

# Contents

ACKNOWLEDGMENT

ABSTRACT **i**

ZUSAMMENFASSUNG **iii**

List of Contents **v**

List of Publications **vii**

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Motivation and Scope . . . . .	1
1.2	Outline . . . . .	2
<b>2</b>	<b>Optimal Electric Bus Charging and Battery Swapping with Renewable Energy and Frequency Control Ancillary Service Through Aggregator</b>	<b>5</b>
2.1	Introduction . . . . .	5
2.2	Unified Modeling Language Sequence Diagram for Frequency Control . . . . .	7
2.3	Operational Planning Modeling . . . . .	9
2.4	Charging Optimization Modeling . . . . .	13
2.4.1	Objective Function . . . . .	14
2.4.2	Constraints . . . . .	16
2.5	Application Scenario and Case Study . . . . .	18
2.5.1	Input Data . . . . .	19
2.5.2	Simulation and Analysis . . . . .	22
2.6	Conclusion . . . . .	34
<b>3</b>	<b>Energy Management for Electric Vehicle Parking Lots With Renewable Energy and Power Network Constraints Using Deep Reinforcement Learning</b>	<b>35</b>
3.1	Introduction . . . . .	35
3.2	Actor Collaboration Framework . . . . .	37
3.3	Markov Decision Process-Based Energy Management Modeling . . . . .	38
3.3.1	System State . . . . .	38
3.3.2	Charging or Discharging Action . . . . .	39

3.3.3	Reward Function . . . . .	39
3.3.4	Discount Factor . . . . .	41
3.4	Deep Reinforcement Learning Method . . . . .	42
3.5	Application and Performance Evaluation . . . . .	44
3.5.1	Input Data for Deep Reinforcement Learning Methods . . . . .	44
3.5.2	Performance Analysis Compared to Deterministic Optimization Method for Linear Energy Management Problem . . . . .	45
3.5.3	Performance Analysis of Deep Reinforcement Learning for Nonlinear Energy Management Problem . . . . .	50
3.6	Conclusion . . . . .	56
4	Optimal Fast Charging and Battery Swapping for Electric Taxis Using Deep Rein- forcement Learning . . . . .	<b>59</b>
4.1	Introduction . . . . .	59
4.2	Charging Framework for Multi-Functional Station . . . . .	61
4.3	Modeling Electric Taxi Visits to Multi-Functional Station . . . . .	63
4.3.1	Battery Swapping Zones . . . . .	63
4.3.2	Fast Charging Zones . . . . .	66
4.4	Optimizing Bidirectional Charging at Multi-Functional Station . . . . .	68
4.4.1	System State . . . . .	68
4.4.2	Bidirectional Charging Action . . . . .	68
4.4.3	Reward Function . . . . .	69
4.4.4	Discount Factor . . . . .	71
4.5	Case Study . . . . .	71
4.5.1	Input Data . . . . .	71
4.5.2	Simulation and Analysis . . . . .	76
4.6	Conclusion . . . . .	79
5	Conclusions . . . . .	<b>85</b>
	List of Abbreviations . . . . .	<b>87</b>
	References . . . . .	<b>89</b>