Abbreviations

ACEA Association des Constructeurs Europeens d'Automobiles
ADB Asian Development Bank
AFV alternative-fuel vehicle
AWD all-wheel drive
BAT best available techniques
BAU business as usual
BEAG Bombay Environmental Action Group
BEST Bombay Electricity and Suburban Transport
BEV battery electric vehicle
BG British Gas
BIS Bureau of Indian Standards
BISS business models for inherently sustainable systems
BSTE bounded sociotechnical experiments
BTA Bombay Taximen’s Association
CARB California Air Resources Board
CH$_4$ methane
CNC computer numerically controlled
CNG compressed natural gas
CO$_2$ carbon dioxide
CUTE Clean Urban Transport for Europe (EU)
DfR design for recycling
DOE Department of Energy (USA)
DTC Delhi Transport Corporation
EIA Energy Information Administration (USA)
ELV end-of-life vehicle
EMAS Eco-Management and Audit Scheme (EU)
EMS environmental management system
EPA Environmental Protection Agency
EPACT Energy Policy Act (USA)
EPCA Environmental Protection and Control Association (India)
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESRC</td>
<td>Economic and Social Research Council (Cardiff University, UK)</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>EV</td>
<td>electric vehicle</td>
</tr>
<tr>
<td>EZB</td>
<td>Easybike</td>
</tr>
<tr>
<td>FC</td>
<td>fuel cell</td>
</tr>
<tr>
<td>FCV</td>
<td>fuel-cell vehicle</td>
</tr>
<tr>
<td>FMVSS</td>
<td>Federal Motor Vehicle Safety Standards (USA)</td>
</tr>
<tr>
<td>FTP</td>
<td>Federal Test Procedure (USA)</td>
</tr>
<tr>
<td>GAIL</td>
<td>Gas Authority of India Ltd</td>
</tr>
<tr>
<td>GAPC</td>
<td>Global Alternative Propulsion Centre (General Motors)</td>
</tr>
<tr>
<td>GDP</td>
<td>gross domestic product</td>
</tr>
<tr>
<td>GHG</td>
<td>greenhouse gas</td>
</tr>
<tr>
<td>GIN</td>
<td>Greening of Industry Network</td>
</tr>
<tr>
<td>GM</td>
<td>General Motors</td>
</tr>
<tr>
<td>GMSA</td>
<td>General Motors South Africa</td>
</tr>
<tr>
<td>GPS</td>
<td>global positioning system</td>
</tr>
<tr>
<td>GRI</td>
<td>Global Reporting Initiative</td>
</tr>
<tr>
<td>GSM</td>
<td>global system for mobile communication</td>
</tr>
<tr>
<td>HEV</td>
<td>hybrid electric vehicle</td>
</tr>
<tr>
<td>HV</td>
<td>high voltage</td>
</tr>
<tr>
<td>HVAC</td>
<td>heating, ventilation and air conditioning</td>
</tr>
<tr>
<td>ICE</td>
<td>internal combustion engine</td>
</tr>
<tr>
<td>ICEV</td>
<td>internal combustion engine vehicle</td>
</tr>
<tr>
<td>ICT</td>
<td>information and communications technologies</td>
</tr>
<tr>
<td>IGL</td>
<td>Indraprastha Gas Ltd (India)</td>
</tr>
<tr>
<td>INEM</td>
<td>International Network for Environmental Management</td>
</tr>
<tr>
<td>IPPC</td>
<td>Integrated Pollution Prevention and Control</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organisation for Standardisation</td>
</tr>
<tr>
<td>ITS</td>
<td>intelligent transport system</td>
</tr>
<tr>
<td>LCA</td>
<td>life-cycle assessment</td>
</tr>
<tr>
<td>LCC</td>
<td>life-cycle costing</td>
</tr>
<tr>
<td>LNG</td>
<td>liquefied natural gas</td>
</tr>
<tr>
<td>LPG</td>
<td>liquefied petroleum gas</td>
</tr>
<tr>
<td>MagLev</td>
<td>magnetic levitation</td>
</tr>
<tr>
<td>MDI</td>
<td>Moteur Développement Internationale</td>
</tr>
<tr>
<td>MEA</td>
<td>membrane electrode assembly</td>
</tr>
<tr>
<td>MFR</td>
<td>micro-factory retailing</td>
</tr>
<tr>
<td>MGL</td>
<td>Mahanagar Gas Ltd (India)</td>
</tr>
<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology (USA)</td>
</tr>
<tr>
<td>Mitka</td>
<td>Mobility Concept for Individual Short-Distance Transport (Netherlands)</td>
</tr>
<tr>
<td>MPV</td>
<td>multi-purpose vehicle</td>
</tr>
<tr>
<td>N2O</td>
<td>nitrous oxide</td>
</tr>
<tr>
<td>NCR</td>
<td>National Capital Region, New Delhi (India)</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Environmental Management Act (South Africa)</td>
</tr>
<tr>
<td>NEV</td>
<td>neighbourhood electric vehicle</td>
</tr>
<tr>
<td>NEVCO</td>
<td>Neighborhood Electric Vehicle Company (Oregon, USA)</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-governmental organisation</td>
</tr>
</tbody>
</table>
NGV natural gas vehicle
NiMH nickel-metal-hydride
NIS national system of innovation
NOVEM Nederlandse Organisatie voor Energie en Milieu (Dutch Organisation for Energy and Environment)
NOx nitrogen oxides
OEM original equipment manufacturer
OPEC Organisation of Petroleum Exporting Countries
PAL Premier Automobiles Ltd
PEM proton exchange membrane
PM particulate matter
PNGV Partnership for Next Generation Vehicles (USA)
PSS product-service system
PZEV partial zero-emission vehicle
R&D research and development
ROI return on investment
RTO Regional Transport Office (India)
SME small or medium-sized enterprise
SNM strategic niche management
SO2 sulphur dioxide
SSI sustainable system innovation
STD Sustainable Technological Development programme (Netherlands)
SULEV super-ultra-low-emission vehicle
SUV sports utility vehicle
TNO Organisation for Applied Scientific Research (Netherlands)
TOD transit-oriented development
TQM total quality management
VOC volatile organic compound
WBCSD World Business Council for Sustainable Development
WSSD World Summit on Sustainable Development
WTO World Trade Organisation
ZEV zero-emission vehicle
ZEV–AT zero-emission vehicle alternative technology
About the contributors

Dr Chris Borroni-Bird joined General Motors in 2000 as Director of Design and Technology Fusion to foster collaboration between design, research and engineering. He has leads GM’s Reinvention of the Automobile programme which includes AUTOnomy, Hy-wire and Sequel. Before joining GM, he was in charge of fuel-cell hybrid vehicle development at DaimlerChrysler and was inducted into the Automotive Hall of Fame as a Young Leader in 2000. Borroni-Bird has a degree in Natural Sciences from Cambridge University, a PhD in Surface Science from Liverpool University (completed at Cambridge University) and performed post-doctoral research at Tokyo University Institute of Solid State Physics.

christopher.borroni-bird@gm.com

Halina Szejnwald Brown is Professor of Environmental Health and Policy at Clark University, Worcester, Massachusetts. She currently works in the areas of environmental policy, sociotechnical innovation for sustainability, sustainability reporting by the corporate sector and pollution management. She has written two books on environmental policy and management in developing countries (Corporate Environmentalism in a Global Economy; Quorum, 1993) and in Poland (Effective Environmental Regulation; Praeger, 2000). Before joining Clark University in 1980 she was a chief toxicologist for the Massachusetts Department of Environmental Protection. Halina is a Fellow of the International Society for Risk Analysis and American Association for the Advancement of Science.

hbro wn@clarku.edu

Catherine Carbone received her master’s degree in environmental science and policy from Clark University, Worcester, Massachusetts, in 2003. She is currently an environmental consultant in New York State.

cassiecarbone@yahoo.com

Gordon Dower MD, FACC is the founder and president of The Ridek Corporation, established to promote and develop the Ridek electric vehicle concept. His background and much of his professional life is associated with medicine, but his interests have ranged widely over the years. More recently he has become intrigued by the quest for sustainable mobility and, as a lone maverick, has been able to arrive at an innovative solution not conceived by the leading vehicle manufacturers or others in the field. Gordon subsequently became involved in the Greening of Industry Network event in San Francisco in 2003, and has also been active in the US electric vehicle scene. He is a keen pilot, and flies his own R-44 helicopter.

dower@whidbey.com
Boelie Elzen is Senior Researcher at the Centre for Science, Technology and Society, University of Twente, Enschede, The Netherlands. His general research interest is in understanding the dynamics of sociotechnical change and using the insights gained to develop solutions to societal problems related to these change processes. Over the past decade he has focused these efforts on passenger mobility, worked on EU research projects in the area and provided consultancy advice to various institutions in The Netherlands as well as abroad.

B.Elzen@bbt.utwente.nl

Prof. Dr Wim A. Hafkamp is Professor of Environmental Studies at the Erasmus University in Rotterdam. He became an environmental economist in the late 1970s having studied econometrics at the Tilburg University. He took his doctor’s degree, on the modelling of the interactions between economic and environmental systems, at the Free University of Amsterdam. Wim is a member of the Dutch Advisory Council on Housing, Spatial Planning and Environment (VROM-raad) and the Dutch Advisory Council for Transport and Infrastructure (V&W-raad). He is President of the European Association of Environmental Management Education and, until 2001, was Chairman of the Programme Commission of the Environment and Economics Strategic Research Programme.

hafkamp@fsw.eur.nl

Dr Marko Hekkert received his master’s degree in chemistry at Utrecht University in 1995. He wrote his PhD thesis on the subject of more efficient material management to reduce greenhouse gas emissions. Currently, Marko is working as Associate Professor in the Department of Innovation and Environmental Sciences at Utrecht University. He co-ordinates research and education in the field of sustainable technology development and innovation, supervising a team of PhD and post-doctoral students on topics related to the transition to a sustainable energy system, hydrogen as fuel, uncertainties in energy transitions and energy innovation systems.

m.hekkert@geo.uu.nl

Tine Herreborg Jørgensen is Associate Professor at the Department of Development and Planning, Aalborg University, Denmark. Her fields of research are environmental management systems, occupational health and safety management systems and integrated management systems.

tine@plan.aau.dk

Merih Kunur is a designer and researcher based in London. His work focuses on intelligent urban transport concepts, as well as sustainability and vehicle recycling. He studied industrial design at the Faculty of Architecture, Mimar Sinan University, Istanbul, Turkey, receiving his degree in 1987. As a student he worked at Koc Holding Research and Development Centre on vehicle design projects, travelling to Zurich, Frankfurt and London to liaise with transport experts. Before joining the Royal College of Art in London as a researcher in 2001, he worked for various textile, fashion, product and architectural design companies. He completed his MPhil thesis on mobility and transport in city centres in 2003. In 2003 he became a Research Associate for the Helen Hamlyn Research Programme, based at the Royal College of Art. He is currently concentrating on PhD research on end-of-life vehicles while developing a design research project on future urban personal transport.

Merih.kunur@rca.ac.uk

Dr Lassi Linnanen is Professor of Environmental Technology, Economics and Management at Lappeenranta University of Technology, Finland. His main research interests include corporate responsibility strategies and system innovations for sustainable development.

lassi.linnanen@lut.fi
Adeline Maijala was a researcher in the Department of Industrial Engineering and Management at the Helsinki University of Technology when EcoTra was developed. She has worked in the sustainability services team of the consulting firm KPMG and has experience in the fields of corporate responsibility, life-cycle assessment and packaging waste management. As a PhD candidate she aims to understand the collaborative processes implied in the implementation of corporate responsibility strategies in supply chains. Today she consults companies on extended producer responsibility at Proventia Solutions.

Eskild Holm Nielsen is Head of Technology, Environment and Society and Associate Professor at the Department of Development and Planning, Aalborg University, Denmark. He has carried out research on the appropriation of companies, but his particular interest has been environmental regulation and self-regulation by companies.

Dr Paul Nieuwenhuis studied in Australia, Belgium, Spain and Scotland and is Assistant Director of the Centre for Automotive Industry Research (CAIR) at Cardiff University which he joined in 1990. CAIR studies economic and strategic aspects of the world motor industry. Paul is a founder member of the ESRC Centre for Business Relationships, Accountability, Sustainability and Society. Paul has written a number of articles and books, including *The Green Car Guide* (Greenprint, 1992), *The Death of Motoring?* (John Wiley, 1997) and *The Automotive Industry and the Environment* (Woodhead, 2003), and is a contributor to the *Beaulieu Encyclopaedia of the Automobile* which won a Cugnot Award from the Society of Automotive Historians in 2000.

Dr Renato J. Orsato is a Senior Research Fellow at the Insead Business in Society (IBiS), INSEAD, Fontainebleau, France; and Visiting Professor at the School of Management, University of Technology, Sydney (UTS), and the Australian Center for Science, Innovation and Society (ACYSIS), University of Melbourne, Australia.

Mahesh Patankar is a PhD candidate at the Shailesh J. Mehta School of Management, Indian Institute of Technology, Bombay. He is currently working in the area of energy efficiency as Senior Project Manager at the International Institute for Energy Conservation, an international not-for-profit non-governmental organisation. Mahesh has a degree in chemical engineering from Tatyasheb Kore Institute of Engineering Technology, Warananagar, India and a master’s in financial management from Jamnalal Bajaj Institute of Management Studies, Bombay. Mahesh works in the area of environment and energy planning, and efficiency improvement, as well as on the broader issues of market transformation processes involved in the diffusion of environmentally sound and energy efficient technologies in the transport, buildings and other end-use segments. He has supported technology assessment and market transformation processes for municipal councils and electrical utilities.

Anand Patwardhan is Executive Director of the Technology Information Forecasting and Assessment Council, an autonomous organisation in the Ministry of Science and Technology, Government of India. Prior to this, he was Professor and Head of the Shailesh J. Mehta School of Management at the Indian Institute of Technology (IIT), Bombay. Anand has a degree in electrical engineering from IIT, a master’s in environmental science and engineering, and a PhD in engineering and public policy, both from Carnegie Mellon University. He has post-doctoral experience as a Fellow in marine policy and ocean management at the Woods Hole Oceanographic Institution. Anand works in the broad area of climate studies, focusing on the assessment of vulnerability and adaptation to climate change, and on the dif-
fusion and adoption of clean technologies. He has been a member of the Indian delegation to the 8th and 9th Conference of Parties to the UNFCCC, and is a member of a core advisory group on climate change for the Indian government. He is a member of the Scientific and Technical Advisory Panel of the Global Environment Facility; a member of the Scientific Steering Committee for the Global Carbon Project; and a co-ordinating lead author for the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

anand@cc.iitb.ac.in

Dr Tuula Pohjola is Professor of Environmental and Quality Management at Helsinki University of Technology, Department of Industrial Engineering and Management. Before joining the university in 2001, she was a consultant at the Finnish Employers Management Development Institute. Her main research interests include environmental business accounting and systems to develop companies' environmental reports.
tuula.pohjola@tkk.fi

Carla K. Smink is Associate Professor at the Department of Development and Planning, Aalborg University, Denmark. She has carried out research on modernisation of environmental regulations. Her PhD dissertation is on the end-of-life vehicle regulations in The Netherlands and Denmark.
carla@plan.aau.dk

Robert van den Hoed completed his PhD thesis at the Faculty of Industrial Design Engineering, Delft University of Technology, The Netherlands, in May 2004. His thesis was an historical examination of the growing popularity of fuel-cell technology in the automotive industry, with a focus on the roles of stringent regulation, competition between automotive companies and competition between technologies. The central research question revolved around how certain technologies become institutionalised while others do not. Robert is now working at Ecofys, a sustainable energy consultancy in Utrecht, with special responsibility for hydrogen, fuel cells and sustainable transport.
R.vandenHoed@ecofys.nl

Tom van der Horst worked for 15 years at the Organisation for Applied Scientific Research (TNO), The Netherlands on sustainable innovation. He is currently manager of the business unit Innovation and Environment of TNO. Tom is a founder of the Knowledge Centre of Sustainable System Innovation and Transitions (TNO/Erasmus University Rotterdam), and is founder and former chair of O2 The Netherlands. He is involved in many different research projects at both national and EU level: for example, the Knowledge network for System Innovation (KSI) and EMUDE (Emerging User Demands for Sustainable Solutions).
Tom.vanderhorst@tno.nl

Prof. Dr Philip J. Vergragt is currently a Visiting Scholar at MIT, Centre for Technology, Policy and Industrial Development, Massachusetts, a Visiting Senior Fellow at Tellus Institute, Boston, and a Visiting Professorial Fellow at the Manchester Business School, University of Manchester, UK. He is Emeritus Professor of Technology at Delft University of Technology, The Netherlands. His current research interests are visioning and backcasting, social learning through bounded sociotechnical experiments, institutional change, transitions to sustainable cities, transitions towards the hydrogen economy, sustainable transportation and sustainable consumption. Philip holds a PhD in chemistry from Leiden University, taught chemistry and society at Groningen University and was a Deputy Director of the Dutch Government’s Programme on Sustainable Technology Development in the 1990s. He is a founding member of the Advisory Board of the Greening of Industry Network.
pvergragt@tellus.org
Dr Peter Wells, after a varied background in geography and then urban planning during which he gained his BA, MSc and PhD, joined Cardiff Business School and became a founder member of the Centre for Automotive Industry Research in 1991. He then became a founder member of the ESRC Centre for Business Relationships, Accountability, Sustainability and Society, also at Cardiff University. Peter is a leading expert and commentator on the automotive industry, particularly in relation to environmental matters and materials choice. He is currently exploring the scope of industrial ecology to inform a redesign of the industry. Of particular interest is the need and scope for innovative business models in the automotive industry to accommodate the many economic, social and environmental pressures the industry faces.

WellsPE@Cardiff.ac.uk

Chad White is a doctoral candidate in the Energy and Resources Group at the University of California in Berkeley. In collaboration with the late Vicki Norberg-Bohm and as part of a Fellowship at the Kennedy School of Government at Harvard University, he conducted this research on government–industry technology partnership. His other academic and publication experience includes research on end-of-life recovery of electronic products and a dissertation on the effect of corporate environmental performance measurement and communication on organisational structures and learning. He has recently been a Fellow at the University of California’s Centre for Information Technology Research in the Interest of Society (CITRIS) and a Fellow in the University of California’s Toxic Substances Research and Training Programme.

cdwhite@berkeley.edu

Andrew Williams is a research associate at the ESRC Centre for Business Relationships, Accountability, Sustainability and Society at Cardiff University. His main research interests include sustainability in the automotive and electronics industries, sustainable supply chain management, and the role of product service systems and other business models in achieving system-level innovation.

WilliamsAM1@Cardiff.ac.uk
Index

Air Car 99
Air quality 12, 19, 142
Apollo space programme 23
Automobility paradigm 17
Automotive industry 13-14, 21, 37
change in see Innovation; Institutional theory;
Micro-factory retailing
economies of scale 23, 39, 40, 81, 86, 87, 92-3, 97
lack of consensus on fuel 24
new entrants 41, 65, 71-72
over-production 81, 94
scale 96-97
AUTOnomy 87, 99-100, 209, 210-12

Backcasting 14
Ballard 61, 71, 72-73, 75, 76, 77, 225, 226
Batteries 72
battery range 15, 104, 105
improved performance 40
recharging 32, 104, 106, 118
storage capacity 37, 39, 52
Battery electric vehicles (BEVs) 15, 49, 61,
62, 67-71, 103-104, 225
criticism 41
General Motors and 74
patents 69-70
TH!NK 98
see also Electric vehicles; Modek
Battery society 61
Bayliss, Trevor 228-29
Berlage Institute 190
BEVs see Battery electric vehicles
Bicycles 20, 37
Easy Rider 136, 137
Easybike 137

Biomass fuels 25, 32
BISS see Business models
BMW 24, 38, 74
environmental strategy in South Africa 157,
163, 164-6, 168
Bookchin, Murray 96
Bounded sociotechnical experiments (BSTEs)
28, 32, 113
as agents of social learning 114-16
idea brokers 116
Sparrow and Gizmo as 120-22
Brazil 13, 20, 225
Breakthrough technologies 46
BSTE see Bounded sociotechnical experiments
Budd, E.G. 86, 92, 229
Building America programme 144, 146-47
Buses 16, 24, 28
CNG-fuelled 16, 178-86
hydrogen fuel-cell vehicles 29, 30-31
India 16, 178-86
see also Public transport
Business models 12, 15
for inherently sustainable systems (BISS)
131-32, 140
see also Micro-factory retailing; Relocalisation
By-wire chassis technology 160, 211, 213, 214,
219
see also Hy-wire

Capoco Design Limited 192
Car body 38, 39, 81, 86, 92

Mitka project 20, 132-39
see also Cycling
Bike-plus 113
Bio-fuels 25, 50, 224, 228
bio-diesel 24, 52

Capoco Design Limited 192
Car-sharing 20, 225
Carbon emissions 12, 20, 26, 54, 162, 171
FCVs and HEVs 51-52
regulations 76
see also Emissions; Greenhouse gas emissions
Carbon sequestration 24-25, 28
Cars 12, 17, 20-21
bodies 38, 39, 81, 86, 92
dominance of multi-purpose vehicles 38-39
lifetime of 157
multi-purpose vehicles 38-39
occupancy 38
performance 38
second-hand 39
sharing 20, 225
sports cars 38
sports utility vehicles (SUVs) 12, 13, 19, 20, 105
status and 15, 19
two-seaters 38, 39
Catalytic converters 1
Ceres Principles 166
Chain mobility solutions 20
China 12, 13, 20, 125, 171, 227, 228-30
Citroën, André 229
Clean Cities programme 144, 145-46, 147, 148-51
Clean Urban Transport for Europe (CUTE) 28, 29
Climate change 12, 21
CNG see Compressed natural gas
Colombia 19-20, 225
Communities of practice 115
Competing technologies 46-7
Competition selection 46
Compressed natural gas (CNG) 227
Indian public transport system 16, 19, 178-86
see also Liquefied natural gas
Congestion 12, 13, 43, 188, 189
Congestion charges 21
Constructivist sociology 36
Corbin Motors 113-14, 116-20
see also Sparrow
Crisis of mobility 11-12
Critical path analysis 15
CUTE see Clean Urban Transport for Europe
Cycling 20, 187
see also Bicycles
DaimlerChrysler 24, 50-1, 67, 70, 72, 74, 75, 76, 77, 80
CUTE project and 29
NECAR I 71, 73, 74
Smart car 38, 98
Delta Motors 167, 169
Delta Plan 133-34
Design dominant design 46
the Gizmo 118
micro-factory retailing 87
the Modek 106, 107
open-source design 99
in product service systems 83-84
public transport 191-92, 194-95
the Ridek 106-107, 109
the Sequel 220-21
the Sparrow 118
sustainable system innovations 134-35, 136
Diesel HEVs 52
Diffusion of innovation 121
Dominant design 46
Door-to-door mobility 19, 20, 21, 188, 191
Driverless vehicles 194-95
Easy Rider 136, 137
Easybike 137
Economics of the people 93
Economies of scale 23, 39, 40, 81, 93, 97
hydrogen fuel-cell vehicles 31
micro-factory retailing 86, 87, 92-93
Edison, Thomas A. 229
Electric vehicles (EVs) 15-16, 21, 35-43, 103
environmental performance 37
fuel independence 40
hybrid vehicles and 40
internal combustion engine compared 37
as a learning technology 41
limitations 39, 42
market failure 36, 39
Mitka project 20, 132-39
motorists’ attitude to 37-38
myth and reality 36-7
neighbourhood EVs (NEVs) 39-40
niche marketing 39, 41
performance 39
see also Battery electric vehicles; Hybrid electric vehicles
ELVs see End-of-life vehicles
Emissions 13, 142
carbon emissions 12, 20, 26, 51-2, 54, 76, 162, 171
hydrocarbon 24
methanol 24
nitrous oxides 24
petrol-reforming and 24
reduction in 35
regulations 13, 19, 21, 22, 36, 76
see also Greenhouse gas emissions
EMSS see Environmental management systems
End-of-life vehicles (ELVs) 161, 162
Environmental activities in the product chain 158-60
Environmental economics 95
Environmental gain 27, 126
Environmental management systems (EMSs) 161, 164-6, 167, 168
barriers to adoption 198
drivers to adoption 197-98
EcoTra 199, 200-206
environmental and financial performance indicators 202-203
quality standards 167, 203-205
SMEs and 196-206
web-based system for SMEs 197, 199-206
Environmental regulation
BMW 163, 164-6, 168
in the car chain 157, 161-62
command and control regulation 160-61
corporate responses 163-4
Delta Motors 167, 169
delta-of-life vehicles (ELVs) 161, 162
General Motors 163, 166-67, 168
modernisation of 160-61
product-oriented strategy 161, 162
public environmental regulations 162
South Africa 163, 164-8
third-generation environmental policy 21, 137
Ethanol 54, 227
EVs
see Electric vehicles
EV1 74, 105-106
Evolutionary economics 21, 28, 36
Exxon 51, 75
Factor 20 solutions 20
Factor x debate 13
FCVs
see Fuel-cell vehicles
Feedback–stimulus mechanism 114-15
Fire-and-forget production 15
First-mover advantage 40
Five Minutes City: The Architecture of [Im]mobility 190
Ford 71, 225, 229
Fossil fuels 32, 37, 51
FreedomCar 55
Fuel
bio-diesel 24, 52
bio-fuels 25, 50, 224, 228
biomass 25, 32
compressed natural gas 16, 19, 178-86, 227
efficiency 37
energy content 37
ethanol 54, 227
fossil fuels 32, 37, 51
fuel independence 29, 40
'gasohol' 20
gasoline 51, 227
hydrocarbons 24, 37
hydrogen
see Hydrogen
ICE cars 37
lack of industry consensus 24
life-cycle costing 27
liquefied natural gas 19, 194, 224
liquefied petroleum gas 16, 227
methane 23
methanol 23, 24, 25, 51, 72, 226, 227
nature of 23
petrol 35, 37, 42, 226, 227
reforming 24-25, 28, 226
supply infrastructure 17, 23-24, 48-50, 56, 226, 227-28
taxes 21, 22
Fuel cells 25, 209, 225-26
advantages 23
commercial future 24
costs 23, 55-56
disadvantages 23
hydrogen fuel cell 12, 22, 23-24, 25, 28, 229
institutionalisation of fuel-cell technology 52-55, 66-75
methanol fuel cell 23, 51
platinum and 226
portable electric appliances 23
power density 72-73
proton exchange membrane (PEM) 23, 56, 61, 71
the Sequel 217-18
stationary generation of electricity 23
types 23
Fuel independence 29, 40
Fuel-cell vehicles (FCVs) 21, 23, 26, 61-62, 103, 104, 226
carbon emissions 51-52
comparative studies 26-27
costs 55-56
drivability 56
environmental performance 52
fuel infrastructure and 23-24, 48-50
gasoline FCVs 50, 52, 58
hybrid vehicles compared 45-58
hydrogen FCVs 50
industry activities 57-58
market factors 55-56
methanol FCVs 51
oil companies and 50-51
patents 57, 69-70
production of 26
research funding 57-58
see also Electric vehicles; Zero-emission vehicles

**Fuelling Road Transport** 25

**Functional sales** 83

‘Gasohol’ 20

**Gasoline** 51, 227

**Gasoline FCVs** 50, 52, 58

**General Motors** 16, 24, 26-27, 71, 75, 76, 77, 80, 209, 225

AUTOnomy 87, 99-100, 209, 210-12

environmental strategy in South Africa 157-58, 163, 166-67, 168

EVI 74, 105-106

Hy-wire 99-100, 209, 213-14

Sequel

see *Sequel*

GIN
see Greening of Industry Network

**Gizmo** 114, 116-20

advertising 118-19

as BSTE 120-22
cost 118
design 118
insurance companies and 118, 120
marketing 119, 120, 121-22

**Greenhouse gas emissions** 24, 28-29, 32
carbon emissions 12, 20, 26, 51-52, 54, 76, 162, 171

China 171

hybrid ICE vehicles and FCVs compared 26

India 171

Kyoto Protocol 54

reduction 25, 26

regulations 13, 19, 21, 22, 36, 76

steam-reforming and 24

see also Zero-emission vehicles

**Greening of Industry Network (GIN)** 11, 17, 224, 228

**GUIDE** 191

**HEVs**

see Hybrid electric vehicles

**Hinterland concept** 93

**Honda** 58

**Hong Kong** 192, 193, 228

**Hy-wire** 99-100, 209, 213-14

**Hybrid electric vehicles (HEVs)** 41, 103, 104
costs 56
diesel HEVs 52, 103
drivability 56
efficiency 46
emission levels 46, 50
environmental performance 52

fuel infrastructure and 48-50
industry activities 57-58
institutional context 52-55
market factors 56
oil companies and 50-51
patents 57, 69-70
public transport 191, 194
research funding 57-58

see also Electric vehicles; Zero-emission vehicles

**Hybrid vehicles** 12, 24, 25, 225

comparative studies 26-27
electric vehicles and 40
environmental gains 27
fuel-cell vehicles compared 45-58
hybrid ICE vehicles 26-27

**Hydrocarbons** 24, 37

**HydroGen** 3 213

**Hydrogen** 22, 23, 24-25, 51

availability 28
biomass 25
carbon sequestration 24-25, 28
electrolysis of water 24, 25, 28
filling stations 51
petrol-reforming 24
problems 24-25
production 24-25
steam-reforming 24-25, 28, 32
stimulation programmes 55
storage 23, 24, 32, 215-17
supply infrastructure 50, 56, 226, 227-28
well-to-tank 27

**Hydrogen economy** 24, 29

**Hydrogen fuel cell** 12, 22, 23-24, 25, 28, 229

**Hydrogen fuel-cell vehicles** 27, 28-32, 50

acceptance by users 28
buses 29, 30-31
carbon emissions 52
comparative studies 26-27
consumer acceptance 30-31
cost-benefit analysis 27
costs 31
economies of scale 31
environmental gains 27
future scenarios 25-27
General Motors 26-27
hybrid vehicles 27
transition to 28

**Hydrogen society** 62

**Hydrogen vision** 55

**Hypercar** 99

**Hypercars** 40

**Iceland** 23, 24, 26, 29, 227

**ICE**

see Internal combustion engine
ICT
see Information and communications technologies

India 12, 13, 20, 125, 227, 228
alternative fuel use 178-84
CNG-fuelled public transport 16, 19, 178-86
Mumbai 16, 181-84
New Delhi 16, 19, 178-81
see also Compressed natural gas

Indonesia 13, 227, 228

Information and communications technologies 20

Innovation
diffusion of 121
fuel infrastructure and 48-50
functional innovation 81-82
innovation system 47
national system of 47
organisational complexity 48, 49
system innovations 81-82, 126, 127
technical novelty 48-9
technological relative advantage 58
technological trajectories 58
technology-specific innovation systems 47
see also Sustainable system innovations

Institute Français d’Architecture 190

Institutional entrepreneurs 65, 73-75

departmentalisation 64-66
definition of ‘institution’ 62
dominant problem definition 65
dominant solution directions 65
exports and new entries 65, 71-72
external shocks or crises 65, 72
fuel-cell technology 52-55, 66-75
institutional change 64-66
institutional context 52-55, 62-63
institutional entrepreneurs 65, 73-75
institutionalisation 64
market changes 66, 75
mimetic institutions 68-71
mimetic pressures 63, 68-71
new practices by established members 65
new technologies 65, 72-73
normative institutions 67-68
normative pressures 63, 67-68
organisational behaviour and 62
organisational field 64-66, 71-75
performance crises 65
radical innovation and 64
regulative institutions 66-67
regulative/coercive pressures 63, 66-67
social structures and 62
technological institutions 63-64
technological regime 36, 64-65
three pillars 63

Internal combustion engine (ICE)
comparative studies 26-27
costs 23
electrical vehicles compared 36, 37
environmental gains 27
fuel 37
fuel infrastructure and 48-50
hybrid ICE vehicles 26-27
hydrogen in 24
reduced emissions 35
technological lock-in 12, 36
technological superiority 36, 37

ISO 14001 167, 203-205

Isomorphism 62

Istanbul 192, 193, 194

Japan 54, 55, 226, 227, 229

Keynes, John Maynard 96

Korea 54

Kyoto Protocol 54

Lightweight vehicles 39, 40

Liquefied natural gas (LNG) 19, 194, 224
see also Compressed natural gas

Liquefied petroleum gas (LPG) 16, 227

LNG
see Liquefied natural gas

Localisation see Relocalisation

London
public transport in 187, 189, 192, 193, 194

Lotus Elise 38

Lovins, Amory 99

LPG
see Liquefied petroleum gas

Lutz, Robert 112

Market changes 66, 75

Massachusetts Institute of Technology (MIT) 26, 27

Materials leasing 99

MDI
see Moteur Développement Internationale

Mercedes 24, 38, 73

Methane 23

Methanol 23, 24, 25, 51, 72, 226, 227

Methanol fuel cell 23, 51

Micro-factory retailing (MFR) 15, 86-90, 92
economies of scale 86, 87, 92-93
innovative vehicle design 87
investment costs 86
plant function 87-88
plant size and location 86-87
see also Product-service systems
Relocalisation

Mies van der Rohe Foundation 190

Index 253
MIMIC 191
MIT see Massachusetts Institute of Technology
Mitka project 20, 132-39
Modek 98, 99, 104-105, 106, 107
benefits of renting 107-109
construction 109
costs 105
crash-resistance 107
design 106, 107
exchange 104, 105, 108-109, 110
range 104, 105
recharging 104, 106
see also Ridek
Modular vehicle system 194-95
see also Ridek
Moteur Développement Internationale (MDI) 99
Motor racing 37
Multi-purpose vehicles (MPVs)
dominance of 38-39
National system of innovation (NIS) 47
Natural gas 24, 54
NECAR I 71, 73, 74
Neighbourhood electric vehicles (NEVs) 39-40
see also Electric vehicles
Neighbourhood Electrical Vehicle Company (NEVCO) 114, 116-20
see also Gizmo
Netherlands
CUTE project 29
Delta Plan 133-34
factor 20 solutions 20
hydrogen fuel-cell buses 29, 30-31
hydrogen supply infrastructure 227
Mitka project 20, 132-39
National Environmental Policy Plan 21
sustainable technological development (STD) 20
NEVs see Neighbourhood electric vehicles; Electric vehicles
NEVCO see Neighbourhood Electrical Vehicle Company
Niche marketing 39, 41, 149
Nike 127, 132, 136
see also Mitka project
NIS see National system of innovation
Nissan 24, 80
Nitrous oxides 24
Nuclear fission 224
Nuclear fusion 224
NUON 29
Oil
dependence on 40
prices 42, 225, 228
supply and demand 228
Oil companies 21
development of HEVs and FCVs and 50-51
OPEC see Organisation of Petroleum Exporting Countries
Open system concepts 130, 131
Open-source design 99
Organisation of Petroleum Exporting Countries (OPEC) 42
Organisational complexity 48
OSCar 99
Partnership for a New Generation of Vehicles (PNGV) 13, 72-73
Partnerships see Voluntary technology partnerships
Patents 57, 69-70
PEM see Proton exchange membrane
Petrochemicals 37
Petrol 226, 227
energy content 37
prices 35, 42
Petrol-reforming 24
PIRATE 191
Platinum 226
PNGV see Partnership for a New Generation of Vehicles
Population growth 20
Porsche 38
Producer responsibility 83
Product-service systems (PSSs) 15, 82
benefits 85
design of products and services 83-84
functional sales 83
information flow 84
limitations 85
meaning 82
ownership 83
producer responsibility 83
producer-consumer interaction 84
see also Micro-factory retailing
Product stewardship 15
Proton exchange membrane (PEM) 23, 56, 61, 71
costs 56
PSA 24
PSSs see Product-service systems
Public transport 16, 20, 29, 187-95
buses 16, 24, 28, 30-31, 178-86
CNG-fuelled 16, 19, 178-86
INDEX 255

design 191-92, 194-95
driverless vehicles 194-95
Hong Kong 192, 193
hydrogen fuel-cell vehicles 29, 30-31
India 16, 19, 178-86
infrastructure needs 190
Istanbul 192, 193, 194
London 187, 189, 192, 193, 194
modular vehicle system 194-95
problems of 190-91
public commuting vehicles 39, 99
transit-oriented development (TOD) 191

Partial ZEV
see Zero-emission vehicles

Quality standards 167, 203-205

Reithofer, Norbert 164
Relocalisation 86-87, 93, 100, 101, 224
Air Car 99
AUTOnomy 99-100
economic basis of locality 95-96
environmental basis of locality 94
transport originations of local sustainability 97-100
HY-wire 99-100
OScar 99
Ridek 99, 107, 108
scale of manufacturing 96-97
socio-cultural basis of locality 93-94
TH!NK 98
see also Micro-factory retailing

Renault 24
Renewable energy 24, 26, 32
Ridek 98-99, 100, 104-105, 106-107
crash-resistance 107
customer appeal 110-11
design 106-107, 109
local manufacture 99, 107, 108
Modek
see Modek
Ridon 98, 99, 104, 105, 106, 107, 109
Rio Earth Summit 100
Road building 12, 189
Roadsters 38
Russia 13, 228

Sailing ship effect 45
Schumacher, E.F. 96-97, 100
Second-hand car market 39
Selection processes 46
Sequel 209, 214-15
by-wire chassis system 219
electrical and controls system 219-20
exterior and interior design 220-21
fuel-cell propulsion 217-18
hydrogen storage system 215-17
thermal management 218-19
vehicle structure 220
Shell 51
Shell Hydrogen 29, 51
Smart car 38, 98
SNM
see see Strategic niche management

Social learning 22
BSTEs as agents of 114-16
communities of practice 115
discourse and 115
feedback-stimulus mechanism 114-15
ger-term learning 32, 113, 114-16
idea brokers 116
lower-order learning 114
urgency and 115

South Africa
automobile industry 164
BMW in 103, 164-66
Delta Motors 167, 169
General Motors in 163, 166-67
Sparrow 113, 116-20
advertising 118-19
as BSTE 120-22
business plan 119-20
cost 118
design 118
insurance companies and 118, 120
marketing 119-20, 121-2

Speed limits 38
Sports cars 38
Sports utility vehicles (SUVs) 12, 13, 19, 20, 105

SSIs
see Sustainable system innovations

STD
see Sustainable technological development

Steam-reforming 24-25, 28, 32
Strategic niche management (SNM) 28
see also Bounded sociotechnical experiments

Strategic problem analysis 140

Sustainable mobility services 20

Sustainable system innovations (SSIs) 126-27
business models for inherently sustainable systems (BISS) 131-32, 140
characteristics 127-28
Delta Plan 133-34
domain explorations 129-31
method 129-39
Mitka project 20, 132-39
multiplication of system innovation 137-39
open system concepts 130, 131
strategic experiments 135, 136
strategic problem analysis 140
system definition 131-34
system design 134-5, 136
third-generation environmental policy 137
Sustainable technological development (STD) 20
SUVs
see Sports utility vehicles
Swan, Joseph 229
System dynamics 21
System innovations 81-82, 126, 127
see also Innovation; Sustainable system innovations
Tank-to-wheel comparisons 27
Taxation 21, 22
Technofix 14
Technological discontinuities 46, 47
Technological forecasting 46
Technological institutions 63-64
see also Institutional theory
Technological lock-in 12, 36
Technological niche 28
Technological novelty 48
Technological regimes 36, 64-5, 172-74
definition 172
transitions in 175-77
Technological relative advantage 58
Technological system 47
definition 47
HEVs and FCVs in 48-57
Technological trajectories 58
Technology diffusion and substitution 172
Technology dynamics theory 46
Technology road map 15
Technology substitution 46
Technology-specific innovation systems 47
Tellus Institute 22
TH!NK 98
Toyota 24, 58, 75, 226-27
Highlander 226
Prius 54, 56, 74
Traffic speed 38
Transition management 21-22
great transition scenario 22
high demand scenario 25
hydrogen fuel-cell mobility 28
scenario construction 22
social learning 22
third-generation environmental policy 21
Transitions 172-74, 175, 177
in alternative-fuel use 174-86
definition 21, 172
final state 21, 46
levels 21, 172
phases 21-22
sociotechnical scenarios 22
stakeholders 22
in technological regimes 175-77
Transport for London 187
Triad countries/regions 93
Two-seater cars 38, 39
United States 229
Building America programme 144, 146-47
California ZEV regulation 19, 21, 52-53, 57,
66, 72, 74, 76
Clean Cities programme 144, 145-6, 147, 148-
51
voluntary technology partnerships 142-55
Unleaded petrol 21
Urban sprawl 12, 19
Variation processes 46
Vernacular economics 93
Volkswagen Beetle 39
Voluntary technology partnerships 142-55
Building America programme 144, 146-47
Clean Cities programme 144, 145-6, 147, 148-
51
shared governance 143
stakeholder teams 147
structure and function 147-50
technology innovation 143
technology progress 150-53
Walking 20, 187
WBCSD
see World Business Council for Sustainable
Development
Well-to-tank 27
Well-to-wheel efficiency 24
World Business Council for Sustainable
Development (WBCSD) 166
World Trade Organisation (WTO) 100
Zero-emission vehicles (ZEVs) 25, 36, 52, 191
California ZEV regulation 19, 21, 52-53, 57,
66, 72, 74, 76
historical perspective 52-54
OScar 99
partial ZEV (PZEV) 53
see also Electric vehicles