

**SAP 2001**

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

2001 EDITION

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**DEFRA**  
Department for  
**Environment,**  
**Food & Rural Affairs**



SCOTTISH EXECUTIVE



Cynulliad Cenedlaethol Cymru  
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Assessment Procedure for Energy  
Rating of Dwellings**

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## SUMMARY

This manual describes the Government's Standard Assessment Procedure (SAP) for producing an energy cost rating (the SAP rating) and a carbon index (the CI) for a dwelling, based on calculated annual energy for space and water heating. The calculation assumes a standard occupancy pattern, derived from the measured floor area of the dwelling, and a standard heating pattern. Both the energy cost rating and the CI are adjusted for floor area so that the size of the dwelling does not affect the results, which are expressed on a scale of SAP rating 1 to 120 and CI 0.0 to 10.0 – the higher the number, the better the standard.

The method of calculating the rating is set out in the form of a worksheet, accompanied by a series of tables. A calculation may be carried out by completing, in sequence, the numbered boxes in the worksheet, using the data in the tables as indicated. Alternatively, and preferably, a computer program approved for SAP calculations by BRE can be used (BRE approves SAP software on behalf of the Department of Environment, Food and Regional Affairs; the Department for Transport, Local Government and the Regions; the Scottish Executive; the National Assembly for Wales; and the Department of Finance and Personnel). A number of companies are authorised by the Government to issue energy cost ratings and CIs on certificates with an official SAP logo to indicate that the results are quality assured – details are available from BRE (see title page). These authorised organisations are entitled to issue SAP ratings and CIs on certificates bearing the official SAP logo because they use computer software that has been approved by BRE as above and they have in place quality assurance systems.

## INTRODUCTION

The Standard Assessment Procedure (SAP) is the Government's recommended system for home energy rating. The SAP energy cost rating is based on energy costs for space and water heating. The carbon index (CI) is based on the carbon dioxide (CO<sub>2</sub>) emissions associated with space and water heating.

Both the SAP rating and the CI are adjusted for floor area so that they are essentially independent of dwelling size for a given built form. They take into account a range of factors that contribute to energy efficiency:

- thermal insulation of the building fabric
- efficiency and control of the heating system
- ventilation characteristics of the dwelling
- solar gain characteristics of the dwelling
- the fuel used for space and water heating.

The calculation is not affected by factors that depend on 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.

Nor is it 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), which provides a framework for the calculation of energy use in dwellings. BREDEM exists in a number of standardised versions that differ in technical detail and in the precise requirements for data related to a particular application. The details of BREDEM are given in earlier BRE reports<sup>[1,2,3,4,5]</sup>. When it is used for new dwellings in connection with Building Regulations, certain default values may be used in the absence of specific details of location, orientation, etc.

The Standard Assessment Procedure was first published by the DOE (now the Department of Environment, Food and Rural Affairs (DEFRA)) 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.

In this edition, known as SAP 2001:

- the Carbon Index is introduced
- the upper limit of the SAP rating is raised from 100 to 120
- the SAP indexing function is revised to make the rating less dependent on floor area

- some additional heating systems are included
- data tables are updated (including those for boiler efficiency and heating controls)
- U-values should be based on European Standards.

## PRESENTATION OF THE RESULTS

The energy cost rating (SAP) and the CI can be presented in one of the following forms:

- *a certificate with the SAP logo*, which can be issued only by companies that are authorised by the Government to issue an energy cost rating and CI on a certificate with the official SAP logo (which indicates that the results are quality assured); no supplementary information or printouts are needed in the case of a certificate with the SAP logo, as the quality assurance procedure assures the quality of the results; however, the input data should be available on request
- *a printout of a calculation*, done by approved computer software, including specification of input data not included in the printout (the type of space and water heating systems, the heating controls and fuels used and, in the case of gas or oil boilers, the printout should indicate the source of boiler efficiency) and the details of the software used for the calculation, including the name of the software and its version number
- *a summary giving the energy cost rating (SAP) and the CI*, stating that the data used in the calculation is not subject to quality control procedures; the data input and the printout of the calculation should be supplied along with the summary form
- *a letter, giving the energy cost rating (SAP) and the CI*, with references to the software/worksheet used for the calculation, the details of the construction and the source of the boiler efficiency (the details should be available on request from the individual or company issuing the letter)
- *a copy of a manual calculation using the SAP worksheet*, with input details as above.

A list of software approved by BRE is available on request (see title page).

## GENERAL PRINCIPLES

### Input precision and rounding

Data should be entered as accurately as possible, although it is unnecessary to go beyond three significant figures (and some product data may only be available to lesser precision). For manual calculations using the worksheet, intermediate calculations should be rounded to at least two decimal places. Any rounding in a SAP calculation should be done to the nearest value, with 1 to 4 being rounded downwards, and 5 to 9 being rounded upwards.

## Manufacturers' data

Where available, use manufacturers' values for input data (boiler efficiency, window U-values). If these values are not available use default data from the tables.

## Existing properties

It should be remembered that the calculation is concerned with the assessment of the dwelling itself, as used by standard or typical occupants, and is 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 which rooms the current occupants heat the most (see section 7.1).

The heating system has a very significant impact on the SAP energy cost rating and CI, and particular care is needed to ensure that it is correctly identified. If there is uncertainty, the principle should be to 'default to the worst' assumption – for example, if there is doubt about the category of heating system (Table 4a or 4b), the category of lower efficiency should be used.

## WORKSHEET CALCULATIONS AND CONVENTIONS

The method of calculating the rating is set out in the form of a worksheet, accompanied by a series of tables. A calculation is carried out by completing the numbered entries in the worksheet sequentially. Some entries are obtained by calculation from entries already made or by carrying forward an earlier entry; highlighting is used to indicate where that applies. Other entries are obtained, using linear interpolation where appropriate, by reference to Tables 1 to 16.

The following notes on calculations and conventions should be read in conjunction with the worksheet.

### 1 DWELLING DIMENSIONS

**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 ground 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, ie if the height of a room extends to two storeys or more, only the actual accessible floor area should be entered. 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 and conservatories:

- *should be included* if they are heated by fixed heating devices
- *should be included* if there is direct access into the dwelling but no separating door, whether they are heated or not
- *should not be included* if they are unheated and there is a separating door into the dwelling. In this context 'porch' means an addition

protruding from the line of the external wall of the dwelling; an entrance lobby that is within such a line should be included.

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* only if heated.

Garages:

- *should be included* if heating is provided within the garage from the main central heating system
- *should not be included* if there is a door between the dwelling and the garage and it is not heated by the central heating system (such a door would be required in new dwellings).

Attics:

- *should be included* if they are habitable rooms, accessed by a fixed staircase
- roof spaces (even though within the insulated envelope, ie where the roof insulation is provided at rafter level) *should not be included* unless they are habitable rooms accessed by a fixed staircase.

When porches, conservatories or garages are not included in the 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 calculated accordingly (see section 3.3).

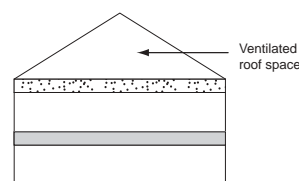
In flats, if corridors and stairwells are heated and the wall between the flat and those spaces is not insulated, treat the wall adjacent to heated corridors/stairwells as a non-heat-loss wall.

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

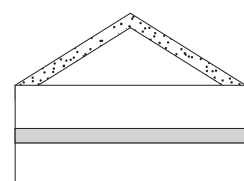
#### 1.1 Pitched roofs

There are three main types of pitched roof construction:

- pitched roof with insulation at ceiling level, insulated between (and perhaps also above) joists, roof space is well ventilated
- 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
- pitched roof insulated either at ceiling level or at rafter level, with roof space converted into habitable space (these have fixed stairs to the room in roof).

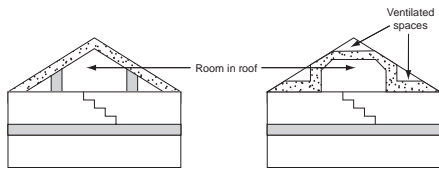


a) Insulation at ceiling level



b) Insulation at rafter level

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



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

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

## 2 VENTILATION RATE

In calculations for a new dwelling for Building Regulations purposes, enter 100% in box (16) for draughtstripping of windows and doors. In the same context, it should be assumed that two sides of the dwelling are sheltered and hence the value '2' should be entered in box (20).

### 2.1 Chimneys and flues

Chimneys and flues should be entered only when they are unrestricted and suitable for use.

For the purposes of the SAP, a chimney is defined as a vertical duct of 200 mm diameter or more (or a rectangular duct of equivalent size) for combustion gases. Vertical ducts with a diameter of 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 blocked-up fireplace fitted with ventilators (if ventilator area does not exceed 0.03 m<sup>2</sup>).

Only open flues should be counted; balanced flues and fan-assisted flues, such as those on many gas boilers and wall-mounted convector heaters, should not.

### 2.2 Fans and passive vents

Extract fans, including cooker hoods and other independent extractor fans, should be included in the 'number of fans' category, but those that form part of a whole-dwelling mechanical ventilation system should be excluded.

The number of fans refers to extract fans, which exhaust air (typically from the kitchen and bathroom). An individual room ventilator with heat recovery should be treated as a fan.

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 entered into the worksheet.

For the purposes of the SAP, a passive stack ventilation system does not qualify as a full mechanical ventilation system since they only extract air and do not deliver fresh air.

Trickle vents or air bricks alone do not count as passive vents and should not be entered into the worksheet.

### 2.3 Optional pressurisation test

A pressurisation test of a dwelling is carried out by installing a fan in the front doorway of a dwelling, sealing all flues and chimneys, and

determining the air flow rate required to maintain an excess pressure of 50 pascals (Pa). The air permeability measured in this way,  $q_{50}$ , expressed in cubic metres per hour per square metre of external surface area must be divided by 20 for use in the worksheet. In this case boxes (11) to (18) of the worksheet are not used.

Whether or not a pressurisation test has been carried out, the ventilation algorithm 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).

### 2.4 Mechanical ventilation

Mechanical ventilation refers to a fan-driven ventilation system, which provides fresh air to the rooms in the dwelling and also exhausts air from the dwelling. The system may or may not be fitted with a heat recovery unit.

### 2.5 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<sup>2</sup> (floor area), it should open into a circulation area, and the door arrangement should be such that a person with a pushchair or similar is able to close the outer door before opening the inner door. It may be heated or unheated and may provide access to a cloakroom (but it should not be counted as a draught lobby if it provides access to other parts of the dwelling).

A draught lobby should be specified only 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.

### 2.6 Sheltered sides

A side of a building is sheltered if there are adjacent buildings or tree-height hedges that 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).

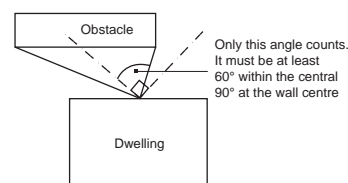


Figure 1 Shelter angle

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.

### 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. The 'other' category, box (35), is included principally to allow for the entry of heat losses to adjoining unheated areas, such as garages and conservatories.

Box (35) can also be used to enter the sum of other heat losses calculated separately in those cases where there are several types of wall or roof. Losses or gains through party walls to spaces in other dwellings or premises that are normally expected to be heated are assumed to be zero.

#### 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.

**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<sup>[6]</sup>. 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' <sup>[7]</sup>.

For existing dwellings, if the construction details are not clearly discernible, U-values should be taken as the maximum permitted by the Building Regulations applicable at the time of construction. Note that this should be the time at which the dwelling obtained approval, which may generally be taken as one year earlier than its completion. Thus a dwelling completed in 2002 should be assigned U-values as required by Regulations in 2001. Account should, however, be taken of insulation known to have been added to the dwelling subsequent to its construction.

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, 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 U-values 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 prEN ISO 10077-2.

Table 6b gives values that can be used in the absence of test data or calculated values. Use a value from Table 6b that corresponds most closely to the description of the actual window; interpolation should not be used in this table.

The factor '0.9' in the calculations supporting boxes (27) to (29) takes account of the assumed use of curtains; it is not optional and must be included. For the purposes of the SAP, treat rooflights as roof windows.

#### 3.3 U-values of elements adjacent to an unheated space

The procedure for the treatment of U-values of elements adjacent to unheated space (previously referred to as semi-exposed elements) is described in BS EN ISO 6946 and BS EN ISO 13789.

- BS EN ISO 6946 gives a simplified procedure, where the unheated space is treated as if it was an additional homogeneous layer.
- BS EN ISO 13789 gives more precise procedures for the calculation of heat transfer from a building to the external environment via unheated spaces, and may be used when a more accurate result is required.
- The following procedure may be used for typical structures (no measurements of the construction providing an unheated space are needed, just select an appropriate  $R_u$  for the appropriate structure in Tables 3.1 to 3.4 below).

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

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,  $m^2K/W$

$R_u$  for typical unheated structures (including garages, access corridors to flats, unheated conservatories 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 (ie less than 10% of the total exposed area of that element). 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).

Note: the following procedure may be useful for building regulation purposes.  $R_u$  can also be used to calculate the U-value between the dwelling and the unheated space,  $U_o$ , which corresponds to a given overall U-value using:

$$U_o = \frac{1}{\frac{1}{U} - R_u}$$

### 3.3.1 Integral and adjacent garages

Values for  $R_u$  are given in Table 3.1.

**Table 3.1**  $R_u$  for integral and adjacent single garages

Garage type	Element between garage and dwelling	$R_u$ for a single garage <sup>1</sup>	
		Inside <sup>2</sup>	Outside <sup>3</sup>
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
Single, adjacent	One wall	0.23	0.09

<sup>1</sup> the table gives  $R$  for single garages; use  $(0.5 \times R)$  for double garages when extra garage is not fully integral, and  $(0.85 \times R)$  for fully integral double garages. Single garage means a garage for one car; double garage means a garage for two cars.

<sup>2</sup> when the insulated envelope of the dwelling goes round the outside of the garage

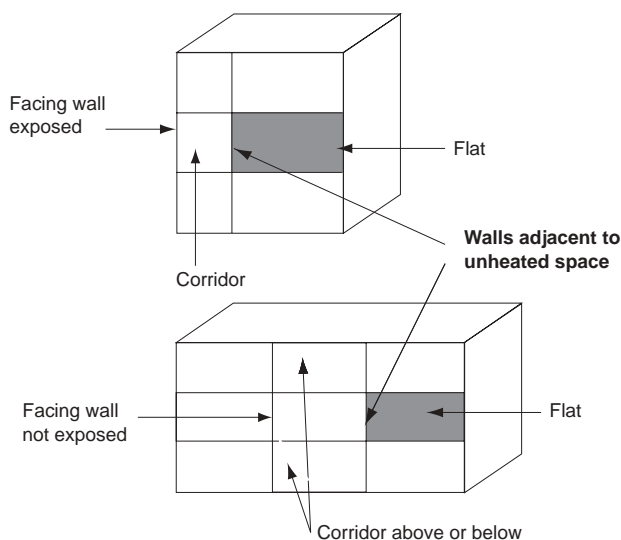
<sup>3</sup> when the walls separating the garage from the dwelling are the external walls

#### Examples of calculated $R_u$ for double garages

Garage type	Element between garage and dwelling	$R_u$ for a double garage	
		Inside	Outside
Double fully integral	Side wall, end wall and floor	$0.68 \times 0.85 = 0.59$	$0.33 \times 0.85 = 0.28$
Double, half integral	Side wall, halves of the garage end wall and floor	$0.68 \times 0.5 = 0.34$	$0.33 \times 0.5 = 0.17$
Double, partially integral displaced forward	Part of the garage side wall, end wall and some floor	$0.56 \times 0.5 = 0.28$	$0.26 \times 0.5 = 0.13$
Double, adjacent	One wall	$0.23 \times 0.5 = 0.13$	$0.09 \times 0.5 = 0.05$

### 3.3.2 Stairwells and access corridors in flats

Figure 3.1 shows examples of access corridors in flats.



**Figure 3.1** Access corridors and stairwells

The following table gives recommended values of the  $R_u$  for common configurations of access corridors.

**Table 3.2**  $R_u$  for common configurations of stairwells and access corridors

Elements between stairwell/corridor and dwelling	$R_u$ for access corridors
<b>Stairwells:</b>	
Facing wall exposed	0.82
Facing wall not exposed	0.90
<b>Access corridors:</b>	
Facing wall exposed, corridor above or below	0.31
Facing wall exposed, corridors above and below	0.28
Facing wall not exposed, corridor above or below	0.43

### 3.3.3 Conservatories

For the purposes of the SAP a conservatory has not less than three-quarters of the area of its roof, and not less than one-half of its external walls made of translucent material.

The effect that a conservatory has on the SAP depends on whether or not there is separation between the conservatory and the dwelling. For this

purpose separation between a dwelling and a conservatory means that:

- walls and floors between conservatory and dwelling, calculated according to BS EN ISO 6946, with the adjustment to take into account the effect of the unheated space (see paragraph 3.3), have U-values comparable to (ie differing by not more than 10%) the U-values of the corresponding exposed elements of the dwelling
- windows and doors between conservatory and dwelling have the same U-value, and for new dwellings the same draughtstripping provisions, as the exposed windows and doors elsewhere in the dwelling.

### 3.3.3.1 Separated conservatories

If there is separation as defined in 3.3.3, then the conservatory should be treated like an unheated space and no solar gain is attributed to the actual glazing of the conservatory. Where a window faces into such a conservatory the solar flux should be taken from Table 6 as normal and not altered. The U-value of the wall adjacent to the unheated conservatory should be corrected to take into account the effect of the unheated space.

**Table 3.3  $R_u$  for conservatory**

Number of walls between dwelling and conservatory	$R_u$ for conservatory
Double glazed:	
one	0.06
two (conservatory in angle of dwelling)	0.14
three (conservatory in recess)	0.25
Single glazed (any number of walls between dwelling and conservatory)	0.10

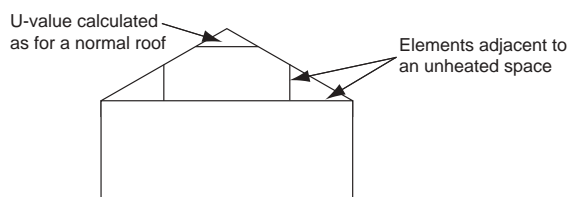
A separated conservatory with fixed heaters should be treated as if it was not separated (ie included as an integral part of the dwelling).

### 3.3.3.2 Conservatories with no separation

If there is no separation then the conservatory should be treated as an integral part of the dwelling. This means that the glazed part of the conservatory should be input as if it were any other glazed component (both in the heat loss section, and in the solar gain section according to its orientation). Where a window faces into such a conservatory it should be ignored and no account should be taken of heat loss or solar gain from that window.

### 3.3.3.3 Room in roof

In the case of room-in-roof construction, the U-value of the walls of the room-in-roof construction is calculated using the procedure described in section 3.3 using thermal resistance  $R_u$  from Table 3.4. The same applies to the ceiling of the room below.



**Figure 3.2 Room in roof**

**Table 3.4  $R_u$  for elements 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
	Insulated ceiling of room below	0.50

## 4 WATER HEATING

### 4.1 Water-heating energy requirements

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. The amount of heat released to the dwelling from storage cylinders and distribution pipework 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.

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 entered 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 'multi-point' water heaters and instantaneous 'combi' boilers are also instantaneous types but, as they normally serve several outlets, they are assumed to have distribution losses.

Stored hot-water systems can either be served by an electric immersion heater or obtain heat from a boiler through a primary circuit. In both cases, water storage losses are incurred to an extent that depends on how well the water storage vessel is insulated. Table 2 gives factors for calculating water storage vessel losses for different thicknesses of insulation. These losses apply for:

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

They are set to zero for other combi boilers and instantaneous water heaters.

A hot water storage vessel carrying third party certification (eg kitemark) should be regarded as having the equivalent of 25 mm insulation, or the actual thickness if greater.

For boiler systems, primary losses are incurred in transferring heat from the boiler to the cylinder; values for primary losses are obtained from Table 3.

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).

For community heating, if there is a hot water cylinder within the dwelling, its size and the appropriate loss factors should be entered in boxes (41) and (42). If there is not a hot water cylinder within the dwelling the calculation should assume a cylinder of 110 litres and loss factor of 0.0079 GJ/litre/year. 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 entered in box (50) in these cases.

## 4.2 Water-heating systems and their efficiencies

For efficiency, see section 9.2.

Systems with no hot water cylinder cannot make use of solar panels.

The SAP allows for primary and secondary space-heating systems, but for only one type of water-heating system. 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 or summertime use 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.

## 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.

Gains from central heating pumps located within the heated space and other items should be added and entered in box (53a), using the values given in the footnote to Table 5.

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 solar access factor describes the extent to which solar radiation is prevented by nearby obstacles from entering the building. The overshadowing categories are dependent on how much the view of the sky through the windows is blocked. The categories are defined in Table 6a in terms of the percentage of sky obscured by obstacles (the 'average' category applies in many cases, and can be used for SAP calculations used for Building Regulations purposes).

Features that affect the shelter factor (see section 2.6) also have a bearing on the amount of overshadowing.

In SAP calculations for Building Regulations purposes, where orientations for new dwellings have not been fixed, glazed elements can be entered for east/west orientations and the solar access factor can be set to 1.

For solar gains when a conservatory is present, see section 3.3.3.1.

### 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, ie excluding framing, mullions, solid panels, transoms, 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

Patio doors that 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 Area-weighted averages

Sometimes a dwelling has more than one type of glazing (eg some double glazing and some single glazing). In these cases the areas, fluxes and gains should be calculated separately for each glazing type, and added in the same manner as boxes (56) to (64), to obtain the entry for box (64a). Alternatively, an area-weighted average solar flux may be calculated for each orientation.

## 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.

## 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 the 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 REQUIREMENTS

The 'useful' energy required from the heating system is calculated from degree days and specific heat loss. The quantity of fuel or electric energy required to meet that demand is then calculated, taking account of the efficiency of the space heating system (obtained from the Boiler Efficiency Database or from Table 4a or 4b).

### 9.1 Heating systems

The SAP assumes that the dwelling has a main heating system capable of heating the entire dwelling.

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).

The procedure for dealing with dwellings that have more than one heating system is described in Appendix A, which gives the combinations of heating systems that may be used in the SAP, together with the proportions of heat assumed to be supplied by main and secondary systems. Appendix A also provides conventions for dwellings with an inadequate heating system.

For community heating schemes and combined heat and power (CHP), 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:

- the Government's Energy Efficiency Best Practice Programme Boiler Efficiency Database
- certified manufacturer's data
- Table 4b of this document.

The preferred source of boiler efficiency is the Government's Energy Efficiency Best Practice Programme Boiler Efficiency Database, which contains boiler efficiency figures intended for use in the SAP. If a new boiler is not included in the database, manufacturers' data certified as explained in D3 should be used if available. If there is no entry in the database and certified manufacturers' data is not available an indicative seasonal efficiency should be taken from Table 4b.

In the Boiler Efficiency Database, 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 [www.boilers.org.uk](http://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 not based on a gas or oil boiler**

For systems not based on a gas or oil boiler, the efficiency should be taken from Table 4a.

For systems not covered by the tables, including cookers and other appliances providing a space-heating function, guidance should be sought from BRE.

### **9.2.3 Room heaters**

Where available, manufacturers' declared values should be used for the efficiency of gas room heaters, certified as explained in Appendix E.

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

## **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 that 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.

### **9.3.8 Flow switch**

A flow switch is a device that 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 may 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 because 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 – 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 devices. For such systems there is no efficiency reduction for the absence of interlock.

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

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, optimum start control, night setback, frost protection, anti-cycling control and hot water override.

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 the two zones independently, as well as having independent temperature controls. 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.)

It is not necessary for these zones to correspond exactly with the zone division that defines the living area fraction.

#### **9.3.13 Weather compensator**

A device, or feature within the 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 the 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.

Storage heaters with automatic charge control are wired to a thermostat that detects the internal temperature and automatically adjusts the charging of the storage heater accordingly.

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 FUEL COSTS**

Fuel costs are calculated using the fuel and electricity requirements calculated earlier in the worksheet and the fuel prices obtained from Table 12. The prices given in Table 12 are averaged over the previous three years and across regions. Other prices must not be used for the purpose of this calculation.

There are two tariffs (10-hour tariff and heat pump tariff), which are based on recent prices and represent a single supplier.

### **10.1 Heating fuels**

There are four items in the SAP that require a fuel, and hence fuel price and a CO<sub>2</sub> emission factor to be specified. These are:

- main system fuel
- secondary system fuel
- water-heating fuel
- electricity for pumps and fans.

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

### **10.2 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 generally straightforward, but the following points should be borne in mind.

#### **10.2.1 Gas systems**

The choices here are gas (mains), bulk liquefied petroleum gas (LPG) and bottled gas. Bottled gas would tend to be used only with gas room-heater systems. In dwellings where the main heating system uses gas (mains) or bulk LPG, any gas-type secondary system should use the same fuel as the main system.

#### **10.2.2 Electric systems**

There are three special heating tariffs available for storage-type systems; 7-hour off-peak, 10-hour off-peak and 24-hour heating tariff.

7-hour off-peak is what would generally be called Economy 7 in England, Wales and Northern Ireland, or Economy White Meter in Scotland.

When the main system is off-peak electricity, any systems that use electricity outside the low-tariff times are charged at the on-peak rate (ie pumps and fans, electric secondary heating and a percentage of the water heating). Standard-rate electricity should not generally be specified in dwellings making use of one of these special electricity tariffs.

The 10-hour tariff provides 10 hours of off-peak electricity in three periods (typically five hours during the night, three hours in the afternoon and two hours in the evening) for space and water heating; lights, appliances, etc, will use standard tariff. The 10-hour tariff is available only in certain areas.

The 24-hour tariff is for use with storage-based systems where the primary and secondary heating, water heating and electricity for pump and fans 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-house heating systems that are designed for about 60% storage and 40% direct-acting heaters. It is available only in certain areas.

The heat pump tariff provides off-peak electricity for three hours in the morning, two hours in the afternoon and three hours in the evening, making eight hours of off-peak heating daily. It is available only in certain areas.

### 10.2.3 Solid-fuel systems

Anthracite nuts and grains will generally be the fuels used in solid-fuel boilers and closed room heaters. For solid-fuel open room fires the fuel would generally be house coal, smokeless fuel or wood.

### 10.3 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.

### 10.4 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.

### 10.5 Electricity for pump 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 usually dependent on the main system fuel or tariff. Note that the allowance in this section for fan-assisted flues applies only for boilers – fan-assisted flues for gas fires should not be counted.

In the worksheet, the instructions alongside box (87) specify the addition of  $(0.002 \text{ GJ} \times \text{dwelling volume})$  for warm-air heating fans and  $(0.004 \text{ GJ} \times \text{dwelling volume})$  for whole-house mechanical ventilation. These should not, however, both be included – if the heating system is a warm-air unit and there is whole-house mechanical ventilation, the warm-air unit fan energy should not be included as the input ventilation fan performs this service (ie in this case use the factor 0.004, not 0.006).

## 11 ENERGY COST RATING (SAP)

The SAP rating is now virtually independent of the floor area for a given built form. It is related to the energy cost factor by the equation:

$$\text{SAP} = 97 - 100 \times \log_{10}(\text{ECF})$$

where ECF = energy cost factor, calculated in box (99).

The SAP ratings may also be obtained by using Table 14.

The SAP rating scale (previously 1-100) has now been extended to 120. A SAP rating of '1' represents a poor standard of energy efficiency while a rating of '120' represents a very high standard.

SAP rating should be rounded to the nearest integer. If the result of the calculation is less than 1, the rating should be quoted as 1; if it is greater than 120, the rating should be quoted as 120.

## 12 CARBON INDEX (CI)

The CI is based on the CO<sub>2</sub> emissions associated with space and water heating, but adjusted for floor area so that it is essentially independent of dwelling size for a given built form. It is related to the carbon factor (CF) by the equation:

$$\text{CI} = 17.7 - 9.0 \log_{10}(\text{CF})$$

Where CF is a carbon factor, calculated using the equation;

$$\text{CF} = \text{CO}_2 / (\text{TFA} + 45.0)$$

Where: CO<sub>2</sub> is the CO<sub>2</sub> emissions in kg/year

TFA is total floor area in m<sup>2</sup>.

The CI is expressed on a scale of 0.0 to 10.0 – the higher the number the better the performance.

The calculation should proceed by completing the appropriate section of the SAP worksheet, designed for calculating CI for:

- individual heating systems and community heating without CHP
- community heating with CHP and waste heat from power stations.

Table 16 is used to obtain the CI from the calculated CF, expressed in kgCO<sub>2</sub>/m<sup>2</sup>/year.

The CI should be expressed as a number between 0.0 and 10.0 rounded to one decimal place. If the result of the calculation is less than 0 the rating should be quoted as 0; if it is greater than 10, the rating should be quoted as 10.

It is anticipated that the CI will take the place of CO<sub>2</sub> emission figure. If, however, the CO<sub>2</sub> emission figure is quoted it should be expressed in tonnes/year rounded to one decimal place.

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BS EN 12524	Building materials and products. Hygrothermal 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: Simplified method	U-values for windows and doors
prEN 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
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## APPENDIX A – Dwellings with more than one heating system

### A1 General principles

The **primary** heating system is that which heats the largest proportion of the dwelling. It is a heating system that is not usually based on individual room heaters and may well provide hot water as well as space heating. Main heating systems are categorised on the basis of generic types in Table 4a.

The **secondary** heating system must be a system based upon a room heater. 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.

A secondary heating system is to be specified if:

- a) the main system is not sufficient in itself to heat the dwelling to the level on which the SAP is based (21°C in the living area and 18°C elsewhere)
- or*
- b) fixed secondary heaters are present (eg gas fires or a chimney and hearth capable of supporting an open coal fire).

In case a), assume direct-acting electric heaters if no actual secondary heaters are present.

The decision to include a secondary heating system should be 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 would not be 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.

A secondary system is always specified when the main system is electric storage heaters.

Table 11 gives the fraction of the heating that is assumed to be supplied by the secondary system. Note that this table limits the allowed secondary heating systems to those that are listed in Table 4a under the section 'Room heater systems'. The type of control used by the secondary system is immaterial for SAP calculation purposes. Consequently, there is never an instance where an efficiency reduction is made to a secondary heating system – the efficiency is always that quoted in Table 4a.

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 that is cheaper to use should be taken as the primary, and if there is still doubt, ie 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 (and the other secondary heaters ignored). If that condition does not resolve the choice, the system that is the cheaper to use should be specified.

### A2 Procedure for dealing with secondary heating systems

- (1) Identify the main heating system. 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. 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.
- (2) If there is still doubt about which system should be selected as the primary, select the system that supplies useful heat to the dwelling at lowest cost (obtained by dividing fuel cost by conversion efficiency).
- (3) Use the responsiveness of the main heating system in calculating the mean internal temperature in section 7 of the SAP calculation.
- (4) Decide whether a secondary heating system needs to be specified, bearing in mind that systems based on stored heat produced from electricity generally require a secondary system for their successful operation. Ignore all portable heaters, such as plug-in electrical radiators and fan heaters or free-standing butane and paraffin heaters. If no secondary system is to be specified, enter zero in box (82).
- (5) If a secondary heating system is to be specified, use Table 11 to select the most appropriate description of the primary/secondary combination. Obtain the proportion of use for the secondary heating system from Table 11 and enter in box (82).
- (6) Obtain the efficiency of the secondary heating system from Table 4a and enter in box (84).
- (7) Calculate the space-heating fuel requirements for both main and secondary heating systems as specified for entry in boxes (85) and (86).

### A3 Dwellings with inadequate heating systems

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 fractions given in Table 11. 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.

## APPENDIX B – Gas and oil boiler systems and boilers with a thermal store

### 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 Tables 2 and 4b.

#### B2.1 Combination boilers

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

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

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

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

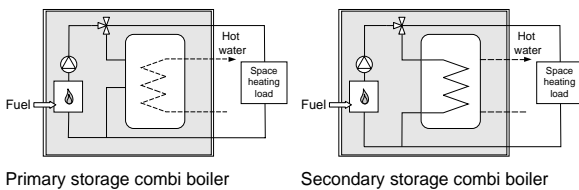


Figure 4 Primary and secondary storage combi boilers

The essential difference between a CPSU (see 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 has a copper heat exchanger or has an internal water content not exceeding 5 litres. If the position is uncertain, the category of 'high thermal capacity' should be used.

#### B2.4 Boiler selected by date

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

#### B2.5 Combined primary storage unit (CPSU)

A CPSU is defined in D1.13. 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 4.

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.

\* Performance specification for thermal stores, Water manufacturers' Association, 1999.

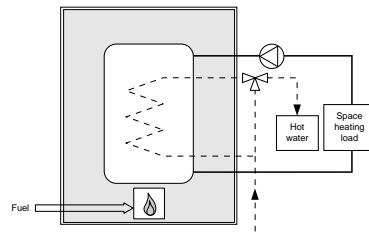


Figure 4 Combined primary storage unit (CPSU)

### 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 (eg 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 5.

For an appliance to qualify as an integrated thermal store, the WMA (formerly British Gas) 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.

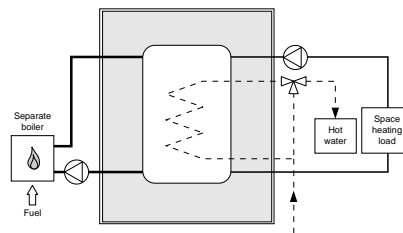


Figure 5 Integrated thermal store

#### 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 6.

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.

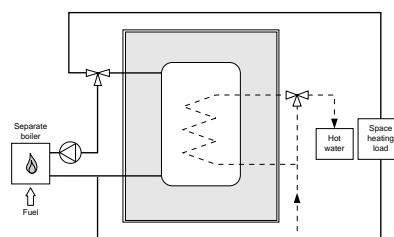


Figure 6 Hot-water-only thermal store

## APPENDIX C – Community heating, including schemes with combined heat and power (CHP) and schemes that recover heat from power stations

### CI 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.

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

CHP plant generates useful energy, at the point of use, in the form of both electricity and heat, with an overall efficiency of typically 80%.

There are essentially two ways of producing heat for community heating by a dedicated plant:

- heat produced by boilers only (Figure 7)
- heat produced by a combination of boilers and CHP units (Figure 8).

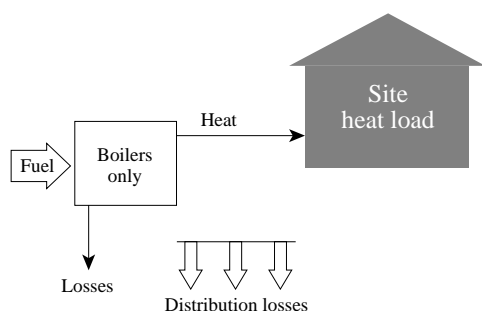


Figure 7 Community heating with heat supplied by boilers only

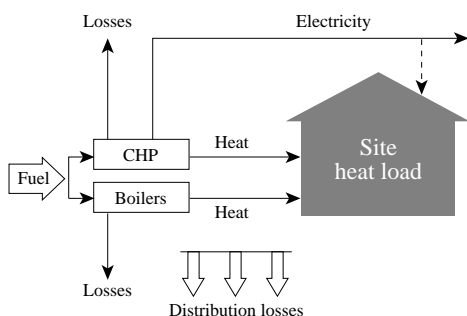


Figure 8 Community heating with heat supplied by a combination of boilers and CHP

For community heating with CHP unit schemes, the CHP 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 CHP and from conventional boilers, and the heat and electrical efficiencies of CHP for the calculation of CO<sub>2</sub> 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.

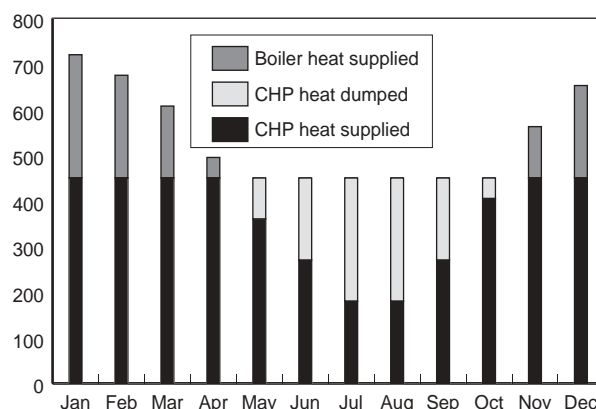


Figure 9 An example of a heat profile chart

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 9).

The heat required for space and water heating is calculated using an alternative worksheet, designed for calculating SAP ratings when space and water heating is provided by community heating (with or without CHP). The 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.

*Note: In the case of community heating with CHP, both heat and electricity are produced and the CO<sub>2</sub> 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<sub>2</sub> emissions factor equivalent to that for electricity generated by new gas-fired power stations, and the remaining CO<sub>2</sub> is assigned to the heat produced.*

### 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.

The CI is calculated using the following procedure:

- use the worksheet for calculating community heating with CHP or schemes that recover heat from power stations
- enter '0' in boxes from (101\*) to (106\*)
- enter '5' in box (107\*) and complete the calculation as normal.

*Note: 5 kg CO<sub>2</sub>/GJ in Table 15 reflects emissions associated with the electricity used for pumping the water from the power station to the dwelling.*

## 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.

### 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 that 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 while 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 while 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.

#### D1.8 On/off instantaneous combination boiler

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

\* 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 L167/17. 21 May 1992, p92.

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

#### D1.9 Modulating instantaneous combination boiler

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

#### D1.10 Storage combination boiler

A combination boiler with an internal hot water store of capacity at least 15 litres but less than 70 litres, or a combination boiler with an internal hot water store of capacity at least 70 litres, in which the feed to the space heating circuit is not taken directly from the store. If the store is at least 70 litres and the feed to the space heating circuit is taken directly from the store, treat as a CPSU (D1.13 or D1.14).

#### D1.11 On/off storage combination boiler

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

#### D1.12 Modulating storage combination boiler

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

#### D1.14 Modulating combined primary storage unit (CPSU)

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

#### D1.15 Low-temperature boiler

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

#### D1.16 Keep-hot facility

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

### D2 Method of calculating the 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 the 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 decimal places 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 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 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.

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

**Table D2.2 Efficiency conversion factors**

Type of fuel	Net-to-gross conversion factor, <i>f</i>
Natural gas	0.901
LPG (butane or propane)	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.

**Table D2.3 Boiler category table**

SEDBUK Equation numbers for different boiler types	Non-condensing (see D1.2)				Low temperature (see D1.15)	Condensing (see D1.2)			
	Gas or LPG		Oil			Gas or LPG		Oil	
	On/off (see D1.4, D1.8, D1.11, D1.13)	Modulating (see D1.5, D1.9, D1.12, D1.14)	On/off (see D1.4, D1.8, D1.11)	Modulating (see D1.5, D1.9, D1.12)		On/off (see D1.4, D1.8, D1.11, D1.13)	Modulating (see D1.5, D1.9, D1.12, D1.14)	On/off (see D1.4, D1.8, D1.11)	Modulating (see D1.5, D1.9, D1.12)
Regular boiler (see D1.4, D1.5)	101	102	201	X	X	101	102	201	X
Instantaneous combi boiler (see D1.7, D1.8, D1.9)	103	104	202	X	X	103	104	202	X
Storage combi boiler (see D1.10, D1.11, D1.12)	105	106	203	X	X	105	106	203	X
Combined primary storage unit (see D1.13, D1.14)	107	107	X	X	X	105	106	X	X

- 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 condensing CPSU (either on/off modulating):
  - set  $b = 1$ .
- e) In the case of a storage combination boiler or a CPSU, obtain the store volume,  $V$ , 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  $t \geq 10$  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 declaration in D3.

### D3 Declaring values of seasonal efficiency

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

- a. they use the SEDBUK calculation procedure given in D2; and
- b. the necessary boiler test data 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:

$$\text{'Seasonal Efficiency (SEDBUK) = s [x]\%}$$

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.

**Table D2.4 Seasonal efficiency, E, for oil 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 D1.13 On/off combined primary storage unit (condensing only)	105	$E = 0.5(E_{full} + E_{part}) - 2.8 + (0.209 \times b \times L \times V) - 4p$
D1.12 Modulating storage combination D1.14 Modulating combined primary storage unit (condensing, only)	106	$E = 0.5(E_{full} + E_{part}) - 1.7 + (0.209 \times b \times L \times V) - 4p$
D1.13 On/off combined primary storage unit (non-condensing only) D1.14 Modulating combined primary storage unit (non-condensing, only)	107	$E = 0.5(E_{full} + E_{part}) - (0.539 \times L \times V) - 4p$

**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	$E = 0.5(E_{full} + E_{part}) - 2.8 + (0.209 \times b \times L \times V)$

**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  $\pm 5\%$  of the natural gas figure.
4. Determine by measurement the percentage dry CO<sub>2</sub> 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.

## APPENDIX E: Method of determining seasonal efficiency for gas room heaters

Note: The data and equations in this appendix are not to be used by SAP assessors.

This appendix sets out the method to be used by manufacturers to determine the declared efficiency for gas room heaters.

Only test results measured by one of the recognised methods given below may be used for this purpose. The methods give comparable results.

**Table E.1 Recognised efficiency test methods**

BS EN 613	Independent gas-fired convection heaters
*prEN 13278	Open fronted gas-fired independent space heaters
*prEN 1266	Independent gas-fired convection heaters incorporating a fan to assist transportation of combustion air and/or flue gases
*BS 7977-1	Specification for safety and rational use of energy of domestic gas appliances. Part 1: Radiant/Convectors
*BS 7977-2	Specification for safety and rational use of energy of domestic gas appliances. Part 2: Combined appliances: Gas fire/Back boiler
PAS 42	Test method for establishing the efficiency of decorative fuel effect fires.

\*Can be used only after publication of the standard by BSI.

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 below.

**Table E.2 Efficiency conversion factors**

Fuel	Net-to-gross conversion factor
Natural gas	0.901
LPG (propane or butane)	0.921

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

'The efficiency of this appliance has been measured by the flue method as specified in [insert appropriate entry from Table E.1] 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. Not less than 270 litres of primary water, heated mainly during off-peak times to approximately 65°C in summer and approximately 85°C in winter, is stored in a thermal store.

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.

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

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

### F1 Procedure for electric CPSUs

Applies to the worksheet from box (82) onwards.

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

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

$$T_{\min} = \{[(37) \times (77)] - C_{\max} + [(39) \times 31.71] - (69)\} / (37)$$

where:

$C_{\max}$  = off-peak heat available from Table F1 (irrespective of power rating of the heating element);

**Table F1 Off-peak heat available ( $C_{\max}$ ) for various operating temperatures**

Indicative $C_{\max}$	CPSU operating temperature (winter)		
	85°C	90°C	95°C
$C_{\max}$ for 270 litre cylinder	1450	1650	1850
$C_{\max}$ for 300 litre cylinder	1620	1830	2050
$C_{\max}$ for 330 litre cylinder	1780	2020	2260

- Find the degree-days (DD) from Table 10 for base temperature  $T_{\min}$ .
- Calculate on-peak energy:  

$$E_{\text{on-peak}} = 8.64 \times 10^{-5} \times (37) \times \text{DD, GJ/year.}$$

2. Calculate on-peak fraction:

$$F = \{E_{\text{on-peak}} / [(81) + (39)]\}, \text{ and enter in box (82).}$$

3. Calculate on-peak percentage, %:

$$P = 100 \times F, \%, \text{ and enter in box (90).}$$

4. Enter 0.47 in box (87a).

5. Calculate fuel cost (£/year) following the normal worksheet calculation.

## APPENDIX G: Treatment of heat pumps in the SAP worksheet

A heat pump is a device that absorbs 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 significantly 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.

The figures used in the SAP calculation apply to electrically driven, vapour compression heat pumps. Heat pump systems are categorised by the low-temperature heat source used (eg air, water, ground) and the seasonal performance factors given in Table 4a 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, eg using surface water from lakes or ponds, using ground water from wells, or using fluid (either refrigerant or a water/antifreeze mixture) circulated in closed pipe loops buried horizontally in shallow trenches or vertically in boreholes.

### G1 Water heating requirement

**In the case of a ground-source or water source heat pump** The heat pump raises the water temperature to a maximum of 45°C, and an immersion heater is then used to raise the water temperature from 45°C to the required delivery temperature. This reduces the on-peak percentage for electricity used by the immersion heater, making the on-peak fraction close to zero. For the purpose of the SAP calculation it is assumed that that 50% of domestic hot water is heated by the heat pump and 50% is heated by the immersion heater using off-peak electricity.

In the SAP worksheet, do not enter efficiency in box (50); instead, calculate the energy required for water heating using the formula

$$[50 \times (49) \div \text{SPF}] + [0.5 \times (49)], \text{ GJ/year, and enter in box (51)}$$

where: SPF - 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 circulation pumps and an auxiliary heater if present).

Then proceed as normal to box (82).

**In the case of an air source heat pump** The domestic hot water is heated by an immersion heater using either standard or off-peak electric tariff. In the SAP worksheet, enter efficiency of 100% in box (50) and proceed the calculation as normal.

### Cost of water heating

Enter the appropriate percentages from the table below into (90) and (91)

Water-heating method	On-peak percentage to be entered in box (90) (%)	Off-peak percentage to be entered in box (91) (%)
Ground source or water source heat pump	17	83
Air source heat pump: Standard tariff water heating	100	0
Off-peak water heating	Percentage from Table 13	Percentage from Table 13

Then proceed as normal.

### G2. Space heating requirement

**In the case of a ground-source 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 smaller ground-source heat pump and a direct-acting electric heater (auxiliary heater). A ground-source heat pump system that includes an auxiliary heater to help meet the maximum demands will have a lower seasonal efficiency (300%) than one without an auxiliary heater (320%).

For ground-source and water-source heat pumps the fraction of the on-peak electricity is 0.7 with the remainder (0.3) charged at off-peak rate.

**In the case of a direct acting air source heat pump.** A heat pump using ambient air as the source will suffer from 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 seasonal efficiency. A secondary heating system (eg. gas or electric heaters) may be present and if so it should be entered in the worksheet in the normal way.

In the SAP worksheet, the space-heating requirement is calculated by the following steps (the procedure applies to both types of heat pump).

- If secondary heating is present, the fraction of heat from secondary heating (from Table 11) should be entered in box (82) and its efficiency in box (84); otherwise enter 0 in boxes (82) and (84).
- Enter the appropriate efficiency of the heat pump from Table 4a in box (83) then proceed with the worksheet calculation as normal to box (87).
- Enter 0.47 in box (87).
- Calculate space heating, entering heat pump as a primary heating and using the appropriate cost of heat pump fuel from the table below (not from Table 12); but for the secondary system use the appropriate fuel cost from Table 12.
- Complete the calculation as normal.

Heat pump electricity tariffs	Additional standing charge (£)	Fuel price (£/GJ)
Standard tariff (air-source heat pump)	0	19.69*
Special heat-pump tariff (ground or water-source heat pump)	40	14.72
7-hour off-peak tariff (ground, water or air-source heat pump)	16	16.94

\* Unit price of standard electricity tariff from Table 12

#### Notes

- The costs of fuel have been pre-calculated, using the cost of fuel from Table 12 and taking into account the appropriate fractions of off-peak electricity.
- Use the normal standing charge from Table 12 (shown above for information).
- Other electricity tariffs should not be used for heat pumps.

The costs of space heating given above were derived using the following calculations:  
In the case of heat-pump tariff:  $(0.7 \times 15.79) + (0.3 \times 12.23) = 14.72 \text{ £/GJ}$   
In the case of 7-hour off-peak tariff:  $(0.7 \times 20.80) + (0.3 \times 7.93) = 16.94 \text{ £/GJ}$   
Where:

	Unit price £/GJ
Electricity 7-hour (on-peak)	20.80
Electricity 7-hour (off-peak)	7.93
Heat pump tariff (on-peak)	15.79
Heat pump tariff (off-peak)	12.23

**SAP WORKSHEET (Version 9.70)**

**1. Overall dwelling dimensions**

	Area (m <sup>2</sup> )		Average room height (m)	=	Volume (m <sup>3</sup> )		
Ground floor	<input type="text"/>	(1a)	×	<input type="text"/>	=	<input type="text"/>	(1b)
First floor	<input type="text"/>	(2a)	×	<input type="text"/>	=	<input type="text"/>	(2b)
Second floor	<input type="text"/>	(3a)	×	<input type="text"/>	=	<input type="text"/>	(3b)
Third and other floors	<input type="text"/>	(4a)	×	<input type="text"/>	=	<input type="text"/>	(4b)
Total floor area	(1a) + (2a) + (3a) + (4a) =					<input type="text"/>	(5)
Dwelling volume	(1b) + (2b) + (3b) + (4b)			=	<input type="text"/>		(6)

**2. Ventilation rate**

			m <sup>3</sup> per hour		Air changes per hour			
Number of chimneys	<input type="text"/>	×	40	=	<input type="text"/>	(7)		
Number of flues	<input type="text"/>	×	20	=	<input type="text"/>	(8)		
Number of fans and passive vents	<input type="text"/>	×	10	=	<input type="text"/>	(9)		
Other					<input type="text"/>	(9a)		
Infiltration due to chimneys, fans and flues	= (7) + (8) + (9) + (9a) =				<input type="text"/>	÷ (6) =	<input type="text"/>	(10)
<i>(Add 40 in box (9a) for each flueless gas fire if present)</i>								
<i>If a pressurisation test has been carried out, proceed to box (19)</i>								
Number of storeys					<input type="text"/>		(11)	
Additional infiltration					<input type="text"/>	[(11) - 1] × 0.1 =	<input type="text"/>	(12)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction					<input type="text"/>		(13)	
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0					<input type="text"/>		(14)	
If no draught lobby, enter 0.05, else enter 0					<input type="text"/>		(15)	
Percentage of windows and doors draughtstripped					<input type="text"/>		(16)	
<i>Enter 100 in box (16) for new dwellings that are to comply with Building Regulations</i>								
Window infiltration	0.25 - [0.2 × (16) ÷ 100]			=	<input type="text"/>		(17)	
Infiltration rate	(10) + (12) + (13) + (14) + (15) + (17)			=	<input type="text"/>		(18)	
If pressurisation test done, then [measured q <sub>50</sub> ÷ 20] + (10), otherwise (19) = (18)					<input type="text"/>		(19)	
Number of sides on which sheltered					<input type="text"/>		(20)	
<i>(Enter 2 in box (20) for new dwellings where location is not shown)</i>								
Shelter factor	1 - [0.075 × (20)]			=	<input type="text"/>		(21)	
If mechanical ventilation with heat recovery,								
effective air change rate	= [(19) × (21)] + 0.17			=	<input type="text"/>		(22)	
<i>(If no heat recovery, add 0.33 air changes per hour to value in box (22))</i>								
If natural ventilation, then air change rate	= (19) × (21)			=	<input type="text"/>		(23)	
	if (23) ≥ 1, then (24) = (23)							
	otherwise (24) = 0.5 + [(23) <sup>2</sup> × 0.5]			=	<input type="text"/>		(24)	
Effective air change rate – enter (22) or (24) in box (25)					<input type="text"/>		(25)	

### 3. Heat losses and heat loss parameters

ELEMENT	Area (m <sup>2</sup> )	U-value (W/m <sup>2</sup> K)	A × U
Doors	<input type="text"/>	× <input type="text"/>	= <input type="text"/> (26)
Windows (type 1)*	0.9 × <input type="text"/>	× <input type="text"/>	= <input type="text"/> (27)
Windows (type 2)*	0.9 × <input type="text"/>	× <input type="text"/>	= <input type="text"/> (28)
Rooflights*	0.9 × <input type="text"/>	× <input type="text"/>	= <input type="text"/> (29)
Ground floor	<input type="text"/>	× <input type="text"/>	= <input type="text"/> (30)
Walls (type 1) <i>excluding windows and doors</i>	<input type="text"/>	× <input type="text"/>	= <input type="text"/> (31)
Walls (type 2) <i>excluding windows and doors</i>	<input type="text"/>	× <input type="text"/>	= <input type="text"/> (32)
Roof (type 1) <i>excluding rooflights</i>	<input type="text"/>	× <input type="text"/>	= <input type="text"/> (33)
Roof (type 2) <i>excluding rooflights</i>	<input type="text"/>	× <input type="text"/>	= <input type="text"/> (34)
Other	<input type="text"/>	× <input type="text"/>	= <input type="text"/> (35)
<i>*the factor 0.9 takes into account the normal use of curtains</i>			
Ventilation heat loss	= <input type="text"/> (25) × 0.33 × <input type="text"/> (6)		= <input type="text"/> (36)
Heat loss coefficient, W/K	= <input type="text"/> (26) + <input type="text"/> (27) + ..... + <input type="text"/> (35) + <input type="text"/> (36)		= <input type="text"/> (37)
Heat loss parameter (HLP), W/m <sup>2</sup> K	= <input type="text"/> (37) ÷ <input type="text"/> (5)		= <input type="text"/> (38)

### 4. Water-heating energy requirements

			GJ/year
Hot water energy requirement (Table 1, column (a))			<input type="text"/> (39)
Distribution loss (Table 1, column (b)), however <i>If instantaneous water heating at point of use, enter '0' in boxes (40) to (43) and (48)</i> <i>For community heating use Table 1(b) whether or not hot water tank present</i>			<input type="text"/> (40)
Water storage volume (litres)	<input type="text"/> (41)		
<i>If no stored water (this includes instantaneous combi boilers) enter '0' in box (41)</i> <i>If heated by community heating and no tank, enter 110 litres in box (41)</i>			
Volume factor (from Table 2a)	<input type="text"/> (41a)		
Water storage loss factor (Table 2), however <i>If community heating and no tank, enter 0.0079</i>	<input type="text"/> (42)		
Energy lost from hot water storage, GJ/year	<input type="text"/> (41) × <input type="text"/> (41a) × <input type="text"/> (42)	=	<input type="text"/> (43)
Area of solar panel, m <sup>2</sup> <i>If no solar panel, enter '0' in boxes (44) to (47) and go to (48)</i>	<input type="text"/> (44)		
Solar energy available	= 1.3 × <input type="text"/> (44)	=	<input type="text"/> (45)
Load ratio	= <input type="text"/> (39) ÷ <input type="text"/> (45)	=	<input type="text"/> (46)
Solar input	= [ <input type="text"/> (45) × <input type="text"/> (46)] ÷ [1 + <input type="text"/> (46)] =		<input type="text"/> (47)
Primary circuit loss (Table 3)			<input type="text"/> (48)
Output from water heater, GJ/year	= <input type="text"/> (39) + <input type="text"/> (40) + <input type="text"/> (43) + <input type="text"/> (48) - <input type="text"/> (47)	=	<input type="text"/> (49)
Efficiency of water heater, % <i>(Use value from Table 4a or 4b reduced by the amount shown in the 'efficiency adjustment' column of Table 4c where appropriate)</i>	<input type="text"/> (50)		
Energy required for water heating	= [ <input type="text"/> (49) × 100] ÷ <input type="text"/> (50)	=	<input type="text"/> (51)
Heat gains from water heating	= [0.25 × <input type="text"/> (39)] + {0.8 × [ <input type="text"/> (40) + <input type="text"/> (43) + <input type="text"/> (48)]}	=	<input type="text"/> (52)

## 5. Internal gains

			Watts
Lights, appliances, cooking and metabolic (Table 5)			<input type="text"/> (53)
Additional gains from Table 5			<input type="text"/> (53a)
Water heating	=	$31.71 \times (52)$	= <input type="text"/> (54)
Total internal gains	=	$(53) + (53a) + (54)$	= <input type="text"/> (55)

## 6. Solar gains

ORIENTATION	Access factor (Table 6a)	Area (m <sup>2</sup> )	Flux (Table 6)	Gains (W)
North	<input type="text"/> ×	<input type="text"/> ×	<input type="text"/>	= <input type="text"/> (56)
North east	<input type="text"/> ×	<input type="text"/> ×	<input type="text"/>	= <input type="text"/> (57)
East	<input type="text"/> ×	<input type="text"/> ×	<input type="text"/>	= <input type="text"/> (58)
South east	<input type="text"/> ×	<input type="text"/> ×	<input type="text"/>	= <input type="text"/> (59)
South	<input type="text"/> ×	<input type="text"/> ×	<input type="text"/>	= <input type="text"/> (60)
South west	<input type="text"/> ×	<input type="text"/> ×	<input type="text"/>	= <input type="text"/> (61)
West	<input type="text"/> ×	<input type="text"/> ×	<input type="text"/>	= <input type="text"/> (62)
North west	<input type="text"/> ×	<input type="text"/> ×	<input type="text"/>	= <input type="text"/> (63)
Rooflights	1.3 ×	<input type="text"/> ×	<input type="text"/>	= <input type="text"/> (64)
Total solar gains			$[(56) + \dots + (64)]$	= <input type="text"/> (65)

Note: for new dwellings where overshadowing is not known, solar access factor is '1'

Total gains, W	$(55) + (65)$	= <input type="text"/> (66)
Gain/loss ratio (GLR)	$(66) \div (37)$	= <input type="text"/> (67)
Utilisation factor (use box (67) and Table 7)		<input type="text"/> (68)
Useful gains, W	$(66) \times (68)$	= <input type="text"/> (69)

## 7. Mean internal temperature

			°C
Mean internal temperature of the living area (Table 8)			<input type="text"/> (70)
Temperature adjustment from Table 4e, where appropriate			<input type="text"/> (71)
Adjustment for gains	=	$\{[(69) \div (37)] - 4.0\} \times 0.2 \times R$	= <input type="text"/> (72)
<i>R is obtained from the 'responsiveness' column of Table 4a or Table 4d</i>			
Adjusted living room temperature	$(70) + (71) + (72)$	=	<input type="text"/> (73)
Temperature difference between zones (Table 9)			<input type="text"/> (74)
Living area fraction (0 to 1.0)	or living room area ÷	$(5)$	= <input type="text"/> (75)
Rest-of-dwelling fraction	=	$1 - (75)$	= <input type="text"/> (76)
Mean internal temperature	=	$(73) - [(74) \times (76)]$	= <input type="text"/> (77)

## 8. Degree days

Temperature rise from gains	$(69) \div (37)$	= <input type="text"/> (78)
Base temperature	$(77) - (78)$	= <input type="text"/> (79)
Degree days (use box (79) and Table 10)		= <input type="text"/> (80)

## 9. Space-heating requirement

$$\text{Energy requirement (useful)} = 0.000\ 086\ 4 \times (80) \times (37) = \boxed{\phantom{000000}} \text{ (81)} \quad \text{GJ/year}$$

### Individual heating systems:

Note: when space and water heating is provided by community heating, use the alternative SAP worksheet (on next page) from this point

$$\text{Fraction of heat from secondary system (Use value from Table 11 or Appendix F)} = \boxed{\phantom{000000}} \text{ (82)}$$

Efficiency of main heating system, %

$$\text{(Use value from Table 4a or 4b, adjusted where appropriate by the amount shown in the 'efficiency adjustment' column of Table 4c.} = \boxed{\phantom{000000}} \text{ (83)}$$

$$\text{Efficiency of secondary heating system (Use value obtained from Table 4a)} = \boxed{\phantom{000000}} \text{ (84)}$$

$$\text{Space-heating fuel (main)} = [1 - (82)] \times (81) \times 100 \div (83) = \boxed{\phantom{000000}} \text{ (85)}$$

$$\text{Space-heating fuel (secondary)} = [(82) \times (81)] \times 100 \div (84) = \boxed{\phantom{000000}} \text{ (86)}$$

Electricity for:

$$\text{each central heating pump (Table 4f)} = \boxed{\phantom{000000}} \text{ (87a)}$$

$$\text{each boiler with a fan-assisted flue (Table 4f)} = \boxed{\phantom{000000}} \text{ (87b)}$$

$$\text{warm-air heating system fans, add } 0.002 \text{ GJ} \times (6) = \boxed{\phantom{000000}} \text{ (87c)}$$

$$\text{dwellings with whole-house mechanical ventilation, add } 0.004 \text{ GJ} \times (6) = \boxed{\phantom{000000}} \text{ (87d)}$$

$$\text{maintaining keep-hot facility for gas combi boiler (Table 4f)} = \boxed{\phantom{000000}} \text{ (87e)}$$

$$(87a) + (87b) + (87c) + (87d) + (87e) = \boxed{\phantom{000000}} \text{ (87)}$$

## 10. Fuel costs

$$\text{GJ/year} \times \text{Fuel price (Table 12)} = \text{£/year}$$

$$\text{Space heating – main system } (85) \times \boxed{\phantom{000000}} = \boxed{\phantom{000000}} \text{ (88)}$$

$$\text{Space heating – secondary system } (86) \times \boxed{\phantom{000000}} = \boxed{\phantom{000000}} \text{ (89)}$$

## Water heating

If off-peak electric water heating:

$$\text{On-peak percentage (Table 13 or Appendix F)} = \boxed{\phantom{000000}} \text{ (90)}$$

$$\text{Off-peak percentage } 100 - (90) = \boxed{\phantom{000000}} \text{ (91)}$$

### Fuel price

$$\text{On-peak cost } [(51) \times (90)] \div 100 \times \boxed{\phantom{000000}} = \boxed{\phantom{000000}} \text{ (92)}$$

$$\text{Off-peak cost } [(51) \times (91)] \div 100 \times \boxed{\phantom{000000}} = \boxed{\phantom{000000}} \text{ (93)}$$

$$\text{Otherwise, water-heating costs } (51) \times \boxed{\phantom{000000}} = \boxed{\phantom{000000}} \text{ (94)}$$

$$\text{Pump and fan energy cost } (87) \times \boxed{\phantom{000000}} = \boxed{\phantom{000000}} \text{ (95)}$$

$$\text{Additional standing charges (Table 12, notes)} = \boxed{\phantom{000000}} \text{ (96)}$$

$$\text{Total heating } (88) + (89) + (92) + (93) + (94) + (95) + (96) = \boxed{\phantom{000000}} \text{ (97)}$$

## 11. SAP rating (conventional heating)

$$\text{Energy cost deflator (Table 12, notes)} = \boxed{1.05} \text{ (98)}$$

$$\text{Energy cost factor (ECF)} = \{[(97) \times (98)] - 30.0\} \div \{(5) + 45.0\} = \boxed{\phantom{000000}} \text{ (99)}$$

$$\text{SAP rating (Table 14)} = \boxed{\phantom{000000}} \text{ (100)}$$

## Community heating

This page should be used when space and water heating is provided by community heating only with or without CHP or heat recovered from power stations. If CHP is not involved enter '0' in box (83\*) and '1.0' in box (84\*).

Overall system efficiency of the heating plant (100% minus the amount shown in the 'efficiency adjustment' column of Table 4c where appropriate)			<input type="text"/>	(82*)
Fraction of heat from CHP unit or fraction of heat recovered from power station (from operational records or system design specification)			<input type="text"/>	(83*)
Fraction of heat from boilers	$1 - (83^*)$	=	<input type="text"/>	(84*)
Distribution loss factor (Table 12a)			<input type="text"/>	(85*)
<b>GJ/year</b>				
Space heating from CHP or recovered, GJ/year	$[(81) \times (83^*) \times 100] \div (82^*) \times (85^*)$	=	<input type="text"/>	(86*)
Space heating from boilers, GJ/year	$[(81) \times (84^*) \times 100] \div (82^*) \times (85^*)$	=	<input type="text"/>	(87*)
Electricity for pumps and fans: enter '0', except for dwellings with whole-house mechanical ventilation, enter 0.004 GJ × (6)			<input type="text"/>	(88*)

## 10. Fuel costs

	<b>GJ/year</b> × <b>Fuel price</b> (Table 12)	=	<b>£/year</b>	
Space heating (CHP or from power stations). Price from Table 12 is irrespective of fuel used by CHP	$(86^*) \times \text{[Fuel Price]}$	=	<input type="text"/>	(89*)
Space heating (community boilers)	$(87^*) \times \text{[Fuel Price]}$	=	<input type="text"/>	(90*)

## Water costs

			<b>Fuel price</b>	
Water heated by CHP or recovered	$[(51) \times (83^*)] \times \text{[Fuel Price]} \times (85^*)$	=	<input type="text"/>	(91*)
Water heated by community boilers	$[(51) \times (84^*)] \times \text{[Fuel Price]} \times (85^*)$	=	<input type="text"/>	(92*)
Water heated by immersion heater (if not heated by immersion heater, go to box (95*))				
On-peak percentage (Table 13)			<input type="text"/>	(93*)
Off-peak percentage	$100 - (93^*)$		<input type="text"/>	(93a*)
			<b>Fuel price</b>	
On-peak cost	$(51) \times (93^*) \div 100 \times \text{[Fuel Price]}$	=	<input type="text"/>	(94*)
Off-peak cost	$(51) \times (93a^*) \div 100 \times \text{[Fuel Price]}$	=	<input type="text"/>	(94a*)
Heating pump and/or fan energy cost	$= (88^*) \times \text{[Fuel Price]}$	=	<input type="text"/>	(95*)
Additional standing charges (Table 12)		=	<input type="text"/>	(96*)
Total heating	$(89^*) + (90^*) + (91^*) + (92^*) + (94^*) + (94a^*) + (95^*) + (96^*)$	=	<input type="text"/>	(97*)

## 11. SAP rating (community heating)

Energy cost deflator (Table 12)			<input type="text"/>	(98*)
Energy cost factor (ECF)	$= \{[(97^*) \times (98^*)] - 30\} \div \{(5) + 45\}$	=	<input type="text"/>	(99*)
SAP rating (Table 14)			<input type="text"/>	(100*)

**Carbon Index (CI) for individual and community heating without CHP**

	Energy (GJ/year)		Emission factor (Table 15)	=	Annual emissions (kg/year)
Water heating – from box (51) <i>if heated by community boilers [(51) × (85*) ÷ 0.75]</i>	<input type="text"/>	×	<input type="text"/>	=	<input type="text"/> (101)
Space heating, main – from box (85) <i>if heated by community boilers [(87*) ÷ 0.75]</i>	<input type="text"/>	×	<input type="text"/>	=	<input type="text"/> (102)
Space heating, secondary – from box (86) <i>if heated by community boilers, enter '0'</i>	<input type="text"/>	×	<input type="text"/>	=	<input type="text"/> (103)
Electricity for pumps and fans – from box (87) or (88*)	<input type="text"/>	×	<input type="text"/>	=	<input type="text"/> (104)
TOTAL CO <sub>2</sub> (space and water) kg/year	[(101) + (102) + (103) + (104)]			=	<input type="text"/> (105)
Carbon Factor (CF) = (105) ÷ [(5) + 45.0]	<input type="text"/>		<input type="text"/>	=	<input type="text"/> (106)
Carbon Index (CI), Table 16	<input type="text"/>		<input type="text"/>	=	<input type="text"/> (107)

**Carbon Index (CI) for community heating schemes with CHP or heat recovered from power stations**

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

			Emission factor (kgCO <sub>2</sub> /GJ)		
Electrical efficiency of CHP unit (eg 0.30) from operational records or the CHP design specification			<input type="text"/>		(101*)
Heat efficiency of CHP unit (eg 0.50) from operational records or the CHP design specification			<input type="text"/>		(102*)
CO <sub>2</sub> emission factor for the CHP fuel from Table 15			<input type="text"/>		(103*)
CO <sub>2</sub> emission factor for electricity (125 kgCO <sub>2</sub> /GJ if CHP present)			125		(104*)
CO <sub>2</sub> emitted by CHP per 1 GJ of generated electricity	(103*) ÷ (101*) =				<input type="text"/> (105*)
Heat to power ratio, enter if known, otherwise	(102*) ÷ (101*) =				<input type="text"/> (106*)
CO <sub>2</sub> emission factor for heat [(105*) – (104*)] ÷ (106*), Note: the value in box (107*) can be negative.					<input type="text"/> (107*)
Water heated by CHP or hot water from power stations (51) × (83*) × (85*)	<input type="text"/>	×	box (107*) <input type="text"/>	=	<input type="text"/> (108*)
Water heated by boilers (51) × (84*) × (85*) ÷ 0.80	<input type="text"/>	×	Table 15 <input type="text"/>	=	<input type="text"/> (109*)
If water heated by immersion heater, box (51)	<input type="text"/>	×	Table 15 <input type="text"/>	=	<input type="text"/> (110*)
Space heating from (CHP) or waste heat, box (86*)	<input type="text"/>	×	box (107*) <input type="text"/>	=	<input type="text"/> (111*)
Space heating from boilers, (87*) ÷ 0.80	<input type="text"/>	×	Table 15 <input type="text"/>	=	<input type="text"/> (112*)
Electricity for pumps and fans, box (88*) (enter "0" in box (113*) if heat recovered from power station)	<input type="text"/>	×	Table 15 <input type="text"/>	=	<input type="text"/> (113*)
TOTAL CO <sub>2</sub> (space and water) kg/year (If negative enter "1" in box (114*))	[(108*) + ..... + (113*)]			=	<input type="text"/> (114*)
Carbon factor (CF)	[(114*) ÷ {(5) + 45.0}]			=	<input type="text"/> (115*)
Carbon index (CI), Table 16				=	<input type="text"/> (116*)

**Table 1: Hot water energy requirements**

Floor area (m <sup>2</sup> )	a)	b)
	Hot water usage (GJ/year)	Distribution loss (GJ/year)
30	4.13	0.73
40	4.66	0.82
50	5.16	0.91
60	5.68	1.00
70	6.17	1.09
80	6.65	1.17
90	7.11	1.26
100	7.57	1.34
110	8.01	1.41
120	8.44	1.49
130	8.86	1.56
140	9.26	1.63
150	9.65	1.70
160	10.03	1.77
170	10.40	1.84
180	10.75	1.90
190	11.10	1.96
200	11.43	2.02
210	11.74	2.07
220	12.05	2.13
230	12.34	2.18
240	12.62	2.23
250	12.89	2.27
260	13.15	2.32
270	13.39	2.36
280	13.62	2.40
290	13.84	2.44
300	14.04	2.48

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:

- Calculate  $N = 0.035 \times TFA - 0.000\ 038 \times TFA^2$ , if  $TFA \leq 420$   
 $= 8.0$  if  $TFA > 420$
- Hot water usage =  $[(61 \times N) + 92] \times 0.85 \div 31.71$
- Distribution loss =  $[(61 \times N) + 92] \times 0.15 \div 31.71$

**Table 2: Hot water storage loss factor (GJ/year/litre)**

Insulation thickness (mm)	Cylinder		Storage combination boiler*		Thermal store and CPSU	
	Factory insulated	Loose jacket	Primary store	Secondary store	Hot-water-only thermal store	Integrated thermal store or CPSU
None	0.0945	0.0945	0.1417	0.0945	0.1417	n/a
12.5	0.0315	0.0725	0.0473	0.0315	0.0473	n/a
25	0.0158	0.0504	0.0236	0.0158	0.0236	n/a
38	0.0104	0.0332	0.0156	0.0104	0.0156	0.0290
50	0.0079	0.0252	0.0118	0.0079	0.0118	0.0221
80	0.0049	0.0158	0.0074	0.0049	0.0074	0.0138
100	0.0039	0.0126	0.0059	0.0039	0.0059	0.0110
150	0.0026	0.0084	0.0039	0.0026	0.0039	0.0074

\* If efficiency source is SEDBUK value.

This is multiplied in the worksheet by the cylinder, thermal store or CPSU volume in litres to obtain the loss rate. These data apply to cylinders and

thermal stores heated by gas, oil and solid-fuel boilers, and to cylinders heated by electric immersion.

Multiply by a factor of 1.3 if a cylinder thermostat is absent.

In the case of a combination boiler:

- the storage loss factor is zero if the efficiency is taken from Table 4b
- the storage loss factor is zero for non-storage combi boilers, including those with keep-hot facility (see notes to Table 3 for the definition of keep-hot facility)
- the loss is to be added for a storage combination boiler if its efficiency is the manufacturers' 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 by the Database).

In the case of electric CPSUs, for the off-peak electric tariffs providing at least 10 hours of heating per day, the water storage loss factor is 0.029 GJ/year/litre (to be entered in box 42).

Alternatively the heat loss factor,  $L$ , may be calculated for insulation thickness of  $t$  mm as follows:

- Uninsulated cylinder:  $L = 0.0945$
- Cylinder, loose jacket:  $t < 25$  mm:  $L = 0.0945 - 0.00176t$
- Cylinder, loose jacket:  $t \geq 25$  mm:  $L = 1.26/t$
- Cylinder, factory-insulated:  $t < 10$  mm:  $L = 0.0945 - 0.0055t$
- Cylinder, factory-insulated:  $t \geq 10$  mm:  $L = 0.394/t$
- Cylinder, 10-hour off-peak electricity tariff: value for cylinder times 1.5
- Storage combination boiler, primary store: value for factory-insulated cylinder times 1.5
- Storage combination boiler secondary store: value for factory-insulated cylinder
- Hot-water-only thermal store: value for factory-insulated cylinder times 1.5
- Hot-water-only thermal store not in airing cupboard: value for factory-insulated cylinder times 2.1
- Integrated thermal store or CPSU in airing cupboard: value for factory-insulated cylinder times 2.8
- Integrated thermal store or CPSU not in airing cupboard: value for factory-insulated cylinder times 3.92

**Table 2a: Volume factor**

When using the data in Table 2, the loss is to be multiplied by a volume factor.

Volume	Volume Factor
40	1.442
60	1.259
80	1.145
100	1.063
120	1.000
140	0.950
160	0.908
180	0.874
200	0.843
220	0.817
240	0.794
260	0.773
280	0.754

Alternatively, the volume factor can be calculated using the equation  $VF = (120 / V)^{1/3}$ . Where: VF - volume factor; V - volume, litres.

**Table 3: Primary circuit and keep-hot losses (GJ/year)**

System type	GJ/year
Electric immersion heater	0.0
Boiler with uninsulated primary* pipework and no cylinder thermostat	4.4
Boiler with insulated primary pipework and no cylinder thermostat	2.2
Boiler with uninsulated primary pipework and with cylinder thermostat	2.2
Boiler with insulated primary pipework and with cylinder thermostat	1.3
CPSU (including electric CPSU)	0.0
Boiler and thermal store within a single casing (cylinder thermostat present).	0.0
Separate boiler and thermal store connected by no more than 1.5 m of insulated pipework.	0.0
Separate boiler and thermal store connected by – uninsulated primary pipe work	1.7
– more than 1.5 m of insulated primary pipe work	1.0
Additional losses for instantaneous combi boilers – without keep-hot facility**	0.8
– with keep-hot facility, controlled by time clock	0.8
– with keep-hot facility, not controlled by time clock***	2.0
Community heating	1.3

\* 'Primary pipework' means the pipes between a boiler and a hot water tank; 'secondary pipeworks' – between a cylinder and a tap.

\*\* 'Keep-hot facility' is defined in Appendix D. If the store is 15 litres or more, the boiler is a storage combination boiler. The facility to keep water hot may have an on/off switch for the user, and may be controlled by a time switch.

In the SAP worksheet:

- 1) If the keep-hot facility is maintained hot solely by burning fuel, use an appropriate loss for combi boiler from the above table and proceed with the worksheet calculation as normal.
- 2) If the keep-hot facility is maintained by electricity, use the following approach:
  - a) include appropriate primary circuit losses in box (48)
  - b) calculate energy required for water heating  $\{(49) - (48)\} \times 100 \div (50)$  and enter in box (51).

\*\*\* In the case of an untimed electrically powered keep-hot facility where the power rating of the keep-hot heater is obtained from the Boiler Efficiency database, the loss should be taken as:

$$\text{Loss} = 0.032 \times P \text{ (GJ/year)}$$

where: P is the power rating in Watts

**Table 4a: Heating system seasonal efficiency (space and water)**

- 1 This 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 the table.
- 3 'Heating type' refers to the appropriate column in Table 8.
- 4 Responsiveness (R) is used in worksheet calculation, box (72).

	Efficiency %	Heating type	R
--	--------------	--------------	---

#### CENTRAL HEATING SYSTEMS WITH RADIATORS OR UNDERFLOOR HEATING

- a. Refer to Group 1 in Table 4e for control options
- b. Check Table 4c for efficiency adjustment due to controls

#### Gas boilers and oil boilers

For efficiency, use boiler database; otherwise use manufacturer's declared value (SEDBUK) if possible, otherwise use efficiency value from Table 4b.

Obtain the heating type and responsiveness from Table 4d.

#### Solid-fuel boilers

Manual feed (in heated space)	60	2	0.75
Manual feed (in unheated space)	55	2	0.75
Autofeed (in heated space)	65	2	0.75
Autofeed (in unheated space)	60	2	0.75
Open fire with back boiler to rads	55	3	0.50
Closed fire with back boiler to rads	65	3	0.50

#### Electric boilers

Dry-core boiler in heated space	100	2	0.75
Dry-core boiler in unheated space	85	2	0.75
Water storage boiler in heated space	100	2	0.75
Water storage boiler in unheated space	85	2	0.75
Electric CPSU in heated space	100	2	0.75
Direct-acting electric boiler	100	1	1.0

#### Heat pumps (see also warm air systems)

Ground-to-water heat pump	320		From Table 4d
Ground-to-water heat pump with auxiliary heater	300		From Table 4d
Water-to-water heat pump	300		From Table 4d
Air-to-water heat pump	250		From Table 4d

#### COMMUNITY HEATING SCHEMES

- |  |     |   |     |
|--|-----|---|-----|
|  | 100 | 1 | 1.0 |
|--|-----|---|-----|
- a. Refer to Group 2 in Table 4e for control options
  - b. Check Table 4c for efficiency and adjustment due to controls

	Efficiency %	Heating type	R
<b>STORAGE RADIATOR SYSTEMS</b>			
<i>Refer to Group 3 in Table 4e for control options</i>			
<i>Off-peak tariff:</i>			
Old (large volume) storage heaters	100	5	0.0
Modern (slimline) storage heaters	100	4	0.25
Convector storage heaters	100	4	0.25
Fan storage heaters	100	3	0.5
Electric underfloor heating	100	5	0.0
Modern (slimline) storage heaters with CELECT-type control	100	3	0.5
Convector storage heaters with CELECT-type control	100	3	0.5
Fan storage heaters with CELECT-type control	100	2	0.75
<i>24-hour heating tariff:</i>			
Modern (slimline) storage heaters	100	3	0.50
Convector storage heaters	100	3	0.50
Fan storage heaters	100	3	0.50
Modern (slimline) storage heaters with CELECT-type control	100	2	0.75
Convector storage heaters with CELECT-type control	100	2	0.75
Fan storage heaters with CELECT-type control	100	2	0.75
<b>WARM-AIR SYSTEMS</b>			
<i>Refer to Group 4 in Table 4e for control options</i>			
<b>Gas-fired warm-air with fan-assisted flue</b>			
Ducted, with gas-air modulation	80	1	1.0
Room heater, with in-floor ducts	77	1	1.0
<b>Gas-fired warm-air with balanced or open flue</b>			
Ducted (on/off control)	70	1	1.0
Ducted (modulating control)	72	1	1.0
Stub ducted	70	1	1.0
Ducted with flue heat recovery	85	1	1.0
Stub ducted with flue heat recovery	82	1	1.0
Condensing	94	1	1.0
<b>Oil-fired warm-air</b>			
Ducted output (on/off control)	70	1	1.0
Ducted output (modulating control)	72	1	1.0
Stub duct system	70	1	1.0
<b>Electric warm-air</b>			
Electricaire system	100	2	0.75
<b>Heat pumps</b>			
Ground-to-air heat pump	320	1	1.0
Ground-to-air heat pump with auxiliary heater	300	1	1.0
Water-to-air heat pump	300	1	1.0
Air-to-air heat pump	250	1	1.0

	Efficiency %	Heating type	R
<b>ROOM HEATER SYSTEMS</b>			
<i>Refer to Group 5 in Table 4e for control options</i>			
<b>Gas</b>			
Gas fire, open flue, pre-1980 (open front)	50	1	1.0
Gas fire, open flue, 1980 or later	60	1	1.0
Gas fire or wall heater, balanced flue	70	1	1.0
Gas fire with back boiler (no radiators)	65	1	1.0
Room heater, fan-assisted flue	75	1	1.0
Condensing gas fire	85	1	1.0
Flush fitting live effect gas fire, sealed to chimney	50	1	1.0
Flush fitting live fuel effect gas fire, fan assisted flue	45	1	1.0
Decorative fuel effect gas fire, open to chimney	20	1	1.0
Gas fire, flueless, <i>add additional ventilation requirements in box (9a)</i>	100	1	1.0
<b>Solid fuel</b>			
Open fire in grate	32	3	0.5
Open fire in grate, with throat restrictor	42	3	0.5
Open fire with back boiler (no rads)	55	3	0.5
Closed room heater	60	3	0.5
Closed room heater with back boiler (no rads)	65	3	0.5
<b>Electric (direct-acting)</b>			
Panel, convector or radiant heaters	100	1	1.0
Portable electric heaters	100	1	1.0
<b>OTHER SPACE-HEATING SYSTEMS</b>			
<i>Refer to Group 6 in Table 4e for control options</i>			
Electric ceiling heating	100	2	0.75
<b>HOT-WATER-ONLY HEATING SYSTEMS</b>			
Independent electric water heating system	100	n/a	n/a
From a heat exchanger built into a gas warm-air system	65	n/a	n/a
Single-point gas water heater	70	n/a	n/a
Multi-point gas water heater	65	n/a	n/a

**Table 4b: Seasonal efficiency for gas and oil boilers**

1. This table is to be used only for gas and oil boilers for which the SEDBUK is not available.
2. The table shows seasonal efficiency for space heating. The same seasonal efficiency should be assumed for water heating when hot water is supplied from a boiler system.
3. See Appendix B for guidance on boiler classification.

	Efficiency %
<b>Gas boilers (including LPG) 1998 or later</b>	
1-1 Non-condensing (including combis) with automatic ignition	73
1-2 Condensing (including combis) with automatic ignition	83
1-3 Non-condensing (including combis) with permanent pilot light	69
1-4 Condensing (including combis) with permanent pilot light	79
1-5 Room heater + back boiler	65
<b>Gas boilers (including LPG) pre-1998, with fan-assisted flue</b>	
2-1 Low thermal capacity	72
2-2 High or unknown thermal capacity	68
2-3 Combi	70
2-4 Condensing combi	84
2-5 Condensing	85
<b>Gas boilers (including LPG) pre-1998 with balanced or open-flue</b>	
3-1 Wall-mounted	65
3-2 Floor-mounted, pre 1979	55
3-3 Floor-mounted, 1979 to 1997	65
3-4 Combi	65
3-5 Room heater + back boiler	65
<b>Gas combined primary storage units (CPSU)</b>	
4-1 With permanent pilot	70
4-2 With automatic ignition	74
} non-condensing	
<b>Oil boilers</b>	
5-1 Standard oil boiler pre-1985	65
5-2 Standard oil boiler 1985 to 1997	70
5-3 Standard oil boiler, 1998 or later	79
5-4 Condensing	83
5-5 Combi, pre-1998	70
5-6 Combi, 1998 or later	76
5-7 Condensing combi	81

**Table 4c: Efficiency adjustments**

	Efficiency adjustment, %	
	Mains gas	Oil/LPG
<b>Gas or oil boiler systems with radiators or underfloor heating</b>		
<i>The adjustments should be applied to the space and water heating seasonal efficiency for both the SEDBUK value and to efficiency values from Table 4b.</i>		
Efficiency adjustment due to low temperature distribution system		
Condensing boiler with load compensator <sup>a)</sup>	+2	+1
Condensing boiler with weather compensator <sup>a)</sup>	+2	+1
Condensing boiler with under-floor heating <sup>a), b)</sup>	+3	+2
Condensing boiler with thermal store	0	0
Efficiency adjustment due to control system:		
No thermostatic control of room temperature <sup>a), d)</sup>		-5
No boiler interlock <sup>a)</sup>		-5
<b>Community heating systems</b>		
Flat rate charging <sup>c)</sup> , no thermostatic control of room temperature		
		-10
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

**Notes**

- These are mutually exclusive and therefore do not accumulate; if more than one applies, the highest applicable efficiency adjustment is to be used.*
- Adjustment is applicable if the boiler supplies only the underfloor heating, and not if it also feeds radiators or supplies hot water.*
- '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.*
- Does not apply to heat pumps.*

**Table 4d: Heating type and responsiveness for gas and oil boilers**

Heat emitter	Heating type	Responsiveness (R)
Radiators	1	1.0
Underfloor heating:		
– pipes in insulated timber floor	1	1.0
– pipes in screed or concrete slab	4	0.25

**Table 4e: Heating system controls**

1. Use Table 4a to select the appropriate Group in this table.
2. 'Control' indicates the appropriate column to use in Table 9.
3. The 'Efficiency adjustment' should be applied to the space and water heating seasonal efficiency (SEDBUK or from Table 4a or Table 4b).
4. The 'Temperature adjustment' modifies the living area mid internal temperature obtained from Table 8 and should be entered into box (71) of the worksheet.

Type of control	Control	Temp adjustment (°C)
<b>GROUP 1: BOILER SYSTEMS WITH RADIATORS OR UNDERFLOOR HEATING</b>		
No thermostatic control of room temperature	1	+0.6
Programmer (time control)	1	0
Room thermostat	1	0
Programmer + room thermostat	1	0
Programmer + roomstat + TRVs	2	0
Programmer + TRVs + bypass	2	0
Programmer + TRVs + flow switch	2	0
Programmer + TRVs + boiler energy manager	2	0
Delayed start thermostat + programmer	1	-0.15
Delayed start thermostat + programmer + TRVs	2	-0.15
Time and temperature zone control	3	0
Additional temperature adjustment for CPSU or integrated thermal stores	0	-0.1
<b>GROUP 2: COMMUNITY HEATING SCHEMES</b>		
Flat rate charging*, no thermostatic control of room temperature	1	+0.3
Flat rate charging*, programmer and roomstat	1	0
Flat rate charging*, programmer and TRVs	2	0
Charging system linked to use of community heating, programmer and TRVs	3	0
<b>GROUP 3: STORAGE RADIATOR SYSTEMS</b>		
Manual charge control	3	+0.3
Automatic charge control	3	0
CELECT-type controls	3	0
<b>GROUP 4: WARM-AIR SYSTEMS</b>		
No thermostatic control of room temperature	1	+0.3
Roomstat only	1	0
Programmer + roomstat	1	0
Time and temperature control	3	0
<b>GROUP 5: ROOM HEATER SYSTEMS</b>		
No thermostatic control	2	+0.3
Appliance stat	3	0
Appliance stat + prog	3	0
Programmer + roomstat	3	0
Roomstat only	3	0
<b>GROUP 6: OTHER SYSTEMS</b>		
No thermostatic control of room temperature	1	+0.3
Roomstat only	1	0
Programmer + roomstat	1	0
Time and temperature control	3	0

\*'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.

**Table 4f: Electricity for fans and pumps and electric keep-hot facility**

Function	GJ/year
Central heating pump (supplying hot water to radiators)	0.47 <sup>a)</sup>
Oil boiler <sup>b)</sup> – pump (supplying oil to boiler) and flue fan <sup>c)</sup>	0.35 <sup>a)</sup>
Gas boiler – flue fan (if fan-assisted flue)	0.16
Warm air heating system fans	0.002 × dwelling volume in box (6)
Whole house mechanical ventilation fans	0.004 × dwelling volume in box (6)
Electricity for maintaining keep-hot facility <sup>d)</sup> of a gas combi boiler	
– keep-hot facility, controlled by time clock	0.8
– keep-hot facility, not controlled by time clock <sup>e)</sup>	2.0

*Notes*

- a) multiply by a factor of 1.3 if room thermostat is absent
- b) applies to all oil boilers
- c) the same motor operates both the pump and flue fan
- d) see notes to Table 3 for the definition of keep-hot facility
- e) In the case of an untimed 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 keep-hot facility should be taken as:  
 $electricity\ consumed = 0.032 \times P (GJ/year)$   
 where: P is the power rating in Watts

**Table 5: Lighting, appliances, cooking and metabolic gains**

Floor area (m <sup>2</sup> )	Gains (W)	Floor area (m <sup>2</sup> )	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

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

- a. Calculate  $N = (0.035 \times TFA) - (0.000\ 038 \times TFA^2)$ , if  $TFA \leq 420$   
 $= 8.0$  if  $TFA > 420$
- b. Gains (W) =  $74 + (2.66 \times TFA) + (75.5 \times N)$  if  $TFA \leq 282$   
 $= 824 + (75.5 \times N)$  if  $TFA > 282$

Additional gains: gains from the following equipment should be added to the totals given above

Central heating pump <sup>a)</sup>	10 W
Warm-air heating system fans <sup>a), b)</sup>	10 W
Mechanical ventilation system	25 W
Oil pump, inside dwelling <sup>c)</sup>	25 W

- a) does not apply to community heating
- b) the 10 W should not be included in addition to the 25 W for a mechanical ventilation system
- c) oil central heating has both oil pump and central heating pump: do not add gains if oil pump is outside of dwelling

**Table 6: Solar flux through glazing (W/m<sup>2</sup>)**

	Horizontal	Vertical				
		North	NE/NW	E/W	SE/SW	South
Single glazed	34	13	15	22	29	32
Double glazed (air or argon filled)	30	11	13	19	26	28
Double glazed (low-E, hard-coat)	28	11	13	18	25	27
Double glazed (low-E, soft coat)	22	9	10	15	19	22
Triple glazed (air or argon filled)	26	10	12	17	23	25
Triple glazed (low-E, hard-coat)	24	9	11	16	21	23
Triple glazed (low-E, soft coat)	21	8	10	14	18	20

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 up to 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, then treat as if it is a vertical window.
3. If low-E but coating not known, assume hard coat.

**Table 6a: Solar access factor**

Overshading	% sky blocked by obstacles	Solar access factor
Heavy	> 80	0.4
More than average	60-80	0.7
Average or unknown	20-60	1.0
Very little	< 20	1.3

Note:

A solar access factor of 1.3 should be used for rooflights.

**Table 6b: Indicative U-values (Wm<sup>2</sup>/K) for windows, doors and roof windows**

The U-values are calculated using BS EN ISO 10077-1. 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.

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 should be applied to manufacturer's window U-values unless the manufacturer provides a U-value specifically for a roof window.

Unless known otherwise, double and triple glazing should be taken as air-filled without low-E coating.

Glazing	Type of frame							
	Window with wood or U-PVC frame (use adjustment column for roof windows)				Adjustment for roof window	Window with metal frame with 4mm thermal break (include an adjustment from notes below for thermal break and for roof windows)		
	Gap between panels (mm)			6		Gap between panels (mm)		
6	12	16 or more	16 or more		6	12	16 or more	
Double-glazed, air-filled	3.1	2.8	2.7		3.7	3.4	3.3	
Double-glazed, air-filled (low-E, ε <sub>n</sub> = 0.2, hard coat)	2.7	2.3	2.1		3.3	2.8	2.6	
Double-glazed, air-filled (low-E, ε <sub>n</sub> = 0.1, soft coat)	2.6	2.1	1.9		3.2	2.6	2.5	
Double-glazed, argon filled	2.9	2.7	2.6		3.5	3.3	3.2	
Double-glazed, argon filled (low-E, ε <sub>n</sub> = 0.2, hard coat)	2.5	2.1	2.0		3.1	2.6	2.5	
Double-glazed, argon filled (low-E, ε <sub>n</sub> = 0.1, soft coat)	2.3	1.9	1.8	+0.2	2.9	2.4	2.3	
Triple glazed, air-filled	2.4	2.1	2.0		2.9	2.6	2.5	
Triple glazed, air-filled (low-E, ε <sub>n</sub> = 0.2, hard coat)	2.1	1.7	1.6		2.6	2.2	2.0	
Triple glazed, air-filled (low-E, ε <sub>n</sub> = 0.1, soft coat)	2.0	1.6	1.5		2.5	2.0	1.9	
Triple-glazed, argon filled	2.2	2.0	1.9		2.8	2.5	2.4	
Triple-glazed, argon filled (low-E, ε <sub>n</sub> = 0.2, hard coat)	1.9	1.6	1.5		2.4	2.0	1.9	
Triple-glazed, argon filled (low-E, ε <sub>n</sub> = 0.1, soft coat)	1.8	1.4	1.3		2.2	1.9	1.8	
Windows and doors, single-glazed				+0.3	5.7			
Solid wooden door				-	-			

Notes:

1. For windows or roof windows with metal frames apply the following adjustments to U-values:
2. 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 (eg solid wooden door (U-value of 3.0 W/m<sup>2</sup>K) half-glazed with double glazing (low-E, hard coat, argon filled, 6 mm gap, U-value of 2.5 W/m<sup>2</sup>K) has a resultant U-value of 0.5 (3.0 + 2.5) = 2.75 W/m<sup>2</sup>K).

	Adjustment to U-value, W/m <sup>2</sup> K	
	Window	Rooflight
Metal, no thermal break	+0.3	+0.7
Metal, thermal break 4 mm	0.0	+0.3
Metal, thermal break 8 mm	-0.1	+0.2
Metal, thermal break 12 mm or more	-0.2	+0.1

**Table 7: Utilisation factor as a function of gain/loss ratio (GLR)**

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

Alternatively, the utilisation factor may be calculated by the formula:

$$\text{Utilisation factor} = 1 - \exp(-18 \div \text{GLR}),$$

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 box (38) on 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	19.82	20.45
6.0 (or higher)	17.78	18.44	19.08	19.73	20.40

Note:

Use heating column (1) when dwelling is heated by community heating.

**Table 9: Difference in temperatures between zones**

Number in brackets is from the 'control' column of Table 4e.

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

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

Base temp °C	Degree Days	Base temp °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

**Table 11: Fraction of heat supplied by secondary heating systems**

Main heating system	Secondary system	Fraction	
Central heating system:	gas fires	0.15	
	– boiler and radiators	coal fires	0.10
	– underfloor heating	electric heater	0.05
	– warm air system		
	– other gas or oil fired systems		
Gas room heaters	gas fires	0.30	
	coal fires	0.15	
	electric heaters	0.10	
Coal room heaters; electric room heaters	gas fires	0.20	
	coal fires	0.20	
	electric heaters	0.20	
Electric storage heaters not fan-assisted; other electric systems	gas fires	0.15	
	coal fires	0.10	
	electric heaters	0.10	
Fan assisted storage heaters	gas fires	0.15	
	coal fires	0.10	
	electric heaters	0.05	
Heat pump	gas fires	0.15	
	coal fires	0.10	
	electric heaters	0.05	

**Table 12: Fuel prices and additional standing charges**

	Additional standing charge (£)	Unit price (£/GJ)
Gas (mains)	28	3.74
Bulk LPG	57	8.22
Bottled gas – propane 47 kg cylinder		11.02
Heating oil		4.53
House coal		4.62
Smokeless fuel		7.46
Anthracite nuts		5.15
Anthracite grains		5.16
Wood		4.50
Electricity (on-peak)		20.80
Electricity (off-peak)	16	7.93
Electricity (standard tariff)		19.69
Electricity 10 hour tariff (on-peak)		16.50
Electricity 10 hour tariff (off-peak)	15	8.75
Electricity (24-hr heating tariff)	48	8.97
Community scheme	28	
Heat from boilers (any fuel)		4.55
Heat from CHP or waste heat		3.17
Energy cost inflator	1.05	

**Notes**

1. The standing charge given for electricity is extra amount for the off-peak tariff, 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 heating.
2. An energy cost inflator term is applied before the rating is calculated. The purpose of the inflator is to ensure that the ratings do not, on average, change with fuel price changes. The energy cost inflator term is currently set at **1.05**. 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: Distribution loss factor for group and community schemes**

Heat distribution system	Factor
Mains piping system installed in 1990 or earlier, not pre-insulated, medium or high temperature distribution (120-140°C), full flow system	1.20
Pre-insulated mains piping system installed in 1990 or earlier, low temperature distribution (100°C or below), full flow system	1.10
Modern higher temperature system (up to 120°C), using pre-insulated mains installed in 1991 or later, variable flow system	1.10
Modern pre-insulated piping system operating at 100°C or below, full control system installed in 1991 or later, variable flow system	1.05

**Note:**

A full flow system is one in which the hot water is pumped through the distribution pipework 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 rate at which the hot water is pumped through the distribution pipework varies according to the demand for heat.

**Table 13: On-peak fraction for electric water heating**

Dwelling total floor area (m <sup>2</sup> )	Cylinder size (litres)							
	7-hour tariff				10-hour tariff			
	110	160	210	245	110	160	210	245
40 or less	12 (56)	7 (18)	2	0	6 (15)	0	0	
60	14 (58)	9 (21)	3	0	8 (19)	0	0	
80	17 (60)	10 (24)	4	0	10 (22)	0	0	
100	19 (62)	12 (27)	5	0	11 (25)	0 (2)	0	
120	21 (63)	14 (30)	6	0	13 (28)	1 (5)	0	
140	24 (65)	15 (33)	6	1	14 (30)	2 (9)	0	
160	26 (66)	16 (35)	7	1	16 (33)	2 (12)	0	
180	27 (68)	18 (37)	8	2	17 (35)	2 (15)	0	
200	29 (69)	19 (40)	9	2	18 (38)	3 (18)	0	
220	31 (70)	20 (42)	10	2	19 (40)	3 (21)	0	
240	32 (71)	21 (43)	10	3	20 (41)	4 (23)	0	
260	33 (72)	22 (45)	11	3	21 (43)	4 (25)	0	
280	35 (73)	23 (47)	11	3	22 (45)	4 (27)	0	
300	36 (74)	24 (48)	12	3	23 (46)	5 (29)	0	
320	37 (75)	24 (49)	12	4	23 (47)	5 (30)	0	
340	38 (75)	25 (50)	13	4	24 (48)	5 (32)	0	
360	38 (76)	26 (51)	13	4	24 (49)	5 (33)	0	
380	39 (76)	26 (52)	13	4	25 (50)	5 (34)	0	
400	39 (76)	26 (52)	13	4	25 (51)	5 (35)	0	
420 or more	40 (77)	26 (52)	13	4	25 (51)	6 (35)	0	

**Notes**

1. Table 13 shows percentage 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.
2. Alternatively, the fraction may be calculated (for V between 110 and 245 litres) from the following equations:
  - a) tariffs providing at least 7 hours of heating per day at the off-peak rate  
Dual immersion:  $(6.8 - 0.024V)N + 14 - 0.07V$   
Single immersion:  $(14530 - 762N)/V - 80 + 10N$
  - b) tariffs providing at least 10 hours of heating per day at the off-peak rate  
Dual immersion:  $(6.8 - 0.036V)N + 14 - 0.105V$   
Single immersion:  $(14530 - 762N)/(1.5V) - 80 + 10N$
where V is the cylinder volume and N is as defined below Table 5. (If these formulae give a value less than zero, set the on-peak fraction to zero.)
3. Do not use this table to obtain the on-peak percentage for an electric CPSU. Calculate the on-peak percentage using the procedure described in Appendix F.
4. Do not use this table for the on-peak percentage for domestic hot water heated by a heat pump. Use on-peak percentages given in Appendix G.

Table 14: SAP rating by energy cost factor

ECF (£/m <sup>2</sup> )	SAP rating	ECF (£/m <sup>2</sup> )	SAP rating
0.59 or less	120	2.6	56
0.60	119	2.70	54
0.65	116	2.70	53
0.70	112	2.80	52
0.75	109	2.90	51
0.80	107	3.00	49
0.85	104	3.15	47
0.90	102	3.30	45
0.95	99	3.45	44
1.00	97	3.60	41
1.05	95	3.75	40
1.10	93	3.90	38
1.15	91	4.00	37
1.20	89	4.25	34
1.25	87	4.50	32
1.30	86	4.75	29
1.35	84	5.00	27
1.40	82	5.25	25
1.45	81	5.50	23
1.50	79	5.75	21
1.55	78	6.00	19
1.60	77	6.25	17
1.65	75	6.50	16
1.70	74	6.75	14
1.75	73	7.00	12
1.80	71	7.25	11
1.85	70	7.50	9
1.90	69	7.75	8
1.95	68	8.00	7
2.00	67	8.25	5
2.10	65	8.50	4
2.20	63	8.75	3
2.30	61	9.00	2
2.40	59	9.25 or above	0
2.50	57		

The values in the above table may be obtained by using the formula:

$$SAP\ Rating = 97 - 100 \times \log_{10}(ECF)$$

where: ECF is an Energy Cost Factor, calculated in box (99).

Table 15: Carbon dioxide emission factors for delivered energy

	kg CO <sub>2</sub> per GJ
Gas (mains)	54
Bulk LPG	69
Bottled gas (propane)	69
Heating oil	75
House coal	81
Anthracite	88
Smokeless solid fuel	109
Electricity	115
Wood	7
Household waste	12
Biomass	7
Biogas (landfill)	7
Waste heat from power stations	5

Table 16: Carbon Index

Carbon Factor (CF) kg/m <sup>2</sup>	Carbon Index (CI)	Carbon Factor (CF) kg/m <sup>2</sup>	Carbon Index (CI)
7.17 or less	<b>10.0</b>	30	<b>4.4</b>
8	<b>9.6</b>	32	<b>4.2</b>
9	<b>9.1</b>	34	<b>3.9</b>
10	<b>8.7</b>	36	<b>3.7</b>
11	<b>8.3</b>	38	<b>3.5</b>
12	<b>8.0</b>	40	<b>3.3</b>
13	<b>7.7</b>	45	<b>2.8</b>
14	<b>7.4</b>	50	<b>2.4</b>
15	<b>7.1</b>	55	<b>2.0</b>
16	<b>6.9</b>	60	<b>1.7</b>
17	<b>6.6</b>	65	<b>1.4</b>
18	<b>6.4</b>	70	<b>1.1</b>
19	<b>6.2</b>	75	<b>0.8</b>
20	<b>6.0</b>	80	<b>0.6</b>
22	<b>5.6</b>	85	<b>0.3</b>
24	<b>5.3</b>	90	<b>0.1</b>
26	<b>5.0</b>	92.5 or more	<b>0.0</b>
28	<b>4.7</b>		

Alternatively, the carbon factor and CI may be calculated by the formulae:

$$CF = CO_2 / (TFA + 45.0)$$

$$CI = 17.7 - 9.0 \log_{10}(CF)$$

where: CO<sub>2</sub> is the CO<sub>2</sub> emissions in kg/year

TFA is total floor area in m<sup>2</sup>.

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