#5751

Energy design guide

Contents

Concept
J D Kay, Chairman BSI Technical committee BDB/2 responsible for BS 8207

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Review of publications
Some of the material in this book has been extracted from British Standards. Readers are reminded that standards are continuously under review and revisions and amendments are published frequently. Up to date information may be obtained from the BSI Enquiry Section: 0908.320066

Disclaimer
While every care has been taken to ensure that advice in this guide is correct neither the Secretary of State for Energy nor the British Standards Institution will accept responsibility for loss, damage etc. however arising, occasioned by the implementation of such advice.

Definition of terms*
Gigajoule: The unit of energy used in this digest. It equals 10^9 joules and corresponds to about 278 kW hours or 9.5 therms.

Primary or gross energy: The (higher) calorific value of the raw fuel, eg oil, coal, natural gas, nuclear and hydro-electricity, which is input into the UK economy. Both nuclear and hydro-power are used only for the generation of electricity and the convention is adopted that the primary energy attributed to these inputs is equivalent to an efficient coal-burning power station producing the same electrical output.

Delivered or net energy: The energy content of the fuel actually received by the final consumer.

Energy overhead: The difference between the gross energy input to a particular fuel industry and the net energy delivered by that producer.

Useful energy: The energy required to perform a given task. The ratio of useful energy to net energy represents the efficiency of the device employed. The useful energy may not always be well defined particularly when the wasted energy of one process serves to reduce the useful demand of another, eg the fortuitous heat gain from the lighting in an office can reduce the demand for heat from the heating system.

**Building Research Establishment : Digest 191 ; Energy consumption and conservation in buildings.*

Introduction : J D Kay

The purpose of this booklet is to illustrate BS 8207 : 1985, the British Standard Code of Practice on Energy efficiency in buildings. This code was produced by the Technical Committee BDB/2, Building performance – energy, on which are represented all the main official, professional and industrial bodies concerned with energy efficiency in buildings. Looking at the field of environmental design as a whole BDB/2 identified the need for a 'head code' – a document setting out general principles and criteria for energy design as a framework to which other codes which were concerned with energy in building could then relate.

The head code
As a head code, it was thought right to make BS 8207 a short document. In four brief sections it establishes the principles of energy efficiency in building, sets out the main stages in design, the chief economic considerations and the key features required for effective energy management of the building in use. The code emphasises the importance of making the client aware of the implications of energy conservation and of involving him in the design process, for example in striking a balance between capital and operating costs.

The head code brings out the importance of the early, conceptual stage in design. If energy requirements are ignored or misunderstood at this stage in the design of a building, it is very difficult to get them right later. An unusual feature of BS 8207 is that it does not state a single, preferred method of calculation for establishing the energy requirement of a building or for assessing the cost-effectiveness of different design options. Instead, the code lists the factors that any method used should encompass, and recommends that the design team should work out what methods are to be employed, agreeing these with the client.

The foreword to BS 8207 states that the chief incentive for energy conservation in buildings is economy, taking into account both capital and running costs, and refers to the national interest in conserving reserves of fuels. At the same time the code points out that:
"energy conservation is only one of the requirements which a building need satisfy; the function for which it is used and its appearance and general economics have also to be taken into account. The designer has to produce a balanced solution of which energy conservation measures are an integral part."

The design guide
It was thought it would be helpful to have available to accompany BS 8207 an illustrated booklet which, while not part of the code, contained examples of a variety of buildings which demonstrated its principles. BS 8207 brings together established best practice in energy design and it has therefore been possible, drawing chiefly upon the CIBS Energy Awards, to find case studies that illustrate the principles of the code, both 'new build' projects and improvements to existing buildings and whose performance in practice, where available, is in line with their designers' objectives.

The first section of the design guide is a worked example which applies the principles of the code to the early design stages of a small primary school, using a typical brief for such a building. In this example compliance with the procedures recommended in clause 3 of BS 8207 is demonstrated in the following ways:

1 The method used for estimating the energy requirement is the calculation procedure given in Section D of the DES Design Note 17. For purpose of the exercise and by way of comparison, the energy requirements of the design were also assessed using the method of calculation given in Part 2 of the CIBS Building Energy Code.

2 Energy targets for the comparison of design options are taken from Design Note 17, which recommends maximum Energy Design Values and Annual Energy Consumption Values for different types of schools.

3 The cost-effectiveness of a number of design options was compared using both simple payback and internal rate of return methods.

4 The measures for efficient energy management adopted in this case include an incentive scheme for the occupants and the provision of a user manual.

Worked example : a primary school

This follows the order of the items in BS 8207, Appendix B CHECK-LIST, The Brief.

School	870
Nursery	96
Family centre	96
Total	1062m^2

The Brief
The brief discussed with the educational client is for a new primary school for 210 children aged 5-11 years and a nursery group of 20 under-5s, with a family centre for parents and others. Based on the Education (School Premises) Regulations 1981, the gross area of the building should not be less than 1062m^2.

The cost is calculated as £459,000 based on DES guidelines at April 1985. The client is prepared to add to the basic nett cost for additional energy conservation measures that show a reasonable short pay-back period.

The client does not expect the use of the school to alter significantly during the life of the building.

The school hall and some ancillary rooms, including the family centre, will occasionally be used out of school hours. This can be assumed to be 2 evenings per week at 2 hours each. It should be possible to use these facilities independently from the remainder of the school and they should be zoned separately for heating and lighting purposes.

The 7 year groups should each have an identifiable teaching area with its own enclosed quiet space. Three craft/practical bases and an audio-visual room will be shared.

The school year is organised in the normal way in three terms with a total of 215 days from 9 am to 4 pm, including cleaning time. The heating season should be taken as 160 days.

The policy of the local authority is to use coal as fuel. The design of the building should satisfy the requirements in DES Design Note 17 (1981) 'Guidelines for Environmental Design and Fuel Conservation in Educational Buildings' (subsequently referred to as DN17). The education authority operates an energy target scheme with financial incentives to the schools. A user manual incorporating advice on good energy management will be provided.

Site
The site is on the outskirts of a city in the Midlands. It is flat and 2.1 hectares in area. It is surrounded on three sides by 2-storey houses and gardens, the exposed northern boundary gives on to open fields.

Design approach
Turning to Section Two of BS 8207, the first five items of the barchart in Table 1 had been covered in the brief from the client. Taking the educational requirements in the brief and the site conditions with the exposed northerly boundary, the plan shape which evolved incorporated a sheltered courtyard opening toward the south. The points in the section of the check-list in Appendix B of BS 8207 covering Building arrangement and shape were considered. Following the advice in this, natural ventilation and daylight were adopted, with all rooms having a depth from the external wall of not more than 6m. The building was planned so that entrance doors were from the sheltered courtyard; draught lobbies were also incorporated. The family centre was located so that it had easy access to the hall; both together making a separate zone for heating and lighting purposes.

Structural options
In the course of design the energy characteristics of two main structural alternatives were compared in relation to the pattern of use of the school. The first had a light steel frame, concrete cladding and relatively lighter steel-faced, plaster-backed partitions. The other was of traditional construction with load bearing walls. Each had a pitched roof with concrete tiles.

Energy requirements
The environmental design objectives correspond to the main recommendations given in DN 17. In daytime the main source of light in working areas is daylight, provided by an area of glazing equal to 40% of the internal elevation of the external walls. After dark the general level of illumination is 300 lux, provided by fluorescent lighting with switching under user control. In order to meet the main recommendations on the thermal environment given in Section C of DN 17, the heating installation of the school is designed to be capable of heating 10m^2 of fresh air per pupil per hour to give a resultant temperature of 18°C at a height of 0.5m above floor level. A normal distribution of thermostats and an optimum start control would be fitted. For the thermal insulation of opaque areas of the walls and roof, various options for the U valve were compared between 0.6 and 0.3W/m^{2}K.
The energy requirements of the design options arising from the brief were then examined using the

procedures recommended in Section One of BS 8207. The energy requirements were assessed using the calculation procedure given in Section D of DN 17. This takes into account all the factors listed in para 4 in Section One of the code, with the exception of incidental solar gain and the effects of shading.

Energy targets

As an energy target for the assessment of the design options a Maximum Energy Design Value of 157W/m^2 Primary Energy Units for a primary school with a floor area of 1043m^2 (excluding boiler room) was obtained from Fig. 5 in DN 17. The calculation sheets in Appendix 2 of DN 17 were used to assess the Energy Design Value of the options. The final sheet of the calculation for the design is given below. It will be seen that it falls just within the target.

The Annual Energy Consumption Value of the design was then estimated, again using the calculation sheets in DN 17. In these the fuel (coal) has been converted into primary energy and the occupancy and hours of use have been derived from the client's brief. The total nett heating requirement and electrical energy amount to 297 kWh/m^2 PEU, ie well within the value indicated in Fig. 6 of DN 17 for the maximum annual energy consumption of a primary school of this size. Each of the structural options given above came within the medium weight category; their thermal responses were not sufficiently different to affect the overall result and both were rapid enough to be appropriate to the intermittent use of the school.

For the purpose of this exercise, the energy requirements of the design were also assessed using the method of calculation given in Part 2 of the CIBS Building Energy Code. This takes into account incidental solar gain. The final pages are reproduced below and it will be seen that the energy requirement falls well within the target.

Fig 5 from DN 17

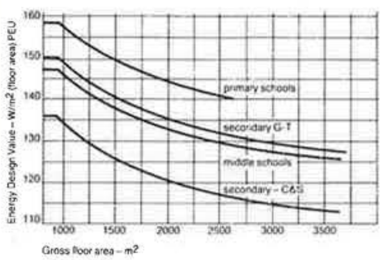
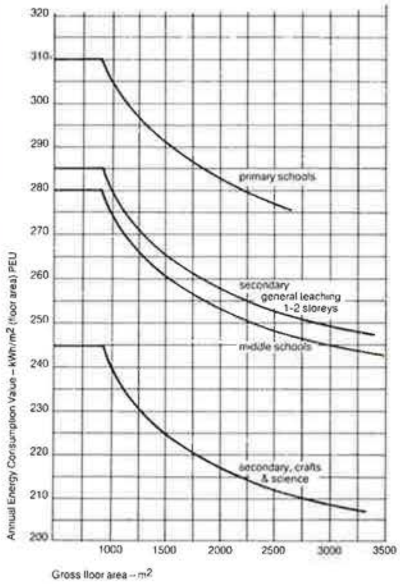
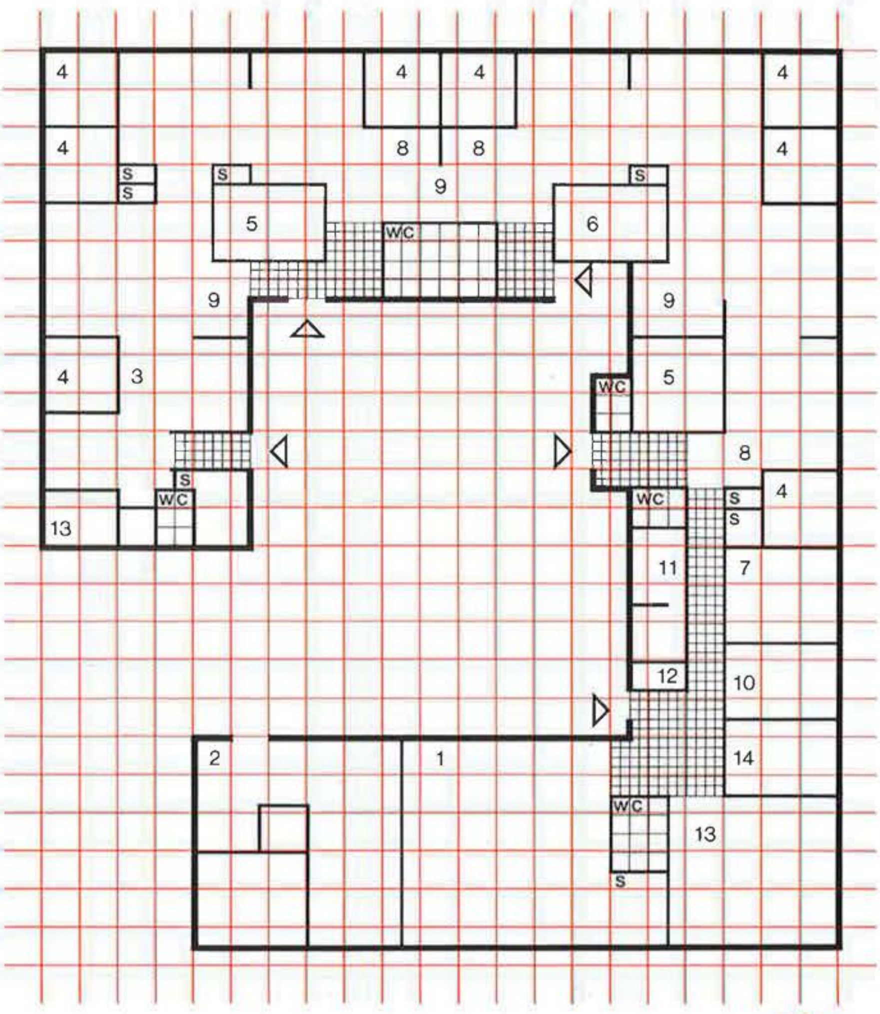


Fig 6 from DN 17





Ground floor plan

0 10m

Key

1 hall
2 family centre
3 nursery
4 quiet
5 practical
6 craft
7 audio visual
8 books
9 dine
10 staff
11 head/sec
12 caretaker
13 kitchen
14 boiler
wc toilets
s store

grid 1.8m

Units of measure
Hot water load
h w/m²
Electric lighting load
l w/m²
Miscellaneous power load
p w/m²
Heating fans and pumps load
f w/m²
Annual hours of occupancy for metabolic gains
H_N hr
Annual hours when lighting is switched on
H_L hr
Annual hours for miscellaneous power use
H_P hr
Annual running hours for fans and pumps
H_F hr
Annual hours for hot water requirement
H_H hr

Symbols
Number of working days
W
Number of degree days
D
Design temperature difference
Δt°C
Base temperature
T_B°C
Ratio $D_d/D_{15.5}$
$T_{15.5}$
Equivalent hours of operation
E hrs
Correction for mode of operation (from CIBSE Guide B18)
5 day week
C_1
intermittent use
C_2
length of day
C_3
Corrected equivalent hours operation
C_E
Total fabric and ventilation loss
H kW
Annual heating requirement
Q
Net annual heating requirement
Q_N
Total annual fuel requirement
A
Seasonal efficiency
μ %
Calorific value of fuel
C_V
Occupancy
N

Data for school
Area = 1043m²
W = 160
D = 2231
Δt = 19°C
T_B = 18°C
$T_{15.5}$ = 1·3
C_1 = ·8
C_2 = ·75
C_3 = ·96
H = 85 kW
N = 230
h = 2 w/m²
l = 12 w/m²
p = 3 w/m²
f = 2 w/m²
H_N = 755 hrs
H_L = 1280 hrs
H_P = 1400 hrs
H_H = 1400 hrs
H_F = 1200 hrs

Cost effectiveness

A cost check for the capital cost of the design was carried out and the basic nett cost was found to come within the DES guidelines referred to above.

A school which met the environmental design objectives given in DN 17 and its main recommendations for energy conservation would be expected to have adequate daylight with view windows, artificial illumination of sufficient quantity, a responsive heating system, good ventilation, thermal transmittance of the opaque areas of wall and roofs of not greater than 0.6 W/m²K, and with draught lobbies and closers on the main external doors.

The design team then considered the offer by the client to pay for additional energy measures which showed a rate of return defined in this case as being equal to or better than HM Treasury's minimum test discount rate of 5% (see Investment Appraisal in the Public Sector, HM Treasury 1982).

The extra-over capital cost of a number of additional energy measures was compared with the saving in fuel to which they would be expected to lead, using a simple payback technique (para 12.2.2 of BS 8207) and the internal rate of return (para 12.2 7). As will be seen from the table below, two of these, involving the draught-stripping of windows and an improved 'U' value, were found to be cost effective.

Energy measure	Additional capital cost £	Annual fuel saving £	Payback period years	Internal rate of return %
Draught-stripping opening windows	500	252	2.00	50.4
Improve 'U' value of walls from 0.6 to 0.3	606	47	12.90	7.70
Double glazing	5500	260	21.20	4.4

Facsimile pro forma from DN 17

APPENDIX 2

CALCULATION SHEETS FOR ENERGY DESIGN VALUE AND ANNUAL ENERGY CONSUMPTION VALUE
(Ref: Section D of DES Design Note 17, 'Guidelines for Environmental Design and Fuel Conservation in Educational Buildings'; 1981).

1. ENERGY DESIGN VALUE (see paragraph 3)

Basic Data

a. Assumed Conversion Efficiencies

Energy Source	Instantaneous Conversion Efficiency %	Primary Energy Input per unit of Delivered Energy
Electricity, normal tariff	100	3.73
Electricity, off peak tariff	90	4.14
Manufactured Fuels	74	1.89
Oil	75	1.44
Natural Gas	74	1.43
Coal	70	1.46

b. Typical Occupation Densities
These should be calculated by dividing the gross floor area of the proposed buildings by the actual number of pupils for which they are designed. For typical values refer to Figure 5.

c. Aspect ratio and average room depth to be derived from perimeter length and area (see Appendix 1 and Figure 4).

Calculation

i	Activity (eg secondary, general teaching)	= Primary
ii	Density of Occupation	= 4·53 pupils/m²
iii	Number of Storeys	= One
iv	Gross Floor Area	= 1043 m²
v	Perimeter	= 236 m
vi	Aspect Ratio (Figure 4)	= 11 : 1
vii	Average Room Depth (Figure 4)	= 4·8 m
viii	Floor-Ceiling Height	= 2·5 m
ix	Window:Wall Ratio (internal elevation of external wall)	= 1 : 1·6
x	Overall Height	= 3·1 m
xi	Roof Light Area	= —— m²
xii	Wall:Floor Ratio	= 1 : 2·3
xiii	Design Temperature Difference (inside–outside)	= 19 °C
xiv	Ventilation Rate (see paragraph C5)	= 38 m³/person/hr

24

Energy management

Following the recommendations in Section Seven of BS 8207, the planning of the school assisted good energy management by grouping the accommodation that would be used separately from the remainder of the school, and thus could be heated separately. Appropriate controls and metering arrangements are provided.

In this case the education authority run an energy target scheme with financial incentives to schools for meeting or improving on the target. A user manual is provided for the teaching and caretaking staff with advice on good energy management along the lines given in the next section – Energy management: an example.

The formula used for calculating the Internal Rate of Return is given in Appendix 4 of DES Building Bulletin 55, Energy Conservation in Educational Buildings (HMSO 1977).

Conclusions

In this case the building which emerged from the early stages of the design process, and which meets the educational requirements and the energy objectives given in DN 17 and BS 8207, is one with a courtyard plan with the joint use areas zoned separately. The building has 40% glazing of which the windows have draught-stripping. The opaque areas of the walls and roofs have a 'U' value of 0.3. A user manual explains the energy objectives of the building to the school staff and the education authority back this up with an incentive scheme.

Facsimile pro forma from DN 17

Heat loss per square metre of floor area			
U values			Heat Loss W/m^2
Opaque Area of Walls	0·6	$W/m^2 °C$	4·7
Opaque Area of Roof	0·3	$W/m^2 °C$	5·7
Ground Floor	0·3	$W/m^2 °C$	5·7
Windows	5·6	$W/m^2 °C$	22·9
Roof Lights	—	$W/m^2 °C$	—
Ventilation	38 ~~30~~	m^3 per person per hour	52·6
Total Heat Loss		(W/m^2, floor area delivered energy)	91·6 (1)

Heat Gain per square metre of floor area	Heat Gain W/m^2
Occupants (70W per person)	16·1
Electric Lighting	12·0
Miscellaneous Power	3·0
Total Heat Gain (W/m^2 floor area delivered energy)	31·1 (2)

NETT HEATING REQUIREMENT (1) – (2) = 60·5 W/m^2 floor area (3)

HEATING FOR HOT WATER SERVICE = 2·0 W/m^2 floor area (4)

Electrical Energy	W/m^2 floor area
Lighting	12·0
Miscellaneous Power	3·0
Heating System Circulators	2·0

TOTAL ELECTRICAL ENERGY = 17·0 (W/m^2 floor area (5)

CONVERSION TO PRIMARY ENERGY (see paragraph 1a)

(3) × heating conversion factor + (4) × hot water heating conversion factor + (5) × electrical conversion factor

= 88·3 W/m^2PEU + 3 W/m^2PEU + 63·4 W/m^2PEU

ENERGY DESIGN VALUE = 155 W/m^2PEU floor area

(Refer to Figure 5 for model value)

25

Facsimile pro formas from CIBSE Building Energy Code

Building Energy Demand Work Sheet 4

4. PRIMARY ENERGY DEMANDS

(a) Thermal demand (D_T)

Heating	Energy	Q_H	14·0
	Fuel factor	e_x	1·03
		$(Q_H e_x)$	14·4
HWS	Energy	Q_{HWS}	1·65
	Fuel factor	e_x	1·03
		$(Q_{HWS} e_x)$	1·7
		$\Sigma (Q e_x)_1 = Q_H e_x + Q_{HWS} e_x$	16·1
Recovered	Energy	Q_R	/
	Fuel factor	e_x	/
		$(Q_R e_x)$	/
Non-depleting	Energy	Q_{ND}	/
	Fuel factor	e_x	/
		$(Q_{ND} e_x)$	/
		$\Sigma (Q e_x)_2 = Q_R e_x + Q_{ND} e_x$	—
		$\Sigma (Q e_x)_1 - \Sigma (Q e_x)_2$	16·1
		A_f	1043
		$D_T = \dfrac{10^3 \{\Sigma (Q e_x)_1 - \Sigma (Q e_x)_2\}}{A_f}$	15·4

(b) Electrical demand (D_E)

Electrical	Energy	Q_E	1·65
	Fuel factor	e_x	3·82
		$(Q_E e_x)$	6·3
Non-depleting	Energy	Q_{ND}	/
	Fuel factor	e_x	/
		$(Q_{ND} e_x)$	/
		$(Q_E e_x) - (Q_{ND} e_x)$	6·3
		A_f	1043
		$D_E = \dfrac{10^3 \{(Q_E e_x) - (Q_{ND} e_x)\}}{A_f}$	6·04

(c) Total demand (D)

Thermal Demand	(D_T)	15·4
Electrical Demand	(D_E)	6·04
Total Demand	$(D_T + D_E)$	21·44

Facsimile pro formas from CIBSE Building Energy Code

Building Energy Demand Work Sheet 5

5. TARGETS

(a) Building Envelope Number (B)

External wall area	A_w	589
Total floor area	A_f	1043
Number of storeys	n_f	1
Floor-ceiling height	h_c	2·5
Building structure constants	k_1	0·5
	k_2	0·2

A_w / A_f	0·56
k_1 / n_f	0·5
$(k_2\ h_c)$	0·5
$B = \dfrac{A_w}{A_f} + \dfrac{k_1}{n_f} + (k_2\ h_c)$	1·56

(b) Thermal Demand Target (T_T)

Building thermal constants	C_1	16
	C_2	−4
	$(C_1\ B)$	25
	$T_T = (C_1 B + C_2)$	21

(c) Electrical Demand Target (T_E)

Mean power requirement (lighting)	$(\bar{q}_l)$	12
Mean power requirement (heat distribution)	$(0.1 T_T)$	2
	$T_E = (\bar{q}_l + 0.1 T_T)$	14

(d) Total Demand Target (T)

Thermal Demand Target	(T_T)	21
Electrical Demand Target	(T_E)	14
Total Demand Target	$(T_T + T_E)$	35

(e) Compliance with Targets

	Thermal	Electrical	Total
Demand	15·4	6·04	21·44
Target	21·0	14·0	35·0
$\left[\dfrac{\text{Demand}}{\text{Target}}\right]$	0·73	0·43	0·61

Energy management; an example

This extract is reproduced from a user manual for a school given in the Department of Education and Science's Design Note 19.

Introduction

Energy saving features designed into the building and the heating and lighting systems can be enhanced by good housekeeping and good management.

The most common and effective measures to reduce unnecessary consumption of energy are given below.

Measures which mainly concern staff or pupils in the everyday use of the building.

All electrical appliances and lights should be switched off when no longer required.

Supplementary heaters, such as electric fires, are costly to run and should only be used in cold spells outside the normal heating season when the main heating system is not operating or when a room is occupied after the main heating period.

During the heating season, if additional ventilation is required, a minimum number of windows should be opened. Excess ventilation will lead to overcooling and will switch thermostats to 'on', thus providing more heat, and wasting gas.

Maximum use should be made of daylight. Blinds and curtains should be drawn back during the day and drawn closed at dusk or when it is clear that electric lighting will be required for the rest of the day. Drawing blinds and curtains at dusk will help conserve heat overnight, saving about 25% of the heat loss through the windows.

External doors should be kept closed as much as possible during cold weather and all windows closed overnight.

The allocation of areas for evening use should be made in relation to heating zones so that the minimum amount of heating plant is used.

An effort should be made to diversify the heavy electrical loads, such as the kiln, so that these are not used during the coldest winter months when the loads from other sources are likely to be high.

Economy should be exercised in the use of hot water, subject to the need for cleanliness and hygiene.

Staff and pupils should be encouraged to wear clothes that are suitable to the internal temperatures for which the thermostats are set.

In addition to the above, the following measures are more appropriate to the efficient use of the school as a whole and therefore fall within the responsibilities of the maintenance and caretaking staff.

Thermostats should be set to give moderate room temperature during the heating season. The Standards for School Premises Regulations 1972* lay down the minimum temperatures for various kinds of space; these include 18.5°C for medical inspection rooms, 17°C for teaching rooms and 14°C for hall, dining rooms and gymnasia.

*The current statutory requirements for schools are given in the Education (School Premises) Regulations 1981, SI. No. 909, and in the DES Design Note 17 (1981).

Faulty washers, especially in hot taps, should be replaced immediately.

Cleaners should be requested to use lights sparingly and to switch them off when not required.

Heating plant and controls should be kept in good working order and should not be started earlier than is necessary to achieve normal working temperature at the beginning of the occupation period.

Record of fuel consumption

In order to monitor the effectiveness of energy conservation measures it is important to accurately record fuel and power consumption in the building throughout the year.

Case study 1 : Manchester housing

Project credits

Title and address
Low Energy Housing, Halliwell Lane Estate, Manchester.

Client
The City of Manchester, Town Hall, Manchester. (acting through the Housing Committee)

Architects
The City Architect, Town Hall, Manchester M60 2JT
A B Tyler Energy Conservation Architect

Service Engineering
The City Architect in conjunction with: N.W. Gas, Norweb, Solid Fuel Advisory Service

Monitoring Organisation and thermal design advice
The University of Manchester Institute of Science and Technology Department of Building
Prof. P Burberry
On behalf of The Department of Energy

Administered by
BRECSU, BRE, Garston, Watford, WD2 7JR

Origin of project

In the late 1970's Manchester City was building houses at the rate of approximately 3000 per year. Bearing in mind that the City also owned about 100 000 dwellings the total resultant level of investment was considered to justify an investigation of ways to provide dwellings that would have lower energy bills for tenants.

Design solution

An early decision was taken to concentrate on achieving energy efficiency by paying particular attention to the building shape and design detailing, rather than installing special heat collecting or recovery equipment.

The design allows for a variety of fuels to be used to supply conventional heating systems with boilers and flues centrally placed.

The building form was designed to be as cuboid as possible to minimise external wall areas, windows being as small as possible but consistent with good natural lighting and external views. The living rooms were designed to have south or south west facing windows.

Manchester City Council

Method of estimating energy requirements

Energy demand was estimated in accordance with the recommendations of the CIBS code using the BRE method for domestic buildings. This was done initially by manual calculation and subsequently refined using micro computer techniques.

Energy targets

Low energy houses were designed to have a reduced heat loss when compared with a standard traditional 3 bedroom, 5 person house. It was assumed that the total theoretical energy saving calculated on an annual basis, using Gas prices at 1 April 1981, would be 8600 Kw (289 therms or £72.00 per house).

Energy design features

The low energy houses were designed as a 'package' of energy-conserving measures bringing together a simple energy-conscious design with high levels of insulation.

1 Highly insulated roof, walls and floor.

2 The avoidance of cold bridges in the structure.

3 Double glazed windows.

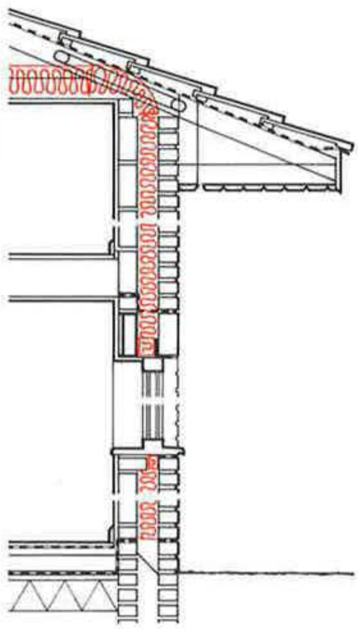
4 Internal draught lobbies to external doors.

5 Draught proofing of windows, doors and at construction joints to reduce heat loss by uncontrolled ventilation.

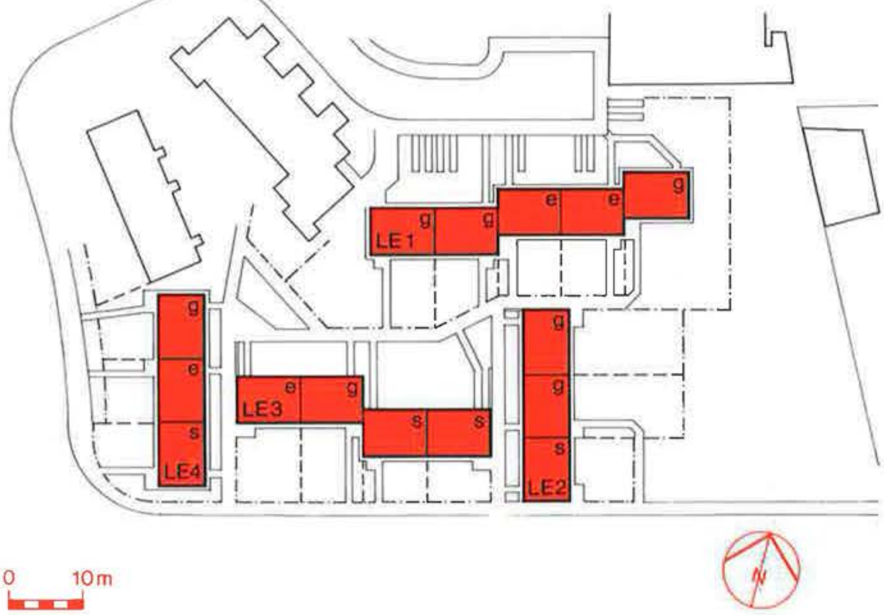
6 Reduced ventilation rates.

7 A centrally located boiler and flue to take advantage of casual losses.

8 Room by room control of temperature levels.

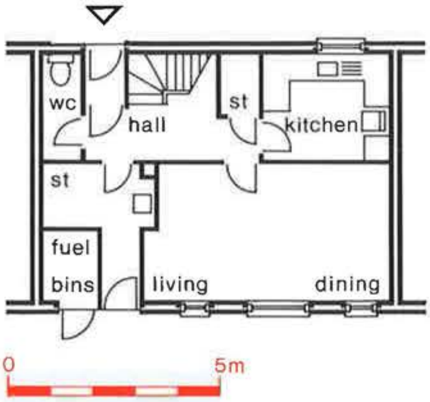


Section through eaves and external wall

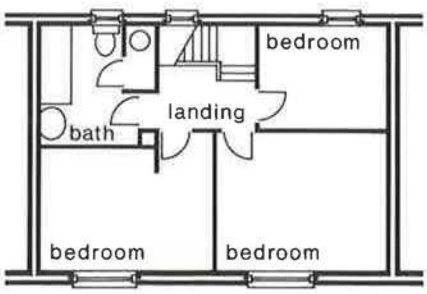


Key
e electricity
g gas
sf solid fuel

Block LE1



Ground floor plan



First floor plan

Source of data:
Low energy houses in the City of Manchester.
A report by Department of Building, University of Manchester Institute of Science and Technology for BRE Conservation Support Unit on behalf of Department of Energy
F/37/84/89

Summary of data

Date of completion	September 1981
Capital cost	£16 470.00 per house
No. of persons	5 per house
Gross floor area	$106.16m^2$ per house
Area per person	$21.23m^2$
Delivered annual energy consumption	Total: 61 GJ per year (30 GJ for 30 weeks heating) Per m^2: 0.57 GJ (0.28 GJ) Per person: 12.20 GJ (6.00 GJ)
Primary annual energy	171 kWh/m^2
Investment cost	1 £278.00 per house (wall mounted boiler) 2 £394.00 per house (back boiler and fire)
Payback period	1 3.86 years (wall mounted boiler) 2 5.52 years (back boiler and fire)
Savings anticipated	£72.00 per year per house

Cost effectiveness

The quantities of energy supplied to individual standard dwellings and their costs were accurately known. Estimates of overall cost saving were made both at the design stage and during the monitoring and evaluation period.

Comparative 'U' values

	Standard house W/m^2	Low energy house W/m^2
Roof	0.40	0.24
Walls	1.00	0.27
Floor	0.78	0.38
	single glazed	double glazed
Windows	5.60	2.80
Ventilation rate		
Changes per hour	1.00	1.70

Energy management

No operating manual was produced. Tenants moving into the properties were taken from the housing waiting list and it was a specific objective of the Development Team to obtain results from the monitoring procedure that would be typical for normal usage. The tenants were however, introduced to the heating systems by the heating Sub-Contractors who were also available to deal with any operating problems that may arise.

Predictions of the cost effectiveness of energy conserving measures made during the early design stages (costs relate to 1981 prices)

System	*Gas back boiler* £	*Gas wall mounted boiler* £	*Electricity* £	*Solid fuel wet system* £	*Solid fuel warm air* £
Basic superstructure cost	11 840	11 840	11 840	11 840	11 840
Additional items:					
Insulation wall and floor	295	295	295	295	295
Roof	22	22	22	22	22
Double glazing	312	312	312	312	312
Fans	100	100	100	100	100
E/O £1000 heating cost assumed	38	–	81	225	–
E/O Flue	–	–	–	27	27
Sub total	12 607	12 569	12 650	12 821	12 596
Savings					
Energy conscious design	369	369	369	369	369
On £1000 heating cost assumed	–	82	–	–	500
Flue	–	–	125	–	–
Average cost of superstructure (1)	12 238	12 118	12 156	12 452	11 727
Extra cost over a standard house	+398	+278	+316	+609	−113
Annual savings space heating (1)	72	72	396(3)	52(2)	64(2)
Cost effectiveness					
Simple return	5.52 yrs.	3.86 yrs.	0.79 yrs.	11.71 yrs.	Immediate
Internal rate of return	17.3%	25.6%	125.3%	5%	Immediate

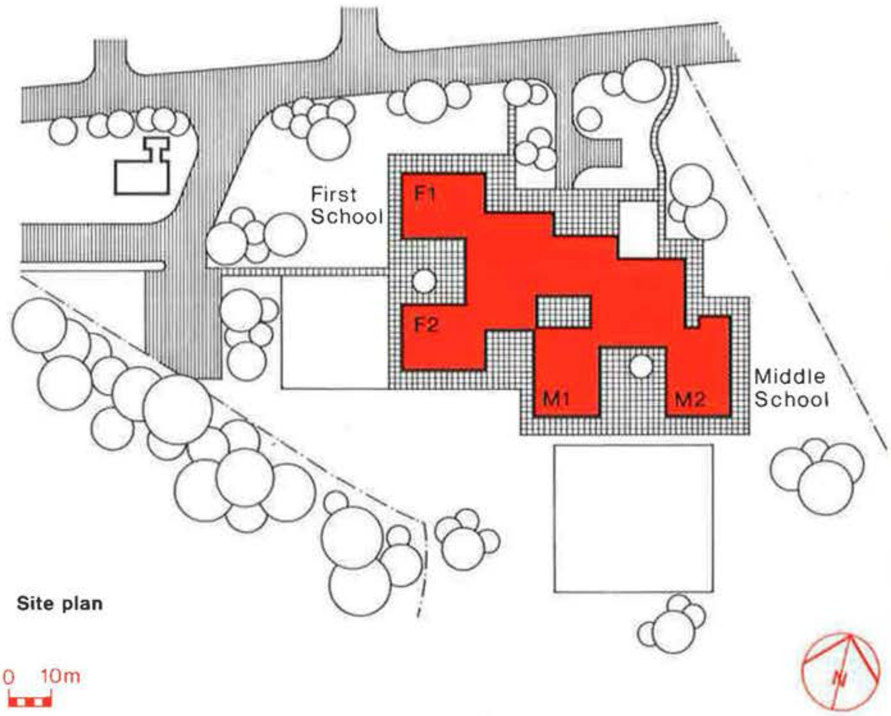
(1) For both costs of superstructure and annual savings an average of gable and terrace conditions is given.
(2) Includes an allowance for no standing charge for gas.
(3) Comparison with electrically heated dwelling to Manchester current standards.

Case study 2 : Walmley Schools

Origin of the project
The Sutton Coldfield Deanery First and Middle Schools at Walmley in the West Midlands are new schools, designed with energy efficiency as an important feature. These schools were adopted in anticipation that the resultant design would provide the basis for an energy conscious approach to design in both new and refurbished schools.

Design solution
The building design which was developed provides two academically separate but physically linked schools with a shared kitchen. The building is single storey with a floor area of approximately 2200m² to accommodate a total of 520 pupils.

The design included a range of energy saving measures covering the building fabric, services and controls, based on a thermally heavyweight construction, with classrooms facing predominatly towards the south to take advantage of sunlight.



Site plan

Project credits

Title and address
The Sutton Coldfield Deanery First and Middle Schools, Walmley, West Midlands

Client
Birmingham Diocesan Education Council
Church House, Harborne Park Road, Birmingham B17 0BH

Architects
The John Osborne Partnership (previously John P Osborne & Son)
Rutland House, 148 Edmund Street, Birmingham B3 2LA

Monitoring organisations
Birmingham School of Architecture
City of Birmingham Polytechnic
Perry Bar, Birmingham B42 2SU
Dr A Hildon

Building Research Establishment
Bucknalls Lane, Garston, Watford WD2 7JR
Dr P Warren


Jeremy Preston
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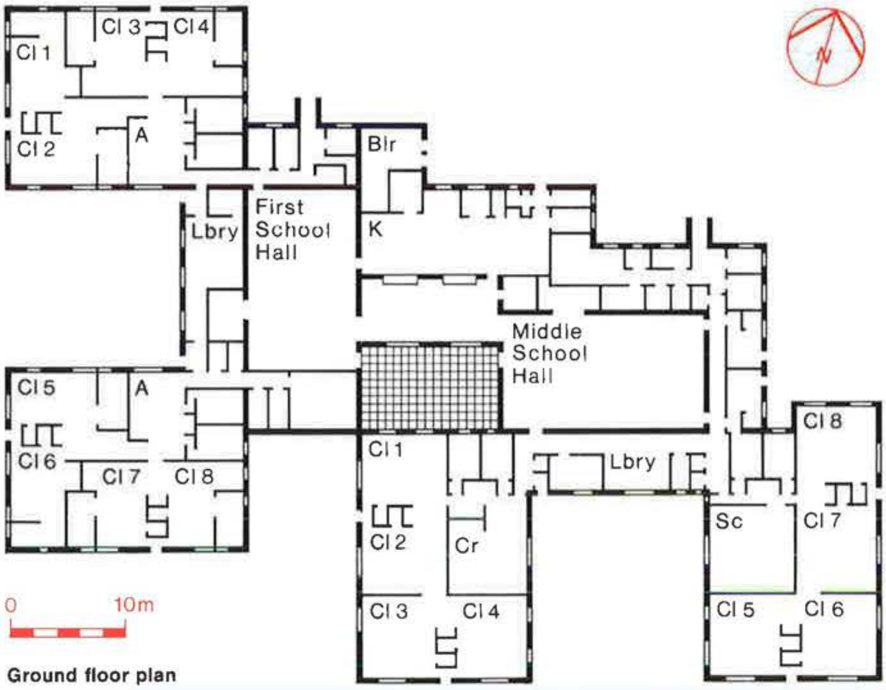
Method of estimating energy requirements
The DES Design Note 17; 'Guidelines for environmental design and fuel conservation in educational buildings' was used.

Energy targets
It was estimated that the energy saving measures at the Walmley Schools would cut fuel heating costs to about half those of an equivalent conventional school. The individual elements of the design combine to give an overall 'U' value for the fabric of 0.38 W/m² and a design heat loss (at –1°C) of 95.5 kW. The heat loss calculation assumes a ventilation rate of one air change per hour:



Ground floor plan

Energy design features
Element Construction and 'U' values

Floor 0.31 W/m²K
Incorporates 900mm deep vertical or 1.5m wide horizontal edge insulation (75mm polystyrene). Variations in site levels and sub-soil conditions reduce the foundation depth for part of the building and here edge insulation is placed horizontally. The additional insulation cost is offset by reduced foundation costs.

Walls 0.30 W/m²K
Brick externally, concrete block internally. 100mm cavity filled with urea formaldhyde foam. At the window and door reveals the 100mm cavity is reduced to 25mm and filled with resin bonded fibreglass batt to eliminate the cold bridge.

Roofs 0.27 and 0.19 W/m²K
Pitched roofs (generally without suspended ceiling) incorporate 100mm polystyrene boards above 75mm reinforced woodwool slabs with a polythene vapour check between and tiling above. Alternatively, plywood replaces the woodwool slabs and the thickness of the expanded polystyrene is increased to 150mm. Rooflights are centre pivoted, fitted with trickle ventilators and Insulight double glazing units.

Flat roofs are conventional timber construction with 150mm polystyrene above a vapour check on softwood boarding. The roofs are asphalted. Rooflights are UPVC double skin dome units with louvre ventilators.

Both flat and pitched roofs have no ventilated cavity and rely on the vapour check to avoid interstitial condensation.

Window 2.50 W/m²K
Property Services Agency Grade A1 (low infiltration) with additional draught strip and double thickness mastic seal. All windows are double glazed, have centre pivot opening and measure 1.4m by 0.7m. Large windows are composed of multiples of the 1.4m x 0.7m units.

External doors 1.90 W/m²K
Internal and external doors to draught lobbies are draught-stripped with neoprene gaskets in aluminium channels.

Cost effectiveness

The total cost of the Walmley Schools, including the energy saving measures was no greater than for contemporary schools of equivalent type and size, however the cost effectiveness of the energy saving measures varied from one to another as shown in the following table.

Energy-saving measure(s)	Marginal cost £	Annual fuel cost saving £	Payback period years
Insulation measures	13,763	2,400	6
Double glazing	3,228	600	5
Infiltration reduction	13,993	500	28
Boiler & controls	4,063	300	14
Room thermostat controls	2,070	Analysis not possible	
Extra insulation of DHW system	516	200	3
Spray mixer taps	1,518	20	76
All 'successful' measures	39,151	4,020	10
All measures installed	69,528	3,920	18

Comparison of annual energy consumption and costs

Schools	Delivered Gas Consumption kWh/m²	%	Cost £/m²	Delivered Electricity Consumption kWh/m²	%	Cost £/m²	Total Fuel Consumption kWh/m²	%	Cost £/m²	%
Walmley	98.4		0.98	31.0		1.70	129.4		2.68	
7 Other (B'ham)	228.0		2.28	21.0		1.16	249.0		3.44	
Saving (Walmley)	129.6		1.30	−10.0		−0.54	119.6		0.76	
% Saving		57%			−48%			48%		22%

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Energy management

Central boiler plant (space heating) was fitted with a 'package' of conventional controls; compensator/optimiser/sequencer.

The caretaker was carefully briefed, in the operation of these, and indeed did use and manage them successfully.

Prototype lighting controls were tested, but found to be user unfriendly. These pre-dated recent commercial developments, and had 'off the shelf' hardware been available savings in lighting use would probably have been achieved.

An owners manual was not issued, other than the usual boiler plant details for the caretaker. However, the design team did spend considerable time with the school staff and pupils in explaining the nature of the school and its energy efficiency features.

Source of data:
Energy conservation measures in the Sutton Coldfield Deanery First and Middle Schools (the Walmley Schools).
Prepared by Birmingham School of Architecture for the Energy Technology Support Unit of AERE Harwell on behalf of the Energy Office, Department of Energy.
F/52/85/11

Energy efficient design in schools.
Expanded Project Profile No. 11
Energy Efficiency Demonstration Scheme
Energy Efficiency Office, Department of Energy.

Summary of data

Date of completion
September 1980 — 30% First School
January 1981 — Part Middle School
September 1981 — 60% Both Schools
September 1982 — 90% Both Schools

Capital cost
£700 000 Total Tender cost (2nd quarter 1982)

Gross floor area
2200m²

Number of persons
designed for 520 pupils

Area per person
4.23m²

Cost per m²
£318

Delivered annual energy consumption
Total: 286 851 kWh
Per m²: 129.4 kWh/m² (0.47 GJ/m²)
Per person: 551.6 kWh

Primary annual energy per m²
220 kWh/m²

Investment cost
£69 528.00 Total marginal capital cost (9.41% building cost)
£39 151.00 Measures contributing to energy saving

Payback period
18 years. Complete package
10 years. Measures contributing to energy saving

Savings anticipated
150 kWh/m² (0.52 GJ/m²) 50 % saving compared with 'typical' school

Case study 3 : Garston BRE office

Project credits

Title and address
Low energy office,
Building Research Establishment,
Garston, Watford
Herts WD2 7JR

Client
Property Services Agency
Directorate of Civil Accommodation

Architects
Property Services Agency
Directorate of Civil Accommodation

Consultants
BRE acted as energy consultants to PSA

Monitoring organisation
Building Research Establishment

Origin of project

The client brief was to provide largely office accommodation at a relatively low density for 75 people, over about 2000 sq metres of gross area. Energy conservation was to be a key design objective, but the building was not to be 'experimental'. It was to incorporate established technology while costs were to be in line with PSA's general construction costs at that time.

Design solution

The shallow office building was built on an east-west axis, using conventional techniques, it provides an internal environment effectively 'energy free' in summer and is an efficient user of a minimum amount of energy in winter. This was achieved by exploiting ambient energy and by giving consideration to the close inter-relationships between the thermal performance of the building fabric, the operator of environmental services and the comfort and behaviour of occupants.

Building Research Establishment

Method of estimating energy requirements – energy targets

A primary energy demand target calculated according to Part 2(a) of the CIBSE Energy Code gives a figure of 1.03 GJ/m^2 for the building shape.

Energy design features

Building fabric

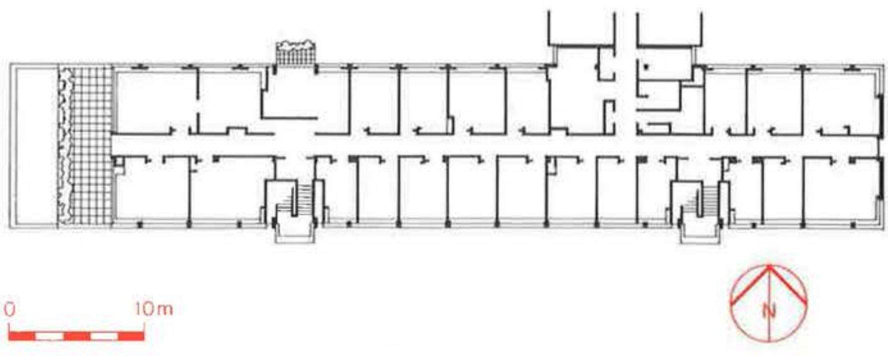
The external envelope and structure has been designed to cushion the internal environment from external climatic variations, with the engineering services providing only fine tuning.

Fenestration

Glazing optima of 45% (south) and 30% (north) were predicted to give a minimum expenditure of primary energy consistent with maintaining comfortable internal conditions.

Winter ventilation

Opening windows are locked so that a low infiltration rate is achieved. Ventilation air is distributed via ducts to perimeter convector units and is extracted through ducts from the centre of the building. Heat is transferred from extract exhaust air to incoming fresh air by means of a hygroscopically coated (latent heat) metal-cored heat wheel.



Second floor plan

Winter heating
The second floor boiler room contains three gas fired atmospheric modular boilers (each 75 kW), firing in sequence according to load to maintain a high burning efficiency. Low temperature hot water is circulated to north and south zones to finned elements in perimeter convectors.

Summer cooling
Large areas of south facing glazing required protection from solar gain in summer, spring and autumn. This is provided by computer controlled roller blinds fitted outside south and west facing offices. Opening windows provide buoyancy ventilation sufficient to restrict temperature rises to acceptable limits.

Lighting
Maximum use of natural light in offices and borrowed light in corridors reduces the use of artificial lighting. To minimise artificial lighting, room switches are overridden by roof-mounted sensors which will not permit the use of lights until daylight has fallen below 300 lux in the offices.

Hot water supply
Hot water to central toilets is provided for one stairwell from a calorifier in the plant room indirectly heated by the main boilers with an immersion heater in reserve. A connection is provided from a preheat calorifier for roof-mounted solar panels which may be installed on an experimental basis. Spray taps are fitted to wash hand basins.

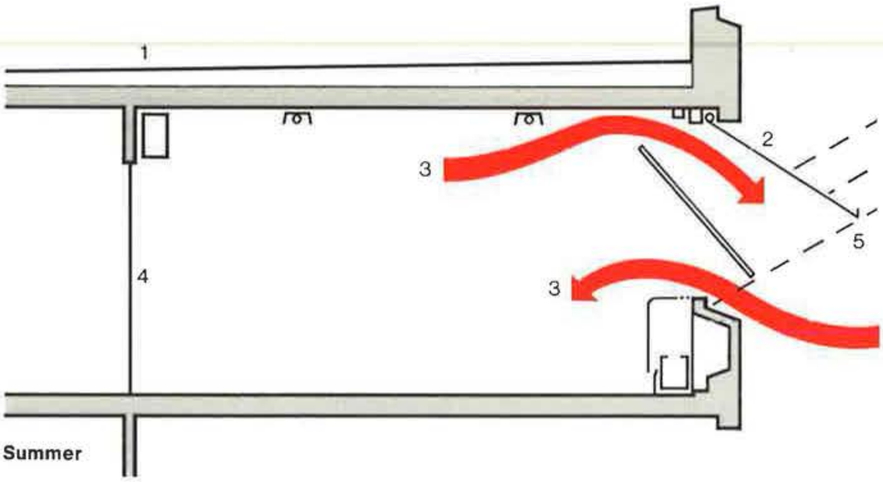
North Facing Office

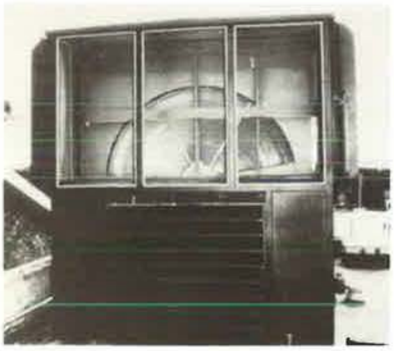
South Facing Office

Key

1 lightweight screed
2 projecting blinds
3 natural ventilation
4 door sidelights light corridor
5 when lowered blinds exclude sun higher than 30°
6 fresh air
7 heat recovery wheel
8 photocell frees lights progressively
9 to perimeter inlet duct
10 extract duct
11 venetian blinds for glare control
12 fresh air mixed with room air
13 windows locked
14 room air
15 insulation
16 to perimeter inlet duct

Section through typical south facing office showing how comfort conditions are achieved in summer and winter





Heat recovery wheel

Individual feature assessment

The features of the office were (along with a performance assessment *for this design,* max ****).

1	Incorporation of low-energy design during the earliest planning	****
2	Use of thermal insulation values to the 1977 Building Regulations	****
3	Daylight contribution from large glazed windows	****
4	Cool summer-time conditions without artificial cooling	****
5	Individual room temperature control to 19°C	***
6	Lighting control	*
7	Optimum start control	*
8	Point-of-use water heaters	****
9	Boiler sequencing	*
10	Air-tight construction	****
11	Mechanical ventilation with heat recovery	**
12	Ease of energy management	**

Cost effectiveness

Monitoring of the building's energy performance has shown that it is possible to construct office accommodation to within the 'best' category of the CIBS Energy Code, with little or no increase above the normal construction budget, using modern design techniques. Annual energy costs were £2.40/m² at 1984 prices. This is some 25-50% less than typical 1960's construction would consume. A major success was the reduction of electricity consumption for lighting due to the provision of natural daylight. Measured lighting consumption was only 10% of the CIBS Code Part 2(a) value.

Capital costs of low-energy technologies: insulation

The external opaque walls consisted of precast concrete spandrel panels seated on floor slab edge beams. A large cavity could therefore be easily provided for filling with a insulant. To have restrained the insulation to a smaller thickness, forming a cavity, would have exceeded the cost of insulant saved. Wall cost was £134/m².

Double glazing

The double glazing employed was £29/m² more expensive than single glazing.

Thermostatic radiator valves

Extra cost over hand valves, £1500.

Lighting control

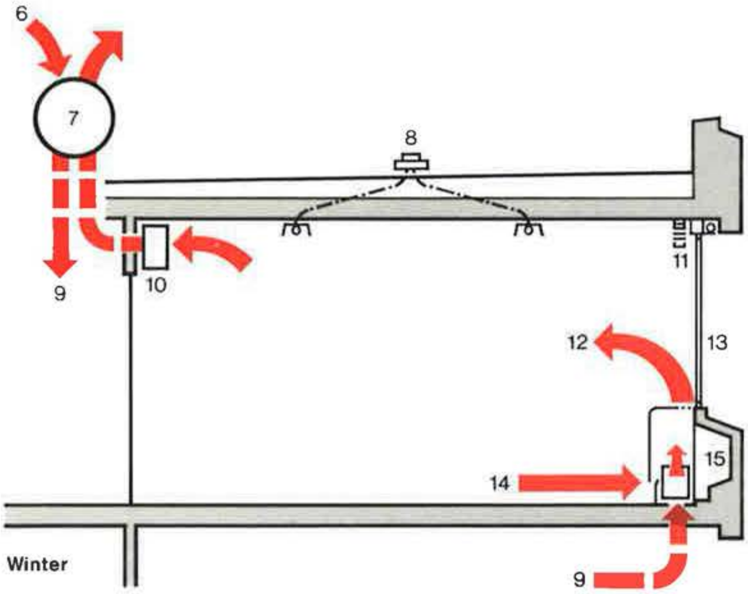
Cost of photocells and cabling, £5000.

Heating and ventilating plant

The mechanical ventilation system was costed at £48 000, and the heat wheel £5000. The mechanical ventilation system was primarily a client requirement, although ventilation heat recovery could not be achieved without it. The estimated saving in H&V plant attributed to the low energy consumption was £35 000. No allowance has been made for savings in plant room size and location, or other contributions to saving in total cost.

Part 4 of the Energy Code of the Chartered Institute of Building Services provides comparison targets for the energy consumption of existing buildings. These targets are in terms of the energy delivered to the building for heating (the thermal target) and electrical services (the electrical energy target). Targets are expressed per unit 'treated floor area'. The results for the BRE low-energy office (corrected to the Code's 'average winter conditions') were:

	CIBS Code 4	*BRE Office*
Thermal energy	940 MJ/m²	450 MJ/m²
Electrical energy	96 MJ/m²	63 MJ/m²
Annual site energy		513 MJ/m²



Energy management

Winter ventilation
Opening windows are locked.

Winter heating
System control is affected by time clock, compensator and optimum start controls, whilst individual room temperatures are controlled by thermostatic radiator valves with remote sensors.

Summer cooling
Roller blinds are computer controlled, designed to lower automatically if solar intensity exceeds a set level and provided that the wind speed is not too high and the building has reached its design temperature of 18.5°C. This ensures that solar gain is fully utilised to heat the building. Occupants may normally override the automatic operation, by means of switches in each room subject to the same restrictions. Occupants also have the option of internal venetian blinds for relief of glare and direct sunshine.

Artificial lighting
The system is set up so that when daylight at a point 2m from the windows falls to 300 lux, the inside bank of lights can be switched on, and when daylight falls to 200 lux, the outside bank can also be used. Lighting banks go off progressively if daylight improves, subject to a higher switch-off setting and a time delay to prevent 'hunting'. Neon indicators remind occupants if switches are left on and a time clock overrides all other controls.

Hot water supply
Spray taps are installed.

***Source of data:**
The BRE low-energy office
A report prepared by BRE for the Energy Technology Support Unit, Harwell, acting on behalf of the Energy Efficiency Office, Department of Energy.

Summary of data

Date of occupation
July 1981

Capital cost
£760 000
(tender at first quarter 1979 prices)

Usable floor area
1745 m²

No. of persons
75

Area per person
23.27 m²

Delivered annual energy consumption

		KWh
Total:	min	166 000
	max	193 000
Per m²:	min	95
	max	110
Per person:	min	22 000
	max	26 000

Primary annual energy
0.7GJ/m²

Annual running cost
£2.44/m²

Case study 4 : JEL factory, Stockport

Project credits

Title and address
JEL Energy Conservation Services Ltd
Bramhall Moor Lane Industrial Park
Pepper Road, Hazel Grove
Stockport SK7 5BW

Client
JEL Energy Conservation Services Ltd

Architects
Dominic Michaelis Associates
Bay 8, 16 South Wharf Road
London W2 1PF

Service engineering
Dominic Michaelis Associates
in association with
JEL Energy Conservation Services Ltd

Origin of project

The client's aim was to achieve a headquarters facility and manufacturing base for JEL with scope for future expansion.

Design solution

The resulting building is approximately 2000m^2 and comprises a two storey office on the south side, which is fully glazed. Offices and other rooms are also located on two storeys either side of a double height production floor. The north end is devoted to storage and escape stairs. The side and north walls are predominantly brick with small glazed openings.

Peter Cook
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Method of estimating energy requirements

Methods adopted for assessing energy demand were internal to the office

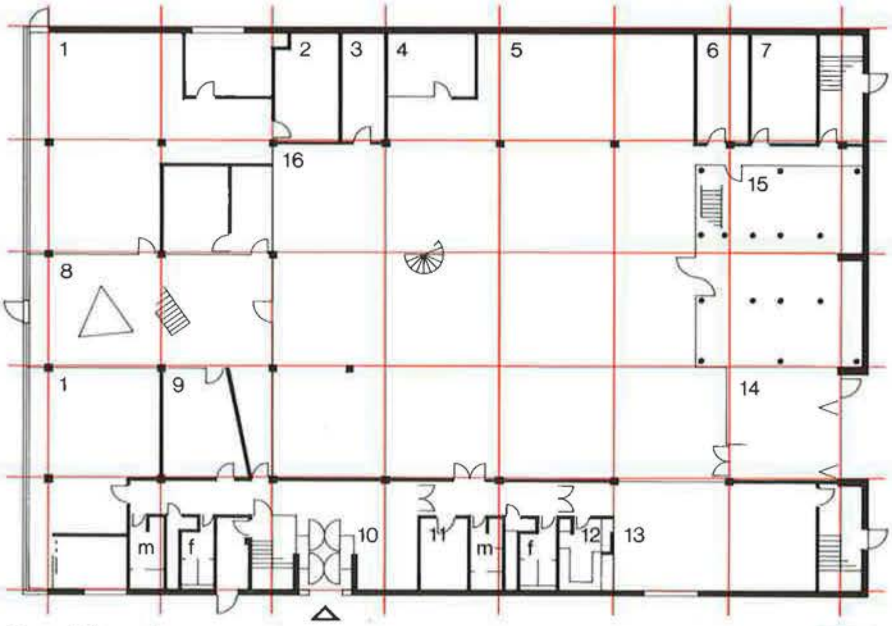
Energy targets

Actual energy consumption
Electricity - 277 GJ
Gas - 574 GJ

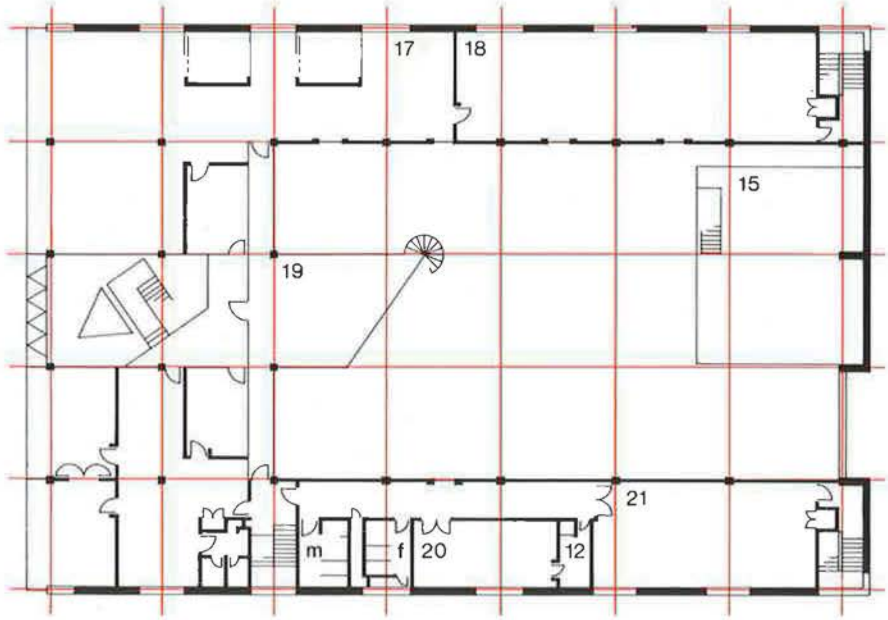
Energy design features

The level of thermal insulation was increased over that required by part FF of the Building Regulations, 0.3w/m^2 instead of 0.6w/m^2.

Doors and windows are draught sealed, and lobbies added to all external doors in regular use. Construction detailing ensures as high a level as possible of joint sealing.



Ground floor plan



First floor plan

Key

1 office
2 computer
3 stationery store
4 works manager
5 test area
6 engineering workshop
7 soak room
8 atrium
9 meeting room
10 reception
11 first aid room
12 kitchen
13 canteen
14 goods
15 stores
16 production
17 energy management
18 research & development
19 display demonstration
20 clients' dining room
21 lecture room

Glazing is orientated to increase the proportion that faces south. Rooflights are also designed to face south thus contributing to the heating load and increasing natural lighting levels with the use of diffusers to control glare, consequently reducing electrical consumption for artificial lighting.

A simple method of utilising solar gain has been introduced through the operation of the warm air heating system, so that excess heat gains in one zone can be transferred to another zone with a heat demand, and also to assist in the prevention of overheating in the summer.

Control of artificial lighting is incorporated, which is automatic, functioning at predetermined times and preset levels of illumination to match the occupancy pattern of the building, including natural breaks etc.

To meet commercial standards for resale, the height of the factory space is approximately 5.6m. To minimise heat stratification a recirculatory fan system is used to draw the warm air from the ceiling down to work level.

Sankey diagram of energy delivered (kWh)

240 000			
		others	9 256
220 000	Electricity	kitchen	3 331
	77 006	computer	8 485
200 000		test/soak	9 368
		r & d	11 780
180 000		lights	13 030
		plants	10 000
160 000		hws	11 250
140 000			
120 000			
100 000			
80 000	Gas	heating	
60 000	159 697		
40 000			
20 000			
0			

Sankey diagram in terms of fuel cost of energy delivered

Fuel cost in pounds			
6.000		£549	others (phones, demo, cleaners, typing, copiers)
5.500		£198	kitchen cooking/ cooling
5.000		£533	acc computer
4.500		£429	test & soak
4.000	Electricity	£699	r & d
3.500	£4.122		
3.000		£773	lights
2.500		£594	plant
2.000		£346	hws (including kitchen)
1.500			
1.000	Gas	£1.877	heating
500			
0			

Summary of data

Date of completion
April 1983

Capital cost
£635 998

Gross floor area
2087m²

Cost per m²
£288.46

Usable area
1889m²

Delivered annual energy per m²
Total: 93 964 kWh
Per m²: 53 kWh
Per person: 1540 kWh

Annual running cost
£5999

Cost effectiveness

Artificial lighting

The original scheme followed current thinking for a low energy lighting design, in the office and production areas, task lighting was provided beside each work station to achieve the desired lighting levels for each particular task. Background lighting to a lower level was provided by 'uplighters' in the offices and high bay luminaires in the production areas, both of which contain the highly efficient high pressure sodium (SON) lamps. Uplighters were also proposed for other areas, such as the demonstration and canteen.

An advantage in the use of uplighters was in their ability to overcome the now very common problem of people being unable to see VDU screens because of the reflected glare from light fittings.

Because of necessary cost cuts, the suspended ceilings were omitted from the design which meant the 'uplighter' scheme had to be reviewed. It was decided to change the scheme to a more conventional layout with fluorescent fittings.

However, by using polyflux, low wattage high performance, tubes in formula one fittings it was possible to achieve a similar low energy result. A low background level was selected of 300 lux with a make-up of task lighting. The production area is illuminated with high pressure sodium, again to 300 lux, with task lighting on the electrical assembly benches of up to 1000 lux. JEL at the same time adopted the use of non glare VDUs which overcame one of the objections of overhead fittings.

Lighting control covers control of supplementary lighting to predetermined levels within selected time frames. It is envisaged that local VDU stations in the building will be used as an additional user control and over-ride for local lighting conditions.

Energy management

JEL's expertise in boiler control and energy management is being used to provide a control package which will ensure zone by zone balance and maximise plant efficiency.

Peter Cook
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Case study 5 : Ystradgynlais Community Hospital

Origin of project
The energy implications of siting and building shape have been influential in the design of the new community hospital at Ystradgynlais in Powys. The hospital is due for completion in November 1985 and will have a 38 bed geriatric ward, general practitioners ward, day hospital, out-patients casualty, physiotherapy and X-ray departments, together with ancillary areas.

The building was considered from the energy points of view from its inception, and at the outset the architect carried out a microclimatic study and sought local experience of site conditions. The energy aspect was one of many design parameters that determined the final building. On several occasions these parameters conflicted and inevitably this led to a compromise of the energy features.

Design solution
The energy aspects of the design were carefully considered from the outset, although the final solution was somewhat restricted for the following reasons:

Costs
The building had to be built within established cost norms and there was very little money available for revenue saving ideas which required initial capital investment.

Planning
The brief required very complicated planning arrangements which sometimes conflicted with the most suitable solutions for energy conservation.

The site
Ystradgynlais is a town which is quite remote from the Health Authority Headquarters, and equipment which increased the maintenance requirements of the hospital was generally not incorporated.

The client
Occasionally the client was not in favour of the proposals and the solution had to be revised (eg. conservatories had to be taken out). However every effort was made to make the most of the site conditions and passive energy design features which did not incur cost penalties, and the engineering installation had incorporated the cost effective ideals which did not involve a great deal of extra capital expenditure.

Method of estimating requirements
Office standard utilising the HEVACOMP software package on an EQUINOX micro computer. The software is based on the CIBS method.

Energy targets

Space heating	2100,000 GJ
D.H.W.	702,000 GJ

Project credits

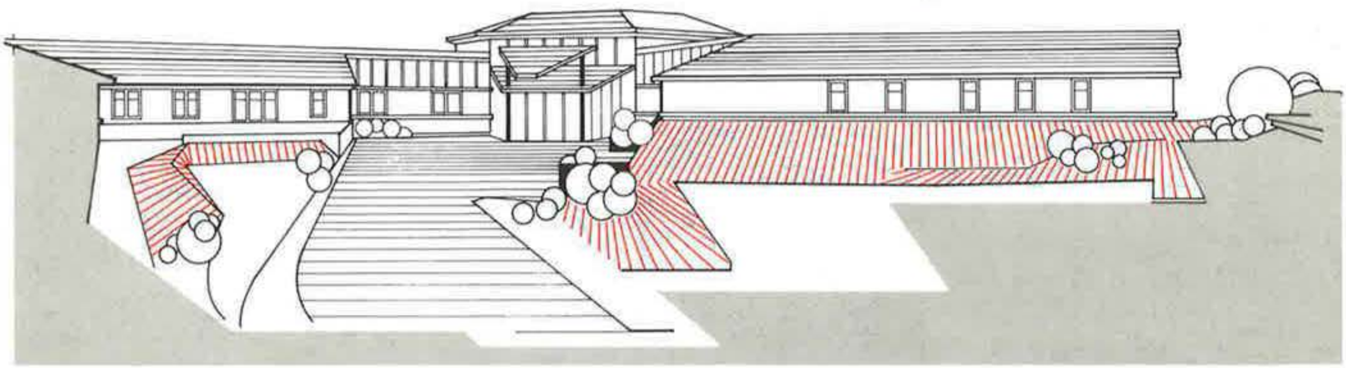
Title and address
Ystradgynlais Community Hospital
Glan Rhyd Road
Powys

Client
Powys Health Authority
Bronllys, Powys

Architects
W H Simpson
Chief Architect
Welsh Health Technical Services Organisation
Heron House
35/43 Newport Road
Cardiff CF2 1SB

Engineer
N E Holloway and Partners
24 St Andrews Crescent
Cardiff

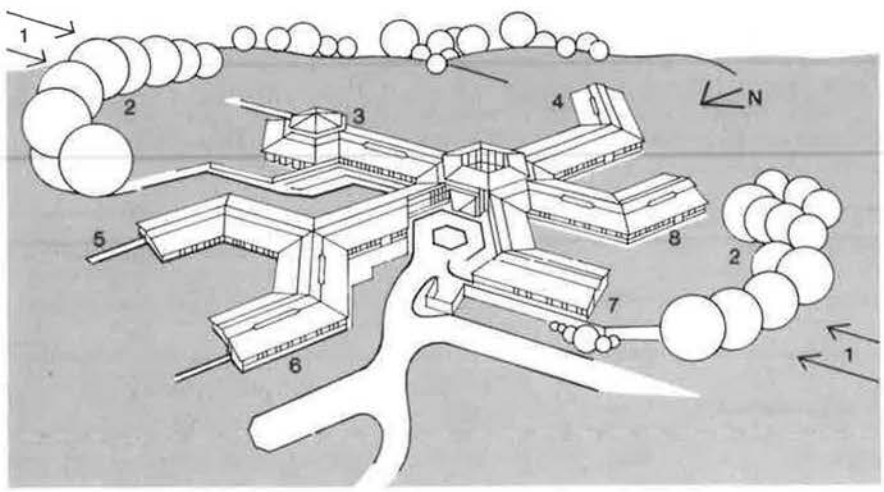
Monitoring organisation
Welsh Health Common Services Authority
(formerly WHTSO)



Main entrance

Birds eye view

Key
1 prevailing winds
2 earth mound with trees to form shelter belt
3 service wing
4 day hospital
5 earth brought up to window level on north elevation
6 geriatric wards
7 out-patients
8 GP ward
9 prevailing winds



Energy design features

A microclimatic study indicated that the site is very exposed to winds from the SW and NE which are channelling along an adjacent river valley. The excavated sub soil has been used to form mounds, which will be planted, to provide shelter from the NE and SW. The site falls towards the south and the building has been set at such a level that the extreme northerly elevations are set into the slope, up to window-cill level, to reduce heat losses and further prevent heat-stripping by the wind.

The building has been planned so that the various departments radiate from a central "hub" which has reduced circulation space. The pan form allows most rooms to be naturally lit and ventilated. The corridors are lit by rooflights which also provide supplementary daylighting to the larger rooms.

Major rooms which have daytime occupancy have been given southerly aspects and large windows, whereas storerooms and other spaces requiring less daylight have kept to the north side where possible. At one stage this passive solar approach extended to attached conservatories linked to the dayrooms but the client was unhappy about this and they were omitted.

Summertime overheating has been reduced by using large overhangs at the eaves and heavyweight ductwork for the internal partitions.

The insulation levels are, generally, not exceptional, since calculations showed that further improvements would not provide a satisfactory pay-back. The roof incorporates 100mm of glass fibre quilt at ceiling level and has a 'U' value of 0.31 W/m^{2}k.

The walls are only insulated to current Building Regulations (0.60 W/m^{2}k) Standards with 25mm of polystyrene fixed in the cavity of the block/brick wall.

Heating
The boiler installation consists of five sequenced modular gas fired boilers which supply a constant temperature circuit to serve modulating stations to each departmental wing of the building.

In areas where 24 hour operations is not required, an optimum start controller is provided with local frost protection.

Further control is provided in selected areas utilising thermostatic radiator valves, to ensure that solar gains save energy rather than cause local overheating.

The LPHW heating systems have commissioning valve stations.

Hot water supply
In order to satisfy the recommendations relating to the control of legionella bacteria, hot water for the patient areas has to be started at 60°C and distributed at 52°C. These conditions have been achieved using a plate heat exchanger which transfers the heat rejected from the H.W.S. flow to the calorifier cold water feed.

Ventilation
Mechanical ventilation is required in a few internal rooms and several other rooms with windows, to intermittently supplement the natural ventilation that is available. Local extract fans have been provided which are controlled by a timer, to reduce the problem of fans being left running when the area it serves is unoccupied. The times can be set for a period of 5-30 minutes.

Cost effectiveness

Heat pump installation
In the course of the design programme, the Department of Trade and Industry offered a 50% grant towards the capital cost of suitable applications for heat pump installations.

On the basis of this offer the scheme Consulting Engineer was briefed to carry out an appraisal as to the economic viability of such an installation. The options included the use of the nearby River Tawe as a heat source.

The results demonstrated that a saving was possible in the order of £4,296 on the gas consumed for the site. However, notwithstanding the possible grant of 50% the payback period of 8 years was considered excessive and the scheme judged not economically viable.

In the course of the appraisal, it became apparent that a CHP installation was a much more likely runner even though a grant for this option was not available at that time. (The Energy Efficiency Office are now looking for such case studies).

However, when maintenance costs were taken into account the payback period was calculated at 9 years and deemed excessive.

Both options would have been more viable if compared to older and less efficient boiler plant. The comparison was however being made to 5 x 95kW modular gas fired boilers fitted with modern controls able to closely follow the load profile of unit to achieve maximum year round efficiency.

As a cross check a present value exercise was undertaken which indicated a benefit to cost ratio for the heat pump at 0.42 i.e. less than the required unity.

Option	Extra capital cost	Net annual saving*	Pay back
Gas engine heat pump	£58 500	£3496	16.7 years
CHP 59 kW – heat 26 kW – electrical	£32 500	£3058	10.6 years
CHP 190 kW – heat 89 kW – electrical	£61 200	£8317	7.4 years
CHP 2 units each giving 190 kW – heat 90 kW – electrical replacing site electricity mains	£77 000	£8317	9.3 years

* Fuel saving less annual maintenance costs

Energy management

Tenders are currently being invited for an integrated energy management system.

The proposal is based on an "intelligent" outstation to be installed at Ystradgynlais in the boiler house.

The outstation will provide control and monitoring facilities to the modular boilers, calorifiers and primary and secondary heating pumps. Facilities exist for optimum start/stop control to the intermittently controlled areas such as the day hospital as well as zone control of the various 'limbs' of the building having a different aspect and hence heat loss.

In all some 110 points are controlled or monitored.

An auto dial modem will connect the outstation to a central controller, display and printer at the Health Authority Headquarters 40 miles away.

There are no resident maintenance staff and both routine and emergency maintenance will be undertaken from Bronllys.

The estimated cost of the system is £25,000 which will be cost effective in terms of 'fine tuning' the controls (5%) and also the reduced revenue consequence of maintenance costs.

Summary of date

Date of completion
October 1985

Capital cost
£2 553 000

Gross floor area
4,274m²

Number of persons
146

Cost per m²
£597.33

Area per person
29.27m²

Delivered annual energy per m²
Total: 2 802 000 GJ
Per m²: 655.59 GJ
Per person: 19 191.78 GJ

Primary annual energy
2 998 140 GJ/m²

Case study 6 : Farnborough swimming pools

Project credits

Project
Farnborough Recreation Centre,
Farnborough, Hants.

Client
Rushmoor Borough Council
Engineer and Surveyor's Department,
Council Offices,
Farnborough, Hants.

Consulting engineers
Adams Green and Partners
4 Carlton Crescent,
Southampton, Hants SO1 2EY.

Monitoring organisation
Building Research Establishment
Garston, Watford,
Herts WD2 7JR.

Origin of project

When remedial work became necessary at the Farnborough Recreation Centre, the Council decided that energy saving measures concerning the pools should be incorporated.

Design solution

A cross-flow heat exchanger was used to recover heat from extract air, two gas-engine heat pumps were installed for additional heat recovery and dehumidification. The result was a reduction of energy consumed to 35% of the system it replaced.

The pools

Size of main pool
33.3m x 12.8m

Department of Energy

Size of learner pool
12.8m x 6.4m
Total pool area
510m²

Department of Energy

Water temperature of main pool
29°C
Water temperature of learner pool
31°C
Air temperature of pool halls
30°C
Water volume
1000m²
Poolwater turnover
1 and 3.5 hours
Relative humidity
50%
Airchange
4-5 per hour
Air dilution (winter)
80-100%
Disinfection
ozonation
Heating
4 gas boilers
Heater rating
4800 kW

Method for estimating energy requirements

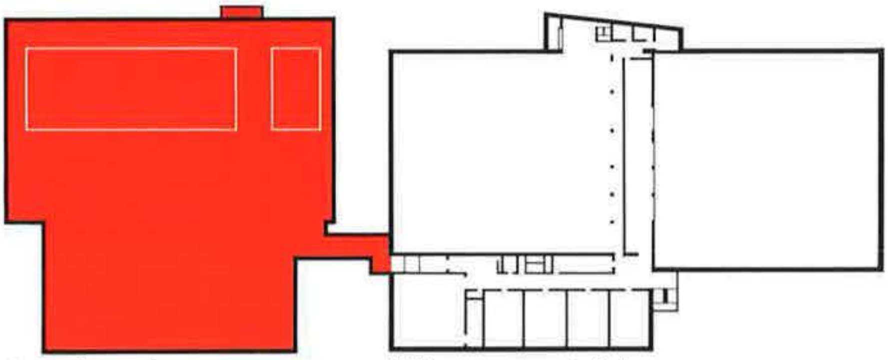
The environmental and climatic conditions of the existing building were considered to be adequate. The objective therefore was to reduce energy consumption without reducing these standards.

In the original building the pools were heated to 28°C and 30°C, while the air temperature was maintained at 29°C. Four 1000 kW gas boilers provided all the space heating and hot water requirements throughout the recreation centre. It was calculated, in retrospect*, that the energy consumption was 138 000 therms a year for heating the pool-hall air and pool water.

Energy targets

The total energy consumption target was established at 48 300 therms/year. This is 35% of the calculated consumption of 138 000 therms/year.*

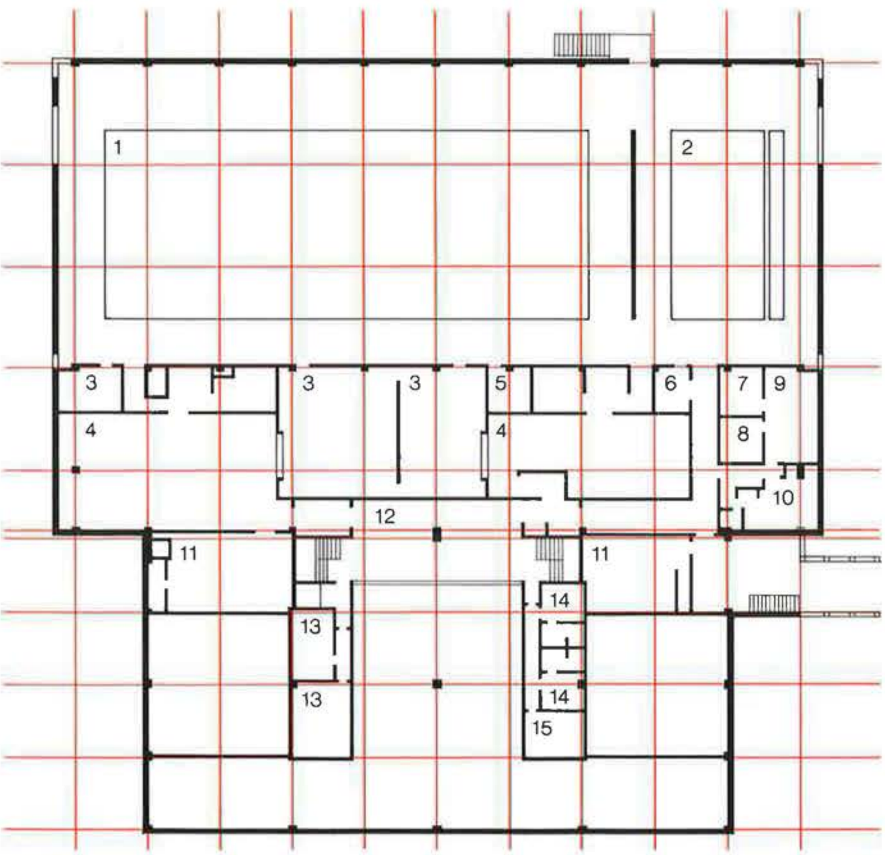
*Past records of energy use were only available for the centre as whole. It was not possible until later when computer simulations of energy requirements for alternative systems were carried out that one relating to a conventional full fresh air arrangement was used to estimate the original energy consumption.



Swimming pools **Multi-purpose sports hall**

Block plan

0 10m

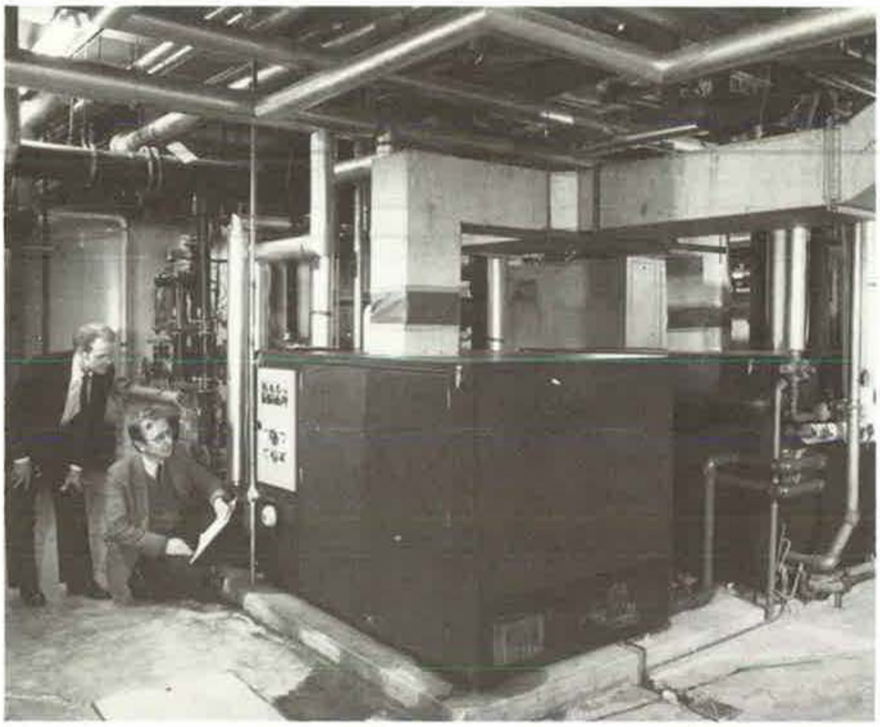


First floor plan

0 10m

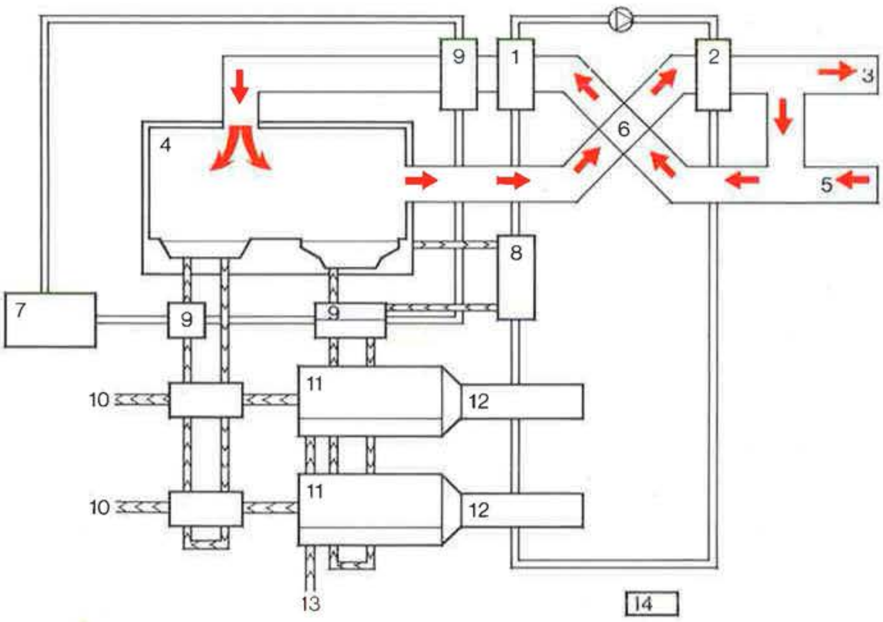
Key

1 main pool
2 learners pool
3 store
4 changing
5 instructor
6 first aid
7 keep fit
8 solarium
9 lounge
10 sauna
11 plant
12 gallery
13 office
14 staff
15 laundry



Department of Energy

Diagram of heat pump system.



Key
1 condenser r/a
2 evaporator
3 air extract
4 pool hall
5 fresh air inlet
6 x-flow heat exchanger
7 gas boilers
8 condenser r/w
9 boiler top up calorifiers
10 exhaust
11 gas engine
12 compressor
13 gas supply
14 heat exchanger

Energy design features

The remedial proposals included the installation of a gas engine driven heat pump both to humidify the pool hall air allowing it to be recirculated, to provide heat for the pools and for the rest of the centre. Energy savings were expected from the lower heat input required of recirculated air when ambient temperatures were low, from heat recovery by the heat pump and from heat recovery elsewhere in the system. Energy was needed to heat the water and to heat the ventilation air, which is needed to keep the moisture of the air in the hall low enough to avoid the damaging effects of condensation.

The system adopted made use of a heat pump circuit incorporating compressors driven by two Ford Kent 1600cc automotive engines converted to run on natural gas. Air was removed from the pool hall and passed through one side of a cross flow heat exchanger before flowing through the evaporator coil in the heat pump circuit. Heat was transferred to incoming pool hall air in the heat exchanger and the further cooling effect by the evaporator caused water to condense out so that the air was dehumidified. This drier air could either be recirculated to the pool hall via the air input side of the cross flow heat exchanger and one of the heat pump condensers, picking up heat on the way, or it could be exhausted to atmosphere and replaced by fresh air.

Another condenser in the circuit heated the main pool water, while heat recovered from the engine exhaust gases was used to heat the learner pool water. Heat was also recovered from the engine jackets and exhausts and used to supply water at up to 90°C to the main boiler circuit. The boilers provided back up heating for both pools.

Originally it was intended that the pool hall air should be fully recirculated and automatic dampers were installed to control the proportion of fresh air to recirculated air. In practice, however, the dampers seized shortly after commissioning resulting in a fresh air intake of approximately 50% for most of the monitoring period. Had full recirculation occurred and similar conditions been maintained, gas consumption would have marginally decreased and the heat pump would have provided more heat eliminating the need for the back up boiler. Operating the present system as a heat reclaim heat pump in variable air volume mode with no recirculation further reduces energy consumption.

Cost effectiveness

As it was the first time that a gas driven heat pump had been used for this purpose in a Municipal pool, the installation was supported by the Energy Efficiency Office under the Energy Efficiency Demonstration Scheme and the performance of the system was monitored for a full year.

The system has worked well and exceeded design expectations: the engine driven heat pump package delivered 2.3 times as much energy as it consumed.

Measurements made during the monitoring period revealed an average annual gas consumption of 38 000 therms for the gas engines and supplementary heating from the gas boiler, giving an annual saving on the calculated 130 000 therms on the original system or 72%. The total cost of the modifications was £150 000, excluding ozone treatment,although some small extras may result from ongoing remedial work. During the monitoring period maintenance costs of about £2000 were incurred. Assuming mainenance costs of this order each year and a gas price of 32.8p/therm, which applied during the monitoring period, the energy savings achieved represented a financial benefit of nearly £33 000/year giving a simple payback period of about 4.8 years.

Had the system been operated as a gas engine heat reclaim heat pump to supply total pool air and water heating needs, then the annual consumption would have dropped further to around 23 000 therms so that savings of some 115 000 therms/year or £37 950/year could have been made. This would have reduced the payback period to around 4.1 years.

Original economic analysis of options

Option	Estimated capital cost £	Predicted annual operating cost £
Original arrangement	–	75 000
Electric heat pump	169 000	60 000
Gas engine heat pump	177 700	51 700
Electric heat pump dehumidifier	170 000	34 900
Gas engine driven heat pump humidifier	178 700	28 400
Extract air heat recovery	135 000	52 300
Direct fired air heater	50 000	65 000
Direct fired air heater with heat recovery	155 000	46 600

Comparison of old and new systems

System	Energy required GJ	Cost/GJ £	Cost/pa £
Original	14 600	3.12	45 592
Present	4 040	3.12	12 620

Summary of data

Date of completion
November 1982

Capital cost of modifications
£150 000

Area of pools
510m²

Delivered annual energy consumption
Total: 4040 GJ

Primary annual energy
4322.8 GJ

Annual running cost
£12 620

Investment cost for remedial work
£150 000

Payback period
4.8 years allowing for maintenance

Savings achieved
100 000 therms/year
£33 000/year

Case study 7 : Shrewsbury library

Project credits

Title and address
Shrewsbury library
Castle Gates, Shrewsbury, Shropshire

Client
Shropshire County Council
The Shirehall, Abbey Foregate, Shrewsbury
SY2 6ND

Architects
John V Bunker, County architect

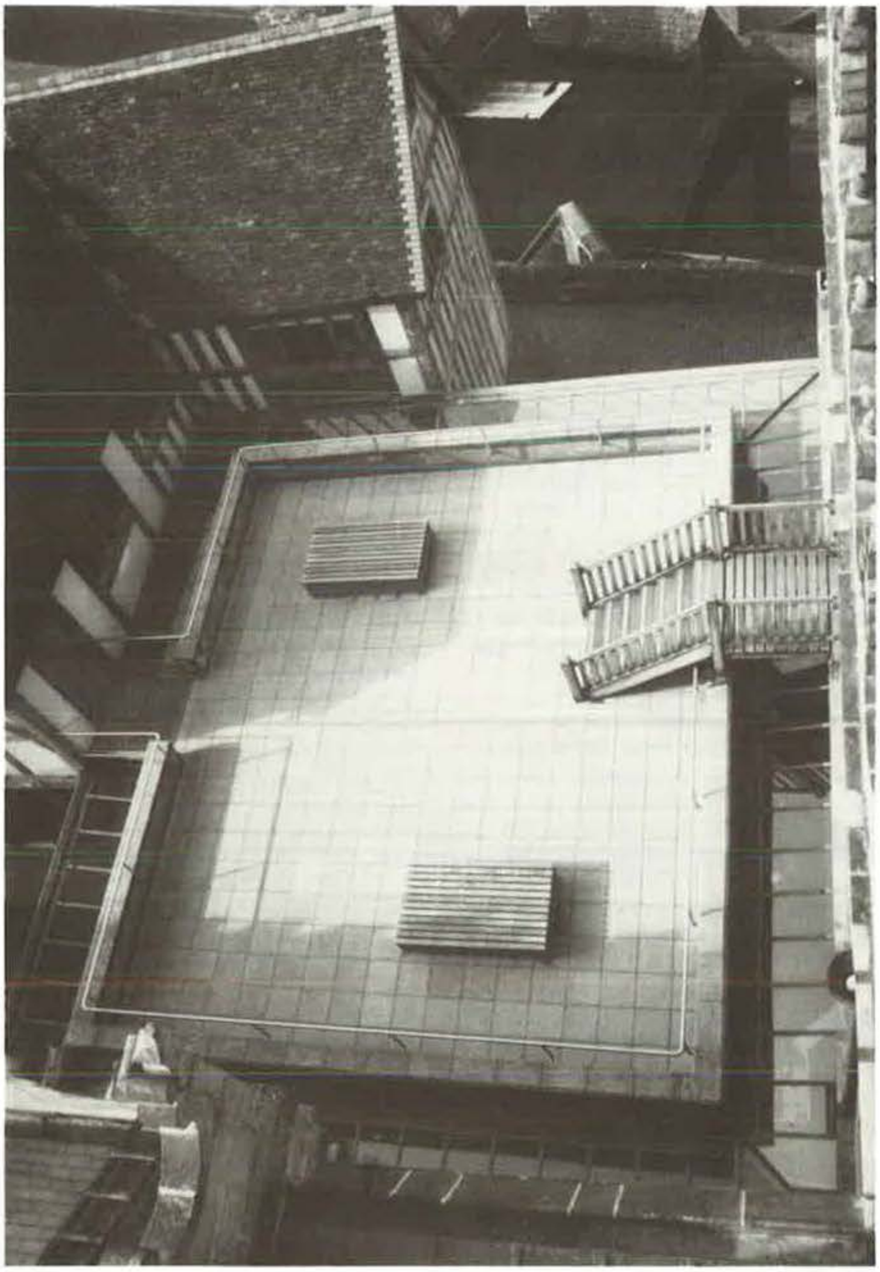
Building services engineers
L Etheridge, Principal mechanical engineer
P Flude, Principal electrical engineer
County architect's department

Origin of project

Building services had to be integral with the building fabric and furnishings, with energy conservation being a significant consideration. Other important considerations were to provide flexibility and the need to be in keeping aesthetically with historic, architectural and public requirements.

Design solution

The refurbishment of what were formerly the original Shrewsbury School buildings, parts of which are over 400 years old, involved extensive structural and architectural re-instatement and the replacement of all building services to satisfy the requirements of the Historic Buildings Council and to make the whole function as a lending, reference and local studies library for the town. Energy conservation measures included zone controls, supply/recirculation air controls, upgrading of the thermal insulation of the building and the selection of the most efficient light sources.

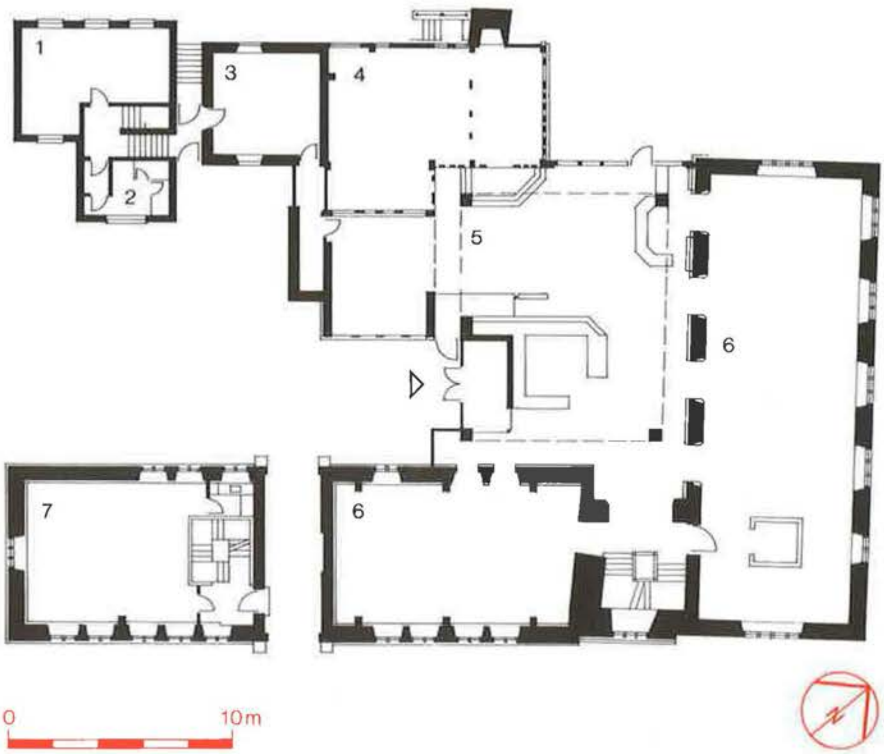


Shropshire County Council

Method of estimating energy requirements
Methods adopted for assessing energy demand were internal to the office.

Energy targets
Statistically determined performance indicators were used to compare actual performance as a guide only. However the actual energy consumption and performance in relation to CIBS Energy Code Part 4, table A6.1, is as follows:
Thermal, space heating and hot water service – 0.62GJ/m² – good.
Electrical, high level of illuminance plus architectural highlighting and external floodlighting – 0.23/GJ/m² – poor.
Actual energy consumption:
Electricity – 430 GJ
Gas – 1450 GJ

Section



Ground floor plan

Key
1 caretaker
2 staff
3 clerical workroom
4 children's library
5 main entrance
6 popular adult lending
7 Hobbs room
8 storage

Summary of data

Date of completion June 1983	
Capital cost £2 250 000	
Gross floor area 2170m²	
Cost per m² £1037	
No of persons 20 permanent 5000 visitors per week	
Delivered annual energy consumption	
Total:	1880 GJ
Per m²	0.87 GJ
Primary annual energy 1.47 GJ/m²	

Shropshire County Council

Energy design features

The challenge at Shrewsbury was to conserve a group of old buildings, to turn them into a first rate library, and to do so in the light not only of building conservation but also of energy conservation. The introduction of a link block, on the site of the old courtyard, was a major contribution. What is interesting is that energy has been conserved wherever possible but not to the detriment of the project. A high level of lighting was required for library purposes, highlighting of architectural features and external floodlighting have been used, which taken together with long opening hours and some essential air conditioning has led to a 'poor' rating in terms of electrical consumption. Since energy features have been tailored to both the function and the variable fabric of the buildings only one of the buildings can be described.

A new main entrance, with maximum glazing, links and provides views of existing buildings. To reduce fabric losses it is double glazed. Lighting is provided by fluorescent luminaires of ceiling module width to give general illumination and to incorporate safety lighting. Around the edge is a lighting track to pinpoint wall hung signs and displays. Special attention was paid to the thermal performance of the roof. Input/extract air handling units are located between roof beams and cowls concealed by oak seats. The plant incorporates automatic control of temperature, with winter operation of 75% recirculation and mechanical extract for summer cooling. Distribution was achieved by a linear slot diffuser incorporating supply, recirculation and extract.

Energy management

1 A number of heating zones are independently controlled.

2 Automatic temperature controls are provided to heating/ventilation systems, and individual return-air stats are provided to fan convectors.

3 Gas and electricity utility meters are supplied but no sub-meters, which would be neither appropriate nor advantageous.

Case study 8 : Glasgow Burrell collection

Origin of project
Sir William Burrell (1861-1958) was a Clydeside ship-owner who gifted his Collection of Art to the City of Glasgow. In return the City agreed to provide a new building for the Collection to be both enjoyed and protected from time to come.

The Collection was formed from Europe, the Middle and the Far East. It consists of stone windows and doorways, carved screens, a timber ceiling, furniture, tapestries and carpets, stained glass, paintings and drawings, and objects of stone, timber, metal, porcelain and glass. It has breadth of time, of scale and of subject.

Sir William also required his three main rooms at Hutton Castle, the residence at Berwick on Tweed to which he retired, to be reproduced within the new building.

The site is a field surrounded by trees and woods in Pollok Park, 3 miles south-west of Glasgow.

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Project credits

Title and address
Burrell collection,
Pollok Park, Glasgow

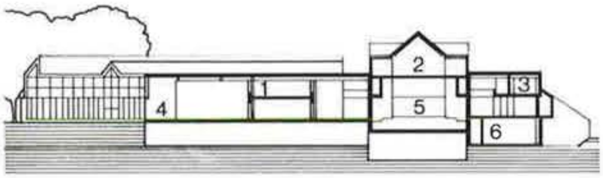
Client
City of Glasgow District Council

Architects
Barry Gasson
150 Ingram Street, Glasgow G1 1EJ

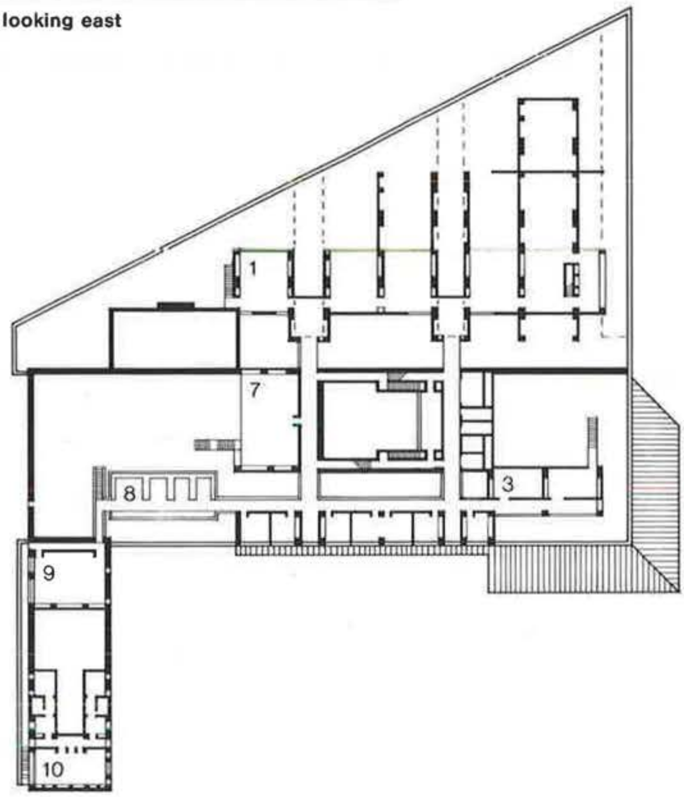
Building services engineers
James R Briggs and Associates
Tollington House, 598-602 Holloway Road
London N19 3PH

Key

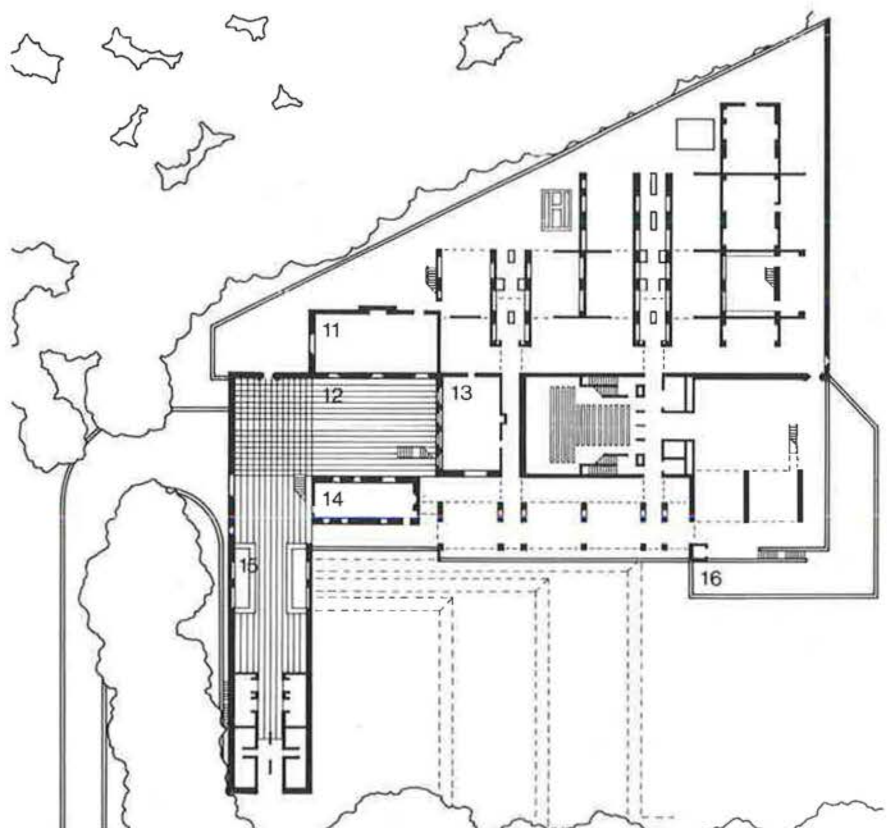
1 study room
2 restorer
3 offices
4 galleries
5 theatre
6 workshop
7 school room
8 library
9 creche
10 flat
11 Hutton drawing room
12 courtyard
13 Hutton hall
14 Hutton dining room
15 sales
16 restaurant



North-south section looking east



Mezzanine plan



Ground floor plan

0 10m

N

Design solution

The building itself at this point in time has to bridge a cultural gap probably wider than ever before, and this thought directed those initial concepts.

Firstly, the Collection should have a feeling of belonging and each subject should have its place.

Secondly, there should be a way of seeing, on a visit, all or only part of the Collection, and that through vistas or interconnecting spaces not only might different parts of the Collection be seen in varying relationship with each other, but that throughout, the philosophy of the display and the integrity of the whole also be understood.

Thirdly, the external world should penetrate the building, the changing seasons and the changing day. The glass edges and the daylit galleries enable natural light in varying and controlled qualities to pervade the whole building. The building against the trees would enable the inside and the outside to become one, and for objects to be seen and considered in a natural context – to make them both a delight to behold and to suggest the essence of their being.

To support these thoughts the building is of materials, that while of necessity used current technology, have associations that are timeless and traditional. Hence the use of stone, timber and plaster, plus areas of carpet to articulate the whole, and into this building fabric is woven the complex systems that control light and air and provide protection.

The display of the Collection is primarily on one level, the level of entry and the surrounding woods, but in total the building is a full working museum with spaces also for the dissemination, conservation and protection of the objects.

However, it has been these aspects of display that have been the most intriguing, working with objects out of time and place, yet hoping to make richer the experience of each object and the Collection as a whole.

Method of estimating energy requirements

The method adopted to establish the energy demand was the production of a full energy audit for each energy consuming item for each month of the year. This was prepared mainly by manual methods but also checked against figures produced by the Electricity Council Building Energy Estimation computer program (BEEP), where the program was applicable.

Energy targets

Energy targets as such were not considered but individual components were costed and the energy consumption taken into account in the decisions made. Estimated annual energy consumption was as follows:

Heating and hot water	1300 MWh
Cooling	600 MWh
Fans and pumps	2200 MWh
Lighting	1100 MWh
Catering and miscellaneous	200 MWh
Total	5400 MWh

Energy design features

The construction of the building is a reinforced concrete shell basement housing the collection storage, the plant rooms and workshops on top of which the exhibition area is constructed of laminated timber beams, stone walls and a significant proportion of glazing.

The engineering services affecting energy consumption comprise full air conditioning to about 90% of the accommodation, meaning control of temperature, generally to 19 $\pm$ 1°C, and relative humidity to 60 $\pm$ 5% RH, lighting, both general and display, domestic hot water, kitchen equipment and a fully automatic control system with supervisory computer.

For a museum the temperature and humidity need to be maintained within the net tolerances 24 hours a day, 365 days per annum, but everything else varies. The weather varies, of course, but so also do the number of people present from densely packed crowds to no-one at all. Another significant variable is the degree of display lighting which is needed for any particular exhibit arrangement.

The installed systems result from a study of the "least", "mean" and "greatest" likely situations with local capacities being selected for the greatest situation, control plant for the mean condition and automatic controls to set for the whole range of conditions.

An all electric building was adopted because the energy consumption was primarily in lighting, cooling and fans with no heat as such needing to be added for the "greatest" situation. Nonetheless, it is an expensive primary energy source and the energy flows of each item were carefully examined and selected for minimum energy consumption. To do this the energy paths were studied commencing from the incoming high voltage electricity supply. All of this energy transforms into heat within the air conditioned spaces, in transmission routes, in plant areas or by losses to outside.

Superimposed on the energy implications is the need for maximum cleanliness which requires maximum recirculation of

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air and the reduction of external air (and dust) entry to the minimum, consistent with a fresh invigorating atmosphere for people.

The features of the building and energy systems designed to respond to these parameters include high quality glazing seals, which are designed to limit air infiltration to a maximum of 8 hours per air change; temperature control in small local areas so as to "follow" large groups of people as they pass from one area to another; air flow balance between one area of the building and another, and many other features too numerous to catalogue in this brief case study.

Cost effectiveness
The significant factor that emerged from the study to produce the energy demand was the cost of energy for fans, lighting and mechanical refrigeration exceeded the cost of space heating and led to a decision to have an all electric building. In the detailed design the factors that were considered were double and triple glazing, high thermal insulation of the roof and solid walls, the limitation of the fresh air quantity which should be compatible with the occupancy in the exhibition areas and the use of *free cooling* in other areas, as much as possible. It is not possible to particularly quantify a saving of energy but it can be reported that the current energy consumption is about 80% of that predicted as the likely consumption under mean operating and external weather conditions. It can also be reported that the building was given the Chartered Institution of Building Services 1984 Award for energy use in the class Buildings for leisure, in which the judging panel noted the energy consumption is comparable to many intermittently used office buildings; that is, the project demonstrates that tight environment control can be achieved with comparatively low energy use.

Energy management
One of the major configurations adopted to reduce the consumption of energy was to arrange for the plant to be switched off during unoccupied hours but with automatic override controls to bring the plant on again in the event of the internal conditions moving outside of the set tolerance range. That is, maximum use is made of the building thermal mass and permitted temperature swings to reduce the operating times of fans and pumps, which are major energy users. Another feature incorporated was the use of the main refrigeration machine as a heat pump by the incorporation of double bundle condenser coils and the introduction of low and high temperature heating circuits.

Summary of data

Date of completion
March 1982

Capital cost
£16 500 000 (1983)

Gross floor area
14 500m²

Number of persons
Permanent: 50
Visitors: 1 million p.a.

Cost per m²
£1066

Area per person
14.4m²

Delivered annual energy consumption

Total:	4 700 000 kWh
Per m²:	326 kWh
Per person:	4700 kWh/ (average person present)

Appendix : Energy efficiency in building – main official and professional bodies

Four Professions Energy Group

The Group comprises representatives from the Chartered Institution of Building Services Engineers, the Chartered Institute of Building, the Royal Institute of British Architects and the Royal Institution of Chartered Surveyors.

Its principal objectives are:

1 to assess the implications of national energy policy for the construction industry;

2 to co-ordinate the long and short term strategies of the four professions with regard to energy conservation;

3 to identify areas in which research work is required, encourage suitable bodies to undertake such research and help to disseminate the results for the benefit of the nation;

4 to assist in the translation of research results into practical solutions to improve energy efficiency in buildings.

The Group welcomes all initiatives to further these objectives and initial contact may be made through any of the constituent bodies.

An *Energy Newsletter* is produced periodically which lists forthcoming events, new publications etc. and copies may be obtained through the Energy Department of the RIBA.

Building Research Establishment

These are a small selection of available BRE publications on energy (minimum order £2).

Information Papers Price 75p each
IP 6/85
Selection of building management systems.
IP 7/85
The cost effectiveness of heat pumps in highly insulated dwellings.

Digests Price £1.00 each
No. 191
Energy consumption and conservation in buildings.
No. 272
Lighting controls and daylight use.
No. 297
Surface condensation and mould growth in traditionally built dwellings.

Reports
SO 018
Solar heating systems for the UK: design, installation and economic aspects. £6.00
BR 043
Cavity insulation of masonry walls. £1.50
BR 047
The BRE low-energy office. Free
BR 058
An economic assessment of some energy conservation measures in housing and other buildings. £12.00
BR 066
BREDEM – BRE domestic energy model. £9.00

Microcomputer package
AP 005
BRE-ADMIT. Prediction of building temperatures and heating/cooling loads using the admittance method. £115 inc. VAT.

Further titles on Energy are listed in the classified BRE Information Directory price £5. This and our regular Information Paper, Digest and Defect Action Sheet series are also available on annual subscription. For details write to the above address.

Publications Sales Office
Garston Watford WD2 7JR
Telephone (0923) 674040

British Standards Institution

Publications
BS 8207, British Standard Code of practice for energy efficiency in buildings, was published by the British Standards Institution on 30 August 1985.

This is the first British Standard to be produced to promote energy efficiency in buildings and to provide a basis on which designers of buildings and their clients can work to achieve this aim. Other Codes of practice will deal more fully with specific building types.

BS 8206: Part 1: Code of practice for artificial lighting was published on 30 September 1985. Other parts of BS 8206 will deal with sunlight and daylight.

Related codes of practice in this area are: BS 5250: 1975 Code of basic data for design of buildings: the control of condensation in dwellings. This is currently being revised.

BS 5925: 1980 Code of practice for design of buildings: ventilation principles and designing for natural ventilation. A revision of this standard will be undertaken in the near future.

2 Park Street, London W1A 2BS

1986 will be the most important year for energy since the discovery of North Sea Oil.

(Because in the 5 seconds it took to read this headline, Britain wasted another £1000 worth of energy.)

Over £200 every second. £19 million every day. £7 billion every year. That's the rate at which Britain wastes energy.

Which is why 1986 is <u>Energy Efficiency Year.</u> And if every business makes the effort, industry will cut its costs by £1 billion in the first year alone.

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