

About the editors	p. xiii
List of contributors	p. xv
Preface	p. xvii
Foreword	p. xix
Acknowledgments	p. xxi
Introduction	p. 1
Evolution to net-zero energy buildings	p. 1
Net ZEB concepts	p. 2
Design of smart Net ZEBs and modeling issues	p. 4
Scope of this book	p. 4
References	p. 7
Modeling and design of Net ZEBs as integrated energy systems	p. 9
Introduction	p. 9
Passive design, energy efficiency, thermal dynamics, and comfort	p. 10
Detailed frequency domain wall model and transfer functions	p. 16
Distributed parameter model for multilayered wall	p. 16
Admittance transfer functions for walls	p. 17
Z-Transfer function method	p. 22
Detailed zone model and building transfer functions	p. 25
Analysis of building transfer functions	p. 30
Heating/cooling load and room temperature calculation	p. 32
Discrete Fourier Series (DFS) method for simulation	p. 32
Building transient response analysis	p. 33
Nomenclature	p. 34
Renewable energy generation systems/technologies integrated in Net ZEBs	p. 34
Building-integrated photovoltaics as an enabling technology for Net ZEBs	p. 35
Technologies	p. 36
Modeling	p. 39
Solar thermal systems	p. 45
Solar thermal collectors	p. 45
Modeling of solar thermal collectors	p. 49
Thermal storage tanks	p. 51
Modeling of thermal storage tanks	p. 52
Solar combi-systems	p. 55
Active building-integrated thermal energy storage and panel/radiant heating/cooling systems	p. 55
Radiant heating/cooling systems integrated with thermal mass	p. 57
Modeling active BITES	p. 58
Methods used in two mainstream building simulation software	p. 62
Nomenclature	p. 63
Heat pump systems - a promising technology for Net ZEBs	p. 63
Solar air-conditioning	p. 64

Solar assisted/source heat pump systems	p. 64
Ground source heat pumps	p. 65
Combined heat and power (CHP) for Net ZEBs	p. 66
References	p. 67
Comfort considerations in Net ZEBs: theory and design	p. 75
Introduction	p. 75
Thermal comfort	p. 76
Explicit thermal comfort objectives in Net ZEBs	p. 77
Principles of thermal comfort	p. 77
A comfort model based on the heat-balance of the human body	p. 78
The adaptive comfort models	p. 83
Standards regarding thermal comfort	p. 85
Long-term evaluation of thermal discomfort in buildings	p. 87
Background	p. 88
The likelihood of dissatisfied	p. 89
Applications of the long-term (thermal) discomfort indices	p. 91
Daylight and visual comfort	p. 92
Introduction	p. 92
Adaptation luminance	p. 94
Illuminance-based performance metrics	p. 95
Daylight autonomy and continuous daylight autonomy	p. 95
Useful daylight illuminance	p. 95
Luminance-based performance metrics	p. 96
Daylight glare probability	p. 96
Daylight and occupant behavior	p. 97
Acoustic comfort	p. 98
Indoor air quality	p. 99
Conclusion	p. 100
References	p. 101
Net ZEB design processes and tools	p. 107
Introduction	p. 107
Integrating modeling tools in the Net ZEB design process	p. 108
Introduction	p. 108
Overview of phases in Net ZEB realization	p. 108
Tools	p. 111
Concept design	p. 112
Daylight	p. 113
Solar protection	p. 114
Building thermal inertia	p. 115
Natural and hybrid ventilation	p. 116
Building envelope thermal resistance	p. 118

Solar energy technologies integration	p. 119
Design development	p. 119
Envelope and thermal inertia	p. 120
Daylight	p. 120
Plug loads and electric lighting	p. 122
RET and HVAC	p. 123
Technical design	p. 124
Integrated design process and project delivery methods	p. 126
Conclusion	p. 133
NET ZEB design tools, model resolution, and design methods	p. 133
Introduction	p. 133
Model resolution	p. 134
Model resolution for specific building systems and aspects	p. 141
Geometry and thermal zoning	p. 141
HVAC and active renewable energy systems	p. 144
Photovoltaics and building-integrated photovoltaics	p. 145
Lighting and daylighting	p. 147
Airflow	p. 149
Occupant comfort	p. 151
Occupant behavior	p. 153
Use of tools in design	p. 157
Climate analysis	p. 157
Solar design days	p. 159
Parametric analysis	p. 160
Interactions	p. 161
Multidimensional parametric analysis	p. 162
Visualization	p. 162
Future needs and conclusion	p. 163
Conclusion	p. 165
References	p. 166
Building performance optimization of net zero-energy buildings	p. 175
Introduction	p. 175
What is BPO?	p. 175
Importance of BPO in Net ZEB design	p. 176
Optimization fundamentals	p. 179
BPO objectives (single-objective and multi-objective functions)	p. 179
Optimization problem definition	p. 180
Review of optimization algorithms applicable to BPS	p. 180
Integration of optimization algorithms with BPS	p. 183
BPO experts interview	p. 184
Application of optimization: cost-optimal and nearly zero-energy building	p. 186

Introduction	p. 186
Case study: single-family house in Finland	p. 188
Results	p. 190
Final considerations about the case study	p. 194
Application of optimization: a comfortable net-zero energy house	p. 195
Description of the building model	p. 195
The adopted methodology and the statement of the optimization problem	p. 196
Discussion of results	p. 199
Final considerations	p. 202
Conclusion	p. 202
References	p. 203
Load matching, grid interaction, and advanced control	p. 207
Introduction	p. 207
Beyond annual energy balance	p. 207
Relevance of LMGI issues	p. 207
Peak demand and peak power generation	p. 207
Load management in the grid and buildings	p. 209
Smart grid and other technology drivers	p. 211
LMGI indicators	p. 212
Introduction	p. 212
Categories of indicators	p. 215
Strategies for predictive control and load management	p. 219
Energy storage devices	p. 219
Electric energy storage	p. 219
Thermal energy storage	p. 220
Predictive control for buildings	p. 220
Preliminary steps	p. 222
Requirements of building models for control applications	p. 223
Modeling of noncontrollable inputs	p. 225
Development of a control strategy	p. 226
Development of models for controls	p. 226
Building components: conduction heat transfer	p. 227
Thermal modeling of an entire building	p. 227
Linear models	p. 228
Continuous-time transfer functions	p. 228
Discrete-time transfer functions (z-transforms transfer functions)	p. 229
Time series models	p. 231
State-space representation	p. 232
Conclusion	p. 235
References	p. 236
Net ZEB case studies	p. 241

Introduction	p. 241
Éco Terra	p. 243
Description of Éco Terra	p. 243
Design process	p. 252
Design objectives	p. 252
Design team and design process	p. 252
Use of design and analysis tools	p. 253
Assessment of the design process	p. 255
Measured performance	p. 256
Redesign study	p. 259
Boundary conditions	p. 260
Form and fabric	p. 260
Operations	p. 260
Renewable energy systems	p. 261
Simulation results	p. 261
Implementation of redesign strategies	p. 262
Conclusions and lessons learned	p. 266
Leafhouse	p. 269
Main features of the leafhouse	p. 269
Description of the design process	p. 272
Purposes of the building design	p. 272
Description of the thermal system plant	p. 272
Monitored data	p. 277
Features and limits of the employed mode!	p. 278
Calibration of the model	p. 280
Redesign	p. 284
Conclusions and lessons learned	p. 288
NRELRSF	p. 289
Introduction to the RSF	p. 290
Key project design features	p. 291
Design process	p. 291
Envelope	p. 292
Daylighting and electric lighting	p. 293
Space conditioning system	p. 293
Thermal storage labyrinth	p. 295
Transpired solar thermal collector	p. 297
Natural ventilation	p. 298
Building operation, typical monitored data, and thermal performance	p. 298
Photovoltaics	p. 301
Building simulation software support	p. 302
Software limitations	p. 303

Significance of the early design stage	p. 304
Abstraction to archetypes	p. 306
Model development	p. 307
Model validation and calibration	p. 311
Integrating design and control for daylighting and solar heat gain - option with controlled shading	p. 312
Alternative design and operation for consideration	p. 319
Building-integrated PV: optimal use of building roof and facade	p. 319
Building-integrated PV/T and transpired collector with air-source heat pump	p. 319
Active building-integrated thermal energy storage	p. 320
Conclusions	p. 320
ENERPOS	p. 321
Natural cross-ventilation and ceiling fans	p. 322
Solar shading and daylighting	p. 323
Microclimate measures	p. 323
Materials	p. 324
Ergonomics and interior design	p. 324
Energy efficiency	p. 325
Artificial lighting	p. 325
Ceiling fans	p. 325
Air-conditioning system	p. 326
Computer network and plug loads	p. 326
Building management system and individual controls	p. 326
Integration of renewable energy technology	p. 327
Description of the design process	p. 327
Design objectives and importance of the design brief	p. 328
Design team and timeline	p. 328
Design tools	p. 328
Human factors consideration in the design	p. 330
Monitoring system	p. 331
Monitored data	p. 331
Measured performance	p. 331
Comparison of model prediction with measurements for ENERPOS	p. 333
Energy use	p. 333
Thermal comfort	p. 336
Thermal comfort experimental study	p. 338
Purpose and methodology	p. 338
Main results of the surveys	p. 339
A comparison between the experimental data and the Givoni comfort zones	p. 339
Lessons learned for future design of Net ZEBs in tropical climate	p. 341
Interior lighting	p. 342
Elevator energy	p. 343

Air-conditioning	p. 343
Occupant behavior	p. 343
Use of building thermal mass and night cooling	p. 343
Conclusions	p. 343
References	p. 345
Conclusion, research needs, and future directions	p. 351
Net ZEB modeling, design, and simulation	p. 351
Future directions and research needs	p. 352
Glossary	p. 355
Index	p. 361

Table of Contents provided by Blackwell's Book Services and R.R. Bowker. Used with permission.