

- List of Figures p. xv
- Preface p. xvii
- 1 History of Electric Power Industry p. 1
 - Origin of the Industry p. 1
 - Development of the National Electric Power Grid p. 3
 - Industry Ownership Structure p. 6
 - Legislation and Regulation p. 8
 - Blackouts and the Reliability Crisis p. 8
 - Environmental Crisis--The Shift to Low-Sulfur Oil p. 9
 - Fuel Crisis--The Shift from Oil p. 9
 - Financial Crisis p. 9
 - Legislative and Regulatory Crisis p. 10
- 2 Electric Power System p. 13
 - Customers p. 14
 - Sources of the Electric Energy--Generation p. 15
 - Delivery System p. 17
 - Interconnections p. 19
 - Grid p. 21
- 3 Basic Electric Power Concepts p. 23
 - Electric Energy p. 24
 - Concepts Relating to the Flow of Electricity p. 26
 - Direct Current p. 27
 - Alternating Current p. 27
 - Three Phases p. 29
 - Synchronism p. 29
 - Characteristics of AC Systems p. 29
 - Resistance p. 29
 - Induction and Inductive Reactance p. 30
 - Inductive Reactance p. 30
 - Capacitance and Capacitive Reactance p. 30
 - Capacitive Reactance p. 31
 - Reactance p. 31
 - Impedance p. 31
 - Ohm's Law for Alternating Current p. 33
 - Power in Alternating Current Circuits p. 33
 - Real Power p. 34
 - Reactive Power p. 34
 - Advantages of AC over DC Operation p. 35
 - Transformers p. 36
 - Power Flow p. 37
 - Division of Power Flow Among Transmission Lines p. 37
 - Voltage Drop and Reactive Power Flow p. 37
 - Power Flow and Phase Angle Differences p. 37
 - Stability p. 38

- Results of Instability p. 40
- 4 Electric Energy Consumption p. 41
 - End-Uses for Electricity p. 41
 - Customer Classes p. 42
 - Rate Classes p. 43
 - Demand and Energy p. 44
 - Energy p. 44
 - Effects of Load Diversity p. 45
 - System Load p. 47
 - Load Management p. 48
 - Reactive Power p. 50
 - Forecasts p. 50
 - Losses and Unaccounted-for Energy in the Delivery System p. 52
- 5 Electric Power--Generation p. 55
 - Types of Generation p. 56
 - Steam Turbines p. 56
 - Combustion (Gas) Turbines p. 57
 - Hydro Turbines p. 57
 - Pumped Storage p. 58
 - Nuclear Units p. 58
 - Reciprocating Engines p. 58
 - Micro Turbines p. 58
 - Other Forms of Generation p. 59
 - Characteristics of Generating Plants p. 60
 - Size p. 62
 - Efficiency p. 64
 - Availability p. 65
 - Capital Cost of Generation p. 66
 - Type of Use p. 66
 - Life Extension p. 67
 - Synchronous Generators p. 67
 - Resource Procurement p. 68
 - Fuel Measurements p. 69
 - Fuel Transportation p. 70
 - Fuel Used p. 70
 - Fuel Purchasing p. 71
 - Emission Rights p. 71
- 6 Technology of the Electric Transmission System p. 73
 - Components p. 73
 - HVAC p. 74
 - Overhead p. 74
 - Ratings p. 74
 - Cable p. 75
 - Submarine Cables p. 76

- Substations p. 76
- Substation Equipment p. 77
- Substation Breaker Arrangements p. 81
- Transmission System Aging p. 82
- HVDC p. 82
- Advantages of HVDC p. 83
- Disadvantages of HVDC p. 84
- Knowledge Required of Transmission System p. 84
- 7 Distribution p. 85
 - Primary Feeders p. 86
 - Radial Systems p. 86
 - Loop Systems p. 87
 - Primary Network Systems p. 87
 - Distribution Transformers p. 87
 - Secondary Systems p. 87
 - Distribution Capacity p. 89
 - Losses p. 90
 - Ratings p. 90
 - Metering p. 90
 - Control of Voltage p. 91
 - Capacitors p. 91
 - Voltage Regulators p. 92
 - Reliability p. 92
 - Quality of Service p. 93
 - Design of Distribution Systems p. 93
 - Distributed Generation p. 94
 - Operation of Distribution Systems p. 94
- 8 Functioning of the Electric Bulk Power System p. 97
 - Coordination p. 97
 - Operation p. 99
 - Control Areas p. 99
 - Operating Reserves p. 102
 - Ancillary Services p. 102
 - Emergencies p. 103
 - Operating Emergencies p. 104
 - Parallel Path Flow and Loop Flow p. 105
 - Power Transfer Limits p. 105
 - Determination of Total Transfer Capability p. 106
 - Reduction of Power Transfers--Congestion Management p. 107
 - Planning p. 107
 - Planning Standards p. 108
 - Generation Planning p. 108
 - Least Cost Planning p. 110
 - Transmission Planning p. 110

- Load-Flow Studies p. 112
- Stability Studies p. 112
- Short-Circuit Duty Studies p. 112
- New Planning Environment p. 113
- 9 Reliability p. 117
 - Costs of Power Outages p. 119
 - Ways to Measure Reliability p. 120
 - Planning and Operating a Reliable and Adequate Power System p. 121
 - Transmission Security and Security Coordinators p. 122
 - Paying for Extra Reliability p. 124
 - Compliance p. 124
 - Generation p. 125
 - Transmission p. 126
 - Transmission System Problems p. 126
 - Planning and Operating Standards p. 127
 - Voltage and Reactive Control p. 128
 - Distribution p. 129
 - Summary p. 129
- 10 Restructuring, Competition and Deregulation p. 131
 - Causes of Restructuring p. 131
 - Types of Restructuring p. 132
 - Effects of Restructuring p. 133
 - Six Networks p. 133
 - Changing Customer Requirements p. 135
- 11 Legislation and Regulation--The Regulatory Network p. 137
 - Pricing and Regulation p. 137
 - Federal Legislation p. 138
 - Public Utility Holding Company Act of 1935 p. 138
 - Federal Power Act p. 139
 - Other Federal Laws p. 140
 - Environmental Laws p. 140
 - Department of Energy Organization Act p. 141
 - PURPA p. 142
 - Energy Policy Act ("EPACT") of 1992 p. 144
 - PUHCA Modifications p. 144
 - FPA Modifications p. 144
 - Federal Regulatory Agencies p. 145
 - FERC p. 145
 - SEC p. 146
 - Environmental Protection Agency (EPA) p. 146
 - Department of Energy (DOE) p. 147
 - Federal Legislation Under Consideration p. 147
 - State Regulatory Authority p. 148
 - Recent Federal Regulation Impacting the Electric Industry p. 148

- Orders 888 and 889 p. 148
- Order 2000 p. 150
- Tariff Basis p. 151
- Transmission Rights p. 151
- Physical Transmission Rights p. 151
- Financial Transmission Rights p. 152
- Average System versus Incremental Costs p. 152
- State Regulation p. 153
- Customer Choice p. 153
- Metering p. 154
- Distribution Rates p. 154
- State and Local Environmental Requirements p. 155
- Overall Regulatory Problems p. 155
- 12 The Business Network p. 157
- Investment and Cost Recovery p. 157
- Changing Industry Structure p. 158
- Utility Responses p. 158
- Holding Company Formation p. 158
- Unbundling p. 159
- New Structure p. 160
- Power Producers p. 160
- Power Plant Divestitures p. 160
- Transmitters p. 162
- Development of Non-Regulated Power Market p. 163
- Distributors p. 163
- Marketers p. 164
- Wheeling and Customer Choice p. 164
- Contracts and Agreements p. 165
- 13 ISOs, RTOs and ITPs p. 167
- ISO Formation p. 167
- Functions of ISOs p. 168
- Regional Operating Functions p. 168
- Regional Planning Functions p. 169
- RTOs p. 169
- 14 The Money Network p. 171
- Allocation of Costs and Economic Benefits p. 172
- Average Costs Versus Incremental Costs p. 173
- Market Versus Operational Control p. 173
- Market Power Issues p. 173
- Price Caps p. 173
- Standard Market Design (SMD) p. 174
- Objectives and Goals p. 174
- Proposals p. 174
- Transmission Owner's Options p. 175

- Independent Transmission Providers (ITPs) p. 175
- Transmission Charges p. 176
- Wholesale Electric Market Design p. 177
- Locational Marginal Pricing (LMP) p. 177
- Resource Adequacy p. 178
- Transmission Tariffs p. 179
- Merchant Transmission p. 179
- Markets for Buying and Selling Rights p. 179
- 15 Information, Communications and Control Network p. 181
- Financial and Business Operations p. 182
- System Operations p. 182
- Distribution Operations p. 183
- Physical Security p. 184
- Commercial Security p. 184
- 16 Role of NERC, NAESB and Other Organizations p. 187
- NERC, Reliability Councils, and RTOs p. 188
- NAESB p. 188
- Enforcement and Dispute Resolution p. 188
- Professional Organizations p. 189
- IEEE p. 189
- CIGRE p. 190
- Industry Associations p. 190
- NARUC p. 190
- AEIC p. 190
- APPA p. 191
- EEI p. 191
- ELCON p. 192
- NRECA p. 192
- Electric Power Supply Association p. 193
- Research Organizations p. 193
- EPRI p. 193
- Other Research p. 194
- NRRI p. 194
- 17 Where Restructuring Stands p. 195
- Required Additional Analyses p. 197
- Abandonment of Deregulation p. 197
- Power Supply p. 197
- 2002 p. 197
- The Future p. 197
- Energy Trading p. 198
- Reliability Concerns p. 198
- Transmission Problems p. 198
- National Power Survey p. 198
- Conclusions p. 199

- Index p. 201
- About the Authors p. 211