METHODOLOGY AND SOFTWARE MANUAL FOR CALCULATING THE

ENERGY PERFORMANCE RATING OF DWELLINGS IN MALTA

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for the

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This document describes the EPRDM Version DM 01, dated 30th April 2009. This version is applicable to new and existing dwellings.

Architects, engineers, energy rating assessors and other users should ensure that they are using the latest version of this document and accompanying software.

Produced by CASA INGINIERA for the Building Regulation Office, Services Divison, Ministry for Resources and Rural Affairs.

SUMMARY

This manual describes the national calculation tool for Energy Performance of Residential Dwellings in Malta (EPRDM), which is the basis for the Maltese official procedure for calculating the energy performance of dwellings. The procedure takes account of the net energy required for space heating and cooling, water heating, lighting, and ventilation, after subtracting any savings from energy generation technologies. It calculates the annual values of delivered energy consumption (energy use), primary energy consumption, and carbon dioxide (CO_2) emissions, both as totals and per square metre of total useful floor area of the dwelling per annum.

The procedure consists of a monthly calculation within a series of individual modules. The individual modules contain equations or algorithms representing the relationships between various factors which contribute to the annual energy demand of the dwelling.

The procedure is based on ISO EN 13790:2008 *Energy performance of buildings – energy use for space heating and cooling* and is compliant with the EU Energy Performance of Buildings Directive (EPBD). Reference has also been made to the Irish Dwelling Energy Assessment Procedure (DEAP), the UK Standard Assessment Procedure (SAP), and the EPA-ED software tool.

A computer software application is also available for implementing the procedure.

INTRODUCTION

The calculation is based on the energy balance on a monthly basis, taking into account a range of factors that contribute to annual energy usage and associated CO_2 emissions for the provision of space heating and cooling, water heating, lighting, and ventilation to a dwelling.

The calculation is made using standardised assumptions regarding occupancy, temperature set points and duration of heating and cooling, usage of domestic electrical appliances, etc. It is thus independent of the individual characteristics of the household occupying the dwelling when the rating is calculated, such as

- Occupancy and composition
- Individual heating and cooling patterns and temperatures
- Ownership and efficiency of particular domestic appliances

The procedure calculates a monthly energy balance for space heating and aggregates these figures over a heating season spanning November to April inclusive. Similarly it calculates a monthly energy balance for space cooling over a cooling season spanning May to October inclusive. The shoulder months of April and November have been included in the heating season since the software calculation for the heating load in these months produces negligible or zero values. It then takes account of hot water energy demand based on the size of the dwelling and the type of hot water system, including the option for solar water heating. Finally, the lighting energy requirement is also calculated to determine the overall results. System efficiencies and renewable energy technologies are then input in order to set-off the energy demand of the building and the final result is calculated.

Calculated results are not affected by the geographical location within the Maltese Islands.

SCOPE OF THE EPRDM PROCEDURE

The procedure is applicable to self-contained dwellings. For dwellings in the form of flats, maisonettes, etc., it applies to the individual dwelling unit and does not include common areas such as access corridors and communal staircases. Similarly garages should not be included whether or not they are accessible through an internal door. Washrooms should be included where accessible through an internal staircase.

Where part of the accommodation is used for business purposes (e.g. as an office or shop), this part should be included as part of the dwelling if the business-related part could revert to domestic use through a change of occupancy. That would be applicable where:

- there is direct access between the business part and the rest of the dwelling, and
- all is contained within the same thermal envelope, and
- the living accommodation occupies a substantial proportion of the whole accommodation unit.

Where a self-contained dwelling is part of a larger building, and the remainder of the building has separate metering, the dwelling is assessed by residential procedure and the remainder by a separate procedure.

GENERAL PRINCIPLES

Input precision and rounding

Data should be entered as accurately as possible, although it is unnecessary to go beyond 2 significant figures (some product data may only be available to a lesser precision).

Input Data

Various tables of performance data are provided as part of this document. The tables are used when specific performance information on the product or system is not available. However, when specific performance information is available for the following items, it should be used in preference to data from the tables, particularly for newly constructed dwellings.

U values – Walls, Floors, Roofs

Whether for newly built or existing dwellings, U values should be calculated on the basis of the actual or envisaged construction.

Thermal Bridging – Linear Thermal Transmittance

The effect of thermal bridging has to be calculated as part of the U values of the particular construction. As default for standard local construction, thermal bridging should be assumed to cover 10% of the area of the external envelope. However, for non standard methods of construction, it is also possible to arrive at a different effect of thermal bridging to that mentioned above. Appendix B of Guide F (Conservation of Fuel, Energy and Natural Resources) reproduced in Appendix 9 - of this manual. shows in detail the procedure of calculating the effect of thermal bridges on the resultant U values using a calculation method known as the 'Combined Method' as set out in EN ISO 6946.

Window Data

Window U values and g-values (total solar energy transmittance) can be obtained from a certified window energy rating or manufacturers' declaration. Both values are needed. Glazing area is to refer to the net clear opening including the frame. Window U values may be obtained from table 6 if the manufacturer's data is not available.

Normally the frame factors in Table 3 may be used. However, manufacturer's values are permitted provided they are representative of the actual windows.

Internal Heat Capacity

This is the effective thermal capacity of an element (wall, floor, ceiling etc), given in J/K. As it takes some time for heat to flow into or out of the building fabric, not all the thermal capacity is useful. The value for internal heat capacity of the building zone, C_m, being considered represents that part which affects the heating and cooling energy demands. For the monthly method being used, it is calculated by summing the heat capacities of all the building elements in direct thermal contact with the internal air of the zone under consideration such that

$$C_m = \sum k_j \times A_j$$

Where

kj is the internal heat capacity per area of the building element j, determined in accordance with Annex A of EN ISO 13786:2007, with maximum effective thickness of 0.1m, expressed in joules per square metres Kelvin.

A_j is the area of the element j, expressed in square metres

The software provides a default value of C_m based on local standard heavyweight construction elements. However, the assessor has the facility to calculate the value of C_m for the construction materials used for any particular dwelling

Boiler Efficiency – Gas, Oil and Solid Fuel

Manufacturer's declarations in terms of boiler seasonal efficiency have to be utilised. In the case that manufacturers data is not available, the values from Table 6 are to be used. Test data and the calculations that are certified by a Notified Body accredited for the testing of boilers by an EU national accreditation service may be used if available. The Notified Body must certify that: 'the full load and part load efficiency test results have been obtained by methods deemed to satisfy the Boiler Efficiency Directive'.

Efficiency of Electric Heat Pumps

Typical efficiencies for various types of heat pump equipment based on Eurovent conditions are listed in Table 6.
For other type of equipment not listed in the table below, manufacturer data may be used as long as this is based on Eurovent conditions.

For equipment which requires the use of circulating pumps such as chillers, the power consumed by the latter has also to be taken into account. This may be calculated by determining the design load of the dwelling in order to calculate the flow rate required from the pump and applying a head of 20m of water to determine the pump power rating. The software also asks the user whether the circulating pumps are timer controlled and whether they are inverter driven. Depending on the answer, operating hours per year are allocated to the circulating pumps to determine the overall power absorbed.

Air leakage - Pressure Test Result

The result of a pressure test can be used instead of the default calculations of infiltration. In the case of a dwelling that is not yet built, a design value of air permeability can be used, subject to verification once the dwelling is built.
Where a pressure test has not been carried out, the software calculates the air infiltration rate through embedded algorithms.

Solar Collector Performance

The zero-loss collector efficiency and the collector's linear heat loss coefficient can be used if obtained from certified test results. Table 10 shows the default values to be used if manufacturer's data is not available for different types of solar collectors.

Existing Properties

The calculation procedure for existing properties follows that for new dwellings. However it may be necessary to use default values, or to infer specific data.

The calculation is concerned with the assessment of the dwelling itself, as used by standard, notional or typical occupants, and not affected by the way current occupants might use it.

CALCULATION PROCEDURE

For carrying out energy assessments, the method of calculating the energy performance is set out in the form of a computer software application. The procedure consists of a step by step calculation in a series of individual steps or modules within the software. These individual steps contain equations or algorithms representing the relationship between the various factors which contribute to the annual energy performance of the dwelling. This calculation software is accompanied by a series of tables containing reference data for users to select and input as appropriate. The tables are included later in this manual.

This manual should be read in conjunction with use of the calculation software.

Any calculation with this software should work sequentially through the individual tabs, leading ultimately to the display of results in the 'Results' tab:

1. INPUTS

1.1. Dwelling dimensions

The boundary of the dwelling consists of all the building elements separating it from the external environment or from adjoining buildings or spaces.

Linear measurements for the calculation of wall, roof, and floor areas, and dwelling volume should be taken between the finished internal faces of the appropriate external building elements. Space taken up by any internal elements (internal partition walls) is disregarded for the purposes of establishing the total floor area of the dwelling. Linear measurements for the calculation of the areas of external door, window, and skylight openings should be taken between internal faces of appropriate sills, lintels, and reveals.

Volume indicates the total volume enclosed by all external elements and includes the volume of non-usable spaces such as stairwells.

1.1.1. Dimensions

These refer to the inner surfaces of the elements forming the external boundary of the dwelling. Thus floor dimensions are obtained by measuring between the inner surfaces of the external and party walls, disregarding the presence of interior walls.

1.1.2. Storey height

This is the total height between the ceiling surface of a given storey and the ceiling surface of the storey below. For a single storey dwelling or the lowest floor of a dwelling with more than one storey, the measurement should be from floor surface to ceiling surface.

1.1.3. Floor area

This should be measured as the actual floor area, i.e. if the height of a room extends to two storeys or more only the accessible floor area should be entered. Similarly in the case of stairs, only the floor from where the staircase originates should be entered in the floor area to be measured. The staircase area in the remaining floors should be left out.

In general, rooms and other spaces, such as fitted wardrobes, should be included in the calculation of the floor area where these are directly accessible from the occupied area of the dwelling. However, unconditioned spaces clearly divided from the dwelling should not be included. The following provides specific guidance:

1.1.4. Porches

In this context porch means an addition protruding from the line of the external wall of the dwelling; an entrance lobby that is within such line should be included, but a porch should be excluded.

1.1.5. Store rooms and utility rooms

These should be included if they are directly accessible from the occupied area of the dwelling, whether conditioned or not

These should not be included if they are accessible only via a separate external door.

1.1.6. Basements

These should only be included if consisting of habitable rooms, connected by an internal staircase to the rest of the dwelling.

1.1.7. Washrooms

These should be included only when connected by an internal staircase to the rest of the dwelling. Washrooms connected by an external staircase should not be included.

1.1.8. Garages

These should not be included even when the garage is incorporated within the dwelling.

When areas which are not included in the floor area, such as garages, either form part of the dwelling or adjoin the dwelling, the walls or parts of wall between these structures and the dwelling contribute to the transmission gains or losses from the dwelling, and the internal temperature of these areas should be calculated accordingly (see Appendix 8) so as to establish the adjusted U value for these walls.

Similarly in buildings incorporating flats, the walls between the flat and the entrance lobby/stairwell should be treated as elements adjacent to an unconditioned space and the internal temperature and adjusted U value should be calculated accordingly.

1.1.9. Utilisation factor

The living area is established by the software as a percentage of the total floor area. The percentage of the living area varies from 60% for dwellings with a total floor area of $60m^2$ to 40% for dwellings with total floor area of $200m^2$ and over. The utilisation factor is the floor area of the living area divided by the total floor area of the dwelling.

2. VENTILATION RATE

The ventilation air change rate is the rate at which outside air enters or leaves a building, expressed in terms of air changes per hour (ach) or m^3/h.

The calculation requires a reasonable estimate of the air change rate in order to calculate the ventilation energy transfer (expressed in W/K) and its effect on the overall heating/cooling requirement. The actual ventilation rate depends on a large number of factors, may be not known precisely (e.g. permeability of materials and inadvertent gaps and openings in the structure) and in most cases cannot be assessed from plans.

The infiltration rate can be assessed using the EPRDM ventilation algorithm. The ventilation algorithm requires the information on chimneys, fans, open flues and passive vents. The number of each of the above shall be inserted in the software programme.

Ventilation rates for chimneys, flues, fans and passive vents, flueless gas fires and passive stack ventilators are given in Table 9. In cases where a pressure test has been carried out, the software allows the input from the pressure test results.

2.1. Chimneys and Flues

Ventilation rate for chimneys and flues should be entered only when they are unrestricted and suitable for use.

For the purpose of calculation a chimney is defined as a vertical duct for combustion gases of diameter 200mm or more (or a rectangular duct of equivalent size). Vertical ducts with a diameter less than 200mm should be counted as flues.

Ventilation rates should be entered only for open flues; they should not be included for room-sealed boilers or room heaters.

2.2. *Fans and Trickle Vents*

Extract fans which exhaust air (typically from the kitchen and bathroom), including cooker hoods and other independent extractor fans, should be included in the 'number of fans' category.

The number of fans refers to extract fans, which exhaust air (typically from the kitchen and bathroom).

Trickle vents (Ventilaturi) are considered as permanent vents.

2.3. *Draught Stripping*

The percentage of windows and doors that are draught stripped should be entered. It is to be noted that sliding aluminium windows are **not** to be considered as draught stripped.

2.4. *Draught Lobby*

A draught lobby is an arrangement of two doors that forms an airlock on the main entrance to the dwelling. A draught lobby should only be specified if there is a draught lobby to the main entrance of the dwelling. If the main entrance has no draught lobby but, for example, a back door does, then no draught lobby should be specified.

Flats with access via an enclosed stairwell or corridor should be classified as having a draught lobby.

2.5. *Party Walls*

The length of party walls (appoggi) that are built up on both sides is to be inserted into the Ventilation sheet as a percentage of the total length of the external walls of the dwelling.

In the case of adjoining properties which have not been constructed yet, the assessor should assume that party walls are to be built up on the other side when the property is constructed in a terraced zone, except on the case of apartment blocks where the terrain indicates that the adjacent block will not be constructed to the same height as that of the apartment being assessed..

2.6. *Mechanical Ventilation*

There is no allowance in the software for dwellings that have a system of mechanical ventilation installed.

3. THE BUILDING ENVELOPE

The software calculates effective thermal heat gains and/or losses through both opaque (walls and roofs) and translucent (glazing) building components based on a monthly calculation method. The net effective thermal gains and/or losses are calculated through a proprietary correction factor, namely the utilisation factor. The utilisation factor is automatically calculated by the software itself. Apart from consideration of the utilisation factor, the software duly allows for re-radiation of heat from the building envelope to the external environment, as well as intermittency of operation of both cooling and heating systems.

3.1. *Opaque Elements*

The information to be entered in this section of the software relates to the thermal properties of the opaque components of the envelope of the building, namely :

- Roofs
- Walls
- Floors

As indicated in Section 1, the areas of building elements are based on the internal dimensions of the surfaces bounding the dwelling.

Only those components which are exposed to the external environment and unconditioned spaces are to be inputted in this section

Wall area is the net area of walls after subtracting the area of windows and doors. Roof area is also net of any skylights. Losses or gains through party walls to spaces in other dwellings or premises that are normally expected to be conditioned are assumed to be zero.

On the Opaque Elements worksheet, the user is required to enter the following data:

- The procedure takes account of the dwelling's capacity to store heat within its structure, represented by the internal heat capacity. The software proposes a default value which is a typical value for the heavy construction characteristic of local dwellings. The assessor may also calculate the value for the dwelling according to the ISO 13786:2007 and input the calculated value.
- The orientation of each external element, selected from five orientation options: North, North East/North West, East/West, South East/South West, South and Horizontal (for roofs)
- For heat transfer purposes the relevant area and U value of each external element. When the details of the construction are known, the U- values should be calculated. This should always be the case for new dwellings being assess from building plans. The U value and its calculation method are dealt with in a separate section of this manual. The U value shall be corrected for thermal bridging (as applicable). The U value for the ground floor slab shall be calculated in accordance with the procedures as recommended in EN ISO 13370. (see Appendix 7)
- For solar heat gain purposes the relevant shading factor for external shading, absorbtivity and emissivity. The shading factor shall be determined by the assessor in the form of an averaged annual value using Table 13 which gives a set of typical values for shading from overhangs.
- For elements adjacent to unconditioned spaces, the area and U value shall be input. The U value and its calculation method are dealt with in Appendix 8.

3.2. *Glazed Elements*

Window area refers to the total area of the openings (windows, doors, skylights) including frames. On the worksheet the user is required to enter the following data.

- The orientation of each glazed component, selected from five orientation options: North, North East/North West, East/West, South East/South West, South and Horizontal (for roof skylights)
- For heat transfer purposes the relevant area, frame factor, and U value of each glazed element. Typical U values for glazed elements can be found in Table 6, though manufacturer's data may also be input where available. Similarly for frame factors, typical values can be found in Table 3, although the actual values can also be used.
- For solar heat gain purposes the relevant shading factor for external shading, the emissivity and the g-value. The external shading factor shall be determined by the assessor in the form of an averaged annual value. (Refer to Table 13 for Overhang shading factors for different orientations). The value of the internal shading factor is fixed at 0.9, since the use of internal shading can vary from user to user. The emissivity of glazing is that of the glass itself and shall reflect the emissivity value of different glazing types/combinations as a result of low-emissivity coatings, body colour tints etc. However it shall not be confused with the g-value of the glazing construction. The g-value is the total solar energy transmittance factor for the glazing combination type. Typical values are included in Table 2.
- The use of user moveable external louvers (e.g. shuttered windows, etc.) shall be considered as having a yearly external shading factor of 0.5.

4. DOMESTIC WATER HEATING

The demand for hot water is derived from the number of persons in the dwelling. The latter in turn is calculated as a direct function of the floor area of the dwelling. Occupancy is calculated at 1 person every $60m^2$ with a minimum of 2 people and a maximum of 7 for the largest residence (i.e. max of $450m^2$). The energy required to produce that amount of hot water is then calculated, taking account of losses in storage and distribution.

A distinction is made between instantaneous water heating, which heats water when it is required, and water heating that relies on storage of hot water in a cylinder, tank or thermal store. 'Distribution' and 'cylinder' losses are not used in the calculation for instantaneous heaters.

'Single-point' heaters, which are located at the point of use and serve only one outlet, do not have distribution losses either. Gas multipoint water heaters and instantaneous combi boilers are also instantaneous types but, as they normally serve several outlets, they are assumed to have distribution losses.

Stored hot water systems can either be served by an electric immersion heater or obtain heat from a boiler or a heat pump through a primary circuit. In both cases, water storage losses are incurred to an extent that depends on how well the water storage is insulated. These losses apply for:

- hot water cylinders;
- the store volume of storage combination boilers (where the boiler efficiency is derived from test data);
- thermal stores;

Water storage losses are set to zero for combi boilers and instantaneous water heaters.

For cylinders, the preferred way of establishing cylinder losses is from measured data on the cylinder concerned, according to BS 1566.

If measured data is not available, losses from the storage vessel are assumed to be a default value of 15% of the energy required at the taps. Similarly, pipework losses can either be calculated or else the losses are assumed at a default value of 15%.

5. SOLAR WATER HEATING

A solar collector coupled with dedicated solar water storage reduces the fuel needed for domestic hot water (see Appendix 2). The solar water storage can be either as the lower part of a multi heat source cylinder, or as a separate solar cylinder. However solar water storage can never be larger than the total DHW storage.

Allowance has been made for the higher usage of DHW during the Winter months in the software. The net input of solar water heating (if any) is deducted from the need of heating of DHW used on a monthly basis. In case there are months where the solar water heating satisfies the full DHW requirement, the net DHW energy required during that particular month results to be zero.

In order to calculate the solar collector's efficiency, the following data is needed:

η_0	zero-loss collector efficiency
a_1	linear heat loss coefficient of collector, W/m^2K

The preferred source of performance data for solar collectors is from a test on the collector concerned. If test data is not available, the values in Table 10 may be used.

6. HEATING AND COOLING SYSTEMS

6.1. *Heating systems*

It is assumed that the building has heating systems capable of heating the entire dwelling.

For a new dwelling that has no heating system specified it should be assumed that the dwelling will be heated by direct acting electric heaters.

For a dwelling that has a heating system installed that does not heat the entire dwelling, it can be assumed that this system is capable of heating the entire dwelling if it is capable of heating a minimum of 40% of the total floor area of the dwelling.

If the installed heating system is not capable of heating a minimum of 40% of the total floor area of the dwelling, it should be assumed that the dwelling will be heated by direct acting electric heaters.

If a dwelling has more than one heating system installed, and the overall heated area exceeds the minimum of 40%, it should be assumed that the dwelling is heated by the system covering the larger floor area.

6.2. *Cooling systems*

It is assumed that the building has cooling systems capable of cooling the entire dwelling.

For a new dwelling that has no cooling system specified it should be assumed that the dwelling will be cooled by split type air conditioning units.

For a dwelling that has a cooling system installed that does not cool the entire dwelling, it can be assumed that this system is capable of cooling the entire dwelling if it is capable of cooling a minimum of 40% of the total floor area of the dwelling.

If the installed cooling system is not capable of cooling a minimum of 40% of the total floor area of the dwelling, it should be assumed that the dwelling will be cooled by split type air conditioning units.

If a dwelling has more than one cooling system installed, and the overall cooled area exceeds the minimum of 40%, it should be assumed that the dwelling is cooled by the system covering the larger floor area.

6.3. *Efficiencies*

6.3.1. Heating System

The heating system efficiency may be obtained from certified manufacturer's data. Typical values can be obtained from Table 6.
Typical efficiencies for various types of heat pump equipment based on Eurovent conditions are also listed in Table 6.

For other type of equipment not listed in Table 6, manufacturer data may be used as long as this is based on Eurovent conditions.

Boiler test data and the calculations that are certified by a Notified Body accredited for the testing of boilers by an EU national accreditation service are to be used if available. The Notified Body must certify that: 'the full load and part load efficiency test results have been obtained by methods deemed to satisfy the Boiler Efficiency Directive'.

6.3.2. Cooling System

The cooling system efficiency may be obtained from certified manufacturer's data. Typical values can be obtained from Table 6.
Typical efficiencies for various types of heat pump equipment based on Eurovent conditions are also listed in Table 6.

For other type of equipment not listed in Table 6, manufacturer data may be used as long as this is based on Eurovent conditions.

6.3.3. Ancillaries

For equipment which requires the use of circulating pumps such as chillers, the power consumed by the former has also to be taken into account. This may be calculated by determining the design load of the dwelling in order to calculate the flow rate required from the pump and applying a head of 20m of water to determine the pump power rating. The software also asks the user whether the circulating pumps are timer controlled and whether they are inverter driven. Depending on the answer, operating hours per year are allocated to the circulating pumps to determine the overall power absorbed.

6.3.4. Domestic Hot Water

The water heating system efficiency may be obtained from certified manufacturer's data. Typical values can be obtained from Table 6.

Boiler test data and the calculations that are certified by a Notified Body accredited for the testing of boilers by an EU national accreditation service are to be used if available. The Notified Body must certify that: 'the full load and part load efficiency test results have been obtained by methods deemed to satisfy the Boiler Efficiency Directive'.

7. TOTAL ENERGY USE

7.1. Energy Use

The annual fuel or electricity consumption, under the standard patterns of occupancy and usage embedded in the procedure, is calculated for the following items or functions:

- Space heating system
- Space cooling system
- Domestic hot water
- Electricity for pumps and fans
- Electricity for lighting

7.2. Energy Factors

The primary energy factors and the CO_2 emission factors associated with different fuels are calculated using the data given in Table 11. Other primary energy or CO_2 emission factors cannot be used for the purpose of this calculation.

The primary energy and CO_2 emission factors in Table 11 account for energy used and emissions released at the dwelling, and also take some account of energy used and emissions released in bringing the fuel or other energy carrier to the dwelling. For example, in the case of electricity they account for energy losses and emissions at the power stations.

7.3. *Electricity for Pumps and Fans*

In relation to heating, air conditioning, and domestic hot water, an allowance is made for energy consumption in the form of electricity used for ancillary equipment. This applies to any of the following items

- Chilled water circulating pump
- Heating water circulating pump
- DHW circulating pump
- Cooling water pumps (for water cooled systems)
- Ventilation fans

The energy consumption for these systems is established on the basis of the rated power and the hours of operation. Correction factors are applied when the systems are timer controlled and/or inverter powered.

7.4. *Electricity for Lighting*

The electricity for lighting is calculated according to the procedure in Appendix 3. The calculation allows for low-energy lighting on the basis of the proportion of light points that have low-energy fittings.

8. ENERGY AND EMISSIONS

The procedure enables the user to calculate the following results, both total and per m^2 of total floor area. All of these relate to the assumed standard occupancy as the energy consumption patterns of real occupants vary widely.

***Delivered energy in kWh/yr*.-** This corresponds to the energy consumption that would normally appear on the energy bills of the dwelling for the assumed standardised occupancy and usage.

Primary energy in kWh/yr:- This includes delivered energy, plus an allowance for the energy incurred in extracting, processing, and transporting a fuel or other energy carrier to the dwelling. For example, in the case of electricity it takes account of the generation efficiency at the power stations.

Carbon dioxide emissions in kg CO_2 per year:- Emissions are calculated on the basis of primary energy consumption, e.g. emissions at power stations associated with the dwelling's electricity use are accounted for.

8.1. EPRDM & DCER Ratings

The Energy Performance Rating of Dwellings in Malta (EPRDM) is the delivered energy per unit area of the dwelling (kWh/m^{2}yr). This rating is independent of any parameters of the building and therefore may be utilised to gauge the efficiency of the dwelling. The lower the result, the more efficient the building is. A result of zero means that the building is self sustainable in terms of energy use.

The Dwelling's Carbon Emission Rate (DCER) is the carbon dioxide emissions per unit area of the dwelling (kg CO_2/m^2yr). This result is a measure of the carbon footprint of the dwelling.

The procedure and software will be used to generate the EPRDM Rating and will form the basis of the Advisory Reports as required under the EPBD. The procedure will apply to new dwellings as from the 2nd January 2009. At the time of publication of this edition of the EPRDM the format and content of the EPRDM Rating and the Advisory Reports has not yet been decided.

9. INTERNAL GAINS

Internal gains have been defined as gains from lights, appliances, and from the occupants of the dwelling (metabolic gains).

The gains from lighting have been based on basic energy consumption per m^2 per year and corrected for proportion of fixed lighting outlets that are low energy and also for the availability of natural daylight as a direct relationship of the glazing ratio of the dwelling. Furthermore the resultant energy used for lighting was then apportioned for the heating and cooling season in a way that allows for the fact that days in the cooling season are longer than those in the heating season and therefore less energy is used for lighting.

Gains from occupants (metabolic) were based on the resultant number of occupants in the dwelling which in turn is based on the floor area of the dwelling.

Gains from cooking and appliances were also based on a factor which is applied to the total floor area of the dwelling.

10. SOLAR HEAT GAINS

Solar gains are calculated on a monthly basis for the heating and cooling season. The average daily heat gain through the building elements (glazed and opaque) is calculated for each month in accordance with EN ISO 13790:2008 from the following equation:

$$\Phi_{sol,k} = F_{sh,ob,k} A_{sol,k} I_{sol,k} - F_{r,k} \Phi_{r,k}$$

where

$F_{sh,ob,k}$	is the shading reduction factor for external obstacles for the solar effective collecting area of surface k
$A_{sol,k}$	is the effective collecting area of surface k with a given orientation and tilt angle, in the considered zone or space, expressed in square metres;
$I_{sol,k}$	is the solar irradiance, the mean energy of the solar irradiation over the time step of the calculation, per square metre of collecting area of surface k, with a given orientation and tilt angle, expressed in watts per square metres;
$F_{r,k}$	is the form factor between the building element and the sky
$\Phi_{r,k}$	is the extra heat flow due to thermal radiation to the sky from building element k, expressed in Watts.

This calculation incorporates solar incidence data for the Maltese Islands on differently orientated surfaces.

Solar gains are calculated separately for each orientation and for roofs/skylights and then totalled for use in the calculation.

11. MEAN INTERNAL TEMPERATURE

Operating Schedule

The hours of use and the internal temperatures in the EPRDM are based on the requirements of a standardised household. The schedule is as follows:

Daily: 8 hours operation

This standardised schedule represents a total operating period of 56 hours per week.

The required set-point internal temperatures during the year as

Winter season (heating):	Living area 23°C
	Rest of dwelling 15°C
Summer season (cooling):	Living area 25°C
	Rest of dwelling 28°C

The required mean internal temperature of the dwelling is calculated as the average of the set-point temperatures in the living area and in the rest of dwelling, weighted by floor area.

12. SPACE ENERGY USE

The energy need for heating and cooling is defined in EN ISO 13790 as the heat to be delivered to, or extracted from, a conditioned space to maintain the intended temperature conditions during a given period of time.
The energy need is calculated and cannot easily be measured.

The calculation of energy need is done on a monthly basis based on the procedure described in EN ISO 13790. A single zone calculation is performed using a single average of mean internal temperature as described in Section 11.

For each month:

- The total heat transfer by transmission is determined as given by the following equations
  - For heating $Q_{tr} = H_{tr,adj}(\Theta_{int,set,H} - \Theta_e)t$
  - For cooling $Q_{tr} = H_{tr,adj}(\Theta_{int,set,C} - \Theta_e)t$

where

$H_{tr,adj}$	is the overall heat transfer coefficient by transmission of the dwelling, expressed in W/K
$\Theta_{int,set,H}$	is the set-point temperature of the building for heating, expressed in degrees Centigrade
$\Theta_{int,set,C}$	is the set-point temperature of the building for cooling, expressed in degrees Centigrade
Θ_e	is the temperature of external environment, expressed in degrees Centigrade
t	is the duration of the calculation step, expressed in mega seconds.

- the total heat transfer by ventilation is calculated for each month as given by the following equations

    - For heating: $Q_{ve} = H_{ve,adj}(\Theta_{int,set,H} - \Theta_e)t$

    - For cooling: $Q_{ve} = H_{ve,adj}(\Theta_{int,set,C} - \Theta_e)t$

where

$H_{ve,adj}$	is the overall heat transfer coefficient by ventilation of the dwelling, expressed in Watts per Kelvin
$\Theta_{int,set,H}$	is the set-point temperature of the building for heating, expressed in degrees Centigrade
$\Theta_{int,set,C}$	is the set-point temperature of the building for cooling, expressed in degrees Centigrade
Θ_e	is the temperature of external environment, expressed in degrees Centigrade
t	is the duration of the calculation step, expressed in mega seconds.

- the internal heat gains for each month are calculated as follows

    - the internal heat flow from occupants determined on the basis of 1.2 W/m^2

    - the internal heat flow from appliances determined on the basis of 1.5 W/m^2

    - The internal heat flow from lighting, determined as outlined in Appendix 3

The internal heat flow rate from hot and mains water and sewage, as well as the internal heat flow rate from heating, cooling and ventilation systems, was not included in the calculation of the building energy needs as the effect was established as negligible in the local context.

- the solar heat gains for each month through glazed and opaque building elements are calculated in Watts using the following equation:

$$\Phi_{sol,k} = F_{sh,ob,k} A_{sol,k} I_{sol,k} - F_{r,k} \Phi_{r,k}$$

where

$F_{sh,ob,k}$	is the shading reduction factor for external obstacles for the solar effective collecting area of surface k,
$A_{sol,k}$	is the effective collecting area of surface k with a given orientation and tilt angle, in the considered zone or space expressed in square metres;
$I_{sol,k}$	is the solar irradiance, the mean energy of the solar irradiation over the time step of the calculation, per square metre of collecting area of surface k, with a given orientation and tilt angle, expressed in Watts per square metre;
$F_{r,k}$	is the form factor between the building element and the sky
$\Phi_{r,k}$	is the extra heat flow due to thermal radiation to the sky from building element k, expressed in watts.

- the dynamic parameters for each month through glazed and opaque building elements are calculated
  - the gain utilisation factor for heating
  - the loss utilisation factor for cooling
  - the building time constant
  - the corrections for intermittency in heating mode
  - the corrections for intermittency in cooling mode

LIST OF STANDARDS

EN ISO 13790:2008, Energy performance of buildings – Calculation of energy use for space heating and cooling

Guide F: Technical Guidance, conservation of fuel, energy and natural resources (minimum requirements on the energy performance of building regulations, 2006)

BS EN ISO 6946, Building components and building elements – Thermal resistance and thermal transmittance – Calculation method

BS EN ISO 13786:2007, Thermal performance of building components – dynamic thermal characteristics – Calculation methods

BS 1566:2002, Copper indirect cylinders for domestic purposes. Open vented copper cylinders. Requirements and test methods.

BS EN 12975-2, Thermal solar systems and components, solar collectors, Part 2, test methods

BS EN ISO 10077-1, Thermal performance of windows, doors and shutters – Calculation of thermal transmittance, Part 1 : General

EN ISO 13370, Thermal performance of buildings – Heat transfer via the ground – Calculation methods

EN ISO 13789, Thermal performance of buildings – Transmission heat loss coefficient – Calculation method

APPENDICES

Appendix 1: WEATHER DATA

Month	Average outdoor temperature (°C)
Jan	12.2
Feb	12.4
Mar	13.4
Apr	15.5
May	19.1
Jun	23.0
Jul	25.9
Aug	26.3
Sep	24.1
Oct	20.7
Nov	17.0
Dec	13.8

Appendix 2: SOLAR WATER HEATING

Solar water systems work on the principle of harnessing solar energy to heat up water. There are two main types of solar hot water setups. Thermosyphon and remote storage. Thermosyphon systems have the solar store directly above the collector panels, while remote storage systems use a circulating pump to move the hot water to the storage vessel.

Water from the cold supply is either fed (directly or via a cold feed cistern) to a preheat zone where it is heated by solar energy. Then the water passes to the domestic hot storage (separate hot water cylinder or upper part of combined cylinder) which is heated to the required temperature by a boiler or an electric immersion.

There are three main types of solar collectors:

- unglazed:	the overall performance of unglazed collectors is limited by high thermal losses;
- glazed flat plate:	a flat plate absorber (which often has a selective coating) is fixed in a frame between a single or double layer of glass and an insulation panel at the back;
- evacuated tube:	an absorber with a selective coating is enclosed in a sealed glass vacuum tube.

The performance of a solar collector is represented by its zero-loss efficiency (proportion of incident solar radiation absorbed in the absence of thermal loss) and its heat loss coefficient (heat loss from collector to the environment per unit area and unit temperature difference).

The monthly solar contribution to domestic hot water is given by

$$Q_s = (S \times Z_{panel} \times A_{ap} \times \eta_o \times UF \times f(a_1/\eta_o) \times f_{s\,vol}) - Q_{sol\,pump}$$

where

Q_s	solar input, kWh/month
S	total solar radiation on collector, kWh/m²/month
Z_{panel}	overshading factor for the solar panel
A_{ap}	aperture area of collector, m²
η_o	zero-loss collector efficiency
UF	utilisation factor
a_1	linear heat loss coefficient of collector, W/m²K
$f(a_1/\eta_o)$	collector performance factor
$f_{s\ vol}$	Solar storage volume correction factor = (V_d/V_s) * N
V_d	daily hot water demand, litres
N	Solar Water Storage Volume Multiplier
$Q_{sol\ pump}$	Electrical consumption of SWH primary pump (if any).

The collector's gross area is the projected area of complete collector (excluding any integral means of mounting and pipework). The aperture area is the opening through which solar radiation is admitted.

The preferred source of performance data for solar collectors is from a test on the collector concerned according to BS EN 12975-2, *Thermal solar systems and components - Solar collectors - Part 2: Test methods*. The aperture area, and the performance characteristics η_o and a_1 related to aperture area, are obtained from the test certificate. If test data are not available, the values in Table 10 may be used.

The solar input is calculated using the procedure given in this appendix and the result is used for calculating the energy required for water heating.

Appendix 3 - ENERGY FOR LIGHTING

The calculation of lighting use is based on the proportion of low energy lighting outlets installed, and on the contribution of daylight.

Allowing for fixed low-energy outlets

Assuming the average energy consumption for lighting at a conservative value of 9.3 kWh/m^2 annually if no low- energy lighting is used.

$$E_B = 9.3 \text{ kWh/m}^2$$

The calculation takes account of lighting outlets with low-energy lamps, by including a correction factor C_1:

$$C_1 = 1 - 0.75 \times N_{LE}/N$$

where N_{LE} is the number of low energy lighting outlets (including sockets or complete luminaries capable of taking only low-energy lamps, and also compact fluorescent lamps that fitted into ordinary lighting sockets) and N is the total number of lighting outlets (only the ratio N_{LE}/N is needed).

Daylighting

Analysis of typical house types gives the following approximate correction factor for lighting energy use depending on glazing ratio G_L (the ratio of glass area to floor area), the glass transmittance and the light access factor.

$$C_2 = 52.2\, G_L^2 - 9.94\, G_L + 1.433 \quad \text{if } GL \leq 0.095$$
$$C_2 = 0.96 \quad \text{if } G_L > 0.095$$

$$GL = \sum \frac{A_w \times 0.9 \times g_l \times LAF}{TFA}$$

where:

A_w	is total area of windows, m^2
TFA	is the total floor area, m^2
g_l	is the solar transmittance
LAF	Light access factor from

The annual energy used for lighting in the house E_L is then

$$E_L = E_B \times TFA \times C_1 \times C_2 \text{ kWh/year}$$

where:

E_B	9.3 kWh/m^2
TFA	is the total floor area, m^2

C_1 and C_2 are defined above

Gains from lighting

The annual energy use from lighting in the dwelling is:

$$E_L = E_B \times TFA \times C_1 \times C_2 \text{ (kWh/year)}$$

The internal heat gains due to lighting for the heating and cooling months are then calculated based on equal number of heating and cooling months and apportioning the calculated total energy used for lighting per year in the ratio of 60% during the heating months and 40% during the cooling months to account for shorter days during the former..

Appendix 4: ENERGY FROM PHOTOVOLTAIC (PV) TECHNOLOGY

Photovoltaic technology converts sunlight directly into electricity. It works during daylight hours but more electricity is produced when the sunshine is more intense (a sunny day) and is striking the PV modules directly. PV produces electricity as a result of interaction of sunlight with semi-conductor materials in the PV cells.

The energy produced per year depends on the installed peak power (kWp) of the PV module (the peak power is the rate of electricity generation in bright sunlight, formally defined as the output of the module under radiation of $1kW/m^2$ at 25°C). PV modules are available in range of types and some produce more electricity per square metre than others. In Malta the electricity produced by fixed installations at different orientations and tilt angles from the horizontal have been calculated as indicated in the table below. Same applies for tracking systems which are more efficient than fixed installations since they follow the movement of the Sun throughout the day.

In the software the user only needs to input the amount of kWp installed, the type of system (i.e. whether fixed or tracking), the orientation and tilt angle (in case of fixed installation). In the case of a building containing more than one dwelling, e.g. a block of flats, then:

a) if the PV output goes to particular individual flats, the annual output is credited to the flats concerned;

b) the PV output generated is divided amongst all the apartments connected to the system in proportion to their floor area if they are connected to a power outlet which is not that of the common area.

c) otherwise the total electricity generated is credited to the common area of the block which will also need a separate energy efficiency certificate although the latter will be of a non residential type and hence issued using a different software.

For calculation of CO_2 emissions and primary energy savings, the factors of grid displaced electricity are used. The same factor is used for all electricity generated, whether used within the dwelling or exported.

Appendix 5: ENERGY FROM WIND TURBINES

Wind turbine technology converts wind power directly into electricity. It works as long as there is wind blowing but more electricity is produced when the wind speed is higher.

For software calculations, the energy produced per year depends on the installed rated power (kW) of the wind turbine (the rated power corresponds to the rate of electricity generation at a manufacturers pre-defined wind speed). Wind turbines are available in a range of types and some produce more electricity than others, depending on the design. In the Maltese climate, an installation with a rating of 1 kW produces about 1000 kWh of electricity per year.

In the software the total installed wind turbine capacity in kW is entered in the systems tab.
In the case of a building containing more than one dwelling, e.g. a block of flats, then:

a) if the wind turbine output goes to particular individual flats, the annual output is credited to the flats concerned;

b) the electricity generated is divided amongst all the apartments connected to the system in proportion to their floor area if they are connected to a power outlet which is not that of the common area.

c) otherwise the total electricity generated is credited to the common area of the block which will also need a separate energy efficiency certificate although the latter will be of a non residential type and hence issued using a different software.

Appendix 6: ENERGY SAVINGS FROM SECOND CLASS WATER SYSTEMS

Second class water system saves electricity by offsetting the energy used by local water services provider to produce water from RO and ground water extraction. The energy saved is dependent on the software's calculation for the number of residents in the dwelling which is related to the total floor area of the dwelling. In order to be eligible for savings from second class water system, the installation has to be connected to a rain water cistern and be used for separate flushing water supply. The energy saved is calculated using the following formula:

$$Q_s = N*(35/1000)*3.15*365$$

where:

Q_s	is the yearly energy saving in kWh
N	is the occupancy of the dwelling

In the software the second class water installation is inputted in the systems tab.

In the case of a building containing more than one dwelling, e.g. a block of flats, the second class water system output goes to each individual flat that has a connection to the second class water system.

Note that second class water system connected to common areas in a development is not considered in the assessments.

Appendix 7: CALCULATION OF U VALUES FOR FLOORS

The calculation of U values for floors shall be carried out in line with the procedures indicated in EN ISO 13370:2007 : "Thermal performance of buildings – heat transfer via the ground – Calculation methods".

The floor U value is a function of the characteristic dimension of the floor, B', and the total equivalent thickness, d_t,

$$d_t = w + \lambda(R_{si} + R_f + R_{se})$$

where :

w	thickness of external walls, m
R_f	thermal resistance of the floor slab, including that of any all-over insulation layers above, below, or within the floor slab, and that of any floor covering. (The thermal resistance of dense concrete slabs and thin floor coverings may be neglected. Hardcore below the slab is assumed to have the same thermal conductivity as the ground, and its thermal resistance should not be included.)

If d_t < B', (in the case of an uninsulated/moderately insulated floor), then:

$$U_f = [2\lambda/(\pi B' + d_t)]*\ln[(\pi B' + d_t)/d_t]$$

If d_t >= B' (in the case of well insulated floors), then:

$$U_f = \lambda/[(0.457*B') + d_t]$$

where:

λ	thermal conductivity of unfrozen ground
λ	1.5 W/mK (clay or silt)
λ	2.0 W/mK (sand or gravel)
λ	3.5 W/mK (homogeneous rock)

Characteristic dimension of floor:

$$B' = A/(0.5*P)$$

where:

A	floor area
P	perimeter

B' is calculated from the area and perimeter of the floor of the basement. The exposed perimeter 'P' of the floor is the total length of external walls dividing the building from the external environment or from an unheated space outside the insulated fabric.

For a complete building, P is the total perimeter of the building and A is its total ground floor area.

For each individual dwelling (e.g. each dwelling in a row of terraced houses), P includes the length of external walls separating the heated space from the external environment and excludes the lengths of walls separating the part under consideration from other heated parts of the building, while A is the ground floor area under consideration.

Unheated spaces outside the insulated fabric of the building (such as porches, attached garages or storage areas) are excluded when determining P and A (but the length of the wall between the heated building and the unheated space is included in the perimeter, the ground heat losses are assessed as if the unheated spaces were not present).

Appendix 8: CALCULATION OF RESULTANT SPACE TEMPERATURE INSIDE UNCONDITIONED SPACES

The resultant temperature inside unconditioned spaces (e.g. Garages, communal staircases etc), is calculated assuming steady state conditions following the procedure as recommended in Annex A of EN ISO 13789.

The resultant temperature inside the unconditioned space is therefore calculated as follows :

$$\theta_u = \frac{(\varnothing + \Sigma(\theta_i A_i U_{iu}) + \Sigma(\theta_a A_a U_{au}) + \Sigma(\theta_e A_e U_{eu}))}{(\Sigma(A_i U_{iu}) + \Sigma(A_a U_{au}) + \Sigma(A_e U_{eu}))}$$

where:

θ	temperature, ^0C
Ø	heat generated within the unconditioned space (including solar heat gains), W
U	heat transfer coefficient, W/m^2K
A	surface area, m^2
i	internal
e	external
a	adjacent
u	unconditioned

Appendix 9: Guide F, Appendix B (Conservation of Fuel, Energy and Natural Resources)

APPENDIX B – Calculating U values

B1 Introduction

When calculating the U value, the effect of thermal bridges should be taken into consideration. Other factors, such as wall ties and air gaps around insulation should also be included where applicable. The calculation method, known as the *"Combined Method"*, is set out in *EN ISO 6946*. The following example illustrates the use of the method for a typical wall.

This example is offered as indicating ways of meeting the requirement but designers also have to ensure that their designs comply with all the other requirements of existing building regulations.

B2 Procedure

The U value is calculated by applying the following steps:

1). Calculate the upper resistance limit (R_{upper}) by combining in parallel the total resistance of all possible heat-flow paths (i.e. sections) through the plane building element.

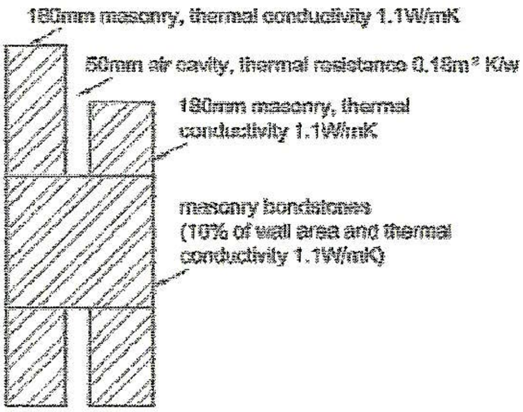
2). Calculate the lower resistance limit (R_{lower}) by combining in parallel the resistance of the heat flow paths of each layer separately and then summing the resistance of all layers of the plane building element.

3). Calculate the U value of the element from $U = \frac{1}{R_T}$

where $$R_T = \frac{R_{upper} + R_{lower}}{2}$$

4). Adjust the U value as appropriate to take account of metal fasteners, bond stones and air gaps.

B3 *Example – U value calculation for a typical double leaf masonry wall*



Layer	Material	Thickness *(mm)*	Thermal conductivity *(W/m.k)*	Thermal resistance *(m^2K/W)*
	External surface	----	----	0.060
1	Outer leaf masonry	180	1.1	0.164
2	Air cavity (unvented)	50	----	0.180
3	Internal leaf masonry	180	1.1	0.164
4	Bond stone 10%	410	1.1	0.373
	Internal surface	----	----	0.100

There are two possible paths through which heat can pass. The upper limit of resistance is therefore given by:

$$R_{upper} = \frac{1}{(\frac{F_1}{R_1} + \frac{F_2}{R_2})}$$

where F_m is the fractional area of section **m** and R_m is the total thermal resistance of section **m**. A conceptual illustration of the upper limit of resistance is shown in Diagram B.1 below.

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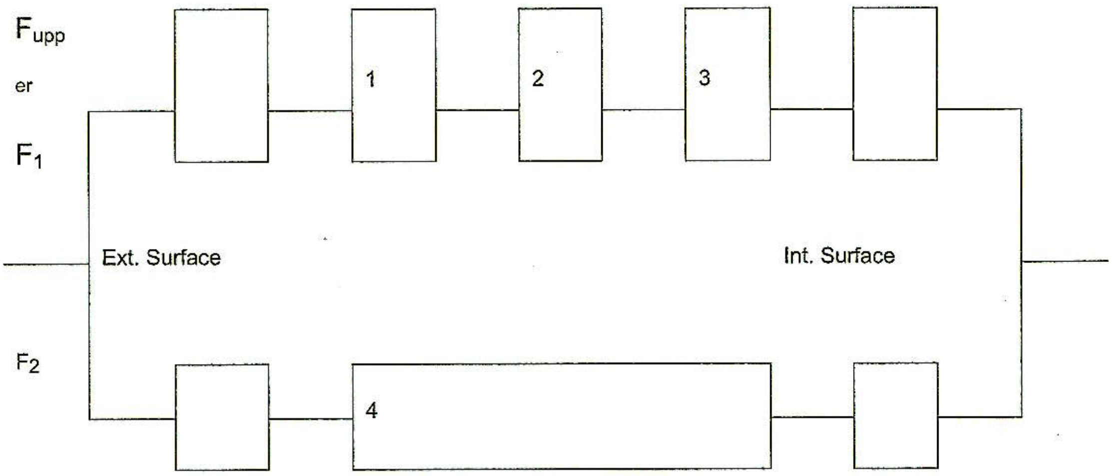
Conceptual illustration of the upper limit of Diagram B.1 resistance



Resistance R_1 through section		
External surface resistance	=	0.060
Resistance of 180mm masonry	=	0.164
Resistance of air cavity	=	0.180
Resistance of 180mm masonry	=	0.164
Resistance of internal surface	=	0.100
Total thermal resistance R_1	**=**	**$0.667m^2K/W$**
Fractional area F_1 = 90%	**=**	**0.9**

Resistance R_2 through section containing bond stone		
External surface resistance	=	0.060
Resistance of 410mm masonry	=	0.373
Resistance of internal surface	=	0.100
Total thermal resistance R_2	**=**	**$0.533m^2K/W$**
Fractional area F_2 = 10%	**=**	**0.1**

Combining these resistances, we obtain:

$$R_{upper} = \frac{1}{\frac{F_1}{R_1} + \frac{F_2}{R_2}} = \frac{1}{\frac{0.9}{0.667} + \frac{0.1}{0.533}} = \frac{1}{1.5365} = 0.651 m^2K/W$$

B4 Lower Resistance Limit

A conceptual illustration of the lower limit of resistance is shown in Diagram B.2.

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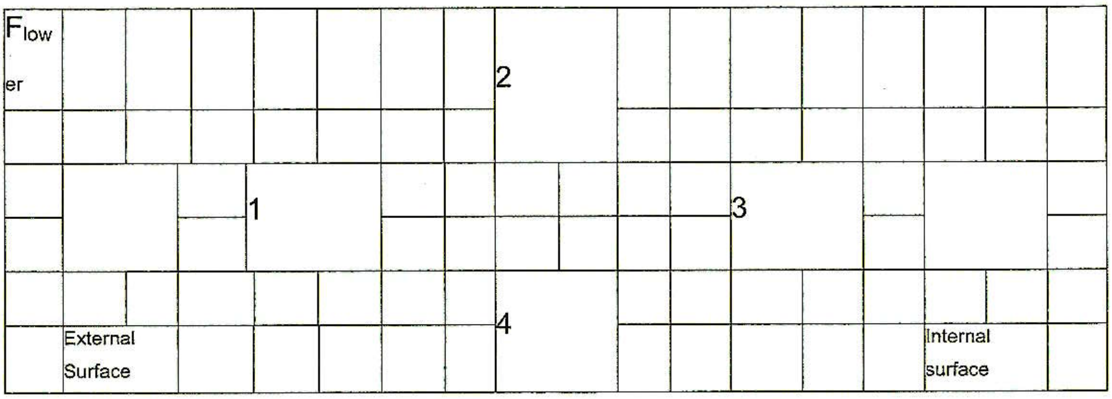
Conceptual illustration of the lower limit of resistance **Diagram B.2**



The resistance of the layers are added together to give the lower limit of resistance.

The resistance of the bridged layer consisting of the cavity and masonry bond stones is calculated using:

$$R = \frac{1}{\frac{F_{cavity}}{R_{cavity}} + \frac{F_{bondstones}}{R_{bondstones}}}$$

The lower limit of resistance is then obtained by adding together the resistance of the layers:

Resistance R_{lower} through section		
External surface resistance		= 0.060
Resistance of 180mm masonry		= 0.164
Resistance of bridged cavity	$= \frac{1}{\frac{0.9}{0.18} + \frac{0.1}{0.045}}$	= 0.139
Resistance of 180mm masonry		= 0.164
Internal surface resistance		= 0.100
Total (R_{lower})		**= 0.626m²K/W**

B5 Total Resistance R_T of wall

The total resistance of the wall is the average of the upper and lower limits of resistance:

$$R_T = \frac{R_{upper} + R_{lower}}{2} = \frac{0.6508 + 0.6262}{2} = 0.638 m^2 K / W$$

B6 U value of the wall

$$U = \frac{1}{R_T} = \frac{1}{0.638} = 1.566 W/m^2K$$

TABLES

Table 1 - Electricity Produced by PV Panels

	Electricity Produced (kWhr/year per kWp installed)					
Tilt Angle	**15**	**30**	**45**	**60**	**75**	**90**
South	1460.9	1510.6	1477	1361.5	1176.7	935.9
South East	1416.8	1437.8	1393.7	1285.9	1127	935.2
South West	1415.4	1432.2	1386	1278.2	1120	926.8
Horizontal	1327.2					
Tracking	2056.6					

Table 2 - Total solar energy transmittance (g-value) & Light Transmittance factors for glazing

Type of glazing	**Total solar energy Transmittance (g-value)**	**Light Transmittance**
Single glazed	0.85	0.9
Double glazed (air or argon filled)	0.76	0.8
Double glazed (Low-E, hard-coat)	0.72	0.8
Double glazed (Low-E, soft-coat)	0.63	0.8
Triple glazed (air or argon filled)	0.68	0.7
Triple glazed (Low-E, hard-coat)	0.64	0.7
Triple glazed (Low-E, soft-coat)	0.57	0.7

Notes:

1. *When the window U-value is declared by the manufacturer (rather than from Table 5) the solar transmittance & Light Transmittance should also be obtained from the manufacturer. Ensure that such values relate to the glazing, not the whole window.*

Table 3 - Frame Factors for Windows and Doors

Frame type	Proportion of opening that is not glazed, (Frame Factor)
Wood	0.3
Metal	0.2
Metal, thermal break	0.2
PVC-U	0.3

Note: If known, the actual frame factor can be used instead of the data in Table 3 above.

Table 4 - Windows, Doors and Roof Windows Indicative U values (W/m2 K)

The U values are calculated using BS EN ISO 10077-1. The values apply to the entire area of the window opening, including both frame and glass, and take account of the proportion of the area occupied by the frame and the heat conducted through it. Unless known otherwise, double and triple glazing should be taken as air-filled without low-E coating. If the U values of the components of the window (glazed unit and frame) are known, window U values may alternatively be taken from the tables in Annex F of BS EN ISO 10077-1, using the tables for 20% frame for metal-framed windows and those for 30% frame for wood or PVC-U framed windows.

When available, the manufacturer's certified U values for windows or doors should be used in preference to the data in this table. Adjustments for roof windows should be applied to manufacturer's window U values unless the manufacturer provides a U value specifically for a roof window.

Notes:

1. For roof windows with wooden or PVC-U frames apply the following adjustments to U values:

Wood or PVC-U frame	U value adjustment for roof window, $W/m^2 K$
Single glazed	+0.3
Double glazed	+0.2
Triple glazed	+0.2

2. For windows or roof windows with metal frames apply the following adjustments to U values:

Metal frames	Adjustment to U value, $W/m^2 K$	
	Window	Roof window
Metal, no thermal break	+0.3	+0.7
Metal, thermal break 4 mm	0	+0.3
Metal, thermal break 8 mm	-0.1	+0.2
Metal, thermal break 12 mm	-0.2	+0.1
Metal, thermal break 20 mm	-0.3	0.0
Metal, thermal break 32 mm	-0.4	-0.1

3. For doors which are half-glazed (approximately) the U value of the door is the average of the appropriate window U value and that of the non-glazed part of the door (e.g. solid wooden door [U value of 3.0 W/m^2K] half-glazed with double glazing [low-E, hard coat, argon filled, 6 mm gap, U value of 2.5 $W/m^2 K$] has a resultant U value of 0.5(3.0+2.5) = 2.75 W/m^2K

Table 5 - Fenestrations Indicative U values (W/m2 K)

	Type of Frame					
	Window with wood or PVC-U frame			Window with metal frame with 4mm thermal break		
	6mm gap	12mm gap	16 or more gap	6mm gap	12mm Gap	16 or more gap
double glazed, air filled	3.1	2.8	2.7	3.7	3.4	3.3
double glazed, air filled low-E, e = 0.2, hard coat	2.7	2.3	2.1	3.3	2.8	2.6
double glazed, air filled low-E, e = 0.15, hard coat	2.7	2.2	2.0	3.3	2.7	2.5
double glazed, air filled low-E, e = 0.1, soft coat	2.6	2.1	1.9	3.2	2.6	2.4
double glazed, air filled low-E, e = 0.05, soft coat	2.6	2.0	1.8	3.2	2.5	2.3
double glazed, argon filled	2.9	2.7	2.6	3.5	3.3	3.2
double glazed, argon filled low-E, e = 0.2, hard coat	2.5	2.1	2.0	3.0	2.5	2.4
double glazed, argon filled low-E, e = 0.15, hard coat	2.4	2.0	1.9	3.0	2.5	2.4
double glazed, argon filled low-E, e = 0.1, hard coat	2.3	1.9	1.8	2.9	2.4	2.3
double glazed, argon filled low-E, e = 0.05, hard coat	2.3	1.8	1.7	2.8	2.2	2.1
triple glazed, air filled	2.4	2.1	2.0	2.9	2.6	2.5
triple glazed, air filled low-E, e = 0.2, hard coat	2.1	1.7	1.6	2.6	2.1	2.0
triple glazed, air filled low-E, e = 0.15, hard coat	2.1	1.7	1.6	2.5	2.1	2.0
triple glazed, air filled low-E, e = 0.1, hard coat	2.0	1.6	1.5	2.5	2.0	1.9
triple glazed, air filled low-E, e = 0.05, hard coat	1.9	1.5	1.4	2.4	1.9	1.8
triple glazed, argon filled	2.2	2.0	1.9	2.8	2.5	2.4
triple glazed, argon filled low-E, e = 0.2, hard coat	1.9	1.6	1.5	2.3	2.0	1.9
triple glazed, argon filled low-E, e = 0.15, hard coat	1.8	1.5	1.4	2.3	1.9	1.8
triple glazed, argon filled low-E, e = 0.1, hard coat	1.8	1.5	1.4	2.2	1.9	1.8
triple glazed, argon filled low-E, e = 0.05, hard coat	1.7	1.4	1.3	2.2	1.8	1.7
Windows and doors, single-glazed	4.8			5.7		
Solid wooden door	3.0					

Table 6 – System Efficiencies

Equipment Type	COPs	
	Cooling	Heating
Air Cooled Split Unit (constant speed)	2.8	3.2
Air Cooled Split Unit (inverter driven)	3	3.5
VRF Units (air cooled)	3	3.5
Air Cooled Chillers	2.8	3.2
Open Fire	-	0.3
Electric Heater	-	1
Condensing Boiler	-	0.85
Electric Underfloor Heater	-	1
Oil Boiler	-	0.65
Gas Boiler	-	0.7
Electric Boiler	-	1
Solid Fuel Boiler	-	0.55
Open Flue Gas Heater	-	0.6
Flueless Gas Heater	-	0.9

Table 7 - Typical Values for Absorptivity of Surfaces of Materials

Bituminous felt	0.88
Bituminous felt, aluminised	0.40
Uncoloured concrete	0.65
Roofing, green	0.86
White marble	0.58
Dark grey paint	0.91
Dark brown paint	0.88
Dark blue-grey paint	0.88
Medium light brown paint	0.80
Medium dull green paint	0.59
Medium orange paint	0.58
Medium yellow paint	0.57
Medium blue paint	0.51
Light green paint	0.47
Very light surface, white stone etc	0.40

Table 8 - Typical Values for Emissivity of Surfaces of Materials

Smooth glass	0.92
Limestone, natural surface	0.92
Plaster (rough coat)	0.91
Asphalt, felt	0.88
Concrete	0.92
Aluminium paint	0.45
Granite	0.44
Marble (polished or white)	0.90

Table 9 -Ventilation Rates

Item	Ventilation rate m^3/hr
Chimney	40
Open Flue	20
Fan	10
Passive Vent	10
Flueless gas fire	40

Table 10 Default Solar Collector Parameters

Collector type	η_o	a_1	Ratio of aperture area to gross area
Evacuated tube	0.6	3	0.72
Flat plate, glazed	0.75	6	0.90
Unglazed	0.9	20	1.00

Table 11 - Fuel Data

Fuel	Primary energy factor	CO_2 emission factor
		[kg/kWh]
LPG (propane or butane)	1.1	0.232
Heating oil	1.1	0.272
Diesel	1.1	0.298
Kerosene	1.1	0.293
Biodiesel	1.2	0.050
Electricity	3.45	0.878
Wood	1.1	0.025

Table 12 - Overshading Factor for Solar Panels

Overshading	% of sky blocked by obstacles	Overshading factor
Heavy	80%-100%	0.5
Significant	60% - 79%	0.65
Modest	20% - 59%	0.8
None or very little	0%-19%	1.0
Note: Overshading must be assessed separately for solar panels, taking account of tilt of the collector. Usually there is less overshading of a solar collector compared to overshading of windows for solar gain.		

Table 13 - Overshading Factor for Glazed and Opaque Elements

Overhang Angle	Overhang Shading Factors		
	S	E/W	N
0	1.00	1.00	1.00
15	0.87	0.87	0.86
30	0.73	0.73	0.71
45	0.58	0.58	0.56
60	0.40	0.41	0.40