Energy Efficiency Best Practice in Housing

Best Practice in new housing – a practical guide

- Straightforward specifications for building energy efficient homes
- Different options for achieving Best Practice
- Recommendations for a range of dwelling types

Energy Efficiency
SAVE ENERGY MONEY ENVIRONMENT

Energy Saving Trust

Introduction

This guide is designed to help designers and builders achieve Best Practice[1] levels of energy efficiency without carrying out a large number of detailed calculations.

Carbon dioxide emissions can be reduced by up to 25% by using these specifications and guidelines. The savings described in the examples have been assessed against building regulations in England and Wales. Equivalent savings can be expected in Scotland, while in Northern Ireland they will be greater.

Best Practice does not require the use of untried technologies or building practices. It is achievable using common products and methods of construction.

If the simplified approach laid out in this publication is not appropriate, the full Best Practice specification should be used: see the publications CE12 (England, Wales and Scotland) and CE24 (Northern Ireland) *Energy efficiency in new housing – Summary of Specifications*.

CE12 and CE24 also provide an 'advanced' specification addressing sustainability issues and reducing environmental impacts beyond Best Practice.

Benefits

Houses built to the Best Practice standard will help companies and organisations achieve the following:

- **increased customer satisfaction**
  This will be attributable to lower heating bills and improved comfort.
- **marketing advantage**
  Prospective homebuyers increasingly consider energy efficiency and environmental considerations an important part of their decision-making process when purchasing a home[2]. In the near future, the EU Energy Performance of Buildings Directive will require that whenever a building is erected, sold or rented out, a certificate detailing its usage is provided to the prospective buyer or tenant.
- **built performance**
  By following the guidance and specifications in this publication energy savings will be achieved in practice and not just on paper.
- **building control approval**
  Building to the Best Practice specification make compliance with building regulations easier.
- **greener image**
  Many companies now take a proactive approach and build to higher energy efficiency standards.

[1] Where the Best Practice standard forms part of a contract or agreement, compliance should be verified against the full specification described in *Energy Efficiency in New Housing – Summary of Specifications* (CE12 & CE24).

[2] A Gallop Survey in 2000 found that 70% of consumers would be willing to pay more for an energy efficient home and the same proportion want to see energy ratings on all homes.

The Best Practice specification goes beyond the energy requirements of building regulations. Following the specification described in this guide should therefore make building regulations approval a straightforward process. However, in rare situations, such as some small electrically heated flats, conflicts can occur. Building regulations compliance should therefore be checked at the design stage.

Basics of Best Practice

Good housing design

Low-energy design principles provide a cheap and effective way of reducing energy use before construction even starts:

- **site considerations**
  Minimise over-shading from trees and other buildings wherever possible.
- **compact design**
  Sprawling layouts are less energy efficient than compact designs. Architectural features can still be added to compact designs to create visual interest while not significantly increasing energy use. This is particularly evident in large detached homes.
- **dwelling orientation**
  The main living areas such as the living room and bedrooms should be on the south side to make best use of heat and light from the sun. This will lower bills and provide bright, attractive rooms. Other areas such as kitchens, bathrooms or utility rooms should be located on the northern side of the dwelling.
- **window areas**
  60-75% of the total window area should face south, with adequate glazing for daylighting purposes elsewhere. Again, this helps to create a feeling of brightness in the main living areas.
- **window type**
  The use of high thermal performance windows to Best Practice standard will enable occupants to feel comfortable even when sitting close to windows. Heat loss will also be minimised.

Heating

For low running costs and reduced environmental impact, it is essential to reduce fossil fuel consumption and choose an efficient heating system that is correctly sized, installed and commissioned. The following should therefore be considered:

- **choosing the right fuel**
  Mains gas is preferred where available. Electricity is generally the most expensive fuel and, in terms of overall UK generation, also the most polluting. Whilst electric heating may be appropriate for flats it should not generally be used on larger properties. One exception is where an electric 'heat pump' is used.
- **efficient heating**
  An efficient heating system is essential and common options are described in the following pages. Some feature fires can be extremely inefficient and an open flue or chimney can lose a lot of heat, even when the fire is not in use. If a fire is essential, then choose one that is enclosed.
- **avoiding unnecessary heating**
  Heating stairwells and corridors in flats is unnecessary, adding to both construction and running costs. In private houses, conservatories and glazed passages linking areas can be very expensive to heat. Heating should not be installed in these zones and external-quality doors should separate them from habitable areas.

Ventilation

Most new homes have high air leakage rates leading to excessive ventilation, discomfort to occupants, and higher fuel bills.

To address these issues, attention must first be paid to those areas where air leakage can occur and then the correct ventilation system must be chosen.

It is very helpful if the building designer identifies on his drawings a continuous airtight envelope: this will make it easier to identify those areas where special attention is needed in order to ensure airtightness.

Major air leakage paths include:

- plasterboard dry-lining on adhesive dabs
- service ducts, particularly those concealing drainage pipes from kitchens, bathrooms and WCs, which all need careful sealing

Energy efficient ventilation in housing (GPG268) gives further guidance on this issue.

On-site practice

Effort at design stage can be wasted if care is not taken when installing insulation and services. Gaps in insulation or incorrect fitting will result in poor performance. Holes created for plumbing and electrical services can result in air leakage if these are too large or incorrectly sealed.

Summary of benefits

Homes built to Best Practice standard offer a number of benefits to house buyers:

- better use of heat and light from the sun enhances visual appeal, improves comfort and reduces heating and lighting bills
- efficient heating systems with improved controls are more responsive to the occupants' needs
- good design and on-site practice reduces draughts and excessive ventilation
- energy efficient lights and appliances reduce electricity bills; these account for a large proportion of running costs in new homes.

Further information on how to achieve Best Practice standards can be found at the end of this guide.

Best Practice requirements

The following pages give a ready-to-use specification for Best Practice. This can achieve savings similar to those shown in examples later in the guide (some house types do have particular requirements which are also detailed in the examples).

Insulation requirements

This section lists the U-values required for walls, roofs, floors and windows together with examples of common types of construction.

As well as mineral wool, insulating boards based upon extruded polystyrene (XPS)[3], polyurethane, polyisocyanurate and phenolic insulants are available. Some of these have lower thermal conductivities than mineral wool, resisting the passage of heat better. Reduced thicknesses of insulation can therefore be installed but the improved thermal performance is generally reflected in higher cost.

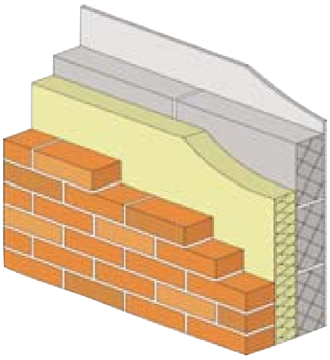
The examples show common ways to achieve Best Practice: they are not the only possible methods. A variety of other constructions can be used, such as SIPS (Structural Insulated Panel Systems), solid wall constructions or pre-fabricated roofs, as long as they achieve the required U-values.

The *Insulation materials chart – thermal properties and environmental ratings* (CE71) is an easy-to-use chart comparing insulation materials. Manufacturers will provide information on their products and can help with calculations if required.

[3] Expanded polystyrene (EPS) is also available. EPS has a thermal conductivity similar to mineral wool.

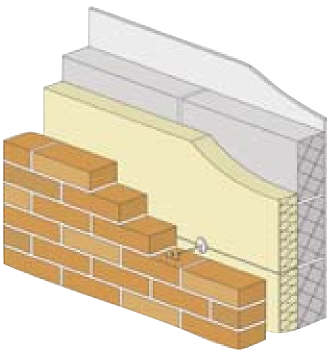
Walls (U-value of 0.25W/m²K required)

Wall ties can make a big difference to the U-value of masonry construction. The insulation thicknesses stated above assume that stainless steel vertical twist ties (or ties to British Standard DD 140-2:1987) have been used. Increased levels of insulation will be required in the case of mild steel wall ties. Plastic ties lose very little heat and so are ideal provided they have the required structural strength and fire performance.



Brick outer leaf, 110mm cavity filled with mineral wool, 115mm high performance insulating block (conductivity 0.11W/m²K) and plasterboard on dabs.

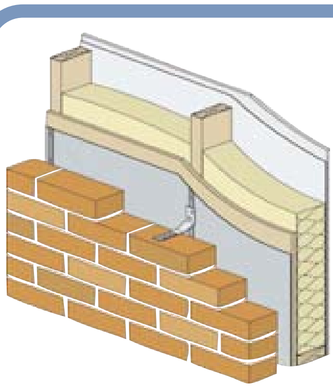
Figure 1: Full-fill



Brick outer leaf, 110mm cavity (50mm clear, 60mm rigid phenolic insulation), 115mm high performance insulating block (conductivity 0.11W/m²K) and plasterboard on dabs.

The phenolic insulation can be replaced by another insulation board, but this will affect the thickness of insulation required as well as the dimensions of other components such as wall ties and lintels.

Figure 2: Partial-fill



Brick outer leaf with 50mm cavity, timber frame panel compromising 170mm studs fully filled with mineral wool, a vapour control layer and plasterboard.

There are many different ways of insulating timber frames and suppliers are able to offer a variety of solutions to achieve the same U-value.

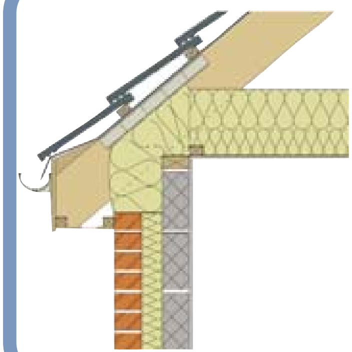
Figure 3: Timber frame

Plasterboard on dabs can lead to high air leakage rates; air can move freely in the gap between the plasterboard and the masonry wall to which it is attached. Perimeter sealing needs to be carried out correctly and so plasterboard on dabs should only be specified where close supervision can be guaranteed. Using plaster instead of plasterboard, or applying a scratch coat of plaster to the external walls before dry-lining, will reduce this problem substantially, although this will impact on the U-value of the wall.

All dwelling examples provided in this guide are assumed to have an air permeability of less than 3m³/h/m² at 50Pa (see *Post-construction testing* (GIR64)). This can only be achieved with good building techniques; Best Practice requires builders to pay close attention to detail.

Roofs (U-value of 0.13W/m²K required)

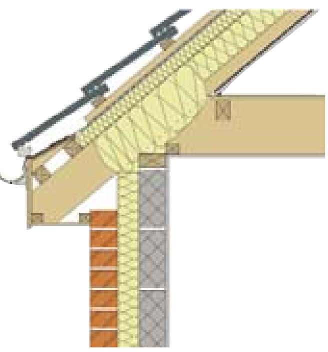
The examples in figures 4 and 5 use mineral wool, but equivalent thicknesses of cellulose insulation (recycled newspaper), or different amounts of insulating foam board can also be used depending upon the situation. Check with the supplier for more details.



100mm mineral wool between joists with 200mm overlaid.

Apply 50mm (minimum) of compressed mineral wool over the wall and ensure that loft insulation meets wall insulation.

Figure 4: Pitched roof with insulation between joists



200mm mineral wool between rafters, 50mm over rafters.

Tightly pack any gaps between wall insulation and roof insulation with mineral wool to limit air leakage.

Figure 5: Pitched roof with insulation between rafters

These examples illustrate full-fill masonry wall constructions, but similar principles apply for other wall types. For detailing for other wall constructions, see the references to Robust details on page 11 of this guide.

What are U-values?

A U-value is a measure of the overall rate of heat transfer under standard conditions, through a particular section of construction (units = W/m^2K). Lower U-Values indicate better thermal insulation. For example, a wall with a U-value of $0.4W/m^2K$ loses heat at half the rate of a wall with a U-value of $0.8W/m^2K$.

Floors (U-value of $0.20W/m^2K$ required)

Heat loss through the ground floor depends on the size and shape of the floor as well as the type and conductivity of the ground below.

Table 1 provides examples of the levels of insulation required (based upon typical expanded polystyrene insulation with a conductivity of 0.038W/mK) for ground floors built on even ground.

Table 1: Levels of insulation required for common types of ground floor construction (on even ground)

Typical dwelling	Floor type			
	Solid	Suspended concrete planks	Block and beam	Suspended timber (insulation between joists)
Ground floor flat or mid-terrace 1-2 bed (Perimeter/Area 0.27)	95mm	105mm	90mm	120mm
Semi-detached 2-3 bed (Perimeter/Area 0.45)	115mm	125mm	110mm	160mm
Standard detached 3 bed (Perimeter/Area 0.5)	120mm	130mm	115mm	160mm
Large detached 4-5 bed (Perimeter/Area 0.33)	100mm	115mm	100mm	150mm

Edge insulation will be needed where wall insulation does not continue beneath the level of the floor insulation (see Robust details on page 11). Homes built on sloping or uneven ground (such as staggered terraces) may require increased insulation thickness compared to the indicative values given in Table 1. For complex non-standard floor plans (not square or L-shaped), the U-value should be calculated first in order to determine the level of insulation required.

Treatment differs for heated and for unheated basements. For dwellings with unheated basements Table 1 can be used; for houses with heated basements, the U-values of both the floor and walls should be calculated.

Windows, doors and rooflights (area weighted average U-value of $1.8W/m^2K$)

Check the manufacturer's declared U-value for these products. A typical specification would include low emissivity glass, argon gas-fill and a minimum gap between glass panes of 12mm. Where the openings account for more than 25% of the total floor area, better U-values for windows, rooflights and doors will be required to achieve the Best Practice requirement.

Heating and hot water systems

There are several common ways of providing heating and hot water in dwellings. Best Practice can usually be achieved by installing a heating system to the specifications given below. However, some house types need particular systems to reduce carbon dioxide emissions to Best Practice levels.

Studying the examples in this publication should enable the most suitable heating system to be chosen.

Wet central heating provided by a boiler

It is currently Best Practice to install a condensing boiler; from April 2005 this will be a required standard in England and Wales. An 'A' or 'B' rated boiler achieves the required efficiency. *CHeSS – Central Heating System Specifications* (CE51) provides a full specification for installing a central heating system. This is summarised in Table 2.

Figure 6: Condensing boiler

Table 2: Best Practice requirements for wet central heating systems (from CHeSS)

	Regular boiler with separate hot water tank	Combi boiler or CPSU[4]
Efficiency	Any 'A' rated boiler.	Any 'A' rated boiler if fuelled by gas or LPG; if fuelled by oil, a 'B', or preferably 'A' rated boiler should be specified.
Hot water store	High performance hot water cylinder.	None – unless included within boiler.
Controls[5]	Programmable room thermostat with additional timing capacity for domestic hot water; cylinder thermostat.	Programmable room thermostat.
	TRVs on all radiators, except in rooms with a room thermostat; automatic bypass valve; boiler interlock.	
CHeSS specification	HR6 (2005)	HC6 (2005)

Choosing an efficient boiler
A list of Energy Efficiency Recommended 'A' rated boilers is available on www.boilers.org.uk. Alternatively, the Little Blue Book of Boilers can be obtained by calling 0845 727 7200. Both are regularly updated. The Energy Efficiency Best Practice in Housing website also provides tools and further information on financial savings and correct boiler sizing at www.est.org.uk/bestpractice/boiler

Electric heating

Storage heaters and dual immersion

Using off-peak appliances is a better option than relying solely upon instantaneous electric heaters, which generally have higher running costs.

Storage heaters, however, should not be preferred to systems such as a gas combi boiler as they have higher energy consumption and carbon dioxide emissions. Solar hot water panels or heat pumps should be considered where electricity is the only available fuel.

Where storage heaters and a dual immersion are to be specified:

- fan-assisted storage heaters should be fitted with 'automatic charge' or 'CELECT' type control. The system will then be accurately controlled and more responsive to the householder's needs
- dual immersions should be sized to provide adequate supplies of hot water; for a small household a 144 litre cylinder is recommended, but larger households should have 210 litres or more. They should have at least 50mm of spray foam insulation (80mm is preferable)

By following these recommendations, a householder's use of expensive on-peak electricity to supplement their heating and hot water requirements will be reduced. Further guidance on electric heating can be found in *Domestic heating by electricity* (GPG345).

What is CELECT type control?
CELECT is an independent central programmer that optimises the charging of individual storage heaters according to different temperatures set by the user.

Renewables

Other options that should be considered include:

Solar hot water

The addition of a solar hot water system will reduce carbon dioxide emissions and running costs and is particularly effective when the fuel used for water heating is electricity.

A solar hot water system uses the sun's energy, rather than electricity or gas, to heat water. The solar energy is harnessed using a 'collector' or 'panel' which comes in two forms: 'flat plate' and 'evacuated tube'.

In the examples given in this guide, solar hot water has only been considered with electric immersion systems because of the increased benefit in these circumstances. The examples, and savings, involve a $4m^2$ flat plate system.

Figure 7: Solar thermal panel

Ground source heat pump

A heat pump extracts heat from the ground, 'moving' energy from one place to another and from a lower to a higher temperature. It is essentially the same technology (in reverse) as a conventional domestic refrigerator.

[4] Combined Primary Storage Unit

[5] More advanced controls, such as weather compensation, may be considered, but at present cannot be confirmed as cost effective.

Electricity is normally used to bring the pre-heated water up to the demand temperature. An off-peak (or special 'heat pump') electricity tariff is therefore essential to achieve running costs generally equivalent to those of gas central heating.

Because a ground source heat pump extracts 'free' heat from the earth, a dwelling using this form of heating system will usually have lower carbon dioxide emissions, despite the supplementary need for electricity. See also the references to Renewable energy on page 11.

Ventilation

Passive Stack Ventilation (PSV), assisted Passive Stack Ventilation (aPSV), or whole-house mechanical ventilation (incorporating a heat recovery system of at least 70% efficiency) should be specified to provide adequate ventilation in an airtight house. *Energy efficient ventilation in housing* (GPG268) gives further guidance.

Lights and appliances

With an efficient heating and hot water system installed, the electricity used for lights and appliances makes up a greater proportion of total running costs.

To address this, Best Practice requires that Energy Efficiency Recommended (EER) appliances are specified – if these are to be provided by the builder. In addition, energy efficient lights must be installed in at least 80% of the rooms – and especially in the hall, living room, kitchen and landing. Dedicated lamp fittings taking a 'pin based' fluorescent lamp are to be used.

Low energy domestic lighting – looking good for less (CE81) gives further information on how low energy lighting can be both functional and attractive.

What is Energy Efficiency Recommended?

The Energy Efficiency Recommended logo endorses products that are amongst the most efficient available. The logo is awarded by the Energy Saving Trust.

The scheme currently covers appliances (washing machines, fridges, freezers, dishwashers and tumble dryers), light bulbs and fittings, gas and oil boilers, heating controls, loft insulation, cavity wall insulation, draught-stripping, external wall and dry-linings, and high performance hot water cylinders.

Look out for the logo at local retailers. There is a searchable product database at www.est.org.uk/myhome/efficientproducts

Reducing costs and impacts

The following recommendations will further improve the running costs and reduce the environmental impacts of the dwelling.

Water usage

Use appliances with low water consumption:

- WCs should consume a maximum of 4 litres
- showers should not deliver more than 8 litres/min
- installed washing machines should use less than 50 litres per wash
- dishwashers should use less than 16 litres per wash

Avoid 'dead legs' in piping where possible. Where these do occur, they should not contain more than 1.5 litres of water (a maximum run of 10 metres of 15mm copper pipe). In systems using mains pressure hot and cold water, outlets should be fitted with dynamic flow regulators.

Post-construction testing

Carry out a pressure test of the property to search for air leakage. See *Post-construction testing* (GIR64) for further information.

Further considerations

Advanced standard

CE12 and CE24 describe an 'advanced' specification for builders wishing to address sustainability issues and further reduce environmental impacts beyond Best Practice.

Communal approaches

Larger developments could include alternative means of space heating and hot water supply, such as group heating arrangements. The government's Community Energy programme (jointly managed by the Energy Saving Trust and the Carbon Trust) offers advice and support for Community Heating schemes across the UK. For more information call 0870 850 6085 or visit www.est.org.uk/communityenergy.

Green materials

The *Insulation materials chart – thermal properties and environmental ratings* (CE71) provides environmental ratings for common insulation types.

Increased use of renewables and other emerging technologies

Some renewables have been considered in this guide, such as solar hot water and heat pumps. Once improvements have been carried out to Best Practice standards, other options could be considered as well, such as photovoltaics and small-scale wind power.

Many new technologies are becoming available such as Micro-CHP (Combined Heat and Power); this is a small domestic boiler capable of providing heat, hot water and electricity.

A wood pellet boiler or room heater will provide heating with very low carbon dioxide emissions, and may be particularly appropriate for properties off the gas network.

EcoHomes
EcoHomes, sponsored by NHBC, is a straightforward, flexible and independently verified environmental assessment method, with environmental performance expressed on a scale of Pass to Excellent.

It is an easily understood, credible label for new and renovated homes, including houses and apartments. EcoHomes rewards developers who improve environmental performance through good design, rather than via high capital-cost solutions.

Best Practice examples

Different heating arrangements and house types are considered here. On the charts, the part of the bar in blue represents savings achievable from using Best Practice standards.

The use of solid fuels, LPG and bottled gas has not been considered in this simplified guide. They are generally more expensive than mains gas or oil, although LPG has less environmental impact. The examples do not have any secondary heating.

For the purposes of this guide, the savings have been assessed against Building Regulations 2000, Approved Document Part L1 – Conservation of Fuel and Power in dwellings, 2002 edition.

Flats and maisonettes

Figure 8: Flats and maisonettes

Flats and maisonettes generally use less energy and have lower running costs than houses. This is primarily because there is a smaller area to heat and fewer occupants. The majority of running costs will typically be attributable to lights, appliances and hot water use. However, the choice of heating system still has a large effect on running costs and carbon dioxide emissions.

Highly exposed flats, eg. those located over driveways or similar situations, will generally require additional energy efficiency measures when electric heating is specified.

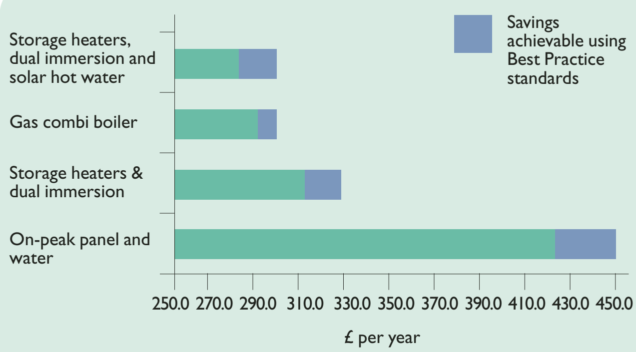


Chart 1: Typical flat (55m^2) running costs

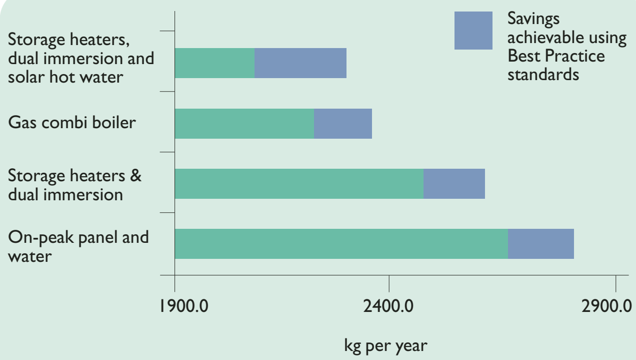


Chart 2: Typical flat (55m^2) CO_2 emissions

Terraced, semi-detached and detached town house dwellings

The Best Practice requirement for a terraced, semi-detached and detached/town houses will be met without any great difficulty by following the specifications on pages 9 and 11.

Figure 9: Terraced house

Figure 10: Semi-detached house

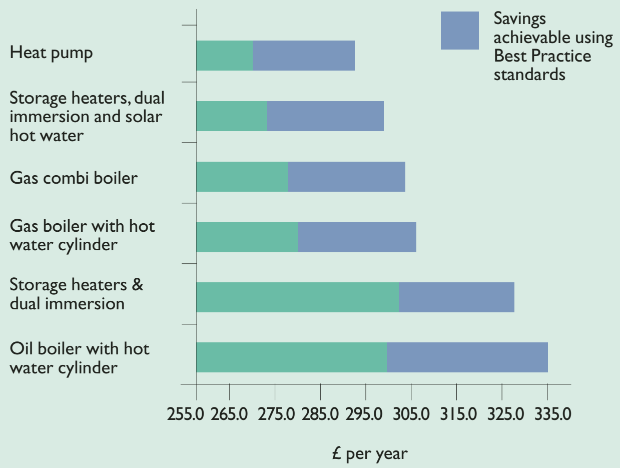


Chart 3: Typical mid-terrace (60m²) running costs

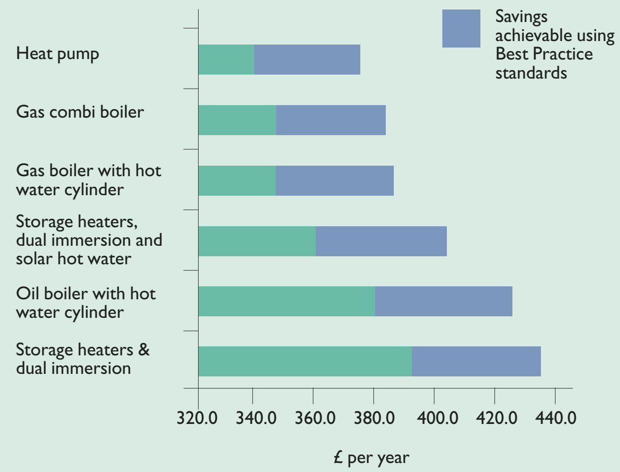


Chart 5: Typical semi-detached (90m²) running costs

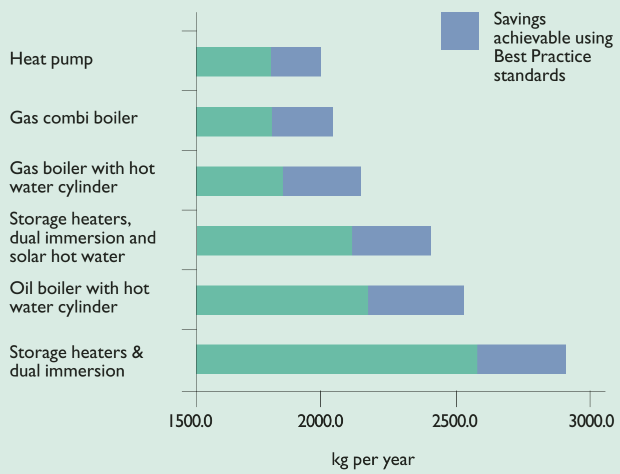


Chart 4: Typical mid-terrace (60m²) CO_2 emissions

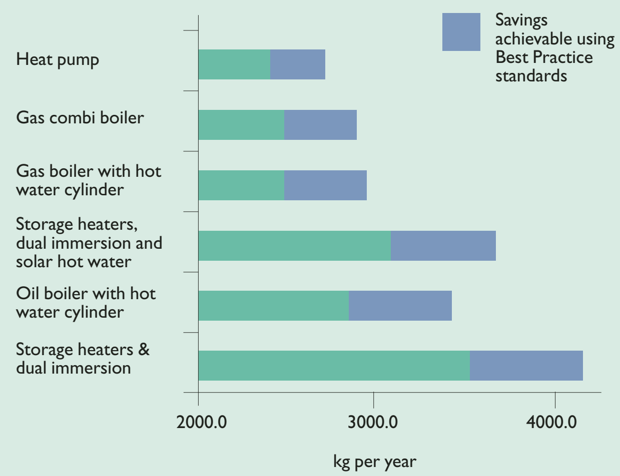


Chart 6: Typical semi-detached (90m²) CO_2 emissions

Figure 11: Detached or town house

A town house or detached dwelling will normally have a higher hot water demand than a semi-detached or mid-terrace – so the use of a combi boiler has not been considered here.

A combination of storage heaters, a dual immersion and a solar hot water panel has running costs similar to an oil boiler system, but the higher CO_2 emissions are not desirable.

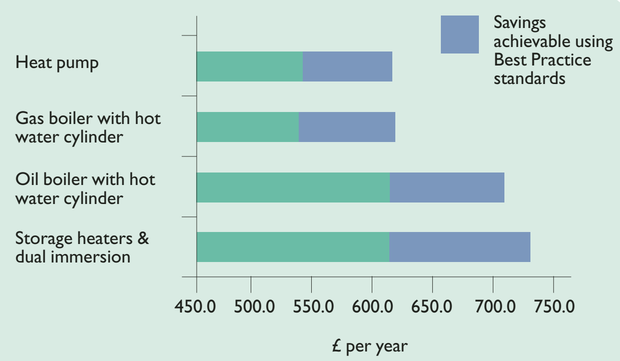


Chart 7: Typical detached 3 storey (130m²) running costs

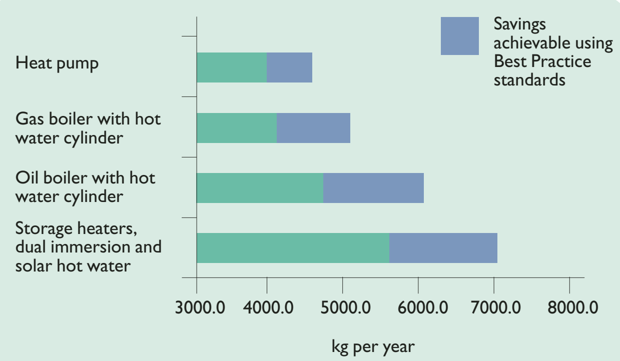


Chart 8: Typical detached 3 storey (130m²) CO_2 emissions

Figure 12: Detached luxury house

A luxury detached house would normally be built on a large plot of land, possibly away from a gas main.

Installing a heat pump would be the best overall option. If mains gas is not available then an oil boiler is also a suitable heating system.

The use of solid fuel, LPG and bottled gas in large homes should be avoided where possible because of their high running costs.

The use of storage heating, even with the addition of a solar hot water panel, would result in very high carbon dioxide emissions for such a large dwelling, and thus is not preferred.

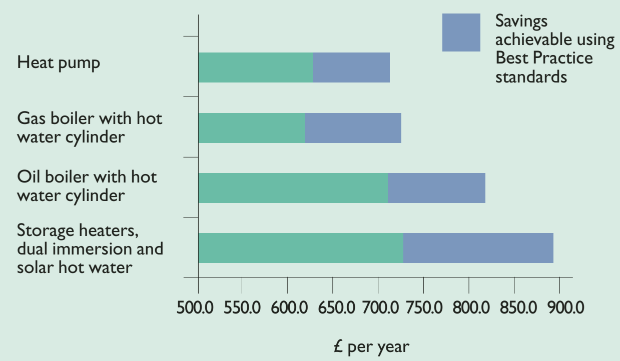


Chart 9: Typical large detached (230m²) running costs

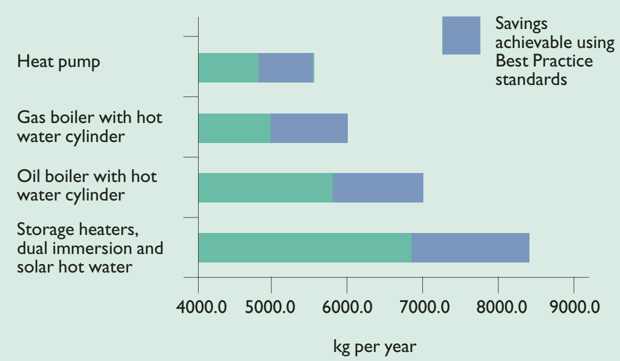


Chart 10: Typical large detached (230m²) CO_2 emissions

References

Energy Efficiency Best Practice in Housing

These publications can be obtained free of charge by telephoning the Helpline on 0845 120 7799 or by visiting the website at **www.est.org.uk/bestpractice**

General new build

Energy Efficiency in New Housing: Summary of Specifications for England, Wales and Scotland (CE12)

Energy Efficiency in New Housing: Summary of Specifications for Northern Ireland (CE24)

Benefits of Best Practice: Heating and Insulation (CE11)

Passive solar house designs – the Farrans study (GIL25)

Insulation

Effective use of insulation in dwellings: A guide for specifiers and contractors (CE23)

Insulation materials chart – Thermal properties and environmental ratings (CE71)

Heating and hot water

Domestic heating and hot water – choice of fuel and system type (CE49)

CHeSS – Central Heating System Specifications (CE51)

Domestic central heating and hot water: Systems with gas and oil-fired boilers – guidance for installers and specifiers (CE48)

Domestic heating by electricity (GPG345)

Lighting

Low energy domestic lighting – looking good for less (CE81)

Glazing

Windows for new and existing housing: A summary of Best Practice (CE66)

Ventilation

Energy-efficient ventilation in housing: A guide for specifiers on the requirements and options for ventilation (GPG268)

Renewables

Renewable energy sources for homes in urban environments (CE69)

Renewable energy sources for homes in rural environments (CE70)

Post-construction testing

Post-construction testing – a professional's guide to testing housing for energy efficiency (GIR64)

Further reading

Robust details

Limiting thermal bridging and air leakage: Robust construction details for dwellings and similar constructions (The Stationery Office)

Robust detail drawings are also available on-line:
www.est.org.uk/bestpractice/robustdetails

Energy and environmental ratings

EcoHomes
Tel: 01923 664462
Web: www.bre.co.uk/ecohomes

National regulations

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

The Building Standards (Scotland) Regulations 1990, 6th amendment, Technical standards to Part J, Conservation of fuel and power.

Building Regulations (Northern Ireland) 2000, Technical booklet F, Conservation of fuel and power (December 1998)

Images on the cover and in the examples are kindly supplied by Bryant Homes Ltd (Taylor Woodrow).

Energy Efficiency Best Practice in Housing

CE95

Best Practice in new housing – a practical guide

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