Domestic central heating and hot water: systems with gas and oil-fired boilers

– guidance for installers and specifiers

Selection of better central heating boilers and systems will:

- reduce running costs
- reduce CO_2 emissions
- help to provide affordable warmth
- increase customer satisfaction

ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

GOOD PRACTICE GUIDE 284

CONTENTS

For specific installation guidance, reference should always be made to manufacturers' instructions, Building Regulations, standards and codes of practice.

This document is based on material drafted by BG Technology Ltd under contract to BRECSU for the Energy Efficiency Best Practice programme.

The following organisations were consulted during preparation and have expressed their support for this Guide: CBF (Condensing Boiler Forum), CHIC (Central Heating Information Council), EST (Energy Saving Trust), HVCA (Heating and Ventilating Contractors' Association), IDHEE (Institute of Domestic Heating and Environmental Engineers), MODUSSE (Manufacturers of Domestic Unvented Supply Systems Equipment), OFTEC (Oil Firing Technical Association for the Petroleum Industry), TACMA (The Association of Controls Manufacturers), WMA (Waterheater Manufacturers' Association).

1 INTRODUCTION

The aim of this Guide is to assist installers, specifiers and purchasers of boilers and central heating systems for use in housing. It provides guidance on selecting boilers and heating systems to improve energy efficiency, reduce running costs and reduce carbon dioxide (CO_2) emissions. The Guide covers gas (including liquefied petroleum gas (LPG)) and oil-fired 'wet' ('hydronic') central heating systems, ie those in which water is circulated to heat emitters from a boiler. It does not include solid-fuel or electric boilers, or ducted warm-air heating systems. Neither does it include individual heating appliances or electric central heating.

The overall energy efficiency of a central heating system has a major impact on both the running costs and the associated CO_2 emissions. The efficiency of all types of boiler has increased in recent years and manufacturers now design for maximum efficiency consistent with durability.

This Guide is published as part of the Government's Energy Efficiency Best Practice programme, the building-related aspects of which are managed by BRECSU. It brings together information on most of the different boiler types that are now available, the types of systems to which they can be fitted, and key points to consider when choosing a boiler for a particular application. For detailed information on the full design of domestic central heating systems see reference [10].

1.1 BOILER EFFICIENCY

The efficiency of the central heating boiler is the major factor affecting the energy efficiency of domestic central heating systems, and the Boiler Efficiency Directive (BED)[1] specifies minimum standards of efficiency required by law for most boiler types.

GIL 59: CENTRAL HEATING SYSTEM SPECIFICATIONS (CHeSS)[26]

This General Information Leaflet, published in February 2001, explains how to specify domestic wet central heating systems that conform to latest good practice or best practice. It is available from BRECSU Enquiries Bureau (see the back cover for details).

WHAT ARE CONDENSING BOILERS?

In any particular heating system a condensing boiler is always more efficient than a non-condensing boiler. It achieves this by including a large heat exchanger which extracts more heat from the flue gases. This has the effect of reducing the temperature of the flue gases, typically from 150-200ºC for a non-condensing boiler to 50-60ºC for a condensing boiler. There is so much heat removed that the water vapour present in the flue gases condenses and the water needs to run to a drain. As the flue gases condense the heat exchanger becomes wet, which makes it more susceptible to corrosion. To avoid this, these boilers have to be made of corrosion-resistant materials, making them more expensive than non-condensing units.

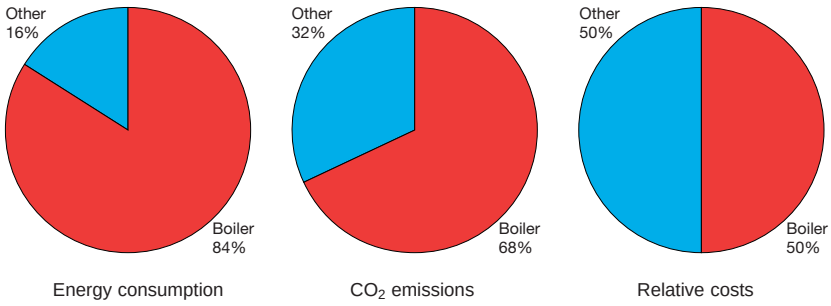

Figure 1 Energy use in the home

In earlier versions of this publication, figure 1 was printed incorrectly with 'Relative costs' and 'CO_2 emissions' interchanged.

2 BOILER TYPES

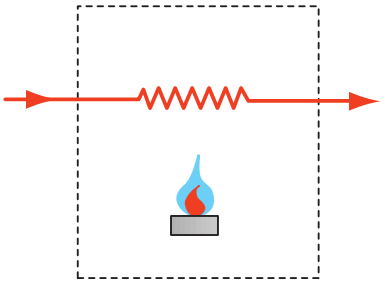

Figure 2 Regular boiler

This Guide considers both gas and oil-fired boilers, and covers the very wide variety of units now available with a range of different performances, installation options and features. All modern gas and oil-fired boilers are much more compact than older units and are generally capable of considerably higher output per unit volume than their predecessors. Many of the boiler features now available are designed to enhance energy efficiency.

Natural gas produces the lowest CO_2 emission level per unit of heat delivered and will also give low running costs for a wide range of dwellings. Boilers operated on LPG are usually very similar in design and efficiency to those operated on natural gas, but LPG is more expensive than natural gas and the additional cost of storage tanks (which are usually rented from the fuel supplier) needs to be considered. Oil-fired boilers are also very efficient and capable of giving the lowest running costs of any fuel, although installation costs are usually higher than gas boilers due to the requirement to provide a storage tank.

In most households a single boiler provides both space heating and domestic hot water. This is achieved in one of two ways:

- indirectly – a boiler with a separate hot water tank (usually a copper cylinder with a heating coil inside)
- directly – a combination boiler with no separate tank.

2.1 REGULAR BOILERS

This is the name given to boilers which are not combination boilers. Historically, they were the most commonly specified boiler and referred to as conventional or traditional units. Regular boilers are available for wall mounting or floor standing. A back boiler unit (BBU) is a regular boiler designed specifically for installation within a fireplace. All regular boilers are capable of providing space heating directly but require connection to a separate hot-water storage system since they do not have the capability to provide domestic hot water directly.

Regular boilers for sealed systems (see section 4.1) which have components such as pumps, expansion vessels, etc, within the boiler casing are known as 'system boilers'.

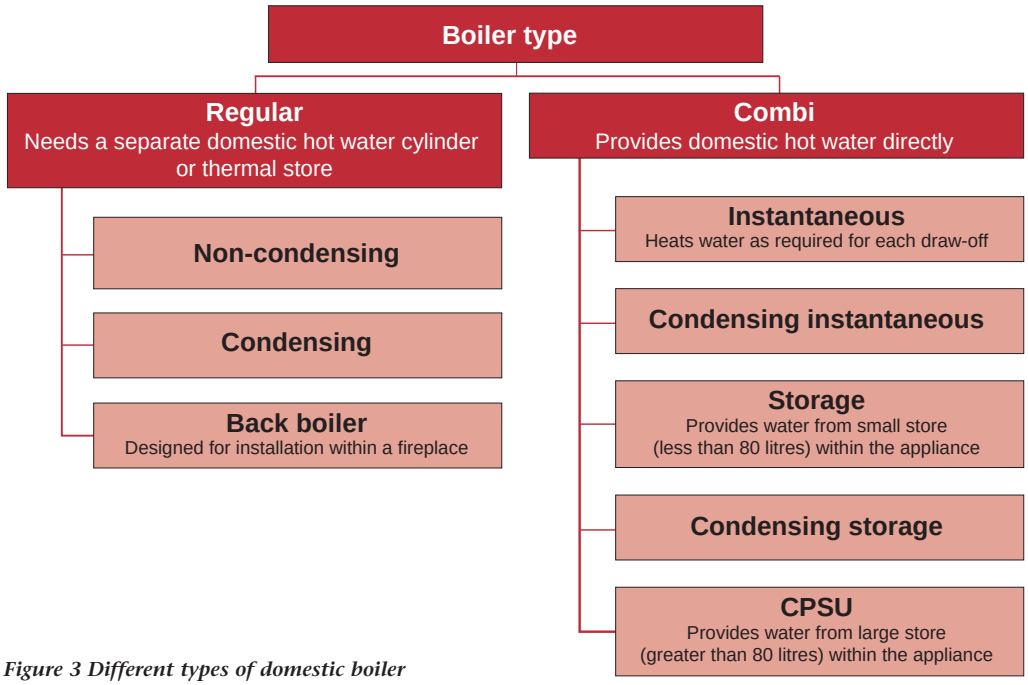

Figure 3 Different types of domestic boiler

BOILER TYPES

2.2 COMBI BOILERS

Combination (combi) boilers provide both space heating and direct domestic hot water. The most common type of unit is the instantaneous combi boiler, which heats water on demand without maintaining an internal store of water already heated. The units are capable of providing hot water continuously, but at a lower flow rate than could be expected from typical hot water storage systems. Therefore, these appliances may be less suitable for dwellings where multiple simultaneous draw-offs from separate taps are likely, ie multi-bathroom/shower room dwellings. Combi boilers will save space because:

- they are fed directly from the water mains supply, and there is no need for a hot water storage cylinder or cistern to feed it
- they are usually intended for use in a sealed system and so do not need a feed and expansion cistern, giving the opportunity to have a 'dry' roof space.

Before selecting a combi boiler it is important to ensure that the dwelling has satisfactory water pressure and an adequate water pipe size to prevent the possibility of inadequate hot water performance.

2.2.1 Space heating service from combi boilers

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. Consequently most combi boilers are designed with modulating burners; ie they reduce the firing rate to match the lower heat output requirements for space heating.

2.2.2 Hot water service from combi boilers

Characteristics of hot water service are:

- time taken for hot water to reach an acceptable temperature at the draw-off point
- flow rate at which hot water at an acceptable temperature is delivered
- how long this can be sustained
- ability to serve more than one draw-off point simultaneously.

Features of combi boilers that affect hot water service are as follows.

- ***Size of internal hot water store.*** An internal hot water store may improve hot water service by reducing the delay in delivering acceptably hot water at the draw-off points. Designs with different amounts of internal hot water storage can be classified as:
  - instantaneous – no internal hot water store
  - 'keep-hot' – no internal hot water store, but keeping the water within the boiler permanently hot to reduce warm-up time when the boiler starts
  - small store – a small hot water store is provided within the boiler sufficient to satisfy small draw-off requirements without delay, but insufficient for a bath
  - large store – a large hot water store is provided within the boiler sufficient to satisfy large draw-off requirements (eg a bath, or multiple draw-off points) without delay
  - combined primary storage units (CPSUs) – see section 2.2.3.
- ***Power.*** Boiler power affects the flow rate at which hot water at an acceptable temperature can be drawn off after any internal hot water store has been exhausted.
- ***Flow rate.*** Boilers may limit hot water flow rate to ensure that an adequate temperature rise is achieved.

2.2.3 Combined primary storage units (CPSUs)

A special category of storage combi boiler is called a combined primary storage unit (CPSU). These units include a very large store of water (usually greater than 80 litres) which is designed to buffer both the domestic hot water and space heating. The store is considered sufficiently large to reduce frequent boiler cycling. They will allow radiators to warm up very quickly and are capable of providing hot tap water at a high flow rate.

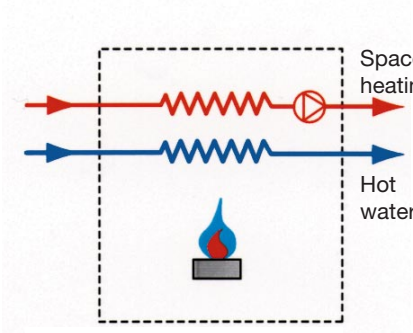

Figure 4 Instantaneous combi boiler

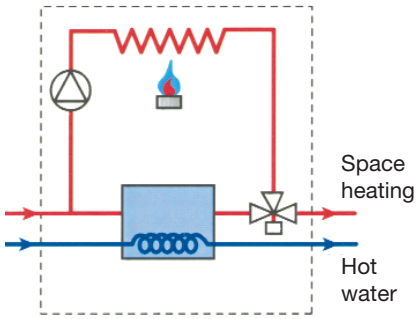

Figure 5 Storage combi boiler

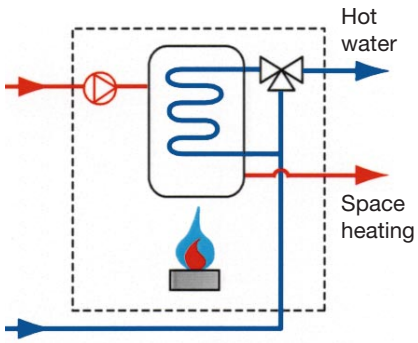

Figure 6 CPSU boiler

BOILER TYPES

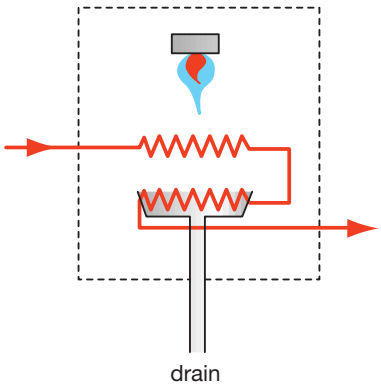

Figure 7 Condensing boiler

2.3 CONDENSING BOILERS

Condensing boilers are becoming an increasingly important choice in the UK when boilers are being specified. In some European countries they are already well established and have a major share of the market. Gas-fired condensing boilers offer significantly higher efficiencies than can be achieved from non-condensing boilers.

They may have a higher capital cost than non-condensing boilers but are usually cost-effective for larger dwellings (houses with three or more bedrooms).

2.3.1 Features

- They have seasonal efficiencies (see section 5) of between 83% and 92% (gas).
- Typically a condensing gas boiler would have seasonal efficiency of 88% compared with a new non-condensing boiler at 75% and older type boiler at 55-60%.
- The system does not need to be designed to condense all the time to achieve improved efficiency.
- They are available as regular and combi models.
- Floor-standing and wall-hung types are available including units with extended flues.
- They are suitable for replacing most existing boilers.

2.3.2 Installation considerations

- They are as easy to install as non-condensing boilers, other than the requirement to connect the condensate outlet to a drain.
- They can be installed in modern fully pumped systems without the need for 'special' system designs.
- It is not necessary to install oversized radiators to give a worthwhile efficiency gain.
- 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 but is not hazardous.

3 FLUES AND VENTILATION

All boilers need a flue to discharge products of combustion. Most boilers are now available in a range of flue types. The choice of flue type may affect the choice of location for the boiler and the ventilation requirements. Figure 8 indicates the flue types that are currently available. The rest of this section deals with the key issues for consideration when choosing a flue type.

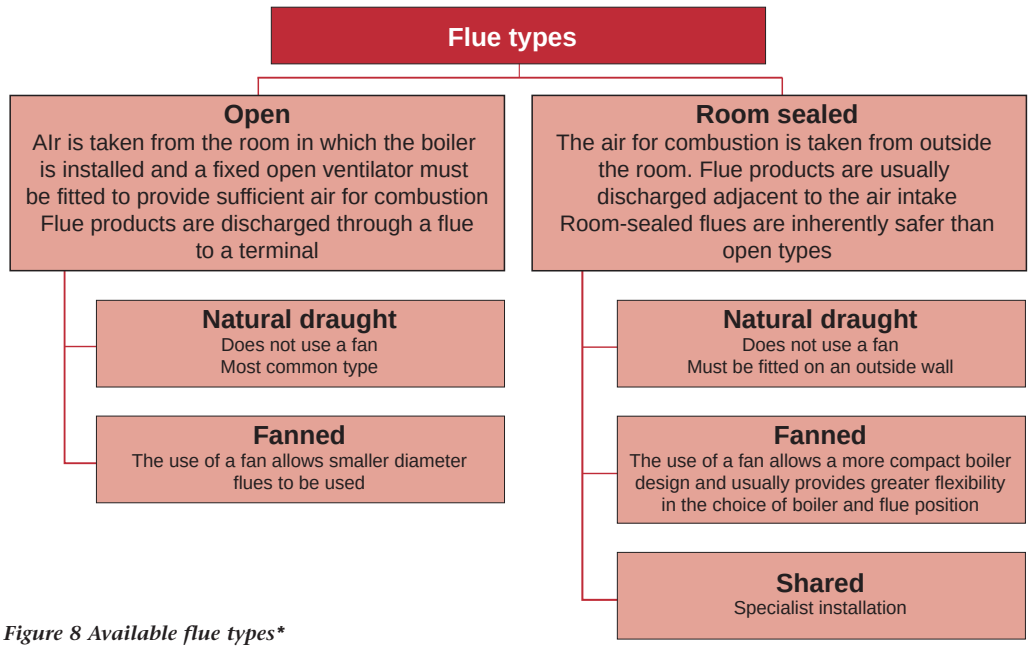

*Figure 8 Available flue types**

**Note:* Many appliances are often referred to as 'balanced flue'. These are room-sealed appliances which draw their combustion air from a point adjacent to the point where the combustion products are discharged. The idea is to have the inlet and outlet sufficiently close together that wind effects are substantially balanced. Room-sealed balanced flue appliances are most common, though there are also some appliances which are room-sealed but are not balanced as the air inlet and flue outlet are separated.

FLUES AND VENTILATION

3.1 ALL BOILERS

- The flue must be correctly designed and sized, use suitable materials and be provided with a suitable terminal[2, 20, 22].
- Back boilers make use of an existing chimney, which must have a suitable flue liner and terminal. Flue liners deteriorate with age and consideration should be given to replacing them at the same time as boiler replacement.
- Special consideration should be given to the siting of flue terminals for condensing boilers due to the possibility of pluming at the terminal. This can cause a nuisance in some situations since the 'plume' will be visible for much of the time the boiler is in operation.
- All open-flue boilers require a purpose-made air vent to ensure there is sufficient air for combustion.
- Room-sealed boilers do not require special provision for combustion air in the room they are installed.
- Boilers installed in a compartment (whether open-flue or room-sealed) may need provision to supply additional air for cooling.
- Where an extract fan is fitted in a room containing an open-flue appliance, additional ventilation may be required to prevent the fan affecting the boiler flue performance. By providing an air vent, colder outside air will enter the room and increase the ventilation heat loss, and so will slightly increase running costs for space heating.

3.2 GAS BOILERS[3, 4, 5]

- Boilers with fan-assisted flues are often more energy efficient than those without fans, since they are usually more compact, have a smaller flue diameter which reduces heat losses when the boiler goes off and are more likely to include automatic ignition. The electrical energy input of the fan is very small relative to the overall gas energy input for space heating and hot water.
- Regular and instantaneous combi boilers are available in all flue options, but for most other types of boiler the range is smaller. Boilers with fan-assisted flues are likely to have the fewest restrictions when siting the flue terminal. New, more stringent requirements for the positioning of natural draft room-sealed flue terminals are expected to be introduced (planned in 2000) which make them more difficult to install near to windows and doors. This makes the selection of a boiler with a fan-assisted flue more attractive since it can be installed in a much wider range of positions.
- A room-sealed boiler should be chosen where possible. Room-sealed boilers are inherently safer than open-flue boilers since in these appliances there is not a direct path for combustion products to spill into the room. However, all new open-flue boilers must incorporate a safety device that, in abnormal draught conditions or flue blockage, is designed to turn off the boiler and limit the release of combustion products into the room[6].
- Extended flues are now available for a wide variety of appliances and an increasing number of boilers have separate connections for the air inlet and the flue pipe. In some cases these allow total flue lengths of over 8 metres with a number of bends.
- Open-flue gas boilers of input greater than 7 kW require a purpose-made non-closable vent in the room to ensure there is sufficient air for combustion.
- Some gas boilers are available to fit to 'shared flues'. Expert advice must be obtained before this option is considered.

3.3 OIL BOILERS[7, 11]

- Oil-fired boilers have open or room-sealed balanced flues. All new boilers now have fan-assisted pressure jet burners, but some other oil-fired appliances use vaporising burners.
- The efficiency of new oil-fired boilers is high and they operate with comparatively low flue-gas temperatures. A correctly sized, well-constructed lined flue is essential for satisfactory operation of open-flue models.
- A wide variety of flues are now available for oil-fired boilers which can be extended horizontally or vertically from the boiler.
- The requirements for flue terminal siting are different from those that apply to gas boilers.
- Open-flue oil boilers of output greater than 5 kW require a purpose-made non-closable vent in the room to ensure there is sufficient air for combustion.

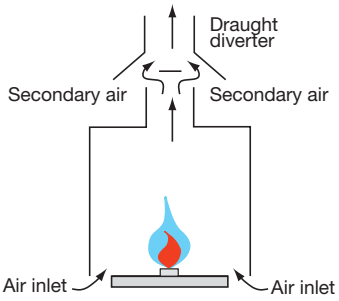

Figure 9 Open flue

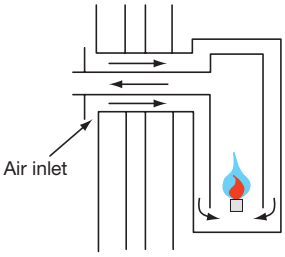

Figure 10 Room-sealed flue

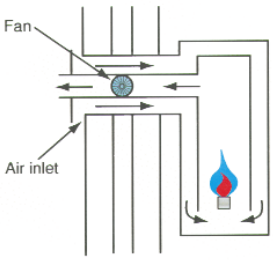

Figure 11 Fanned flue

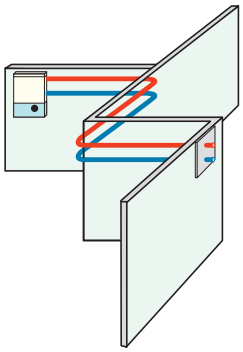

Figure 12 Extended flue

4 SYSTEM CHOICE

4.1 OPEN OR SEALED SYSTEMS[8, 9, 10, 18]

The most common type of system used with a regular boiler is the open-vented system with an indirect hot-water cylinder. It is termed 'open vented' because it includes a separate vent pipe, which is open to atmosphere. It also includes a feed and expansion cistern, which will allow for changes in the system water volume resulting from fluctuations in water temperature. The cistern must be at the highest point in the system, usually in the loft space where it must be protected from freezing.

An increasingly popular arrangement is the 'sealed' system, in which the expansion cistern is replaced by an expansion vessel that incorporates a diaphragm to accommodate the changes in water volume. The system is not open to atmosphere and the pressure within the system increases as the temperature rises. As the system is not open to atmosphere there is little possibility of oxygen being absorbed into the water, and therefore reduced risk of corrosion occurring within the system. These systems also require additional safety controls (often incorporated into the boiler) since there is no open vent, nor is there a permanent connection to a water supply. The system will include a relief valve, which will need connection to a suitable external discharge point. These systems may remove the need to install pipes and cisterns in the roofspace and so reduce the risk of freezing.

4.2 REPLACEMENT SYSTEMS

Most boilers installed are replacements for older units. Many of the older boilers were installed with gravity circulation to the hot water cylinder. This provides a relatively poor hot water service and it will not usually have a boiler interlock, which can give rise to excessive cycling, ie the boiler fires to keep itself hot even though there may not be a real heating or hot water demand.

When boilers are replaced the systems should always be upgraded to full pumping for both space heating and hot water circuits and new controls installed as this has a significant impact on efficiency. This will give the system an improved response and more effective control of room and domestic hot water temperature. Additional controls which give further enhanced features may also be considered[13, 24].

When converting from gravity to fully pumped operation, it should be noted that the pump may need to be repositioned, motorised valve(s) installed, and additional piping and wiring will be required between the boiler and the hot water cylinder. These alterations are best done before kitchens and bathrooms are modernised.

Simple size-for-size boiler replacement is not recommended. The dwelling heating and hot

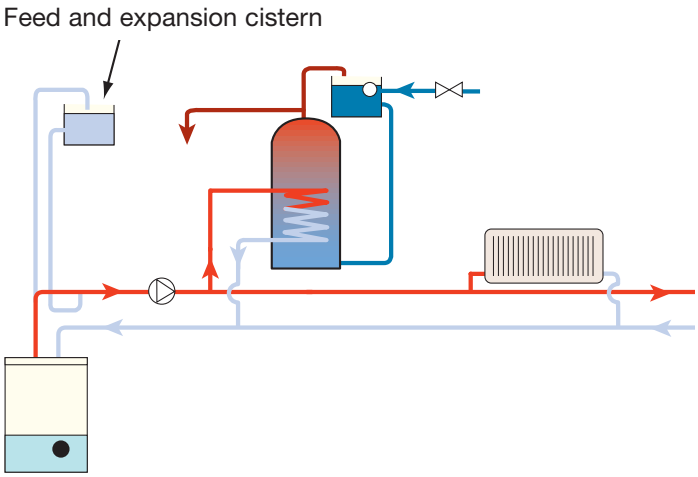

Figure 13 Open system

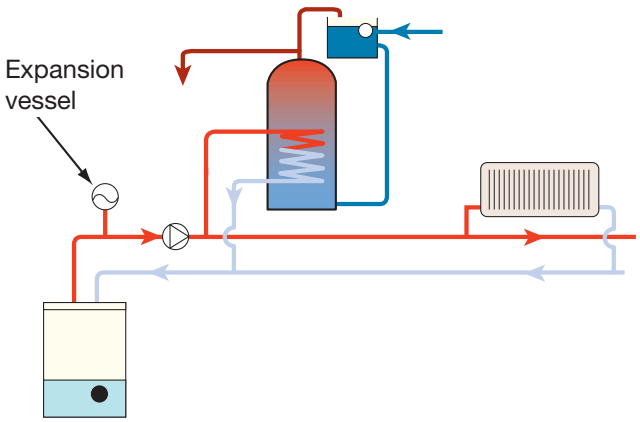

Figure 14 Sealed system

water requirements should be checked before a new boiler is selected, since insulation levels may have been improved or the original sizing may have been incorrect. Oversizing will lead to less efficient operation as well as unnecessarily increased capital cost. A boiler sizing worksheet is available from BRECSU.

4.3 MINIMUM REQUIREMENTS FOR NEW SYSTEMS

For completely new systems the recommended minimum system design requirements are as follows.

4.3.1 For all systems

- Calculate required boiler power. A boiler sizing worksheet is available from BRECSU.
- Select a boiler on the basis of high SEDBUK* and suitability as described in boiler selection.
- Fully pumped system – both space- and water-heating circuits pumped.
- Controls as outlined in section 4.5.

4.3.2 For non-combi systems

- High-recovery hot water cylinder with factory-applied insulation[19]. Where a thermal store is fitted it should meet the requirements of the Waterheater Manufacturers Association (see reference [12]).

4.3.3 For combi systems

- Some boilers require the installation of a scale reduction unit on the cold water supply.

4.4 DOMESTIC HOT WATER

Hot water systems have different characteristics. For combis, this is discussed in section 2.2. The main issues for considerations are:

- what hot water flowrate is required?
- how many people will live in the dwelling?
- how many baths/showers are there?
- is there space for a hot water cylinder or storage combi/CPSU?
- is a dry loft important?

Regular boiler systems will often employ a vented indirect storage hot water cylinder. For small dwellings with a single bathroom this is typically of 120 litres capacity. Larger dwellings with more than one bathroom will require a larger cylinder capacity. Unvented cylinders are also available which operate at mains pressure with either an internal expansion facility or a dedicated external expansion vessel.

High-performance cylinders are now available containing a rapid heating coil, which reduces the time taken for the water to be heated, and may reduce boiler cycling. This helps to increase the system efficiency, especially with older boilers. Most hot water cylinders and thermal stores are now supplied with factory-applied insulation. Hot water cylinders should meet British Standards Requirements[19]. Pre-coated cylinders should always be used in preference to cylinders with separate jackets.

* The SEDBUK is derived from manufacturers' test results which have been independently certified. These can include some measurement uncertainties and, therefore, small differences between efficiencies should be ignored.

A website with individual boiler efficiency results is available on:

www.boilers.org.uk

Type	Domestic hot water flowrate		
	Low	Moderate	High
Instantaneous combi[1]	X	X	
Storage combi[2]	X	X	X
CPSU[2]		X	X
Thermal store		X	X
Unvented storage[3]			X
Vented storage[4]			X

Table 1 Hot water provision

Notes:
1 Depends on boiler heat output
2 Depends on boiler heat output and storage capacity
3 Depends on adequate mains water supply
4 Requires high-level feed cistern

SYSTEM CHOICE

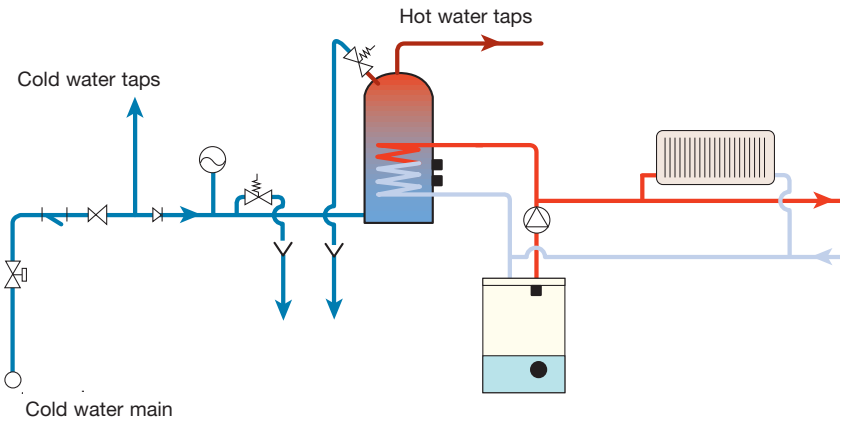

Figure 15 Unvented hot water system

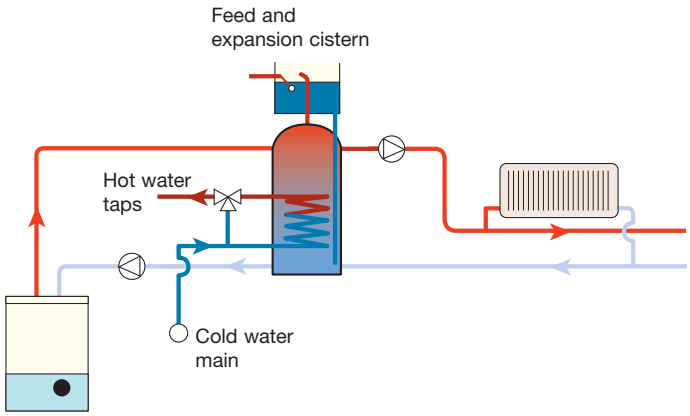

Figure 16 Thermal storage system

Thermal stores are also available where the high-temperature water from the boiler is stored directly. These systems are available either for 'hot water only' or 'hot water and space heating'.

Mains-fed water systems such as combi boilers, unvented cylinders, thermal stores and CPSU units are available which usually provide higher water pressures. These are particularly beneficial where multiple draw-offs are required. However, it is particularly important to ensure that the incoming water supply pressure and flow to the dwelling are adequate before these units are fitted.

4.5 CONTROLS

All wet central heating systems should have a minimum set of controls to meet basic energy efficiency requirements, as illustrated in table 2 on page 11 (see also reference [13]).

In addition, the following aspects should be considered.

- Thermostatic radiator valves (TRVs) will provide the extra benefits of individual room-temperature control and greater energy savings. It is important that the boiler manufacturer's requirements regarding the installation of TRVs are checked prior to installation. There are often specific requirements as to system bypasses and the use of automatic bypass valves.

- Frost protection for the dwelling or exposed parts of the heating system can be provided by the installation of a frost thermostat. This will be particularly important if the boiler is installed in an unheated or exposed area. The use of a frost thermostat will increase running costs during very cold weather. To minimise this, it is recommended that the frost thermostat be installed in conjunction with a pipe thermostat mounted on the return pipe to the boiler. This will ensure that the boiler will not fire unnecessarily and waste fuel. Some boilers incorporate frost protection, but consideration should be given to whether this adequately protects the system as a whole.
- A wide range of additional controls are available which may provide additional energy-saving benefits. A Good Practice Guide covering central heating controls is available[13] from BRECSU (details on back cover).

4.6 HEAT EMITTERS

A wide range of heat emitters are available (see table 3). Modern radiators are usually slightly smaller than older types for an equivalent heat output. Many modern radiators are also of smaller water content which provides for an improved warm-up performance. Radiators placed under windows will usually give the most comfortable room environment.

Boilers with separate hot water storage	Combi systems
Room thermostat (standard or programmable) Cylinder thermostat	Room thermostat (standard or programmable) Cylinder thermostat
Two-channel programmer (with standard room thermostat) **or** hot-water time switch (with programmable room thermostat)	Time switch (with standard room thermostat)
Motorised valves for pumped space and water heating	
Boiler interlock*	
* A boiler interlock refers to the wiring arrangement of the boiler and the controls. The boiler should be wired such that the boiler cannot fire unless there is a demand from either the space heating or domestic hot water.	

Table 2 Minimum set of controls for wet central heating systems

Type	Comment
Panel radiator	The most common type installed in modern housing. Available in wide range of outputs and sizes to suit all rooms.
Column radiator	Available in wide range of colours and shapes.
Low surface temperature (LST) radiator	Safe option where young children or elderly may be at risk. Limited to a surface temperature of 43°C to prevent injury.
Towel rail	For towel warming and some heat for bathroom.
Fan convector	Wall hung or kickspace units available. Provides more rapid heating response. Needs electrical supply.
Underfloor heating coils	Requires specialist installation and controls.

Table 3 Heat emitter types

5 ENERGY EFFICIENCY

One of the aims of this Guide is to provide information which will lead to improved energy efficiency in dwellings, and selection of the most suitable but energy-efficient boiler is vital to that process. Boiler choice should be influenced by the following factors.

- What are the typical seasonal (ie annual in-use) efficiencies of the different boiler types (see section 5.3)?
- What are typical heating and hot water running costs for different types of dwellings?
- What are typical CO_2 emissions for space and water heating?

5.1 BOILER EFFICIENCY

The term 'boiler efficiency' needs further explanation since there are many values that are quoted which are arrived at in different ways. The efficiency now used in the UK Building Regulations is called SEDBUK, an acronym which stands for 'Seasonal Efficiency of a Domestic Boiler in the UK'. It represents the best estimate presently available of typical overall seasonal in-use boiler efficiency for providing space heating and hot water, and is used in this Guide. Other efficiency figures should be disregarded since they will not necessarily be consistent. Full details of SEDBUK can be found in 'The Government's Standard Assessment Procedure for energy rating of dwellings'[14].

The Standard Assessment Procedure (SAP) is part of the UK Building Regulations[15, 21, 23], and is used to assess the overall energy efficiency of new and refurbished dwellings. The type and model of boiler and central heating system chosen will affect the SAP rating of dwellings. SEDBUK makes use of actual boiler test data, which has been measured for each boiler in the laboratory to meet the requirements of the European Boiler Efficiency Directive (BED). Therefore there is an incentive to boiler manufacturers to design their products for maximum boiler efficiency.

It should be noted that SEDBUK is an indicator of the average annual boiler efficiency determined by the amount of heat delivered into the primary (boiler water) heating circuit. It is assumed that the boiler is installed in a fully pumped system, correctly designed with adequate controls.

As the SEDBUK has been designed specifically for SAP energy rating purposes, it takes account of heat losses during the generation of space heating and hot water but does not take account of surface heat losses from any hot water cylinder or store within or external to the boiler. Surface heat losses are treated separately in SAP, since they may provide a small but useful amount of heat to the dwelling during the heating season. This is important when comparing SEDBUK values, since cylinders and stores with high heat losses will increase energy consumption.

Figure 17 Typical SEDBUK ranges for boiler types

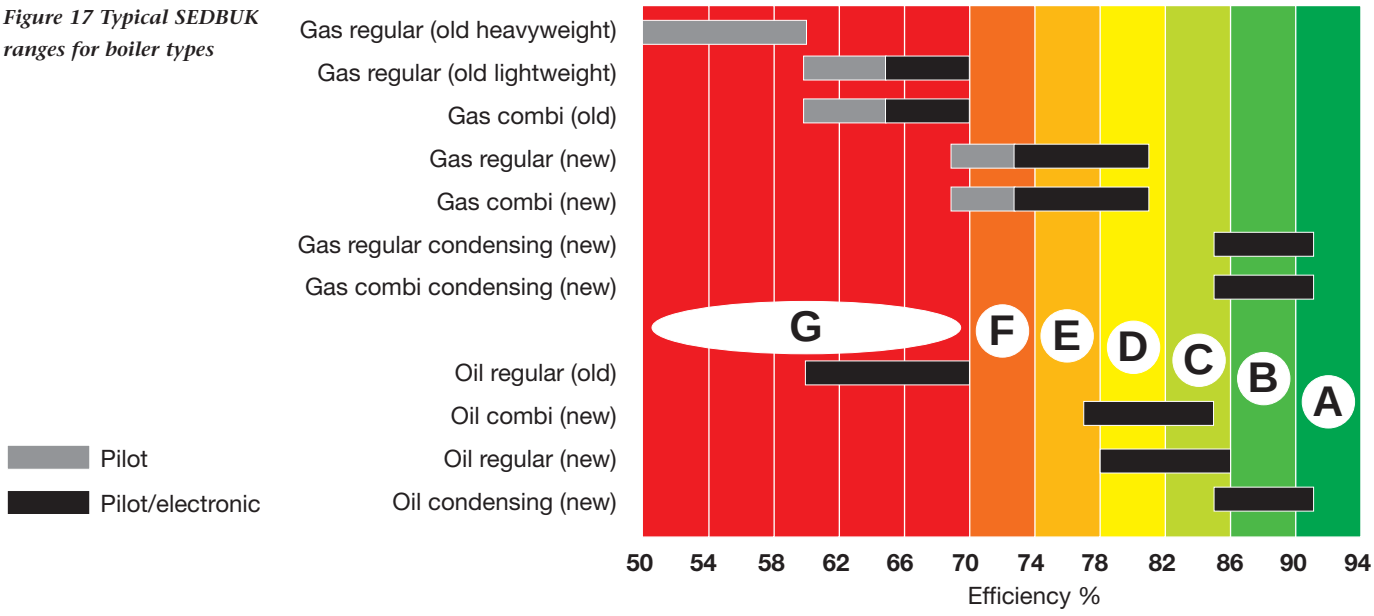

Figure 17 shows the typical ranges of seasonal efficiency for both new and older boilers.
In practice there are limits to the minimum efficiency due to requirements of the BED and the maximum permitted value based on theoretical considerations (ie if the boiler heat exchanger was perfect).

5.2 THE STANDARD ASSESSMENT PROCEDURE

Home energy ratings are a measure of the energy efficiency of a dwelling and are intended to give householders information on the relative overall energy efficiency of different homes. The SAP is the Government's home energy rating, and is based on the space- and water-heating running costs. Its value will depend on the type of building, fuel and heating system design. SAP ratings are expressed on a scale of 1 to 100 – the higher the better.

SAP rating depends on:

- building insulation
- building design
- solar heat gains
- building ventilation
- heating and hot water efficiency and controllability (using SEDBUK).

Figure 17 provides typical values of seasonal efficiency for both old and new boilers, based on the work carried out during the development of SAP (1998). These values have been used to estimate typical energy consumptions and CO_2 emissions shown in tables 4 and 5.

5.3 RUNNING COSTS

Table 4 shows typical running costs for central heating and hot water for five typical UK dwellings. The energy consumption has been estimated using BREDEM-12 [25]. This program was developed by the Building Research Establishment (BRE) and estimates annual domestic energy usage based on house design, insulation levels, local climate, and heating system design, including efficiency and heating usage. It is widely recognised as the preferred method for calculating domestic fuel running costs in the UK.

The running costs also use typical SEDBUK efficiency values. Figures are shown for average UK weather conditions (Midlands). Consumption is 3-6% lower in the south and 3-6% higher in the north. Fuel costs have been taken from SAP (1998)[14], Table 12. Costs exclude standing charges, LPG tank rental, maintenance and circulating pump running costs (see box on the right).

Natural gas	1.49p/kWh
Oil (kerosene)	1.46p/kWh
LPG	2.61p/kWh

5.4 THE BOILER EFFICIENCY DATABASE

There is now a boiler database showing the efficiency of gas and oil domestic boilers sold in the UK. It can be seen on the Internet at www.boilers.org.uk. Both current and obsolete boilers are included, and the database is kept up to date with a new issue every month.

For current boilers, most of the entries give SEDBUK efficiency figures and an efficiency band. 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 entry in the database. For obsolete boilers, and others for which certified test results are not available, a generic efficiency for the type of boiler is quoted instead of SEDBUK.

As a simple guide to efficiency, there is a temporary scheme with SEDBUK efficiency bands assigned to boilers on an 'A' to 'G' scale, as shown in figure 17. The band is shown in the database and may be used on product literature and labels, though there is no requirement for manufacturers to do so. The scheme is temporary as it will be withdrawn when a European directive on boiler energy labelling is introduced.

5.5 CARBON DIOXIDE EMISSIONS

Natural gas provides the lowest emissions. LPG and oil give higher emissions. Table 5 shows typical CO_2 emissions (for natural gas, LPG and oil) in tonnes of CO_2/year for the same five typical dwellings.

5.6 INSTALLATION, COMMISSIONING AND SERVICING

When a new central heating boiler is installed it is important to ensure that all parts of the central heating system and hot water system are functioning correctly for safe and energy-efficient operation.

ENERGY EFFICIENCY

- The boiler and system should be cleaned using a recognised flushing procedure.
- The key system components should be checked for correct operation and controls set to optimum settings.
- The customer should be instructed on how to operate the controls and the importance of regular servicing of the system.

The 'Benchmark' scheme has now been introduced to raise the standard of the installation, commissioning and servicing of central heating systems in the UK. The majority of new boilers sold will contain a log book for the installer to complete and leave with the householder. A CORGI or OFTEC registered installer is required to sign the log book to confirm he has installed and commissioned the gas boiler following manufacturer's instructions and also completed a record of servicing. The 'Benchmark' scheme is intended to ensure that all new boilers installed are both safe and energy-efficient throughout their service life. Householders should be encouraged to ask for the log book and keep it safely.

Table 4 Typical annual running costs for central heating and hot water

	SEDBUK (%)	Flat	Bungalow	Terraced	Semi- detached	Detached
Natural gas						
Old boiler (heavy weight)	55	£251	£328	£342	£387	£549
Old boiler (light weight)	65	£212	£278	£289	£328	£465
New boiler (non-condensing)	75	£184	£241	£251	£284	£403
New boiler (condensing)	88	£157	£205	£214	£242	£343
Oil (kerosene)						
Old boiler	65	£204	£267	£278	£315	£447
New boiler (non-condensing)	82	£162	£212	£220	£250	£354
New boiler (condensing)	88	£151	£197	£205	£233	£330
LPG						
Old boiler (heavy weight)	55	£439	£575	£599	£678	£961
Old boiler (light weight)	65	£372	£486	£507	£574	£813
New boiler (non-condensing)	75	£322	£421	£439	£492	£705
New boiler (condensing)	88	£275	£360	£374	£424	£601

	SEDBUK (%)	Flat	Bungalow	Terraced	Semi-detached	Detached
Natural gas						
Old boiler (heavy weight)	55	3.2	4.2	4.4	4.9	7.0
Old boiler (light weight)	65	2.7	3.5	3.7	4.2	5.9
New boiler (non-condensing)	75	2.3	3.1	3.2	3.6	5.1
New boiler (condensing)	88	2.0	2.6	2.7	3.1	4.4
Oil (kerosene)						
Old boiler	65	3.8	4.9	5.1	5.8	8.2
New boiler (non-condensing)	82	3.0	3.9	4.1	4.6	6.5
New boiler (condensing)	88	2.8	3.6	3.8	4.3	6.1
LPG						
Old boiler (heavy weight)	55	4.1	5.4	5.6	6.3	8.9
Old boiler (light weight)	65	3.5	4.5	4.7	5.3	7.6
New boiler (non-condensing)	75	3.0	3.9	4.1	4.6	6.6
New boiler (condensing)	88	2.6	3.3	3.5	3.9	5.6

Table 5 Annual tonnes of CO_2 emissions for typical dwellings

6 BOILER SELECTION PROCESS

Choosing a central heating boiler requires consideration of the heating and hot water requirements of the household and the positions in which it is physically possible to fit the boiler. In considering the boiler location, account must be taken of the requirements for flueing and ventilation. For gas installations, condensing boilers should be chosen in preference to other types unless the costs outweigh the benefits or where there are serious difficulties with terminal siting, pluming, or connection to a drain. For oil installations, non-condensing boilers have efficiencies closer to those for condensing types. Where possible, it is preferable to use a room-sealed boiler, except in the case of back boilers which are only available as open flue.

The key choices to be made are:

- what fuel?
- what boiler type?
- what location?
- what type of mounting?
- what flue type?
- what ventilation requirement?
- open or sealed system?
- what type of hot water system?
- what controls?
- what heat emitters?

The following checklists provide a reminder of the key points to be considered when selecting a boiler. Section numbers in the third column indicate where additional relevant information can be found in this Guide.

SELECT FUEL		
Gas (natural)	Piped supply widely available. Does not require special provisions for storage.	
Gas (LPG)	More expensive running costs. Requires storage tank (usually rented).	
Oil	Lowest running costs. Requires storage tank.	

IS THERE ROOM?		
Size of room	Is it adequate for combustion air and boiler cooling?	3
Space around boiler	Is it adequate for installation, maintenance and servicing?	3
Space for flue	Can flue be easily fitted? Is external wall required? – see flue types page 16.	3

BOILER POSITION		
Heated area	Preferred – energy saving.	3.1
Unheated area	Requires frost protection.	3
Compartment/ airing cupboard/ understairs	May require special provision for ventilation and sometimes fire resistance.	3
Bathroom/ shower room/ sleeping room	Restrictions on installing open flue boilers. Special requirements for electrical work in bath and shower rooms[16].	
Roofspace/loft/attic	Need to consider weight of boiler, ventilation and safe access.	
Fireplace	Usually for back boilers (BBUs).	3.1
Garage	Room sealed only.	
Basement/cellars	Not for boilers using LPG[17].	

BOILER SELECTION PROCESS

SELECT FLUE TYPE		
Open	Usually uses an existing chimney. Must include suitable flue liner and terminal. Consideration should be given to replacing the flue liner when a boiler is replaced. All BBUs are open flue.	3
Room sealed – natural draft	Must be fitted on an outside wall. New requirements for the positioning of flue terminals for gas boilers will make siting more difficult.	3
Fanned	Offers greatest choice for siting the flue terminal. Requirements for oil and gas boilers are different. Extended fanned flues allow boiler to be installed some distance from an external wall. Extended flues are available for installation both horizontally and vertically.	3

AIR SUPPLY AND VENTILATION		
None required?	Room-sealed appliances do not usually require special provision for ventilation. Some may require ventilation when fitted in a compartment.	
Purpose-made for room	Open-flue boilers require a purpose-made non-closable air vent to ensure that there is sufficient air for combustion. Special provision may be required where an extract fan is fitted.	3
Purpose-made for compartment	Boilers fitted in a compartment will usually require additional air for cooling in addition to that required for combustion.	3

OPEN OR SEALED SYSTEM?		
Open	Requires an expansion cistern which must be at highest point in system.	4.1
Sealed	Incorporates an expansion vessel. System pressure increases as temperature rises. Require additional safety controls (which are normally part of boiler [18]).	4.1

HOT WATER SYSTEM		
All	Initial choice depends on whether regular or combi boiler is selected.	4.4
All mains-fed systems	Ensure water supply pressure and flow to dwelling is adequate.	4.4
All storage systems	Ensure hot water cylinders are well insulated [19]. High-recovery cylinders are preferred. 120 litre cylinder is usually adequate for smaller dwellings with a single bathroom.	4.4
All combis	Storage combis or CPSUs usually provide a higher hot water flow rate than instantaneous combis.	4.4
Vented storage	Requires cold water cistern and usually provides a high hot water flow rate at low pressure.	4.4
Unvented storage	Is mains-fed and usually provides a high hot water flow rate at high pressure.	4.4
Thermal storage	Is also mains-fed and provides a moderate/high hot water flow rate at high pressure.	4.4

BOILER SELECTION PROCESS

SELECT BOILER TYPE		
Regular or combi?	Regular boilers provide maximum flexibility in system design. 'System' and combi boilers include some system equipment which reduces installation time. Combis usually require a 22 mm gas supply pipe.	2.1 2.2
Instantaneous combi	Maximum hot water flow rate possible at the tap will depend on the boiler heat output (as well as the draw-off pipe design) and usually take longer to fill a bath and also longer to provide water at an acceptable temperature, compared with hot water storage systems. Some units have a 'keep hot' facility which reduces the delay to hot water being delivered, but may increase running costs.	2.2
Storage combi	May be capable of a higher water flow rate at the tap than an equivalent instantaneous unit. The flow rate and the capability to sustain this flow rate will depend on the volume of the store and the boiler heat input.	2.2
CPSU	Has a comparatively large store and is capable of high water flow rates at the tap. Will warm the radiators more quickly as both the domestic hot water and the space heating are taken from the water store.	2.2
Regular BBU	Open-flue only and usually includes an integral fire.	
Sizing	Ensure the boiler is sized correctly to meet the heating requirements of the dwelling and hot water requirements of the user. Oversizing may increase running costs. A boiler sizing worksheet is available from BRECSU.	4.2

SELECT BOILER FEATURES		
Condensing or non-condensing?	For gas installations, condensing provides significantly higher efficiencies than non-condensing. Condensing boilers may be more expensive than non-condensing, require connection to a drain and care in siting flue terminal.	2.3 5.1
Ignition	Automatic electronic ignition is preferred. Permanent pilot ignition reduces SEDBUK gas boiler efficiencies by 4%.	5.1

SELECT CONTROLS		
Minimum set	Regular boilers: should have pumped space and water heating, room and cylinder thermostats, motorised valves, two-channel programmer and a boiler interlock. When boilers are replaced the controls should be upgraded to at least this level. Combi boilers: should have time switch plus standard room thermostat ***or*** programmable room thermostat.	4.5
TRVs	It is preferable to install TRVs but they should be in addition to a room thermostat or other systems which provide a boiler interlock. Automatic bypass valves should be specified in preference to manual types.	4.5
Frost protection	Frost protection for the dwelling and the central heating system should always be considered.	4.5
Other controls	Additional controls can also be advantageous – see references [13] and [24].	4.5

REFERENCES

[1] Boiler Efficiency Directive, 92/42/EEC 21/5/92 L 167/17

[2] The Building Regulations 1990, Heat Producing Appliances, Approved Document J

[3] BS 5440: Part 1: 1990, Installation of flues and ventilation for gas appliances of rated input not exceeding 60 kW (1st, 2nd and 3rd family gases), Part 1 Specification for installation of flues

[4] BS 5440: Part 2: 1990, Installation of flues and ventilation for gas appliances of rated input not exceeding 60 kW (1st, 2nd and 3rd family gases), Part 1 Specification for installation of ventilation for gas appliances

[5] BS 5847: Part 1: 1991, Installation of gas fires, convector heaters, fire/back boilers and decorative fuel effect gas appliances, Part 1 Gas fires, convector heaters and fire/back boilers (1st, 2nd and 3rd family gases)

[6] Council Directive 90/396/EEC, On the approximation of the laws of the member states relating to appliances burning gaseous fuels (90/396/EEC)

[7] BS 5410: Part 1: 1997, Code of Practice for oil firing Part 1 Installations up to 45 kW output capacity for space heating and hot water purposes

[8] BS 5449: 1990, Forced circulation hot water central heating systems for domestic premises

[9] BS 6798: 1994 Specification for installation of gas fired hot water boilers of rated input not exceeding 60 kW

[10] HVCA and CIBSE, Domestic Heating Design Guide, November 2000

[11] OFTEC Technical Information Book 4, Domestic Heating Systems Design, Operating Principles and Energy Efficiency, 1993

[12] Waterheater Manufacturers Association – Performance Specification for Integrated Thermal Stores for heating and Hot Water and Buffer Stores, 1999

[13] Good Practice Guide 143, 'Upgrading controls in domestic wet central heating systems – a guide for installers'. DETR, London, 1994

[14] The Government's Standard Assessment Procedure for energy rating of dwellings. 1998 edition

[15] The Building Regulations 1995, Conservation of fuel and Power, Approved Document L

[16] BS7671, IEE Regulations

[17] BS5482, Code of Practice for domestic butane and propane gas burning installation

[18] BS7074: Part 1: 1989 Application, selection and installation of expansion vessels and ancillary equipment for sealed water systems Part 1 Code of practice for domestic heating and hot water supply

[19] BS1566: Part 1: 1990 Copper indirect cylinders for domestic purposes

[20] The Building Standards (Scotland) Regulations 1990, Part F, Heat-Producing installations and storage of liquid and gaseous fuels

[21] The Building Standards (Scotland) Regulations 1990, Part J, Conservation of Fuel and Power

[22] The Building Regulations (N. Ireland) 1990 Technical Booklet L, Heat Producing Appliances

[23] The Building Regulations (N. Ireland) 1999 Technical Booklet F, Conservation of Fuel and Power

[24] Good Practice Guide 132, 'Heating controls in small commercial and multi-residential buildings'. DETR, London, 1996

[25] BREDEM-12, Building Research Establishment Report BR315. BRE, Garston, 1996

[26] General Information Leaflet 59, 'Central Heating System Specifications (CHeSS) – Year 2000'. DETR, London, 2001

FURTHER READING

ENERGY EFFICIENCY BEST PRACTICE PROGRAMME DOCUMENTS

The following Best Practice programme publications are available from the BRECSU Enquiries Bureau. Contact details are given on the back cover.

Energy Consumption Guide

3 A tenant's guide to affordable heating

General Information Leaflets

19 Condensing boilers in housing – results of a market survey

83 Domestic boiler anti-cycling controls. An evaluation

General Information Report

32 Review and development of energy efficient refurbishment standards for housing associations

Good Practice Case Studies

10 Energy efficiency in new housing. Llanerchydol Park, Welshpool. Frank Galliers Ltd

78 Modern domestic heating systems. Dual gas-fired condensing boilers in new sheltered housing

79 Energy efficiency in large residential buildings: condensing gas boilers. Condensing gas boilers for heating and hot water in a student hall of residence

84 Domestic oil-fired condensing boilers

108 Energy efficiency in housing. Low-energy sheltered housing in Scotland

239 Energy efficient refurbishment of housing. Barbican District of Plymouth

257 Northern Ireland's Energy Saver House

306 Application of energy efficient pattern book housing

313 Community heating in Nottingham: domestic refurbishment

315 Energy efficient refurbishment of solid walled houses

316 Energy efficient refurbishment of solid walled flats

318 Energy efficient refurbishment of cavity walled flats

Good Practice Guide

143 Upgrading controls in domestic wet central heating systems – a guide for installers

New Practice Final Report

20 Low NOx condensing boilers in large residential buildings. Penfield Court, Edgware

ENERGY SAVINGS ADVICE FOR HOUSEHOLDERS

For advice and details of energy savings offers, householders should contact the Energy Efficiency Hotline on 0845 7277200.

A website with individual boiler efficiency results is available on:

www.boilers.org.uk

Energy Efficiency Best Practice in Housing

Tel: 0845 120 7799
www.est.org.uk/bestpractice

Energy Efficiency Best Practice in Housing is managed by the Energy Saving Trust on behalf of the Government. The technical information was produced by BRE.