TEHVA
The Electric Heating & Ventilation Association

DOM 8: GUIDE TO THE DESIGN OF ELECTRIC SPACE HEATING SYSTEMS

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Introduction

Electric heating is clean, quiet in operation and requires no regular maintenance. Over the years, electric heating has generally been understood to comprise a combination of both a storage component and a direct acting component, with the storage heating forming the base load and direct acting heating forming the finer adjustment for close control of the required temperatures. Direct acting heating also provides the heat required in rooms with no storage heating. As insulation levels have steadily improved over the years, primarily due to the requirements of Building Regulations, so manufacturers have developed more sophisticated heating equipment and, particularly, its control.

The primary application for electric heating is for decentralised systems, which are ideal for accurate zone control. If it is so desired, each room could be treated as a separate zone, and so could be controlled individually; such is the flexibility of electric decentralised systems. Customers, however, do not usually request this level of control, at the present time.

In existing dwellings, where the levels of thermal insulation are not usually up to current Building Regulation standards, the most common system to install is the system generally associated with electric heating, namely storage in the main living areas and hall and direct acting in bedrooms, kitchen and bathrooms. If major refurbishment is being undertaken, other systems can be considered, such as under floor heating, for both storage and direct heating, or ceiling heating as the direct component. With these systems, if the procedures in this guide are followed, 90% of the heating energy should be provided at the off-peak rate and just 10% at the on-peak rate. As a general rule, all homes must always be well insulated if electric heating is to be installed.

In new dwellings, which are necessarily built to very high standards of insulation, systems defined by the Government's Standard Assessment Procedure (SAP) as integrated systems offer great advantages. At present two systems are recognised by SAP as having the necessary parameters to qualify. These systems are a storage heater system with radiant panels built in and which are controlled as a single unit, and under floor heating with elements providing both off-peak and on-peak heating, again controlled as a single unit. Integrated systems are designed to use at least 80% of the heating energy at the off-peak rate and no more then 20% at the on-peak rate.

In new, smaller dwellings, as the energy requirement can be very low, direct acting heating alone is often used. Direct acting systems generally use less energy than storage based systems and consequently produce lower carbon emissions. Even though direct acting heating does not use storage, it is usual for an off-peak tariff to be used in the home, primarily for the hot water; see DOM 9:Guide to the Design of Electric Hot Water Heating: 2006. It has been found that around 35% of the energy used in a direct acting heating system is generally used on the off-peak rate by householders.

Electric centralised systems are available, if required, as there is a demand for radiator systems. These systems include electric flow boilers, CPSUs (combined primary storage units) and air to water heat pumps, however these systems are not within the scope of this guide although guidance is given later to references where further information can be obtained.

This brief guide considers systems that comprise the three types of system mentioned above, namely traditional storage/direct systems, integrated storage/direct systems and direct acting systems.

This guide deals with the *principles* of the design of electric systems but focuses on the sizing of the systems rather than detailed system design guidance.

For detailed design guidance, particularly with under floor heating and ceiling heating, it is essential that the manufacturer is fully involved throughout the design process. The guide is intended for use once the decision for a particular type of heating system has been taken; it is not intended to be used as a process in order to arrive at that decision. However, some advantages of the various heating systems have been outlined which could influence choice.

Principles of Storage Based Heating Systems

Storage heating is charged during off-peak hours when the cost of electricity is substantially lower than at other periods. Typically electricity suppliers offer a 7-hour night tariff and some also offer other periods of off-peak supply during the day, however, these can vary between suppliers, so the off-peak availability should always be taken into consideration when sizing a system or when changing energy supplier. In sizing storage heating systems in this guide a 7-hour off-peak period has been taken as the norm.

The principle of sizing storage heating entails calculating the 24-hour heating requirement of a room on a design day, taking into account:

- the heat loss of the structure
- the air infiltration loss
- the effectiveness of heat gains to the room
- the heating period
- the thermal mass of the structure (ie whether it is timber framed or building block construction)
- the approximate percentage of direct acting required for both economic considerations and accurate control.

The heat loss of a room will always need to be calculated and this is dealt with later in the guide together with guidance on limiting U-values required to comply with current Building Regulations. In order to evaluate the effectiveness of heat gains, the variation in infiltration rates in various structures and the required heating period, a series of factors have been derived from extensive field measurements. These are known as 'z' factors and are presented in Table 1. The z factors will vary from room to room, as the heat gains vary depending upon the use. As the level of insulation increases the heat loss of the room will drop and the effect of heat gains will become more, thus reducing the z factor.

Storage based heating systems are designed typically to provide between 80 and 100% of the room heating requirements for the season. Factors for the calculation of the percentage of on-peak energy required, known as the 'y' factor, are given in Table 2.

The y factors are the relationship between design day stored energy and the seasonal day energy. The y factors have been derived empirically from data collected over a number of years from field trials.

The formula for living areas is:

$$\text{Design day \% (y)} = 1 - 0.06\sqrt{SD}$$

Where SD is the seasonal day percentage required

The formula for halls and bedrooms is:

$$\text{Design day \% (y)} = 1 - 0.10\sqrt{SD}$$

Where SD is the seasonal day percentage required

Table 1 – Values of z for storage heating systems

	Dwelling insulation standard		
Room	**50 W/m²**	**35 W/m²**	**25 W/m²**
Living room	0.70	0.50	0.42
Dining room, study	0.75	0.60	0.60
Kitchen-diner	0.50	0.40	0.34
Hall/landing	0.45	0.36	0.30
Bedroom	0.80	0.64	0.54

Notes
1. *For timber framed dwellings, reduce z factors by 0.05 in each case*
2. *z factors for the hall/landing appear low due to the relatively high design air change rate (1.5 ac/hr) allocated to this area. The average over 24 hours is much lower, thus influencing the magnitude of the z factor.*

Table 2 – Values of y

Seasonal day energy, %	Proportion met by storage on a design day, y	
	Living and dining rooms	Hall and bedrooms
0	1.00	1.00
5	0.87	0.78
10	0.81	0.68
15	0.77	0.61
20	0.73	0.55

This necessarily means that on very cold days a higher proportion of direct acting heating will be needed to maintain comfort temperatures. It should also be remembered that some of the direct acting energy would be provided during the off-peak periods as well, thus contributing to the overall seasonal off-peak energy usage.

Storage systems are not recommended for dwellings with chimneys, unless the chimneys have an effective restrictor fitted, because of the substantial amount of heat that can be lost to the atmosphere. The effect of chimneys is shown in Table 3.

The simple formula for calculating the 24 hour heat requirement (kWh) for each room is therefore: **24Hzy + c,**

where:
H is the design day heat loss in kW
z is the heat gain and infiltration factor
y is the seasonal on-peak energy factor
c is the allowance for chimneys

An additional allowance is required to account for the warm air drift from rooms with storage heating to the rooms without storage heating. This allowance is to be added to the hall storage heating requirement in homes with cellular rooms, and to the storage heating requirement in the room from which the stairs rise in an open plan home. In two storey homes the warm air drift is 50% of the heat requirement of rooms opening onto the hall and landing. In single storey homes the allowance is 25%.

If the storage component is provided by under floor heating, then an allowance must be included for the additional small amount of heat that is lost downwards through the floor.

Table 3 – Allowance for heat lost through chimneys

Chimney restrictor	Outside air vent into room with chimney	Value of c, kWh		
		Living room with chimney	Hall	Total
No	Yes	8	4	12
Yes	Yes	6	2	8
No	No	2	2	4
Yes	No	1	1	2

Note: *For open-plan dwellings with a chimney, the total allowance is added to the living room heater.*

Storage Heaters with Direct Acting Heating

General approach

A typical system comprises storage heaters in the living room and dining room to provide the majority of the heating, with a focal point fire, panel heater or other direct acting component, for top-up comfort, as required. As the living room is generally the most used room in a dwelling, the storage is usually sized to provide 95% of the seasonal heat requirement. A storage heater in the hall provides the heat required there plus a general background level of heating in the upstairs rooms (warm air drift). Direct acting heating in the upstairs rooms can then give full comfort when required. In larger bedrooms a storage heater may also be required, but because bedrooms are occupied primarily at night, direct acting heating is generally more appropriate. Systems designed on these principles should consume around 90% of the electricity for heating on the off-peak rates.

An alternative to storage heaters and separate direct heating, is a combination storage heater which incorporates a direct acting convector heater so, if panel heaters are used as the supplementary heat source, a saving can be made on wall space. A further alternative, particularly if the dwelling is unoccupied during the day, is a fan storage heater. Storage fan heaters lose approximately 50% of their heat through their casing and the remaining 50% is available on demand through the use of the fan, which can be timed, or switched, to suit the householders' requirements.

Positioning of heaters

In normal domestic circumstances, where possible, heaters would be placed at the point of greatest heat loss, generally under the windows. However, in well insulated dwellings, it is far less critical and heaters can be placed away from windows and the inconvenience of restrictions caused by curtaining, they are then best sited on an internal wall but adjacent to an external wall, where possible, in order to minimise heater "back-losses".

Sizing

The sizing of storage heaters for individual rooms is calculated by the formula for the design day energy required, namely 24Hzy + c.

The sizing of direct acting heating is not an energy calculation so all that is required is to include an 'overload factor' to be applied to the design heat loss in order to allow the room to heat up from cold in a reasonable time. For lightweight structures, such as timber frame, the factors are low, but for heavier structures, such as blockwork the factors are higher as the structures themselves require heating. Simple guidance is given in Table 4.

Controls

As the function of storage heaters is to store energy to be used later in the day, the controls necessarily need to have an anticipatory element to them. The most basic controls are of the manual type incorporated within a storage heater. The householder, based on his assessment of the next day's heat requirements, sets the amount of charge required for each heater. However, manual controls would only be used in existing systems, new systems demand more energy saving controls.

An automatic charge control can be incorporated into storage heaters, which senses the rate of change of the internal temperature, which is largely dictated by the external temperature, but is also affected by other factors, such as the thermal mass and the insulation standard. When the temperature falls to a predetermined level, the storage heater will commence being charged. These controls can save up to 15% of the seasonal heating energy when compared to a manual control. Controls can also be supplemented by an external weather sensor, which tends to act as a limiting device to prevent the storage heaters from overcharging.

Central control systems can also be installed, which will control both the storage and direct acting components of the system. These have the advantage of being able to select heating times and temperatures in each room from a single central point. One method of control controller is the Celect central control.

Celect is the generic name for a smart centrally controlled system for electric space heating. It uses two-way mains signalling technology, utilising the existing mains wiring to link between dedicated heaters and the controller. There is no need for additional signal wiring. A continuous electricity supply is all that is needed for the controller.

The controller manages three individual areas or zones within each dwelling. Each zone can be programmed individually for multiple daily heating periods and temperature settings. By programming separate heating periods and temperature profiles for each zone, energy usage can be optimised for each weekday.

Heaters suitable for use with Celect control normally include integral transceivers to communicate with the controller. Additional control circuitry and sensors determine both the characteristics of the room and the pattern of the restricted hours supply, allowing the individual heaters to adjust the ratio of the on and off-peak consumption in response to the time/temperature profile programmed into the controller. The level of charge taken is determined from a rolling historic analysis of the system behaviour. Celect control is compliant with Part L of the current Building Regulations.

A typical Celect system would consist of a mixture of fan storage heaters, combination storage heaters and panel convector heaters, managed by a central controller. Celect type controllers are recognised in SAP and granted a grade higher responsiveness and, if fitted with storage fan heaters, the responsiveness is equal to that for integrated storage/ direct systems.

Table 4 – Overload factors for direct acting heating in a storage heated dwelling

Room	Overload factor		
	Masonry construction	New masonry construction	Timber frame construction
Rooms with a storage heater	1.0	0.9	0.8
Kitchens (no storage heater)	1.2	1.0	0.9
Rooms without a storage heater	1.5	1.1	0.9

Note: If the direct acting heating is provided by ceiling heating, then an allowance must be included for the small amount of additional heat lost upwards through the ceiling.

Integrated Storage/Direct Systems

In new dwellings, which are necessarily built to very high standards of insulation, two systems are recognised by SAP as having the necessary parameters to qualify as integrated systems. In recognising these systems, SAP allocates them a higher category of responsiveness within its calculation process when assessing SAP ratings and carbon emissions. The two systems are a storage heater system with radiant panels built in and which are controlled as a single unit, and under floor heating with elements providing both off-peak and on-peak heating, again controlled as a single unit. Both systems are designed to use at least 80% of the heating energy at the off-peak rate and no more then 20% at the on-peak rate.

Integrated storage/direct systems have the advantage of being able to balance the use of off-peak and full rate electricity for maximum economy and more accurate temperature control. The integrated control of both storage and direct acting elements allows the direct element to be sized to a capacity somewhat lower than that recommended in Table 4.

Integrated storage/radiant heater systems

The principle of system design for integrated storage/radiant heater systems is similar to that for other storage based systems, namely that direct acting heating would usually be provided on the first floor of a dwelling, with integrated units generally being installed on the ground floor.

Controls

Controls for storage heating are necessarily predictive, as they need to ensure that the correct amount of energy is stored for the following day's use. Room temperature control is achieved by the use of an integral adjustable electronic room thermostat controlling the operation of the direct acting radiant panel. The input charge for the storage component is controlled by an adjustable electronic room temperature sensing thermostat with an external temperature sensor, which will limit the charge in relation to room temperature during the off-peak period. Alternatively a central controller can be used to provide mains borne or pilot wire signaling so that the radiant panel can be time and zone controlled. A thermal control device limits surface temperature of the radiant component to 75°C for safety reasons.

Integrated under floor heating

Under floor heating is not an 'off the shelf' product and it is essential that the manufacturer is fully involved throughout the design and installation process. Under floor heating has the advantage of taking up no wall space, particularly if the direct acting component is also installed under the floor or in the ceiling, thus allowing complete freedom with internal design. Permanently located furniture, such as kitchen cabinets, must be taken into account and should not be considered to be part of the active floor area under which the heating elements will be installed.

Under floor heating is a low temperature radiant heating system and provides even heat emission because of the large surface area utilised, resulting in low vertical temperature gradients and good comfort conditions.

The level of thermal insulation in under floor heating systems for ground and exposed floors needs to comply with current Building Regulations. These floors are required to have an R-value of not less than 0.5m^{2}K/W. The screed thickness for a direct heating system must be no more than 50mm, although the usual screed thickness used is 40mm, which provides a reasonable heat up period. When under floor heating is laid within a wooden floor construction to operate as direct heating, it has been allocated as a system with maximum responsiveness in the Government's Standard Assessment Procedure (SAP).

When installing under floor heating in a bathroom it is essential to protect the system from the ingress of water. Installing a continuous metal sheath and an earth wire will comply with regulations. Cables should comply with IEC 8000, the relevant reference in the Wiring Regulations is 601-09-04.

In two storey dwellings under floor heating can be installed both in the ground floor and in the first floor. The ground floor will be primarily storage, while the first floor will be primarily direct acting. Where floor warming is used as a storage system, the minimum screed thickness of 65mm is applicable to a 10-hour off-peak charging period, whereas for a 7-hour off-peak charging period a 75mm screed thickness would be more appropriate. For a direct heating system, the screed thickness must be no more than 50mm; the usual screed thickness used is 40mm, which provides a reasonable heat up period. When under floor heating is laid beneath wooden flooring, to operate as direct heating, it is classified as a very responsive system.

Controls

The controls for under floor heating systems again are predictive. Because the floorwarming load can be matched very closely to individual room requirements, an external temperature sensing controller is recommended. However, in early autumn and late spring, when there can be large temperature fluctuations between day and night, it is often recommended that the external control is switched off to avoid the risk of over-charging, and the small amount of heat required on those days can be provided by the direct acting component. As with the integrated storage heater and direct acting system, the control of the integrated floor warming system provides economies with both the total amount of heating energy used and the proportion of off-peak energy provided. Current Building Regulations specify the minimum level of control required, depending upon the specification of the under floor heating system.

Direct Acting Heating Systems

In new, smaller dwellings, as the energy requirement can be very low, direct acting heating alone can be used very effectively. Direct acting systems invariably use less energy than storage based systems and consequently produce lower carbon emissions. Even though direct acting heating does not use storage, it is usual for an off-peak tariff to be available in the home, primarily for the hot water usage. It has been found that around 35% of the energy used in a direct acting heating system is generally used on the off-peak rate by householders.

Direct acting systems are very well suited for new apartments, particularly those where the occupants are out at work during the day. If a home is very well insulated, the amount of heating energy required can be very small, and the fact that a kWh of on-peak electricity is more expensive than off-peak is not of any real significance, as the actual difference in total cost will generally be small.

Table 5 – Overload factors for direct acting heating

Room	Overload factor		
	Masonry construction	New masonry construction	Timber frame construction
Living rooms	1.7	1.5	1.2
Kitchen	1.5	1.3	1.1
Bedrooms	1.5	1.3	1.1
Hall	1.5	1.3	1.1
Bathrooms (when required)	2.0	2.0	2.0

Notes: Smaller bathrooms frequently have a manually controlled warm air heater installed, relying on heat from the hall to provide background heating. The warm air heater provides very rapid response to heat demand.

In direct systems the overload capacity required to provide a reasonable heat-up period will be higher than those required for direct acting heaters when installed in conjunction with storage heating (Table 4), because in a direct acting system the heaters will have to heat a room up from cold. A table of overload factors required is given in Table 5.

The direct acting heating systems or products in this guide include:

a) Panel heaters
b) Ceiling heating
c) Under floor heating
d) Feature fires

The principles of sizing the first three systems are similar, although they each have their own particular qualities and requirements. Feature, or focal point, fires are dealt with separately.

Panel heaters

The advantage of panel heaters is that they are arguably the cheapest and most simple system to install. They are light, easy to position and, like the majority of electric systems, need little or no maintenance. They are available in a wide range of capacities, being able to match the room heating requirements very accurately. Their responsiveness to control means that, even if the size of the heater has been over-estimated, there will be no penalties in terms of inefficiency.

Panel heaters - Controls

Controls for panel heaters can be as simple as integrated timers and thermostats in each heater. Alternatively, they can have a central control which will enable the householder to control heating times and comfort and set-back temperatures from a convenient central point. There is no limit to the number of separately controlled zones required.

Ceiling heating

Like under floor heating, ceiling heating is not an 'off the shelf' product and, again, it is essential that the manufacturer is fully involved throughout the design and installation process. Ceiling heating also has the advantage of taking up no wall space, thus allowing complete freedom with internal design. Ceiling heating provides even heat emission because of the large surface area utilised. It is a radiant heating system and its low surface temperature helps maintain an even temperature gradient between floor and ceiling, providing a good level of comfort. It is essential that the area above the ceiling heating element is very well insulated in order to minimise the heat lost upwards.

The amount of heat lost upwards should be added to the design heat loss when calculating overload factors in Tables 4 and 5.

Ceiling Heating - Controls

One of the advantages of ceiling heating systems is that it is easy and relatively economic to have individual room temperature control. If required, an individual room timer control can also be provided, however this is usually unnecessary as zone control is generally sufficient. The controls for ceiling heating provide accurate and rapid response of the system to changes in temperature or heat gains. They include thermostats in each room with central, zoned timeswitches and setback control (for use overnight or for periods of absence from the home) and again should be discussed with the manufacturer. For greater accuracy of control, electronic thermostats are recommended, which provide much closer temperature control in a space, when compared with the cheaper bimetallic thermostats.

Under floor heating

When under floor heating is used as a direct acting heating system, the screed thickness must be no more than 50mm, although the usual screed thickness used is 40mm, which provides a reasonable heat up period. As stated previously, it has the advantage of taking up no wall space, allowing great flexibility with internal room design. Like ceiling heating, under floor heating is a low temperature radiant heating system and provides even heat emission because of the large surface area utilised, resulting in low vertical temperature gradients and good comfort conditions.

It is essential that the floor is very well insulated in order to keep to a minimum the heat lost downwards. The heat loss through the floor should be added to the design heat loss when calculating the overload factors in Tables 4 and 5. It should be remembered that when under floor heating is laid beneath wooden flooring to operate as direct heating it has been allocated as a system with maximum responsiveness in the SAP.

Under floor heating – Controls

Individual room temperature control would generally be provided, however where adjacent rooms are inter-dependent such as bedrooms and en-suite bathrooms, or kitchens and utility rooms, one thermostat could, as a minimum, be sufficient for both rooms and would be located in the most used room. For greater control, and to reflect householders' requirements, it is more usual to install separate thermostats, particularly where the temperatures of the rooms are different such as bedrooms and en-suite bathrooms. For greater comfort set-back temperature control, for use overnight or for periods of absence from the home, are recommended. Timed zone control, with as many zones as is practical or required, can be located at a convenient central point within the home.

Feature fires

Feature fires, as the name suggests, are used primarily to provide a focal point in a room. They also provide heat either to supplement a storage heating system on particularly cold days or when the main heating system is not in operation. There is a wide range of designs of feature fires including look-alike solid fuel burners, look-alike wood/coal fires and electronic representation of flames.

Electric Centralised Systems

Electric centralised systems are available, if required, as there is a demand for hot water radiator systems. These systems include electric flow boilers, CPSUs (combined primary storage units) and air to water heat pumps, however these systems are not within the scope of this guide.

Installation and Operating Costs

Decentralised heating systems are almost always cheaper to install than centralised systems, but it could be misleading to provide any definitive advice as so much depends upon the particular circumstances of the installation. The costs could vary considerably in relation to the age of the home, how well it is insulated and who is carrying out the installation. Costs in city centres are likely to be higher than those in rural areas. For guidance on comparative costs see the GPG 345; Domestic Heating by Electricity: 2006.

Operating costs can also vary considerably, depending on the energy supplier, the tariffs available and the method of payment selected for the energy supplied. The accuracy of running cost comparisons is also subject to sudden changes in world market value for oil and gas which, in turn, affects electricity prices, although not so immediately.

Table 6 – Recommended design temperatures and infiltration rates

Room	Room air temperature °C	Air changes per hour	Infiltration heat loss factors W/m²K
Living room	21	1	0.33
Dining room	21	1	0.33
Study	21	1	0.33
Kitchen/diner	21	1.5	0.50
Kitchen	18	2	0.67
Hall	18	1.5	0.50
Landing	18	1.5	0.50
Bedroom	18	0.5	0.17
Bathroom	22	2	0.67
Cloakroom	18	2	0.67

Design Heat Loss Calculations

General

The design heat loss of a dwelling is calculated using details of the building construction, individual room sizes, temperatures to be maintained and rates of air change. The design heat loss has two main component parts – fabric heat losses and infiltration heat losses.

Fabric heat losses are due to the transmittance of heat by conduction through the various elements of the building structure; windows, walls, roof and floor.

Infiltration heat losses are due to warm air from within the home escaping to the outside.

Design Temperatures

The design internal temperatures to be used when calculating the design heat loss are shown in Table 6. The design external temperature is traditionally taken at –1°C although some designers are tending to use –3°C. The value applies throughout England and Wales and is simply a standard figure for design purposes, not a heating limit.

Heating systems sized in accordance with this guide can cope on days colder than -1°C, but on very cold days the proportion of direct acting heating would be greater.

For a living room the temperature difference to be used when calculating the heat loss through infiltration and through the fabric is 21-(-1)=22K, while for a bedroom the difference is 18-(-1)=19K.

In homes intended specifically for the elderly, the recommended design temperatures are 22°C in the bathroom and 21°C in all other rooms.

Fabric Heat Loss

The rate at which heat is lost through the fabric depends upon its construction and the temperature difference between inside and outside air. For each element of a building there is an overall coefficient of heat transmission. This is called the U-value and indicates the steady state heat transmission through a unit area of building fabric for unit temperature rise. The units for U-value are W/m2K. U-values must be calculated using the methods and conventions set out in BR 443, "Conventions for U-value calculations".

According to the current Building Regulations, the limiting U-value standards for new homes are shown in Table 7.

To determine the heat loss through a surface the U-value is multiplied by the surface area and by the design temperature difference, the answer being in Watts. The total fabric heat loss for a room is the sum of the individual losses for each surface (wall, window, floor and roof). Within the dwelling there are losses or gains through the fabric where adjoining rooms are at different temperatures. This does not alter the total heat loss of the dwelling, only the individual heat losses of the rooms (and therefore possibly the heater size). For the design heat loss calculation it is assumed that there is no heat loss or gain through party walls to an adjoining dwelling, however there may be specific instances where an allowance is made, and this would be left to the discretion of the designer depending upon the particular circumstances. Losses to an attached garage, common stairways or other unheated spaces should, however, be included. Temperatures in these areas are usually assumed to be 5°C.

Infiltration

The heat loss due to natural infiltration is the product of the room volume, number of air changes per hour, temperature difference and the specific heat of air (usually taken as 0.33 W/m3K). In practice it is convenient to use an 'equivalent U-value' which is the product of air change rate and the specific heat of air; for example, an air change rate of 1.5 per hour would give an equivalent U-value of 1.5 x 0.33 = 0.5. So to find the heat loss due to infiltration it is necessary only to multiply the volume of the room by the equivalent U-value and by the design temperature difference, the answer being in Watts. Table 6 shows the design air change rates for heat loss purposes.

These design air change rates should always be used when calculating the design heat loss. The effect on actual air change rates due to a number of factors, including the way a home is used by the occupants, is taken into account in the z factors.

Severe Exposure

Where dwellings are situated on exposed hillsides, on or close to the coast, or are flats above the fifth floor in suburban areas and above the ninth floor in a city location, the exposure is considered to be severe. In this case the individual room heat losses should be increased by a factor of 1.15. This will take into account the increase in both fabric and infiltration heat loss. This factor is to be used only in the case of genuinely exposed locations as described above and should not be used as a general safety factor.

Table 7 – Limiting U-value Standards (W/m²K)

Element	Area-weighted dwelling average	Worst individual sub-element
Wall	0.35	0.70
Floor	0.25	0.70
Roof	0.25	0.35
Windows, roof windows, roof lights & doors	2.20	3.30

References

DOM 9; Guide to the Design of Electric Hot Water Heating: 2006
TEHVA, Westminster Tower, 3 Albert Embankment, London SE1 7SL
Tel: 020 7793 3008

GPG 345; Domestic Heating by Electricity: 2006
Energy Efficiency Best Practice in Housing, Energy Saving Trust
Tel: 0845 120 7799

BR 443; Conventions for "U-value Calculations"
BRE, Garston, Watford, WD2 7JR
Tel: 01923 664000

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