

Driven by Demand

How Energy Gets its Power

JIMMY Y. JIA AND JASON CRABTREE

CAMBRIDGE
UNIVERSITY PRESS

Contents

<i>List of figures</i>	<i>page xi</i>
<i>List of tables</i>	<i>xiii</i>
<i>Acknowledgments</i>	<i>xv</i>

Part I Introduction 1

1 You get what you ask for	3
1.1 The energy we buy	4
1.2 A few guiding principles	5
1.3 Features versus benefits	6
1.4 Where we are headed	7
1.5 Chapter 1 Summary	9

Part 13 Three frameworks 11

2 Energy: the product	13
2.1 Energy and power are not equivalent	14
2.2 The three laws of thermodynamics	16
2.3 Thermal energy	20
2.4 Controlling factors are often unrelated to energy	21
2.5 Chapter 2 Summary	23
3 Energy: the delivery system	24
3.1 How we consume energy	29
3.2 Generation	35
3.3 Transmission and transportation	44
3.4 Chapter 3 Summary	52

4	Energy: the value proposition	53
4.1	The properties of a wicked problem	55
4.2	The clumsy solution	55
4.3	Competitive approaches	60
4.4	Hierarchical approaches	71
4.5	Egalitarian approaches	81
4.6	Chapter 4 Summary	88
Part III Critical decisions		91
5	The International Niagara Commission of 1891	93
5.1	The business of generating power	94
5.2	The International Niagara Commission	97
5.3	Generation and transmission technologies of 1891	99
5.4	Received proposals	101
5.5	No award	101
5.6	Modern-day lessons	104
5.7	Chapter 5 Summary	107
6	Trash as treasure	109
6.1	The creation of municipal solid waste	110
6.2	The collection of rubbish	112
6.3	The treatment of trash	113
6.4	Prioritization and economics	122
6.5	Chapter 6 Summary	127
7	Paying for pavement	128
7.1	Transportation basics	129
7.2	Roads: a means to an end	131
7.3	The pressures on spending priorities	133
7.4	The erosion of revenue	135
7.5	Role of taxes	138
7.6	Energy effects of spending priorities and taxes	145
7.7	Chapter 7 Summary	147
8	Heat without the hot air	149
8.1	Properties of heat	150

8.2	Transmission constraints	154
8.3	The value proposition of managing risks	158
8.4	Upfront costs to provide energy	162
8.5	What is the value of well-managed heat?	163
8.6	Chapter 8 Summary	165
9	The collision of two critical infrastructures	166
9.1	A centralized grid emerges	167
9.2	A "smarter" grid	170
9.3	An introduction to cyber-physical systems	172
9.4	Conflicting values and design criteria	179
9.5	Evolving and disruptive security requirements	181
9.6	Stuxnet and the debunking of ICS/SCADA security myths	184
9.7	Chapter 9 Summary	187
Part IV Energy futurism		189
10	Towards better management of energy infrastructures	191
10.1	Complex versus complicated	192
10.2	The future of the grid	197
10.3	Towards open-access transactive energy networks	203
10.4	Chapter 10 Summary	210
11	Risk management in energy	211
11.1	Security and risk	213
11.2	Threats	221
11.3	Towards operational risk management	229
11.4	Chapter 11 Summary	234
12	Resilience as a core value	236
12.1	Exploring (inter)dependence	237
12.2	Valuing diversity and future freedom of action	238
12.3	Historic US blackouts	245
12.4	India goes dark	252
12.5	Chapter 12 Summary	256

13 Exploring energy security	258
13.1 Energy and water	259
13.2 Strategic Petroleum Reserve (SPR)	269
13.3 Fukushima	271
13.4 Integration of the North American power grid	275
13.5 Electromagnetism and the power grid	276
13.6 Chapter 13 Summary	283
14 Energy-as-a-service	284
14.1 Buying electricity today	285
14.2 Energy products versus energy services	287
14.3 Making energy visible	292
14.4 Chapter 14 Summary	305
PartV Societal advancement	307
15 Bringing it all together	309
15.1 Ages of energy	311
15.2 Putting the present in context	318
15.3 Earth's energy future	322
15.4 The enabler of civilizations	327
15.5 Still driven by demand	328
<i>References</i>	333
<i>Index</i>	379