

# Contents

<b>1 Challenges of Smart Grids Implementation . . . . .</b>	1
1.1 Overview . . . . .	1
1.2 Definitions . . . . .	1
1.3 Micro Grid [5] . . . . .	4
1.4 Advantages of Smart Grid. . . . .	7
1.4.1 Reducing Environmental Impacts . . . . .	7
1.4.2 Improving Reliability . . . . .	8
1.4.3 Increasing Efficiency . . . . .	9
1.5 Main Challenges of Smart Grids Implementations . . . . .	9
1.5.1 Investment Costs . . . . .	9
1.5.2 Security and Privacy . . . . .	10
1.5.3 Data Management . . . . .	10
1.5.4 Stability and Decreasing Rate of Flexibility. . . . .	11
1.6 Organization of the Book . . . . .	11
References . . . . .	12
<b>2 On the Concept of Flexibility in Electrical Power Systems:</b>	
<b>Signs of Inflexibility . . . . .</b>	17
2.1 Overview . . . . .	17
2.2 What is the Power System Flexibility? . . . . .	17
2.3 Signs of Inflexibility . . . . .	22
2.3.1 Challenges in Demand-Supply Balancing . . . . .	22
2.3.2 Significant Renewable Energy Curtailments. . . . .	23
2.3.3 Area Balance Violations. . . . .	24
2.3.4 Negative Market Prices . . . . .	24
2.3.5 Price Volatility . . . . .	24
References . . . . .	25

<b>3 Investigating Different Sources of Flexibility in Power System . . . . .</b>	<b>27</b>
3.1 Overview . . . . .	27
3.2 Challenges in Supply-Side Flexibility . . . . .	27
3.2.1 Conventional Power Plants . . . . .	28
3.2.2 Renewable Energy Sources . . . . .	28
3.3 Quantifying Grid Side Flexibility . . . . .	29
3.3.1 Flexibility for Power . . . . .	29
3.3.2 Flexibility for Energy . . . . .	29
3.3.3 Flexibility for Transfer Capacity . . . . .	30
3.4 Flexibility for Voltage . . . . .	30
3.5 Exploiting Demand-Side Flexibility (DSF) . . . . .	31
References . . . . .	35
<b>4 Forecasting Available Demand-Side Flexibility . . . . .</b>	<b>39</b>
4.1 Overview . . . . .	39
4.2 Importance of Forecasting Flexibility . . . . .	39
4.3 Forecasting Parameters . . . . .	40
4.4 Improving Forecasts with Machine Learning Methods . . . . .	43
4.5 Optimization-Based Approaches . . . . .	44
4.6 Evaluation Metrics . . . . .	45
References . . . . .	47
<b>5 New Approaches for Increasing Demand-Side Flexibility . . . . .</b>	<b>51</b>
5.1 Overview . . . . .	51
5.2 Enabling Demand-Side Flexibility . . . . .	52
5.3 Electrical Vehicle (EV) Charging as Alternative Storage [47] . . . . .	55
5.4 Increasing Available Flexibility; Case Study, Estonia . . . . .	56
5.5 Challenges in Increasing Available Flexibility . . . . .	59
References . . . . .	60