

Contents

Section 1. Wind Energy and Their Applications

1. Wind Energy Resources: Theory, Design and Applications	3
<i>Fang Yao, Ramesh C. Bansal, Zhao Yang Dong, Ram K. Saket and Jitendra S. Shakya</i>	
1.1 Introduction	4
1.2 Power in the Wind	5
1.3 Wind Turbine Design Considerations	12
1.4 Grid Connected Wind Farms	13
1.5 Hybrid Power Systems	15
1.6 Economics of Wind Power Systems	18
1.7 Conclusion	19
References	19
2. Wind Turbine Systems: History, Structure, and Dynamic Model	21
<i>S. Masoud Barakati</i>	
2.1 Wind Energy Conversion System (WECS)	21
2.2 Overall Dynamic Model of the Wind Turbine System and Small Signal Analysis	35
References	47
3. Wind Turbine Generation Systems Modeling for Integration in Power Systems	53
<i>Adrià Junyent-Ferré and Oriol Gomis-Bellmunt</i>	
3.1 Introduction	53

3.2	Wind Turbine Modeling	54
3.3	Wind Modeling	55
3.4	Mechanical Transmission Modeling	57
3.5	Electrical Generator Modeling	58
3.6	Converter Modeling	62
3.7	Control Modeling	64
3.8	Electrical Disturbances	67
3.9	Conclusions	67
	References	68
4.	Technologies and Methods used in Wind Resource Assessment	69
	<i>Ravita D. Prasad and Ramesh C. Bansal</i>	
4.1	Introduction	69
4.2	Literature Review, Methods and Software used in WRA	70
4.3	Wind Characteristics for Site	81
4.4	To Find the Optimum Wind Turbine which Yields High Energy at High Capacity Factor	87
4.5	Uncertainties Involved in Predicting Wind Speeds using the Different Approaches of WRA	93
4.6	Concluding Remarks	95
	References	95
5.	Economic Analysis of Wind Systems	99
	<i>Ravita D. Prasad and Ramesh C. Bansal</i>	
5.1	Introduction	99
5.2	Wind System Economic Components	101
5.3	Economic Analysis Methods	105
5.4	Case Study for the Economic Analysis of a Wind Turbine	108
5.5	Conclusions	117
	References	117
6.	Line Side Converters in Wind Power Applications	119
	<i>Ana Vladan Stankovic and Dejan Schreiber</i>	
6.1	Introduction	119
6.2	Line Side Converters	120
6.3	Principle of Operation	121
6.4	Control of a Line-Side Converter under Balanced Operating Conditions	123

6.5	Line Side Converters under Unbalanced Operating Conditions	127
6.6	Analysis of the PWM Converter under Unbalanced Operating Conditions	128
6.7	Control Method for Input-Output Harmonic Elimination of the PWM Converter under Unbalanced Operating Conditions . . .	130
6.8	Examples	134
6.9	Concluding Remarks	145
	References	145
7.	Wake Effects from Wind Turbines on Overhead Lines	147
	<i>Brian Wareing</i>	
7.1	Introduction	147
7.2	Literature Survey and Review of any Modeling or Field Test Work	149
7.3	Effect of Wind Speed and Turbulence on Overhead Lines . . .	160
7.4	CENELEC Standards	166
7.5	Wind Tunnel Results	168
7.6	Comparison with Other Data	179
7.7	Effect of Multiple Turbines on the OHL	181
7.8	Solutions	182
7.9	Summary	182
	References	184

Section 2. Solar Energy Systems

8.	Solar Energy Calculations	189
	<i>Keith E. Holbert and Devarajan Srinivasan</i>	
8.1	Introduction	189
8.2	Earth's Orbit	190
8.3	Solar Constant and Solar Spectra	191
8.4	Solar Angles	192
8.5	Collector Angles	195
8.6	Solar Irradiance	197
8.7	Comparison to Measured Data	201
8.8	Photovoltaic Energy Conversion	202

8.9	Concluding Remarks	203
	References	203
9.	Photovoltaic Systems	205
	<i>Ravita D. Prasad and Ramesh C. Bansal</i>	
9.1	Introduction	205
9.2	PV Modules	206
9.3	Types of PV Systems	210
9.4	Concluding Remarks	222
	References	223
10.	Solar Thermal Electric Power Plants	225
	<i>Keith E. Holbert</i>	
10.1	Introduction	225
10.2	Solar Thermal Systems	225
10.3	Concentrating Solar Power Systems	230
10.4	Low Temperature Solar Thermal Approaches	241
10.5	Environmental Impact	243
10.6	Concluding Remarks	243
	References	243
11.	Maximum Power Point Tracking Charge Controllers	247
	<i>Ashish Pandey, Nivedita Thakur and Ashok Kumar Mukerjee</i>	
11.1	Solar Battery Charging	247
11.2	Various Sources of Losses	248
11.3	Charge Control in Battery Backed PV Systems	252
11.4	Maximum Power Point Tracking (MPPT)	254
11.5	Advance Issues and Algorithms	256
11.6	Conclusion	263
11.7	Further Readings	264
	References	264
12.	Non-grid Solar Thermal Technologies	267
	<i>Mahendra S. Seveda, Narendra S. Rathore and Vinod Kumar</i>	
12.1	Introduction	268
12.2	Solar Collectors	268
12.3	Solar Drying	270

12.4	Solar Cooking	276
12.5	Solar Water Heating	279
12.6	Solar Distillation	281
12.7	Solar Heating of Buildings	283
12.8	Conclusions	287
	References	287
13.	Solar Tunnel Dryer — A Promising Option for Solar Drying	289
	<i>Mahendra S. Seveda, Narendra S. Rathore and Vinod Kumar</i>	
13.1	Introduction	290
13.2	Principle of Drying	291
13.3	Open Sun Drying	291
13.4	Types of Solar Dryers	293
13.5	Factors Affecting Solar Drying	295
13.6	Selection of Solar Dryers	296
13.7	Solar Tunnel Dryer	297
13.8	Case Studies on Solar Tunnel Dryer for Drying Agricultural Product (Embilica Officinalis Pulp)	299
13.9	Case Studies on Solar Tunnel Dryer for Drying Industrial Product (Di-basic Calcium Phosphate)	311
13.10	Conclusions	319
	References	320

Section 3. Bio Fuels

14.	Biomass as a Source of Energy	323
	<i>Mahendra S. Seveda, Narendra S. Rathore and Vinod Kumar</i>	
14.1	Introduction	324
14.2	Types of Biomass	326
14.3	Energy Content of Biomass	327
14.4	Harvesting Methods of Biomass	328
14.5	Conversion of Biomass	330
14.6	Thermo-Chemical Conversion of Biomass	332
14.7	Biodiesel Production	340
14.8	Bioethanol Production	341
14.9	Conclusions	343
	References	343

15.	Forest Biomass Production	345
	<i>Severiano Pérez, Carlos J. Renedo, Alfredo Ortiz, Mario Mañana and Carlos Tejedor</i>	
15.1	Introduction	345
15.2	Bioclimatic Potential	347
15.3	Forest Species	349
15.4	Evaluation of Forest Biomass	350
15.5	Collection Systems for Forest Biomass	359
15.6	Environmental Impact Resulting from the Generation and Exploitation of Forest Biomass	362
15.7	Conclusions	366
	References	367
16.	Bioethanol	369
	<i>Alfredo Ortiz, Severiano Pérez, Carlos J. Renedo, Mario Mañana and Fernando Delgado</i>	
16.1	Technical Fundamentals	369
16.2	Level of Development	379
16.3	Strengths and Weaknesses	381
16.4	Environmental Impact	384
16.5	Economics	387
16.6	Combination with Conventional Sources	389
16.7	Conclusions	392
	References	393
17.	Biodiesel	395
	<i>Carlos J. Renedo, Alfredo Ortiz, Severiano Pérez, Mario Mañana and Inmaculada Fernández</i>	
17.1	Technical Fundamentals	395
17.2	Level of Development	414
17.3	Strengths and Weaknesses	420
17.4	Environmental Impact	423
17.5	Economics	426
17.6	Combination with Conventional Sources	427
17.7	Conclusions	428
	References	429

Section 4. Ocean and Small Hydro Energy Systems

18. Technologies and Methods used in Marine Energy and Farm System Model	435
<i>V. Patel Kiranben and M. Patel Suvin</i>	
18.1 Introduction	436
18.2 Marine Energy: How Much Development Potential is There?	437
18.3 Understanding the Power of Marine Energy	437
18.4 Global Development of Marine Energy	439
18.5 Possible Impacts	440
18.6 Ocean Wave Energy	442
18.7 Ocean Tide Energy	450
18.8 Mathematical Modeling of Tidal Schemes	464
18.9 Global Environmental Impact	465
18.10 Operating Tidal Power Schemes	465
18.11 Conclusions	466
References	466
19. Operational Challenges of Low Power Hydro Plants	469
<i>Arulampalam Atputharajah</i>	
19.1 Introduction	469
19.2 Low Power Hydro Plants	471
19.3 Micro Hydro Plants	477
19.4 Concluding Remarks	482
References	482
20. Frequency Control in Isolated Small Hydro Power Plant	485
<i>Suryanarayana Doolla</i>	
20.1 Introduction	485
20.2 Mathematical Modeling of an Isolated SHP Plant	488
20.3 Frequency Control using On/Off Control Valve with Reduced Size of Dump Load	492
20.4 Frequency Control using Servo Motor Along with On/Off Control Valve	502
20.5 Conclusions	514
References	514

Section 5. Simulation Tools, Distributed Generation and Grid Integration

21.	Simulation Tools for Feasibility Studies of Renewable Energy Sources	519
	<i>Juan A. Martinez-Velasco and Jacinto Martin-Arnedo</i>	
21.1	Introduction	519
21.2	Modeling for Feasibility Studies	521
21.3	Economic Modeling	537
21.4	Greenhouse Gas Emission Reduction	539
21.5	Simulation Tools	540
21.6	Application Examples	544
21.7	Discussion	557
	References	560
22.	Distributed Generation: A Power System Perspective	563
	<i>Hitesh D. Mathur, Nguyen Cong Hien, Nadarajah Mithulananthan, Dheeraj Joshi and Ramesh C. Bansal</i>	
22.1	Introduction	564
22.2	Distributed Generation Systems	565
22.3	Impact of Distributed Generation on Electrical Power System	571
22.4	Conclusions	583
	References	583
23.	DG Allocation in Primary Distribution Systems Considering Loss Reduction	587
	<i>Duong Quoc Hung and Nadarajah Mithulananthan</i>	
23.1	Introduction	587
23.2	Distributed Generation	589
23.3	Loss Reduction in Distribution Systems	595
23.4	Loss Reduction Using DG	602
23.5	Numerical Results	614
23.6	Conclusions	632
	References	633
24.	Renewable-Based Generation Integration in Electricity Markets with Virtual Power Producers	637
	<i>Zita A. Vale, Hugo Morais and Hussein Khodr</i>	

24.1	Introduction	638
24.2	Electricity Markets and DG	641
24.3	Virtual Power Producers (VPP)	643
24.4	VPP and Electricity Market Simulation	661
24.5	Conclusions and Future Perspectives	668
	References	669

Section 6. Induction Generators, Power Quality, Power Electronics and Energy Planning for Renewable Energy Systems

25.	Modern Power Electronic Technology for the Integration of Renewable Energy Sources	673
	<i>Vinod Kumar, Ramesh C. Bansal, Raghuvveer R. Joshi, Rajendrasinh B. Jadeja and Uday P. Mhaskar</i>	
25.1	Introduction	673
25.2	Various Topologies of Power Electronic Converters	674
25.3	Current Wind Power Technology	685
25.4	Future Trends in Wind-Power Technology	690
25.5	Grid-Interconnection Requirements for Wind Farms: Overview	694
25.6	Power Electronics in Photovoltaic (PV) System	700
25.7	Recent Trends in Energy-Storage Technologies	706
25.8	Conclusions	710
	References	711
26.	Analysis of Induction Generators for Renewable Energy Applications	717
	<i>Kanwarjit S. Sandhu</i>	
26.1	Introduction	717
26.2	Equivalent Circuit Model of Induction Machine	718
26.3	Slip in Terms of Per Unit Frequency and Speed	719
26.4	Grid Connected Induction Generator	720
26.5	Self-Excited Induction Generators [SEIG]	726
26.6	Conclusions	755
	Appendix	755
	References	756

27.	Control of Doubly Fed Induction Generators under Balanced and Unbalanced Voltage Conditions	757
	<i>Oriol Gomis-Bellmunt and Adrià Junyent-Ferré</i>	
27.1	Introduction	757
27.2	Nomenclature	758
27.3	General Considerations	759
27.4	Control of the Doubly Fed Induction Generator under Balanced Conditions	760
27.5	Control of the Doubly Fed Induction Generator under Unbalanced Conditions	764
27.6	Simulation Results	773
27.7	Conclusions	782
	References	783
28.	Power Quality Instrumentation and Measurement in a Distributed and Renewable Environment	785
	<i>Mario Manana, Alfredo Ortiz, Carlos J. Renedo, Severiano Perez and Alberto Arroyo</i>	
28.1	Introduction	785
28.2	Regulatory Framework	786
28.3	State-of-the-art	787
28.4	Instrumentation Architecture	788
28.5	PQ Monitoring Surveys in Distributed and Renewable Environments	792
28.6	Summary	798
	References	798
29.	Energy Resource Allocation in Energy Planning	801
	<i>Sandip Deshmukh</i>	
29.1	Introduction to Energy Planning Process	801
29.2	Energy Requirement and Energy Resource Estimations	809
29.3	Energy Resource Allocation	818
29.4	Region Dependent Development in Energy Planning	829
29.5	Conclusions	842
	References	843
	Index	847