TRANSPORT SECTOR DECARBONISATION

a **social sciences and humanities**
annotated bibliography

SHAPE ENERGY

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Executive Summary

The challenge

- By 2014, transport had overtaken power companies as the sector with the highest carbon emissions across the European Union (EU).
- From 1990 to 2014, EU road transport emissions rose by 17% and aviation emissions by 82%. Road transport accounted for 70% of EU transport emissions in 2014.

Aim

- European energy policy has so far mainly relied on research from Science, Technology, Engineering and Mathematics (STEM) disciplines. Energy-related Social Sciences and Humanities (energy-SSH) have been significantly underrepresented. This bibliography provides a broad overview of SSH perspectives on transport decarbonisation. It is not intended to be comprehensive, but rather aimed at presenting initial insights into the variety of questions posed, areas explored, and methods used by SSH scholars and demonstrating their relevance for EU energy policy.

Coverage

- This bibliography presents publications from History, Human Geography, Sociology, Urban Planning, Political Science, Psychology, Anthropology, Theology, Economics, Philosophy and Ethics, Criminology, as well as intersectional disciplines such as Transport, Tourism, and Gender studies.
- In order to better represent SSH debates, some transport publications which were of wider relevance to decarbonisation (but did not solely focus on it) were included.

Key findings

- Much research concerns technological fixes and individual consumer choices. Consumer research tends to focus on attitudes towards technologies or policies, what determines transport mode preference, or what might prompt mode shift. There is less research on institutional and systemic issues, as well as the role of corporations.
- Since the 1990s, the so-called 'Mobilities turn' has become dominant, associated with Miriam Sheller, John Urry, Tim Cresswell and Marc Augé. This paradigm emphasises the role of travel, globalisation and movement for our contemporary world.
- A large volume of research was found on the car (including electric cars), cycling, commuting, and short distance urban travel.
- Underrepresented topics include rural mobility, long distance travel, and shipping and freight. Walking has received far less decarbonisation focused enquiry than cycling.
- Whilst not all EU research could be represented, intra-EU differences were noted: e.g. the greater importance of two wheelers in Latvia; how more children to walk to school in Eastern European countries; the renaissance of the tram in France; and the large proportion of urban Finns frequently driving to their rural second home.
- Across the span of SSH, researchers frame the problem of transport decarbonisation differently (both from each other, and from more technical disciplines). These framings often point towards different solutions. For instance, they ask: what is the effect of technological, demographic and economic trends on transport emissions?; why do policymakers/scholars focus on certain transport solutions over others?; how do transport modes 'compete'?; how does the meaning of transport change over time?; and why do we travel?

Contents

Introduction

A taste of energy-SSH

This annotated bibliography on transport sector decarbonisation is one of four annotated bibliographies created as part of the EU Horizon 2020 Platform *Social Sciences and Humanities for Advancing Policy in European Energy* (SHAPE ENERGY)[1]. SHAPE ENERGY aims to develop Europe's expertise in using and applying energy-related Social Sciences and Humanities (energy-SSH)[2]. Compared to Science, Technology, Engineering and Mathematics (STEM) research on energy, energy-SSH has been significantly underrepresented in informing European energy policy. In funding SHAPE ENERGY, the European Commission is supporting a better integration of energy-SSH into the policy process.

The aim of the annotated bibliographies is to give non-experts (such as policymakers, practitioners, and academics from a range of disciplines) a taste of the diversity of energy-SSH research in, or of relevance to, Europe. They thereby contribute to making the capabilities of energy-SSH more visible and they provide a convincing statement of the policy relevance of perspectives from the Humanities and Social Sciences. However, it is important to note that energy-SSH represents a diversity of disciplines, and many different, sometimes contradictory, perspectives and approaches to energy-related issues.

As part of the SHAPE ENERGY scoping work package, the annotated bibliographies will also feed into other SHAPE ENERGY activities, such as 18 multi-stakeholder workshops in cities across Europe, an Early Stage Researcher programme, Horizon 2020 sandpits, and the SHAPE ENERGY 2020-2030 research and innovation agenda. The scoping work package also includes four cross-cutting theme reports with practical recommendations for how to be sensitive to gender, multi-stakeholder interests, energy justice, and active consumers, which readers may be interested in. Both the theme reports and the annotated bibliographies may be useful as teaching resources.

The four energy topics

The annotated bibliographies cover the four main energy topics that the SHAPE ENERGY project spans:

1. Energy efficiency and using less

2. Competitive, secure, low-carbon energy supply

3. Energy system optimisation and smart technologies

4. Transport sector decarbonisation

These topics have been selected based on their relevance for EU-policy; in particular, they are inspired by the priorities set out in the Strategic Energy Technology (SET) Plan[3] and consequently the Horizon 2020 energy work programme priorities. Hence, the bibliographies focus on the potential contributions of energy-SSH to these particular challenges. Although these four energy topics are very broad and can incorporate much of the existing energy-SSH, it is clear that through selecting these topics, other possible topics have been left out. Further, due to the broadness of the four topics, a comprehensive presentation of all energy-SSH research of relevance for the topics was, of course, impossible. Many very interesting articles had to be omitted. The bibliographies therefore present a selection of energy-SSH literature based on criteria such as impact (citations), quality assessment, disciplinary and regional diversity.

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1   shapeenergy.eu

2   SHAPE ENERGY will work across the full range of social sciences and humanities, including energy-related research (both current and potential) within: Business, Communication Studies, Development, Economics, Education, Environmental Social Science, Gender, History, Human Geography, Law, Philosophy, Planning, Politics, Psychology, Science and Technology Studies, Sociology, Social Anthropology, Social Policy, and Theology.

3   Commission Communication 2015/6317/EC *Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation*, [online] Available at: https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v8_0.pdf [Accessed 21 May 2017].

How to use the annotated bibliographies

Each annotated bibliography is divided into several sections, which again contain several subsections on different sub-topics. Each subsection provides a list of references, based on published literature including books, journal articles, working papers, reports, etc. Short, accessible annotations are provided under each reference that summarise key points, such as the questions being asked by the authors, the approach taken, headline findings, and/or policy relevant recommendations. They are (of course) not a substitute for reading the original publication, but rather provide a 'window in' that the reader can then follow up, if desired. Longer, more academic abstracts are usually available online. An email request to the author(s) may be a good way to obtain to full text documents which are not public.

Note that the four bibliographies are independent documents and one reference may feature in more than one bibliography.

Coverage

The annotated bibliographies aimed at both disciplinary and geographical diversity (within Europe) when selecting references. However, there is a clear dominance of some disciplines, particularly Economics, in energy-SSH research. Therefore, we intentionally added other disciplines that are not so visible and cited. There was a balance to be struck between including seminal work, and yet emphasising work that is also important, but so far not so visible. In addition, it is not always possible to easily determine which discipline(s) an author sees their work as sitting within. Given that energy-SSH research operates at the intersection between SSH and technology, the bibliographies not only include work by scholars from SSH-disciplines, but also work by scholars from STEM disciplines, who used methods from the Social Sciences and Humanities to approach their particular research problem. Furthermore, although most bibliographies have authors from different disciplines, our own disciplinary bias needs to be mentioned.

Geographical diversity was similarly difficult to achieve. There is a clear Western/Northern European (and particularly UK) dominance in energy-SSH research, and English language publications may achieve a wider readership. Again, a balance needed to be found between including seminal work and highlighting research from underrepresented regions, particularly Eastern Europe, and languages other than English. Whilst doing the search work for the bibliographies, we also discovered that, for example, google scholar automatically filters results based on which country you are from. This of course contributes to geographical and language bias.

As the four energy topics both differed in span and disciplinary coverage, and the expertise of the authors differed, each merited a slightly different approach to searching and compiling of the research literature.

The topic of this bibliography: transport sector decarbonisation

Transport concerns how we get around. It involves different modes (car, train etc.), fuels, infrastructure and professional sectors, but also serves a wide variety of different purposes - from the pilgrimage to the daily commute. As a society, we are travelling more and more. By 2014, transport had overtaken power companies as the sector with the highest carbon emissions across the European Union (EU)[4]. From 1990 to 2014 - in contrast to all other major sectors, whose emissions decreased - EU road transport emissions rose by 17% and aviation emissions by 82%[5]. Road transport accounted for 70% of EU transport emissions in 2014[6]. Transport is thus both a priority for EU decarbonisation strategies, and a highly challenging area in which to achieve this. We have taken the transport sector to include different modes of transport, travel and their provision. Aspects of the transport sector that we have not focused on are SSH research in the

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4   Dings, Jos. 2016. *Transport is now Europe's biggest climate problem - EEA data*. [online] Transport & Environment. June 21. Available at: https://www.transportenvironment.org/press/transport-now-europe%E2%80%99s-biggest-climate-problem-eea-data [Accessed 16 May 2017].

5   European Environment Agency. 2016. *EU greenhouse gas emissions at lowest level since 1990.* [online] European Environment Agency. June 21. Available at: https://www.eea.europa.eu/highlights/eu-greenhouse-gas-emissions-at [Accessed 16 May 2017].

6   European Commission Climate Action. 2017. *A European Strategy for low-emission mobility*. [online] European Commission Climate Action. May 12. Available at: https://ec.europa.eu/clima/policies/transport_en [Accessed 24 May 2017].

area of decarbonisation of vehicle production and recycling[7]. As described above, the bibliography is not intended to be comprehensive, but rather aimed at presenting insights into the very wide variety of different questions posed, areas explored, and methods used by SSH scholars working on questions relevant to transport decarbonisation. This bibliography is ultimately be a prompt for further transport decarbonisation reading and, consequently, cross-disciplinary endeavours.

As is typical across SSH, a variety of methods are being used by scholars researching the transport sector, with examples including: media analyses, interviews, participant observation, backcasting, analyses of social media data and data from cellphones, travel diaries, researcher diaries, data from GPS or swiping in at underground stations, video analyses, and surveys. Additionally, many research publications consist of meta-studies (which compare the results of a larger number of studies) based on literature reviews, policy analyses or historical scholarship on past transport transitions. When it comes to topics, rather than approaches, a large volume of research was also found on the car (including electric cars) and on cycling. Similarly, research has addressed commuting and short distance travel, especially short distance urban travel. However less literature was found on rural mobility, long distance travel, decarbonisation of the bus and underground, and especially shipping. Walking has received comparatively far less enquiry than cycling.

Across the span of SSH, researchers frame the problem of transport decarbonisation differently (both from each other, and from more technical disciplines). These framings often point towards different solutions. For instance, they ask: what is the effect of technological, demographic and economic trends on transport emissions?; why do policymakers/scholars focus on certain transport solutions over others?; how do transport modes 'compete'?; how does the meaning of transport change over time?; and why do we travel? To move toward greater decarbonisation of transport, it is vital that these issues are processed and understood.

Methodology

In researching this bibliography, searches were performed for the google scholar highest ranking impact journals across a wide range of social science and humanities disciplines. However, the most relevant literature was ultimately found in transport-specific journals (see Appendix), pointing to a 'silo-isation' of transport in research. In order to achieve a somewhat more balanced gender ratio than from citations alone, first names were noted. Disciplinary diversity was stressed, however many transport-related articles do not identify the discipline of the authors, which proved to be an unexpected challenge. Meta-studies were given some preference over single case studies. Finally, we note that appropriate search terms are highly sensitive to both discipline (e.g. the term 'mobilities' is particularly associated with sociology), and the time period for the research (e.g. 'decarbonisation' is newer than 'emissions'). Whilst walking and cycling are most 'decarbonised', this was not found to be a frequent focus of SSH research into those modes. Instead, walking and cycling interventions are often addressed from a health paradigm. Similarly, large parts of non-economic public transport SSH research focuses on the experience of the public transport. It was therefore decided to include wider issues related to possible mode switch and mode choice. For a more detailed description of the searching methods employed, see Appendix.

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7   See for example Breen, Deborah, 2011. Constellations of mobility and the politics of environment – preliminary considerations of the shipbreaking industry in Bangladesh. *Transfers*, 1 (3), pp. 24-43.

Structure

After a section outlining overviews of the area (section 1), this bibliography is divided into two parts: sections 2-6 concern different transport modes, and sections 7-13 concern themes which cut across modes. Each section starts with a brief introduction to the area, and the papers presented. Within each section, subsections were generally chosen according to the types of questions researchers were seeking to address. The papers are in alphabetical order within subsections. Footnotes are used for sources for which annotations are not included within this bibliography.

1. Overviews of transport decarbonisation

This first section presents a number of literature reviews which provide general introductions to the area, pertain to more than one transport mode, and/or discuss overarching issues in transport decarbonisation. They are written by transport scholars who combine insights from both more technological studies and the social sciences. Many conclude that new technologies alone will not be sufficient to meeting emissions targets. Thus they point to other critical factors including human behaviour, the social organisation of transport, and the role of policymakers.

Bernardino, João; Aggelakakis, Aggelos; Reichenbach, Max; Vieira, João, Boile, Maria; Schippl, Jens; Christidis, Panayotis; Papanikoaou, Anestis; Condeco Melhorado, Ana Margarida; Garcia Herranz and Krail, Michael, 2015. Transport demand evolution in Europe—factors of change, scenarios and challenges. *European Journal of Futures Research*, 3 (1), p. 1-13.
A future analysis of the European transport sector with different scenarios and visions of what a radically altered decarbonised future in transport could look like.

Chapman, Lee, 2007. Transport and climate change: a review. *Journal of Transport Geography*, 15 (5), pp. 354-367.
This very highly cited paper features sections on walking and cycling, shipping, aviation, road freight and car use. In each section Chapman discusses issues and an overview of possible solutions. He advocates behavioural change solutions (e.g. incentivising people to buy more fuel efficient cars) as key, in part since larger infrastructural changes take a very long time.

Goldman, Todd and Gorham, Roger, 2006. Sustainable urban transport: four innovative directions. *Technology in Society*, 28, pp. 261-273.
Goldman and Gorham explore four areas. (1) Developments in new mobility (i.e. bikesharing, carsharing, one fare for all public transport); (2) city logistics; (3) so-called intelligent system management (such as congestion charges which charge cars in cities each day for the congestion they cause); and (4) 'livability', an extension to the concept of walkability (see subsection 2.1. 'Walking and Walkability').

Hickman, Robin and Banister, David, 2004. *Transport, Climate Change and the City*. **London: Routledge.**
In addition to two general chapters and one chapter on backcasting (a technique through which a possible future scenario is imagined and then it is traced back to see what pathways might lead there), this book contains comparative case studies of the urban transport of Delhi (India), Auckland (New Zealand), London (UK), Jinan (China) and Oxfordshire (UK).

Moriarty, Patrick and Honnery, Damon, 2013. Greening passenger transport: A review. *Journal of Cleaner Production*, 54, pp. 14-22.
Moriarty and Honnery's review aims to determine whether energy efficiency and technical solutions alone will be sufficient for climate mitigation; they conclude that they will not, and travel demand will also need to be reduced. However technical solutions to transport decarbonisation are often promoted by special interests, e.g. car companies. Having refuted technical solutions, Moriarty and Honnery consider research into top-down non-technical solutions for passenger transport decarbonisation – including a high carbon tax and reduction of urban sprawl. They reject land use changes based on research by Jeffrey Kenworthy and Christina Inbakaran[8], showing for 13 cities that greater density also equalled greater travel demand. Nonetheless, it would be possible to achieve emissions reductions even with the existing building structures if people moved closer to work. The authors additionally advocate closing more areas of central cities to cars.

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[8]   Kenworthy, Jeffrey and Inkabaran, Christina, 2011. Differences in transport and land use in thirteen comparable Australian, American, Canadian and European cities between 1995/6 to 2005/6 and their implications for more sustainable transport. *Australasian Transport Research Forum 2011 Proceedings. 28 - 30 September 2011, Adelaide, Australia,* [online] Available at: http://atrf.info/papers/2011/2011_Kenworthy_Inbakaran.pdf [Accessed 2 Jun 2017].

Santos, Georgina; Behrendt, Hannah and Teytelboym, Alexander, 2010. Part II: Policy instruments for sustainable road transport. *Research in Transportation Economics*, 28, pp. 46-91.

This report, funded by Shell, is a vast ranging meta-analysis of current research into sustainable road transport. Highly recommended. It concludes that 'soft policies' will not be enough to achieve sustainability. The topics covered include urban transport, long distance transport, freight, road extension and urban shopping. A few highlights:

- Long-distance passenger transport: Electric trains with renewable energy and intercity buses are least polluting. But there is a question over whether adding more trains would shift passengers from cars to train or merely create additional travel demand.
- Urban transport: Re-usable travel cards which are valid for different modes (like London's oyster card) increase bus and underground trips. The London congestion charge led to a public transport use increase of 16%. A common barrier to cycling is the perceived (rather than real) risk. Copenhagen reduces its parking space by 3% annually as an anti-car measure.
- Vehicle occupancy has gone down since the 1970s due to *"decreasing fuel costs, improved vehicle efficiency, smaller families, increased time commitments ... and higher demands for greater privacy, comfort and convenience"* (p. 73).
- Car sharing: *"reduces total personal vehicle miles travelled ...by between 28% and 45% in Europe"* (p. 73).

Schwanen, Tim, 2016. Geographies of transport I: Reinventing a field?. *Progress in Human Geography*, 40 (1), pp. 126-137.

In his review of current transport geography research, Schwanen distinguishes between: a) supply (transport infrastructure provision), b) demand (user behaviour and practices) and c) regulation. Schwanen is sceptical of the current political interest in transport infrastructure as this tends to focus on investment, economic growth and jobs, rather than reducing emissions. Scholars also ignore freight, aviation and maritime transport – where the steepest emissions increases lie. Schwanen criticises policymakers who seem to favour *"individualistic approaches to behaviour change informed by social psychology and behavioural economics"* (p.130), rather than more effective regulation.

Schwanen, Tim; Banister, David and Anable, Jillian 2011. Scientific research about climate change mitigation in transport: A critical review. *Transportation Research Part A*, 45, pp. 993-1006.

This is a review of transport research published in leading transport journals in the 2000s. They find that most research concerns the effect of technology on carbon emissions – biofuels, hydrogen, electrification, fuel efficiency - as this means questions concerning economic growth and emissions can be avoided. Economic instruments, such as fiscal measures and emissions trading schemes are also commonly discussed in the literature. The majority of the literature contains an assumed 'logic of provision' - if you provide technology, people will automatically use it as intended. The focus on attitudes and personal norms emphasises consumer responsibility, erasing policymakers and corporations. Consumer rationality is also presumed – this is problematic as consumers often do not act 'rationally' and do not use technology in the ways predicted. Other topics covered are transport infrastructure provision, land use, telecommuting, changes in attitudes, lifestyles and values and their effect on transport. Research methods employed are mostly quantitative rather than e.g. interview-based.

A. Transport modes

2. Walking

Walking is both arguably emissions-free and, for the walker, cost-free. Nonetheless, walking may be marginalised and taken for granted - if we describe something as 'pedestrian', it is unsophisticated and ultimately not modern enough. Perhaps an unwarranted criticism in the age of Pokemon Go[9] and the mobile phone wayfarer app[10].

Increases in walking certainly contribute to the decarbonisation of transport, but Social Science and Humanities research in the area analyses a wide range of interconnected aspects of walking, not solely emissions. The most common frame of research trying to increase walking is public health (Ogilvie, 2007; Giles-Corti, 2003)[11].

A key concept used in policies and research to increase walking is walkability (De Bourdeaudhiuj et al, 2011; Forsyth, 2015). One important aspect of walkability, which receives a lot of research attention, is safety. Urban planners and policymakers consciously or unconsciously may work to keep roads predominantly for cars – leading to vulnerability of pedestrians (Cuttler and Malone, 2005). There are also issues of safety for women and walking, such as street harassment, which may not be addressed by walkability (Belding and ElSherief, 2015). When women (and minorities) choose the car as a transport mode due to safety concerns this has direct implications for emissions (see also Hiscock et al., (2002) in subsection 5.1. 'Drivers and driving').

Walking as a transport mode has in some areas of our lives steeply declined, in part due to such safety concerns, whether objective or created through media narratives. An example is the way children travel to school. In 1975, only 7% were driven in a car and 55% walked in the UK. By 2012, 26% were chauffeured by their parents and 38% walked[12]. There are however intra-European differences here: in Bosnia and Slovenia 70% of children walk to school, but similar patterns of walking decline as in the UK can be seen in Spain and in the Czech Republic[13]. At the end of this section, research assessing interventions to reverse such changes and increase walking and their relative effectiveness or ineffectiveness, are outlined (Giles-Corti, 2003; a Special Issue of World Transport Policy, 2001; Ogilvie et al., 2007).

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9   Colley, Ashley; Degraen, Donald; Fischman, Benjamin; Häkkilä, Jonna and Kuehl, Kate, *The Geography of Pokémon GO: Beneficial and Problematic Effects on Places and Movement*, *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, [online] Available at: http://www.brenthecht.com/publications/chi17_geographyofpokemongo.pdf [Accessed 23 May 2017].

10   Brown, Barry; Laurier, Eric and McGregor, Moira, 2016. Mediated pedestrian mobility: walking and the map app. *Mobilities, 11(1), pp.117-134.*

11   See also Maibach et al's commentary suggesting such a combined climate change and decarbonisation approach, emphasising marketing campaigns for walking. Maibach, Edward; Steg, Linda and Anable, Jillian, 2009. Promoting physical activity and reducing climate change: Opportunities to replace short car trips with active transportation. *Preventive Medicine, 49(4), pp.326-327.*

12   Easton, Sue and Ferrari, Ed, 2015. Children's travel to school—the interaction of individual, neighbourhood and school factors. *Transport Policy.* 44 (9), p. 10

13   McMinn, David; Row, David; Murtagh, Shemane et al, 2014. Psychosocial factors related to children's active school travel: A comparison of two European regions. *International Journal of Exercise Science*, 7(1), p. 9.

2.1. Walking and walkability

See also section 10. 'Built environment and transport'.

De Bourdeaudhuij, Ilse; Cardon, Greet; Deforche, Benedicte and van Dyck, Delfien, 2011. Do adults like living in high-walkable neighborhoods? Associations of walkability parameters with neighbourhood satisfaction and possible mediators. *Health and Place*, 17, pp. 971-977.

In this survey of Ghent (Belgium), the authors find that walkability is *negatively* correlated with perceptions of the neighbourhood by people who live there: more walkable areas are deemed more polluted, less safe and uglier. The survey highlights that walkability alone is insufficient to fulfil people's demands of a neighbourhood.

Forsyth, Ann. 2015. What is a walkable place? The walkability debate in urban design. *Urban Design International*, 20 (4), pp. 274- 292.

In this article, Forsyth tries to untangle the concept of 'walkability' and how it is used, both in academia and popular discourse. According to Forsyth, walkability includes consideration of: (1) the *means* for walking, for example, barrier-free, with benches, sidewalks, pedestrian crossings, safe, and aesthetically pleasing; and (2) the desired *outcomes* of people walking more: e.g. reduction in emissions, health outcomes, social interactions; but (3) it is also used as shorthand for, '*good urban design*', or slower-paced design focused on humans.

Forsyth, Ann and Southworth, Michael, 2008. Cities Afoot—Pedestrians, Walkability and Urban Design. *Journal of Urban Design*, 13 (1), pp. 1-3.

In her joint editorial to a special issue, Forsyth and Southworth add an additional dimension to the concept of walkability, related to gentrification and class. A walkable place is *"...upscale, leafy, or cosmopolitan. ... pleasant for upper middle-class professionals, who have other choices for getting around. This is the perspective in much popular and architectural commentary. Such places have several of the following dimensions: an area with coffee shops and interesting stores; a mix of housing types including apartments and condominiums; a grid street pattern and full pedestrian infrastructure including pleasant tree-lined or architecturally interesting streets; well-maintained or scenic green spaces with clear pedestrian paths; a lack of litter, graffiti and obviously down-and-out people. Finally, there should be transit or taxis in case interest lapses. This type of walking is not necessarily brisk"* (p. 2).

Middleton, Jennie, 2011. Walking in the city: The geographies of everyday pedestrian practices. *Geography Compass*, 5 (2), pp. 90—105.

Walking is seen as something self-evident, something 'people just do'. Middleton observes that in transport policy walking is commonly (and unhelpfully) lumped together with cycling although they require different infrastructures. She highlights that walking may have a democratising influence through the possibility of contact with strangers (in a way that the car prevents). Nonetheless, she is deeply critical of de Certeau and what she deems the romanticisation of walking. French philosopher de Certeau[14] identifies walking as *"political resistance against the planners and architects 'imposing order' on city spaces"* (p. 93). Middleton cautions that this is not how the average walker experiences the city. In contrast with a whimsical view of walking as slow romantic travel, she cites Bauman[15] as stating that walking is a dangerous practice that only people without cars engage in (especially in the United States).

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14   Certeau, Michel, 1980. *L'invention du quotidian*. Paris: Gallimard.

15   Bauman, Zygmunt, 1994. Desert spectacular. In: Tester, Keith, ed. *The flaneur*. London / New York: Routledge, pp. 148

2.2. Walking and safety

Belding, Elizabeth and ElSherief, Mai, 2015. The Urban Characteristics of Street Harassment: A First Look. Paper presented at *UrbanGIS 2015! International Workshop on Smart Cities and Urban Analytics,* **[online] Available at:** https://pdfs.semanticscholar.org/a1db/708c75c9725ce3d4a46a7bf2a3194c086f4c.pdf **[Accessed 23 May 2017].**
The researchers use data for ca. 8,000 street harassment incidents reported to the *Hollaback* mobile phone app from 2011-2015. Most of these came from London, Berlin, Paris, Rome, San Francisco, Los Angeles, New York, Boston, Toronto, Buenos Aires. The paper then examines the walkability score of the exact location where the street sexual harassment took place, finding that 54% of all street harassment occurred in the 10% most walkable places. There was also a higher percentage of reports in the least walkable areas (lowest 10% score), with fewer bystanders. ElSherief and Belding conclude that walkability alone is not a useful metric to assess what streets should be like.

Cuttler, Sasha, and Malone, Ruth, 2005. Using marginalization theory to examine pedestrian injury. *Advances in Nursing Science,* **28 (3), pp. 278-286.**
Using feminist marginalisation theory[16] Cuttler and Malone show how cars hitting pedestrians are seen as unavoidable and 'accidental', although this is preventable. Pedestrian bodies are thus marginalised as less important than the rights of cars to be the sole user of most roads. Pedestrian injury or death becomes constructed as 'unavoidable' and 'background noise'.

Stratford, Elaine, 2016. Mobilizing a Spatial Politics of Street Skating: Thinking About the Geographies of Generosity. *Annals of the American Association of Geographers*, **106 (2), pp. 350-357.**
Similar to Cuttler and Malone (2005), Stratford shows how skateboarding, although emission free, fast and a possible way to commute, is marked as deviant and marginalised by urban planners who aim to contain it in special parks. Roads, in this construction, are again only for cars.

2.3. Interventions to increase walking

Giles-Corti, Billie and Donovan, Robert, 2003. Relative Influences of Individual, Social Environmental, and Physical Environmental Correlates of Walking. *American Journal of Public Health*, **93 (9), pp. 1583-1589.**
This American study investigates determinants for people walking, from a public health/behavioural psychology perspective. Positively related to walking are dog ownership, many trees in the streets and green spaces, the availability of shops and sidewalks. Walking was negatively correlated to gym and other membership – people seem to drive or take public transport there and see this as enough exercise.

Whitelegg, John (ed.), 2001. Special Issue of World Transport Policy & Practice on Walking. 7 (4) [online] Available at: http://www.eco-logica.co.uk/pdf/wtpp07.4.pdf **[Accessed 23 May 2017].**
This international special issue includes contributions from scholars across transport, architecture and policy studies, as well as those working at various levels of policymaking. It includes articles on policies aimed at increasing walking, walking infrastructure for the elderly, deterrents to walking, marketing to promote walking and case studies on pedestrians in Delhi (India) and Copenhagen (Denmark).

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16   Hall, Joanne; Stevens, Patricia and Meleis, Ibrahim, 1994. Marginalization: A guiding concept for valuing diversity in nursing knowledge development. Advances in Nursing Science, 16 (4), pp.23-41.

3. Cycling

See also subsections 7.3. 'Urban freight', 8.1. 'Early bicycle invention and climate change' and 12.1. 'Social differences'.

Cycling wins bronze - other than staying home and walking, cycling may be the safest bet as a low carbon form of transport. The bicycle was itself invented to address the disastrous effects of a climatic change event on animal-based transport (see Lessing (2003) in subsection 8.1. ' Early bicycle invention and climate change ').

Some of the questions Social Sciences and Humanities researchers have investigated on cycling include: Who cycles and why? Who does not cycle and why? (Heinen et al., 2010) What do people feel when they cycle? When do people switch to cycling from other modes of transport? (Pucher, 2010) Which types of infrastructure do cyclists prefer? (Pucher, 2010) And how do urban planners and governments treat cycling? (Koglin and Rye, 2014; Aldred, 2012).

Cycling as a mode choice has experienced lows and highs and, recently, a renaissance (for earlier periods see also Gaboriau (1991) under 8.1. 'Early bicycle invention and climate change'). The first subsection explores views of cycling and cyclists. To some, it has become an identity – to be a 'cyclist' rather than just a 'person who cycles' (Furness, 2010). For others, especially People of Colour, it may be viewed as not for them (Fishman et al., 2013; and see also Steinbach (2011), under 12.1. 'Social differences'). Cycling as an identity includes a historical account of the *Critical Mass* movement to take back the roads cyclists historically fought so hard for from cars (Furness, 2010; cf. Reid (2014) in 8.1. 'Early bicycle invention and climate change').

Political interest in cycling is increasing. Some associate cycling (once again) with modernity, youth and urban cosmopolitan culture. It also fits right in with desires for more individualised transport. The second subsection highlights a range of pro-cycling policies (Pucher et al., 2010) including consideration of urban planning for cycling (Koglin and Rye, 2014). It also highlights the almost global urban explosion of bikeshare programmes (Fishman et al., 2013) and their somewhat more complex effectiveness in decarbonisation.

The final subsection examines how mode shift to the bicycle from the car and thus transport decarbonisation, could be increased by addressing some downsides of cycling – including vulnerability to bad weather, inability to easily transport goods/children, and physical labour– might be addressed in the future through velomobiles (Cox, 2007), cargo bikes (Riggs, 2016), and lanes for rickshaws/pedicabs (Tiwari, 2014) respectively.

3.1. Cycling and cyclists

Aldred, Rachel, 2012. Governing transport from welfare state to hollow state: The case of cycling in the UK. *Transport Policy*, 23, pp. 95–102.
Aldred examines governmental discourse around cycling and finds that it represents cycling not as 'serious transport', but instead as something for kids or that one does for one's health. Due to neoliberal interpretations of what the state 'is for', it is argued, there is not enough investment in cycling infrastructure. Instead private actors and NGOs are largely in charge of cycling policy – it has been outsourced. Additionally, none of the UK major political parties wish to curb other modes of transport, such as flying.

Heinen, Eva; van Wee, Bert and Maat, Kees, 2010. Commuting by Bicycle: An Overview of the Literature, *Transport Reviews*, 30 (1), pp. 59-96.
Amongst other things, Heinen et al find the following in their literature review: Men cycle work more than women, although women live closer to work. Car ownership decreases cycling. Students, childless people, the unemployed and part-time workers without children are more likely to use a bicycle. In the Netherlands at least, White native Dutch people cycle more. Cyclists are more relaxed after their commute than either drivers or those who use public transport. Cycling is identified as the most dangerous mode of transport by all societal groups – more dangerous than using the car, public transport or walking. People with high

incomes and men see it as safer than women and people with lower incomes. Paying people a small daily sum (€2 or €3) to commute to work would increase cycling.

Furness, Zachary, 2010. *One Less Car: Bicycling and the Politics of Automobility*. Philadelphia: Temple University Press.

Furness charts nothing less than how cycling has become an identity and how political this can be. This includes discussion of cycle activism from the *Critical Mass* monthly protest rides, to feminism and cycling (both historically and today), the 1960s Dutch *Provo* group and their free white bicycles (a non-capitalist precursor of bikeshare schemes today) to early 20th century socialism and discussions whether bicycles were bourgeois or whether workers should use them. Furness also assesses media representations of cyclists as less 'potent' – 40 year old virgins – than virile car drivers.

3.2. Interventions to increase cycling

Fishman, Elliott; Washington, Simon and Haworth, Narelle, 2013. Bike Share: A Synthesis of the Literature. *Transport Reviews*, 33 (2), pp. 148–165.

This review finds that globally, bike share programmes have exploded from 2008 – from 50,000 share bikes in 2007 to 400,000 share bikes globally in 2012, in over 300 bike share programmes. There is however a paucity of data for many of these programmes. The average length of a bike share trip was under 15 minutes – thus mainly replacing walking rather than public transport or a car. A further issue concerning the carbon footprint of bikeshares is rebalancing: the bicycles need to be driven around overnight in order to ensure all docking stations have bikes in the morning. This rebalancing is usually done through petrol-fuelled trucks. One suggestion is to pay people to cycle bikes back rather than drive them overnight. A study of the bike share system in Washington DC found that although 50% of residents are African American, only 2% of bikeshare users were Black. For the London bike share system, it was found that there are fewer docking stations in poorer parts of London, but that adjusted for this, poorer people use the bikes more than the more affluent (without this adjustment, in general figures, the opposite holds true).

Koglin, Till and Rye, Tom, 2014. The marginalisation of bicycling in Modernist urban transport planning. *Journal of Transport & Health*, 1, pp. 214–222.

This paper discusses the role of planning in encouraging (or discouraging) cycling. The authors argue that current urban planning does not sufficiently take cyclists and cycling into account, instead transport models are focused on car and rail. They develop a *"new theory for bicycle planning, the politics of vélomobility"* (p. 214), based on Creswell's 'Politics of Mobility'[17], in order to counter the urban planner's exclusive car paradigm. Thus they advocate:

"1. ...infrastructure for bicycling without obstacles and the creation of free and safe flow for cyclists.
2. ...the consideration of power relations between the different [road user] groups ... and creating spaces where cycling is not marginalised.
3. Positive representations of bicycling ... targeted to different groups of people ...a shared meaning of bicycling...
4. Everyday practice and the experience of cycling [taken into account]" (p. 221).

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17   Cresswell, Tim., 2010. Towards a politics of mobility. *Environment and planning D: society and space*, 28 (1), pp.17–31.

Pucher, John; Dill, Jennifer and Handy, Susan, 2010. Infrastructure, programs, and policies to increase bicycling: An international review. *Preventive Medicine*, 50, pp.106–125.

Pucher et al analyse 139 studies (in English) since 1990 on the effects of bicycle policy interventions, and 14 city case studies. They only, however, included studies with quantifiable results. Both revealed preference (measured through e.g. reported *behaviour*, or GPS) and stated preference (asking what forms of transport are favoured) studies were included. Stated preferences are seen as less reliable but may be used if a certain policy has not been enacted yet, thus real usage cannot be measured.

Results included: (1) Educational campaigns had no effect, infrastructure did; (2) Cyclists prefer paths which are more separate from motoring than on-road bike lanes; (3) Traffic signs that go green first for cyclists and only later for cars had a large safety impact. Car-free zones in city centres and speed limits increase cycling; (4) Cycle parking has a strong positive effect. Allowing bicycles on trains also increases cycling, but currently provision is far lower than demand; (5) Bike share programmes had stronger shift from public transport to bike than from driving to bike; (6) Strong effect of contract programmes - a free bike and free bus tickets for a year; (7) Helmet laws decrease cycling; (8) Barcelona was the most successful case study: cycling doubled in only two years.

3.3. What's next for cycling? Velomobiles, cargo bikes, rickshaws.

Cox, Peter and van de Walle, Frederick, 2007. Bicycles don't evolve: velomobiles and the modelling of transport technologies. In: Horton, Dave; Rosen, Paul and Peter Cox, eds. *Cycling and Society*. **Aldershot: Ashgate, pp. 113–133.**

Cox and van de Walle argue for a de-marginalisation of the velomobile, a covered bicycle, in this critique of conventional cycle scholarship. This is identified as usually portraying the bicycle as 'final', mostly unchanged since the 1890s, and following a strictly linear technological evolution. This linearity also implicitly highlights the bicycle as obsolete and anachronistic as the car superseded it. In contrast to this framing, new velomobiles make cycling in heavy rain easier.

Riggs, William, 2016. Cargo bikes as a growth area for bicycle vs. auto trips: exploring the potential for mode substitution behaviour. *Transportation Research Part F: Traffic Psychology and Behaviour*, 43, pp. 48–55.

Riggs finds, through use of a survey, that families with cargo bikes (bicycles with large boxes or trailers for carrying goods or children) - who were all White, wealthy, had children and owned several cars - reduced their short distance car trips after the purchase of cargo bikes by 1 or 2 trips *daily*. This was specifically due to the goods/people carrying functionality of the car – with a cargo bike this could be substituted in good weather.

Tiwari, Geetam, 2014. The role of cycle rickshaws in urban transport: Today and tomorrow. *Transfers: An Interdisciplinary Journal of Mobility Studies*, 4 (1), pp. 83–96.

Cycle rickshaws are one of the most important transport modes in India, Bangladesh and Pakistan. Cycle rickshaws represent 13% of all trips taken by the 17 million people in Bangladesh's capital Dhaka. Due to India's huge population of 1.3 billion, rickshaws have an important role to play in global decarbonisation (and/or prevention of increased carbon emissions). Nonetheless, the Indian government is moving to outlaw rickshaws in inner cities (as is already the case in Delhi) and shift them to batteries, asserting the physical labour required is dehumanising and rickshaws contribute to higher carbon emissions by cars due to congestion. Tiwari convincingly refutes this – advocating specific rickshaw lanes instead. If rickshaw trips were to shift to cars, or even motorised two wheelers, emissions and congestion would go up substantially.

4. Public transport: bus and rail

See also subsection 10.2. 'Transport infrastructure: roads, parking and other places'.

What do durian fruit have to do with Social Science and Humanities perspectives on transport decarbonisation? On public transport in Singapore, durian fruit are forbidden due to their smell being deemed a nuisance to other passengers[18]. The experience of public transport, including interactions between passengers, is a major area of Social Science exploration, and the topic of the first subsection here. One school of thought is that this helps determine whether passengers choose public transport or switch to more 'solitary' and potentially energy intensive modes. Subway and bus ethnography (observation of people in situ) has played a major role in exploring these experiences in depth (Augé, 1986). The ability to work, read and use smartphones can make public transport more attractive than a car commute (Lyons et al., 2008). Recently, the decarbonisation effects of people moving away from car travel ('Peak Car', see subsection 5.3. 'What's next for personal transport?') have been assessed in this light: many social scientists theorise youth to eschew the car since as 'digital natives' they do not wish to remain offline for the length of a car ride.

In exploring ways to increase public transport use, some researchers have attempted to identify the key factors in provision which may affect uptake, as outlined in the second subsection. Clayton et al. (2016), Guiver (2007), Joireman et al. (2004), Currie and Wallis (2008) and Hodgson et al. (2013) all assess why people choose to take public transport and how to make public transport more attractive. Some cities have introduced free public transport although – since demand increases significantly – there are questions over the decarbonisation effects of this strategy (Fearnley, 2013). Relatedly, Schwanen (2016) - in section 1. 'Overviews of transport decarbonisation' - examines policymakers' preference for high speed rail projects due to economic and prestige concerns and critiques this in light of a decarbonisation paradigm, since economic growth increases carbon emissions.

The final subsection highlights work discussing the changing nature of public transport, and our relationship with it. The effect of an alienation from nature and de-localisation (with accompanying hypermobility and resource use) through rail travel was first theorised by Schivelbusch (1977). Newman et al. (2013) provide a general overview of the rise of light rail in developed and emerging economies in the last decades, a development which took place at the same time as 'Peak Car'.

When researching the literature for this section on public transport, less work was found exploring to what extent mode switching to light rail (tram, underground/subway) and bus takes place from walking and cycling rather than the car. Long distance bus travel and the energy fuelling public transport appear to also be under-researched.

4.1. How people use and experience public transport

Augé, Marc, 1986. *Un ethnologue dans le métro*. Paris: Hachette.
In this highly influential – and relatively short – book, anthropologist Augé describes his ethnographic study of the Parisian metro. He weaves personal narrative together with observation of the diverse and multi-cultural nature of modern Paris, and the conventions, rites and institutions which can be seen through Parisians' everyday use of the metro. He uses this case to illustrate some of contemporary anthropology's wider themes.

Guiver, Josephine, 2007. Modal talk: discourse analysis of how people talk about bus and car travel. *Transportation Research Part A: Policy and Practice*, 41 (3), pp. 233–248.
This paper uses 'discourse analysis' to investigate how people talk about bus and car travel. It was found that bus travel was often talked about in an 'episodic' way (rather than car travel as a more consistent experience), and that particularly bad experiences of bus travel were focused on. Car travel was portrayed as a safer space. Both modes were also seen differently when viewed from the 'inside' (as a user) vs.

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18   Gasik, Lindsay, 2014. Illegal Durians: How Much Trouble Will You Really Get In?. *The Year of the Durian*, [online] October 29. Available at: http://www.yearofthedurian.com/2014/10/Illegal-durians-how-much-trouble-wi.html [Accessed 23 May 2017].

the 'outside' (others using it). The paper begins with a discussion of the reliance of transport research on quantifiable (cause and effect) models, and highlights how qualitative research may offer additional insights. In this case, these insights concern how *different* travel modes may be evaluated against *different* criteria by users, and the inconsistencies and ambiguities in these evaluations. Discourse analysis not only pays attention to the words used, but also *how* they are said, turn-taking in conversations, and so forth.

Guo, Zhan, 2011. Mind the map! The impact of transit maps on path choice in public transit. *Transportation Research Part A*, **45, pp. 625–639.**

Train, underground or bus maps can misrepresent actual physical geography through e.g. showing stations further or closer than they actually are, or in the wrong direction. For the London tube map, the walking distance between some stations is only four minutes, while others shown exactly as far apart are 76 minutes apart[19]. This article uses a large volume of data from trips taken on the London underground to quantitatively analyse the paths chosen by travellers, and how these compare to both appearance on the tube map, and alternative (potentially shorter) paths. Guo finds that even extremely experienced tube users choose the path that looks closer on the map rather than the one they should know from experience to be faster. It is on the map, therefore it is true.

Joireman, Jeffrey; van Lange, Paul and van Vugt, Mark, 2004. Who cares about the environmental impact of cars? Those with an eye toward the future. *Environment and Behavior*, **36 (2), pp.187–206.**

Psychological research testing the validity of the commuting 'social dilemma' hypothesis. This classic argument states that people who commute have to decide between 'selfish' (car personal preference) behaviour and 'social' (public transport is better collectively due to climate change) actions. The present article finds after testing this that pro-social attitudes only correlate with commuting by public transport if the individual additionally is worried about the future.

Lyons, Glenn; Holley, David and Jain, Juliet, 2008. The business of travel time: a matter of time use. In: Hislop, Donald, ed. *Mobility and Technology in the Workplace*. **London: Routledge, pp. 74–87.**

Prompted by the authors' own experiences of train travel, this ethnographic study examines how the train has increasingly become an area of work for many. They explore, through interviews and observation, how commuters may create 'offices' for themselves, and reflect on the changing nature of work and leisure which is linked to these changing practices. While conventional wisdom holds that travel time is a 'negative' that people wish to reduce and make as speedy as possible, the authors highlight that this is to be challenged when it comes to people being able to work on their mode of transport.

Newman, Peter; Kenworthy, Jeffrey and Glazebrook, Garry, 2013. Peak car use and the rise of global rail: why this is happening and what it means for large and small cities. *Journal of Transportation Technologies*, **3, pp. 272–287.**

The authors chart the rise of (light) rail, with an interest in what this means for traditionally car-dependent cities. In the decade from 1995 to 2005, *"total rail seat km per person"* increased by around a third in Europe, the USA, Singapore and Hong Kong. The authors link this light rail boom to 'Peak Car' – see also subsection 5.2. 'Interventions in car use' of this bibliography. Among those aged 16-34, car usage fell by one fourth in the 2000s in the USA, with light rail doubling, walking going up by 37% and biking by 122%. In the 1960s, cars were faster than light rail in inner cities – this has now dramatically reversed.

Schivelbusch, Wolfgang, 2014. *The Railway Journey: The Industrialization of Time and Space in the 19th Century.* **Oakland: University of California Press.**

Originally published in 1977, this is a classic on the history of the railway. One of Schivelbusch's most important insights, in the context of this bibliography on transport decarbonisation, is his emphasis that the train for the first time truly made passing through an environment, mastering the environment (including all fauna and flora) possible without having any contact with it. It thus estranged humans from nature in a way no mode of transport had done before.

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19   Harris, Sarah Ann, 2015. Tube Map Reveals Walking Distances Between Different London Underground Stations, *Huffington Post*, 10 November, [online] Available at: http://www.huffingtonpost.co.uk/2015/11/10/tube-walking-map-london-underground-official-times_n_8524402.html [Accessed 17 May 2017].

4.2. Interventions to increase public transport

Clayton, William; Jain, Juliet and Parkhurst, Graham, 2016. An ideal journey: making bus travel desirable. *Mobilities*, **pp. 1–20.**

How might bus travel be made more attractive, in particular as an alternative to the dominance of car travel? Through online discussions, focus groups, and a quantitative survey of 840 bus travellers, the authors of this paper explore the activities undertaken during bus trips such as reading, listening to music, and online activity. The possibility to undertake these relaxation-focused activities is seen by the authors as a possible route to 'selling' bus travel as a more desirable transport mode. However they also caution that these advantages can be easily offset (in passengers' eyes) by shortcomings such as poor punctuality.

Currie, Graham, and Wallis, Ian, 2008. Effective ways to grow urban bus markets—a synthesis of evidence. *Journal of Transport Geography*, **16 (6), pp. 419–429.**

A review of (primarily quantitative) studies concerned with how improvements in bus provision across Australia, the UK, and Europe more widely, have affected numbers of bus travellers. 'Elasticity' ratios quantify how changes in: frequency and reliability (most important), fares, or speed of journey (least important) impact upon demand. The paper also includes data from a 'Delphi' expert review where initial findings from international bus experts were then fed back to that same group for review. This process identified cities seen as 'best practice' cases by these experts (including in Brazil, Canada and Australia), as well as highlighting an additional expert focus on aspects such as branding and marketing.

Fearnley, Nils, 2013. Free fares policies: impact on public transport mode share and other transport policy goals. *International Journal of Transportation*, **1 (1), pp. 75–90.**

Although this paper, which explores the provision of free public transport, is not solely about the bus, that is the primary mode explicitly cited. A number of free public transport schemes are described, with a focus on European examples, before an attempt to synthesis work (from both academic and non-academic sources) which has looked at the impacts of these schemes. Whilst (many) more people will use public transport if it is freely provided, this brings impacts on e.g. time spent at stops, crowding on services and vandalism. However, unexpected benefits have included traffic safety. The author concludes however that the primary effect of free provision is simply large passenger number growth, and other goals (including mode shifting or carbon reduction) may not be met.

Hodgson, Paul; Potter, Stephen; Warren, James and Gillingwater, David, 2013. Can bus really be the new tram?. *Research in Transportation Economics*, **39 (1), pp. 158–166.**

Whilst some countries (France, for example) have seen a renaissance in the tram, in the UK some projects have been abandoned (Liverpool, Leeds). People often have more positive attitudes towards trams than buses and are more willing to trade the car for a tram rather than a bus, yet municipalities may prefer buses as these are cheaper to install. The article therefore focusses on so-called 'Bus Rapid Transit' (BRT) – guided busways and trolley buses – which can combine advantages of both. The article calculates the financial cost of tram vs BRT systems, together with their environmental impact. BRT costs are estimated at two thirds that of a tram system, less than is usually claimed, with similar operational costs between the two. Tram (light rail) has a higher CO_2 emission per vehicle, but lower emissions for the entire fleet.

5. Personal fuelled transport: the car, motorbikes and mopeds

As a dominant transport mode, we note first that there is a huge volume of Social Science and Humanities perspectives on personal transport, and the car in particular.

An early 2000s climate change campaign addressing Christians asked *"What would Jesus drive?"* [20]. The campaign did not consider that Jesus might not drive at all and instead use more communal modes of transport. One school of thought in transport scholarship asserts that cars and motorbikes relate to modern individualisation and notions of freedom, both of which avoid interaction with strangers (Hiscock et al, 2002). The first subsection therefore covers questions of why we drive, but also the practice of driving and how this is embedded in wider social infrastructure (Mattioli et al., 2016). This includes research on the role of habits in transport (Schwanen et al., 2012) and how the car is constructed as making the driver powerful and dominating nature (Dalby and Paterson, 2006).

The second subsection explores a range of different intervention types in car use. These include the use of information campaigns on the environmental impact of cars, as well as rationing (Tertoolen et al., 1998; Eskeland and Feyzioglu, 1997). Other articles ask if carsharing can be a first step towards decarbonisation (Dowling and Kent, 2013), or if marketing is required to make the car less glamourous (Wright and Egan, 2000).

The share of young people with driving licences is in fact lower than that of preceding generations at the same age, for most developed countries. (But note that at the same time, the babyboomer generation drive cars much longer than previous generations (cf. Sirén et al. (2010) in subsection 12.1. 'Social differences'). A subsequent subsection focusses on the related so-called 'Peak Car' debate (Kuhnimhof et al., 2012; McDonald, 2015), with different scholars ascribing to differing theories regarding the cause of this phenomenon. In another move away from the car, this subsection also addresses the increase in the Western world of motorised two wheelers (Austin et al, 2010 and Kopp, 2011). While motorcycles emit less than conventional cars [21], some questions remain over their role in reducing carbon emissions (see Percoco (2014) in subsection 10.2. 'Transport infrastructure: roads, parking and other places'), especially since the mode shift here may be from public transport rather than replacing the car. In large parts of the world, two wheelers have long been the dominant mode of transport (Howarth, 2012).

This section would not be complete without explorations of possible 'revolutions' in this sector, most notably an uptake of electric cars, but also the possibility of self-driving vehicles (Wadud et al., 2016). The (wide) range of literature on electric cars examines different theories on why consumers adopt (or fail to adopt) electric cars (Bodin et al, 2015), contrasts this with what policymakers *think* electric car users want (Ryghaug and Toftaker, 2016), as well as looking at the profiles of electric car drivers (Klöckner et al., 2013). Sovacool and Hirsh (2009) and Wentland (2016) more specifically explore vehicle to grid (V2G) issues – while Sovacool and Hirsh assess which societal barriers exist to V2G, Wentland investigates the future imaginaries of V2G. Kahn (2007) assesses what driving an electric vehicle with modest emissions savings may have to do with 'keeping up with the Joneses'.

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20   Evangelical Environmental Network. *What would Jesus drive*.
Campaign poster here: http://adage.com/images/random/jesus_ad.gif Burkeman, Oliver, 2002. 'What would Jesus drive?' gas-guzzling Americans are asked. *The Guardian* [online] 14 November. Available at: https://www.theguardian.com/world/2002/nov/14/usa.oliverburkeman [Accessed 23 May 2017].

21   Vasic, Ana-Marija. and Weilenmann, Martin, 2006. Comparison of real-world emissions from two-wheelers and passenger cars. *Environmental Science & Technology, 40 (1), pp.149-154.*

5.1. Drivers and driving

Dalby, Simon and Paterson, Matthew, 2006. Empire's ecological tyreprints, *Environmental Politics*, **15 (1), pp. 1–22.**
Dalby and Paterson provide an interesting analysis of car (especially 4x4) advertisement narratives. The advertisements link cars with mastering nature – dominating the world. The advertisements refer back to the military origin of specific car technology and in this form increase the idea that a car makes the driver powerful. This mastery of nature links directly with what the authors term 'carboniferous capitalism'.

Hiscock, Rosemary; Macintyre, Sally; Kearns, Ade and Ellaway, Anne, 2002. Means of transport and ontological security: Do cars provide psycho-social benefits to their users?, *Transportation Research Part D*, **7 (2), pp. 119–135.**
In the interviews in Glasgow that this study is based on, cars were seen as safer since there are no other passengers who could be violent. Cars were also seen as more comfortable from a weather perspective - bus stops do not give any protection against rain or wind most of the time.

Lucas, Karen and Schwanen, Tim, 2011. Understanding Auto Motives. In Lucas, Karen; Blumenberg, Evelyn and Weinberger, Rachel, eds. *Auto Motives: Understanding Car Use Behaviours*. **Bradford: Emerald, pp. 3–39.**
This chapter tries nothing less than to answer the question of why people drive. Factors assessed include personal values, location and provision of services, land use, culture and price. Reasons for car use include accessibility, its greater speed outside of cities and the flexibility it provides, especially concerning time.

Mattioli, Giulio; Anable, Jillian and Vrotsou, Katerina, 2016. Car dependent practices: Findings from a sequence pattern mining study of UK time use data. *Transportation Research Part A: Policy and Practice*, **89, pp. 56–72.**
The article identifies 'car dependent practices' – such as taking items to the dump – to highlight the inadequacies in transport research that focuses solely on the attributes of *individuals* in order to explain car dependence. In focusing on car dependent *activities* instead this study provides evidence for the importance of the 'cargo function' of car travel (being able to transport stuff), which needs to be addressed in making transport more sustainable.

5.2. Interventions in car use

Abraham, Charles; Graham-Rowe, Ella; Skippon, Stephen and Gardner, Benjamin, 2011. Can we reduce car use and, if so, how? A review of available evidence. *Transportation Research Part A*, **45, pp. 401–418.**
The research project, financed by Shell, reviewed 77 studies of car-use reduction interventions. They assessed their methodological quality and found it to be very weak, in terms of statistical good practice. Only 12 of the 77 studies (16%) had a high quality methodology (including being representative). Most of these 12 interventions studied were not effective in reducing car travel. One exception concerned providing information on alternatives. This helped for participants with strong driving habits.

Behrendt, Hannah; Maconi, Laura; Santos, Georgina; Shirvani, Tara and Teytelboym, Alexander, 2010. Externalities and economic policies in road transport. *Research in Transportation Economics*, **28, pp. 2–45.**
This work, funded by Shell, discusses impacts of road transport and two types of government responses to this: (1) incentive-based responses and (2) regulations. The 'externalities' of the title refer to road transport impacts such as: accidents, biodiversity and landscape loss due to road building, pollution, congestion and oil dependence. (Notably, climate change is not one of the externalities considered by the authors.) Incentive-based responses include price controls (taxes, subsidies) and quantity controls (emissions trading schemes). Incentive-based policies may fail to reach the intended result (example: emissions trading). Regulations include outlawing something (lead in petrol), fuel standards and vehicle standards.

Eskeland, Gunnar and Feyzioglu, Tarhan, 1997. Rationing can backfire: the 'day without a car' in Mexico City. *The World Bank Economic Review*, 11 (3), pp. 383–408.

Eskeland and Feyzioglu assess the licence plate driving ban of 1989 in Mexico City. The ban limited driving to certain licence plate numbers. While the ban was generally seen to be enforced, driving and emissions still increased rather than decreased since wealthier people bought a second or third car to circumvent the ban. Traditionally, Mexico City was a car exporter, but now had to import cars due to increased demand. People started using older cars more (additional licence plates), which had a lower fuel economy.

Innocenti, Alessandro; Lattarulo, Patrizia and Pazienza, Maria Grazia, 2013. Car stickiness: Heuristics and biases in travel choice. *Transport Policy*, 25, pp. 158–168.

The prevalent rational behaviour model employed in transport policy and research often assumes that travellers' decisions are not impacted by cognitive biases and that they have complete information. Transport policy interventions favour providing passengers real-time information through apps, for example. Recalling previous research which found that passengers process new information on transport better when they *"lack long-term experience on travel time distribution"* (p. 159), the authors caution that this means paradoxically travel apps may be inefficient at best or even counterproductive. The fact that travel choice is often repeated daily reinforces cognitive bias. Through a lab-based psychological experiment on choosing the car or the subway, the authors confirm the role of cognitive biases, including habit, in decision making. In the experiment, participants were given information on cost and time involved in travel.

Kent, Jennifer and Dowling, Robyn, 2013. Puncturing automobility? Carsharing practices. *Journal of Transport Geography*, 23, pp. 86–92.

Kent and Dowling turn to carsharing as one possible answer to the question how car use can be reduced. Evidence for this argument includes: carsharing cars are often smaller than average cars, more fuel efficient, hybrid or electric; carsharers either never own a car or delay car ownership; they do not use cars for regular trips (such as commute), but only for special occasions. All of this distances carsharers from the car as status symbol and identity giver. Carsharing is most common in higher density cities with a dense public transport network. It does however require car parking to be available. Cars are prebooked online, unlocked with a smartcard or phone, and can be remotely disabled. All of this, the authors argue, makes carsharing feel 'progressive' and 'futuristic', which may make it more attractive to younger generations. Carsharers often need a specific life event to get converted to carsharing such as moving or a divorce with one partner keeping the car. Arguments potentially *against* carsharing include that most of the knowledge required, the actual actions, are still of course related to driving a car.

Schwanen, Tim; Banister, David and Anable, Jillian, 2012. Rethinking habits and their role in behaviour change: the case of low-carbon mobility. *Journal of Transport Geography*, 24, pp. 522–532.

The authors mostly reject the notion that information campaigns can be effective for transport decarbonisation. They argue that habits are automatically triggered and largely ignored in transport policy interventions and research, but need to be disrupted for behaviour change to occur. Interventions here may be more effective when there is already a life change (move to new town, baby born etc). Research has also overly focused on transport mode choice rather than destination or travel distance, which also matter for decarbonisation. The authors argue for a shift away from the individual consumer towards other stakeholders - the transport lobby, the retail lobby, politicians, the media. The cultural meaning of the car as embodying 'freedom' may need to change and 'unfreedoms' highlighted.

Wright, Chris and Egan, John, 2000. De-marketing the car. *Transport Policy*, 7, pp. 287–294.

The authors advocate 'de-marketing' the car. Three types of de-marketing are outlined: (1) negative marketing (direct attack against); (2) demand restraint (example: campaigns to stop people from going to the GP for extremely minor illnesses); and (3) indirect conservation. Wright and Egan caution that improved public transport often leads people to give up the bicycle or stop walking rather than working for car users. Wright and Egan suggest discouraging short distance car use with messages such as *"Real men cycle"*, *"Walk and live longer"*, *"Do not let your child get overweight - walk to school"*, *"When you drive, you risk killing your child"*, *"You will not be able to park when you get there"*.

5.3. What's next for personal transport?

Austin, Mark; Gagné, Patricia and Orend, Angela, 2010. Commodification and popular imagery of the biker in American culture. *The Journal of Popular Culture*, 43 (5), pp. 942–963.

Austin et al argue that motorbikes as a cultural commodity have led to an increase of sales in the new millennium. Motorbikes are being 'gentrified', as new users with different backgrounds adopt them. The article addresses relations between the 'old' previous bikers and the 'new'.

Howarth, Narelle, 2012. Powered two wheelers in a changing world: challenges and opportunities. *Accident Analysis and Prevention*, 44, pp. 12–18.

Narelle Howarth charts the recent increase of motorbikes and mopeds worldwide. 4 of the 10 countries with the most mopeds and motorbikes per capita are in Europe: Greece (#2 worldwide after Malaysia), Italy at #5 (#3 is Thailand, #4 Cambodia), Switzerland at #8 and Latvia at #10. The fleet of mopeds and motorbikes in China rose from 20 million in 1995 to 100 million in 2006. During the same time period, ownership of motorbikes and mopeds doubled in India, tripled in Indonesia, increased by 60% in Australia and 75% in the United States. The percentage of women riding motorbikes and scooters increased fivefold in the United States in 15 years (1990–2005), albeit from a low base (women now 10%). The motorbikes and mopeds bought are much more powerful (more energy use) than those bought before. (Example: Japan from 13% of sales over 250 cc in 1978 to ca. 60% in 2006.) Death rate is 30 times that of car users.

Kopp, Pierre, 2011. The unpredicted rise of motorcycles: A cost benefit analysis. *Transport Policy*, 18, pp. 613–622.

The author explores the rise of motorised two wheelers (mopeds and motorcycles, not electric bicycles) in Paris, and reasons for this mode choice through interviews with motorcyclists. The number of vehicle kilometres driven by two wheelers in Paris increased by 36% from 2000–2007 according to governmental data. Kopp's own counts in 2009 found two wheelers' road share to be 17% compared to only 0.1% for bicycles (64% for private cars). From the interviews, over 90% of the two wheelers were used for commuting, and almost 60% of motorcyclists do not own a car. Around half of the kilometres driven due to this increase in two wheelers were a switch from public transport. Kopp however offers limited energy or carbon insights, as this is not the focus of the piece.

Kuhnimhof, Tobias; Armoogum, Jimmy; Buehler, Ralph; Dargay, Joyce; Denstadli, Jon Martin and Yamamoto, Toshiyuki, 2012. Men shape a downward trend in car use among young adults – evidence from six industrialized countries. *Transport Reviews*, 32 (6), pp. 761–779.

A study using data from 20 national travel surveys and driving licence data from the mid-1970s to 2010s on young adult car availability and car travel in Germany, France, Norway, Japan and USA. Kuhnimhof et al find that both driving licences and car ownership have declined in this age cohort and that this decline is much more pronounced for men. Importantly, per capita car use of elderly travellers is increasing. Reasons behind 'Peak Car' appear to differ from country to country: USA – economic crisis, higher fuel prices than previously. Norway and Sweden – urbanisation of youth. Great Britain – greater youth urbanisation, more students, lower overall incomes among young adults. Germany – more students. Gender disparity confirmed for UK, Germany, Sweden, USA where male car use dropped more (albeit from higher levels). Germany was the only country were young men especially switched their travel to bicycles or public transport, and German women's non-car travel increased. This meant that in Germany, travel mileage stayed the same. For all other countries the daily travel decreased. 'Peak Travel' has been coined for stabilisation, stagnation or decrease of daily travel[22].

McDonald, Noreen, 2015. Are Millennials Really the 'Go-Nowhere' Generation?. *Journal of the American Planning Association*, 81 (2), pp. 90–103.

Good overview of the 'Peak Car' debate and two key scholarly theorems. Overview on all industrialised countries, but more detail on the USA. Millennials (those born after 1980) possess fewer driving licences, and/or drive less, than their predecessors in all industrialised countries. There are two scholarly theories

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22   Millard-Ball, Adam and Schipper, Lee, 2011. Are we reaching peak travel? Trends in passenger transport in eight industrialized countries. *Transport Reviews*, 31 (3), pp.357–378.

as to why that is: (1) millennials prefer living in cities with good public transport and walkable shops, or live large segments of their lives online; or (2) millennials have not been able to afford cars, due to the economy, and have postponed parenthood. McDonald weighs in on this debate for the United States and finds *"little evidence of increased sustainable transport modes"* (p. 90). This means that millennials in the United States travel less. A Dutch government report has suggested: *"not car-less, but car-later"*[23].

Tertoolen, Gerard; van Kreveld, Dik and Ben Verstraten, 1998. Psychological resistance against attempts to reduce private car use. *Transportation Research***, 32 (3), pp. 171–181.**
In their study on information campaigns emphasising the environmental and financial cost of car travel, the authors found a mismatch between environmentalism (attitudes) and behaviour. They furthermore warn of the danger of reactance – a psychological phenomenon whereby efforts to reduce or restrain behaviours (e.g. smoking, drugs, cars) can lead to an increased desire of precisely these behaviours. This explains why some information campaigns emphasising the negative effects of car use may result in an increase rather than a drop in driving. *"Those respondents who were relatively environmentally aware before they were exposed to the [information campaign] ... and who used their car more than they had anticipated, showed a reduction in their environmental awareness. ...financial information weakens the effect of environmental information... By showing people how expensive car driving is, the environmental policy is seen to be (partly) responsible for the high expenses"* (p. 180).

Wadud, Zia, MacKenzie, Don and Leiby, Paul, 2016. Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles. *Transportation Research Part A: Policy and Practice***, 86, pp.1–18.**
In this paper, the authors identify key possible energy consumption effects of automated (self-driving) vehicles. Automated vehicles could increase car use and/or emissions through: (1) affording greater comfort and the ability to work in the car; (2) recruiting new car users (e.g. people with disabilities, the elderly); and (3) generating additional demand due to time savings; (4) an increase in highway speeds, due to the increased safety and less congestion. In contrast, technological factors through which automated vehicles are assumed to decrease fossil fuel energy use include that: (1) fully automated electric vehicles could recharge with little time costs for the driver; (2) due to increased safety, automated vehicles could be more lightweight and thus need less material; and (3) they could also have less powerful engines and be smaller. In addition, a number of issues could decrease energy per individual trip, but *could* have systemic effects that increase overall energy use (rebound issues): (1) due to fuel efficient driving, the cost of driving will go down, which will however increase travel demand; and (2) carsharing models could decrease car ownership/journeys, but the fuel needed to have the car drive itself back can be as high. The authors argue that ultimately high levels of automation are likely to *decrease* energy saving potential.

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23   Dutch Ministry of Infrastructure and the Environment, 2014. *Not car-less, but car-later*. The Hague, The Netherlands: Ministry of Infrastructure and the Environment, [online] Available at: https://english.kimnet.nl/publications/reports/2014/06/10/not-carless-but-car-later [Accessed 23 May 2017]

5.4. Electric vehicles

Bodin, Jan; Rezvani, Zeinab and Jansson, Johan, 2015. Advances in consumer electric vehicle adoption research: A review and research agenda, *Transportation Research Part D*, **34, pp. 122–136.**

In their literature review, the authors examine research from 2007–2014 on barriers or drivers to consumer adoption of electric vehicles. They find five theoretical frameworks employed in existing research, all focused on psychology:

1. Theory of planned behaviour & rational choice theory – assumes that consumers act rationally, with the information available to them, examine costs and benefits and then choose a vehicle.
2. Environmental attitudes – electric car users do this due to their environmental conscience. Their actions are driven by personal values.
3. Symbols, self-identity and lifestyle – car users choose the car which most closely models the message they wish to give to others on what type of person they are.
4. Consumer innovativeness – electric car users are pioneers. They like the novelty and gadgets. They like feeling at the forefront of technological innovation.
5. Emotions – car users will choose the car that makes them happy.

A bias in existing literature is identified by the authors towards focussing mainly on early adopters of electric cars and people already considering a purchase.

Calef, David and Goble, Robert, 2007. The allure of technology: How France and California promoted electric and hybrid vehicles to reduce urban air pollution. *Policy Sciences*, **40 (1), pp.1–34.**

This article compares and contrasts governmental support for, and lobby reactions to, the 1990s electric vehicle programs in France and California. The California *Zero Emissions Vehicle* (ZEV) law was ambitious and mandated car companies to produce electric vehicles. It was ultimately unsuccessful, and this article extensively details the multimillion dollar car and oil lobby and astroturf activities (meaning the setup of fake 'grassroots' organisations that are paid by corporations). The authors identify the attempt of stringent legislation in California as an exception to general American 'policy styles', which are not based on strong legislation. In France, the electric car fleet target was not reached by a wide margin, yet around the year 2000 France was still the country with the highest number of electric cars, most of which run on nuclear-generated energy. This car fleet was almost entirely purchased for state agencies in public procurement programmes, which also achieved limited resistance from lobby actors. Instead, Renault and Peugeot were involved in the design of the programme and worked with the government.

Kahn, Matthew, 2007. Do greens drive Hummers or hybrids? Environmental ideology as a determinant of consumer choice. *Journal of Environmental Economics and Management*, **54 (2), pp. 129–145.**

Kahn analyses the cars that Californians who identify as environmentalists drive (using Green Party supporting districts as a proxy for environmentalism). He finds that overall, environmentally conscious neighbourhoods indeed feature less polluting vehicles. Of particular note is the Toyota Prius effect – this car is preferred by environmentally conscious people in the USA in comparison to other 'greener' cars. The actual fuel savings are modest; yet Kahn argues due to marketing it communicates one's environmentalism more clearly than other greener vehicles.

Klöckner, Christian; Nayum, Alim and Mehmet Mehmetoglu, 2013. Positive and negative spillover effects from electric car purchase to car use. *Transportation Research Part D*, **21, pp.32–38.**

In September 2012, 5.2% of all new cars sold in Norway were electric cars. This article is based on questionnaires with petrol fuel and electric car buyers. Electric car owners were better educated, younger, and more likely to be employed, in a relationship and have children, than owners of petrol cars. Electric cars were usually purchased (in over 90% of all cases) as 2nd or 3rd cars. In contrast, 50% of fuel car owners had only that one car. For electric car users, their use of the car as a transport mode increased, but the electric car was used more often than the 1st or 2nd fossil fuel car. Environmental attitudes and understanding of the car as harmful were reduced for electric car buyers. This could lead to rebound effects (increased, rather than decreased, use).

Ryghaug, Marianne and Toftaker, Marit, 2016. Creating transitions to electric road transport in Norway: The role of user imaginaries. *Energy Research & Social Science*, 17, pp. 119-126.

This research explores 'user imaginaries' – that is, constructions by policymakers, technology designers, or others, of what users represent and want. There is a tendency towards rational choice assumptions by policymakers and industry officials. Through interviews with stakeholders, user imaginaries are studied in relation to electric cars, and in particular the role these imaginaries themselves play in the ongoing transition towards electrification of the transport sector.

Ryghaug, Marianne and Toftaker, Marit, 2014. A transformative practice? Meaning, competence, and material aspects of driving electric cars in Norway. *Nature and Culture*, 9 (2), pp. 146-163.

An article focusing on the introduction of electric vehicles in Norway, and how electric cars are understood culturally. Theoretically interesting in that it combines elements of both social practice theory (see e.g. Shove et al (2015) in subsection 10.1. 'Designing towns and cities: land density and urban planning') and domestication theory (how technologies change as they are incorporated into real domestic lives). The analysis demonstrates that electric car driving alters user habits by making transportation needs more salient ('top of mind') and can raise both the technological and energy consumption awareness of users.

Sovacool, Benjamin and Hirsh, Richard, 2009. Beyond batteries: An examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition. *Energy Policy*, 37(3), pp.1095-1103.

Sovacool and Hirsh work to bring the (as they claim) often ignored socio-cultural and political or business barriers to the widescale application of hybrid cars and vehicle-to-grid into the spotlight. They argue that, contrary to widespread beliefs, consumers do not take fuel consumption into account when buying a car and are unwilling to accept the long time frame over which an electric car will offset (through fuel savings) the larger upfront purchase cost. The car and oil industry are formidable opponents who in the past, so the authors propose, have disseminated faulty research that overestimated pollution from electric car batteries by a factor of 10. Car repair shops and contractors would also lose business, thus will fight against electric vehicles.

Wentland, Alexander, 2016. Imagining and enacting the future of the German energy transition: electric vehicles as grid infrastructure, *Innovation: The European Journal of Social Science Research*, 29 (3), pp. 285-302.

Wentland, a sociologist, visited different electric vehicle-to-grid (V2G) projects in Germany to study what visions of the future are supported by these projects. He argues that Germany is the perfect paradox to examine these, as Germany is at once car-obsessed – with a large car industry – and has a large environmentalist movement. The projects emphasise the image of the 'prosumer' (portmanteau of producer and consumer, as V2G electric cars also produce energy and give this back to the grid). He identifies two possible utopias of the *envisioned 'symbiosis' of mobility, energy and communication technology"* (p. 94). One is the *"imaginary of seamless interconnectivity, synergy, and delegation to higher order systems"* (p. 94), while the other underlines images of independence and control over one's own life in a world in which individual control has been lost. He proposes that different consumers will be drawn to each.

6. Flying and tourism

Raya, a dating app for 'elites' (actors, models, musicians, millionaires, etc.) does not have the ability to input your city or even continent[24]. It is assumed that anyone who is elite enough to have been accepted by the membership panel is hypermobile enough to not care that prospective partners are a plane trip away. This section will examine hypermobility, including both business (Higham, 2014; Lassen, 2010) and leisure trips (Randles and Mander, 2009; Luzecka, 2016; Barr et al., 2010).

Tourism and other leisure travel represented one third of all trips in the European Union in 2008[25]. Leisure travel may involve longer distances and more energy-intensive travel modes than daily trips. Tourism overall accounted for 3.5% of CO_2 emissions, putting it fifth place if it were a nation, and 40% of these emissions are aviation-based[26]. Lyth cautions that surveys have shown that people believe that flying is *the* major cause of climate change, not realising that instead aviation is one of the sectors with the fastest *growing* emissions[27]. Nonetheless, large segments of scholarship focus on daily trips like commuting instead – although we note the importance of bodies of work from the tourism research field in this area.

This section discusses research which asks how demand for hypermobility is created, how hypermobility (travelling a great deal) became glamorous (Luzecka, 2016; Cohen and Gössling, 2015) and normalised (Randles and Mander, 2009). Hypermobility is also traced by Rosa (2003). This glamour and social capital associated with long distance travel may also partially explain the resistance encountered by Hingham et al (2014) and Lassen (2010) against reducing flying. Barr et al. (2011) found cognitive dissonance: people who stated the highest environmentalism travelled the furthest on vacation and flew the most overall. Researchers have also explored differences in behaviours when home and on vacation: sustainable behaviours tended to be dropped during leisure time (Barr et al., 2011 and Lassen, 2010). Becken (2017) looks at the other side: tourism industry executives' attitudes towards Peak Oil.

Barr, Stewart; Shaw, Gareth and Coles, Tim, 2011. Times for (Un)sustainability? Challenges and opportunities for developing behaviour change policy. A case-study of consumers at home and away. *Global Environmental Change*, **21, pp. 1234-1244.**
The authors research environmental attitudes in general and environmental behaviours at home and compare these with air travel for vacation. A cognitive disconnect was revealed – the people with the strongest commitment to environmentalism flew the longest distances and most frequently.

Becken, Susanne, 2017. Evidence of a low-carbon tourism paradigm?. *Journal of Sustainable Tourism*, **25 (6), pp. 832-850.**
In order to study potentials for paradigm shifts, Becken did word associations with over 100 tourism industry executives and academics in locations ranging from New Zealand to Hungary on four topics: 'Peak Oil', 'Low Carbon Tourism', 'Future Risks for Tourism' and 'Tourism Growth'. She then coded the results. 'Tourism Growth' was most closely associated with economic challenges and factors. 'Low Carbon Tourism' in contrast had mainly the following reactions: emotional exclamations, the assertion that this was impossible or hypocritical with some expressing theoretical importance or support. Behaviours were emphasised rather than technologies. 'Peak Oil' was associated with a phenomenon that is poorly understood and far away and again elicited emotional exclamations. It was also seen as industry external and in need of technical solutions. The most common responses to 'Future Risks for Tourism' were 'Safety', the 'Economy' and 'Climate Change', 'Disasters', 'Pandemics' and 'Energy Constraints' were also mentioned.

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24   Sciortino, Karley. 2016. Why Raya Is the Soho House of Dating Apps. *Vogue,* [online] 13 July. Available at: http://www.vogue.com/article/breathless-karley-sciortino-raya-dating-apps [Accessed 17 May 2017].

25   Holden, E., Linnerud, K., 2011. Troublesome leisure travel: the contradictions of three sustainable transport policies. *Urban Studies* 48, p. 3088.

26   Gössling, Stefan, 2009. Carbon neutral destinations: A conceptual analysis. *Journal of Sustainable Tourism*, 17(1), p.17.

27   Lyth, Peter, 2016. Plane Crazy Brits: Aeromobility, Climate Change and the British Traveller. In: Divall, Colin; Pooley, Colin and Hine, Julian, eds. *Transport Policy: Learning Lessons from History*. London: Ashgate, p.172.

Cohen, Scott, and Gössling, Stefan, 2015. A darker side of hypermobility. *Environment and Planning A.* **47, pp. 1661 – 1679.**

Cohen and Gössling trace the different ways in which travelling is made desirable and the social capital people receive through travel. They highlight that we are socialised since childhood to see constant travel as exciting. In the past, this would mainly been through *"objects, such as large or powerful cars, private aircraft or yachts, frequent business trips, often to long-haul destinations, or signifiers of frequent flyers, such as often golden or otherwise 'status-coloured' frequent flyer high status cards attached to bags."* (p. 1664). This now exists alongside social media showcasing hypermobile lives in a constant competition. Films like the "Fast and Furious" franchise and events like Formula 1 celebrating fossil fuelled speed are also mentioned by Cohen and Gössling. This hypermobility is contrasted with ignored negative health and social effects (loneliness) of frequent travel and a global rather than locally anchored outlook on life. This piece created a large debate in mainstream media outlets, which Cohen, Gössling and Paul Hanna trace in the March 2017 follow up piece "The dark side of business travel".[28] It shows that the media almost completely ignored the actual content of the original article and instead concluded that those experiencing negative effects of frequent travel must simply be doing it wrong.

Hall, Michael; Le-Klähn, Diemh-Trimh and Ram, Yael, 2017. *Tourism, Public Transport and Sustainable Mobility.* **Bristol: Channel View.**

This book features insightful EU case studies on tourism and decarbonisation of transport. Case studies include such varied topics as the Kusttram (coastal train) in Belgium and electric vehicles for people with disabilities in Spain.

Higham, James; Cohen, Scott and Cavaliere, Christina, 2014. Climate Change, Discretionary Air Travel and the 'Flyers' Dilemma'. *Journal of Travel Research***, 53 (4), pp. 462–475.**

The researchers conducted interviews with comparatively affluent, well-educated people who fly often in Stavanger (Norway), Bournemouth (UK) and Berlin in 2009 and 2010. Interviewees in all three countries openly admitted not being willing to change their travel patterns, knowing the consequences for the planet. Norwegian and German participants were clear on the existence of anthropogenic climate change, the UK participants showed stronger climate denial. Norwegians felt personally responsible and capable of action for climate change, British interviewees did not and saw personal responses as futile. But also for *"Germany and Norway, while not showing climate denial, expressions of the entrenched nature of air travel practices, and deep personal resistance to change, were common"* (p. 469). A young British participant identified frequent flying as part of *"growing up in England... it's a way of life now"* (p. 469). Participants did not know whether driving long distance or taking the train or flying would be better regarding emissions. Several highlighted low frills airlines as bad practice. German and Norwegian interviewees (in contrast to the British interviewees) expressed that this was an area for policymakers and regulation.

Lassen, Claus, 2010. Environmentalist in Business Class: An Analysis of Air Travel and Environmental Attitude, *Transport Reviews***, 30 (6), pp. 733–751.**

Lassen used questionnaires to research attitudes towards air travel and climate change among highly educated employees of two institutions in Denmark: Aalborg University and Hewlett Packard Denmark. He finds that participants are unwilling to see air travel as detrimental to the environment and engage in reactance behaviours once this is pointed out to them. His interviewees instead shifted the conversations towards the harmful impact of the car.

Luzecka, Paulina, 2016. "Take a gap year!" A social practice perspective on air travel and potential transitions towards sustainable tourism mobility. *Journal of Sustainable Tourism***, pp. 1–17.**

Luzecka's research looks at how teachers, parents, university tutors and previous participants collectively create a context in which emission-intensive 'gap-year' travel becomes desirable for younger people.

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28   Cohen, Scott; Hanna, Paul and Gössling, Stefan, 2017. The dark side of business travel: A media comments analysis. *Transportation Research Part D: Transport and Environment. (Not yet published in print).*

Rosa, Hartmut, 2003. Social acceleration: ethical and political consequences of a desynchronized high–speed society. *Constellations* **10 (1), pp. 3–33.**
In this article German sociologist Rosa assesses acceleration and time in modern contemporary society through the complexities of economics, technology and culture.

Randles, Sally, and Mander, Sarah, 2009. A Sociological Examination of Frequent Flying. In: Gössling, Stefan and Upham, Paul, eds. *Climate Change and Aviation: Issues, Challenges and Solutions***. London: Earthscan, pp. 273–293, [online] Available at:** http://www.gci.org.uk/Documents/Aviation-and-Climate-Change_.pdf **[Accessed 23 May 2017].**
In this book Randles and Mander show how as air travel becomes normalised in society it becomes a constituent part of other practices such as flying away celebrating birthdays or weddings, thereby 'ratcheting' up the frequency with which flying.

B. Topics cutting across transport modes

7. Trade and freight

If worldwide maritime shipping was a country, it would be the 6th largest carbon emitter[29]. One of the buzzwords in logistics due to speed and cost considerations is 'seamless' (Martin, 2013). 90%[30] of our world's goods are transported via container ship and then on to roads to be logistically distributed – which is what the 'seamless' refers to, the integration of different transport modes. Yet climate change is very much a 'seam'. Another indication of this 'seam' is the fact that one third of the 9.2 billion tons of goods transported on ships were liquid fuels – oil and petroleum mostly[31].

Academic Michael Browne asks whether - similar to *"peak beard, peak Beyonce"* [32] - we could ever reach 'peak freight' (see also subsection 5.3. 'What's next for personal transport?'). So far there are no signs of this happening - freight is increasing and road freight more than sea and rail (Eom et al., 2012). An intermodal shift of freight from road to sea and rail, to reverse this trend, has long been a EU policy aim. McKinnon (2015) explores different ways governments can achieve road transport decarbonisation.

Most changes in freight are hidden from the public. This might (in addition to its construction as unglamourous) be why there is a relative dearth of social science and humanities scholarship in the area. This 'hiddenness' is supported by social constructions of the sea as a void, as a seamless surface (see Martin, 2013; Steinberg, 1999) akin to a road. In this move, nature itself is eradicated, which is why geographer Steinberg (1999) refers to one aspect of the common imagination of the sea as *"an empty void to be annihilated by hypermobile capital"* (p. 416). Urry and Birthnell (2015) go so far as to refer to cargo shipping as akin to magic to the consumer, who is removed from it entirely.

Labour deregulation has played a significant role in making this ever growing freight delivery of goods possible – from cargo ships' open registry (any flag)[33] to (emissions free) cycle food delivery, and truck and van drivers, which Gregson (2015) refers to as the 'logistics precariat'. Bicycle delivery, which is in urgent need of further scholarly attention, is a decarbonisation hope for inner cities, but may receive resistance from other road users (Ho et al., 2016).

In the past it may have been hoped that online shopping could reduce individual shopping trips, with impacts on carbon emissions (Rosqvist and Hiselius, 2016). In fact, road freight is booming even more due to this:

> *"This is the age of the online shop, of the one-click purchase and the convenient delivery window, and to make it all possible, more vans ...are on UK roads than ever before. Last year, the total topped 4m for the first time. ...vans now account for a fifth of traffic on urban streets and motorways. At the end of 2015 (the last time such an eccentric calculation was undertaken), the total yearly distance covered by the UK's vans reached 46.9bn miles, or enough for a few round-trip deliveries to Pluto"*[34].

Gregson (2015) in her ethnographic research on van drivers picking up goods from ports for delivery shows energy and fuel inefficiency issues.

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29 2007 figures provided by Narula, Kapil, 2014. Emerging Trends in the Shipping Industry–Transitioning Towards Sustainability, *Maritime Affairs*, 10 (1), p. 121.

30 George, Rose, 2013. *Ninety Percent of Everything: Inside Shipping, the Invisible Industry That Puts Clothes on Your Back, Gas in Your Car, and Food on Your Plate*. New York City: Metropolitan Books.

31 Narula, Kapil, 2014. Emerging Trends in the Shipping Industry–Transitioning Towards Sustainability, *Maritime Affairs*, 10 (1), p. 114.

32 Browne, Michael, 2015. Peak Freight: could it ever happen?. In: McKinnon, Alan; Browne, Michael; Piecyk, Maja and Whiteing, Anthony, eds. *Green Logistics: Improving the environmental sustainability of logistics*. 3rd edition. London: Kogan, p. 411.

33 See van Fossen, Anthony, 2016. Flags of Convenience and Global Capitalism. *International Critical Thought*, 6 (3), pp. 359-377.

34 Lamont, Tom. 2017. White Van Nation. *The Guardian* [online] 15 April. Available at: https://www.theguardian.com/money/2017/apr/15/white-van-nation-drivers-behind-on-demand-economy [Accessed 22 May 2017].

Finally, the issue of transport decarbonisation through local sourcing of goods is addressed: small scale urban agriculture (North, 2010) and buying goods that do not have to be flown in (Garnett, 2015). Drones and 3D printing (Birthnell, Urry, Cook and Curry, 2013) are future hopes for carbon efficiencies in how we get our goods - might they revolutionise freight?

7.1. Container shipping

Birtchnell, Thomas and Urry, John, 2015. The mobilities and post-mobilities of cargo. *Consumption, Markets and Culture*, 18 (1), pp. 25-38.
Urry and Birtchnell refer to cargo shipping as the "*magic system*" (p.30) – 'magic' as it is invisible for most people, yet has transformed our entire world. In their treatise of cargo shipping, the sociologists link mass consumption and globalisation back to the cargo cults (religious movements) of the 1940s and 1950s. During World War II, Allied forces brought vast amounts of cargo in proto-containers by plane and ships to previously remote islands. Since the native population had not seen these vast quantities of products be manufactured by the colonial power using them, the indigenous population believed that a deity under human direction had made them and getting the deity's approval would overthrow the colonial power. For this, the islanders started carving wooden shipping containers. Urry and Birthnell identify these cargo cults as "*canaries in the coalmine for a much larger cargo cult of consumers charmed by the magic system of marketing in the Global North*" (p. 29). According to the authors, modern consumers through ignoring the 'hidden' emissions in globalisation and cargo shipping are themselves cargo cultists who believe that these objects have just 'appeared' through 'magic'.

Martin, Craig, 2013. Shipping container mobilities, seamless compatibility, and the global surface of logistical integration. *Environment and Planning A*, 45, pp. 1021-1036.
Martin, of the Edinburgh College of Art, explores how cargo shipping requires the pretense of a "*seamless*" transition between and integration of road and ocean. The ocean as "unruffled" (p. 1024) surface. This is according to him a different social construction of the ocean than existed before – the ocean previously was a brute uncontrollable force. The ocean becomes nothing but a surface on which goods can glide. The article also discusses how the mass adoption of cargo shipping changed port communities – cargo shipping delinked many traditional maritime communities from ports as the sea beds were not deep enough for cargo ships. *Cf. Steinberg (1999) also in this subsection.*

McKinnon, Alan, 2016. Freight transport deceleration: its possible contribution to the decarbonisation of logistics. *Transport Reviews*, 36 (4), pp. 418-436.
Based on interviews with shippers, McKinnon argues against prevailing orthodoxy for a deceleration of logistics, showing that this would contribute to a decarbonisation of freight and is feasible as for example interviewees stated that only about 10% of deep sea container contents were time-sensitive. McKinnon furthermore highlights the importance of "*near-shoring*" (p. 427), ecolocalisation, to lower travel distances.

Steinberg, Philip, 1999. The maritime mystique: sustainable development, capital mobility, and nostalgia in the world ocean. *Environment and Planning D: Society and Space,* 17 (4), pp. 403-426.
In this article, Steinberg dissects the social construction of the ocean. He identifies three different constructions: the sea as site of past glory to be consumed through tourism, the sea as a void without nature which can be used to transport goods to increase capital and as locus for possible sustainable development.

7.2. Surface freight

Carrara, Samuel and Longden, Thomas, 2016. Freight futures: The potential impact of road freight on climate change, *Transportation Research D.*

These economists develop future scenarios modelling of road freight emissions. Under all scenarios, road freight decarbonises less than other areas of economic activity (GDP link). This means that a greater attention by policymakers has to be paid to road freight and greater modal shift is necessary.

Eom, Jiyong; Schipper, Lee and Thompson, Louis, 2012. We keep on truckin': Trends in freight energy use and carbon emissions in 11 IEA countries. *Energy Policy*, 45, pp. 327–341.

This study examines the CO_2 trends of freight of 11 countries (including Spain, France, Germany, Denmark, the UK, Sweden and the USA) from 2007-2010. They find no evidence of a shift from road freight to short sea shipping or rail. Instead, while the countries experienced 'Peak Car', trucking increased in freight share. The data even underestimates trucking as passing through traffic is often not registered. Ironically, a large part of goods being shipped by rail is the fossil fuel needed for road freight and other driving. The USA and Canada have a much larger share than Europe in rail freight. This is powered by diesel. The authors find *"several countries where the rail freight sector is energy-efficient from the final energy point of view, owing to their high rail electrification, turned out to be relatively carbon-intensive because of their high carbon coefficient of electricity. These countries include Spain and Germany ..."* (p.338). Nonetheless, switching to rail could still improve the CO_2 bottom lines.

Gregson, Nicky, 2015. Logistics at Work: Trucks, Containers and the Friction of Circulation in the UK. *Mobilities*, pp. 1–22.

Geographer-turned-sociologist (her own description) Gregson conducts interviews and participant-observation (she travels with them) ethnography with truckers in England picking up and bringing boxes to and from ports. Gregson describes the inefficiency associated with the work. A big issue is fuel inefficiency and the cost of fuel. Because of this and to avoid motorway congestion, the drivers arrive several hours early to wait for the port to open. Due to deregulation of the industry, whereby the cost of fuel has to be borne by the nominally self-employed truckers instead of the corporations or the consumer, the truckers resort to illegal practices or leave the job. Gregson describes how this is in part made possible through the influx of Eastern European truck drivers.

McKinnon, Alan, 2015. The role of government in promoting green logistics. In: McKinnon, Alan; Browne, Michael; Piecyk, Maja and Whiteing, Anthony, eds. *Green Logistics: Improving the environmental sustainability of logistics*. 3rd edition. London: Kogan, pp. 375–396.

Noting *"It is ironic that while liberalization measures have been facilitating the growth of freight movement, governments have been intensifying their efforts to reduce the impact of freight movement on the environment"* (p. 342), McKinnon provides an audit of possible government policy interventions for the decarbonisation of the freight sector. These include more stringent container ship exhaust fuel laws, fuel economy standards for newer vehicles and scrappage for older vehicles, fuel efficient driving schemes and higher fuel duty. McKinnon argues counterintuitively for deregulating truck weight limits (although this may lead to further mode shift from rail to trucks) and general trucking deregularisation legally but with higher taxation and investment in rail infrastructure.

7.3. Urban freight

Birtchnell, Thomas; Urry, John; Cook, Chloe and Curry, Andrew, 2013. *Freight Miles: The Impacts of 3D Printing on Transport and Society*, **ESRC Project report, [online] Available at:** http://eprints.lancs.ac.uk/66198/1/Freight_Miles_Report.pdf **[Accessed 23 May 2017].**

The question this report attempts to answer is: if 3D printing will become widespread in the near future, what will this mean for transport decarbonisation? 3D prints use a feeder material, most commonly a certain type of plastic called ABS (acrylonitrile-butadiene-styrene) and then create the desired object layer by layer. Because of this layering, it is also referred to as 'additive manufacturing' (as opposed to 'traditional manufacturing'). ABS, like 95% of all packaging worldwide, is however made from oil. It will however take a while until 3D printing is fast enough to compete with next day delivery. Since the end user would in most scenarios have a 3D printer at home, offshored cheap manufacturing workforce, factories and container shipping would be reduced. It is possible with 3D printing to personalise or replicate items indefinitely – issues of scale disappear. The authors highlight transport-related items that have recently been 3D printed: the UK Olympic Cycling team's bike helmets, an entire hybrid car and a 2 metre drone. The report ends with four possible future scenarios for 3D printing and their implications for transport emissions.

Cohen-Blankshtain, Galit and Rotem-Mindali, Orit, 2016. Key research themes on ICT and sustainable urban mobility. *International Journal of Sustainable Transportation*, **10 (1), pp. 9-17.**

The authors provide an expansive overview of existing research and their own additional theorisation regarding the effect of ICT on decarbonisation of short distance travel. Cohen-Blankshtain and Rotem-Mindali emphasise that there are three possible *direct* effects on travel demand: (1) substitution or reduction of travel and thus travel decarbonisation through reduced demand for travel, (2) generation of additional travel demand (emissions increase) or (3) a change in travel patterns. The authors assert that the third possible effect is often neglected. Furthermore, ICT can have an *indirect* effect on travel sustainability. ICT can increase the experience, cost, travel mode, route choice, speed and fuel efficiency of transport through intelligent transport systems in cars, due to change of land use or accessibility of places. The authors then proceed to address energy use effects of (a) telecommuting, (b) online shopping and (c) leisure travel. Regarding the commute, apps can make carpooling easier, but people also often combine going into different shops in the same place whereas with online shopping, these'd all be different logistics shipments. Online shopping items are also more often returned or stored at a local pickup point, which adds further travel. Firms have also moved their warehouses to more remote locations with the help of ICT.

Garnett, Tara, 2015. The food miles debate: Is shorter better?. In: McKinnon, Alan; Browne, Michael; Piecyk, Maja and Whiteing, Anthony, eds. *Green Logistics: Improving the environmental sustainability of logistics*. **3rd edition. London: Kogan, pp. 358-371.**

The 'food miles' paradigm was pioneered by an NGO in the 1990s with an originally intersectional meaning, incorporating *"a broad range of environmental, social and economic problems resulting from the globalizing of food supply systems"* (p. 358). It has evolved to refer to the idea that purchasing food that was produced locally and not airlifted is desirable for decarbonisation. Garnett cautions that the reality is more complex – the extent of decarbonisation depends on seasons, load of vehicles and efficient manufacturing. If food is grown out of season in Northern countries, the greenhouse lighting will require enough energy to make longer distance freight transport less carbon intensive. The same applies if local apples are refrigerated for the winter. Garnett highlights that food miles can be a *"distraction"* (p. 360) when ignoring that meat should not be consumed at all due to the emissions inherent to animal husbandry, not addressing the carbon inherent in food waste by supermarkets and customers and ignoring water shortages. However, Garnett advocates not dismissing food miles out of hand, as many scholars she cites have done, since she believes that this public debate can lead governments and supermarkets to invest in better local freight transport options.

Ho, Helen; Le, Dorothy; Giampieri, Mario; Chen, Xiaodeng; Banks, Melyssa and Lee, Do, 2016. Delivering (in)Justice: Food Delivery Cyclists in New York City. In: Golub, Aaron; Hoffmann, Melody; Lugo, Adonia Lugo and Sandoval, Gerardo, eds. *Justice and Urban Transformation: Biking for all?*. **Milton Park: Routledge, pp. 114-130.**

The authors analyse media reports on food delivery cyclists in New York City. The food couriers are represented as 'deviant', not following traffic rules and therefore endangering everyone else. What this type of reporting renders invisible is the fact that the rise of bicycle delivery drivers necessitates further investments in cycling infrastructure and that delivery cyclists violate traffic rules due to the precarious and underpaid working conditions with an emphasis on speed.

North, Peter, 2010. Eco-localisation as a progressive response to peak oil and climate change – A sympathetic critique. *Geoforum*, **41 (4), pp. 585–594.**

North argues that eco-localisation is necessary and posits himself in opposition to Erik Swyngedouw[35], who has argued that such responses to climate change are 'post-political' and therefore counterproductive. North contrasts intentional eco-localisation, sourcing goods primarily locally for decarbonisation reasons to immanent eco-localisation, a market response to high fuel prices. The former is political, the latter will not result in political shifts.

Rosqvist, Lena and Hiselius, Lena, 2016. Online shopping habits and the potential for reductions in carbon dioxide emissions from passenger transport. *Journal of Cleaner Production*, **131, pp.163-169.**

Over 3000 people in Sweden filled in questionnaires on their online shopping habits, trip modes and everyday trip numbers for this study assessing possible decarbonisation effects from online shopping. The authors find that almost half of the respondents shop online at least sometimes and about 10% frequently. They make the same amount of car trips than people who do not shop online and additionally make more trips per person per day on other modes of transport (public transport, bicycles and walking). This would make a higher rather than lower carbon profile likely. More men shop online than women. They conclude that online shopping does not decrease travel demand. Online shoppers are younger and more likely to live in cities rather than rural areas.

Visser, Johan; Nemoto, Toshinori and Browne, Michael, 2014. Home Delivery and the Impacts on Urban Freight Transport: A Review. *Procedia - Social and Behavioral Sciences*, **125, pp. 15 – 27.**

This is a comprehensive exploration of online shopping's effects on energy use and freight mileage according to different logistics models - pick up points, home delivery by contracted logistics companies in vans or bicycle couriers and click and collect. The authors furthermore compare the CO_2 emissions from small vans (currently most common for home delivery, although bicycle delivery is common for food orders) and trucks (most likely for delivery to a physical store) and discuss various decarbonisation strategies.

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35   Swyngedouw, Erik, 2010. Apocalypse forever?. *Theory, Culture & Society*, *27* (2-3), pp.213-232.

8. Historical transport and change processes

Transport decarbonisation requires changes in how we relate to transport (and the world), how we choose to travel, how much we travel, and our use of technology. This section includes articles on from past transport changes, including explorations of:

▪ What happened when a new transport technology was introduced? How did people use it? How did people relate to it?

▪ How were past transport sustainability problems addressed?

▪ What determined which transport technology 'won' and became dominant?

▪ What lessons on transport decarbonisation can we draw from past experiences?

The bicycle - whose origins are the topic of the first subsection - was invented because of a sudden climatic change (a volcanic eruption in 1815) which led to the death of many horses (Lessing, 2003). A historical perspective can show the friction that occurs when a new technology is introduced. In this case the bicycle was initially seen as a bourgeois frippery, and not for serious transport. Importantly for transport decarbonisation, innovations can appear rather randomly - in 1861, Cora Pearl revolutionised the bicycle by having pedals installed (before it was similar to a scooter) in order to be able to mount it to attract attention while cycling - in itself considered improper for women at the time (Gaboriau, 1991).

We may have a rather rose-tinted view of our collective transport past, as explored in the second subsection on the move away from animal-based transport. When horses were the primary mode of transport, their life expectancy in cities due to poor conditions and hard labour was three years (compared with 30 years today). This also represents a previous transport growth limit and extremely negative effects of strong transport demand growth. This demand growth was created through industrialisation and the correlated urbanisation. In larger cities, distances stopped being walkable. Many important sustainability issues already existed with horses:

> "[New York's] production of horse droppings ran to at least 45,000 tons a month. ... In the early part of the [19th] century, farmers in the surrounding counties had been happy to pay for the city's manure, which could be converted into rich fertilizer, but by the later part the market was so glutted that stable owners had to pay to have the stuff removed, with the result that it often accumulated in vacant lots, providing breeding grounds for flies. .... When the world's first international urban-planning conference was held, in 1898, it was dominated by discussion of the manure situation. Unable to agree upon any solutions—or to imagine cities without horses—the delegates broke up the meeting, which had been scheduled to last a week and a half, after just three days"[36].

In 2009, the 'fin de siècle sustainability' debate – concerning these sustainability issues surrounding horse-based transport - surfaced again due to the popular book *SuperFreakonomics* by Levitt and Dubner[37]. The authors downplay the climate crisis and argue that the fact that this problem of horse manure was 'solved' by cars demonstrates that humans can always solve issues through technological innovation. The combustion engine, whilst solving the horse manure flies issue, created a far worse problem in global warming with its "side effects" of species depletion, flooding etc. In fact, Geels (2005), shows that the international combustion engine car did not replace the horse in cities at all – it was the electric tram:

> "In 1890, 16% of American street railways were electrified, about 70% were horse or mule powered and 14% consisted of cable cars or steam railways. By 1902, 97% of American street railways were electric. So, with regard to tram propulsion, electric motors replaced horses in 14 years. ...Operational costs were lower, reducing the cost per car-mile from 8–11 cents for horsepower to 1.5 cents for electric power. ... Electric light companies promoted the electric tram, because it provided an additional electricity market that perfectly complemented their night-time light market. Local authorities and urban reformers also

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36   Kolbert, Elizabeth, 2009. Hosed: Is there a quick fix for the climate?. *The New Yorker [online]* 16 November. Available at: http://www.newyorker.com/magazine/2009/11/16/hosed [Accessed 23 May 2017].

37   Levitt, Steven and Dubner, Stephen, 2009. *SuperFreakonomics.* New York City: William Morrow.

promoted the tram as a means to enhance sub-urbanization. In addition... the electric tram linked up well with the general cultural enthusiasm for electricity and its uses" (p.458).

Tram companies however faced a number of problems, including strict regulation, increases in sexual harassment on trams, and, since trams were often used by African Americans, White people stopped using them. Cars were also faster. The biggest decline came in the 1930s. The tram lost, at this point the car did win. And, whilst solving the horse manure issue, arguably created a far worse problem in climate change.

Two further issues in the second subsection also concern perspectives on today's dominance of the internal combustion engine (ICE) car. The ICE car 'winning' against the electric car is explored not as a result of a logical superiority of the technology. Instead it was the result of several coincidences and policies. Additionally, we forget that road improvements were originally for cyclists (Reid, 2014), not cars, and were once lobby ground for cyclists arguing for their rights.

The third subsection discusses an area of repeated interest to social science and humanities scholars: the disruptive effect of new technologies. When the railway was first introduced, people thought that it led to an illness called 'railway spine'. When the car was introduced in rural America, its motor was used often to churn butter. We might ask: what are the 'railway spine' misconceptions of today? What users do can be completely different from the expected use, and can make carbon projections all the more difficult.

8.1. Early bicycle invention and climate change

Gaboriau, Philippe, 1991. Les trois âges du vélo en France. *Vingtième Siècle - Revue d'histoire*, 29, pp. 17–33.
In his article, Gaboriau distinguishes between three ages of the bicycle in France:

1. From the 1820s onwards, the so-called 'Draisienne' was met with ridicule - a toy for manchildren. Bicycles were used for acrobatics at aristocratic balls. Women were not generally allowed to cycle and instead used something akin to rickshaws. By 1869, only 5,000 men in France own a bicycle. The industrial revolution at this point instead mostly needed (and used) another (revolutionary) transport mode: the railway and steam train, to transport goods and raw materials.
2. In the final decade of the 19th century, cycling explodes - initially as a sport rather than transport. Companies like Peugeot and Michelin were founded as bicycle companies. Women are now allowed to ride bicycles. In 1900, there are almost 980,000 bicycles in France - and this figure more than doubles in the next seven years.
3. Since the upper class is moving on to something that the working class cannot yet afford - the car and the plane - the bicycle becomes associated with workers up until the 1950s. Through the bicycle one can trace the inter-class diffusion of cultural practices. From the 1970s onwards, environmentalism leads to a renaissance of bikes.

Lessing, Hans–Erhard. 2003. *Automobilität - Karl Drais und die unglaublichen Anfänge.* **Leipzig: Maxime.**
In 1815, a volcano in Indonesia erupted. The impact was disastrous: because of the ashes dimming the sun, 1816 became the "Year without a summer". It snowed in July (!) in Europe and North America. There were of course under these circumstances no harvests and about 100,000 people and many animals starved, including many horses, causing a dearth of transportation options. This situation of scarcity inspired Baron Karl Drais to invent the very first bicycle, the so-called "Laufmaschine" (Run-machine).

Reid, Carlton, 2014. *Roads were not built for cars.* **Washington DC: Island Press, [online] Available at:** http://roadswerenotbuiltforcars.com/notes **[Accessed on 23 May 2017].**
Reid reminds us that *"History is a social construct, written by the winners, and the winners in highway history have been motorists"* (p. XVII). He works to unearth this hidden history of cyclists' contribution to roads through this book. Many car companies had their origin in cycling – including Rolls Royce, Aston Martin, Peugeot, GMC, Chevrolet and Cadillac. Cyclists in the USA and the UK founded the first lobby organisations for better, smoother roads. Yet today, highways are closed to anything other than cars and motorcycles and even on roads that are open to cyclists, they often encounter aggression. This exclusion took place in

a short space of time: "*just twelve years after Britain's 'Emancipation Act' had legalised the use of motor cars, ... the Permanent International Association of Road Congresses [PIARC] excluded horse-drawn traffic from its remit at its first conference, held in Paris in 1908. ... At the London conference held in 1913, cycling was removed completely. Roads, decided the PIARC delegates, were only for A-to-B travel propelled by motors*" (p.55).

8.2. The historical electric car and replacing the animal

Geels, Frank, 2005. The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriages to Automobiles (1860-1930). *Technology Analysis & Strategic Management*, **17 (4), pp. 445-476.**

Geels is known as a pioneer of the Multi-Level Perspective (MLP) on transitions, a sociology of technology paradigm (see section 13. 'Paradigms and transport research'), which examines how new technologies may emerge in 'niches' and may or may not, ultimately make it to the mainstream. He argues that horses were not replaced by the internal combustion engine (ICE) car, but by the electric tram. He cites different stages at which different transport options competed, and then some were eliminated. Phases:

1. *"Horse-Based Transportation (1860-1885)"* (p. 455). Horse most common. Bicycles, electric vehicles and steam automobiles entered as exotic niche vehicle.
2. Electric tram breakthrough (1885-1903). In this phase, horses became seen as negative due to hygiene concerns (p. 457, cf. Tarr and McShane (1997), also in this subsection).
3. *"Expansion of Electric Trams and Stabilization of ... Car (1903-1914)"* (p. 463). *"Horses disappeared from urban passenger transport. Bicycle lost importance and became a children's toy. Electric tram ... became the dominant urban transport system."* (p. 465)
4. *"Car-based personal transportation regime ...(1914-1930s)"* (p. 465).

Geels believes that the fuel infrastructure, cultural values and maintenance network had a larger role to play than technological issues, in terms of the lack of uptake of the electric car. He furthermore argues that the ICE, electric cars and steam engine cars were initially not really competing but were instead used in their own niches.

Høyer, Karl Georg, 2008. The history of alternative fuels in transportation: The case of electric and hybrid cars. *Utilities Policy*, **16, pp. 63-71.**

Høyer relates the history of the electric vehicle and the battery. The first electric vehicle (a tricycle) was shown in 1881 in France. Benz only showed the first internal combustion engines in 1885. Edison then developed more powerful batteries and imagined a great future for electric cars. Høyer declares the period from 1880-1920 the golden age of the electric car. The hybrid was developed by Porsche for the Paris Expo in 1900 and in 1900 New York had innovative coin-operated electric car charging facilities. "*At this time, three types of cars were contesting for market control; the electric car, the steam engine and the gasoline ICE car. In 1903, New York had about 4000 ... [cars]: 53% steam-powered, 27% gasoline ICEs, and 20% electric. ... the electric cars outsold the other two types in the USA as a whole. ... But ....[after] 1909, the Ford-T model had really begun to achieve market dominance*" (p.64). During World War I, many cars were requisitioned for the war, which led to an increase of electric cars. Japan had a popular electric car until 1952 due to post-war fuel shortages. In the 1960s and 1970s, several new projects were started due to environmentalist impetuses, but none of them took off. The Sustainable Development discourse emerging in the 1980s was not, according to Hoyer, interested in transport.

Kirsch, David, 1997. The electric vehicle and the burden of history: Studies in Automotive Systems Rivalry in America, 1890-1996. *Business and Economic History*, **26 (2), pp. 304-310.**

David Kirsch contests what he refers to as the generally accepted wisdom that the combustion engine petrol car 'won' the competition against the early (1890s till 1920s) electric car because the technology was better: "*scholars have tended to view alternatives like steamers and electric cars as ...technological curiosities that stood no real chance.... In this sense, automotive historians have long labored under the weight of their own intellectual path-dependence. ... tautology. The best technology won because it was the best technology; moreover, because it had won - and was therefore the best technology - there was no need to question the fundamental criteria by*

which it was selected as the best technology" (p. 305). Kirsch highlights the short history of electric taxis in New York, in the last years of the 19th and first years of the 20th century. There were about 2000 electric taxis at the time, but all companies had declared bankruptcy by 1902. Kirsch believes this to be the case due to warehouse fires, shareholder suits and other issues entirely unrelated to technology.

Tarr, Joel and McShane, Clay, 1997. The Centrality of the Horse to the 19th Century American City. In: Mohl, Raymond, ed. *The Making of Urban America.* **New York City: SR Publishers, pp. 105–30.**

A fascinating account of the role horses had in Western cities in the late 19th century. Horses in cities caused severe sustainability issues, for many reasons: the modern human and its economy required so much transportation at this point that there were many more horses than the city could actually handle – from a carcass, urine, manure, sound and many other perspectives. In the first half of the 19th century, steam trains started being outlawed in city centres or urban areas. Instead trains had to be stopped and 'turned off' outside towns and were then drawn in by horses. This evolved into horse-drawn trams. The number of horse car riders in New York alone tripled in 10 years in the 1860s. By 1890, 32.5 million passengers in the urban USA rode horse-drawn streetcars operated by almost 800 companies. Horse trams made the first commuter suburbs possible. In 1900, there were over 24 million horses in the United States. The horse population was urbanising at a 50% higher rate than humans due to the transport needs of cities.

8.3. Reactions to and repercussions of new transport technology

Kline, Ronald and Pinch, Trevor, 1996. Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States. *Technology and Culture,* **37 (4), pp. 763-795.**

Kline and Pinch perform a social construction of technology analysis of the car at its early introduction in the rural United States. Initially farmers rejected the car and there were conflicts between wealthy urban car drivers and rural farmers. Cars were seen as immoral and were seen as danger to Christianity in rural America. Several counties outlawed cars completely. The state of Vermont required a person with a red flag to slowly walk in front of the car to alert people of the car – making driving rather pointless. Just as had happened when the bicycle first entered the stage (also through wealthy urban types), farmers started shooting, beating or otherwise attacking car drivers. At this point the train was the dominant long distance vehicle in America. By 1920 this fight was lost and more farm households than non-farm households owned cars (30% to 24%). The reason was that the car was not used in the way we use it today by farms: It was used as stationary motor to milk cows, shear sheep, pump water, saw wood, grind corn etc. rather than for transport alone or even predominantly.

O'Rourke, Kevin and Williamson, Jeffrey, 2002. When did globalisation begin?. *European Review of Economic History,* **6 (1), pp. 23-50.**

O'Rourke and Williamson add to research on the elusive start date of globalisation. They argue that globalisation really only began around 1870 onwards due to a transport revolution and the creation of the Suez Canal. The evidence for this is a price convergence in all goods except the most perishable ones (refrigeration wasn't available yet). Their conclusion: *"Globalisation did not begin 5000 years ago, or even 500 years ago. It began in the early nineteenth century. In that sense, it is a very modern phenomenon"* (p. 49).

Thraikill, Jane, 2010. Railway Spine, Nervous Excess and the Forensic Self. In: Salisbury, Laura and Shail, Andrew eds. *Neurology of Modernity – A Cultural History of Nervous Systems.* **Basingstoke: Palgrave Macmillan, pp. 96-113.**

In the second half of the 19th century, medical academic journals like *The Lancet* were debating an important issue – some men appeared to be in agitated moods and 'hysterical', yet agitation and 'hysteria' were as 'everyone knew' based in the uterus. Since men do not have a uterus, this was a paradox for physicians. These states of male 'hysteria' were often linked to men taking the railway – usually railway accidents, sometimes merely the usage of the train. The men appeared physically unharmed. The so-called 'railway spine' entered the scene. It was argued that the jolting of the railway damaged these men's spine. In reality, most of the men would have had PTSD from the accident and others were faking or just overwhelmed by the new technology and new sensation. Some of them would have had concussions.

Wheelersburg, Robert, 1987. New Transportation Technology among Swedish Sami Reindeer Herders. *Arctic Anthropology*, **24 (2), pp. 99–116.**

This is an anthropological account of how small planes and the snowmobile radically changed Sami life – from their introduction (1953 plane, 1961 snowmobile) until the late 1980s, when this article was published *[we note that the situation is of course entirely different now]*. Snowmobiles led to different relationships with the animals they herded. Planes changed their diet now many more goods could be flown in. Since snowmobile and small planes were expensive, it bound the Sami to wage labour and created a stricter wealth hierarchy. In Sweden, funds for snowmobiles in part came from a strong increase in Sami fishing. Settlement locations changed completely - while before Sami often lived along rivers for boats, the planes made this unnecessary and the settlements were relocated to lakes. Samis started commuting to work. The snowmobile at least in the first years was gendered - women did not use them. Fewer herders were now needed for a herd and this meant that many Sami needed a different career.

9. Fuels

There is an urban myth that - due to the high carbon emissions of food production - it is often better to drive with a fossil fuel car than walk, run or cycle[38]. While this is an oversimplification, fuels (how they are produced, distributed, and used) are naturally one of the most important issues in transport decarbonisation.

This section addresses cross-cutting issues of fuels, which are applicable to different transport modes – buses, railway, boats, planes and trains can all run on petrol, diesel or biofuel, for example. The four subsections focus on diesel fuel and taxation, rebound effects and fuel efficiency, alternative fuels including biofuels and batteries and the related issue of fuel hype.

Diesel - the topic of the first subsection - has been subject to a number of regulatory schemes. Diesel has been promoted through taxation in Europe in order to reach decarbonisation goals (Neumaier, 2014). This however resulted in greater nitrogen dioxide emissions, leading to low emissions zones being introduced in many cities in Europe[39] (Ruef and Marckard, 2010). The effect of diesel cars on carbon emissions is diminishing since drivers are choosing larger and more powerful cars which use more fuel (Schipper and Fulton, 2013).

A major overarching issue here is that of feedback effects or rebound effects. These are also known as Jevons' paradox - first observed by William Jevons in the 19th century concerning the coal efficiency of trains. If there are efficiency savings in one area, and if there is no overall cap, then money or time saved is spent doing something else – which may be *more* carbon intensive. If travelling the same distance becomes cheaper due to increased fuel efficiency, for example, then the demand for travelling will rise and people will choose to travel further (Polimeni, 2008). Other policy measures where rebound effects have been explored include scrappage programmes for inefficient cars, and road improvements[40].

Alternative fuels, including biofuels and batteries, are discussed in the third subsection (see also subsection 5.4. on 'Electric vehicles' for more consumer-focused literature).

The final subsection examines fuel 'hype' (Melton et al., 2016; Ruef and Marckard, 2010). Here is how fuel hype works (Melton et al., 2010, pp. 1-2):

> *"The beginnings or continuation of a hype may or may not involve technology breakthroughs ... or policies ... that attract interest in that technology. Innovation stakeholders such as scientists, industry and governments inflate and communicate positive expectations or technological promises to attract attention and resources. Collectively, the optimistic promises and expectations of industry, government agencies, political leaders and the media become part of the social discourse, creating an incentive for an even greater number of stakeholders to promote the technology and further contribute to the hype (raising expectations further still)."*

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38   MacKay, David, 2009. *Sustainable Energy – without the hot air*. Cambridge, UK: UIT, [online] Available at: https://www.withouthotair.com/c13/page_79.shtml [Accessed 23 May 2017].

39   For an overview of such zones see: Urban Access Regulations website: http://urbanaccessregulations.eu/

40   Mogridge, Martin, 1997. The self-defeating nature of urban road capacity policy: A review of theories, disputes and available evidence. *Transport Policy, 4(1), pp.5-23*. In this classic paper, Mogridge reviews the evidence for or against the Downs/Thomson paradox: that increasing road capacity increases congestion.

9.1. Diesel, taxation

Bogelund, Pia, 2007. Making green discourses matter in policy-making: Learning from discursive power struggles within the policy area of car taxation. *Ecological Economics*, 63, pp. 78–92.

Bogelund looks at discourse-coalitions (actors using the same narratives) in car taxation debates in Sweden and Denmark in the 1980s and 1990s. The author finds that environmentalist actors and discourses were actively marginalised by the government ministries involved. The economic ministries worked to counter emissions targets and to exclude environmentalist groups and actors. Environmentalist groups tried to use this same economic discourse in order to gain access. Therefore all work became economics-oriented and environmentalism was sidelined.

Holman, Claire, Roy Harrison, and Xavier Querol, 2015. Review of the efficacy of low emission zones to improve urban air quality in European cities. *Atmospheric Environment*, 111, pp. 161–169.

The authors review existing research on urban low emissions zones in Italy, Denmark, the Netherlands, the UK, Germany, Sweden, Greece and Portugal. These zones restrict certain vehicles, either always or at specific times or in specific seasons. The zones are not standardised (neither within countries nor at European level). The metastudy concludes that only in Germany have small particle (PM10) and NO_2 (nitrogen dioxide) been reduced, pointing to a poor design of the schemes. Carbonaceous particles were reduced to a much stronger extent, the reduction was strongest in Berlin, where their concentration was reduced by 56%.

Schipper, Lee and Fulton, Lewis, 2013. Dazzled by diesel? The impact on carbon dioxide emissions of the shift to diesels in Europe through 2009, *Energy Policy* (Special Section on "Decades of Diesel"), 54, pp. 3–10.

Schipper and Fulton trace recent developments in diesel vehicles. They find that customers keep buying ever larger and more powerful diesel cars. This means that the actual CO_2 emissions advantage over petrol cars of the diesel cars amounted only to 2% in 2009.

Sterner, Thomas, 2007. Fuel taxes: An important instrument for climate policy, *Energy Policy*, 35, pp. 3194–3202.

Sterner assesses the effect of fuel taxes on carbon emissions. Western European fuel taxation is overall much higher than American fuel taxes. Sterner shows that lesser taxation has favoured diesel over gasoline, which is problematic from an environmental viewpoint. He furthermore estimates *"that the atmospheric carbon content would have been 1ppm [part per million] higher than it is today if gasoline taxes"* were not the same level they actually were in Europe (p. 3198).

9.2. Alternative fuels

Hansen, Janus, 2014. The Danish Biofuel Debate: Coupling Scientific and Politico-Economic Claims, *Science as Culture*, 23 (1), pp. 73–97.

This sociological article charts two competing scientific claims on biofuels in Denmark: a pessimistic one which claims that they prolong fossil fuel dependence in a lock-in and an optimistic narrative identifying biofuels as truly transformative. Hansen identifies the impact on policy of both these camps and identifies which actors form part of these coalitions (including NGOs and corporations). Hansen reminds us that Denmark was a slower mover on biofuels than e.g. Sweden and Germany.

Iles, Alastair, 2013. Choosing our mobile future: the degrees of just sustainability in technological alternatives. *Science as Culture*, 22 (2), pp. 164–171.

Iles argues from a sociological standpoint that alternative fuels are not automatically socially or environmentally just – they function on a spectrum. The production of alternative fuels can still be linked to environmentally damaging practices and needs closer inspection: *"Lithium may be sourced from ecologically fragile salt plains in the Bolivian and Chilean Andes, and displace local indigenous communities while benefiting multinational corporations ... Tenants ... may be unable to charge cars at home overnight because of building restrictions"* (p. 166/167).

Raman, Sujatha, 2013. Fossilizing Renewable Energies. *Science as Culture*, 22 (2), pp. 172–180.

Fellow sociologist Raman addresses the sustainability of the supply chain of electric cars, in particular rare earths. He reminds us that these are not "rare" at all, but derive their name from how rare their extraction became due to environmental damage. Raman mentions that climate denier forces use environmental issues associated with the supply chain of electric cars to support the status quo and inaction. He concludes *"On closer interrogation, most advocates for RE would make the point that renewables do not offer a free lunch, but rather a set of options that are vastly superior to fossil fuel or nuclear alternatives"* (p. 178).

9.3. Fuel hype and rebound effects

Font Vivanco, David; Freire-Gonzalez, Jaume; Kemp, René and van der Voet, Ester, 2014. The remarkable environmental rebound effect of electric cars: a microeconomic approach. *Environmental Science & Technology*, 48, pp. 12063–12072.

This study assesses environmental rebound effects for electric cars. Their assessment includes not only climate change, but other environmental resource depletion issues, such as for phosphate needed for electric car production, are calculated. Many of the rebound effects are high. The authors conclude that it would be better to strongly increase the price of fossil fuels, focusing on demand reduction.

Melton, Noel; Axsen, Jonn and Sperling, Daniel, 2016. Moving beyond alternative fuel hype to decarbonize transportation. *Nature - Energy*, 13.

As Melton et al remind us, George Bush Jr announced methanol vehicles by 1996, George Bush Sr demanded large numbers of biofuel cars by 2012 and President Obama declared that America would have one million electric cars by 2015. None of these things happened and by 2014, American cars were still virtually all using fossil fuels (there are some niche hybrids and some cars that use 10% biofuel and 90% petrol – both rely for most of their energy on fossil fuel). According to the authors, responsible for these bubbles of fuel hype, which do not lead to decarbonisation of transport, are two actors: the car industry, which pretends that 'the solution' which will "de-problematise" their problematic product is just around the corner, and politicians. For their analysis, the authors assess articles written by the *New York Times* from 1980 to 2013 about alternative fuels. This investigation leads to four waves of hype in this time period: 1) the first electric car hype in the 1990s (California); 2) the hydrogen hype from 1999 onwards, when the US Department of Energy increased hydrogen research funding by a factor of five; 3) the biofuel hype ca. 2004-2008 and 4) the second electric car hype from 2005 onwards.

Polimeni, John; Mayumi, Kozo; Giampietro, Mario and Alcott, Blake, 2008 eds. *The Myth of Resource Efficiency: The Jevons Paradox*. London: EarthScan.

In this book the authors provide an historical literature review of studies on the Jevon's paradox and a synopsis of empirical evidence for the Jevons' paradox on fuel efficiency. Their discussion returns frequently to fuel efficiency in fossil fuel cars.

Ruef, Annette, and Markard, Jochen, 2010. What happens after a hype? How changing expectations affected innovation activities in the case of stationary fuel cells. *Technology Analysis & Strategic Management*, 22 (3), pp. 317–338.

This article identifies conferences, R&D projects, public funding, academic articles published and media reports on stationary fuel cells in Germany from 1993-2005. In their analysis of content, the authors determine that the primary narrative frames employed were initially "revolution", then "climate change", policy and energy supply and finally "market and economy". It is concluded that while some media reports remained positive, the rather grand expectations were dialled down. Institutions and funding that may have emerged or been granted during the hype phase can carry the technology even after the hype.

10. Built environment and transport

See also subsection 2.1. 'Walking and walkability'.

Roads, airports, motorways and Pete Seeger's 'Little Boxes'[41] of suburban sprawl could be considered the stepchildren of transport. Mundane, banal, 'non-places', which we always pass (Augé, 1995). But then again, in 2015 the *New York Times* invited its illustrious readers to *"follow the international cool kids, local families and graying ravers to Klunkerkranich"*[42]... which is a car park of a shopping mall, with a decarbonising urban garden project (and bar) on top. This is what a social science and humanities perspective invites the reader to do in this area: take a second look.

This section concerns the built environment as it intersects with energy usage and transport decarbonisation. A fundamental aspect is how we design our towns and cities - topics explored in the first subsection - and urban sprawl, which may or may not lead to longer car journeys (Mees, 2010; Bart, 2010). Active policy measures to promote rail commuting from satellite towns are discussed by Cervero (1995), whereas Shove et al. (2015) highlight the ways urban planning (and thus the understandings and conventions of professional planners) may work to reinforce the car dependence of certain activities. The two-way, interactive, relationship between planning and transport use is again emphasised by Wegener (2013).

The second subsection focuses more closely on infrastructure for transport itself - roads, parking, cycle paths - and policies concerning such infrastructure. A scholarly debate concerns whether road improvements cause an increase of driving or not, and whether roads can thus truly be considered a 'public good' (Dalakoglu and Harvey, 2012; see also Reid (2014) in subsection 8.2. on 'The historical electric car and replacing the animal'). Similar discussions to the question of road provision have been had regarding parking space provision and whether it leads to more driving (Kodranksy and Hermann, 2011; Merriman, 2016). Road tolls (Percoro, 2014) have been one policy tool employed in an attempt to decarbonise roads. Another, newer, policy designed to encourage fewer cars with only one passenger is high occupancy vehicle lanes (Chan and Shaheen, 2012). More recently, bicycles have achieved their own roads - cycle highways (Godefroij, 2011).

10.1. Designing towns and cities: land density and urban planning

Bart, István, 2010. Urban sprawl and climate change: A statistical exploration of cause and effect, with policy options for the EU. *Land Use Policy*, 27 (2), pp. 283–292.
This report, from an author at the European Commission, explores trends in land-use change across EU member states, and how this interacts with transport CO_2, GDP, and population. From the premise that *"growing demand for urban, car-based transport is a main driver in the growth of transport emissions"* (p. 283), this statistical analysis shows significant increase in transport emissions when 'urban sprawl' takes place. The report highlights the importance of transport-relevant policy in addressing climate change issues, as one of the most rapidly growing areas of emissions.

Cervero, Robert, 1995. Sustainable new towns: Stockholm's rail-served satellites. *Cities*, 12 (1), pp. 41–51.
Cervero's study explores the interrelations between *"land use patterns of Stockholm's new towns and the commuting choices of their residents and workers"* (p. 42). After giving an account of the past 50 years of Stockholm's rail network development, the author uses demographic data from across Stockholm's satellite towns to explore patterns of commuting. The notion of 'self-containment' is also discussed, that is, when people live and work in the same place, which has proven less successful than planners intended. Ultimately though, Cervero sees this as a positive example of effective promotion of rail commuting.

41   Seegers, Pete, 1963. Little Boxes (songwriter: Malvina Reynolds).

42   Wilder, Charly, 2015. 36 Hours in Berlin. *New York Times*. [online] 12 August Available at: https://www.nytimes.com/2015/08/16/travel/what-to-do-in-36-hours-in-berlin.html?_r=0 [Accessed 23 May 2017].

Hiltunen, Mervi Johanna and Rehunen, Antti, 2014. Second home mobility in Finland: Patterns, practices and relations of leisure oriented mobile lifestyle, *Fennia*, **192 (1), pp. 1–22.**

Hiltunen and Rehunen study transport to vacation or weekend homes in Finland. Around 15% of all Finns own second homes and a higher percentage have access to one of these rural homes. According to the authors, one fifth of all domestic leisure travel in Finland is to the second home and, due to the rural location of the second homes, these trips are almost entirely by private car.

Holden, Erling, 2007. *Achieving Sustainable Mobility: Everyday and leisure time travel in the EU.* **Aldershot: Ashgate.**

In four different case studies, Holden assesses issues of sustainable transport with a focus on Norway. One chapter contains a comparison of different lifecycles of various fuels, another represents a case study of transport in Oslo, which concludes that both a reduction of cars is necessary and increased public transport, as the latter alone will not bring about the necessary emissions reductions. Another chapter analyses land use and urban sprawl. Holden finds that the relationship between land use, urban sprawl and travel is complex: having a garden for example reduces leisure travel (but increases land use). Holden finds that those living in the most densely populated areas of Norway do show low levels of daily travel, but also the greatest air travel. Overall, Holden argues for smaller compact towns rather than large cities. Based on the case studies Holden presents 14 theses for sustainable transport. One highlight from his findings concerns environmental attitudes and environmental travel behaviours - he identifies membership in an environmental NGO as correlated to a more polluting lifestyle, which he labels cognitive dissonance (see also Barr et al. (2011) in section 6. 'Flying and tourism').

Mees, Paul, 2010. *Transport for suburbia: beyond the automobile age.* **Earthscan: London.**

One of the central ideas in this book is that public transport can work even in low-density (and high car ownership) areas. This is illustrated through a number of examples, accompanied by stories of policymaker decision processes. Mees advocates a particular 'networking' approach to public transport planning, which promotes quick and convenient transfers between modes, but sees this as requiring a centralised approach. This, he argues, is often in opposition to privatisation and profit-maximisation trends.

Shove, Elizabeth; Watson, Matt and Spurling, Nicola, 2015. Conceptualizing connections: Energy demand, infrastructures and social practices. *European Journal of Social Theory*, **18 (3), pp. 274–287.**

This theoretical article concerns the notion of car dependence and impacts on energy consumption. The authors are known for their work on the reorganisation of 'social practices' – everyday activities such as shopping – for which the car may today be an integral part. They look at how car dependence emerges through the interconnections between infrastructure, everyday activities, and urban planning. The paper thus raises questions about *"planners' and designers' roles in shaping the material elements and arrangements of which multiple practices are constituted"* (p. 284).

Wegener, Michael, 2013. Land-use transport interaction models. In: Fischer, Manfred and Nijkamp, Peter, eds. *Handbook of Regional Science.* **Berlin: Springer. pp. 741–758.**

Wegener provides an overview of relevant research debates across transport planning, urban economics, and social geography, before focussing on the use of 'integrated models' in research. Such models account for the *interactions* between urban land use and transport use, rather than solely using one to predict the other. Wegener raises two questions currently debated by academics: whether equilibrium or dynamic models are most useful, and at what scales the models should operate.

10.2. Transport infrastructure: roads, parking and other places

Augé, Marc, 1995. *Non-lieux.* **London: Verso.**

Augé (also cited in subsection 4.1. 'How people use and experience public transport' for his ethnographic work on the metro) is a leading French anthropologist. In this classical work, he proposed the new term 'non-lieux' (or 'non-place') to describe accelerating places specifically designed to simply be passed through, and upon which we leave little mark. Examples are often transport-based, such as motorways or airports

(and hotels). These places of constant transition, Augé argues, are products of the 'supermodernity' (or 'surmodernité') period.

Chan, Nelson and Shaheen, Susan, 2012. Ridesharing in North America: Past, Present, and Future. *Transport Reviews*, **32 (1), pp. 93-112.**

Some cities in the United States have so-called High Occupancy Vehicle (HOV) lanes on the highway. These can only be used by cars with three or more occupants to bypass rush hour congestion. The practice is referred to as 'slugging' and the additional two people that the driver of the vehicle picks up are called 'slugs'. There are slug stops (slug lines) akin to bus stops (sometimes with signage) where the drivers pick up 'slugs'. Nelson and Shaheen provide a useful review of the evolution in ridesharing from carpooling in the second World War, up to the modern day usage of smart phone apps. They see significant potential for this practice to help improve congestion and tackle climate change issues, however they call for more research in the area.

Dalakoglu, Dimitris and Harvey, Penny, 2012. Roads and anthropology: ethnographic perspectives on space, time and (im)mobility. *Mobilities*, **7 (4), pp. 459-465.**

This article introduces a special issue on Roads and Anthropology. The authors propose roads as fascinating sites of research enquiry, raising questions about *"the moral complexity of establishing the infrastructures as a 'public good'"* (p. 460) and bringing together numerous levels of policy and financial regime (from the international to the local) into one site.

Godefrooij, Tom and van Goeverden, Kees, 2011. *The Dutch Reference Study - Cases of interventions in bicycle infrastructure reviewed in the framework of Bikeability*. **Delft: TU Delft Department of Transport and Planning.**

This report was undertaken in order to gain insights from Dutch pro-cycling policies and infrastructures for possible policy transfer to Denmark. Three case studies from across the Netherlands were chosen, as well as a review of more recent 'interurban cycling highways' – high quality bicycle routes of up to 20km length. The authors put forward a number of straightforward findings, such as that *perceptions* of safety and improved infrastructure are not fully reflected in decreased accidents and increased cycling, and that journey time is more important to travellers than journey distance. The highways are however seen as particularly suitable for electric bikes, which are increasing in popularity, rather than fuel and energy-free bicycles.

Hermann, Gabrielle and Kodransky, Michael, 2011. *Europe's Parking U Turn*. **New York: Institute for Transportation & Development Policy.**

In their report on developments in European parking policies, Kodransky and Hermann highlight the numerous goals parking policies may seek to achieve. These include reducing congestion (including from people searching for a space), as well encouraging mode shift in order to reduce pollution and carbon emissions, and making streets more 'liveable'. A review of numerous case studies of innovative parking policies across Europe are then provided. Four policy mechanisms are identified: charging, regulation, physical design, and outsourcing with performance based contracts.

Merriman, Peter, 2016. Mobility Infrastructures: Modern Visions, Affective Environments and the Problem of Car Parking, *Mobilities*, **11 (1), pp. 83-93.**

Merriman provides an overview of the history of parking in the UK. The first cars could not be locked, so had to be kept in garages. By the 1920s, cars began to be parked on the street. This led to complaints and by the 1940s, planners were trying to address what came to be known as the 'parking problem'. By 1958, coin-operated parking meters were installed, and in the 1950s and 1960s huge futuristic, brutalist (concrete) multi-storey car parks appeared. Car parks are an environmental and climate change issue in several respects: they encourage people to drive rather than use public transport, but there can also be issues with flooding, and they create heat islands. Therefore, in more recent years, some urban planners have moved towards smaller structures with grass and trees. Some cities have also adopted different parking costs for different car emissions.

Percoco, Marco, 2014. The effect of road pricing on traffic composition: Evidence from a natural experiment in Milan, Italy. *Transport Policy*, 31, pp. 55-60.

This work, from a transport economics and geography scholar, estimates the impact of road pricing in Milan on traffic volume and composition. Milan has particularly high levels of car ownership and pollution, amongst European cities. By comparing data during a short-term suspension of the road pricing with periods before and after Percoco quantitatively models the congestion charge's effects. Interestingly, he finds that *"environmental benefits of the [road toll] policy were limited by a substantial increase in the usage of motorbikes"* (p. 55), and thus a potential ineffectiveness of such policies which do not fully anticipate behavioural changes.

11. Institutions and stakeholders

Large segments of the transport decarbonisation literature focus on the consumer and their individual preferences, attitudes and rational or non-rational considerations of different transport modes. This approach can downplay institutional context, and active role of governments, local policymakers, corporations, international and civil society organisations, as well as power imbalances between these groups. This section covers research on precisely these - sometimes overlooked - actors.

Anderton (2017) analyses the role of the Bavarian state in weakening the EU's *CO₂ and Cars* directive (Regulation [EC] No 443/2009) for their car industry. Gulbrandsen and Christensen (2014) also examine this directive, but by comparing whether car corporations exerted greater influence through their national governments or by lobbying the European Commission directly. Both studies find that corporations had a significant input into the drafting (and weakening) of the road transport decarbonisation directives. Mikler (2005) compares car decarbonisation legislation in the USA, Japan and the European Union. He finds that while on paper the EU and Japan have more stringent legislation, emissions do not differ. He concludes that due to different institutional cultures, car corporations achieve non-decarbonisation in all three case studies, but through different means. Gössling et al. (2016) take a closer look at intraorganisational conflicts in the European Commission on transport decarbonisation, as well as member state foot-dragging on decarbonisation legislation. Lindenthal (2014) observes and charts the transport decarbonisation process at the international level in the context of the International Civil Aviation Organization (ICAO). Whereas Lindenthal focuses on the intergovernmental level of aviation decarbonisation policy, Marsden et al. (2014) examine local, city-level implementation of national UK transport decarbonisation targets, and Clemente and Gabbioneta (2017) assess the role of the media through its framing of car emissions test cheating.

All these studies emphasise the determining importance of corporate, government and EU stakeholders on transport decarbonisation and highlight that effective transport decarbonisation policy is hampered due to the dominance of economic growth.

Anderton, Karen, 2017. Understanding the role of regional influence and innovation in EU policymaking: Bavaria and Cars and CO2. *Environment and Planning C: Politics and Space.*
Through interviews with NGOs, German government officials, EU policy officers and the Bavarian representation to the EU in Brussels, Anderton assesses the influence the state government of Bavaria had jointly with the Bavarian car industry (BMW, Audi) on the content of the 2009 Cars & CO₂ directive. She delineates lobbying activities including events held and outreach by Bavarian MEPs. The primary finding is that some targets were chosen for BMW. The state government saw economic growth as more important than transport decarbonisation. Cf. Gulbrandsen (2014) in this section.

Clemente, Marco and Gabbioneta, Claudia, 2017. How does the media frame corporate scandals? The case of German newspapers and the Volkswagen diesel scandal. *Journal of Management Inquiry.*
We included this article as indicative of the dominance of economic growth over transport decarbonisation, in this case another stakeholder – the media. The authors conducted an analysis of the frames employed by four different German newspapers, two 'national' (Süddeutsche Zeitung and Bild) and two regional newspapers from the city in which VW is based in. They find only limited reporting on emissions and decarbonisation effects of the emissions cheating – instead large parts of the reporting focused on image issues for the corporations and economic growth.

Gössling, Stefan; Cohen, Scott Allen and Hares, Andrew, 2016. Inside the black box: EU policy officers' perspectives on transport and climate change mitigation. *Journal of Transport Geography*, **57, pp. 83–93.**
Taking the issue of the 'gap' between transport decarbonisation requirements for climate mitigation and real world policy implementation as their starting point, Gössling, Cohen and Hares conducted interviews with 12 officials from three European Commission Directorates-General (DG MOVE, DG CLIMA, DG ENV). They found that some of their interviewees in DG MOVE did not view emissions from transport as their prerogative, but rather as solely in DG CLIMA's portfolio. General deprioritising of transport

decarbonisation in favour of economic growth was highlighted, including fuel taxation exemptions for some growing sectors. The officers themselves saw the power of lobbyists over the DGs as problematic, including the fact that higher ranking officials had strong industry ties. The other DGs (CLIMA & ENV) criticised DG MOVE as being *"captured"* (p. 88) by lobby groups. A transport decarbonisation blind spot the officers identified was an overemphasis on planes, cars and technology and a search for magic solutions, which led to fuel hype (see subsection 9.3. 'Fuel hype and rebound effects'). The self-identified role of transport policy officers was mentioned as being related to transport supply increase.

Gulbrandsen, Lars and Raaum Christensen, Anne, 2014. EU Legislation to Reduce Carbon Emissions from Cars: Intergovernmental or Supranational Policy Making?. *Review of Policy Research*, **31 (6), pp. 503–528.**

In their research, Gulbrandsen and Christensen explore the drafting of the Cars & CO_2 directive and the influence industry had either directly (through direct lobbying of the European Commission) or indirectly (through lobbying of their national government). According to the authors, the directive was significantly watered down through direct intervention of especially the German government. Their analysis shows the policy process as a complex interplay between car industry, European Commission, national governments and transport NGOs like Transport & Environment. The governments with car manufacturers of smaller cars (Italy for example) pushed for stronger targets than those with larger cars (Germany) as they believed this would provide their national car industry an advantage over those who typically produce larger cars. *Cf. Anderton (2017) in this section.*

van Lier, Tom and Macharis, Cathy, 2015. Transport: Addicted to Oil. In Dupont, Claire and Oberthür, Sebastian, eds. *Decarbonization in the European Union: Internal Policies and External Strategies*. **Basingstoke: Palgrave Macmillan. pp. 115–136.**

In this chapter, van Lier and Macharis outline existing European Commission policy roadmaps in the context of transport, including the 2011 Low-Carbon Roadmap and the Transport White Paper. They proceed to outline four barriers to the effective implementation of a transport decarbonisation: a) rebound effects from different overlaps between transport and other policy areas, b) the policy implementation of split incentives and technological scale ups, c) the importance of the public understanding why policy measures are necessary (thus understanding that there is a problem in the first place) and d) institutional architecture including lobbyism.

Lindenthal, Alexandra, 2014. Aviation and climate protection: EU leadership within the International Civil Aviation Organization. *Environmental Politics*, **23 (6), pp. 1064–1081.**

Lindenthal gauges the leadership of the EU in the ICAO (International Aviation Organization) in working to achieve an inclusion of aviation in emissions trading. She concludes that while the EU was proactive in its support for a carbon price in aviation, the ICAO's largest other member states (Russia, the USA and China) did not follow this 'leadership'.

Marsden, Greg; Ferreira, Antonio; Bache, Ian; Flinders, Matthew and Bartle, Ian, 2014. Muddling through with climate change targets: a multi-level governance perspective on the transport sector. *Climate Policy*, **14 (5), pp. 617–636.**

Marsden et al. through interviews chart how local governments, NGOs and business in Leeds, Manchester, Glasgow and Edinburgh as well as European actors view implementation of UK decarbonisation targets established in the 2008 UK Climate Change Act. They find that economic growth trumps decarbonisation and that there are some institutional capacity issues especially due to defunding and the 'hollowing' out of the state. Their outlook is "*pessimistic*" (p. 632).

Mikler, John. 2005. Institutional reasons for the effect of environmental regulations: passenger car CO2 emissions in the European Union, United States and Japan. *Global Society*, **19 (4), pp. 409–444.**

Political scientist John Mikler analyses the effects of stringent and/or early CO_2 emissions legislation from cars for decarbonisation in this case study featuring the EU, Japan and the United States. Comparing regulations with actual emissions from cars, he concludes that what really matters is the relationship of the car industry with the relevant governments or agencies. While regulation is much stronger in Japan

and the EU than in the United States, they are similar in the less regulated United States. Mikler writes that while car companies co-draft policy in the EU and Japan, in the United States, which has a different institutional culture, they sue the government instead in order to stall legislation on fuel efficiency. The results are similar.

12. Social inclusion and ethics

On gender see also subsection 2.2. 'Walking and safety' and subsection 5.3 'What's next for personal transport'.

This section emphasises the importance of nuance. There is not one story, there are many. The subsections here concern how race and ethnicity, gender, wealth and poverty, rural living, old age and demographic change interlink with travel mode choice and thus carbon emissions. The final subsection also provides some religious and ethical perspectives on transport decarbonisation.

Examples of issues considered include why cyclists are predominantly White (Steinbach et al., 2011; see also Fishman et al., (2013) in subsection 3.2. 'Interventions to increase cycling'), and whether baby boomers fly more or less than previous generations (Shreshtra et al., 2016; Levin, 2009). Work on rural living looks at how remoteness is changed by the internet, how both the Welsh and Finnish countryside are becoming second home ghost towns, with implications for car carbon emissions (Hiltunen and Rehunen, 2014; Milbourne and Kitchen, 2014). Scholars also examine whether women's (Hanson, 2010) and sub-Saharan African (Pirie, 2009) travel modes might not be pioneer models for sustainable transport futures. Other articles provide ethical and religious reflections on climate decarbonisation (Melin, 2008; El Hanandeh, 2013).

Perhaps the most important point is that while all demographic groups contribute to transport carbon emissions (Carlsson-Kanyamma and Linden, 1999), policymakers should focus their interventions more on the most mobile and wealthiest (Brand and Preston, 2010): the top 10% emitted 43% of carbon through their travels.

12.1. Social differences

Brand, Christian and Preston, John, 2010. '60-20 emission' – The unequal distribution of greenhouse gas emissions from personal, non-business travel in the UK. *Transport Policy,* **17 (1), pp. 9-19.**
Geographers Brand and Preston evaluate travel pattern surveys from Oxford and surrounding rural areas. They find that 61% of all transport carbon emissions were produced by 20% of people. The highest 10% of travel emitters were responsible for a staggering 43% of emissions, whilst the bottom 20% of their sample produced only 1% of overall travel emissions. They recommend that policymakers concerned with transport decarbonisation target the top emitters. These top emitters tended to be in their 30s and 40s and had a higher income, whereas those with the lowest emissions were in lower income groups. Air and car travel were responsible for almost the same percentage of CO_2 emissions. People in rural areas drove the car more often, but those in central Oxford flew more. Company cars were driving 50% further than private cars. The authors conclude that *"Most of the increase in UK flights has come from wealthier individuals flying more. ..."* (p. 10).

Carlsson-Kanyama, Annika and Linden, Anna-Lisa, 1999. Travel patterns and environmental effects now and in the future: implications of differences in energy consumption among socio-economic groups. *Ecological Economics***, 30, pp. 405-417.**
The authors use travel data from 45,000 people in Sweden to compare the environmental impact of different genders and socio-economic groups. All socio-economic groups had travel emissions above the level deemed sustainable, and men in high income brackets used nine times more energy than this level. Cars were the dominant mode of transport for all groups. The most important determinants of travel distance were wealth and age - middle-aged people with the highest income travelled furthest and flew more than any other group. Women in all income groups used trains and other public transport more than men. Elderly people travelled least. Elderly women much less likely to have a driver's licence. Women's workplaces were closer to their home.

El Hanandeh, Ali, 2013. Quantifying the carbon footprint of religious tourism: the case of Hajj. *Journal of Cleaner Production*, **52, pp. 53–60.**

El Hanandeh attempts to calculate the carbon footprint of the 3 million people making the Hajj (pilgrimage to Mecca) each year. He finds that each pilgrim averages 60.5 kg CO_2 emissions per day of the Hajj, 60% of which is long haul air travel. The author suggests different avenues through which traditional conservation values in Hajj rituals could be strengthened by carbon neutrality.

Milbourne, Paul and Kitchen, Lawrence, 2014. Rural mobilities: Connecting movement and fixity in rural places. *Journal of Rural Studies*, **34, pp. 326–336.**

This geographical study provides an overview of travel in rural remote Wales based on interviews and surveys. Observing that rural spaces have long been socially constructed as 'stable' and immobile, and rural people are seen as having greater place-based attachments, Milbourne and Kitchen contrast this with depletion of the countryside due to young people moving away and instead second home owning city dwellers 'invading' and 'capturing' the place each summer. Milbourne and Kitchen highlight class differences in these developments. In their survey, they found that 40% believed the bus service had deteriorated in the previous five years, and 94% stated that a private car was essential to survival in the area - no one surveyed used the bus to commute. The authors were especially interested in the effect of the internet on rural marginalisation and travel. Facebook and Skype were mentioned as a way to 'meet' friends, as the nearest person may be 5 km away. A fast internet connection was deemed essential to being able to live and function in the area by almost 60% of people, yet many areas did not have this yet.

Motte-Baumvol, Benjamin and Nassi, Carlos, 2012. Immobility in Rio de Janeiro, beyond poverty. *Journal of Transport Geography*, **24, pp. 67–76.**

In their study of immobility (very low levels of, or no, travel) in Rio de Janeiro, the authors find that immobility is higher than in European cities. In a 2002/2003 survey, nearly half of all residents said they hadn't left the house during the day. In Europe, this figure is between 10% and 26% depending on the country and city. Almost 60% of all trips by the poorest are made on foot, whereas in France even poorer households often still have access to cars. According to Motte-Baumvol and Nassi, poverty leads to immobility because travel often costs money but expenses at the destination can also be avoided if one does not travel. Poverty and unemployment are linked and this study found unemployment a much better predictor than poverty for immobility.

Shrestha, Birendra; Millonig, Alexandra; Hounsell, Nick and Mcdonald, Mike, 2016. Review of Public Transport Needs of Older People in European Context. *Journal of Population Ageing*, **pp. 1–19.**

This is a review of results of the European Commission's *Growing Older and Staying Mobile* project. The EU's population over 65 will double from 2010 to 2060 (to 152.6 million people). The study found that after the age of 55 car use continuously declines and older people reduce their travel, walk more and take more public transport. The authors identify five different types of transport user over the age of 65 and delineate their public transport needs, with a focus on buses and bus stop facilities such as real time travel information. Older people are more strongly affected by poverty, therefore affordable fares are recommended. Trip reasons and frequency also change in old age, especially after lifechanging events such as children moving out, retirement, divorce, birth of grandchildren, death of spouse, illness. Men travel more than women.

Sirén, Anu; Hjorthol, Randi and Levin, Lana, 2010. Mobility in different generations of older persons: The development of daily travel in different cohorts in Denmark, Norway and Sweden. *Journal of Transport Geography*, **18 (5), pp. 624–633. Special issue: "The mobility of older people".**

This cohort analysis of travel among babyboomers in Denmark, Norway and Sweden found significantly higher car use and overall travel than previous generations at the same age, especially for women. Vacation and leisure travel was not reduced until quite a high age.

Steinbach, Rebecca; Green, Judith and Datta, Jessica, 2011. Cycling and the city: A case study of how gendered, ethnic and class identities can shape healthy transport choices. *Social Science & Medicine*, **72 (7), pp. 1123–1130.**

Although London is 40% non-White, and People of Colour (PoC) in London are less likely to own a car, the vast majority of London cyclists are White. The authors set out to find out - through almost 80 interviews

- why PoC in London do not see cycling as 'for them'. White people saw cycling as behaviour of educated wealthier left-wing people. They thus identified cycling as status symbol. This was the opposite for many PoC and poorer people, who instead saw *cars* as a status symbol and associated cycling with poverty. For some PoC, cycling was seen as 'inappropriate' for women from their ethnic background. Black women cyclists were dismayed that media representations of Black people cycling weren't available – further cementing it as 'for White people'.

Vinz, Dagmar, 2009. Gender and Sustainable Consumption – A German environmental perspective. *European Journal of Women's Studies*, **16 (2), pp. 159–179.**

Vinz's article in a section on gender and mobility in this article provides different reflections on women's travel patterns. She asserts, amongst other things, that women are less likely to own a car, drive shorter distances per year and - if they do drive - one fourth of trips are for care work, whether for elderly relatives or children.

12.2. Reframing debates on social differences

Hanson, Susan, 2010. Gender and mobility: new approaches for informing sustainability. *Gender, Place & Culture*, **17 (1), pp. 5–23.**

Hanson criticises scholars who identify women's lower mobility as negative and automatically akin to less civic participation. While this may be the case for example for women being prohibited from driving in Saudi Arabia and women 'everywhere' being told to be careful when travelling after nightfall, Hanson emphasises that women's lesser in general, and less car-focused, mobility supports transport decarbonisation.

Levin, Lena, 2009. Mobility in Later Life: Time, Choice, and Action in Vannini, Phillip, ed. *The Cultures of Alternative Mobilities: Routes Less Travelled*. **Farnham: Ashgate, pp. 141–159.**

Levin presents the findings of interviews and participant observation with elderly people in Sweden. She criticises research which divides older people into patronising brackets which overemphasise frailty and according to her derive more from the authors' social construction of older people rather than their real life travel patterns. Her research (extending earlier work, see Sirén et al. (2010) in subsection 12.1. 'Social differences') found that almost half of people over the age of 65 never use public transport for their everyday mobility, and use planes, coaches and high speed rail for vacations. Overall, public transport use by older people in Sweden has decreased in the last 20 years. Levin warns "*Older people are believed to slow down and carry out fewer trips per day compared to younger people, but such knowledge is inaccurate and partly based on past practice*" (p. 147).

Mattioli, Giulio, 2016. Transport needs in a climate-constrained world. A novel framework to reconcile social and environmental sustainability in transport. *Energy Research & Social Science*, **18, pp. 118–128.**

Using data from the UK, this study examines tensions between ensuring fair levels of access to transport, and achieving a rapid reduction in transport emissions and energy consumption in developed countries.

Melin, Anders, 2008. Travelling as pilgrimage: ecotheological contributions to mobility ethics. In: Bergmann, Sigurd, ed. *Spaces of Mobility: Essays on the Planning, Ethics, Engineering and Religion of Human Motion*. **London: Equinox. pp. 81–100.**

Melin suggests that for decarbonisation and sustainability, travel should be 'resacralised', using the idea of a pilgrimage as metaphor: "*Because it can function as a contrasting image to our current ideal of high-speed and effortless transportation, it can help us rethink what mobility can and should be. … Contrary to the ideal of effortless transportation, a pilgrimage is normally connected with certain physical difficulties that the pilgrim has to endure*" (p. 93).

Mullen, Caroline and Marsden, Greg, 2016. Mobility justice in low carbon energy transitions. *Energy Research & Social Science*, **18, pp. 109–117.**

Mullen and Marsden look at the relationship of mobility with social justice in the context of sustainability policies. Their assessment includes the lack of affordability of low emission vehicles and the justice implications of policies geared towards that approach.

Pirie, Gordon, 2009. Virtuous mobility: Moralising vs measuring geographical mobility in Africa. *Afrika Focus*, 22, pp. 21–35.

Pirie, a historian and geographer based at the University of Cape Town, wonders whether sub-Saharan Africans couldn't be viewed as pioneers in moving toward low carbon travel. He points to privileged tourism patterns as typical in their promotion *"of Africa as an unencumbered playground for mobile and leisured foreigners"* (p. 23) and asserts that *"An uncritical media entrenches glorification of unencumbered fast-car mobility and even depends on doing so: motor vehicle manufacturers and private sellers account for a significant share of advertising revenue"* (p. 28). He puts forward that road provision has too often been about corrupt vanity projects in sub-Saharan Africa and the export of outdated technology as 'development aid'. He furthermore contends that there are negative effects of mobility such as the spread of pandemics, or unemployment and deskilling (for those involved in more labour intensive forms of transport).

Schwanen, Tim, 2017. Geographies of transport III: New spatialities of knowledge production?. *Progress in Human Geography*.

Schwanen provides an overview of how transport concepts and research have moved around the world. He discusses three categories: 'transfer', 'mobility' and 'worlding'. Transfer involves the uptake of Western transport concepts in the Global South including car-dominance in India and high speed rail effects in China. Mobility considers how Western theories have been adapted in Africa, South America or Asia, such as research on commuting in China, within the Communist system. He references a study looking at childcare impacts on women's transport in Nanjing (China). Worlding relates to transport research that directly challenges Western viewpoints. As one example, according to Schwanen, the Mobilities paradigm (see also section 13. 'Paradigms and transport research') is not applicable to rural sub-Saharan Africa.

13. Paradigms and transport research

This section contains work on research paradigms commonly used in Social Science and Humanities (SSH) research on transport decarbonisation: theoretical frameworks for viewing, or seeking to understand, the world. Such frameworks are intimately related to which questions one seeks to answer, what methods one chooses to use, and ultimately the kinds of answers you might get out of the research process. It is important to note that different schools of thought in research will advocate different paradigms, and these may not be complementary. For every researcher endorsing a specific framework, there will likely be several colleagues debating with her or him at academic conferences on its relative merits or downsides. Since they often focus on more abstract ideas (rather than presenting new data from studies), and may require some knowledge of ongoing scholarly debate, some of the papers presented here may be less accessible to the non-expert.

As has been the case throughout this bibliography, our purpose is not to present a comprehensive view of all research paradigms in SSH work on transport. Instead, we highlight debates about a few common paradigms, as follows:

1. Multi-Level Perspective (sociotechnical transitions) - as pioneered by Geels (see subsection 8.2. 'The historical electric car and replacing the horse'), which is used to research the uptake of innovations and societal responses to technology transitions. It has often been used to explore transport transitions. It is critically explored in Whitmarsh (2012) in this section.

2. Mobilities paradigm - introduced by Miriam Sheller and John Urry (2006) and referenced in this bibliography multiple times, which explores how mobility and movement are central to our modern world. This section contains the founding article itself, and work critiquing it can be found elsewhere in the bibliography (see Pirie (2009) in subsection 12.2. 'Reframing debates on social differences');

3. Sociotechnical imaginaries - developed by Sheila Jasanoff and Sang-Hyun Kim[43]. This paradigm seeks to unearth underlying constructions of and assumptions about the nature of progress, the public good and purpose of technology. (In this bibliography see also Wentland's article (2016) in subsection 5.4. 'Electric vehicles');

4. Theories of practice – these move our attention from *individuals* to the *practices* which they perform. By considering how practices themselves are organised and reproduced by society, and how they evolve over time, we might better understand how to change them. They are discussed by leading thinkers in the area: Shove (see 10.1. 'Built Environment and transport') and Watson (2012) in this section, primarily in the context of energy demand;

5. Behavioural Economics and Psychology – this large body of work seeks to better understand individual behaviour, from a number of angles. Behavioural Economics focuses on rational utility maximising when making a choice between different options, with some caveats. Many psychological approaches focus on identity, attitudes towards a specific transport mode and how belief systems' impact on transport mode. From this perspective, it may be the role of researchers to identify barriers to action, test incentivising or nudging strategies, and document reasons for 'irrational' decision making. Their similar point of departure in trying to pin down the process of individual decision making leads Avineri (2012) to compare and contrast the two. Other common psychological paradigms employed in transport decarbonisation research include the Theory of Planned Behaviour[44], the Norm-Activation Model[45] and the ABC (Attitude, Behaviour, Context) model[46]. The Theory of Planned Behaviour relates intended

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43   Jasanoff, Sheila and Kim, Sang-Hyun, 2009. Containing the atom: Sociotechnical imaginaries and nuclear power in the United States and South Korea. *Minerva*, 47 (2), pp.119-146.

44   Ajzen, Icek, 1985. From Intentions to Actions: A Theory of Planned Behavior. In: Kuhl, Julius, ed. *Action Control: From Cognition to Behavior.* Berlin: Springer, pp. 11-18. See also Ajzen, Icek and Fishbein, Martin, 1977. Attitude-behavior relations: A theoretical analysis and review of empirical research. *Psychological Bulletin*, *84* (5), pp.888-918.

45   Schwartz, Shahlom, 1977. Normative influences on altruism. *Advances in Experimental Social Psychology*, 10, pp. 221-279.

46   Stern, Paul, 2000. New environmental theories: toward a coherent theory of environmentally significant behavior. *Journal of Social Issues*, *56* (3), pp. 407-424.

behaviours to the perceived ease of behaving in that way, and norms. The Norm-Activation Model emphasises pro-environmental norms in decision-making. In the context of transport, the ABC model identifies internal (Attitude) and external factors (Context) and their impact on our mode choice.

Other papers in this section compare and contrast paradigms (Cairns et al., 2014), explore best practices (Gudmundsson, 2003), and highlight new methodologies (D'Andrea, 2011) or trends in methods (Schwanen, 2016).

Avineri, Erel, 2012. On the use and potential of behavioural economics from the perspective of transport and climate change. *Journal of Transport Geography*, Special Section on "Theoretical Perspectives on Climate Change Mitigation in Transport", 24, pp. 512–521.

Avineri provides an overview of psychological approaches and behavioural economics, exploring the differences and similarities between these two. He presents prospect theory, which combines behavioural economics and psychology insights. Prospect theory assumes that humans are more susceptible to negative impacts of their choices rather than positive ones. Behavioural economists do however acknowledge that humans miscalculate, especially the likelihood of something occurring. It therefore highlights nudging and information campaigns through individually tailored travel plans, for example. Avineri advocates against providing financial incentives for more decarbonised travel choices based on behavioural economics.

Cairns, Sally; Harmer, Clare; Hopkin, Jean, and Skippon, Stephen, 2014. Sociological perspectives on travel and mobilities: A review. *Transportation research part A: policy and practice*, 63, pp. 107–117.

This research, financed by Shell, provides an informative overview of four sociological paradigms concerning people and transport: (1) a focus on travel practices themselves, rather than individual travellers; (2) societal shifts including individualisation (divorce, smaller families) and the creation of one's identity through consumption; (3) car lock in, car 'tribes' and cultures (such as vintage car enthusiasts) and the car as symbol in our society; (4) the 'Mobilities' paradigm, including values and mobility, as well as new technologies and transport (example: ICT makes it easier to have far away friends which can lead to more long distance travel) and an emphasis on societal levels.

Creutzig, Felix. 2016. Evolving Narratives of Low-Carbon Futures in Transportation, *Transport Reviews*, 36 (3), pp. 341–360.

Creutzig analyses the underlying assumptions present in the three categories of low carbon transport models and scenarios he identifies. He refers to these three future imaginaries as (1) integrated assessment, (2) transport sector, and (3) place-based. Each assume different things about the world and belong to differing disciplines, levels and focus on disparate aspects of decarbonisation: integrated assessment is global, features primarily economical perspectives and focuses on fuel choice and technologies, transport sector imaginaries are developed by engineers and focus on infrastructure and efficiency and place-based scenarios are developed by geographers, are focused on local particularities, thus cannot easily be upscaled to the global level and concentrate on behaviours. He argues that taking all three paradigms into account will be most effective in leading to a larger transport decarbonisation.

D'Andrea, Anthony, Ciolfi, Luigina and Gray, Breda, 2011. Methodological challenges and innovations in mobilities research. *Mobilities*, 6 (2), pp. 149–160.

This article introduces a special issue on research methodologies from 'Mobilities' scholars, who *"by interlinking migration, transport and tourism studies … [address] emerging challenges and discourses concerning environmental, development, justice and security issues at local and global levels"* (p.150). The authors propose that advances in empirical (data gathering) and conceptual (theories about how to view the world) areas, have not been matched by advances in methodologies (critical reflections on how groups of methods are used). The special issue covers discussion of: video ethnography (observation), to allow scholars to study sensations of journeys in progress; collaborative multi-media artworks made with refugees by a performance studies scholar; changes in ethnographic practice, from working in single locations, to across multiple sites; and the critical questions raised when working with those who are forced to migrate.

Gudmundsson, Henrik, 2003. Making concepts matter: sustainable mobility and indicator systems in transport policy. *International Social Science Journal*, 55, pp. 199–217.

Gudmundsson provides an overview of six sustainable mobility definitions (from organisations including the OECD and the Canadian government) and the indicators used to assess them. He constructs a best practice indicator system, advocating that such systems should: (1) be comprehensive, and include developments over time; (2) include causal factors, and estimate environmental impact; (3) link to measures of environmental pressure; (4) track progress against policy aims; (5) enable this information to be fed into the policy process.

Schwanen, Tim, 2016. Geographies of transport II: Reconciling the general and the particular. *Progress in Human Geography*, pp. 1–10.

In this article on changes in methodology in transport research, Schwanen discusses the current and future effect of big data, from mobile phones, swiping travelcards, to bike sharing docks, being employed as source for transport research. Schwanen is concerned about this as it misses many aspects in favour of generalisations: Schwanen cautions that gender and race are made invisible, as it is not a data point. He foresees a problematic turn towards the positivistic (the idea that there is one reality for all, which can be observed) and quantitative methods in research.

Sheller, Miriam and Urry, John, 2006. The new mobilities paradigm. *Environment and Planning A*, 38 (2), pp. 207–226.

In their seminal article, Sheller and Urry critique social sciences as thus far being too static and 'sedentarist' (p. 209) to account for 'modern times': *"All the world seems to be on the move. Asylum seekers, international students, terrorists, members of diasporas, holidaymakers, business people, sports stars, refugees, backpackers, commuters, the early retired, young mobile professionals, prostitutes, armed forces. These and many others fill the world's airports, buses, ships, and trains. The scale of this travelling is immense."* (p. 207). They outline theoretical foundations for a new paradigm. These influences include previous scholarship by Simmel[47], the 'spatial turn' in social sciences, SSH research that focuses on the affective nature of transport, citing Schivelbusch (see subsection 4.1. 'How people use and experience public transport'), research on social networks and dynamic systems. Methods suggested for this new paradigm are mobile ethnography, time-space diaries, online research, multimedia methods and the analysis of travel objects such as souvenirs.

Stephenson, Janet; Hopkins, Debbie and Doering, Adam, 2015. *Conceptualizing transport transitions: Energy Cultures as an organizing framework*. Energy and Environment, 4 (4), pp. 354–364.

In this insightful article, the authors provide a model for societal energy and carbon lock in factors. These reinforcing issues which may prevent or facilitate a meaningful carbon transition in transport are norms, practices and the material culture of a given society.

Whitmarsh, Lorraine, 2012. How useful is the Multi-Level Perspective for transport and sustainability research?. *Journal of Transport Geography*, 24, pp. 483–487.

This accessibly written paper discusses the popular Multi-Level Perspective (see also Geels (2005) in subsection 8.2. 'The historical electric car and replacing the animal'). The Multi-Level Perspective (MLP) distinguishes between three levels in the innovation process: 'niche' (small-scale actors), 'regime' (current norms) and 'landscape' (wider societal factors). MLP offers a framework for considering how e.g. technologies move between these levels. Whitmarsh reflects on what the MLP does well, and what it may not capture. For example, the MLP was developed in the context of travel changes which *increased* consumption, rather than reduced it – how suitable is it then for helping to stimulate sustainable transitions? She suggests insights from a number of other literatures (from habits and norms, to practices) that the MLP could work to integrate further.

Watson, Matt, 2012. How theories of practice can inform transition to a decarbonised transport system. *Journal of Transport Geography*, 24, pp. 488–496.

In this paper, Watson addresses two criticisms of Theories of Practice (ToP) in their ability to help address sustainability transitions in transport. These criticisms are firstly that ToP are not well able to capture change

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47   Simmel, Georg, 1997. *Simmel on Culture*. Frisby, David and Featherstone, Mike, eds. London: Sage, (originally published in 1918).

processes (they are said to be better at conceptualising stability), and secondly that they tend to focus attention on the micro-level details of 'doing' something, rather than the wider systems of which the practices are a part. Watson argues that understanding the dynamics of how practices relate to other practices (as part of a system) is key to understanding change. As such, he recommends that we look beyond the individual performances of practices by 'consumers', as part of considering the interconnections between professional practices and everyday domestic practices: *"practices recruit carriers* [people who perform and reinforce/evolve them] *in board rooms, the physical spaces of futures trading and government offices as much as they do on streets and in homes"* (p.496).

Appendix: methods for this bibliography, journals

Methodology

Searching: Initially, google scholar searches were performed for the top 2 to 5 highest ranking journals (depending on their geographic location and focus) across the wide range of disciplines covered by the SHAPE ENERGY project. However, the most relevant literature was still found in transport-specific journals, pointing to a 'silo-isation' of transport. Then a general google scholar search with certain terms was done as well as searches in academic journal databases (Taylor and Francis, Wiley, ScienceDirect, Elsevier etc). Some of these were more helpful than others as for example Taylor and Francis explicitly allows a selection of only articles coded 'Humanities' or 'Social Science' whereas the disciplines for google scholar are quite different and some of the journal databases (e.g. Wiley) do not allow a search by discipline. ScienceDirect automatically recommends the top 3 articles most often read together. The *Transport Research Board Database*[48] proved particularly helpful.

Search terms: Search terms employed were "transport" to see what came up in general, "transport" and "low carbon", "transport" and "decarbonisation", "transport" and "energy", "sustainable transport", "transport" and "emissions", "transport" and "climate change", "mobility". Additionally mode-specific and cross-cutting theme specific searches were performed (examples: "freight", "cargo", "gender" or "fuel").

Search terms are highly discipline and time sensitive - decarbonisation and low carbon are the newest terms. Sociology uses "mobilities" more often (but note: "social mobility" came up more frequently) and tourism scholars prefer simply "travel" or "flying". Anthropology contrasted "mobile" with "sedentary people". Whilst walking and cycling are the transport modes that use the least energy and are most decarbonised, this was not found to be a frequent SSH paradigm. Instead policy walking and cycling interventions are addressed from a health paradigm. Similarly, large parts of non-economic public transport SSH focuses on the experience of the public transport. It was therefore decided to focus on issues related to possible mode switch and mode choice and decarbonisation implications for these transport modes.

Inclusion/exclusion: Economics research was de-emphasised, as were books and PhD theses due to access and time issues. Citation figures were taken into account. However, newer research will automatically have a very low citation count. In order to be able to ascertain an at least somewhat more balanced gender ratio than citations alone will achieve, first names were noted in the abstracts titles. Disciplinary diversity was stressed, inter alia in the section 12. 'Social inclusion and ethics'. It was found that many transport-related articles do not identify the discipline of the authors, an unexpected challenge. Meta-studies were given preference over studies with a less robust evidence base.

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48   http://www.trb.org/Main/Home.aspx

Journals

Climate-relevant journals employed here:

1. Climate Policy
2. Journal of Cleaner Production
3. Journal of Environmental Psychology
4. Energy Policy
5. Environmental Politics
6. Future Cities and Environment
7. Global Environmental Change

Transport Journal Rankings:

http://www.scimagojr.com/journalrank.php?category=3313

Transport-specific journals:

1. Applied Mobilities
2. Aviation
3. Case Studies on Transport Policy
4. Cities
5. Economics of Transportation
6. European Journal of Transport and Infrastructure Research
7. European Transport Research Review
8. International Association of Traffic and Safety Sciences (IATSS) Research
9. International Journal of Rail Transportation
10. International Journal of Sustainable Transportation
11. International Journal of Transportation Science and Technology
12. Journal of Intelligent Transportation Systems
13. Journal of Modern Transportation
14. Journal of Public Transportation
15. Journal of Sustainable Mobility
16. Journal of Rail Transport Planning & Management
17. Journal of Transport Economics and Policy
18. Journal of Transport Geography
19. Journal of Transport & Health
20. Journal of Transportation Technologies
21. Land Use Policy
22. Maritime Economics & Logistics
23. Maritime Policy & Management
24. Mobilities
25. Mobility in History
26. OECD Transport
27. Public Transport
28. Research in Transportation Business & Management
29. Research in Transportation Economics
30. Technological Forecasting & Social Change

31. Transfers: An Interdisciplinary Journal of Mobility Studies
32. Transport Policy
33. Transportation and Land Use
34. Transportation Letters
35. Transportation Planning and Technology
36. Transportation Research Record
37. Transportation Reviews
38. Transportation Research Part A: Policy and Practice
39. Transportation Research Part B: Methodological
40. Transportation Research Part C: Emerging Technologies
41. Transportation Research Part D: Transport and Environment
42. Transportation Research Part E: Logistics and Transportation Review
43. Transportation Research Part F: Traffic Psychology and Behaviour
44. Transportation Research Procedia
45. Transportmetrica A: Transport Science
46. Transportmetrica B: Transport Dynamics
47. Travel Behaviour and Society
48. Urban, Planning and Transport Research
49. Urban Rail Transit
50. Vehicular Communications
51. World Transport Policy & Practice

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