

# Contents

<b>1 Introduction</b>	1
1.1 Traditional Grid	1
1.2 Drivers of Change	3
1.2.1 Renewable Energy Systems	3
1.2.2 Electric Vehicles	4
1.2.3 Battery Storage Systems	5
1.2.4 Emerging Challenges and Opportunities	6
1.3 Enabling Technologies for the Control of Active End-Nodes	6
1.3.1 Pervasive Measurement and Communication	7
1.3.2 Pervasive Control	7
1.4 Need for a New Approach for Control of Active End-Nodes	8
1.4.1 Goals	9
1.4.2 Optimal Control in Quasi Real-Time	10
1.5 Chapter Summary	11
References	11
<b>2 Related Work</b>	13
2.1 The Impact of Active End-Nodes on the Distribution Grid	13
2.1.1 Impact of EV Adoption	14
2.1.2 Impact of PV Adoption	15
2.2 Control of EV Chargers	16
2.2.1 Pre-Dispatch Scheduling	17
2.2.2 Near Real-Time Control	19
2.3 Control of Renewable Inverters	24
2.4 Joint Control of Elastic Loads and Renewable Energy Systems	25
2.5 Chapter Summary	25
References	26

<b>3</b>	<b>System Model</b>	29
3.1	Power Distribution System	29
3.1.1	Network Model	30
3.1.2	Operating Constraints	31
3.2	End-Node Models and Constraints	33
3.2.1	Inelastic Loads	33
3.2.2	Solar Photovoltaic Systems	33
3.2.3	Battery Storage Systems	34
3.2.4	Electric Vehicle Chargers	35
3.2.5	Load Aggregation at Buses	36
3.3	Power Flow Model	36
3.4	Fairness and Resource Allocation	38
3.5	Chapter Summary	38
	References	39
<b>4</b>	<b>Optimal Control of Active End-Nodes</b>	41
4.1	The Synergy Between EV Chargers and PV Inverters	41
4.2	Control Objectives	43
4.2.1	Objective 1—Maximizing Revenue Through Fair Power Allocation to EV Chargers	44
4.2.2	Objective 2—Minimizing Solar Curtailment	44
4.2.3	Objective 3—Minimizing the Use of Conventional Power	45
4.3	Optimal Control	45
4.3.1	Optimization Problems	45
4.4	Multi-Tier Control Architecture	49
4.5	Benchmarks	50
4.5.1	Without Local Storage	51
4.5.2	With Local Storage	52
4.6	Chapter Summary	52
	Reference	53
<b>5</b>	<b>Evaluation</b>	55
5.1	Simulation Framework	55
5.1.1	Architecture	56
5.1.2	Interactions Between Software Components	57
5.1.3	Programming Interface	57
5.2	Simulation Scenarios	58
5.2.1	Test Distribution System	59
5.2.2	Load Profiles	60
5.2.3	Solar Traces	63
5.2.4	Storage	63
5.2.5	EV Model	63

- 5.3 Results . . . . . 64
  - 5.3.1 The Effect of Uncontrolled EV Charging . . . . . 64
  - 5.3.2 The Effect of Uncontrolled Solar Generation. . . . . 67
  - 5.3.3 Evaluating the Proposed Control . . . . . 67
- 5.4 Chapter Summary . . . . . 72
- References . . . . . 73
- 6 Conclusion . . . . . 75**
  - 6.1 Summary of Achieved Goals . . . . . 75
  - 6.2 Limitations and Future Work . . . . . 76
    - 6.2.1 TCP-Style Control for Active End-Nodes. . . . . 76
    - 6.2.2 Generalizing to Unbalanced Multi-Phase Distribution Systems . . . . . 77
    - 6.2.3 Optimizing Capacitor Banks and Load Tap Switching Operations. . . . . 77
  - 6.3 Concluding Remarks . . . . . 77
  - References . . . . . 78
- Index . . . . . 79**



<http://www.springer.com/978-3-319-39983-6>

Integration of Renewable Generation and Elastic Loads  
into Distribution Grids

Ardakanian, O.; Keshav, S.; Rosenberg, C.

2016, XV, 79 p. 15 illus., Softcover

ISBN: 978-3-319-39983-6