

Contents

Part I. ICT solutions for water supply systems	1
1 Role of ICT in water supply systems: requirements, current status and challenges	3
<i>by Andreas Pirsing, Moritz Allmaras, Roland Rosen, Tim Schenk, and Annelie Sohr</i>	
1.1 Introduction	3
1.2 Basic concepts of digitalization	4
1.3 Enabling technologies of digitalization	6
1.4 Basic IT security technologies	8
1.5 Decision support systems for water supply systems	11
1.5.1 Methodological approaches for decision support systems	12
1.5.2 Practical aspects of decision support systems	13
1.5.3 Technological components	14
1.6 Energy aspects	14
Bibliography	15
2 EWave energy management system	19
<i>by Constantin Blanck, Stefan Fischer, Michael Plath, Moritz Allmaras, Andreas Pirsing, Tim Schenk, and Annelie Sohr</i>	
2.1 Objectives	19
2.2 Requirements to the water supply	20
2.2.1 Electricity stock exchange	22
2.2.2 Atypical grid utilization	23
2.2.3 Control energy	23
2.3 Pilot network – Dorsten-Holsterhausen	25
2.3.1 Water production	25
2.3.2 Water purification	26
2.3.3 Water distribution	28
2.4 Basic concepts of the decision support system	29
2.4.1 Time aspects	30
2.4.2 System models	31
2.4.3 Coupling simulation and optimization	32
2.4.4 Prognosis	33
2.4.5 Boundary conditions	33
2.4.6 Data access	34
Bibliography	34

Part II. Theoretical aspects	37
3 Demand forecast	39
<i>by Patrick Hausmann</i>	
3.1 Introduction	39
3.1.1 Necessity of a demand forecast	39
3.1.2 Concept, model approach, and classification	40
3.2 Demand forecast	41
3.2.1 Data clustering	41
3.2.2 Model parametrization	42
3.2.3 Artificial increase of time resolution	43
3.2.4 Program flow	45
3.2.5 Results and accuracy	46
3.3 Summary	49
Bibliography	49
4 Hydraulic modeling and energy view	51
<i>by Gerd Steinebach and Oliver Kolb</i>	
4.1 Introduction	51
4.2 Water supply network modeling	52
4.2.1 Component-based network approach	52
4.2.2 Modeling equations	53
4.2.3 Energy view	57
4.3 Simulator TWaveSim	57
4.3.1 Coupling conditions within PDAE system	58
4.3.2 Semidiscretization in space and boundary conditions	59
4.3.3 Initial values	61
4.3.4 DAE solver	62
4.4 Simulator Anaconda	63
4.5 Test application	64
4.5.1 Problem setup	64
4.5.2 Simulation results	67
4.6 Conclusion	70
Bibliography	70
5 Optimization	73
<i>by Björn Geißler, Alexander Martin, Antonio Morsi, Maximilian Walther, Oliver Kolb, Jens Lang, and Lisa Wagner</i>	
5.1 Introduction	73
5.2 Discrete optimization	75
5.2.1 Water supply network model	75
5.2.2 Solution approach	89
5.2.3 Computational results	99
5.3 Continuous optimization	100
Bibliography	102

Part III. Practical aspects	105
6 Network aggregation	107
<i>by Tim Jax</i>	
6.1 Introduction	107
6.2 Theoretical aspects	109
6.2.1 General objectives	109
6.2.2 General concept	111
6.2.3 Assumptions and requirements	113
6.2.4 Layout definition	114
6.2.5 Pipe aggregation	116
6.2.6 Generating artificial tanks	118
6.2.7 Sink realization	120
6.3 Generator TWaveGen	120
6.3.1 General aspects	120
6.3.2 Pipe selection	122
6.3.3 Tank generation	124
6.4 Conclusion and outlook	125
Bibliography	127
7 Setup of simulation model and calibration	129
<i>by Gerd Steinebach, David Dreistadt, Patrick Hausmann, and Tim Jax</i>	
7.1 Introduction	129
7.2 Application: model Holsterhausen	130
7.2.1 Modeling waterworks Dorsten-Holsterhausen	130
7.2.2 Modeling pressure zone Holsterhausen	131
7.3 Calibration	133
7.3.1 Calibration of characteristic pump curves	133
7.3.2 Calibration of valve coefficients	135
7.3.3 Calibration of network model	137
7.4 Model operation and simulation results	143
7.4.1 Input data and program handling	143
7.4.2 Discussion of simulation results	144
7.5 Summary	145
Bibliography	146
8 Field data, automation, instrumentation and communication	147
<i>by Constantin Blanck, Stefan Fischer, and Michael Plath</i>	
8.1 Data provision, network analysis and acquisition of additionally required measurement and control technology	147
8.2 Electricity price forecast	149

- 9 New ICT architecture** 151
by Tim Schenk, Moritz Allmaras, Andreas Pirsing, and Annelie Sohr
- 9.1 Requirements 151
- 9.2 General architecture and model-based approach 153
 - 9.2.1 Overview 153
 - 9.2.2 Process and data flow 155
 - 9.2.3 Structure of the data model 156
 - 9.2.4 The calculation module interface 161
- 9.3 The EWave sequence 165
 - 9.3.1 Overview 165
 - 9.3.2 Simulation state calculation 165
 - 9.3.3 Optimization 167
 - 9.3.4 Simulation forecast 168
 - 9.3.5 Measurement processing 169
 - 9.3.6 Processing of boundary conditions 171
 - 9.3.7 Demand prognosis 175
 - 9.3.8 Cyclic evaluation 177
 - 9.3.9 Evaluation of switch messages 178
 - 9.3.10 Summary 181
- Bibliography 181

- 10 Water cockpit: dashboards for decision support systems** 183
by Michael Plath, Constantin Blanck, Stefan Fischer, Moritz Allmaras, Andreas Pirsing, Tim Schenk, and Annelie Sohr
- 10.1 Energy and process 183
 - 10.1.1 Industry-specific indicators, especially efficiencies 183
 - 10.1.2 Application test of efficiencies 186
- 10.2 User interface technologies 189
 - 10.2.1 User roles 189
 - 10.2.2 System qualities & decisions 190
 - 10.2.3 User interface 190
 - 10.2.4 Communication 196
 - 10.2.5 Technologies 197
- Bibliography 198

Part IV. Outlook 199

11 Field test 201
*by Annelie Sohr, Constantin Blanck, Stefan Fischer, Michael Plath,
 Moritz Allmaras, Tim Schenk, and Andreas Pirsing*

11.1 Implementation and pilot application 201
 11.1.1 Preparation of the pilot application 202
 11.1.2 Test phase I 202
 11.1.3 Test phase II 206
 11.1.4 Drinking water demand forecast test 208
 11.1.5 Conclusion: pilot application 208

11.2 Comparative calculations 209
 11.2.1 Concept 209
 11.2.2 Verification 211

11.3 Conclusion & outlook 215

Bibliography 216

Acronyms 217

Symbols and Parameters 219

Glossary 221

List of Contributors 223

Index 225