

Contents

Abstract	v
List of Tables	xi
List of Figures	xiii
1 Introduction	1
1.1 Background and motivation	1
1.1.1 Emergence of smart active distribution system	1
1.1.2 Innovations in energy trading approaches for smart active distribution system	6
1.2 Literature survey	9
1.2.1 DER: Types, their coordination, and objectives	9
1.2.2 Energy trading approaches in network-connected multi-microgrid system	12
1.3 Research gap	17
1.4 Objectives and scope of the thesis	18
1.5 Organization of the thesis	19
2 Energy Management: Frameworks and Solution Approaches	21
2.1 Introduction	21
2.2 Energy Management Frameworks	21
2.2.1 Centralized energy management framework	22
2.2.2 Distributed energy management framework with multiple operating agents	23
2.2.3 Hierarchical energy management framework	24

2.3	Methodologies	25
2.3.1	Dantzig-Wolfe decomposition method	25
2.3.2	ε -constraint method	29
2.3.3	Shapley value method	30
2.4	Summary	30
3	Optimal Scheduling of PHEVs and D-BESSs in the Presence of DGs in Distribution System	31
3.1	Introduction	31
3.2	Problem formulation	32
3.2.1	Objective functions	32
3.2.2	Constraints	36
3.3	Stochastic model of PHEVs	38
3.4	Methodology	40
3.4.1	Dantzig-Wolfe decomposition method for decentralized scheduling .	40
3.4.2	The ε -constraint method	42
3.5	System data and assumptions	43
3.6	Results and discussions	45
3.6.1	Comparison of objective functions	45
3.6.2	Case Studies to demonstrate the system behavior	47
3.7	Summary	59
4	Decentralized Scheduling of Multi-Microgrid	61
4.1	Introduction	61
4.2	System architecture	62
4.2.1	Stochastic Model of Parking Lot	64
4.3	Problem formulation for energy cost minimization	66
4.3.1	Parking lots and distributed battery energy storage cost function .	66
4.3.2	Microgrid cost function	68
4.4	Methodology	70
4.4.1	Decentralized scheduling based on Stochastic Dantzig-Wolfe decomposition	70
4.4.2	Shapley value method for cost/profit allocation	73

4.4.3	Tariff update	73
4.4.4	Decentralized scheduling algorithm for network connected multi- microgrids system	74
4.5	Simulation results and discussions	76
4.5.1	System data	76
4.5.2	A comparative analysis of different power trading and pricing mech- anisms	77
4.6	Summary	89
5	Hierarchical Scheduling of Active Distribution System with Multi-Microgrid	91
5.1	Introduction	91
5.2	System model	93
5.3	Problem formulation for different decision making agents	94
5.3.1	End-User Aggregator (EUA) level modeling	94
5.3.2	Microgrid operator level modeling	96
5.3.3	Distribution utility level modeling	97
5.4	Methodology	100
5.4.1	MGO model based on Info-gap decision theory	100
5.4.2	Solution approach for three-level optimization	101
5.5	Results and discussion	105
5.5.1	System description	105
5.5.2	Game-theoretic pricing based energy management	109
5.5.3	Impact of risk-averse and risk-seeker decision making of MGOs on the cost of DU	117
5.5.4	Validation of proposed approach on unbalanced distribution system	119
5.6	Summary	129
6	Conclusions and Future Scope	131
6.1	Conclusions	131
6.1.1	Optimal Scheduling of DGs, PHEVs, and D-BESSs	131
6.1.2	Decentralized Scheduling of Multi-Microgrid	132
6.1.3	Hierarchical Scheduling of Active Distribution System with Multi- Microgrid	133

6.2 Future Scope	134
Appendix I	135
Appendix II	137
List of Publications	167