm	75 mm	-
K	solid	100 mm	100 mm	100 mm

[1] Where floor construction is unknown

[2] For floors which have retro-fitted insulation, use the greater of 50 mm and the thickness according to the age band.

[3] Solid ground floor if underfloor heating.

S5.5 U-values of exposed and semi-exposed upper floors

To simplify data collection no distinction is made in terms of U-value between an exposed floor (to outside air below) and a semi-exposed floor (to an enclosed but unheated space below) and the U-values in Table S12 are used.

Table S12 : Exposed/Semi-exposed floor U-values

Age band	U-value (W/m²K)	
	Insulation unknown or as built	**Insulated (usually retro-fit)**
A to G	1.20	0.50
H or I	0.51	0.50
J	0.25	0.25
K	0.22	0.22

S5.6 U-value of floor above a partially heated space

The U-value of a floor above partially heated premises is taken as 0.7 W/m²K. This applies typically for a flat above non-domestic premises that are not heated to the same extent or duration as the flat.

S5.7   Allowance for thermal bridging

The thermal bridging factor, y, as defined in Appendix K is taken from Table S13.

Table S13 : Thermal bridging

Age band	Thermal bridging factor y (W/m²K)
A to I	0.15
J	0.11
K	0.08

y is determined according to the age band of the main dwelling and applied to the all the exposed area including main dwelling, extensions, and non-separated conservatory.

S6   Conservatory

The floor area and volume of a <u>non-separated conservatory</u> are added to the total floor area and volume of the dwelling. Its roof area is taken as the same as its floor area, and wall area is taken as the product of its exposed perimeter and its height. Its height can be estimated from the equivalent number of storey heights of the dwelling to the nearest half storey (based on average internal height within the conservatory). The conservatory walls and roof are taken as fully glazed (and this glazed area applied in addition to that from Table S4). Glazed walls are taken as windows, glazed roof as rooflight, see Table S14.

The number of storey heights are translated into an actual height according to:
- 1 storey: ground floor room height
- 1½ storey: ground floor room height + 0.25 + 0.5*(first floor <u>room</u> height)
- 2 storey: ground floor room height + 0.25 + first floor <u>room</u> height
etc.

In the case of a <u>separated conservatory that has fixed heater(s)</u> this is noted for the EPC but does not affect the energy calculations (calculations done as if conservatory were not present).

S7   Solar gains

Solar gains are calculated for average overshading (Table 6d) and for East/West orientation of all windows. A conservatory roof is taken as horizontal for the purposes of Table 6a.

S8   Windows and doors

S8.1   Window U-values and g-values

The U-value of windows and the solar transmittance of glazing is taken from Table S14.

Table S14 : Window characteristics

Glazing	Installed	Frame (for Table 6c)	U-value (window)	U-value (roof window)**	g-value
Single	any	wood frame frame factor 0.7	4.8	5.1	0.85
Double glazed unit*	England & Wales: before 2002, Scotland: before 2003 N. Ireland: before 2006	PVC frame frame factor 0.7	3.1	3.3	0.76
Double glazed unit	England & Wales: 2002 or later, Scotland: 2003 or later N. Ireland: 2006 or later	PVC frame frame factor 0.7	2.0	2.2	0.72
Secondary glazing	any	wood frame frame factor 0.7	2.4	2.6	0.76
Triple glazing	any	PVC frame frame factor 0.7	2.0	2.2	0.68
* Use this row for conservatories and for other double glazing whose installation date is unknown. ** Applies only where all windows are measured individually. Otherwise all glazing is assigned to windows. U-values are adjusted for curtains (section 3.2 of the SAP specification)					

Table S15 applies to a non-separated conservatory.

Table S15 : Non-separated conservatory

Glazing	Age band	Frame (for Table 6c)	Window U-value	Roof U-value	g-value
Single	any	wood frame	4.8	5.1	0.85
Double	any	PVC frame	3.1	3.3	0.76
U-values are adjusted for curtains (section 3.2 of the SAP specification)					

The orientation of windows is not recorded, thus solar gains are calculated using the default solar flux (East/West orientation for windows, horizontal for roof windows) in all cases.

S8.1   Door U-values

Table S15A : Doors

Door opens to	Age band	Door U-value
Outside	A to J	3.0
	K	2.0
Unheated corridor or stairwell	any	1.4
Heated corridor or stairwell	any	(assume no heat loss)

S9   Room count and living area fraction

S9.1   Room count

The room count is equal to the number of habitable rooms[*].

> Habitable rooms include any living room, sitting room, dining room, bedroom, study and similar; and also a non-separated conservatory. A kitchen/diner having a discrete seating area also counts as a habitable room.
>
> A non-separated conservatory adds to the habitable room count if it has an internal quality door between it and the dwelling.
>
> Excluded from the room count are any room used solely as a kitchen, utility room, bathroom, cloakroom, en-suite accommodation and similar; any hallway, stairs or landing; and also any room not having a window.
>
> For open plan dwellings count all spaces thermally connected to the main living area (e.g. a living/dining room) as one room.
>
> For a kitchen to be a kitchen/diner it must have space for a table and 4 chairs.
>
> A lounge/dining room where the door was temporarily removed (i.e. architrave and hinges still there) is two habitable rooms.
>
> A lounge/dining room with the door permanently removed (hinge holes filled etc) is one habitable room.

S9.2   Living area fraction

The living area fraction is determined from the number of habitable rooms.

Table S16 : Living area fraction

Number of rooms:	1	2	3	4	5	6	7	8
Living area fraction:	0.75	0.50	0.30	0.25	0.21	0.18	0.16	0.14
Number of rooms:	9	10	11	12	13	14	15+	
Living area fraction:	0.13	0.12	0.11	0.10	0.10	0.09	0.09	

S10   Space and water heating

S10.1   Main space heating system

In the case of a gas or oil boiler, the database is to be used whenever possible. There is a significant difference between the database values and the defaults in Table 4b in many cases.

Otherwise space heating systems are those marked "rd" in Tables 4a and 4b. Some systems which are difficult to distinguish in a site survey are omitted; the SAP assessor selects the nearest equivalent from those available in the reduced data set. The following are to be assumed as not fan-assisted:
- gas boiler pre 1998 with balanced or open flue
- oil boiler
- gas warm air, balanced or open flue

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[*] In Scotland, usually referred to as "apartments".

Where no space heating system is present, the calculation is done for portable electric heaters (with no controls) in all habitable rooms. The heating type for this case (as is needed for SAP Table 9) is 2, the same as for portable electric heaters with no controls.

For treatment of unheated habitable rooms see A4 in Appendix A.

If both underfloor and radiators, enter radiators. This is because if radiators are present there has to be a higher flow temperature.

If electric storage heaters are present as main heating but single meter, enter as electric panel heaters and include addendum 6 (see S12). If the storage heaters are fan-assisted suppress the recommendation for fan-assisted storage heaters.

If boiler/heating system is present but not working (or condemned) it should still be entered as the main heating system. However if boiler is not present enter no heating system even though a boiler is intended.

A community heating system is one that serves more than one dwelling. Select the actual fuel used by the community system where that can be ascertained; if it cannot be, select mains gas.

Enter a micro-CHP system as a condensing boiler and include addendum 5 (see S12)..

S10.2   Space heating controls

Space heating controls are those marked "rd" in Table 4e. Some control features whose effect is small are omitted.

If the dwelling has only TRVs for heating controls of a boiler system select the option "no controls" (code 2101) and include addendum 7 (see S12).

S10.3   Secondary heating

Include a secondary heater if there is a fixed emitter present regardless of whether "central heating" heats all rooms.

If more than one secondary heater:
(a) select the device that heats greatest number of habitable rooms;
(b) if that does not resolve it, select the device using the cheapest fuel;
(c) if that does not resolve it, select the device with the lowest efficiency.

Electric focal point fires are included even if not wired by fixed spur.

An open fireplace is to be considered in the heating assessment if capable of supporting an open fire, even if no fuel is present: use fuel specified in SAP Table 12.

Open fires in bedrooms are disregarded when identifying the heating systems (main and secondary) and heated habitable room count. They are counted in the number of open chimneys, if appropriate.

S10.4   Water heating

The size of a hot-water cylinder is taken as according to Table S17.

Table S17 : Cylinder size

Descriptor	Indicative size range	Size to be used in SAP calculation
Inaccessible		if off-peak electric dual immersion: 210 litres if from solid fuel boiler: 160 litres otherwise: 110 litres
Normal	90 – 130 litres	110 litres
Medium	131 – 170 litres	160 litres
Large	> 170 litres	210 litres

If water heating is from a community system providing DHW only, enter the heating as gas multipoint and include addendum 3 on the EPC (see S12). If there is then a recommendation for a gas boiler (fuel switch), deselect it.

If there is a range cooker supplying DHW only, enter secondary heating as a closed room heater with boiler using the same fuel as the range cooker and add addendum 2. Any additional secondary heater is not included in the assessment; in that case record the presence of additional secondary heater in site notes with comment that it could not be included.

S10.5   Back boilers

Where water heating is from a back boiler or room heater with boiler, and the boiler provides water heating only, the appropriate fire or room heater is identified in the data collection process, and the water heating is identified as from main system or from secondary system.

Where the back boiler provides space heating:
- if gas, the back boiler is selected as main heating, the associated fire is selected as the secondary heating, and the water heating is from main system.
- if oil or solid fuel, the combination of room heater and boiler is selected as main heating and the water heating is from main system.

For the purposes of the calculation the appropriate fire or room heater is substituted. In the case of a gas fire with back boiler, the efficiency of the fire is from the room heater section of Table 4a according to the type of fire and the efficiency of the back boiler is 65% (from water heating section of Table 4a). In the case of oil or solid fuel, the efficiency from the room heater section of Table 4a is applied to both the fire/room heater and the boiler.

S10.6   No water heating system

Where no water heating system is present, the calculation is done for an electric immersion heater. If the electric meter is dual the immersion heater is also dual, but is a single immersion otherwise (including unknown meter). The calculation is done for a cylinder defined by the first row of Table S17 and the first row of Table S18.

S10.7   Space and water heating assumptions

Parameters not included in the data collection (Table S19) are defined in Table S18.

Table S18 : Heating and hot water parameters

Parameter	Value
Hot water cylinder insulation if not accessible	Age band of main property A to F: 12 mm loose jacket Age band of main property G, H: 25 mm foam Age band of main property I to K: 38 mm foam
Cylinderstat if no access	No cylinderstat (but see also 9.3.7)
Insulation of primary pipework	Age bands A to J: no Age band K: yes
Space heating circulation pump for wet systems	Within heated space
Oil pump for oil boilers	Not in heated space
Gas boilers pre 1998, balanced or open flue	Not fan-assisted
Oil boilers from SAP table	Not fan-assisted
CPSU	In airing cupboard Gas: if data from Table 4b, store volume 80 litres, store loss rate 2.72 kWh/day Gas: if data from database use store volume and insulation thickness from database Electric: store volume 300 litres, store loss rate 3.16 kWh/day, store temperature 90°C
Gas warm air system, balanced or open flue (not the fan-assisted types)	Not fan assisted
Solid fuel boiler or room heater	Not HETAS approved
Underfloor heating	If dwelling has a ground floor, then according to the floor construction (see Table S11 if unknown): - solid, main property age band A to E: concrete slab - solid, main property age band F to K: in screed - suspended timber: in timber floor - suspended, not timber: in screed Otherwise (i.e. upper floor flats), take floor as suspended timber if the wall is timber frame and as solid for any other wall type, and apply the rules above.
Hot water separately timed	Age bands A to I: no Age bands J, K: yes
Hot water cylinder in heated space	Yes
Boiler interlock	Assumed present if there is a room thermostat and (for stored hot water systems heated by the boiler) a cylinder thermostat. Otherwise not interlocked.
Summer immersion where DHW is provided by a solid fuel open fire or closed room heater	Yes, single immersion
Supplementary immersion heater for DHW from heat pump	Yes
Electricity tariff	See S11

Parameter	Value
Solar panel	If present, the parameters for the calculation are: - panel aperture area 3 m² - flat panel, $\eta_0 = 0.80$, $a_1 = 4.0$ - facing South, pitch 30°, modest overshading - if regular boiler: combined cylinder, solar part one-third of total (if separate pre-heat cylinder, assess total cylinder size (Table S17) on the basis of both cylinders) - if combi boiler or CPSU or instantaneous water heater or DHW from community system: 75 litre pre-heat cylinder - pump for solar-heated water is electric (75 kWh/year)
Photovoltaics	If present, the parameters for the calculation are: - PV area is roof area for heat loss (before amendment for any room-in-roof), times percent of roof area covered by PVs, and if pitched roof divided by cos(35°). If there is an extension, the roof area is adjusted by the cosine factor only for those parts having a pitched roof. - kWp is $0.12 \times$ PV area. - facing South, pitch 30°, modest overshading
Wind turbine	1 turbine with 1.75 m rotor diameter and 2 m hub height.

Community heating scheme	system based on boiler with efficiency 80% or heat pump with efficiency 300%
	   piping installed before 1990, pre-insulated
	
	If CHP (if waste heat or geothermal treat as CHP):
	   fraction of heat from CHP = 0.35
	   CHP overall efficiency 75%
	   heat to power ratio = 2.0

S11   Electricity tariff

The electricity meter is recorded as single, dual (two separate readings), dual 24-hour (only in Scotland) or unknown (if inaccessible).

If single, it is standard electric tariff.

If dual, it is off-peak 7-hour tariff, except when the main heating is an electric CPSU or a direct-acting electric boiler, for which the off-peak 10-hour tariff applies.

Off-peak tariff is needed for:
- electric storage heaters
- underfloor heating, main dwelling age bands A to E (concrete assumed)
- electric dry core or water storage boiler
- electric CPSU
- dual electric immersion
and the data is inconsistent if a single meter is indicated when any of these are present. However a dual meter is possible even if off-peak is not used for heating or DHW.

If dual, assign electricity uses to tariffs according to 10.4.2.

If unknown, use standard tariff except where main heating or water heating require an off-peak tariff (per systems listed above) or where main heating is ground source or water source heat pump.

> If electric storage heaters or off-peak electric underfloor heating is the main system, the assessor must specify a secondary system (see Appendix A); if no secondary heater has been identified the secondary system is portable electric heaters.

S12   Addendum to EPCs

Where a feature, e.g. wall type or heating system, is not part of the reduced data set, a near equivalent should be selected. For the circumstances indicated below, an explanation can be provided on the EPC by way of an addendum.

Reference Number	Circumstances	Addendum text on EPC
1	Wall type does not correspond to options available in RdSAP	The dwelling has a type of wall that is not included in the available options. The nearest equivalent type was used for the assessment.
2	Room heater specified for water heating instead of a range cooker	The water heating in this property is from a range cooker. A room heater using the same fuel, which gives similar ratings, was used for the assessment.
3	Space heating from individual system and water heating from community system	The water heating for this property is supplied from a community system. A multipoint gas heater, which gives similar ratings, was used for the assessment.
4	Dwelling has a swimming pool	The energy assessment for the dwelling does not include energy used to heat the swimming pool.
5	Dwelling has micro-CHP	The dwelling has a micro-CHP system. This is outside the scope of the assessment methodology and a condensing boiler was used for the assessment.
6	Off-peak appliance(s) with single meter	A dual rate appliance(s) is present with a single-rate supply. A single-rate appliance has been used for the assessment. Changing the electricity tariff to an off-peak (dual rate) supply is likely to reduce fuel costs and improve the energy rating.
7	Heating controlled by TRVs only	It has been noted that the heating is controlled by TRVs only, which is not one of the currently available options. The recommendation on heating controls should be understood as adding a programmer and room thermostat alongside the existing TRVs.
8	PVs or wind turbine present on the property (England, Wales or Scotland)	The assessment does not include any feed-in tariffs that may be applicable to this property.

In most cases the addenda are a temporary measure; if an addendum is used frequently the reduced data set will be extended in a future revision so as to avoid the need for it. The list of addenda shown above is current at the date of this document; items will be modified or added as appropriate.

> Software displays the current list of possible addenda (showing the 'circumstances' for each one); the assessor can select one or more to be included on the EPC.

S13   Improvement measures

The effect of improvement measures is assessed by amending the data for the existing dwelling according to the improvement measure being considered. When a number of measures are being considered, the effect

of any one of them on the SAP and Environmental Impact ratings depends, in general, on the order in which they are introduced. A standard list of improvement measures and how their effect on energy performance is to be assessed is provided in Appendix T.

> Recommendations should be removed only if there is evidence, visual or documentary, showing that a specific recommendation is not appropriate. The EPC contains caveats to the effect that further guidance on specific recommendations should be sought from an appropriate professional organisation, for example heating engineers, building control officers, product manufacturers, trade associations, energy efficiency adviser, etc.. A listed building or a property in a conservation area is not sufficient grounds in its own right to suppress a recommendation.
>
> If a recommendation is removed this must be recorded with reasons in site notes.

An improvement measure is assessed by adjusting the values within the reduced data set. For increased loft insulation, for example, the calculation would be re-done with a different roof U-value taken from Table S9 according to the proposed new thickness of the loft insulation. For some cases involving new technology, appropriate data may be added in future via the Appendix Q procedure.

S14   Data to be collected

Table S19 : Data to be collected

Item	Data	Comment
Transaction type	One of: - marketed sale* - non-marketed sale - rental (social) - rental (private) - not sale or rental * termed "single survey" in Scotland	Non-marketed sale includes right-to-buy Private rental includes institutions (e.g. university) EPC not required by regulations if not sale or rental; this case will be uncommon
Built form and detachment	Classification according to S1.	Detachment does not need to be recorded for flats/maisonettes, provided that internal dimensions are being used.
Age band	According to S2.	Identify age band separately for: – main property – any extension – rooms in roof (separately for main dwelling and any extension)
Number of rooms	Number of habitable rooms Number of heated habitable rooms	Total as defined in S9.1, inclusive of main property and any extension. A heated room is one with a fixed heat emitter in the room.
Dimension type	Measured internally or externally	Applies to areas and perimeters. Room heights always measured internally within the room. See S3.
Dimensions	Area, average room height and exposed perimeter for each floor (from lowest occupied floor up to lowest occupied + 6)	Measured separately for main property and any extension For rooms-in-roof, measure floor area only, inside the dwelling
Conservatory	One of - no conservatory - separated, no fixed heaters - separated, fixed heaters - not separated	If separated with fixed heaters, is noted on EPC
Non-separated conservatory.	Floor area Glazed perimeter Double glazed (yes/no) Height (number of half storeys of main dwelling)	See section 3.3.3.

Item	Data	Comment
Flats and maisonettes	Heat loss corridor, one of: - no corridor - heated corridor - unheated corridor	
	If unheated corridor, length of sheltered wall	The length of wall between flat and corridor
	Floor level (0 for ground floor) and number of floors in block	The lowest floor level of a maisonette. If there is a basement, the basement is level 0 and the other floors from 1 upwards.
	For flats other than ground floor flats, floor is one of: - above another dwelling - above partially heated space - above unheated space - fully exposed	A heated space below applies when it is above another flat. A partially heated space below applies when it is above non-domestic premises. An unheated space below applies when it is above a space not used for habitation. Where the flat is above more than one type, it is classified according to the largest floor area concerned.
Floor construction	One of: - unknown - solid - suspended timber - suspended, not timber	Recorded separately for main dwelling and any extension. Not if another dwelling or other premises below.
Floor insulation	One of: - unknown - as built - retro-fitted	Recorded separately for main dwelling and any extension. Not if another dwelling or other premises below. There must be evidence for retro-fit insulation
Wall construction	One of: - stone (granite or whin) - stone (sandstone) - solid brick - cob - cavity - timber frame - system build (i.e. any other)	Recorded separately for main dwelling and any extension.

Item	Data	Comment
Wall insulation	One of: - external - filled cavity - internal - as built - unknown	Recorded separately for main dwelling and any extension. External, cavity or internal insulation to be indicated only if added subsequent to original construction and evidence exists. If it has only the insulation that was part of the original construction it is "as built".
Alternative wall construction (if present)	- Location - construction (as preceding item) - insulation (as preceding item) - net area of alternative wall	Location identifies whether part of main wall or an extension wall
Roof construction	One of: - pitched (slates or tiles), access to loft - pitched (slates or tiles), no access - pitched (thatch) - flat - another dwelling above	Recorded separately for main dwelling and any extension
Roof insulation (if not another dwelling above)	One of: - none - at joists - at rafters - flat roof insulation - unknown	Recorded separately for main dwelling and any extension There must be evidence for joist, rafter or flat roof insulation, otherwise it is "unknown"
Roof insulation thickness (pitched roof with insulation at joists, applies to roof or parts of roof without roof room)	One of: - 12, 25, 50, 75, 100, 150, 200, 250, ≥300 mm	Only for roof insulation at joist level and where can be accessed. Recorded separately for main dwelling and any extension. If none or unknown this is recorded via the preceding item.
Roof room insulation	One of: - unknown - no insulation - flat ceiling only - all elements	Only when there is a roof room in the building part concerned There must be evidence for insulation of flat ceiling or all elements, otherwise it is "unknown".
Roof room insulation thickness (on flat part of roof of roof room)	One of: - 12, 25, 50, 75, 100, 150, 200, 250, ≥300 mm, not applicable	Only if roof room insulation is "flat ceiling only" or "all elements" "not applicable" is for the case of (documentary) evidence of insulation of all elements, but it is a vaulted ceiling with no flat part.

Item	Data	Comment
Windows (of the dwelling only, not including any conservatory)	Area: one of – typical – less that typical – much less than typical – more than typical – much more than typical	"Typical" refers to normal construction for the property type and age band concerned. If assessed as much more or much less than typical the area of each window should be measured.
If window area is typical, less than typical or more than typical	Proportion with multiple glazing Multiple glazing type, one of: - d/g pre year xxxx - d/g during or post year xxxx - d/g unknown date - secondary glazing - triple glazing	As percentage xxxx is: - 2002 in England & Wales - 2003 in Scotland - 2006 in Northern Ireland If more than one type, assessor selects the most prevalent
If window area is much less or much more than typical	For each window: - area (including frame) - glazing type (as above) - window or roof window - in main, extension or extension 2	This option can also be used if more than one type of multiple glazing
Fireplaces	Number of open fireplaces	
Main heating system (option to say "none")	Fuel for main heating	If none, the calculation is done for portable electric heaters with no controls
	Boiler identification whenever possible, otherwise system (marked "rd") from Table 4a or 4b	If boiler can be identified, its characteristics are obtained via the boiler efficiency database
	Flue type, one of - open - room-sealed	Applies to boilers and warm-air systems. For fires and roomheaters use normal flue type indicated in Table 4a
	For gas boilers 1998 or later, the ignition type, one of - auto-ignition - permanent pilot light	Not if from database
	For gas boilers 1998 or later, the whether or not fan-flued	Not if from database
	For gas and oil boilers, for heat pumps to water and for electric CPSUs, the heat emitter type, one of - radiators - underfloor	If underfloor downstairs and radiators upstairs, select radiators
Community heating system	Fuel used by community system If CHP then CHP fuel	If fuel cannot be ascertained, use mains gas
Main heating controls	Item from Table 4e according to main system type	Some additional items are now in Table 4e

Item	Data	Comment
Secondary heating system	Fuel for secondary heating, and system from room heater section of Table 4a	"None" if no secondary heating system
Water heating	Either - from main heating system, or - from secondary system, or - item (marked "rd") from hot-water-only section of Table 4a, or - no DHW system present	If no system, the calculation is done for an electric immersion , see text below Table S17.
	Cylinder size, one of: - no cylinder - no access - normal (90-130 litres) - medium (131-170 litres) - large (> 170 litres)	Separate thermal store (hot-water only or integrated) treated as if it were a cylinder
	Cylinder insulation type, one of - no access - none - jacket - spray foam	
	Cylinder insulation thickness, one of: 0, 12, 25, 38, 50, 80, 120, 160 mm	
	If immersion, whether single or dual	
	Cylinderstat (yes/no)	
Mechanical ventilation	yes/no, and if yes whether extract-only or balanced	Applies to whole house ventilation system only. Otherwise natural ventilation is assumed. Intermittent extract fans (kitchen and bathrooms) are not a mechanical ventilation system for SAP calculations, but continuously running extract fans in wet rooms are treated as mechanical extract ventilation..
Electricity meter	Dual/single/24-hour/unknown	See S11

Item	Data	Comment
Mains gas available	yes/no	Yes means that there is a gas meter or a gas-burning appliance (e.g. cooker) in the dwelling. A closed-off gas pipe does not count. Where a boiler is present attached to a heating system (not in a box), and the mains gas meter has been removed for security reasons, enter a gas boiler as the main form of heating and indicate that mains gas is present. Can be relevant to improvement recommendations.
Solar water heating	Solar panel (yes/no)	
Photovoltaic array	yes/no, and if yes the % of external roof area with PVs	
Terrain	One of: - dense urban - low rise urban or suburban - rural	Used to generate wind turbine recommendation where appropriate – data item must always be collected
Wind turbine	yes/no	
Low energy lighting	Percentage of fixed outlets	LEDs are considered as low energy lights. Where there are 4 or more downlighters/ceiling lights divide the bulb count by 2. Include fixed under-cupboard kitchen strip lights/
Swimming pool	A swimming pool is not included in the data set.	Count the room containing the swimming pool as a habitable room and add addendum 4 (see S12).

Appendix T: Improvement measures

Section T1 defines the circumstances under which each recommendation is made for existing dwellings. The texts used on the EPC for the recommendations are published separately.

Section T2 defines the circumstances under which each recommendation is made for new dwellings. The texts used on the EPC for the recommendations are published separately.

T1   Table of improvement measures for existing dwellings

Software tests for the relevance of improvement measures, and applies them where relevant, in the order shown in this table.
Several heating measures apply when mains gas is not available. When mains gas is available they are substituted by a fuel switch recommendation (item T). A recommendation is actually made only if it increases the SAP rating by at least 0.95 (or 0.45 in the case of LEL, item E).

Item	Measure	To be considered when existing dwelling has:	Recommended if existing dwelling has:	Improve to:	Rec. number
LOW COST MEASURES					
A	Loft insulation	Pitched roof (slates or tiles), accessible loft, insulation at ceiling level. Note: This does not include insulation of a room-in-roof	<= 150 mm insulation	250 mm insulation. See Note 2	5
B	Cavity wall insulation	Unfilled cavity wall (assessed as "as built" and not "unknown")	Wall U-value (from RdSAP tables) > 0.6	Cavity filled wall. U-value from RdSAP tables according to age of wall. See Note 3	6
C	Hot water cylinder insulation	Cylinder present and accessible.	No cylinder insulation	160 mm jacket	1
			Factory-applied insulation <= 25 mm	Add 80 mm jacket. See Note 1	3
			Jacket < 100 mm	Make up to 160 mm	2
D	Draughtproofing	Single glazed windows present	Double glazed windows between 51% and 80% of total window area.	Draught-proofing for all single glazed windows. Draught-proofed area includes all windows (but not doors)	10

Item	Measure	To be considered when existing dwelling has:	Recommended if existing dwelling has:	Improve to:	Rec. number
E	Low energy lights	All cases	Low energy lights < 100% of fixed outlets	Low energy lamps in all fixed outlets	35
F	Cylinder thermostat	Cylinder present and accessible	No cylinderstat (Note: cylinderstat is assumed for electric immersions)	Cylinderstat	4
G	Heating controls for wet central heating system	Main heating by boiler with radiators	No controls	Roomstat, programmer and TRVs	11
			Programmer only	do.	12
			Roomstat only	do.	15
			Programmer, single roomstat (no TRVs)	do.	13
			Programmer, TRVs (no roomstat or BEM)	do.	14
			Programmer and at least two roomstats	Time and temperature zone control	16
		Main heating by boiler with underfloor heating	Less than time and temperature zone control	Time and temperature zone control	16
		Main heating by heat pump with radiators or underfloor heating	Less than time and temperature zone control	Time and temperature zone control	16
H	Heating controls for warm air system	Main heating by mains gas or LPG warm air (including heat pumps)	No control	Programmer and roomstat	17
			Programmer only	do.	18

Item	Measure	To be considered when existing dwelling has:	Recommended if existing dwelling has:	Improve to:	Rec. number
HIGHER COST MEASURES					
I	Upgrade boiler, same fuel	Main heating by mains gas boiler (including range cooker boiler) or CPSU or by LPG or oil boiler (including range cooker boiler) and mains gas not available	Boiler, not condensing, hot water cylinder in dwelling	Band A regular boiler, same fuel as original. See Note 4	20
			Boiler, not condensing, no hot water cylinder in dwelling	Band A combi boiler, same fuel as original. See Note 4	21
			CPSU, not condensing	Condensing CPSU. See Note 5	36
			Range cooker boiler, hot water cylinder in dwelling	Band A regular boiler, same fuel as original. See Note 4	37
			Range cooker boiler, no hot water cylinder in dwelling	Band A combi boiler, same fuel as original. See Note 4	38
J	Biomass boiler	Independent solid fuel boiler (not biomass or dual fuel)	Mains gas not available	Manual feed biomass boiler in heated space (wood logs) with radiators, HETAS approved	22
K	Biomass room heater with boiler	Solid fuel open fire with or without boiler (not biomass or dual fuel)	Mains gas not available	Wood pellet stove with radiators, HETAS approved, summer immersion heater. See Note 8.	23
		Solid fuel room heater with or without boiler (not biomass or dual fuel)	Mains gas not available	Wood pellet stove with radiators, HETAS approved, summer immersion heater. See Note 8.	39

L	New or replacement storage heaters	Main heating by storage heaters, Old (large volume) or Modern (slimline)	Mains gas not available, and hot-water heating by cylinder with single immersion, or from solid-fuel secondary heater	Fan-assisted storage heaters and dual immersion water heating, large cylinder with 50 mm factory-applied insulation Secondary electric heaters if no existing secondary	24
			Mains gas not available, and any other hot water system	Fan-assisted storage heaters Secondary electric heaters if no existing secondary	25

		Main heating by:
		  - electric room heaters
		  - electric ceiling heating
		
		Also if no space heating system present
			Mains gas not available, and hot-water heating by cylinder with single immersion or from solid-fuel secondary heater or no hot water system present	Fan-assisted storage heaters, 7-hour of-peak tariff and dual immersion water heating, large cylinder with 50 mm factory-applied insulation
				
				Secondary electric heaters if no existing secondary
					30

			Mains gas not available, and any other hot water system	Fan-assisted storage heaters, 7-hour of-peak tariff Secondary electric heaters if no existing secondary	31
M	Replacement warm-air unit	Main heating by mains gas or LPG warm air	Age before 1998	New (non-condensing) warm-air unit, same fuel as original, on-off control, fan-assisted flue	26

Item	Measure	To be considered when existing dwelling has:	Recommended if existing dwelling has:	Improve to:	Rec. number
FURTHER MEASURES					
N	Solar water heating	House or bungalow, not thatched roof	No solar panel	Solar panel with parameters per Table S18. Increase a normal size cylinder to medium (not not applicable to combi boiler or CPSU or instantaneous water heater or community heating with no cylinder in dwelling).	19
O	Double glazing	Single glazed windows present	Double glazed windows less than 51% of total opening area (total opening area includes doors)	If all windows measured, all single glazed windows replaced by double glazing with U = 2.0 and g = 0.72. Otherwise all windows changed to double glazing with U = 2.0 and g = 0.72.	8
P	Secondary glazing	Single glazing present but assessor de-selected measure O. See Note 6	Double or secondary glazed windows less than 51% of total opening area (total opening area includes doors)	If all windows measured apply secondary glazing to single glazed windows with U = 2.4 and g = 0.76. Otherwise all windows changed to secondary glazing with U = 2.4 and g = 0.76.	9
Q	Solid wall insulation	Solid wall, stone or brick (assessed as "as built" and not "unknown")	Wall U-value (from RdSAP tables) > 0.6	Internal or external wall insulation. U-value from RdSAP tables according to age of wall. See Note 7	7
R	Condensing oil boiler	Main heating by oil warm air	Mains gas not available, hot water cylinder in dwelling	Band A regular oil boiler, radiators. See Note 4	28
			Mains gas not available, no hot water cylinder in dwelling	Band A combi oil boiler, radiators. See Note 4	43

Item	Measure	To be considered when existing dwelling has:	Recommended if existing dwelling has:	Improve to:	Rec. number
S	Change heating to Band A gas condensing boiler (no fuel switch)	Main heating by mains gas fires	Hot water cylinder in dwelling	Band A regular mains gas boiler, radiators. See Note 4	40
			No hot water cylinder in dwelling	Band A combi mains gas boiler, radiators. See Note 4	41
T	Change heating to Band A gas condensing boiler (fuel switch)	Main heating by: - solid mineral fuel boiler - LPG boiler (non-condensing) - oil boiler (non-condensing) - LPG fires - oil warm air - solid mineral fuel room heaters - electric storage heating - electric off-peak underfloor heating - electric room heaters - electric ceiling heating Also if no space heating system present	Mains gas available, hot water cylinder in dwelling	Band A regular mains gas boiler, radiators. See Note 4	29
			Mains gas available, no hot water cylinder in dwelling	Band A combi mains gas boiler, radiators. See Note 4	32
		Main heating by LPG CPSU	Mains gas available	Mains gas condensing CPSU	42
U	Photovoltaics	House or bungalow, not thatched roof	Photovoltaics less than 1.0 kWp	Photovoltaics, 2.5 kWp (2.5 kWp in total, including any existing)	34
V	Wind turbine	House or bungalow	No wind turbine	1 wind turbine, blade diameter 1.75 m, hub height 2.0 m	44

Note 1. SAP Table 2 is constructed on the basis that 80 mm jacket is equivalent to 25 mm factory-applied insulation. Therefore an additional 80 mm jacket can be implemented by increasing the existing insulation thickness by an additional 25 mm. [E.g. 12 mm factory-applied + 80 mm jacket becomes 37 mm factory-applied with cylinder loss factor of 0.184 kWh/litre/day before application of volume correction.]

Note 2. Loft insulation is considered separately for main roof, extension 1 and extension 2 as applicable and applied to all <u>accessible</u> roofs with insulation <= 150 mm. In the Energy Report the total cost saving for the measure is shown without any mention of "main", "extension", etc.

Note 3. Cavity wall insulation is considered separately for main wall, extension 1, extension 2 and alternative wall as applicable and applied to all fillable walls. In the Energy Report the total cost saving for the measure is shown without any mention of "main", "extension", etc.

Note 4. Replacement boiler is condensing, 90% efficient, auto-ignition, room-sealed, fan-assisted flue, and provides space and water heating. For the purposes of the calculation of the improvement it is treated as "manufacturer declaration" with the foregoing parameters. Controls are:
- for radiator systems, programmer, roomstat and TRVs (or time and temperature zone control if already present), interlocked system, separate timing of space and water heating (if regular boiler);
- for underfloor systems: time and temperature zone control
- in the case of measure I, leave cylinder as it is (but with cylinderstat and improved insulation if applied earlier in the sequence)
- in the case of measures R, S and T, if regular boiler, cylinder of normal size (no solar panel) or medium size (solar panel present) with 50 mm factory-applied insulation and cylinderstat

Note 5. Replacement CPSU is condensing, 90% efficient, room-sealed, fan-assisted flue, store volume 80 litres with heat loss 2.72 kWh/day, and provides space and water heating with separate timing of space and water heating. For the purposes of the calculation of the improvement it is treated as "manufacturer declaration" with the foregoing parameters. Controls are programmer, roomstat and TRVs, interlocked system.
(At present there are no condensing CPSU's available but they are expected to be produced in future. The nearest equivalent is a condensing primary storage combi, which gives an almost identical rating to a condensing CPSU.)

Note 6. If 50% or less of the windows are single glazed, a recommendation should be made for double glazing of all single-glazed windows. If the assessor cancels this recommendation, e.g. because it is a listed building or in a conservation area where double glazing would be inappropriate, a recommendation is made for secondary glazing for the single-glazed windows. The secondary glazing option should appear only in these circumstances.

Note 7. Solid wall insulation is considered for main wall, extension 1, extension 2 and alternative wall as applicable and applied to all applicable walls. Implemented by changing the wall insulation to internal solid wall insulation but leaving the RdSAP building dimensions the same (thus the dimensions used in SAP will change if external dimensions are being used and will not change if external dimensions are being used). In the Energy Report the total figure for the measure is shown without any mention of "main", "extension", etc. This measure is not applied to system built walls.

Note 8. Heating controls are programmer, room thermostat and TRVs. Water cylinder unchanged.

<u>Heating upgrades</u>
An improvement to a heating system by adoption of any of the following measures:
    I, J, K, M, R, S, T
is taken as extending the main heating system to the whole dwelling where that is not the case in the existing dwelling. Thus when implementing any of the above measures, the number of heated habitable rooms is to be set equal to the number of habitable rooms. This rule affects the results where there are unheated habitable rooms and no identified secondary heater. If there is an identified secondary heater, the secondary heater remains throughout the sequence of calculations of improvement measures. Also,

in the case of measure T upgrading storage heaters to a condensing gas boiler, if the secondary heating has been given as <u>portable</u> electric heaters the secondary heating becomes none after the upgrade.

T2   Table of improvement measures for new dwellings

Software tests for the relevance of improvement measures, and applies them where relevant, in the order shown in this table.
A recommendation is actually made only if it increases the SAP rating by at least 0.95 (or 0.45 in the case of LEL, item E).

Item	Measure	To be considered when dwelling has:	Recommended if dwelling has:	Improve to:	Rec. number
LOW COST MEASURES					
E	Low energy lights	All cases	Low energy lights < 100% of fixed outlets	Low energy lamps in all fixed outlets	35
FURTHER MEASURES					
N	Solar water heating	House or bungalow	No solar panel	Solar panel, 3 m² aperture area, evacuated tube with η=0.70, a_1=1.80, facing South, pitch 30°, modest overshading.	19
				Electrically powered pump for solar heated water.	
				If combi boiler or CPSU or instantaneous water heater or DHW from community with no cylinder in dwelling: separate solar cylinder of 75 litres;	
				Otherwise (cylinder or thermal store): cylinder or thermal store at least 190 litres in total (increase to 190 if smaller), combined cylinder with solar part 75 litres.	
U	Photovoltaics	House or bungalow	No photovoltaics	Photovoltaics, 2.5 kWp, facing South, pitch 30°, modest overshading,	34
V	Wind turbine	House or bungalow	No wind turbine	1 wind turbine, blade diameter 1.75 m, hub height 2.0 m	44

SAP 2005 with amendments version 9.81 and RdSAP version 9.83

1. Overall dwelling dimensions

	Area (m²)		Average storey height (m)		Volume (m³)	
Ground floor	_____	(1a) ×	_____	=	_____	(1)
First floor	_____	(2a) ×	_____	=	_____	(2)
Second floor	_____	(3a) ×	_____	=	_____	(3)
Third and other floors	_____	(4a) ×	_____	=	_____	(4)

Total floor area (1a) + (2a) + (3a) + (4a) = _____ (5)

Dwelling volume (1) + (2) + (3) + (4) = _____ (6)

2. Ventilation rate

			m³ per hour	
Number of chimneys	_____	× 40 =	_____	(7)
Number of open flues	_____	× 20 =	_____	(8)
Number of intermittent fans or passive vents	_____	× 10 =	_____	(9)
Number of flueless gas fires	_____	× 40 =	_____	(9a)

Infiltration due to chimneys, flues and fans = (7)+(8)+(9)+(9a) = _____ ÷ box (6) = _____ (10) **Air changes per hour**

If a pressurisation test has been carried out, proceed to box (19)

Number of storeys in the dwelling _____ (11)

Additional infiltration $[(11) - 1] \times 0.1 =$ _____ (12)

Structural infiltration: *0.25 for steel or timber frame or 0.35 for masonry construction* _____ (13)
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

If suspended wooden floor, *enter 0.2 (unsealed) or 0.1 (sealed)*, else enter 0 _____ (14)

If no draught lobby, enter 0.05, else enter 0 _____ (15)

Percentage of windows and doors draught stripped _____ (16)

Window infiltration $0.25 - [0.2 \times (16) \div 100] =$ _____ (17)

Infiltration rate (10) + (12) + (13) + (14) + (15) + (17) = _____ (18)

If based on air permeability value, then $[q_{50} \div 20] + (10)$ in box (19), otherwise (19) = (18) _____ (19)
Air permeability value applies if a pressurisation test has been done, or a design or specified air permeability is being used

Number of sides on which sheltered _____ (20)
(Enter 2 in box (20) for new dwellings where location is not shown)

Shelter factor $1 - [0.075 \times (20)] =$ _____ (21)

Adjusted infiltration rate $(19) \times (21) =$ _____ (22)

Calculate effective air change rate for the applicable case:

If balanced whole house mechanical ventilation air throughput (in ach, see 2.6.6) = _____ (22a)

If balanced with heat recovery fficiency in % allowing for in-use factor = _____ (22b)

a) If balanced mechanical ventilation with heat recovery $(22) + (22a) \times [1 - (22b) \div 100] =$ _____ (23)

b) If balanced mechanical ventilation without heat recovery $(22) + (22a) =$ _____ (23a)

c) If whole house extract ventilation or positive input ventilation from outside
if (22) < 0.25, then (23b) = 0.5; otherwise (23b) = 0.25 + (22) _____ (23b)

d) If natural ventilation or whole house positive input ventilation from loft
if (22) ³ 1, then (24) = (22); otherwise (24) = 0.5 + [(22)² × 0.5] _____ (24)

Effective air change rate - enter (23) or (23a) or (23b) or (24) in box (25) _____ (25)

Worksheet-1

3. Heat losses and heat loss parameter

ELEMENT	Gross area (m²)	Openings	Net Area (m²)	U-value	A×U (W/K)
Doors			☐ ×	☐ =	☐ (26)
Windows (type 1)*			☐ ×	1/[(1/U-value)+0.04] =	☐ (27)
Windows (type 2)*			☐ ×	1/[(1/U-value)+0.04] =	☐ (27a)
Rooflights*			☐ ×	1/[(1/U-value)+0.04] =	☐ (27b)
Ground floor			☐ ×	☐ =	☐ (28)
Walls (type 1)	☐ - ☐ =		☐ ×	☐ =	☐ (29)
Walls (type 2)	☐ - ☐ =		☐ ×	☐ =	☐ (29a)
Roof (type 1)	☐ - ☐ =		☐ ×	☐ =	☐ (30)
Roof (type 2)	☐ - ☐ =		☐ ×	☐ =	☐ (30a)

Total area of elements ΣA, m² ☐ (32)

for windows and rooflights, use effective window U-value calculated as given in paragraph 3.2
the above table is expanded as necessary to allow for all different types of element e.g. 6 wall types

Fabric heat loss, W/K	(26)+(27)+(27a)+(27b)+(28)+(29)+(29a)+(30)+(30a) =	☐ (33)
Thermal bridges - Σ (l×Ψ) calculated using Appendix K		☐ (34)

if details of thermal bridging are not known calculate y´ (32) [see Appendix K] and enter in (34)

Total fabric heat loss	(33) + (34) =	☐ (35)
Ventilation heat loss	(25) × 0.33 × (6) =	☐ (36)
Heat loss coefficient, W/K	(35) + (36) =	☐ (37)
Heat loss parameter (HLP), W/m²K	(37) ÷ (5) =	☐ (38)

4. Water heating energy requirement

kWh/year

Energy content of hot water used from Table 1 column (b) ☐ (39)

Distribution loss from Table 1 column (c) ☐ (40)

If instantaneous water heating at point of use, enter "0" in boxes (40) to (45)
For community heating use Table 1 (c) whether or not hot water tank is present

Water storage loss:

a) If manufacturer's declared loss factor is known (kWh/day): ☐ (41)

Temperature factor from Table 2b ☐ (41a)

Energy lost from water storage, kWh/year (41) × (41a) × 365 = ☐ (42)

b) If manufacturer's declared cylinder loss factor is not known :

Cylinder volume (litres) including any solar storage within same cylinder ☐ (43)
If community heating and no tank in dwelling, enter 110 litres in box (43)
Otherwise if no stored hot water (this includes instantaneous combi boilers) enter '0' in box (43)

Hot water storage loss factor from Table 2 (kWh/litre/day) ☐ (44)
If community heating and no tank in dwelling, use cylinder loss from Table 2 for 50 mm factory insulation in box (44)

Volume factor from Table 2a ☐ (44a)

Temperature factor from Table 2b ☐ (44b)

Energy lost from water storage, kWh/year
(43) × (44) × (44a) × (44b) × 365 = ☐ (45)

Enter (42) or (45) in box (46) ☐ (46)

If dedicated solar storage is within cylinder, box (47) = (46) × [(43) − (H11)] ÷ (43), else (47) = (46) ☐ (47)

Primary circuit loss from Table 3 ☐ (48)

Combi loss from Table 3a (enter "0" if not a combi boiler) ☐ (49)

Solar DHW input calculated using Appendix H (enter "0" if no solar collector) ☐ (50)

Output from water heater, kWh/year (39)+(40)+(47)+(48)+(49) − (50) = ☐ (51)

Heat gains from water heating, kWh/year 0.25 × [(39)+(49)]+0.8 × [(40)+(47)+(48)] = ☐ (52)

include (47) in calculation of (52) only if cylinder is in the dwelling or hot water is from community heating

Worksheet-2

5. Internal gains

		Watts	
Lights, appliances, cooking and metabolic (Table 5)			(53)
Reduction of internal gains due to low energy lighting (calculated in Appendix L)			(53a)
Additional gains from Table 5a			(53b)
Water heating	$(52) \div 8.76 =$		(54)
Total internal gains	$(53) + (53b) + (54) - (53a) =$		(55)

6. Solar gains

	Access factor Table 6d		Area m²		Flux Table 6a		$g_\perp$ Table 6b		FF Table 6c		Gains (W)	
North		×		×		× 0.9 ×		×		=		(56)
Northeast		×		×		× 0.9 ×		×		=		(57)
East		×		×		× 0.9 ×		×		=		(58)
Southeast		×		×		× 0.9 ×		×		=		(59)
South		×		×		× 0.9 ×		×		=		(60)
Southwest		×		×		× 0.9 ×		×		=		(61)
West		×		×		× 0.9 ×		×		=		(62)
Northwest		×		×		× 0.9 ×		×		=		(63)
Rooflights		×		×		× 0.9 ×		×		=		(64)

Total solar gains:	$[(56) + ... + (64)]$	=	(65)
Total gains, W	$(55) + (65) =$		(66)
Gain/loss ratio (GLR)	$(66) \div (37) =$		(67)
Utilisation factor (Table 7, using GLR in box (67)			(68)
Useful gains, W	$(66) \times (68) =$		(69)

7. Mean internal temperature

		°C	
Mean internal temperature of the living area (Table 8)			(70)
Temperature adjustment from Table 4e, where appropriate			(71)
Adjustment for gains	$\{[(69) \div (37)] - 4.0\} \times 0.2 \times R$ =		(72)

R is obtained from the 'responsiveness' column of Table 4a or Table 4d

Adjusted living room temperature	$(70) + (71) + (72)$ =		(73)
Temperature difference between zones (Table 9)			(74)
Living area fraction (0 to 1.0)	living room area ÷ (5) =		(75)
Rest-of -house fraction	1 - (75) =		(76)
Mean internal temperature	$(73) - [(74) \times (76)]$ =		(77)

8. Degree days

Temperature rise from gains	$(69) \div (37)$ =		(78)
Base temperature	$(77) - (78)$ =		(79)
Degree-days, *use box (79) and Table 10*			(80)

9. Space heating requirement

Space heating requirement (useful), kWh/year	$0.024 \times (80) \times$ (37)	=	(81)

For range cooker boilers where efficiency is obtained from the Boiler Efficiency Database or manufacturer's declared value, multiply the result in box (81) by (1 − Φ_{case}/Φ_{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 value.

9a. Energy requirements - individual heating systems, including micro-CHP

Note: when space and water heating is provided by community heating use the alternative worksheet 9b

Space heating:

Fraction of heat from secondary/supplementary system *(use value from Table 11, Appendix F or Appendix N)* _____ (82)

Efficiency of main heating system, % _____ (83)
  (SEDBUK or from Table 4a or 4b, adjusted where appropriate by the amount shown in the 'efficiency adjustment' column of Table

Efficiency of secondary/supplementary heating system, % *(use value from Table 4a or Appendix E)* _____ (84)

Space heating fuel (main) requirement, kWh/year $[1 - (82)] \times (81) \times 100 \div (83) =$ _____ (85)

Space heating fuel (secondary), kWh/year $(82) \times (81) \times 100 \div (84) =$ _____ (85a)

Water heating:

Efficiency of water heater, % _____ (86)
  (SEDBUK or from Table 4a or 4b, adjusted where appropriate by the amount shown in the 'efficiency adjustment' column of Table

Energy required for water heating, kWh/year $(51) \times 100 \div (86) =$ _____ (86a)

Electricity for pumps and fans: kWh/year

each central heating pump, (Table 4f) _____ (87a)
each boiler with a fan-assisted flue (Table 4f) _____ (87b)
warm air heating system fans (Table 4f) _____ (87c)
mechanical ventilation - balanced, extract or positive input from outside (Table 4f) _____ (87d)
maintaining keep-hot facility for gas combi boiler (Table 4f) _____ (87e)
pump for solar water heating (Table 4f) _____ (87f)

Total electricity for the above equipment, kWh/year $(87a) + (87b) + (87c) + (87d) + (87e) + (87f) =$ _____ (87)

10a. Fuel costs - individual heating systems

	Fuel kWh/year		Fuel price (Table 12)		Fuel cost £/year	
Space heating - main system	(85)	×	_____	× 0.01 =	_____	(88)
Space heating - secondary	(85a)	×	_____	× 0.01 =	_____	(89)

Water heating (electric off-peak tariff)

On-peak fraction (Table 13, or Appendix F for electric CPSUs) _____ (90)
Off-peak fraction $1.0 - (90) =$ _____ (90a)

			Fuel price			
On-peak cost	$(86a) \times (90) \times$		_____	× 0.01 =	_____	(91)
Off-peak cost	$(86a) \times (90a) \times$		_____	× 0.01 =	_____	(91a)
Water heating cost (other fuel)	(86a)	×	_____	× 0.01 =	_____	(91b)
Pump and fan energy cost	(87)	×	_____	× 0.01 =	_____	(92)
Energy for lighting (calculated in Appendix L)	_____	×	_____	× 0.01 =	_____	(93)
Additional standing charges (Table 12)					_____	(94)

Renewable and energy-saving technologies (Appendices M, N and Q)

Energy produced or saved, kWh/year _____ (95)

Cost of energy produced or saved, £/year $(95) \times$ _____ × 0.01 = _____ (95a)

Energy consumed by the technology, kWh/year _____ (96)

Cost of energy consumed, £/year $(96) \times$ _____ × 0.01 = _____ (96a)

Total energy cost $(88)+(89)+(91)+(91a)+(91b)+(92)+(93)+(94) - (95a)+(96a) =$ _____ (97)

11a. SAP rating - individual heating systems

Energy cost deflator (SAP 2005) **0.91** (98)

Energy cost factor (ECF) $\{[(97) \times (98)] - 30.0\} \div \{(5) + 45.0\} =$ _____ (99)

SAP rating (Table 14) _____ (100)

9b. Energy requirements - Community heating scheme

This page should used when space and water heating is provided by community heating. If boilers or heat pumps only, enter "0" on box (83), and "1.0" in box (84*)*

Overall efficiency allowing for space heating control ☐ (82*)
  (*100 % minus the amount shown in the 'efficiency adjustment' column of Table 4c(3) where appropriate*)

Fraction of heat from CHP unit or fraction of heat recovered from power station/geothermal ☐ (83*)
  (*from operational records or the plant design specification*)

Fraction of heat from boilers or heat pump   1 - (83*)   =   ☐ (84*)

Distribution loss factor (Table 12c) ☐ (85*)

	kWh/year

Space heating from CHP or recovered/geothermal heat, kWh/year $[(81) \times (83*) \times 100] \div (82*) \times (85*)$ =   ☐ (86*)

Space heating from boilers or heat pump, kWh/year $[(81) \times (84*) \times 100] \div (82*) \times (85*)$ =   ☐ (87*)

Water heated by CHP or recovered/geothermal heat $[(51) \times (83*) \times 100] \div (82*) \times (85*)$ =   ☐ (87a*)

Water heated by boilers or heat pump $[(51) \times (84*) \times 100] \div (82*) \times (85*)$ =   ☐ (87b*)

Electricity for pumps and fans: from Table 4f for dwellings with mechanical ventilation, otherwise enter "0"   ☐ (88*)

10b. Fuel costs - Community heating scheme

	Fuel required ×	Fuel price =	Fuel cost
Space heating	kWh/year	(Table 12)	£/year
Space heating (CHP or recovered/geothermal)	(86*) ×	☐ × 0.01 =	☐ (89*)
For CHP price from Table 12 is irrespective of fuel used by CHP			
Space heating (community boilers or heat pump)	(87*) ×	☐ × 0.01 =	☐ (90*)

Water heating

		Fuel price	
Water heated by CHP or recovered/geothermal heat	(87a*) ×	☐ × 0.01 =	☐ (91*)
Water heated by boilers or heat pump	(87b*) ×	☐ × 0.01 =	☐ (92*)

Water heated by immersion heater only; *if not heated by immersion heater, go to box (94*)*

On-peak fraction (Table 13) ☐ (93*)

Off-peak fraction   1.0 - (93*) =   ☐ (93a*)

		Fuel price	
On-peak cost	(51) × (93*) ×	☐ × 0.01 =	☐ (93b*)
Off-peak cost	(51) × (93a*) ×	☐ × 0.01 =	☐ (93c*)
Pump and fan energy cost	(88*) ×	☐ × 0.01 =	☐ (94*)
Energy for lighting (calculated in Appendix L)	☐ ×	☐ × 0.01 =	☐ (94a*)
Additional standing charges (Table 12)			☐ (94b*)

Renewable and energy-saving technologies (Appendices M and Q)
Energy produced or saved, kWh/year ☐ (95*)

Cost of energy produced or saved, £/year   (95*) ×   ☐ × 0.01 =   ☐ (95a*)

Energy consumed by the technology, kWh/year ☐ (96*)

Cost of energy consumed, £/year   (96*) ×   ☐ × 0.01 =   ☐ (96a*)

Total heating   (89*)+ (90*)+(91*)+(92*)+(93b*)+(93c*)+(94*)+(94a*)+(94b*) - (95a*) +(96a*) =   ☐ (97*)

11b. SAP rating - Community heating scheme

Energy cost deflator (Table 12)   **0.91** (98*)

Energy cost factor (ECF) $\{[(97*) \times (98*)] - 30.0\} \div \{(5) + 45\} =$ ☐ (99*)

SAP rating (Table 14) ☐ (100*)

12a.	**CO$_2$ Emissions**				

**12a. CO$_2$ Emissions
 for individual heating systems (including micro-CHP) and community heating without CHP**

	Energy kWh/year		Emission factor kg CO$_2$/kWh		Emissions kg CO$_2$/year	
Individual heating system:						
Space heating main from box (85)	[ ]	×	[ ]	=	[ ]	(101)
Space heating secondary from box (85a)	[ ]	×	[ ]	=	[ ]	(102)
Energy for water heating from box (86a)	[ ]	×	[ ]	=	[ ]	(103)
Community scheme:						
Efficiency of community boilers %	[ ] (104) *use actual efficiency if known, or value in Table 4a*					
Energy for space heating	(87*) × 100 ÷ (104)	×	[ ]	=	[ ]	(105)
Energy for water heating	(87b*) × 100 ÷ (104)	×	[ ]	=	[ ]	(106)
Space and water heating	[(101) + (102) + (103)] or [(105) + (106)]			=	[ ]	(107)
If negative, enter "0" in (107)						
Electricity for pumps and fans from box (87) or (88*)	[ ]	×	[ ]	=	[ ]	(108)
Energy for lighting from Appendix L	[ ]	×	[ ]	=	[ ]	(109)
Energy produced or saved in dwelling	(95) or (95*)	×	[ ]	=	[ ]	(110)
Energy consumed by the above technology	(96) or (96*)	×	[ ]	=	[ ]	(111)
Total CO$_2$, kg/year	(107) + (108) + (109) - (110) + (111)			=	[ ]	(112)
Dwelling CO$_2$ Emission Rate			(112) ÷ (5)	=	[ ]	(113)

**12b. CO$_2$ Emissions
 for community heating schemes with CHP or heat recovered from power stations or geothermal source**

(for community schemes that recover heat from power stations refer to C2 in Appendix C and omit (101) to (106*))*

	Energy kWh/year	Emission factor kg CO$_2$/kWh	Emissions (kg CO$_2$/year)	
Electrical efficiency of CHP unit (e.g. 30%) *from operational records or the CHP design specification*			[ ]	(101*)
Heat efficiency of CHP unit (e.g. 50%) *from operational records or the CHP design specification*			[ ]	(102*)
CO$_2$ emission factor for the CHP fuel from Table 12		[ ] (103*)		
CO$_2$ emission factor for electricity generated by CHP (from Table 12)		[ ] (104*)		
CO$_2$ emitted by CHP per kWh of generated electricity		(103*) ÷ (101*) × 100 =	[ ]	(105*)
Heat to Power ratio *enter if known, otherwise* (102*) ÷ (101*)			[ ]	(106*)
CO$_2$ emission factor for heat		[(105*) - (104*)] ÷ (106*) =	[ ]	(107*)

Note: with CHP the value in (107) can be negative;
with heat recovered from power station or geothermal enter emission factor for waste heat or geothermal from Table 12 in (107*)*

	Energy	Emission factor:	Emissions	
Water heated by CHP or recovered/geothermal heat:	(87a*) ×	(107*)	= [ ]	(108*)
Efficiency of community boilers/heat pump % [ ] (109*) *use actual efficiency if known, or value in Table 4a*				
Water heated by boilers/heat pump:	(87b*) × 100 ÷ (109*)	× [ ] =	[ ]	(110*)
If water heated by immersion heater,	(51)	× [ ] =	[ ]	(111*)
Space heating from CHP or recovered/geothermal heat	(86*)	× (107*) =	[ ]	(112*)
Space heating from boilers/heat pump	(87*) × 100 ÷ (109*)	× [ ] =	[ ]	(113*)
Electricity for pumps and fans	(88*)	× [ ] =	[ ]	(114*)
Total CO$_2$ associated with boilers, CHP or recovered/geothermal heat	[(108*) + (110*) + ... + (114*)] =		[ ]	(115*)
If negative, enter "0" in (115)*				
Energy for lighting from Appendix L	[ ]	× [ ] =	[ ]	(116*)
Energy produced or saved in dwelling	(95*)	× [ ] =	[ ]	(117*)
Energy consumed by the above technology	(96*)	× [ ] =	[ ]	(118*)
Total CO$_2$, kg/year	(115*) + (116*) - (117*) + (118*) =		[ ]	(119*)
Dwelling CO$_2$ Emission Rate	(119*) ÷ (5) =		[ ]	(120*)

Worksheet-6

Table 1: Hot water energy requirements

Floor area TFA (m²)	(a) Hot water usage V_d (litres/day)	(b) Energy content of water used (kWh/year)	(c) Distribution loss (kWh/year)
30	63	1146	202
40	71	1293	228
50	79	1437	254
60	87	1577	278
70	95	1713	302
80	102	1846	326
90	109	1976	349
100	116	2102	371
110	123	2225	393
120	129	2344	414
130	136	2460	434
140	142	2572	454
150	148	2681	473
160	154	2787	492
170	159	2889	510
180	165	2987	527
190	170	3082	544
200	175	3174	560
210	180	3262	576
220	185	3347	591
230	189	3428	605
240	193	3506	619
250	197	3581	632
260	201	3652	644
270	205	3719	656
280	209	3783	668
290	212	3844	678
300	215	3901	688

Notes:

Alternatively, the hot water usage and the distribution loss may be calculated from the total floor area of the dwelling (TFA), using the following steps:

(a) Calculate $\quad N = 0.035 \times TFA - 0.000038 \times TFA^2, \quad$ *if TFA £ 420*
$\quad\quad\quad\quad\quad N = 8 \quad\quad\quad\quad\quad\quad\quad\quad\quad\quad$ *if TFA > 420*
(b) Hot water usage = (25 × N) + 38
(c) Energy content of water used = [(61 × N) + 92] × 0.85 × 8.76
(d) Distribution loss = [(61 × N) + 92] × 0.15 × 8.76

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.

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.

In the case of a combination boiler:
    a) the storage loss factor is zero if the efficiency is taken from Table 4b;
    b) 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	**Loose 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:
1. 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: $L = 0.005 + 0.55/(t + 4.0)$
2. The data for factory insulated cylinder apply to all cases 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.
3. 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
40	1.442
60	1.259
80	1.145
100	1.063
120	1.00
140	0.950
160	0.908
180	0.874
200	0.843
220	0.817
240	0.794
260	0.773
280	0.754

Notes:
1. When using the data in Table 2, the loss is to be multiplied by the volume factor.
2. Alternatively, the volume factor can be calculated using the equation $VF = (120 / V_c)^{1/3}$

Table 2b: Factors to be applied to losses for cylinders, thermal stores and CPSUs

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 ≥ 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 ≥ 115 litres: 0.60 Store volume < 115 litres: $0.60 + 0.0016 \times (115 - V_c)$
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: winter operating temperature 85°C 90°C 95°C	 1.09 1.15 1.21	 1.00

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*

Table 3: Primary circuit losses

System type	kWh/year
Electric immersion heater	0
Boiler with uninsulated primary pipework* and no cylinder thermostat	1220
Boiler with insulated primary pipework and no cylinder thermostat	610
Boiler with uninsulated primary pipework and with cylinder thermostat	610
Boiler with insulated primary pipework and with cylinder thermostat	360
Combi boiler	0
CPSU (including electric CPSU)	0
Boiler and thermal store** within a single casing	0
Separate boiler and thermal store connected by no more than 1.5 m of insulated pipework	0
Separate boiler and thermal store connected by: - uninsulated primary pipe work - more than 1.5 m of insulated primary pipe work	470 280
Community heating	360

Notes:
* "Primary pipework" means the pipes between a boiler and a hot water tank
** Thermal stores have a cylinder thermostat

Table 3a: Additional losses for combi boilers

Combi type	kWh/year
Instantaneous, without keep-hot facility*	600 [a]
Instantaneous, with keep-hot facility controlled by time clock	600
Instantaneous, with keep-hot facility not controlled by time clock	900
Storage combi boiler** store volume $V_c \geq 55$ litres	0
Storage combi boiler** store volume $V_c < 55$ litres	$600 - (V_c - 15) \times 15$ [a]

[a] If the hot water usage from Table 1 is less than 100 litres/day, multiply by (daily hot water usage) / 100

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 switch. 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 the 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 (49);
b) calculate energy required for water heating as [(51) – (49)] x 100 ¸ (86) and enter in box (86a). 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:
   $LE = 8.76 \times P$ (kWh/year) (subject to maximum of the value from Table 3a)
   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.

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. *'Heating type' refers to the appropriate column in Table 8.*
4. *'Responsiveness (R) is used to calculate entry in box (72) of worksheet.*
5. *Systems marked "rd" in the right-hand column are part of the reduced data set (see S10 in Appendix S)*
6. *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					
Refer to Group 0 in Table 4e for control options and temperature adjustments due to control					
Electric heaters (assumed)	100	1	1.0	699	rd
CENTRAL HEATING SYSTEMS WITH RADIATORS OR UNDERFLOOR HEATING					

Gas boilers and oil boilers
For efficiency, use boiler database (www.boilers.org.uk) if possible, otherwise use efficiency from Table 4b.
Use Table 4c for efficiency adjustments.
Use Table 4d for heating type and responsiveness.
Refer to Group 1 in Table 4e for control options and temperature adjustments due to control.

Micro-cogeneration (micro-CHP)
See Appendix N. Performance data to be obtained from boiler database (www.boilers.org.uk).
Use Table 4c for efficiency adjustments.
Refer to Group 1 in Table 4e for control options and temperature adjustments due to control.

Solid fuel boilers
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 9.2.3). 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.
Refer to Group 1 in Table 4e for control options

	(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"
‡ column (B) only

Electric boilers
Refer to Group 1 in Table 4e for control options

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	

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
[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					

Heat pumps (see also warm air systems)
Refer to Group 2 in Table 4e for control options

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
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

For calculation of SAP rating: efficiency is 100% reduced by the amount in the "efficiency adjustment" column of Table 4c.
For calculation of CO_2 emissions: if known, use manufacturer's declared efficiency instead of value from this table.
Refer to Group 3 in Table 4e for control options.
Check Table 4c for efficiency adjustment due to controls.
Allow for distribution loss (see Table 12c).

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
Community boilers only	75	1	1.0	301	rd
Community CHP and boilers	75	1	1.0	302	rd
Community waste heat from power station and boilers	75 [a]	1	1.0	303	
Community heat pump	300	1	1.0	304	
Community geothermal heat source and boilers	75 [a]	1	1.0	305	

[a] Efficiency of boilers; apply 100% to the heat fraction from waste heat or geothermal

ELECTRIC STORAGE SYSTEMS

Refer to Group 4 in Table 4e for control options.

Off-peak tariffs:

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
Old (large volume) storage heaters	100	5	0.0	401	rd
Modern (slimline) storage heaters	100	4	0.25	402	rd
Convector 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	
Convector 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

24-hour heating tariff:

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
Modern (slimline) storage heaters	100	3	0.5	402	rd
Convector 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	
Convector 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

Refer to Group 7 in Table 4e for control options.

Off-peak tariffs:

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
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	100	3	0.50	423	

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
control					
Standard tariff:					
In screed above insulation	100	2	0.75	424	rd
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

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
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

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
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

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
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

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
Electricaire system	100	2	0.75	515	rd

Heat pumps

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
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)	Heating type	Respon-siveness (R)	Code	Rd SAP
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

		Efficiency %		Heating type	Respon- siveness (R)	Code	Rd SAP
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
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	none	90	92	1	1.0	613	rd

(add additional ventilation requirements in box (9a)

	Flue	Efficiency %	Heating type	Respon- siveness (R)	Code	Rd SAP
Oil room heaters:						
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)	Heating type	Respon- siveness (R)	Code	Rd SAP
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
‡ column (B) only

	Efficiency %	Heating type	Respon- siveness (R)	Code	Rd SAP
Electric (direct acting) room heaters:					
Panel, convector or radiant heaters*	100	1	1.0	691	rd
Fan heaters	100	1	1.0	692	
Portable electric heaters	100	1	1.0	693	rd

* use this category for water or oil filled electric radiators

OTHER SPACE HEATING SYSTEMS					

Refer to Group 7 in Table 4e for control options.

	Efficiency %	Heating type	Respon- siveness (R)	Code	Rd SAP
Electric ceiling heating	100	2	0.75	701	rd

HOT WATER SYSTEMS			

If water heating from main system or secondary heater, use efficiency of main system or secondary heater except for those marked *.

	Efficiency %		Code	Rd SAP
No hot water system present - electric immersion assumed	100	n/a	999	rd
From main heating system	efficiency of main system		901	rd
From secondary system	efficiency of secondary heater		902	rd
Electric immersion (on-peak or off-peak)	100	n/a	903	rd
*Back boiler (hot water only), gas	65	n/a	904	rd
*From a circulator built into a gas warm air system, pre 1998	65	n/a	905	rd
*From a circulator built into a gas warm air system, 1998 or later	73	n/a	906	rd
Single-point gas water heater (instantaneous at point of use)	70	n/a	907	rd
Multi-point gas water heater (instantaneous serving several taps)	65	n/a	908	rd
Electric instantaneous at point of use	100	n/a	909	rd

	Efficiency %	Heating type	Respon-siveness (R)	Code	Rd SAP
Gas boiler/circulator for water heating only	65	n/a		911	
Oil boiler/circulator for water heating only	70	n/a		912	
Solid fuel boiler/circulator for water heating only	55	n/a		913	
Range cooker with boiler for water heating only:					
Gas, single burner with permanent pilot	46	n/a		921	
Gas, single burner with automatic ignition	50	n/a		922	
Gas, twin burner with permanent pilot pre 1998	60	n/a		923	
Gas, twin burner with automatic ignition pre 1998	65	n/a		924	
Gas, twin burner with permanent pilot 1998 or later	65	n/a		925	
Gas, twin burner with automatic ignition 1998 or later	70	n/a		926	
Oil, single burner	60	n/a		927	
Oil, twin burner pre 1998	70	n/a		928	
Oil, twin burner 1998 or later	75	n/a		929	
Solid fuel, integral oven and boiler	45	n/a		930	
Solid fuel, independent oven and boiler	55	n/a		931	
From hot-water only community scheme - boilers	75	n/a		950	
From hot-water only community scheme - CHP	75	n/a		951	
From hot-water only community scheme - heat pump	300	n/a		952	

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. *The table shows seasonal efficiencies for space heating. The same seasonal efficiencies should be assumed for water heating when hot water is supplied from a boiler system.*
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
Gas boilers (including LPG) 1998 or later			
Regular non-condensing with automatic ignition	73	101	rd
Regular condensing with automatic ignition	83	102	rd
Non-condensing combi with automatic ignition	73	103	rd
Condensing combi with automatic ignition	83	104	rd
Regular non-condensing with permanent pilot light	69	105	rd
Regular condensing with permanent pilot light	79	106	
Non-condensing combi with permanent pilot light	69	107	rd
Condensing combi with permanent pilot light	79	108	
Back boiler to radiators	65	109	rd
(select gas fire as secondary heater, see section 9.2.5)			
Gas boilers (including LPG) pre-1998, with fan-assisted flue			
Low thermal capacity	72	110	
High or unknown thermal capacity	68	111	rd
Combi	70	112	rd
Condensing combi	83	113	rd
Condensing	83	114	rd
Gas boilers (including LPG) pre-1998, with balanced or open flue			
Wall mounted	65	115	rd
Floor mounted, pre 1979	55	116	rd
Floor mounted, 1979 to 1997	65	117	rd
Combi	65	118	rd
Back boiler to radiators	65	119	rd
(select gas fire as secondary heater, see section 9.2.5)			
Combined Primary Storage Units (CPSU) (mains gas and LPG)			
With automatic ignition (non-condensing)	74	120	rd
With automatic ignition (condensing)	83	121	rd
With permanent pilot (non-condensing)	70	122	
With permanent pilot (condensing)	79	123	
Oil boilers			
Standard oil boiler pre-1985	65	124	
Standard oil boiler 1985 to 1997	70	125	rd
Standard oil boiler, 1998 or later	79	126	rd
Condensing	83	127	Rd
Combi, pre-1998	70	128	rd
Combi, 1998 or later	76	129	rd
Condensing combi	81	130	rd
Oil room heater with boiler to radiators, pre 2000	65	131	rd
Oil room heater with boiler to radiators, 2000 or later	70	132	rd
Range cooker boilers (mains gas and LPG)			
Single burner with permanent pilot	46	133	rd
Single burner with automatic ignition	50	134	rd
Twin burner with permanent pilot (non-condensing) pre 1998	60	135	
Twin burner with automatic ignition (non-condensing) pre 1998	65	136	rd
Twin burner with permanent pilot (non-condensing) 1998 or later	65	137	

Twin burner with automatic ignition (non-condensing) 1998 or later	70	138	
Range cooker boilers (oil)			
Single burner	60	139	rd
Twin burner (non-condensing) pre 1998	70	140	rd
Twin burner (non-condensing) 1998 or later	75	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 the SEDBUK value and for efficiency values from Table 4b.

	Mains gas	Oil or LPG
(1) Efficiency adjustment due to lower temperature of distribution system:		
Condensing boiler with load compensator [a]	+2	+1
Condensing boiler with weather compensator [a]	+2	+1
Condensing boiler with under-floor heating [a] [b]	+3	+2
Condensing boiler with thermal store [a]	0	0

(2) Efficiency adjustment due to control system	
No thermostatic control of room temperature [c]	-5
No boiler interlock [c]	-5

Community heating systems:

(3) Efficiency adjustment due to controls	
Flat rate charging [d], no thermostatic control of room temperature	-10
Flat rate charging, programmer, no room thermostat	-10
Flat rate charging, room thermostat	-5
Flat rate charging, programmer and room thermostat	-5
Flat rate charging, programmer and TRVs	0
Charging system linked to use of community heating, programmer and TRVs	0

Heat pumps:	Multiply efficiency by:	
	Space	DHW
(4) Efficiency adjustment due to temperature of heat supplied		
Heat pump with underfloor heating	1.0	
Heat pump with radiators without load or weather compensation [e]	0.7	
Heat pump with radiators and load or weather compensation [e]	0.75	
Heat pump supplying all DHW		0.7
Heat pump supplying 50% DHW (see Appendix G)		1.0

Notes:

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 passive flue gas heat recovery device.*

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. The last entry under 'Community heating schemes' 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 with heat supplied to radiators or underfloor heating

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

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 living area mean internal temperature obtained from Table 8 and should be entered into box (71) of the worksheet.*
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
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		

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*, programmer and TRVs	2	0	Table 4c(3)	2305	rd
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. The last entry refers 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
Celect-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
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 - keep-hot facility, not controlled by time clock	 600 900
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 Solar water heating pump, PV powered	75 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 m³.*
[e)]   *See notes to Table 3a for the definition of keep-hot facility.*
   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 x P (kWh/year) (subject to maximum of the value from Table 3a)
       where P is the power rating of the heater in watts
   with the remainder (either 600 – LE or 900 – LE) provided by the fuel.
[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 electricity consumed for maintaining the keep-hot facility should be taken as in footnote 3) to Table 3a.*
[g)]   *SFP is specific fan power in W/(litre/sec), see paragraph 2.6 and Table 4g, V is volume of the dwelling in m³. 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 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

Type of mechanical ventilation	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]	1.70	1.40	-	-	-
Mechanical extract ventilation or positive input ventilation from outside, decentralised [a]	1.45	1.30	1.15	-	-
Balanced whole house mechanical ventilation, without heat recovery [a]	1.70	1.40	-	-	-
Balanced whole house mechanical ventilation, with heat recovery [a]	1.70	1.40	-	0.70	0.85
Default data from Table 4g (all types) [b]	2.5			0.70	

[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 <u>all</u> ductwork is within the insulated envelope of the building even though ductwork is not itself insulated.

Table 5: Lighting, appliances, cooking and metabolic gains

Floor area (m^2)	Gains (W)	Floor area (m^2)	Gains (W)
30	230	170	893
40	282	180	935
50	332	190	978
60	382	200	1020
70	431	210	1061
80	480	220	1102
90	528	230	1142
100	576	240	1181
110	623	250	1220
120	669	260	1259
130	715	270	1297

140	760	**280**	1334
150	805	**290**	1349
160	849	**300**	1359

Notes:

Alternatively, gains may be calculated from the total floor area of the dwelling (TFA), using the following steps:

(1) Calculate $N = 0.035 ´ TFA - 0.000038 x TFA^2$ if TFA £ 420
         $N = 8$ if TFA > 420

(2) Calculate gains (W) $= 74 + 2.66 ´TFA + 75.5 ´N$ if TFA £ 282
            $= 824 + 75.5 ´N$ if TFA > 282

If there is low-energy lighting the gains should be reduced to take account of the reduced gains from lighting (see Appendix L).

Table 5a: Gains from fans and pumps

Function	Gains (W)
Central heating pump [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	$SFP \times 0.12 \times V$
Fans for balanced whole house mechanical ventilation without heat recovery	$SFP \times 0.06 \times V$

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.*
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: Solar flux (W/m^2)

	Horizontal	Vertical				
		North	NE/NW	E/W	SE/SW	South
Heating season	75	29	34	48	64	72
Summer period (use in Appendix P)	187	75	89	109	112	107

Notes:

1. Use E/W orientation when the orientation is not known.

2. For a roof window in a pitched roof with a pitch of less than 70°, use the value under 'North' for orientation within 30° of North and the value under 'Horizontal' for all other orientations. If the pitch is 70° or greater, treat as if it is a vertical window.

3. Solar flux for heating season should be used in SAP worksheet.

4. Solar flux for summer period should be used for calculating summer overheating (Appendix P).

Table 6b: Transmittance factors for glazing

Type of glazing	Total solar energy transmittance, $g_\wedge$ (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	0.80
Double glazed (Low-E, soft-coat)	0.63	0.80
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	0.70
Triple glazed (Low-E, soft-coat)	0.57	0.70

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 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 can be used instead of the data in Table 6c provided that it is obtained either for the standard window configuration defined in BR 443 or it is an area-weighted average of all windows in the dwelling.

Table 6d: Solar and light access factors

Overshading	% of sky blocked by obstacles.	Winter solar access factor (for calculation of solar gains in section 6 of the worksheet)	Summer solar access factor (for calculation of 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

Note: 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/m^{2}K) 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 (use adjustment in Note 1)				Window with metal frame with 4mm thermal break (use adjustments in 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, $\varepsilon_n = 0.2$, hard coat)	2.7	2.3	2.1		3.3	2.8	2.6
double-glazed, air filled (low-E, $\varepsilon_n = 0.15$, hard coat)	2.7	2.2	2.0		3.3	2.7	2.5
double-glazed, air filled (low-E, $\varepsilon_n = 0.1$, soft coat)	2.6	2.1	1.9		3.2	2.6	2.4
double-glazed, air filled (low-E, $\varepsilon_n = 0.05$, 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, $\varepsilon_n = 0.2$, hard coat)	2.5	2.1	2.0		3.0	2.6	2.5
double-glazed, argon filled (low-E, $\varepsilon_n = 0.15$, hard coat)	2.4	2.0	1.9		3.0	2.5	2.4
double-glazed, argon filled (low-E, $\varepsilon_n = 0.1$, soft coat)	2.3	1.9	1.8		2.9	2.4	2.3
double-glazed, argon filled (low-E, $\varepsilon_n = 0.05$, 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, $\varepsilon_n = 0.2$, hard coat)	2.1	1.7	1.6		2.6	2.1	2.0
triple-glazed, air filled (low-E, $\varepsilon_n = 0.15$, hard coat)	2.1	1.7	1.6		2.5	2.1	2.0
triple-glazed, air filled (low-E, $\varepsilon_n = 0.1$, soft coat)	2.0	1.6	1.5		2.5	2.0	1.9

triple-glazed, air filled (low-E, $\varepsilon_n = 0.05$, 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, $\varepsilon_n = 0.2$, hard coat)	1.9	1.6	1.5	2.3	2.0	1.9
triple-glazed, argon filled (low-E, $\varepsilon_n = 0.15$, hard coat)	1.8	1.5	1.4	2.3	1.9	1.8
triple-glazed, argon filled (low-E, $\varepsilon_n = 0.1$, soft coat)	1.8	1.5	1.4	2.2	1.9	1.8
triple-glazed, argon filled (low-E, $\varepsilon_n = 0.05$, 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 with wooden or PVC-U frames apply the following adjustments to U-values:*

Wood or PVC-U frame	U-value adjustment for roof window, W/m^2K
Single glazed	+0.3
Double glazed	+0.2
Triple glazed	+0.2

2. *For windows or roof windows with metal frames apply the following adjustments to U-values:*

Metal frames	Adjustment to U-value, W/m^2K	
	Window	Roof window
Metal, no thermal break	+0.3	+0.7
Metal, thermal break 4 mm	0	+0.3
Metal, thermal break 8 mm	-0.1	+0.2
Metal, thermal break 12 mm	-0.2	+0.1
Metal, thermal break 20 mm	-0.3	0.0
Metal, thermal break 32 mm	-0.4	-0.1

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: Utilisation factor as a function of gain/loss ratio (GLR)

GLR	Utilisation factor	GLR	Utilisation factor
1	1.00	**16**	0.68
2	1.00	**17**	0.65
3	1.00	**18**	0.63
4	0.99	**19**	0.61
5	0.97	**20**	0.59
6	0.95	**21**	0.58
7	0.92	**22**	0.56
8	0.89	**23**	0.54
9	0.86	**24**	0.53
10	0.83	**25**	0.51
11	0.81	**30**	0.45
12	0.78	**35**	0.40
13	0.75	**40**	0.36
14	0.72	**45**	0.33
15	0.70	**50**	0.30

Note:
Alternatively, the utilisation factor may be calculated by the formula:
   Utilisation factor = 1 - exp (- 18 ¸ GLR),
   where GLR = [total gains, box(66)] ¸ [heat loss coefficient, box (37)]

Table 8: Mean internal temperature of living area

Number in brackets is from the 'heating type' column of Table 4a or 4d.
HLP is item (38) in the worksheet

HLP	(1)	(2)	(3)	(4)	(5)
1.0 (or lower)	18.88	19.32	19.76	20.21	20.66
1.5	18.88	19.31	19.76	20.20	20.64
2.0	18.85	19.30	19.75	20.19	20.63
2.5	18.81	19.26	19.71	20.17	20.61
3.0	18.74	19.19	19.66	20.13	20.59
3.5	18.62	19.10	19.59	20.08	20.57
4.0	18.48	18.99	19.51	20.03	20.54
4.5	18.33	18.86	19.42	19.97	20.51
5.0	18.16	18.73	19.32	19.90	20.48
5.5	17.98	18.59	19.21	19.83	20.45
6.0 (or higher)	17.78	18.44	19.10	19.76	20.42

Notes:
1 Use heating column (1) when dwelling is heated by community heating.
2 Use linear interpolation between rows of the table.

Table 9: Difference in temperatures between zones

1. Number in brackets is from the 'control' column of Table 4e.
2. HLP is item (38) in the worksheet

HLP	(1)	(2)	(3)
1.0 (or lower)	0.40	1.41	1.75
1.5	0.60	1.49	1.92
2.0	0.79	1.57	2.08
2.5	0.97	1.65	2.22
3.0	1.15	1.72	2.35
3.5	1.32	1.79	2.48
4.0	1.48	1.85	2.61
4.5	1.63	1.90	2.72
5.0	1.76	1.94	2.83
5.5	1.89	1.97	2.92
6.0 (or higher)	2.00	2.00	3.00

Use linear interpolation between rows of the table.

Table 10: Degree-days as a function of base temperature

Base temperature °C	Degree-days	Base temperature °C	Degree-days
1.0	0	**11.0**	1140
1.5	30	**11.5**	1240
2.0	60	**12.0**	1345
2.5	95	**12.5**	1450
3.0	125	**13.0**	1560
3.5	150	**13.5**	1670
4.0	185	**14.0**	1780
4.5	220	**14.5**	1900
5.0	265	**15.0**	2015
5.5	310	**15.5**	2130
6.0	360	**16.0**	2250
6.5	420	**16.5**	2370
7.0	480	**17.0**	2490
7.5	550	**17.5**	2610
8.0	620	**18.0**	2730
8.5	695	**18.5**	2850
9.0	775	**19.0**	2970
9.5	860	**19.5**	3090
10.0	950	**20.0**	3210
10.5	1045	**20.5**	3330

Use linear interpolation between rows of the table.

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	all secondary systems	0.10

Electric storage heaters (not integrated)
   - not fan-assisted
   - fan-assisted
	all secondary systems	
		 0.15
		 0.10

Integrated storage/direct-acting electric systems		0.10
Electric CPSU		See Appendix F
Electric room heaters		0.20
Other electric systems		0.10
Community heating	-	0

Notes:
1. See also Appendix A.
2. If an off-peak tariff is present, an electric secondary heater uses the on-peak tariff.

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	34	1.63	0.194	1.15	1
bulk LPG	62	3.71	0.234	1.10	2
bottled LPG		4.32	0.234	1.10	3
Oil:					
heating oil		2.17	0.265	1.19	4
Solid fuel:[b]					
house coal		1.91	0.291	1.07	11
anthracite		1.99	0.317	1.07	15
manufactured smokeless fuel		2.67	0.392	1.30	12
wood logs		2.20	0.025	1.10	20
wood pellets (in bags, for secondary heating)		5.00	0.025	1.10	22
wood pellets (bulk supply in bags, for main heating)		3.00	0.025	1.10	23
wood chips		1.60	0.025	1.10	21
dual fuel appliance (mineral and wood)		2.10	0.187	1.10	10
Electricity:					
standard tariff		7.12	0.422	2.8	30
7-hour tariff (on-peak) [c]		7.65	0.422	2.8	32
7-hour tariff (off-peak) [c]	20	2.94	0.422	2.8	31
10-hour tariff (on-peak) [c]		7.83	0.422	2.8	34
10-hour tariff (off-peak) [c]	17	4.29	0.422	2.8	33
24-hour heating tariff	51	4.09	0.422	2.8	35
electricity sold to grid		5.70[d]			36
electricity displaced from grid			0.568[d]	2.8[d]	37
electricity, unspecified tariff					39
Community heating schemes:	34				
heat from boilers – gas, oil, solid fuel		1.99	as above[e]	as above[e]	as above[e]
heat from heat pump		1.99	as above[e]	as above[e]	as above[e]
heat from boilers – waste combustion		1.99	0.057	1.10	42
heat from boilers – biomass		1.99	0.025	1.10	43
heat from boilers – biogas		1.99	0.025	1.10	44
waste heat from power stations		1.39	0.018	1.05	45
geothermal heat source		1.39	0.018	1.05	46
heat from CHP		1.39	as above[e]	as above[e]	as above[e]
electricity generated by CHP			0.568[d]	2.8[d]	49

Energy Cost Deflator[f] = 0.91

Notes:

(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. Standing charges for gas and for off-peak electricity are added to space and water heating costs where those fuels are used for main heating or hot water.

(b) 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.

(c) With certain appliances using an off-peak tariff, some of the consumption is at the off-peak rate and some at the on-peak rate. The on-peak percentages to be used are given in Table 12a, the remainder being provided at the off-peak rate.

(d) Deducted from costs, emissions or primary energy

(e) Take factor from further up the table according to fuel used.

(f) 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, in such a way as to ensure that the SAP is not affected by the general rate of inflation. However, individual SAP ratings are affected by relative changes in the price of particular heating fuels.

Table 12a: On-peak 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 off-peak and on-peak rates. Use an electricity price for the main heating system weighted between the on-peak and off-peak unit price using the fraction from the table. Secondary heating with fraction according to Table 11 is applied as well.

System	Tariff	Fraction at on-peak rate	
		Space heating	**Water heating**
Integrated (storage+direct-acting) systems (storage heaters and underfloor heating)	7-hour	0.20	-
Direct-acting electric boiler [(a)]	7-hour	0.90	-
	10-hour	0.60	-
Ground/water source heat pump:			
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 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 systems	7-hour or 10-hour	1.00	-
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 exactly the same for both cases.

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 10.3.3 and note (b) to Table 12 as regards fuel selection for SAP calculations.

	Possible fuels	
Appliance	**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 Authorised Smokeless	Anthracite nuts 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 Authorised Smokeless Wood logs if Exempted Appliance	House coal Anthracite nuts 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

Heat distribution system	Factor
Mains piping system installed in 1990 or earlier, not pre-insulated medium or high temperature distribution (120-140ºC), full flow system	1.20
Pre-insulated mains piping system installed in 1990 or earlier, low temperature distribution (100ºC or below), full flow system.	1.10
Modern higher temperature system (up to 120ºC), using pre-insulated mains installed in 1991 or later, variable flow system.	1.10
Modern pre-insulated piping system operating at 100ºC 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: On-peak 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
40 or less	0.12 (0.56)	0.07 (0.18)	0.02	0	0.06 (0.15)	0	0
60	0.14 (0.58)	0.09 (0.21)	0.03	0	0.08 (0.19)	0	0
80	0.17 (0.60)	0.10.(0.24)	0.04	0	0.10 (0.22)	0	0
100	0.19 (0.62)	0.12 (0.27)	0.05	0	0.11 (0.25)	0.00 (0.02)	0
120	0.21 (0.63)	0.14 (0.30)	0.06	0	0.13 (0.28)	0.01 (0.05)	0
140	0.24 (0.65)	0.15 (0.33)	0.06	0.01	0.14 (0.30)	0.02 (0.09)	0
160	0.26 (0.66)	0.16 (0.35)	0.07	0.01	0.16 (0.33)	0.02 (0.12)	0
180	0.27 (0.68)	0.18 (0.37)	0.08	0.02	0.17 (0.35)	0.02 (0.15)	0
200	0.29 (0.69)	0.19 (0.40)	0.09	0.02	0.18 (0.38)	0.03 (0.18)	0
220	0.31 (0.70)	0.20 (0.42)	0.10	0.02	0.19 (0.40)	0.03 (0.21)	0
240	0.32 (0.71)	0.21 (0.43)	0.11	0.03	0.20 (0.41)	0.04 (0.23)	0
260	0.33 0.(72)	0.22 (0.45)	0.11	0.03	0.21 (0.43)	0.04 (0.25)	0
280	0.35 (0.73)	0.23 (0.47)	0.11	0.03	0.22 (0.45)	0.04 (0.27)	0
300	0.36 (0.74)	0.24 (0.48)	0.12	0.03	0.23 (0.46)	0.05 (0.29)	0
320	0.37 (0.75)	0.24 (0.49)	0.12	0.04	0.23 (0.47)	0.05 (0.30)	0
340	0.38 (0.75)	0.25 (0.50)	0.13	0.04	0.24 (0.48)	0.05 (0.32)	0
360	0.38 (0.76)	0.26 (0.51)	0.13	0.04	0.24 (0.49)	0.05 (0.33)	0
380	0.39 (0.76)	0.26 (0.52)	0.13	0.04	0.25 (0.50)	0.05 (0.34)	0
400	0.39 (0.76)	0.26 (0.52)	0.13	0.04	0.25 (0.51)	0.05 (0.35)	0
420 or more	0.39 (0.77)	0.26 (0.52)	0.13	0.04	0.25 (0.51)	0.06 (0.35)	0

Notes:

1) *Table 13 shows fractions of electricity required at on-peak rates for cylinders with dual immersion heaters, and in brackets for cylinders with single immersion heaters, for tariffs providing at least 7 hours of heating per day at the off-peak rate and for tariffs providing at least 10 hours of heating per day at the off-peak 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 off-peak 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 off-peak 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 below Table 1. (If these formulae give a value less than zero, set the on-peak fraction to zero; if greater than one, set to one.)

3) *Do not use this table to obtain the on-peak fraction for an electric CPSU. Calculate the on-peak fraction using the procedure described in Appendix F.*

4) *Do not use this table for the on-peak fraction for domestic hot water heated by a heat pump. Use on-peak fraction given in Table 12a.*

Table 14: SAP rating by energy cost factor

ECF	SAP 2005
-3.0	142
-2.5	135
-2.0	128
-1.5	121
-1.0	114
-0.5	107
0.0	100
0.5	93
1.0	86
1.5	79
2.0	72
2.5	65
3.0	58
3.5	51
4.0	45
4.5	39
5.0	34
5.5	30
6.0	25
6.5	22
7.0	18
7.5	15
8.0	12
8.5	9
9.0	6
9.5	3
10.0	1

Note:

Alternatively these formulae can be used:

for ECF >=3.4, SAP 2005 = 111 - 110 ´ $log_{10}(ECF)$

for ECF < 3.4, SAP 2005 = 100 – 13.96 ´ ECF

Table 15 : 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 16 : Relationship between SAP 2001 ratings and SAP 2005 ratings

Where possible, SAP ratings previously calculated using SAP 2001 should be re-calculated using SAP 2005. The table indicates typical differences between the ratings.

SAP 2001	SAP 2005 for main heating fuel as:				
	Mains gas	**LPG**	**Oil**	**Solid fuel**	**Electricity**
1	1	(-5)	(-5)	3	3
10	10	5	5	13	13
20	20	16	16	23	22
30	30	26	26	33	32
40	40	36	36	43	41
50	50	45	45	52	50
60	58	54	54	59	58
70	65	61	61	66	64
80	71	67	67	71	69
90	76	72	72	75	72
100	80	75	76	78	75
110	83	77	78	80	77
120	85	79	80	82	78