
Contents

FOREWORD	xiii
PREFACE	xvii
ACKNOWLEDGMENTS.	xix
LIST OF FIGURES	xxi
LIST OF ACRONYMS.	xxv
WELCOME TO “ADVANCED SMART GRIDS”	xxxix
CHAPTER 1. DISTRIBUTION SYSTEM OPERATORS IN A CHANGING ENVIRONMENT	1
1.1. Energy policies promoting the energy transition	1
1.2. A new era of technological revolution	9
CHAPTER 2. THE EXISTING DISTRIBUTION NETWORKS: DESIGN AND OPERATION	13
2.1. Above all, smart grids remain grids!	14
2.2. The DSO, a player at the heart of the power system	15
2.3. A necessary mastery of technical and regulatory constraints.	18

2.4. Generalities of network design	22
2.4.1. Energy transformers	24
2.4.2. Wiring and architectures	25
2.4.3. Safeguard devices	28
2.4.4. Sensors, digital equipment and software	29
2.4.5. The importance of telecommunication for operating the distribution networks	31
2.5. The factors that differentiate network architecture.	33
2.5.1. Voltage levels	34
2.5.2. The neutral point treatment in MV networks	36
2.5.3. The balance between automation, redundancy and reliability.	39
2.5.4. The density and layout of the serviced area.	40
2.5.5. The variation in building design.	41
2.6. Network safety and planning	41
2.6.1. Development of distribution networks	43
2.6.2. Operating distribution networks	43
2.6.3. Studies in operational safety	44
2.6.4. Monte Carlo method.	44
2.6.5. Some results from applying the Monte Carlo method.	45
2.7. Progressive modernization of a distribution network – the French example.	46
2.7.1. Standardization (1950–1965) and expansion of the network (1965–1985).	47
2.7.2. Achieving a minimal quality level for every customer	48
2.7.3. Targeted improvement of quality according to needs	50
2.7.4. Progressive desensitization of networks toward climate hazards.	51
CHAPTER 3. MAIN DRIVERS AND FUNCTIONS OF ADVANCED SMART GRIDS	53
3.1. Drivers of the evolution of distribution grids	53

3.1.1. Massive integration of renewable energy sources.	53
3.1.2. Contribution to the development of electric vehicle and the charging infrastructures	55
3.1.3. Implementation of new market mechanisms (peak shaving, capacity market, etc.)	57
3.1.4. Participation in the development of new uses contributing to energy efficiency	60
3.1.5. Urban renewal and the rise of the smart city in favor of resource optimization.	61
3.1.6. Integration of energy storage solutions.	62
3.2. Main functions of the advanced smart grid.	68
3.2.1. Toward dynamic network management by the distribution system operators	68
3.2.2. Structuring the target model based on key functions.	69
3.2.3. Enhancing efficiency in day-to-day grid operation	72
3.2.4. Ensuring network security, system control and quality of supply	75
3.2.5. Improving market functioning and customer service	77
3.2.6. European network codes.	79
CHAPTER 4. METERING: A CORE ACTIVITY OF THE DSOS.	81
4.1. Smart meters are key tools for the deployment of smart grids	81
4.2. A continuous improvement and innovation approach	82
4.2.1. From manual to remote reading for mass market customers	82
4.2.2. 20 years of smart metering and remote reading for industrial clients	83
4.3. AMI metering systems.	84

4.4. Focus on Linky smart metering system	90
4.4.1. Scope of the project	90
4.4.2. Architecture and technical choices	92
4.4.3. A point on system operation	94
4.4.4. Scalability and security of the Linky system	99
4.4.5. Techno-economic analysis	100
4.5. Focus on G3-PLC technology	101
4.5.1. Communication principles of the power line carrier.	101
4.5.2. Different types of physical level PLC modulation technique	101
4.5.3. The characteristics of G3-PLC technology	105
4.5.4. G3-PLC is a mature standard	109
4.6. The contribution of smart meters for the development of advanced smart grids	111
4.6.1. France: Linky at the service of the distribution network	111
CHAPTER 5. FOCUS ON FLEXIBILITY OPTIONS.	119
5.1. Flexibility, a complementary tool for DSOs.	119
5.1.1. Introduction	119
5.1.2. DSO needs in terms of flexibility.	120
5.1.3. The value of flexibility	123
5.1.4. Alliander Smart Grids Cost Benefits Analysis (source: Alliander).	124
5.1.5. Two major categories of levers can be activated.	126
5.1.6. Analysis of the Merit Order	127
5.1.7. Information exchange mechanism between DSO and TSO	128
5.1.8. Lessons learned from several international business cases	128
5.2. Participation of end users to flexibility services.	130
5.2.1. Introduction	130
5.2.2. Focus on different tools and services downstream of the smart meter	132

5.2.3. The necessary engagement of end-customers	137
5.2.4. International benchmark and lessons learnt	138
5.3. Data management as key success factor	139
5.3.1. DSOs have a long experience in data management.	139
5.3.2. DSO, the market facilitator	142
CHAPTER 6. PILOT PROJECTS AND USE CASES	145
6.1. A global dynamic with regional specificities	145
6.2. North America	147
6.2.1. Drivers of smart grids development	147
6.2.2. Primary experimental approaches	148
6.3. Asia	150
6.3.1. Drivers of smart grids development	150
6.3.2. A proactive experimental approach.	151
6.4. Europe	154
6.4.1. Drivers of smart grids development	154
6.4.2. Primary experimental approaches	157
6.5. The European project Grid4EU, fosters and accelerates experience sharing	158
6.5.1. A large-scale demonstration project bringing together six European DSOs	158
6.5.2. DEMO 1 (Germany – RWE) MV network operation automation and determining the ratio of decentralized intelligence in secondary substations.	160
6.5.3. DEMO 2 (Sweden – Vattenfall): a tool for LV operation and in particular identifying LV failures	161
6.5.4. DEMO 3 (Spain – Iberdrola) MV and LV failure detection, reconfiguration of the MV network during an incident	162
6.5.5. DEMO 4 (Italy – ENEL) economic model and technical operation of storage, MV voltage regulation, anti-islanding of decentralized generation	164

6.5.6. DEMO 5 (Czech Republic – CEZ) operating islanding with co-generation, MV and LV failure detection and reconfiguration of the MV network following an incident	165
6.5.7. DEMO6 (France – ERDF): project NiceGrid	167
6.6. An approach based on use cases	168
6.6.1. Definition.	168
6.6.2. Advantages.	169
6.6.3. The development of use cases	169
6.7. Focus on some advanced projects of the ISGAN case book about Demand Side Management.	171
6.7.1. Denmark – EcoGrid EU	173
6.7.2. Japan – Kitakyushu Smart Community Creation Project	174
6.7.3. The Netherlands – PowerMatchingCity	175
6.7.4. Canada – a virtual power plant to balance wind energy	177
CHAPTER 7. SMART GRIDS ARE THE FUTURE FOR DSO	181
7.1. Advanced smart grids for DSOs worldwide	181
7.1.1. The evolution towards smart grids is ineluctable.	181
7.1.2. The development of smart grids is a necessity for the DSOs.	183
7.1.3. But also an opportunity	185
7.2. A necessary evolution of skills and jobs of the DSOs.	186
7.2.1. Competences are necessary to conduct experimentations successfully and to get the most feedback from them.	186
7.2.2. Once the experiments are finished, the resources and competences need to be reinforced in preparation for large-scale industrialization and deployment	187

7.3. The French electrical sector mobilizes: the “Smart Grids” plan	189
CHAPTER 8. KEY FINDINGS	193
8.1. Smart grids or the real network revolution	193
8.1.1. Smart grids	194
8.2. More RES means more network	195
8.3. The DSO is a facilitator	196
8.4. Consumer or “consum’player”?	197
8.5. Smart meter at the service of smart grids	199
8.6. A smart bubble?	199
8.7. Invest to save?	201
8.8. Smart grids: a genuine industrial opportunity	201
BIBLIOGRAPHY	203
INDEX.	211