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John Littler and Randall Thomas
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CAMBRIDGE URBAN AND ARCHITECTURAL STUDIES

8 DESIGN WITH ENERGY
THE CONSERVATION AND USE OF ENERGY IN BUILDINGS

CAMBRIDGE URBAN AND ARCHITECTURAL STUDIES

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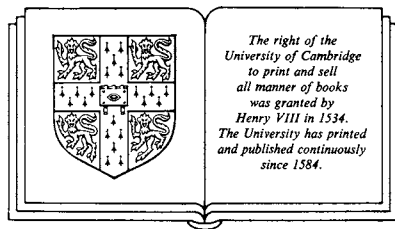
Design with energy

The conservation and use of energy in buildings

JOHN LITTLER

and

RANDALL THOMAS



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For David Bullett and Michèle Thomas

Contents

<i>Units, symbols, abbreviations, conventions and conversion factors</i>	<i>page</i> xi
<i>Preface</i>	xv
1 Energy and buildings	1
1.1 Introduction	1
1.2 Energy and the built environment – past and present	2
1.3 Energy and the built environment – the future	5
2 Site planning and analysis	14
2.1 Introduction	14
2.2 Solar radiation	16
2.3 Wind	24
2.4 Soil	33
3 Building design	42
3.1 Introduction	42
3.2 Energy demand and thermal response	42
3.3 The internal environment	47
3.3.1 Comfort	47
3.3.2 Temperature	48
3.3.3 Room air movement, ventilation and relative humidity	52
3.4 Size and type	59
3.5 Form and orientation	60
3.6 External and internal layout	67
3.7 Construction – general	70
3.8 Foundations and walls	76
3.9 Floors	83
3.10 Windows	84
3.11 Doors	87
3.12 Ceilings and roofs	88
4 Passive solar design	97
4.1 Introduction	97
4.2 Elements of passive solar systems	100
4.2.1 Glazing	100
4.2.2 Single and multiple glazing	103
	vii

viii	<i>Contents</i>
4.2.3 Insulating blinds and shutters	109
4.2.4 Shading	116
4.2.5 Radiation enhancement using reflectors	117
4.2.6 Thermal storage	118
4.3 Passive solar heated buildings	123
4.3.1 Direct gain	123
4.3.2 Attached sun spaces	128
4.3.3 Thermal storage walls	137
4.3.4 Roof ponds	144
4.3.5 Roof-space collectors	146
4.3.6 Convective loops	147
4.4 Design methods for passive solar buildings	148
4.4.1 Introduction	148
4.4.2 Characteristics of a perfect design model	150
4.4.3 Models approaching the desired degree of flexibility	150
5 Active solar heating	159
5.1 Introduction	159
5.1.1 Definitions	159
5.1.2 Popularity of solar heating	159
5.1.3 Outline of the active systems	159
5.1.4 Approximate energy available	160
5.1.5 Hot water compared to hot water + space heating	161
5.2 Solar air heating	161
5.2.1 Collectors	162
5.2.2 Air to water heat exchangers	163
5.2.3 Dampers	163
5.2.4 Auxiliary energy	163
5.2.5 Pebble beds	163
5.2.6 Controls	165
5.2.7 Results of monitored systems	170
5.3 Solar water heating	171
5.3.1 Outline of systems	171
5.3.2 Collectors	173
5.3.3 Pumps	175
5.3.4 Heat exchangers	175
5.3.5 Thermal storage	175
5.3.6 Drain-down valves	176
5.3.7 Transfer fluid	176
5.3.8 Controllers	177
5.4 New types of system	177
5.4.1 Evacuated tubes	177
5.4.2 Plastic collectors	177
5.4.3 Zeolite heating and cooling collectors	178
5.4.4 Refrigerant-charged loop	178
5.5 Installed systems	179
5.6 Multifamily installations	182

<i>Contents</i>	ix
5.7 Predictive methods	182
6 Space heating and ventilation	189
6.1 Introduction	189
6.2 Solid-fuel heating	196
6.3 Water-distribution systems	205
6.4 Forced-air systems	217
6.5 Heating with electricity	225
6.6 Heat pumps	228
6.7 Group schemes	234
6.8 Conclusion	236
7 Thermal storage	241
7.1 Introduction	241
7.2 Sensible-heat storage in water	243
7.3 Sensible-heat storage in rock	249
7.4 Phase-change energy storage	252
7.5 Developments in storage	255
7.6 Conclusion	258
8 Wind energy	262
8.1 Introduction	262
8.2 Power extracted by turbines	264
8.2.1 Power in the wind	264
8.2.2 Variation of wind speed with location	264
8.2.3 Variation of wind speed with height	267
8.3 Power extracted by real turbines	268
8.4 Types of turbine	270
8.5 Electrical generation	278
8.5.1 Electrical generators	278
8.5.2 Gearboxes	280
8.5.3 Electricity storage	280
8.6 Use of wind-generated electricity	282
8.6.1 AC or DC?	282
8.6.2 Inverters	283
8.6.3 Thermal storage	283
8.7 Economies of scale	284
8.8 Installed systems	284
8.8.1 Conservation house at NCAT	284
8.8.2 Wind-powered cottage at NCAT	287
9 Water-supply systems	289
9.1 Introduction	289
9.2 The Cambridge Autarkic House water-supply system	290
10 Waste disposal and utilization	293
10.1 Introduction	293
10.2 Aerobic systems	294

x	<i>Contents</i>
10.3 Anaerobic systems	295
10.4 Methane digestion	296
11 Domestic-energy saving	304
11.1 Introduction	304
11.2 Domestic hot water	304
11.3 Electrical power	306
11.4 Cooking	307
11.5 Space heating	308
11.6 Transportation	308
12 Housing case studies	310
12.1 Introduction	310
12.2 New houses – three solar air-heated houses in Peterborough	310
12.3 New houses – energy-efficient houses in Newnham, Cambridge	315
12.4 Rehabilitated houses – renovation of a farmhouse to include a sun space (contributed by Peter Clegg)	317
12.5 Rehabilitated houses – house conversion incorporating a roof-space collector (contributed by Peter Clegg)	319
12.6 Rehabilitated houses – a nineteenth-century terraced house	322
13 Non-domestic case studies	326
13.1 Introduction	326
13.2 The swimming pool, Sheiling Schools	326
13.3 The new BRS office building	328
13.4 Agricultural buildings	329
13.5 School buildings (contributed by Nick Baker)	330
Appendix 1: Weather data	342
A 1.1 Introduction	342
A 1.2 Solar spectrum	342
A 1.3 Global solar radiation data for the UK – Kew and Bracknell	343
A 1.4 Global solar radiation data on the horizontal for three UK stations	343
A 1.5 Direct and diffuse solar radiation for Kew, UK	343
A 1.6 Temperature data for the UK	344
A 1.7 Wind data	344
Appendix 2: Thermal performance	347
Appendix 3: Interstitial condensation	358
<i>Index</i>	363

Units, symbols, abbreviations, conventions and conversion factors

(1) Principal units

(In some cases a base unit is combined with a multiplier because this is its most common form.)

°C	degree Celsius
d	day
g	gram
h	hour
ha	hectare
J	joule
K	degree kelvin
kcal	kilocalorie
l	litre
MTCE	megatonnes of coal equivalent
m	metre
mb	millibar
N	newton
p	person
Pa	pascal (N/m ²)
ppm	parts per million
s	second
t	tonne
V	volt
W	watt

The principal units are frequently used with the following multiples and submultiples:

10 ⁻¹	deci	d	10	deca	da
10 ⁻²	centi	c	10 ²	hecto	h
10 ⁻³	milli	m	10 ³	kilo	k
10 ⁻⁶	micro	μ	10 ⁶	mega	M
10 ⁻⁹	nano	n	10 ⁹	giga	G

(2) Symbols

(Where two meanings are given, the correct one should be evident from the context of the chapter.)

A	area
C_v	ventilation heat loss
c_p	specific heat; power coefficient of wind turbine
E	energy
G	mean rate of moisture emission; gust ratio
g_i	mean inside moisture content
g_o	mean outside moisture content
H	effective height
I	insolation
k	extinction coefficient
N	number of room air changes per hour
ΔP	indoor–outdoor vapour pressure difference
Δp	pressure drop between points (of an element of construction)
q	energy transferred to the water in a solar collector
R	thermal resistance
r_t	individual thermal resistance
r_v	vapour resistance
T	temperature
t_{ai}	inside air temperature
t_r	mean radiant temperature
t_{res}	dry resultant temperature
Δt	temperature drop
U	thermal transmittance
V	wind speed, volume
v	indoor air speed, volumetric rate of air change
Y	admittance
ρ	density
θ	tilt angle
μ	absolute viscosity

(3) Abbreviations

AIA	American Institute of Architects
BRE	Building Research Establishment
BRS	Building Research Station
BSS	British Standard Specification
CIBS	Chartered Institution of Building Services (formerly IHVE)
CSTC	Centre Scientifique et Technique de la Construction
IHVE	Institute of Heating and Ventilation Engineers
PCL	Polytechnic of Central London
RIBA	Royal Institute of British Architects

Units, symbols and abbreviations

xiii

(4) Conventions

$\sqrt{(3X)}$ denotes the square root of $3X$.

(5) Conversion factors

Length

1 cm = 0.394 in.

1 m = 3.281 ft

Area

1 m² = 10.76 ft²

1 ha = 2.471 acre

Volume

1 m³ = 35.31 ft³

1 l = 0.2642 gallons (US) = 0.220 gallons (UK)

Mass

1 kg = 2.205 lb

Density

1 kg/m³ = 0.062 lb/ft³

Force

1 N = 0.2248 lb (force)

Pressure

1 Pa = 0.004 in. H₂O

1 kPa = 0.145 psi

Energy, work, heat

1 kJ = 0.948 Btu

1 kWh = 3414 Btu

1 GJ = 278 kWh

1 therm = 105.5 MJ

1 tonne coal equivalent (TCE) = 26.4 GJ

1 tonne oil equivalent = 44.7 GJ

Power

1 kW = 1.341 hp

Heat flux

1 W/m² = 0.317 Btu/(ft² h)

Thermal conductivity

1 W/(m K) = 0.578 Btu/(ft² h °F)

Heat transfer coefficient

$$1 \text{ W}/(\text{m}^2 \text{ K}) = 0.176 \text{ Btu}/(\text{ft}^2 \text{ h } ^\circ\text{F})$$

Specific heat

$$1 \text{ kJ}/(\text{kg K}) = 0.239 \text{ Btu}/(\text{lb } ^\circ\text{F})$$

Temperature

$$^\circ\text{C} = (5/9) (^\circ\text{F} - 32)$$

Temperature intervals

$$1 \text{ } ^\circ\text{C} = 1.8 \text{ } ^\circ\text{F}$$

Preface

The authors have rendered a valuable service to the building industry by the preparation of this volume with its wealth of actually built, rather than projected, examples. The book is well and soundly written with its emphasis maintained from start to finish on their basic theme, the necessity for the use in buildings of energy in many forms and the increasing desirability of learning how to minimize the use of non-renewable forms of energy in meeting those essential needs. Directed primarily towards architects, builders and owners in the United Kingdom, and consequently written within the scope of SI units, the book will be helpful to all who plan to build in latitudes north of the 50th parallel, where winter heating is more important than summer cooling.

Proper ventilation and the admission of outdoor air under suitable circumstances are not neglected, however. Building design features which are recommended by the authors are liberally illustrated by photographs and drawings of residential, institutional and commercial structures which actually exist. The soundness of their recommendations has been verified in most cases by the first-hand knowledge of the authors.

Many of the 'Energy' books which have appeared in recent years have dealt almost exclusively with non-renewable forms such as the wind and the sun. These are not neglected here but their applicability is subjected to careful and objective analysis, with the intent of giving guidance which is based upon knowledge and experience rather than upon enthusiasm alone.

The reader may well divide the book into three sections. The first, Chapters 1 through 3, deals with energy and the built environment, the building site and its energy attributes and with a general discussion of building design principles. The second section, Chapters 4 through 7, is devoted to space heating by passive and active solar systems, to conventional space heating and to thermal storage as it can be accomplished with the three currently available materials, water, rocks and phase-change substances. The third section, Chapters 8 through 13, discusses wind energy, water supply and waste disposal, energy conservation in the home and case studies for built and operating residential and institutional structures.

The appendices are filled with useful data pertaining to the atmospheric temperatures and solar intensities which prevail throughout the UK. The concluding appendix is particularly pertinent, since it deals quantitatively with the amount of moisture which is added to the indoor environment by the occupants. This is an aspect of design which is all too often overlooked

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Frontmatter

[More information](#)

xvi

Preface

until it is encountered by the individuals whose cooking, cleaning, bathing and breathing are responsible for the rise in indoor vapor pressure.

The literary styles of the two authors are so similar that the book is a first-rate example of collaboration, with each writer contributing the material with which he is most familiar. A convenient list of conversion factors is included for the assistance of readers to whom SI units are still unfamiliar. *Design with energy* is destined to become a valuable addition to the libraries of both professionals and owners who are concerned with the use and conservation of energy in buildings.

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