

# Contents

## Part I About Electricity

<b>1</b>	<b>What is Electricity?</b> . . . . .	3
1.1	Electricity: Simply Expressed. . . . .	3
1.2	How Do We Measure Electricity?. . . . .	4
1.3	The Big Differences Between Electricity and Water . . . . .	5
1.4	The Power Makers' Challenge . . . . .	6
<b>2</b>	<b>Faraday's Miracle</b> . . . . .	9
2.1	Faraday's Contribution . . . . .	9
2.2	Generators Explained . . . . .	10
2.3	What Drives the Generator?. . . . .	10
2.4	What Powers the Engines?. . . . .	11
2.5	Power Generator Types . . . . .	12
2.6	Comparing Generators. . . . .	12
2.7	Capacity Factor . . . . .	13
<b>3</b>	<b>Poles and Wires</b> . . . . .	15
3.1	Electricity Networks . . . . .	15
3.2	Transmission Losses . . . . .	16
3.3	Controlling the Network . . . . .	17
3.4	Advantages of Transmission Networks . . . . .	18
<b>4</b>	<b>The Balancing Act</b> . . . . .	19
4.1	Demand and Supply . . . . .	19
4.2	Network Reliability. . . . .	21
4.3	Reserve Capacity . . . . .	21
<b>5</b>	<b>Dollars and Cents.</b> . . . .	23
5.1	Calculating Generating Costs . . . . .	23
5.2	Typical Generating Costs. . . . .	24

5.3	Baseload, Intermediate, and Peak Load . . . . .	24
5.4	Getting the Mix Right . . . . .	25
5.5	Transmission Costs . . . . .	26
5.6	Energy Efficiency . . . . .	26
5.7	Energy Conservation . . . . .	27
5.8	Energy Reduction Targets . . . . .	28
	References . . . . .	28
<b>6</b>	<b>The Carbon Challenge . . . . .</b>	<b>29</b>
6.1	Climate Change Summary . . . . .	29
6.2	Reducing Emissions . . . . .	30
6.3	A Price on Carbon . . . . .	30
6.4	Emission Intensity . . . . .	30
6.5	The Power Makers' Response . . . . .	31
	References . . . . .	32
 <b>Part II Renewable Energy</b>		
<b>7</b>	<b>Many Options . . . . .</b>	<b>35</b>
7.1	Wind . . . . .	35
7.2	Solar . . . . .	36
7.3	Hydro . . . . .	36
7.4	Biomass . . . . .	37
7.5	Geothermal . . . . .	38
7.6	Tidal . . . . .	39
7.7	Waves . . . . .	39
7.8	Dilute Resources . . . . .	39
7.9	Variability . . . . .	40
<b>8</b>	<b>Nature's Curse . . . . .</b>	<b>41</b>
8.1	Natural Variability of RE Resources . . . . .	41
8.2	Why RE Variability is a Problem . . . . .	42
8.3	Negative Load . . . . .	42
8.4	Forecasting . . . . .	43
8.5	Measuring Variability . . . . .	43
8.6	Variability Across Generators . . . . .	45
8.7	Managing Variability . . . . .	45
	References . . . . .	45
<b>9</b>	<b>Nature's Saviors . . . . .</b>	<b>47</b>
9.1	Reliable and Proven . . . . .	47
9.2	More Hydropower . . . . .	47
9.3	More Conventional Geothermal . . . . .	48

9.4	More Biomass . . . . .	49
9.5	CSP with Storage . . . . .	50
9.6	EGS . . . . .	51
9.7	Summary . . . . .	51
	References . . . . .	52
<b>10</b>	<b>Storing Electricity . . . . .</b>	<b>53</b>
10.1	Why Do We Need Energy Storage? . . . . .	53
10.2	Pumped-Hydro Storage . . . . .	54
10.3	Compressed Air Energy Storage . . . . .	55
10.4	Hydrogen Energy Storage . . . . .	56
10.5	Batteries . . . . .	56
10.6	Energy Storage Costs . . . . .	57
10.7	Demand Management: An Alternative to Storage? . . . . .	58
10.8	Energy Storage Summary . . . . .	58
	References . . . . .	59
<b>11</b>	<b>Smoke and Mirrors . . . . .</b>	<b>61</b>
11.1	Comparing Apples with Oranges . . . . .	61
11.2	Comparing Energy Outputs . . . . .	62
11.3	Capacity Credit . . . . .	62
11.4	Comparing RE Penetration. . . . .	63
11.5	Comparing Different Networks. . . . .	64
11.6	Comparing the Costs of Electricity . . . . .	64
11.7	RE Energy Use. . . . .	65
11.8	Comparing Efficiencies . . . . .	66
11.9	Comparison of Building Materials . . . . .	66
11.10	Comparing Land Use . . . . .	67
11.11	Baseload Myths . . . . .	68
	References . . . . .	69
 <b>Part III Clean Coal</b>		
<b>12</b>	<b>Why Clean Coal? . . . . .</b>	<b>73</b>
12.1	Reducing the Coal Emission Intensity . . . . .	73
12.2	Carbon Capture and Storage. . . . .	74
12.3	Alternatives to Coal . . . . .	75
	References . . . . .	75
<b>13</b>	<b>Baseload Alternatives . . . . .</b>	<b>77</b>
13.1	What Makes a Baseload Power Station? . . . . .	77
13.2	Which Energy Sources Can Replace Coal? . . . . .	78

13.3	Can Gas Deliver Us From Coal? . . . . .	78
13.4	But Isn't Nuclear Dangerous?. . . . .	79
	Reference . . . . .	79

## **Part IV Fission Energy**

<b>14</b>	<b>Fission, Not Combustion . . . . .</b>	<b>83</b>
14.1	How Do Coal and Fission Energy Produce Electricity? . . . . .	83
14.2	Fission Reactors . . . . .	83
14.3	Fuel and Waste. . . . .	84
14.4	Carbon Dioxide Emissions . . . . .	85
14.5	Cost . . . . .	85
14.6	What's the Drama? . . . . .	85
	Reference . . . . .	85
<b>15</b>	<b>Safety First . . . . .</b>	<b>87</b>
15.1	Reactor Safety . . . . .	87
15.2	Nuclear Waste . . . . .	90
15.3	Proliferation of Nuclear Weapons . . . . .	91
15.4	Safety Summary . . . . .	91
	References . . . . .	92
<b>16</b>	<b>More Smoke and Mirrors . . . . .</b>	<b>93</b>
16.1	Myth 1: Renewables Make Nuclear Unnecessary . . . . .	93
16.2	Myth 2: Nuclear Energy is Too Expensive. . . . .	94
16.3	Myth 3: Nuclear Plants Could Not be Built in Time . . . . .	94
16.4	Myth 4: Uranium Supplies are Not Sustainable . . . . .	95
16.5	Myth 5: All Radiation is Dangerous . . . . .	95
16.6	Myth 6: Nuclear GHG Emissions are Huge . . . . .	96
16.7	Myth 7: Gas is Less Risky for Investors . . . . .	96
	References . . . . .	96
<b>17</b>	<b>Is Fission Really Necessary? . . . . .</b>	<b>97</b>
17.1	Challenging Times . . . . .	97
17.2	Renewable Energy . . . . .	98
17.3	Clean Coal. . . . .	98
17.4	Fission Energy . . . . .	98
<b>18</b>	<b>The Next Generation of Fission. . . . .</b>	<b>101</b>
18.1	Fuel Recycling . . . . .	101
18.2	Generation III Reactors . . . . .	101

18.3	Modular Construction . . . . .	102
18.4	Fast Reactors . . . . .	102
	References . . . . .	103

## **Part V The Melting Pot**

<b>19</b>	<b>Variable Loads are Here to Stay . . . . .</b>	<b>107</b>
19.1	Intermediate and Peak Loads . . . . .	107
19.2	Variability Won't Go Away . . . . .	108
	Reference . . . . .	109
<b>20</b>	<b>Cost Matters . . . . .</b>	<b>111</b>
20.1	Comparing Generator Costs . . . . .	111
20.2	The Generator Mix . . . . .	112
20.3	The Impact of a Rising Carbon Price . . . . .	113
	Reference . . . . .	113
<b>21</b>	<b>Distributed Generation and Storage . . . . .</b>	<b>115</b>
21.1	Distributed Generation. . . . .	115
21.2	Decentralized Energy . . . . .	116
21.3	Community Energy Storage . . . . .	117
21.4	Reducing Demand Variability . . . . .	117
21.5	Distributed Generation Future . . . . .	117
<b>22</b>	<b>Smart Grids . . . . .</b>	<b>119</b>
22.1	The Vision. . . . .	119
22.2	What Would be Needed for a Smart Grid? . . . . .	120
22.3	What are the Benefits? . . . . .	120
22.4	What are the Risks? . . . . .	121
	References . . . . .	121
<b>23</b>	<b>Electric Transport . . . . .</b>	<b>123</b>
23.1	The Demise of Oil . . . . .	123
23.2	The Rise of the Electric Car. . . . .	123
23.3	How Will We Refuel Our Electric Vehicles? . . . . .	124
23.4	How Much Electricity Would Transport Need? . . . . .	124
23.5	What Will be the Impact on the Electricity Network? . . . . .	125
<b>24</b>	<b>Summing It All Up. . . . .</b>	<b>127</b>
24.1	Carbon Challenge . . . . .	127
24.2	Reducing Emissions . . . . .	127
24.3	An All-Renewable Future . . . . .	128
24.4	Clean Coal and Gas . . . . .	129

24.5	Fission Energy . . . . .	130
24.6	Melting Pot . . . . .	131
24.7	Future Technologies . . . . .	131
24.8	Conclusion. . . . .	132
	Reference . . . . .	132
	<b>Author Biography . . . . .</b>	<b>133</b>
	<b>Appendix A: Definition of Terms . . . . .</b>	<b>135</b>
	<b>Appendix B: Power Generation and Network Control . . . . .</b>	<b>139</b>
	<b>Appendix C: Wind Power . . . . .</b>	<b>147</b>
	<b>Appendix D: Solar Power . . . . .</b>	<b>155</b>
	<b>Appendix E: Energy Storage . . . . .</b>	<b>165</b>
	<b>Appendix F: Carbon Capture and Storage . . . . .</b>	<b>173</b>
	<b>Appendix G: Nuclear Power . . . . .</b>	<b>177</b>
	<b>Appendix H: Electricity Costs and Markets . . . . .</b>	<b>187</b>
	<b>Index . . . . .</b>	<b>195</b>

The Power Makers' Challenge  
And the Need for Fission Energy

Nicholson, M.

2012, XXIV, 200 p., Hardcover

ISBN: 978-1-4471-2812-0