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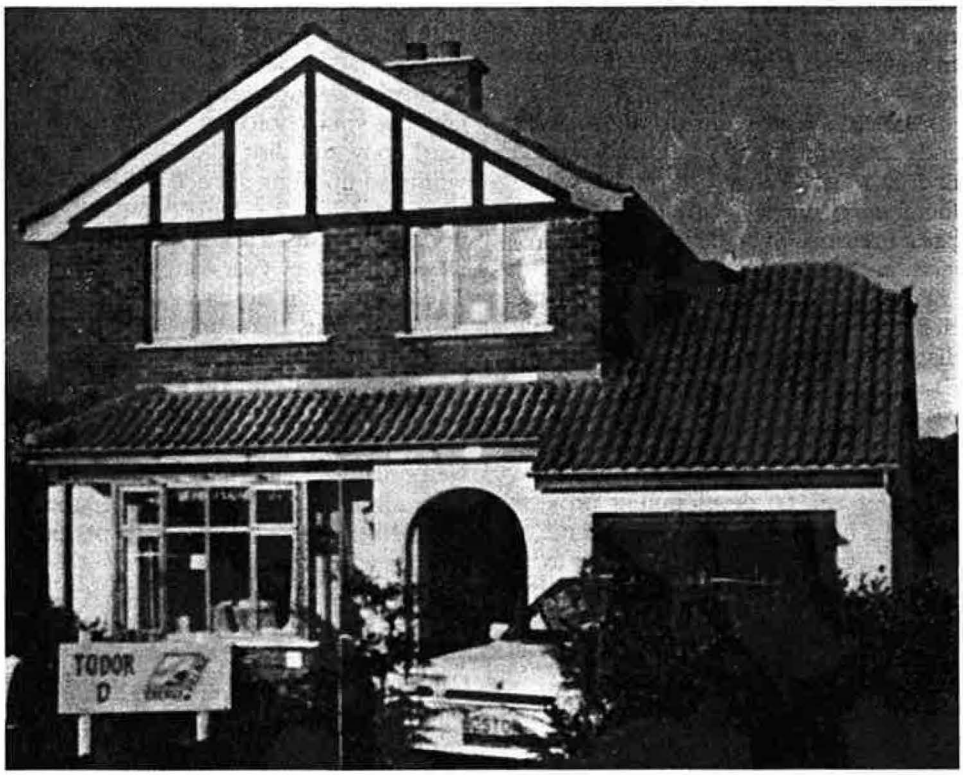
Energy assessment for dwellings using BREDEM worksheets

by Brian Anderson

BREDEM, the Building Research Establishment Domestic Energy Model, was developed for the Departments of Environment and Energy so as to provide a convenient method of obtaining realistic estimates of annual energy use in dwellings. It is suitable both for obtaining estimates of total annual running costs, and for assessment of the effect of efficiency measures that might be applied in new and refurbished housing (see *Energy Management*, June 1988, pp 32-33).



A recently constructed energy efficient house.

The calculation method has now been put in the form of a worksheet. This consists of a series of numbered boxes, and the procedure is to work sequentially through the worksheet, entering data in the boxes until the final result is obtained. The appropriate arithmetic operations are indicated in the worksheet: these are restricted to the basic four functions of addition, subtraction, multiplication and division, allowing the worksheet to be completed using a simple handheld calculator.

The advantage of laying out the calculation method in this way is that it allows the user to see and understand how the various factors affect the final result.

The data needed for calculations are either provided by the user or are obtained from tables which form part of the worksheet. The user, for instance, specifies areas, U-values, the heating system and controls; while tabular information is given on internal temperature, degree-days, solar gains. To avoid the worksheet becoming too complex, manual calculations using it are restricted to a single heating pattern – the whole house heated morning and evening. The calculator and computer implementations mentioned below, however, allow the user to designate any heating pattern.

Computer worksheets displayed on IBM- AT together with hand calculator.

A feature of BREDEM is that the dwelling is divided into two zones, each of which may be heated to a different level or for different periods. In addition, part of the house, represented by one of the zones, may not be directly heated at all. Zone 1 is the living area and zone 2 is the remainder of the dwelling. This has the advantage of representing more realistically the way that houses are actually used, compared with a basis that assigns only a single internal temperature; but the drawback in earlier implementations was the need to proportion the areas of external fabric elements between the zones.

In the worksheet, the data entry has been simplified by using only the total areas of external elements. The two-tone aspect is retained by calculating the temperature separately for each zone, and then combining these in proportion to the floor area of each zone, to give an average internal temperature which is used for the energy calculation.

A variety of heating systems can be specified: gas, oil, electric and solid fuel. The heating control options are:

(a) control of the temperature in the living area during heating periods – a single thermostat, for example.
(b) separate temperature controls in the second zone such as TRVs.
(c) separate time and temperature controls in the two zones; in that case a shorter evening heating period is assumed for zone 2.

The basic calculation is done for UK average values of degree-days and solar flux through windows. Tabulated factors allow these to be adjusted to specific regions of the country when appropriate.

The worksheet goes through to the calculation of the annual fuel consumption for space heating, water heating, cooking, and lights and appliances. These fuel consumptions are translated into costs using current fuel prices, the sum of which gives the total annual energy cost for the dwelling.

To assist users wishing to undertake several calculations, the worksheet has been programmed onto a hand-held calculator and onto a floppy disc for IBM-compatible microcomputers. In both cases all the tabular data is stored in the machine and recalled automatically when needed.

The calculator has a two-line alphanumeric display which prompts the user for each input. After data entry there is the facility to alter any data item and recalculate.

The computer version displays the worksheet on the screen. After data entry any item can be amended and the display, including the final result, is immediately updated.

The worksheets are contained in a recent BRE Information Paper *Energy Assessment for Dwellings using BREDEM Worksheets*. For further information about the worksheets, and the calculator and computer versions, contact Brian Anderson, Scottish Laboratory, Building Research Establishment, Kelvin Road, East Kilbride, Glasgow G75 0RZ, Tel: 03552-33001; or Margaret Gidman, Energy Economics and Statistics Section, Building Research Establishment, Garston, Watford, WD2 7JR, Tel: 0923-894040.

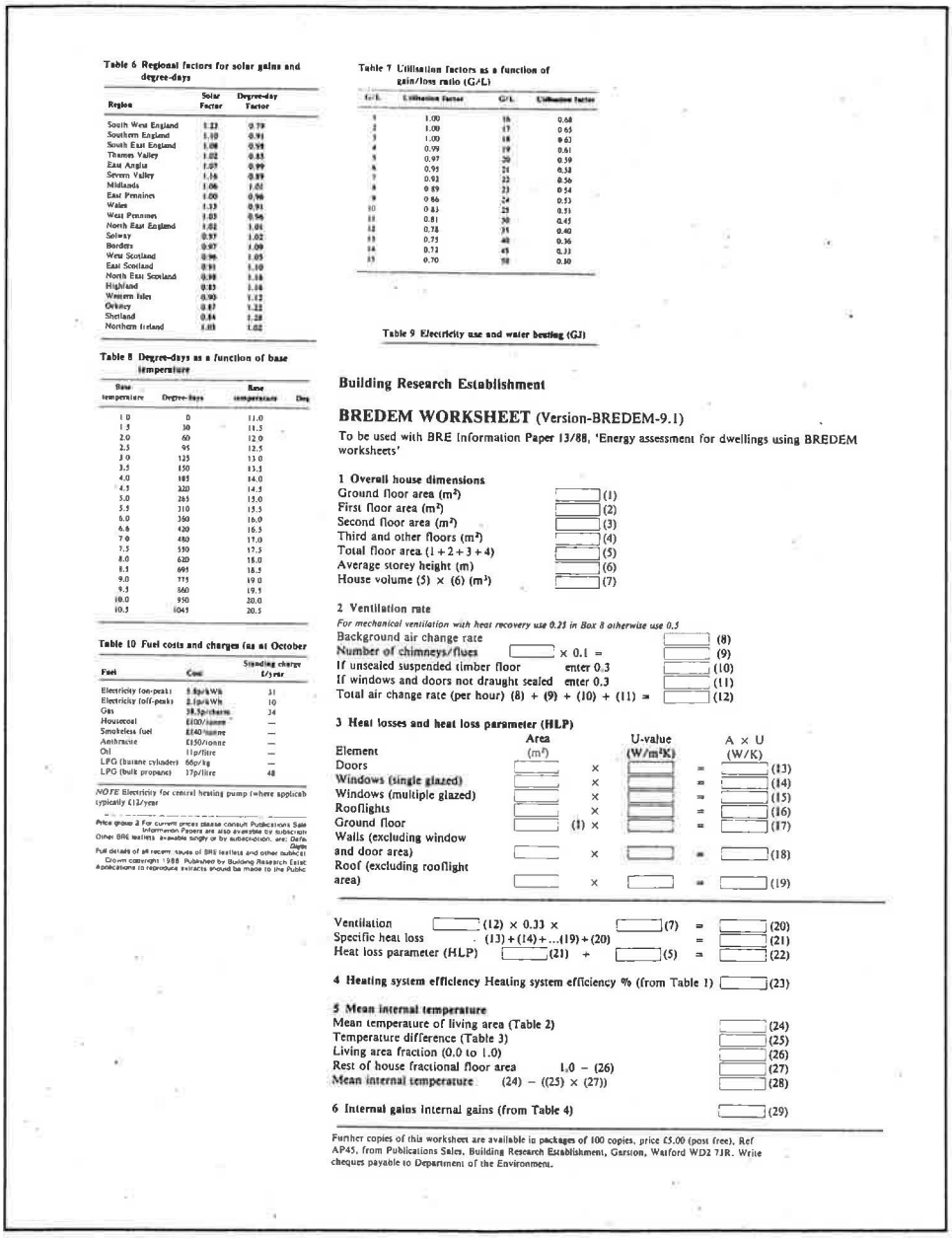


Table 6 Regional factors for solar gains and degree-days

Region	Solar Factor	Degree-day Factor
South West England	1.23	0.79
Southern England	1.10	0.91
South East England	1.08	0.98
Thames Valley	1.02	0.85
East Anglia	1.07	0.99
Severn Valley	1.16	0.89
Midlands	1.06	1.01
East Pennines	1.00	0.96
Wales	1.13	0.91
West Pennines	1.03	0.96
North East England	1.02	1.01
Solway	0.97	1.02
Borders	0.97	1.09
West Scotland	0.96	1.05
East Scotland	0.91	1.10
North East Scotland	0.90	1.16
Highland	0.83	1.16
Western Isles	0.90	1.12
Orkney	0.87	1.22
Shetland	0.84	1.28
Northern Ireland	1.05	1.02

Table 7 Utilisation factors as a function of gain/loss ratio (GAL)

[illegible]	Utilisation factor	GAL	Utilisation factor
1	1.00	16	0.68
2	1.00	17	0.65
3	1.00	18	0.63
4	0.99	19	0.61
5	0.97	20	0.59
6	0.95	21	0.58
7	0.93	22	0.56
8	0.89	23	0.54
9	0.86	24	0.53
10	0.83	25	0.51
11	0.81	30	0.45
12	0.78	35	0.40
13	0.75	40	0.36
14	0.72	45	0.33
15	0.70	50	0.30

Table 8 Degree-days as a function of base temperature

Base temperature	Degree-days	Base temperature	Deg
1.0	0	11.0	
1.5	30	11.5	
2.0	60	12.0	
2.5	95	12.5	
3.0	125	13.0	
3.5	150	13.5	
4.0	185	14.0	
4.5	220	14.5	
5.0	265	15.0	
5.5	310	15.5	
6.0	360	16.0	
6.6	420	16.5	
7.0	480	17.0	
7.5	550	17.5	
8.0	620	18.0	
8.5	695	18.5	
9.0	775	19.0	
9.5	860	19.5	
10.0	950	20.0	
10.5	1045	20.5	

Table 9 Electricity use and water heating (GJ)

Table 10 Fuel costs and charges (as at October

Fuel	Cost	Standing charge £/year
Electricity (on-peak)	5.8p/kWh	31
Electricity (off-peak)	2.1p/kWh	10
Gas	38.5p/therm	34
Housecoal	£100/tonne	—
Smokeless fuel	£140/tonne	—
Anthracite	£150/tonne	—
Oil	11p/litre	—
LPG (butane cylinder)	66p/kg	—
LPG (bulk propane)	17p/litre	48

NOTE Electricity for central heating pump (where applicable) typically £12/year

Price group 2 For current prices please consult Publications Sales Information Papers are also available by subscription. Other BRE leaflets available singly or by subscription, are: Defa Depts

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BREDEM WORKSHEET (Version-BREDEM-9.1)

To be used with BRE Information Paper 13/88, 'Energy assessment for dwellings using BREDEM worksheets'

1 Overall house dimensions

Ground floor area (m²)		(1)
First floor area (m²)		(2)
Second floor area (m²)		(3)
Third and other floors (m²)		(4)
Total floor area (1 + 2 + 3 + 4)		(5)
Average storey height (m)		(6)
House volume (5) × (6) (m³)		(7)

2 Ventilation rate

For mechanical ventilation with heat recovery use 0.25 in Box 8 otherwise use 0.5

Background air change rate		(8)
Number of chimneys/flues	× 0.1 =	(9)
If unsealed suspended timber floor	enter 0.3	(10)
If windows and doors not draught sealed	enter 0.3	(11)
Total air change rate (per hour) (8) + (9) + (10) + (11) =		(12)

3 Heat losses and heat loss parameter (HLP)

Element	Area (m²)		U-value (W/m²K)		A × U (W/K)	
Doors		×		=		(13)
Windows (single glazed)		×		=		(14)
Windows (multiple glazed)		×		=		(15)
Rooflights		×		=		(16)
Ground floor		(1) ×		=		(17)
Walls (excluding window and door area)		×		=		(18)
Roof (excluding rooflight area)		×		=		(19)

Ventilation	(12) × 0.33 ×	(7)	= (20)
Specific heat loss	(13) + (14) + ... (19) + (20)		= (21)
Heat loss parameter (HLP)	(21) ÷	(5)	= (22)

4 Heating system efficiency Heating system efficiency % (from Table 1) (23)

5 Mean internal temperature

Mean temperature of living area (Table 2)	(24)
Temperature difference (Table 3)	(25)
Living area fraction (0.0 to 1.0)	(26)
Rest of house fractional floor area 1.0 – (26)	(27)
Mean internal temperature (24) – ((25) × (27))	(28)

6 Internal gains Internal gains (from Table 4) (29)

Further copies of this worksheet are available in packages of 100 copies, price £5.00 (post free), Ref AP45, from Publications Sales, Building Research Establishment, Garston, Watford WD2 7JR. Write cheques payable to Department of the Environment.

BREDEM worksheets: Version Bredem- 9.1.

The worksheets also feature in the BSI *Designer's Manual for the Energy Efficient Refurbishment of Housing* which includes examples of construction details of various measures. It is available from BSI, Linford Wood, Milton Keynes MK14 6LE, price £10.00.

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