

# Amendments to SAP for Occupancy Assessment

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## 1 Energy for water heating

At SAP worksheet (42) use the actual number of occupants from the Occupancy Assessment (OA) instead of the formula.

At worksheet (43) use the following formulation.

$$V_{d,average} \text{ (litres/day)} = V_{d,shower} + V_{d,bath} + V_{d,other}$$

where

$$V_{d,shower} \text{ (litres/day)} = \text{Showers per day} * \text{hot water per shower from table below}$$

$$V_{d,bath} \text{ (litres/day)} = \text{Baths per day} * 50.8 \text{ litres}$$

$$V_{d,other} \text{ (litres/day)} = 9.8 * N + 14$$

where N is the actual number of occupants.

Showers and baths per day comes from the OA. If showers per day is unknown then:

$$\text{Showers per day} = 0.45 * N + 0.65$$

If the number of baths per day is unknown then:

$$\text{Baths per day (no shower present)} = 0.35 * N + 0.50$$

$$\text{Baths per day (shower also present)} = 0.13 * N + 0.19$$

(A bath is assumed to be present even when bathing data has not been provided.)

Continue as for normal SAP assessment from worksheet (44).

Shower type	Hot water used per shower (litres)
None	0
Mixer (not combi)*	28.8
Mixer (combi)*	44.4
Pumped	43.5
Electric	0
Unknown	18.7

\* Combi applies when the water is heated by a combi boiler. Not combi applies in all other cases.

## 2 Calculation of space heating

### 2.1 Heating systems

A3 in SAP Appendix A, which is concerned with assigning heating to all rooms, does not apply. In the occupancy assessment, unheated rooms are treated as such and do not have heaters assigned to them.

If the occupancy assessment has identified that the main heating system given in the RdSAP assessment is not used, use the room heaters defined in the occupancy assessment for calculation on the dwelling as-is. Under these circumstances (a) do not make a recommendation for improved heating controls and (b) any heating system recommendation is for the system recommended on the EPC but without altering the number and extent of rooms heated. The following assumptions should be made about room heater systems when entered as part of the occupancy assessment (and therefore not as fully defined as in a normal RdSAP assessment):

- For heating control type assume electric room heaters have appliance thermostats (control type 3); assume all other types of room heater have no thermostatic control (control type 2).
- Assume solid fuel room heaters are not HETAS approved when choosing their efficiency from SAP table 4a.
- Do not attempt adjust the number of flues or chimneys to include those associated with the new heating type. Even if they were assumed not to be used in the RdSAP calculation, their presence should have already been recorded there.

If the occupancy assessment has indicated a different secondary heater compared to the RdSAP assessment, use the one from the occupancy assessment.

## **2.2 Proportion of heat from each system**

The data collected during the occupancy assessment includes a list of the heating systems used in each habitable room and states whether rooms are partially heated or unheated. This data is processed to estimate what proportion of the heat required is provided by each heating system. (It is also used later to estimate what proportion of the dwelling is heated.)

The proportion from the secondary heating system is calculated first, as described below. The remainder is then split between the two main systems if necessary.

### **2.2.1 Secondary heating**

- a) If secondary heating is used in the living room, include the secondary fraction from SAP Table 11.
- b) If secondary heating is used in another room, disregard if the main heating also supplies the room.
- c) If secondary heating is used in another room and there is no main heating in the room, use a secondary fraction of 0.25 divided by the total number of rooms other than living room.
- d) The sum of the above fractions gives the proportion of heat provided by the secondary system.

### **2.2.2 Two main systems**

The proportion of heat provided by the main systems,  $p_{main}$ , is 1 minus the proportion provided by the secondary system. If there are two main systems, this is split as follows.

- a) Add up the number of rooms served by main system 1, giving a weighting of 1.5 to the living room (because it is usually larger) and 1 to other rooms.
- b) Multiply by 0.5 where a room is served by both main systems
- c) Multiply by 0.5 (again) where a room has been marked as partially heated.

- d) Sum the individual room figures in the same way for the second main system
- e) Divide this by the total number of rooms heated by main 1 or main 2 (with weighting 1.5 for the living room) to get the fraction from main system 2.
- f) The remainder (i.e. 1 minus the proportion from main 2) is assumed to come from main 1.
- g) Multiply the proportions for main 1 and main 2 by  $p_{\text{main}}$  to calculate the overall fractions from main 1 and main 2.

### 2.2.3 Rounding

Round the secondary fraction and main 1/main 2 fractions to two decimal places.

An accompanying spreadsheet illustrates the above procedure.

## 3 Calculation of monthly internal temperatures

SAP Table 9 is adapted as follows:

**Table 9 (occupancy assessment): Heating periods and heating temperatures**

Living area		Elsewhere		
Temperature $T_{h1}$ (°C)	Hours of heating off $t_{\text{off}}$	Heating control type (Table 4e)	Temperature $T_{h2}$ °C	Hours of heating off $t_{\text{off}}$
$T_d$ from the occupancy assessment <sup>a</sup>	Up to 4 periods from the occupancy assessment	1	$T_{h1} - 0.5 \text{ HLP}$	Same as living area
		2	$T_{h1} - \text{HLP} + 0.085 \text{ HLP}^2$	Same as living area
		3	$T_{h1} - \text{HLP} + 0.085 \text{ HLP}^2$	see <sup>b</sup> below
<sup>a</sup> If unknown use 21°C <sup>b</sup> if the number of off periods for the living area is 1 and is less than 12 hours duration include it plus a second off period of duration 9 hours; otherwise the shortest off period plus 2 hours and the other periods the same as the living area  If $\text{HLP} > 6.0$ use $\text{HLP} = 6.0$ for calculation of $T_{h2}$				

Calculate  $\text{MIT}_{h,m}$  for the heated rooms and applicable heating systems and controls (SAP Tables 9, 9b and 9c) leading to worksheet (93). Suffix h denotes heated and m is the month number. In SAP Table 9c replace  $T_{\text{weekday}}$  and  $T_{\text{weekend}}$  by

$$T_{\text{normal}} = T_h - (u_1 + u_2 + u_3 + u_4)$$

$$T_{\text{alternative}} = T_h - (u_1 + u_2 + u_3 + u_4)$$

and

$$\text{Mean temperature} = (n_{\text{normal}} T_{\text{normal}} + n_{\text{alternative}} T_{\text{alternative}}) / 7$$

where  $u_1, u_2, u_3$  and  $u_4$  are related to the hours of heating off as defined in SAP Table 9b.

If all rooms are fully heated by the main system (or by one of them if there are two) set  $MIT_m = MIT_{h,m}$  to calculate the space heating requirement for each month.

If there are any unheated rooms, partially heated rooms, or rooms heating by secondary heating only:

a. Calculate the mean temperature  $MIT_{u,m}$  in the unheated rooms from

$$f_u = (n_u + 0.5 n_p + 0.5 n_{s-only}) / n_{total}$$

$$H_{2,m} = H_m \times f_u$$

$$G_{2,m} = G_{s,m} \times f_u$$

$$MIT_{u,m} = \frac{MIT_{h,m} \times H_3 + T_{e,m} \times H_{2,m} + G_{2,m}}{H_3 + H_{2,m}}$$

in which:

$H_m$  is worksheet (39);

$n_u$  is the number of unheated rooms;

$n_p$  is the number of partially heated rooms;

$n_{s-only}$  is the number of rooms heated by secondary only;

$n_{total}$  is the weighted total number of rooms (number of habitable rooms plus 0.5);

$G_{s,m}$  are the solar gains for month  $m$ ;

$H_3$  is 100 W/K.

b. Set  $MIT_m = (1 - f_u) \times MIT_{h,m} + f_u \times MIT_{u,m}$

## 4 Cooking, electrical appliances and electricity standing charge

The energy use for cooking and electrical appliances is estimated and included in the total energy for the purposes of comparing with fuel bills. The data given in this section replaces that in SAP Appendix L. Also there are some modifications to internal heat gains for cooking and electrical appliances.

### 4.1 Cooking

The energy required for cooking,  $E_c$  (kWh/yr), is a function of the actual number of occupants and the type of cooker. The following equations should be used:

Electric cooker:  $E_c = 275 + 55.0 * N$

Gas cooker:  $E_c = 481 + 96.3 * N$

Gas/electric cooker:  $E_c = 138 + 27.5 * N$  (elec)

$E_c = 241 + 48.2 * N$  (gas)

Range cooker (any fuel):  $E_c = 631 + 136 * N$

N is the actual number of occupants. Monthly totals,  $E_{c,m}$  (kWh/month), are then calculated as follows:

$$E_{c,m} = E_c / 365 * n_m$$

Assume half of  $E_{c,m}$  is used by the hob and half by the oven, except in the case of 'gas/electric cooker', for which the amounts for each are explicitly calculated, as described above.

Where gas or gas/electric is selected, assume this means mains gas if mains gas is available in the property (i.e. if it was identified as being used for any purpose in the RdSAP assessment), or bottled LPG if not.

#### 4.1.1 Additional energy requirement for ranges

For the purposes of this assessment ranges are defined as cookers which stay hot all the time, producing a significant amount of additional heat. The energy they use for cooking has been accounted for in the equations above, but the additional energy they use when not cooking,  $E_{R,m}$  (kWh), must also be considered.

$$E_{R,m} = Q_R * f_r * 0.024 * n_m - E_{c,m}$$

$Q_R$  is the average fuel consumption rate of the range cooker in watts. Use 2000W for a range burning fossil fuel or 1500W for an electric range.

$f_r$  is the efficiency with which the range converts fuel into heat. For a range burning fossil fuel use a figure of 60%; for an electric range use 100%.

## 4.2 Appliances

L2 and L3 in Appendix L do not apply and the following is used instead for electricity use by appliances and the resulting internal heat gains.

#### 4.2.1 Tumble dryer

Use the following equation to estimate the annual electricity requirement for tumble drying,  $E_{TD}$  (kWh/yr).

$$E_{TD} \text{ (kWh/yr)} = (78.4 * N + 166) * f_{TD} / 0.5$$

$f_{TD}$  is the fraction (percentage/100) of clothes drying done using a tumble dryer, from the OA.

#### 4.2.2 Cold appliances

The electricity requirement for cold appliances,  $E_{cold}$  (kWh/yr), is equal to product of the number of each appliance and the assumed use per appliance given in the following table:

Cold appliance type	Typical consumption (kWh/yr)
Fridge-freezer	500
Refrigerator	200
Freezer	300

### 4.2.3 Other appliances

Use the following equation to estimate the annual energy consumption for ‘other’ appliances,  $E_{A,other}$ , in kWh:

$$E_{A,other} = 127.9 * (TFA * N)^{0.4714}$$

Add this to the electrical consumption calculated for cold appliances and tumble drying to get the total electrical consumption for appliances,  $E_A$  (kWh/yr):

$$E_A = E_{A,other} + E_{TD} + E_{cold}$$

Monthly values,  $E_{A,m}$  (kWh/month), are then calculated as in the normal SAP calculation using:

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

Where:

$m$  is the month number (1 = Jan, 12 = Dec)

$n_m$  is the number of days in the month

### 4.2.4 Showers

Calculate the electricity used for showers:

$$E_{shower,m} \text{ (kWh/month)} = \text{Showers per day} * \text{electricity use per shower from table below} * n_m$$

where  $n_m$  is the number of days in the month

Shower type	Electricity used per shower (kWh)
None	0
Mixer (not combi*)	0
Mixer (combi*)	0
Pumped	0
Electric	0.93
Unknown	0.45

### 4.2.5 Electricity standing charge

All electric standing charges are to be included in the calculation of total energy costs. These are taken from actual fuel tariff data where available. When actual fuel tariffs are not available include an additional £52 since the SAP fuel price data omits the electricity standing charge for standard tariff.

## 5 Internal Gains

Internal heat gain is calculated as in SAP Table 5 column (A), with the exception of electric showers and cooking appliances. The heat gain from electric showering is a new category which needs to be added in. Cooking is dealt with differently for the Occupancy Assessment. Both calculation methods are described next.

Note. The heat gain from appliances is based on the electricity used as calculated in 4.2.3 above.

### ***Gains from electric showers***

For electric showers 25% of the electricity used is assumed to contribute usefully to the internal gains:

$$G_{\text{shower},m} \text{ (W)} = 0.25 * E_{\text{shower},m} / (0.024 * n_m)$$

The above is used in addition to the items from SAP Table 5.

### ***Gains from cooking appliances***

The following table of cooking gains factors,  $f_{cg}$  (dimensionless), describes what proportion of cooking energy is assumed to contribute to useful heat gains.

<b>Cooking fuel/type</b>	<b>Cooking gains factor</b>
Gas (incl. LPG)	0.75
Electricity	0.9
Gas/electric	0.825
Range (electric)	0.9
Range (fossil fuel)	0.6

For gas hob / electric oven, apply

The gains from cooking,  $G_{C,m}$  (W), is therefore:

$$G_{C,m} = E_{C,m} * f_{cg} / (0.024 * n_m)$$

The above is used instead of the value from SAP Table 5.

In addition 75% of the (non-cooking related) heat output from range cookers is assumed to be useful,  $G_{R,m}$  (W), so this is also added to the total:

$$G_{R,m} = E_{R,m} * 0.75 / (0.024 * n_m)$$

## **6 Bill data reconciliation**

### **6.1 Predicted fuel usage**

Obtain the calculated total annual energy use by fuel. Include all end uses (those additional to a normal SAP calculation are shown in italics):

- Main space heating
- Second main space heating
- Secondary heating
- *Heat supplied by range*
- Main water heating
- Alternative water heating (i.e. summer immersion)
- *Fuel used by electric shower (always electricity)*
- Lighting (always electricity)
- *Appliances (incl. tumble dryer + cold appliances) (always electricity)*

- Pumps and fans (always electricity)
- *Cooking (hob)*
- *Cooking (oven) [can be different fuel from hob]*

Include the standing charge for electricity, gas, LPG and community heating.

## 6.2 Energy used from fuel bills

Obtain total number of units purchased and scale to one year. If renewable generation is present (e.g. PV), add beta times the amount generated per year to the amount purchased per year to estimate the total used in the dwelling., where beta is 0.5 for PVs, 0.4 for micro-CHP and 0.4 for wind turbines.

Where the unit is other than kWh, convert using the following calorific values:

Fuel and unit	kWh per unit
LPG, litres	7.11
LPG, kg	13.89
oil, litre	10.35
coal, kg	8.34
smokeless, kg	8.90
anthracite, kg	9.66
wood, kg	4.70

## 6.3 Adjustment of predicted energy use

The occupancy assessment data provides a reliability indicator for each fuel:

Reliability indicator	Description
1	Gas or electricity based on actual meter readings
2	Gas or electricity based on estimated reading, or oil/LPG based on invoices/receipts.
3	Solid fuel based on invoices/receipts.
4	Unknown, includes fixed charge community heating
5	Unusual energy-using item affecting this fuel

If the reliability indicator is 4 or 5, omit the reconciliation process for that fuel.

Otherwise (reliability indicator 1, 2 or 3) for each fuel obtain the ratio of calculated energy used to the energy used from the bill data (see 6.2). In the case of electricity, use the total calculated energy excluding any locally generated electricity. For example, if electricity use is 30% higher than predicted, and the household has an electric cooker and electric secondary heaters, increase the predicted energy use for appliances, lights, cooking and secondary heating by 30% so that the total



electricity use matches. Apply this to all fuels. The same adjustment factors are to be applied when re-running the calculation to work out the savings from measures, for example:

Uncorrected gas use = 25,000 kWh/yr

Billed gas use = 20,000 kWh/yr

Correction factor =  $20,000/25,000 = 1.25$

The **same** factor of 1.25 is to be applied to all subsequent gas consumption results.

## 6.4 Tariffs

Where tariff data is available, amend the fuel prices used to calculate annual costs and savings as follows. In general there is an annual standing charge (£/year) and a unit price (p/kWh). In the case of off-peak electricity there are high-rate and low-rate unit prices.

### 6.4.1 Mains gas and electricity

- where a standing charge is applicable, scale it to one year:
    - e.g. if given in p/day, multiply by 365 and divide by 100 to give £/year
    - if given in £/quarter, multiply by 4and round to nearest £1.
  - where two unit prices apply (initial units per period and follow-on units), obtain the difference in price between initial and follow-on units, scale to one year, round to nearest £1 and assign to standing charge:
    - e.g. 600 kWh per quarter @ 8p, rest at 3p: standing charge =  $0.01 \times 600 \times (8.0 - 3.0) \times 4 = £120$
  - set the unit price to the follow-on unit price
- for off-peak tariffs set the standing charge and the high-rate unit price as above, and the low-rate unit price is as given

### 6.4.2 Other fuels

- where a fixed cost applies and if the data is for other than 12 months, scale it to 12 months, round to nearest £1 and assign to standing charge (otherwise standing charge is 0)
- divide cost for unit-based purchases by number of units purchased and assign to unit price

### 6.4.3 Community heating

- if the charging basis is fixed (not depending on the amount of heat used) no reconciliation can be done
- if there is information on the charging basis per unit of heat, assign this (p/kWh) to the unit price for community heating and any fixed annual charge is the standing charge for community heating; in this case it does not depend on the community heat sources

## 7 In-use factor for energy cost savings

In-use factors ( $\leq 1.0$ ) have been defined for each improvement measure and are applied to cost savings to reflect underperformance that has been found for some measures and to ensure that the savings are not over-estimated. Multiply the cost saving for each improvement measures by the in-use factor for the improvement measure concerned. A table of in-use factors will be published separately.

## 8 Display of fuel costs and fuel cost savings on the OA report

The total fuel cost shown on the OA report is the sum of the costs for each fuel use. Where there is local electricity generation subtract beta times the amount of electricity generated (beta is defined in 6.2 above).

The maximum Green Deal annual repayment is the annual cost saving for the measure using SAP values of the occupancy factors, multiplied by the applicable in-use factor.

The fuel cost savings for the actual household are those calculated using the actual occupancy factors, multiplied by the applicable in-use factor. They are shown as a range which depends on the reliability indicator (see 6.3).

Reliability indicator	Range	
1	larger of £10 and $\pm 5\%$ ,	Range calculated as: multiply £ saving by 2 x percentage, round to nearest £10, set to £10 if less than 10.
2	larger of £10 and $\pm 10\%$	
3	larger of £10 and $\pm 15\%$	
4 or 5	larger of £10 and $\pm 20\%$	

The above percentages are to be reviewed following trials.