# Contents

**Foreword by Thierry Magnin** . . . . . xi

**Foreword by Audrey Linkenheld** . . . . . xvii

**Introduction** . . . . . xxv

**Chapter 1. From Transition Challenges to Smart Grids and Smart Buildings** . . . . . 1

1.1. Introduction . . . . . 1
1.2. Climatic challenges . . . . . 3
1.3. Four inspiring social and climate scenarios . . . . . 5
1.4. Sufficiency or prosperity . . . . . 13
1.4.1. Personal, shared and organizational sufficiency . . . . . 13
1.4.2. From smart sharing to wise sharing . . . . . 14
1.4.3. From sufficiency to prosperity . . . . . 16
1.4.4. Spirituality and ecological transition . . . . . 19
1.5. Ethical and political issues . . . . . 22
1.5.1. Ethical issues in the ecological transition . . . . . 22
1.5.2. Questions of governance or the need to reinvent democracies . . . . . 23
1.5.3. Eco-anxiety . . . . . 29
1.6. Bifurcating research . . . . . 31
1.7. Smarter energy networks . . . . . 33
1.7.1. From 100% renewable energy to a combination of solutions . . . . . 33
1.7.2. Towards the decentralization of electricity grids . . . . . 36
1.7.3. Smart grids, self-generation and self-consumption . . . . . 38
1.7.4. An increasingly miraculous electricity fairy – yes but? . . . . . 39
1.8. Smarter buildings in a desirable habitat . . . . . 45
1.8.1. Buildings and living spaces . . . . . 45
1.8.2. Building trends in 2050. . . . . 46

1.8.3. Smart buildings . . . . . 47
1.9. Smart buildings as nodes of smart grids . . . . . 50
1.10. Methodological contributions . . . . . 52
1.11. The question of artificial intelligence . . . . . 53
1.12. References . . . . . 54

**Chapter 2. Smart City, Smart Building, Smart User: The Imaginaries of Smart and its Dead Ends** . . . . . 59

2.1. Introduction . . . . . 59
2.2. Reducing energy consumption: changing technologies or changing practices? . . . . . 60
2.2.1. Limits to energy efficiency . . . . . 60
2.2.2. Limits of an approach focused (solely) on practices . . . . . 61
2.2.3. Usage dependence on the technology used . . . . . 64
2.3. The smart imaginary and its dead ends . . . . . 67
2.3.1. Technical distancing as a common denominator . . . . . 68
2.3.2. The smart city or the imaginary of a city without inhabitants . . . . . 68
2.3.3. The smart building or the imaginary of a building parasitized by its users . . . . . 70
2.4. Conclusion: in search of the smart user? . . . . . 71
2.5. References . . . . . 73

**Chapter 3. Forecasting the Production and Consumption of Electrical Energy** . . . . . 77

3.1. Introduction . . . . . 77
3.2. Variability in production and consumption . . . . . 78
3.3. Photovoltaic production forecast . . . . . 80
3.3.1. Satellite image-based forecasting . . . . . 82
3.3.2. Short-term forecast by camera . . . . . 83
3.3.3. Neural network prediction . . . . . 85
3.3.4. Case study: 24-hour production forecast for the photovoltaic power plant at the Université Catholique de Lille . . . . . 89
3.4. Forecasting electricity consumption . . . . . 96
3.4.1. Important factors for forecasting electricity consumption . . . . . 96
3.4.2. Electricity consumption prediction methods . . . . . 97
3.4.3. Case study: 24-hour forecast of electricity consumption for a block of buildings at the Université Catholique de Lille . . . . . 98
3.5. Valorization of forecasts and feedback . . . . . 104
3.5.1. Using forecasts to manage energy for the Université Catholique de Lille smart grid demonstrator . . . . . 104
3.5.2. Load forecasting in a distribution network at a high-voltage/medium-voltage (HV/MV) source substation . . . . . 107

3.5.3. The importance of meteorological forecasting . . . . . 111
3.5.4. The importance of uncertainty analysis . . . . . 112
3.5.5. Importance of database size and quality . . . . . 113
3.6. Conclusion . . . . . 113
3.7. Acknowledgments . . . . . 114
3.8. References . . . . . 114

**Chapter 4. Taking Actors into Account in Energy Management Strategies** . . . . . 117

4.1. Introduction . . . . . 117
4.2. A system of actors in an electrical network . . . . . 120
4.2.1. The role of actors . . . . . 120
4.2.2. System operator . . . . . 121
4.2.3. Aggregator . . . . . 121
4.2.4. Producer . . . . . 122
4.2.5. Consumer . . . . . 123
4.2.6. Consumer–producer (prosumer) . . . . . 124
4.3. Methodology for managing energy flexibility involving actors . . . . . 124
4.3.1. Defining key concepts . . . . . 124
4.3.2. Comprehensive methodology for energy supervision . . . . . 126
4.4. Modeling actor profiles . . . . . 127
4.4.1. An interdisciplinary approach . . . . . 127
4.4.2. Existing actor profiles . . . . . 129
4.4.3. Observable profiles . . . . . 132
4.4.4. Integrable profiles . . . . . 132
4.5. Residential actor profiles . . . . . 134
4.5.1. Return feedback from experimentation/scale-one projects . . . . . 134
4.5.2. Consumer profile research . . . . . 135
4.5.3. Sociological approaches for accepting participation in network management . . . . . 136
4.5.4. Economic approaches for consumer involvement . . . . . 138
4.5.5. The need for interdisciplinarity . . . . . 139
4.5.6. Characterizing flexibility . . . . . 140
4.5.7. Parameters influencing flexibility . . . . . 144
4.6. Identification of residential actor profiles . . . . . 147
4.6.1. Introduction . . . . . 147
4.6.2. A microeconomic approach to price sensitivity . . . . . 147
4.6.3. A sociological approach to environmental awareness . . . . . 157
4.7. Profiles of selected residential actors . . . . . 158
4.7.1. Economical . . . . . 158
4.7.2. Eco-sensitive . . . . . 159
4.7.3. Technophiles . . . . . 159
4.7.4. Indifferent – moderate opportunists . . . . . 159

4.7.5. Disengaged . . . 159
4.7.6. Discussions . . . 159
4.8. Conclusion . . . 161
4.9. Acknowledgments . . . 162
4.10. References . . . 162

**Chapter 5. Energy Supervision of a Local Residential Network with Actor Involvement** . . . 169

5.1. Introduction . . . 169
5.2. Energy supervision methodology . . . 170
5.3. Modeling a residential case study . . . 171
5.3.1. Electricity network under consideration . . . 171
5.3.2. Modeling consumption . . . 172
5.3.3. Discussion of model limitations . . . 174
5.4. Day ahead supervision (before D-1) . . . 174
5.4.1. Discussion of predictive supervision . . . 174
5.4.2. Implementing the D-1 supervisor . . . 180
5.4.3. Scope statement . . . 181
5.4.4. Modeling actor profiles . . . 185
5.4.5. Supervisor structure . . . 190
5.4.6. Global optimization and game theory . . . 192
5.4.7. Local optimization using dynamic programming . . . 195
5.5. Real-time supervision . . . 198
5.5.1. Discussion of real-time supervision . . . 198
5.5.2. Implementation of supervision in real time . . . 202
5.5.3. Continuity with D-1 supervisor . . . 202
5.5.4. Fuzzy logic supervisor . . . 203
5.5.5. Indicators . . . 213
5.6. Two-week prospective simulations of the global supervisor . . . 213
5.6.1. Scenarios . . . 213
5.6.2. Results and discussion . . . 215
5.7. Conclusion . . . 221
5.8. Acknowledgments . . . 223
5.9. References . . . 223

**Chapter 6. Self-Consumption within a Local Renewable Energy Community** . . . 227

6.1. Introduction . . . 227
6.2. Local renewable energy communities . . . 230
6.3. Modeling a tertiary-sector case study . . . 231
6.3.1. Historic block at the Université Catholique de Lille . . . 231
6.3.2. Modeling the electrical network . . . 233

6.4. Distributed energy optimization . . . . . 234
6.4.1. Introduction . . . . . 234
6.4.2. Energy exchanges within communities . . . . . 235
6.4.3. Distributed optimization of energy exchanges with game theory . . . . . 239
6.4.4. Simulation results . . . . . 251
6.5. Managing energy exchanges using blockchain technology . . . . . 258
6.5.1. Introduction . . . . . 258
6.5.2. The principle of blockchain . . . . . 259
6.5.3. Development of a local blockchain for managing energy exchanges in the renewable energy community . . . . . 261
6.5.4. Simulations and results . . . . . 269
6.6. Interpretations and experience feedback . . . . . 275
6.7. Conclusion . . . . . 275
6.8. Acknowledgments . . . . . 276
6.9. References . . . . . 277

**Chapter 7. Sustainable and Desirable Living Thanks to Smart Buildings** . . . . . 281

7.1. Introduction . . . . . 281
7.2. Smart building . . . . . 284
7.2.1. Definition of a smart building . . . . . 284
7.2.2. Services provided by a smart building . . . . . 285
7.3. Data processing and building management . . . . . 295
7.3.1. Introduction . . . . . 295
7.3.2. Dynamic energy optimization for buildings . . . . . 296
7.3.3. Indoor and outdoor air quality in a building . . . . . 306
7.3.4. Blockchain and buildings . . . . . 309
7.4. Environmental and climate impact of the building . . . . . 310
7.4.1. Introduction . . . . . 310
7.4.2. Renovating instead of building new . . . . . 311
7.4.3. Socio-technical management of a building . . . . . 313
7.4.4. Sufficiency in residential buildings . . . . . 315
7.5. Acknowledgments . . . . . 317
7.6. References . . . . . 318

**Chapter 8. Demonstration Sites** . . . . . 321

8.1. Introduction: full-scale implementation . . . . . 321
8.2. Technology Readiness Level . . . . . 322
8.3. Development of a smart grid demonstration site . . . . . 323
8.3.1. Demonstration projects . . . . . 325
8.4. An all-in-one demonstration site . . . . . 327

8.4.1. Introduction . . . . . 327
8.4.2. Controlling photovoltaic production . . . . . 327
8.4.3. Integration and control of electric vehicle charging . . . . . 330
8.4.4. Controlling electrical loads in buildings . . . . . 335
8.4.5. Electrical energy storage control . . . . . 343
8.4.6. Communication networks . . . . . 346
8.4.7. IT developments . . . . . 347
8.4.8. Perspectives . . . . . 348
8.5. The contribution of occupants of a service sector site to electricity savings . . 349
8.5.1. Evolution of the sources of energy consumption reduction . . . . . 350
8.5.2. Shaving potential at tertiary sites . . . . . 352
8.5.3. Exploring potential for load shedding in commercial sites . . . . . 357
8.5.4. Concluding remarks on both case studies . . . . . 365
8.6. Conclusion . . . . . 365
8.7. Acknowledgments . . . . . 366
8.8. References . . . . . 366

**Postface** . . . . . 369

**Index** . . . . . 375