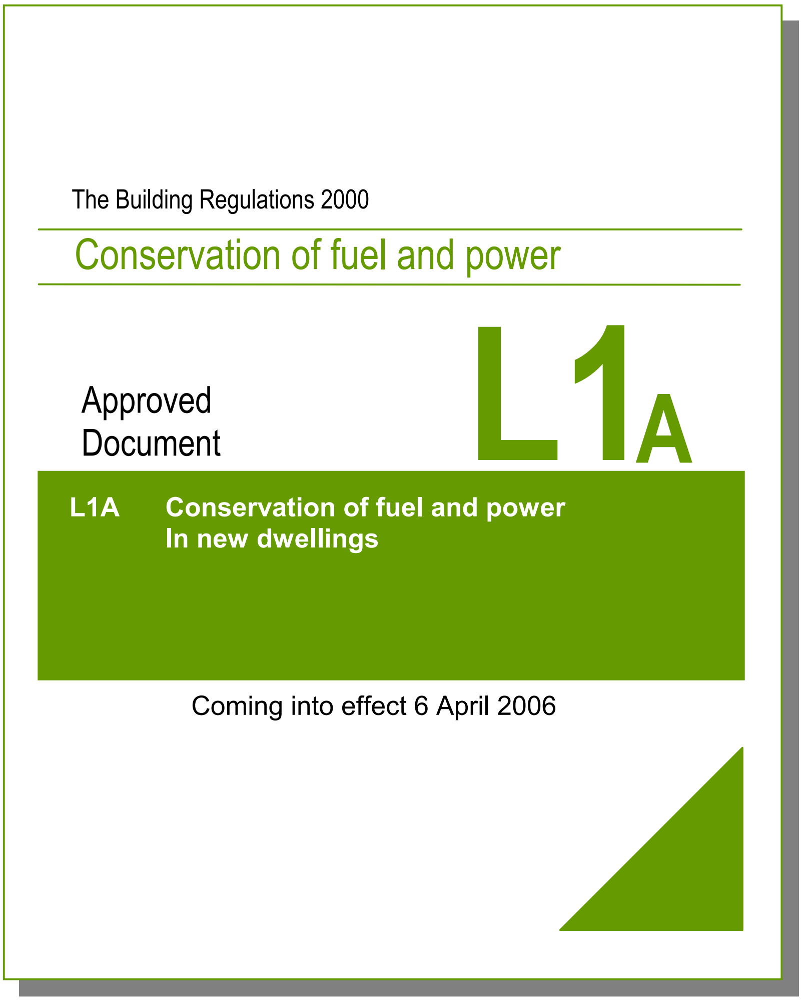
British Flue and Chimney Manufacturers Association

A Designers Guide to Specifying Chimneys or Flues for use with Secondary Heating In New Dwellings


The Building Regulations 2000

Conservation of fuel and power

Approved Document L1A

L1A Conservation of fuel and power
In new dwellings

Coming into effect 6 April 2006

On 6th April 2006 APPROVED DOCUMENT L1A: CONSERVATION OF FUEL AND POWER (NEW DWELLINGS) (2006 EDITION) came into force replacing the existing APPROVED DOCUMENT L1: CONSERVATION OF FUEL AND POWER IN DWELLINGS. This new publication, Approved Document L1a (ADL1a) brings about far reaching changes to ensure energy efficiency is improved in all new dwellings. The change goes part way towards achieving the government's target of reducing total UK CO_2 emissions by 20% below 1990 levels by the year 2010.

This paper uses an example house to show the effects that different natural draught secondary heating set-ups can have on the overall CO2 emissions of a design. Making the right secondary heating choice can:

- Make significant savings on the cost of construction,
- Improve design flexibility,
- Provide a sought after focal point in the living room,
- Allow the use of less expensive fuels,
- Reduce the environmental impact of the dwelling.

The main Difference Between ADL1: (2002) and ADL1a: (2006)

ADL1: (2002) contained 3 methods of compliance. The Elemental method gave minimum U-values that had to be met for each element of the design, it was easy to use but limited the designers choice. The Target U-Value method allowed a limited degree of flexibility by trading off values of one element against another. The Carbon Index method used the SAP 2002 calculation to provide an energy rating for the dwelling, this provided most flexibility in the design. The Elemental and Target U-Value methods did not account for energy used by secondary heating and designers were free to specify their choice of appliance, fuel and flue or chimney. The Carbon Index method accounted for the use of secondary heating by calculating the ventilation rates of chimneys or flues, together with the appliance efficiencies and fuels. It was generally considered that primary heating would be sufficient for all heating requirements within the Carbon Index method and because the end result was not compared against a target level, it was not prohibitive to the use of secondary heating.

ADL1a: (2006) introduces a new methodology to calculate the CO_2 emissions of a dwelling. The Elemental and Target U-value methods have been withdrawn, and the Carbon index method has been substantially re worked using the new SAP 2005 calculation. The SAP 2005 calculation now quantifies the CO_2 improvements over a similar house constructed to the 2002 regulations. By holistically calculating the amount of CO_2 a house design produces and comparing the results to a Notional House of the same size and shape but constructed using 2002 efficiencies and U-values, a 20% improvement level for CO_2 reduction can be quantified. This improved target level of CO_2 within the SAP 2005 calculation is known as the Target Emission Rate (TER) and the amount of CO_2 generated by the proposed design is known as the Dwelling Emission Rate (DER), which must be no higher in terms of CO_2 than the TER.

ADL1a Factors Affecting Chimneys and Flues used for Secondary Heating

SAP 2005 adopts a holistic approach for completing the CO_2 emission rate of the proposed dwelling. The dynamic nature of the calculation method means it is affected by almost every element of the design. Changes to any of the heat producing appliances, rates of air changes within the building, or insulation levels of the exterior envelope will affect the outcome of the calculation. Whilst every element is indirectly affected by changes to other elements of the design, the key areas directly affecting secondary heating are:

- Ventilation rate of the chimney or flue.
- Heating appliance efficiency.
- Type of fuel used.

<u>Standing Ventilation Loss</u>
The standing ventilation loss is the rate at which air will pass from within the building to outside when a natural draught appliance is not in use. Every chimney or flue generates a certain amount of air movement from the passive stack effect. This is accounted for within SAP by specifying the number of chimneys or flues used in the dwelling. SAP 2005 defines a chimney as being 200mm diameter or larger and a flue as less than 200mm. It apportions a default level of air loss to the chimney or flue as follows:

- Chimney 40 m^3/hour
- Flue 20 m^3/hour

The following situations are also considered a flue:

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

It can be seen that by adopting an installation with a flue the standing ventilation loss is halved compared to a similar installation with a chimney. Also it is possible for appliance manufacturers to test the standing ventilation loss of their appliances and the declared value can be substituted for the default levels. It is thought that many appliances will show substantial improvements over the default levels. Declared appliance ventilation rates are expected to be published in the regularly updated Annex Q of SAP 2005 and posted on the BRE web site.

Whilst still on the subject of standing ventilation loss it should be noted that "Flue less Gas Fires" also incurs a ventilation penalty of 40 m^3/hour within the SAP 2005 calculation.

Heating Appliance Efficiency

No matter what fuel is used with the appliance, the efficiency of the appliance has a marked effect on the outcome of the calculation. Traditionally, open solid fuel fires (SAP minimum efficiency 37%) have been used as a means of heat, however, efficiency was not a consideration with the availability of cheap fuel. This left a substantial amount of the available heat energy being wasted. Decorative Fuel Effect gas fires (DFE) (SAP minimum Efficiency 20%) were also popular to give the appearance of a traditional open fire without the hassle of cleaning out the ash or loading up the fuel. Again these were good as a decorative feature but wasteful of the available energy. Fortunately, modern appliances are now available at much higher efficiency levels.

Open inset solid fuel convector fires are now available at above 50% efficiency Inset Live Fuel Effect gas fires (ILFE), that give the appearance of a traditional open grate, are available at above 60% efficiency. Glass fronted solid fuel stoves and gas fires are available at above 70% efficiency. Making the right choice of appliance will show a substantial improvement in the SAP result.

Type of Fuel Used

The SAP 2005 tables give a CO_2 rating for fuels as kilograms of carbon dioxide per kilowatt-hour of energy ($KgCO_2/kWh$). Table 1 gives the carbon rating of the most generally used fuels:

Fuel	**$KgC0_2/kWh$**
Electricity	0.422
Manufactured Smokeless Fuel (coal)	0.393
Oil	0.265
LPG	0.234
Gas	0.194
Dual Fuel (wood & coal)	0.187
Wood	0.025

Table 1. CO_2 rating of common fuels

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Table 1 is listed with worst at the top to best at the bottom, therefore choosing one of the low carbon fuels will assist in the outcome of the calculation.

How SAP 2005 Evaluates Secondary Heating

To evaluate how secondary heating is handled in the SAP 2005 calculation, we must first look at how the TER is generated. The TER is based on a Notional House of the same size and shape as the proposed design but with the values given in table 2. The figures are taken from Appendix R of SAP 2005.

Element or system	Value
Size and shape	Same as actual dwelling
Opening areas (windows and doors)	25% of total floor area
Walls	U = 0.35 W/m²K
Floors	U = 0.25 W/m²K
Roofs	U = 0.16 W/m²K
Opaque door	U = 2.0 W/m²K
Windows and glazed doors	U = 2.0 W/m²K
Living area fraction	Same as actual dwelling
Shading and orientation	All glazing orientated E/W
Number of sheltered sides	2
Allowance for thermal bridging	0.11 x total exposed surface area (W/K)
Ventilation system	Natural ventilation
Air permeability	10 m³/m².h at 50 Pa
Chimneys	None
Open flues	None
Extract fans	3 with floor area greater than 80 m^2, 2 for smaller dwellings
Primary heating fuel (space and water)	Mains gas
Heating system	Boiler and radiators
Boiler	SEDBUK 78% room-sealed fanned flue
Heating system controls	Programmer + room thermostat + TRVs boiler interlock
Hot water system	Stored hot water heated by boiler
Hot water cylinder	150 litre cylinder
Primary water heating losses	Primary pipework not insulated cylinder temperature controlled by thermostat
Secondary space heating	10% electric
Low energy light fittings	30% of fixed outlets

For the full notional house parameters please see Appendix R of SAP 2005

Table 2. Notional House Properties

It can be seen from the highlighted row, that secondary space heating is accounted for in the target calculation with an electric fire taking 10% of the dwellings total heat requirement. Electricity in this situation, having a high CO_2 rating, will account for more than 10% of the CO_2 within the TER. When the total CO_2 is calculated for the Notional House, a reduction of 20% is applied to this figure, setting the TER 20% below the theoretical CO_2 level of an equivalent 2002 dwelling.

With secondary heating accounting for more than 10% of the CO_2 generated by the notional house, ADL1a requires secondary heating to be accounted for in the proposed design and gives the following guidance:

Secondary Heating

*28 When calculating the **DER**, it shall be assumed that a secondary heating appliance meets part of the space heat demand. The fraction provided by the secondary heating system shall be as defined by SAP 2005 for the particular combination of primary heating system and secondary heating appliance. The following secondary heating appliance shall be used when calculating the **DER**.*

*a. Where a secondary heating appliance is fitted, the efficiency of the actual appliance with its appropriate fuel shall be used in the calculation of the **DER**.*

*b. Where a chimney or flue is provided but no appliance is actually installed, then the presence of the following appliances shall be assumed when calculating the **DER**.*

i. If a gas point is located adjacent to the Hearth, a decorative fuel effect fire open to the chimney or flue with an efficiency of 20%

ii. If there is no gas point, then an open fire in grate with an efficiency of 37% burning multi-fuel, unless the dwelling is in a smoke control area where the fuel should be taken as smokeless solid mineral fuel.

c. Otherwise an electric room heater shall be taken as the secondary heating appliance

In short, this effectively means that if you do not specify secondary heating, the SAP 2005 calculation will automatically default to an electric room heater with in most situations 10% of the proposed dwellings heat load. If a chimney or flue is fitted and an appliance is not specified, the SAP 2005 calculation will also default to either an inefficient open solid fuel or DFE gas fire. All these default levels are inefficient compared to what can be achieved with the right choice of appliance, flue and fuel. These default levels will require costly compensation for their wasteful production of CO_2.

Minimum Requirements

Whilst ADL1a and SAP 2005 allow the designer a great deal of freedom in the choice of design elements, there are a number of prescriptive minimum standards that should be met in normal circumstances. ADL1a gives a list of minimum values for the external envelope of the building, these being walls at 0.35 W/m^2K, floors at 0.25 W/m^2K, roof at 0.25 W/m^2K, and windows at 2.2 W/m^2K, with these being based on an area-weighted average.

Constraints are also placed on the minimum efficiency of heating appliances and these are detailed in the Domestic Heating Compliance Guide. The minimum efficiencies of the most commonly used natural draught appliances, used for secondary heating, are detailed in table 3 below.

Appliance	Fuel	Minimum Efficiency
Radiant/Convector to BS 7977-2:2002 (not ILFE)	Gas	63%
Inset Live Fuel Effect to BS 7977-2:2002	Gas	40%
Convection Heaters to BS EN 613:2001	Gas	58%
Open fronted independent space heaters to BS EN 13278:2003	Gas	45%
Open fire - Inset	Solid fuel	37%
Open fire - Freestanding convector	Solid fuel	47%
Open fire - Inset convector	Solid fuel	45%
Dry room heater	Solid fuel	65%

Table 3: Minimum appliance efficiencies

Making the Right Choice

When designing a house, the reasons why a particular type of secondary heating is chosen are a lot more complicated than simply assessing its CO2 rating within SAP 2005. Some of the key aspects that should be considered are:

- **Focal Point**. Many modern secondary heating appliances are designed to simulate the traditional open fireplace, a feature sought after by many homeowners.

- **Internal air quality**. The Asthma UK fact file: "The Indoor Environment & Asthma" states; "*Good ventilation benefits people with asthma. It reduces humidity, which reduces the number of house-dust mites and moulds. It also helps to disperse gases produced by heating and cooking*". A good driver to promote natural air changes within a dwelling is a flue or chimney. The passive stack effect will provide a pressure difference to assist the house ventilation, promoting a healthy environment.

- **Added Value**. The addition of a feature fireplace is a sought after option for many homeowners. In the self-build market, where customers have the choice, the inclusion of a feature fireplace is common. Including a feature fireplace with its flue will add value to the dwelling and if the correct appliance, flue and fuel choice is made, it can also offer the builder a substantial saving in CO_2 and money.

Natural draught secondary heating types broadly fit into three categories. The following describes the secondary heating types and the CO_2 losses or gains that can be expected from them, together with possible compensations or benefits. Any figures quoted are approximations based on a 100 metre square detached house.

Traditional open fire

Traditionally, open fires have been constructed using a Clay fire-back with a mineral fuel grate or gas DFE basket. These are considered inefficient and penalized in the SAP 2005 calculation. A substantial amount of costly CO_2 compensation would be required including extra insulation to the external envelope and possibly the addition of renewable technologies such as solar water heating.

Convector open fire

These include mineral, dual fuel and wood open fronted fires with double skinned metal fire-backs. The fire-backs also contribute to the rooms heat from air moving through the convection chambers. With this type of appliance, mineral fuel is again penalized due to its high carbon rating. However, the use of dual fuel appliances of around 50% efficiency discharging into a flue of less than 200mm diameter are equivalent to the default electric fire and when tested values are available may have a lower standing ventilation loss than the default levels declared in the SAP 2005 tables. Often this type of set-up will provide a small carbon credit to the designer. If the manufacturer designates the appliance as wood only and provides the appliance with a wood ash pan rather than a grate, a substantial carbon credit can be obtained. This type of appliance, flue combination provides a purchaser with the ambiance and warmth of a traditional wood open fire but with improved energy efficiencies.

Gas ILFE fires also fall into this category, as they usually have a convection box to provide extra efficiency compared to a traditional DFE gas fire. To be equivalent, in terms of CO_2 to an electric room heater, a gas ILFE fire would need to be around 53% efficient. Many ILFE gas fires are now available at above 60% efficient.

Closed appliance

A variety of mineral fuel, dual fuel and wood closed appliances are available and typically have efficiencies ranging from 60% to over 70%. Again, mineral fuel doesn't fair well in the SAP 2005 calculation due to its high carbon content. However dual fuel used with a closed appliance in carbon dioxide terms, performs much better than the open convector fires giving a useful carbon credit. Wood in this type of appliance gives the best possible results, with a substantial saving in carbon compared to the TER. It should also be considered that clean burning wood appliances are available with exemptions allowing them to be used in smoke control areas. The choice of a SEDBUK band 'A' gas boiler together with a wood-burning closed appliance for secondary heating would, in many instances, account for nearly all the required carbon savings.

Comparison of Different Appliance, Flue and Fuel Set-ups

The following details give some examples of the effect choosing different secondary heating setups can have on the result of the SAP 2005 calculation. The results are calculated for a detached house with the parameters as detailed in table 4 using SAP 2005 v4.18.

Size	100m2
Window area	25% of floor
Window U-value	1.9
Door U-value	2.0
Ground Floor U-value	0.2
Walls U-value	0.3
Roof U-value	0.16
Air Leakage	$7m^3/(h.m^2)$ at 50Pa
Primary Heating	Gas 90% efficient

Table 4. Reference house details

The reference house was setup using an electric room heater for secondary heating and the U-values adjusted so that the DER matched the TER. The secondary heating was then substituted for other appliance, flue and fuel setups to compare the CO_2 variance against that of the default electric room heater. Table 5 gives results of the comparison detailed as the annual CO_2 variance.

Appliance	% Efficiency	Fuel	Flue/ Chimney	TER	DER	Variance CO_2/kg/yr
Electric room heater	100%	Electric	No	23.92	23.91	**1**
Open Fire	37%	Smoke-less	Chimney	23.92	28.17	**-425**
Open Fire (DFE)	20%	Gas	Chimney	23.92	27.67	**-375**
Open Convector	51%	Dual-Fuel	Flue	23.92	23.90	**2**
Open Convector	51%	Wood	Flue	23.92	22.14	**178**
Open Convector (ILFE)	61%	Gas	Flue	23.92	23.63	**29**
Closed Appliance	70%	Dual-Fuel	Flue	23.92	23.34	**58**
Closed Appliance	70%	Wood	Flue	23.92	22.06	**186**
Closed Appliance	70%	Gas	Flue	23.92	23.40	**52**

Table 5. CO_2 comparison

In the reference house, the U-values were adjusted to set the DER as close as possible to the TER, the 0.1 difference giving an annual CO_2 surplus of just 1kg.

By substituting the secondary heating for other natural draught appliances, fuels and flues, a large carbon variance on the default electric room heater can be seen. Rows 2 and 3 of table 5 show the default setting for an installation with a chimney. The open smokeless fuel fire, (the default if a chimney is fitted without an appliance or gas point in a smoke control areas) is the worst performer, having a CO_2 deficit of some 425kg. This would effectively amount to 18% of the total CO2 permitted and would require a substantial amount of compensation to achieve the TER. It would almost certainly require the addition of renewable technology such as solar water heating and improved U-values, possibly at the cost of many thousands of pounds. The Decorative Fuel Effect gas fire in row 3 of table 4, (the default when a chimney is specified with an available gas point but without an appliance) gives a similar poor result. It is evident from the poor performance of the default setups and substantial amount of CO_2 they generate, that these default levels should be avoided at all costs.

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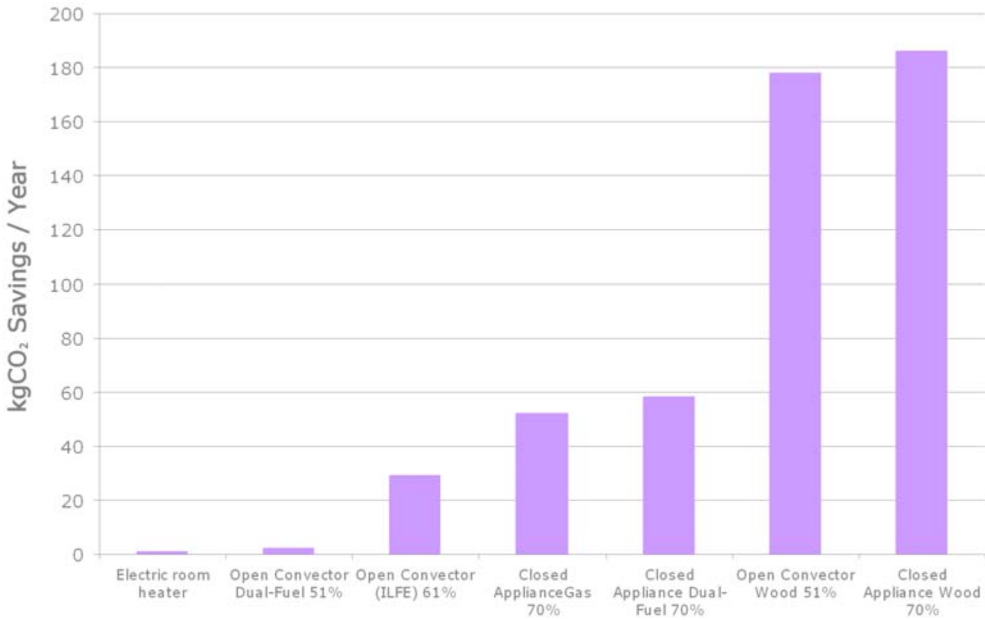
The performance of other more modern appliances gives an altogether better result. The convector fire operates much the same way a traditional open fire but at much higher efficiency levels. This means the convector fires would be suited to customers who wish to retain the traditional appearance of an open fire. Convector fires are available for solid fuel with the possibility of burning a variety of fuels such as wood or mineral fuel and are ideally suited for use in rural areas. An open convector manufactured for only burning wood can provide a significant CO_2 saving. When used with natural gas as the fuel, the convector fires would fall into the category of the more efficient Inset Live Fuel Effect gas fires that also give the appearance of a traditional open fire but with the convenience and controllability of gas. The modern efficient ILFE fires again give a better CO_2 performance than the default electric room heater.

By far the best performing appliances are those with a controlled combustion chamber, typically enclosed behind a glass screen. For solid fuel appliances, dual-fuel and wood stoves fall into this category with efficiencies ranging from 61% to above 80%. These appliances give excellent CO_2 savings and an efficient stove with wood as the fuel, can provide almost 50% of the total CO_2 savings required. There are also many glass fronted gas appliances both modern and traditional in appearance that perform substantially better than the default SAP 2005 options.



Graph 1. CO2 variance for appliance, fuel and flue types

Graph 1 shows the significant benefits that can be obtained from choosing the most suited combination of flue, appliance and fuel, compared to the default electric room heater.

Benefit of the CO2 Savings

In the example dwelling above, the savings shown for the various secondary heating set-ups could equate to the following construction and design benefits compared to those shown in table 4:

- **Open Convector Dual-Fuel 51% efficient saving 2 kg CO_2/year**. This small saving wouldn't equate to a benefit elsewhere in the design, however it does show an open fire is still a viable option even with a mix of different solid fuels.

- **Gas Inset Live Fuel Effect Fire 61% efficient saving 29 kg CO_2/year.** This could give a variety of design options, being; either relaxing the design air leakage to 8m^3/(h.m^2) at 50Pa, or relaxing the door and window U-value to 2.2 and 2 W/m^{2}K respectively, or increasing the wall U-value to 0.32 W/m^{2}K, or increasing the window area from 25% to 29% of the floor area, thus improving day lighting and giving Architects more design freedom for the elevations. This ILFE fire will allow either greater design flexibility or savings on material and construction costs.

- **Glass fronted gas fire 70% efficient saving 52 kg CO_2/year.** This could give the following possible design options, being: either relaxing the design air leakage to 9m^3/(h.m^2) at 50Pa, or relaxing the door and window U-value to 2.2 and 2.1 W/m^{2}K respectively, or increasing the wall U-value to 0.33 W/m^{2}K, or increasing the window area from 25% to 33% of the floor area. This type of gas fire will allow even greater design flexibility or savings on material and construction costs than the ILFE.

- **Multi-fuel stove 70% efficient saving 58 kg CO_2/year.** This gives similar possibilities to the glass fronted gas fire above but allows the use of other fuels and possible future fuel switching. The savings from this appliance being: either relaxing the design air leakage to 9 m^3/(h.m^2) at 50Pa, or relaxing the door and window U-value to 2.2 and 2.1 W/m^{2}K respectively, or increasing the wall U-value to 0.34 W/m^{2}K, or increasing the window area from 25% to 34% of the floor area. This type of fire will allow even greater design flexibility or savings on material and construction costs than the ILFE.

- **Open Convector burning wood 51% efficient, saving 178 kg CO_2/year.** This gives excellent savings that could equate to: either relaxing the design air leakage to 10 m3/(h.m2) at 50Pa together with relaxing the door and window U-value to 2.2 W/m^{2}K and increasing the wall U-value to 0.34 W/m^{2}K, or increasing the window area from 25% to 57% of the floor area. The use of wood is extremely beneficial however the open convector appliance must be supplied with the capability of only burning wood as the fuel.

- **Wood burning stove 70% efficient, saving 186 kg CO_2/year.** This gives the best savings that could equate to: either relaxing the design air leakage to 10 m^3/(h.m^2) at 50Pa together with relaxing the door and window U-value to 2.2 W/m^{2}K and increasing the wall U-value to 0.35 W/m^{2}K, or increasing the window area from 25% to 58% of the floor area. As with the open convector fire the use of wood is extremely beneficial. Closed appliances are more efficient and require less fuel to heat the house giving further environmental benefits. Closed appliances are also available with exemptions to burn wood in smoke control areas.

As can be seen, there are great possibilities for the designer to choose the most suited secondary heating and gain the benefit of either reducing the cost of construction, adding more adventurous design features or simply designing the most environmental house possible.

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Design Pointers

- Secondary heating is accounted for in ADL1a. If secondary heating is omitted from the design details, SAP will default to electric as the heating type.

- If a chimney is fitted but an appliance is not specified, SAP will default to an appliance efficiency of 20% and gas as the fuel, or 37% efficiency and smokeless or dual fuel if gas is not available. Both these options have a high carbon rating and will require expensive compensation to other areas of the design. It is therefore essential to specify the correct appliance at the design stage.

- In the calculation, a chimney (200mm or larger) has an air leakage of $40m^3$ and a flue (Less than 200mm) has an air leakage of $20m^3$. As appliance manufacturers improve their appliances, more options will become available that only require a flue of less than 200mm. If the appliances are tested for standing air loss, the tested figures can be used in the calculation rather than the default values above.

- Using a lower carbon fuel than the default electric option, can, in many situations, result in a substantial carbon credit. This would allow more Architectural freedom and choice in the selection of other building elements, or simply provide a carbon buffer that can be held back in case the tested air leakage results are not up to the design requirements.

- An Aga type stove in a kitchen, with a natural draught flue, can also provide the kitchen ventilation requirements - reducing the total standing air loss from ventilators and flues.

- Providing an open feature fire is still a viable option in house design and, as you have seen above, can provide many advantages to both the designer and house occupant.

Useful Links

Building Regulations ADL1a
Domestic Heating Compliance Guide
    www.communities.gov.uk
SAP 2005
    projects.bre.co.uk/sap2005
British Flue and Chimney Manufacturers Association
    www.feta.co.uk/bfcma
The Scottish Building Standards Agency
    www.sbsa.gov.uk
Smoke Control Areas UK & exempt appliances
    www.uksmokecontrolareas.co.uk

The information in this document has been compiled using ADL1a and SAP 2005 v4.18 and is intended as a guide to assist designers explore the possibilities of different types of secondary heating. The tables show results for one specific size of property, these results will change if any elements of the house are changed such as different window areas or U-values are implemented. SAP 2005 is a fluid and dynamic calculation method and the effects of changes to the secondary heating in your design can only be assessed by carrying out full SAP 2005 calculations on each dwelling and design change.

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