

# Contents

Abstract	ii
Contents	xi
1 Introduction and Objectives	19
1.1 Introduction	19
1.2 Justification	20
1.3 Objectives	21
1.4 Outlines of the Thesis	22
2 State of the Art - Electric Vehicle Integration in Smart Grids	25
2.1 Introduction	25
2.2 Electric vehicles	26
2.3 Charging EV	31
2.4 Overview of Electric Power Systems	37
2.5 Smart Grid	40
2.6 Microgrid	46
2.7 Electric Vehicles in Smart Grid	52

2.8 Conclusion of the Chapter . . . . .	63
<b>3 State of the Art - Charging Strategies and Grid Configurations for the Electric Vehicle adoption</b>	<b>65</b>
3.1 Introduction . . . . .	65
3.2 Issues of EV massive penetration in Distribution Grids. . . . .	66
3.3 Smart Charging of EVs in Distribution Grid. . . . .	70
3.4 Smart Charging of EVs in high RES deployment grid. . . . .	75
3.5 Planning EVs in Distribution Systems . . . . .	76
3.6 Conclusions of the Chapter . . . . .	77
<b>4 New Methodology: Smart Charging Using Customer Choice Products (CCPs)</b>	<b>79</b>
4.1 Introduction . . . . .	79
4.2 New Methodology . . . . .	81
4.3 Problem formulation. . . . .	89
4.4 Sensibility Analysis and Determination of Parameters Evaluated . . . . .	91
4.5 Conclusion . . . . .	95
<b>5 Case Study: Distribution System of Quito-Ecuador</b>	<b>97</b>
5.1 Introduction . . . . .	97
5.2 Case study characteristics . . . . .	98
5.3 Results and discussion . . . . .	104
5.4 Sensitivity Analysis Results for the Case Study. . . . .	113
5.5 Conclusion . . . . .	123
<b>6 Smart Charging Application to provide Ancillary Services</b>	<b>127</b>
6.1 Introduction . . . . .	127
6.2 Background: Ancillary Services . . . . .	128
6.3 Methodology formulation. . . . .	130
6.4 Case study . . . . .	138
6.5 Results. . . . .	139

6.6 Conclusion of the Chapter . . . . .	141
7 New Methodology: EV Charging mechanisms for Distribution systems with high penetration of renewable generation . . . . .	143
7.1 Introduction . . . . .	143
7.2 Methodology description . . . . .	146
7.3 Case Study: Santa Cruz, the Galapagos Islands . . . . .	152
7.4 Results and discussion . . . . .	158
7.5 Conclusion . . . . .	165
8 Energy Planning in isolated environments considering integration of EVs: Application to Santa Cruz, Galapagos islands . . . . .	167
8.1 Introduction . . . . .	167
8.2 Background. . . . .	169
8.3 Case Study: Santa Cruz, the Galapagos Islands . . . . .	171
8.4 Results and Discussion . . . . .	178
8.5 Impact of the CCP System in the Energy Planning . . . . .	186
8.6 Conclusions. . . . .	188
9 Thesis Conclusions . . . . .	189
9.1 Conclusions of the Dissertation. . . . .	189
9.2 Main Contributions . . . . .	192
9.3 Future developments. . . . .	192
9.4 Publications . . . . .	193
Bibliography . . . . .	201