GERPISA (the Permanent Group for the Study of the Automobile Industry and its Employees) started out as a network of French economics, management, history and sociology researchers interested in the automobile industry. Founded by Michel Freyssenet (CNRS sociologist) and Patrick Fridenson (EHESS historian), it was transformed into an international network in 1992 to carry out a research programme on ‘The emergence of New Industrial Models’.

With Robert Boyer (CEPREMAP, CNRS, EHESS economist) and Michel Freyssenet supervising its scientific orientation and under the management of an international committee, the programme (which lasted from 1993 to 1996) made it possible, thanks to its study of the automobile firms’ (and their transplants’) trajectories, productive organization and employment relationships, to demonstrate that lean production, which, according to Womack et al., the authors of The Machine that Changed the World, was supposed to become the industrial model of the twenty-first century, was in fact an inaccurate amalgamation of two completely different productive models – the ‘Toyotian’ and the ‘Hondian’. Moreover, it showed that there are, have always been, and probably always will be several productive models that are capable of performing well at any given time. Shareholders, executives and employees are not only not obliged to adopt a one best way, they also have to devise a ‘company governance compromise’ covering the means that will allow them to implement one of the several profit strategies that are relevant to the economic and social environment in which they find themselves.

A second programme (running from 1997 to 1999) entitled ‘The Automobile Industry, between Globalization and Regionalization’, and co-ordinated by Michel Freyssenet and Yannick Lung (Montesquieu University – Bordeaux IV economist), tested the analytical framework that had been developed during the first programme in an attempt to better understand the new wave of car manufacturer and component-maker internationalization that had been observed over the previous decade. The outcome was that the
viability of the choices being made depends primarily on the chosen profit strategies’ compatibility with the growth modes in the areas in which the investments are being made.

The third programme (2000–2) has been developed under Yannick Lung’s co-ordination. It focuses on the issues at stake in the ‘Coordination of Knowledge and Competencies in Regional Automotive Systems’. Supplementing existing studies of forms of regionalization in the automobile industry, the programme analysed the sector’s new contours as well as the development of new relational and co-operative modes among its actors.

The fourth programme (2003–6), entitled ‘Variety of Capitalism and Diversity of Productive Models’ and co-ordinated by Bruno Amable (CNRS economist) and Yannick Lung, discussed the thesis of national productive models. It showed the diversity of productive models in each type of capitalism by exploring the interaction between micro, meso and macro levels. It emphasized the importance of political compromises at the meso and macro levels to manage competition and employment conditions.

The fifth programme (2007–10), developed under the direction of Bernard Jullien (Bordeaux IV economist), focused on ‘Sustainable Development and the Automobile Industry’. It analysed the emergence of this theme and compared the discourses and practices of automobile entreprises. The impact of the 2008–9 crisis has allowed the broad issue of sustainability to be placed at the crossroads of ecological, economical and social sustainability, and to identify the synergies and trade-offs between these different dimensions.

In 2011, GERPISA included 350 members from 27 different countries. Since 2010, it has become a Groupement d’Intérêt Scientifique based at the École Normale Supérieure de Cachan. As such, it is supported by the French Ministries of Industry and of the Environment, by the professional associations of French car companies (CCFA), of French suppliers (FIEV) and of French dealers and repair shops (CNPA); also by the École des Hautes Études en Sciences Sociales (EHESS) and Montesquieu University – Bordeaux IV.

The international steering committee comprises the following members: Robert Boyer (CNRS-EHESS, Paris), Jorge Carrillo (Colegio de la Frontera Norte, Mexico), Elsie Charron (CNRS, Paris), Dan Coffery (University of Leeds, UK), Michel Freyssenet (CNRS, Paris), Patrick Fridenson (EHESS, Paris), Takahiro Fujimoto (University of Tokyo, Japan), Bernard Jullien (Université de Bordeaux IV), Bruno Jetin (Université Paris XIII), Ulrich Jurgens (WZB, Berlin, Germany), Yveline Lecler (MRASH/IAO, Lyon), Yannick Lung (Université de Bordeaux IV), Tommaso Pardi (EHESS, Paris), Sigfrido Ramirez (Institut européen, Florence, Italy), Mario Sergio Salerno (University of São Paulo, Brazil), Koichi Shimizu (University of Okayama, Japan), Koichi Shimokawa (Hosei University, Tokyo, Japan), Carole Thornley (Keele University, UK).
References


GERPISA’s publications

GERPISA edits, in English and French, a quarterly review entitled Actes du GERPISA and a monthly newsletter, La Lettre du GERPISA. The review combines the writings the network’s members have presented on a specific topic in various work meetings. The newsletter comments on news from the automotive world and provides up-to-date information on what is happening in the network. Findings from the first and second programmes have been published in a series of books:

Programme ‘Emergence of New Industrial Models’


Programme ‘The Automobile Industry, between Globalization and Regionalization’


Appendix


**Programme ‘Co-ordination of Knowledge and Competencies in Regional Automotive Systems’**


**Programme ‘Variety of Capitalism and Diversity of Productive Models’**


**Programme ‘Sustainable Development and the Automobile Industry’**


Information on GERPISA’s activities can be obtained by contacting:

GIS GERPISA, École normale supérieure de Cachan, Bât Laplace, 61, avenue du Président Wilson, 94235 Cachan cedex.

Telephone: +33 1 47 40 68 53

E-mail: gerpisa@ens-cachan.fr

Website: http://gerpisa.org/
Index

Notes:  
Bold = extended discussion or term highlighted in text;  
f = figure, n = endnote/footnote, t = table.

AC/DC converter 219, 226, 227  
see also electric motors  
acceleration 292, 294, 295f, 296n, 298  
ACEA (European Automobile Manufacturers’ Association) 110n, 289n  
Achtnicht, M. 287, 302  
Active Wheel (Michelin) 58  
ADEME (Environment and Energy Management Agency, France) 98  
Adzel joint venture 234  
AEA Technology 29(n2)  
aero-engines 122  
see also alternative engines  
aesthetics 3, 50–1, 53–5  
affordability 25, 142, 243, 248, 254, 270, 273t, 277, 278f, 294, 299, 312  
see also price  
Africa 149–50t, 150, 169, 181, 243  
Agassi, S. 58–9  
Aggeri, F. 91–2, 101  
agreements and joint ventures in EV industry 7–8, 23, 225–39  
case studies 226, 233–7, 238  
disruptive innovations 226–9  
economic theory 226, 229–33  
growth strategies 229–31  
implications for policy-makers 8, 226, 238  
and innovation 232–3  
literature 234  
some concluding remarks 237–8  
agribusiness 6, 165, 166, 172, 174, 181t  
agrofuels 28, 305–9, 310t  
Ahlvik, P. 161(n2), 161  
an air pollution 39, 43, 60, 140, 274t, 276f, 279, 307  
an air quality 162, 271, 279, 294  
an air-conditioning 216, 244  
Ajzen, I. 126, 138  
Alaska 246  
alcohol 169, 171, 181t  
see also ethanol  
Algeria 149t, 155t  
Allegrini, L., 145–6n, 146, 148n, 162  
Alston, L. J. 166, 182  
an alternative engines 29(n1), 135t, 286  
versus alternative fuels 301(n1)  
versus conventional engines (mental perspectives) 287, 292–4, 295f, 301(n7), 302  
see also car engines  
an alternative fuels 29(n1), 162, 266–7, 280, 284, 291t, 304  
forecasting framework for evaluating 9, 263–85  
research 278, 278f, 279  
scenarios 2, 9, 263, 267, 272, 276–84  
Alternative Motor Fuels Act (California, 1988) 176  
an alternative vehicles (AVs) 2, 13, 16, 25, 29(n1), 240, 284  
antomotive industry race 14–15, 19–22, 30(n9–11)  
consumer attitudes 9, 286–303  
context 7  
definition 301(n1)  
development 7  
development (surrounding conditions) 7–10, 205–322  
motivation for purchase 26  
production plans 25  
technological trajectories 4–7, 23, 87–204  
see also battery electric vehicles  
aluminium 54, 59, 192, 197  
Amable, B. 324

327
Amatucci, M. xxi, 6, 164–84
analytic hierarchy process (AHP)
advantages and disadvantages 267
application to problem 263, 271–2, 273–5t
construction of hierarchies 271–2
criteria to find ‘best motor vehicle fuel’ 271–2, 273–5t, 276f
‘forecasting tool’ 266–7
levels 9, 263
pair-wise comparisons 271, 281–2f
result-synthesis 271
sensitivity analysis 271, 272, 277
analytic hierarchy process: ‘best motor vehicle fuel’ quest 9, 263
‘culture’ category 271–2, 273–4t, 276f, 276–7, 281f, 282
‘development time’ category 272, 275t, 276f, 281f, 283
‘economics’ category 271–2, 273t, 276f, 276–7, 281f, 283
‘environment’ category 271–2, 274–5t, 276f, 276–7, 281f, 282, 283
‘long-term sustainability’ category 271–2, 275t, 276f, 281f, 282, 283
scenarios 2, 272, 276–84
Anderson, J. 243, 252
Annual Energy Outlook 2007 (EIA) 219
architectural innovation 117, 196f
‘architectures’ 36, 200
comparative advantage 36
‘compatibility’ 36
constraints and 35–6
evolution 38–9
integral type 34, 35, 36, 42
modular (mix and match) type 34, 35, 39
products and processes 38, 38f
Argentina 152t, 155t
Argonne National Laboratory 315, 318
Armenia 155t
artefacts (products) 35, 36
definition 40
design information 33
design, production, consumption 40–2
design, production, usage conditions 46
‘growing complexity’ 46
integral-type ‘architecture’ 39
‘no specific architecture’ 38
structure, function, operation 41f
‘such as prototypes’ 91
see also new products
ASEAN 37
Asensio, A. 57–8, 67
Asia ii, 2, 37, 40, 48, 149–50t
Asia-Pacific 111f, 122, 150
Asociación española de fabricantes de automóviles y camiones (ANFAC) 140, 162
asset development 96
Associação Nacional dos Fabricantes de Veículos Automotores (ANFAVEA) xiii, 166, 168f, 175, 182(n1, n3)
Audi 116, 134, 135–6t, 138(n6), 300, 301t, 301(n8)
Audi A6 299
Austin (Texas) 29
Austin, H. 56
Austin Seven (1922) 56
Australia 150, 155t, 235, 313, 316t
Austria 27t, 151t, 153f, 156–7t, 159
Autolib Paris 29, 50, 58, 62–5
fees 65
Automobile Club d’Italia (ACI) 146–7n, 147, 148n, 161
automobile design
Loewy 55
automobile industry
C21 challenge 47
classical 256
‘crisis’ 46–7
future 46–7
mainstream 246
non-mainstream 8
traditional versus new players 23
see also automotive industry
Automobile Industry Executive Group (GEIA), Brazil 174
automobiles 41–2
architecture 46, 312
bodywork 54
‘commodification’ (developed nations) 43–4
design evolution 39
development cycles 104
devices (various) 18
versus digital commodities (definitive difference) 43
‘dominant mode of transport’ 54
eco-friendly 14
integral versus modular type 45
low-cost 45, 46
‘misnomer’ 305–6
‘oversized means of transport’ 50
period of transition 66
small, popular 56
see also cable cars
automotive chain 168f
innovation 174–9
path dependence 174
automotive consumption practice 287–9, 301(n2–4)
automotive industry 25, 101, 277, 278
‘best example of industrial rationality’ 257
competition between ‘new’ and ‘old’ technologies in race for sustainable solutions 5, 103–23
dominant design challenged by environmental issues 70–1
financial difficulties 65
hybrid manufacturing model wanting 257
innovative design 3–4, 69–85
innovative design and sustainable development 13–31
institutional and technological innovation 175–8
new business model required 257, 260
over-production and market segmentation 258–9, 261–2(n1)
R&D processes for sustainable development 3–4, 69–85
race for AVs 14–15, 19–22, 30(n9–11)
restructuring (in Europe) 260
‘sailing-ship’ effects 5, 103–23
‘still very young’ 321
strategic crisis 256, 257, 258–9
territorial organization 24
urban mobility 8–9, 254–62
value-added versus oil import bill (Europe) 142
see also carmakers
automotive industry: greening 1–10, 19
learning from experiment 70, 78–81, 81–2
new R&D processes 70, 78–81
urban mobility 8–9, 14, 254–62
see also second automotive revolution
Automotive News 106, 112, 119, 122
automotive sector 303
capital accumulation model (social pressure to transform) 3, 49
commercial innovations 167, 178–9
profit model 49
automotive telematics services 102
Avis-RATP-SNCF-Vinci Park consortium 63
Baden-Württemberg 313
bagasse (biofuel) 100
Baker, R. A. 144n, 162
Bangalore 37
Bangkok 242
Bangladesh 152t, 155t
Banque National de Paris 237
Bascap (Bolloré subsidiary) 65
batteries 16, 17, 21, 24, 30, 51, 53, 93, 95–6, 105, 107–8, 112, 120, 161, 193, 216, 223, 229, 236, 261, 305
bulk, weight, power, safety 22
capacity 119
characteristics 225
charging time 22, 210, 227
costs 26, 45
ergy and power density 234
essential materials 28
improved performance 19
limited storage capacity 268
new 230, 237
new (partnerships between firms) 234
new chemicals 233
rechargeable 23, 219
safety criterion 17–18
second-generation 311, 319
secondary 227
third-generation 312, 318, 319
see also energy storage
battery autonomy 318, 319
Index

battery charging/recharging 7, 59, 61, 94, 100, 158, 217, 225–6, 227, 228, 234–5, 244, 245, 268, 304

cost-efficient 213
daily patterns 207
en-route versus at-home 235, 306
new forms of organization 233
overnight 211, 248, 250–1
at parking areas 235
‘smart’ versus ‘non-smart’ 211–12
technical constraints 211, 212

techniques 210
see also charging
battery component producers 23
battery control systems 112, 118
battery electric vehicles (BEVs) 209, 210, 218, 220, 292, 294, 298, 304
global projection (2020) 215
refuelling 210
see also CNG vehicles
battery energy 209
battery exchange 211, 235, 311
battery maintenance 18
battery manufacturers 22, 65, 120, 315, 318
competition with carmakers 23–4
battery materials 44–5
‘high cost’ 45
battery packs 209, 237
battery performance 310
battery prices 25
battery recycling 237, 248
battery rental 97
battery sharing 77
battery technology 99, 210, 279, 280
BB1 (concept car) 58
Beaume, R. xxiv, 93, 102
behaviour 127
behavioural model 126, 138
Belarus 152t, 155t
Belgium 27t, 151t, 153f, 155t, 157t, 307t
Berggren, C. xxii, 5, 6–7, 103–23, 185–204
Berlin 29, 126
Bernard, J. 2
Bernardes, R. C. 175, 182
Bertone (Italy) 58
Bertone, G. 56
Better Place 29, 58–9, 66, 94, 226, 235–6, 238, 318
bicycles 53–4, 209, 244–5, 250, 257, 260–1, 302, 315, 319
Bijker, W. B. 298, 302
biodiesel 17, 164, 265, 271, 276f, 282f, 282, 283
B20 biodiesel 268–9
pollution and safety issues 268–9
biofuels 4, 14, 16–17, 21, 28, 29(n1), 159, 163–4, 169–71, 301(n1)
EU directive (2003) 25
biogas 6, 143–4, 148, 154, 159–60, 161(n7), 163
biomass 17, 21, 66, 160, 170
biomethane 17, 159, 160, 163
biotechnology 169, 279
bipolar lead-acid battery 227
Bluecar (Autolib project, 2005–) 50, 62–5; 64f
Bluecar (Pininfarina-Bolloré, 2009–) 64
BMW 22, 30(n8), 113n, 117, 237, 308, 309, 310t, 315
average CO2 emissions of cars sold in Europe (1997–2010) 141t
diesel engine patents (1990–2007) 115f
‘Boeing 787’ 208
Bolivia 155t
Bolloré Group 24, 66, 66(n3), 315, 316t
Bolloré-Pininfarina joint venture 63–4
Bompard, E. xxii, 207–24
Bordeaux IV 324
Borloo, J.-L. 100
Bosch/Robert Bosch 104, 118, 175–8, 184
partnership with Daimler 230, 234, 237
partnership with PSA Group 233, 237
product development executives 182(n1)
Bosnia and Herzegovina 151t
Boston Consulting Group 26, 30, 261–2(n1)
Bower, J. L. 22, 30, 241, 252
Boyer, R. ii, xxiii, 323, 325
BP 150, 162
BP Statistical Review of World Energy (2010) 262(n2)
braking energy 189, 199
see also regenerative braking
Brandberg, A. 161(n2), 161
brands 40, 60, 75, 191, 291t, 299, 300
brand design 37
brand identity 57, 58
brand image 22, 58
brand loyalty 288, 301(n3), 302
Brazil 21, xxvi, 28, 155t, 307t, 307–8, 313, 315, 316t
car sales (1980s) 180
economic growth (1972–9) 173t
external debt (1972–9) 172, 173t
flex-fuel evolution (2003–12) 178f
GDP (1972–9) 173t
oil production 172
origin of name 169
Portuguese arrival 166–7, 168
sugar exports 169
sustainable development strategies 6
vehicles powered exclusively by ethanol 172
Brazil: ethanol and automotive industries 6, 17, 21, 164–84
automotive industry: institutional and technological innovation 175–8
automotive sector: commercial innovations 167, 178–9
economic growth, external debt, oil account (1972–9) 173t
ethanol production:
commercialization innovation 166, 171–4, 175
ethanol production: institutional and technological innovation 169–71, 182(n7)
ethanol: phases in use as fuel 179–81
flex-fuel technology (number of cars/trucks, 2003–12) 178f
innovation in automotive chain 174–9
innovation within ethanol chain 164, 167–74
institutional changes and governance structure 167f
lessons 6, 165, 179–81
model 167, 167f
path dependence in automotive chain 174
path-dependence and innovation in sugar cane sector 164, 168–9, 182(n6)
system innovation and institutional theoretical approaches 164, 165–7, 168f, 182(n2–5)
technological innovation (market adoption) 167f
Brazil: Law 17,917 (1931) and Law 25,174 (1948) 171
Brazil: Ministry of Environment (MMA) 178n, 183
Brazil: protocol of 19 September 1979 172, 175
Brazil: regions
centre 171
north-east 165, 169
south 170, 171
south-east 165, 170
Brazilian Agricultural Research Organization (EMBRAPA) xiv, 166, 168f, 169, 182(n7)
website 182(n5)
Brazilian VW 177, 179, 182(n1)
Bremmer, I. 265–6
BRIC xiii, 234, 243, 258
carmakers 319t
registered cars (estimate for 2014) 262(n1)
Brittany 313
Brown, R. C. 144, 162
Brown, T. 53–4, 67
Brundtland Commission 51, 67
Buick Y-Job model 55
Bulgaria 155t, 157t
buses 4, 27, 76, 77, 157t, 159, 189, 255, 261
CNGVs 154
electric 209
hybrid 185, 187f, 187, 198–200, 202t
parallel hybrid versus series
hybrid 193, 201–2t
see also heavy hybrid vehicles
business 18, 21, 49
innovative strategy 29
see also ‘environment/business’
business model innovation 2, 322
caracterisation 241–2, 252–3
emerging markets 242–3, 252
Index

business model innovation: Shifeng group (case study) 8, 244, 246–50
background 247
building business model for LSEVs 247–8
building market for LSEVs 248–50
methodology 247
business model innovation and development of EV industry in China 7, 28, 240–53
business models 240–4
defining low-speed EV 8, 245–6
e-mobility in China 244–6
emerging markets 8, 242–3
implications for Western carmakers 8, 250–2
business models 4, 29, 94, 240–4, 252, 253
automotive industry 257, 260
carmakers 13–14
‘defined in various ways’ 241
differentiation 241
disruptive 244
originating in emerging markets 243–4
business opportunities 134
BYD Automobile Company 24, 231, 237, 310t, 315, 316t
cable cars 257, 261
see also cars
Calanz 243
California 25, 116, 126, 177, 235, 242, 313
California: Air Resources Board 124, 176
California: Fuel Cell Partnership 125
California Institute of Arts 66(n1)
Calkins, M. 251, 252
Camry programme (Toyota, 2011–) 119
Canada 149–50t, 156t, 236, 307t, 308, 312–13, 313t, 316t, 318
car body-makers 315, 316–17t
car consumers
stated preferences 287, 289–91, 301(n5–6)
sub-frames 294
car emissions/vehicle emissions 9, 161(n5), 290, 291t
decarbonization 259
electrification ‘by no means permanent solution’ 22
car engines 292
versus car preferences 301(n5)
consumer perspectives (existing literature) 286–7
firm perspectives 125–6
see also diesel engines
car mass and fuel consumption (trends 1980–2005) 289f
car ownership 251, 260
car parks 61, 238
car prices 13, 29(n2), 319
‘vehicle price’ 19
car purchases/sales
current trends 9
information sources 288, 296
‘two-stage process’ 288
car rental 58, 260, 312
car-focused mobility crisis 254–5
car-sharing 54, 61, 62, 66, 77, 94, 313
see also Autolib
Car2go 29
carbon dioxide (CO₂) 31, 124, 144, 146, 207, 269
greenhouse effect (versus methane) 143
carbon dioxide emissions 1, 13, 14, 15, 17, 22, 29(n2), 30(n8), 71, 77, 90, 95, 98, 101, 101(n1), 147, 158, 259, 269, 279, 287, 291, 302
data 141, 161(n1)
EU target (2020) 25
proportion derived from road transport 140
sequestration 19
carbon dioxide emissions-reduction 6 by substitution and by ‘methanization’ 146, 146t
investment 19
carbon monoxide (CO) 141, 268, 269–70
carbon taxes 312
agreements and joint ventures with suppliers 7
attitudes 4
changes in preferences 310t
cleaner automobile strategies (2011) 310t
competition with battery manufacturers 23–4
design and manufacturing platforms 58
diesel engine patents (1990–2007) 115f
hydrogen technology: behavioural intention 133
hydrogen technology: perspectives 5, 124–39
hydrogen technology: perspectives (three groups) 125
international competition 57
Japanese competition intensified (1980s) 56
measures of innovativeness 104–6
most powerful 320
newcomers 310–11, 320–1
option for rupture scenario (listed) 315
patents related to hybrids (1992–2007) 113f
‘permanent reduction of costs’ profit strategy 308, 309
perspectives on engines 125–6
profit strategies 310, 311, 319, 321, 323
‘quality’ strategy 309
‘regional’ versus ‘global’ 308
strategies (role of industrial designers) 3
strong relationships with suppliers (EV components) 8
traditional 230, 231
trajectories 13
‘vehicle makers’: new forms 6–7, 185–204
‘volume and diversity’ profit strategy 308, 309
Western (implications of Chinese LSEV production) 250–2
see also automobile industry
cars 13, 52, 164, 255, 257, 264, 309
age 142, 145–6, 160
age (Europe/USA averages) 140
‘by-products of mobility’ (Garibaldo) 8, 254, 256
cleaner models 319t, 319–20
CNGVs 154
common parts 39
dual-fuelling (CNG and petrol) 143
electronic control 39
flex-fuel evolution (Brazil, 2003–12) 178f
integral-type architecture 32
luxury-level 288–9
new 146
‘new architectures’ 305
new ones sold versus old ones scrapped (no correspondence) 142
older (equipped with CNG device) 145–6
perceptions 66, 255
performance criteria 77
petrol-CNG hybrid 161(n4)
premium sector 259
‘private and collective’ 77
scrapping 142, 154, 160; see also End-of-Life Vehicle Directive
second-hand 301(n3)
size 288–9
small 32, 104, 319t
‘that facilitate use of public transport’ 78
trend towards comfort 288–9, 303
see also city car
Carvalho, R. Q. xxvi
case studies 37, 49, 50, 60–5
agreements and joint ventures in EV industry 226, 233–7, 238
AutoX 4, 69–85
electric vehicles 93–6
innovative design 3–4, 69–85
Shifeng Group 8, 246–50
CCFA (professional association of French car companies) 324
CENARGEN (Genetic Resources and Biotechnology Centre for Plants, Brazil) xiii, 169, 182(n7)
Central America 149–50t, 169
Central Europe 26
Centro de Tecnología Canavieira (CTC) xiii, 166, 168f, 169, 182(n4)
Centro Esperienze Costruzione Modelli Prototipi (Cecomp) 64
CEPREMAP xiii, 323
Ceschin, F. 29, 30
CHAdemo consortium (Japan) 236
Chanaron, J.-J. ii, 20, 30, 107, 121, 325
charging/recharging 215, 311
   facilities 314
   fast 211
   infrastructure 27, 90, 94, 98, 236–8, 315, 318
   methods 90
   profiles 218
   scenarios (EVs) 216–19
   timing ‘not unimportant’ 216–17
   smart devices 219
   technical features 211
see also refuelling
charging/recharging stations 29, 58, 64–5, 95–7, 100–1, 218, 251
   recharging distance 311
charging/recharging systems 17, 18, 99, 213, 259
   smart 221
   standards 25, 236
Charue-Duboc, F. xxii, 4–5, 89–102
Chee, W. 266, 284
Chesbrough, H. W. 240, 241, 252
Chevrolet Volt (GM, USA, 2011–) 109, 119
Chile 152t, 155t
China xxiii, xxvii, 24, 38, 40, 44–5, 168, 171, 218, 228, 231, 235, 237, 259, 278, 305, 307t, 307–8, 310, 312, 313, 315, 316t, 318, 322
   adoption of all-electric vehicle 318–19
   business model innovation 7, 240–53
   car production and sales 28
   carmakers 310t
   cars 264
   CNG pump prices (versus petrol and diesel, 2011) 152t
   CNG reserves (2008) 149t
   CNGVs and CNG filling stations 155t
   coastal areas 37
   definition of LSEV 244
   development of EV industry 7, 240–53
   economic opening up (1980s–) 248
   EV development 7
   EVs: target number 313t
   growth in demand for oil 264
   household income (rural versus urban) 248, 252, 253
   industrial architectural geopolitics 37
   leapfrogging strategy 28
   locally-designed vehicles 32
   production of two-wheeled e-vehicles 244
   provincial or local governments 245, 249, 250
see also BRIC
China: General Administration of Quality Supervision, Inspection, and Quarantine (AQSIQ) 249
China: Ministry of Industry and Telecommunications 245, 249
China: Ministry of Technology 249
China: National People's Congress 249
China: State Council 249
China: State Council: Development Research Centre 249
China Electric Engineering Technology Association 247
choice of fuel 282, 283
see also analytic hierarchy process
Christensen, C. M. 22, 30, 120–1, 241–2, 246, 243, 252
Chrysler 56, 246, 310t
Cicero 164
   cities 13, 29, 45, 52–3, 76, 95, 112, 119, 143, 160, 189, 193, 199, 247–8, 260, 312
   central areas 27, 260
   coastal 280, 283
   listed 313–14
   ‘mega cities’ 258
   ‘metropolises’ 256
   small cars 104
   ‘vertical-shaped’ 257
see also urban areas
Citroën 2 CV (1948) 56
Clapaud, A. 67
Clark, K. B. 117, 121
Clean Air Act Amendments (USA, 1990–) 176
‘clean diesel’ engine 104, 108–17, 120
Clermont Ferrand 62
Clio 183
Cloodt, M. 105, 121
Club of Rome 51, 67
clutch 190f, 192
CNG (compressed natural gas) 4, 16, 301(n1)
average cost-saving (versus petrol and diesel) 151–2t, 153
average emissions in urban situation (Euro standards) 145t, 146
average pollutant emissions 145t
conversion incentives 160
ecological benefits 143, 144
economic and environmental benefits 140
features (as fuel) 142
octane index and heat of combustion comparison 144t
‘possible intermediate stage’ 141, 142
price (versus petrol and diesel) 150–3
see also gas
CNG cars/engines 158, 207
environmental performance 144, 161(n4)
number on road (Italy) 147t
CNG cars: sustainable mobility 5–6, 16, 21, 28, 140–63
assumptions 142
crucial stage in race towards ZEVs 141–3, 161(n1)
data deficiencies 146
economic perspective: CNG availability and cost 148–54, 161(n6)
future technological opportunities for development of CNGVs 158–60, 161(n7)
literature 162
payback time 153, 153f
policy implications 160–1
reducing emissions through conversion to CNG (Italian example) 143–8, 161(n2–5)
see also compact cars
CNG cylinders 161(n4)
CNG dual-fuel-powered products 143
CNG filling (home network) 28–9
CNG fuel injection systems 161(n4)
CNG refuelling stations 154, 159, 160, 161
CNG technology ‘can be applied to existing cars’ 140–1
CNG vehicles (CNGVs) 21, 22, 28, 207
bi-fuel 6
diffusion 154–7
future technological opportunities 158–60, 161(n7)
‘not ultimate solution’ to pollution 158
price and performance 16
see also commercial vehicles
CNPA 324
CNR-Ceris (National Research Council: Institute for Research on Firms and Growth), Moncalieri iii, xxii, xxv, xxvii, 2
CNRS xiii, xxii–iii, 323, 324
Cobasys 234
Cold War 33
Coles, C. B. 241, 242, 251, 252–3
Colombia 155t
Colorado 313
commercial vehicles 44, 319t
CNGVs 154
see also consumer attitudes towards alternative vehicles
compact cars 43, 46, 51
integral-type versus modular-type 35, 38
see also concept cars
companies/firms xix, 1, 5, 23, 25, 28, 33, 36, 40, 46, 52, 82, 165, 175, 180, 238, 250
aggregate number of patents 106
capability-building ability 38, 38f
Chinese 35
gen engagement with hydrogen technology (three groups) 132–3
EV industrial sector 7–8
‘governance compromise’ 323
high-technology 233, 237–8
industrial 89, 314
internal capabilities 230
innovation capabilities 230
innovation behaviour (structural model) 127
innovative performance 105
Japanese 35, 42, 43, 47
Korean 47
large fleets of service vehicles 314
most dynamic 232
companies/firms – continued
partnership agreements (case studies) 233–4
partnerships with public institutions (case studies) 233, 234–5
perspectives: car engines 125–6
perspectives: hydrogen technology 5, 124–39
small 49, 233
specialized 238
company fleets 66
listed 314
costs 105
design and manufacture (new players) 23
most important (for EVs) 226–8
new 8, 19
compressed biogas (CBG) 17
compressed natural gas see CNG
concept cars 53, 56–8, 64, 66, 104
electric 57
two-seater 58
see also dual-fuel cars
concepts-knowledge (C-K) theoretical framework 4, 70, 74, 80, 91
congestion 76, 217–18, 254, 258, 305, 313
congestion charges 312
Connecticut 246
consumer attitudes 7, 128
consumer attitudes towards alternative vehicles 9, 14, 286–303
analysis of engine choice 299, 300f
car mass and fuel consumption (trends 1980–2005) 289f
interviews 301t
mental perspectives of conventional and alternative engines 287, 292–4, 295f, 301(n7)
stakeholder consultation 300
stated preferences of car consumers 287, 289–91, 301(n5–6)
summary and conclusion 296, 298–9
trends in automotive consumption practice 287–9, 301(n2–4)
see also diesel vehicles
consumer ‘framing’ 2, 9, 286–7, 298
consumer movements 52
consumer pressure 308
consumer segments 287, 294–6, 297f, 301(n8–9)
see also market segmentation
car choice: environmental factors ‘do not play major role’ 9, 14, 289, 298
empowerment (C21) 288
‘internal search’ versus ‘external search’ 288
see also customers
consumption 41–3, 45, 51, 222
artefacts 40–2
Fordist revolution 50, 55
impact on oil price 264
consumption mode
challenged by eco-design 52
context 3, 7, 8, 92, 212, 213
product usage 4
technological trajectories in AVs 4
control systems 105, 187, 201, 203t, 226
hybrid and electric vehicle applications 200
patents (1990–2009) 188f
software 233
Cooper, A. C. 107, 121
corn: ethanol yield per acre 269
cost/s 9, 15–19, 29(n4), 59, 63, 65, 72, 79, 93, 150, 175, 263, 312
initial 36
material versus variable 45
switching to alternative technology 23
see also running costs
cost-benefit analysis 92
cost-competitiveness 58, 59
cost-constraints 57
cost-effectiveness 186, 197
‘cost-saving green car’ 76
cost-sensitivity 105
Coulomb Technologies 237
Creswick, B. P. 267, 277, 278n, 284
Cristal transport system 62, 63f
Croatia 151t
Crowther, S. 55, 67
cryogenic fuels 270
CTC see Sugar Cane Technology Centre
Cybergo (eight-passenger shuttle) 60–2; 61f
cylinder deactivation 19, 29(n5)
Czech Republic 27t, 151t, 156–7t
DAF Trucks 136t
Dahlman, C. J. 175, 183
Daim, T. U. xxii, 9, 263–85
Daimler 24, 113n, 135t, 138(n6), 185, 236, 308–9, 310t, 315
agreement with Bosch 230, 234, 237
agreement with BYD (2010) 231, 237
agreement with Evonik
Industries 234, 237
agreement with Tesla 234, 237
diesel engine patents (1990–2007) 115f
emissions of cars sold in Europe (1997–2010) 141t
fuel cell R&D 126, 138(n3)
Danaher Motion 191
Dassault 24, 57–8, 315, 316t
David, P. A. 164, 166, 183
dealers/dealerships 26, 324
dedicated switch stations (batteries) 211
Delhi 162, 163, 314
delivery 186, 192, 197
delivery vans 210
Delphi (components) 175
demand 13, 28, 137t, 141, 277, 280, 306, 308, 312
electricity 216
‘more than simply sales levels’ 9, 286
Denmark 25, 27t, 59, 157t, 235, 307t, 315, 316t
Depuis, D. 136t
design 23, 35, 45
artefacts 40–2
computer-assisted 56
concept-knowledge theory 4, 70
environmental responsibilities versus corporate strategies 60
evaluation and validation 73
integral-type 3
meaning 40–1
modular-type 3, 39, 42
rule-based 2, 4, 73, 78, 80
Sloanian model versus design thinking model 60
validation 81
see also industrial design
‘design’ (engineering principle) 35
design companies 56
design costs 59
design information 32–3, 34, 40–1, 43–4, 48
evolutionary pathway 35
formal aspect 34
design location 2
comparative advantage 3, 34–5, 36
design process 91
‘increasingly integrated’ 57
design quality 47
design reasoning 74
design research human-centred perspective 53–4
lack of continuity 58
design spaces
new 75–6
design structure constraints 39
design theory 70
design thinking 3, 49, 60
new approach to mobility 50–4
design-driven approach 2, 15
designers‘social responsibility’ 51
Designers Associés 64–5
Detroit 47, 111
Deutsche Bank 20, 20n, 30, 214, 223
Diedre Design 50, 60–2
diesel 17, 19, 150
average emissions in urban situation (Euro standards) 145t, 146
average pollutant emissions 145t
market battlefield (USA) 116–17
octane index and heat of combustion comparison 144t
price (versus CNG) 150–3
diesel car sales 106
Europe and USA (2005–10) 110f
Index

diesel engine/s 20, 44, 122, 124, 125, 138(n5), 140, 144, 158, 161(n4), 191, 193, 268, 292, 299, 300f
average emissions (Italy) 148t
consumer ‘frames’ 294, 298
cost advantages and disadvantages 116
evolution (European success story) 109–11, 115f
failure in USA 111
‘modular innovation’ 117–18
negative reputation (USA) 111, 116
number of cars on road (Italy) 147t
patents 106, 115f
small 29(n4)
see also electric engines
diesel fuel/s 144
low-sulphur (lack of availability in USA) 116
diesel hydriods 120
diesel price 171
diesel technology 5, 103–4
contest with hybrid vehicles 104
patent activity (1992–2007) 112, 113f
patents relating to emissions reduction (1990–2007) 114f, 114
diesel vehicles
advanced 26
relative costs 120
see also E85 vehicles
Dijk, M. xxii, 5, 9, 14, 19, 30, 124–39, 286–303
direct fuel injection 19
direct injection (DI) diesel systems 298
consumer ‘frames’ 294, 295f
disruptive innovations 2, 241, 242, 252
‘better theory’ needed 242, 252
EV industry 226–9
disruptive searchlights 82
disruptive technologies 7, 22, 30, 126, 138(n8), 241, 244, 246, 251–2
see also technology
distance 18, 22, 50, 95, 96, 100, 311, 312
long 13, 237, 251
medium 311
short 66, 246, 258, 311, 314
see also commuters
distributed power generation 221
distribution grid
EV-supporting 7, 215, 219–21
see also electricity grids
distribution mode
challenged by eco-design 52
distribution networks 16, 18, 28
constraints (EVs) 7, 207–8
DIWAhybrid (Voith Turbo) 193
Dominican Republic 156t
door-to-door transport system solution to crisis 304–5
Dow Chemical 126, 234
downstream area (EV sector) 236, 237
drive-train components 117
dual clutch transmission 19
dual fuel cars 21, 177
average emissions (Italy) 148t, 148
first generation 176
versus flex fuel 176
petrol/CNG 148t, 148, 154
petrol-LPG 154
see also electric cars
Dublin University 236
Dunning, J. H. 231, 239
E85 (ethanol) vehicles 269, 270
see also electric vehicles
Earl, H. 55
East Asia 243
Eastern Europe 26, 151–2t, 153
EASYBAT project 236
Eco and Eco car 4, 69–85
AutoX ‘did not know what was valuable’ 79
connection to other transport modes ‘critical’ 77
‘that supports use of public transport’ 80–1
‘Eco and Eco Innovation’ 74
eco-design 3, 50–4
eco-innovation 16, 69, 81
École Normale Supérieure de Cachan (Paris) iii, xx, 324
‘ecological’ (notion) 76
ecology 324
‘ecology of the artificial’ 52
Economic Commission for Europe blue corridor report (2003) 159, 162
‘ecosystem’ (product support) 4–5, 97, 99
micro-level 95–6
documents 201
hybrid technology and electric motor technology 189–90
hybrid vehicle development processes at Volvo and Scania 186–7
‘important challenge’ 186
interviews 186, 201, 201–3t
interviews at Scania 201–2t
interviews at Voith 203t
interviews at Volvo 202t
interviews with professors 203t
knowledge bases (comparative analysis) 194
organizing effective collaborations (comparative analysis) 196–7
patents 200
Scania: problems of developing two technologies in parallel 198–9
Scania-Voith collaboration 186, 193–4
Scania-Voith electric motor development 192–4
sourcing and knowledge development 190–1, 192–3
technological dynamics of electrical drive systems 186, 187–8
technology and application novelty (comparative analysis) 194–5, 196f
technology as search process with spillover effects 200
‘three essential issues’ 7, 197–8
Volvo: advantage of focus 199–200
Volvo-Kollmorgen collaboration 186, 191–2
Volvo-Kollmorgen electric motor development 190–2
electric motor efficiency 225
electric motor suppliers 185
electric motors 118, 120, 187–8, 191, 227, 230, 234, 236–7, 244, 246, 304, 306, 309, 315
AC (asynchronous versus synchronous) 189
AC versus DC 189
asynchronous 193
axial 189–90
classification by operating principle 189–90
control system 191
in-house production 185
new materials 233
electric motors – continued
patents (1990–2009) 188f
radial 189–90
three-phase 190
transverse flux 189–90
Volvo patent (2005) 191
electric plug-in facilities 306
electric power 222, 236, 259
electric power systems 7
‘electronic power’ systems 22
electric vehicle (EV) components
strong relationships (carmakers and suppliers) 8
electric vehicle firms
agreements and joint ventures 7–8, 225–39
China 244–6
China (business model innovation)
7, 240–53
clusters 238
corporate flexibility required 226
corporate growth strategies 7–8
downstream 8
new players 225–6
partnerships with electricity producers 233, 235–6
structure 225–6
Electric Vehicle Network 314
electric vehicle sector: agreements and joint ventures 236–7
core business 236, 237
downstream area 236, 237
upstream area 236
Electric Vehicle Industry Alliance (China) 318
Electric Vehicle Technology for Réunion (VERT) 100–1
electric vehicles (EVs) 16–18, 24, 26, 28–9, 30(n7, n9–10), 30, 32, 59, 65, 66(n3), 104, 117, 119, 122, 124, 161, 249, 251, 261, 268, 296, 304, 307t, 307–8, 310t, 310–12, 319t, 321
affordability 21
battery-run 21–2
breakthrough strategies 90
classification 7, 208–10
cost and benefit analysis for year 2020 20, 20t
diffusion 7, 234
diffusion scenarios 213, 224
dissemination ‘not easy’ 44–5
distance able to travel 100
environmental breakthrough
innovations 4
‘eternally emerging’ technology (Fréry) 19, 31
‘first steps in life-cycle’ 225, 237
fleet renewal 29
impact on grid 7, 218–19
incentives 25, 216–19
innovation race 101
issues to be solved 319
lack of continuity 58
maintenance issues 96
‘massive deployment’ (by 2020) 214
models 20
modular 3, 44, 45, 63
‘most likely scenario’ 237
number (2015–50 targets) 313t
performance structure (comparison with ICES) 22
potential diffusion 210
price gaps 30(n11)
profitability 311
pure versus hybrid 225
recharging 95
refuelling 7, 210–12
role in reducing electricity supply and demand mismatch 221
running costs 314
sales 27, 27t, 207
second-generation 314
small urban 54
start-ups and newcomers (2011): listed 316–17t
subsidies 228
supporting distribution grid 7, 215, 219–21
technological progress 208
testing 318
total energy requirement (forecast for 2050) 215
turnover 207
urban 228
usage cost (versus ICES) 27
see also flexible-fuel vehicles
electric vehicles: balancing strategic intent and experimental approach 4–5, 89–102
electric vehicles and power grids: challenges and opportunities 7, 22, 207–24
classification of electric vehicles 7, 208–10
EV impact on electric energy systems 7, 208, 213–19
refuelling EVs 7, 210–12
smart grids 7, 208, 212–13
‘time for joint research projects’ 222
V2G: EV supporting distribution grid 7, 215, 219–21
electric-petrol hybrids (Toyota takes initiative) 108–9
electrical appliances 46
electrical components 120, 189
electrical energy system (EES) 221
‘electric energy systems’ 207, 213–19
electrical engineering 105, 118, 119, 202t
electricity 14, 22, 27, 30(n12), 66, 100, 119, 234, 306–7
access 318
bi-directional flow 220, 222
cost 222
distributed storage 222
ex-ante versus real-time mechanisms 218–19
generation, transmission, and distribution devices 208
global consumption 219
global production (2008) versus EV requirement (2050 forecast) 215
home outlet 211
import capacity 216
‘just-in-time’ production 216
market mechanisms versus top-down control 217–18
non-polluting sources 213–14
peak-demand hours 215–22
pollution and safety issues 268
production (decoupled from consumption) 222
production and distribution cycle 207–8
production-transmission system (centrally-operated) 221
rational use 217–18
use scenarios 218–19
electricity consumption 95, 225
electricity demand 217, 235–6
electricity distribution 214, 218, 238
electricity grids 7, 101, 207, 208, 210, 211, 214, 235, 268, 283, 306
hardware 215
impact of ground transport 209
low-voltage (LV) versus medium-voltage (MV) 215, 220
performance 215
see also smart grids
electricity load profiles 216, 218
electricity prices 28, 31, 90, 219
electricity storage 212
electricity supply 207, 213, 218, 219
diffusion of EVs 7
smart grids (emerging paradigm) 212–13
electricity taxes 27t, 28
electricity utilities 24, 311, 315, 318
large fleets of service vehicles 314
partnerships with EC firms 233, 235–6
electricity-generating plants 208
de-carbonization 22
dispersed 214
fuels 266
global capacity (2008) 215
inefficiency 216–17
polluting 217
primary input prices 213
see also energy companies
electrification 19, 120
electro-technical industry 186
electromagnetic grid 259
electromagnetic valve train 29(n5)
electronic:
commands 53
control systems 108
control units 236
devices 46
injection systems/devices 176, 177
management systems 18
mapping 260
electronics 226, 236
revolution in cars 23
Elektromotive 236
Elmquist, M. xxii–iii, 3–4, 69–85
ElvoDrive (Voith Turbo) 193
EM-Motive joint venture 234
Embraer 175
EMBRAPA see Brazilian Agricultural Research Organization
emissions xix, xx, 3, 22, 25, 41, 52, 76, 89, 100, 101(n1), 110, 116, 124, 137(n1), 176, 268, 283
cars sold in Europe (1997–2010) 141, 141t
see also pollution
emissions legislation 110, 120, 125, 134
see also European emission standards
emissions testing
distinct cycles 25
emissions-reduction 117
conversion to CNG (Italy) 143–8
Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) xiv, 166, 168f, 169, 182(n7)
website 182(n5)
Enel 236, 237
Enerdata 142, 162
energy 28, 32, 35, 45, 50, 51, 107, 194, 214
alternative sources of improvement (impact on oil price) 265
clean 257
cost comparisons 21
new green 225
price gap 27
scarce resources 35, 39
energy companies 23, 94, 95, 100–1
‘energy producers’ 98, 235
see also power plants
energy consumption 18, 35–6, 58, 76, 79, 94, 210
regulations 39
energy converters 190f, 191
energy density 19, 234
energy efficiency 141, 208, 240, 264, 286
Energy Efficiency and New-Energy Automotive Industry Planning
2011–2020 (Chinese policy document) 249
energy policies 306, 309
energy production 100, 260
Energy Research Institute of Beijing 264
energy security 240
energy storage 112, 185, 190–3, 201, 210
see also lithium
energy supply 256
political risk 265–6
and time horizon (portfolio of solutions) 259, 262(n2–3)
energy-saving/conservation 43, 46, 47, 212
engenho 169
engenhoca 169
gene capacity (horsepower) 41, 89, 179, 269, 293f, 294, 295f, 296n, 298, 299
gene choice 299, 300f
gene design 94
gene efficiency 144, 161(n3–4), 268, 301(n8)
gene structure 295f
gene systems 19
gene timing (advances) 19
gene types (diversification) 44
gene volume 293f, 295f, 298
gene weight 293f, 294, 299
gene ‘alternative’ versus ‘conventional’ 287, 292–4, 295f, 301(n7), 302
endothermic 259
hybrid electric 287
low-pollution 53
oil-powered 308
thermal efficiency 161(n2)
traditional 21
see also flex-fuel engines
environment (general)
AHP category 271–2
business 20, 25, 242
day-to-day 51
economic 175–6, 323
industrial 54
institutional 165, 166, 168f, 181
macroeconomic xix
organizational 168f
political 20, 175–6
social 54, 128, 323
urban versus non-urban 256
environment (natural) 1, 4, 6, 18, 22, 26, 28, 45, 53, 72, 127, 136, 137t, 217, 222, 228, 240, 243, 251, 261, 271–2
see also ‘perceived environmental risk (EV)’
environmental concerns 277, 278f, 278–81
environmental constraints 32, 35, 39, 46, 47
Environmental Grenelle on Réunion: Making Innovation Work (2007–) 100
environmental impact 7, 30, 50, 90, 207, 214, 290, 291t, 291, 292, 293f, 296, 296t, 297f, 298, 301(n7)
environmental initiatives 4, 90, 91–3, 97
environmental innovation 89, 90–3
environmental issues 52, 69
challenge to dominant automotive design 70–1
impact on oil price 265
environmental movements 309, 318
environmental performance xix, 212, 320–1
environmental policies 139, 259, 306
environmental regulations 9, 44, 127, 290
environmental studies 72
environmental taxes 89
ERDF 318
Espace Autolib stations 65
Estonia 151t, 157t
ethanol 4, 17, 159, 271, 276f, 279, 282f, 283
for aircraft 180
alcohol-based 269
from cellulose 181t
consumer price 174
future (as fuel) 180, 181t
‘GHG neutral’ 269
new sources 180
pollution and safety issues 269–70
‘second-generation’ 170
system innovation (mature market economy) 166
use as fuel (common elements of three phases) 180–1
use as fuel (three phases) 180, 181t
yield per acre of corn 269
ethanol and automotive industries (Brazil) 6, 164–84

economic growth, external debt, oil account (Brazil, 1972–9) 173t
transactions (TA 1–2, TE 1–2) 167, 168f, 168n
ethanol car/engine 6, 166, 174–6
‘reconversion’ to petrol 179
see also hybrid cars
ethanol chain 168f
innovation 164, 164–74
ethanol industrialization 168f
ethanol market
establishment and deregulation (1999) 169
ethanol price 171
ethanol production 179
commercialization innovation 166, 171–4

governance structure 170
institutional and technological innovation 169–71, 182(n7)
ethanol production organizations 166, 182(n2)
ethanol retail distribution 182(n1)
ethanol sugar cane industry 6, 166
ethanol value chain 164
ethanol-only engine 172, 175–9
second phase 170–1, 179–80, 180, 180–1, 181t
see also gasohol
ethanol-petrol mixtures 180
ethyl alcohol (ethanol) 269
‘EU FP7’ 236
Eurasia 149–50t
Eurasia Group 265–6
‘Euro NCAP tests’ 24
Europe ii, xxiii, 1, 2, 8, 20–1, 24,
26, 30, 44, 46, 104, 106, 114,
142, 149, 235, 243–4, 250–1, 303,
313–14
automotive market (size) 258,
261(n1)
biogas use ‘increasing’ 159
‘clean diesel’ engine 104, 108–16,
120
definition of LSEV 244, 245
diesel car sales (2005–10) 110f
EV deployment (2020 scenario) 214
hybrid car sales (2006–9) 111f
industrial architectural geopolitics 37
LNG consumption 150
natural gas production (2009) 150t
reserves of CNG (2008) 149t
sourcing strategies (specialization) 118–19
Europe: Western 110, 151t, 153, 153f,
312, 313
Europe 2020 strategy 29(n4)
Europe’s Energy Portal 27, 27n, 31
European Automobile Manufacturers’ Association (ACEA) 110n, 289n
European Centre for Mobility Documentation (ECMD), Netherlands 289n
European Climate Foundation 259, 262(n3)
European Commission 111–12, 147
European Community (EC) 52
European Council 162
European emission standards
Euro 0 standard 146–7, 146–7t
Euro 0-3 standards 144, 160
Euro 0-4 standards 145t, 146–7, 147t
Euro 1-6 standards 14, 141
Euro 3 standard 140
Euro 4 standard 24
Euro 5 standard (2009) 24, 145–6t, 146
Euro 6 standard (2015) 24, 120
see also emissions legislation
European Environment
Agency 101(n1), 102
European Federation for Transport and Environment (T&E) 141n,
163
European Fuel Cells and Hydrogen Joint Undertaking 259
European Parliament 141, 162
European Patent Office (EPO) 105–6,
113n, 114f, 115n, 193, 195n, 200,
204
European Union 14, 25, 26, 60,
137t, 140–1, 228, 234, 236, 307,
307t, 309
data source 145–6n, 148n, 162
directive 92/61/EEC 246
directive 2002/24/EEC 246
electric mobility (transnational development projects) 25
EVs (target number) 313t
‘political implosion’ 258
political leadership ‘missing’ 25
Regulation EC 715 (2007) 162
European Union: EU-15 101(n1)
European Union: EU-27 89, 163
diffusions of CNGVs 154
natural gas vehicles (latest figures) 157t
Eurostat 27n, 31
Evonik Industries 234, 237
excise duties 16, 25, 27t, 28, 153
experimental approach versus strategic intent (EVs) 4–5, 89–102
Exxon 150, 162

FAW 231, 237, 315, 316t
FCC (Spanish company) 160
FDI xiv, 230
Federal Motor Vehicle Security Standards (USA) 245
Ferrara 260
Ferrato, E. xxvi
FIAT 19, 22, 112, 113n, 174–5, 181t, 258–9, 307–8, 310t
average CO2 emissions of cars sold in Europe (1997–2010) 141t
diesel engine patents (1990–2007) 115f
FIAT 500 model 52
FIAT 500 ‘Topolino’ (1936) 56
FIAT 600 (1956) 56
FIAT Powertrain (FTP) 182(n1)
FIAT-Chrysler alliance 59, 235, 236
‘Field of Invention’ (USPTO) 106
FIEV 324
Figueiredo, J. B. de O. 175
filling stations 16, 29, 178, 248, 268
see also petrol stations
Finizio, G. 53, 67
Finland 151t, 153f, 155t, 157t, 315, 316t
Fischer, F. 30(n6)
Fisker 226, 315, 317t
fleet renewal 26, 29
flex-fuel 168f
versus dual-fuel 176
flex-fuel car 181t
flex-fuel engines 164, 165, 170, 174, 177
see also hybrid engines
flex-fuel technology 6, 166, 168, 175–9, 182(n1), 184
‘Phase III’ 180, 180–1, 181t
flexible fuel vehicles (FFVs) 25, 269
see also fuel-cell vehicles
Ford, H. 50, 54–5, 67
Ford 109, 174, 175, 309, 310t
emissions 141t
fuel cell R&D 126
patents 112, 113f, 115f
Ford C-Max 300f
Ford Europe 112
Ford Explorer (SUV) 109
Ford Fiesta 300f
Ford Focus 299, 300f
Ford Model T 55
Ford Nederland 301t
Fordist industrial revolution 50, 55
forecasting framework and scenarios: AV fuels 9, 25, 263–85
AHP model 9, 263, 266–7, 267, 276f
AHP model: application to problem 263, 271–2, 273–5t
alternatives 263, 268–71
challenge (growing oil demand versus shrinking supply) 263–7
conclusion 284
criteria to find best motor vehicle fuel 9, 263, 273–5t
meaning of oil price 263, 264–7
pollution and safety issues 268–71
results and discussion 281–3
scenario 1: ‘status quo’ 9, 278f, 278–9
scenario 2: ‘environmental challenge’ 9, 278f, 279
scenario 3: ‘economic challenge’ 9, 278f, 280
scenario 4: ‘catastrophe’ 9, 278f, 280–1
scenarios 9, 263, 267, 272, 276–84
see also alternative vehicles
fossil fuels 6, 25, 28, 50, 66, 103, 166, 208, 259, 263, 266, 279, 282–3
reserves 60
Foster, R. 108, 121
Francastel, P. 54, 67
France xxii–iii, xxv, xxvii, 25, 27–8, 30(n12), 54, 60, 96, 100, 109, 116, 135, 236, 246, 287, 307t, 314, 316t, 318

AV market 28
CNG: payback period 153f
CNG pump prices (versus petrol and diesel, 2011) 151t
CNGVs and CNG filling stations 156t
diesel technology 112
distance travelled between home and workplace 50
dual-fuel cars 154
EVs 27t, 313t
natural gas vehicles (latest figures) 157t
night-time recharging 98
France: Ministry of Environment 324
France: Ministry of Industry 324
Frankfurt 57, 58, 120, 260
Fréry, F. 19, 31
Freyssenet, M. ii, xxiii, 9–10, 304–22, 325–6
co-founder of GERPISA 323
Fridenson, P. 323
Fritschtak, C. R. 175, 183
fuel consumption 18, 21, 41, 65, 69, 71, 94, 209, 289f, 289–90, 291t
fuel cost 273t, 275t, 276f
fuel economy 14–16, 21, 43, 105, 109, 110–12, 117, 120, 158, 186, 198–9, 251, 265, 287, 290, 290t, 292, 294, 301(n8), 303
fuel efficiency 9, 273t, 290, 291, 292, 293f, 294, 295f, 296, 298, 298, 299
fuel gauges 55
fuel mix 119, 172
fuel prices 5, 25, 103, 120, 111, 180, 207, 213, 287, 292
fuel use 292
fuel use lifetime 275t, 276f
fuel-cell electric vehicles (FCEVs) 209
fuel-cell vehicles (FCVs) 4, 5, 14, 16, 21–2, 28, 29(n3), 107, 126, 137t, 137–8(n2), 209, 271, 319t
R&D investment 138(n3)
see also fully-electric vehicles
fuel-cells 19, 21–2, 71, 103, 259, 261, 265, 303–4, 307t, 309

see also hydrogen
fuelling infrastructure development time 275t, 276f
fuelling pipeline of future projects 81
fuels
distribution network 21
‘less polluting’ 310t
new 22
Fujimoto, T. ii, xxii, 3, 32–48, 325
fully-electric vehicles 124, 287, 298, 312
‘all-electric vehicles’ 10, 28, 311, 318–19
‘pure EVs’ 214, 237, 240
see also green vehicles
FUPET consortium (Japan) 236
future 4, 5, 7, 38, 44, 46–7, 50–1, 53, 66–7, 69, 70, 78, 81, 82, 96, 107, 119–20, 125, 129, 131–2, 134, 153–4, 180, 181t, 212, 225, 231, 250, 259, 260, 266, 272, 276, 277, 284
best motor fuel 9, 263
city size 258
CNGVs 158–60
see also Knightian uncertainty

Galicia 29
Garibaldo, F. xxii, 8–9, 254–62
Garnero, M. 173n, 183
gas 16, 21, 259, 262(n2), 306, 310t
gas carrier ships 17, 149, 160
see also LNG
gasohol (fuel) 172, 174–5, 179, 180–1, 181t
see also ethanol-only engine
gasoline see petrol
Gastaldi, L. 91, 102
GDP 173t
GEA (urban planning consultancy) 62
Geels, F. W. 165, 183
Geely (Chinese owner of Volvo) 308, 315, 316t
Geisel, E. 172, 183
General Command for Aerospace Technology (CTA, Brazil, 1947) 168f, 181t, 175
General Electric (GE) 234, 314
General Electric Motorcars (GEM, 1998–) 246, 317t
General Motors (GM) 20, 57–8, 109, 111, 174–5, 178, 182, 234, 258, 309, 310t, 315, 319
agreement with LG Chem 230
agreement with SAIC 231, 237
EV 242
fuel cell R&D 126
patenting 112
patents: diesel engines (1990–2007) 115f
patents: hybrids (1992–2007) 113f
plug-in hybrids 119
style department (1927) 55
General Motors Ampera 30(n10)
General Motors Volt 21, 30(n10), 189
generation capacity (electricity) 7, 207
generators 192, 192f, 193
patents (1990–2009) 188f
Genetic Resources and Biotechnology Centre for Plants (CENARGEN) xiii, 169, 182(n7)
genetically-modified crops 169
sugar cane 180
Geneva 57, 63, 112
Georgia (country) 155t, 312
geothermal plants 18
Germany xxii, 25–8, 30(n12), 109, 116, 126, 135, 236, 287–8, 302, 307–9, 312, 316t, 318
biomethane use 159
changing position (type of vehicle) 307t, 308
CNG pump prices (versus petrol and diesel, 2011) 151t
CNG system: payback period 153f
CNGVs 154
CNGVs and CNG filling stations 155t
EVs (target number) 313t
natural gas vehicles (latest figures) 157t
regional administrations 308
GERRI project (2007–) 100
Geurts, F. 301t
GGE (energy content in gallon of petrol equivalent) 273t
Ghia, C. 56
Ghosn, C. 101(n3)
Giacosa, D. 56
Gifford, J. D. 144, 162
Gilfillan, S. C. 107, 121
Giolito, R. 52–3, 67
global warming concerns 13, 15, 35, 39, 43, 240, 274t, 276f, 277–80, 305, 309, 314
Gothenburg: Chalmers University of Technology 203t
Goyal, S. P. 143, 162
GPS 260
grain alcohol (ethanol) 269
Greece 151t, 153f, 155t, 157t
‘green’ consumers 296t, 297f, 299
Green eMotion project 236, 318
‘green innovation approach’ 225
green vehicles
architecture 3, 32–48
see also heavy duty vehicles
greenhouse gases (GHG) 52, 101(n1), 102, 140, 159, 208, 221
along entire fuel cycle 274t
emission-reduction 104, 146, 213–14, 309
emission-reduction: international efforts (impact on oil price) 265
emissions 89, 103, 112, 222, 271, 274t
‘illusory abatement’ 119
methane 143–4
Greening European transportation infrastructure project 236
Grid Point 237
GS Yuasa 234, 315
GSM 234
Guangdong 313
Guédon, P. 63
Gulf of Aden 266
Gulf of Mexico 265
Hagedoorn, J. 105, 121
Hao, Z. 248, 253
Hart, S. L. 242, 243, 252
Harvard Business School xxiii
Hatchuel, A. 70, 73, 82, 83–4, 92, 101–2
Hawaii 312
Hayek, N. 57, 58–9
heat of combustion 144t, 161(n2)
heavy duty vehicles (HDVs) 110, 154, 157t, 159
use of CNG ‘highly recommended’ 160
hybrid diesel-electric propulsion systems 208–9
hybrid driving systems 22, 194, 195f
Volvo patent (1997) 191
Volvo patent application (2009) 191
hybrid electric traction systems 209
hybrid electric vehicles (HEVs) 3, 4, 16, 20, 112, 117, 124–5, 138(n5), 185, 203t, 210, 240, 298–9
‘charge-sustaining’ versus ‘charge-depleting’ 209
consumer attitudes (frames) 286–7, 292–4, 298
cost and benefit analysis for year 2020 20, 20t
frames (2000, 2005) 293f
market share 294, 296, 301(n9)
micro-hybrid, mild-hybrid, power-split full-hybrid 209, 214
purchase motivation 291, 303
sales worldwide (by 2011) 286
see also hybrid vehicles
hybrid electric-petrol cars
versus clean diesels 104, 108–12
hybrid engines 21, 50, 144, 305, 309
cost disadvantage versus diesel 116
petrol-electricity 5, 22
see also hydrogen engines
hybrid fuel 282f, 282, 283
hybrid parallel powertrains 200
hybrid power control unit (HPCU) 190
hybrid powertrains 104–5, 118, 119, 185, 190–1, 193–4, 196f, 199
cost disadvantage versus diesel 116
hybrid powertrains 104–5, 118, 119, 185, 190–1, 193–4, 196f, 199
cost disadvantage versus diesel 116
hybrid technology 69, 126, 135
innovation (architectural and modular) 118
hybrid technology 69, 126, 135
innovation (architectural and modular) 118
major challenges 112
hybrid vehicles 13, 18, 32, 44, 45, 90, 107, 112, 117, 185, 121–2, 201, 227, 283, 304, 307–8, 310t
CNG-electric 161
development processes (Scania and Volvo) 186–7
patents 105–6
‘temporary step’ 20–1, 30
see also light-duty vehicles
hydrocarbons 141, 270
hydrogen 14, 17, 30(n8), 66, 103, 144, 160, 270, 276f, 279, 282f, 282–3
mixing with CNG 158
production and storage 126
see also fuel-cells
hydrogen cars/vehicles 19, 21, 129, 130f, 161, 287
scenario 18
‘without fuel cells’ 16
see also passenger cars
hydrogen engines 5, 22, 137–8(n2)
see also internal combustion engine
hydrogen fuelling systems 267, 284
hydrogen infrastructure 280
hydrogen sulphide 143
hydrogen technology: firm perspectives 5, 14, 16, 18, 124–39
‘central question’ 124
date of survey 138(n8)
discussion and conclusion 125, 133–4
engagement in developing a hydrogen vehicle 129, 130f
firm perspectives on car engines 125–6
‘major question’ for business 134
methodology 125, 126–8, 133
possible sources of bias 128
potential drivers of engagement 129–33
questionnaire 127, 128–37, 138(n5, n9)
questionnaire survey respondents 134–5
results: engagement and beliefs regarding hydrogen technology 125, 128–33, 135, 137–8(n2)
stakingholder consultation 134–6
stakeholder interviews 135
stakeholder interviews: format 135–6
Hyundai-Kia 309, 310t, 315
India 44, 45, 59, 168, 278, 305, 307t, 307–8, 310, 312, 315, 316t
adoption of all-electric vehicle 318–19
carmakers 310t
cars 264
CNG pump prices (versus petrol and diesel, 2011) 152t
CNGVs and CNG filling stations 155t
growth in demand for oil 264
industrial architectural geopolitics 37
low-cost vehicles (integral nature) 32
see also BRIC
Individual and Public Urban Transport Programme (TULIP) 58
Indonesia xxvi, 149t, 152t, 155t
Induct (company, 2004–) 50, 60–2
industrial architectural geopolitics 37
industrial design (in-house) 56, 57
see also innovative design
industrial designers and challenges of sustainable development 3, 15, 49–68
Bluecar for Autolib project 64f
Bolloré-Pininfarina, Bluecar, and ‘Autolib’ in Paris 50, 62–5
case studies 3, 49, 50, 60–5
crystal transport system 63f
Cybergo and Modulgo Induct projects with Diedre Design 60–2
design thinking as new approach to mobility and eco-design theory 50–4
Diedre Design sketches for Cybergo vehicle 61f, 62
LOHR Industrie group and Cristal project 50, 62, 63f
mobility as product/service: challenge from new players 50, 60–5
mobility as service offer: from style to design 50, 54–60
industrial development 244
industrial instruments 46
industrial locations 255
industrial perspective
new paradigm implied 257
industrial policy 238, 259, 260–1
horizontal versus vertical measures 25
Iceland 151t
IDEO (design firm) 53–4
IER Group (subsidiary of Bolloré Group) 65
Île-de-France 313
Independent Paris Transport Authority (RATP) xvi, 74, 83(n3), 314
industrial rationality 257
industrial renewal 260
industrial sector 158
industrial standards 225, 232, 236
industrial transition 260–1
industrialization 48, 50, 51, 56, 174, 305
competence/capability 104, 106
industry 170
capability-building
competitiveness 38, 38f
non-polluting complexes 51
industry groups 41
industry structure 34–5
effect on company strategies 231
information technology 15, 255
ICT 212, 226, 257, 259
infrastructure 6, 8, 18, 25, 28–9, 89, 92, 95, 126, 142–3, 160, 228, 241, 255, 257, 259, 260, 270, 311
CNG-hydrogen mixture 158–9
cost 271
cost-benefit ratio (criterion to find best motor vehicle fuel) 273t, 276f
designed for mobility 256
urban 261
innovation ii, xxvii, 3, 49, 67, 82, 89–90, 102, 104, 138(n5), 213, 230, 253, 294
agreements and joint ventures in EV industry 232–3
agricultural 165
alternative approach 54
architectural versus modular 5, 108, 117–18, 120
attacker’s advantage 108, 121
attitudes 127, 129, 130
automotive chain 174–9
changing nature 73
commercial 181t
commercial (automotive sector) 178–9
as cultural project (Manzini) 51
‘design-driven process’ 49, 53
discontinuous (and technological trajectories) 14, 15–19, 29–30(n3–8)
environmental breakthrough 4
within ethanol chain 164, 167–74
FFE and FE 72
human-centred approach 53
incremental 73
incremental (versus ‘exploratory’ projects) 90
institutional 181t
institutional, technological, commercial (Brazil) 6, 164–84
institutional and technological (automotive industry) 175–8
literature 15, 78, 79
market adoption 167f
potential sources 243, 252
sugar cane sector 168–9
social 180
technological 180, 181t
typology (Henderson and Clark, 1990) 117, 121
innovative design
for alternative vehicles 3–4, 11–85
and sustainable development in automotive industry 2, 13–31
innovative design 3–4, 16, 69–85
addressing sustainable development through innovative design 70, 74–8
‘C’ phase: introducing disruptions 76–7, 82
capturing value 79–80
case studies: AutoX 4, 70–3
characteristics 73
complementing R&D processes 71–3
conclusion 81–2
creating breakthroughs ‘taking limited risks’ 80–1
discontinuous innovation and technological trajectories 14, 15–19, 29–30(n3–8)
dominant design challenged by environmental issues 70–1
dominant design challenged by environmental issues 70–1
empirical studies 70, 79, 82
framework 73
fuelling pipeline of future projects 81
industrial policy implications 15, 24–9, 30(n11–12)
innovative and sustainable strategies (way of developing) 80–1
‘K’ phase: creating new design spaces 75–6, 82
KCP method 4, 70, 74–8, 82, 83(n3–4), 83–4
learning from experiment 78–81
literature 70, 72, 78, 79
‘missing knowledge’ (identification method) 78–9
new potential strategic spaces (way of crafting) 81
new research areas (identification) 82
new strategic players and relationships 15, 23–4
‘P’ phase: proposing path through sustainable strategies 77–8, 82
producing new knowledge 78–9
quest for breakthrough innovation at AutoX 71–3
race for AVs in automotive industry 14–15, 19–22, 30(n9–11)
research methodology 75
short-term initiatives and long-term strategies 80
sustainable development in automotive industry 70–3
towards new R&D processes in greening of automotive industry 70, 78–81
valuation criteria 79–80
innovative and sustainable strategies path through 77–8, 82
way of developing 78, 80–1
Institut National de Recherche en Informatique et en Automatique (INRIA) 60
institutions supranational 181, 181t
see also public institutions
integral-type products competitive advantage 36
integrated systems urban mobility 261
‘integrated-type manufacturing’ 33
internal combustion engine (ICE) 8, 14–22, 45, 49–50, 59, 71, 89–90, 94, 100–1, 104, 107, 117, 124, 130, 208–9, 233, 240, 244, 246, 271, 286–7, 294, 311, 318–19
versus EVs (usage cost) 27
environmental performance 22
fossil-fuel-driven 19
hydrogen-powered 22, 30(n8), 137(n2)
improvement 19
improvement (incremental) 103
oil-powered 304–5, 306
penalties for use 228
performance 16
performance structure (comparison with EVs) 22
petrol and diesel 4
spark-ignition 161(n3)
transition to FCV 28
wider scenario 17
see also petrol engines
International Energy Agency (IEA) 264
inverters 191, 226, 227
investment 6, 13, 16, 25, 30(n9), 55, 57, 60, 90, 92, 94, 99, 101, 111, 125, 132, 141, 143, 160, 166, 169–70, 180, 185, 200, 208, 214, 215, 221, 226, 228–9, 235, 238, 255, 257, 264, 277, 279, 309, 310–12, 324
greenfield 230
infrastructural 18, 28
internal 232, 233
lock-in (technological and economic) 256
in production capacity (impact on oil price) 265
public 18, 259, 261
quasi-irreversibility 167
reductance 213
types 230
Iran 149t, 152t, 155t, 174, 264–6, 307, 307t
Iraq 149t
Ireland 27t, 153f, 313t, 157t
Israel 25, 59, 94, 235, 307t, 312
Italy xxi–iii, xxv–vii, 6, 26–8, 30(n12), 58, 162, 168, 236, 260, 307, 307t, 312, 316t
AV market 28
average CO2 emissions of cars (standard, fuel type, class) 148t
cars on road, 2009 (class, fuel type, Euro standard) 147t
CNG filling stations 155t
CNG pump prices (versus petrol and diesel, 2011) 151t
CNG system: average payback period 153t
CNGVs 154, 155t
Italy – continued
electric vehicles (2010–11 statistics) 27t
electricity load profiles 216, 217f
electricity statistics 224
emission-reduction through
conversion to CNG 143–8,
161(n2–5)
natural gas vehicles (latest
figures) 157t
peak power 215
pipelines 149

Jacobsson, S. 105, 121
Jakarta 242
Janatzy, C. 54
Japan 24, 28, 32–48, 103–4, 110, 114,
120, 236, 307, 307t, 309, 313, 316t
CNG pump prices (versus petrol and
diesel, 2011) 152t
CNGVs and CNG filling
stations 156t
commodification and loss of
competitiveness 40
comparative advantage 34–5
design cost (comparative
advantage) 34
fuel cell R&D 126
hybrid car sales (2006–9) 111f
industrial architectural geopolitics 37
in-house sourcing 118–19
manufacturing capability
(‘integration’ type) 34
over-engineering, under-engineering
problems 47
patent protection 105
product design, quality, function
‘excessive’ 40
Jato Dynamics 27n, 31
Johnson, P. 254, 262
Joui n 65
Josefson, L. 203t
Juice Technologies 226
Jullien, B. ii, xix–xx, 1, 324, 326
Katz, B. 54, 67
Kazakhstan 149t
Kazazian, T. 53, 67
KCP method 4, 70, 74–5, 82, 83–4
K (knowledge-sharing) phase: creating
new design spaces 74, 75–6, 82
C (concept) phase: introducing
disruptions 74, 75, 76–7, 82
P (proposal) phase: proposing path
through innovative and sustainable
strategies 74, 77–8, 82
KCP process 78, 80–1
‘complementary activity’ to R&D
81
‘cross-disciplinary approach’ 82
‘describes new value spaces’ 79–80
helps ‘to generate new valuation
criteria’ 80
technique to decide which ideas
should be explored’ 79
Kemp, R. 19, 30
Kempton, W. 220, 222
Khan, A. R. 248, 252
Kimble, C. xxiii–iv, 7, 240–53, 317n,
319n, 322
‘Knightian uncertainty’ (known
unknowns) 73, 79, 90–1
see also scenarios
knowledge 74, 83(n4), 138(n4)
external 72, 82, 132, 133
incomplete 291
missing areas (identification) 75
new 79, 82, 198
new (identification) 81
producing new 78–9
research-based 24
knowledge accumulation 92, 106
knowledge base/s 23, 82, 190, 195t,
195f, 202t
architectural 194, 195, 198, 200
electric motor development for
heavy hybrid vehicles (comparative
analysis) 194
internal 7, 72, 82, 197, 198
knowledge development
Scania 192–3
knowledge gaps 79
knowledge models 2
knowledge networks 24
knowledge transfer 29
knowledge-based clusters 121
Koenig, G. 51–2, 67
Kollmorgen 186, 191–2, 194–5
architectural knowledge 195t
brands 191
compound knowledge 195t
Index  353

data source  191, 204
subsidiary of Danaher Motion  191
Korea  155t, 312, 317t
Kroon, A.  187
Kubic, M.  290n, 302
Kubitschek, J.  174
Kuwait  149t
Kyoto standards  147
Kyrgyzstan  152t

La Jamais Contente (electric car, 1899)  54
labour-retaining capability (ASEAN)  37
Lacerda, A. C.  173n, 183
Lambert-Pandraud, R.  301(n3), 302
Landi Renzo company  161(n4)
Lane, B.  290–1, 303
Latvia  151t, 155t, 157t
Lausanne  62
Law of Road and Transportation Security (China)  245
Le Masson, P.  73, 80, 84, 91, 102
Le Quément, P.  56
lead-acid battery  210, 244, 246
Leclerc, E.  318
LED/OLED  xv, xvi, 19
Lenfle, S.  91, 102
Lévy, R.  56
Lexus LX400h  116
Liaocheng City: Gaotang County  249
Lindqvist, S.  107, 121
Linköping University xxii, 203t
liquefied natural gas (LNG)  149, 162
global trade (2006)  150
pollution and safety issues  270
refuelling stations  159
source of supply  150
storage  270
tankers  150
vehicles  159–60
see also natural gas
liquefied petroleum gas (propane)  16, 28, 144, 154, 271, 276f, 279, 282f, 283, 304
average pollutant emissions  145t
pollution and safety issues  270–1
LPG drivers  294
LPG vehicles  21
liquid hydrogen  19, 30(n8)
lithium cobalt oxide (LCO)  227–8
lithium iron phosphate (LFP)  228
lithium manganese oxide (LMO)  228
lithium nickel cobalt aluminium oxide (NCA)  228
lithium nickel manganese cobalt oxide (NMC)  228
lithium polymer batteries  60, 210
‘polymer battery’  19
lithium titanate (LTO)  228
lithium-ion (Li-Ion) batteries  17–21, 24, 63, 93, 210, 225, 227–8, 230, 311
see also batteries
lithium-metal-polymer (LMP) batteries  63
lithium-sulphur  227
Lithuania  151t, 157t
Liu Cheng Qiang  247
Liu Yifa  247, 249
Loch, C. H.  91, 102
Loewy, R.  55, 67
LOHR Industrie group  50, 62, 63f
London  29, 254, 313
London, T.  242, 252
Lotti, G.  52, 60, 67
Lotus  24, 315, 317t
low-speed electric vehicles (LSEVs)  8, 316–17t, 319
advantages  251
business model  247–8
business model: dual structure of Chinese economy ‘key factor’  248
Chinese exports  250
commercialization (wanting)  246, 251
consumer acceptability  251
definition (international consensus lacking)  244–5
main market  247
market  248–50
low-speed electric vehicles (LSEVs) – continued
models on sale (2011 and by 2015) 305t
‘not seen as road vehicles’ 248, 249
potential advantages for urban consumers 248
prospects outside China 251
running costs ‘low’ 248
scenarios 250
Shifeng involvement (2008–) 247
see also ‘new-energy vehicles’
Lucassen, J. 301t
Lung, Y. ii, 323–6
Luxembourg 151t, 153f, 156–7t

Maastricht 301t
Machine that Changed the World
(Womack et al., 1990) 323, 325
Madeira 168
Madlener, R. xxiv, 9, 14, 286–303
Madrid 163
Magneti Marelli 175–9, 182(n1)
Magnusson, T. xxiv, 5, 6–7, 103–23, 185–204
Magretta, J. 241, 252
Mahla, S. K. 144n, 163
Malaysia 149t, 152t, 155t
MAN 185
Mandart, D. 62
manufacturing 23, 25, 191, 201, 257, 267
costs 18
design information view 48
Fordist 50, 55
‘integrated’ type 36
manufacturing capability
‘division of labour’ type 34
‘integrated’ type 34
manufacturing capability and architecture of green vehicles 3, 15, 18, 32–48
basic forms of production (structure, function, and operation of artefacts) 41f
commodification (developed nations) 43–4
commodification and loss of competitiveness (Japan) 40
comparative advantage of design location 34–5
competitive advantage in integral-type products 36
conditions of commodification 42–3
constraints and architectures 35–6
crisis in automobile industry and future 46–7
design, production, and consumption of artefacts 40–2
design-based comparative advantage 38f
dissemination of EVs ‘not easy’ 44–5
increasing complexity versus commodification 45–6
industrial architectural geopolitics 37
‘level-headed discussion’ required 45
manufacturing management (broad concept) 32–4
organizational capability and architecture 34, 38–9
Manzini, E. 51, 53, 67
Marchionne, S. 258–9
Maritz 287, 303
market adoption 181
market context 213
market distortion 26
market dynamics 140, 259
market economy 242
market entry mode 231
market experience 119
market failures 225, 231, 234, 238
market forces 261
market imperfections 229, 230, 231
market intelligence department 75
market launch 200
versus economic success 105
market leadership loss 241
market maturity 27
market mechanisms
electricity (rational use) 217–18
market needs 33, 36
market niches/niche markets 14, 53, 89, 92, 92–3, 97, 104, 112, 199, 241, 251–2, 259, 286, 309
market pressure (MP) 29, 128–31, 137t
see also perceived capabilities
market pull 15
market push 49, 54
market requirements 38, 38f, 39
market segmentation 3, 51, 56, 58, 66, 101, 256, 258–9, 260, 299, 301(n3)
see also consumer segments
market share 40, 119–20, 244, 258
market size 308
market transactions strategies (corporate growth) 229
market trends 72, 135
marketing 72–3, 75, 116, 267, 287, 301t, 301(n7)
competence/capability 104, 106
‘green’ 52
markets 24–5, 36, 106, 165, 175, 177, 207, 211, 309
‘base-of-pyramid’ 242–3, 252, 253
domestic 244
external 172
global 40, 45, 47, 134, 181t
high-income 243
internal 261
international 171
mainstream 241
mature 258
new 15, 50, 65, 233
potential 199
pure competitive 178
selected 200
world heterogeneity 308
Markides, C. 242, 243, 252
Marx, K. H. 256
Matra 56, 63, 316t
concept car (2005) 64
maximum speed 293f, 295f, 296n
see also speed
Maxwell (supplier) 192
Mazda 310t
Meadows, D. H. 51, 67
Megane 59
Melville, K. 59
mentality 278f, 278–9
conventional versus alternative engines 287, 292–4, 295f, 301(n7), 302
Mercedes 57
Mercedes S-class 299
Mercedes-Benz 116
Mercosur 165
methane 142, 150, 159, 160, 270
greenhouse effect 143–4
pipeline networks 6, 143
thermal efficiency 161(n2)
methodology
business model innovation (case study) 247
firm perspectives on hydrogen technology 126–8
Mexico 152t, 155t, 307, 307t
Michelin 24, 56, 58, 316t
micro hybridization 117, 120
Middle East 149–50t, 150, 307, 307t
instability (impact on oil price) 266
Midler, C. xxiv, xxvii, 4–5, 89–102
Milan 29
Mines ParisTech 74
Minguet, C. xxvii
minicars 30(n10), 319t
Mississippi 246
Mitsubishi 119, 234, 310t, 315
electric vehicles 44
partnership with PSA Group 237
Miyazaki (Japan) 313
MMA (Ministério do Meio Ambiente) xv, 178n, 183
mobility 7, 54, 72, 240
‘actual product’ 256
car-focused (crisis) 254–5
case studies 3
‘collective as well as personal right’ 256
design thinking as new approach 50–4
individual right to be safeguarded (Garibaldo) 8, 255
‘low-cost package’ 76
‘network dimension’ 255
new 49, 58
‘primary drive needing to be elaborated’ 257
as product/service: challenge from new players 50, 60–5
‘real product’ 256
as service 52, 53
as service offer: from style to design 50, 54–60
short-distance 66
social approach 66
as social asset (Garibaldo) 8, 255
social organization 49
subscription system 66
Mobility House TMH 318
mobility operators 23, 318
mobility platforms 261
mobility system/s 257
networked social dimension 8, 261
‘mobilization capability’ (China) 37
Mobivia 318
Modulgo (small EV) 60–2
Moldova 151t, 155t
Monaco 134
Montalvo, C. xxiv–v, 5, 124–39
Montana 246
Montbéliard 62
Montesquieu University – Bordeaux IV 324
Morris, M. 241, 253
Morvannou, P. xxiii
motor cycles 243, 261
motor drive system 191
see also electric drive systems
motor power 209
motor shows 57, 58, 63, 90, 120, 134
motor vehicle architecture 321
motorbus 255
motorcycles 164, 244–5, 248
multi-mobility 54
Mytelka, L. K. 287, 289–90, 290n, 301(n5), 303
National Agency for Petroleum, Natural Gas and Biofuels (ANP Brazil) xiii, 168f, 171, 182
National Alliance for Advanced Transportation Battery Cell Manufacture 318
National Association of Motor Vehicle Manufacturers (ANFAVEA, Brazil) xiii, 166, 168f, 175, 182(n1)
website 182(n3)
National Highway Traffic Safety Administration (USA) 246
National Institute for Research in Computer Science and Control (INRI) 60
National Research Council: Institute for Research on Firms and Growth (CNR-Ceris, Moncalieri) iii, xxi, xxv, xxvii, 2
natural gas (NG) 4, 16, 21, 28, 29(n1), 138(n5), 142–3, 154, 271, 276f, 279, 282f, 283, 304–5, 307, 307t, 309
efficiency of WTW supply path 144
geographical distribution 148, 149t
known reserves 6, 143
pipelines 160
production (2009) 150t
refining process 148
reserves 17, 148, 161(n6), 162
technological advances 149
see also compressed natural gas
NEC 230, 234, 237, 315
Netherlands xxii, xxiv, 27t, 151t, 153f, 155t, 157t, 169, 315
AVs (consumer attitudes) 286–303
EVs (target number) 313t
new-car prices 289, 301(n4)
New European Driving Cycle (NEDC) 100, 144, 145t, 146, 161(n5)
new product development (NPD) 72, 89
literature 97
NPD process 191
NPD projects 197
spillover effects 200
New South Wales 313
New York 266, 314
New York Stock Exchange 171
New Zealand 155t, 312
NGVA Europe 152–3n, 154, 156–7n, 163
niche markets see market niches
nickel-hydride battery technology 19
nickel-metal hydrate battery 210
nickel-metal hydride (NiMH) batteries 20, 108
Nielsen, L. 203t
Nigeria 149t, 265, 266
Nijhuis, J. xxv, 9, 14, 286–303
Nissan 22, 59, 90, 135t, 138(n6)
Nissan Leaf (EV) 119, 228
see also Renault
nitrogen oxide 30(n8)
see also oxides of nitrogen
nitrous oxide (N2O) 159
noise 26, 76, 110, 160, 293f, 295f
non-methane hydrocarbons (NMHC) 145t
North, D. C. 165–6, 182, 183
North America 2, 21, 149–50t, 150, 243
North American Reliability Corporation (NERC) 219
Norway 27t, 149t, 151t, 153f, 155t, 315, 317
NOx see oxides of nitrogen
nuclear energy 28, 100, 259, 261, 275t

Oak Ridge National Laboratory (Tennessee) 216, 219
Obama administration 307, 307t
Obasanjo, O. 265
Oceania 149–50t
octane 144, 144t, 158, 269
Ogden, J. M. 143, 162
oil 154, 162, 214, 259, 262(n2), 291, 308
less-polluting engines 306–7, 307t
new sources (difficult locations): impact on oil price 265
percentage devoted to road transport 142
potential replacements 264
unavailability 283
oil companies 14, 100, 265, 278, 280
oil imports 142, 172, 173t, 174, 268–9, 271, 274t, 283
‘oil peak’ 264
oil price 15, 25–6, 162, 179, 277–81, 282, 299, 305, 309, 312, 318
fluctuations 290
meaning 263, 264–7
peak (potential triggering factors) 264–6
uncertainty 9, 263, 277
upper limit 280
oil reserves 17, 148, 278, 279
(‘late 1980s’) 111
oil supply 258, 280
Oliveira, E. S. de 175
Olson, M. 166, 183
omnibus (horse-drawn) 254, 255, 256
on-board chargers 210, 211
One North East 235
Ontario 313
OPEC behaviour/impact on oil price 265
Opel 141t, 258, 300, 301t
Opel Ampera 21
Oregon 313
Our Common Future (Brundtland Commission, 1987) 51, 67
oxides of nitrogen (NOx) 106, 110, 141, 145t, 146, 269, 271, 282
NOx Trap 114f
Ozaki, R. 291, 303

Pacific Northwest National Laboratory (PNNL) 216, 219
Padua 62
Pakistan 155t, 307, 307t
Palo Alto (California) 29
Panasonic 315
Panasonic/Sanyo (Toyota Group) 118, 229
Papanek, V. 51, 66(n1), 68
parallel hybrid configuration (Volvo) 190, 190f
parallel hybrid electric drive
Scania patent (2001) 193
‘parallel hybrid system’ 186–7, 201, 201t
parallel hybrid technology 200
parallel pilot testing
‘ecosystem’ formation support 94–6
parallel structures versus series layout (range-extender) 21
parallel systems (hybrid powertrains) 189
parallelism (in development processes) 98
‘parallelism and selection’ 91
Pardi, T. 2, 326
Paris xxi, xxiii, xxv, xxvii, 29, 50, 57, 62–5, 90, 254
Parkeon 234
particulate filter 111
particulate matter (PM) 141, 160, 269
smaller than 10 micrometres in diameter (PM10) 145t, 146
passenger cars/vehicles 4, 26, 185, 188, 250–1
see also rental cars
Patel, P. 105, 122
patent applications 200
  Scania (2010) 193
  Volvo (2008–9) 191
patent data 105–6
  literature 114, 116
  patents/patenting 79, 104, 118, 135, 194, 197
  Danaher Motion 191
diesel technology (1893–) 109
electric motor (Volvo, 2005) 191
electric motor development 200
electric motor development (hybrid vehicles, 1990–2009) 188f
  hybrid drive system (Volvo, 1997) 191
  parallel hybrid electric drive (Scania, 2001) 193
  Voith 193
weak performance of European producers 112–16
path dependence/path-dependency 6, 32, 165, 167
automotive chain 174
definition (David) 167
and innovation in sugar cane sector 164, 168–9
sources 13–14
theory 2
Paulus, I. 136t
Pavitt, K. 105, 122
Pelata, P. 101(n3)
Pennsylvania 246
Pennsylvania Railroad Company 55
Perrin, J. 101(n3)
Persian Gulf instability
  impact on oil price 266
Persson, M. 161(n7), 163
Peru 155t
Perugia 260
Petrobras 172
petrol 17, 19, 27, 44, 53, 144, 154, 164, 177, 269–71, 276f, 282f
  average emissions in urban situation (Euro standards) 145t, 146
  combination with ethanol 176
  competitive disadvantage (rural China) 248
  octane index and heat of combustion comparison 144t
pollution and safety issues 268
  premium ‘blue’ 174
  price (versus CNG) 150–3
  rationing 172
  retail price 20
taxes 27t
  thermal efficiency 161(n2)
  unleaded 27t, 30(n12)
petrol distribution monopolies 172
petrol engines/petrol ICE 6, 16, 20, 110, 124–5, 138(n5), 140, 143–4, 158, 161(n4), 176, 179, 227, 274t, 280–1, 299, 300f, 318, 321
  average emissions (Italy) 148t
  cost advantage versus diesel 116
  evolution 119–20
  number of cars on road (Italy) 147t
  patent activity (1992–2007) 112, 113f
see also aero-engines
petrol hybrid vehicles 103, 112, 120
  market battlefield (USA) 116–17
  patent activity (1992–2007) 112, 113f
see also plug-in hybrid electric vehicles
  petrol price/s 28, 60, 65, 109, 170, 171, 174, 278–80, 283
petrol stations 165, 172, 174
see also filling stations
Peugeot (Peugeot-Citroën/PSA Group/PSA Peugeot Citroën) 22, 56–8, 104, 110–11, 113n, 114, 117, 119, 122, 134, 135–6t, 138(n6), 236, 300, 301t, 309, 310t
  average CO2 emissions of cars sold in Europe (1997–2010) 141t
  diesel engine patents (1990–2007) 115f
  diesel hybrid (2011) 120
  partnership with Bosch 233, 237
  partnership with Mitsubishi 237
Peugeot ‘3008 Hybrid 4’ 233
Peugeot Automotive Design Network (2004) 57
Peugeot Ion 63
photovoltaic panels/systems 19, 100, 101, 306
Phylla solar car 235
Piedmont 30, 235
pilot projects 4–5, 29, 90–3, 99
  characteristics 92
  ecosystem formation support 94–6
long-term framework agreements 98
means of developing assets and generating support 96
opportunity for collective learning 96
parallel 94–6
role in Renault’s EV strategy 95
simultaneous 98
source of learning 89
strong local component 97–8
tool for building micro-level ‘ecosystem’ 95–6, 97
Pininfarina, B. 56
Pininfarina Group 63–4, 66, 66(n3), 316t
pipelines 6, 17, 143, 149, 150, 154, 160, 270
Pizzinatto, N. K. xxvi
plug-in hybrid electric vehicles
(PHEVs) 10, 28–9, 109, 112, 117, 119, 120, 214, 216, 220, 222, 223–5, 234, 237, 304, 307–12, 313t, 319t
blended plug-in; extended plug-in;
green-zone plug-in 209
cost-benefit analysis (for 2020) 20, 20t
deployment (impact on US power grid) 219
global projection (2020) 215
models on sale (2011 and by 2015) 305t
refuelling 210
see also smart vehicles
Poland 152t, 155t, 157t, 307, 307t
Polaris Industries 246
policy implications 2
agreements and joint ventures in EV industry 8, 226, 238
business model innovation (China) 8, 226, 238
innovative design 15, 24–9, 30(n11–12)
Polk 110–11n, 122
pollutants 4, 69, 141, 143, 146
trans-border 35, 39
pollution 6, 9, 16, 26, 28, 76, 158, 164, 207–8, 215, 217, 240, 251, 258, 263, 282–3, 305, 311
responsibility ‘shared by designers’ (Papanek) 51
see also emissions
pollution issues 268–71
pollution-reduction 228, 307, 307t, 309, 312
Porsche 309, 310t
Porter, M. E. 175, 183
Porter’s diamond 175
Portugal 25, 27t, 151t, 153f, 156–7t, 166–9, 182(n6), 307t
power control unit 226
power electronic converters 219, 220
power electronics 16, 105, 118, 120, 187, 188, 190, 200
patents (1990–2009) 188f
power flows
bi-directional 215–16
‘power for convenience’ consumers 296t, 297f
power grids
electric vehicles: challenges and opportunities 7, 207–24
power industry 25
Power Information Network 110n
power plant capacity 215
power plant emissions 268
power plant inefficiency 221
power plants 212
coal-burning 119, 268
fossil-fuel 22
oil-fired 221
thermal and nuclear-thermal 222
thermo-electric 214
see also electricity-generating plants
power profile 211–12
daily (smoothing) 222
power quality 219, 220
PowerStream 236
powertrain architecture 209
powertrain control systems 16
powertrain systems 187
powertrain technologies 103
powertrains 7, 13, 71, 76, 104, 106, 107, 110, 117, 256, 304, 305
clean 9, 260
electric 315
future evolution 120
hybrid 116, 118
hybrid or purely electric 209
modularization and standardization 319
parallel hybrid 199
PPG 234
Prencipe, A. 104, 122
Prius see Toyota Prius
PROALCOOL programme (1975–) 166, 168f, 172, 179, 181t
law No 75,593 (Brazil, 1975) 169
processes 3, 32–5, 38, 38f, 41, 89–90, 98, 272
high-involvement 288
hybrid vehicle development 186–7
industrial 256
new 91, 105, 256
see also R&D processes
product appearance 55
product architecture 33, 35, 45, 242, 246, 253
integral versus modular 46
product categories 35, 38
product concepts 81
product cycle hypothesis 40
product design 15, 39, 42
product development 15, 56, 58, 80, 99, 175
product development collaboration 7
adaptation to knowledge contributions of organizations involved 197
product development competence 104, 106
product differentiation 79, 80, 81
product failure 241
product function 33–4, 39
product launch technology frame 134
product life-cycle 53, 70, 72, 76
product life-cycle management (PLM) 57–8
product strategy 52, 53
‘product support’ 99
product-process architecture 3, 33–4
‘integral type’ 34
‘modular (mix and match) type’ 34
production 1, 2, 15, 21, 26, 32, 45, 46, 51, 105, 181, 222, 265
artefacts 40–2
basic forms 41f
constraints 42
internationalization 58
methods 19
over-capacity 65
see also mass production
production costs 19, 59, 312
production goods 41
production mode
challenged by eco-design 52
production processes 3, 33–4
productivity 36, 56, 170, 181, 308
products 30, 32, 36, 41, 51–2, 78
cultural meanings 49
electronic 3, 15, 45
high-involvement 288
integral-type 37, 47
modular-type 43
modular-type (capital-intensive) 37
modular-type (knowledge-intensive) 37
modular-type (labour-intensive) 37
modularization and commodification 42–3
new meanings 3, 49
see also artefacts
propane see LPG
prototype electrified lanes 211
prototypes 57, 58, 80, 95–6, 99, 125, 167f, 175, 178, 181t, 187f, 187, 190, 193, 195, 197–200, 235, 305t
reduction in number 50
tool for validation and learning 97
PSA Group/PSA Peugeot-Citroën see Peugeot
Qatar 149t
quadricycles 58, 246
Quebec 313
radial flux technology 193–5, 196f, 200
Ragazzi, E. xxv, 207–24
Ranis, G. 248, 253
rapid-charging stations 235
rare earths 225
recharging see charging
recycling 3, 24, 52, 61, 237
reduction gear 227
refineries 266
accidents (impact on oil price) 265
refuellng 207, 274t, 276f, 294
see also battery charging
regasification 150, 154, 160, 162
regenerative braking 18, 19, 89, 227, 228
see also braking energy
Index 361

Régie Autonome des Transports Parisiens (RATP) 74, 83(n3)
Renault 4, 22, 57, 59, 66, 83(n2), 110, 135t, 138(n6), 175
average CO2 emissions of cars sold in Europe (1997–2010) 141t
EV: commercial launch 90, 101(n2)
EV strategy: breakthrough 93–4
EV strategy: case study 93–6, 101(n3)
EV strategy: pilot testing 95
four electric car projects 59, 94
‘style centre’ (later Department of Industrial Design) 56–7
Renault: Electric Vehicle Business Development (BDVE, 2009–) 93–5, 101(n2)
Renault Fluence 59
Renault Kangoo Express Z.E. 59
Renault Logan 59
Renault Technocentre (1998) 57
Renault Twingo 57, 59
Renault Twizy 59, 66(n2)
Renault ZEV initiative 93–4
battery technology 93
business model 94
optimization for electric engines 94
Renault-Daimler alliance 59
Renault-Nissan 19–20, 30(n9), 114, 119, 310t, 315
agreement with NEC 230, 234, 237
agreement with One North East 235
agreements with municipalities 231, 235, 237
diesel engine patents (1990–2007) 115f
patents related to hybrids (1992–2007) 113f
see also Nissan
renewability
criterion to find best motor vehicle fuel 275t, 276f
renewable energy 17, 148, 164, 170, 220–2, 268, 271, 274–5t, 276f, 279, 305, 311
distributed generators 214
small-scale distributed generators 212
rental cars 311, 313
companies listed 314
see also saloon cars
research and development 14, 30, 56–8, 60, 66, 71–3, 103, 111, 120, 124–6, 161, 177, 191, 201, 201–2t 228–30, 259, 312
conventional methods ‘no longer sufficient’ 81
high levels of cost 232
in-house 126
new processes in greening of automotive industry 70, 78–81
personal interviews 118, 123
role 261
rule-based 79
stage-gate processes 73
technology frame 134
research and development:
agreements 237
centres 232
departments 105
expenditure 134
investment 138(n3), 232, 236, 308
managers 105
networks 233
phases 16
processes 3–4, 16, 69–85
subsidies 234
research octane number (RON) 144t, 161(n3)
Rénove 316t
Reva: G-Wiz EV 24
Rheims Auscher 54
Ricart, J. 243, 253
Rifkin, J. 66, 68
Riley, R. Q. 266, 284
Riskin, C. 248, 252
Rolfo, S. 2
Romania 27t
Roordink, R. 301t
Rosenbloom, R. S. 241, 252
Rothschild 54
Rouen: Community of Agglomeration 318
4R Energy Corporation 237
Réseau Francilien de Recherche sur le Développement Soutenable (R2D2) 82(n1)
retailing 97, 172, 174, 211, 212
Reunion pilot testing 95, 97, 98, 312
EV technology 100–1
Reva 316t
Reva: G-Wiz EV 24
Rheims Auscher 54
Ricart, J. 243, 253
Rifkin, J. 66, 68
Riley, R. Q. 266, 284
Riskin, C. 248, 252
Rolfo, S. 2
Romania 27t
Roordink, R. 301t
Rosenbloom, R. S. 241, 252
Rothschild 54
Rouen: Community of Agglomeration 318
4R Energy Corporation 237
Russian Federation 28, 155t, 264, 307t, 307–9, 317t
carmakers 310t
CNG pump prices (versus petrol and diesel, 2011) 152t
natural gas production (2009) 150t
reserves of CNG (2009) 149t
‘Soviet Union’ 37
see also BRIC
RWE 236, 237
Saab 135t, 138(n6)
Sadarangani, C. 203t
safety 17–18, 24–6, 28, 32, 35–6, 39, 41–4, 46–7, 54, 58, 60, 71, 268–71, 288, 290t
heaviness versus lightness bias 55
Sagem 74
SAIC 231, 237
‘sailing ship effect’ origin 106–8, 121
‘sailing ship effects’ in global automotive industry 5, 19, 103–23
conclusion and discussion 104, 119–21
diesel car sales (Europe and USA, 2005–10) 110f
electric-petrol hybrids (Toyota takes initiative) 108–9
evolution of diesel engines (European success story) 109–11
hybrid car sales (Europe versus Japan/USA: explanation for huge difference) 111–12
hybrid car sales (USA 2000–10) 109f
hybrid car sales (USA, Asia-Pacific, Europe, 2006–9) 111f
‘hybrid electric-petrol cars versus clean diesels 104, 108–12
‘key questions/issues’ 119, 120–1
literature 103, 106–7, 114, 116
measures of car manufacturers’ innovativeness 104–6
measuring technological competence 105–6
modular versus architectural innovation’ 104, 117–18
origin of ‘sailing ship effect’ 106–8
plug-in hybrids 119
product development, industrialization, marketing competence 106
selection bias 108
sourcing strategies (in-housing sourcing in Japan, specialization in Europe) 104, 117–19
technological activities (weak patent performance of European producers) 112–16
technologies and market performance 104, 108–12
US market (diesel versus petrol hybrids) 116–17
Saitama (Japan) 313
Sánchez, P. 243, 253
São José dos Campos (São Paulo) 175
São Paulo 170, 313
São Paulo state 170, 171
São Paulo University: Technological Research Institute (IPT) 168f, 177
SAP (software company) 58
Saudi Arabia 149t
Scania 185, 194, 200, 204
architectural knowledge 195t
component knowledge 195t
data source 192n, 204
heating system (patent application, 2010) 193
hybrid vehicle development processes 187
in-house development 192
interviews 201, 201–2
parallel hybrid system 199
patent for parallel hybrid electric drive (2001) 193
permanent-magnet synchronous motors (transverse flux) 190
problems of developing two technologies in parallel 198–9, 200
series hybrid application 199
series hybrid powertrain 192, 192f
sourcing and knowledge development 192–3
technology and application innovations of electric motors relative to suppliers 196f
timeline 187f
Scania-Voith collaboration 186, 192–4, 195–8, 200
technology innovations relative to vehicle manufacturers 196f
scenario of diversity 10, 306–9
conditions required for success 308
scenario of progressiveness 10, 309–11
scenario of rupture 10, 311–20
cleaner car models (by types of producer) 319t
consequences 320
electric vehicle start-ups and newcomers (2011) 316–17t
many active supporters to form coalitions 312–18
number of cleaner models (by type of vehicle) 319t
technical versus geopolitical conditions 318–20
two stages 311–12, 313t
scenarios 7–8, 24, 212, 259
advantages 276–7
AV fuels 9, 263
in confrontation (second automotive revolution) 9–10, 304–22
definition 272
non-quantitative factors 277
use 276
see also uncertainty
scenarios: ‘best motor vehicle fuel’ 272, 276–84
assumptions 277, 282
catastrophe scenario 277–8, 278f, 280–1, 281–2f, 283, 284
choice of fuel results 282f
economic challenge scenario 277, 278f, 280, 281–2f, 282, 284
environment challenge scenario 277, 278f, 279, 281–2f, 282–3
environmental concerns 277
external influences 277
first-tier criteria comparison results 282f
mentalities 278f, 278–81
oil price 277
players/actors 277
status quo scenario 277, 278f, 278–9, 281–2, 283
Schendel, D. 107, 121
Schneider Electric 98, 234, 318
scooters 244–5, 248, 315, 319
second automotive revolution: scenarios in confrontation ii, xx, 9–10, 28, 304–22
‘door-to-door’ transport system (solution to crisis) 9, 304–5
economic policy decisions 9–10, 306
formation of coalitions between public and private actors 9, 305–6
‘gradual’ versus ‘all at once’ scenario 309–11
scenario of diversity 10, 306–9, 320–1
scenario of progressiveness 10, 309–11, 320–1
scenario of rupture 10, 311–20, 320–1
three of four conditions about to be fulfilled 9, 304–6
transfer of new technologies developed in other sectors 9, 305
Segrestin, B. xxv–vi, 3–4, 69–85
Seoul 314
Serbia 152t, 155t
series hybrid technology 187, 189, 192, 192f, 194, 200
services 52, 258
after-sale 14
Cultural meanings 49
new 242
new meanings 3, 49
use-oriented and result oriented 29
Sevastyanova, K. 291, 303
Shandong Province 247
Shanghai 62, 242
Shanghai Kanelaqiu Science and Technology Company 247
Shifeng (Group) Company Ltd (1993–) 316t
background 247
business model innovation (case study) 246–50
location 249
production of LSEVs (2007–) 248–9
Shimano (bicycle parts manufacturer) 53
Shimizu, K. ii, 325
Shove, E. 289, 303
Shrestha, R. M. 143, 162
Siciliano, L. de B. 175
Siemens 118, 237
Silicon Valley (California) 24
Sina-Newchance New Energy Technology Co. Ltd. 247
Singapore 152t, 155t, 236, 312
Sloan, A. 55
Slovanian model 60
Slovakia 152t, 155t, 157t
Slovenia 152t, 157t
Smart car (petrol-engined) 57
Smart EV 24, 59, 63
usage cost 27–8m 30(n12)
Smart Fortwo 66(n2)
smart grids xxi, 2, 7, 207–8, 212–13, 215, 218, 221–2, 225, 235–7 feasibility 213, 223
smart meters 218, 219
smart vehicles 257, 260
see also sport utility vehicles
Smith, A. ii, 89, 92, 97, 102, 326
sodium nickel chloride 227
software fuel sensor (SFS) 176–7
soil 51, 170, 268, 269
solar cars 19, 64
solar energy 18, 71, 76, 98, 101, 268, 274–5t, 279
Solar Print 236
Somalia 266
Sorgenia (Italy) 236
sourcing 5, 108
electric motor development 192–3
in-house sourcing (Japan) versus specialization (Europe) 104, 117–19, 120–1
Scania 192–3
South Africa 315, 317t
South America 2, 149–50t, 313
South Asia 243
South Korea 37, 47, 307t, 307–9
Southeast Asia 243
Southeast Electric Reliability Council 216
Spain 25, 27–8, 30(n12), 151t, 153f, 155t, 157t, 182n6), 307t, 313t, 313, 315, 317t
speed 55, 248, 251, 258, 314
see also LSEVs
Spers, E. E. xxi, xxvi, 6, 164–84
split-axle hybrid 233, 237
sport utility vehicles (SUVs) 46, 71, 109, 210, 319t
see also ultra low-emission vehicles
sports car 315, 316–17, 319t
see also used cars
stakeholders 92, 95–6, 99, 127, 300
firm perspectives on hydrogen technology 134–6
Steg, L. 287, 303
Stocchetti, A. xxvi, 5–6, 140–63
Stockholm 187, 314
Stockholm: SL (public transport provider) 197
Stockholm: Royal Institute of Technology (KTH) 203t
stop-start features 19, 89, 117
storage 271
storage capacity (oil) 266
strategic intent versus experimental approach (EVs) 4–5, 89–102
Studebaker models 55
Stumpf, U. E. 175
sugar cane (Saccharum officinarum) 6, 100, 159, 165–7, 168f, 180–1, 181t, 269
path-dependence and innovation 168–9, 182(n6)
Sugar Cane and Ethanol Industry Association (UNICA) xvi, 166, 168f, 170, 181, 182(n2)
Sugar Cane Technology Centre (CTC), Brazil xiii, 166, 168f, 169, 182(n4)
sugar price 169–70, 171, 180
sulphur oxides (SOx) 282
Sumitomo 237
suppliers 57, 58, 82, 125, 128, 137t, 167, 168f, 175, 177–9, 233, 316–17t, 319t, 324
agreement and joint ventures with carmakers 7
complementary technical knowledge 197, 198
independence 6–7, 185–204
late versus early involvement 196–7, 198
listed 315
new 226
strong relationships with carmakers (EV components) 8
tier-one 23
supply chains 5, 150, 263, 310
supply and demand  xxii, 23, 142, 154, 165, 171, 178, 258
market-clearing price  217
mismatch (role of EVs in reducing)  221
oil  264
smart grids  212
Sushandoyo, D.  xxvi, 5, 6–7, 103–23, 185–204
sustainability  170, 180, 181t, 183, 261, 278f, 279, 284, 290, 324
social urban model  256
transitions  102
see also analytic hierarchy process
sustainable development  8, 14, 29, 92, 98, 240
addressed through innovative design  70, 74–8
aesthetic form  51
Brundtland definition  51
concept  2
industrial designers and challenges of  3, 49–68
innovation design  3–4
innovative design in automotive industry  13–31
literature xix
new R&D processes in automotive industry  3–4, 69–85
requirements and constraints  3
scope  3, 15
strategies (Brazil)  6
sustainable mobility  5–6, 140–63
Sustainable Mobility Institute 101(n2)
sustainable solutions ‘new’ versus ‘old’ technologies (global automotive industry) 5, 103–23
Sweden  xxvi, xxiii, 25, 27t, 111, 151t, 153f, 155t, 157t, 160, 307, 307t, 317t
biogas production  159
Swedish Hybrid Vehicle Centre (SHVC) 203t
Switzerland  27t, 151t, 155t, 159, 160, 307t, 312, 313t, 315, 317t
synchronous AC generator  227
synthetic fuels  17, 21
Syria  168
Taiwan  37, 40, 312, 316t
Tajikistan  152t
Tata Motors  315, 316t
Tata Motors: Nano  45
tax incentives  90, 97–9, 116, 172, 177, 179, 181, 273t, 293f
tax on industrial products (IPI, Brazil)  172
taxation  1, 27t, 28, 89, 110–12, 228, 245, 249, 291t, 291, 296, 301(n4, n9), 312
taxi  45, 77, 314
technological innovation/s  xix–xx, 6, 92, 139, 164–5, 167, 181t, 197, 199, 228, 241, 292, 298, 302
Brazilian ethanol production  170–1
electric motors relative to suppliers  196f
impact on oil price  265
relative to vehicle manufacturers  196f
technological trajectories  2, 8, 14, 15–19, 29–30(n3–8), 104
alternative vehicles  4–7, 87–204
technology/technologies  3, 5, 36, 49, 52, 70, 168f, 226, 272
adoption ‘involves more than producing technologically-elegant solution’  8, 240
alternative  125
CNGVs  158–60
co-existence  108
‘commercialization via business model’  240, 243
design process  89
and market performance  104, 108–12
mature  19
new  8, 226, 233–4, 237–8, 259, 305
‘no single objective value’ (Chesbrough)  240
‘old’ versus ‘new’ (race for sustainable solutions in automotive industry) 5, 103–23
‘old’ versus ‘new’ (‘sailing-ship effect’)  107
‘old’ versus ‘new’ (synthesis)  120
put in motion  181
relationship between frame, willingness, and belief structure  133f
technology/technologies – continued
‘search process with spillover
  effect’s 200
second-generation 176–7
state-of-art 232
successful adoption 8
supply-side and demand-side
  co-evolution 165
system-dependent and
capital-intensive 108
unpredictability 8, 226
see also disruptive technologies
Technology Service Centre for EVs 247
Teece, D. J. 241, 253
Tenconi, A. 207–24
Tennenbaum, M. 101(n3)
Tennessee 313
Terna 216n, 224
Teske, J. 20, 30, 107, 121
Tesla Motors 24, 226, 238, 315, 317t
  agreement with Daimler 234, 237
Thailand 152t, 155t
Thalès 74
Tholen, J. xxiii
Tianjin 62
TK Advanced Battery 234
TNO 29(n2)
‘TNS-Emnid/AutoScout24’ 288, 303
Tokyo 314
Tomic´, J. 220, 222
top-down control
  electricity (rational use) 217–18
torque 108, 110, 158, 192, 227, 294,
  295f, 298
torque-to-inertia ratio 189
Toyota 19, 21–2, 90, 104, 117–23, 185,
  229, 234, 236–7, 309, 310t, 323
  average CO₂ emissions of cars sold in
  Europe (1997–2010) 141t
  challenge 47
  construction of US truck factory
    ‘overly slow’ 46
diesel engine patents
  (1990–2007) 115f
electric-petrol hybrids 108–9
fuel cell R&D 126
hybrid evolution 114
hybrid technology (US market
  battlefield) 116
in-house sourcing 118, 119, 121
manufacturing system (evolution) 47
over-reliance on US market 46–7
patents related to hybrids
  (1992–2007) 113f
‘pioneered patents in hybrids’ 112
plug-in hybrids 119
quality problems 46
recall problem 32
Toyota Hybrid System (THS) 118
Toyota Prius (1997–) 16, 58, 108–9,
  119, 122
driving comfort 291
launched in Netherlands
  (2000) 292–4, 301(n7)
  post-purchase justification versus
    pre-purchase motivation 291
  UK buyers (questionnaire) 291
Toyota Production System 33
trade-offs xix, 1, 18, 267, 324
  ‘battery leasing’ versus ‘fast
    charging’ 18
traffic congestion see congestion
tramcar system 255
tramways 62, 256, 257
transformers 215, 216
Transitec (Swiss consultancy) 62
transmission (transferring power to
  wheels) 117, 118, 120, 190, 190f,
  191–2
transmission grids (electricity) 212
transport 54, 65, 94, 100, 150, 174,
  240, 261
  emissions 89, 101(n1)
  inter-nodal 255
  long-distance 13, 237, 251
  revolution (C19) 254
Transport Urbain Libre Individuel et Public
  (TULIP) 58
transverse flux machine/motor
  (TFM) 193, 195, 196f, 197
Tropsch, H. 30(n6)
trucks 4, 135, 136t, 185, 199
  flex-fuel evolution (Brazil,
    2003–12) 178f
  light 178f, 247
  parallel hybrid 187, 201–2t
  three-wheeled 247
see also heavy hybrid vehicles
  turbochargers 19, 110, 158
Turin xxi, xxv–vii, 56, 64, 314
Turkey 155t
Turkmenistan 149t
tyres 19, 24

UAE 149t, 156t
UBS 117, 122
Ukraine 152t, 155t
Uløm 29
ultra low-emission vehicles (ULEVs) 124, 125
see also vehicles
underground railways 209, 255, 256, 261
União da Indústria de Cana de Açúcar (UNICA, Brazil) xvi, 166, 168f, 170, 181, 182(n2)
United Kingdom xxiii, 24, 27–8, 30(n12), 58, 235, 287, 307t, 315, 317t
CNG pump prices (versus petrol and diesel, 2011) 151t
CNG system (payback period) 153f
CNGVs and CNG filling stations 156t
electric vehicles (2010–11 statistics) 27t
natural gas vehicles (latest figures) 157t
United Nations 159, 162
UNFCCC 102
‘America’ 8, 244, 251
anhydrite ethanol 176
automobile crisis 32
boom and bust 46
cars 264
changing position (new preference for plug-in hybrid and EVs) 307t, 308
CNG reserves (2008) 149t
CNGVs and CNG filling stations 156t
coal-fired power plants 268
definition of LSEV 244–5
diesel car sales (2005–10) 110f
electronic fuel injection 176
EV deployment (2020 scenario) 214
EVs (target number) 313t
hybrid car sales (2000–10) 109f
hybrid car sales (2006–9) 111f
hybrid and diesel sales (2007–12 advance estimate) 117
industrial architectural geopolitics 37
‘low-level of diesel patenting’ by European car-makers 116
low-sulphur diesel fuel lacking 116
manufacturing capability (‘division-of-labour’ type) 34
market battlefield (diesel versus petrol hybrids) 116–17
natural gas production (2009) 150t
‘playing a catch-up game’ 103–4
Prius sales 108–9
tariff on ethanol imports 171
US Congress 109, 171
US Department of Defence 266
US Department of Energy (DOE) 126, 219, 268, 269, 285
US dollar decline 266, 283
US Energy Information Administration (EIA) 148, 149–50n, 161(n6), 162, 219
US Environment Protection Agency (EPA) 176
US Patent and Trademark Office (USPTO) 105–6, 113n, 114f, 115n, 188, 188n, 191, 193, 195n, 200
see also North America
University of California (Berkeley) 213–14, 223
Upadhyay, J. D. xxvi, 9, 263–85
Uppsala University 203t
urban areas 18, 27, 210, 237, 249, 306, 313
planning 251, 255, 260
pollution 21
subscription services 66
transport networks (service vehicles) 314
urban mobility 3, 15, 52, 54, 62, 66
electric systems 29
product of systemic change 8–9, 254–62
urban mobility: greening of automotive industry 8–9, 14, 254–62
crisis of car-focused mobility 8, 254–5
energy supply and time horizon (portfolio of solutions) 259, 260, 261, 262(n2–3)
forma urbis and infrastructures 260
industrial policies 260–1
integrated systems and role of R&D 261
mobility as actual product 256
over-production and market segmentation 258–9, 261–2(n1)
shaping the network 255–7
systemic change 259–61
utility value as vector for change 8, 256–7, 261
urbanization 255
used cars 142, 179
see also automobiles
Uzbekistan 149t, 152t, 155t

Valeo 104, 118
Vallourec 74
Van den Burg, S. xxv
Van der Cluijs, Mr 301t
van der Heijden, P. 136t
VAT 301(n4)
Vauxhall 141t
vehicle cost
criterion to find best motor vehicle fuel 273t, 276f
vehicle development time 275t, 276f
vehicle maintenance cost
criterion to find best motor vehicle fuel 273t, 276f
vehicle maker: new forms 6–7, 185–204
vehicle modularization 319
vehicle ranges 56, 57, 58
vehicle-to-grid (V2G) 222
EV-supporting distribution grid 7, 215, 219–21, 222
vehicles 7, 19, 100
eco-efficient 9, 286, 299
energy-efficiency 7
energy-saving 53
high-fuel-economy 65
lighter 53
new fuels 266
obsolete (most polluting) 141–2
public 77
range-extender 13
‘specific-purpose’ 260
two-seater 30(n10)
see also ZEVs
Velib system (bicycle-sharing) 65
Vendée 313
Venezuela 149t, 155t
VERT (EV Technology for Réunion) 100–1
Vervaeke, M. xxvii, 3, 15, 49–68
Vezzoli, C. 29, 30
Viarisio, E. 2
vibration 191–2, 209
Victoria (Australia) 313
Virginia and Carolinas (VACAR) 216
Vitali, G. xxvii, 225–39
Voith/Voith Group 186, 193–4, 195
architectural knowledge 195t
component and architectural knowledge (electric motors/hybrid drive systems, 1990–2009) 194, 195f
component knowledge 195t
divisions 193
interviews 201, 203t
patents 193, 197
transverse flux motor 192
Turbo division 193
volatile organic compounds (VOC) 145t
Volkswagen (VW) 104, 110, 112, 113n, 117, 122–3 135, 174–5, 301(n8), 309, 310t
agreement with FAW 231, 237
average CO2 emissions of cars sold in Europe (1997–2010) 141t
diesel engine patents (1990–2007) 115f
diesel engines 116
Golf platform (sixth generation, 2008–) 117
strategic approach 21
Volkswagen (Brazil): Gol Power 1.6 Total Flex (2003–) 177, 179
Volkswagen Beetle (1946) 56
Volkswagen BlueMotion 117, 301(n8)
Volkswagen Jetta 116
Volkswagen Touareg Hybrid 189
Volpato, G. ii, xxiii, xxvii, 5–6, 140–63, 325–6
voltage-boosting converter 226, 227
Volvo 123, 194, 196, 204, 307–8, 310
advantage of focus 199–200
architectural knowledge 195t
competences 190–1
component knowledge 195t
data source 190n, 204
in-house development 190, 191–2
interviews 201, 202t
parallel hybrid configuration 190, 190f
parallel hybrid powertrain 199–200
patent applications (2008–9) 191
patent for electric motors 195
patents 191
permanent-magnet synchronous motors (radial) 190
sourcing and knowledge development 190–1, 192–3
technology and application innovations of electric motors relative to suppliers 196f
Volvo: business package team (BPT) 191, 201, 202t
Volvo-Kollmorgen collaboration 197, 198
electric motor development 190–2
technology innovations relative to vehicle manufacturers 196f
Volvo Trucks 185, 200
hybrid vehicle development processes 186–7
timeline 187f
Volvo V60 model 21
VTLIB (Véolia urban transport) 63
VU Log (urban mobility information systems) 62
Wallonia 313
Wang, H. xxiv, xxvii, 7, 240–53, 317n, 319n, 322
Washington DC 126
waste 76, 144, 159
watch design 57, 58
weight/weight-reduction 19, 59, 60, 112, 227, 225, 234, 246, 271, 289f
Weil, B. 73, 83–4, 85
well-to-wheel (WTW) 19, 144, 161, 207
Well-to-Wheels Report (European Commission, 2007) 153–4, 162
West Indies 169
West Midlands (Australia) 313
Williamson, O. E. 166, 184
wind energy 18, 76, 220, 222, 268, 274–5t, 279, 306
Winebrake, J. J. 267, 277, 278n, 284
Womack, J. P. 323, 325
Wuhan 231, 313
Xerox Corporation 241, 252
Yang, D. H. 248, 253
Yedla, S. 143, 162
Yin R. K. 247, 253
Yokohama 314
Yu, A. S. O. 176, 184
Zero Emission Vehicles (ZEVs) 13, 25, 100, 119, 140, 142, 260
see also alternative vehicles
ZF (component maker) 118
Zhang, C.-H. 144, 163
Zhao, J. 240, 253
zinc-air battery 227
Zirpoli, F. xxiii
Zoe (Renault) 59