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Determination of thermal insulation properties of buildings and structures’ external envelope using infrared thermal imaging.

RONALD FREND

A thesis submitted to the University of Huddersfield
in fulfilment of the requirements for
the degree of Master of Science

The University of Huddersfield

October 2011
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I would like to thank professor Andrew Ball for his insistent support to get this project started and for his ongoing assistance and guidance.

I would also like to give especial thanks to my wife who has stood by and deflected the many potential distractions while keeping me provided with hot tea and unconditional understanding.
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Abstract

The primary thrust of this study is to quantify the thermal properties of the various components in the building structural and insulation envelope; to that end the heat flux through the structural envelope must be quantified. If one assumes zero mass flow through the envelope then all heat lost from the building is in the form of radiation and a combined convection/conduction at the external surfaces.

This study identifies methods of quantification of heat flux through building thermal envelope components in terms of conductive, convective and radiative heat transfer. Each type of heat flux is considered in sufficient depth to allow quantification and development of models to be used in a database with a graphical user interface.

The author quantifies the radiative and convection/conduction heat loss at the building external surface and then calculates the conductive heat flux through the building structural envelope. With a knowledge of inner and outer temperatures and the quantified heat flux the author develops a model to calculate the thermal resistance, thermal conductivity and, with the surface area, the U-values.

The model developed is used in a MS-Access database to record parameters necessary to calculate U and R values for each building component. Local area environmental parameters are then used with the calculated U-value to predict annual energy loss through the building envelope in terms of kilowatt hours and in financial terms.

The study finishes with a thorough evaluation of a large commercial building with recommendations for improvement of insulation in accordance with this study and legislative requirements.

Word count = 17,343
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Acronyms and Abbreviations

$\Delta T$ temperature difference ($^\circ$C or K)

$\mu$ dynamic viscosity (kg/m.s)

$A$ Surface area of component under study (m$^2$)

ASHRAE American Society of Heating, Refrigeration and Air-Conditioning Engineers

$C_f$ Skin friction coefficient

CHTC Convective Heat Transfer Coefficient (W/m$^2$.K)

$C_p$ specific heat at constant pressure (J/kg.K)

$E$ infrared emittance

$\varepsilon$ infrared emittance

GUI Graphical user Interface

$h$ Planck’s constant

$h_c$ Convective Heat Transfer Coefficient (W/m$^2$.K)

$K_b$ Wien’s Displacement Constant ($2.897 \ 7685 \times 10^{-6}$ m.K)

$k$ K-Factor - thermal conductivity (W/m.K)

$L$ Linear dimension (m)

$\lambda$ lambda - wavelength (m)

MoWiTT Mobile Window Thermal Test facility

$Nu$ Nusselt number

$Pr$ Prandtl number

$Q$ Heat flow (W)

$q$ heat flux (W/m$^2$)

$Q_c$ Convective heat flux (W)

$Q_{cond}$ Conductive heat flux (W)

$Q_{ir}$ Heat loss by radiation (W)

$Q_{sky}$ thermal radiation from the sky (clouds & buildings) (W)

$Q_{solar}$ thermal radiation from the sun (W)

$R$ infrared reflectance

$R_f$ ASHRAE roughness factor

$Re$ Reynolds number

$R$-Value thermal resistance

$\sigma$ Stefan-Boltzmann Constant ($5.6704 \times 10^{-8}$ W/m$^2$)

$\tau$ infrared transmittance

$Ta$ Temperature of air at edge of boundary layer ($^\circ$C or K)

$Ts$ Temperature of emitting surface ($^\circ$C or K)

$u$ Wind velocity normal to the surface (m/s)

$U_{\infty}$ Mean air velocity (m/s) of free air stream

$U$-Value thermal conductance (W/m$^2$.K)

$V$ Wind velocity

$v$ Wind velocity parallel to the surface (m/s)

$w$ Wind velocity vertical to the surface (m/s)

$W_b$ blackbody spectral radiant emittance at wavelength lambda (W/m$^2$)

$\rho$ density (kg/m$^3$)
Chapter 1

1.0 Introduction

In 2004 the author was asked by Blackpool Borough Council to produce a thermal map of the Blackpool Metropolitan area. The thermal map was to be used as an interactive display at the Solaris Centre which is the showpiece of environmental conservation for the council. The intention of the map was to allow residents to identify their home using a graphical user interface (GUI) on a PC and see just how much heat was being lost from their homes.

The process of collecting thermal images necessitated hiring a small aeroplane with a pilot and flying at 500 feet over Blackpool in a grid pattern so that each image could be referenced to a map location for later inclusion into the GUI. After collating the images into the software the author showed the resultant system to his wife and family for their impressions before the author submitted it to the council. Almost immediately his wife asked “Can I see our house?” With a flourish the author clicked onto the section showing the part of the street with his house and his wife exclaimed “Why does our house look so red?” With considerable embarrassment the author had to reply to her that it was because her house was losing the most heat in the street (figure 1).
Blackpool Council was very pleased with the resulting programme and many people used the interface to look at their homes in infrared. However, the author had to embark on a journey to identify exactly where his house was losing the heat and to come up with a cost effective solution for insulating the house. The author was horrified at the cost of double glazing but he could not be sure how effective cavity wall insulation would be and which of the two solutions would be the most effective. The author also looked at options of improving existing insulation in the converted attic space. Relying on previous thermal imaging surveys carried out to determine the effectiveness of cavity wall insulation the author realised that the conventional process of using “industry standard” values for insulation effectiveness was fraught with problems:

- U-value depends on the way in which the insulation is applied
- Air leaks (mass transfer) have a huge effect on heat loss
- Specified U-values for double glazed windows are dependent on “standard” environmental conditions that rarely reflect real life conditions.
• The amount of heat loss depends on how the interior of the house is heated and the use factor of individual rooms.

The author decided to start an empirical process in which he would measure the heat loss from individual rooms by measuring internal and external temperatures using standard thermocouples as well as a thermal imaging camera. It soon became apparent that the amount of heat loss was very dependent on how windy it was as well as outside temperature, the wind direction (those rooms facing the wind lost more heat) and whether it was raining or not (more heat was lost on wet days).

The author decided to treat each different type of material separately, i.e.

• Doors
• Walls
• Flat Roofs
• Pent Roofs
• Vertical Windows
• Pent Roof Windows

The intention was to determine the amount of heat loss from each external surface and sum those heat losses for each room thereby identifying if it would be more cost effective to install double glazing, cavity wall insulation or even additional roof insulation. The result should be able to identify which rooms would benefit the most from the improved insulation.

To make the eventual outcome as useable as possible the author decided to correlate the heat loss with the actual cost of the heating fuel, be that gas, oil or electricity with the intention of predicting the actual cost of heating the home; the end result would be that he could make an informed decision on the most cost effective method of insulating the home.
1.2 Aims
To determine the thermal insulation properties of buildings and structures’ external envelope by measurement of surface and air temperatures with special regard to conductive heat flow through the envelope, thermal radiation heat loss and the effect of air movement on convection effects.

1.3 Objectives.

1. To perform a literature study of the field of solid/air convective and radiative heat transfer and the use of infrared thermal imaging for radiometric surface temperature measurement.

2. To identify the components needed to create a model of heat transfer through various types of building components in vertical, horizontal and angled planes when subject to a range of external air movements.

3. To develop a model for the calculation of R and U insulation factors by calculation of total heat conductive, convective and radiative heat flow.

4. To embed the model within a GUI and to provide the following functionality:
   a. Determination of total heat loss from each surface component and each external elevation.
   b. Determination of U and R value for each surface component.
   c. Calculation of total heat loss from each room in a building.
   d. Calculation of the cost of heating/cooling a building

5. To evaluate the model using experimental / baseline test-set data by measurement of heat transfer through a component wall with a set temperature differential when the cooler side of the wall is subject to a range of air speeds and directions.

6. To refine the model with an accurate compensation for wind speed and angle of attack.
7. To trial the model on several dwellings and/or commercial buildings in Britain during autumn and winter months thereby correlating calculated heat loss data with actual heating fuel consumption.

8. To draw conclusions and to make recommendations for further development work.
1.4 Methods of Research

The research project was necessarily carried out using a combination of numerical and experimental methods.

The initial research was to determine existing models of heat transfer and determine if any of these existing models were suitable for inclusion in a comprehensive model for determination of building component U-values and R-values. The literature research revealed several possible models for convective heat transfer whereas the Stefan-Boltzmann model for radiative and the Fourier model for conductive heat transfer were identified as being mature and well proven.

As the model for convective heat transfer was to be used on buildings, the research focused on those models using wind as the heat transfer medium against vertical and inclined surfaces.

The next stage in the research was to prove the models. To this end a hot box was constructed and various building materials used to make one wall for each test. A heat source of a known wattage was placed inside the hot box and the radiative heat loss was calculated. As the conductive heat loss through the wall must equal the radiative heat loss plus the convective heat loss, the convective models could be proven by comparing the model predictions against the calculated difference between actual heat input and calculated radiative losses.

Once the most accurate convective heat model was selected this model was used along with the radiative model to calculate the total conductive heat flow through each component. With a known value of the conductive heat flow and physical dimensions of the thermal boundary components it was then possible to calculate the U and R-values.

The complete model was used as the base calculation in a database to calculate the U-value and R-value of discrete components in the building's structural and thermal envelope.
Chapter 2

2.0 Literature Review

In this chapter the author collates information from several sources so as to build a foundation on which to construct the model for heat flux through the building’s thermal envelope.

The literature review was aimed at three areas of concern:

1) Convective heat losses from buildings
2) Radiative heat losses from buildings
3) The use of infrared thermal imaging cameras to detect building component surface temperatures.

2.1 Convective Heat Losses from Buildings

In 1985 Klems (1) suggested a standardised method for measuring window (fenestration) performance using a MOBILE WINDOW Thermal Test (MoWITT) facility. The MoWITT measures the heat flow through a fenestration system considering heat losses and inputs from inside and outside (Figure 2).
Figure 2 The MoWITT measures the net energy flow through a fenestration system by determining the net heat balance on the adjacent room-sized space

The MoWITT was a large portable facility and was delivered to various locations and left on site so as to be exposed to a wide range of climatic conditions. Klems claimed that existing heat flow models suffered inherent inaccuracies due to the ASHRAE imposed “standardized” conditions especially the standard wind speed of 15mph.

Klems’ achievement was the development of a portable facility that facilitated the calculation of U and R values from measurement of physical values. A prime difficulty facing Klems was the difficulty in accurate measurement of the surface temperature across the complete surface and thus heat flow through the envelope; his technique was to estimate the average heat flow through the envelope component under investigation from several discreet heat flow measurements. By quantifying the total heat flow through the wall as heat loss (this was a controlled variable as the wall temperature was controlled) and calculating the radiated heat flow from the hot fenestration to the inside of the MoWITT, Klems was able to calculate the convective
heat flow from the fenestration as well as the conductive heat flow through the fenestration and thus the U-value.

In 1999 Svoboda (2) presented a numerical model of convective-conductive heat transfer in building components. The model demonstrated that wherever the insulation of the envelope was non-uniform or where cracks had developed then air movement within the insulation enabled relatively vigorous heat flow. One major implication of the Svoboda study is that calculation of convective, conductive or radiative heat flow is only accurate if mass flow across the insulating medium is negligible.

Clear et al (3) in 2001 carried out measurements that eventually allowed the development of a correlation of the outside convective air film coefficient as a function of $\Delta T$ (inside and outside air temperature), wind speed, wind direction, area and surface roughness. The study was limited to flat roofs but it laid down a basis for future development of Convective Heat Transfer Coefficient (CHTC) by extending the results to a study of tilted roof (see conclusion in paragraph 4, page 27 of the study).

In the Discussion (page 26) Clear notes that the correlation developed in the study is not a direct correlation of several variables with CHTC but rather correlations of these variables to net heat flow. The components of the net heat flow included radiation heat flow due to solar radiation ($Q_{\text{solar}}$), radiation from the sky (clouds and buildings) ($Q_{\text{sky}}$), heat flow across the roof by conduction ($Q_{\text{cond}}$) as well as heat losses by radiation ($Q_{\text{IR}}$). A heat balance was an essential component of the study to determine the heat loading into the building and thence the air conditioning load requirement. By determining the heat load, the temperature difference and the roof area Clear was able to calculate CHTC.

$$Q_{\text{solar}} + Q_{\text{sky}} + Q_{\text{cond}} - Q_{\text{IR}} - h_c \Delta T = 0$$

Where:

- $Q_{\text{solar}}$ = solar radiation absorbed by roof (W/m$^2$)
- $Q_{\text{sky}}$ = sky long-wave radiation absorbed by roof (W/m$^2$)
- $Q_{\text{cond}}$ = conductive heat flow into roof (W/m$^2$)
- $Q_{\text{IR}}$ = long-wave radiation emitted by roof (W/m$^2$)
- $h_c \Delta T$ = the convective heat transfer from the roof to the outside air (W/m$^2$)
- $h_c$ = surface convection coefficient (W/m$^2$-K)
• \( \Delta T = \text{roof outside surface temperature minus outside air temperature (K)} \)

The positive and negative signage is explained as the Clear study was considering buildings in high ambients so he was concerned with heat absorbed by the building in order to estimate air conditioning loads. Heat absorbed by the building was signed positive whereas heat lost by the building was signed negative.

Clear’s study took special note of the influence that solar heating had on the heat flow through the roof as his main objective was to determine the cooling load. Clear determined that solar heating was not the only heat load and he quantified heating from the sky via infrared radiation with the main difference between solar and sky radiation being the wavelength (see wavelength against object temperature figure 9).

All convective heat calculations carried out by Clear were carried out using the turbulent, forced convection model where:

\[
10^5 < Re < 10^8 \text{.............................................................Eq2}
\]

*See discussion of Reynolds Number on page 18.*

and a Nusselt number of:

\[
Nu = 0.0269 \text{Re}_x^{4/5} \cdot \text{Pr}^{1/3} \text{.............................................................Eq3}
\]

*See discussion of Nusselt Number (section 3.1) on page 29.*

Where

• \( x = \text{the distance from the leading edge of the roof to the point at which the Reynolds number is evaluated (metres).} \)
• \( Re = \text{the Reynolds Number} \)
• \( Pr = \text{the Prandtl Number (0.713 for air at 20°C)} \)
• \( Nu = \text{the Nusselt Number} \)

The study showed no correlation with wind direction but, as the study was based on flat roofs, this is not surprising. Heat flux through a flat roof is expected to be
independent of wind direction assuming the building profile is consistent on all elevations. The roofs under consideration by Clear were uniform in all directions so wind flow across the roof would be similar no matter from which direction the wind was coming.

A further and more important outcome from Clear’s study is that natural and forced convections are additive and this is shown in the CHTC values at zero wind speed as shown in Figure 3 which shows a value for CHTC of approximately 5 W/m².K at zero wind speed (i.e. natural unforced convection).

Figure 3 shows data of CHTC against wind speed. A curve fit of the data in figure 3 shows a linear curve fit line (y=ax+b) which crosses the zero wind speed line at a value of CHTC=5 W/m²K. This indicates that natural convection of the flat roof gives a CHTC of value 5, but as the wind speed increases and the convection becomes forced convection, the CHTC increases linearly (within the bounds of data scatter) inferring that the natural and forced convection effects are additive.

![Figure 3 Measured convective heat transfer coefficient at roof center against wind speed](image)

*Figure 3 Measured convective heat transfer coefficient at roof center against wind speed (reused here by kind permission of Elsevier – license No. 2731430520618) n.b. the line has been added by the author of this document.*
A further evaluation of Reynolds Number (Re) indicated that the value of Re varies linearly with distance from the wind entry edge but that it is possible to make a valid estimation by averaging over the complete area. Clear showed that it is possible to make an evaluation at the centre point and use that as the average.

Hatton and Awbi (4) presented results for heated surfaces adjacent to cool walls and empirically derived values of CHTC for laminar and turbulent convection. In their experiment Hatton and Awbi not only used traditional platinum resistance thermometers for point temperature measurements but they also used an infrared imaging camera. The infrared camera was used not only to investigate the temperature distribution on the cold wall but also to determine the emissivity of the surfaces under consideration.

Hatton and Awbi calculated the convective heat flux by measuring the known heat flux from a heating element (Qin) and then subtracting the radiative losses (Qir). A subsequent calculation (Eq5) was then used to calculate CHTC.

\[ h_c = \frac{Q_c}{A(T_s - T_a)} \]  

\( h_c \) = the Convective Heat Transfer Coefficient (W/m\(^2\)-K)  
\( Q_c \) = Convective heat flow (Watts)  
\( A \) = Surface area of the component (m\(^2\))  
\( T_s \) = Temperature of the emitting surface (K)  
\( T_a \) = Temperature of the air at the edge of the boundary layer (K)

Hagishima et al (9) compared the results of experimental results for CHTC of various urban surfaces. In this study it Hagishima concluded that (for a vertical wall) that although the effect of wind direction is small, the effect of whether or not the wall exterior is in way of the wind or not is significant; in other words, the flow path of the wind.
The Hagashima study concurred with the Clear study that there is a correlation between CHTC and wind speed on various surfaces. The various studies examined indicated a correlation exists whether the surfaces be oriented vertically, horizontally or slanted. One important conclusion of the study was that the use of models of buildings for determination of CHTC, while being useful for approximation of CHTC, gave results that vary significantly from full size building; the reason given for the difference in results (model/full size) is the difference in Reynolds and Nusselt numbers. A discussion of Reynolds and Nusselt numbers is given later in this document.

In a prior study, Hagishima and Tanimoto (6) conducted research into various techniques to measure CHTC. Hagashima used a linear curve fit of the data to predict CHTC using ax+b curve fit where b is a factor related to wind speed and a is indicative of the amount of natural convective heat loss with zero wind. The study further showed that the curve fit formula changed depending on whether the measurement was carried out on a flat vertical wall or a roof with the implication that the wind flow is dependent on the surface under observation.

One of their conclusions was that on flat surfaces the CHTC can be correlated successfully to the summation of the wind velocities for horizontal surfaces (Eq5):

\[ h_c = 3.96 \sqrt{u^2 + v^2 + w^2} + 6.42 \]  

Eq5

and for vertical surfaces (Eq6):

\[ h_c = 10.21 \sqrt{u^2 + v^2 + w^2} + 4.47 \]  

Eq6

where u, v and w are wind velocities normal, parallel and vertical to the surface under examination.

The Hagishima study went one stage further by combining horizontal and vertical surfaces into a dimensionless analysis using Nusselt and Reynolds numbers (Eq7).

\[ N_u = 0.023 \cdot Re^{0.891} \]  

Eq7
Hagishima then went on to substitute the Prandtl number for air at 20°C to finally give Eq8.

\[ h_c = 11.42 \cdot l^{-0.109} \cdot \left( \sqrt{\frac{u^2 + p^2 + w^2}{u^2}} \right)^{0.891} \]  

Equation 8 is, again, an estimation but it shows that the CHTC is a function of \( l \) (the distance from the edge) as well as the wind velocity such that CHTC will be much larger for small components such as test models. By making \( l \) the midpoint of the surface, Eq8 allows for an average calculation of the entire surface.

The conclusion of Hagishima and Tanimoto is very important to this study as it clearly demonstrates that the convective heat transfer coefficient of any flat surface may be estimated purely by a knowledge of the wind speed and the size of the component. This knowledge will be applied further in the study to help in the calculation of total heat flux and thence the U-values of various building components.

Wallenden (16) examined CHTC calculations from various sources and concluded that the best accuracy was ±15% for a window and ±20% for a wall. The author will endeavour to prove that better accuracy can be achieved by taking into account the size of the surface under examination, the temperature difference between the wall surface and the ambient as well as consideration of the heat flux quantity.
2.2 Radiative Heat Loss from Buildings

In Fairey’s study on radiant energy transfer and radiant barrier systems (12) he identifies that infrared radiation as a means of transferring energy has the major dissimilarity from conduction or convection in that it does not require a physical medium. The importance of this fact for this study is that the amount of radiation leaving the building is independent of wind (unlike convection) or any contact with a thermally conductive medium (unlike conduction). In figure 9 we see that a surface at 300K (23°C) has a maximum amplitude wavelength at about 10µm (this is calculated using Wien’s Displacement Law – Eq19).

As the surface of the building thermal envelope will be close to ambient then the radiative heat energy being lost is being removed at close to 10µm. According to an article published by Protek-USA (14) the infrared radiation being emitted from the surface of the building has no temperature, only energy. The factor that affects the amount of energy is the surface temperature and it’s emissivity (see a further discussion on emissivity on page 32).
2.3 The use of infrared thermal imaging cameras to detect building component surface temperatures

Bradley (11) identified that fabric heat loss from a building is a combination of radiative, convective and conduction exchanges. He further goes on to state that “research carried out for the Low Carbon Housing Learning Zone at Leeds Met has shown that a significant discrepancy exists between the energy performance of a dwelling as designed and that realised in practice, typically around 20% higher than predicted by modelling.”.

He goes on to suggest that the difference may be accounted for by problems with thermal bridging, actual U-values being different to predicted U-values and building errors such as leaks allowing mass transfer. The comments by Bradley indicate the need for an actual measurement of the building insulation performance “as-built” instead of a theoretical calculation.

Ocaña et al (13) pointed out the theoretical basis of using infrared radiation to quantify heat loss is the ability of a thermal detector to turn the emission pattern of an object into a visible image. The result of a thermal image based on the infrared portion of the electromagnetic spectrum is shown in figure 4. Note that figure 4 shows spot temperatures (those temperatures prefixed with SP) and area temperatures (those temperatures prefixed by AR). It is possible to record average, maximum or minimum temperatures of any given area using the software supplied with the thermal imaging infrared camera.
Snell (15) has identified several problems that can be identified by using thermal imaging cameras on building envelopes:

1) excessive energy use due to missing or damaged insulation, insulation that is performing inadequately, and excessive air-leakage across the thermal perimeter
2) moisture damage due to leaks or condensation, especially in the walls or roofs
3) ice damage to sloped roofs
4) poor HVAC distribution or performance
5) inadequate verification of construction details or structural performance
6) delaminations of façade materials
7) “sick building syndrome,” mold growth and other health related issues

Snell notes that it is quite easy to identify damaged or non-performing insulation as well as certain construction details such as thermal bridging which could have an effect on the overall thermal performance of the building. Snell further goes on to identify the benefits of using a thermal imager, as opposed to point temperature readings, is the ability to take readings non-contact and to measure a complete map of a surface enabling measurement of maximum, average or minimum temperatures within an area.
2.4 A Discussion on Dimensionless Numbers

According to the Free Dictionary by Farlex (http://www.thefreedictionary.com) “a dimensionless number is a number representing a property of a physical system, but not measured on a scale of physical units (as of time, mass, or distance). Drag coefficients and stress, for example, are measured as dimensionless numbers”.

To investigate fluid flow near and around buildings, the literature review has shown a requirement to use certain factors describing and characterising the flow of air. In this chapter the author aims to identify and describe the dimensionless numbers that may be used in the analyses in subsequent chapters to develop a working model of heat flux in line with objectives 2 and 3 (page 11). These dimensionless numbers are used in this study to develop models of heat flow.

The dimensionless numbers of interest in this study are:

- Reynolds Number
- Nusselt Number
- Prandtl Number

2.5 Reynolds Number (Re)

The purpose of the Reynolds Number (7) is to characterise flow regimes (e.g. laminar or turbulent). Low Reynolds Number indicates laminar flow (where viscous forces dominate) whereas a high Reynolds Number indicates turbulent flow (where inertial forces dominate); the calculation of the Reynolds Number therefore requires quantification of the inertial forces and the viscous forces and this is calculated as a ratio of inertial/viscous properties.

Reynolds’ (1842-1912) work on turbulence was initially based on the analysis of fluid dynamics by George Gabriel Stokes. Stokes published papers on the flow of incompressible fluids in the mid nineteenth century with detailed analysis of friction of moving fluids and motion and equilibrium of elastic solids. Stokes reviewed the methods and hypotheses of Navier, Poisson, Saint-Venant (8) and his own work to present a rational derivation of the Navier-Stokes equations which describe the movement of incompressible fluids.

The inertial properties of the Reynolds Number are characterised by density, velocity and distance (Eq9):
The viscous forces are characterised by the viscosity. The viscous force (Eq10), is shown by

\[
\text{viscous force} = \mu v L \quad \text{........................................Eq 10}
\]

Where:
- \(\rho\) = density of the fluid \ (kg/m\(^3\))
- \(v\) = mean velocity of the fluid \ (m/s)
- \(L\) = characteristic linear dimension \ (m)
- \(\mu\) = dynamic viscosity of the fluid \ (kg/m.s)

Taking the ratio of inertial/viscous forces we obtain (Eq11):

\[
Re = \frac{\rho v L}{\mu} \quad \text{........................................Eq 11}
\]

Once the Reynolds Number of a particular flow regime is known an estimate may be made as to whether the flow is laminar or turbulent. Reynolds discovered that (with liquid flow) the flow would always be laminar if \(Re < 2100\) (8) although with care the laminar flow could persist up to \(Re = 10,000\). At larger values of \(Re\) the layer of fluid contacting the wall (the boundary layer) exhibits vortexing and becomes unstable until, with even higher values of \(Re\), the flow becomes fully turbulent.

For the purpose of this study it is important to understand whether the flow is turbulent or not as this will affect the rate of heat transfer. If a fluid flow is laminar the heat flow is restricted to a boundary layer that is fairly static and beyond the boundary layer the fluid flow is parallel to the component. If the flow is turbulent then the resulting vortexing will mean the boundary layer will be much thinner and may even collapse, leading to greater degree of contact between the wall and the fluid and hence greater heat flow.

A calculation of the Reynolds number of air flow against the vertical wall of a dwelling may be calculated quite easily using Eq11. For a dwelling with a 10m high vertical wall, a wind speed of 5m/s at 23°C (300K) the following parameters apply:

- Dynamic viscosity: \(1.983 \times 10^{-5}\) kg/m.s
- Density \(1.205\) kg/m\(^3\)
• Mid point of wall 5m (to determine average Reynolds Number)
• Wind velocity 5m/s

\[ Re = \frac{1.205 \times 5}{19.83 \times 10^{-6}} = 1519162.885 \]

Keeping dimensions the same but calculating for a variety of wind speeds from 0.5 to 5.0 m/s we get the following Reynolds Numbers.

Table 1 Reynolds number against wind speed for a height of 5m at 20°C

<table>
<thead>
<tr>
<th>Wind velocity m/s</th>
<th>Reynolds No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>151916.2885</td>
</tr>
<tr>
<td>1</td>
<td>303832.5769</td>
</tr>
<tr>
<td>2</td>
<td>607665.1538</td>
</tr>
<tr>
<td>3</td>
<td>911497.7307</td>
</tr>
<tr>
<td>4</td>
<td>1215330.308</td>
</tr>
<tr>
<td>5</td>
<td>1519162.885</td>
</tr>
</tbody>
</table>

Using the same correlations for laminar/turbulent as Clear et al (3) (table 2) we see that the Reynolds number for forced convection (i.e. a wind speed > 0 m/s) a Reynolds number greater than $10^5$ indicates turbulent air flow. Table 1 shows that any wind velocity of 0.5 m/s or greater is turbulent when measured at the midpoint of a 10m high wall for air at 20°C.

Table 2 Reynolds number correlation for air flow against a building (Clear – 3)

<table>
<thead>
<tr>
<th>Type of convection</th>
<th>Applicable range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminar</td>
<td>$Re &lt; 10^5$</td>
</tr>
<tr>
<td>Turbulent</td>
<td>$10^5 &lt; Re &lt; 10^8$</td>
</tr>
</tbody>
</table>
2.6 Nusselt Number (Nu)

The Nusselt number is the ratio of convection heat flux over conductive heat flux (10) into the thermal boundary layer so that a Nusselt number of near unity means that convection and conduction are of similar magnitude. Leinhard (9 page 274) gives a definition formula for Nusselt number in Eq 12:

\[ Nu = \frac{\text{convective heat transfer}}{\text{conductive heat transfer}} = \frac{h_c \Delta T}{k \Delta T} = \frac{h_c L}{k} \] .............Eq 12

Where

- \( h_c \) – convective heat transfer coefficient (W/m\(^2\).K)
- \( L \) – linear length
- \( k \) – thermal conductivity (W/m.K)
- \( \Delta T \) – temperature difference between surface of the wall and the temperature of the free stream fluid.

A larger Nusselt number indicates the flow is much more turbulent – typically above \( 10^2 \). As the air flows in this study are in the main turbulent, large Nusselt numbers are expected.

According to Leinhard (9 – page 325) the Nusselt number may be calculated as follows (Eq13):

\[ Nu = 0.032Re^{0.8}Pr^{0.43} \] .............................................Eq 13

2.7 Prandtl Number(Pr)

The Prandtl number is the ratio of momentum diffusivity (kinematic viscosity) to thermal diffusivity (9 page 297).

\[ Pr = \frac{\nu}{\alpha} = \frac{\text{viscous diffusion rate}}{\text{thermal diffusion rate}} = \frac{\nu}{\alpha} = \frac{\nu}{\alpha} = \frac{c_p \mu}{k} \] .....................Eq 14

Where

- \( \nu \) = kinematic viscosity (m\(^2\)/s)
- \( \alpha \) = thermal diffusivity (m\(^2\)/s)
- \( \mu \) = dynamic viscosity (Pa s = (N.s)/m\(^2\))
- \( k \) = thermal conductivity (W/(m.K))
- \( c_p \) = specific heat at constant pressure (J/(kg.K))
Note that unlike the Reynolds number, the Prandtl number does not require a dimensional component of the surface under consideration, therefore the Prandtl number is a property of the fluid only. A high Prandtl number means that the fluid has good convective properties and a low Prandtl number indicates suitability for conduction as the heat diffuses quickly even at low fluid velocities.

The Prandtl number (Pr) for air varies from 0.711 at 40°C to 0.715 at 0°C.
2.8 Heat Transfer Mechanisms

In order to identify the components needed to create a model of heat transfer through various types of building components in vertical, horizontal and angled planes when subject to a range of external air movements in a realistic and practical model of heat transfer through components in the building envelope it is necessary to have a thorough understanding of the methods of heat transfer. This chapter will consider the base calculations used to calculate the heat flux and build on the concepts explored in the literature review.

Heat can be transferred from one material or body to another in one of four ways

1. Conduction
2. Convection
3. Radiation
4. Mass transfer

This study will concern itself with the first three methods of heat transfer as the primary focus is on heat transmission through building’s structural envelope without physical exchange of air from inside to outside or vice versa.

The second law of thermodynamics concerns the state of entropy in a closed system and dictates that over time the entropy of such a system which is not in equilibrium will tend to increase. The second law can be written as \( \Delta s \geq 0 \) (where \( \Delta s \) is the entropy change). The second law of thermodynamics therefore necessitates that energy (or heat) can only travel from a higher temperature to a lower as a reverse flow would reduce entropy. In the building envelope under consideration our heat flow is from the warm interior to the cold outside.

For the purpose of this study it is necessary to quantify this heat transfer. The target is to determine the conductive heat flow through the envelope which must necessarily flow from the warmer surface to the cooler surface. All heat flowing through the surface will be dissipated to the external environment assuming a warm building interior with a cooler exterior environment. With zero mass flow the exterior heat
flow dissipation must be via radiation and a combined conductive/convective heat flow mechanism at the exterior wall/atmospheric interface. The next section explores each of these heat flow mechanisms.
2.9 Conduction

Conduction is the process of transferring heat across a body or from one body to another when they are in physical contact and a temperature gradient exists. Examples of this are:

- A cooking pan on an electric hob,
- Household walls where insulation is used to reduce the heat transfer through conduction
- Double glazing - A vacuum or gas gap is inserted between the glass panes to reduce heat loss through conduction

Conductive heat is transferred through a body by excitation of the molecules. As molecules receive energy in the form of heat, they tend to vibrate at higher amplitudes; this molecular vibration causes some of the energy to be passed on to adjacent molecules that in turn pass their energy on to others and so on. Materials that are poor insulators (therefore good thermal conductors) have very active and free molecules. On the other hand, materials that are poor thermal conductors (good insulators) have very tightly bound molecules and very few free electrons.

As the number of molecules available for heat transfer decreases so does the density and the thermal conductivity, so fluids (especially gases) generally do not conduct heat as well as solids. For most solids it is possible to identify rates of heat transfer by referencing well known and documented thermal conductivity and thermal resistance tables. The unit of thermal conductivity was defined by Fourier and is:

\[ \text{watts/Kelvin/m} \quad (\text{W/K/m}) \]
2.9.1 Fourier’s Law of Heat Conduction

According to Fourier the rate of heat transfer through a material is directly proportional to the temperature gradient, directly proportional to the area and is perpendicular to the gradient giving equation 15:

\[ \dot{q} = k\Delta T \]  
Eq15

Where

- \( q \) = local heat flux W/m\(^2\)
- \( k \) = conductivity of the material W/m/K
- \( \Delta T \) = temperature gradient K/m

Integrating Eq14 over the surface of the material we get Eq16 for heat flow in a homogenous material between two points:

\[ \Delta Q = kA \frac{\Delta T}{\Delta x} \]  
Eq16

Where

- \( \Delta Q \) = heat flow |(Watts)
- \( A \) = cross sectional area (m\(^2\))
- \( \Delta T \) = temperature difference across the ends (K)
- \( \Delta x \) = distance between the ends (m)
- \( k \) = conductivity (W/m.K)

The conductance (U) of a material is the conductivity divided by the thickness:

\[ U = \frac{k}{\Delta x} \]  
(W/m\(^2\).K)  
Eq17
The thermal resistance (R) is the reciprocal of the conductance.

2.10 Radiation

Radiation is an emotive word implying the horrors of atomic bomb blasts and subsequent radiation sickness with everything that entails. However, radiation from the bomb is only one small part of the electromagnetic spectrum. A major part of the electromagnetic spectrum is light between 0.4 and 0.8 micron wavelength (see figure 5).

Infrared radiation is the type of heat transfer that interests us at this point. Every object will emit energy in the form of radiation and the amount of heat a body radiates away depends upon its emissivity and its absolute temperature. At the same time that the body is emitting radiation, it is also absorbing radiation. So long as the amount of radiation emitted from a body is the same as the amount of radiation that is absorbed, then the temperature of the body will remain the same – in other words it is in thermal equilibrium.

Prepared using data from Fundamentals of Photonics (22 – page 158)
The wavelengths of infrared radiation are divided (somewhat arbitrarily) along the following lines:

### Table 3 Wavelength division of the Infrared portion of the spectrum ([http://paths.sheffield.ac.uk/wikiana/wiki/Infra-red](http://paths.sheffield.ac.uk/wikiana/wiki/Infra-red))

<table>
<thead>
<tr>
<th>Division</th>
<th>International Commission on Illumination</th>
<th>ISO 20473</th>
<th>Sensor response division scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near Infrared (NIR)</td>
<td>0.7-1.4 𝜇m</td>
<td>0.78-3 𝜇m</td>
<td>0.7-1.0 𝜇m</td>
</tr>
<tr>
<td>Short Wave Infrared</td>
<td>N/A</td>
<td>N/A</td>
<td>1.0-3.0 𝜇m</td>
</tr>
<tr>
<td>Mid Infrared (MIR)</td>
<td>1.4-3.0 𝜇m</td>
<td>3-50 𝜇m</td>
<td>3.0-5.0 𝜇m</td>
</tr>
<tr>
<td>Long Wave (far) Infrared (FAR)</td>
<td>&gt; 3.0 𝜇m</td>
<td>50-1000 𝜇m</td>
<td>8.0-12.0 𝜇m</td>
</tr>
<tr>
<td>Very Long Wave Infrared</td>
<td>N/A</td>
<td>N/A</td>
<td>12.0-30.0 𝜇m</td>
</tr>
</tbody>
</table>

The Sensor Response Division Scheme is based on response of various detectors.

- Near infrared: from 0.7 to 1.0 𝜇m. From human eye response
- Short-wave infrared: 1.0 to 3 𝜇m (from the cut off of silicon to that of the MWIR atmospheric window. InGaAs covers to about 1.8 𝜇m; the less sensitive lead salts cover this region.
- Mid-wave infrared: 3 to 5 𝜇m (defined by the atmospheric window and covered by Indium antimonide and HgCdTe and partially by lead selenide).
- Long-wave infrared: 8 to 12 𝜇m, or 7 to 14 𝜇m: the atmospheric window (Covered by HgCdTe and microbolometers).
- Very-long wave infrared (VLWIR): 12 to about 30 𝜇m, covered by doped silicon.

#### 2.10.1 Blackbody Radiation

A “Black Body” is defined as an object that absorbs all (but does not reflect or transmit any) electromagnetic radiation that falls on it at any wavelength (17 – p47).
Kirchhoff’s law also states that any body capable of absorbing such radiation would also be capable of emitting radiation. Because a Black Body is considered to be a perfect emitter we say that it has an emissivity of 1 (or 100%). In other words, all of the radiation coming off the body is emitted because of its temperature.

At low temperatures the emitted radiation is invisible to the human eye but as the temperature increases to above 525°C the source becomes visible indicating that the wavelength has moved into the visible portion of the electromagnetic spectrum. As the temperature increases further we see that the colour of the radiation changes from red, through orange, yellow and eventually white. As the temperature has increased the wavelength of the radiation has changed.

\[ E \text{ (emissivity)} = A \text{ (absorbency)} \]

If the law of conservation of energy can written by the relative fractions:

\[ E + R + T = 1 \]

Eq18

where

- \( E \) = Emissivity
- \( R \) = Reflectance
- \( T \) = Transmittance
2.10.2 Emissivity

As a Black Body can absorb or emit infrared radiation so can other heat sources; the difference is that the Black Body cannot reflect or transmit light so \( R = 0 \) and \( T = 0 \) therefore \( E = 1 \). In the real world most objects will allow some heat from other sources to be reflected so the observer could overestimate the temperature of the body if he tried to correlate the wavelength to the temperature without compensation for the reflection. For most components in the building envelope (apart from glass) transmittance will be zero, so as the reflectivity increases the emissivity decreases.

The value of emissivity is dependant therefore on the percentage of heat reflected and the amount of heat transmitted – anything left is absorbed or emitted.

For most components there are published tables of emissivity. The emissivity values of several materials are shown in appendix 3, table 10.
2.10.3 Reflectance

This causes more errors when carrying out thermographic readings than any other single aspect. In figure 7 we see three phases of bus bars which were recorded inside an electrical cabinet. The bars were of bright copper that had a low emissivity (therefore high reflectivity). The operator first thought that the left bar had a higher temperature than the others. On closer inspection, however, the supposed “high temperature” moved relative to the bar every time the operator moved; this could not happen if he was looking at a fixed heat source. The operator, in fact, was looking at his own reflection in the bus bar.

With a little care it is possible to look at the reflection and see the dark spots where the operator was wearing safety glasses in the left-most bus bar (spot 1) with a temperature of 29.6°C.

![Figure 7 Example of reflectance in a thermographic image](recorded by the author)

Typical reflections in the infrared include lamps, personnel, solar reflections or anything behind the operator that is at a relatively high temperature.
2.10.4 Transmittance

Most materials will not allow infrared radiation to pass *through* (or be transmitted through) the body. However, some materials, such as thin Perspex, will transmit a certain amount of IR radiation. Figure 8 shows how certain materials transmit particular wavelengths of light.

![Figure 8 Transmittance values of various materials](image)

*Figure 8 Transmittance values of various materials*

Prepared using data from *Fundamentals of Photonics* (22 – page 175)

Due to the thickness of most components of the building envelope, transmittance is assumed to be zero for brick and roof components in this paper.

Generally speaking, “long wavelength” thermal imaging cameras use lenses that are constructed from germanium and shorter wavelength cameras use lenses which are made from silicon. This allows cameras using germanium lenses to detect lower
temperatures whereas silicon lens cameras can, in theory, detect very high temperatures.
2.10.5 Planck’s Law

Max Planck (17 – page 48) described the wavelength distribution of electromagnetic radiation from a Black Body with the formula shown in Eq19:

\[
W\lambda_b = \frac{2\pi hc^2}{\lambda hc} \times 10^{-6} [\text{Watt/m}^2\mu\text{m}] \lambda^5 \left(e^{\frac{hc}{kT}} - 1\right)
\]

Eq19

Where:
- \(W\lambda_b\) = blackbody spectral radiant emittance at wavelength \(\lambda\) (W/m²)
- \(c\) = speed of light (299,792,458 m/s)
- \(h\) = Planck’s constant (6.62606896×10⁻³⁴)
- \(k\) = Boltzmann’s constant (1.3806504×10⁻²³)
- \(T\) = Temperature (K)
- \(\lambda\) = wavelength (m)

It can be readily seen that as the temperature increases the shorter the wavelength at which maximum emittance occurs. This formula gives a distinct wavelength at which the emittance is maximum as shown in Figure 8 for a black body at a temperature of 300K.

![Figure 9 Radiant Emittance of a Black Body at 300K](image-url)
2.10.6 Wien’s Displacement Law

By differentiating Planck’s Law with respect to wavelength and finding the maximum we get Wiens’s displacement law (17 – page 49) Eq11:

\[ \lambda_{\text{max}} = \frac{k_b}{T} \]

Eq20

Where:

- \( \lambda_{\text{max}} \) = peak wavelength (m)
- \( K_b \) = Wien’s Displacement Constant \((2.8977685 \times 10^{-6} \text{ m.K})\)
- \( T \) = Absolute temperature (K)

Inputting data for temperatures of 0°C to 50°C into Eq20 we get the resultant curve shown in Figure 10.

Figure 10 Wien’s Displacement Curve for 0 to 50°C
2.10.7 The Stefan-Boltzmann Law

Instead of differentiating Planck’s Law (as with Wien’s Law) we integrate it from λ=0 to λ=∞ we get the Stefan-Boltzmann formula (17 – page 50) (Eq21) for the total radiant emittance (Wₜ) from a black body.

\[ Wₜ = \sigma T^4 \]  

Eq21

Where:

- \( Wₜ \) = Total radiant Emittance (W/m²)
- \( \sigma \) = Stefan-Boltzmann Constant (5.6704 x 10⁻⁸ W/m²)
- \( T \) = Absolute temperature (K)

This only considers the radiation from a black body but in the real world the object will not be a black body so it will have a value for emissivity (\( \varepsilon \)) other than 1. It will also receive radiation from the environment so for practical applications the formula is modified to take into account the surrounding temperature and the area of the surface that is radiating (Eq22).

\[ W = \varepsilon \sigma (Tₜ^4 - Tₗ^4) A_c \]  

Eq22

Where:

- \( W \) = emitted power (W)
- \( \varepsilon \) = emittance
- \( Tₜ \) = Hot body temperature (K)
- \( Tₗ \) = Surroundings temperature (K)
- \( A_c \) = Surface area of the emitting object (m²)
2.11 Convection

Convection is the process of heat transfer using mass transfer of a fluid (liquid or gas) as a medium. By using an infrared thermographic camera it is possible to see the effect of this heat transfer process as a change in temperature of a dynamically moving stream of air in way of a hot component.

A common example of convection is the cooling coil at the back of a refrigerator. The refrigeration system dumps its excess heat into the coil and air is gradually warmed by the heat from the coil. As the air warms it rises as the thermal expansion of the air reduces its specific gravity, allowing cooler air to come into its place continuing the heat transfer process – this is convection. A common example often seen in the home is a suspended ceiling lamp above a central heating radiator – the convection air currents act on the lamp causing it to move apparently erratically.

Study of various papers including Winkelmann et al (3), Defraeye et al (20) and Saha et al (21) show that there are three accepted modes of convective heat transfer:

1. Natural Convection (with a robust boundary layer)
2. Forced Convection (with a reduced boundary layer due to high wind velocities)
3. Evaporative Cooling (Convection on a surface wetted by rain).

2.11.1 Natural Convection

According to Defraeye et al (20) the Convective Heat Transfer Coefficient (CHTC) of an external wall may be modelled by relating the heat flux \( q_{c,w} \) normal to the external surface of the wall to the wall surface temperature \( T_w \) and the reference air temperature \( T_{ref} \) far enough away from the wall to be unaffected by the wall temperature. The CHTC is defined in Eq1 as:

\[
 h_{c,e} = \frac{q_{c,w}}{(T_w - T_{ref})} \quad \text{Eq23}
\]
Newton’s Law of Cooling further states that if the surface area $A$ of the convective body is included we have:

$$ h = \frac{Q}{A(T_w - T_{ref})} \quad \text{Eq24} $$

The work of Clear et al (3) shows that the Convective Heat Transfer Coefficient for flat roofs to air at very low wind conditions (natural convection) is about 7 but Clear states that this data should not be used on vertical walls.

Hagishima (5, 6) on the other hand has a variation of Clear’s linear prediction and has further refined this for vertical and horizontal surfaces with a further adjustment for wall length or height (depending on the direction of the wind). Hagishima’s refinement however would indicate that the heat flux would be zero at zero wind speeds (Eq 8). Clear stated that turbulent convective heat flux and natural (laminar) convective heat flux are additive which is at odds with Hagishima’s results. Later in the study the author will show empirically how to resolve the differences between Clear and Hagishima.
2.11.2 Forced Convection

According to Leinhard (9) a boundary layer will remain laminar on a flat plate even with large levels of disturbance

\[(\text{Re}_x \leq 6 \times 10^4)\]

where \(x\) is the thickness of the boundary layer (9 – page 274). With relatively undisturbed conditions, a transition value may be realised for \(\text{Re}_x\) of between, approximately, \(3 \times 10^5\) to \(5 \times 10^5\). In extreme conditions, (say laboratory conditions) it is possible to remain laminar up to \(\text{Re}_x \approx 3 \times 10^6\) but the transition to turbulent can practically be said to be complete before \(\text{Re}_x \approx 4 \times 10^6\) and usually much earlier. These specifications are for a smooth, flat plate or wall. If the surface is not flat or smooth such as the wall of a building, then turbulence will happen much earlier at significantly lower values if \(\text{Re}_x\).

So if the Reynolds number of the wind flow is more than \(10^5\) we can say that the flow of the wind is turbulent. The actual value of the transition depends upon several factors including the shape of the leading edge, the roughness of the wall, and other acoustic or structural borne vibrations.

In the case of a building we can express the Reynolds’s number for a fluid (air) in a free stream as follows (9 – page 271):

\[\text{Re} = \frac{U_\infty x}{v}\]  

\text{Eq 25}

Where

- \(U_\infty\) = Velocity of the free air stream (m/s)
- \(x\) = Distance from the plate or wall leading edge (m)
- \(v\) = kinematic viscosity (m\(^2\)/s)

So for wind at 23°C and a speed of 5m/s at a distance of 5m from the wall edge we achieve a Reynolds number of \(5 \times \frac{5}{15.68 \times 10^{-6}} = 1.594 \times 10^6\). This value is typical for a value midway along and/or halfway up a vertical wall and is typical of a turbulent condition.

According to Leinhard et al (9 – page 322) an accurate formula for skin friction coefficient (Cfx) may be calculated as follows:

\[C_{fx} = \frac{0.455}{[\ln(0.06 \times \text{Re}_x)]^2}\]  

\text{Eq26}
Leinhard also gives us the following two forms for calculating the CHTC in turbulent boundary layers (9 – page 322/328) based on the Stanton Number (9-Appendix C page 731):

\[ h_x = \rho \times C_p \times U_\infty \times \frac{Cf/2}{1 + 12.8 \times (Pr^{0.68} - 1) / \sqrt{Cf/2}} \]  

Eq27

Where:

- \( h_x \) = CHTC at a distance \( x \) from the component surface (W/m\(^2\).K)
- \( \rho \) = density (kg/m\(^3\))
- \( C_p \) is the specific heat under constant pressure (for dry air \@20^\circ C = 1005 \text{j/kgK})
- \( U_\infty \) is the mean air velocity (m/s)
- \( Cf \) is the skin friction factor
- \( Pr \) is the Prandtl Number (for dry air \@20^\circ C = 0.713)

Alternatively, based on the Nusselt number correlation of Equation 28

\[ h_x = \frac{k}{x} \times 0.032 Re_x^{0.8} \times Pr^{0.43} \]  

Eq28

Where

- \( h_x \) = CHTC at a distance \( x \) from the component surface (W/m\(^2\).K)
- \( Re \) is the Reynolds Number
- \( k \) is the thermal conductivity of the air W/m.K
- \( Pr \) is the Prandtl number (for dry air \@20^\circ C = 0.713)
- \( x \) is the distance away from the wall (m)

Equation 28 is based on the Nusselt number calculation (Eq4) which is the ratio of convective to conductive heat transfer. While this is perfectly acceptable for heat flow across heat exchangers, particularly with a liquid medium, Leinhard insists this method is not as accurate for extremely turbulent flow (such as onto a building wall) where the convective heat flow far outstrips the conductive heat flow into the air.
2.11.3 Surface Roughness

The ASHRAE Hand Book of Fundamentals gives the data shown in Table 4. The value for CHTC is directly affected by the surface roughness ($R_f$) as shown in Equation 29.

$$Nu_{fx} = R_f0.0296Re_x^{0.8}Pr^{0.43}$$  \hspace{1cm} \text{Eq29}

Note that ASHRAE give a value for the multiplier (0.0269) in this formula which is at odds with the value given by Leinhard and several other sources (0.032). The difference is due to whether the writer of individual articles is investigating a liquid or a gaseous (air) medium. Leinhard suggests manipulating the constant (9 – page 325) to get better agreement with the data for specific Reynold Number conditions.

As the Nusselt number is directly affected and the CHTC is a direct function of the Nusselt number (Eq 27 & Eq 28), there is a direct relationship between $R_f$ and CHTC (shown in Eq 21 as $h_{fx}$).

$$h_{fx}=R_f\times p\times c_p\times u_{\infty} \frac{c_f/2}{1+12.8\times(Pr^{0.68}-1)\sqrt{c_f/2}}$$ \hspace{1cm} \text{Eq30}

Where

- $h_{fx}$ is CHTC considering roughness factor at a distance $x$ from the component surface

<table>
<thead>
<tr>
<th>ASHRAE Roughness number</th>
<th>Example surfaces with this roughness number</th>
<th>Forced convection multiplier, $R_f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Glass, paint on pine</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>Smooth plaster</td>
<td>1.11</td>
</tr>
<tr>
<td>4</td>
<td>Clear pine</td>
<td>1.13</td>
</tr>
<tr>
<td>3</td>
<td>Concrete</td>
<td>1.52</td>
</tr>
<tr>
<td>2</td>
<td>Brick, rough plaster</td>
<td>1.67</td>
</tr>
<tr>
<td>1</td>
<td>Stucco</td>
<td>2.10</td>
</tr>
</tbody>
</table>
2.12 Literature Review Summary

This chapter has collated information from several sources that will be used later in the document to build a working model for heat flux through buildings’ external envelope.

The model for radiative heat transfer is well documented and the Stefan-Boltzmann model will be used henceforth to calculate heat flow radiated from a hot surface to a cool surface. The Fourier model of conductive heat transfer is again a proven model and shall be used henceforth to calculate heat flow through a solid material.

The convective model is not so clear cut. When concentrating on convective heat loss from buildings the literature review has identified three possible models:

1. The Clear model (further refined by Hagishima) in Equation 6.
2. The modified Hagishima model (Eq 8) that also considers turbulence and wall size, and
3. The Leinhard model as modified by ASHRAE (Eq30).

The ASHRAE model additionally makes use of ROUGHNESS Factor that will be included in the Hagishima models for improved accuracy in the research herein. Each of the three convective models will be tested experimentally in ensuing chapters.

The use of infrared thermal imaging cameras will be addressed further into the research document to allow for quicker spot measurements and temperatures averaged over a surface for greater accuracy.
Chapter 3 Building the Models

The amount of heat flowing through any component in the building’s thermal envelope is now seen to be:

1. conductive flow from the interior, through the fabric of the component and then
2. a radiative heat flow from the component surface to the environment in parallel with
3. a convective heat flow from the component surface to the environment via air.

\[ Q_{\text{cond}} = Q_{\text{rad}} + Q_{\text{conv}} \] .................................Eq 31

Where

- \( Q_{\text{cond}} \) = Conductive heat flux through the component
- \( Q_{\text{rad}} \) = Radiative heat flux from the surface of the component
- \( Q_{\text{conv}} \) = Convective heat flow from the surface via air

In order to develop a comprehensive model for the heat flow and, ultimately, for the U-value it is necessary to build models for convective and radiative heat flows.
3.1 Radiation

The Stefan-Boltzmann equation to determine the amount of heat follow from the building is shown at Equation 22.

The variables required to calculate the radiation heat loss for each component are:

- $\varepsilon$ = Emittance
- $T_h$ = Temperature of the wall surface (K)
- $T_c$ = Surroundings temperature (K)
- $A_c$ = Surface area of the emitting component (m$^2$)

For each building component surface the emittance, the surface temperature and the surface area must be measured. For the surface shown in figure 12, as example, the components would be identified as follows:

*Figure 12 Front elevation visual image of semi-detached dwelling (left-most building)*
Front Elevation components:

1. Front door
2. Ground floor front window  
   a. Glazing
   b. Window frame
3. First floor window – bedroom 1  
   a. Glazing
   b. Window frame
4. First floor window – bedroom 2  
   a. Glazing
   b. Window frame
5. Brick wall  
   a. Below ground floor front window
   b. Between ground floor and first floor front windows
   c. Gable wall above first floor window
   d. Front wall around front door (hall exterior surface)
   e. Front wall on either side of ground floor front window
   f. Front wall on either side of first floor front window (bedroom 1)
   g. Front wall surrounding first floor window (bedroom 2).

Due to the differing possible internal temperatures, U-values and thus external temperatures, care should be taken in the decision of what constitutes a component.
Examination of figure 13 shows significant differences in external temperature for the glazing and the window frame, probably caused by differing emissivities as well as differences in actual surface temperatures.

Around the front door it is also possible to see differences in apparent temperature on the masonry blocks surrounding the front door as compared to the local brickwork. As the emissivity of paint of the masonry block (ε=0.94) and brickwork (ε=0.93) are very similar (see Appendix 3 - Table 10 and Emissivity Tables (19)) the temperatures must be substantially different indicating different heat flow through the brick as compared to heat flow through the masonry block and therefore different U-values. This demonstrates the importance of identifying specific components if accurate heat flux must be calculated.

There is no apparent reason for not using the Stefan Boltzmann mathematical model for radiative heat flow so equation 22 will be used for the radiation heat flux although accurate modeling will require calculations for each type of surface.
3.2 Convection

Although convection uses the same basic Fourier formula for heat flow as conduction it is not usually possible to calculate CHTC directly as the heat flow would first be required as per Equation 24.

The intention is to calculate the heat flow so we must first calculate the CHTC. At this stage the author was not sure which model would be the most effective so data was collected to satisfy Leinhard, Clear and Hagishima’s models. The following variables were collected:

1. Ambient conditions:
   a. Ambient air temperature
   b. Wind speed
   c. Wind direction
   d. Air density
   e. Air dynamic viscosity
   f. Specific heat of air at constant pressure
   g. Air Prandtl number

2. For each component
   a. Surface roughness
   b. Surface area
   c. Surface temperature

The various methods of calculating CHTC that have been discussed are evaluated below for a particular set of conditions:

1. Method 1: Linear curve fit ax+b as per Clear (3) and later modified by Hagishima (6) Eq 6
2. Method 2: Equation 8 as per Hagishima et al (6)
3. Method 3: Equation 30 as per Leinhard (9), modified by ASHRAE

This section illustrates the quantitative differences between the three methods when considering identical variables on a typical building. Three scenarios where considered for the comparison:
1) Low wind conditions (wind speed = 0.5m/s) 
2) Light wind conditions (wind speed = 5m/s) 
3) Heavy wind conditions (wind speed = 20 m/s) 

Variables set as follows:

a. Ambient air temperature 5°C 
b. Wind direction normal to surface 
c. Air density 1.205 kg/m³ 
d. Air dynamic viscosity 1.983x10^-5 kg/m.s 
e. Specific heat of air at constant pressure 1005 j/kg.K 
f. Air Prandtl number 0.719 
g. Surface roughness (assume brick wall) 1.67 
h. Surface area 10 m² 
i. Surface temperature 9°C 

Table 5 Calculated CHTC (W/m².K) for three different calculation methods

<table>
<thead>
<tr>
<th>wind speed m/s</th>
<th>Method 1</th>
<th>Method 2</th>
<th>Method 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>9.575</td>
<td>5.167264</td>
<td>2.046412</td>
</tr>
<tr>
<td>5</td>
<td>55.52</td>
<td>40.2032</td>
<td>13.80629</td>
</tr>
<tr>
<td>20</td>
<td>208.67</td>
<td>138.2599</td>
<td>45.02422</td>
</tr>
</tbody>
</table>

From table 5 it is apparent that while the relationship between CHTC and wind speed is virtually linear in all cases there are substantial differences between the methodologies as the wind speed is increased.
Method 1 uses a very simplistic application of wind speed only \((ax+b)\) and does not consider the size of the wall under consideration. The fluid properties are intrinsic as the results are based on empirical data collected on air blown buildings but as Hagishima pointed out, the results will vary depending on building size as the amount of turbulence will vary depending on the distance from the wall edge.

Method 2 again uses empirical data to compensate for fluid (air) properties and the size of the wall is included in the calculation.

Method 3 is theoretical and has been compiled for gaseous and liquid fluids. The values of certain fixed parameters should be changed depending on fluid type (Leinhard – 9 page 324). The fixed parameter values given by Leinhard and ASHRAE are generic and, as with method 1, there is no adjustment for wall size.

The experimental data section will set out to determine CHTC values empirically and will be used to decide which of the above models is most suitable for buildings.

### 3.3 Model development

To calculate the \(U\)-value and \(R\)-value of the building thermal envelope components one must first calculate the heat flow through the building envelope. Combining the heat flow and dividing by the component surface area and the temperature gradient across the component one arrives at the \(U\)-value.

\[
\begin{align*}
U &= \frac{Q}{(A \Delta T)} \\
R &= \frac{1}{U}
\end{align*}
\]

#### Calculate radiative heat flow

\[
Q_{\text{rad}} = \varepsilon \cdot 5.67 \cdot 10^{-8} \cdot A \cdot (T_o^4 - T_a^4)
\]

#### Calculate convective heat flow

\[
Q_{\text{conv}} = H_c \Delta T \cdot A \cdot R_f
\]

#### Calculate total heat flow

\[
Q = Q_{\text{radative}} + Q_{\text{convective}}
\]

#### Figure 14 Model workflow to calculate \(U\)-value
Figure 14 gives a summary workflow of the model to calculate U-value and R-value. All components are well understood with the exception of the calculation of $h_c$ (CHTC). The techniques available and identified in this study to calculate CHTC have been listed in section 5.0 (page 53) – the author identifies the most effective method of calculating CHTC in chapter 4 by the use of experiment.

Chapter 3 and Chapter 2 have defined the measurements required to identify heat loss through the building so objective 2 is satisfied.
Chapter 4

4.0 Experimental Data

4.1 Setup

To determine the total amount of heat loss from the building envelope via discrete components it is assumed that there is zero mass transfer. This means that the heat transfer from the exterior surface is limited to either conduction, convection or radiation. The Literature Review shows that the current state of empirical knowledge regarding convective heat transfer typically incorporates any conductive heat transfer at the external envelope surface by incorporating the boundary layer, the transitional layer and the free air layer.

Empirical data for external heat transfer therefore needs only to include radiation and a convective/conductive mechanism. Summing the external heat mechanisms gives the total heat loss from the external surface. The heat flux travels from the building interior to the exterior via conduction and convection (in the case of a cavity). If one assumes that the total heat flux from internal to external surface is via conduction then one can calculate the equivalent heat conductivity or resistivity for each component allowing direct comparison of one component to another for thermal insulation purposes.

In order to develop a realistic model for heat loss the author needed to develop a specific model for CHTC. The author decided to follow the hotbox/MoWITT path and test three different materials under controlled conditions. A box with five insulated sides was prepared so that the open side could be fitted with the test media. The box selected was a COLEMAN 50 litre cool-box with removable lid and a separate drain connection. There are no data on the actual insulation value of the cool-box walls (despite numerous requests to Coleman) but there was no measureable temperature difference to ambient at the outside of the box once the tests were under way so it may be assumed that thermal resistivity of the box walls is so high as to allow only insignificant heat flux.
A heat source was placed inside the hotbox as shown in figure 15. The heat source was an electric lamp of known wattage. A 13w fan was also fitted inside the hotbox to ensure optimal temperature distribution. A heat shield was placed between the heat...
source and the tested component to minimise radiation transmission through the tested component.

![Hotbox fitted with heat source lamp & circulation fan](image)

**Figure 16 Hotbox fitted with heat source lamp & circulation fan**

Temperature probes were fitted at the following positions:

1. Inside the hotbox at the horizontal mid-position, 5cm from the test medium wall and 5cm from the top of the hotbox.
2. At the geometric centre of the test medium wall inside in contact with the test medium.
3. Outside the hotbox in the wind flow.

The three media tested were as follows:

1. Plasterboard – 9mm thickness - British Gypsum Gyproc
   a. The Gyproc was trimmed to size and fitted inside the coolbox lid spigot in the same manner as the glass media. The gyproc was sealed to the coolbox wall to avoid mass transfer.
2. Glass – single thickness of 6mm – Pilkington’s Optifloat Glass.
   a. The glass was purchased locally and trimmed to size by the vendor so as to fit inside the spigot surface. To ensure maximum strength, the glass was fitted in a wooden frame as shown in Figure 18, which was inserted into the spigot.
b. The optifloat was sealed into the wooden frame and the wooden frame into the lid spigot using silicon white sealant to avoid heat transfer through air leakage (mass transfer).

c. The glass was painted with white spray paint on the inside to minimise radiation being transmitted through the glass during the test (figure 19). Several spots of red electrical insulating tape of known emissivity value were placed on the outside of the glass.

![Figure 19 6mm Optifloat glass fitted & sealed inside wooden frame](image)
   a. Due to the much thicker dimension of the brick it was considered unfeasible to trim the brick to the spigot size. In this case the coolbox was attached to an existing wall and sealed against the wall around the outer edges of the coolbox opening.

b. Figure 21 Exterior brick surface. Red tape indicates position of hotbox on the other side of the wall.
4.2 Experiment Results

After setting up the hotbox and energizing the heat source, three sets of readings were taken for the glass and the gyproc.

1. No external air movement (forced convection) so that natural convection takes place.

2. Air mover (fan) placed 1 metre from the hotbox with an air speed controlled at 2.7 and then 5.4 m/s.

3. Air mover placed at an angle of 45° to the hotbox with an air speed of 5.4 m/s.

Due to space limitations the brick wall was tested under wind conditions of

a. Natural convection and
b. Air speed of 2.7 m with the air mover at a fixed position so that wind direction is normal to the wall

The infrared thermal images are attached in Table 9.

Data is attached in Table 6. In each scenario the time to achieve thermal stability was significant and measured in hours. Scenario 3 (single brick envelope) took ten hours to achieve thermal stability under natural convection conditions. Due to the long time to collect the data the number of data are limited.
4.3 Thermal sensor error compensation.
Even though the thermometers were sold as accurate to ±0.1°C it was considered prudent to check the accuracy; to that effect the sensors were placed in a bath of ice and fresh water which was agitated and mixed well to achieve an actual temperature of 0.0°C. Several thermal images were taken and one is shown below as figure 22.

![Thermal sensor error measurement](image)

*Figure 22 - Thermal sensor error measurement*

Of the temperature measurement taken the following errors were noted:

*Table 6 Temperature Corrections*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Outside air temperature: reading was 0.5°C high</td>
</tr>
<tr>
<td>2.</td>
<td>Inside wall temperature: reading was 0.3°C low</td>
</tr>
<tr>
<td>3.</td>
<td>Thermal Imaging camera: reading was 2.2°C high</td>
</tr>
</tbody>
</table>

The thermal imager consistently read 2.2°C high at an actual temperature of 0°C. Imager documentation claims a *sensitivity* of <0.1°C whereas it claims an *accuracy* of ±2%. The sensitivity only means that temperature differences of better than 0.1°C may be identified using the thermal imager. The accuracy is worse, however and (even with an accurate emissivity value) the actual error of the camera should be checked if accurate data are required.
For all calculations involving temperature, the corrected temperature is used in this document.

4.4 The Calculation & Analysis Steps

Step 1
The temperature data collected were corrected accordingly as per table 6.

Step 2
The area of the tested fabric was calculated.

Step 3
The outside temperature of the tested component was averaged over the subject area using the IRWIN software. The averaged temperature is shown on each image in Table 5 as AR01 (before error correction).

Step 4
The wind speed was recorded using the ultrasonic anemometer.

The wind value was further recorded and modified by direction to give an effective wind speed. *The purpose of this step is to identify any differences in CHTC affected by the angle of attack.*

\[ W_{eff} = V \times \sqrt{\sin \theta} \]  \hspace{3cm} Eq32

Where

- \( W_{eff} \) = effective wind speed (m/s)
- \( V \) = wind velocity (m/s)
- \( \theta \) = Angle of attack of air against the wall (90° is normal to the wall, 0° is parallel to the wall).

Step 5
The radiant heat loss was calculated as per equation 21.

Step 6
The convective heat transfer coefficient was calculated. Using various power consumptions at zero wind speed on each of the materials under investigation, an average value of \( C_{HTC_{laminar}} \) was calculated. The wide differences in
CHTC were a matter of concern to the author until he applied the ASHRAE roughness factors.

By subtracting the radiant power from the input power we are left with the power being convected. By averaging the convective power at zero wind speed we obtained a base value for $\text{CHTC}_{\text{laminar}}$.

$$\text{AVG}(11.181 \text{ gyproc}, 9.6803 \text{ optifloat}, 12.403 \text{ optifloat}, 19.662 \text{ brick}) = 13.232$$

By dividing each CHTC by the appropriate ASHRAE roughness factor a commonised value for CHTC was obtained.

$$\text{AVG}(10.0725 \text{ gyproc}, 9.6803 \text{ optifloat}, 12.403 \text{ optifloat}, 10.9825, \text{ brick}) = 10.9825$$

**Step 7**

The turbulent CHTC was calculated using the three models being evaluated. Where applicable the CHTC was added to the laminar CHTC to give an overall CHTC. Each value was then compared to the input power and the calculated convective power (input less radiant) to see which was most accurate.

**Step 8**

a) CHTC was calculated using Leinhard’s format. As the Leinhard formula gives zero CHTC at zero wind speed, the averaged CHTC at zero wind speed based on the difference between input heat and radiant heat was added to the calculated CHTC.

b) CHTC was then calculated using Hagishima’s refined model (Eq 8). As this model gives zero CHTC at zero wind speed, the averaged CHTC at zero wind speed based on the difference between input heat and radiant heat was added to the calculated CHTC.

c) Using Hagishima’s format for derivation of CHTC ($ax+b$) with a value of 10.21 for $a$ and 4.47 for $b$ the value for CHTC thus became

$$\text{CHTC} = 10.21 \times U_\infty + 4.47$$  

Eq33

The convective heat loss power was calculated using Equation 16.

**Step 9**

Values were then calculated for
• Conductive heat loss

Step 10

Values were calculated for

• K-value, \[ K = \frac{Q \times t}{A \times \Delta T} \]
• U-value \[ U = \frac{q}{A \times \Delta T} \]
• R-value, \[ R = \frac{A \times \Delta T}{Q} \]
4.4.1 Discussion of Results

Table 7 shows the data reduced to those data recorded under steady state conditions.

Table 7 Reduced Data

<table>
<thead>
<tr>
<th>Power</th>
<th>Date</th>
<th>Time</th>
<th>Image #</th>
<th>Surface</th>
<th>Corrected Ambient</th>
<th>Area</th>
<th>Tinside wall</th>
<th>Tair inside</th>
<th>Thickness</th>
<th>Wind Speed</th>
<th>Wind Direction</th>
<th>Internal Air Speed</th>
<th>emissivity</th>
<th>ASHRAE Roughness factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>31/08/2010</td>
<td>13:40</td>
<td>7</td>
<td>Gyproc 9.5</td>
<td>18.00</td>
<td>17.50</td>
<td>0.161</td>
<td>36.10</td>
<td>0.0095</td>
<td>3</td>
<td>90</td>
<td>0.95</td>
<td>1.11</td>
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<tr>
<td>53</td>
<td>31/08/2010</td>
<td>14:10</td>
<td>10</td>
<td>Gyproc 9.5</td>
<td>18.30</td>
<td>17.80</td>
<td>0.161</td>
<td>34.30</td>
<td>0.0095</td>
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<td>90</td>
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<td></td>
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<tr>
<td>53</td>
<td>31/08/2010</td>
<td>14:25</td>
<td>14</td>
<td>Gyproc 9.5</td>
<td>18.50</td>
<td>18.00</td>
<td>0.161</td>
<td>35.70</td>
<td>0.0095</td>
<td>5.4</td>
<td>45</td>
<td>0.95</td>
<td>1.11</td>
<td></td>
</tr>
</tbody>
</table>

25W+13W

<table>
<thead>
<tr>
<th>Power</th>
<th>Date</th>
<th>Time</th>
<th>Image #</th>
<th>Surface</th>
<th>Corrected Ambient</th>
<th>Area</th>
<th>Tinside wall</th>
<th>Tair inside</th>
<th>Thickness</th>
<th>Wind Speed</th>
<th>Wind Direction</th>
<th>Internal Air Speed</th>
<th>emissivity</th>
<th>ASHRAE Roughness factor</th>
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<tr>
<td>38</td>
<td>01/09/2010</td>
<td>13:15</td>
<td>8</td>
<td>Gyproc 9.5</td>
<td>18.20</td>
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25W+13W

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<th>Area</th>
<th>Tinside wall</th>
<th>Tair inside</th>
<th>Thickness</th>
<th>Wind Speed</th>
<th>Wind Direction</th>
<th>Internal Air Speed</th>
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Painted/Shielded/Potted

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<tr>
<td>53</td>
<td>04/09/2010</td>
<td>08:10</td>
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<td>Single Brick</td>
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<td>18.10</td>
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<td>2</td>
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<td>1.67</td>
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The data shown in table 7 reflects those data taken recorded during steady state thermal conditions. Much of the recorded data was taken as the temperatures were increasing – those data may not be used in the analysis as the heat flow analysis requires a steady state condition in which the heat entering the building envelope component equals the heat flow from the component and the component temperature is exhibiting no recordable temperature change.
<table>
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<tr>
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<th></th>
<th>Hagishima Method Eq 8</th>
<th></th>
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<td>Est Qh Eq 30</td>
<td>least squares</td>
<td>Eq8 CHTC</td>
<td>Eq8 CHTC + Lam</td>
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Leinhard Method Eq 30
Least squares
Sum 51.63439
Least squares Sum 31.70903
Least squares
Error 14.76%

Hagishima Method Eq 8
Least squares
Sum 31.70903
Least squares Sum 40.52362
Least squares
Error 6.22%

Hagishima Method Eq 6
Least squares
Sum 40.52362
Least squares
Error 10.61%
Table 8 shows the three different methods of calculating CHTC:

1. Leinhard and ASHRAE method as per Equation 30
2. Hagishima method as per Equation 8
3. Hagishima method as per Equation 6

Considering the fact that the convective heat flux was determined by the heat source (assuming no heat loss through the insulated walls), then the convective heat loss is the conductive heat flow through the target material less the radiative heat loss from the target material.

The wind speed was modified by the SINE of the angle of attack in STEP 4 of the Analysis of Results and gave more consistent results than just using the wind speed alone (see tables 7 and 8). This satisfies Objective 5.

The methodology used to calculate the “least squares” error was as follows:

1. Determine the actual heat input into the hotbox.
   a. This is the wattage of the lamp plus the wattage of the circulating fan inside the hotbox.
2. Calculate the radiant heat loss using Stefan-Boltzmann Eq22.
3. Subtract the radiant heat loss from the actual heat input to determine the “target” convective heat loss.
4. Subtract the calculated heat loss from the target heat loss to determine the error.
5. Square the error and add the squares to provide a sum of error squares.
6. Calculate the square root of the error squares and compare that to the sum of the actual convective heats to provide a percentage error, independent of sign.

The best result of the least squares comparison was the Hagishima Eq8 methodology.

The least squares error is quantification of the error between the calculated convective heat flux and the actual convective heat flux. The least squares error for Hagishima method Equation 8 (6.4 step 8c) gives the least error at 6.22% so this is the method to be used in the model.

Chapter 4 has so far identified a working and proven model so Objectives 3 and 4 are satisfied.
Table 9 shows thermal images of the hotbox during test conditions.

<table>
<thead>
<tr>
<th>Image #</th>
<th>Date/Time</th>
<th>Test Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0831-07</td>
<td>31 Aug 2010</td>
<td>Gyproc 9.5 mm</td>
</tr>
<tr>
<td>13:40 hrs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A0831-10</td>
<td>31 Aug 2010</td>
<td>Gyproc 9.5 mm</td>
</tr>
<tr>
<td>14:10 hrs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A0831-14</td>
<td>31 Aug 2010</td>
<td>Gyproc 9.5 mm</td>
</tr>
<tr>
<td>14:25 hrs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A0902-02</td>
<td>2 Sept 2010 15:45 hrs</td>
<td>Floatglass 6mm</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>A0902-03</td>
<td>3 Sept 2010 10:35 hrs</td>
<td>Floatglass 6mm</td>
</tr>
<tr>
<td>A0902-05</td>
<td>3 Sept 2010 10:35 hrs</td>
<td>Floatglass 6mm</td>
</tr>
</tbody>
</table>
It should be noted that the time taken to achieve thermal stability was significant so the number of data collected is necessarily limited.

The thermal images of the GYPROC (A0831-7, A0831-10, A0831-14) test show substantial differences in temperature (up to 3.9°C) across the test surface. The temperature differences are probably due to variations in the heat flow inside the hot box. The internal fan was placed at the right hand side of the hot box (viewed from the front) and was chosen to distribute the heat as uniformly as possible throughout the hot box by blowing onto the internal lamp heater.

The heat capacity of Gypsum is 1.09 J/g.K whereas Silica Glass is 0.84 (according to The Engineering Toolbox - [http://www.engineeringtoolbox.com/specific-heat-solids-d_154.html](http://www.engineeringtoolbox.com/specific-heat-solids-d_154.html)) but glass has a higher density (2579 kg/m³) than Pulverised Gypsum (1121 kg/m³) so the actual heat capacity of the gypsum used in the experiment is much less than of the glass. This means that transient temperatures inside the hot box will show more quickly at the exterior of the Gypsum than at the exterior of the glass as is seen in the thermal images in table 5. As the brick is even heavier it is not possible to see the apparent temperature differences in A0903-16 and A0904-1.
4.5 Proving the Model

On the 18\textsuperscript{th} February 2011 a survey was carried out at the Priory Hospital in Bartle, near Preston. The Chief Engineer, Mr Nick Erdbeer, gave his kind permission to use the hospital to prove or adjust the model as necessary.

The methodology for selecting and proving the model is shown in figure 23.

\begin{itemize}
  \item \textbf{1. Modeling} \hspace{2cm} \begin{itemize}
    \item Identify potential models
    \item Test models in lab environment
    \item Choose the appropriate model
  \end{itemize}
  \item \textbf{2. Testing} \hspace{2cm} \begin{itemize}
    \item Test selected model in real world environment
    \item Calculate U-values
  \end{itemize}
  \item \textbf{3. Prediction} \hspace{2cm} \begin{itemize}
    \item Obtain predicted ambient temperatures & wind
    \item Estimate energy use over a 1-year period
    \item Calculate annual energy cost
  \end{itemize}
  \item \textbf{4. Verify and Adjust} \hspace{2cm} \begin{itemize}
    \item Compare predicted energy cost against actual usage
    \item Modify model to comply with actual energy cost & usage
  \end{itemize}
\end{itemize}

\textit{Figure 23 Methodology for proving the model}

Part 1 has been addressed previously. The remaining parts will be addressed herein.
Part 2 is considered in section 6.5.1 by carrying out a physical survey on a large multi storey commercial building.
4.5.1 Survey details

Priory hospital has residential facilities for nineteen patients as well as day care and a therapy services department.

![Figure 24 Priory Hospital, Preston](image)

The original building is shown in figure 24 (to the right of the tree) with a newer (larger) extension on three floors added later to the left of the main building. The services department intends to keep the inside temperature at about 23°C but are aware of heating losses in both buildings but particularly in the older building which is a converted manor house.

The complete building has UPVC double glazing fitted throughout but the quality of the fitting varies from one window to another. The building is heating throughout with hot water radiators. The hot water circulating system is heated by a LPG fired boiler with a quoted efficiency of 80%. Mr Erdbeer advised that the annual cost of energy at the hospital during 2010 was:

- LPG £28,071.35
- Water £583.55
- Electric £5551.79
According to the Biomass Energy Centre
(http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,59188&_dad=portal)

the cost of bulk LPG is as follows:

<table>
<thead>
<tr>
<th>Price per Litre</th>
<th>kWh per litre</th>
<th>Pence per kWh</th>
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</thead>
<tbody>
<tr>
<td>49p</td>
<td>6.6 kWh/litr</td>
<td>7.4p /kWh</td>
</tr>
</tbody>
</table>
4.5.2 Survey Procedure
The survey was carried out on 10 February 2011. The author, with an assistant, arrived at the hospital at 9am and met with the chief engineer who gave the required site entry authorisation.

The equipment used on site was:

- FLIR PM575 thermal imaging camera
- Samsung handheld visual camera
- 5m steel measurement tape
- LCD digital thermometer for ambient temperature (corrected as per section 6.3 table 6 item 2.
- Ultrasonic wind speed meter.

The survey was carried out as follows:

1. Ambient data was collected at the start of the survey
   a. Wind direction and strength
   b. Ambient temperature
2. Thermal images and visual images were taken of each external elevation
3. The thermal imaging camera was used to measure average internal surface temperatures for each component in each room.
4. Physical size measurements were recorded for each external component (doors, windows, walls, roof etc.).
5. The survey was completed by 11am and ambient data recorded again.

4.5.3 Analysis of on-site data
The thermal images were analysed using IRWIN software from AGEMA systems and the average external temperature was extracted from each thermal image for each component:

Averaged external and internal temperatures were corrected as per section 6.3, table 6, item 1. The ambient and component temperature and wind data were recorded into a database and U-values for each component calculated using Equation 8.

Average ambient data was collected from the following sources for future energy prediction:
1. Wind
   a. Department of Energy & Climate Change
      i. Wind speed database – data can be extracted for any National Grid location at various heights above the ground. Data for 10m above ground was used for this survey.

2. Temperature
   a. UK National Meteorological Office
      i. Climate averages for specific locations – the location used for this survey was Blackpool – it is the closest available to the Priory Hospital at a distance of 11.3 miles.

Using the calculated U-values and the averaged ambient data, an estimate was made of predicted energy usage for heating for this building.

4.5.4 Reconciliation of the Model to the results
Using only equation 8 for the calculation of CHTC was not possible on the day of the survey as there was no wind. The Hagishima model Equation 8 requires turbulent air flow \((Re > 10^5)\), at each component external surface - a modification was therefore required.

The alternative Hagishima model (equation 6) was used to calculate CHTC in the event of laminar convective flow \((Re < 10^5 \text{ or zero wind flow})\) and the primary Hagishima model (equation 8) was used if wind was measureable.

Combining Hagishima Equation 6 and Equation 8 in the database as follows:

\[
H_c: IIf([\text{We}]<0.01,[\text{NoWind}],11.42*([\text{WL}]/2)^{-0.109*[\text{We}]^{0.891}})
\]

Where:

- \(H_c = \text{CHTC}\)
- \(\text{We} = \text{effective wind speed}\)
- \(\text{NoWind} = \text{is the zero wind speed crossing value (4.47 in Equation 6)}\).
- \(\text{WL}/2 = \text{Distance from the component centre point to the component edge}\)
The calculated energy loss using this method was £27,034.90 against an actual cost of £28,071.35 giving an error of 3.69%. The model satisfies the requirements as stated in Objective 7.

The report attached as appendix 9 calculates the heat loss by component type and ranks the heat loss as follows (highest loss first):

1. Brick walls
2. Roof
3. Windows
4. Doors.

From the data (see Appendix 8 and appendix 9) it is apparent that the most cost effective solution for the hospital would be to improve the insulation of the walls – probably through cavity wall insulation and secondly to improve the roof thermal insulation.
Chapter 5

5 Development of the Graphical User Interface.

5.1 Introduction
Determination of heat loss through a building requires a great many calculations leading to a requirement for computational capability. In the first part of this document the calculations were carried out using spreadsheets but it soon became apparent to the author that the very large spreadsheets became ungainly and difficult to use.

This chapter will describe the development of a database to enable manipulation of large amounts of data with an easy to understand visual output for the layman.

The database software used was Microsoft Access 2010.

5.2 Database Structure
5.2.1 Tables
The database is designed to accept data input and then carry out calculations of various parameters such as CHTC, radiation heat flux, conductive heat flux etc. The first stage therefore is to ensure the necessary data for the calculations are available within subsets or tables.

Figure 25 Relationships of tables
Figure 24 shows the base tables for data entry. The lines joining the tables show the relationships to enable the database to function and to enable the build of queries and reports. The leftmost table in figure 24 is titled “Building”. The Building table is the master table from which all other tables are eventually joined,

The Building table has the basic data for identification of the building being surveyed with the following fields:

- ID  a unique identifier
- Housename  a text field to identify the building
- Street Address
- Area
- Town
- County
- Post Code
- BldgPic  this is a link to a visual image of the building.

The other tables such as Room include information about each room such as the name of each room as well as fields for the storage of thermal and visual images. The ExternalSurface table holds temperature data for each surface as well as the type of surface component (door, window, wall etc.), and emissivity. If there is a recommendation for improvement, that is also stored in the ExternalSurface table.

The SurfaceTypes table stores data about each various types of surface such as ASHRAE roughness factor and the maximum allowable U-value for each component based on Part L ADL2B and ADL2A 2010 Building Regulations 2000.

Several other tables also exist for storage of information such as the value of zero wind crossing factor as specified in Equation 6 as well as ambient data for each survey, power costs and annual average ambient data for different areas.
5.3.2 Calculations and Queries

Before any reports can be generated several basic calculations must be performed and data organised into queries so that similar data or data required for a particular report are grouped.

Within the database there are four main queries (not including queries for data entry etc.):

- **Base Queries**
  - Calc Query 1
    - This is used for the initial calculation of U-value under “as measured” conditions
  - Calc Query Avg
    - This is used to gather the data and initial calculation for energy and cost predictions.

- **Report Preparation Queries**
  - report detail query
    - This is used to prepare data and calculations for presentation into reports based on “as measured” data.
  - Report Avg Detail Query
    - This query prepares data and calculations for reports of predicted energy usage and future costs.
5.3.3 Data Entry Forms

To make the database as user friendly as possible the author decided to have data entered through pre-defined forms that are linked to the data tables.

![Figure 26 Data entry form for Building data](image)

Figure 26 shows the data entry form for basic information such as address and location of the building under survey.

![Figure 27 Detailed entry form for temperatures and areas](image)

Figure 26 shows the data entry form for more detailed information about each component. In this form is entered such information as the visual and thermal images as well as essential data such as areas, temperatures, wall thickness, emissivity and the compass direction of the external surface.
5.3.4 Menu Structure
Within MS-Access the default menu system is based around “Switchboards”. The main switchboard is shown in figure 27.

![Figure 28 Main Switchboard](image)

The main switchboard has a number of “push buttons” for quick and easy access to each of the main functions such as data entry, data editing and report generation.

5.3.5 Report Generation
The database has five reports defined from the main switchboard:

- Initial Conditions
  - Heat Loss Detail Report
  - Heat Loss Overview Report
- Future Energy Usage & Cost Prediction
  - Annual Averaged Data Report
    - This report provides a prediction of heat energy usage over a 12 month period.
  - Predicted Annual Heat Loss Report by Room
    - This is a more detailed report giving heat loss per component and per room with an estimate of energy and cost savings if the component is brought up to Part L ADL2 minimum requirements.
Predicted Heat Loss by Component

- An overview report of predicted heat loss by component type.

A copy of each report is provided in the appendix.

As the database is working as a GUI with the following functionality, Objective 7 has been achieved.

- Determination of total heat loss from each surface component and each external elevation.
- Determination of U and R value for each surface component.
- Calculation of total heat loss from each room in a building.
- Calculation of the cost of heating/cooling a building
Chapter 6

6 Conclusions and Recommendations for Further Development

6.1 Discussion of Results

6.1.1 Model veracity

The primary conclusion is that it is possible to estimate with a reasonable degree of accuracy (<5%) the quantitative heat loss from a building by using a thermal imaging camera and some simple additional tools.

The model used in the calculation of predicted heat energy losses is based on a heat energy balance (Eq30) in which the total heat loss (i.e. the conductive heat loss through the building fabric for each component) is a sum of the radiative and convective heat flows (see figure 14). In order to calculate the convective heat loss it was found necessary to first determine the convective heat transfer coefficient and the method thereof was determined to be a combination of Hagishima’s methods described in equations 6 and 8 (see section 6.4 page 69).

The convective heat loss from the external surface of a building may be accurately estimated by using the empirical formulae developed by Hagishima et al as follows:

a. With laminar wind flow (Re < 10^5) use:

\[ h = 10.21 \sqrt{u^2 + v^2 + w^2} + 4.47 \]

b. With turbulent wind flow (Re > 10^5) use:

\[ h = 11.42 \cdot l^{-0.109} \cdot \left( \sqrt{\frac{u^2 + v^2 + w^2}{u^2 + v^2 + w^2}} \right)^{0.891} \]

The report in appendix 8 shows a predicted heat loss cost of £27,034.90 whereas the actual heat loss cost in 2010 was £28,071.35 (page 74) giving an error of only -3.69%.

A further benefit of the accuracy of the model is shown in figure 29. The detailed breakdown of each type of component for the Priory Hospital shows that of the four types of components considered, the highest energy loss was from the walls.

1. Brick Walls
   a. Heat loss = 16.89kW
   b. Energy loss cost per annum = £13,685.56
2. Roofs
   a. Heat loss = 10.49kW
   b. Energy loss cost per annum = £8,503.11
3. Windows
   a. Heat loss = 5.63kW
   b. Energy loss cost per annum = £4,562.73
4. Doors
   a. Heat loss = 0.35kW
   b. Energy loss cost per annum = £283.50

The conclusion for the building is that the highest energy loss is through the walls. Associated CO₂ emissions would be most reduced by insulating the walls to the standard required by Part L ADL2 2010 Building Regulations (see section 7.2.1).

<table>
<thead>
<tr>
<th>Component</th>
<th>Heat Loss (kW)</th>
<th>Cost of Heating/Year (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>16.89494858</td>
<td>5737.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11152.5</td>
</tr>
<tr>
<td>Window</td>
<td>5.630917765</td>
<td>1214.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3574.03</td>
</tr>
<tr>
<td>Door</td>
<td>0.94986528</td>
<td>229.92</td>
</tr>
<tr>
<td></td>
<td></td>
<td>529.102</td>
</tr>
<tr>
<td>Pennroof</td>
<td>10.4578136</td>
<td>2124.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5068.86</td>
</tr>
</tbody>
</table>

Figure 29 Extract from Report 5 summarising heat loss and costs by component.

6.1.2 U-Value Calculation
Once the methodology for determining the CHTC was selected (section 8.1) the actual heat loss may be calculated using Newton’s law of cooling (equation 24 page 45).

The conductance is a property of a given material (equation 16) whereas the conductivity or U-value (equation 16) is specific to a given component that has been constructed and incorporated into the building’s thermal envelope.

The detail components required to calculate U-value (figure 14) are:
- \( Q \) = heat flow (watts)
- \( A \) = component surface area (m\(^2\))
- \( T_o \) = outside wall temperature (°C)
- \( T_i \) = inside wall temperature (°C)

Report 3 (appendix 8 – see excerpt figure 30) gives calculated U-value for all components in the building. Perusal of the calculated U-values reveals a significant variation in value in (apparently) identical components (see figure 30).

Figure 30 Excerpt from report 3 showing differences in calculated U-value for adjacent similar components in F4 Bedroom 10.

Whereas government building regulations give guidelines on how to calculate U-value and thus heat loss using target U-values and conductivity for materials it is apparent that the U-values of the installed components varies significantly (section 2.3 - Bradley).

The conclusion must be that an accurate calculation of U-value using typical conductivities of materials is subject to a degree of inaccuracy. Actual U-values may be measured accurately using the methodology described herein.
The U-values of components calculated using the methodology in this paper are more accurate and easier to calculate than the methodology advised in the Building regulations 2000 as the Building Regulations require a separate calculation for each sub component and that they be combined into an effective U-value.

6.1.3 Thermal Imaging Camera Accuracy
An intrinsic component of the methodology to determine U-value and R-value in this paper is determination of the radiative heat flow (equations 21 and 30). The method used in this paper to measure the wall surface temperatures to be used in the determination of radiative heat flow was an infrared thermal imaging camera FLIR PM575.

It was discovered during the course of the experimentation with the hot box to identify the best model for heat loss that the thermal imaging (InfraRed or IR) camera was reading high by 2.2°C (section 6.1 and figure 22). The quoted sensitivity of the subject IR camera is less than 0.1°C but the measurement accuracy is ±2%. With a range of -20°C to +350°C (appendix 2) a 2% error equates to an actual error of 7.4°C.

While the IR camera used in the data gathering was within the quoted error, it is too high an error to be used for quantitative measurement without error compensation (section 6.1).
6.2 Conclusions

1. The literature study

   a. The literature study identified several possible models in the field of solid/air convective and radiative heat transfer as per the requirements of the initial objectives. The model selected for radiative heat transfer was the Stefan-Boltzmann model and the model for convective heat flow was short listed to
      i. The Clear/Hagishima Linear curve fit (Eq6)
      ii. The Hagishima model including wall size (Eq8)
      iii. The ASHRAE model (Eq30).

   b. The study also identified precedent for the use of infrared thermal imaging for radiometric surface temperature measurement. Thermal imaging cameras allow for temperature averaging over a complete surface which improves the accuracy of the selected models.

2. Based on the selected models, the components needed to create a model of heat transfer through various types of building components in vertical, horizontal and angled planes when subject to a range of external air movements were identified as follows:
   i. Wall surface temperature, inside and outside
   ii. Free outside air temperature
   iii. Wind speed and direction relative to the building surface
   iv. Wall physical properties.
       1. Dimensional height, width & thickness
       2. Outside wall Roughness factor
       3. Outside wall Emissivity

3. The Hagishima Eq8 model was selected for the convective model. Adding the convective heat flow (watts) to the radiative heat flow (watts) the total conductive heat flow was calculated. With knowledge of the dimensions of each component and the thickness, the author was then able to calculate the
U-value for each component and thence the R-value as required in the initial objectives.

4. The model was embedded within a GUI and providing the following functionality as per initial objectives:
   a. Determination of total heat loss from each surface component and each external elevation.
   b. Determination of U and R value for each surface component.
   c. Calculation of total heat loss from each room in a building.
   d. Calculation of the cost of heating a building

5. The model was evaluated using a hot box with a known internal heat source. The experimental data correlated well with the published U-value data for GYPROC, OPTIFLOAT and SINGLE BRICK when the outside wall was subject to fan blown air. This proves that the models selected were accurate when used in the experimental environment as per the initial objectives.

6. The hot box was subject to various wind speeds and angle of attack. The wind speed was directly compensated for with the selected convective model but greater accuracy was realised when the wind speed was multiplied by the SINE of the angle of attack. The author postulates that a wind angle of attack normal to the wall will disrupt the boundary layer severely whereas an angle of attack parallel to the wall will have less effect on the boundary layer – this should be a matter for further research.

7. The model was trialled on a working hospital during the winter of early 2011. The projected results were consistent with actual heat losses and costs from the previous twelve month period with a projected cost error of less than 5%. This objectively proves the veracity of the final model and satisfies objective seven.
6.3 Recommendations for Further Development

1. While the calculation for radiative heat loss is well understood, the method used for calculating convective heat loss from a building should be considered as being based on an effective theory and not a quantitative theory. The method described in this paper is largely empirical even though it is based on sound science.

As the Hagishima formulae are divided into two distinct regimes, a suitable topic for further investigation would be to analyse how the changeover from laminar flow to turbulent flow occurs on large external windblown structures and combine both formulae into one coherent formula. A review of angle of attack should be included in this research.

2. The GUI developed by the author for this paper should be further developed for air cooled buildings to assess air conditioning load.

3. This paper does not consider mass exchange. A development of this paper would be to measure and include the amount of energy lost because of fresh air exchange in the normal ventilation of a building, both commercial and dwelling.
Appendix 1 - References


7 Reynolds, Osborne. “An experimental investigation of the circumstances which determine whether the motion of water shall be direct or sinuous, and the law of resistance in parallel channels”. 1883. Philosophical Transactions of the Royal Society 174 (0) 935-982. 10.1098/rstl.1883.0029. JSTOR 109431.


Thijs Defraeye\textsuperscript{a}, Bert Blocken\textsuperscript{b}, Jan Carmeliet\textsuperscript{c}, Jan Carmeliet\textsuperscript{c}, Convective heat transfer coefficients for exterior building surfaces: Existing correlations and CFD modelling, 2010
\textsuperscript{a} Laboratory of Building Physics, Department of Civil Engineering, Katholieke Universiteit Leuven, Kasteelpark Arenberg 40, 3001 Heverlee, Belgium
\textsuperscript{b} Building Physics and Systems, Eindhoven University of Technology, P.O. Box 513, 5600 Eindhoven, The Netherlands
\textsuperscript{c} Chair of Building Physics, Swiss Federal Institute of Technology Zurich (ETHZ), Wolfgang-Pauli-Strasse 15, 8093 Zürich, Switzerland
\textsuperscript{d} Laboratory for Building Science and Technology, Swiss Federal Laborataries for Materials Testing and Research (Empa), Überlandstrasse 129, 8600 Dübendorf, Switzerland


### Technical specifications

#### 7.1 General specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object temperature measurement range</td>
<td>-20° to 1360° C (-4° to 2662° F), two ranges. Up to +1000°C (+1832°F) with high temperature option.</td>
</tr>
<tr>
<td>Measurement accuracy</td>
<td>± 2 %</td>
</tr>
<tr>
<td>Thermal sensitivity</td>
<td>&lt; 0.1 °C (0.18 °F)</td>
</tr>
<tr>
<td>Field of view (F x V)</td>
<td>See &quot;Lens data&quot; on page 43.</td>
</tr>
<tr>
<td>Detector type</td>
<td>Focal Plane Array (FPA), uncooled microbolometer, 320 x 240 pixels.</td>
</tr>
<tr>
<td>Spectral range</td>
<td>7.5 - 13 μm, built-in atmospheric filter with cut-off @ 7.5 μm.</td>
</tr>
<tr>
<td>Video output</td>
<td>Standard VHS or S-VHS</td>
</tr>
<tr>
<td>Viewfinder</td>
<td>Color LCD (TFT)</td>
</tr>
<tr>
<td>PC-card drive</td>
<td>One slot for Type I or Type III PC-cards. Either FLASH cards or hard disks (ATA compatible) can be used.</td>
</tr>
<tr>
<td>Image storing</td>
<td>Full dynamics, 14-bit digital storage</td>
</tr>
</tbody>
</table>

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Figure 31 Thermal Imager Technical Specifications
### Appendix 3 - Emissivity Values

**Table 10 Emissivity values for building materials from ASHRAE Handbook Fundamentals 2009**

<table>
<thead>
<tr>
<th>MATERIAL SURFACE</th>
<th>EMISSIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td>0.90 – 0.98</td>
</tr>
<tr>
<td>Aluminium Foil</td>
<td>0.03 – 0.05</td>
</tr>
<tr>
<td>Brick</td>
<td>0.93</td>
</tr>
<tr>
<td>Concrete</td>
<td>0.85 – 0.95</td>
</tr>
<tr>
<td>Glass (unglazed)</td>
<td>0.95</td>
</tr>
<tr>
<td>Fibreglass</td>
<td>0.80 – 0.90</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.36 – 0.90</td>
</tr>
<tr>
<td>Marble</td>
<td>0.93</td>
</tr>
<tr>
<td>Paper</td>
<td>0.92</td>
</tr>
<tr>
<td>Plaster</td>
<td>0.91</td>
</tr>
<tr>
<td>Silver</td>
<td>0.02</td>
</tr>
<tr>
<td>Mild Steel</td>
<td>0.12</td>
</tr>
<tr>
<td>Wood</td>
<td>0.90</td>
</tr>
</tbody>
</table>
Appendix 4 – Reuse License

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Appendix 5. (Report 1.pdf)
Heat Loss Snapshot Detail Report

Please note: This report is based only on ambient conditions encountered during the on-site survey.

Client Name: The Priory Hospital
Location: Rosemary Lane, Bartlett, Preston, PR4 0HB
Contact: Mr Nick Erdbeer
Project Number: 000214
Date: 18th February 2011

 Priory Hospital
Rosemary Lane
Preston
Lancashire
PR4 0HB

Date of Survey: 10/02/2011
Cost per kWhour: 0.074
Wind Speed m/s: 0.000
Wind Direction (compass angle) 0.000

Page 1 of 46
04 October 2011
### Radiant Heat Loss

<table>
<thead>
<tr>
<th>Window</th>
<th>North Window</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>North Window</td>
<td>0.7425</td>
<td>10</td>
<td>21</td>
<td>11.139</td>
<td>10.953</td>
<td>22.092</td>
<td>2.705</td>
<td>0.370</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>North Wall</td>
<td>6.9375</td>
<td>9</td>
<td>24</td>
<td>76.160</td>
<td>119.112</td>
<td>195.272</td>
<td>1.876</td>
<td>0.533</td>
</tr>
<tr>
<td>Window</td>
<td>West Window</td>
<td>0.7425</td>
<td>10</td>
<td>21</td>
<td>11.139</td>
<td>10.953</td>
<td>22.092</td>
<td>2.705</td>
<td>0.370</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>West Wall</td>
<td>6.9375</td>
<td>9</td>
<td>24</td>
<td>76.160</td>
<td>119.112</td>
<td>195.272</td>
<td>1.876</td>
<td>0.533</td>
</tr>
</tbody>
</table>

Total heat loss from this room: **434.72753 watts**

Cost per kWh: **£0.0740**

Boiler Efficiency: **80%**

- Cost of heating the room per hour: **£0.0402**
- Cost of heating the room per day: **£0.9651**
- Cost of heating the room per calendar month: **£29.35**
- Cost of heating the room per year: **£352.26**

### Recommendations

- IR : max 14.5°C
- IR : min 6.3°C
- AR01 : avg 9.8°C

04 October 2011
<table>
<thead>
<tr>
<th>Brick Wall</th>
<th>Wall</th>
<th>5.86</th>
<th>Outside Surface Temperature °C</th>
<th>9</th>
<th>Inside Surface Temperature °C</th>
<th>24</th>
<th>Radiant Heat Loss (watts)</th>
<th>64.331</th>
<th>Convective Heat Loss (watts)</th>
<th>100.612</th>
<th>Total Heat Loss (watts)</th>
<th>164.943</th>
<th>U Value</th>
<th>1.876</th>
<th>R Value</th>
<th>0.533</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>Window</td>
<td>0.7425</td>
<td>Outside Surface Temperature °C</td>
<td>10</td>
<td>Inside Surface Temperature °C</td>
<td>21</td>
<td>Heat Loss (watts)</td>
<td>11.139</td>
<td>Convective Heat Loss (watts)</td>
<td>10.953</td>
<td>Total Heat Loss (watts)</td>
<td>22.092</td>
<td>U Value</td>
<td>2.705</td>
<td>R Value</td>
<td>0.370</td>
</tr>
</tbody>
</table>

Total heat loss from this room 187.03503 watts

Cost per kWh £0.0740
Boiler Efficiency 80%

Cost of heating the room per hour: £0.0173
Cost of heating the room per day £0.4152
Cost of heating the room per calendar month £12.63
Cost of heating the room per year £151.55
### F13 Bedroom 2

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>6.965</td>
<td>9</td>
<td>24</td>
<td>76.462</td>
<td>119.584</td>
<td>196.046</td>
<td>1.876</td>
<td>0.533</td>
</tr>
<tr>
<td>Window Window</td>
<td>0.7425</td>
<td>9</td>
<td>21</td>
<td>7.722</td>
<td>7.634</td>
<td>15.356</td>
<td>1.723</td>
<td>0.580</td>
</tr>
</tbody>
</table>

- **Outside Surface Temperature:** 5.6°C
- **Inside Surface Temperature:** 13.6°C

**Recommendations**

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max23.1°C</td>
</tr>
<tr>
<td>IR</td>
<td>min6.6°C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg10.2°C</td>
</tr>
</tbody>
</table>

**Cost per kWh:** £0.0740

**Boiler Efficiency 80%**

- **Total heat loss from this room:** 0.211401889 kWh
- **Cost of heating the room per hour:** £0.0196
- **Cost of heating the room per day:** £0.4693
- **Cost of heating the room per calendar month:** £14.27
- **Cost of heating the room per year:** £171.30
### F14 Bedroom 3

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>6.965</td>
<td>9</td>
<td>24</td>
<td>76.462</td>
<td>119.584</td>
<td>196.046</td>
<td>1.876</td>
<td>0.533</td>
</tr>
<tr>
<td>Window Window</td>
<td>2.041</td>
<td>10</td>
<td>21</td>
<td>30.620</td>
<td>30.107</td>
<td>60.726</td>
<td>2.705</td>
<td>0.370</td>
</tr>
</tbody>
</table>

**Total heat loss from this room:** 107.082 watts 149.6908 watt 256.77236 watts

**Cost per kWh:** £0.0740

**Boiler Efficiency 80%**
- Total heat loss from this room 0.256772356 kW
- Cost of heating the room per hour: £0.0238
- Cost of heating the room per day £0.5700
- Cost of heating the room per calendar month £17.34
- Cost of heating the room per year £208.06
## F15 Bedroom 4

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>6.965</td>
<td>9</td>
<td>24</td>
<td>76.462</td>
<td>119.584</td>
<td>196.046</td>
<td>1.876</td>
<td>0.533</td>
</tr>
<tr>
<td>Window</td>
<td>0.7425</td>
<td>10</td>
<td>21</td>
<td>11.139</td>
<td>10.953</td>
<td>22.092</td>
<td>2.705</td>
<td>0.370</td>
</tr>
</tbody>
</table>

**Radiant**

- 87.6012 watts
- 130.5366 Watt
- 218.13782 watts

**Cost per kWh** £0.0740

**Boiler Efficiency 80%**

- Total heat loss from this room 0.218137815 kW
- Cost of heating the room per hour: £0.0202
- Cost of heating the room per day: £0.4843
- Cost of heating the room per calendar month: £14.73
- Cost of heating the room per year: £176.76

### Recommendations

- LabelValue
- IR : max19.8°C
- IR : min4.7°C
- AR01 : avg9.2°C

---

04 October 2011
<table>
<thead>
<tr>
<th>Area sq m</th>
<th>Outside Surface Temperature ºC</th>
<th>Inside Surface Temperature ºC</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.965</td>
<td>9</td>
<td>24</td>
<td>76.462</td>
<td>119.584</td>
<td>196.046</td>
<td>1.876</td>
<td>0.533</td>
</tr>
<tr>
<td>0.7425</td>
<td>9</td>
<td>21</td>
<td>7.722</td>
<td>7.634</td>
<td>15.356</td>
<td>1.723</td>
<td>0.580</td>
</tr>
</tbody>
</table>

**Recommendations**

- Label: Value
  - IR : max 19.8 ºC
  - IR : min 4.7 ºC
  - AR01 : avg 9.2 ºC

**Cost per kWh £0.0740**

- Boiler Efficiency 80%
- Total heat loss from this room 0.211401889 kW
- Cost of heating the room per hour: £0.0196
- Cost of heating the room per day: £0.4693
- Cost of heating the room per calendar month: £14.27
- Cost of heating the room per year: £171.30
### F17 Bedroom 6

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Area (sq m)</th>
<th>Outside Temperature °C</th>
<th>Inside Temperature °C</th>
<th>Radiant Loss (watts)</th>
<th>Convective Loss (watts)</th>
<th>Total Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>0.7425</td>
<td>9</td>
<td>16</td>
<td>7.722</td>
<td>7.634</td>
<td>15.356</td>
<td>2.954</td>
<td>0.338</td>
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<tr>
<td>Brick Wall</td>
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<td>9</td>
<td>20</td>
<td>76.462</td>
<td>119.584</td>
<td>196.046</td>
<td>2.559</td>
<td>0.391</td>
</tr>
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</table>

**Total heat loss from this room:** 211.40189 watts

**Cost per kWh:** £0.0740

**Boiler Efficiency 80%**

Total heat loss from this room: 0.211401889 kW

- Cost of heating the room per hour: £0.0196
- Cost of heating the room per day: £0.4693
- Cost of heating the room per calendar month: £14.27
- Cost of heating the room per year: £171.30

### Recommendations

- **Label**: Value
- **IR : max**: 19.8 °C
- **IR : min**: 4.7 °C
- **AR01**: avg 9.2 °C

---

04 October 2011
**F19 Bedroom 7**

<table>
<thead>
<tr>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>9.244</td>
<td>12</td>
<td>237.632</td>
<td>365.729</td>
<td>603.361</td>
<td>5.439</td>
<td>0.184</td>
</tr>
<tr>
<td>Window</td>
<td>2.756</td>
<td>15</td>
<td>106.808</td>
<td>102.250</td>
<td>209.058</td>
<td>12.643</td>
<td>0.079</td>
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</table>

**Recommendations**

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR : max</td>
<td>20.4 °C</td>
</tr>
<tr>
<td>IR : min</td>
<td>4.7 °C</td>
</tr>
<tr>
<td>AR01 : avg</td>
<td>9.5 °C</td>
</tr>
</tbody>
</table>

**Cost per kWh** £0.0740

**Boiler Efficiency** 80%

Total heat loss from this room 0.81241896 kW

Cost of heating the room per hour: £0.0751

Cost of heating the room per day: £1.8036

Cost of heating the room per calendar month: £54.86

Cost of heating the room per year: £658.30
### F2 Bedroom 12

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature ºC</th>
<th>Inside Surface Temperature ºC</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>1.485</td>
<td>11</td>
<td>19</td>
<td>29.185</td>
<td>28.543</td>
<td>57.728</td>
<td>4.859</td>
<td>0.206</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>13.515</td>
<td>11</td>
<td>24</td>
<td>280.369</td>
<td>433.819</td>
<td>714.188</td>
<td>4.065</td>
<td>0.246</td>
</tr>
</tbody>
</table>

**Total heat loss from this room:** 771.91649 watts

**Cost per kWh:** £0.0740

**Boiler Efficiency 80%**

- Total heat loss from this room: 0.771916486 kW
- Cost of heating the room per hour: £0.0714
- Cost of heating the room per day: £1.7137
- Cost of heating the room per calendar month: £52.12
- Cost of heating the room per year: £625.48

**Recommendations**

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Page 11 of 46
### F21A Bedroom

<table>
<thead>
<tr>
<th></th>
<th>Area (sq m)</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>2.756</td>
<td>13</td>
<td>21</td>
<td>80.210</td>
<td>77.612</td>
<td>157.822</td>
<td>7.158</td>
<td>0.140</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>6.965</td>
<td>12</td>
<td>24</td>
<td>179.046</td>
<td>275.563</td>
<td>454.609</td>
<td>5.439</td>
<td>0.184</td>
</tr>
</tbody>
</table>

**Recommendations**

- **Total heat loss from this room:** 612.43089 watts
- **Boiler Efficiency:** 80%
- **Cost per kWh:** £0.0740
- **Total heat loss from this room:** 0.612430892 kW
- **Cost of heating the room per hour:** £0.0566
- **Cost of heating the room per day:** £1.3596
- **Cost of heating the room per calendar month:** £41.35
- **Cost of heating the room per year:** £496.25
## F21B Bedroom

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>2.756</td>
<td>13</td>
<td>21</td>
<td>80.210</td>
<td>77.612</td>
<td>157.822</td>
<td>7.158</td>
<td>0.140</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>6.965</td>
<td>12</td>
<td>24</td>
<td>179.046</td>
<td>275.563</td>
<td>454.609</td>
<td>5.439</td>
<td>0.184</td>
</tr>
</tbody>
</table>

Total heat loss from this room 612.43089 watts

- **Cost per kWh**: £0.0740
- **Boiler Efficiency 80%**
  - Total heat loss from this room 0.612430892 kW
  - Cost of heating the room per hour: £0.0566
  - Cost of heating the room per day: £1.3596
  - Cost of heating the room per calendar month: £41.35
  - Cost of heating the room per year: £496.25

**Recommendations**

---

04 October 2011
### F3 Bedroom 11

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>Wall</td>
<td>20</td>
<td>9</td>
<td>219.561</td>
<td>343.385</td>
<td>562.946</td>
<td>2.165</td>
<td>0.462</td>
</tr>
<tr>
<td>Window</td>
<td>Window</td>
<td>1.1</td>
<td>10</td>
<td>16.502</td>
<td>16.226</td>
<td>32.729</td>
<td>2.705</td>
<td>0.370</td>
</tr>
</tbody>
</table>

Total heat loss from this room: 595.67486 watts

Cost of heating the room per hour: £0.0551

Cost of heating the room per day: £40.22

Cost of heating the room per calendar month: £482.68

Cost per kWh: £0.0740

Boiler Efficiency: 80%

Total heat loss from this room: 0.595674855 kW

Cost of heating the room per hour: £0.0551

Cost of heating the room per day: £1.3224

Cost of heating the room per calendar month: £40.22

Cost of heating the room per year: £482.68
### F4 Bedroom 10

<table>
<thead>
<tr>
<th></th>
<th>Area (sq m)</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>East Wall</td>
<td>9.75</td>
<td>11</td>
<td>202.264</td>
<td>312.966</td>
<td>515.230</td>
<td>4.804</td>
<td>0.208</td>
</tr>
<tr>
<td>Window</td>
<td>East Window</td>
<td>0.7525</td>
<td>11</td>
<td>14.789</td>
<td>14.464</td>
<td>29.253</td>
<td>4.859</td>
<td>0.206</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>South Wall</td>
<td>14.257</td>
<td>10</td>
<td>225.769</td>
<td>351.209</td>
<td>576.978</td>
<td>3.372</td>
<td>0.297</td>
</tr>
<tr>
<td>Window</td>
<td>South Window</td>
<td>0.55</td>
<td>12</td>
<td>13.394</td>
<td>13.030</td>
<td>26.425</td>
<td>6.864</td>
<td>0.146</td>
</tr>
</tbody>
</table>

#### Recommendations

- Label: Value
  - IR: max 23.1 °C
  - IR: min 6.6 °C
  - AR01: avg 10.2 °C

**Total heat loss from this room:** 1,147.886 watts

**Cost per kWh:** £0.0740

**Boiler Efficiency:** 80%

**Cost of heating the room per hour:** £0.1062

**Cost of heating the room per day:** £2.5483

**Cost of heating the room per calendar month:** £77.51

**Cost of heating the room per year:** £930.13

---

04 October 2011
<table>
<thead>
<tr>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7525</td>
<td>11</td>
<td>19</td>
<td>14.789</td>
<td>14.464</td>
<td>29.253</td>
<td>4.859</td>
<td>0.206</td>
</tr>
<tr>
<td>14.2575</td>
<td>11</td>
<td>22</td>
<td>295.773</td>
<td>457.652</td>
<td>753.425</td>
<td>4.804</td>
<td>0.208</td>
</tr>
</tbody>
</table>

Cost of heating the room per hour: £0.0724
Cost of heating the room per day: £1.7375
Cost of heating the room per calendar month: £52.85
Cost of heating the room per year: £634.20

BOiler Efficiency 80%

Total heat loss from this room: 0.78267789 kW
### F6 Bartle Room

<table>
<thead>
<tr>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>1.485</td>
<td>12</td>
<td>36.165</td>
<td>35.181</td>
<td>71.346</td>
<td>5.338</td>
<td>0.187</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>13.515</td>
<td>10</td>
<td>214.019</td>
<td>332.931</td>
<td>546.950</td>
<td>13.515</td>
<td>0.346</td>
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**Recommendations**

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
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<tbody>
<tr>
<td>IR</td>
<td>max 60.8 °C</td>
</tr>
<tr>
<td>IR</td>
<td>min 5.2 °C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg 11.3 °C</td>
</tr>
</tbody>
</table>

**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

Total heat loss from this room: 618.29603 watts

Cost of heating the room per hour: £0.0572

Cost of heating the room per day: £1.3726

Cost of heating the room per calendar month: £41.75

Cost of heating the room per year: £501.01

---

04 October 2011
<table>
<thead>
<tr>
<th>Component</th>
<th>Area (sq m)</th>
<th>Outside Surface Temperature (°C)</th>
<th>Inside Surface Temperature (°C)</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>1.485</td>
<td>9</td>
<td>21</td>
<td>15.444</td>
<td>15.267</td>
<td>30.712</td>
<td>1.723</td>
<td>0.580</td>
</tr>
<tr>
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<td>10.515</td>
<td>10</td>
<td>24</td>
<td>166.512</td>
<td>259.028</td>
<td>425.540</td>
<td>2.891</td>
<td>0.346</td>
</tr>
</tbody>
</table>

Total heat loss from this room: 456.25197 watts

Cost per kWh: £0.0740

Boiler Efficiency 80%

Total heat loss from this room: 0.456251972 kW

Cost of heating the room per hour: £0.0422

Cost of heating the room per day: £1.0129

Cost of heating the room per calendar month: £30.81

Cost of heating the room per year: £369.70
G1 Entrance Lobby

<table>
<thead>
<tr>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door</td>
<td>0.78</td>
<td>15</td>
<td>31.908</td>
<td>28.939</td>
<td>60.847</td>
<td>39.004</td>
<td>0.026</td>
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</tbody>
</table>

Total heat loss from this room 60.846728 watts

Cost per kWh £0.0740
Boiler Efficiency 80%

Total heat loss from this room 0.060846728 kW
Cost of heating the room per hour £0.0056
Cost of heating the room per day £0.1351
Cost of heating the room per calendar month £4.11
Cost of heating the room per year £49.30
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>5.4214</td>
<td></td>
<td></td>
<td>59.516</td>
<td>93.081</td>
<td>152.598</td>
<td>1.759</td>
<td>0.568</td>
</tr>
<tr>
<td>Window Window</td>
<td>2.1306</td>
<td>9</td>
<td>20</td>
<td>22.159</td>
<td>21.905</td>
<td>44.063</td>
<td>1.880</td>
<td>0.532</td>
</tr>
</tbody>
</table>

Recommendations

- **81.6752 watts**
- **114.9862 watt**
- **196.66134 watts**

**Cost per kWh £0.0740**

**Boiler Efficiency 80%**

Total heat loss from this room **0.196661341 kW**

Cost of heating the room per hour: **£0.0182**

Cost of heating the room per day: **£0.4366**

Cost of heating the room per calendar month: **£13.28**

Cost of heating the room per year: **£159.35**
<table>
<thead>
<tr>
<th>Material</th>
<th>Type</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>Wall</td>
<td>5.4214</td>
<td>8</td>
<td>25</td>
<td>33.460</td>
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<td>1.071</td>
</tr>
<tr>
<td>Window</td>
<td>Window</td>
<td>2.1306</td>
<td>10</td>
<td>20</td>
<td>31.964</td>
<td>31.428</td>
<td>63.392</td>
<td>2.975</td>
<td>0.336</td>
</tr>
</tbody>
</table>

Cost per kWh: £0.0740
Boiler Efficiency 80%

Total heat loss from this room: 149.46342 watts
Cost of heating the room per hour: £0.0138
Cost of heating the room per day: £10.09
Cost of heating the room per calendar month: £121.11

Recommendations

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max17.8°C</td>
</tr>
<tr>
<td>IR</td>
<td>min4.4°C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg10.3°C</td>
</tr>
</tbody>
</table>

04 October 2011
<table>
<thead>
<tr>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>5.4214</td>
<td>8</td>
<td>23</td>
<td>33.460</td>
<td>52.611</td>
<td>86.071</td>
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</tr>
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<td>Window Window</td>
<td>2.1306</td>
<td>9</td>
<td>20</td>
<td>22.159</td>
<td>21.905</td>
<td>44.063</td>
<td>1.880</td>
</tr>
</tbody>
</table>

Cost per kWh £0.0740

Boiler Efficiency 80%

Total heat loss from this room 0.130134717 kW

Cost of heating the room per hour: £0.0120

Cost of heating the room per day £0.2889

Cost of heating the room per calendar month £8.79

Cost of heating the room per year £105.45
### Heat Loss Calculations

<table>
<thead>
<tr>
<th>Material</th>
<th>Area (sq m)</th>
<th>Outside Surface Temp (°C)</th>
<th>Inside Surface Temp (°C)</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>2.1306</td>
<td>10</td>
<td>20</td>
<td>31.964</td>
<td>31.428</td>
<td>63.392</td>
<td>2.975</td>
<td>0.336</td>
</tr>
<tr>
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<td>9</td>
<td>23</td>
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<td>93.081</td>
<td>152.598</td>
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#### Recommendations

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
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<tbody>
<tr>
<td>IR : max</td>
<td>18.0 °C</td>
</tr>
<tr>
<td>IR : min</td>
<td>5.0 °C</td>
</tr>
<tr>
<td>AR01 : avg</td>
<td>9.8 °C</td>
</tr>
</tbody>
</table>

#### Cost Calculations

- **Cost per kWh**: £0.0740
- ** Boiler Efficiency**: 80%
- **Total heat loss from this room**: 215,990.5 watts
- **Cost of heating the room per hour**: £0.0200
- **Cost of heating the room per day**: £0.4795
- **Cost of heating the room per calendar month**: £14.58
- **Cost of heating the room per year**: £175.02
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Intside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>2.1306</td>
<td>10</td>
<td>20</td>
<td>31.964</td>
<td>31.428</td>
<td>63.392</td>
<td>2.975</td>
<td>0.336</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>5.4214</td>
<td>10</td>
<td>23</td>
<td>85.851</td>
<td>133.552</td>
<td>219.403</td>
<td>3.113</td>
<td>0.321</td>
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</table>

Total heat loss from this room: 282.79535 watts

Cost per kWh: £0.0740
Boiler Efficiency: 80%

- Total heat loss from this room: 0.282795346 kW
- Cost of heating the room per hour: £0.0262
- Cost of heating the room per day: £0.6278
- Cost of heating the room per calendar month: £19.10
- Cost of heating the room per year: £229.15
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Intside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>10.1124</td>
<td>12</td>
<td>25</td>
<td>259.955</td>
<td>400.087</td>
<td>660.042</td>
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<tr>
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<td>83.458</td>
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Total heat loss from this room: 824.25414 watts

Cost per kWh: £0.0740

Boiler Efficiency 80%

Total heat loss from this room: 0.824254136 kW

Cost of heating the room per hour: £0.0762

Cost of heating the room per day: £1.8298

Cost of heating the room per calendar month: £55.66

Cost of heating the room per year: £667.89
### Radiant Heat Loss

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Area (sq m)</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
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<td>9</td>
<td>21</td>
<td>30.889</td>
<td>30.535</td>
<td>61.423</td>
<td>1.723</td>
<td>0.580</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>12.03</td>
<td>11</td>
<td>20</td>
<td>249.563</td>
<td>386.152</td>
<td>635.715</td>
<td>5.872</td>
<td>0.170</td>
</tr>
</tbody>
</table>

**Total heat loss from this room**: 697.1381 watts

**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

**Cost of heating the room per hour**: £0.0645

**Cost of heating the room per day**: £1.5476

**Cost of heating the room per calendar month**: £47.07

**Cost of heating the room per year**: £564.89
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>3.983</td>
<td>12</td>
<td>25</td>
<td>102.389</td>
<td>157.583</td>
<td>259.973</td>
<td>5.021</td>
<td>0.199</td>
</tr>
<tr>
<td>Window Window</td>
<td>0.737</td>
<td>14</td>
<td>21</td>
<td>24.987</td>
<td>24.049</td>
<td>49.036</td>
<td>9.505</td>
<td>0.105</td>
</tr>
</tbody>
</table>

Total heat loss from this room: 309.00881 watts

Cost per kWh: £0.0740

Boiler Efficiency 80%

Total heat loss from this room: 0.30900815 kW

Cost of heating the room per hour: £0.0286

Cost of heating the room per day: £0.6860

Cost of heating the room per calendar month: £20.87

Cost of heating the room per year: £250.39

Recommendations
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>10.02</td>
<td>12</td>
<td>25</td>
<td>257.580</td>
<td>396.431</td>
<td>654.011</td>
<td>5.021</td>
<td>0.199</td>
</tr>
<tr>
<td>Window</td>
<td>1.98</td>
<td>13</td>
<td>21</td>
<td>57.625</td>
<td>55.759</td>
<td>113.384</td>
<td>7.158</td>
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Total heat loss from this room 315.205 watts
Cost per kWh £0.0740
Boiler Efficiency 80%
Total heat loss from this room 0.767394972 kW
Cost of heating the room per hour: £0.0710
Cost of heating the room per day £1.7036
Cost of heating the room per calendar month £51.82
Cost of heating the room per year £621.82
## G30 Conservatory

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PentRoof</td>
<td>14.875</td>
<td>14</td>
<td>18</td>
<td>504.321</td>
<td>728.079</td>
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<td>20.713</td>
<td>0.048</td>
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<tr>
<td>Window</td>
<td>24.5</td>
<td>13</td>
<td>19</td>
<td>713.041</td>
<td>689.945</td>
<td>1,402.986</td>
<td>9.544</td>
<td>0.105</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>10.5</td>
<td>11</td>
<td>24</td>
<td>217.823</td>
<td>337.040</td>
<td>554.863</td>
<td>4.065</td>
<td>0.246</td>
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</tbody>
</table>

**Total heat loss from this room:** 3190.2492 watts

Cost per kWh **£0.0740**
Boiler Efficiency 80%

- Total heat loss from this room: 3.190249178 kW
- Cost of heating the room per hour: **£0.2951**
- Cost of heating the room per day: **£7.0824**
- Cost of heating the room per calendar month: **£215.42**
- Cost of heating the room per year: **£2,585.06**

### Recommendations

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
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<tr>
<td>IR</td>
<td>min 7.4°C</td>
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<tr>
<td>AR01</td>
<td>avg 14.6°C</td>
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</table>

04 October 2011
### G31 Multi Function Space

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door</td>
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<td>11</td>
<td>19</td>
<td>64.856</td>
<td>63.429</td>
<td>128.285</td>
<td>4.859</td>
<td>0.206</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>11.7</td>
<td>10</td>
<td>22</td>
<td>185.277</td>
<td>288.220</td>
<td>473.497</td>
<td>3.372</td>
<td>0.297</td>
</tr>
</tbody>
</table>

#### Calculations

- Total heat loss from this room: 601.78194 watts
- Cost of heating the room per hour: £0.0557
- Cost of heating the room per day: £40.64
- Cost of heating the room per calendar month: £487.62
- Cost of heating the room per year: £0.0740

**Recommmendations**

- IR : max 17.7 °C
- IR : min 4.9 °C
- AR01 : avg 11.8 °C

**Remarks:**

- 04 October 2011
<table>
<thead>
<tr>
<th>Component</th>
<th>Area (sq m)</th>
<th>Outside Surface Temp ('C)</th>
<th>Inside Surface Temp ('C)</th>
<th>Radiant Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>1.98</td>
<td>12</td>
<td>19</td>
<td>48.220</td>
<td>46.908</td>
<td>95.128</td>
<td>6.864</td>
<td>0.146</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>13.02</td>
<td>10</td>
<td>22</td>
<td>206.180</td>
<td>320.737</td>
<td>526.917</td>
<td>3.372</td>
<td>0.297</td>
</tr>
</tbody>
</table>

254.400 watts \[\text{ Radiant Loss }\] 367.6451 watt \[\text{ Convective Heat Loss }\] 622.0454 watts \[\text{ Total Heat Loss }\]

Cost per kWh £0.0740
Boiler Efficiency 80%

Total heat loss from this room 0.62204554 kW
Cost of heating the room per hour: £0.0575
Cost of heating the room per day £1.3809
Cost of heating the room per calendar month £42.00
Cost of heating the room per year £504.04

Recommendations

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max17.7°C</td>
</tr>
<tr>
<td>IR</td>
<td>min4.9°C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg11.8°C</td>
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</tbody>
</table>
### G6 Changing Room

<table>
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<tr>
<th>Material</th>
<th>Type</th>
<th>Area (sq m)</th>
<th>Outside Surface Temperature ('C)</th>
<th>Inside Surface Temperature ('C)</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>Wall</td>
<td>3.983</td>
<td>9</td>
<td>23</td>
<td>43.726</td>
<td>68.385</td>
<td>112.111</td>
<td>2.011</td>
<td>0.497</td>
</tr>
<tr>
<td>Window</td>
<td>Window</td>
<td>0.737</td>
<td>10</td>
<td>20</td>
<td>11.057</td>
<td>10.871</td>
<td>21.928</td>
<td>2.975</td>
<td>0.336</td>
</tr>
</tbody>
</table>

**Total heat loss from this room:** 134.039 watts

**Cost per kWh:** £0.0740

**Boiler Efficiency 80%**

- Total heat loss from this room: 0.134038875 kW
- Cost of heating the room per hour: £0.0124
- Cost of heating the room per day: £0.2976
- Cost of heating the room per calendar month: £9.05
- Cost of heating the room per year: £108.61

---

**Recommendations**

- IR : max 56.8 °C
- IR : min 4.6 °C
- AR01 : avg 9.0 °C

---

04 October 2011
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>2.1306</td>
<td>10</td>
<td>20</td>
<td>31.964</td>
<td>31.428</td>
<td>63.392</td>
<td>2.975</td>
<td>0.336</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>2.5894</td>
<td>9</td>
<td>23</td>
<td>28.427</td>
<td>44.458</td>
<td>72.885</td>
<td>2.011</td>
<td>0.497</td>
</tr>
</tbody>
</table>

Total heat loss from this room: 136.27685 watts

Cost per kWh: £0.0740
Boiler Efficiency 80%
Total heat loss from this room: 0.136276847 kW

Cost of heating the room per hour: £0.0126
Cost of heating the room per day: £0.3025
Cost of heating the room per calendar month: £9.20
Cost of heating the room per year: £110.43

Recommendations
## G9 Pantry

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brick Wall West</strong></td>
<td>3.983</td>
<td>8</td>
<td>22</td>
<td>24.582</td>
<td>38.653</td>
<td>63.235</td>
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</tr>
<tr>
<td><strong>Brick Wall North</strong></td>
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<td>8</td>
<td>22</td>
<td>24.582</td>
<td>38.653</td>
<td>63.235</td>
<td>1.134</td>
<td>0.882</td>
</tr>
<tr>
<td><strong>Window West</strong></td>
<td>0.737</td>
<td>9</td>
<td>21</td>
<td>7.665</td>
<td>7.577</td>
<td>15.242</td>
<td>1.723</td>
<td>0.580</td>
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<tr>
<td><strong>Window North</strong></td>
<td>0.737</td>
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<td>21</td>
<td>7.665</td>
<td>7.577</td>
<td>15.242</td>
<td>1.723</td>
<td>0.580</td>
</tr>
</tbody>
</table>

### Recommendations

- **64.4948 watts**
- **92.45921 watt**
- **156.95399 watts**

**Cost per kWh £0.0740**

**Boiler Efficiency 80%**

- **Total heat loss from this room 0.156953986 kW**
- **Cost of heating the room per hour: £0.0145**
- **Cost of heating the room per day £0.3484**
- **Cost of heating the room per calendar month £10.60**
- **Cost of heating the room per year £127.18**
### SE1 Roof Space

<table>
<thead>
<tr>
<th>PentRoof</th>
<th>Roof Void West</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Intside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>79.8</td>
<td>11</td>
<td>13</td>
<td>1,620.603</td>
<td>2,300.754</td>
<td>3,921.357</td>
<td>24.570</td>
<td>0.041</td>
</tr>
</tbody>
</table>

Total heat loss from this room: 3,921.357 watts

Cost per kWh: £0.0740

Boiler Efficiency: 80%

- Cost of heating the room per hour: £0.3627
- Cost of heating the room per day: £8.7054
- Cost of heating the room per calendar month: £264.79
- Cost of heating the room per year: £3,177.48

**Recommendations**

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max 17.5 °C</td>
</tr>
<tr>
<td>IR</td>
<td>min 5.0 °C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg 10.7 °C</td>
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</table>

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Page 35 of 46
### SE11 Bedroom 14

<table>
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<tr>
<th>Material</th>
<th>Type</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>Window</td>
<td>2.028</td>
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<td>2.705</td>
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</tr>
<tr>
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<td>Wall</td>
<td>5.58</td>
<td>9</td>
<td>24</td>
<td>61.257</td>
<td>95.805</td>
<td>157.062</td>
<td>1.876</td>
<td>0.533</td>
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</table>

**Recommendations**

<table>
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<th>Label</th>
<th>Value</th>
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</thead>
<tbody>
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<tr>
<td>IR : min</td>
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<tr>
<td>AR01 : avg</td>
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</tbody>
</table>

**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

Total heat loss from this room: 217,401.53 watts

- Cost of heating the room per hour: £0.0201
- Cost of heating the room per day: £0.4826
- Cost of heating the room per calendar month: £14.68
- Cost of heating the room per year: £176.16

---

04 October 2011

Page 36 of 46
### SE12 Bedroom 15

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>5.58</td>
<td>10</td>
<td>24</td>
<td>88.363</td>
<td>137.459</td>
<td>225.822</td>
<td>2.891</td>
<td>0.346</td>
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<tr>
<td>Window</td>
<td>2.028</td>
<td>10</td>
<td>21</td>
<td>30.424</td>
<td>29.915</td>
<td>60.340</td>
<td>2.705</td>
<td>0.370</td>
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**Recommendations**

<table>
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<tr>
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</thead>
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<td>IR : min</td>
<td>3.3 °C</td>
</tr>
<tr>
<td>AR01 : avg</td>
<td>9.6 °C</td>
</tr>
</tbody>
</table>

- **Total heat loss from this room**: 118.787 watts, 167.3737 watt, 286.16118 watts

- **Cost per kWh**: £0.0740
- **Boiler Efficiency 80%**
- **Total heat loss from this room**: 0.286161183 kW
- **Cost of heating the room per hour**: £0.0265
- **Cost of heating the room per day**: £0.6353
- **Cost of heating the room per calendar month**: £19.32
- **Cost of heating the room per year**: £231.88
## SE13 Bedroom 16

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<th>Type</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
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<td>Brick Wall</td>
<td>Wall</td>
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<td>8</td>
<td>22</td>
<td>34.439</td>
<td>54.150</td>
<td>88.589</td>
<td>1.134</td>
<td>0.882</td>
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<td>Window</td>
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<td>20.850</td>
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<td>0.725</td>
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### Recommendations

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<tr>
<td>IR</td>
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</tr>
<tr>
<td>IR</td>
<td>min3.2 °C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg8.5 °C</td>
</tr>
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</table>

### Thermal Image

Temperature range: 4.4 °C to 12.4 °C

- **Cost per kWh**: £0.0740
- **Boiler Efficiency**: 80%
- **Total heat loss from this room**: 0.130530785 kW
- **Cost of heating the room per hour**: £0.0121
- **Cost of heating the room per day**: £0.2898
- **Cost of heating the room per calendar month**: £8.81
- **Cost of heating the room per year**: £105.77
### SE14 Bedroom 17

<table>
<thead>
<tr>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Intside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>Wall</td>
<td>5.58</td>
<td>9</td>
<td>24</td>
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<td>95.805</td>
<td>157.062</td>
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<tr>
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<td>Window</td>
<td>2.028</td>
<td>10</td>
<td>21</td>
<td>30.424</td>
<td>29.915</td>
<td>60.340</td>
</tr>
</tbody>
</table>

**Recommendations**

- IR : max20.0°C
- IR : min3.2°C
- AR01 : avg8.5°C

**Calculations:**

- Total heat loss from this room: 217.40153 watts
- Cost per kWh: £0.0740
- Boiler Efficiency: 80%
- Cost of heating the room per hour: £0.0201
- Cost of heating the room per day: £0.4826
- Cost of heating the room per calendar month: £14.68
- Cost of heating the room per year: £176.16

---

04 October 2011
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<tr>
<th>Surface Type</th>
<th>Area (sq m)</th>
<th>Outside Surface Temperature ('C)</th>
<th>Inside Surface Temperature ('C)</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>2.028</td>
<td>10</td>
<td>21</td>
<td>30.424</td>
<td>29.915</td>
<td>60.340</td>
<td>2.705</td>
<td>0.370</td>
</tr>
<tr>
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<td>5.58</td>
<td>9</td>
<td>24</td>
<td>61.257</td>
<td>95.805</td>
<td>157.062</td>
<td>1.876</td>
<td>0.533</td>
</tr>
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</table>

Cost per kWh: £0.0740
Boiler Efficiency: 80%

- Total heat loss from this room: 217.40153 watts
- Cost of heating the room per hour: £0.0201
- Cost of heating the room per day: £0.4826
- Cost of heating the room per calendar month: £14.68
- Cost of heating the room per year: £176.16

Recommendations

<table>
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<tr>
<td>IR: min</td>
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</tr>
<tr>
<td>AR01: avg</td>
<td>8.5°C</td>
</tr>
<tr>
<td></td>
<td>Area sq m</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Brick Wall Wall</td>
<td>9.257</td>
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<tr>
<td>Window Window</td>
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</table>

330.964 watts 455.7505 watt 786.71473 watts

Cost per kWh £0.0740
Boiler Efficiency 80%

Total heat loss from this room 0.786714733 kW
Cost of heating the room per hour: £0.0728
Cost of heating the room per day £1.7465
Cost of heating the room per calendar month £53.12
Cost of heating the room per year £637.47

Recommendations

<table>
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## SE19 ATP Office

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<th>Outside Surface Temperature ('C)</th>
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<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
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<th>R Value</th>
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<tr>
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<tr>
<td>Brick Wall</td>
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<td>12</td>
<td>143.443</td>
<td>220.767</td>
<td>364.210</td>
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<td>0.184</td>
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</table>

Total heat loss from this room 480.34247 watts

Cost per kWh £0.0740

Boiler Efficiency 80%

Total heat loss from this room 0.480342475 kW

Cost of heating the room per hour: £0.0444

Cost of heating the room per day £1.0664

Cost of heating the room per calendar month £32.44

Cost of heating the room per year £389.22

### Recommendations

04 October 2011
<table>
<thead>
<tr>
<th>Material</th>
<th>Surface</th>
<th>Area sq m</th>
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<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
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<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>Window</td>
<td>2.028</td>
<td>13</td>
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<td>57.111</td>
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<td>12</td>
<td>24</td>
<td>143.443</td>
<td>220.767</td>
<td>364.210</td>
<td>5.439</td>
<td>0.184</td>
</tr>
</tbody>
</table>

Total heat loss from this room: 480.34247 watts

Cost per kWh: £0.0740

Boiler Efficiency 80%

Total heat loss from this room: 0.480342475 kW

Cost of heating the room per hour: £0.0444

Cost of heating the room per day: £1.0664

Cost of heating the room per calendar month: £32.44

Cost of heating the room per year: £389.22
<table>
<thead>
<tr>
<th></th>
<th>Area (sq m)</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
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<td>21</td>
<td>22.278</td>
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<tr>
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<td>24</td>
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</table>

**Recommendations**

- **137.712 watts**
- **202.4401 watt**
- **340.15255 watts**

**Cost per kWh £0.0740**

**Boiler Efficiency 80%**

- Total heat loss from this room 0.340152545 kW
- Cost of heating the room per hour: £0.0315
- Cost of heating the room per day £0.7551
- Cost of heating the room per calendar month £22.97
- Cost of heating the room per year £275.63
### SE9 Bedroom 13

<table>
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<tr>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
<th>R Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall North Wall</td>
<td>6.965</td>
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<td>24</td>
<td>42.987</td>
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<tr>
<td>Window West Window</td>
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<td>21</td>
<td>10.727</td>
<td>10.547</td>
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<tr>
<td>Brick Wall West Wall</td>
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<tr>
<td>Window North Window</td>
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<td>21</td>
<td>7.436</td>
<td>7.351</td>
<td>14.787</td>
<td>1.723</td>
</tr>
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</table>

**Total heat loss from this room:** 342.68444 watts

**Cost per kWh:** £0.0740

**Boiler Efficiency 80%**

Total heat loss from this room: 0.342684439 kW

Cost of heating the room per hour: £0.0317

Cost of heating the room per day: £0.7608

Cost of heating the room per calendar month: £23.14

Cost of heating the room per year: £277.68

---

**Recommendations**

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR : max</td>
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</tr>
<tr>
<td>IR : min</td>
<td>2.6 °C</td>
</tr>
<tr>
<td>AR01 : avg</td>
<td>9.2 °C</td>
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04 October 2011
<table>
<thead>
<tr>
<th>Total radiant loss</th>
<th>10,015.732 watts</th>
<th>Total convective loss</th>
<th>14,020.655 watts</th>
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</thead>
<tbody>
<tr>
<td>Total heat loss from the building</td>
<td>24.036386559 kW</td>
<td>Cost of heating the building per hour</td>
<td>£2.22</td>
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<tr>
<td>Cost of heating the building per day</td>
<td>£53.36</td>
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<tr>
<td>Cost of heating the building per calendar month</td>
<td>£1,623.06</td>
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<td>Cost of heating the building per year</td>
<td>£19,476.68</td>
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</table>
**Heat Loss Snapshot Overview Report**

Please note: This report is based on actual ambient conditions encountered during the on-site survey.

**Priory Hospital**
Rosemary Lane  
Preston  
Lancashire  
PR4 0HB

<table>
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<tr>
<th>Date of Survey:</th>
<th>Cost per kWhour:</th>
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<tbody>
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<td>10/02/2011</td>
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<td>0.000</td>
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</table>

| Wind Direction (compass angle) | 0.000 |

<table>
<thead>
<tr>
<th>Total radiant loss</th>
<th>Total convective loss</th>
<th>Total heat loss from the building</th>
<th>Cost of heating the building per hour</th>
<th>Cost of heating the building per day</th>
<th>Cost of heating the building per calendar month</th>
<th>Cost of heating the building per year</th>
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<tr>
<td>10,015.732 watts</td>
<td>14,020.655 watts</td>
<td>24.036386559 kW</td>
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<td>£53.36</td>
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<td>Inside Surface Temperature (°C)</td>
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<td>---------------------------</td>
<td>------------------------------</td>
<td>-------------------------</td>
</tr>
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<tr>
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<td>134.083</td>
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<td></td>
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</tr>
</tbody>
</table>

**Cost per kWh** £0.0740

**Boiler Efficiency** 80%

- Total heat loss from this room: 0.471296763 kW
- Cost of heating the room per hour: £0.0436
- Cost of heating the room per day: £1.0463
- Cost of heating the room per calendar month: £31.82
- Cost of heating the room per year: £381.89
<table>
<thead>
<tr>
<th>Material</th>
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<th>Outside Surface Temperature ºC</th>
<th>Inside Surface Temperature ºC</th>
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<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
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<td>Window</td>
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<td>11.139</td>
<td>14.266</td>
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<td><strong>Totals</strong></td>
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<td><strong>75.470</strong></td>
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<td><strong>202.99445</strong></td>
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**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

- Total heat loss from this room: 0.20299445 kW
- Cost of heating the room per hour: £0.0188
- Cost of heating the room per day: £0.4506
- Cost of heating the room per calendar month: £13.71
- Cost of heating the room per year: £164.49
### F13 Bedroom 2

<table>
<thead>
<tr>
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<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
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<th>U Value</th>
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<tr>
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</table>

**Totals**: 84.184 watts 143.719 watt 227.90369 watts

---

**Cost per kWh**: £0.0740  
**Boiler Efficiency**: 80%  
**Total heat loss from this room**: 0.227903688 kW  
**Cost of heating the room per hour**: £0.0211  
**Cost of heating the room per day**: £0.5059  
**Cost of heating the room per calendar month**: £15.39  
**Cost of heating the room per year**: £184.67
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>6.965</td>
<td>9</td>
<td>24</td>
<td>76.462</td>
<td>134.614</td>
<td>211.076</td>
<td>1.876</td>
</tr>
<tr>
<td>Window Window</td>
<td>2.041</td>
<td>10</td>
<td>21</td>
<td>30.620</td>
<td>39.216</td>
<td>69.835</td>
<td>2.705</td>
</tr>
</tbody>
</table>

**Totals**  107.08 watts  173.83 watt  280.9115 watts

**Cost per kWh** £0.0740

**Boiler Efficiency** 80%

Total heat loss from this room 0.280911499 kW

Cost of heating the room per hour: £0.0260

Cost of heating the room per day £0.6236

Cost of heating the room per calendar month £18.97

Cost of heating the room per year £227.62
<table>
<thead>
<tr>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>6.965</td>
<td>9</td>
<td>76.462</td>
<td>134.614</td>
<td>211.076</td>
<td>1.876</td>
</tr>
<tr>
<td>Window Window</td>
<td>0.7425</td>
<td>10</td>
<td>11.139</td>
<td>14.266</td>
<td>25.406</td>
<td>2.705</td>
</tr>
</tbody>
</table>

**Totals** 87.601 watts 148.881 watt 236.48178 watts

**Cost per kWh £0.0740**

**Boiler Efficiency 80%**

Total heat loss from this room 0.236481777 kW

Cost of heating the room per hour: £0.0219

Cost of heating the room per day £0.5250

Cost of heating the room per calendar month £15.97

Cost of heating the room per year £191.62
<table>
<thead>
<tr>
<th>Area</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall</td>
<td>9</td>
<td>24</td>
<td>76.462</td>
<td>134.614</td>
<td>211.076</td>
<td>1.876</td>
</tr>
<tr>
<td>Window</td>
<td>9</td>
<td>21</td>
<td>7.722</td>
<td>9.105</td>
<td>16.827</td>
<td>1.723</td>
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</tbody>
</table>

**Totals**: 84.184 watts, 143.719 watt, 227.90369 watts

**Cost per kWh £0.0740**

**Boiler Efficiency 80%**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total heat loss from this room</td>
<td>£0.227903688 kW</td>
</tr>
<tr>
<td>Cost of heating the room per hour</td>
<td>£0.0211</td>
</tr>
<tr>
<td>Cost of heating the room per day</td>
<td>£0.5059</td>
</tr>
<tr>
<td>Cost of heating the room per calendar month</td>
<td>£15.39</td>
</tr>
<tr>
<td>Cost of heating the room per year</td>
<td>£184.67</td>
</tr>
<tr>
<td>Surface Type</td>
<td>Area (sq m)</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Window</td>
<td>0.7425</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>6.965</td>
</tr>
</tbody>
</table>

**Totals**

- **outside_surface**
- **inside_surface**
- **radiant_heat_loss**
- **convective_heat_loss**
- **total_heat_loss**
- **u_value**

**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

- **Total heat loss from this room**: 0.234420357 kW
- **Cost of heating the room per hour**: £0.0217
- **Cost of heating the room per day**: £0.5204
- **Cost of heating the room per calendar month**: £15.83
- **Cost of heating the room per year**: £189.95

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Page 8 of 45
### F19 Bedroom 7

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>9.244</td>
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<td>24</td>
<td>237.632</td>
<td>498.972</td>
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<tr>
<td>Window Window</td>
<td>2.756</td>
<td>15</td>
<td>21</td>
<td>106.808</td>
<td>246.849</td>
<td>353.656</td>
<td>12.643</td>
</tr>
</tbody>
</table>

**Totals**

- Radiant Heat Loss: 344.44 watts
- Convective Heat Loss: 745.820 watt
- Total Heat Loss: 1090.2595 watts

**Cost per kWh** **£0.0740**

**Boiler Efficiency** **80%**

- Total heat loss from this room: 1,090.2595 kW
- Cost of heating the room per hour: **£0.1008**
- Cost of heating the room per day: **£2.4204**
- Cost of heating the room per calendar month: **£73.62**
- Cost of heating the room per year: **£883.44**
<table>
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<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
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<td>19</td>
<td>29.185</td>
<td>44.058</td>
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<tr>
<td>Brick Wall</td>
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<td>11</td>
<td>24</td>
<td>280.369</td>
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<td>832.304</td>
<td>4.065</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>309.55</strong></td>
<td><strong>595.992</strong></td>
<td></td>
<td><strong>905.54669</strong></td>
<td></td>
<td><strong>905.54669</strong></td>
<td></td>
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</table>

Cost per kWh £0.0740

Boiler Efficiency 80%

Total heat loss from this room 0.90554669 kW

Cost of heating the room per hour: £0.0838

Cost of heating the room per day £2.0103

Cost of heating the room per calendar month £61.15

Cost of heating the room per year £733.76

06 November 2011
<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Area sq m</th>
<th>Outside Temperature °C</th>
<th>Inside Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
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</thead>
<tbody>
<tr>
<td>Window</td>
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<td>21</td>
<td>80.210</td>
<td>139.754</td>
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<tr>
<td>Brick Wall</td>
<td>6.965</td>
<td>12</td>
<td>24</td>
<td>179.046</td>
<td>375.956</td>
<td>555.002</td>
<td>5.439</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>259.26</strong></td>
<td><strong>515.71</strong></td>
<td><strong>774.96603</strong></td>
<td><strong>774.96603</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cost per kWh: £0.0740
Boiler Efficiency: 80%

Total heat loss from this room: 0.774966027 kW
Cost of heating the room per hour: £0.0717
Cost of heating the room per day: £1.7204
Cost of heating the room per calendar month: £52.33
Cost of heating the room per year: £627.95
### F21B Bedroom

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>2.756</td>
<td>13</td>
<td>21</td>
<td>80.210</td>
<td>139.754</td>
<td>219.964</td>
<td>7.158</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>6.965</td>
<td>12</td>
<td>24</td>
<td>179.046</td>
<td>375.956</td>
<td>555.002</td>
<td>5.439</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>259.26 watts</strong></td>
<td><strong>515.71 watt</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>774.96603 watts</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Cost per kWh**: £0.0740  
**Boiler Efficiency**: 80%  
**Total heat loss from this room**: 0.774966027 kW  
**Cost of heating the room per hour**: £0.0717  
**Cost of heating the room per day**: £1.7204  
**Cost of heating the room per calendar month**: £52.33  
**Cost of heating the room per year**: £627.95  

---

06 November 2011
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>20</td>
<td>9</td>
<td>22</td>
<td>219.561</td>
<td>393.184</td>
<td>612.745</td>
<td>2.165</td>
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<tr>
<td>Window</td>
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<td>1.1</td>
<td>10</td>
<td>16.502</td>
<td>21.135</td>
<td>37.638</td>
<td>2.705</td>
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<tr>
<td><strong>Totals</strong></td>
<td><strong>236.06 watts</strong></td>
<td><strong>414.32 watt</strong></td>
<td><strong>650.38323 watts</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Cost per kWh**: £0.0740  
**Boiler Efficiency**: 80%  
**Total heat loss from this room**: 0.650383233 kW  
**Cost of heating the room per hour**: £0.0602  
**Cost of heating the room per day**: £1.4439  
**Cost of heating the room per calendar month**: £43.92  
**Cost of heating the room per year**: £527.01
### F4 Bedroom 10

<table>
<thead>
<tr>
<th>Surface</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>9.75</td>
<td>11</td>
<td>22</td>
<td>202.264</td>
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</tr>
<tr>
<td>Brick Wall</td>
<td>14.257</td>
<td>10</td>
<td>22</td>
<td>225.769</td>
<td>430.544</td>
<td>656.313</td>
<td>3.372</td>
</tr>
<tr>
<td>Window</td>
<td>0.55</td>
<td>12</td>
<td>19</td>
<td>13.394</td>
<td>23.034</td>
<td>36.428</td>
<td>6.864</td>
</tr>
</tbody>
</table>

**Totals**

- **456.22** watts
- **889.573** watt
- **1345.7899** watts

---

**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

- **Total heat loss from this room**: 1,345,789.958 kWh
- **Cost of heating the room per hour**: £0.1245
- **Cost of heating the room per day**: £2.9877
- **Cost of heating the room per calendar month**: £90.87
- **Cost of heating the room per year**: £1,090.49

---

06 November 2011
<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>0.7525</td>
<td>11</td>
<td>19</td>
<td>14.789</td>
<td>22.326</td>
<td>37.115</td>
<td>4.859</td>
</tr>
</tbody>
</table>

**Totals**

- **310.56 watts**
- **627.238 watt**
- **937.79994 watts**

**Cost per kWh** £0.0740

**Boiler Efficiency** 80%

- Total heat loss from this room 0.937799941 kW
- Cost of heating the room per hour: £0.0867
- Cost of heating the room per day: £2.0819
- Cost of heating the room per calendar month: £63.32
- Cost of heating the room per year: £759.90

06 November 2011
<table>
<thead>
<tr>
<th>Location</th>
<th>Area (sq m)</th>
<th>Outside Surface Temperature (°C)</th>
<th>Inside Surface Temperature (°C)</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>1.485</td>
<td>12</td>
<td>21</td>
<td>36.165</td>
<td>56.189</td>
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<td>24</td>
<td>214.019</td>
<td>397.393</td>
<td>611.412</td>
<td>2.891</td>
</tr>
</tbody>
</table>

**Totals**  
250.18 watts  
453.581 watt  
703.76548 watts

**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

**Total heat loss from this room**: 0.703765475 kW

**Cost of heating the room per hour**: £0.0651

**Cost of heating the room per day**: £1.5624

**Cost of heating the room per calendar month**: £47.52

**Cost of heating the room per year**: £570.26
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
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<td>9</td>
<td>21</td>
<td>15.444</td>
<td>18.210</td>
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<td>1.723</td>
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<tr>
<td>Brick Wall</td>
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<td>10</td>
<td>24</td>
<td>166.512</td>
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<td>475.693</td>
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</tr>
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</table>

**Totals**: 181.96 watts 327.392 watt 509.34814 watts

**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

- Total heat loss from this room: 0.509348138 kW
- Cost of heating the room per hour: £0.0471
- Cost of heating the room per day: £1.1308
- Cost of heating the room per calendar month: £34.39
- Cost of heating the room per year: £412.72
### G1 Entrance Lobby

<table>
<thead>
<tr>
<th>Door</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door</td>
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<td>17</td>
<td>31.908</td>
<td>155.196</td>
<td>187.104</td>
<td>39.004</td>
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</table>

**Costs**

- **Cost per kWh**: £0.0740
- **Boiler Efficiency**: 80%
- **Total heat loss from this room**: 0.18710369 kW
- **Cost of heating the room per hour**: £0.0173
- **Cost of heating the room per day**: £0.4154
- **Cost of heating the room per calendar month**: £12.63
- **Cost of heating the room per year**: £151.61

**Label/Value**

- IR : max 16.1 °C
- IR : min 6.9 °C
- AR01 : avg 14.8 °C

**Image**: Thermogram of the entrance lobby with temperature readings and cost calculations.
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
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<td>25</td>
<td>59.516</td>
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<td>163.566</td>
<td>1.759</td>
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<td>20</td>
<td>22.159</td>
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<td>48.670</td>
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<tr>
<td><strong>Totals</strong></td>
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<td></td>
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<td><strong>212.23595</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Cost per kWh**: £0.0740  
**Boiler Efficiency**: 80%  
**Total heat loss from this room**: 0.212235949 kW  
**Cost of heating the room per hour**: £0.0196  
**Cost of heating the room per day**: £0.4712  
**Cost of heating the room per calendar month**: £14.33  
**Cost of heating the room per year**: £171.97
<table>
<thead>
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<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>5.4214</td>
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<td>25</td>
<td>33.460</td>
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<td>20</td>
<td>31.964</td>
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<td></td>
<td><strong>97.790</strong></td>
<td></td>
<td><strong>163.21409</strong></td>
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</tr>
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</table>

Cost per kWh £0.0740
Boiler Efficiency 80%

Total heat loss from this room 0.163214092 kW
Cost of heating the room per hour: £0.0151
Cost of heating the room per day £0.3623
Cost of heating the room per calendar month £11.02
Cost of heating the room per year £132.25
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>5.4214</td>
<td>8</td>
<td>23</td>
<td>33.460</td>
<td>56.341</td>
<td>89.801</td>
<td>1.058</td>
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<td>Window Window</td>
<td>2.1306</td>
<td>9</td>
<td>20</td>
<td>22.159</td>
<td>26.511</td>
<td>48.670</td>
<td>1.880</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>55.619</td>
<td>watts</td>
<td>82.8524</td>
<td>watt</td>
<td>138.47111</td>
<td>watts</td>
<td></td>
</tr>
</tbody>
</table>

Cost per kWh £0.0740
Boiler Efficiency 80%
Total heat loss from this room 0.138471107 kW
Cost of heating the room per hour: £0.0128
Cost of heating the room per day £0.3074
Cost of heating the room per calendar month £9.35
Cost of heating the room per year £112.20
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Intside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window Window</td>
<td>2.1306</td>
<td>10</td>
<td>20</td>
<td>31.964</td>
<td>41.888</td>
<td>73.852</td>
<td>2.975</td>
</tr>
<tr>
<td>Brick Wall Wall</td>
<td>5.4214</td>
<td>9</td>
<td>23</td>
<td>59.516</td>
<td>105.616</td>
<td>165.133</td>
<td>2.011</td>
</tr>
</tbody>
</table>

**Totals** 91.480 watts 147.504 watt 238.98458 watts

**Cost per kWh** £0.0740

**Boiler Efficiency** 80%

Total heat loss from this room 0.238984581 kW

Cost of heating the room per hour: £0.0221

Cost of heating the room per day £0.5305

Cost of heating the room per calendar month £16.14

Cost of heating the room per year £193.65
<table>
<thead>
<tr>
<th>Surface</th>
<th>Area (sq m)</th>
<th>Outside Temp ('C)</th>
<th>Inside Temp ('C)</th>
<th>Radiant Loss (watts)</th>
<th>Convective Loss (watts)</th>
<th>Total Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>2.1306</td>
<td>10</td>
<td>20</td>
<td>31.964</td>
<td>41.888</td>
<td>73.852</td>
<td>2.975</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>5.4214</td>
<td>10</td>
<td>23</td>
<td>85.851</td>
<td>161.399</td>
<td>247.250</td>
<td>3.113</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>117.82 watts</strong></td>
<td><strong>203.287 watt</strong></td>
<td><strong>321.10238 watts</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

Total heat loss from this room: 0.321102381 kW

Cost of heating the room per hour: £0.0297

Cost of heating the room per day: £0.7128

Cost of heating the room per calendar month: £21.68

Cost of heating the room per year: £260.19
<table>
<thead>
<tr>
<th>Surface</th>
<th>Area (sq m)</th>
<th>Outside Temp (°C)</th>
<th>Inside Temp (°C)</th>
<th>Radiant Loss (watts)</th>
<th>Convective Loss (watts)</th>
<th>Total Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>10.1124</td>
<td>12</td>
<td>25</td>
<td>259.955</td>
<td>534.634</td>
<td>794.589</td>
<td>5.021</td>
</tr>
<tr>
<td>Window</td>
<td>2.8676</td>
<td>13</td>
<td>21</td>
<td>83.458</td>
<td>145.413</td>
<td>228.871</td>
<td>7.158</td>
</tr>
</tbody>
</table>

**Totals**

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR max</td>
<td>20.5°C</td>
</tr>
<tr>
<td>IR min</td>
<td>6.4°C</td>
</tr>
<tr>
<td>AR01 avg</td>
<td>14.5°C</td>
</tr>
<tr>
<td>AR02 avg</td>
<td>14.4°C</td>
</tr>
<tr>
<td>AR03 avg</td>
<td>14.2°C</td>
</tr>
<tr>
<td>AR04 avg</td>
<td>14.4°C</td>
</tr>
<tr>
<td>AR05 avg</td>
<td>11.5°C</td>
</tr>
</tbody>
</table>

### Total Heat Loss

1023.4597 watts

### Cost per kWh

£0.0740

### Boiler Efficiency

80%

### Total heat loss from this room

1.023459722 kW

### Cost of heating the room per hour:

£0.0947

### Cost of heating the room per day:

£2.2721

### Cost of heating the room per calendar month:

£69.11

### Cost of heating the room per year:

£829.31
### G2 Reception

<table>
<thead>
<tr>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>Windows</td>
<td>2.97</td>
<td>9</td>
<td>21</td>
<td>30.889</td>
<td>36.421</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>Wall</td>
<td>12.03</td>
<td>11</td>
<td>20</td>
<td>249.563</td>
<td>538.017</td>
</tr>
</tbody>
</table>

**Cost per kWh**: £0.0740  
**Boiler Efficiency**: 80%  
**Total heat loss from this room**: 0.854889694 kW  
**Cost of heating the room per hour**: £0.0791  
**Cost of heating the room per day**: £1.8979  
**Cost of heating the room per calendar month**: £57.73  
**Cost of heating the room per year**: £692.72
<table>
<thead>
<tr>
<th></th>
<th>Area (sq m)</th>
<th>Outside Surface Temperature (°C)</th>
<th>Inside Surface Temperature (°C)</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>3.983</td>
<td>12</td>
<td>25</td>
<td>102.389</td>
<td>210.578</td>
<td>312.967</td>
<td>5.021</td>
</tr>
<tr>
<td>Window Window</td>
<td>0.737</td>
<td>14</td>
<td>21</td>
<td>24.987</td>
<td>49.618</td>
<td>74.605</td>
<td>9.505</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>127.38</strong></td>
<td><strong>watts</strong></td>
<td><strong>260.196</strong></td>
<td><strong>387.57212</strong></td>
<td><strong>watts</strong></td>
<td><strong>watts</strong></td>
<td></td>
</tr>
</tbody>
</table>

Cost per kWh £0.0740
Boiler Efficiency 80%
Total heat loss from this room 0.387572123 kW
Cost of heating the room per hour: £0.0359
Cost of heating the room per day £0.8604
Cost of heating the room per calendar month £26.17
Cost of heating the room per year £314.05
## G27 Dining Room

<table>
<thead>
<tr>
<th>Surface</th>
<th>Area sq m</th>
<th>Outside Surface Temperature 'C</th>
<th>Inside Surface Temperature 'C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>Wall</td>
<td>10.02</td>
<td>12</td>
<td>25</td>
<td>257.580</td>
<td>529.749</td>
<td>787.328</td>
</tr>
<tr>
<td>Window</td>
<td>Window</td>
<td>1.98</td>
<td>13</td>
<td>21</td>
<td>57.625</td>
<td>100.404</td>
<td>158.029</td>
</tr>
</tbody>
</table>

**Totals** 315.21 watts 630.152 watt 945.3577 watts

**Cost per kWh** £0.0740

**Boiler Efficiency** 80%

- Total heat loss from this room 0.945357571 kW
- Cost of heating the room per hour: £0.0874
- Cost of heating the room per day £2.0987
- Cost of heating the room per calendar month £63.84
- Cost of heating the room per year £766.02
### G30 Conservatory

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Area (sq m)</th>
<th>Outside Surface Temperature (°C)</th>
<th>Inside Surface Temperature (°C)</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PentRoof</td>
<td>14.875</td>
<td>14</td>
<td>18</td>
<td>504.321</td>
<td>1,852.644</td>
<td>2,356.965</td>
<td>20.713</td>
</tr>
<tr>
<td>Window</td>
<td>24.5</td>
<td>13</td>
<td>19</td>
<td>713.041</td>
<td>1,426.512</td>
<td>2,139.553</td>
<td>9.544</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>10.5</td>
<td>11</td>
<td>24</td>
<td>217.823</td>
<td>428.806</td>
<td>646.629</td>
<td>4.065</td>
</tr>
</tbody>
</table>

**Totals:** 1435.2 watts, 3707.96 watts, 5143.1477 watts

Cost per kWh: £0.0740

**Boiler Efficiency:** 80%

- Total heat loss from this room: 5.143147725 kW
- Cost of heating the room per hour: £0.4757
- Cost of heating the room per day: £11.4178
- Cost of heating the room per calendar month: £347.29
- Cost of heating the room per year: £4,167.49
<table>
<thead>
<tr>
<th>Surface</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door</td>
<td>3.3</td>
<td>11</td>
<td>19</td>
<td>64.856</td>
<td>97.906</td>
<td>162.761</td>
<td>4.859</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>11.7</td>
<td>10</td>
<td>22</td>
<td>185.277</td>
<td>353.326</td>
<td>538.603</td>
<td>3.372</td>
</tr>
</tbody>
</table>

| Total         |           |                                 |                             | 250.13                   | 451.231                     | 701.36435               |         |

**Cost per kWh**: £0.0740  
**Boiler Efficiency**: 80%  
**Total heat loss from this room**: 0.70136435 kW  
**Cost of heating the room per hour**: £0.0649  
**Cost of heating the room per day**: £1.5570  
**Cost of heating the room per calendar month**: £47.36  
**Cost of heating the room per year**: £568.32
### G32 Multi Function Space

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>1.98</td>
<td>12</td>
<td>19</td>
<td>48.220</td>
<td>82.921</td>
<td>131.141</td>
<td>6.864</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>13.02</td>
<td>10</td>
<td>22</td>
<td>206.180</td>
<td>393.188</td>
<td>599.368</td>
<td>3.372</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>254.40</strong> watts</td>
<td><strong>476.109</strong> watt</td>
<td><strong>730.50952</strong> watts</td>
<td></td>
</tr>
</tbody>
</table>

**Cost per kWh**: £0.0740  
**Boiler Efficiency**: 80%  
**Total heat loss from this room**: 0.730509516 kW  
**Cost of heating the room per hour**: £0.0676  
**Cost of heating the room per day**: £1.6217  
**Cost of heating the room per calendar month**: £49.33  
**Cost of heating the room per year**: £591.93
## G6 Changing Room

<table>
<thead>
<tr>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>3.983</td>
<td>9</td>
<td>23</td>
<td>43.726</td>
<td>77.594</td>
<td>121.320</td>
</tr>
<tr>
<td>Window</td>
<td>0.737</td>
<td>10</td>
<td>20</td>
<td>11.057</td>
<td>14.490</td>
<td>25.546</td>
</tr>
</tbody>
</table>

**Totals**

- **54.782 watts**
- **92.083 watt**
- **146.86611 watts**

**Cost per kWh** £0.0740

**Boiler Efficiency** 80%

- Total heat loss from this room 0.146866113 kW
- Cost of heating the room per hour: £0.0136
- Cost of heating the room per day £0.3260
- Cost of heating the room per calendar month £9.92
- Cost of heating the room per year £119.01
<table>
<thead>
<tr>
<th></th>
<th>Area (sq m)</th>
<th>Outside Surface Temperature (°C)</th>
<th>Inside Surface Temperature (°C)</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>2.1306</td>
<td>10</td>
<td>20</td>
<td>31.964</td>
<td>41.888</td>
<td>73.852</td>
<td>2.975</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>2.5894</td>
<td>9</td>
<td>23</td>
<td>28.427</td>
<td>50.445</td>
<td>78.872</td>
<td>2.011</td>
</tr>
</tbody>
</table>

**Totals**: 60.390 watts, 92.333 watt, 152.72351 watts

**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

Total heat loss from this room: 0.152723512 kW

Cost of heating the room per hour: £0.0141

Cost of heating the room per day: £0.3390

Cost of heating the room per calendar month: £10.31

Cost of heating the room per year: £123.75
<table>
<thead>
<tr>
<th>Surface</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>3.983</td>
<td>8</td>
<td>22</td>
<td>24.582</td>
<td>41.588</td>
<td>66.171</td>
<td>1.134</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>3.983</td>
<td>8</td>
<td>22</td>
<td>24.582</td>
<td>41.588</td>
<td>66.171</td>
<td>1.134</td>
</tr>
<tr>
<td>Window West</td>
<td>0.737</td>
<td>9</td>
<td>21</td>
<td>7.665</td>
<td>9.038</td>
<td>16.703</td>
<td>1.723</td>
</tr>
<tr>
<td>Window North</td>
<td>0.737</td>
<td>9</td>
<td>21</td>
<td>7.665</td>
<td>9.038</td>
<td>16.703</td>
<td>1.723</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>64.495</strong></td>
<td><strong>101.252</strong></td>
<td><strong>165.7472</strong></td>
<td></td>
</tr>
</tbody>
</table>

Cost per kWh £0.0740

Boiler Efficiency 80%

Total heat loss from this room 0.165747198 kW

Cost of heating the room per hour: £0.0153

Cost of heating the room per day £0.3680

Cost of heating the room per calendar month £11.19

Cost of heating the room per year £134.30

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06 November 2011
<table>
<thead>
<tr>
<th>PentRoof</th>
<th>Roof Void West</th>
<th>Area sq m</th>
<th>Outside Temperature 'C</th>
<th>Inside Temperature 'C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>79.8</td>
<td>11</td>
<td>13</td>
<td>1,620.603</td>
<td>6,516.213</td>
<td>8,136.816</td>
<td>24.570</td>
</tr>
</tbody>
</table>

Total heat loss from this room: 8,136.8159 watts

Cost of heating the room per hour: £0.7527
Cost of heating the room per day: £18.0637
Cost of heating the room per calendar month: £549.44
Cost of heating the room per year: £6,593.26
### SE11 Bedroom 14

<table>
<thead>
<tr>
<th>Material</th>
<th>Type</th>
<th>Area (sq m)</th>
<th>Outside Surface Temp (°C)</th>
<th>Inside Surface Temp (°C)</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>Window</td>
<td>2.028</td>
<td>10</td>
<td>21</td>
<td>30.424</td>
<td>38.966</td>
<td>69.390</td>
<td>2.705</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>Wall</td>
<td>5.58</td>
<td>9</td>
<td>24</td>
<td>61.257</td>
<td>107.846</td>
<td>169.103</td>
<td>1.876</td>
</tr>
</tbody>
</table>

**Totals**: 91.682 watts, 146.812 watt, 238.49388 watts

**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

- Total heat loss from this room: 0.238493879 kW
- Cost of heating the room per hour: £0.0221
- Cost of heating the room per day: £0.5295
- Cost of heating the room per calendar month: £16.10
- Cost of heating the room per year: £193.25
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall Wall</td>
<td>5.58</td>
<td>10</td>
<td>24</td>
<td>88.363</td>
<td>164.073</td>
<td>252.436</td>
<td>2.891</td>
</tr>
<tr>
<td>Window Window</td>
<td>2.028</td>
<td>10</td>
<td>21</td>
<td>30.424</td>
<td>38.966</td>
<td>69.390</td>
<td>2.705</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>118.79</strong></td>
<td><strong>watts</strong></td>
<td><strong>203.039 watts</strong></td>
<td><strong>321.82681 watts</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cost per kWh £0.0740  
Boiler Efficiency 80%  
Total heat loss from this room 0.321826806 kW  
Cost of heating the room per hour: £0.0298  
Cost of heating the room per day £0.7145  
Cost of heating the room per calendar month £21.73  
Cost of heating the room per year £260.78
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>5.58</td>
<td>8</td>
<td>22</td>
<td>34.439</td>
<td>58.263</td>
<td>92.702</td>
<td>1.134</td>
</tr>
<tr>
<td>Window</td>
<td>2.028</td>
<td>9</td>
<td>24</td>
<td>21.092</td>
<td>24.065</td>
<td>45.157</td>
<td>1.379</td>
</tr>
</tbody>
</table>

**Totals**

55.531 watts 82.328 watt 137.85938 watts

**Cost per kWh** £0.0740
**Boiler Efficiency** 80%

Total heat loss from this room 0.137859377 kW
Cost of heating the room per hour: £0.0128
Cost of heating the room per day £0.3060
Cost of heating the room per calendar month £9.31
Cost of heating the room per year £111.71

06 November 2011
<table>
<thead>
<tr>
<th>Area</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>5.58</td>
<td>9</td>
<td>24</td>
<td>61.257</td>
<td>107.846</td>
<td>169.103</td>
</tr>
<tr>
<td>Window</td>
<td>2.028</td>
<td>10</td>
<td>21</td>
<td>30.424</td>
<td>38.966</td>
<td>69.390</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>238.49388</td>
</tr>
</tbody>
</table>

Cost per kWh £0.0740
Boiler Efficiency 80%
Total heat loss from this room 0.238493879 kW
Cost of heating the room per hour: £0.0221
Cost of heating the room per day: £0.5295
Cost of heating the room per calendar month: £16.10
Cost of heating the room per year: £193.25
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature 'C</th>
<th>Inside Surface Temperature 'C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>2.028</td>
<td>10</td>
<td>21</td>
<td>30.424</td>
<td>38.966</td>
<td>69.390</td>
<td>2.705</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>5.58</td>
<td>9</td>
<td>24</td>
<td>61.257</td>
<td>107.846</td>
<td>169.103</td>
<td>1.876</td>
</tr>
</tbody>
</table>

**Totals** 91.682 watts 146.812 watt 238.49388 watts

Cost per kWh £0.0740
Boiler Efficiency 80%

Total heat loss from this room 0.238493879 kW
Cost of heating the room per hour: £0.0221
Cost of heating the room per day £0.5295
Cost of heating the room per calendar month £16.10
Cost of heating the room per year £193.25

06 November 2011
## SE18 Group Room

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>9.257</td>
<td>12</td>
<td>24</td>
<td>237.966</td>
<td>499.673</td>
<td>737.639</td>
<td>5.439</td>
</tr>
<tr>
<td>Window</td>
<td>2.743</td>
<td>14</td>
<td>21</td>
<td>92.998</td>
<td>184.670</td>
<td>277.669</td>
<td>9.505</td>
</tr>
</tbody>
</table>

**Totals**: 330.96 watts  684.344 watt  1015.3078 watts

---

**Cost per kWh**: £0.0740  
**Boiler Efficiency**: 80%  
**Total heat loss from this room**: 1.015307803 kW  
**Cost of heating the room per hour**: £0.0939  
**Cost of heating the room per day**: £2.2540  
**Cost of heating the room per calendar month**: £68.56  
**Cost of heating the room per year**: £822.70
<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>13</td>
<td>21</td>
<td>59.022</td>
<td>102.838</td>
<td>161.860</td>
<td>7.158</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>12</td>
<td>24</td>
<td>143.443</td>
<td>301.197</td>
<td>444.639</td>
<td>5.439</td>
</tr>
</tbody>
</table>

**Totals**

- Radiant Heat Loss: 202.47 watts
- Convective Heat Loss: 404.034 watt
- Total Heat Loss: 606.49941 watts

**Cost per kWh**: £0.0740

**Boiler Efficiency**: 80%

- Total heat loss from this room: 0.606499411 kW
- Cost of heating the room per hour: £0.0561
- Cost of heating the room per day: £1.3464
- Cost of heating the room per calendar month: £40.95
- Cost of heating the room per year: £491.45
### SE20 Bedroom

<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Window</strong></td>
<td>2.028</td>
<td>13</td>
<td>21</td>
<td>59.022</td>
<td>102.838</td>
<td>161.860</td>
<td>7.158</td>
</tr>
<tr>
<td><strong>Brick Wall</strong></td>
<td>5.58</td>
<td>12</td>
<td>24</td>
<td>143.443</td>
<td>301.197</td>
<td>444.639</td>
<td>5.439</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>202.47</strong></td>
<td><strong>404.034</strong></td>
<td><strong>606.49941</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Cost per kWh £0.0740**

**Boiler Efficiency 80%**

- Total heat loss from this room **0.60649941 kW**
- Cost of heating the room per hour: **£0.0561**
- Cost of heating the room per day: **£1.3464**
- Cost of heating the room per calendar month: **£40.95**
- Cost of heating the room per year: **£491.45**
<table>
<thead>
<tr>
<th></th>
<th>Area sq m</th>
<th>Outside Surface Temperature ºC</th>
<th>Inside Surface Temperature ºC</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>1.485</td>
<td>10</td>
<td>21</td>
<td>22.278</td>
<td>28.533</td>
<td>50.811</td>
<td>2.705</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>10.515</td>
<td>9</td>
<td>24</td>
<td>115.434</td>
<td>203.226</td>
<td>318.660</td>
<td>1.876</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>137.71</strong></td>
<td><strong>231.759</strong></td>
<td><strong>369.47103</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Cost per kWh £0.0740**  
**Boiler Efficiency 80%**  
Total heat loss from this room **0.369471032 kW**  
Cost of heating the room per hour: **£0.0342**  
Cost of heating the room per day **£0.8202**  
Cost of heating the room per calendar month **£24.95**  
Cost of heating the room per year **£299.38**
<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Wall Type</th>
<th>Area sq m</th>
<th>Outside Surface Temperature °C</th>
<th>Inside Surface Temperature °C</th>
<th>Radiant Heat Loss (watts)</th>
<th>Convective Heat Loss (watts)</th>
<th>Total Heat Loss (watts)</th>
<th>U Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick Wall</td>
<td>North Wall</td>
<td>6.965</td>
<td>8</td>
<td>24</td>
<td>42.987</td>
<td>72.083</td>
<td>115.070</td>
<td>0.992</td>
</tr>
<tr>
<td>Window</td>
<td>West Window</td>
<td>0.715</td>
<td>10</td>
<td>21</td>
<td>10.727</td>
<td>13.738</td>
<td>24.465</td>
<td>2.705</td>
</tr>
<tr>
<td>Brick Wall</td>
<td>West Wall</td>
<td>6.965</td>
<td>9</td>
<td>24</td>
<td>76.462</td>
<td>134.614</td>
<td>211.076</td>
<td>1.876</td>
</tr>
<tr>
<td>Window</td>
<td>North Window</td>
<td>0.715</td>
<td>9</td>
<td>21</td>
<td>7.436</td>
<td>8.768</td>
<td>16.204</td>
<td>1.723</td>
</tr>
</tbody>
</table>

**Totals**
- 137.61 watts
- 229.203 watt
- 366.81499 watts

**Cost per kWh** £0.0740

**Boiler Efficiency** 80%

- Total heat loss from this room 0.366814986 kW
- Cost of heating the room per hour: £0.0339
- Cost of heating the room per day: £0.8143
- Cost of heating the room per calendar month: £24.77
- Cost of heating the room per year: £297.23

---

**Image**: 13.6°C

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR: max</td>
<td>15.3°C</td>
</tr>
<tr>
<td>IR: min</td>
<td>2.6°C</td>
</tr>
<tr>
<td>AR01: avg</td>
<td>9.2°C</td>
</tr>
<tr>
<td>AR02: avg</td>
<td>8.4°C</td>
</tr>
<tr>
<td>AR03: avg</td>
<td>10.1°C</td>
</tr>
<tr>
<td>AR04: avg</td>
<td>8.2°C</td>
</tr>
</tbody>
</table>

**Date**: 06 November 2011

**Page**: 44 of 45
<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Total radiant loss</td>
<td>10,015.732 watts</td>
</tr>
<tr>
<td>Total convective loss</td>
<td>192,678.853 watts</td>
</tr>
<tr>
<td>Total heat loss from the building</td>
<td>33.364062831 kW</td>
</tr>
<tr>
<td>Cost of heating the building per hour</td>
<td>£3.09</td>
</tr>
<tr>
<td>Cost of heating the building per day</td>
<td>£74.07</td>
</tr>
<tr>
<td>Cost of heating the building per calendar month</td>
<td>£2,252.91</td>
</tr>
<tr>
<td>Cost of heating the building per year</td>
<td>£27,034.90</td>
</tr>
</tbody>
</table>
Annual Heat Losses by Room

This report is based on expected ambient conditions throughout the year.

Building Details

Priory Hospital

Location: Rosemary Lane
Preston
PR4 0HB

Date: 10/02/2011

Cost per kWh £0.0740
Boiler Efficiency 80%
### Room or Area Name: F10 Asst Ward Manager

#### North Window

- **0.7425 sq. m.**
- **Test Data:**
  - **Outside Temperature:** 10°C
  - **Inside Temperature:** 21°C

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max14.5°C</td>
</tr>
<tr>
<td>IR</td>
<td>min6.3°C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg9.8°C</td>
</tr>
<tr>
<td>AR02</td>
<td>avg9.8°C</td>
</tr>
</tbody>
</table>

#### Heat Loss

- **Annual Heat Loss from this Window:** 222.55236 kwHrs

<table>
<thead>
<tr>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.705</td>
<td>3.3</td>
</tr>
</tbody>
</table>

#### Cost Savings

- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:**
  - **potential savings are up to:** -82.68883 kwHrs per year
  - **Potential annual cost savings are:** -£7.65

#### North Wall

- **6.9375 sq. m.**
- **Test Data:**
  - **Outside Temperature:** 9°C
  - **Inside Temperature:** 24°C

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max14.5°C</td>
</tr>
<tr>
<td>IR</td>
<td>min6.3°C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg9.8°C</td>
</tr>
<tr>
<td>AR02</td>
<td>avg9.8°C</td>
</tr>
</tbody>
</table>

#### Heat Loss

- **Annual Heat Loss from this Brick Wall:** 1841.7275 kwHrs

<table>
<thead>
<tr>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.876</td>
<td>0.7</td>
</tr>
</tbody>
</table>

#### Cost Savings

- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:**
  - **potential savings are up to:** 1108.1163 kwHrs per year
  - **Potential annual cost savings are:** £102.50

#### West Window

- **0.7425 sq. m.**
- **Test Data:**
  - **Outside Temperature:** 10°C
  - **Inside Temperature:** 21°C

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max14.5°C</td>
</tr>
<tr>
<td>IR</td>
<td>min6.3°C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg9.8°C</td>
</tr>
<tr>
<td>AR02</td>
<td>avg9.8°C</td>
</tr>
</tbody>
</table>

#### Heat Loss

- **Annual Heat Loss from this Window:** 222.55236 kwHrs

<table>
<thead>
<tr>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.705</td>
<td>3.3</td>
</tr>
</tbody>
</table>

#### Cost Savings

- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:**
  - **potential savings are up to:** -82.68883 kwHrs per year
  - **Potential annual cost savings are:** -£7.65

#### West Wall

- **6.9375 sq. m.**
- **Test Data:**
  - **Outside Temperature:** 9°C
  - **Inside Temperature:** 24°C

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max14.5°C</td>
</tr>
<tr>
<td>IR</td>
<td>min6.3°C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg9.8°C</td>
</tr>
<tr>
<td>AR02</td>
<td>avg9.8°C</td>
</tr>
</tbody>
</table>

#### Heat Loss

- **Annual Heat Loss from this Brick Wall:** 1841.7275 kwHrs

<table>
<thead>
<tr>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.876</td>
<td>0.7</td>
</tr>
</tbody>
</table>

#### Cost Savings

- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:**
  - **potential savings are up to:** 1108.1163 kwHrs per year
  - **Potential annual cost savings are:** £102.50
### Potential cost savings report

**Room or Area Name:** F11 Store Room

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR: max</td>
<td>23.1 °C</td>
</tr>
<tr>
<td>IR: min</td>
<td>6.6 °C</td>
</tr>
<tr>
<td>AR01: avg</td>
<td>10.2 °C</td>
</tr>
<tr>
<td>AR02: avg</td>
<td>8.8 °C</td>
</tr>
<tr>
<td>AR03: avg</td>
<td>9.4 °C</td>
</tr>
<tr>
<td>AR04: avg</td>
<td>9.0 °C</td>
</tr>
</tbody>
</table>

#### For this room:
- Potential savings are up to **853.3** kWh per year
- Potential annual cost savings are **£78.93**

---

#### Wall Data:
- **5.86 sq. m.**
- **Test Data:**
  - Outside Temperature: **9 °C**
  - Inside Temperature: **24 °C**
- **Annual Heat Loss from this Brick Wall:** 1555.679 kWh
- **Actual U-value:** **1.876**
- **Target U-value as per Building Regulations approved Documents ADL 12:** **0.7**

---

#### Window Data:
- **0.7425 sq. m.**
- **Test Data:**
  - Outside Temperature: **10 °C**
  - Inside Temperature: **21 °C**
- **Annual Heat Loss from this Window:** 222,552.36 kWh
- **Actual U-value:** **2.705**
- **Target U-value as per Building Regulations approved Documents ADL 12:** **3.3**

---

<table>
<thead>
<tr>
<th>Room or Area Name: F11 Store Room</th>
<th>For this room:</th>
<th>potential savings are up to</th>
<th>853.3</th>
<th>kWh per year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Potential annual cost savings are</td>
<td>£78.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wall</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5.86 sq. m.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test Data:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside Temperature: <strong>9 °C</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside Temperature: <strong>24 °C</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Annual Heat Loss from this Brick Wall:</strong> 1555.679 kWh</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Actual U-value:</strong> <strong>1.876</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Target U-value as per Building Regulations approved Documents ADL 12:</strong> <strong>0.7</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>potential savings are up to</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>936.00883 kWh per year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Potential annual cost savings are</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>£86.58</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Room or Area Name: F11 Store Room</th>
<th>For this room:</th>
<th>potential savings are up to</th>
<th>-82.68883 kWh per year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Potential annual cost savings are</td>
<td><strong>£7.65</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Window</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.7425 sq. m.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test Data:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside Temperature: <strong>10 °C</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside Temperature: <strong>21 °C</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Annual Heat Loss from this Window:</strong> 222,552.36 kWh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Actual U-value:</strong> <strong>2.705</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Target U-value as per Building Regulations approved Documents ADL 12:</strong> <strong>3.3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>potential savings are up to</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-82.68883 kWh per year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Potential annual cost savings are</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>£7.65</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Room or Area Name: **F13 Bedroom 2**

#### Room Temperature
- **IR : max** 23.1°C
- **IR : min** 6.6°C
- **AR01 : avg** 10.2°C
- **AR02 : avg** 8.8°C
- **AR03 : avg** 9.4°C
- **AR04 : avg** 9.0°C

#### Significant Heat Loss
- Heat is being lost
- Some Heat is being lost at this position
- Minimal heat is being lost at this position
- No measurable heat loss at this position

<table>
<thead>
<tr>
<th>Wall</th>
<th>6.965 sq. m.</th>
<th>Annual Heat Loss from this Wall</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1849.0280 kwHrs.</td>
<td>1.876</td>
<td>0.7</td>
<td>potential savings are up to 1112.5088 kwH per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Potential annual cost savings are £102.91</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Window</th>
<th>0.7425 sq. m.</th>
<th>Annual Heat Loss from this Window</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>147,408.30 kwHrs.</td>
<td>1.723</td>
<td>3.3</td>
<td>potential savings are up to -158.3470 kwH per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Potential annual cost savings are -£14.65</td>
</tr>
</tbody>
</table>
Room or Area Name: F14 Bedroom 3

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max 23.1 °C</td>
</tr>
<tr>
<td>IR</td>
<td>min 6.6 °C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg 10.2 °C</td>
</tr>
<tr>
<td>AR02</td>
<td>avg 8.8 °C</td>
</tr>
<tr>
<td>AR03</td>
<td>avg 9.4 °C</td>
</tr>
<tr>
<td>AR04</td>
<td>avg 9.0 °C</td>
</tr>
</tbody>
</table>

For this room:
Potential savings are up to **885.2** kHz per year
Potential annual cost savings are **£81.88**

- **Significant Heat Loss**
- **Heat is being lost**
- **Some Heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measureable heat loss at this position**

<table>
<thead>
<tr>
<th>Wall</th>
<th>6.965 sq. m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>9 °C</td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>24 °C</td>
</tr>
<tr>
<td>Annual Heat Loss from this Brick Wall</td>
<td>1849.0280 kwH</td>
</tr>
<tr>
<td>Actual U-value</td>
<td>1.876</td>
</tr>
<tr>
<td>Target U-value as per Building Regulations approved Documents ADL 12</td>
<td>0.7</td>
</tr>
</tbody>
</table>
| If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to..................
| potential savings are up to **1112.5088** kHz per year
| Potential annual cost savings are **£102.91**

<table>
<thead>
<tr>
<th>Window</th>
<th>2.041 sq. m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>10 °C</td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>21 °C</td>
</tr>
<tr>
<td>Annual Heat Loss from this Window</td>
<td>611.75673 kwH</td>
</tr>
<tr>
<td>Actual U-value</td>
<td>2.705</td>
</tr>
<tr>
<td>Target U-value as per Building Regulations approved Documents ADL 12</td>
<td>3.3</td>
</tr>
</tbody>
</table>
| If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to..................
| potential savings are up to **-227.2968** kHz per year
| Potential annual cost savings are **£56.587**

Page 5 of 45
Room or Area Name: **F15 Bedroom 4**

### Potential cost savings report

#### For this room:
- Potential savings are up to **1030** kWh per year
- Potential annual cost savings are **£95.26**

#### Significant Heat Loss

- **Wall:** 6.965 sq. m.
  - **Test Data:**
    - Outside Temperature: 9 °C
    - Inside Temperature: 24 °C
  - **Annual Heat Loss from this Brick Wall:** 1849.0280 kWh
    - **Actual U-value:** 1.876
    - **Target U-value:** 0.7
    - **as per Building Regulations approved Documents ADL 12**
    - **Potential savings are up to 1112.5088 kWh per year**
    - **Potential annual cost savings are £102.91**

- **Window:** 0.7425 sq. m.
  - **Test Data:**
    - Outside Temperature: 10 °C
    - Inside Temperature: 21 °C
  - **Annual Heat Loss from this Window:** 222.55236 kWh
    - **Actual U-value:** 2.705
    - **Target U-value:** 3.3
    - **as per Building Regulations approved Documents ADL 12**
    - **Potential savings are up to -82.68883 kWh per year**
    - **Potential annual cost savings are £20.586**
## F16 Bedroom 5

<table>
<thead>
<tr>
<th>Wall</th>
<th>6.965 sq. m.</th>
<th>Annual Heat Loss from this Brick Wall</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>If you improve the U-Value to that required in Building Regs approved documents BR ADL 1 and 2 you will save up to</th>
<th>Potential annual cost savings are</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>potential savings are up to 1112.5088 kwH per year</td>
<td>£102.91</td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>9 °C</td>
<td></td>
<td></td>
<td></td>
<td>Potential annual cost savings are</td>
<td>£13.635</td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>24 °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1849.0280 kwH</td>
<td>1.876</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>= £171.035</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Window</th>
<th>0.7425 sq. m.</th>
<th>Annual Heat Loss from this Window</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>If you improve the U-Value to that required in Building Regs approved documents BR ADL 1 and 2 you will save up to</th>
<th>Potential annual cost savings are</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>potential savings are up to -158.3470 kwH per year</td>
<td>-£14.65</td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>9 °C</td>
<td></td>
<td></td>
<td></td>
<td>Potential annual cost savings are</td>
<td>-£14.65</td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>21 °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>147.40830 kwH</td>
<td>1.723</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>= £13.635</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Room or Area Name:

For this room:

- **Label**
  - IR : max 19.8 °C
  - IR : min 4.7 °C
  - AR01 : avg 9.2 °C
  - AR02 : avg 9.0 °C
  - AR03 : avg 8.3 °C
  - AR04 : avg 8.3 °C
  - AR05 : avg 8.7 °C
  - AR06 : avg 8.3 °C
  - AR08 : avg 9.1 °C
  - AR09 : avg 9.1 °C
  - AR07 : avg 8.8 °C
  - AR10 : avg 9.0 °C

- **Value**
  - IR : max 19.8 °C
  - IR : min 4.7 °C
  - AR01 : avg 9.2 °C
  - AR02 : avg 9.0 °C
  - AR03 : avg 8.3 °C
  - AR04 : avg 8.3 °C
  - AR05 : avg 8.7 °C
  - AR06 : avg 8.3 °C
  - AR08 : avg 9.1 °C
  - AR09 : avg 9.1 °C
  - AR07 : avg 8.8 °C
  - AR10 : avg 9.0 °C

- **Significant Heat Loss**
  - Heat is being lost
  - Some Heat is being lost at this position
  - Minimal heat is being lost at this position
  - No measureable heat loss at this position

- **Room or Area Name:** F16 Bedroom 5
- **Potential savings are up to 954.2 kwH per year**
- **Potential annual cost savings are £88.26**
## Potential cost savings report

### Room or Area Name: F17 Bedroom 6

**Label** | **Value**  
--- | ---  
IR : max | 19.8°C  
IR : min | 4.7°C  
AR01 : avg | 9.2°C  
AR02 : avg | 9.0°C  
AR03 : avg | 8.9°C  
AR04 : avg | 8.3°C  
AR05 : avg | 8.3°C  
AR06 : avg | 8.7°C  
AR07 : avg | 8.8°C  
AR08 : avg | 9.1°C  
AR09 : avg | 9.1°C  
AR10 : avg | 9.0°C  

#### Window
- **Test Data:**
  - Outside Temperature: 9°C
  - Inside Temperature: 16°C
- **Annual Heat Loss from this Window:** 156.61632 kwHrs
- **Actual U-value:** 2.954
- **Target U-value as per Building Regulations approved Documents ADL 12:** 3.3
- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:**
  - Potential savings are up to **-41.81809 kwH per year**
  - Potential annual cost savings are **-£3.87**

#### Wall
- **Test Data:**
  - Outside Temperature: 9°C
  - Inside Temperature: 20°C
- **Annual Heat Loss from this Brick Wall:** 1896.9060 kwHrs
- **Actual U-value:** 2.559
- **Target U-value as per Building Regulations approved Documents ADL 12:** 0.7
- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:**
  - Potential savings are up to **1331.2243 kwH per year**
  - Potential annual cost savings are **£123.14**

---

For this room:
- Potential savings are up to **1289 kwH per year**
- Potential annual cost savings are **£119.27**

| Significant Heat Loss | Heat is being lost | Some Heat is being lost at this position | Slight heat loss at this position | Minimal heat is being lost at this position | No measurable heat loss at this position |
**Room or Area Name:** F19 Bedroom 7

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR : max</td>
<td>20.4°C</td>
</tr>
<tr>
<td>IR : min</td>
<td>4.7°C</td>
</tr>
<tr>
<td>AR01 : avg</td>
<td>9.5°C</td>
</tr>
<tr>
<td>AR02 : avg</td>
<td>9.4°C</td>
</tr>
<tr>
<td>AR03 : avg</td>
<td>9.5°C</td>
</tr>
<tr>
<td>AR04 : avg</td>
<td>9.4°C</td>
</tr>
<tr>
<td>AR05 : avg</td>
<td>10.7°C</td>
</tr>
<tr>
<td>AR06 : avg</td>
<td>10.4°C</td>
</tr>
<tr>
<td>AR07 : avg</td>
<td>8.7°C</td>
</tr>
<tr>
<td>AR08 : avg</td>
<td>7.4°C</td>
</tr>
<tr>
<td>AR09 : avg</td>
<td>8.7°C</td>
</tr>
<tr>
<td>AR10 : avg</td>
<td>8.9°C</td>
</tr>
<tr>
<td>AR11 : avg</td>
<td>8.7°C</td>
</tr>
</tbody>
</table>

**For this room:**
- Potential savings are up to **7454** kWh per year
- Potential annual cost savings are **£689.48**

- **Significant Heat Loss**
- **Heat is being lost**
- **Some Heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measurable heat loss at this position**

### Wall
- **Wall Size:** 9.244 sq. m.
- **Test Data:**
  - Outside Temperature: **12°C**
  - Inside Temperature: **24°C**
- **Annual Heat Loss from this Wall:**
  - **6452.643** kWh per year
  - **£596.869**

### Window
- **Window Size:** 2.756 sq. m.
- **Test Data:**
  - Outside Temperature: **15°C**
  - Inside Temperature: **21°C**
- **Annual Heat Loss from this Window:**
  - **3098.0307** kWh per year
  - **£286.568**

### Calculations
- **Actual U-value:** 5.439
- **Target U-value:** 0.7
- **Actual U-value:** 12.643
- **Target U-value:** 3.3

- If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...
  - **potential savings are up to 5479.2027 kWh per year**
  - **Potential annual cost savings are £506.83**

- If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...
  - **potential savings are up to 1974.5834 kWh per year**
  - **Potential annual cost savings are £182.65**

---

"04 October 2011"
## Potential cost savings report

### Room or Area Name: **F2 Bedroom 12**

<table>
<thead>
<tr>
<th>Window</th>
<th>1.485 sq. m.</th>
<th>Annual Heat Loss from this Window</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td></td>
<td>as per Building Regulations approved Documents ADL 12</td>
<td></td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>11 °C</td>
<td>641.6056 kwHours</td>
<td>4.859</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>19 °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall</td>
<td>13.515 sq. m.</td>
<td>Annual Heat Loss from this Brick Wall</td>
<td>Actual U-value</td>
<td>Target U-value</td>
<td>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...</td>
</tr>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td></td>
<td>as per Building Regulations approved Documents ADL 12</td>
<td></td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>11 °C</td>
<td>7290.9834 kwHours</td>
<td>4.065</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>24 °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**For this room:**
- Potential savings are up to **5984** kWh per year
- Potential annual cost savings are **£533.50**

- Significant Heat Loss
- Heat is being lost
- Some Heat is being lost at this position
- Slight heat loss at this position
- Minimal heat is being lost at this position
- No measurable heat loss at this position

---

*04 October 2011*
Room or Area Name: **F21A Bedroom**

**For this room:**
- Potential savings are up to **4928** kWh per year
- Potential annual cost savings are **£455.84**

### Window
- **2.756 sq. m.**
- Test Data:
  - Outside Temperature: **13 °C**
  - Inside Temperature: **21 °C**
- Annual Heat Loss from Window: **1926.8830 kWhours**
- Actual U-value: **7.158**
- Target U-value: **3.3** as per Building Regulations approved Documents ADL 12
- If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:
  - Potential savings are up to **799.6188 kWh per year**
  - Potential annual cost savings are **£73.96**

### Wall
- **6.965 sq. m.**
- Test Data:
  - Outside Temperature: **12 °C**
  - Inside Temperature: **24 °C**
- Annual Heat Loss from Brick Wall: **4861.8194 kWhours**
- Actual U-value: **5.439**
- Target U-value: **0.7** as per Building Regulations approved Documents ADL 12
- If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:
  - Potential savings are up to **4128.3694 kWh per year**
  - Potential annual cost savings are **£381.87**

---

04 October 2011
Room or Area Name: **F21B Bedroom**

**For this room:**
- Potential savings are up to **4928** kWh per year
- Potential annual cost savings are **£455.84**

- **Significant Heat Loss**
- **Heat is being lost**
- **Some Heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measureable heat loss at this position**

### Window
- **2.756 sq. m.**
- **Test Data:**
  - Outside Temperature: **13 °C**
  - Inside Temperature: **21 °C**
- Annual Heat Loss from this Window: 1926.8830 kWhours
- Actual U-value: **7.158**
- Target U-value: **3.3**
- As per Building Regulations approved Documents ADL 12

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...................
- Potential savings are up to **799.61881** kWh per year
- Potential annual cost savings are **£73.96**

### Wall
- **6.965 sq. m.**
- **Test Data:**
  - Outside Temperature: **12 °C**
  - Inside Temperature: **24 °C**
- Annual Heat Loss from this Brick Wall: 4861.8194 kWhours
- Actual U-value: **5.439**
- Target U-value: **0.7**
- As per Building Regulations approved Documents ADL 12

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...................
- Potential savings are up to **4128.3694** kWh per year
- Potential annual cost savings are **£381.87**

---

04 October 2011
# Potential cost savings report

## Room or Area Name: F3 Bedroom 11

**Label**
- **Value**
  - IR : max 14.5°C
  - IR : min 6.3°C
  - AR01 : avg 9.8°C
  - AR02 : avg 8.6°C

### For this room:
- **Potential savings are up to** 3376 kWh per year
- **Potential annual cost savings are** £312.23

#### Significant Heat Loss
- Heat is being lost
- Some heat is being lost at this position
- Slight heat loss at this position
- Minimal heat is being lost at this position
- No measurable heat loss at this position

### Wall
- **Size:** 20 sq. m.
- **Test Data:**
  - **Outside Temperature:** 9°C
  - **Inside Temperature:** 22°C
- **Annual Heat Loss from this Wall:** 5367.6499 kWh
  - **Actual U-value:** 2.165
  - **Target U-value:** 0.7
  - **As per Building Regulations approved Documents ADL 12**
- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...............**
  - **Potential savings are up to** 3498.0147 kWh per year
  - **Potential annual cost savings are** £323.57

### Window
- **Size:** 1.1 sq. m.
- **Test Data:**
  - **Outside Temperature:** 10°C
  - **Inside Temperature:** 21°C
- **Annual Heat Loss from this Window:** 329.7072 kWh
  - **Actual U-value:** 2.705
  - **Target U-value:** 3.3
  - **As per Building Regulations approved Documents ADL 12**
- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...............**
  - **Potential savings are up to** -122.502 kWh per year
  - **Potential annual cost savings are** -£11.33
## Potential cost savings report

### Room or Area Name: F4 Bedroom 10

- **East Wall**: 9.75 sq. m.
  - Test Data:
    - Outside Temperature: 11 °C
    - Inside Temperature: 22 °C
  - Annual Heat Loss from this Brick Wall: 5395.5841 kWHours = £499.092
  - Actual U-value: 4.804
  - Target U-value: 0.7
  - If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...................
  - Potential annual cost savings are £840.92

- **East Window**: 0.7525 sq. m.
  - Test Data:
    - Outside Temperature: 11 °C
    - Inside Temperature: 19 °C
  - Annual Heat Loss from this Window: 325.12338 kWHours = £30.074
  - Actual U-value: 4.859
  - Target U-value: 3.3
  - If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...................
  - Potential annual cost savings are £5.53

- **South Wall**: 14.257 sq. m.
  - Test Data:
    - Outside Temperature: 10 °C
    - Inside Temperature: 22 °C
  - Annual Heat Loss from this Brick Wall: 5749.3016 kWHours = £531.810
  - Actual U-value: 3.372
  - Target U-value: 0.7
  - If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...................
  - Potential annual cost savings are £531.810

- **South Window**: 0.55 sq. m.
  - Test Data:
    - Outside Temperature: 12 °C
    - Inside Temperature: 19 °C
  - Annual Heat Loss from this Window: 319.11013 kWHours = £29.518
  - Actual U-value: 6.864
  - Target U-value: 3.3
  - If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...................
  - Potential annual cost savings are £11.61

---

**For this room:**

- potential savings are up to 9091 kW per year
- Potential annual cost savings are £840.92
Room or Area Name: **F5 Bedroom 9**

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR : max</td>
<td>17.3°C</td>
</tr>
<tr>
<td>IR : min</td>
<td>4.1°C</td>
</tr>
<tr>
<td>AR01 : avg</td>
<td>11.0°C</td>
</tr>
<tr>
<td>AR02 : avg</td>
<td>11.2°C</td>
</tr>
<tr>
<td>AR03 : avg</td>
<td>11.3°C</td>
</tr>
<tr>
<td>AR04 : avg</td>
<td>11.4°C</td>
</tr>
<tr>
<td>AR05 : avg</td>
<td>10.7°C</td>
</tr>
<tr>
<td>AR06 : avg</td>
<td>11.3°C</td>
</tr>
</tbody>
</table>

**For this room:**

- **Potential savings are up to** 6621 kWh per year
- **Potential annual cost savings are** £612.46

- Significant Heat Loss
- Heat is being lost
- Some Heat is being lost at this position
- Minimal heat is being lost at this position
- No measurable heat loss at this position

<table>
<thead>
<tr>
<th>Geometry</th>
<th>Area (sq. m.)</th>
<th>Heat Loss (kW)</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>Savings Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>0.7525</td>
<td>325.12338</td>
<td>4.859</td>
<td>3.3</td>
<td>59.798812 kWh</td>
</tr>
<tr>
<td>Wall</td>
<td>14.2575</td>
<td>7890.0041</td>
<td>4.804</td>
<td>0.7</td>
<td>6561.3764 kWh</td>
</tr>
</tbody>
</table>

If you improve the U-Value to that required in Building Regs approved documents BR ADL 1 and 2 you will save up to.................

- Potential savings are up to 59.798812 kWh per year
- Potential annual cost savings are £5.53
  
- Potential savings are up to 6561.3764 kWh per year
- Potential annual cost savings are £606.93

---

04 October 2011
## Potential cost savings report

### Room or Area Name: F6 Bartle Room

![Image of heat loss diagram]

**Label** | **Value**
--- | ---
IR : max | 60.8°C
IR : min | 5.2°C
AR01 : avg | 11.3°C
AR02 : avg | 11.7°C
AR03 : avg | 12.1°C
AR04 : avg | 12.0°C
AR05 : avg | 12.3°C

**For this room:**
- Potential savings are up to **4129**  kwh per year
- Potential annual cost savings are **£381.97**

### Potential Heat Loss
- **Significant Heat Loss**
- **Heat is being lost**
- **Some Heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measureable heat loss at this position**

### Window
- **1.485 sq. m.**
- **Test Data:**
  - **Outside Temperature:** 12°C
  - **Inside Temperature:** 21°C
- **Annual Heat Loss from this Window:** 809.01859 kW-hours
- **Actual U-value:** 5.338
- **Target U-value as per Building Regulations approved Documents ADL 12:** 3.3
- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:**
  - **potential savings are up to** 200.59284  kwh per year
  - **Potential annual cost savings are** **£18.55**

### Wall
- **13.515 sq. m.**
- **Test Data:**
  - **Outside Temperature:** 10°C
  - **Inside Temperature:** 24°C
- **Annual Heat Loss from this Brick Wall:** 5355.967 kW-hours
- **Actual U-value:** 2.891
- **Target U-value as per Building Regulations approved Documents ADL 12:** 0.7
- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:**
  - **potential savings are up to** 3928.7982  kwh per year
  - **Potential annual cost savings are** **£363.41**

---

**Page 16 of 45**

04 October 2011
**Potential cost savings report**

**Room or Area Name:** **F8&9 Nurse Station/Sluice**

### Room Data

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR : max</td>
<td>55.5°C</td>
</tr>
<tr>
<td>IR : min</td>
<td>5.4°C</td>
</tr>
</tbody>
</table>

**For this room:**

Potential savings are up to **2740** kWh per year

Potential annual cost savings are **£253.45**

- **Significant Heat Loss**
- **Heat is being lost**
- **Some Heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measurable heat loss at this position**

<table>
<thead>
<tr>
<th>Window</th>
<th>1.485 sq. m.</th>
<th>Annual Heat Loss from this Window</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>Annual Heat Loss from this Brick Wall</th>
<th>Potential savings are up to</th>
<th>Potential annual cost savings are</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
<td>294.81661 kwHrs</td>
<td>1.723</td>
<td>3.3</td>
<td>2.891</td>
<td>0.7</td>
<td>4167.0731 kwHrs</td>
<td>-316.6941 kWh per year</td>
<td>-£29.29</td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>9°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>21°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall</td>
<td>10.515 sq. m.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>10°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>24°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

04 October 2011
**Room or Area Name:** G1 Entrance Lobby

<table>
<thead>
<tr>
<th>Door</th>
<th>0.78 sq. m.</th>
<th>Annual Heat Loss from this Door: 1639.0283 kwHours</th>
<th>Actual U-value: 39.004</th>
<th>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to: 1397.4606 kwH per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td>Target U-value: 3.5</td>
<td>Potential savings are up to 1397 kwH per year</td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>15 °C</td>
<td></td>
<td>as per Building Regulations approved Documents ADL 12</td>
<td>Potential annual cost savings are £129.27</td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>17 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**For this room:**

Potential annual cost savings are £129.27

**Potential savings are up to 1397 kwH per year**

---

**LabelValue**

IR : max 16.1 °C
IR : min 6.9 °C
AR01 : avg 14.8 °C

---

**Significant Heat Loss**

---

**Heat is being lost**

---

**Some Heat is being lost at this position**

---

**Slight heat loss at this position**

---

**Minimal heat is being lost at this position**

---

**No measurable heat loss at this position**

---

**Potential cost savings report**

---

**Ron Frend**

---

04 October 2011
Room or Area Name: **G12 Consulting Room 1**

<table>
<thead>
<tr>
<th>Wall</th>
<th>5.4214 sq. m.</th>
<th>Annual Heat Loss from this Wall: 1432.8367 kWh</th>
<th>Actual U-value: 1.759</th>
<th>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to ....... potential savings are up to 826.3026 kWh per year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Target U-value: 0.7</td>
<td>Potential annual cost savings are £76.43</td>
</tr>
<tr>
<td></td>
<td>Test Data:</td>
<td></td>
<td>as per Building Regulations approved Documents ADL 12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outside Temperature: 9 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inside Temperature: 25 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Window 2.1306 sq. m.</td>
<td>Annual Heat Loss from this Window: 426.35023 kWh</td>
<td>Actual U-value: 1.880</td>
<td>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to ............... potential savings are up to -389.4218 kWh per year</td>
</tr>
<tr>
<td></td>
<td>Test Data:</td>
<td></td>
<td>Target U-value: 3.3</td>
<td>Potential annual cost savings are £36.02</td>
</tr>
<tr>
<td></td>
<td>Outside Temperature: 9 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inside Temperature: 20 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Potential cost savings report

For this room: potential savings are up to 436.9 kWh per year

Potential annual cost savings are £40.41

- **Significant Heat Loss**
- **Heat is being lost**
- **Some Heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat loss at this position**
- **No measurable heat loss at this position**

---

04 October 2011
Room or Area Name: G13 Consulting Room 2

For this room:
- Potential savings are up to 8.128 kWh per year
- Potential annual cost savings are £0.75

Wall
- Test Data:
  - Outside Temperature: 8°C
  - Inside Temperature: 25°C
- Annual Heat Loss from this Brick Wall: 782.81283 kWh
- Actual U-value: 0.934
- Target U-value: 0.7
- As per Building Regulations approved Documents ADL 12
- If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to... potential savings are up to 175.48241 kWh per year
- Potential annual cost savings are £16.23

Window
- Test Data:
  - Outside Temperature: 10°C
  - Inside Temperature: 20°C
- Annual Heat Loss from this Window: 646.94261 kWh
- Actual U-value: 2.975
- Target U-value: 3.3
- As per Building Regulations approved Documents ADL 12
- If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to... potential savings are up to -167.3541 kWh per year
- Potential annual cost savings are £15.48
### Room or Area Name: G14 Hospital Manager

#### For this room:
- Potential savings are up to **-144** kWh per year
- Potential annual cost savings are **-£13.28**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR: max</td>
<td>18.0°C</td>
<td></td>
</tr>
<tr>
<td>IR: min</td>
<td>5.0°C</td>
<td></td>
</tr>
<tr>
<td>AR01</td>
<td>avg. 9.8°C</td>
<td></td>
</tr>
<tr>
<td>AR02</td>
<td>avg. 9.5°C</td>
<td></td>
</tr>
<tr>
<td>AR03</td>
<td>avg. 9.7°C</td>
<td></td>
</tr>
<tr>
<td>AR04</td>
<td>avg. 9.5°C</td>
<td></td>
</tr>
<tr>
<td>AR05</td>
<td>avg. 9.0°C</td>
<td></td>
</tr>
<tr>
<td>AR06</td>
<td>avg. 9.1°C</td>
<td></td>
</tr>
<tr>
<td>AR07</td>
<td>avg. 9.5°C</td>
<td></td>
</tr>
</tbody>
</table>

#### Wall
- **Wall Area:** 5.4214 sq. m.
- **Test Data:**
  - Outside Temperature: **8°C**
  - Inside Temperature: **23°C**

<table>
<thead>
<tr>
<th>Annual Heat Loss from this Wall</th>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>786.65667 kWhours</td>
<td>1.058</td>
<td>0.7</td>
</tr>
</tbody>
</table>

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to **245.8143 kWh per year**, potential savings are up to **£22.74**.

#### Window
- **Window Area:** 2.1306 sq. m.
- **Test Data:**
  - Outside Temperature: **9°C**
  - Inside Temperature: **20°C**

<table>
<thead>
<tr>
<th>Annual Heat Loss from this Window</th>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>426.35023 kWhours</td>
<td>1.880</td>
<td>3.3</td>
</tr>
</tbody>
</table>

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to **-389.4218 kWh per year**, potential savings are up to **£36.02**.

---

**04 October 2011**

Page 21 of 45
### Room or Area Name: G15 Therapy Service

#### Potential annual cost savings are £68.37

<table>
<thead>
<tr>
<th>Window</th>
<th>2.1306 sq. m.</th>
<th>Annual Heat Loss from this Window</th>
<th>646.94261 kwHours</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>2.975</th>
<th>3.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td>Outside Temperature:</td>
<td>10 °C</td>
<td>Inside Temperature:</td>
<td>20 °C</td>
<td>Actual U-value as per Building Regulations approved Documents ADL 12</td>
<td>646.94261 kwHours</td>
<td>2.975</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall</td>
<td>5.4214 sq. m.</td>
<td>Annual Heat Loss from this Brick Wall</td>
<td>1446.5623 kwHours</td>
<td>Actual U-value Target U-value</td>
<td>2.011</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Test Data:</td>
<td>Outside Temperature:</td>
<td>9 °C</td>
<td>Inside Temperature:</td>
<td>23 °C</td>
<td>Actual U-value Target U-value as per Building Regulations approved Documents ADL 12</td>
<td>1446.5623 kwHours</td>
<td>2.011</td>
</tr>
</tbody>
</table>

#### For this room:
- **Potential savings are up to 739.2 kWh per year**
- **Potential annual cost savings are £68.37**

#### Significant Heat Loss

#### Heat is being lost

#### Some Heat is being lost at this position

#### Slight heat loss at this position

#### Minimal heat is being lost at this position

#### No measurable heat loss at this position

---

**04 October 2011**
Potential cost savings report

Room or Area Name: **G16 Marketing Office**

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max 18.0°C</td>
</tr>
<tr>
<td></td>
<td>min 5.0°C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg 9.8°C</td>
</tr>
<tr>
<td>AR02</td>
<td>avg 9.5°C</td>
</tr>
<tr>
<td>AR03</td>
<td>avg 9.7°C</td>
</tr>
<tr>
<td>AR04</td>
<td>avg 9.5°C</td>
</tr>
<tr>
<td>AR05</td>
<td>avg 9.0°C</td>
</tr>
<tr>
<td>AR06</td>
<td>avg 9.1°C</td>
</tr>
<tr>
<td>AR07</td>
<td>avg 9.5°C</td>
</tr>
<tr>
<td>AR08</td>
<td>avg 9.9°C</td>
</tr>
</tbody>
</table>

### For this room:

Potential savings are up to **1459 kWH per year**

Potential annual cost savings are **£134.99**

- **Significant Heat Loss**
- **Heat is being lost**
- **Some heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measureable heat loss at this position**

<table>
<thead>
<tr>
<th>Window</th>
<th>2.1306 sq. m.</th>
<th>Annual Heat Loss from this Window</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to.................</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>646.94261 kWHours</td>
<td>2.975</td>
<td>3.3</td>
<td>potential savings are up to -167.3541 kWH per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= £59.842</td>
<td></td>
<td></td>
<td>Potential annual cost savings are -£15.48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wall</th>
<th>5.4214 sq. m.</th>
<th>Annual Heat Loss from this Brick Wall</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to.................</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2165.9142 kWHours</td>
<td>3.113</td>
<td>0.7</td>
<td>potential savings are up to 1626.6645 kWH per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= £200.347</td>
<td></td>
<td></td>
<td>Potential annual cost savings are £150.47</td>
</tr>
</tbody>
</table>
### Room or Area Name: G18 Assisted Bath

#### Wall
- **Test Data:**
  - Outside Temperature: 12 °C
  - Inside Temperature: 25 °C
- **Wall Size:** 10.1124 sq. m.
- **Annual Heat Loss from this Wall:** 6960.598 kwH
- **Actual U-value:** 5.021
- **Target U-value:** 0.7
- **Actual U-value as per Building Regulations approved Documents ADL 12:**
- **Potential savings are up to:** 6666 kwH per year
- **Potential annual cost savings are: £616.58**

#### Window
- **Test Data:**
  - Outside Temperature: 13 °C
  - Inside Temperature: 21 °C
- **Window Size:** 2.8676 sq. m.
- **Annual Heat Loss from this Window:** 2004.9092 kwH
- **Actual U-value:** 7.158
- **Target U-value:** 3.3
- **Actual U-value as per Building Regulations approved Documents ADL 12:**
- **Potential savings are up to:** 831.99815 kwH per year
- **Potential annual cost savings are: £76.96**

---

For this room:
- **Potential savings are up to:** 6666 kwH per year
- **Potential annual cost savings are: £616.58**

- **Significant Heat Loss**
- **Heat is being lost**
- **Some Heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measurable heat loss at this position**

---

04 October 2011

Page 24 of 45
## Potential cost savings report

### Room or Area Name: G2 Reception

![Thermal Image]

### For this room:
- Potential savings are up to **5292** kWh per year
- Potential annual cost savings are **£489.54**

### Windows

- **2.97 sq. m.**
- **9 °C** (Outside Temperature)
- **21 °C** (Inside Temperature)
- **589.63321 kWhrs**
- **£54.541**

### Wall

- **12.03 sq. m.**
- **11 °C** (Outside Temperature)
- **20 °C** (Inside Temperature)
- **6899.2005 kWhrs**
- **£638.176**

---

**annual Heat Loss from this Window**

- **589.63321 kWhrs**
- **£54.541**

**annual Heat Loss from this Brick Wall**

- **6899.2005 kWhrs**
- **£638.176**

---

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...

- **potential savings are up to -633.3882 kWh per year**
- **Potential annual cost savings are -£58.59**

---

**04 October 2011**

Page 25 of 45
Room or Area Name: **G21 Hospital Director**

### Wall

- **Area:** 3.983 sq. m.
- **Outside Temperature:** 12 °C
- **Inside Temperature:** 25 °C

**Annual Heat Loss from this Brick Wall**

- Actual U-value: 5.021
- Target U-value: 0.7
- Actual Heat Loss: 2741.5907 kwH
- Potential heat savings: up to 2297.7367 kwH
- Potential annual cost savings: £212.54

### Window

- **Area:** 0.737 sq. m.
- **Outside Temperature:** 14 °C
- **Inside Temperature:** 21 °C

**Annual Heat Loss from this Window**

- Actual U-value: 9.505
- Target U-value: 3.3
- Actual Heat Loss: 653.54111 kwH
- Potential heat savings: up to 352.60236 kwH
- Potential annual cost savings: £32.62

---

**Notes:**

- Significant Heat Loss
- Heat is being lost
- Some Heat is being lost at this position
- Slight heat loss at this position
- Minimal heat is being lost at this position
- No measurable heat loss at this position
## Potential cost savings report

### Room or Area Name: G27 Dining Room

<table>
<thead>
<tr>
<th>Wall</th>
<th>10.02 sq. m.</th>
<th>Test Data:</th>
<th>12 °C</th>
<th>Outside Temperature:</th>
<th>25 °C</th>
<th>Inside Temperature:</th>
<th>12 °C</th>
<th>Actual Heat Loss from this Wall</th>
<th>6896.9969 kWHours</th>
<th>Potential savings are up to 6355 kWh per year</th>
<th>Potential annual cost savings are £587.83</th>
</tr>
</thead>
</table>

### Window

<table>
<thead>
<tr>
<th>Window</th>
<th>1.98 sq. m.</th>
<th>Test Data:</th>
<th>13 °C</th>
<th>Outside Temperature:</th>
<th>21 °C</th>
<th>Inside Temperature:</th>
<th>13 °C</th>
<th>Actual Heat Loss from this Window</th>
<th>1384.3354 kWHours</th>
<th>Potential savings are up to 5780.3972 kWh per year</th>
<th>Potential annual cost savings are £534.69</th>
</tr>
</thead>
</table>

**For this room:**

- **Potential savings are up to 6355 kWh per year**
- **Potential annual cost savings are £587.83**
- **Significant Heat Loss**
- **Heat is being lost**
- **Some heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measureable heat loss at this position**

**Note:**
- If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to..............
- **Potential savings are up to 5780.3972 kWh per year**
- **Potential annual cost savings are £534.69**

**Significant Heat Loss**

**Heat is being lost**

**Some heat is being lost at this position**

**Slight heat loss at this position**

**Minimal heat is being lost at this position**

**No measureable heat loss at this position**

---

04 October 2011
Potential cost savings report

Room or Area Name: **G30 Conservatory**

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max 17.3°C</td>
</tr>
<tr>
<td>IR</td>
<td>min 7.4°C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg 14.6°C</td>
</tr>
<tr>
<td>AR02</td>
<td>avg 14.4°C</td>
</tr>
<tr>
<td>AR03</td>
<td>avg 12.6°C</td>
</tr>
<tr>
<td>AR04</td>
<td>avg 13.5°C</td>
</tr>
<tr>
<td>AR05</td>
<td>avg 12.4°C</td>
</tr>
</tbody>
</table>

For this room:
- Potential savings are up to **34835** kWh per year
- Potential annual cost savings are **£3,222.22**

- **Significant Heat Loss**
- **Heat is being lost**
- **Some Heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measurable heat loss at this position**

### Glass Roof

- **14.875 sq. m.**
- **Test Data:**
  - **Outside Temperature:** 14°C
  - **Inside Temperature:** 18°C
- **Annual Heat Loss from this PentRoof:**
  - **20647.018 kWhours**
  - **£1,909.849**

### Glass Wall

- **24.5 sq. m.**
- **Test Data:**
  - **Outside Temperature:** 13°C
  - **Inside Temperature:** 19°C
- **Annual Heat Loss from this Window:**
  - **18742.485 kWhours**
  - **£1,733.680**

### Lower Wall

- **10.5 sq. m.**
- **Test Data:**
  - **Outside Temperature:** 11°C
  - **Inside Temperature:** 24°C
- **Annual Heat Loss from this Brick Wall:**
  - **5664.4710 kWhours**
  - **£523.964**

### Calculation:

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:

- **Glass Roof:**
  - **20139.636 kWhours**
  - **£1,862.92**
  - **£1,909.849**

- **Glass Wall:**
  - **10137.942 kWhours**
  - **£937.76**
  - **£1,733.680**

- **Lower Wall:**
  - **4557.2252 kWhours**
  - **£421.54**
  - **£523.964**

---

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Page 28 of 45
# Potential cost savings report

## Room or Area Name: G31 Multi Function Space

<table>
<thead>
<tr>
<th>Door</th>
<th>3.3 sq. m.</th>
<th>Annual Heat Loss from this Door</th>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td>4.859</td>
<td>3.5</td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>11°C</td>
<td>1425.7902 kwH</td>
<td>as per Building Regulations approved Documents ADL 12</td>
<td></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>19°C</td>
<td>= £131.886</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wall</th>
<th>11.7 sq. m.</th>
<th>Annual Heat Loss from this Brick Wall</th>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td>3.372</td>
<td>0.7</td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>10°C</td>
<td>4718.1615 kwH</td>
<td>as per Building Regulations approved Documents ADL 12</td>
<td></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>22°C</td>
<td>= £436.430</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### For this room:

- **Potential savings are up to** 3818 kWh per year
- **Potential annual cost savings are** £353.15

- **Significant Heat Loss**
- **Heat is being lost**
- **Some Heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measurable heat loss at this position**

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...

- Potential savings are up to 191.72248 kWh per year
- Potential annual cost savings are £17.73

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...

- Potential savings are up to 3626.1435 kWh per year
- Potential annual cost savings are £335.42

---

04 October 2011
Potential cost savings report

Room or Area Name: **G32 Multi Function Space**

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR</td>
<td>max 17.7°C</td>
</tr>
<tr>
<td>IR</td>
<td>min 4.9°C</td>
</tr>
<tr>
<td>AR01</td>
<td>avg 11.8°C</td>
</tr>
<tr>
<td>AR02</td>
<td>avg 11.7°C</td>
</tr>
<tr>
<td>AR03</td>
<td>avg 11.4°C</td>
</tr>
<tr>
<td>AR04</td>
<td>avg 11.4°C</td>
</tr>
<tr>
<td>AR05</td>
<td>avg 9.9°C</td>
</tr>
<tr>
<td>AR06</td>
<td>avg 10.0°C</td>
</tr>
</tbody>
</table>

**For this room:**
Potential savings are up to 4487 kWh per year
Potential annual cost savings are £415.07

- **Significant Heat Loss**
- **Heat is being lost**
- **Some Heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measurable heat loss at this position**

**Window**
- **1.98 sq. m.**
- Test Data:
  - Outside Temperature: 12°C
  - Inside Temperature: 19°C
- Annual Heat Loss from this Window:
  - 1148.7965 kWhours
  - £106.264

<table>
<thead>
<tr>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.864</td>
<td>3.3</td>
</tr>
</tbody>
</table>

If you improve the U-Value to that required in Building Regs approved documents BR ADL 1 and 2 you will save up to.................
- Potential savings are up to 452.03782 kWh per year
- Potential annual cost savings are £41.81

**Wall**
- **13.02 sq. m.**
- Test Data:
  - Outside Temperature: 10°C
  - Inside Temperature: 22°C
- Annual Heat Loss from this Brick Wall:
  - 5250.4669 kWhours
  - £485.668

<table>
<thead>
<tr>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.372</td>
<td>0.7</td>
</tr>
</tbody>
</table>

If you improve the U-Value to that required in Building Regs approved documents BR ADL 1 and 2 you will save up to.................
- Potential savings are up to 4035.2469 kWh per year
- Potential annual cost savings are £373.26
<table>
<thead>
<tr>
<th>Room or Area Name: G6 Changing Room</th>
</tr>
</thead>
</table>

### Potential cost savings report

#### Room or Area Name: G6 Changing Room

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR max</td>
<td>56.8°C</td>
</tr>
<tr>
<td>IR min</td>
<td>4.6°C</td>
</tr>
<tr>
<td>AR01 avg</td>
<td>9.0°C</td>
</tr>
<tr>
<td>AR02 avg</td>
<td>8.4°C</td>
</tr>
</tbody>
</table>

#### For this room:
- Potential savings are up to **608.1** kW per year
- Potential annual cost savings are **£56.25**

#### Significant Heat Loss
- Heat is being lost
- Some heat is being lost at this position
- Slight heat loss at this position
- Minimal heat is being lost at this position
- No measurable heat loss at this position

### Wall
- **3.983 sq. m.**
- **Outside Temperature:** 9°C
- **Inside Temperature:** 23°C
- **Annual Heat Loss from this Wall:** 1062.762 kW\(\text{hours}\)
  - = **£98.305**

#### Potential savings are up to **666.00036** kW per year
- Potential annual cost savings are **£61.61**

#### Window
- **0.737 sq. m.**
- **Outside Temperature:** 10°C
- **Inside Temperature:** 20°C
- **Annual Heat Loss from this Window:** 223.78518 kW\(\text{hours}\)
  - = **£20.700**

#### Potential savings are up to **-57.88977** kW per year
- Potential annual cost savings are **£-5.35**
Potential cost savings report

Room or Area Name: **G7 Waiting Area**

For this room:
- potential savings are up to **265.6** kWh per year
- Potential annual cost savings are **£24.57**

### Window

**2.1306 sq. m.**

Test Data:
- Outside Temperature: **10 °C**
- Inside Temperature: **20 °C**

Annual Heat Loss from this Window:
- **646.94261** kwHrs
- **£59.842**

Actual U-value: **2.975**
Target U-value: **3.3**

Approved Documents ADL 12

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to..............
- potential savings are up to **-167.3541** kWh per year
- Potential annual cost savings are **-£15.48**

### Wall

**2.5894 sq. m.**

Test Data:
- Outside Temperature: **9 °C**
- Inside Temperature: **23 °C**

Annual Heat Loss from this Brick Wall:
- **690.91535** kwHrs
- **£63.910**

Actual U-value: **2.011**
Target U-value: **0.7**

Approved Documents ADL 12

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to..............
- potential savings are up to **432.97548** kWh per year
- Potential annual cost savings are **£40.05**
<table>
<thead>
<tr>
<th>Room or Area Name: G9 Pantry</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Wall</td>
</tr>
<tr>
<td>3.983 sq. m.</td>
</tr>
<tr>
<td>Test Data:</td>
</tr>
<tr>
<td>Outside Temperature: 8°C</td>
</tr>
<tr>
<td>Inside Temperature: 22°C</td>
</tr>
<tr>
<td>Annual Heat Loss from this</td>
</tr>
<tr>
<td>579.65634 kwHrs</td>
</tr>
<tr>
<td>Actual U-value</td>
</tr>
<tr>
<td>1.134</td>
</tr>
<tr>
<td>Target U-value</td>
</tr>
<tr>
<td>0.7</td>
</tr>
<tr>
<td>If you improve the U-Value</td>
</tr>
<tr>
<td>to that required in</td>
</tr>
<tr>
<td>Building Regs approved</td>
</tr>
<tr>
<td>Documents ADL 12</td>
</tr>
<tr>
<td>potential savings are up to</td>
</tr>
<tr>
<td>99.12 kwH per year</td>
</tr>
<tr>
<td>Potential annual cost</td>
</tr>
<tr>
<td>savings are</td>
</tr>
<tr>
<td>£9.17</td>
</tr>
<tr>
<td>North Wall</td>
</tr>
<tr>
<td>3.983 sq. m.</td>
</tr>
<tr>
<td>Test Data:</td>
</tr>
<tr>
<td>Outside Temperature: 8°C</td>
</tr>
<tr>
<td>Inside Temperature: 22°C</td>
</tr>
<tr>
<td>Annual Heat Loss from this</td>
</tr>
<tr>
<td>579.65634 kwHrs</td>
</tr>
<tr>
<td>Actual U-value</td>
</tr>
<tr>
<td>1.134</td>
</tr>
<tr>
<td>Target U-value</td>
</tr>
<tr>
<td>0.7</td>
</tr>
<tr>
<td>If you improve the U-Value</td>
</tr>
<tr>
<td>to that required in</td>
</tr>
<tr>
<td>Building Regs approved</td>
</tr>
<tr>
<td>Documents ADL 12</td>
</tr>
<tr>
<td>potential savings are up to</td>
</tr>
<tr>
<td>206.7334 kwH per year</td>
</tr>
<tr>
<td>Potential annual cost</td>
</tr>
<tr>
<td>savings are</td>
</tr>
<tr>
<td>£19.12</td>
</tr>
<tr>
<td>West Window</td>
</tr>
<tr>
<td>0.737 sq. m.</td>
</tr>
<tr>
<td>Test Data:</td>
</tr>
<tr>
<td>Outside Temperature: 9°C</td>
</tr>
<tr>
<td>Inside Temperature: 21°C</td>
</tr>
<tr>
<td>Annual Heat Loss from this</td>
</tr>
<tr>
<td>146.31639 kwHrs</td>
</tr>
<tr>
<td>Actual U-value</td>
</tr>
<tr>
<td>1.723</td>
</tr>
<tr>
<td>Target U-value</td>
</tr>
<tr>
<td>3.3</td>
</tr>
<tr>
<td>If you improve the U-Value</td>
</tr>
<tr>
<td>to that required in</td>
</tr>
<tr>
<td>Building Regs approved</td>
</tr>
<tr>
<td>Documents ADL 12</td>
</tr>
<tr>
<td>potential savings are up to</td>
</tr>
<tr>
<td>157.174 kwH per year</td>
</tr>
<tr>
<td>Potential annual cost</td>
</tr>
<tr>
<td>savings are</td>
</tr>
<tr>
<td>£14.54</td>
</tr>
<tr>
<td>North Window</td>
</tr>
<tr>
<td>0.737 sq. m.</td>
</tr>
<tr>
<td>Test Data:</td>
</tr>
<tr>
<td>Outside Temperature: 9°C</td>
</tr>
<tr>
<td>Inside Temperature: 21°C</td>
</tr>
<tr>
<td>Annual Heat Loss from this</td>
</tr>
<tr>
<td>146.31639 kwHrs</td>
</tr>
<tr>
<td>Actual U-value</td>
</tr>
<tr>
<td>1.723</td>
</tr>
<tr>
<td>Target U-value</td>
</tr>
<tr>
<td>3.3</td>
</tr>
<tr>
<td>If you improve the U-Value</td>
</tr>
<tr>
<td>to that required in</td>
</tr>
<tr>
<td>Building Regs approved</td>
</tr>
<tr>
<td>Documents ADL 12</td>
</tr>
<tr>
<td>potential savings are up to</td>
</tr>
<tr>
<td>157.174 kwH per year</td>
</tr>
<tr>
<td>Potential annual cost</td>
</tr>
<tr>
<td>savings are</td>
</tr>
<tr>
<td>£14.54</td>
</tr>
</tbody>
</table>
Room or Area Name: **SE1 Roof Space**

<table>
<thead>
<tr>
<th>Label</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR : max</td>
<td>17.5°C</td>
</tr>
<tr>
<td>IR : min</td>
<td>5.0°C</td>
</tr>
<tr>
<td>AR01 : avg</td>
<td>10.7°C</td>
</tr>
<tr>
<td>AR02 : avg</td>
<td>9.6°C</td>
</tr>
<tr>
<td>AR03 : avg</td>
<td>9.9°C</td>
</tr>
<tr>
<td>AR04 : avg</td>
<td>9.0°C</td>
</tr>
<tr>
<td>AR05 : avg</td>
<td>9.9°C</td>
</tr>
<tr>
<td>AR06 : avg</td>
<td>9.2°C</td>
</tr>
<tr>
<td>AR07 : avg</td>
<td>10.8°C</td>
</tr>
<tr>
<td>AR08 : avg</td>
<td>10.0°C</td>
</tr>
<tr>
<td>AR09 : avg</td>
<td>9.5°C</td>
</tr>
<tr>
<td>AR10 : avg</td>
<td>8.8°C</td>
</tr>
<tr>
<td>AR11 : avg</td>
<td>11.2°C</td>
</tr>
</tbody>
</table>

**Potential savings are up to 69762 kwH per year**

Potential annual cost savings are **£6,453.01**

- **Significant Heat Loss**
- **Heat is being lost**
- **Some heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measurable heat loss at this position**

**For this room:**

<table>
<thead>
<tr>
<th>Room Void West</th>
<th>79.8 sq. m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Heat Loss from this PentRoof</td>
<td>71278.507 kwH</td>
</tr>
<tr>
<td>= Potential savings</td>
<td>£6,593.262</td>
</tr>
</tbody>
</table>

**Actual U-value** 24.570

**Target U-value** 0.35

If you improve the U-Value to that required in Building Regs approved documents BR ADL 1 and 2 you will save up to...

**Potential savings are up to 69762.308 kwH per year**

**Potential annual cost savings are £6,453.01**

---

04 October 2011
Room or Area Name: **SE11 Bedroom 14**

**Potential annual cost savings are £61.55**

**For this room:**

- **Window 2.028 sq. m.**
  - **Annual Heat Loss from this Window:** 607.86019 kwH
  - **Target U-value as per Building Regulations approved Documents ADL 12:** 3.3
  - **Actual U-value:** 2.705
  - **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...................**
  - **Potential savings are up to -225.8491 kwH per year**
  - **Potential annual cost savings are -£20.89**

- **Wall 5.58 sq. m.**
  - **Annual Heat Loss from this Brick Wall:** 1481.3462 kwH
  - **Target U-value as per Building Regulations approved Documents ADL 12:** 0.7
  - **Actual U-value:** 1.876
  - **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...................**
  - **Potential savings are up to 891.28486 kwH per year**
  - **Potential annual cost savings are £82.44**

**Test Data:**

- **Outside Temperature:** 10°C
- **Inside Temperature:** 21°C

- **Outside Temperature:** 9°C
- **Inside Temperature:** 24°C
**Potential cost savings report**

**Room or Area Name:** SE12 Bedroom 15

**For this room:**
- Potential savings are up to 1396 kWh per year
- Potential annual cost savings are £129.15

<table>
<thead>
<tr>
<th>Significant Heat Loss</th>
<th>Heat is being lost</th>
<th>Some Heat is being lost at this position</th>
<th>Slight heat loss at this position</th>
<th>Minimal heat is being lost at this position</th>
<th>No measureable heat loss at this position</th>
</tr>
</thead>
</table>

### Wall
- **Area:** 5.58 sq. m.
- **Test Data:**
  - **Outside Temperature:** 10°C
  - **Inside Temperature:** 24°C
- **Potential savings are up to 1396 kWh per year**
- **Potential annual cost savings are £129.15**

#### Heat Loss from Wall
- **Annual Heat Loss from this Brick Wall:** 2211.3426 kWh
- **Actual U-value:** 2.891
- **Target U-value:** 0.7
- **Actual U-value as per Building Regulations approved Documents ADL 12:** 2.891

#### Target U-value
- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:**
  - Potential savings are up to 1622.1009 kWh per year
  - Potential annual cost savings are £150.04

### Window
- **Area:** 2.028 sq. m.
- **Test Data:**
  - **Outside Temperature:** 10°C
  - **Inside Temperature:** 21°C
- **Potential savings are up to -225.849 kWh per year**
- **Potential annual cost savings are -£20.89**

#### Heat Loss from Window
- **Annual Heat Loss from this Window:** 607.86019 kWh
- **Actual U-value:** 2.705
- **Target U-value:** 3.3
- **Actual U-value as per Building Regulations approved Documents ADL 12:** 2.705

#### Target U-value
- **If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:**
  - Potential savings are up to -225.849 kWh per year
  - Potential annual cost savings are -£20.89

---

**04 October 2011**

**Page 36 of 45**
For this room:
potential savings are up to -326 kW per year
Potential annual cost savings are £30.14

- **Significant Heat Loss**
- **Heat is being lost**
- **Some heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measurable heat loss at this position**

### Wall

<table>
<thead>
<tr>
<th>Test Data</th>
<th>Outside Temperature: 8 °C</th>
<th>Inside Temperature: 22 °C</th>
<th>Annual Heat Loss from this Brick Wall</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>Potential savings as per Building Regulations approved Documents ADL 12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>812.0719 kWHours</td>
<td>1.134</td>
<td>0.7</td>
<td>-289.62405 kW per year, Potential annual cost savings are £26.79</td>
</tr>
</tbody>
</table>

### Window

<table>
<thead>
<tr>
<th>Test Data</th>
<th>Outside Temperature: 9 °C</th>
<th>Inside Temperature: 24 °C</th>
<th>Annual Heat Loss from this Window</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>Potential savings as per Building Regulations approved Documents ADL 12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>395.57624 kWHours</td>
<td>1.379</td>
<td>3.3</td>
<td>-615.4136 kW per year, Potential annual cost savings are £56.93</td>
</tr>
</tbody>
</table>
Potential cost savings report

Room or Area Name: SE14 Bedroom 17

For this room:
- potential savings are up to 665.4 kWh per year
- Potential annual cost savings are £61.55

| Wall      | 5.58 sq. m. | Annual Heat Loss from this | Brick Wall | Actual U-value | Target U-value as per Building Regulations approved Documents ADL 12 | If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...............
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Temperature:</td>
<td>9 °C</td>
<td>1481.3462 kWhours</td>
<td>1.876</td>
<td>0.7</td>
<td><strong>1174.8306 kWhours</strong></td>
<td><strong>137.025 kWhours</strong></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>24 °C</td>
<td>= £137.025</td>
<td></td>
<td></td>
<td>Potential annual cost savings are <strong>£82.44</strong></td>
<td><strong>Potential annual cost savings are £56.227 kWhours</strong></td>
</tr>
</tbody>
</table>

| Window | 2.028 sq. m. | Annual Heat Loss from this Window | 607.86019 kWhours | Actual U-value | Target U-value as per Building Regulations approved Documents ADL 12 | If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...............
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside Temperature:</td>
<td>10 °C</td>
<td>= £56.227</td>
<td>2.705</td>
<td>3.3</td>
<td><strong>53.82145 kWhours</strong></td>
<td><strong>56.227 kWhours</strong></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>21 °C</td>
<td></td>
<td></td>
<td></td>
<td>Potential annual cost savings are <strong>-£20.89 kWhours</strong></td>
<td><strong>Potential annual cost savings are -£20.89 kWhours</strong></td>
</tr>
</tbody>
</table>

04 October 2011
**Potential cost savings report**

**Room or Area Name:** SE15 Bedroom 18

Label | Value
--- | ---
IR : max | 20.0°C
IR : min | 3.2°C
AR01 : avg | 8.5°C
AR02 : avg | 8.2°C
AR03 : avg | 8.4°C
AR04 : avg | 8.0°C
AR05 : avg | 9.7°C
AR06 : avg | 9.5°C
AR07 : avg | 8.6°C
AR08 : avg | 10.0°C
AR09 : avg | 9.9°C
AR10 : avg | 9.0°C

For this room:
- Potential savings are up to **665.4** kWh per year
- Potential annual cost savings are **£61.55**

- Significant Heat Loss
- Heat is being lost
- Some heat is being lost at this position
- Slight heat loss at this position
- Minimal heat is being lost at this position
- No measurable heat loss at this position

### Window

- **2.028 sq. m.**
- **Outside Temperature:** 10°C
- **Inside Temperature:** 21°C
- **Annual Heat Loss from this Window:** 607.66019 kWh
  - **Actual U-value:** 2.705
  - **Target U-value:** 3.3
  - **as per Building Regulations approved Documents ADL 12**

- **Potential savings are up to -225.8491 kWh per year**
- **Potential annual cost savings are -£20.89**

### Wall

- **5.58 sq. m.**
- **Outside Temperature:** 9°C
- **Inside Temperature:** 24°C
- **Annual Heat Loss from this Brick Wall:** 1481.3462 kWh
  - **Actual U-value:** 1.876
  - **Target U-value:** 0.7
  - **as per Building Regulations approved Documents ADL 12**

- **Potential savings are up to 891.28486 kWh per year**
- **Potential annual cost savings are £82.44**

---

04 October 2011
### Room or Area Name: SE18 Group Room

#### Potential Cost Savings Report

**For this room:**
- Potential savings are up to **6799** kWh per year
- Potential annual cost savings are **£628.93**

#### Significant Heat Loss
- Room/Area: AR01
- U-value: 0.7
- Potential savings: up to **5486.9082** kWh per year
- Annual cost savings: **£507.54**

#### Heat Loss
- Room/Area: AR02
- U-value: 3.3
- Potential savings: up to **1312.3314** kWh per year
- Annual cost savings: **£121.39**

#### Some Heat Loss
- Room/Area: AR03
- U-value:
- Potential savings:
- Annual cost savings:

#### Slight Heat Loss
- Room/Area: AR04
- U-value:
- Potential savings:
- Annual cost savings:

#### Minimal Heat Loss
- Room/Area: AR05
- U-value:
- Potential savings:
- Annual cost savings:

#### No Measurable Heat Loss
- Room/Area: AR06
- U-value:
- Potential savings:
- Annual cost savings:

#### Wall Data

<table>
<thead>
<tr>
<th>Test Data</th>
<th>Outside Temperature</th>
<th>Inside Temperature</th>
<th>Annual Heat Loss</th>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall</td>
<td>9.257 sq. m.</td>
<td>12°C</td>
<td>6461.7174 kwHrs</td>
<td>5.439</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24°C</td>
<td>$597.709</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Window Data

<table>
<thead>
<tr>
<th>Test Data</th>
<th>Outside Temperature</th>
<th>Inside Temperature</th>
<th>Annual Heat Loss</th>
<th>Actual U-value</th>
<th>Target U-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window</td>
<td>2.743 sq. m.</td>
<td>14°C</td>
<td>2432.3789 kwHrs</td>
<td>9.505</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21°C</td>
<td>$224.995</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

04 October 2011

Page 40 of 45
Room or Area Name: **SE19 ATP Office**

For this room:
- Potential savings are up to **3896** kWh per year
- Potential annual cost savings are **£360.36**

**Window** 2.028 sq. m.
- Test Data:
  - Outside Temperature: **13 °C**
  - Inside Temperature: **21 °C**
- Annual Heat Loss from this Window: **1417.8950** kwH
- Actual U-value: **7.158**
- Target U-value as per Building Regulations approved Documents ADL 12: **3.3**

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...............
- potential savings are up to **588.39875** kWh per year
- Potential annual cost savings are **£54.43**

**Wall** 5.58 sq. m.
- Test Data:
  - Outside Temperature: **12 °C**
  - Inside Temperature: **24 °C**
- Annual Heat Loss from this Brick Wall: **3895.0398** kwH
- Actual U-value: **5.439**
- Target U-value as per Building Regulations approved Documents ADL 12: **0.7**

If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to...............
- potential savings are up to **3307.4373** kWh per year
- Potential annual cost savings are **£305.94**

---

**Significant Heat Loss**
- Heat is being lost
- Some Heat is being lost at this position
- Slight heat loss at this position
- Minimal heat is being lost at this position
- No measurable heat loss at this position
**Potential cost savings report**

**Room or Area Name:** **SE20 Bedroom**

---

### For this room:
- **Potential savings** are up to **3896 kWh per year**
- **Potential annual cost savings** are **£360.36**

#### Significant Heat Loss
- **Heat is being lost**
- **Some heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measureable heat loss at this position**

---

<table>
<thead>
<tr>
<th>Window</th>
<th><strong>2.028 sq. m.</strong></th>
<th><strong>Annual Heat Loss from this Window</strong></th>
<th><strong>Actual U-value</strong></th>
<th><strong>Target U-value</strong></th>
<th><strong>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>588.39875 kWh per year</strong></td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>13 °C</td>
<td></td>
<td></td>
<td></td>
<td><strong>Potential annual cost savings</strong> are <strong>£54.43</strong></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>21 °C</td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
<tr>
<td><strong>Actual</strong></td>
<td><strong>Target</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
<tr>
<td><strong>U-value</strong></td>
<td><strong>U-value</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
<tr>
<td><strong>7.158</strong></td>
<td><strong>3.3</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
<tr>
<td><strong>£131.155</strong></td>
<td><strong>-</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Wall</th>
<th><strong>5.58 sq. m.</strong></th>
<th><strong>Annual Heat Loss from this Brick Wall</strong></th>
<th><strong>Actual U-value</strong></th>
<th><strong>Target U-value</strong></th>
<th><strong>If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>12 °C</td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>24 °C</td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
<tr>
<td><strong>Actual</strong></td>
<td><strong>Target</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
<tr>
<td><strong>U-value</strong></td>
<td><strong>U-value</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
<tr>
<td><strong>5.439</strong></td>
<td><strong>0.7</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
<tr>
<td><strong>£360.291</strong></td>
<td><strong>-</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>potential savings</strong> are up to <strong>3307.4373 kWh per year</strong></td>
</tr>
</tbody>
</table>
## Room or Area Name: **SE8 Medical Secretary**

### For this room:
- **Potential savings** are up to **1514** kWh per year
- Potential annual cost savings are **£140.06**

### Significant Heat Loss
- **AR01, AR02, AR03, AR04, AR05, AR06, AR07, AR08, AR09, AR10, AR11, AR12, AR13, AR14, AR15, AR16, AR17, AR18, AR19**

### Heat is being lost
- **AR20, AR21, AR22, AR23**

### Some Heat is being lost at this position
- **AR24, AR25, AR26, AR27, AR28, AR29, AR30, AR31, AR32**

### Slight heat loss at this position
- **AR33, AR34, AR35, AR36, AR37, AR38, AR39, AR40**

### Minimal heat is being lost at this position
- **AR41, AR42, AR43, AR44, AR45, AR46, AR47, AR48, AR49, AR50**

### No measureable heat loss at this position
- **AR51, AR52, AR53, AR54, AR55, AR56, AR57, AR58, AR59, AR60**

### Potential heat loss calculations

#### Window 1.485 sq. m.
- **Test Data:**
  - Outside Temperature: **10 °C**
  - Inside Temperature: **21 °C**
- **Annual Heat Loss from this Window:**
  - **445.10473 kWhours**
  - **£41.172**
- **Actual U-value:** **2.705**
- **Target U-value:** **3.3**
- As per Building Regulations approved Documents ADL 12

#### Wall 10.515 sq. m.
- **Test Data:**
  - Outside Temperature: **9 °C**
  - Inside Temperature: **24 °C**
- **Annual Heat Loss from this Brick Wall:**
  - **2791.4615 kWhours**
  - **£258.210**
- **Actual U-value:** **1.876**
- **Target U-value:** **0.7**
- As per Building Regulations approved Documents ADL 12

### If you improve the U-Value to that required in Building Regs approved documents BR ADL1 and 2 you will save up to:
- **Window:** **165.3777 kWh per year**
- Potential annual cost savings are **£15.30**
- **Wall:** **1679.5449 kWh per year**
- Potential annual cost savings are **£258.210**

---

04 October 2011

Page 43 of 45
Room or Area Name: **SE9 Bedroom 13**

**For this room:**
- Potential savings are up to **1151** kWh per year
- Potential annual cost savings are **£106.46**

- **Significant Heat Loss**
- **Heat is being lost**
- **Some heat is being lost at this position**
- **Slight heat loss at this position**
- **Minimal heat is being lost at this position**
- **No measurable heat loss at this position**

<table>
<thead>
<tr>
<th>North Wall</th>
<th>6.965 sq. m.</th>
<th>Annual Heat Loss from this Brick Wall</th>
<th>Actual U-value</th>
<th>Target U-value</th>
<th>as per Building Regulations approved Documents ADL 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>8 °C</td>
<td>1008.0129 kwHours</td>
<td>0.992</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>24 °C</td>
<td>= £93,241</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Window</td>
<td>0.715 sq. m.</td>
<td>Annual Heat Loss from this Window</td>
<td>Actual U-value</td>
<td>Target U-value</td>
<td>as per Building Regulations approved Documents ADL 12</td>
</tr>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>10 °C</td>
<td>214.30968 kwHours</td>
<td>2.705</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>21 °C</td>
<td>= £19,824</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Wall</td>
<td>6.965 sq. m.</td>
<td>Annual Heat Loss from this Brick Wall</td>
<td>Actual U-value</td>
<td>Target U-value</td>
<td>as per Building Regulations approved Documents ADL 12</td>
</tr>
<tr>
<td>Test Data:</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>9 °C</td>
<td>1849.0280 kwHours</td>
<td>1.876</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>24 °C</td>
<td>= £171,035</td>
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<td></td>
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</tr>
<tr>
<td>North Window</td>
<td>0.715 sq. m.</td>
<td>Annual Heat Loss from this Window</td>
<td>Actual U-value</td>
<td>Target U-value</td>
<td>as per Building Regulations approved Documents ADL 12</td>
</tr>
<tr>
<td>Test Data:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside Temperature:</td>
<td>9 °C</td>
<td>141.94874 kwHours</td>
<td>1.723</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Inside Temperature:</td>
<td>21 °C</td>
<td>= £13,130</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Potential cost savings report

<table>
<thead>
<tr>
<th>Actual Total radiant loss</th>
<th>Actual Total convective loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,015.732 watts</td>
<td>23,348.331 watts</td>
</tr>
</tbody>
</table>

Actual heat loss from the building: 33.36406283 kW
Cost of heating the building per year: £27,034.90

If all items in this report have their U-VALUES improved to existing Building Regulations MINIMUM requirements there would be an annual cost saving of: £20,010.15
Annual Averaged Heat Loss Component Report

Please note: This report estimates the costs associated with heat losses over a 12 month period based on averaged ambient data.

<table>
<thead>
<tr>
<th>Priory Hospital</th>
<th>Date of Survey: 10/02/2011</th>
<th>Cost per kWhour: 0.074</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosemary Lane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preston</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lancashire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PR4 0HB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annual Average Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed m/s: 3.500</td>
</tr>
<tr>
<td>Boiler Efficiency 80%</td>
</tr>
<tr>
<td>Cost per kWh £0.0740</td>
</tr>
<tr>
<td>Component</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Brick Wall</td>
</tr>
<tr>
<td>Door</td>
</tr>
<tr>
<td>PentRoof</td>
</tr>
<tr>
<td>Window</td>
</tr>
</tbody>
</table>

Total radiant loss 10,015.732 watts  
Total convective loss 192,678.853 watts

Total heat loss from the building 33,364.062831 kW
Cost of heating the building per hour £3.09
Cost of heating the building per day £74.07
Cost of heating the building per calendar month £2,252.91
Cost of heating the building per year £27,034.90