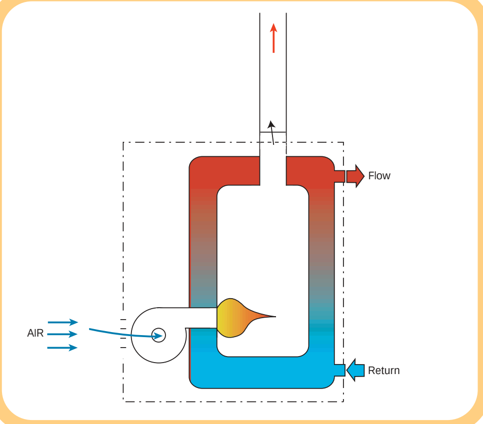
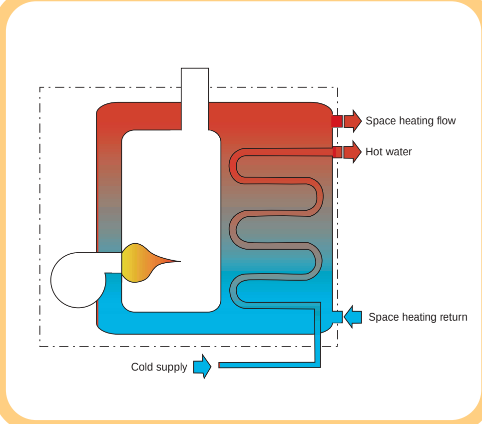
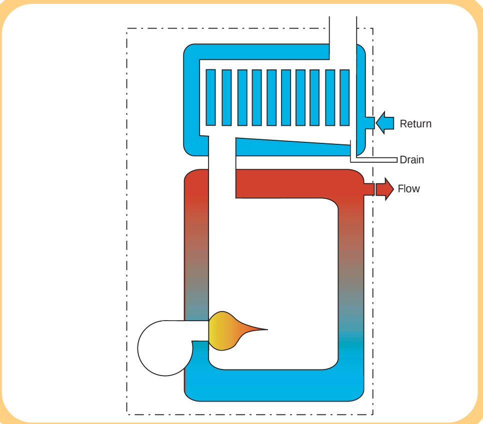
Energy Efficiency Best Practice in Housing

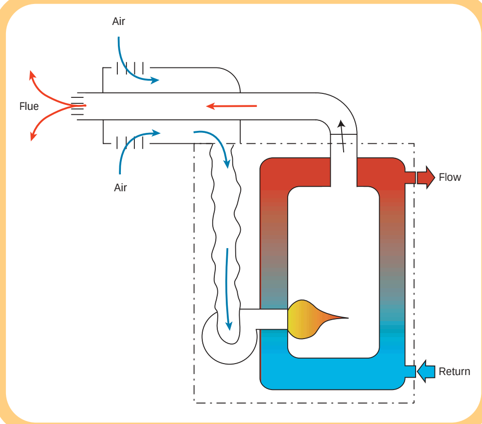
Domestic heating by oil: boiler systems

Guidance for installers and specifiers









Energy Saving Trust

Contents

Home energy use is responsible for 28 per cent of UK carbon emissions which contribute to climate change. By following Best Practice standards, new build and refurbished housing will be more energy efficient and will reduce these emissions, saving energy, money and the environment

This guide is designed to help installers, specifiers and purchasers of domestic central heating systems to select the most appropriate system for their needs. It gives advice on how to achieve better energy efficiency, lower running costs and reduced carbon dioxide (CO_2) emissions.

In particular, this publication is concerned with the encouragement of Best Practice. While the requirements for satisfying building regulations in various parts of the UK are described, the main purpose is to explain how to achieve considerably better performance through careful choice of systems and practices.

This publication focuses on 'wet' or 'hydronic' central heating systems in which the water is circulated to heat emitters from an oil-fired boiler. The oil used would normally be kerosene although gas-oil is sometimes used for domestic heating. Specifically, this publication addresses issues concerning the selection of boilers, hot water storage vessels, controls and indeed complete systems. It brings together information on most types of boiler currently available, the systems to which they can be fitted and key points to consider when choosing equipment for a particular installation. More detailed information on the specification, installation and use of oil-fired equipment is available from the Oil Firing Technical Association (OFTEC) website at www.oftec.org.

How to use this guide

The guide is set out as follows:

Section 2 explains the building regulations for heating and hot water systems in different parts of the UK.

Sections 3, 4 and 5 go into some detail about the range of systems, boilers and controls currently available.

Section 6 reproduces the Central Heating Systems Specifications (CHeSS). These set out specifications for meeting the basic efficiency levels needed to comply with building regulations as well as higher performance levels regarded as current Best Practice. They can be used as ready-made purchase specifications.

Section 7 focuses on the benefits to be obtained from choosing Best Practice.

Section 8 covers the practical issues affecting the selection of boilers, systems and controls.

Section 9 is concerned with proper installation, especially with regard to the flues and drains needed for condensing boilers, as well as oil storage and supply issues.

Section 10 offers guidance on commissioning and other related issues such as servicing and information to be provided to customers.

The appendices provide additional notes to the CHeSS specification, together with definitions of different boiler types and controls.

Note: the superscript numbers in brackets in the text refer to documents listed at the end of this guide.

1.1 Boiler efficiency

The efficiency of the boiler is the main factor in the overall efficiency of a domestic central heating system. This is why minimum standards of efficiency are required by law for most boiler types - as set out in the Boiler Efficiency Directive and equivalent UK legislation ([17,20]). Best Practice, though, requires substantially better performance.

The efficiency of the overall system in turn has a major impact on running costs and the associated CO_2 emissions. Boiler efficiency depends upon:

- fuel;
- boiler type and design;
- the load on the boiler due to the weather;
- boiler and radiator sizing relative to the design heat load;
- system controls;
- flow and return temperatures;
- installation and commissioning;
- regular servicing and maintenance.

When older boilers are replaced, the advances in boiler technology mean that substantial efficiency improvements can be expected from newer equipment. Manufacturers now design for maximum efficiency consistent with durability. The greatest energy efficiency benefits are obtained from installing condensing boilers - these are always more efficient than non-condensing models. In England and Wales it is a requirement of the building regulations from 1 April 2007 that newly installed oil-fired boilers should be condensing, with a Seasonal Efficiency of a Domestic Boiler in the UK (SEDBUK) efficiency of 86 per cent or more, unless an exception is allowed (see Section 2.1.2).

Why are condensing boilers more efficient?

A condensing boiler has a large heat exchanger which extracts more heat from the flue gases. In a non-condensing boiler, the flue gases are at a temperature of 120-200°C. In a condensing boiler, more heat is removed and the temperature falls to below 100°C and as low as 50°C for the most efficient boilers operating at reduced boiler return temperature. The water vapour in the gases condenses (hence the name) and the resulting liquid has to be drained away. As the heat exchanger gets wet in the process, it is more susceptible to corrosion. To avoid this, it has to be constructed from corrosion-resistant materials eg. stainless steel.

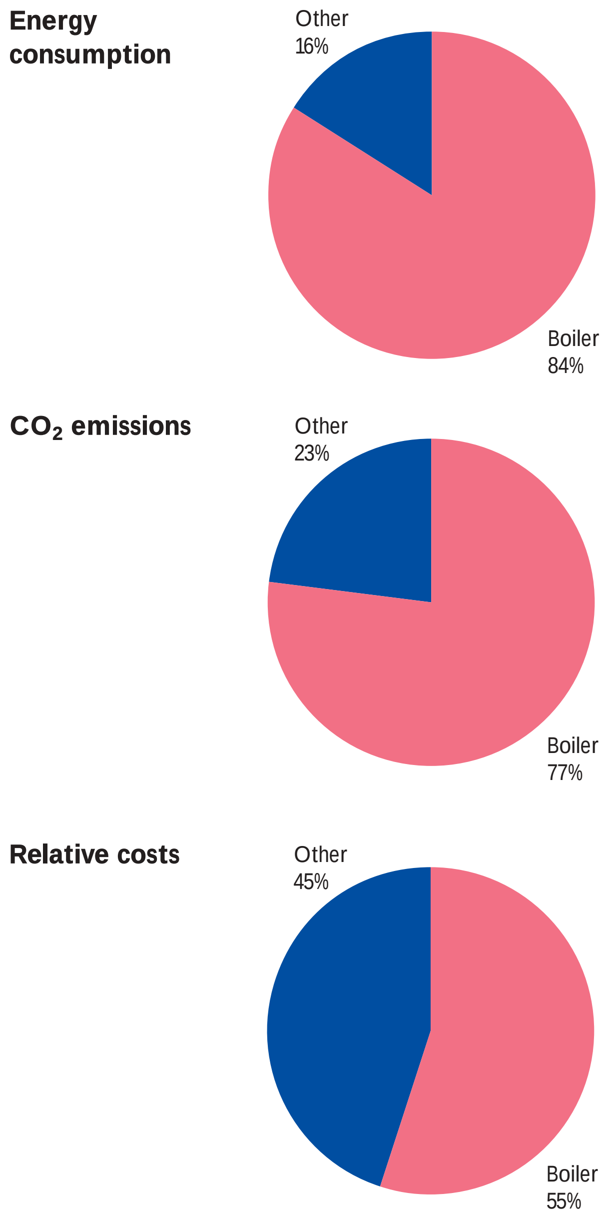
For more information on different boiler types see Section 3.

1.2 Energy consumption and emissions

Boilers for heating and hot water represent the greatest proportion of domestic CO_2 emissions. They consume far more energy than household appliances. For similar output, emissions are higher from oil-fired boilers than from gas or LPG ones, even though oil boilers are normally more efficient.

The average household with central heating consumes about 23,000 kilowatt-hours (kWh) of energy each year. Of this, nearly 84 per cent is for heating and hot water. To reduce fuel costs and cut emissions, it is particularly important to choose efficient boilers and install them in suitably designed and controlled systems.

Figure 1: Heating and hot water as a proportion of total energy usage in homes heated by oil



This section outlines the minimum standards for heating efficiency as set out in the building regulations. The remainder of this guide then concentrates on Best Practice - a higher standard.

There are different building regulations in England and Wales, Scotland, and Northern Ireland. All contain provisions for conservation of fuel and power ([22,23,24]). These restrict the type of heating system that may be installed in new dwellings. In the case of England and Wales, new and replacement heating systems in existing dwellings are also covered. A summary of the main points of the regulations is given below.

Other parts of the regulations (Part J in England and Wales, Section 3: Environment in Scotland and Part L in Northern Ireland) deal with the related issues of the safety of heating installations and with fuel storage.

U-values measure the rate of heat transfer through materials, in units of watts per square metre per degree of temperature difference (W/m^2K). The lower the figure, the lower the rate of heat loss.

The Standard Assessment Procedure (SAP) is the UK Government's procedure for calculating home energy ratings, enabling the householder to compare the energy performance of different buildings ([26]). In SAP 2001 the index is a number from 1 to 120, where higher numbers indicate greater efficiency. All new homes in the UK are required to have a SAP rating to comply with the building regulations.

SAP 2001 is expected to be replaced by SAP 2005 in England, Wales and Northern Ireland in January 2006.

The carbon index is calculated as part of SAP 2001. CO_2 is emitted as a result of burning fuel, or generating electricity, to meet the demand for space and water heating. Expressed on a scale from 0.1-10.0, higher values represent lower emissions.

In SAP 2005 the carbon index will be replaced by a Dwelling Carbon Emissions Rate (DCER).

2.1 England and Wales

The building regulations set a legal requirement to make 'reasonable provision . . . for the conservation of fuel and power in dwellings'. However, the approved guidance notes that 'there may well be alternative ways of achieving compliance' (Part L1) and different strategies can be adopted provided it can be shown they are at least as good as those given in the guidance. More detailed guidance on this is available from the Office of the Deputy Prime Minister (ODPM) website ([21]).

2.1.1 New buildings

New dwellings must comply with Part L1 of the regulations ([22]). Three methods of demonstrating compliance are given using boiler efficiencies, based on Seasonal Efficiency of Domestic Boilers in the UK (SEDBUK) values. Only SEDBUK efficiency ratings are acceptable and the Boiler Efficiency Database is the best source of this information (see www.boilers.org.uk).

The elemental method

Here, the boiler should have a SEDBUK efficiency at or above a 'reference efficiency' of 85 per cent for regular oil-fired boilers or 82 per cent for oil-fired combination boilers (combis).

The 'target U-value' method

Under this method, an average U-value (see panel) is calculated from the values for the various elements of the building envelope. This figure must not exceed a target value for the structure. If the SEDBUK value for the chosen boiler is different from the reference value referred to above, the target U-value is adjusted to take account. In this case, the target U-value is multiplied by the factor.

$$\frac{\text{efficiency of proposed boiler (\%)}}{\text{reference value (\%)}}$$

If the chosen boiler is less efficient than the reference value, the effect will be to reduce the target U-value, requiring improved thermal performance from the building fabric. If the boiler is more efficient, then more flexibility in fabric insulation levels is permitted.

The carbon index method

The third method is the carbon index method (see panel) - a value of 8.0 or better must be achieved. The choice of fuel will have a direct impact on the carbon index.

Storage vessels

Hot water storage vessels should be insulated in accordance with BS1566, BS3198 or BS7206 ([27,28,29]), and the internal heat exchanger should be sized accordingly. There should be pumped circulation through the primary circuit to the heat exchanger. If a thermal store is used, it should meet the requirements of the Waterheater Manufacturers' Association 1999 performance specification ([30]).

Controls

Zone controls should allow different air temperatures to be set for living and sleeping areas (other than in small open-plan flats and other properties where these areas are not separated). In most dwellings, both temperature zones can be controlled by a single time switch or programmer channel. However, in properties with a floor area of more than 150m^2, multiple timing zones are required (with no zone larger than 150m^2).

Separate timing controls should be provided for hot water, unless this is provided by a combi boiler.

Boiler interlock (see Section 5.1) is needed to ensure that the boiler is switched off when neither heat nor hot water is wanted. Thermostatic radiator valves (TRVs) alone will not provide a boiler interlock. These must be supplemented by a room thermostat or other device to prevent unnecessary boiler cycling.

Pipework

Pipes should be insulated wherever they pass outside the heated living space. In addition, all hot water pipes connected to the hot water cylinder (including the vent pipe and the primary flow and return) should be insulated for at least 1m from the connection.

Commissioning

Upon completion of the installation, the system should be inspected and then brought into service so that it operates efficiently and meets its specified performance levels. The owner or occupier should also be given information on the operation and maintenance of the system. The installer (competent person) should provide details of the installation to OFTEC who will send a certificate to the householder and supply any relevant information to the local authority Building Control Department. Alternatively installers or their customers can use the Local Authority Building Control route for building regulation notification for which a charge is made.

2.1.2 Existing buildings

Part L1 of the Building Regulations applies to work on 'controlled services or fittings' in existing dwellings, as well as in new ones. Certain types of heating system are 'controlled', including central heating systems with boilers. Alterations to controlled services or fittings require a Building Control Notice, unless they are carried out by a recognised competent person allowed to self-certify the work.

In particular, any new boiler (whether or not it replaces an existing unit) should meet or exceed the same reference efficiency as that quoted for a new building, except in dwellings where the total floor area is less than 50m2.

From 1 April 2005 the reference efficiency is set at 86 per cent for existing buildings - a level only achievable by condensing boilers. Where the installation of a condensing boiler would be impractical or excessively costly, it is reasonable to install a non-condensing boiler instead (see panel). It has been agreed that all oil boilers installed before 1 April 2007 will qualify automatically as a reasonable exception, and the minimum allowable efficiency meanwhile remains at 85 per cent for regular oil-fired boilers or 82 per cent for oil-fired combis. Nevertheless, the assessment form from the Condensing Boiler Installation Assessment Procedure should still be completed when non-condensing boilers are installed in existing dwellings in the period April 2005 to March 2007.

New or replacement hot water storage vessels and controls should meet the same requirements as in new buildings. Ensuring adequate controls are in place should be a priority whenever a boiler or hot water storage vessel is installed. Commission and handover procedures should also be undertaken as in new buildings.

Condensing boiler exceptions

To determine the conditions under which a non-condensing boiler is accepted as reasonable, an assessment of the property should be carried out following the Condensing Boiler Installation Assessment Procedure. The procedure is shown in outline in Appendix A, and given in full detail in ([21]). There is an assessment form, with instructions for completion, and a technical guide.

Key points include the following.

- The assessment considers fuel type, dwelling type, boiler position, flue options, flue terminal positions and condensate drain points.
- The lowest cost installation position must be found, as defined by the procedure.
- Standardised costs and benefits are assumed, which will not be the same as actual costs and benefits in any particular property.
- The installation position is based on the characteristics of the empty building, ignoring furniture and fittings as well as any position preferred by the owner.
- A simple points system determines whether the lowest cost installation option exceeds a fixed threshold.
- The assessment form must be completed and signed by a competent person and a copy given to the building owner, who should retain it as evidence an assessment has been carried out. A non-condensing boiler may then be installed. The form may be needed when the building is sold.
- Even if an exception is allowed, a condensing boiler is preferable and a grant may be available to the householder to assist with the extra installation cost.
- The boiler installed, whether condensing or non-condensing, does not have to be installed in the position evaluated for the purpose of the assessment.

2.2 Scotland

From 1 May 2005, new dwellings must comply with the Building (Scotland) Regulations ([23]). There are three alternative methods of demonstrating compliance in which the efficiency of the boiler is taken into account. In each case the efficiency measurement to be used is SEDBUK (see Section 7.1), and the Boiler Efficiency Database (see Section 7.5) is the best source of SEDBUK figures for all domestic boilers in the UK. Efficiency figures other than SEDBUK are inadmissible.

The elemental method

The first method, known as the elemental method, distinguishes between a boiler which has a SEDBUK efficiency above or below a 'reference efficiency'. The 'reference efficiency' is 85 per cent for oil-fired regular boilers or 82 per cent for oil-fired combi boilers. If the boiler has a SEDBUK efficiency below the reference efficiency, then lower (more onerous) maximum U-values (see panel) are applied to the elements of the building fabric, which will tend to increase construction costs.

The 'target U-value' method

The second method is known as the target U-value method, in which an average U-value is calculated for the various elements of the building envelope and must not exceed a target which depends on the ratios of total floor, ground floor, and roof areas to the total area of all exposed elements of the dwelling. No adjustment is needed to the target U-value if the boiler meets or exceeds the reference efficiency level needed for the elemental method (explained above), but if the boiler efficiency is lower then the target U-value is multiplied by the following factor.

$$\frac{\text{proposed boiler SEDBUK (\%)}}{\text{reference boiler SEDBUK (\%)}}$$

The factor will have the effect of making the target U-value lower (i.e. harder to meet).

The carbon index method

The third method of demonstrating compliance is the carbon index method (see panel), by which a result of 8.0 or higher must be obtained when the overall energy performance of the building is assessed under SAP. The fuel used for heating and hot water directly affects the carbon index.

Storage vessels, pipework and controls

Hot water storage vessels must be adequately insulated, and all pipes used for space heating and hot water supply must be suitably insulated where they lie outside the heated living space.

The space heating system must be controlled by room thermostats or TRVs, and an adjustable seven day time switch or programmer. Boiler interlock (see Section 5.1) must ensure the boiler is switched off when there is no requirement for heat or hot water. TRVs alone are not sufficient to achieve boiler interlock, and must be supplemented by a room thermostat or other device to prevent unnecessary boiler cycling.

Commissioning

At completion of installation, systems must be inspected, tested, and brought into service so as to meet the specified performance and operate efficiently. Written information on the operation and maintenance of the system must be provided for the occupier.

2.3 Northern Ireland

The relevant building regulations are the Building Regulations (Northern Ireland) 2000, and specifically Building Regulations F3 and F4. These call for 'reasonable provisions' to be made for space heating and hot water supply.

The installation, alteration or replacement of any heating system must comply with the relevant regulations. All new heating systems should be notified to Building Control and any alteration to an existing heating system where a structural alteration is also involved. Where an existing heating system is extended, the extension to the system must be insulated to comply with regulation F4.

'Technical Booklet F: Conservation of fuel and power' (24) gives provisions that are deemed-to-satisfy the requirements of Regulations F3 and F4. Although it is not essential to follow Technical Booklet F, it is obligatory to comply with Building Regulations F3 and F4.

Technical Booklet F has two methods of demonstrating compliance, explained here. For both methods a SAP rating (see Section 7.2) must first be calculated, and different requirements then apply according to whether or not the SAP rating exceeds 60.

The elemental method

Under the elemental method, boiler efficiency is not specified explicitly, although it affects the SAP rating achieved. If the SAP rating is 60 or less then lower (more onerous) maximum U-values (see panel) are applied to the elements of the building fabric. This will tend to increase construction costs.

The 'target U-value' method

Under the target U-value method, the target is calculated by reference to the total floor area and total area of exposed elements, and raised (i.e. relaxed) where the SAP rating exceeds 60. The target can be relaxed further by as much as 10 per cent where there is a high efficiency heating system.

A heating system with a gas boiler of seasonal efficiency above 72 per cent qualifies, and between 72 per cent and 85 per cent, the target U-value may be increased by up to 10 per cent pro rata. Above 85 per cent boiler efficiency the target U-value may be increased by the maximum of 10 per cent.

Storage vessels, pipework and controls

Hot water storage vessels shall be insulated to a specified standard, and all hot water pipes connected to the vessel (including the vent pipe and primary flow and return) shall be insulated for at least 1m from the connection. Other pipes shall be insulated where they lie outside the heated living space.

The heating and hot water systems shall be controlled by thermostats or TRVs, allowing for independent zones where different temperatures are required (eg. separate sleeping and living areas). A time switch or programmer shall be provided to control operating periods. Boiler interlock (see Section 5.1) shall ensure the boiler is switched off when there is no requirement for heat or hot water, and TRVs alone are not sufficient. They shall be supplemented by other devices to prevent unnecessary boiler cycling.

While this guide describes all types of oil-fired boilers, it concentrates on condensing units which provide optimum performance with low running costs and reduced CO_2 emissions.

Modern oil boilers are very efficient with reasonably low running costs. As such they are particularly suitable in areas where no mains natural gas is available. LPG is also an option in this situation. See the gas boiler systems guide for more information.

When seeking estimates of installation costs for oil-fired boilers, ensure that the provision and installation of an adequate oil storage tank is taken into account as well.

In most households, a single boiler provides both space heating and hot water, either:

- indirectly, through a regular boiler and separate hot water tank (which is usually a copper cylinder with a heating coil inside); or
- directly, using a combination boiler with no separate tank.

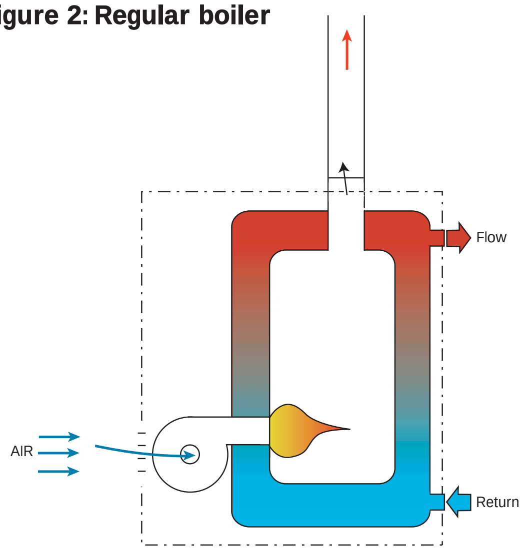
3.1 Regular boilers

Units that are not combination boilers (see below) are commonly referred to as 'regular', 'conventional' or 'heat only' boilers. They can be wall-mounted or floor-standing. Space heating is provided directly, but for hot water they need to be connected to a separate hot water storage system.

Oil-fired back boilers with a 'fuel effect' fire on the front (usually electric powered) can be installed in a fireplace, but condensing versions are not available.

Regular boilers for sealed systems (see Section 4.1) which have components such as pumps and expansion vessels within their casings are known as 'system boilers'.

Figure 2: Regular boiler



A back boiler unit (BBU) is one designed to be installed within a fireplace. Condensing BBUs are not available.

3.2 Combination boilers

Combination or combi boilers provide both space and hot water heating directly. Most oil-fired units are 'storage combis' and have an internal hot water store.

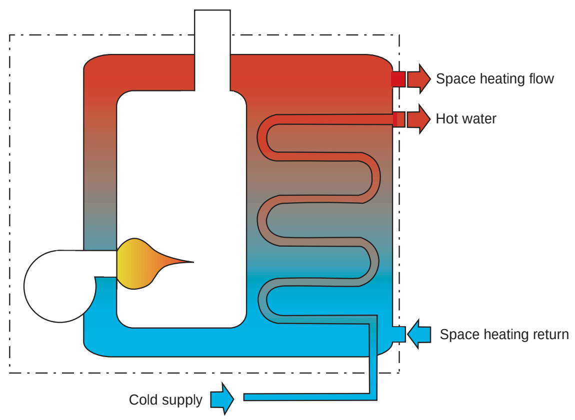
These boilers are capable of providing a continuous flow of hot water, but at a lower rate than typical hot water storage systems. As such, they may be less suitable for dwellings where there may be simultaneous demands for hot water ie multiple bathrooms.

Combi boilers save space because:

- they are fed directly from the water main, with no need for a hot water storage cylinder or cold water feed cistern;
- they are usually intended for use in a sealed system which does not require a feed-and-expansion cistern (allows a 'dry' roof space).

Before selecting a combi boiler, check the manufacturers' instructions to ensure that the dwelling has both satisfactory water pressure and an adequately-sized water supply pipe. Otherwise, hot water service may not be adequate.

Figure 3: Combi boiler



Space heating

The power (rate of heat output) of combi boilers is usually governed by hot water service requirements, and often exceeds that needed for space heating. Most oil-fired combis have fixed rate burners and a hot water store.

Hot water

Factors to consider are:

- the time taken for hot water to reach an acceptable temperature;
- hot water flow rate at the acceptable temperature;
- how long this rate can be sustained;
- can hot water be drawn off at more than one point simultaneously?

These factors will be influenced by the following.

- The size of the internal hot water store. A store can reduce the delay in delivering hot water. There are four different types:
  - instantaneous: no internal hot water store (rarely oil-fired);
  - 'keep hot': small or no internal hot water store - keeps water within the boiler permanently hot to reduce warm-up time at boiler start-up (sometimes called 'warm-start');
  - medium store: sufficient to meet small hot water requirements without delay, but insufficient for a bath;
  - large store: sufficient for a bath or multiple simultaneous draw-off without delay.
- Power. Boiler power affects the rate at which hot water at the required temperature can be drawn off after any internal store is exhausted.
- Flow rate. Boilers generally limit the hot water flow rate to ensure the declared temperature rise.

3.3 Cooker boilers

Some oil-fired cookers have a hot water boiler (either integral or separate). The latest units have two burners: one is for heating and hot water; the other is for cooking and has independent control. The casings of these cooker boilers have relatively high heat loss, which can be useful in winter but not in summer. Condensing units are not available.

3.4 Condensing boilers

Condensing boilers are the only type that meet Best Practice requirements and should always be considered as first choice in any application. In England and Wales it is a requirement of the building regulations from 1 April 2005 that newly installed oil-fired boilers have a boiler exception form completed. From 1 April 2007 boilers installed must be condensing, with a SEDBUK efficiency of 86 per cent or more, unless an exception is allowed (see Section 2.1.2). Even if an exception is allowed, a condensing boiler should always be the first choice and a grant may be available to the householder to assist with the extra installation cost.

Domestic oil-fired condensing boilers are usually only available for use with kerosene. Refer to the boiler manufacturer when the use of gas-oil is being considered.

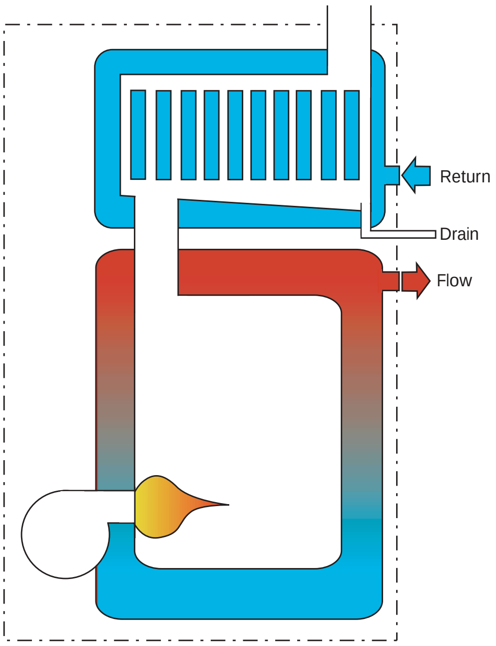
Features of condensing boilers

- SEDBUK efficiencies between 86 per cent and 97 per cent (with kerosene as the fuel).
- Typically a new condensing oil boiler will have an efficiency of 93 per cent, compared with 85 per cent for a new non-condensing boiler and 60-70 per cent for older types.
- The system does not need to be designed to make the boiler condense all the time to achieve improved efficiency.
- Mostly regular types but combis being introduced.
- Mostly floor standing.
- Room-sealed and open-flue models are available for domestic applications.
- Many have extended flue options.
- Suitable for replacing most existing boilers (but not BBUs in the same position).

Installation considerations for condensing boilers

- They are as easy to install as non-condensing boilers, but need a connection from the condensate outlet to a drain.
- Can be installed in modern fully-pumped systems.
- Oversized radiators will increase efficiency but good efficiency can still be obtained with 'normally sized' radiators.
- Care is needed in siting the flue terminal due to the plume of water vapour usually present during boiler operation. The plume will be visible for much of the time the boiler is in operation.
- Can employ a range of extended flue options, with the visible plume less likely to be a nuisance at high levels.

Figure 4: Condensing boiler



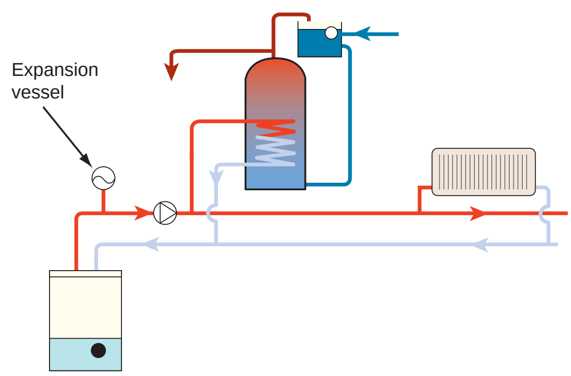
Systems may either be sealed to prevent ingress or escape of air, or open-vented. In the past, most installations were open-vented, but many are being replaced by sealed systems. Whether a system is sealed or open vented makes no difference to its energy efficiency.

4.1 Sealed and open-vented systems

Sealed

This is a popular option for new systems and increasingly used for boiler replacements. The feed-and-expansion cistern is replaced by an expansion vessel incorporating a diaphragm to accommodate variations in water volume. As the system is not open to the atmosphere, the pressure rises with increasing temperature, and additional safety controls must be installed (these are often within the boiler). The system will need a relief valve connected to an external discharge point, which must be placed where any discharge of hot water will be harmless. There is no permanent connection to a water supply, and the system may have to be topped up with water occasionally.

Figure 5: Sealed system



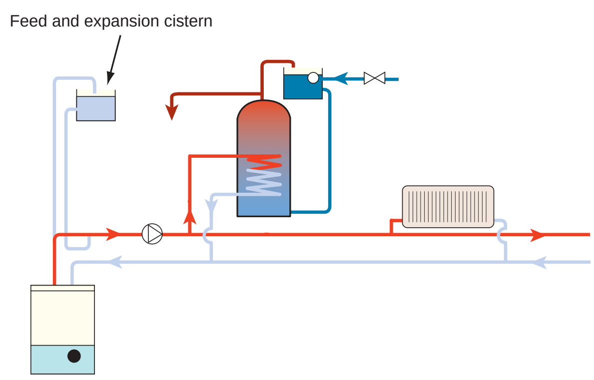
As the system is not open to the atmosphere, there is little possibility of oxygen being absorbed into the water and, consequently, reduced risk of corrosion. Because these systems may remove the need to install pipes and cisterns in the roof space, they reduce the risk of freezing.

Most combi boilers and all system boilers are designed for use with sealed systems and will usually incorporate system components, including a pump, expansion vessel and safety controls within the boiler case. In such cases, it must be ensured that this integral expansion vessel has sufficient capacity to allow for the water expansion of the whole system.

Open-vented

The majority of existing systems with a regular boiler and an indirect hot water cylinder are open vented. 'Open vent' refers to the separate vent pipe which is open to the atmosphere. The system also needs a feed-and expansion cistern to allow for changes in water volume with temperature. This cistern has to be at the highest point of the system, usually in the loft space where it must be protected against freezing.

Figure 6: Open system



4.2 Domestic hot water

The main issues to be considered regarding domestic hot water are:

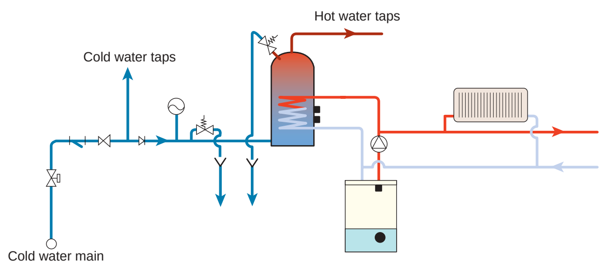
- the number of people in the dwelling;
- the number of baths/showers/taps;
- the hot water flow rate required;
- likelihood of simultaneous hot water draw-offs;
- availability of space for a hot water cylinder, or storage-combi;
- importance of a dry loft;
- feasibility of solar water heating.

Specific issues relating to combis are given in Section 3.2.

Most existing regular boiler systems employ a vented, indirect, hot water storage cylinder. In households with a single bathroom, these are typically of 117-140 litre capacity, but for larger dwellings with more than one bathroom (and perhaps with separate shower facilities), a larger cylinder capacity will be required ([19]). A larger cylinder will also be required, with an additional heat exchanger, if a solar collector or other supplementary heat source is to be exploited. A solar collector system, installed separately from the main heating system but connected to a different heat exchanger in the same cylinder, can make a significant contribution to hot water requirements, and save boiler fuel. Separate guidance and advice on solar systems should be sought ([50]). Alternative supplementary heat sources that may be connected are a heat pump, or wood burning stove.

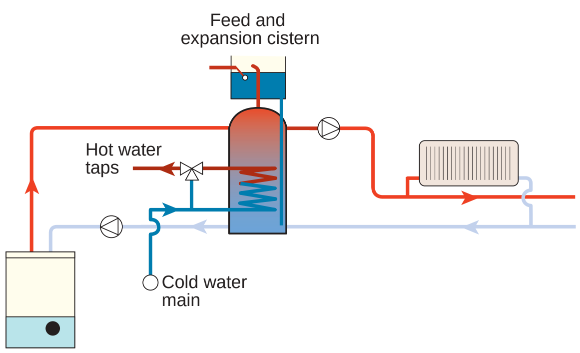
High performance cylinders contain a rapid heating coil. This is a heat exchanger with larger surface than normal, which reduces the time taken to heat the water and may reduce boiler cycling. It gives a valuable reduction in recovery time between large draw-offs (such as baths), and helps to increase system efficiency (especially with older boilers). High performance cylinders often have improved factory-applied insulation as well.

Figure 7: Unvented hot water system



Unvented cylinders are increasingly used in new systems. These operate at mains pressure. They employ an internal expansion facility or a dedicated external expansion vessel, and do not require a feed cistern in the loft.

Figure 8: Thermal storage system



Most hot water cylinders and thermal stores are supplied with factory-applied insulation and these should always be used in preference to cylinders with separate jackets. Cylinders should satisfy British Standards ([27,28,29]).

Medium-duty cylinders have inferior performance and do not meet CHeSS basic requirements or those of the building regulations, and so should not be used for either new or replacement installations.

Thermal stores can be obtained that hold water at high temperatures, heated by the boiler directly. These are available for 'hot water only' or 'hot water and space heating'.

Mains-fed systems such as combi boilers, unvented cylinders and thermal stores can supply hot water at mains pressure. This is extremely beneficial when high pressure is needed at the outlet eg for showers. It is therefore important to ensure that the incoming water supply pressure and flow to the dwelling are adequate and that all showers have the hot and cold water supply at the same nominal pressure. This eliminates the need for a shower pump.

Table 1: Domestic hot water flow rates

System type	Flow rate low	Flow rate medium	Flow rate high
Instantaneous combi [1,3]	x	x	
Storage combi [2,3]	x	x	x
Thermal store [3]		x	x
Unvented storage [2,3]		x	x
Vented storage [4]		x	x

Notes:
[1] rarely applied to oil-fired boilers and depends on boiler heat output; less satisfactory for two or more simultaneous draw-offs
[2] depends on boiler heat output and storage capacity
[3] depends on adequate mains water supply
[4] requires high level feed cistern

4.3 Upgrading systems

Many existing wet central heating systems are poorly controlled and of obsolete design. Poor design features which fail to meet Best Practice requirements include:

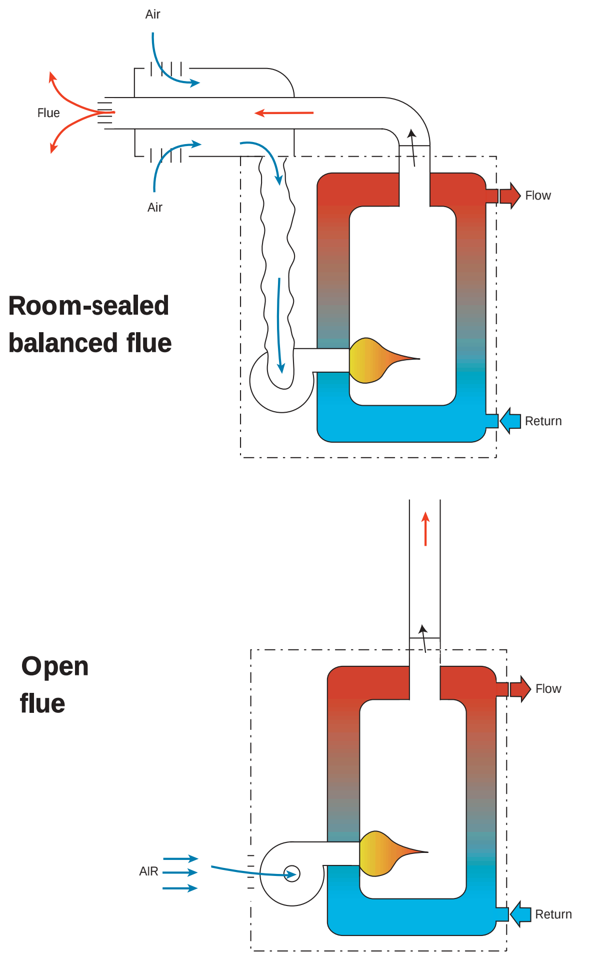
- gravity circulation to the hot water cylinder, which results in stored water being slow to re-heat;
- lack of cylinder thermostat, resulting in excessive stored water temperature;
- lack of room thermostat (rooms are too hot);
- lack of TRVs, causing excessive room temperatures and poor system balancing;
- absence of boiler interlock, causing the boiler to stay hot and to cycle unnecessarily during programmed periods.

When upgrading, use the CHeSS specifications (see Section 6).

4.4 Flue types

Most new boilers installed will be of the condensing type and in most cases they will be replacing non-condensing units. The different flue arrangements of the existing model may affect the siting of the new boiler. Figure 9 shows typical flue types found in existing systems.

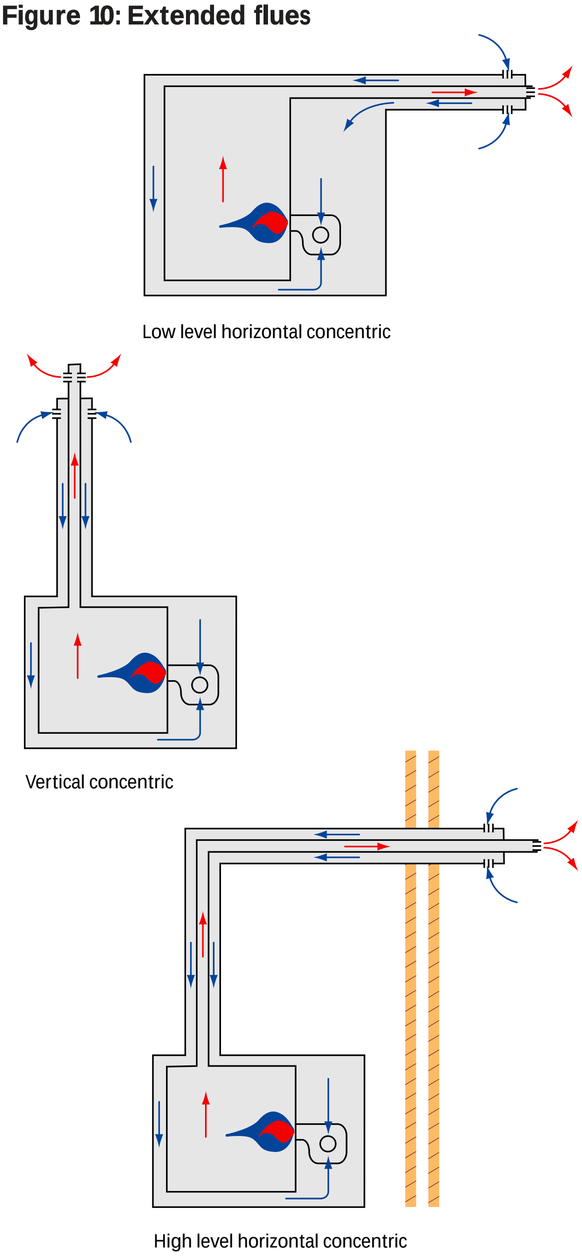
Figure 9: Existing flue types



The following is a list of important factors to consider when replacing a non-condensing boiler with a condensing unit.

- New oil-fired boilers are very efficient and operate with comparatively low flue-gas temperatures. A correctly sized, well-constructed, lined flue is essential for efficient performance.
- The flue must be correctly designed and sized using suitable, corrosion resistant materials and it must be provided with a suitable terminal ([32]).
- Most, but not all, new condensing boilers are room-sealed with a balanced flue. Room-sealed boilers do not require special provision for combustion air in that room but compartment ventilation may be required for cooling purposes ([32]).
- Boilers with open flues should, when possible, be located in a separate boiler room where combustion air is taken directly from the outside. If it is to be installed in a regularly used room such as a kitchen, advice should be sought from the manufacturer.
- The plume will be visible for much of the time the boiler is in use and can sometimes cause a nuisance. For this reason, special consideration should be given to the siting of the new flue terminal (see Section 9.2).
- Extended and vertical flues are available for many condensing boilers using concentric ducts. In some cases these allow flue lengths of over 5m, with a number of bends. Concentric extended flue options are available for horizontal and vertical applications (see Figure 10).
- Low level balanced flues must not be used with boilers fired by gas-oil fuel.
- New boilers will all have fan-assisted pressure jet burners, but the existing unit may use a vaporising burner.
- Rooms containing existing open-flue boilers will normally have a purpose-made vent to ensure sufficient air for combustion. However, this is unlikely to be required if the replacement is a room-sealed boiler ([32]).

Figure 10: Extended flues



4.5 Heat emitters

A wide range of heat emitters are available (see Table 2). Radiators remain the most popular type and modern versions are usually slightly smaller for an equivalent heat output. Many modern radiators also have a smaller water content, making for a faster warm-up.

The heat output of the radiators should be carefully calculated ([19]). All radiators should be fitted with a TRV (see CHeSS) excluding those in a room with a controlling room thermostat.

Underfloor heating is an attractive alternative in the right circumstances, but it needs to be installed by specialists. It also requires careful control in accordance with the manufacturer's guidance.

Other important points regarding heat emitters include the following.
- Radiators sited under windows counteract cold downdraughts and so give a more comfortable environment in the room.
- Radiators should be installed close to the floor, preferably 100-150mm above finished floor level.
- Wide, low radiators will be more effective at heating the room evenly than tall, narrow 'designer' styles.
- Enclosures around radiators reduce the heat output.

4.6 Circulator pumps

A circulator pump must be selected with sufficient design pressure and flow rate for the total system resistance when operational. If the pump is undersized or is set too low, the flow may be inadequate to meet the manufacturer's minimum requirement. This will result in the boiler operating with a larger temperature rise than intended. On the other hand, a pump that is larger than required will result in excessive water velocity noise as well as unnecessary electricity consumption.

Circulator pumps are built into combi and system boilers and it must be ensured that the pump has adequate head and flow rate to meet the system design.

Pumps that are installed separately (ie not supplied as part of the boiler unit) and that have automatic speed control should only be used in heating systems with TRVs if the design of the pump and system ensures that the minimum flow rate through the boiler (as specified by the boiler manufacturer) is certain to be maintained under all conditions. If a pump with automatic speed control is used in a system with an automatic bypass, ensure that the minimum water flow rate (as specified by the boiler manufacturer) can be maintained under all operating conditions.

Multiple pumps (one for each water circuit) may be used as an alternative to a single pump with motorised valves, provided that each water circuit has a non-return valve. Advice on pump sizing can be obtained from the British Pump Manufacturers' Association (BPMA) website at www.bpma.org.uk

Table 2: Heat emitters

Type	Comment
Panel radiator	The most common type in modern housing. Available in a wide range of outputs and sizes.
'Compact' radiator	A radiator or convector fitted with top grille and side covers.
'Column' and 'designer' radiators	Available in a wide range of colours and shapes.
Low Surface Temperature (LST) radiator	Safe option where young children or the elderly may be at risk. Limited to a surface temperature of 43°C in order to prevent injury.
Towel rail	For towel warming and will give some heat to the bathroom.
Fan convector	Wall hung and 'kickspace' units available. These provide a more rapid heating response. They need an electrical supply and there may be some fan noise.
Underfloor heating coils	Requires specialist installation and controls. May be less suitable for rooms requiring only intermittent heating.

Installing effective controls can have a major impact on the energy consumption of heating and hot water systems. This section describes the types of controls now available and outlines which are most appropriate for different heating systems.

Effective controls will increase operating efficiencies, especially when older systems are being updated. They also provide the householder with the opportunity to minimise energy consumption by ensuring the right comfort temperatures are maintained and so reducing overheating. Reducing room temperatures will also save energy (see panel). Timed space and water heating periods will also help to avoid excessive use of energy. Heating fuel is expensive (oil-fired boilers typically consume 25-50 pence of fuel an hour when operating) and reducing the firing time will make a proportionate difference to running costs.

What is a 'good' control system? It is one which ensures the boiler does not operate unless there is a demand and that only provides heat where and when it is needed in order to achieve the required temperatures. The selection of appropriate controls plays a key part in minimising the overall running costs of a heating or hot water system.

To maximise the efficiency of a heating system, control standards must meet Best Practice. However, in order just to achieve the SEDBUK efficiency claimed for a boiler, at least the basic set of controls given in CHeSS must be installed (see Section 6).

The cost benefit of controls should not be underestimated. Upgrading the controls on older heating systems can save up to 18 per cent on energy bills, for example when a full set of controls is fitted to a system which previously had none. This is important, as over 80 per cent of the energy a householder uses in the home is for space and hot water heating.

VAT on heating controls
Heating controls for domestic wet central heating systems are recognized by the Government as an energy efficiency measure. VAT is therefore charged at a lower rate - currently five per cent instead of the full rate of 17.5 per cent. This lower rate applies to both equipment and installation costs, but only when the work is carried out by an installer registered for VAT.

Energy savings from good controls

- Installing a minimum standard of controls on a system which previously had none can reduce fuel consumption and CO_2 emissions by 18 per cent.
- Reducing higher than necessary room temperatures will cut energy use. Turning down the room thermostat by 1°C will reduce space heating consumption by 6-10 per cent.
- An easy to use programmer that is adjusted to match the householder's occupancy pattern helps reduce wasteful heating when no one is at home.

5.1 Individual controls

This section describes the range of controls commonly used in oil-fired systems, what they do and why they are important.

The controls listed here are normally installed separately from the boiler although some may be incorporated within it. For clarity of specification, Appendix C contains a full list of controls including those often fitted within appliances and gives industry-agreed definitions.

In the following listing, Best Practice controls are noted.

Time Switch - A simple time control that will only switch one circuit. It should be chosen so that it is easy to understand and reset, especially when there is a change to the householder's domestic routine.

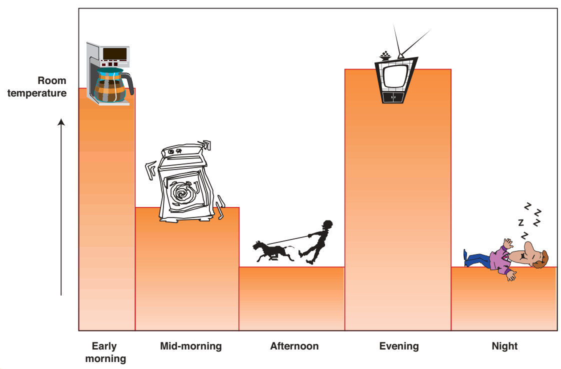
Programmer - This can switch two circuits separately (usually heating and hot water). There are three basic types:

- a mini-programmer allows space heating and 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 fully independent time setting for space and hot water heating.

Room thermostat - A simple room temperature control. Most room thermostats include an accelerator or anticipator, which has the effect of smoothing out the temperature cycle so that on and off periods are not too long. Wireless units that provide increased flexibility in positioning and eliminate visible wiring are now available (see note on page 17 regarding wireless controls).

Programmable room thermostat (Best Practice) - This allows different temperatures to be set for different periods of the day or week and so can provide a good match to householder living patterns, particularly if occupancy varies. This device also has a 'night setback' feature where a minimum temperature can be maintained. Many of these models are battery-operated and can replace a conventional thermostat without the need for additional cabling. Some versions also allow time control of hot water provision.

Figure 11: A programmable room thermostat offers greater flexibility in setting temperatures and times than a standard room thermostat, producing greater savings



Cylinder thermostat (Best Practice) - A simple control of stored hot water temperature, usually strapped to the side of the hot water cylinder. It is commonly used with a motorised valve to provide close control of water temperature.

Frost thermostat - A simple override control used to prevent frost damage to the dwelling and/or boiler system. The frost air thermostat should be fitted in a suitable place within the dwelling to ensure a minimum temperature is always maintained.

Pipe thermostat - Where the boiler is installed in an unheated area such as a garage, a pipe thermostat should be fitted to the exposed pipework. This is in addition to the frost air thermostat and is designed to prevent the boiler from firing unnecessarily in cold weather and so wasting fuel. If the boiler incorporates its own frost thermostat, a separate pipe thermostat is normally not required.

Thermostatic radiator valve (TRV) (Best Practice) - TRVs are used to limit the temperature in individual rooms. They also prevent overheating from solar and other incidental gains. In this way, they cut down on unnecessary consumption. Programmable units, which can be timed to switch on and off, are also available.

Thermostatic hot water temperature limit valve - These self-acting valves without motors are used to limit hot water temperature in domestic hot water cylinders. Some units sense primary water (boiler) temperature, others have a separate remote sensor for stored water temperature. Cylinder controls should not be used with these unless they also operate an electrical switch to provide boiler interlock. Otherwise the boiler will cycle unnecessarily.

Motorised valve (Best Practice) - These control water flow from the boiler to heating and hot water circuits. Two-port valves can also be used to provide zone control eg. allowing lower temperatures to be set for sleeping areas or different heating times. An explanation of the different types is given in Appendix D. Multiple pumps are an alternative to motorised valves (see Section 4.6).

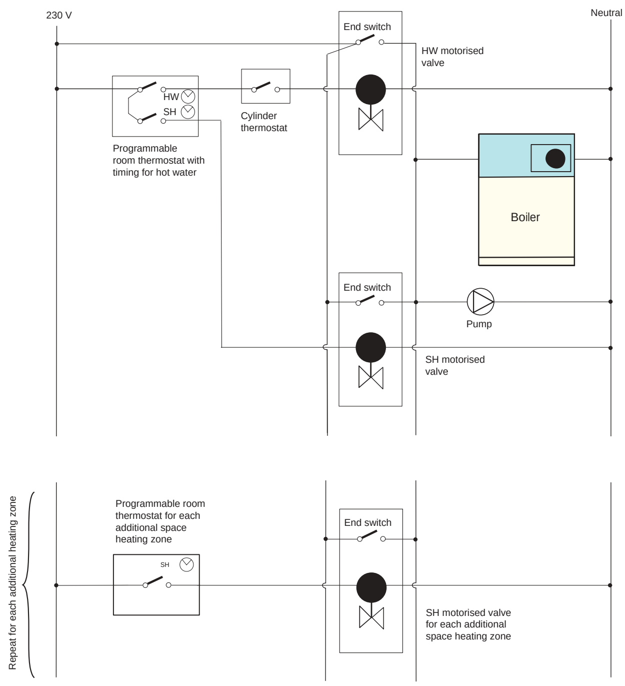
Boiler interlock (Best Practice) - This is not a device, but rather a wiring arrangement to prevent the boiler firing when there is no demand for heat. The boiler is 'interlocked' when it is switched on and off by thermostats containing electrical switches. All thermostats in the heating system fitted with electrical switches should be wired in this way. This includes room thermostats, programmable room thermostats, cylinder thermostats and some types of boiler energy managers. In many cases, the interlock is also applied to the operation of the pump, although any requirements for pump overrun stipulated by the boiler manufacturer must be observed. Without interlock, a boiler is likely to cycle on an off regularly, wasting energy by keeping hot unnecessarily.

Achieving interlock depends upon the boiler type and the controls fitted. Typical examples of boiler interlock are as follows.

- Regular boiler with one 3-port or at least two 2-port motorised valves. The interlock is usually arranged so that the room or cylinder thermostat switches the power supply to the boiler (and sometimes the pump) through the motorised valve 'end' switches. In other words, electrical power from the programmable room thermostat (or separate programmer and room thermostat) and the cylinder thermostat will drive the valve motor to the open position. Once the motor is fully open, the end switch will close and electrical power is then passed to the boiler (and pump). Once the power to the valve is removed (programmer off-period, or thermostat is satisfied) the end switch will open and the boiler and pump will stop.
- Regular boiler with 'dual head' pump. The dual head unit includes a dedicated wiring centre which ensures that boiler interlock is achieved. Where separate pumps are used, advice from the manufacturer is needed in regard to the correct use of relays, check valves, etc.
- Combi boiler. This only requires a room thermostat connection to provide interlock as hot water delivery is controlled directly by the boiler.

A boiler energy manager may need a different wiring arrangement, achieving interlock by an alternative method.

Figure 12: Boiler interlock in a system with two, 2-port valves (this shows the general logic and should not be interpreted as an installation instruction, as the actual wiring will depend on the particular products used).



Automatic bypass valve (Best Practice) - This controls water flow according to the pressure of the water across it. It is used to maintain a minimum flow rate through the boiler and to limit the circulation pressure when alternative water paths are closed. A bypass circuit must be installed if the boiler manufacturer requires one, or specifies that a minimum flow rate has to be maintained while the boiler is firing. The installed bypass circuit must then include an automatic bypass valve, not a fixed position valve. The use of an automatic bypass is important where the system includes a large number of TRVs. When most of these are open, the automatic bypass remains closed, allowing the full water flow to circulate around the heating system. As the TRVs start to close, the automatic bypass starts to open, maintaining the appropriate water flow through the boiler. It is also likely to reduce noise in the system caused by excess water velocity.

An automatic bypass is always preferable to a fixed bypass. With a fixed bypass, there is a constant flow of hot water coming out of the boiler, which is fed directly into the return at all times. This means that the boiler operates at a higher temperature, reducing efficiency and restricting the amount of heat transferred to the system.

It is very important that both automatic and fixed bypasses are correctly adjusted. Poor adjustment will give rise to increased boiler return temperatures and reduced boiler efficiency.

Particular care is required when selecting a pump with automatic speed control for a system with an automatic bypass. It is important to ensure that the boiler manufacturer's minimum recommended water flow rate is maintained under all operating conditions.

Boiler energy manager - These are self-contained devices which have a number of the functions found in other individual controls described in this section. They usually have a number of control functions including weather or load compensation and sometimes optimum start, frost protection, night setback, anti-cycling control and hot water override. Table 3 lists a range of control functions which may be included.

Wireless controls

Wireless controls should be designed with adequate immunity to blocking by other radio transmissions. If not, they may become unreliable or cease to work as nearby radio frequency bands become increasingly used for mobile phones and other communication services. See CHeSS Note 12 in Appendix B for details on how to specify wireless controls.

5.2 Selecting controls

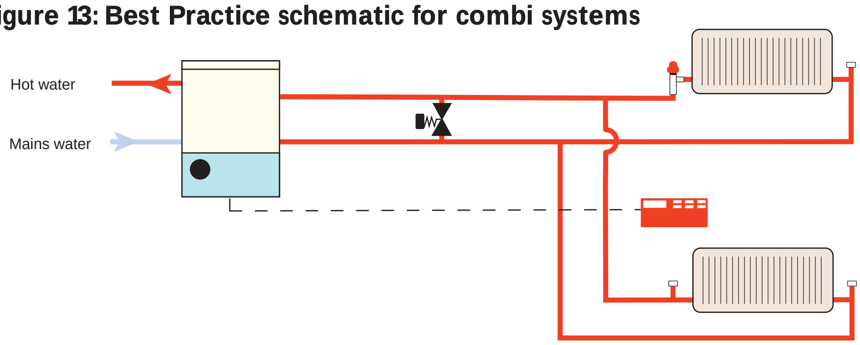
The minimum sets of controls consistent with satisfactory heating system performance are those listed as basic in the CHeSS specification (see Section 6). However, it is recommended that the Best Practice level is followed. Figures 13 and 14 show Best Practice for combi and regular boiler systems.

New systems must always be fully pumped and existing semi-gravity systems (ie with gravity circulation to the hot water cylinder) should be converted. Published boiler efficiencies cannot be achieved unless the whole system is fully pumped and effectively controlled.

Table 3: Control functions commonly built into boilers and control units

Compensator	Reduces boiler water temperature for space heating according to internal/external air temperature. It should increase the efficiency of condensing boilers by reducing the average water temperature of the system.
Delayed start	Reduces energy use by delaying boiler start time when the weather is mild.
Optimum start	Adjusts the heating start time to give the required dwelling comfort temperature at a chosen time
Night setback	Allows a low temperature to be maintained at night, providing improved comfort and reduced warm-up time in the dwelling in cold weather. In this way it can reduce the risk of hypothermia. A programmable room thermostat can fulfil this function.
Self-adaptive function	Reduces appliance 'on' time by learning from previous temperature characteristics.
Anti-cycling control	Delays boiler firing in order to reduce cycling frequency, but is unlikely to produce significant energy savings ([33]). In some circumstances consumption may be reduced, but normally at the expense of performance or comfort. Standalone units (ie those not supplied as part of the boiler) are not generally recommended as they provide little or no improvement over the basic level of control detailed in CHeSS

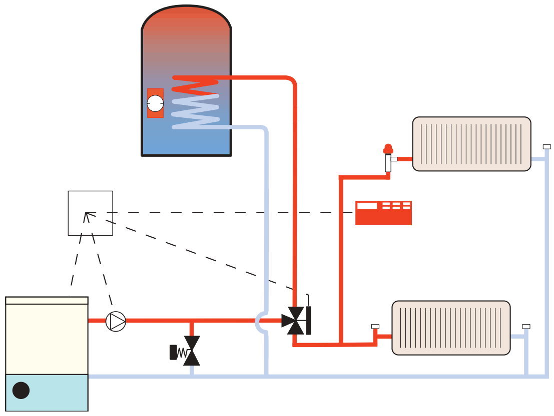
Figure 13: Best Practice schematic for combi systems



Best Practice - Combi boilers

- Programmable room thermostat
- Cylinder thermostat
- TRVs on all radiators except in rooms with a room thermostat
- Automatic bypass valve
- Boiler interlock

Figure 14: Best Practice schematic for regular boiler systems (the programmable room thermostat must have an additional hot water timing capability)



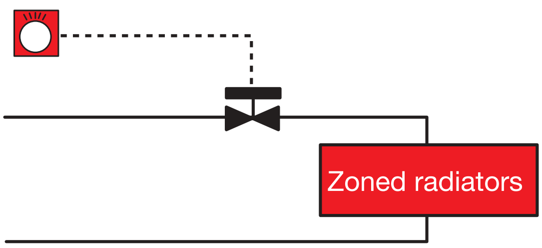
Best Practice - Regular boilers

- Programmable room thermostat with additional hot water timing capability
- Cylinder thermostat
- TRVs on all radiators except in rooms with a room thermostat
- Automatic bypass valve
- Boiler interlock

5.3 Further control improvements

Zone control - CHeSS Best Practice and basic options already include zone temperature control, achieved using TRVs. If zones are to be independently time controlled as well, it will usually be necessary to install additional room thermostats and a two-port motorised valve (this is to allow the programmer to shut off water circulation). The wiring in such situations must be arranged so that boiler interlock works in all zones.

Figure 15: Zone controls

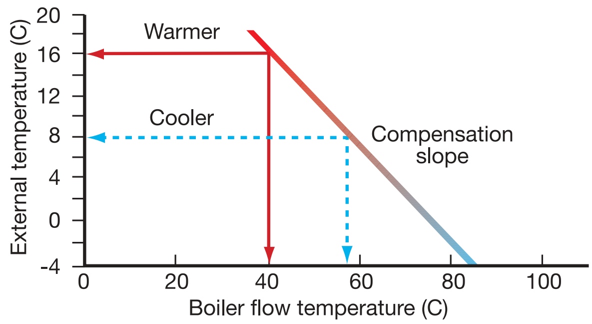


Zone control is particularly beneficial in larger, poorly insulated buildings. Building Regulations in England and Wales require that no zone is larger than 150m^2 in floor area and each zone should be capable of independent time and temperature control.

Systems that provide multiple zone control are now available which allow time and temperature control of individual rooms or multiple zones, thereby providing more effective and efficient heat distribution in the dwelling.

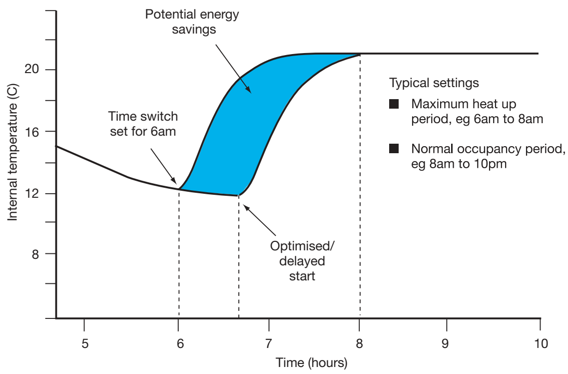
Weather compensation - As external temperatures rise, so a weather compensating function reduces average water circulation temperature (see Figure 16). Greatest benefit is achieved with condensing boilers.

Figure 16: Weather compensation



Delayed/optimum start - During mild weather, heat-up times are reduced. A delayed start function takes advantage of this. An optimum start control varies the start time to ensure the dwelling only reaches the desired temperature when the householder needs it (see Figure 17). Room thermostats with a delayed start function are now available.

Figure 17: Delayed/optimum start function



Home automation - Whole house control systems are now available, integrating the operation and control of a wide range of systems and appliances. Of particular relevance for energy efficiency are:

- time and temperature control of individual rooms;
- features to permit remote setting and operation of time switches, ie programmers and thermostats;
- feedback for the householder on energy use, which can encourage energy efficiency.

CHeSS provides a series of ready-made specifications for purchasing the components that critically affect the energy efficiency of wet central heating systems. Following them will improve energy efficiency and reduce carbon emissions. Purchasers should use these specifications to ensure their heating installations will meet Best Practice or basic requirements. Installers can use them to quote for systems of defined quality, comparable with those of their competitors.

The main elements are reproduced in the following tables and the explanatory notes can be found at the end of this document. The complete specification is available in a separate Energy Efficiency Best Practice in Housing document ([18]). That publication also contains quantified energy, carbon and cost savings for the different specifications.

The basic specifications HR5 and HC5 are sufficient to comply with the building regulations. The two Best Practice specifications HR6 and HC6 are to be preferred (see overleaf).

Basic (2005)

Reference	**CHeSS - HR5 (2005)**
Description	Domestic wet central heating system with regular boiler and separate hot water store.
Boiler *(see notes 5 and 6)*	• A regular boiler (not a combi) which has a SEDBUK efficiency of at least: - 86% if fuelled by natural gas (bands A and B); - 86% if fuelled by LPG (bands A and B); - 85% if fuelled by oil (bands A and B, and some from band C).
Hot water store	EITHER • Hot water cylinder, whose heat exchanger and insulation properties both meet or exceed (see note 7) those of the relevant British Standards (see Refs [7] , [8]). OR • Thermal (primary) storage system, whose insulation properties meet or exceed those specified in Ref[9].
Controls *(see notes 10, 11 and 12)*	• Full programmer. • Room thermostat. • Cylinder thermostat. • Boiler interlock (see note 13). • TRVs on all radiators, except in rooms with a room thermostat. • Automatic bypass valve (see note 14).
Installation	See notes 1, 2, 3 and 4.

Basic (2005)

Reference	**CHeSS - HC5 (2005)**
Description	Domestic wet central heating system with combi or CPSU boiler.
Boiler *(see notes 5 and 6)*	• A combi or CPSU boiler which has a SEDBUK efficiency of at least: - 86% if fuelled by natural gas (bands A and B); - 86% if fuelled by LPG (bands A and B); - 82% if fuelled by oil (bands A to C).
Hot water store	None, unless included within boiler.
Controls *(see notes 10, 11 and 12)*	• Time switch. • Room thermostat. • Boiler interlock (see note 13). • TRVs on all radiators, except in rooms with a room thermostat. • Automatic bypass valve (see note 14).
Installation	See notes 1, 2, 3 and 4.

In the CHeSS specifications reproduced above, the notes referred to have been placed in Appendix B of this guide.

Recommended Best Practice (2005)

Reference	**CHeSS - HR6 (2005)**
Description	Domestic wet central heating system with regular boiler and separate hot water store.
Boiler (see notes 5 and 6)	• A regular boiler (not a combi) which has a SEDBUK efficiency of at least: - 90% if fuelled by natural gas (band A); - 90% if fuelled by LPG (band A); - 90% if fuelled by oil (band A).
Hot water store	EITHER • High-performance hot water cylinder (see note 8). OR • High-performance thermal (primary) storage system (see note 9). In suitable buildings, consideration should be given to fitting a cylinder with an additional heat exchanger to allow for solar water heating.
Controls (see notes 10, 11 and 12)	• Programmable room thermostat, with additional timing capability for hot water. • Cylinder thermostat. • Boiler interlock (see note 13). • TRVs on all radiators, except in rooms with a room thermostat. • Automatic bypass valve (see note 14). More advanced controls, such as weather compensation, may be considered, but at present cannot be confirmed as cost effective.
Installation	See notes 1, 2, 3 and 4.

Recommended Best Practice (2005)

Reference	**CHeSS - HC6 (2005)**
Description	Domestic wet central heating system with combi or CPSU boiler.
Boiler (see notes 5 and 6)	• A combi or CPSU boiler which has a SEDBUK efficiency of at least: - 90% if fuelled by natural gas (band A); - 90% if fuelled by LPG (band A); - 86% if fuelled by oil (bands A and B).
Hot water store	None, unless included within boiler.
Controls (see notes 10, 11 and 12)	• Programmable room thermostat. • Boiler interlock (see note 13). • TRVs on all radiators, except in rooms with a room thermostat. • Automatic bypass valve (see note 14). More advanced controls, such as weather compensation, may be considered, but at present cannot be confirmed as cost effective.
Installation	See notes 1, 2, 3 and 4.

In the CHeSS specifications reproduced above, the notes referred to have been placed in Appendix B of this guide.

The information in this guide is designed to improve the energy efficiency of dwellings. Selecting the most energy efficient boilers suitable for the particular application is vital. Several factors need to be considered when choosing a boiler:

- seasonal (ie annual in-use) efficiency;
- typical heating and hot water running costs for the dwelling(s);
- typical CO_2 emissions for space and water heating.

Minimising demand

Whilst this guide aims to improve heating and hot water systems through careful selection of boilers and controls, it is important to remember that other factors affect the overall energy efficiency of the dwelling. In particular, it is essential to minimise:

- fabric heat loss through walls, floors, roofs and windows;
- ventilation heat loss from windows, unused chimneys and cracks or gaps in the structure of the dwelling.

7.1 Comparing boiler efficiencies

The term 'boiler efficiency' needs some explanation since there are many values that may be quoted, and these are calculated in different ways. In any comparison of the efficiency of alternative products, it is essential to ensure that the same method is being used.

The efficiency value now used in the Government's Standard Assessment Procedure and in the building regulations is known by the acronym SEDBUK, (Seasonal Efficiency of a Domestic Boiler in the UK). SEDBUK represents the best estimate presently available of overall seasonal in-use boiler efficiency for space heating and hot water in UK dwellings. It is used throughout this guide as well as in CHeSS, the Energy Saving Trust's 'Energy Efficiency Recommended' scheme, and other programmes designed to promote efficient boilers.

A boiler's SEDBUK efficiency is an indicator of the average annual boiler efficiency determined by the amount of heat delivered to the primary (boiler water) heating circuit. It is assumed that the boiler is installed in a fully-pumped system which has been correctly designed and which has adequate controls. The claimed SEDBUK efficiency level will not be achieved otherwise.

The SEDBUK calculation process (which can be found in Appendix D of the SAP ([26])) uses actual boiler test data, the measurements being taken by methods defined in European standards to meet the requirements of the European Boiler Efficiency Directive ([20]). This provides manufacturers with an incentive to make their products as efficient as possible.

As SEDBUK has been designed specifically for SAP energy rating purposes, it takes account of heat losses associated with space and water heating. It does not, however, include surface heat losses from any hot water store within or external to the boiler. These are treated separately as they may provide a small amount of useful heat to the dwelling during the heating season. This is important when comparing products, as stores with high heat losses will increase annual energy consumption but do not affect SEDBUK values.

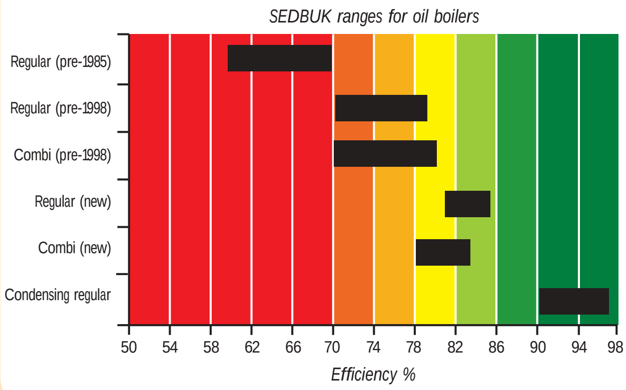
The best source of SEDBUK figures is the Boiler Efficiency Database (see Section 7.5). Where this is not available, purchasers should look for this standard form of words in manufacturers' literature:

"Seasonal efficiency (SEDBUK) = [x]%
The value is used in the UK Government's Standard Assessment Procedure (SAP) for energy rating of dwellings. The test data from which it has been calculated have been certified by [name and/or certification of Notified Body]."

Energy efficiency figures calculated by other methods may not be consistent with SEDBUK - and should be disregarded.

Figure 18 shows typical SEDBUK efficiencies for both new and older boilers. In practice there are limits both to the minimum efficiency due to the requirements of the Boiler Efficiency Directive, and to the maximum permitted value based on theoretical considerations.

Figure 18: Typical SEDBUK values for different boiler types



7.2 The Standard Assessment Procedure (SAP)

Home energy ratings are designed to give an indication of the energy efficiency of a dwelling and so allow householders to compare different homes. The SAP is the Government's chosen rating system and indicates the running costs of space and water heating. The building regulations procedures require all new dwellings to be assessed in this way.

The current version of SAP is SAP 2001. SAP 2005 is under development and will be introduced at the end of 2005. In SAP 2001, ratings are expressed on a scale of 1-120, with higher figures representing greater efficiency and lower running costs. The actual figure depends on certain characteristics of the building and its heating systems, in particular:

- building design;
- insulation levels;
- solar heat gains;
- ventilation;
- heating and hot water efficiency (SEDBUK) and controls.

7.3 Energy consumption and running costs

Table 4 gives typical annual fuel costs for some of the more common types of dwelling found in the UK - both existing properties and new buildings. Existing housing is typical of the existing housing stock ([35]). New housing has the same floor areas for comparison, but is built with insulation levels that would satisfy the latest building regulations. The flat is on the top floor (a top floor flat has an energy consumption intermediate between a ground and mid-floor flat). Hot water costs are related to a typical number of occupants for the size of property.

Figures shown assume average UK weather conditions (the Midlands). Consumption would be around 3-6 per cent lower in the south and 3-6 per cent higher in the north.

Typical energy consumption has been calculated using the Building Research Establishment (BRE) Domestic Energy Model, BREDEM-12 ([34]). This estimates annual domestic energy usage associated with house design, insulation levels, local climate and type of heating system (including efficiency and heating usage). The model is widely used for calculating domestic fuel running costs.

Fuel costs of 1.63 pence per kWh are taken from the 2001 edition of the SAP (Table 12). These costs do not include standing charges, maintenance or circulating pump running costs.

7.4 Carbon dioxide emissions

Table 5 gives typical values of annual CO_2 emissions for the same types of dwelling. Carbon intensity values are taken from SAP (2001) Table 15.

7.5 The Boiler Efficiency Database

The Boiler Efficiency Database ([25]) is an independently authenticated record of the efficiency of most gas and oil-fired domestic boilers in the UK. Most of the data in it can be viewed at the website www.boilers.org.uk. Both current and obsolete boilers are included and the database is updated regularly, with a new edition issued each month. For heating installers, a printed extract from the database is published at intervals by the Energy Saving Trust under the title *The Little Blue Book of Boilers.*

For boilers currently on sale, the database gives SEDBUK efficiency figures derived from independently certified tests and the corresponding efficiency band (see panel). Manufacturers send details of their products to the database manager, who checks that efficiency test results have been independently certified by an approved testing organisation and then calculates SEDBUK figures for the database entry. For obsolete boilers, where certified test results may not be available, a generic efficiency for the type of boiler concerned is quoted instead of SEDBUK.

As a simple guide to efficiency, SEDBUK values are divided into seven bands, from A (most efficient) to G (see panel on next page). The entries for each boiler on the database give the banding which may be used on product literature and labels, although there is no requirement to do so.

In addition to the database, the website also has two interactive programs. The first is an annual fuel cost estimator for boilers of known efficiency in different types of housing. The second is a whole-house boiler sizing calculator to help estimate a suitable boiler size for individual properties where dimensions and other relevant data are known.

Table 4: Annual fuel (oil) costs for heating and hot water in different property types

		EXISTING HOUSING					NEW HOUSING				
Type of oil boiler	SEDBUK	Flat	Bungalow	Terraced	Semi-detached	Detached	Flat	Bungalow	Terraced	Semi-detached	Detached
Regular (pre- 1985)	65%	£232	£304	£317	£359	£508	-	-	-	-	-
Regular (pre- 1998)	75%	£201	£263	£274	£311	£441	-	-	-	-	-
Combi (pre- 1998)	75%	£201	£263	£274	£311	£441	-	-	-	-	-
Regular (new)	85%	£178	£232	£242	£274	£389	£58	£73	£73	£91	£108
Combi (new)	82%	£184	£241	£251	£284	£403	£60	£75	£75	£94	£112
Condensing regular (new)	93%	£162	£212	£221	£251	£355	£53	£66	£66	£83	£99

Table 5: CO_2 emissions (tonne/yr) for oil heating and hot water in different property types

		EXISTING HOUSING					NEW HOUSING				
Type of oil boiler	SEDBUK	Flat	Bungalow	Terraced	Semi-detached	Detached	Flat	Bungalow	Terraced	Semi-detached	Detached
Regular (pre- 1985)	65%	3.85	5.03	5.24	5.94	8.42	-	-	-	-	-
Regular (pre- 1998)	75%	3.33	4.36	4.55	5.15	7.30	-	-	-	-	-
Combi (pre- 1998)	75%	3.33	4.36	4.55	5.15	7.30	-	-	-	-	-
Regular (new)	85%	2.94	3.85	4.01	4.54	6.44	1.37	1.72	1.72	2.15	2.55
Combi (new)	82%	3.05	3.99	4.16	4.70	6.68	1.42	1.79	1.79	2.22	2.64
Condensing regular (new)	93%	2.69	3.52	3.66	4.15	5.88	1.25	1.58	1.58	1.96	2.33

SEDBUK range	Band
90% and above	A
86% - 90%	B
82% - 86%	C
78% - 82%	D
74% - 78%	E
70% - 74%	F
Below 70%	G

7.6 Saving energy with better controls

It is better to replace both boiler and controls when upgrading a heating system. However, in some circumstances, it may be appropriate to leave an existing boiler in place and upgrade the controls. Table 6 shows what savings could be obtained by fitting new controls (to CHeSS standards) to older types of boiler.

Table 6: Typical energy savings achievable by upgrading the controls on existing systems

Existing system has the following controls:	Add the following for 'Best Practice' controls:	Approximate average savings[2] (% of the existing fuel consumption)
Older Boiler with gravity DHW		
	Programmable thermostat, Cylinder thermostat, Motorised valve, Boiler interlock, TRVs on most radiators	18%
Room thermostat	Cylinder thermostat, Motorised valve, Boiler interlock, TRVs on most radiators	13%
Room thermostat, Cylinder thermostat, Boiler interlock[3]	Motorised valve, Boiler interlock, TRVs on most radiators	12%
Room thermostat, Cylinder thermostat, Motorised valve, Boiler interlock	TRVs on most radiators	4%
TRVs on most radiators	Programmable thermostat, Cylinder thermostat, Motorised valve, Boiler interlock	10%
Older Boiler - Fully pumped[4]		
	Programmable thermostat, Cylinder thermostat, Motorised valve, Boiler interlock, TRVs on most radiators	17%
Room thermostat, Cylinder thermostat, Motorised valve	Boiler interlock, TRVs on most radiators	10%
Room thermostat, Cylinder thermostat, Motorised valve, Boiler interlock	TRVs on most radiators	4%
TRVs on most radiators	Programmable thermostat, Cylinder thermostat, Motorised valve, Boiler interlock	9%
Older Combi Boiler[4]		
	Programmable thermostat, Boiler interlock, TRVs on most radiators	15%
TRVs on most radiators	Programmable thermostat, Boiler interlock	7%
Room thermostat, Boiler interlock	TRVs on most radiators	4%

NOTES
1. All improved systems must include a programmable room thermostat (replaces existing room thermostat).
2. These are average savings assuming normal controls, systems and user behaviour. Actual savings may be significantly different. The savings only apply where an older-type boiler is fitted. It is assumed that the SEDBUK (see7.1) is 60% for the Gravity DHW system and 68% for the fully-pumped and combi systems.
3. This option provides only a partial interlock (hot water only)
4. All improved systems should include an automatic bypass valve if a bypass circuit is necessary (see Appendix B note 14)

Room thermostat

Programmable thermostat

Cylinder thermostat

Boiler interlock

TRVs on most radiators

Motorised valve

When choosing which Best Practice system to install the following questions should be addressed.

1. Which boiler type is most appropriate?
2. What size boiler is required?
3. Where will the boiler be positioned?
4. What will be the flue terminal position and arrangement?
5. Where does the condensate drain go?
6. What are the arrangements for the oil tank and oil supply?
7. Are there any special ventilation requirements
8. Will it be an open or sealed system?
9. What type of hot water system is most appropriate?
10. What type and size of heat emitters are required?
11. What controls are needed?

CHeSS (see Section 6) specifies the main components needed to achieve Best Practice in wet central heating systems, but there are many additional aspects of the installation to consider. The following tables outline the key points.

8.1 Which type of boiler is most appropriate? ([36,39])

Regular or combi?	Best Practice regular boilers (see CHeSS HR6) provide most flexibility in system design. A combi (see Chess HC6) incorporates some system equipment which reduces installation time. Oil-fired condensing combis are being introduced.
Condensing or non-condensing?	Use condensing types as specified in CHeSS HR6 or HC6 only. These provide significantly higher efficiency than non-condensing types, although they do require connection to a drain as well as particular care in sitting the flue terminal. Condensing boilers must be installed in England and Wales from 1 April 2007 unless an exception is allowed (see panel in Section 2.1.2).
Combi hot water performance	The maximum flow rate at the hot water tap will depend on the boiler's heat output, the design of the draw-off pipe and the capacity of the internal hot water store. Combis usually take more time to fill a bath than a conventional storage system.
Cooker boilers and back boilers	These are not recommended as they are not currently available in condensing versions. Back boilers are only available in open-flue models and usually include an integral electric fire in front.
Large boilers	For boilers with output greater than 50kW, refer to suitable publications at www.thecarbontrust.co.uk.

8.2 What size boiler is required? ([19,39])

Maximum load	The boiler needs to be sized to meet the maximum load expected on the system: this includes the heat used by the emitters, the hot water system and the pipework.
New systems	A full design heat loss method should be employed to identify the most appropriate boiler. An example can be found at www.centralheating.co.uk.
Boiler replacements	Size for size replacement is not recommended. Insulation levels may have been improved or the original sizing may have been incorrect. Heating and hot water requirements should be re-checked before a new boiler is chosen. Oversizing will result in lower efficiency and unnecessary capital costs. An interactive procedure for correctly sizing boilers up to 25kW can be found at www.boilers.org.uk.
Combis	Power rating is normally determined by hot water requirements and there is generally more than enough heat output for space heating. This should always be checked in large and/or poorly insulated dwellings.

8.3 Where will the boiler be positioned? (19,21,36,39)

General issues	
Exception: is it difficult to install a condensing boiler?	If an exception is being considered, follow the exceptions procedure (see panel in Section 2.1.2) before a boiler position is considered.
Space	It has to be adequate for the boiler type (including flue pipe space).
Access	It needs to be sufficient for installation, maintenance and servicing.
Flue position	Can a flue be fitted easily? Is an extended horizontal or vertical flue required, and will angled flue bends be necessary? See Section 8.4.
Condensate drain	Is there a suitable adjacent drain point? See Section 8.5.
Location?	
- heated area	Preferred, saves energy.
- unheated area	Requires frost protection. Consider externally mounted boiler.
- understairs	There are special requirements in this case regarding the height of the building (maximum 2 stories); fire resistance; whether it is intended to use it as a storage area as well; instruction notices; and the provision of a self-closing door.
- bathroom, shower room, sleeping room	There are regulations regarding electrical work in bath and shower rooms. Open-flue boilers must not be installed where they can draw combustion air from a bathroom or bedroom. Room-sealed boilers should not be installed in sleeping areas if avoidable.
- roofspace, loft, attic	This option should only be considered in exceptional circumstances. The local fire authority and house insurers will need to be notified. The weight of the boiler, the provision of ventilation and safe access must all be taken into account.
- fireplace	Condensing back boilers (BBU) are not currently available. Where boilers are located inside a living space, particular consideration must be given to the position of the flue, the air supply routes and the provision of suitable condensate drainage.
- garage	Frost protection will be required. Only room-sealed models are permitted in Northern Ireland.
- basements and cellars	Ensure a practical connection to a drain point is available - consider using a condensate pump.

8.4 What will be the flue terminal position and arrangement? (32,38)

Condensing boilers	
Plume	A plume is present most of the time that the boiler operates. Avoid terminal positions where a plume would be directed: • towards or across a door or window; • towards a frequently used area (eg. patio, access route or car parking space); • across a neighboring dwelling or boundary; • in close proximity to an opposite wall or surface.
Freezing	Avoid situations where: • condensate from a terminal may drip onto a path, then freeze and cause a hazard; • the plume may condense then freeze, damaging a wall or surface.
Terminal guards	Usually required where terminal is less than 2m from ground level. These need to withstand corrosive effect of condensate.
Extended flues	If the plume may cause a nuisance, consider an extended vertical/horizontal flue or alternative boiler position.

8.5 Where does the condensate drain go? ([38])

Boiler position	Ensure the chosen drain point can be reached from the proposed boiler position.
Drain points	Condensate can be drained to: • an internal stack pipe; • a waste pipe; • an external drain, gully or rainwater hopper; • a purpose-made soakaway.
Boiler condensate siphons	Check whether the chosen boiler has a fitted condensate siphon. If not, externally situated condensate pipework is more likely to freeze in cold weather.
Condensate traps	Check whether the chosen boiler has an internal condensate trap with a water seal greater than 75mm. If not, an air-break and additional trap with a seal greater than 75mm must be installed.
Pipework	All pipework must have a fall of 2.5 degrees and be securely clipped. External runs must not exceed 3m and be insulated. Corrosion resistant pipe materials (not copper or steel) must be used.
Pipe sizes	Where there is no manufacturer's guidance: • pipes in a heated area should have a nominal diameter of at least 22mm; • externally run pipes should have a nominal diameter of at least 32mm.
Condensate pumps	If gravity will not take the condensate to the drain point (for example if the boiler is situated in a basement) a condensate pump will need to be considered.

8.6 What are the arrangements for the oil tank and oil supply?

Building regulations	There are mandatory requirements for the installation of oil storage tanks and supply systems. It is essential to refer to the building regulations and to OFTEC guidance. Note that requirements differ around the UK.
Oil tanks (refer to OFTEC website www.oftec.org)	**Type -** Tanks are generally made from steel or plastic. Integrally bunded (see below) and underground units are also available. **Sizes -** This choice will depend on the rated output of the boiler and the likely frequency of fuel deliveries. **Position -** There are mandatory fire protection requirements covering the minimum distance of tanks from buildings and boundaries. At the same time, there needs to be good access for deliveries, inspection and maintenance. **Base -** This must be fireproof and larger than the tank's 'footprint'. **Bunding -** It is a mandatory requirement to carry out an assessment on whether bunding is needed to satisfy environmental protection safeguards. Written proof of this assessment must be maintained. A standard risk assessment form (TI/133) is available from OFTEC which will indicate whether secondary containment can be omitted.
Oil supply pipework (refer to OFTEC website www.oftec.org)	This can be installed above or below ground. It should be sleeved and protected against damage. The choice of gravity or suction supply will depend on the relative heights of tank and burner. The position of the tank fuel outlet (top or bottom) will affect the arrangement of the pipes. A remote sensing fire valve must be fitted in the pipeline outside the dwelling. The sensor must be located higher than the level of the burner. An oil filter should be fitted in the oil supply line.

8.7 Are there any special ventilation requirements? ([32,36])

Room sealed	Room-sealed balanced-flue appliances do not require special provision for room ventilation. Open-flue boilers need a purpose-made, correctly-sized, non-closable air vent to ensure that there is sufficient air for combustion. Special provision may be required where an extract fan is fitted.
Compartment	Some boilers may require purpose made ventilation when a boiler is fitted in a compartment.

8.8 Will it be an open or sealed system? ([19, 36])

Sealed	Commonly used in new systems, especially with combis and all system boilers. They incorporate an expansion vessel. The system pressure rises with temperature. The necessary additional safety controls are normally incorporated as part of the boiler. It is important to check that this expansion vessel has enough capacity for the whole installed system.
Open	Typical of existing installations, these systems require an expansion cistern which must be at the highest point in the system.

8.9 What type of hot water system is most appropriate?

Mains fed (combis, unvented cylinders, thermal stores, CPSUs)	Ensure that water supply to the dwelling (both pressure and flow rate) is adequate (with both hot and cold water running). The flow rate obtainable from an instantaneous combi will also depend on its maximum heat output.
Storage systems	Cylinders meeting current Best Practice standards use high recovery coils and are well insulated. It is no longer permitted to install 'medium-duty' cylinders, which have inferior performance. Ensure existing hot water cylinders are well insulated. Cylinders of 117-140 litre capacity are usually adequate for smaller households with a single bathroom ([19]).
Unvented storage	These are mains fed and usually give a high hot water flow rate at high pressure ([29]).
Thermal storage	These are also mains fed and will provide a high hot water flow rate at high pressure ([30]).
Vented storage	This type needs a cold water cistern and will usually provide a high hot water flow rate at low pressure ([27,28]).
Solar systems	In suitable properties (especially those with an unobstructed south-facing roof), solar water heating systems can make a significant contribution to the hot water energy requirements, and save boiler fuel. A hot water cylinder with an additional coil for connection to the solar collector system is necessary. If solar water heating is likely to be installed in the near future, it is advisable to choose a suitable cylinder at the time the main heating system is installed, as it will save cost and disruption later. Separate guidance and advice on solar water heating should be sought ([50]).

8.10 What type and size of heat emitters are required? ([19, 36])

Heat emitter type	Panel radiators offer the lowest cost option. Use Low Surface Temperature (LST) radiators where young children or elderly are likely to be present and may be at risk.
Size	Avoid undersizing as it will result in unsatisfactory heating performance and may give rise to reduced boiler efficiency from excessive boiler cycling. Use a full design heat loss calculation method. An example can be found at www.centralheating.co.uk.
When used with condensing boilers	Increasing radiator sizes can reduce average boiler operating temperatures and therefore increase efficiency. However, care should be exercised when oversized radiators are installed in a room with a controlling room thermostat. If radiators in other rooms are not similarly oversized, the controllability of the whole system may be affected.

8.11 What controls are needed? (18,19)

Best Practice	Use Best Practice controls wherever possible. • Regular boilers use a programmable room thermostat with separate timing capability for hot water. All systems should be fully pumped, have both room and cylinder thermostats, use motorised valves or multiple pumps, and have separate zones for heating and hot water. They should also have TRVs, an automatic bypass valve and a boiler interlock. • Combi boilers use a programmable room thermostat, TRVs and boiler interlock. Install an automatic bypass valve if the manufacturer advises that a bypass should be fitted.
Basic	The basic CHeSS specification is the minimum acceptable standard. The system should include a full programmer (a time switch for combis). All other controls as for Best Practice.
Thermostatic Radiator Valves (TRVs)	TRVs must be installed on all radiators except in rooms with a room thermostat. An automatic bypass valve must be installed if the manufacturer's instructions require one or if a minimum flow rate has to be maintained while the boiler is firing.
Pumps	Advice on pump selection is available from www.bpma.org.uk. See Section 4.6 for pumps with automatic speed control.
Systems with gravity hot water	These must be converted to fully pumped to comply with Best Practice requirements.
Very large dwellings	These should be divided into separate zones not exceeding 150m^2 in floor area. Each zone should be capable of independent time and temperature control.
Frost protection	This should always be considered for both the dwelling and the central heating system.
Other controls	Additional controls can also be beneficial (see Section 5.3).

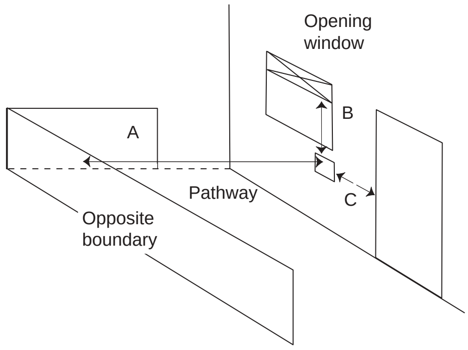
9.1 'Competent person' requirements

In England and Wales, installation details of oil-fired heating systems, oil-fired combustion appliances, oil storage tanks and the pipes connecting them, must be made available to OFTEC. OFTEC will then send a copy of the certificates to the householder and to the local authority Building Control Department. An individual registered under the Oil Firing Registration Scheme run by OFTEC is deemed competent to install oil-fired equipment and can undertake this work. Alternatively installers or their customers can use the local authority Building Control route for notification, for which a charge is made.

Other parts of the United Kingdom are considering the adoption of similar arrangements.

All installations of unvented hot water systems must be carried out by a 'competent person' who is approved by an appropriate body.

Figure 19: Statutory minimum distances for terminal siting



A – minimum distance 600mm – may be a nuisance if it 'wets' opposite boundary, crosses main pathway or condensate can drip on pathway.
B – minimum distance 600mm – may be a nuisance as plume could obscure window.
C – minimum distance 600mm – may be a nuisance if plume crosses door.

9.2 Installing the boiler

While condensing boilers can normally be installed in a similar location to non-condensing units, additional factors need to be considered:

- the plume from the flue terminal should not cause a nuisance;
- there must be a convenient drain point for the condensate.

Where a boiler, particularly a replacement unit, is being installed inside a dwelling it may not be appropriate to site it in the same location. Even where it is, extended flue options may have to be considered as well as the practicalities of finding (and connecting to) a suitable drain point. Where there are particular difficulties with installing a condensing boiler, a boiler exception can be considered (see panel in Section 2.1.2). Even if an exception is allowed, a condensing boiler should always be considered due to increased efficiency and lower running costs.

Flue terminal position

Condensing boilers will produce a visible plume of water vapour for a significant proportion of their operating time. To avoid this causing a nuisance, a vertical flue can remove the plume to a high level.

At low level, the plume may be a nuisance. Minimum statutory distances from terminals to obstacles (such as opposite walls) are shown in Figure 19, although in some cases these may still not be sufficient. Some boilers eject flue gases horizontally in a powerful jet which may not disperse for a considerable distance. Refer to building regulations ([22,23,24]) which show all minimum statutory distances from flue terminals.

Refer to the condensing boiler exceptions procedure before the boiler/flue terminal position is decided. In any event particular care is required where it is intended to fit a flue terminal which will be positioned less than 2.5m from a facing wall, boundary fence or neighbouring property. Where the plume from a terminal may cause a nuisance, consider an extended vertical or horizontal flue or moving the boiler to an alternative position which may provide a more acceptable terminal position.

The plume should not cross:

- a frequently used access route;
- any frequently used area (such as a patio or car parking space);
- a neighbouring dwelling.

Nor should it be directed towards a window or door, or be sited close to a facing wall or other surface.

There are also other aspects to consider when planning the flue terminal position.

- A free passage of air is needed at all times to aid plume dispersal - which may be difficult in sheltered locations.
- In cold weather, the condensate could cause a safety hazard if it freezes on pathways, or if it results in frost damage to surfaces.
- The plume could trigger infra-red security lighting if sited in the wrong place.
- Ensure terminals do not obscure security camera field of vision.
- The terminal guards must be able to resist corrosive properties of the condensate.

Condensate drain point

The amount of condensate produced by a condensing boiler depends upon a number of factors but four litres a day is not unusual. The liquid is slightly acidic (about the same as tomato juice, a pH value of between three and six) and must be disposed of correctly. Suitable drain points include:

- an internal stack pipe;
- a waste pipe;
- an external drain or gully;
- a rainwater hopper that is part of a combined system (ie sewer carries both rainwater and foul water);
- a purpose-made soakaway.

Internal drain points are to be preferred as they are less likely to become blocked by leaves, or by frozen condensate ([38]).

Installing the condensate drain pipe

Condensate traps - Building regulations require a trap to be installed in the condensate pipe from the boiler:

- if this goes straight to a gully or rainwater hopper, a water seal of at least 38mm is required;
- if connected to another waste pipe, the water seal must be at least 75mm to prevent foul smells entering the dwelling.

Internal traps already fitted within the boiler may not always satisfy the building regulations. Unless otherwise stated by the manufacturer's instructions, an additional trap of either 38mm or 75mm (depending on the proposed connection) will be required. An air break between the traps is also necessary (see Figure 20).

Pipe runs - These should be as short as possible. If a condensate drainpipe runs outside the dwelling, this external run should be restricted to a maximum of 3m in order to reduce the risk of freezing. If the boiler is installed in an unheated space such as a garage, all the condensate drainpipes should be regarded as 'external'.

Pipe slope - A minimum of 2.5 degrees away from the boiler.

Bends - These should be kept to a minimum. Similarly, the number of fittings or joints outside the dwelling needs to be minimised in order to reduce the risk of condensate being trapped.

Fixings - These must be sufficient to prevent sagging. A maximum spacing of 0.5m for horizontal and 1.0m for vertical sections is recommended.

Pipe sizes - Follow the boiler manufacturer's instructions. In the absence of such guidance:

- the minimum nominal diameter for internal pipe runs is 22mm;
- a larger diameter (at least 32mm nominal diameter) is required for externally run pipes to reduce the risk of freezing.

Pipe materials - These should be resistant to the acid condensate. The plastics used for standard wastewater plumbing systems and cistern overflow pipes are suitable. Copper or mild steel pipes and fittings must not be used.

Condensate siphons - Many boilers have a siphon fitted as part of the condensate trap arrangement. This intermittently discharges the condensate, reducing the risk of freezing where part of the pipework runs externally. If the boiler does not include a siphon, avoid external pipework as far as possible. Where necessary it should have a minimum nominal diameter of 32mm.

Condensate pumps - These may be considered where the boiler is in the basement or a drain point cannot be reached by gravity. Pump manufacturers' instructions must always be followed.

Condensate drain termination

Connecting to an internal stack - This is the preferred method of connection. The stack must be made of a material resistant to the corrosive effect of the condensate, such as the plastics recommended for condensate pipes.

A trap with a minimum condensate seal of 75mm is required. The boiler may incorporate a trap of this size, if not one will have to be fitted to the condensate drainpipe. A visible air break is required between this and any other trap.

For single dwellings up to three stories high, the condensate drainpipe should discharge into the stack at least 450mm above the invert of the tail of the bend at the foot of the stack. If this point is not visible, then the height should be measured from the bottom of the lowest straight section of stack to be seen. This height should be increased for buildings of more storeys.

The stack connection should not cause cross flow into any other branch pipe, nor should it allow flow from that branch into the condensate pipe. This can be ensured by maintaining an offset between branch pipes of at least 110mm on a 100mm diameter stack, or 250mm on a 150mm stack.

Figure 20: Condensate trap options

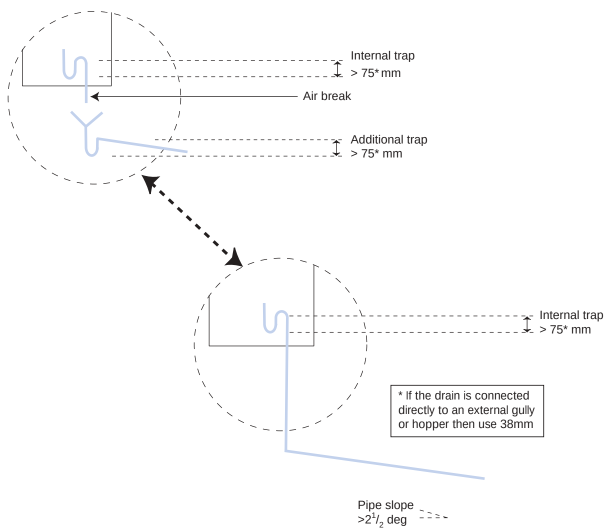
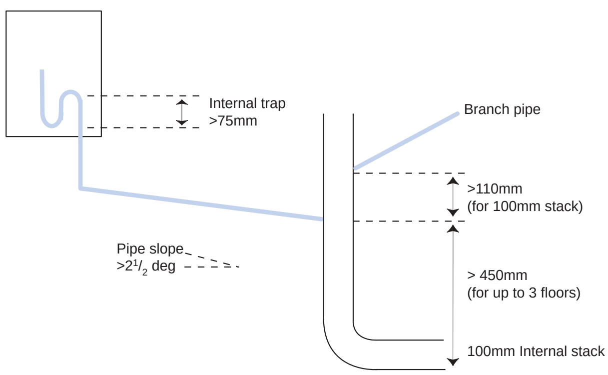


Figure 21: Condensate connection to an internal stack



Connecting to an external stack - In addition to the requirements detailed above, care must be paid to reducing any risk of the drain blocking due to the condensate freezing. The length of pipe external to the dwelling should be kept as short as possible and certainly less than 3m. Traps in the drainpipe must be inside the building. In exposed locations, the pipe should be protected with waterproof insulation.

Connecting to an internal waste pipe - The most convenient (and most frequently used) method of connection is via an internal discharge branch to a kitchen sink, washing machine or dishwasher drain. It can be connected up- or down-stream of the relevant waste trap and if practical should be mounted onto the top of the pipe. If connected upstream of the waste trap an air break is necessary between this trap and the boiler's own trap. This is usually provided by the sink waste pipe itself, as long as the sink has an integral overflow (see Figure 22).

If, on the other hand, the condensate drain is connected downstream of the sink (or other appliance) waste trap, and the boiler does not have an integral trap with a seal of at least 75mm, an additional trap with that seal must be fitted. An air break must be included between the traps (see Figure 23). In either case the trap and airbreak should be above the level of the sink to prevent flows into the boiler or airbreak.

It is preferable to connect to a washing machine drain rather than a kitchen sink. This reduces the likelihood of solid waste and fats blocking or restricting the condensate drain entry point.

Connecting to an external drain point - If the condensate cannot be drained via an internal route, then direct connection to an external gully or rainwater hopper can be considered. A rainwater hopper must be connected to a combined system (i.e. sewer carries both rainwater and foul water). The open end of the pipe should be below the grid level but above the water level in the gully or hopper. Condensate must not be disposed of in 'grey water' systems.

Connecting to a soakaway - If none of the previous solutions are possible then a purpose made soakaway can be used. The soakaway should be located as close as possible to the boiler but clear of the building foundations and not in the vicinity of other services such as gas, electricity or water connections. The position and presence of a soakaway must be taken into account when carrying out a risk assessment for installation of an oil storage tank. The external pipework must be kept to a minimum and not more than 3m in length. The pipe may be taken below or above the ground level.

Figure 24 shows a suitable soakaway design (see also Part H3 of Approved Document H of the Building Regulations). The size of the soakaway will depend to a large extent on the soil conditions. Unlike the case of a rainwater soakaway, the soil does not have to accommodate large water volumes over short periods. A soakaway approximately 200mm in diameter and 400mm deep (with limestone chippings) will normally be sufficient.

Figure 22: Connection to an internal sink waste (upstream of sink trap)

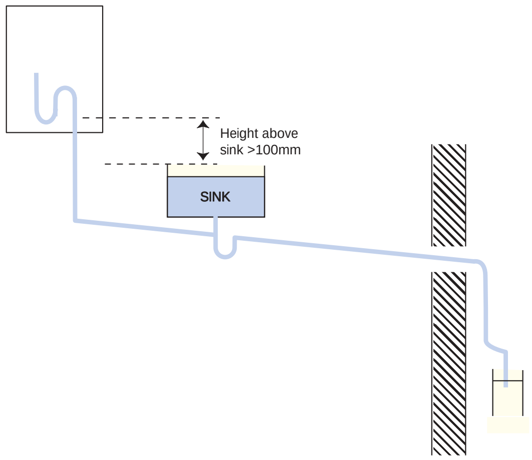


Figure 23: Connection to an internal sink waste (downstream of sink trap)

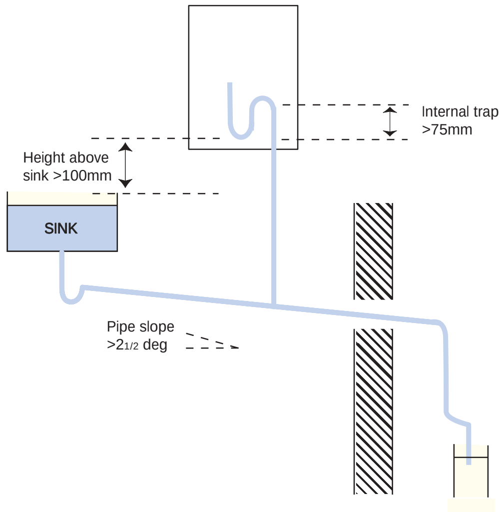
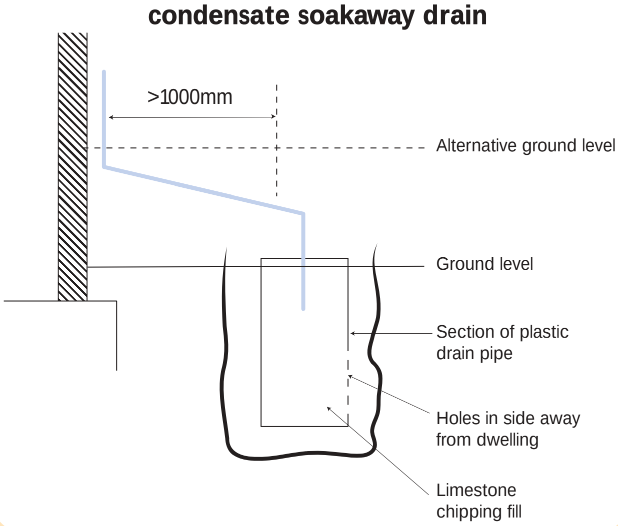


Figure 24: Possible configuration for a condensate soakaway drain



9.3 Controls

There are a number of points to be considered when installing commonly-used central heating controls.

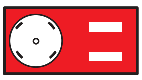
Programmable Room Thermostat

CHeSS Best Practice specification

If fitted with a regular boiler, this must have a hot water timing capability. In larger dwellings, where separate time/temperature zones are required, only one programmable room thermostat needs this hot water timing capability. A programmable room thermostat should be located in a regularly heated area. While free movement of air is important, it should be mounted away from draughts, internal heat sources and direct sunlight. It should not be fitted in a room where supplementary room heating (such as electric heaters or open fires) can affect it. So do not site one in a kitchen or combined kitchen and living room. Only install one in a main living room if it is certain that no supplementary heating is used there. Appropriate positions would be in the hall or a living room without supplementary heating.

The unit should be readily accessible to the householder, not hidden away in a cupboard or behind furniture. It should be located at a height of about 1.5m above floor level unless the occupants include wheelchair users. In this instance a suitable height in excess of 1m should be agreed with the homeowner.

Time switch/programmer

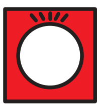


CHeSS basic systems only

Time switches can only switch one circuit (such as combi heating), while programmers can control two (eg. heating and hot water). Ensure that the unit is appropriate.

These controls should be installed where they can be easily reached, read and altered. Do not fit them in places inconvenient for the householder (eg. in an airing cupboard).

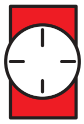
Room thermostat



CHeSS basic systems only

Installation considerations are the same as for the programmable room thermostat.

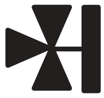
Cylinder thermostat



CHeSS Best Practice specification

This control is usually strapped onto the cylinder about one third of the way up from the base. The strap needs to be tight to ensure good thermal contact and be adjusted to about 60°C. If set too high, it may result in scalding, but if too low it can increase the risk of legionella bacteria which could result in serious health problems ([36,37]).

Motorised valve



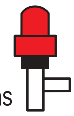
CHeSS Best Practice specification

The most common types of motorised valves are two- and three-port. How each will be used depends on pipework layout and preference - as displayed in the following examples.

- Three-port valves can provide separate heating and hot water circuits; most three-port units feature a mid-position which allows shared flow.
- Where there is more than one heating zone, as well as a hot water zone, use a separate two-port valve for each zone.
- Valves of 22mm can be used on boilers up to around 20kW. Beyond that, 28mm or larger should be used.

Note: motorised valves must not be positioned in the line of the open safety vent pipe or the feed-and-expansion pipe.

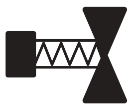
Thermostatic Radiator Valve (TRV)



CHeSS Basic and Best Practice specifications

TRVs must be used in systems meeting either specification. They should be installed in all rooms except those in which a controlling room thermostat provides a boiler interlock. Many TRVs can be fitted on the flow or return to the radiator and many are bi-directional. If not, the direction of the water flow must be taken into account when installing them.

Automatic bypass valve



CHeSS Basic and Best Practice specifications

These should be used for systems meeting either specification unless the boiler manufacturer does not require a bypass circuit be fitted to ensure a minimum flow rate. The valve should be installed between the boiler primary flow and return, taking account of the direction of flow. Ensure that the valve has adequate flow capacity. It should be set so as ensure adequate flow through the boiler when all motorised valves and/or TRVs close.

Frost protection (air and pipe thermostat)

Where both air and pipe thermostats are used, the contacts should be wired in series from a live supply* that is not switched by a timeswitch/programmer or thermostats. This ensures that protection is available 24 hours a day. Some boilers already include their own frost protection, but the level of protection for the whole dwelling needs to be considered.

* for units that require thermostats with voltage-free contacts, refer to the manufacturer's instructions.

Weather compensator or unit with external sensor

The external sensor should be positioned on a north-facing wall, away from direct sunlight and other heat sources.

9.4 Oil storage and supply

The installation of oil storage tanks and supply pipework is subject to building regulations in the different parts of Great Britain ([42,49]). The relevant building regulations in Northern Ireland are currently under review. Environmental legislation that affects this is in force in England and Wales ([43]), being drafted in Scotland ([48]), and being reviewed in Northern Ireland. Detailed guidance is set out in BS 5410 Part 1 1997([32]) and more details are available from OFTEC.

The key considerations are as follows.

- Size of tank - The amount of oil to store will depend both on boiler size and the expected frequency of fuel deliveries. OFTEC recommendations ([40]) are given in the table below.
- Tank position - Domestic oil storage tanks of up to 3500 litres should be mounted on a fireproof base at least 300mm larger than the tank in all directions. The tank must be a minimum of 1.8m from a building and 760mm from a boundary. If these conditions cannot be achieved, additional fire protection will be needed ([32]). Larger tanks face more stringent requirements ([32,44]).
- Accessibility - The tank must be located so that there is good access for deliveries, inspection and maintenance. Where possible, it should be visible from the delivery tanker and be less than 30m from the tanker stand.
- Bunding - A bund is a secondary containment system. It should be capable of holding 110 per cent of the maximum tank contents in the event of leakage, overfilling or spill. Oil tanks of up to 2,500 litres serving a single family private dwelling may not need bunding - a risk assessment must be carried out to confirm this. Risk assessment forms are available from OFTEC ([41]).
- Supply pipework - This can be installed above or below ground. It should be sleeved and protected against damage ([45]). The choice of gravity or suction supply will depend on the relative heights of tank and burner ([40,46]) Also see manufacturer's instructions for further guidance. The position of the tank fuel outlet (top or the bottom) will affect the arrangement of the pipes.
- Fire valve - This should be remote sensing and fitted outside the dwelling in the oil supply pipework. Note that the remote sensor must be fitted above the level of the appliance's burner.
- Oil filter - This should be installed in the oil supply line.
- Tank gauge - This should be fitted on the tank (manual gauges) or remotely positioned (electronic) in a convenient to read location.

9.5 Water treatment

Three types of water treatment should be considered:

- cleaning and flushing of the system before use;
- corrosion inhibition;
- softening the water supply in the case of combi boilers to prevent excessive scaling of the heat exchanger (particularly important in hard water areas).

Damage may be caused by inappropriate treatment so the boiler manufacturer's instructions should always be followed. Cleaning is essential for both new and replacement systems and (if recommended by the boiler manufacturer) a suitable chemical cleaning agent can be used. When a boiler is replaced, it is essential to drain and flush all the old water from the system in case it contains a corrosion inhibitor unsuitable for the new boiler. More advice is available on water treatment, the need for it, methods and dealing with problems ([36,37]).

10.1 Commissioning

For safe and energy-efficient operation, all parts of a new central heating and hot water system need to be checked to ensure they are working properly. In particular:

- the boiler and system should be cleaned using a recognised flushing procedure;
- the burner should be adjusted for optimum combustion and thereby maximum efficiency;
- the key system components such as gauges, valves, fire valves, burner and system controls must be checked for correct and safe operation;
- controls should be set to their optimum settings;
- the customer should be instructed on how to operate the controls, and the importance of regularly servicing the system needs to be made clear.

In England and Wales, OFTEC Registered Technicians who carry out this work must send details of to OFTEC who will send certificates to the householder and the local authority Building Control. Alternatively installers or their customers can use the local authority Building Control route for notification. Other parts of the UK are considering similar arrangements.

10.2 Advising householders

Installers must instruct the householder how to set and use the controls properly and effectively. In particular, the operation of programmers can be difficult to understand and homeowners will gain little or no benefit from an incorrectly set device. In fact, they will probably end up wasting energy.

As a bare minimum, the manufacturer's instructions should be left with the householder. However, it will usually be necessary to demonstrate:

- how to set the programmer clock and adjust for GMT and BST;
- the use of the time control override function;
- how to set summer hot water only;
- how to separate space heating and domestic hot water time settings (regular boilers only);
- how to set room and cylinder thermostats;
- how to set TRVs.

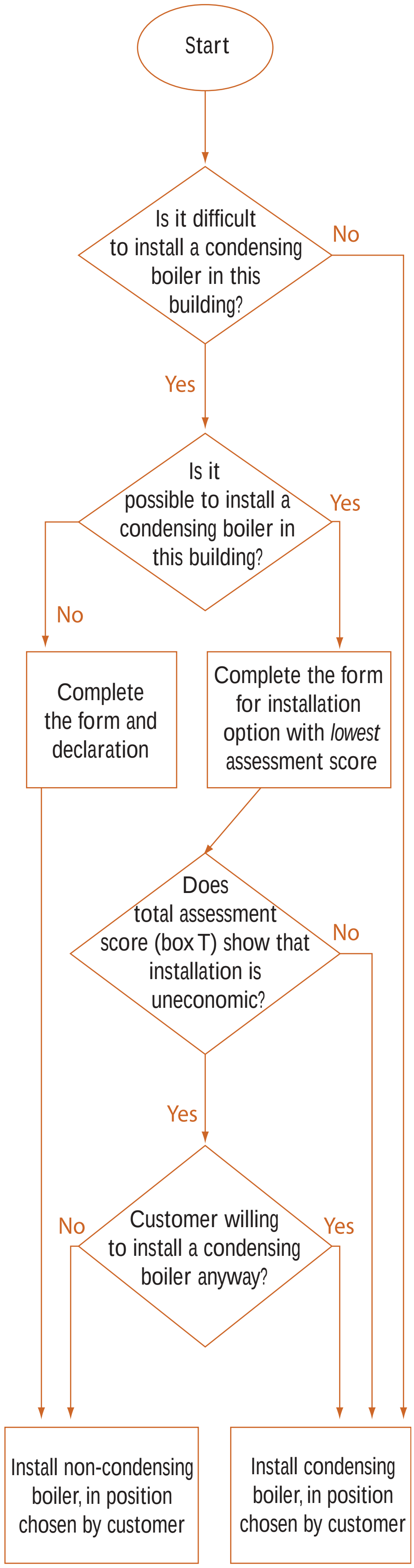
The installer will also need to explain:

- the function of room thermostats and TRVs (for example, that they should be left alone once set, rather than used as on/off switches);
- that the cylinder thermostat needs to be left at approximately 60°C, since setting it higher may result in scalding while setting it lower can allow the growth of legionella bacteria;
- that the radiator lockshield and automatic bypass valve should not be adjusted once set by the installer;
- why it is best to switch space and water heating off when not required;
- why it is best to turn the room thermostat down to frost protection levels (approximately 12°C) unless a separate frost protection system has been fitted;
- that sealed boiler systems must have adequate system pressure and what to do if re-pressurising is needed;
- operational and safety aspects of the oil storage and supply system, including how to use the tank contents gauge, and the necessary arrangements for re-filling.

10.3 Servicing

Users should be made aware of the importance of regular servicing - both of the boiler and the system as a whole (including the oil supply system). This will help maintain its safety and efficiency. In particular, users should consider taking out a regular service contract where a competent service engineer (registered with OFTEC) will clean and maintain the boiler as well as checking the operation of the system and controls.

Figure 25: Exception procedure flowchart



Appendix B - Notes to CHeSS 2005

CHeSS is published in full as ref([18]) and reproduced here in Section 6

1. **Other components:** The specifications list only the principal components of a heating system affecting energy efficiency. Other components will be required, such as radiators, circulator pumps (see Note 4), cisterns (feed and expansion tanks), and motorised valves. All components must be selected and sized correctly.

2. **Design and installation:** Heating systems should be designed and installed in accordance with relevant safety regulations, manufacturers' instructions, the Benchmark scheme (see Ref[10]), building regulations (see Refs[1], [2], [11]), and British Standards (see Refs[12], [13]). More detailed advice on domestic wet central heating systems is given in the government's Energy Efficiency Best Practice Programme in Housing good practice guides (see Refs[3], [4]), and Ref[5]. In England and Wales commissioning and handover of information on operation and maintenance is a requirement of Building Regulations Part L1 (see Ref[1]) and a suitable commissioning certificate is published as part of Benchmark (see Ref[10]).

3. **Water treatment:** Three types of water treatment should be considered - (a) cleaning and flushing of the system before use; (b) corrosion inhibition, and (c) softening of the water supply to combi boilers for hot water service in hard water areas. In each case the recommendation of the boiler manufacturer must be followed as damage may be caused by unsuitable treatment. For both new and replacement systems, cleaning is essential and, if recommended in the boiler manufacturer's instructions, a suitable chemical cleaning agent can be used. When a boiler is replaced it is essential to drain and flush all old water from the system lest it contains a corrosion inhibitor unsuitable for the new boiler. Advice on the need for treatment is given in clauses 26 and 38 of BS 5449 (see Ref[12]), and on causes of problems and methods of treatment in BS 7593 (see Ref[14]).

4. **Circulator pump:** Advice on pump dimensioning is available from the BPMA (British Pump Manufacturers' Association) website at www.bpma.org.uk Pumps installed separately from the boiler (not supplied as part of the boiler unit) which have automatic speed control should not be used in heating systems with TRVs unless the design of the pump and system ensures that the minimum flow rate through the boiler (as specified by the boiler manufacturer) is certain to be maintained under all conditions.

5. **Boiler size and type:** The whole house boiler sizing method for houses and flats gives guidance on boiler size and is available on the website www.boilers.org.uk.

   A **regular boiler** does not have the capability to provide domestic hot water directly, though it may do so indirectly via a separate hot water store.
   A **combination (combi) boiler** does have the capability to provide domestic hot water directly, and some models contain an internal hot water store.
   A **combined primary storage unit (CPSU)** is a boiler with a burner that heats a thermal store directly.

   Each of these may be either a condensing or non-condensing boiler, and condensing boilers are always more efficient. Gas and LPG boilers in the CHeSS specifications HR5 and HC5, and all boilers in HR6 and HC6, are condensing boilers. From April 2005, Building Regulations Part L1 in England & Wales require all new gas boilers to be condensing, whether installed in new or existing housing, unless there are exceptional circumstances that would make the installation impractical or excessively costly. Condensing boilers are fitted with a drain to dispose of the liquid condensate.
   For further definitions of boiler types see Appendix D of Ref[6].

6. **Boiler efficiency:** SEDBUK (Seasonal Efficiency of Domestic Boilers in the UK) is the preferred measure of the seasonal efficiency of a boiler installed in typical domestic conditions in the UK, and is used in SAP assessments and the building regulations. The SEDBUK efficiency of most current and obsolete boilers can be found on the website www.boilers.org.uk. Although SEDBUK is expressed as a percentage, an A to G scale of percentage bands has also been defined (see Section 7 of the guide).
   For gas boilers, the distinction between bands A and B is small, and standard tests do not measure the difference reliably. Consequently, it is not cost effective to purchase band A rather than band B unless the additional cost is low

7. **Hot water cylinder (basic):** Vented cylinders shall comply with BS 1566:2002 (see Ref[7]). Unvented cylinders shall either comply with BS 7206 (see Ref[8]) or be approved by the BBA or other equivalent body. All cylinders must be factory insulated such that the standing heat loss will not exceed 1.6 x (0.2 + 0.051 $V^{2/3}$) kWh per 24 hours, where V is the capacity in litres. This is equivalent to about 0.8 watt per litre for the popular 117 litre cylinder.

8. Hot water cylinder (high performance): A high performance cylinder may be either vented or unvented. The manufacturer must confirm that the heat exchanger and insulation properties exceed the requirements of the relevant British Standards (see Refs[7], [8]) as follows:
   (i) The standing heat loss must not exceed 1.28 x (0.2 + 0.051 $V^{2/3}$) kWh per 24 hours, where V is the capacity in litres. This is equivalent to about 0.64 watts per litre for the popular 117 litre cylinder.
   (ii) For vented cylinders the re-heat time for a capacity of 117 litres and above as measured in BS 1566: 2002 shall not exceed 20 minutes. Cylinders below 117 litres shall have a proportionately lower re-heat time (eg. not more than 10 minutes for a 58.5 litre cylinder).
   (iii) The re-heat performance of unvented cylinders should be tested and certified using the procedure in BS 7206 (see Ref[8]) by the BBA or other third party. With a 15 litres/minute primary flow rate, the re-heat time for cylinders of 120 litres and above shall not exceed 20 minutes. Cylinders below 120 litres shall have a proportionately lower re-heat time (eg. not more than 10 minutes for a 60 litre cylinder).
   (iv) For unvented cylinders tested with a 20 litres/minute primary flow rate (as per the Water Research Centre Procedure), the re-heat time for cylinders of 120 litres and above shall not exceed 17.5 minutes. Cylinders below 120 litres shall have a proportionately lower re-heat time (eg. not more than 8.75 minutes for a 60 litre cylinder).

Solar-compatible cylinders contain an additional heat exchanger for connection to a solar water heating system. They offer the opportunity to install a solar water heating system at greatly reduced cost and with less disruption in the future.

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9 **Thermal store (high performance):** A high-performance thermal (primary) storage system must have insulation properties exceeding by at least 15 per cent those given in the WMA Performance Specification for Thermal Stores (see Ref[9]), and comply with the Specification in other respects.

10. **Circuits and zones:** Systems with regular boilers must have separately controlled circuits to the hot water cylinder and radiators, and both circuits must have pumped circulation. Large properties must be divided into zones not exceeding 150 m^2 floor area, so that the operation of the heating in each zone can be timed and temperature controlled independently.

11. Definitions of **heating controls** are given in Ref[4]. The most common are repeated below.
A **time switch** is an electrical switch operated by a clock to control either space heating or hot water, or both together but not independently.
A **full programmer** allows the time settings for space heating and hot water to be fully independent.
A **room thermostat** measures the air temperature within the building and switches the space heating on and off. A single target temperature may be set by the user.
A **programmable room thermostat** is a combined time switch and room thermostat which allows the user to set different periods with different target temperatures for space heating, usually in a weekly cycle. Some models also allow time control of hot water, so can replace a full programmer.
A **cylinder thermostat** measures the temperature of the hot water cylinder and switches the water heating on and off.
A **TRV (thermostatic radiator valve)** has an air temperature sensor which is used to control the heat output from the radiator by adjusting water flow.

12. **Wireless controls** should be designed with a satisfactory level of immunity to blocking by other radio transmissions. Otherwise they may become unreliable, or cease to work, as nearby radio frequency bands become increasingly heavily used for mobile phone and other communication services.
Compliance with the essential requirements of the European Radio and Telecommunications Terminal Equipment (RTTE) Directive 1999/5/EC is insufficient, as the directive is designed only to ensure that wireless products do not cause harmful interference to other transmissions. It does not give any assurance that the product has a satisfactory level of immunity to interference from other radio transmissions.
Consequently it is not sufficient for the manufacturer to confirm compliance with the RTTE Directive. The manufacturer should also confirm that the switching range (and preferably alignment range) do not include any frequencies below 430 MHz, and that in regard to ETSI EN 300 220-1 v1.3.1 (see Ref[15]) the receiver classification (clause 4.1.1) is either Class 1 or Class 2, and the device is marked in accordance with clause 4.3.4..

13. **Boiler interlock** is not a physical device but an arrangement of the system controls (room thermostats, programmable room thermostats, cylinder thermostats, programmers and time switches) 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 interconnection of the room thermostat, cylinder thermostat, and motorised valve(s). It may also be achieved by more advanced controls, such as a boiler energy manager. TRVs alone are not sufficient for boiler interlock.

14. An **automatic bypass valve** controls water flow in accordance with the water pressure across it, and is used to maintain a minimum flow rate through the boiler and to limit circulation pressure when alternative water paths are closed. A bypass circuit must be installed if the boiler manufacturer requires one, or specifies that a minimum flow rate has to be maintained while the boiler is firing. The installed bypass circuit must then include an automatic bypass valve (not a fixed-position valve). Care must be taken to set up the automatic bypass valve correctly, so as to achieve the minimum flow rate required (but not more) when alternative water paths are closed.

Appendix C - Definitions of boiler types

As given in SAP Appendix D ([26])

B1.1 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.

B1.2 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 B1. 3 to B1. 14 inclusive. Boilers not so designed, or without the means to remove the condensate in liquid form, are called 'non-condensing'.

B1.3 Regular boiler
A boiler which does not have the capability to provide domestic hot water directly (i.e. not a combination boiler). It may nevertheless provide domestic hot water indirectly via a separate hot water storage cylinder.

B1.4 On/off regular boiler
A regular boiler without the capability to vary the fuel burning rate whilst maintaining continuous burner firing. This includes those with alternative burning rates set once only at time of installation, referred to as range rating.

B1.5 Modulating regular boiler
A regular boiler with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

B1.6 Combination boiler
A boiler with the capability to provide domestic hot water directly, in some cases containing an internal hot water store.

B1.7 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.

B1.8 On/off instantaneous combination boiler
An instantaneous 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.

B1.9 Modulating instantaneous combination boiler
An instantaneous combination boiler with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

B1.10 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 (B1. 13 or B1. 14).

B1.11 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.

B1.12 Modulating storage combination boiler
A storage combination boiler with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

B1.13 On/off combined primary storage unit (CPSU)
A single appliance designed to provide both space heating and the production of domestic hot water, in which there is a burner that heats a thermal store which contains mainly primary water which is in common with the space heating circuit. The store must have a capacity of at least 70 litres and the feed to the space heating circuit must be taken directly from the store. The appliance does not have the capability to vary the fuel burning rate whilst maintaining continuous burner firing. This includes those with alternative burning rates set once only at time of installation, referred to as range rating.

B1.14 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.

B1.15 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 (i.e.; the part load test was carried out at average boiler temperature of 40°C).

B1.16 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.

Appendix D - Definitions of heating controls

The list of definitions has been discussed and agreed with industry representatives, and, for completeness, includes some controls for heating systems other than oil central heating.

Automatic bypass valve
A valve to control water flow, operated by the water pressure across it. It is commonly used to maintain a minimum flow rate through a boiler and to limit circulation pressure when alternative water paths are closed (particularly in systems with TRVs).

Boiler anti-cycling device
A device to introduce a time delay between boiler firing. Any energy saving is due to a reduction in performance of the heating system. The device does not provide boiler interlock.

Boiler auto ignition
An electrically controlled device to ignite the boiler at the start of each firing, avoiding use of a permanent pilot flame.

Boiler energy manager
No agreed definition, but 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, anticycling control and hot water override.

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.

Boiler modulator (air temperature)
A device, or feature within a device, to vary the fuel burning rate of a boiler according to measured room temperature. The boiler under control must have modulating capability and a suitable interface for connection.

Boiler modulator (water temperature)
A device, or feature within a device, to vary the fuel burning rate of a boiler according to measured water temperature. It is often fitted within the boiler casing. The boiler under control must have modulating capability.

Boiler thermostat
A thermostat within the boiler casing to limit the temperature of water passing through the boiler by switching off the boiler. The target temperature may either be fixed or set by the user.

'CELECT-type' electric heating control
Integrated central control system for electric storage and panel heaters that provides programmed space temperatures at different times of the day for a number of separate heating zones in the dwelling. It minimises the charge period of the storage heaters according to the external temperature.

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.

Delayed start
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.

Frost thermostat
A device to detect low air temperature and switch on heating to avoid frost damage, arranged to override other controls.

Load compensator
A device, or feature within a device, which adjusts the temperature of the water circulating through the heating system according to the temperature measured inside the building.

Motorised valve
A valve to control water flow, operated electrically. A two-port motorised valve controls water flow to a single destination. A three-port motorised valve controls water flow to two destinations (usually for space heating and hot water), and may be either a diverter valve (only one outlet open at a time) or a mid-position valve (either one, or both, outlets open at a time). The valve movement may also open or close switches, which are used to control the boiler and pump.

Night setback
A feature of a room thermostat that allows a lower temperature to be maintained outside the period during which the normal room temperature is required.

On/off-peak hot water controller
A control to switch the electrical supply to the main immersion heater from the off-peak electricity supply. It may also include a boost function so that some of the stored water can also be heated using on-peak electricity.

Optimum start
A device, or feature within a device, to adjust the starting time for space heating according to the temperature measured inside or outside the building, aiming to heat the building to the required temperature by a chosen time.

Optimum stop
A device, or feature within a device, to adjust the stop time for space heating according to the temperature measured inside (and possibly outside) the building, aiming to prevent the required temperature of the building being maintained beyond a chosen time.

Pipe thermostat
A switch governed by a sensor measuring pipe temperature, normally used in conjunction with other controls such as a frost thermostat.

Programmable cylinder thermostat
A combined time switch and cylinder thermostat that allows the user to set different periods with different target temperatures for stored hot water, usually in a daily or weekly cycle.

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.

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.

Pump modulator
A device to reduce pump power when not needed, determined by hydraulic or temperature conditions or firing status of the boiler.

Pump over-run
A timing device to run the heating system pump for a short period after the boiler stops firing to discharge very hot water from the boiler heat exchanger.

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.

Self-adaptive (or self-learning) control
A characteristic of a device (of various types) that learns from experience by monitoring, and modifies its subsequent behaviour accordingly.

Temperature and time zone control (or full zone control)
A control scheme in which it is possible to select different temperatures at different times in two (or more) different zones.

Time switch
An electrical switch operated by a clock to control either space heating or hot water, or both together but not independently. The user chooses one or more 'on' periods, usually in a daily or weekly cycle.

Thermostatic radiator valve
A radiator valve with an air temperature sensor, used to control the heat output from the radiator by adjusting water flow.

Weather compensator
A device, or feature within a device, that adjusts the temperature of the water circulating through the heating system according to the temperature measured outside the building.

Zone control
A control scheme in which it is possible to select different times and/or temperatures in two (or more) different zones.

References used in CHeSS (year 2005)

[1] The Building Regulations 2000. Approved Document L1, Conservation of fuel and power in dwellings, 2002 Edition

[2] Section 6: Energy, of the Domestic Technical Handbook on possible ways of complying with the Building (Scotland) Regulations 2004. See website www.sbsa.gov.uk.

[3] Domestic heating by gas: boiler systems : guidance for installers and specifiers: Energy Efficiency Best Practice in Housing (CE30)

[4] Domestic heating by oil: boiler systems : guidance for installers and specifiers: Energy Efficiency Best Practice in Housing (CE29)

[5] Domestic Heating Design Guide, CIBSE, May 2003

[6] The Government's Standard Assessment Procedure for Energy Rating of Dwellings, 2001 Edition

[7] BS 1566: 2002, Copper indirect cylinders for domestic purposes

[8] BS 7206: 1990, Specification for unvented hot water storage units and packages

[9] Waterheater Manufacturers' Association Performance Specification for Thermal Stores, 1999

[10] Benchmark Code of Practice for the Installation, Commissioning and Servicing of Central Heating Systems (available from Heating & Hotwater Information Council, website www.centralheating.co.uk or telephone 0845 600 2200)

[11] The Building Regulations (Northern Ireland) 2000. Technical booklet F, Conservation of fuel and power (December 1998). See website www2.dfpni.gov.uk/buildingregulations/.

[12] BS 5449: 1990 incorporating Amendment No.1 issued March 2002, Specification for forced circulation hot water central heating systems for domestic premises

[13] BS 7671: 2001, Requirements for electrical installations, IEE Wiring Regulations, Sixteenth edition

[14] BS 7593: 1992, Code of Practice for Treatment of water in domestic hot water central heating systems

[15] European Standard (Telecommunications series) ETSI EN 300 220-1 v1.3.1 (2000-09): Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1000 MHz frequency range with power levels ranging up to 500 mW;Part 1: Technical characteristics and test methods

References used elsewhere in this Guide

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

18 Central Heating System Specifications (CHeSS) - Year 2005 (GIL 59)

19 Domestic Heating Design Guide, CIBSE, May 2003

20 Council Directive 92/42/EEC on efficiency requirements for new hotwater boilers fired with liquid or gaseous fuels. Official Journal of the European Communities No L/167/17. 21 May 1992, p. 92.

21 ODPM website www.odpm.gov.uk; see 'Building Regulations' then 'The Building Act 1984 and building regulations' then 'Approved documents'.

22 The Building Regulations 2000. Approved Document L1, Conservation of fuel and power in dwellings, 2002 Edition

23 Section 6: Energy, of the Domestic Technical Handbook on possible ways of complying with Building (Scotland) Regulations 2004 (see website www.sbsa.gov.uk)

24 The Building Regulations (Northern Ireland) 2000. Technical Booklet F: Conservation of fuel and power (December 1998 edition) (accessible on website www.dfpni gov.uk)

25 Boiler Efficiency Database: see website www.boilers.org.uk.

26 The Government's Standard Assessment Procedure for Energy Rating of Dwellings, 2001 Edition

27 BS 1566:2002, Copper indirect cylinders for domestic purposes

28 BS 3198:1981, Specification for copper hot water storage combination units for domestic purposes

29 BS 7206:1990, Specification for unvented hot water storage units and packages

30 Waterheater Manufacturers' Association Performance Specification for Thermal Stores, 1999.

31 Benchmark Code of Practice for the Installation, Commissioning and Servicing of Central Heating Systems (available from Heating & Hotwater Information Council, website www.centralheating.co.uk or telephone 0845 600 2200)

32 BS 5410-1:21997, Code of Practice for oil firing - Part 1. Installations up to 45kW output capacity for space heating and hot water supply purposes

33 General Information Leaflet 83, 'Domestic boiler anti-cycling controls - an evaluation', London, 1997

34 BREDEM-12, Building Research Establishment Report BR315. BRE, Garston, 1996

35 BRE Report BR354 : Domestic Energy Fact File 1998, L D Shorrock and G A Walters

36 BS 5449:1990 incorporating Amendment No. 1 issued March 2002, Specification for forced circulation hot water central heating systems for domestic premises

37 BS 7593:1992, Code of Practice for Treatment of water in domestic hot water central heating systems

38 HHIC Guidance Notes for the installation of domestic gas high efficiency (condensing) boiler, HHIC, September 2002

39 Technical Information Book 4, OFTEC

40 Technical Information Book 3, OFTEC

41 Aspects of the risk of environmental damage caused by spillage from oil storage tanks, OFTEC Ref TI/133

42 The Building Regulations 2000. Approved Document J, Combustion Appliances & Fuel Storage Systems

43 Statutory Instrument 2001 No. 2954. The control of Pollution (Oil Storage) (England) Regulations 2001

44 Fire Protection of Oil Storage Installations for Classes 2 and 3, OFTEC Ref TI/136

45 Installing Oil Supply Pipes Underground, OFTEC Ref TI/134

46 Installation of Top Outlet Fuel Storage Tanks and Suction Oil Supply Pipe Sizing, OFTEC Ref TI/139

47 Technical Information Book 2, OFTEC

48 Statutory Instrument 1991 No. 1156 (S. 43) The Control of Pollution (Continuation of Byelaws) (Scotland) Order 1991

49 Section 3: Environment, of the Domestic Technical handbook on possible ways of complying with building (Scotland) Regulations 2004 (see website www.sbsa.gov.uk)

50 Solar hot water installation guide: Energy Efficiency Best Practice Programme in Housing CE131 [to be published autumn 2005]

CE29

Energy Efficiency Best Practice in Housing

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