

Calculation Method: CALCM:02

SAP 2016 SEASONAL EFFICIENCY VALUES FOR BOILERS (ALL FUELS)

Issue DRAFT8.0

DOCUMENT REVISIONS

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Technical or other changes which affect product recognition requirements (for example) will result in a new issue. Minor or administrative changes (e.g. corrections of spelling and typographical errors, changes to address and copyright details, the addition of notes for clarification etc.) may be made as amendments.

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DOCUMENT REVISION LOG

DATE	VERSION NO.	AMENDMENT DETAILS	APPROVED BY
15/11/16	DRAFT3.0	First issue	PD
15/11/17	DRAFT7.0	Clarified use of net-to-gross conversion factors	WG
20/11/17	DRAFT8.0	Corrected equation error in Table 9 (Storage combination < 55 litres)	WG

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1. Introduction

This document defines the method used by SAP 2016 to determine the seasonal efficiency of gaseous (mains gas or LPG), liquid (oil) and solid fuel boilers when test data has been made available as a result of Ecodesign regulation No. 811/2013 or 2015/1187. SAP is the National Calculation Methodology for energy rating of dwellings.

Calculated efficiency values arising from this method are entered in the SAP 2016 Product Characteristics Database (PCDB).

EN 15502-1, EN 15034 and EN12809 describe acceptable test procedures for gaseous, liquid and solid fuel boilers respectively.

2. Definitions

These definitions apply to boilers fuelled by gaseous or liquid fuels except for 2.1 which also applies to solid fuels.

2.1 Boiler

A gaseous, liquid or solid fuel appliance designed to provide hot water for space heating. It may (but need not) be designed to provide domestic hot water also.

2.2 Condensing boiler

A boiler designed to make use of the latent heat released by the condensation of water vapour in the combustion 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 2.5 and 2.9 inclusive. Boilers not so designed, or without the means to remove the condensate in liquid form, are called 'non-condensing'.

2.3 Modulating boiler

A boiler with the capability to vary the fuel burning rate whilst maintaining continuous burner firing, to achieve a heat output no greater than 30% of nominal heat output. 'Modulating' may be applied to the definitions 2.5 and 2.9 inclusive.

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2.4 On/off boiler

A boiler without the capability to vary the fuel burning rate whilst maintaining continuous burner firing or a boiler unable to achieve a heat output of 30% or less whilst continuously firing. This includes those with alternative burning rates set once only at time of installation, referred to as range rated. 'On/off' may be applied to the definitions 2.5 and 2.9 inclusive.

2.5 Regular boiler

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

2.6 Combination boiler

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

2.7 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.

2.8 Storage combination boiler

A combination boiler with an internal hot water store (primary or secondary/potable water) of capacity at least 15 litres but less than 70 litres.

OR

A combination boiler with an internal secondary/potable hot water store of capacity at least 70 litres.

OR

A combination boiler with an internal primary 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. Stored heat is only used for potable hot water service, i.e. via a heat exchanger. 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 (see 2.9).

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The boiler's internal hot water store must be declared as either primary or secondary/potable during applications to the PCDB.

2.9 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.

2.10 Low temperature boiler

A non-condensing boiler designed and tested as a low temperature boiler, as defined by EN 15502-1. This calculation method cannot be applied to low temperature boilers.

2.11 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.

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3. Seasonal efficiencies for gaseous and liquid fuelled boilers

The method of calculation is applicable only to boilers for which the full load and the 30% part load efficiency values, obtained by methods that satisfy Ecodesign regulation No. 811/2013, are available. These are gross efficiency values. It is essential that both test results are appropriate to the type of boiler and fuel, as defined in the EN15502:1 and EN 15034. The calculation method cannot be applied to low temperature boilers.

The efficiencies calculated by this procedure are:

- a) SEDBUK (Seasonal Efficiency of Domestic Boilers in the UK). This is used as a general indicator of efficiency for gas and oil boilers; it is no longer used for SAP calculations but provides an intermediate calculation step.
- b) Winter and summer seasonal efficiencies for SAP calculations. The winter seasonal efficiency is used for space heating. The summer seasonal efficiency (η_{summer}) applies to water heating in summer; the water heating efficiency during winter is derived from both.
- c) The comparative hot water efficiency is a general indicator of efficiency for boilers; it is not used for SAP calculations.¹

In the calculation method the data are converted, if necessary, 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 and operational temperatures.

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

¹ For combination boilers and CPSUs it is determined in accordance with EN 13203-2 tapping profile M test results. For regular boilers or combination boilers and CPSUs not tested in accordance with that standard, an alternative procedure is provided.

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3.1 Annual efficiency for non-condensing boilers

The annual efficiency, referred to interchangeably as SEDBUK (2009) or SEDBUK (2016)² for non-condensing boilers (only), is derived using the following procedure:

1. Determine fuel for boiler type

The fuel for boiler type must be one of natural gas³, LPG (butane or propane), or oil (kerosene, gas oil or biodiesel). The calculation as yet cannot proceed for other fuels.

2. Obtain test data

Retrieve the *full-load efficiency* and *30% part-load efficiency* test results. Tests must have been undertaken using the same fuel as the fuel for boiler type, except as provided in Section 5.

3. Convert net efficiencies to gross

Establish whether the efficiency test results are gross or net (i.e. calculated on the basis of gross or net calorific value for the fuel used in the tests). If gross proceed to step 4. If net convert to gross using the following equation with the appropriate factor taken from the test report. For reference, indicative values (only) are reproduced in Table 1⁴.

$$\eta_{\text{gross}} = f \times \eta_{\text{net}} \quad \% \text{ gross}$$

² Although the SEDBUK annual efficiency is not used in SAP calculations, it is required in order to calculate the summer and winter seasonal efficiencies.

³ SEDBUK values derived from tests using natural gas can be used for boilers fired by LPG, see Section 5.

⁴ Oil figures are based on BS 2869:2017 (Part C5)

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Fuel	Net-to-gross conversion factor, f
Natural gas	0.901
LPG (propane or butane)	0.921
Oil (kerosene C2)	0.937
Oil (gas oil/light heating fuel)	0.934
Oil (biodiesel)	0.937

Table 1 – Illustrative efficiency conversion factors

4. Apply correction to high test results

Apply an adjustment to full-load efficiency and to part-load efficiency to correct for observed bias in test results, according to Table 2 and Table 3.

Fuel	Full-load efficiency(η_{FL})		
	Threshold value	Correction if $\eta_{FL} >$ threshold	Correction if $\eta_{FL} \leq$ threshold
Natural Gas	86.0455	- 0.673 ($\eta_{FL} - 86.0455$)	0
LPG	87.9555	- 0.673 ($\eta_{FL} - 87.9555$)	0
Oil	89.4835	- 0.673 ($\eta_{FL} - 89.4835$)	0

Table 2 - Efficiency correction term for full-load tests

Fuel	30% Part-load efficiency (η_{PL})		
	Threshold value	Correction if $\eta_{PL} >$ threshold	Correction if $\eta_{PL} \leq$ threshold
Natural Gas	87.0366	- 0.213 ($\eta_{PL} - 87.0366$)	0
LPG	88.9686	- 0.213 ($\eta_{PL} - 88.9686$)	0
Oil	90.5142	- 0.213 ($\eta_{PL} - 90.5142$)	0

Table 3 - Efficiency correction term for part-load tests

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5. Reduce to maximum gross efficiency values

Table 4 gives the maximum values of gross efficiency for each fuel that may be used. Reduce any greater value (after adjustment according to Table 2 or Table 3) to the appropriate value given in Table 4.

	Condensing boilers			Non-condensing boilers		
	Natural gas	LPG	Oil	Natural gas	LPG	Oil
Full-load	88.298	90.258	91.826	82.892	84.732	86.204
Part-load	97.308	97.626	97.448	88.991	83.811	87.141

Table 4 - Maximum gross efficiency values (in %)

6. Categorise the boiler

- a) Select the appropriate category for the boiler according to the definitions given in Section 2.
- b) If a gas or LPG boiler, determine whether it has a permanent pilot light:
 - if it has a permanent pilot light, set $p = 1$
 - if not, set $p = 0$.
- c) In the case of a storage combination boiler (either on/off or modulating) determine from the test report whether the losses from the store were included in the values reported (this depends on whether the store was connected to the boiler during the tests):
 - if the store loss is included, set $b = 1$
 - if not, set $b = 0$.
- d) In the case of a storage combination boiler or a CPSU, obtain the store volume, V_{cs} , in litres from the specification of the device and the standby loss factor, L , using the following equation:

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

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

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

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7. Calculation of the annual efficiency

- a) Use the boiler category and other characteristics as defined in Section 2 (non-condensing or condensing; gas or LPG or oil; on/off or modulating) to look up the appropriate equation number in Table 5 or Table 6. If no equation number is given the calculation cannot proceed.
- b) Substitute the gross full and part load efficiencies (found in step 5) and p, b, V and L (found in step 6).
- c) Round η_{annual} to one decimal place; i.e. to nearest 0.1%. The result may be described as SEDBUK (2009) or SEDBUK (2016) for non-condensing boilers only. These results are used in Section 3.2.

Gas or LPG boiler type	No	Equation
On/off regular	101	$\eta = 0.5(\eta_{\text{full}} + \eta_{\text{part}}) - 2.5 - 4p$
Modulating regular	102	$\eta = 0.5(\eta_{\text{full}} + \eta_{\text{part}}) - 2.0 - 4p$
On/off instantaneous combination	103	$\eta = 0.5(\eta_{\text{full}} + \eta_{\text{part}}) - 2.8 - 4p$
Modulating instantaneous combination	104	$\eta = 0.5(\eta_{\text{full}} + \eta_{\text{part}}) - 2.1 - 4p$
On/off storage	105	$\eta = 0.5(\eta_{\text{full}} + \eta_{\text{part}}) - 2.8 + (0.209 \times b \times L \times V_{\text{cs}}) - 4p$
Modulating storage combination	106	$\eta = 0.5(\eta_{\text{full}} + \eta_{\text{part}}) - 1.7 + (0.209 \times b \times L \times V_{\text{cs}}) - 4p$
On/off or Modulating CPSU	107	$\eta = 0.5(\eta_{\text{full}} + \eta_{\text{part}}) - (0.539 \times L \times V_{\text{cs}}) - 4p$

Table 5 - Annual efficiency for natural gas and LPG non-condensing boilers

Oil boiler type	No	Equation
On/off Regular	201	$\eta = 0.5(\eta_{\text{full}} + \eta_{\text{part}}) - 1.1$
On/off Instantaneous combination	202	$\eta = 0.5(\eta_{\text{full}} + \eta_{\text{part}}) - 2.8$
On/off Storage combination	203	$\eta = 0.5(\eta_{\text{full}} + \eta_{\text{part}}) - 2.8 + (0.209 \times b \times L \times V_{\text{cs}})$

Table 6 - Annual efficiency for non-condensing oil boilers

3.2 Summer and winter efficiency for non-condensing boilers

For non-condensing boilers, modify the annual efficiency η_{annual} obtained at step 7 c) of 3.1 to obtain the winter seasonal efficiency η_{winter} and the summer seasonal efficiency η_{summer} as follows:

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

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

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

3.3 Summer, winter and annual efficiency for condensing boilers

For condensing boilers, use the gross full and part load efficiencies (found in Section 3.1, step 5) to obtain the winter seasonal efficiency η_{winter} , the summer seasonal efficiency η_{summer} and the annual efficiency η_{annual} :

$$\eta_{\text{winter}} = 0.5 \times (\eta_{\text{full}} + \eta_{\text{part}}) + \Delta\eta_{\text{winter,c}} - 4p$$

$$\eta_{\text{summer}} = 0.5 \times (\eta_{\text{full}} + \eta_{\text{part}}) + \Delta\eta_{\text{summer,c}} - 4p$$

$$\eta_{\text{annual}} = 0.5 \times (\eta_{\text{full}} + \eta_{\text{part}}) + \Delta\eta_{\text{annual,c}} - 4p$$

where $\Delta\eta_{\text{winter,c}}$, $\Delta\eta_{\text{summer,c}}$ and $\Delta\eta_{\text{annual,c}}$ are given in Table 7 according to fuel and boiler type. For 'p' see Section 3.1, step 6b.

Round the results to one decimal place, i.e. to nearest 0.1%. This annual efficiency result may be described as SEDBUK (2016) for condensing boilers.

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Fuel and boiler type	Winter annual offset $\Delta\eta_{\text{winter}}$	Summer annual offset $\Delta\eta_{\text{summer}}$	Winter mean offset $\Delta\eta_{\text{winter,c}}$	Summer mean offset $\Delta\eta_{\text{summer,c}}$	Annual mean offset $\Delta\eta_{\text{annual,c}}$
Natural gas or LPG					
On/off regular	+0.9	-9.2	-4.7	-11.7	-5.3
Modulating regular	+1.0	-9.7	-3.2	-11.7	-4.0
On/off instantaneous combi	+0.8	-8.5	-4.7	-11.3	-5.3
Modulating instantaneous combi	+0.9	-9.2	-3.2	-11.3	-3.9
On/off storage combi	+0.7	-7.2	-4.7	-10	-5.2
Modulating storage combi	+0.8	-8.3	-3.2	-10	-3.8
On/off CPSU	+0.22	-1.64	-4.7	-1.64	-4.4
Modulating CPSU	+0.22	-1.64	-3.2	-1.64	-3.1
Oil					
On/off regular	+1.1	-10.6	-4.1	-11.7	-4.8
On/off Instantaneous combination	+1.0	-8.5	-4.1	-11.3	-4.7
On/off Storage combination	+0.9	-7.2	-4.1	-10	-4.6
Modulating regular	+1.1	-10.6	-2.5	-11.7	-3.3
Modulating instantaneous combination	+1.0	-8.5	-2.5	-11.3	-3.3
Modulating storage combination	+0.9	-7.2	-2.5	-10	-3.2

Table 7 - Seasonal efficiency offsets

3.4 Electrical power consumption

Where *full-load efficiency* and *30% part-load efficiency* test results include electrical power measurements (which will exclude the water circulation pump), the boiler's annual electrical energy consumption (kWh/yr) should be calculated in accordance with the equations below.

For modulating boilers:

$$P_{elec} = [(elmin \times 0.79 + elmax \times 0.21) \times 2754 + (P_{SB} \times 6006)] \div 1000$$

For on/off boilers:

$$P_{elec} = [(elmax \times 1236) + (P_{SB} \times 7524)] \div 1000$$

Where:

elmin is part load electrical power (W)

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el_{max} is full load electrical power (W)

P_{SB} is standby electrical power (W)

Calculated values are used in SAP 2016 worksheet box 230 (d) for oil-fuelled boilers and 230 (e) for gas-fuelled boilers. If test data is unavailable, default values from SAP 2016 Table 4f are used.

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4. Method for calculating water heating performance data for gas and oil boilers

The boiler's water heating efficiency, known as the summer seasonal efficiency (η_{summer}), is not constant but varies appreciably with hot water use. To account for this variation two parameters are introduced: the efficiency during continuous hot water operation and constant term called the combi loss.

For combination boilers and CPSUs the two parameters are calculated from laboratory water heating test results, as detailed in Sections 4.1 and 4.2. If such results are unavailable, the summer seasonal efficiency (η_{summer}) in Section 3.2 or 3.3 and additional combination losses as noted in SAP 2016 Table 3a are assumed.

Comparative hot water efficiency aids the comparison of the hot water performance between boiler types and is detailed in Section 4.3 and 4.4; it is not used in SAP calculations.

4.1 Summer seasonal value for one result only (M)

When test results are submitted for a combination boiler or CPSU obtained in accordance with tapping cycle M (only) of EN 13203-2 or OPS 26, a modified procedure to calculate summer seasonal efficiency (η_{summer}) and additional combi loss for the appliance (SAP 2016 Table 3b) is used as follows:

1. Calculate the summer seasonal efficiency (η_{summer}) by retrieving the full-load efficiency from the space heating measurements (in %, gross calorific terms), converting from net to gross efficiency, if necessary (Section 3.1, step 3), applying the correction factor (Section 3.1, step 4) and any capping (Section 3.1, step 5). This replaces the value calculated in Section 3.2.

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2. Calculate the proportion of rejected energy (r_1) by retrieving from water heating measurements the wasted volume of water in percentage terms and dividing by 200.
3. Obtain the daily (corrected) fuel consumption (Q_{fuel}) expressed in terms of the gross calorific value in kWh/day (e.g. EN 13203-2 clause 5.2.2.3). This is not the seasonally adjusted value and if a net value is retrieved convert it to gross terms by dividing by conversion factor, f , Table 1.
4. Calculate the heat loss factor F_1 in kWh/day where:

$$F_1 = (\eta_{summer} \times Q_{fuel} \div 100) - 5.845 \times (1 + r_1)$$
 If the result is negative set it to zero. The heat loss factor (F_1) and rejected energy proportion (r_1) are used to calculate the additional combi loss for the appliance in accordance with SAP 2016 Table 3b.

4.2 Summer seasonal value for two results (M & S or M & L)

When test results are submitted for a combination boiler or CPSU tested in accordance with tapping cycle M and S or M and L of EN 13203-2 or OPS 26, a modified procedure to calculate summer seasonal efficiency (η_{summer}) and additional combi loss for the appliance (SAP 2016 Table 3c) is used. Follow the calculation procedure below:

1. Estimate the proportion of rejected energy, r_M and r_x by retrieving from test results the wasted volume of water in percentage respectively for cycle M and S or L and by dividing each by 200.
2. Retrieve from test results the daily (corrected) fuel consumption for profile M ($Q_{fuel,M}$) and for profile S or L ($Q_{fuel,x}$) respectively, expressed in terms of the gross calorific value in kWh/day. If net values are quoted then convert to gross by dividing by conversion factor, f , Table 1.
3. Calculate the summer seasonal efficiency (η_{summer}) in gross calorific terms:

$$\eta_{summer} = 100 \times [(Q_{dhw} \times (1 + r_x)) - (5.845 \times (1 + r_M))] \div [Q_{fuel,x} - Q_{fuel,M}]$$

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where Q_{dhw} is 11.655 kWh/day for cycle L and 2.1 kWh/day for cycle S.

- Confirm whether the hot water tests included a flue gas heat recover system (FGHRS) active and limit the result in 3 (η_{summer}) to the maximum noted in Table 8.

	Condensing boiler		
	Natural gas	LPG	Oil
With FGHRS active	98.9	98.9	98.9
Without FGHRS active	88.2	90.3	91.5

Table 8 - Maximum gross efficiency for summer hot water efficiency

Note: η_{summer} replaces the value calculated in Section 3.2.

- Calculate the heat loss factor F_2 in kWh/day from:

$$F_2 = [\{ (5.845 \times (1 + r_M)) \div Q_{\text{fuel,M}} \} - \{ (Q_{\text{dhw}} \times (1 + r_x)) \div Q_{\text{fuel,x}} \}] \div [(1 \div Q_{\text{fuel,x}}) - (1 \div Q_{\text{fuel,M}})]$$

If the result is negative set it to zero.

- Calculate the heat loss factor F_3 (change in wasted energy proportion per litre change in water usage) from:

$$F_3 = (r_M - r_x) \div (V_U - 100.2) \quad \text{where } V_U = 199.8 \text{ or } 36 \text{ for Profile L or S respectively.}$$

Note: The heat loss factors F_2 and F_3 and rejected energy proportion (r_1) are used to calculate the additional combi loss for the appliance in accordance with SAP 2016 Table 3c.

4.3 Comparative hot water efficiency if test results available

Comparative hot water efficiency (η_{com}) aids the comparison of the hot water performance between boiler types, but is not used in SAP calculations. It is defined as the ratio of useful heat extracted to the heat input of the fuel during tapping profile M, EN 13203-2⁵ or OPS 26.

$$\eta_{com} = 584.5 \div Q_{fuel,M}$$

4.4 Comparative hot water efficiency if test results are unavailable

When data for a combination boiler or CPSU are submitted without test results in accordance with tapping profile M of EN 13203-2 or OPS 26 and for all regular boilers calculate the comparative hot water efficiency as follows:

1. Determine the boiler type and retrieve the summer seasonal efficiency calculated in Section 3.2 or 3.3.
2. For storage combination boiler or CPSU retrieve the volume of the store in litres (V_{cs}) and calculate the storage heat loss in kWh/day (Q_{cs}) using data from the manufacturer, if supplied, as set out in SAP 2016 Section 4.2, including the temperature factor in SAP 2016 Table 2b. If manufacturer's data is not supplied use SAP 2016: Table 2, Table 2a and Table 2b, which is also discussed in SAP 2016 Section 4.2.
3. According to boiler type, look-up or calculate the efficiency divisor in Table 9.
4. Divide the summer seasonal efficiency calculated in Section 3.2 or 3.3 on a gross calorific basis by the divisor to obtain the comparative hot water efficiency.

⁵ Tapping profiles may be referenced in standards as: '1', which is equivalent to S; '2', which is equivalent to M; '3', which is equivalent to L.

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Boiler type (natural gas, LPG or oil)	Efficiency divisor
Regular	1.369
Instant combination – keep hot (untimed)	1.422
Instant combination – keep hot (timed)	1.281
Instant combination – no keep hot	1.281
Storage combination \geq 55 litres	$1 + (Q_{CS} \div 5.845)$
Storage combination $<$ 55 litres	$1.2812 + (Q_{CS} \div 5.845) + 0.007031 \times (15 - V_{CS})$
Close-coupled store (SAP 2016 G1.5)	$1 + (Q_{CS} \div 5.845)$
CPSU	$1 + (Q_{CS} \div 5.845)$

Table 9 - Comparative hot water efficiency divisor

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

If the fuel for boiler type is LPG but the fuel used to obtain heating efficiency test results is natural gas then the seasonal efficiency may be calculated subject to certain conditions using the procedure given below. The seasonal efficiency will be lower than if the fuel used to obtain the test results had been LPG. This provision does not apply hot water test data and calculations in section 0.

1. Note the restrictions set out at the start of Section 3, which still apply.
2. Any differences between the boiler fuelled by natural gas (used to obtain full-load and 30% part-load efficiency test results) and the boiler fuelled by LPG (for which seasonal efficiency is required) must be minor. Examples of minor differences are a change of gas injector or adjustment by a single screw on the gas valve.
3. Determine the nominal heat input on a gross calorific value basis for both the natural gas boiler and the LPG boiler. The LPG figure must lie within $\pm 5\%$ (not percentage points) of the natural gas figure.
4. Determine from measurement the percentage of CO₂, by volume, in dry air at the maximum nominal heat input rate for both the natural gas boiler (V_{NG}) and the LPG boiler (V_{LP}). Calculate the lower threshold for the CO₂ reading ($V_{LP,lim}$) for the LPG boiler from:

$$V_{LP,lim} = (753.97 \times V_{NG}) \div (656.97 - (1.3888 \times V_{NG}))$$

Round up the threshold to the nearest decimal place. If the CO₂ measurement for the LPG boiler is lower than the rounded threshold then the natural gas boiler efficiencies cannot be used as basis for the LPG boiler efficiencies. The basis of the threshold is that the excess air fraction of the LPG boiler must not exceed that of the natural gas boiler by more than 5% of the natural gas figure.

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5. Retrieve the *full-load efficiency* and *30% part-load efficiency* test results. Establish whether the efficiency test results are gross or net and convert if necessary, as in step 3 of Section 3.1
6. Apply correction to high test results as in step 4 of Section 3.1.
7. If the boiler is a condensing boiler then deduct 2.0262 percentage gross points from the corrected *30% part-load gross efficiency* test result.
8. Follow the calculation procedure in 3.1 from step 5 onwards and in 3.2, taking the fuel for boiler type as LPG.

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6. Method for calculating seasonal efficiency and case emission of a twin-burner range cooker boiler

1. The method of calculation of the Seasonal Efficiency is applicable only to cooker boilers for which the full load and the 30% part load efficiency values for the boiler function, obtained by the methods deemed to satisfy Ecodesign regulation No. 811/2013, are available.

Note: A range cooker boiler which does not have the capability to provide domestic hot water directly (i.e. is not a combination boiler), but which may nevertheless provide domestic hot water indirectly via a separate hot water storage cylinder, exactly matches the definition at Section 2.5 for a Regular Boiler. Consequently the methods deemed to satisfy Ecodesign regulation No. 811/2013 for a Regular Boiler will equally satisfy this requirement for the equivalent type of range cooker boiler.

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

When undertaking the efficiency test, record

- input power (net) at full load conditions, $\Phi_{\text{input,net}}$, in kW.
 - heat transfer to the water under full load conditions, Φ_{water} , in kW
 - flue loss (net) under full load conditions, $\Phi_{\text{flue,net}}$, in kW according to the method given in EN 304:1992 + Amendment 1: 1998 or other method assured by the independent test laboratory as providing comparable results for the product under test.
2. Calculate the seasonal efficiencies according to Section 3 using the appropriate equation for a regular boiler.
 3. Calculate the case heat emission at full load from

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

where Φ_{water} is the heat transferred to water under full load conditions;

$\Phi_{\text{flue,net}}$ is the flue gas loss measured according to BS EN 304.

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4. If $\Phi_{\text{case}} < 0.2$ kW and the case temperatures of the range cooker are below 80°C, the case emission may, as an alternative, be derived from measurements of the case temperatures according to Supplement 1 to OFTEC Standard OFS A101, subject to a maximum figure of $\Phi_{\text{case}} = 0.2$ kW.

Note: Supplement 1 to OFTEC Standard OFS A101 (applicable for oil and gas) can be obtained from OFTEC (Oil Firing Technical Association)

5. If Φ_{case} exceeds either of $0.05 \times \Phi_{\text{water}}$ or 1 kW, reduce Φ_{case} to $0.05 \times \Phi_{\text{water}}$ or 1 kW (whichever is the smaller).
6. Provide the values of Φ_{case} and Φ_{water} in kW as part of the test report.

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7. Method for calculating seasonal efficiency for solid fuel boilers

This section specifies how to obtain a seasonal efficiency from test data on a solid fuel boiler.

1. Convert net efficiencies to gross

Establish whether the efficiency test results are gross or net. If gross proceed to step 2. If net convert to gross using the following equation with the appropriate factor from Table 10.

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

Solid Fuel	Net-to-gross conversion factor, f
House coal	0.97
Anthracite	0.98
Manufactured smokeless fuel	0.98
Wood logs	0.91
Wood chips	0.91
Wood pellets	0.91

Table 10 – Efficiency conversion factors

2. Calculate the seasonal efficiency

a) Part load efficiency values available

The efficiency at full load is obtained from:

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

and the efficiency at part load from:

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

If the boiler is outside the boundary of the dwelling as defined in SAP section 1, “Dwelling dimensions”, the heat to room is omitted in the above equations.

The seasonal efficiency is:

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

b) Part load efficiency values not available

If the data for the part load test are not available, the part load efficiency is taken as 95% of the full load efficiency, so that:

$$\text{Seasonal efficiency} = 0.975 \eta_{\text{full}}$$

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