Deriving A and B factors for the UK climate based on standard EWERS methodology

Dr Robin Kent

Project Manager

BFRC

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1. Introduction

This short paper is to record the methodology used to determine the A and B factors used in the BFRC EWERS rating system. The derivation of the values follows the standards set out by the EU Save project to provide a consistent approach throughout Europe.

Once set the A and B values are not recalculated and become fundamental to the rating of windows for the geographical conditions selected.

2. The basic assumptions

The Level 2 energy rating method is based on the following assumptions:

- The method is a simple heat balance over the window for the heating season.
- The Level 2 rating will not contain any cooling calculations.
- The heat balance will contain a utilisation factor for heat gains.
- The utilisation factor and heating season length are based on a residential reference building including a reference occupancy.
- The specified window parameters to be used in the calculation are: U, L and g.
  - U: U-value
  - G: Window Solar Factor
  - L: Air Leakage
- The heat balance will have the following form: Rating = A*g – B*(U+L)
- The heat balance will be based on an average orientation of windows in the vertical position.

2.1. The basic equation

The balance for the window for the heating season is described below:

$$q_{net} = \eta_g (g_w) G_{sol} - (U_w + L_w)(\overline{T}_{i,setpoint} - \overline{T}_e)t \qquad (1)$$

Where:

q_{net} = the net heat load in MJ (per m^2 window)

η_g = utilisation factor for solar heat gain [-],

G_{sol} = total amount of solar radiation on vertical surface for an average orientation in the heating period in MJ (m^2 window)

$T_{i,setpoint}$ = is the average setpoint temperature of the room at the inside of the window in °C

T_e = is the average outdoor temperature in the heating season in °C

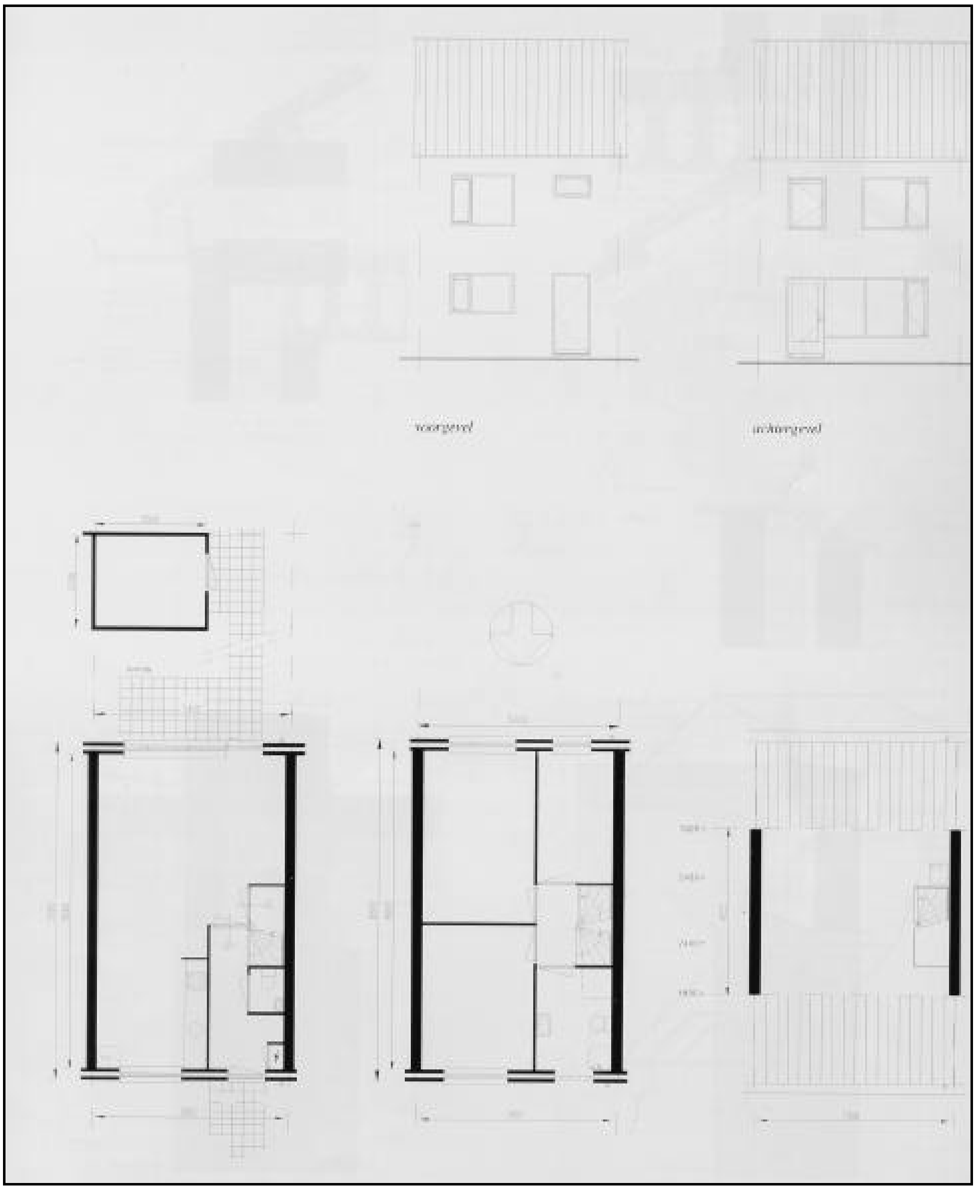
t = time of heating season in Ms

For orientation of solar radiation an average orientation (equal average between north, east, south and west) is used.

3. Defining the reference building

As a reference building the IEA 27 reference 'Residential Building' is proposed but this is not complete. A Dutch residential reference building, the 'Tuinkamer-tussenwoning' ('Garden room-town house') has therefore been used for the calculations[1] until the IEA building model is available.

A drawing of the reference building is given below.



The occupancy parameters used are those of the Dutch energy performance standard[2] are used until the IEA building model reference occupancy patterns are available.

It is possible to specify the building and / or occupancy parameters for each climate zone or region but at this stage this is not considered useful and the IEA building data will be substituted (when available) to at least give a consistent building model and occupancy pattern across Europe.

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[1] **Novem, 'Referentiewoningen 98' (Residential reference buildings 98). Utrecht, March 1999, in Dutch.**

[2] **NEN 5128: 2001, "Energy performance of residential buildings", December 2001, in Dutch.**

4. The reference building parameters

The reference building then gives the following parameters:

1. Total usable floor area = 110 m^2
2. Total volume = 330 m^3.
3. Wall area (including windows) = 58 m^2
4. Floor area = 47 m^2
5. Roof area = 57 m^2
6. Window area = 4.9 m^2 (north) and 9.4 m^2 (south)
7. R_c, walls, floor, roof = 3 m^2K/W
8. U_{window} = 1.7, $g_{0\text{-}window}$ = 0.7, frame factor = 0.7, F_w = 0.9 (g = g0*F_w)

   ⇒ H_{trans} = 67 W/K (ca. 43 W/K through opaque parts and 1.7W/m^2K*14.3m^2 through windows)
9. Total infiltation and ventilation rate = 0.72 h-1: ⇒ H_{vent} = 80 W/K
10. Internal heat gains: 670 W (ca 6W/m^2)
11. Thermal mass: C = 17640 Wh/K. (With H = H_{trans} + H_v = 147 W/K: time constant τ = 120 h.)
12. Average daily indoor temperature setpoint for heating = 18°C

This results in the parameters:

$T_{isetpoint}$ = 18

Q_i = 670

A_{ws} = 9.4

A_we = 0

A_{wn} = 4.9

A_{ww} = 0

g_0 = 0.7

F_w = 0.9

Frame factor = 0.7

C = 17640

$U_{windowreference}$ = 1.7

$H_{trwallsreference}$ = 42.69

$H_{trwindowsreference} = U_{windowreference} * (A_{ws} + A_{we} + A_{wn} + A_{ww})$

$H_{tr} = H_{trwallsreference} + H_{trwindowsreference}$

H_v = 80

These parameters are combined with climate data as part of the input data for the A and B value calculation.

5. The climate data - daily or monthly data

To derive the constants A and B for a specific climate zone the following procedure is followed:

1. Derive the season length in accordance with EN 832:1998 [3] and as described more precisely in paragraph 4.1 of EWERS document ‘Development of energy rating method. Part 2 – Discussion document’ [4].
   In short: Use the reference building parameters (see Section 4) to derive daily heat gains and losses. The heating season is cut off where 96% of the annual heating demand is reached (cutting off 2% at the beginning and 2% at the end)
2. Derive:

- the total amount of solar radiation on a vertical surface for an average orientation in the heating period, G_{sol},
- the average outdoor temperature in the heating season, T_e
- the length of heating season, t

using the heating season length and hourly climate data of the climate zone.

3. Derive the utilisation factor in accordance with EN 832:1998 [3] using the reference building and G_{sol}, T_e and t.
4. Calculate A and B using $T_{i,setpoint}$ from the reference building and the above calculated utilisation factor $ç_g$, G_{sol}, T_e and t.

5.1. Hourly climate data format

If hourly climate data is available, there is an Excel spreadsheet and macro available for the calculation of A and B but these are not used for the calculation of the UK parameters.

5.2. Monthly climate data format

An equivalent process is followed if monthly data is available instead of hourly data. This uses an Excel spreadsheet and the monthly data to calculate the A and B co-efficients for the rating equation (available from the BFRC web site: www.bfrc.org/Technical_Publications-A&B_Calculation.xls)

This spreadsheet uses the monthly data and calculates the A and B co-efficients for the rating equation.

6. The 'A' and 'B' parameters

Climate data was used for the following locations:

- Plymouth
- Manchester
- Aberdeen

The A and B values derived are shown below:

A and B for EWERS heat balance		
	kWh	
	A	B
Plymouth	198.4	54.7
Manchester	215.7	68.5
Aberdeen	241.8	82.1
UK Avg.	**218.6**	**68.5**

It would be possible to divide the UK into many small climate zones and then to generate many sets of co-efficients that were very specific to the microclimate.

The original BFRC investigations and scheme treated the UK as a single climate zone and found little cross-over of ratings in doing this. The major benefit was that manufacturers and consumers would have a single UK wide rating for comparison purposes.

Therefore, the decision was taken to retain the single UK climate zone and to use the values for A and B as 218.6 and 68.5 respectively and the UK rating equation is:

Rating = 218.6 x Window Solar Factor - 68.5 x (Window U-value + Air Infiltration Factor)

Rating = $218.6g_{window} - 68.5(U_{window} + L_{50})$.

The units are $kWh/m^2/year$.

7. The window data

The parameters which are the outputs of the basic physical parameters of the window (Level 1) are the U-, L-, and g-values of the total window.

It is essential that these are total window values and not simply glass or frame values etc.

7.1. g_{window}

For the rating it is assumed that the g-value of the window in Level 1 is given as the $g_{\perp}$-value. The conversion to the time-averaged g_w-value is carried out in the method of calculating the Level 2 values according to the simplified method in the EN 832: $g_{\perp} = Fw * g_w$, with Fw = 0,9.

The g-value to be used in the rating equation is that of g_{window} (the whole window g-value) and it is therefore necessary to know the window sightlines to calculate this, i.e. calculate the frame fraction and apply this to g_{glass} to calculate g_{window}.

7.2. U_{window}

Similarly, the U-value used for the rating equation is that of the window and not that of the glass.

The centre pane U-value of the glass is not to be used.

Use U_{window} as calculated from simulations carried out by BFRC Certified simulators.

7.3. L_{50}

This is the air leakage loss rate and for the rating, it is assumed that the L-value is known in W/m^2K. This is done to be able to add U and L directly in the rating method. If L is given in another unit, it has to be converted into W/m^2K.

This conversion is based on: $L = 1.2\ qv\ W/m^2K$

where qv is the air flow rate per m^2 window in dm^3/s.

8. References

1. Novem, 'Referentiewoningen 98' ('Residential reference buildings 98'). Utrecht, March 1999, in Dutch.
2. NEN 5128: 2001, "Energy performance of residential buildings", December 2001, in Dutch.
3. EN 832: 1998, "Thermal performance of buildings – Calculation of energy use for heating – residential buildings', September 1998
4. Spiekman, M.E., van Dijk, H.A.L., 'Development of energy rating method. Part 2 – Discussion document', 13 January 2002, EWERS- document.
5. Spiekman, M.E., van Dijk, H.A.L., 'Development of energy rating method. Part 3 – Discussion document', 25 April 2002, EWERS- document.