

Table of Contents

About the editors	IX
List of Contributors	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 evaluation 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