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The business of sustainable mobility

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The international Greening of Industry Network (GIN) has, for more than ten years, been working to bring together experts and thinkers from business, industry, academia, government and non-governmental organisations (NGOs). Its main aim is to deal with issues of how to build a more sustainable industrial culture by combining the conceptual with the practical. The Network's 2003 conference, held that year in San Francisco, saw **sustainable mobility** designated as a key theme: this book is based on that conference. It develops and updates some of the papers presented at San Francisco and includes a number of additional chapters to capture many of the themes to emerge from the 2003 conference. We hope this publication makes a significant contribution to the ongoing sustainable mobility debate.

Crisis, what crisis?

In many parts of the world, there is a crisis of mobility. The choices we have made over the past 200 years about modes and technologies of transportation have brought us

unprecedented global interaction and, in many respects, increased personal freedom. However, this enhanced mobility has come at a high cost—to society, to the economy and to the environment—but few seem aware of the full extent of the mobility crisis. Though most people are aware of issues such as congestion, accidents (although this aspect is often overlooked), parking restrictions and fuel prices, few will have considered the implications of the dramatic increase in personal mobility anticipated in China, India and elsewhere. Nor do many people consider the contribution of cars to climate change or the impact of climate change on the environment.

It is often thought that technology alone can solve this problem. For some observers, salvation could be achieved by means of hydrogen fuel cells, hybrid cars, increased fuel efficiency or even by telematics to reduce congestion. This book shows that ‘technology’ may well not be enough in itself and that for a genuinely sustainable transport future far more radical change, affecting many aspects of society, is needed. It is likely that, as well as users and consumers adopting new forms of behaviour, **new business models** will be needed. Technological innovation may well contribute, but it will need to be induced by a combination of market forces and government regulation.

Few cultural artefacts of the modern era reflect the dilemma of sustainability as well as the car. At the social level, many people have been excluded from the advances offered by the car, and many have become its victims—in many of the poorest countries more people are killed or injured by cars and trucks than by war or famine. At the economic level, congestion, resource depletion and pollution bring significant, though largely uncertain, costs. At the environmental level, although some areas of concern, notably toxic emissions, are relatively well understood, the impact of others, such as carbon dioxide emissions on climate change, are not. As other causes of climate change begin to be addressed in the near future, car transportation will stand out as the single most intractable issue.

Even for those of us who benefit from the advances in personal and collective mobility, the costs are undeniable. In the US, more citizens have been killed on roads than in all the wars the US has ever been involved in, including terrorist acts (Williams 1991). Road building has reconfigured urban and suburban areas, creating social exclusion for many while enhancing the means of social interaction for others. Urban centres around the world have become congested with barely moving metal, while air quality has deteriorated. Urban sprawl, spreading suburbs far out into the countryside, is entirely due to individual car ownership; sprawl also makes it difficult to conceptualise a transportation alternative without the individually owned car, thus creating a situation of **technological lock-in**. Indeed, the environmental and social impacts of car ownership are extremely diverse, pervasive and complex (Nielsen *et al.* 1996; Sydbom *et al.* 2001).

Addressing the challenges

The recognition that we need to do something about these interconnected problems came initially with the realisation that deteriorating urban air quality, particularly in southern California, was car-related (Brilliant 1989; Mondt 2000), prompting a wave of legislation aimed at controlling automobile emissions. This has now extended into

other areas, including car production and use. Regulation now applies to safety, noise, end-of-life vehicles and fuel efficiency, while in the future it is likely to take an increasingly holistic or life-cycle perspective.

The roll-out of such legislation is very much a cat-and-mouse game whereby legislators acting on the basis of political imperatives try to tighten regulation, industry claims dire consequences if the regulation goes ahead, and some kind of compromise position is reached. Not all of this regulation has been concerned with 'control' in the traditional sense; indeed, it was in recognition of the limitations of such regulation that initiatives such as the US Partnership for a New Generation of Vehicles were originally conceived (Wells 1996; Nieuwenhuis and Wells 1997: 54-62). Nevertheless, the regulatory approach, with successive generations of emissions standards, has created vehicles that are much improved in many respects. A modern car, driven under the right conditions, can be up to 95–99% 'cleaner' in terms of toxic emissions than its equivalent of 40 years ago (Mondt 2000: 213). By 2008, EU truck emissions will have improved tenfold compared with those of a truck built in the late 1980s (ACEA 2000).

So, have we solved the problem of sustainability for the automotive industry and its products? It would appear not. While individual vehicles have become cleaner, quieter, more durable, more recyclable and, in some respects, more efficient, various factors have combined to undermine these achievements. First, there is the fact that vehicle numbers have increased, distances driven have increased and growing congestion has resulted in longer periods where stationary cars continue to consume fuel and emit toxic exhaust gases. In addition, cars themselves have become heavier and more complex, with many more comfort and safety features. At the same time, there has been a move—led by the US—to generally heavier sports utility vehicles (SUVs), pick-up trucks and minivans or 'people carriers' for personal transport. Just as importantly, the newly motorising economies of China, India, Indonesia, Russia and Brazil are potentially markets of such magnitude that, collectively, they could easily outgrow the established 'triad' markets of Europe, North America and Japan within the next 20 or 30 years, thus doubling the global burden imposed by motorisation in many respects. Clearly, we need to think of more radical solutions than have been implemented so far. It was the **factor x debate** that first highlighted the need to improve resource efficiency by an order of magnitude if people in the emerging economies are to enjoy an equivalent standard of material welfare to those in the established economies (Vergragt and van Grootveld 1994; Ryan 1998; von Weizsäcker *et al.* 1997). As the single largest manufacturing sector in the world, the automotive industry is strongly implicated in this debate.

The industry has largely ignored the challenges described above and has continued to produce heavier and less efficient cars and SUVs in order to benefit financially from the high profit margins on these vehicles. Nevertheless, the large car companies have also engaged in R&D on alternative fuels and powertrains, recognising the challenges and seeing the profitable opportunities that environmentalism can offer the sector. Consequently, radical alternative technologies are under development by many of the world's largest car- and truck-making concerns and their suppliers. However, moving these from the R&D arena to the commercial market is a bigger step than is often appreciated, especially for an essentially conservative industrial culture. The industry appears almost paralysed by its own structural condition, characterised by high capital intensity alongside low returns on capital (Nieuwenhuis and Wells 1997, 2003; Maxton and Wormald 2004). More profoundly, it is simply not possible for there to be a magic-

bullet solution in the form of a new car technology that can render the industry entirely sustainable. Although theoretically imaginable, the practical barriers are such as to make it impossible from the current perspective. The best that can be achieved is that the industry will become relatively more sustainable than it is today, with products that are less polluting and more resource-efficient.

Beyond the technofix

Much of the effort reflected in the chapters in this book is concerned with going beyond the **technofix** of designing new, more environmentally friendly cars, to confront the more difficult challenges of institutional, cultural and social change within and beyond the industry that must be resolved in the transition towards sustainability. We therefore seek to break through the conventional boundary between engineering and the social sciences, with contributors from both sides of this traditional albeit unnecessary divide, including economists, engineers, geographers and designers.

About this book

The focus of this book is on motorised land-based mobility. We consider it obvious that a world of pedestrians and cyclists would be much more sustainable, and have therefore not covered these. Air transport has also been excluded. Although we recognise that this is a growing and significant issue, research on its impact is still in progress and thinking about possible solutions is in its infancy. For these reasons we therefore focus on land transport.

The central problem is the private car—how to power it; how to build it; and how to deliver it to customers in a more sustainable way. We start with ideas of radical innovation in the propulsion system of the car, notably the hydrogen fuel cell. In this context, Chapter 3 by Renato Orsato explores why the battery electric vehicle (BEV) has once again failed to make its long-awaited breakthrough. The competition for credibility between fuel-cell cars and hybrid electric cars is explored by Marko Hekkert and Robert van den Hoed in Chapter 4, while Chapter 5, by Robert van den Hoed and Philip Vergragt, examines the gradual rise of fuel-cell technology to a more institutionalised status. Many of the chapters thus deal with particular aspects of these broader changes. Chapters 2–5 therefore have the broad theme of **transition to a hydrogen economy** with a focus on one of the more promising alternative powertrain technologies, the fuel cell. The issue of transition has been given considerable theoretical and empirical treatment by those concerned with sustainability, particularly academics and policy-makers. Techniques and approaches have been developed. **Backcasting** (Quist and Vergragt 2004), for example, sets a final target or state, and then looks backwards from that point to ask what steps have to be taken in order to reach that point from the position we are in today. An alternative approach, much favoured by those charged with

disbursing public R&D funds as well as with companies, is the **technology road map**. This is somewhat akin to **critical path analysis** (and is therefore popular with those from an engineering and science tradition), as it seeks to identify the necessary features or steps that need to be in place in order for some future scenario to come to pass. Chapter 3, however, sounds a warning over the difficulties inherent in this kind of forecasting by wondering whatever happened to the BEV: just ten years ago this technology was hailed as a possible saviour. Why, then, did it fail to gain market acceptance?

We are nevertheless aware that powertrain improvements alone cannot solve the problem of sustainable mobility. The section on **sustainable business and industry models** (Chapters 6–7) considers the possible business models that could be used to deliver **automobility** in a more sustainable manner. In line with our assertion that we cannot change one element of the system without considering the impact of such change on the whole, the section looks at how the car is made and used, and at how these aspects affect the quest for sustainable mobility. So embedded are notions of status and aesthetic pleasure with car ownership, changing the culture of automobility is by no means easy. Nevertheless, it must be seriously doubted whether automobility will ever be sustainable under the current philosophy of **fire-and-forget production**. New business models are needed that not only allow product-service system (PSS) concepts to become reality, but that also offer an escape from relentless over-production as well as a means of realising the potential of **product stewardship** while enhancing customer care in the process. Chapter 5 begins to address this issue and can be seen as providing a link to Chapters 6 and 7. In Chapter 6, Andrew Williams explores the opportunities offered by the PSS concept in introducing new business models to the automotive sector. It also introduces the concept of **micro-factory retailing** as a possible alternative business model for delivering automobility in a more sustainable world. Chapter 7 by Peter Wells and Paul Nieuwenhuis presents this concept in more detail and highlights some of its social and economic advantages, particularly within the context of a relocation of economic activity, thus linking in with a debate rarely addressed in the context of the automotive manufacturing sector.

The theme of **vehicle alternatives and their introduction trajectories** is explored in Chapters 8–10 which consider a number of recently introduced vehicles and alternative vehicle concepts and how these might be introduced within the context of a dominant existing paradigm. The history of the automotive industry shows how extremely difficult it has been to introduce alternative technology concepts, particularly when associated with new-entrant companies with no brand identity in the market. The alternative concepts discussed vary from a powertrain exchange concept that could breathe new life into the electric vehicle (Chapter 8) to minimalist single-seater commuter vehicles (Chapters 9 and 10). Again, important lessons can be learned even where such new concepts fail to achieve market success, not least by seeking to identify the reasons for such a failure, be they ‘internal’ to the technology itself, associated with the company that sought to introduce the alternative or embedded in the operating context by virtue of existing regulations, etc. In Chapter 8, Gordon Dower presents a concept that addresses one of the key concerns of electric vehicles—battery range—but broadens this into a more universally applicable vehicle concept which could be of particular interest for certain transport niches. This is followed, in Chapter 9, by Halina Szejnwald Brown and Catherine Carbone who report on their investigation into the modest success of two personal electric vehicles in the US, and by Tom van der Horst

and Philip Vergragt in Chapter 10 with his report on the development of a hybrid electric–human-powered vehicle. Chapter 10 pulls together a number of stakeholders in a novel experiment in system innovation, so providing a link to the next section.

The section, **current trends and cases in greening mobility**, reports on current practice and experience in the initial moves towards sustainable automobility. Chapters 11–15 give a more near-term perspective on how we can start this process. Again, this is important because there is clearly a need to resolve issues in the ‘here and now’ as much as to construct elegant long-term trajectories to a sustainable future. This section is intended to show the sceptics (who may have raised questions during their reading of the previous sections) that it is possible to initiate change towards greater sustainability today and that people are actually doing so. We recognise that there is an underlying tension here between ameliorative reformism and radical systemic change, but the approach taken is one of inclusiveness. This book reveals the broad range of work being undertaken within the general theme of sustainable (automotive) mobility.

Thus, Charles White in Chapter 11 reports on efforts in the US towards greener cars, particularly the role of new combinations of stakeholders in this process. In Chapter 12, Carla Smink, Eskild Holm Nielsen and Tine Herreborg Jørgensen provide their analysis of the extent to which multinational car-makers have been able to transfer their environmental policies to developing countries, particularly South Africa.

Public transport is often presented as a greener alternative to private or personal modes, although the delivery of public transport via large 10–15 tonne diesel-powered commercial vehicles (buses) in urban areas is often not ideal, as such vehicles do not tend to mix well with more benign modes, such as walking or cycling, while most are significant polluters in their own right. Cleaning up existing buses may well be a first step towards more optimised urban public transport delivery and some initiatives are currently under way to do this, from compressed natural gas (CNG) and liquefied petroleum gas (LPG) buses to fuel-cell experiments. In Chapter 13, Mahesh Patankar and Anand Patwardhan describe and analyse the very rapid adoption of CNG as a cleaner fuel for public transport vehicles in Delhi and Mumbai—a transition possible thanks only to the involvement of a number of key stakeholders. In Chapter 14, Merih Kunur draws on his background in product design, offering a more radical solution to the problem of mixing heavy public transport vehicles with more benign modes, by presenting a concept of a more sustainable system for delivering public transport in urban and suburban areas.

This issue is also relevant for goods transport and, here too, considerable improvement is possible. Thus, Chapter 15, by Adeline Majjala, Lassi Linnanen and Tuula Pohjola, describes a simple management tool aimed at transport operators, particularly smaller businesses, which enables them to analyse their own environmental performance. Many players currently involved in the transport business do not recognise the problem; this tool offers a first step towards change.

The final section, comprising Chapters 16–18, presents some more visionary views. Chris Borroni-Bird’s explanation in Chapter 16 of the thinking behind, and implications of, some of General Motors’ more radical concept vehicles shows that even the existing players recognise the need for radical change and that some are actively working to meet that need. At the same time, more sceptical voices are raised over the roar of a more exciting automotive future: given social, economic, regulatory and market constraints, what can we realistically achieve, how soon and by what means? This final sec-

tion also considers what conclusions can be drawn from the chapters outlined above and incorporates some of the outcomes of the workshops at GIN 2003 in San Francisco. Chapter 17 draws these strands together and suggests possible future scenarios. Finally, in Chapter 18, Wim Hafkamp and Boelie Elzen present a vision of a future mobility lifestyle.

We must accept that personal and, in particular, private motorised transport—the car—is one of the greatest obstacles slowing our progress towards sustainable mobility. Un-inventing the car or returning to human and animal power alone is not a viable option if we want to retain the complex economies and flexible lifestyles we have created. For this reason, much of the book is focused on ways of improving the automobility system in terms of sustainability. Tackling ‘the car’ in isolation may seem easier to many commentators; however, it is important to recognise the car as part of a system we have created over the past 100 years or so. This system, which we have called the **automobility paradigm** (Nieuwenhuis and Wells 1997, 2003), includes the car, truck and bus production system and its complete supply chain from mineral extraction onwards. It includes the car itself, how it is used and the social and cultural changes it has brought with it. It also includes the infrastructures created for it and the fuels that power these vehicles and their supply chains.

It is often not appreciated to what extent our modern culture is integrated with the car and its systems: we have built our world around the car and this inevitably shapes the scope for constructing sustainable mobility. We therefore need to tackle any change to the current automobility paradigm on a very broad front, and we need to be prepared for the possibly dramatic social and economic impacts we may bring about by changing just a few of these elements.

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