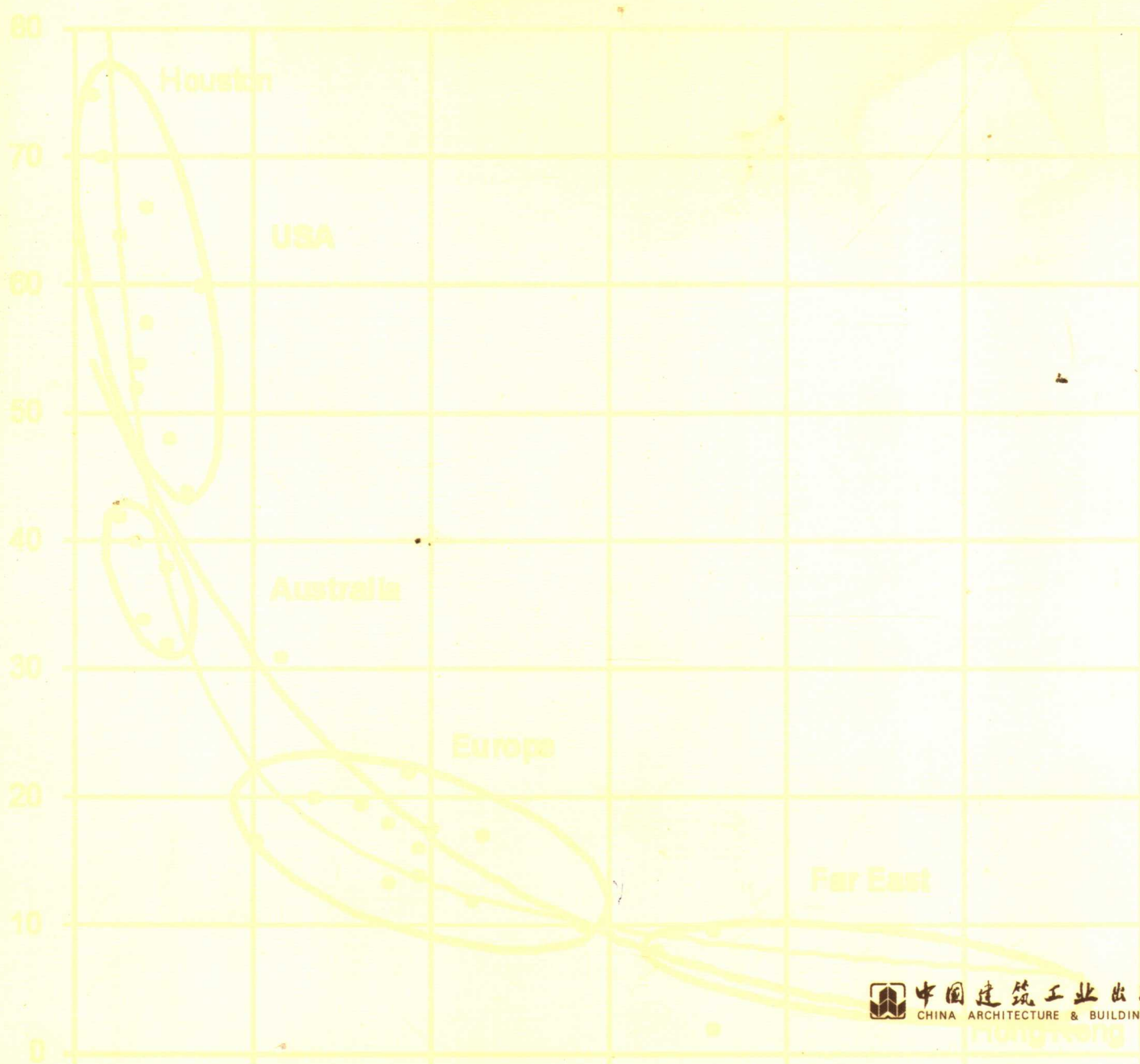


# Sustainable Urban and Architectural Design

## 可持续城市与建筑设计 (中英文对照版)

Runming Yao, Koen Steemers, Baizhan Li

姚润明 昆·斯蒂摩司 李百战 著



中国建筑工业出版社  
CHINA ARCHITECTURE & BUILDING PRESS

# 可持续城市与建筑设计 (中英文对照版)

---

*Sustainable Urban and Architectural Design*

姚润明 昆·斯蒂摩司 李百战 著

Runming Yao, Koen Steemers, Baizhan Li

中国建筑工业出版社

## 图书在版编目(CIP)数据

可持续城市与建筑设计(中英文对照版)/姚润明, 斯蒂摩司, 李百战著. —北京: 中国建筑工业出版社, 2006

ISBN 7-112-08099-1

I. 可... II. ①姚... ②斯... ③李... III. 城市—可持续发展—能效  
建筑—建筑设计—中、英 IV. TU201

中国版本图书馆 CIP 数据核字(2006)第 012318 号

这是一本面向中国读者的、全面论述了可持续建筑设计关键问题的著作。全书共 4 章: 第 1 章介绍了气候变迁的影响, 以及在可持续城市与建筑设计中, 建筑专业人员所面临的挑战和应起的作用。同时也介绍了中国建筑能源消耗的一些信息; 第 2 章主要介绍城市设计问题。如城市形态、城市密度和城市微气候, 并讨论了能源供求以及城市舒适问题; 第 3 章主要介绍能效建筑设计。首先, 作者介绍了建筑设计的气候条件与舒适及工效问题。然后介绍了能效建筑设计的理念与方法, 如建筑围护结构、自然通风、太阳能利用、自然采光以及可再生能源等。最后, 作者介绍了新开发的建筑方案设计工具; 第 4 章介绍了世界上可持续城市与建筑设计和营建方面的实例。这些最佳实例既有新建建筑, 也有现存建筑, 既有单体建筑, 也有大型社区。主要涵盖的建筑类型有: 办公建筑、学校建筑、宾馆建筑, 以及住宅建筑。主要的地理位置及气候特征涵盖了中国建筑热工设计的大部分气候区。

责任编辑: 戚琳琳

责任设计: 郑秋菊

责任校对: 王雪竹 关 健

## 可持续城市与建筑设计(中英文对照版)

Sustainable Urban and Architectural Design

姚润明 昆·斯蒂摩司 李百战 著

\*

中国建筑工业出版社出版、发行(北京西郊百万庄)

新华书店经销

制版: 北京嘉泰利德制版公司

北京建筑工业印刷厂印刷

\*

开本: 880 × 1230 毫米 1/16 印张: 17 $\frac{3}{4}$  字数: 600 千字

2006 年 3 月第一版 2006 年 3 月第一次印刷

印数: 1—3,500 册 定价: 48.00 元

ISBN 7-112-08099-1

(14053)

版权所有 翻印必究

如有印装质量问题, 可寄本社退换

(邮政编码 100037)

本社网址: <http://www.cabp.com.cn>

网上书店: <http://www.china-building.com.cn>

# 前 言 Preface

21 世纪初始, 气候变迁已成为世界面临的最大挑战之一。由于化石燃料的燃烧所带来的温室气体排放被认为是造成全球变暖的主要原因。目前, 中国的建筑能耗已占到总能耗的 28%, 预计到 2010 年将上升到 1/3。大量的经验表明通过能效建筑设计可以达到显著的节能效果, 因此, 可持续城市与建筑设计在温室气体减排与环境保护方面将起着重要作用。本书旨在介绍可持续城市与建筑设计方面的理念、方法、技术以及优秀实例。本书可作为建筑学、城市规划、建筑环境与设备工程专业学生的参考书或专业英语教材, 同时也可作为设计及工程技术人员的设计指南。

Climate change is one of the major challenges facing the world at the start of the 21st century. Greenhouse gas emissions due to the burning of fossil fuel are considered the main cause of global warming. China's buildings sector currently accounts for 28% of China's total energy use and is projected to increase to one-third by 2010. Experience has shown that significant energy savings in buildings can be achieved through energy efficient design, therefore sustainable urban and architectural design will play an important role in mitigating emissions and environmental protection. This book aims to introduce the concept, methods, technologies and best practice examples of sustainable urban and architectural design. It can be used as a reference book or a specific course English language teaching material for Chinese students of architecture, urban planning, building services and environmental engineering. It can also be used as design guidance for architectural and engineering professionals.

## 资助单位



Foreign &  
Commonwealth  
Office



UNIVERSITY OF  
CAMBRIDGE



重庆大学  
CHONGQING UNIVERSITY

## 项目顾问

Nicola Willey (英国驻北京大使馆第一秘书)

王蕾 (英国驻北京大使馆全球机遇基金项目总管)

## 项目团队

剑桥大学 (英国):

姚润明

Koen Steemers

Samantha Lawton

郝 林

重庆大学 (中国):

李百战

刘 猛

乐 勇

李 楠

刘晓东

丁 勇

白雪莲

罗 庆

刘 红

杨明宇

## 致 谢

本书得到了英国外交部全球机遇基金项目——“中国西部清洁及可再生能源发展与能效建筑设计”的支持。衷心感谢 Samantha Lawton 女士为本书英文进行校核，成镭、李文杰、段胜举、吴明华、潘信峰等的帮助及王建辉的插图制作。感谢乐勇为本书中文进行校核。感谢在资料准备阶段提供支持的人士：英国建筑研究院的 James Fisher、加拿大的 Peter Busby、加拿大房产组织的 Michael Afar、香港大学的许俊明、英国剑桥大学的 Nick Baker。感谢英国特许建筑设备工程师协会 (CIBSE) 的支持。受水平限制，撰写时间仓促，书中难免存在缺点和错误，欢迎读者批评指正。

# Content

## Preface

|                                                        |   |
|--------------------------------------------------------|---|
| <b>Chapter 1 Introduction</b> <i>Runming Yao</i> ..... | 1 |
| 1.1 The problem of climate change .....                | 2 |
| 1.1.1 Action on carbon emission reduction .....        | 3 |
| 1.1.2 Energy and building in China .....               | 3 |
| 1.1.3 Energy and city .....                            | 6 |
| 1.2 Key issues of sustainable development .....        | 6 |
| 1.3 Summary of the book .....                          | 6 |
| References .....                                       | 7 |

|                                                                      |    |
|----------------------------------------------------------------------|----|
| <b>Chapter 2 Sustainable urban design</b> <i>Koen Steemers</i> ..... | 9  |
| 2.1 Introduction .....                                               | 10 |
| 2.1.1 Energy demand .....                                            | 10 |
| 2.1.2 Transport and urban form .....                                 | 13 |
| 2.1.3 Energy and the city .....                                      | 15 |
| 2.1.4 Summary .....                                                  | 23 |
| 2.2 The urban microclimate .....                                     | 23 |
| 2.2.1 The urban heat island .....                                    | 23 |
| 2.2.2 Street canyons .....                                           | 25 |
| 2.2.3 Pollution .....                                                | 27 |
| 2.2.4 Noise .....                                                    | 27 |
| 2.3 Urban morphology .....                                           | 28 |
| 2.3.1 Density .....                                                  | 28 |
| 2.3.2 Form .....                                                     | 28 |
| 2.3.3 Environmental design parameters .....                          | 29 |
| 2.3.4 Renewable solar potential .....                                | 32 |
| 2.4 Urban comfort .....                                              | 34 |
| 2.4.1 Diversity .....                                                | 35 |
| 2.4.2 Mapping comfort .....                                          | 36 |
| Acknowledgements .....                                               | 39 |
| References .....                                                     | 39 |

|                                                                                        |    |
|----------------------------------------------------------------------------------------|----|
| <b>Chapter 3 Sustainable building design</b> <i>Runming Yao &amp; Baizhan Li</i> ..... | 41 |
| 3.1 Climate .....                                                                      | 42 |
| 3.1.1 World climate .....                                                              | 42 |
| 3.1.2 Climatic parameters .....                                                        | 42 |
| 3.1.3 Climate zones for building design .....                                          | 43 |
| 3.1.4 Climate zones in China .....                                                     | 44 |
| 3.1.5 Microclimate and building design .....                                           | 45 |
| 3.1.6 Climatic building design .....                                                   | 45 |
| 3.2 Comfort and productivity .....                                                     | 47 |
| 3.2.1 Thermal comfort .....                                                            | 47 |
| 3.2.2 Factors that influence thermal comfort .....                                     | 47 |
| 3.2.3 Local thermal discomfort .....                                                   | 50 |
| 3.2.4 Evaluation .....                                                                 | 51 |
| 3.2.5 Productivity .....                                                               | 53 |

|                                                              |     |
|--------------------------------------------------------------|-----|
| 3.2.6 Summary .....                                          | 54  |
| 3.3 Strategic design method .....                            | 54  |
| 3.3.1 General .....                                          | 54  |
| 3.3.2 Architectural strategic design .....                   | 55  |
| 3.3.3 The passive zone concept .....                         | 57  |
| 3.3.4 Passive design .....                                   | 57  |
| 3.3.5 Strategic design tool .....                            | 58  |
| 3.3.6 Summary .....                                          | 59  |
| 3.4 Envelope design .....                                    | 59  |
| 3.4.1 General .....                                          | 59  |
| 3.4.2 Insulation .....                                       | 60  |
| 3.4.3 Thermal mass .....                                     | 69  |
| 3.4.4 Airtightness .....                                     | 72  |
| 3.4.5 Summary .....                                          | 73  |
| 3.5 Solar design .....                                       | 73  |
| 3.5.1 General .....                                          | 73  |
| 3.5.2 Useful solar gain - passive solar heating design ..... | 74  |
| 3.5.3 Prevent unwanted solar gain - shading devices .....    | 76  |
| 3.5.4 Summary .....                                          | 77  |
| 3.6 Lighting design .....                                    | 81  |
| 3.6.1 General .....                                          | 81  |
| 3.6.2 Design for daylight .....                              | 81  |
| 3.6.3 Advanced daylighting system .....                      | 83  |
| 3.6.4 Artificial lighting .....                              | 87  |
| 3.6.5 Strategic daylighting design tool .....                | 88  |
| 3.6.6 Summary .....                                          | 90  |
| 3.7 Natural ventilation design .....                         | 91  |
| 3.7.1 General .....                                          | 91  |
| 3.7.2 Design requirement .....                               | 91  |
| 3.7.3 Driving force for natural ventilation .....            | 92  |
| 3.7.4 Natural ventilation types .....                        | 94  |
| 3.7.5 Control of natural ventilation .....                   | 102 |
| 3.7.6 Strategic design tool .....                            | 103 |
| 3.7.7 Summary .....                                          | 105 |
| 3.8 Renewable energy applied in buildings .....              | 106 |
| 3.8.1 General .....                                          | 106 |
| 3.8.2 Solar energy .....                                     | 106 |
| 3.8.3 Wind energy .....                                      | 108 |
| 3.8.4 Geothermal energy .....                                | 109 |
| 3.8.5 Biomass .....                                          | 110 |
| 3.8.6 Summary .....                                          | 110 |
| Acknowledgements .....                                       | 111 |
| References .....                                             | 111 |

|                                                                                   |     |
|-----------------------------------------------------------------------------------|-----|
| <b>Chapter 4 Energy efficient building best practice</b> <i>Runming Yao</i> ..... | 115 |
| 4.0 Introduction .....                                                            | 116 |
| 4.1 BRE office of the future - Garston, UK .....                                  | 116 |
| 4.1.1 Background .....                                                            | 116 |
| 4.1.2 Energy efficient design features .....                                      | 117 |

|                                                           |     |
|-----------------------------------------------------------|-----|
| 4.1.3 Performance .....                                   | 120 |
| 4.2 Commerzbank headquarters - Frankfurt, Germany .....   | 121 |
| 4.2.1 Background .....                                    | 121 |
| 4.2.2 Energy efficient design features .....              | 122 |
| 4.2.3 Performance .....                                   | 124 |
| 4.3 Eco-building - Shanghai, China .....                  | 124 |
| 4.3.1 Background .....                                    | 124 |
| 4.3.2 Energy efficient design features .....              | 125 |
| 4.3.3 Performance .....                                   | 127 |
| 4.4 Berlaymont building in Brussels- refurbishment .....  | 127 |
| 4.4.1 Background .....                                    | 127 |
| 4.4.2 Energy efficient design features .....              | 128 |
| 4.4.3 Summary .....                                       | 129 |
| 4.5 Kadoorie biological science building-Hong Kong .....  | 130 |
| 4.5.1 Background .....                                    | 130 |
| 4.5.2 Energy efficient design features .....              | 131 |
| 4.5.3 Performance .....                                   | 132 |
| 4.6 Low-energy consumption project - Beijing, China ..... | 132 |
| 4.6.1 Background .....                                    | 132 |
| 4.6.2 Energy efficient design features .....              | 134 |
| 4.6.3 Performance .....                                   | 135 |
| 4.7 Hotel and conference centre - Spain .....             | 136 |
| 4.7.1 Background .....                                    | 136 |
| 4.7.2 Energy efficient design features .....              | 137 |
| 4.7.3 Performance .....                                   | 138 |
| 4.8 20 River Terrace - the Solaire, New York, USA .....   | 139 |
| 4.8.1 Background .....                                    | 139 |
| 4.8.2 Energy efficient design features .....              | 140 |
| 4.8.3 Performance .....                                   | 143 |
| 4.9 BedZED-Beddington, UK .....                           | 143 |
| 4.9.1 Background .....                                    | 143 |
| 4.9.2 Energy efficient design features .....              | 144 |
| 4.9.3 Performance .....                                   | 147 |
| 4.10 Sainsbury's supermarket - Greenwich Peninsula .....  | 147 |
| 4.10.1 Background .....                                   | 147 |
| 4.10.2 Energy efficient design features .....             | 148 |
| 4.10.3 Performance .....                                  | 150 |
| 4.11 A City of tomorrow - Sweden .....                    | 150 |
| 4.11.1 Background .....                                   | 150 |
| 4.11.2 Energy efficient design features .....             | 151 |
| 4.11.3 Performance .....                                  | 152 |
| 4.12 Dockside green-Vancouver, Canada .....               | 152 |
| 4.12.1 Background .....                                   | 152 |
| 4.12.2 Energy efficient design features .....             | 153 |
| 4.12.3 Performance .....                                  | 155 |
| Acknowledgements .....                                    | 156 |
| References .....                                          | 156 |



# 目 录

## 前 言

|                                 |     |
|---------------------------------|-----|
| <b>第一章 概论 姚润明</b> .....         | 157 |
| 1.1 气候变迁 .....                  | 158 |
| 1.1.1 温室气体减排行动 .....            | 158 |
| 1.1.2 中国的能源与建筑 .....            | 159 |
| 1.1.3 能源与城市 .....               | 159 |
| 1.2 可持续发展的关键问题 .....            | 160 |
| 1.3 本书概要 .....                  | 160 |
| <b>第二章 可持续城市设计 昆·斯蒂摩司</b> ..... | 161 |
| 2.1 引言 .....                    | 162 |
| 2.1.1 能源需求 .....                | 162 |
| 2.1.2 交通与城市布局 .....             | 164 |
| 2.1.3 能源与城市 .....               | 166 |
| 2.1.4 小结 .....                  | 171 |
| 2.2 城市微气候 .....                 | 172 |
| 2.2.1 城市热岛效应 .....              | 172 |
| 2.2.2 街谷 .....                  | 174 |
| 2.2.3 污染 .....                  | 175 |
| 2.2.4 噪声 .....                  | 175 |
| 2.3 城市形态学 .....                 | 175 |
| 2.3.1 密度 .....                  | 176 |
| 2.3.2 形式 .....                  | 176 |
| 2.3.3 环境设计参数 .....              | 176 |
| 2.3.4 太阳能 .....                 | 179 |
| 2.4 城市舒适性 .....                 | 181 |
| 2.4.1 多样性 .....                 | 181 |
| 2.4.2 舒适性图像 .....               | 182 |
| 致谢 .....                        | 184 |
| <b>第三章 建筑能效设计 姚润明 李百战</b> ..... | 185 |
| 3.1 气候 .....                    | 186 |
| 3.1.1 世界气候 .....                | 186 |
| 3.1.2 气候参数 .....                | 186 |

|       |                  |     |
|-------|------------------|-----|
| 3.1.3 | 建筑热工设计气候分类       | 187 |
| 3.1.4 | 中国建筑热工设计分区       | 187 |
| 3.1.5 | 微气候与建筑设计         | 188 |
| 3.1.6 | 气候建筑设计           | 189 |
| 3.2   | 舒适性与工效           | 189 |
| 3.2.1 | 热舒适              | 189 |
| 3.2.2 | 影响热舒适的因素         | 190 |
| 3.2.3 | 局部热不舒适           | 192 |
| 3.2.4 | 评价               | 193 |
| 3.2.5 | 工效               | 194 |
| 3.2.6 | 小结               | 195 |
| 3.3   | 方案设计方法           | 195 |
| 3.3.1 | 概述               | 195 |
| 3.3.2 | 建筑方案设计           | 196 |
| 3.3.3 | 被动区域概念           | 197 |
| 3.3.4 | 被动设计             | 198 |
| 3.3.5 | 设计工具             | 198 |
| 3.3.6 | 小结               | 199 |
| 3.4   | 围护结构设计           | 199 |
| 3.4.1 | 概述               | 199 |
| 3.4.2 | 保温               | 200 |
| 3.4.3 | 蓄热材料             | 206 |
| 3.4.4 | 气密性              | 209 |
| 3.4.5 | 小结               | 209 |
| 3.5   | 太阳能利用设计          | 209 |
| 3.5.1 | 概述               | 209 |
| 3.5.2 | 有用的太阳得热——被动太阳能设计 | 210 |
| 3.5.3 | 防止不需要的太阳得热——遮阳设施 | 212 |
| 3.5.4 | 小结               | 215 |
| 3.6   | 照明设计             | 215 |
| 3.6.1 | 概述               | 215 |
| 3.6.2 | 自然光照明设计          | 216 |
| 3.6.3 | 先进的自然采光系统        | 217 |
| 3.6.4 | 人工照明             | 220 |
| 3.6.5 | 自然采光方案设计工具       | 221 |
| 3.6.6 | 小结               | 222 |
| 3.7   | 自然通风设计           | 223 |
| 3.7.1 | 概述               | 223 |
| 3.7.2 | 设计要求             | 223 |
| 3.7.3 | 自然通风的驱动力         | 224 |
| 3.7.4 | 自然通风的类型          | 225 |

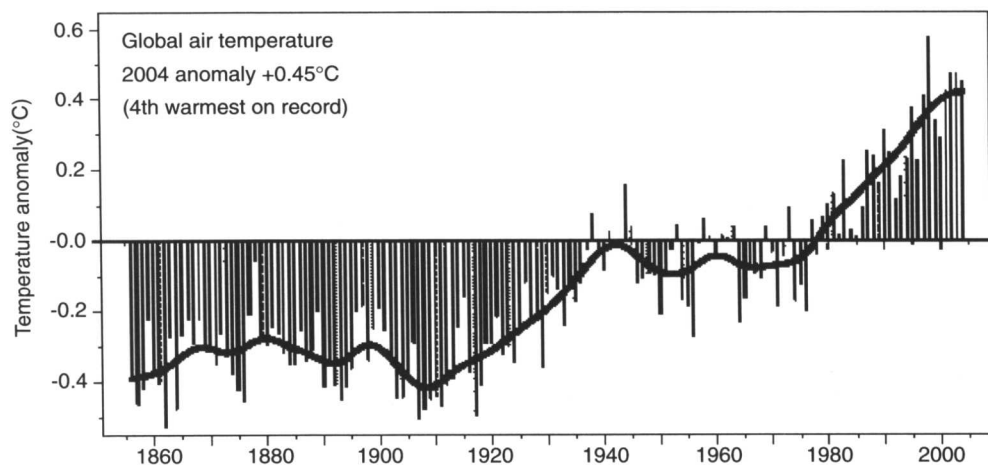
|                                      |     |
|--------------------------------------|-----|
| 3.7.5 自然通风的控制 .....                  | 230 |
| 3.7.6 自然通风方案设计工具 .....               | 231 |
| 3.7.7 小结 .....                       | 232 |
| 3.8 可再生能源在建筑中的应用 .....               | 232 |
| 3.8.1 概述 .....                       | 232 |
| 3.8.2 太阳能 .....                      | 233 |
| 3.8.3 风能 .....                       | 234 |
| 3.8.4 地热能 .....                      | 235 |
| 3.8.5 生物能 .....                      | 236 |
| 3.8.6 小结 .....                       | 237 |
| 致谢 .....                             | 237 |
| <br>第四章 能效建筑设计优秀实例 姚润明 .....         | 239 |
| 4.0 概述 .....                         | 240 |
| 4.1 英国建筑研究院新办公楼——英国加斯顿 .....         | 240 |
| 4.1.1 背景 .....                       | 240 |
| 4.1.2 能效设计特点 .....                   | 241 |
| 4.1.3 性能 .....                       | 243 |
| 4.2 Commerzbank 总部——德国法兰克福 .....     | 243 |
| 4.2.1 背景 .....                       | 243 |
| 4.2.2 能效设计特点 .....                   | 244 |
| 4.2.3 性能 .....                       | 246 |
| 4.3 上海生态楼——中国上海 .....                | 246 |
| 4.3.1 背景 .....                       | 246 |
| 4.3.2 能效设计特点 .....                   | 247 |
| 4.3.3 性能 .....                       | 248 |
| 4.4 布鲁塞尔的议会大厦——改建 .....              | 248 |
| 4.4.1 背景 .....                       | 248 |
| 4.4.2 能效设计特点 .....                   | 249 |
| 4.4.3 小结 .....                       | 251 |
| 4.5 香港大学 Kadoorie 生物科技大楼——中国香港 ..... | 251 |
| 4.5.1 背景 .....                       | 251 |
| 4.5.2 能效设计特点 .....                   | 252 |
| 4.5.3 性能 .....                       | 253 |
| 4.6 北京低能耗建筑——中国北京 .....              | 253 |
| 4.6.1 背景 .....                       | 253 |
| 4.6.2 能效设计特点 .....                   | 254 |
| 4.6.3 性能 .....                       | 256 |
| 4.7 西班牙酒店与会议中心——西班牙 .....            | 256 |
| 4.7.1 背景 .....                       | 256 |
| 4.7.2 能效设计特点 .....                   | 257 |

|                                  |     |
|----------------------------------|-----|
| 4.7.3 性能 .....                   | 258 |
| 4.8 索拉尔湖边联排住宅——美国纽约 .....        | 258 |
| 4.8.1 背景 .....                   | 258 |
| 4.8.2 能效设计特点 .....               | 259 |
| 4.8.3 性能 .....                   | 261 |
| 4.9 英国 BedZED 零能耗社区——美国贝丁顿 ..... | 261 |
| 4.9.1 背景 .....                   | 261 |
| 4.9.2 能效设计特点 .....               | 262 |
| 4.9.3 性能 .....                   | 264 |
| 4.10 森斯伯瑞超市——格林尼治半岛 .....        | 264 |
| 4.10.1 背景 .....                  | 264 |
| 4.10.2 能效设计特点 .....              | 265 |
| 4.10.3 性能 .....                  | 267 |
| 4.11 未来城市——瑞典 .....              | 267 |
| 4.11.1 背景 .....                  | 267 |
| 4.11.2 能效设计特点 .....              | 268 |
| 4.11.3 性能 .....                  | 268 |
| 4.12 港口绿色小区——加拿大温哥华 .....        | 269 |
| 4.12.1 背景 .....                  | 269 |
| 4.12.2 能效设计特点 .....              | 270 |
| 4.12.3 性能 .....                  | 272 |
| 致谢 .....                         | 272 |

# **Chapter 1 Introduction**

## 1.1 The problem of climate change

Climate change is one of the major challenges facing the world at the start of the 21st century. The mean global surface temperature has increased by about 0.3 to 0.6°C since the late 19th century and by about 0.2 to 0.3°C over the last 40 years, which is the period with most reliable data. Recent years have been among the warmest since 1860 - the period for which instrumental records are available. For example, the global average surface temperature in the year 2002 was approximately 0.8 °C above the average temperature at the end of the 19th century, making it the second warmest year in the 142-year global instrumental temperature record. The average land temperature was almost 1.2 °C above that at the end of the 19th century. The year 2004 was the fourth warmest on record, exceeded by 1998, 2002 and 2003. Fig.1.1 shows the combined global land and marine surface temperature record from 1856 to 2004 (by the Climatic Research Unit and the UK Met. Office Hadley Centre).



**Fig.1.1** Combined global land and marine surface temperature (source: Climate Research Unit, UK)

Warming is evident in both sea surface and land surface air temperatures. Urbanization in general and desertification could have contributed only a small fraction to overall global warming, although urbanisation may have been an important influence in some regions.

The rise in temperatures has been accompanied by changes in the world around us:

- ice caps are retreating from many mountain peaks like Kilimanjaro;
- global mean sea level rose by an average of 1 ~ 2mm a year during the 20th century; summer and autumn arctic sea ice has thinned by 40% in recent decades;
- global snow cover has decreased by 10% since the 1960s;
- El Nino events have become more frequent and intense during the last 20 ~ 30 years;
- usage of the Thames Barrier has increased from once every two years in the 1980s to an average six times a year over the past 5 years; and
- weather-related economic losses to communities and businesses have increased ten-fold over the last 40 years.

The Intergovernmental Panel on Climate Change in its most recent report stated:

*'Most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations.'*

Humanity's greenhouse gas emissions are expected to lead to climatic changes in the 21st century and beyond. These changes will potentially have wide-ranging effects on the natural environment as well as on human societies and economies. Climate change is real. The first challenge we face is environmental. We cannot escape some climate change. But the worst effects can be avoided if greenhouse gases in the atmosphere are stabilised

instead of being allowed to go on increasing. Levels of carbon dioxide (CO<sub>2</sub>) in the atmosphere, one of the main causes of climate change, have risen by more than a third since the industrial revolution and are now rising faster than ever before. Climate induced environmental changes cannot be reversed quickly, even if the anthropogenic emissions of CO<sub>2</sub> are stabilized or reduced, the CO<sub>2</sub> content in the atmosphere will still increase for some time. Global warming cannot be solved by a single nation alone and needs to be tackled internationally.

### 1.1.1 Action on carbon emission reduction

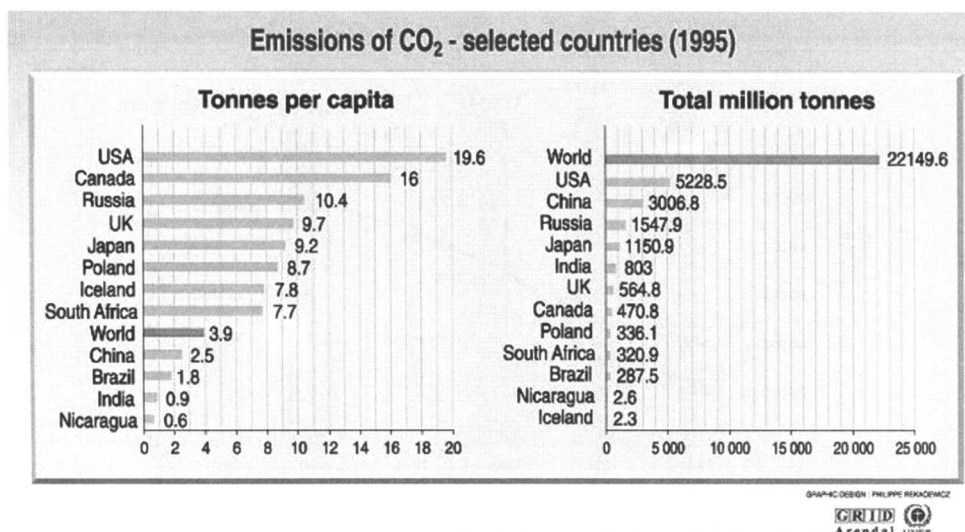
An agreement on global warming was reached by the United Nations Conference on Climate Change in Kyoto, Japan, in 1997. The major industrial nations pledged to reduce their emissions of greenhouse gases between 2008 and 2012. A general framework was defined for this, with specifics to be detailed over the next few years. This became known as the Kyoto Protocol. 141 countries, accounting for 55% of greenhouse gas emissions, have ratified the treaty, which pledges to cut these emissions by 5.2% by 2012.

The UK Energy White Paper addresses environmental challenges and gives a new direction for energy policy. The UK specified a target of reduction in carbon dioxide emissions of some 60% from current levels by about 2050. China approved the Kyoto Protocol of the United Nations Framework Convention on Climate Change and signed the pact on May 29, 1998. The Chinese government believes that the United Nations Framework Convention on Climate Change and its Kyoto Protocol set forth fundamental principles and provide an effective framework and a series of rules for international cooperation in combating climate change, and as such they deserve worldwide compliance.

### 1.1.2 Energy and building in China

Fig.1.2 shows CO<sub>2</sub> emissions of selected countries in 1995. China has the second biggest emissions of Greenhouse gas emission in the world. However, per capita the Chinese emissions are very low compared to the no. 1 on the list, the USA.

China has seen a rapid economic growth for much of the past two decades. This growth has had huge implications for energy consumption and the environment. For example, with growing income and affluence, urban households are dramatically increasing their material consumption and demand for energy. The total stock of refrigerators rose from four million in 1985 to 60 million in 1996 and refrigerators now account for half of residential energy

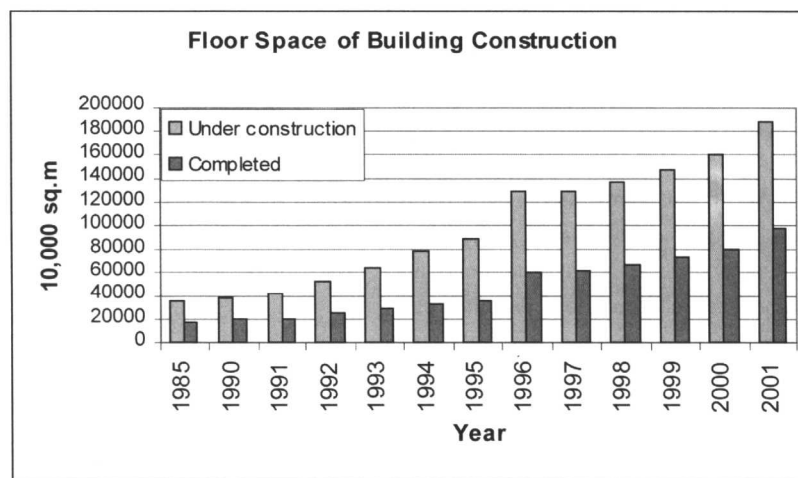


Source : International Energy Agency, 1996.

**Fig.1.2** CO<sub>2</sub> emissions of selected countries in 1995

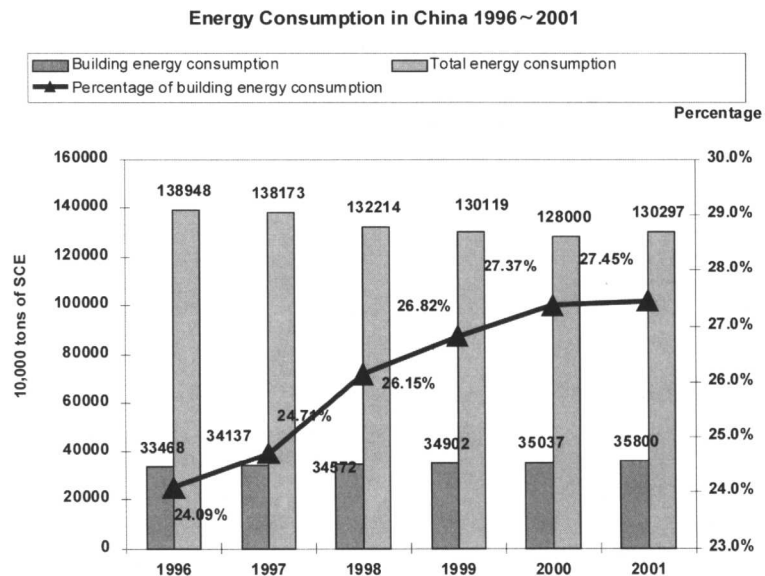
consumption. Energy consumption in the residential sector grew by 16 percent annually on average from 1980 to 1994. Air conditioners are now becoming ubiquitous in urban areas as well. Private automobile ownership, at one time illegal, grew to four million in 1996 and is now rising by an estimated one million cars annually. The environmental consequences of this economic growth are staggering, as accelerating air and water pollution threaten public health, damage ecosystems, and add to global climate change.

Building construction is the third largest player in the Chinese economy. The decade 2000 ~ 2010 is expected to include a residential construction boom in China. Fig.1.3 shows the trend for building construction. Building energy consumption accounted for about 27.6% of total energy in 2001. It is projected that energy consumption in buildings will increase to 35% in 2020. Fig.1.4 shows building energy consumption in China in 1996 ~ 2001. As part of building energy consumption, heating and air conditioning accounts for 65%, heating for water 15%,



**Fig.1.3** Floor space of building construction 1985 ~ 2001

Source: Chinese Statistic Yearbook 2002, National Bureau of Statistics



SCE: Standard coal equivalent

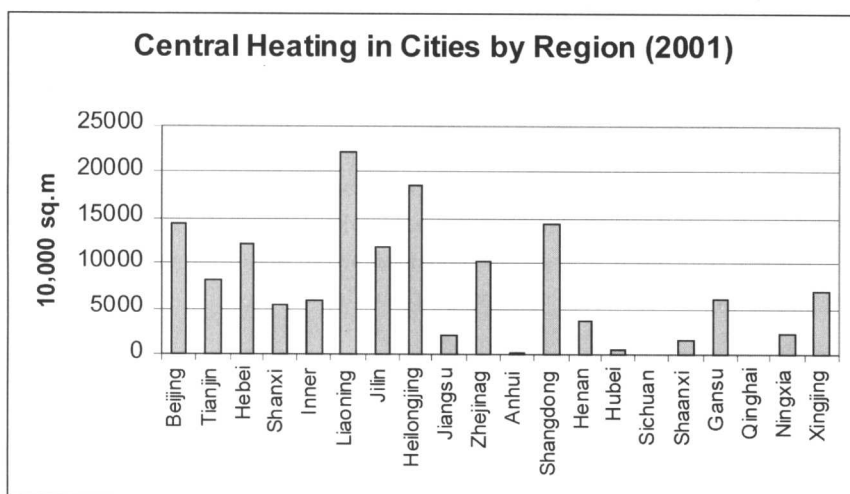
**Fig.1.4** Building energy consumption 1996 ~ 2001

Source: Construction Ministry Energy Conservation Centre

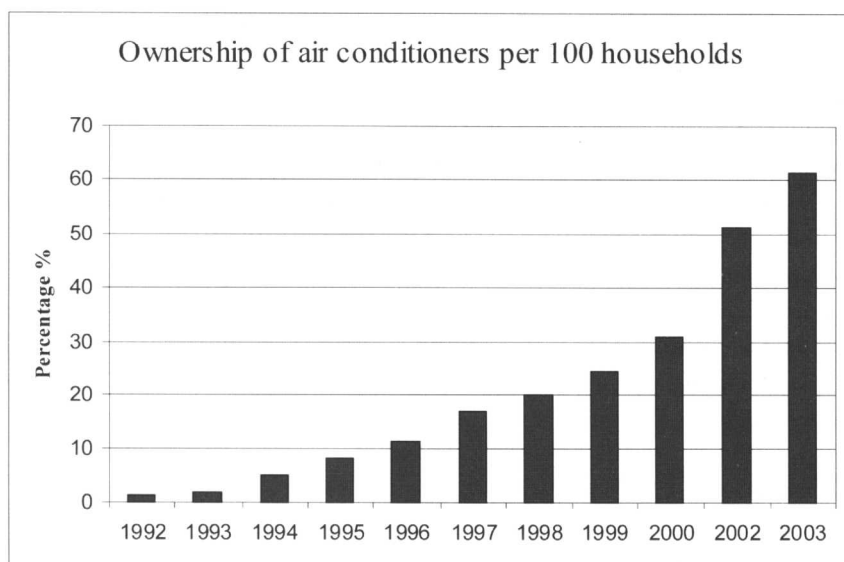


electric lighting 14% and cooking 6%. From these Figures we can see that heating and cooling consume, by far, the most energy. According to national statistics, in 2001 central heating in China was used to heat an area of north China equivalent to  $1.46 \times 10^9$  square meters. Fig.1.5 shows the area heated in different regions in north China (China Statistic Year Book 2002). Air conditioners are now becoming common in urban areas. Fig.1.6 shows the growth of air conditioner ownership in China.

According to a government survey in 2000, only 5.7% of buildings are designed to the thermal design code. Up to 2001, a total area of existing building is 370 hundred million square metres, of which 110 hundred million square metres is in the urban area. Only 2.3 thousand million square metres are built to the required standard, which accounts for only 2.1% of the urban area. The government encourages the implementation of energy policy in the built environment via various measures.



**Fig.1.5** Central heating in cities in different regions  
Source: Chinese Statistic Yearbook 2002, National Bureau of Statistics



**Fig.1.6** Ownership of air conditioners  
Source: China Energy Databook and Statistic Book 2002, 2004