

Contents

Preface.....	xiii
Biographical Notes.....	xvii
Acknowledgements.....	xix
Acronyms, Initialisms, Symbols and Units used in this book	xxi
CHAPTER 1 The Evolution of Unsustainable Road Transport	1
1.1 Bicycles and beyond.....	1
1.2 Steam takes to the road	4
1.2.1 Early pioneers: 1765–1840	4
1.2.2 Steam traction engines	10
1.2.3 Steam cars	13
1.2.4 Steam vans and lorries.....	17
1.2.5 Steam buses, trams and cable cars	20
1.3 The age of electricity.....	24
1.3.1 Birth of the electrical power industry.....	24
1.3.2 Battery road vehicles.....	26
1.3.3 Off-road battery vehicles.....	35
1.3.4 Mains electric traction.....	35
1.4 The age of the motor vehicle – from dream to necessity	37
1.4.1 The internal-combustion engine.....	37
1.4.2 Cars	41
1.4.3 Motorcycles	46
1.4.4 Motor scooters.....	49
1.4.5 Trucks.....	52
1.4.6 Buses	54
1.5 Growth of the petroleum industry	56
1.6 Development of roads	57
1.6.1 Road construction.....	57
1.6.2 Super highways	60
1.6.3 Traffic regulations and road accidents.....	62
1.7 Growth of the automotive sector.....	63
CHAPTER 2 Drivers for Change	65
2.1 Challenges for new-generation road vehicles	65
2.2 Demographics and vehicle ownership.....	66
2.2.1 World population statistics	66
2.2.2 Vehicle production and ownership	68

2.3	Petroleum production and consumption.....	71
2.4	Conventional petroleum reserves	73
2.5	Atmospheric pollution.....	76
2.5.1	Emission regulations	78
2.6	Fuel and vehicle efficiencies	79
2.7	Emissions and climate change	80
2.8	Electricity and hydrogen as energy carriers	84
CHAPTER 3	Unconventional Fuels.....	86
3.1	The need for ‘unconventional fuels’	86
3.2	Raw materials.....	86
3.2.1	Oil sands.....	87
3.2.2	Heavy oil deposits	89
3.2.3	Oil shales.....	90
3.2.4	Natural gas	92
3.2.5	Coal	94
3.2.6	Energy crops.....	95
3.3	Motor fuels	98
3.3.1	Liquid petroleum gas.....	98
3.3.2	Natural gas	100
3.3.3	Ethanol	101
3.3.4	Bio-diesel	104
3.3.5	Methanol	105
3.4	Summary	107
CHAPTER 4	Development of Road Vehicles with Internal-Combustion Engines	109
4.1	Early days of the motor industry	109
4.2	Developments in vehicle body design.....	111
4.2.1	Body size and shape	112
4.2.2	Body welding	113
4.2.3	Surface treatment	114
4.2.4	Modern body materials	115
4.3	Engines and transmissions	116
4.3.1	Types of internal-combustion engine	116
4.3.2	Fuel supply	129
4.3.3	Engine ignition systems	130
4.3.4	Engine starting	131
4.3.5	Power output	132
4.3.6	Position of engine.....	133
4.3.7	Current developments in engine technology	134
4.3.8	Transmission	135
4.3.9	Two-wheel and four-wheel drives	137

4.4	Suspension, steering, brakes	138
4.4.1	Springs.....	139
4.4.2	Shock absorbers	139
4.4.3	Struts	140
4.4.4	Steering	140
4.4.5	Brakes.....	142
4.5	Exhaust systems and emissions.....	144
4.5.1	Exhaust catalyst technology: petrol engines	145
4.5.2	Exhaust treatment: diesel engines	146
4.5.3	Exhaust systems	147
4.6	Other key components.....	147
4.6.1	Wheels	147
4.6.2	Tyres	148
4.6.3	Lights.....	149
4.7	Safety.....	151
4.8	Accessories.....	152
4.8.1	Driving aids	152
4.8.2	Convenience	153
4.8.3	Comfort	154
4.8.4	Entertainment and communications.....	154
4.9	The future for internal-combustion-engined vehicles	155
CHAPTER 5	Progressive Electrification of Road Vehicles.....	157
5.1	Electricity to the rescue.....	157
5.2	Stop–start and hybrid electric vehicles	160
5.2.1	Stop–start vehicles	161
5.2.2	Medium and full hybrids.....	163
5.2.3	Power electronics	168
5.2.4	Energy characteristics and economics of stop–start vehicles and hybrids.....	168
5.2.5	Downsize and boost	169
5.2.6	Hybrid electric buses and trucks	172
5.2.7	Hybrid trolleybus concepts.....	173
5.3	Electric vehicles with batteries charged from the mains.....	175
5.3.1	Plug-in hybrids	176
5.3.2	Extended-range electric vehicles.....	178
5.3.3	Battery electric vehicles	179
5.4	Solar cars.....	187
5.5	Benchmarks of progress towards cleaner and more efficient vehicles.....	189
5.5.1	Energy efficiency.....	189
5.5.2	Carbon dioxide emissions	190
5.6	Road transport in transition.....	191

CHAPTER 6 Mains Electricity Supply for Charging Vehicle Batteries	193
6.1 Why is electricity supply relevant to road transport?.....	193
6.2 Electricity – a driving factor in the world economy.....	194
6.3 Generation and distribution of electricity	195
6.3.1 Coal-fired electricity plant.....	195
6.3.2 Oil-fired and gas-fired electricity plant	196
6.3.3 Nuclear power	196
6.3.4 Electricity from renewable energy	198
6.3.5 Combined heat and power (co-generation)	199
6.3.6 Distributed generation	201
6.4 Electricity availability in selected countries: contemporary case studies	201
6.4.1 Iceland.....	202
6.4.2 United Kingdom.....	203
6.4.3 India.....	206
6.4.4 China	208
6.4.5 United States of America	210
6.5 Recharging electric vehicles.....	211
6.6 De-regulation of electricity markets.....	215
CHAPTER 7 Batteries and Supercapacitors for Use in Road Vehicles	217
7.1 Fundamentals of energy storage in batteries	217
7.2 Key criteria for candidate batteries	221
7.2.1 Capacity.....	221
7.2.2 Energy	221
7.2.3 Power.....	221
7.2.4 Charge-acceptance	221
7.2.5 Battery life and modes of failure.....	221
7.2.6 Thermal issues.....	223
7.2.7 Cost	224
7.3 Battery duty in different road vehicles	224
7.3.1 Dynamic charge-acceptance.....	225
7.4 Lead–acid batteries.....	226
7.4.1 Principles of operation	226
7.4.2 Manufacturing processes.....	229
7.4.3 Failure mechanisms and remedies	231
7.4.4 Battery management.....	231
7.4.5 Summary	236
7.5 Nickel–metal-hydride batteries	237
7.5.1 Principles of operation	238
7.5.2 Manufacturing processes.....	238
7.5.3 Failure mechanisms and remedies	238
7.5.4 Battery management.....	239
7.5.5 Summary	239

7.6	Lithium-ion batteries	240
7.6.1	Principles of operation	240
7.6.2	Manufacturing processes.....	243
7.6.3	Failure mechanisms and remedies	244
7.6.4	Battery management.....	244
7.6.5	Summary	245
7.7	Sodium–metal-halide batteries.....	246
7.7.1	Principles of operation	247
7.7.2	Manufacturing processes.....	248
7.7.3	Failure mechanisms and remedies	250
7.7.4	Battery production and utilization.....	250
7.7.5	Summary	250
7.8	Characteristics of batteries used in hybrid electric and battery electric vehicles.....	251
7.9	Supercapacitors	253
7.10	The UltraBattery TM	255
7.11	Better batteries: future prospects.....	256
CHAPTER 8	Hydrogen, Fuel Cells and Fuel Cell Vehicles	260
8.1	Why use hydrogen?.....	260
8.2	Hydrogen as a fuel	260
8.3	Present uses for hydrogen	262
8.4	Hydrogen from fossil fuels and biomass.....	262
8.4.1	Reforming of natural gas.....	262
8.4.2	Solar–thermal reforming	263
8.4.3	Coal gasification.....	264
8.4.4	Biomass gasification.....	264
8.5	Hydrogen from water	265
8.5.1	Electrolysis.....	266
8.5.2	Thermochemical cycles.....	266
8.5.3	Electrochemical photolysis	267
8.5.4	Biophotolysis.....	269
8.6	Hydrogen distribution and storage	269
8.6.1	Gaseous and liquid hydrogen	270
8.6.2	Metal hydrides.....	270
8.6.3	Simple hydrogen-bearing chemicals	272
8.6.4	Complex chemical hydrides	272
8.6.5	Nanostructured materials	272
8.7	Hydrogen utilization: fuel cells	273
8.7.1	Characteristics of fuel cells	274
8.7.2	Proton-exchange-membrane fuel cells	277
8.7.3	Fuel cell efficiency	280

8.8	Hydrogen-fuelled road transport	282
8.8.1	Internal-combustion-engined vehicles	282
8.8.2	Fuel cell vehicles.....	283
8.8.3	Infrastructure: hydrogen highways	293
8.9	Present status and outlook for fuel cell vehicles	294
CHAPTER 9	The Shape of Things to Come	296
9.1	Over-arching issues	296
9.2	Global climate change: extent and consequences	299
9.3	Choice of vehicle technology	304
9.4	Roads.....	310
9.5	Choice of fuel: hydrocarbon, hydrogen or electricity	311
9.6	The carrot and the stick: role of governments.....	312
9.7	Possible futures	313
	Glossary of Terms	317
	Index	335

For historic Milestones in transport visit the companion website:
<http://booksite.elsevier.com/9780124046160>