
Table of Contents

List of Contributors	IX
About the editors	XIII
IEA Solar Heating and Cooling Programme	XVII
Foreword	XIX
Acknowledgments	XXI
1 Introduction	1
1.1 Why another book on net zero energy buildings?	1
1.2 What is a net zero energy building?	2
1.2.1 IEA SHC Task 40/EBC Annex52: Towards net zero energy solar buildings	2
1.2.2 Target audience: Designers and their clients	3
1.3 Structure of this book	5
References	6
2 Net zero energy building design fundamentals	7
2.1 Net zero energy building definition and classification	7
2.1.1 Physical boundary	8
2.1.2 Balance boundary	10
2.1.3 Weighting system	11
2.1.4 Normalization	11
2.1.5 Balance period	12
2.1.6 Balance types	12
2.1.7 Further requirements	13
2.2 Net ZEB case studies: building, climate and measure classifications	14
2.2.1 Climate classification	15
2.2.2 Building type classification	16
2.2.3 Net ZEB measure classification	16
2.3 Net-zero energy strategies and measures	18
2.3.1 Passive approach strategies	19
2.3.2 Passive measures	21
2.3.3 Energy efficiency strategies	25
2.3.4 Energy efficiency measures	28
2.3.5 Renewable energy system strategies	29
2.3.6 Renewable energy measures	32
2.4 Summary: solution sets	33
2.4.1 Net ZEB solution sets and associated categories	33
2.4.2 Other considerations of net ZEB design and solution sets	34
References	36
3 Net ZEB case study buildings, measures and solution sets	39
3.1 Introduction	39
3.2 The case study buildings	40
3.2.1 Residential buildings	41
3.2.2 Non-residential buildings	45

3.3	Net ZEB measures	51
3.4	Net ZEB measures in case study buildings	53
3.4.1	Passive measures	54
3.4.2	Energy efficiency measures	65
3.4.3	Renewable energy measure	74
3.5	Net ZEB measure summaries and solution sets	87
3.5.1	Net ZEB measures deployment summaries	87
3.5.2	Solution sets in residential buildings	100
3.5.3	Solution sets in non-residential buildings	101
	References	101
4	Net ZEB design opportunities and challenges	103
4.1	Introduction	103
4.2	Architectural design and the net ZEB objective	104
4.2.1	Energy balance and building shape	104
4.2.2	Renewable energy systems design	108
4.3	The integrated design process	113
4.3.1	The importance of the brief	113
4.3.2	The role of the architect	114
4.3.3	Organizational design decision making	114
4.3.4	Integrated design process and net ZEBs	115
4.4	The influence of renewable energy systems on building design	117
4.4.1	Envelope integrated supply options: photovoltaics vs. solar thermal	118
4.4.2	Photovoltaics	121
4.4.3	Solar thermal	123
4.4.4	Photovoltaic – Thermal combined systems	124
4.4.5	Wind turbines	126
4.5	New design opportunities and existing barriers	129
4.5.1	The right to sunshine	129
4.5.2	A new idea of building physical footprint	130
4.5.3	Listed buildings	132
4.5.4	Renovation of post-war period buildings	132
4.6	The appearance of future net ZEBs	133
4.6.1	Net ZEBs shapes and performances: a typological repertoire	133
4.6.2	A new aesthetics driven by net ZEBs	141
4.7	Concepts for future cities	141
4.7.1	Urbanization versus sprawl: towards net zero energy communities?	142
4.7.2	Net ZEBs, smart grids and smart cities	143
	References	147
5	Monitoring and post-occupancy evalution of Net ZEBs	153
5.1	Introduction	153
5.2	Why monitor building energy and comfort?	154
5.2.1	Interests and issues related to monitoring buildings	154
5.2.2	Monitoring to improve overall building performance	156
5.3	A standard monitoring protocol for Net ZEBs	158

5.3.1	Monitoring system planning	160
5.3.2	Monitoring system design	162
5.3.3	Monitoring system installation	163
5.3.4	Monitoring system operation	163
5.4	Building energy monitoring protocols	165
5.4.1	Energy monitoring protocol	165
5.4.2	Case study: energy monitoring at ENERPOS	166
5.5	Indoor environmental quality monitoring and post-occupancy evaluation	170
5.5.1	Indoor environmental quality (IEQ) monitoring protocol	170
5.5.2	Case study: comfort monitoring at ENERPOS	174
5.6	Experience from monitoring at 5 Net ZEBs	182
5.6.1	Monitoring at 5 case study buildings	182
5.6.2	Building management system	186
5.6.3	Energy results	187
5.6.4	Comfort measurements	190
5.6.5	General observations on occupant behavior	190
	References	191
6	Feedback from building designers, engineers and occupants	195
6.1	Introduction	195
6.2	Lessons learned from the design process	195
6.2.1	General observations from the design process	195
6.2.2	Design hierarchy	197
6.2.3	Motivations	198
6.3	Lessons learned from building designers, engineers and occupants	199
6.3.1	Passive design	199
6.3.2	Energy efficiency	202
6.3.3	Renewable energy	205
6.3.4	Recommendations	206
6.4	Occupant consideration in the design and operation of Net ZEBs	208
6.4.1	Effects of the occupant behavior on energy use and comfort	208
6.4.2	Automation vs user controls	209
6.4.3	Occupant behavior can hinder building performance	210
6.4.4	Lessons from occupant behavior in Net ZEBs	211
	References	215
	Glossary	217
	Index	223

