

TRANSPORT AND SUSTAINABILITY • Volume 20

Towards Transport Net Zero



Edited by
Jon Shaw
Stephen Ison
Maria Attard

TOWARDS TRANSPORT NET ZERO

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TRANSPORT AND SUSTAINABILITY

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TRANSPORT AND SUSTAINABILITY,
VOLUME 20

TOWARDS TRANSPORT NET ZERO

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INVESTOR IN PEOPLE

This book is dedicated to Professor Donald Shoup, a world renowned scholar in the area of parking management.

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Donald Shoup sadly passed away during the production of this volume. He was Distinguished Research Professor in UCLA's Department of Urban Planning. His research focussed on how parking policies affect cities, the economy, and the environment. He was a Fellow of the American Institute of Certified Planners and an Honorary Professor at the Beijing Transportation Research Center. The American Planning Association gave him its National Excellence Award for a Planning Pioneer, and the American Collegiate Schools of Planning gave him its Distinguished Educator Award.

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In founding and editing the *Transport and Sustainability* series, we owe a sincere debt of gratitude to a number of people. At Emerald, the entire team is due a huge ‘thankyou’ and we’d especially like to mention, from over the years, Cristina Irving Turner, Jen McCall, Nick Wolterman, Amber Stone-Galilee, Iram Satti, David Mulvaney, Daniel Ridge, and Lauren Kammerdiener. We are grateful to the Editorial Advisory Board members for their guidance, and it goes without saying that the Volume Editors have made an enormous contribution to the success of the series. They developed the initial ideas for their edited books and brought together the contributors necessary to sustain it over the years and, now, 20 volumes. It is maybe unwise to single out individual editors, although we would like to make special mention of John Parkin, who was the first to show faith in the series, and Corinne Mulley and Lucy Budd, who, respectively, co-edited four and two of the following volumes. And to each and every one of the more than 500 contributors: heartfelt thanks for your analysis and insight that brings each of the volumes in the series to life.

Specifically in relation to this volume, we would like to thank the contributors for writing their excellent chapters in the context of many other demands on their time (not to mention tedious emails from us). Jamie Quinn, of the Geomapping Unit at the University of Plymouth, expertly drew all of the artwork, also in the context of many other demands on his time, and at Emerald, Brindha Thirunavukkarasu and Lydia Cutmore helped us navigate the ‘final mile’. Jon would additionally like to thank Paul Simpson, Ralph Fyfe and Chris Fogwill for their sage advice on keeping up a REF submission while doing fun things like edited books. Alex Belton, Richard Preziosi, Adrian Dawson and Dafydd Moore provided much needed strategic discussion. *Pisces non sunt animalia*. Without Donella Bone’s fantastic assistance, the diary contortions necessary to fit all of this in simply wouldn’t have been possible.

Jon Shaw, Stephen Ison and Maria Attard, May 2025.

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CHAPTER 1

TOWARDS TRANSPORT NET ZERO

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ABSTRACT

The Transport and Sustainability book series was established in 2009 and its first volume, Cycling and Sustainability, was published in 2012. This is the 20th volume in the series and comprises chapters from editors of and key contributors to the preceding 19 books. They discuss significant issues associated with the subject matter of their own edited volumes as they relate to the transport net zero agenda. In this chapter, we provide an overview of the Transport and Sustainability series and explain why we chose transport net zero as the focus of this volume. We summarise the contents of this book, which have been ordered to first 'set the scene' before dealing with active modes, mechanised personal vehicles, mechanised shared modes, transport's role in economic sectors, and progress towards net zero through a geographical lens and, finally, from different social and demographic perspectives. We conclude by identifying key themes and potential future directions that emerge from the analysis contained within the various chapters.

Keywords: Transport net zero; transport modes; sustainability; decarbonisation; greenhouse gas; grand challenge

INTRODUCTION

This is the 20th volume in the *Transport and Sustainability* series. The idea for the series came from a conversation between Steve and Jon in 2009, in Loughborough,

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the evening before a PhD viva, and Maria officially joined the team a couple of years later. All three of us wanted to initiate a series to fill what we thought was a gap in an area that linked the essence of our own research work and an expanding area of research in general. We saw the potential for a series that brought together the widest range of perspectives on issues and policies at the interface between transport and sustainability. Our aims were for the series to be international, inclusive, and based on cutting-edge research that was rigorously peer reviewed. It would be a collection of edited rather than sole-authored books, precisely to increase the range of contributors and thus perspectives. We were delighted that Emerald shared our vision for the series, which has now been in existence for almost a decade and a half.

Fifteen years after we began sketching out our proposal (quite literally in the sense of completing the necessary paperwork) we are proud of how the series has progressed; it now represents a substantial body of work. The 19 volumes preceding this one address transport and sustainability issues by mode (walking, cycling, railways, aviation), policy area (safety, paratransit, parking, participation, response to pandemic disruption), demographic considerations (gender, older people), and economic sector (logistics, tourism), as well as geographically (urban areas, China, Latin America) and technologically (electric vehicles, connected and autonomous vehicles (AVs)). It was also important to dedicate an entire volume early in the series to the relationship between transport and climate change.

The contributors are academics and practitioners from a wide range of fields, spanning the career stages of their respective professions. All told, 38 different editors have secured the contributions of more than 500 authors, 40% of whom are women, based in 37 countries on all five inhabited continents. There have been nearly 112,000 downloads of these contributions, again from all five continents. Around 30% have come from north and west Europe, with China, Australasia, South and East Europe, East Asia and North America accounting for the next largest proportions. At the time of writing, the most downloaded volume is *Sustainable Logistics* (over 15,000), and the most downloaded chapter is *The Health Benefits of Walking* (nearly 2,400 – around a quarter, or almost a half, depending on which study you believe, of your recommended daily number of steps!).

Not only is this volume the 20th in the *Transport and Sustainability* series, but it is also the first as Series Editors we have edited together. We thought it fitting to choose a theme that was globally significant and, to mark the milestone the 20th volume represents, could be explored through analyses relating to topics covered by the other 19 volumes in the series. Of all the sustainability grand challenges faced by humanity today, net zero stood out. Transport is particularly acutely associated with net zero and climate change, because of the sheer significance and apparently unrelenting nature of its contribution to overall carbon emissions as a sector. Globally, transport generates more than eight gigatonnes of CO₂ emissions each year – around a quarter of all greenhouse gas emissions – and almost all of the sector relies heavily on fossil fuels; fully 91% of its final energy use came from oil products in 2022 ([International Energy Agency \(IEA\), 2023](#)). Before the COVID-19 pandemic, transport was the largest source of energy-related

greenhouse gas emissions in 45 countries, and everywhere else it was the second largest (United Nations (UN), 2021). With growth in the sector predicted to be high – one recent study suggests a doubling of pre-pandemic activity levels by 2050 (Tjandra et al., 2024) – swift and radical action, technologically, culturally, and behaviourally, is needed to decarbonise the ways we move people and goods around.

In this context, we invited editors and contributors from the previous volumes to write chapters that related to net zero from the point of view of the themes explored in their own books. What results is a significant and novel contribution to debates about the way in which the transport sector can – and must – navigate its way towards net zero. Since it focuses exclusively upon topics covered elsewhere in the series, our approach is not intended to be comprehensive. That said, in curating *Transport and Sustainability* as a wide-ranging series, we always had in mind the possibility of producing a book of this nature, providing the longevity of the series allowed. Most of the key themes are as such addressed in their own chapter, and others are discussed in the context of related topics at various places in the text (the need for a just decarbonisation transition and the relationship between decarbonisation and broader notions of sustainability are good examples). We thus present this volume as a celebration of the *Transport and Sustainability* series and its contributors, as well as a credible and authoritative source of information and insight on transport and decarbonisation. We summarise this information and insight in the next section of this chapter.

OVERVIEW OF THIS BOOK

Chapter 2 sets the scene by explaining why decarbonising the transport sector is so important in tackling climate change. Tim Ryley establishes key trends in global transport demand and related emissions, providing more details on the extent of the sector's contribution to total global carbon emissions. He notes that 'most governments and many non-state actors, such as companies and educational institutions, have committed to being net zero by 2050', and importantly in the context of the inexorable rise in transport's carbon emissions over recent decades, that 'addressing the CO₂ emissions of transport activities is a major component of this commitment'. While road transport still accounts for the largest share of the sector's CO₂ emissions at 74%, it is air transport that has witnessed the most significant growth (115% above 1990 levels). In this context, Tim explains that any progress towards a net zero emission pathway is complex and fraught with difficulty, and he identifies five major issues that are especially germane to any meaningful decarbonisation effort. The first three relate to mitigation: the need to reduce CO₂ emissions from the multitude of transport activities across different spatial scales, making swift use of technology where appropriate, and recognising the need for behaviour change. The fourth relates to adaptation. With 2024 confirmed as the hottest year on record and Earth's temperature 'clearly exceeding' 1.5 degrees above pre-industrial levels (Copernicus Programme, 2024, unpaginated), the transport industry needs to be 'planned and ready' for

disturbances – more powerful storm events, flooding, wind damage, and excess heat – associated with climate change that has already happened and looks set to continue at pace. Finally, he calls for governments and the transport sector alike to be mindful of the need to ensure moves towards transport net zero are socially just, a theme that recurs throughout this book.

Chapters 3 and 4 focus on walking and what John Parkin refers to as the ‘human-scale’ modes. In their analysis of walking for net zero, Yuting Zhang and Corinne Mulley emphasise the significance of walking as a means not only of lessening dependence on fossil fuels but also of realising a host of social and personal health benefits. They argue that building robust walking infrastructure – accounting for the built environment, location, user characteristics, and enjoyment in its design – is a necessary but not sufficient component of the policymakers’ toolkit. Such interventions not only need to be made on the basis of a detailed understanding of relevant data, but they also need to take place alongside sustained efforts to cultivate a culture of walking. Future societies in which walking is ingrained as a more popular way of completing many more different types of journey will be fitter, healthier, and more socially just, as well as further down the path towards transport net zero.

John in Chapter 4 is concerned essentially with small, wheeled vehicles – different kinds of cycles, e-bikes, scooters, and e-scooters. He sets out in the first part of the chapter lifecycle CO₂ equivalent (CO₂eq)¹ emissions from these human-scale mobility modes as compared with other modes (generally far less than vehicles with internal combustion engines (ICEs), although the comparisons with battery electric vehicles, especially in relation to shared human-scale mobility schemes, might surprise you), before moving on to discuss the nature of strategies and policies needed to promote their use. John’s conclusion that promoting human-scale mobility is a prerequisite for any successful net zero transport agenda is clear. So too is his view that well-designed infrastructure is delivered in the context of a wide-ranging and logically consistent approach, from legislative underpinnings, through strategy and policy, to delivery on the ground. He refers to the Welsh Government’s Future Generations (Wales) Act of 2015 that ‘sets out requirements for improving the social, economic, environmental and cultural well-being of Wales and its citizens’ as an example of how this is being attempted in practice.

Next, Graham Parkhurst provides the first of three chapters that deal largely (but not exclusively) with personal vehicles. In his detailed discussion of the transition to electric cars, Graham highlights key areas of progress (which is heartening) alongside three significant challenges that are proving resilient and not entirely straightforward to overcome (which is less so). In short, while take-up is increasing, it is geographically patchy and, in any event, technical difficulties still need to be overcome to produce *genuinely* net zero electric cars. Assuming this becomes achievable, we encounter cultural barriers because certain ease-of-use characteristics associated with an automobility regime that has grown up around ICE vehicles are awkward to replicate with electric equivalents. There are also problems in realising an ‘attractive, affordable and profitable’ environment for the mass take-up of electric vehicles for a host of reasons. Encouragingly,

breakthroughs are being made on a number of these fronts, and in a world where there are still around 1 billion conventional ICE vehicles, a stringent policy approach '[b]ringing forward the point at which new ICEs no longer enter the global fleet is ... important'.

Eda Beyazit details in Chapter 6 the opportunities and challenges for net zero transport afforded by AV technology. Much hype has surrounded the introduction of AVs, not least because of their potential to 'free up' both drivers from the burden of having to control their vehicles and car-centric automobility systems from the burden of human drivers. There are indeed many potential benefits of AVs, including enhanced efficiency – computers are able to overcome driver unpredictability to the point where, other things being equal, it becomes possible to reduce congestion – as well as better safety and increased social inclusion. Positive net zero effects can also arise, especially when AVs are electric.² At the same time, realising significant net zero and congestion reduction benefits is a long-term aspiration because it depends on high market penetration rates, and there is the distinct risk that an automobility system based predominantly on AVs could materially increase vehicle kilometres travelled.

One reason for this is they can obviate the need to park once drivers (passengers!) have reached their destination. Why pay to leave one's car nearby when it can be sent home and summoned to return on demand? It is to the subject of parking that we turn in Chapter 7. Donald Shoup proposes parking reforms 'to improve cities and cool the planet'. He begins with the thought-provoking point that '[c]ars are parked for 95% of their lives, so the rubber meets the road mainly in parking spaces. Parked cars don't produce any carbon emissions, so parking reforms might seem a poor way to reduce carbon emissions'. You might expect Donald is setting up a straw person and you would be right: he goes on to advocate eight market-based initiatives, all of which have been adopted by city governments in California and beyond. The underlying idea is to transfer more of the cost of parking to parkers themselves and, in the process, 'make cities more expensive for cars and better for people'.

The next four chapters deal with shared transport modes – flexible transport services, railways, aviation, and maritime transport. In Chapter 8, Corinne Mulley and John D. Nelson focus on those passenger services that 'are flexible on one or more of the dimensions of the route: vehicle allocation, vehicle operator, type and time of payment and passenger category'. They illustrate their discussion with reference to eight issues that need to be addressed if flexible transport schemes (FTSs) are to be successful, ranging from the use of technology to the role of marketing the type of provision that is on offer. Their wide-ranging contribution discusses various examples around the world. While such schemes have the potential to act as a substitute for private car journeys in certain circumstances, we can't lose sight of the fact that a fundamental reason for their existence is to promote mobility and social inclusion among disadvantaged groups. Greening the vehicle fleet, especially in developing countries, becomes an especially important policy goal as a result.

Chapter 9 focuses on railways. In relation to other modes, train travel is often held up as something of a poster child of low-carbon transport, with, for example,

the idea of ‘slow tourism’ (see [Barr, 2018](#)) emphasising the environmental advantages of substituting rail for air journeys when selecting and travelling to/from holiday destinations. John Preston and Simon Blainey commend rail’s ‘energy efficiency per traffic unit that other modes cannot match, with commensurate environmental benefits’. At the same time, they note that the mode’s environmental advantage has been eroded as innovations elsewhere (e.g., electric cars) have outpaced developments in rail technology, and that delivering a truly net zero railway is not necessarily an easy proposition. Using a framework of ‘nine grand narratives’, they outline how this might be achieved through action by the rail industry, government, and end users adopting strategies to improve their current practices, shifting the emphasis from existing activities to other, greener, alternatives, and avoiding certain endeavours altogether.

Chapters 10 and 11 cover arguably the most difficult modes to decarbonise, aviation and shipping. Evangelia Pantelaki and Lucy Budd lament that claims ‘for a future in which ‘sustainable’ aviation is possible have been made for over 20 years’ in response to the sector having been pushed repeatedly by policymakers, politicians, and consumers. Unfortunately, ‘contemporary evidence suggests there is still a long way to go before the promised solutions ... mitigate aviation’s environmental externality effects’. After discussing aviation emissions, Evangelia and Lucy provide a critical evaluation of the various technological propositions (that revolve around fuel and propulsion mechanisms) and regulatory interventions (ranging from banning certain domestic flights where feasible rail alternatives are available, to market-based approaches such as emissions trading schemes) that can be brought into play. They conclude that while the aviation sector has begun its journey towards net zero, ‘the status quo cannot continue’, and any realistic prospect of aviation decarbonisation will inevitably involve ‘considerable financial investment, political will, technological innovation and concerted stakeholder engagement’.

The story is not entirely dissimilar in the maritime sector. Indeed, Jason Monios commences Chapter 11 with the warning that the sector ‘is not yet serious about decarbonisation’. Like Evangelia and Lucy’s, Jason’s first substantive section covers the sector’s energy demand and associated emissions. He then reviews potential alternative fuels and operational methods before evaluating the role of policy that, as with the aviation sector, involves a range of measures including emissions trading. In his conclusion, Jason sets out six clear policy steps that in his view need to be enacted as part of a strong, international policy response. He asks whether policymakers and the industry itself are ready to accept them but doesn’t think the prospects are promising: ‘Excuses are already in place and industry representatives expect the sector to be largely fossil-fuelled well past 2050, probably until around 2070’.

In Chapter 12, Jonathan Köhler, Clemens Brauer, and Lóránt Tavasszy focus on the decarbonisation and digitalisation transition in logistics systems, in the first of two contributions dealing specifically with transport’s role in different economic sectors. The logistics industry is undergoing something of a transformation, with continuing growth of supply chains and demand for logistics

services, not least in the context of burgeoning e-commerce activity. A key problem, however, is that while ‘it is true that digitalisation ... increases transport efficiency ... [the increase] it is not expected to be sufficiently strong to allow the system to achieve its decarbonisation targets without intervention’. Such intervention requires policy modelling which addresses the processes of digitalisation and the interaction between digitalisation and decarbonisation. In their chapter, Jonathan, Clemens, and Lóránt develop a transition scenario that they assess through simulation modelling, concluding that ‘socio-technical simulation could help stakeholders to understand which are the feasible and effective pathways towards change’.

Chapter 13 is concerned with tourism and travel. By 2030, tourism-related transport is expected to account for more than 5% of global emissions (UN World Tourism Organization, 2019), and Luca Zamparini notes there are questions about whether decarbonising the tourism sector is possible. This is because of obstacles including the relentless growth of the industry, the institutionalisation of interests, flawed policymaking, and the nature of the geography of tourism (people increasingly like to travel to destinations that they reach by air). In addressing CO₂ emissions produced by travel to and from tourist destinations, Luca makes the now familiar argument that technological developments alone will not be sufficient, and large-scale shift in behaviour and policy development – nothing less than a shift of paradigm – will be necessary. Even then, Luca reminds us that this is only part of the story. Accommodation and catering services in tourist destinations, not to mention the activities that tourists engage in, all have their own carbon emissions, a good proportion of which are transport-related thanks to fossil fuel-dependent supply chains. There are also tourist destinations themselves, for example cruise ships, that are transport based in their own right. Fortunately, efforts are underway to promote the kind of shared visions necessary to achieve net zero tourism, but no-one should pretend there will be anything other than a hard road ahead.

Chapters 14 and 15 discuss progress towards transport net zero through a geographical lens. Maria Attard in Chapter 14 looks at urban transport in net zero cities. Urban areas are home to over half of the world’s population and in Europe generate 23% of all transport-related CO₂ emissions. The huge advantages European urban dwellers derive from their transport networks come at high cost, not just in terms of carbon emissions but also congestion, pollution, safety challenges, noise, and social exclusion. Maria explores the policy challenges of balancing benefits and costs through numerous examples in a discussion that unfolds over five sections: public transport, active travel, and micromobility; freight transport; multimodality; land use and transport integration; and the smart city and technological fixes. She also stresses the point that both technological advancement and behaviour change will be needed, and ultimately, her message is one of systems thinking:

the future of city transport systems will depend on how well we manage to integrate the pieces and develop strategies that complement each other, rather than work in silos and designing systems and infrastructures that serve only one mode (the car) and are not inclusive.

In Chapter 15, Daniel Oviedo, Maria A. Wilches-Mogollon, and Natalia Villamizar Duarte examine transport net zero initiatives in rapidly growing economies, with a focus on Latin America. While some of the challenges, such as the dominance of the private car, will be familiar to policymakers in other countries, Latin America's 'urbanisation dynamics, informal transport systems and stark socio-spatial inequalities' present particular complexities. At the same time, they bring opportunities, and Daniel, Maria, and Natalia exemplify Latin America's history of pioneering sustainable transport initiatives. Active travel schemes involve a range of approaches from closing streets to promote cycle use to co-creating school programmes with children and adolescents. Bus rapid transit schemes have come to play 'a fundamental role in improving urban mobility in dense and congested cities'. Aerial cable cars have become an increasingly common part of the urban transport landscape across Latin America since 2004. Participatory and inclusive planning approaches are especially promising, not least because they offer a direct means of adapting to often diverse local circumstances in a situation where 'the lessons from the region underscore that achieving low-carbon mobility is inseparable from the broader goals of social inclusion and urban resilience in the global south'.

The last four chapters of this book address decarbonising the transport sector from different, but complementary, social and demographic perspectives. Lucy Budd focuses on gender and the transition to net zero transport in Chapter 16. Until recently, relatively little has been written relating to gender and the gendered implications of the move towards net zero transport, which is perhaps unsurprising given that gender equality, transport, and climate change have long been seen as separate from each other. It is also extremely unfortunate. Between the genders, there are differences in travel and employment experiences, environmental attitudes and behaviours, and average carbon intensity of mobility. But as Glenn Lyons (2004) wrote over 20 years ago, transport systems seem to have been shaped around the needs of men, and particularly middle-class, middle-aged professional ones at that. Lucy first constructs a gender perspective in the context of decarbonising transport, before moving on to discuss the nature of women's work in the transport sector. Not only are women under-represented in the workforce (constituting around 17% globally) but they also face particular challenges at work and as users of transport systems – including physical and sexual assault – because of their gender. Lucy concludes that transport decarbonisation strategies need to include a gender perspective and address issues of diversity in the workforce, not least because 'a transport system that is not designed for and with everyone (irrespective of age, gender, race, nationality, or disability) will not achieve its decarbonisation targets'.

In Chapter 17, Charles Musselwhite discusses ageing, transport, and decarbonisation. The current cohort of older people has in many countries driven more than any other generation, and although studies point to the fact that they can find it very difficult to stop driving, Charles suggests that older people shouldn't be absolved from the responsibility to use their cars less on the basis of age alone. It may well be that targeted approaches to help older people engage in more sustainable mobility behaviours are necessary, and there is certainly evidence to