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Low Carbon Innovation in Chinese Urban Mobility: Prospects, Politics and Practices

David Tyfield, Dennis Zuev, Ping Li and John Urry

E-Mobility

LOW CARBON INNOVATION IN CHINA
中国低碳创新

China Low Carbon Report 3

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LOW CARBON INNOVATION IN CHINA 中国低碳创新

Low Carbon Innovation in Chinese Urban Mobility: Prospects, Politics and Practices

China represents a test-case of global significance regarding the challenges of urban mobility transition to more sustainable models. The country not only suffers the effects of air pollution, urban gridlock and more, but also is the site of significant government and corporate innovation efforts focused on the development of electric vehicles (EVs). At the same time, the lower-technology electric two-wheeler (E2W) has emerged as a global market entirely dominated by small Chinese firms and their Chinese customers. This report explores the relevant literature around urban electric mobility transitions in China and describes the project's research approach, arguing that, despite the disappointment to date regarding EVs, the evidence shows a highly dynamic and geographically diverse situation in China, yet one in which a successful urban mobility transition as currently envisaged remains improbable.

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About China Low Carbon Reports

The project 'Low Carbon Innovation in China: Prospects, Politics and Practice' is led from Lancaster University and is a collaboration between British and Chinese researchers to investigate different models of innovation and their potential role in low carbon transitions. The China Low Carbon Reports detail the project's activities and findings in order to inform research and policy at national and international levels. Further information on this STEPS Centre affiliate project is available on the website **http://steps-centre.org/project/low-carbon-china/**

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71 Low Carbon Innovation in Chinese Urban Mobility: Prospects, Politics and Practices

72 Pathways Towards Sustainable Maize Production and Consumption in China: Prospects, Politics and Practices

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Contents

Figures

Tables

Boxes

Acronymns

AQI	Air Quality Index
BEV	Full Battery Electric Vehicle
CCP	Chinese Communist Party
CLR1	China Low Carbon Report 1
EIA	Environmental Impact Assessment
EU	European Union
EV	Electric Vehicle
E2W	Electric Two-Wheeler
FCEV	Fuel Cell Electric Vehicle
FT	Financial Times
FYP	Five Year Plan
HEV	Hybrid Electric Vehicle
GHGs	Greenhouse Gas Emissions
IEA	International Energy Agency
ICE	Internal Combustion Engine
LEV	Light Electric Vehicle
IMF	International Monetary Fund
MEP	Ministry of Environmental Protection (China)
MGI	McKinsey Global Institute
MITT	Ministry of Industry and Information Technology
MOST	Ministry of Science and Technology
NBS	National Bureau of Statistics of China
NDRC	National Development and Reform Commission of China
NGO	Non-Governmental Organisation
OICA	International Organization of Motor Vehicles Manufacturers

PBL	Netherlands Environment Assessment Agency
PX	Paraxylene
RAEng	Royal Academy of Engineering
R&D	Research and Development
RDD&D	Research, Development, Deployment and Diffusion
SASAC	State-owned Assets Supervision and Administration
SATNAV	Satellite Navigation
SEZ	Special Economic Zone
SOE	State-Owned Enterprises
SPRG	Sustainable Practices Research Group
TNC	TransNational Corporations
UK	United Kingdom
UNDP	United Nations Development Programme
US	United States
WTO	World Trade Organization

Abstract

China represents a test-case of global significance regarding the challenges of urban mobility transition to more sustainable models. On the one hand, transportation accounts for approximately one quarter of global greenhouse gas emissions (GHGs). China is globally central to 'greening' mobility as already the world's largest car market but with significant further growth predicted. On the other hand, the growth of (fossil-fuelled) urban mobility is a key feature of the immense changes that have occurred since 1978 in China. Yet in both respects, the need for a change in the model of urban mobility is increasingly urgent, as manifest in issues of emissions and air pollution, urban gridlock and its social costs, and intensifying unrest around urban mobility issues. China, however, is also the site of significant government and corporate innovation efforts focused on opportunities for 'catch-up' in a key industry of the twenty first century around the electric vehicle (EV). At the same time, the much lower-technology electric two-wheeler (E2W) has emerged as a global market entirely dominated by small Chinese firms and their Chinese customers.

This is one of a series of four China low carbon reports outlining the STEPS Centre affiliate project 'Low Carbon Innovation in China: Prospects, Politics and Practice', led from Lancaster University. Taking a perspective that explores specific domains of low carbon innovation in China through the lens of changing power relations and associated social practices, this Working Paper provides an introduction to the e-mobility research package of the project, reviewing the relevant literature around urban electric mobility transitions in China and describing the project's research approach and potential contribution to knowledge in this area. It argues that, despite the disappointment to date regarding EVs, the evidence shows a highly dynamic and geographically diverse situation in China, but one in which a successful urban mobility transition as currently envisaged remains improbable.

Introduction

In the context of the urgent global decarbonisation of society, the UK-China research project 'Low Carbon Innovation in China: Prospects, Politics and Practice' is exploring the prospects of real-time qualitative low carbon system transition in China.[1] Breaking from the top-down and technologically-focused perspective of most studies to date in this crucial arena, this focuses particularly on changing *power relations* and *everyday social practices* and their complex interdependencies.[2] Such prospects and trajectories of socio-technical change are different across domains. The project is thus investigating three such domains, with urban mobility examined in this Working Paper.[3] China is a globally significant test-case regarding the challenges of transition to ecologically-sustainable and resilient models of future urban mobility.

While offering major new insights into this unfolding process, the costs of assuming an analytical lens of power relations and social practices is that it potentially opens up a sprawling set of issues, constitutive of changing socio-technical systems, that thereby becomes methodologically unmanageable. To focus the project's empirical work, therefore, a comparative frame has been adopted, investigating two key case studies in contemporary Chinese developments in the domain (here) of urban mobility transitions, namely new sociotechnical transformations around electric vehicles (EVs), and electric two-wheeler bicycles (E2Ws). These are prima facie opposites in many regards, including: the high- or low-tech 'imaginaries' behind them; the level of government support and hence the dominance or not of that model in official policy discourse; and, ironically, the inversely proportional evidence of success of each 'niche' to date. We compare the power relation dynamics within the diverse innovation networks in each case (Truffer and Dürrenberger 1997) to illuminate both: (1) how these different models are supported and constrained by evolving political debates and coalitions, including in China's changing policy-making environment concerning such innovation; and (2) how they relate to changing practices among various groups of producers and consumers, culminating in broader social change.

In comparing these two case studies, therefore, this paper provides an introduction to China's urban mobility innovation system, drawing out key lessons regarding e-mobility transition in China, including the three political economic geographies of innovation within China upon which the research will focus. The paper starts by first introducing the theoretical perspective adopted in this study and exploring the background and significance of e-mobility transition in China from this perspective. It then proceeds to explore the prospects, politics and practices for each case study in turn. In doing so, it considers first the imaginary dominant in current efforts at urban mobility transition of the electric car (Section 2), then the bottom-up, indigenous but low-cost and lower-technology socio-technical innovation of the E2W (Section 3), before finally drawing these threads together towards the end of the paper. While this paper is thus primarily an introduction to the case studies and the broader field

[1] We are grateful to the UK's Economic and Social Research Council (ESRC) for funding this project (ES/K006002/1), 2013-6. We are also grateful to our colleagues at CeMoRe, Lancaster and SPRU, Sussex for their comments and advice.

[2] For more on this overarching framework see 'China Low Carbon Report 1' – Overarching Introduction to the Low Carbon Innovation in China Project (Tyfield *et al.* 2014).

[3] See also China Low Carbon Report 2 (Urban and Geall *et al.* 2014) on Solar energy (PV and thermal); and China Low Carbon Report 4 (Ely *et al.* 2014)) on Agri-food innovation (focusing on maize).

of e-mobility transition in China, in further work we will developing the reciprocal insights for theories of system transition arising from this research.

1.1 Powering the global green transition

As we argue in depth in the China Low Carbon Report 1 (CLR1) (Tyfield *et al.* 2014), low carbon innovation and system transition is currently of paramount importance and interest to both policy and politics more generally. Yet even the most sophisticated literature has only dealt inadequately with the central role of power in the construction, constitution, shaping, and driving of such transitions. In seeking to rectify this gap, analysis tends also to take for granted political (and political economic and cultural) contexts that relate only in the regions where such scholarship tends to originate (the global North more broadly). This is especially problematic given the importance of the need for *global* low carbon transition, and of how states and socio-economies have strikingly different political contexts. In both its importance to global transition and the difference to the assumed norm of its political system, China is absolutely key.

However, in placing politics at the centre, we are not just referring to specific issues of political contention, let alone official policies and their implementation, such as innovation/industrial policy within the specific domains in question (agriculture, urban mobility, energy). Rather, we are concerned more broadly with the transformation and [re-]constitution of power relations, as evidenced in the transformations and reconstitution of nexuses of social practices (Reckwitz 2002; McMeekin and Southerton 2012; Shove *et al*. 2012) and associated group boundaries (Zietsma and Lawrence 2010) that constitute a given social formation. We thus study the *empowering*, and not just the shielding and/or nurturing, of specific 'niches' of innovation (Smith and Raven 2012), where these are taken as significant sites in which power relations are being actively remade, possibly with wider social implications. Our study is thus of embryonic low-carbon system transitions involving potential transformations of assemblages of sociotechnical-mediated power relations as they may play out in real-time.

Low carbon innovations can be understood as driving a broader shift at the 'level' of socio-technical regimes only to the extent that new coalitions of agents, institutions and artefacts are enabled – while other groups are disabled – regarding the strategic alignment of 'regime' (and even 'landscape') with pursuit of their interests and projects. And in both cases these are manifest through changing social practices and the social identities and norms that accompany these (Tyfield 2014a). Hence once low-carbon transition is conceptualised *as* a power transition, it entails researching the changing power relations associated with – conditioning and affected by – such low-carbon innovation, in multiple forms, sites and scales (local, sub-national, national, regional, global). This especially includes new consumer/user[4] collective identities and patterns of social stratification, as well as changing forms of the corporation that emerge in parallel with such innovations, and not just the official and informal structures of state policy-making. This working paper sets out an initial analysis of these processes regarding major e-mobility innovations within contemporary China.

1.2 China's environmental governance and the challenge of transition

The contemporary challenges of environmental governance in China are intense, complex and globally significant. As discussed in CLR1 (Tyfield *et al.* 2014), they must also be set within the context of the key tension of contemporary Chinese politics – especially where the trajectory and prospects of low-carbon transition are understood as a process of transforming power relations constitutive of a society

[4] The term 'user' is problematic in the context of our study (see e.g. Oudshoorn and Pinch 2003) but we stick with the term, while remaining cognizant of its shortcomings, due to the lack of clearly superior alternatives.

and of its political order. This tension results from the determination of the Chinese Communist Party (CCP) party-state to maintain the monopoly of legitimate political organisation, as against China's deepening encounter with global capitalism which is highly dynamic, changing in structure and facing ongoing challenges of stagnation/crisis/geopolitical epochal change. The latter is also a key pillar of the popular legitimacy of the former within China in securing high and continuing economic growth and improvement of individual/household consumerist life-styles.[5]

With regard to contemporary low carbon innovation politics in China this translates into two key issues, broadly, regarding the perspectives of 'producers' and of 'users' of innovations. On the one hand, given that innovation and technology is understood by the government as a key route towards the attainment of these twin goals and the balance between them, low-carbon innovation politics is characterised by a techno-nationalism-in-the-context-of-a-changing-global-political-economy (Zhao 2010). Crucial here too, therefore, regarding the propagation and implementation of 'techno-nationalist' policy, is the constitution of the state itself (Hughes 2007) and its 'fragmented authoritarianism', both vertical across scales/tiers of government and horizontal amongst ministries (see below). This includes questions regarding the 'entrepreneurial state' (Mazzucato 2013) and, conversely, the dangers and challenges of 'state-capture' by state-owned enterprises that are at the very least more powerful than local environmental protection bureaus (EPBs) (Jiang forthcoming). On the other hand, as Chinese society is changing in its encounter with global capitalism and globalising socio-technical novelty, a key arena of change in the contemporary bottom-up constitution of power relations and political sentiment and identities in China is the conjunction of emerging class discourses (especially regarding the rising so-called middle class(es)), and the politics of socio-technical knowledges, uncertainties and risk (see Tyfield 2014c; Curran 2013; Beck 2013; Han and Shim 2010). For instance, the prospects of specific low-carbon innovations depend upon 'consuming' these innovations. This, in turn, is a matter of the dynamic interaction of such innovations with practices and identities of consumerism and the cultural politics of their use and shaping, even *as* technologies (MacKenzie and Wacjman 1999). These, in turn, are likely to be pivotal in the formation of new (stratified) social identities. Concretely, the 'middle class(es)' now emerging in contemporary (urban) China are increasingly enabled and apparently turning from economic growth to greater 'quality of life' concerns. This connects to significant shifts both in the politics of pollution and environmental issues and, as putative users of emerging low carbon innovations, of socio-technical novelties and risks associated with attempts to deal with these problems (Li 2010; Zhou and Qin 2010; Han 2010; Chen 2010).

In light of these reflections, we turn directly to a brief consideration of environmental governance. China has a long history of widely differing approaches to the governance of its environment. These range from the era of 'Mao's war against nature', when numerous projects affecting the environment, such as hastily built dams and land reclamation schemes, were carried out with what Shapiro (2001) described as 'utopian urgency' and 'dogmatic uniformity', to China's eventual participation in the United Nations Conference on the Human Environment in Stockholm held in 1972. This turning point led to the establishment of China's first national environment agency, which later became the environment ministry.

China's centralised and integrated national Five-Year Plans (FYPs) continue to set the country's key strategic and economic priorities. In the first decades of the People's Republic, these emphasised ever-higher production targets in industries such as coal and steel. However, the Sixth FYP (1981-1985), at

[5] We note that equivalent pressures of legitimacy crises of contemporary state forms and political regimes are evident in the major polities of the liberal democratic global North, notably the US, EU and UK, and particularly since the global financial crisis of 2008. This is not, therefore, a challenge facing China alone.

the start of China's Reform Era, was the first to include an energy conservation programme. Around the same time, China passed the first of its many environmental laws and regulations, including the Environmental Protection Law (1979) and the Water Pollution Law (1984).

In the 1990s, sustainable development first became a theme in Chinese Government literature and the Ninth FYP (1996-2000) was the first to include it as a term (Geall and Pellisery 2012). The Fifteenth Party Congress in September 1997 listed the 'huge environmental and resource pressures caused by population growth and economic development', as major difficulties facing the nation (Meng 2012). In 2007, China's National Development and Reform Commission (NDRC), a key economic planning body, published the first national climate change plan developed within any developing country. This established China's commitment to addressing climate change mitigation and adaptation and participating in international cooperation with regard to climate change, while also upholding the principle of 'common but differentiated responsibilities' and integrating climate change into other policies for national and social economic development. Most recently, Xi Jinping's speech at the Third Plenum of CCP in 2013 encouraged the vision of an 'ecological civilization' where the mountains, water and forests are all regarded as a 'living community', but it proposed little substantive change through, for example, decarbonising transportation across China (Geall *et al.* 2014).

The prominence of the NDRC in climate-change policy helps to illustrate another feature of China's environmental governance, its vertical fragmentation due to the proliferation of competing and overlapping decision-making bodies. While in theory, China's Ministry of Environmental Protection (MEP) is the highest central government institution regulating the environment, other organisations will often take the lead on particular environmental issues. Rather than being a monolithic system, Chinese environmental governance at the elite level is characterised by 'fragmented authoritarianism' (Lieberthal 1992), protracted bargaining between bureaucratic units, including ministries, advisory bodies and top-level 'National Leading Groups' specifically established to coordinate cross-jurisdictional issues.

Furthermore, such vertical fragmentation is matched by horizontal fragmentation and thus splitting of responsibilities into myriad agencies, with overlapping power jurisdictions on various topics. The considerable devolution of power to the provinces and localities, first introduced in the early Reform Era, has created a complex arrangement often described by the Chinese metaphor *tiao kuai* (branches and lumps). Central government authorities often lack the capacity to demand enforcement of environmental laws and policies at the local level. Local environmental bureaus, for example, are funded by local governments, rather than the MEP, which means they tend to act in the interests of those very institutions they are tasked with regulating. Furthermore, economic targets often mean that local officials are rewarded politically by central government for achieving GDP growth, even if it comes at the expense of the local environment.

Over the past 15 years, a number of influential officials and policymakers at the central level have supported citizen oversight, media coverage and other forms of public participation by civil society in order to improve local enforcement of environmental regulations, for example, through laws and regulations like the Environmental Impact Assessment (EIA) Law (2002), transparency initiatives on open environmental information and innovations like Hotline 12369, a phone tip-off line for citizens to report pollution incidents and environmental violations operated by the Ministry of Environmental Protection. However, most institutional procedures for such public participation are vague and poorly enforced. Despite the flourishing of green NGOs, both registered and unregistered environmental advocacy is closely monitored and subject to periodic crackdowns (Economist 2014a). According to a 2012 Government report, there were a staggering 492,000 legally registered social organisations in China report, many being in some sense green.

However, concerns have increased about environment, health and food safety issues among China's growing middle class, with opinions expressed more freely and rapidly due to the near ubiquitous social media and messaging technologies. A successful protest by residents in the south-eastern Chinese city of Xiamen in 2007 opposed to a factory proposing to manufacture the petrochemical paraxylene (PX) began a trend of urban protests focused on the lack of transparency and accountability around potentially polluting developments. Since then, conflicts around, for example, the route of a Maglev train route in Shanghai in 2007, a petrochemical plant in Sichuan province in 2008, a copper refinery in Shifang, Sichuan, in 2012, and PX projects in Kunming and Maoming in 2013, suggest that environmental governance issues represent a new social and political challenge for government, and at the very least an unprecedented pluralisation of opinion regarding pathways to sustainability within China (Geall 2014).

1.3 Sustainability challenges in Chinese urban mobility

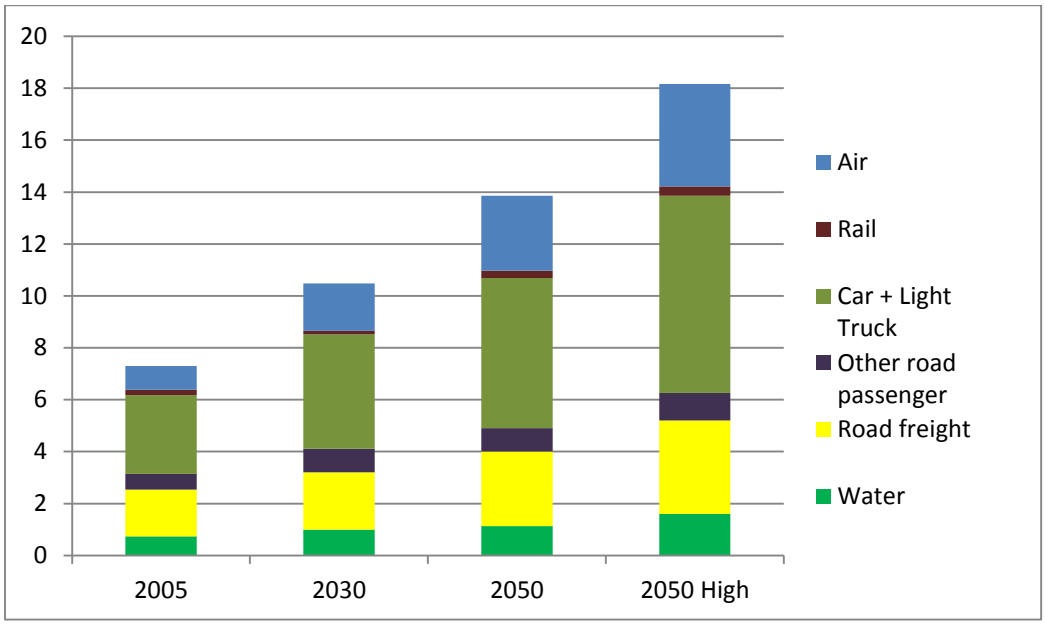
In turning to the specific issue of urban mobility, China represents a test-case of global significance regarding the challenges of transition to more sustainable models. On the one hand, transportation, which accounts for approximately one quarter of global greenhouse gas emissions (GHGs), is key to efforts to mitigate climate change and China is globally central to such a process. Mobility in the 'rich' global North, historically responsible for the lion's share of associated GHG emissions, has, it appears, stopped growing at the same rate. Transport-related emissions may be plateau-ing though actual decarbonisation is not yet in evidence. From 1990–2009 annual transport emissions rose, though relatively slowly. In the EU they rose from 0.8 to 1.0 Gt CO_2 and in the US from 1.4 to 1.7 Gt CO_2 (Schwanen *et al.* 2011; Lyons and Goodwin 2014 (on 'peak car')).

Conversely, growth of transport emissions is expected in large and fast-developing societies such as China and India, leading to significant growth at a global level (Figure 1.1). Since 2009 China has been the world's largest car market. Yet transport accounts for only about seven per cent of total emissions in China, as against 25.5 per cent for the EU or 31.1 per cent for the USA (IEA 2011). Similarly, transport emissions *per capita* were around only 0.3 tonnes CO_2 in 2005 in China compared with two tonnes in the EU and over six tonnes in the USA (Sentance, 2010). More recently, Chinese figures for overall emissions *per capita* have risen to EU levels (PBL 2013), but remain only one half of those in the US, even as China is already the largest absolute emitter of total GHGs, Indeed, it has now roughly double the overall emissions of the [second placed] US, having overtaken them only around 2007 (Economist 2014b). There are a comparatively small number of cars *per capita* in China, with much commensurate room for huge growth (see Figures 1.2 and 1.3). With the largest population and undergoing unprecedented urbanisation, this growth in China of machine-based mobility and associated emissions dominates overall global trends in automobility.

On the other hand, from the perspective of Chinese society, the growth of (fossil-fuelled) urban mobility is a key feature of the immense changes that have occurred, and are still continuing, since 1978. China, now central to the world economy, has in twenty-five years gone from a society predominantly based upon slow means of travel, especially walking, carts and cycling, to one based upon fast modes. This includes, especially, car and truck transport, but also high-speed trains, as well as slow moving oil tankers and container ships (French and Chambers 2010). The pace of growth in the last decade has been spectacular, despite the downturn of 2008/9 and even though the overall

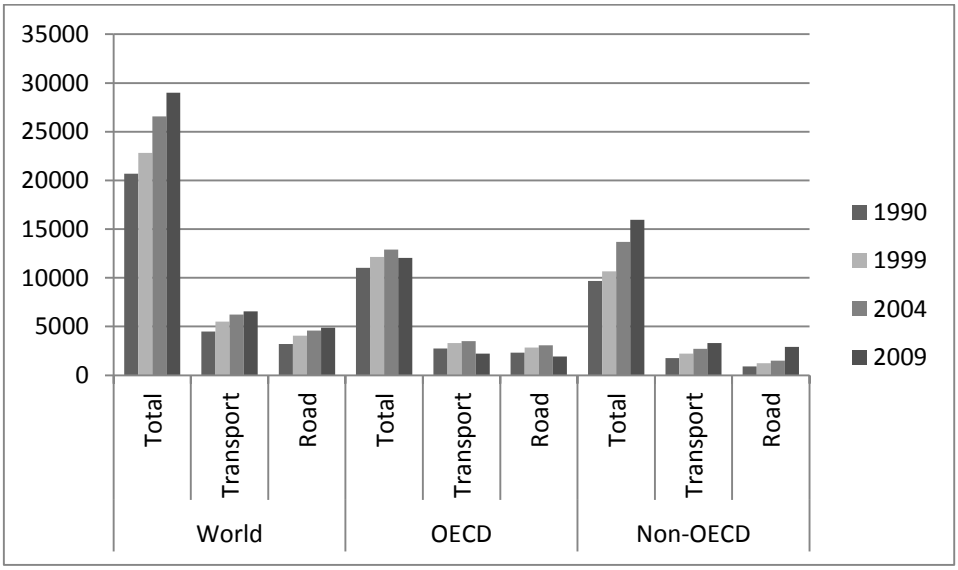
motorisation rate in China remains low compared with other large, developing (BRICS) countries, let alone the US or EU (to which levels of automobility China aspires).[6]

Figure 1.1: Projected Global Transport GHG Emissions ($MtCO_2$ per year)



Source: IEA (2008)

Figure 1.2: Total GHG Emissions ($MtCO_2e$)



Source: IEA (2001; 2006; 2011) ('Non-OECD' is dominated by China)

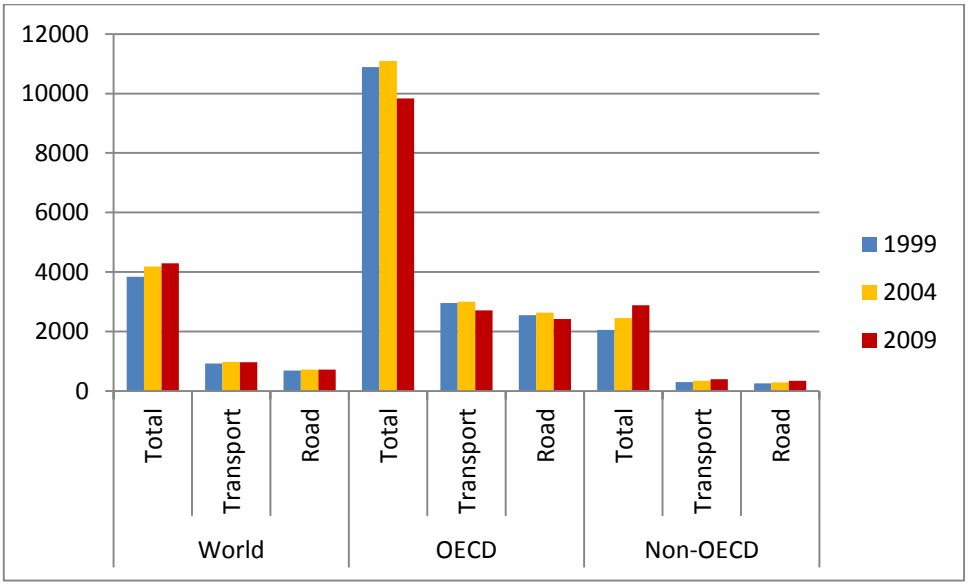
This automobilising transition in China is one of the fastest ever (Urry 2013). Cars in China increased from 9.2 million (2004) to 40.3 million (2010), the total number of vehicles from 27.4 million to 90.9 million (NBS 2005; NBS 2011), increasing more than six times between 2002 and 2013 to 137 million

[6] http://www.oica.net/category/vehicles-in-use/

(OICA 2013). Growth is expected to continue at 7/8 per cent *per annum* in the medium term (Sperling and Gordon 2009: 209). Future forecasts vary but they are unanimous with regard to enormous growth, with estimates ranging from 60 million cars by 2020 and 300 million by 2050 (Feng *et al.* 2004), to 100 million as early as 2015 (Chen *et al.* 2004, quoted in Winebrake *et al.* 2008: 217). The International Monetary Fund (IMF) estimated vehicle numbers in China would rise from 21 million in 2005 to 573 million by 2050 (Urry 2013). Another estimate sees cars growing tenfold 2005–2030, with oil consumption likely to increase from 110Mt to 500Mt per year (Watts 2009).

Furthermore, the number of private cars – as opposed to corporate or government fleets, taxis, public transport or freight – is growing faster at 22 per cent per annum. Cars are increasingly individually owned. China has become the top priority of car companies around the world. China's diversity of brands and makes of cars is eclipsing even that of the USA (Time 2014), with a staggering 647 models available from 111 brands. In these circumstances, one may ask whether this forward momentum of steel-and-petroleum cars can be slowed down even to a limited degree.

Figure 1.3: Per Capita Emissions (kg CO_2e per capita)



Source: IEA (2001; 2006; 2011)

Yet this 'car-ing' of Chinese society also constructs China as a test-case in the challenges of decarbonising urban mobility that face established 'car' societies in the global North, not just those of rapidly developing countries. Decarbonising urban mobility is not merely pressing but is also a 'wicked' set of intractable, huge and *system* problems. Indeed, automobility is arguably the 'hardest case' (Geels *et al.* 2013: xiii; Tyfield 2013) of low-carbon transition, and current efforts are at best a trickle, at worst stalling, still stuck in the garage! The system of automobility, 'automobile use and everything that makes it possible (Rajan 1996), is deeply locked-in and stabilised (Unruh 2000).

Indeed the automotive sector is still the most important global industrial sector (Mikler 2009), the 'industry of industries' (Dicken 2007: 278), accounting for vast employment and resource consumption worldwide and the 'paradigm case of globalized industry' (Paterson 2007: 98). As such, it is also a key policy focus on Chinese industrial policy, one of the country's four 'pillar industries' (Nolan 2004) and a totem in the broader top-priority policies of moving China 'up the value chain' towards 'indigenous innovation' (*zizhu chuangxin*) (Schwaag-Serger and Breidne 2007). In the late 1970s there had been just 56 small car plants producing 150,000 cars a year, mainly for Party and State officials (Thun 2006: 54). By 2013, Chinese production capacity was 31 million cars per year (Bradser 2011).

To these industries we must add the interlocking industries of car parts, road infrastructure, oil/gasoline, glass, rubber, fast food, motels, as well as government policies and (often hidden) subsidies and support, financial and insurance firms and practices, and the skills and competences involved and invested in cars (Wells *et al.* 2013: 124). Automobility also crucially depends upon, and is performed by, particular subjectivities, borne of affective experiences of driving, movement and mobility, and of being 'in the car' (Sheller 2004), social status and cultural politics particularly regarding consumerism and the association of cars with freedom (Paterson 2007). And, indeed, these issues of consumer politics and identity and everyday social practices (both of mobility itself and that construct demands for mobility) are also profoundly important, if still in-formation, within contemporary China and its efforts at mobility transition (see below).

Hence, while even within the past decade there have been hopes that China could 'leapfrog' the internal combustion engine (ICE) car to a cleaner and more efficient mode of urban mobility (Gallagher 2006; Altenburg *et al.* 2012; Rock *et al.* 2009), this now looks increasingly improbable. Instead, China is constructing, at exceptional pace, a system transition *to* ICE automobility, to the 'steel-and-petroleum' car (Dennis and Urry 2009). China's transformation *beyond* the 'car' is thus particularly challenging, as if seeking to change trajectory in mid-flight. Conversely, there is embryonic, evidence of 'peak car' and a generational shift of the already-automobilised 'West' with younger people less likely to hold a license and to own a vehicle (Cohen 2012; Lyons 2014).

Yet, the pressure towards a mobility transition being engineered within China is not merely from the global and abstract issue of climate change. On the contrary, the precipitous construction of automobility in China's cities is creating further problems demanding increasingly urgent domestic political attention. The key environmental issue presenting itself to the population within many Chinese cities is worsening air pollution, a problem caused not just by transport emissions, but it significantly worsenes as traffic continues to increase.[7] For instance, in February 2014, air quality levels of toxic gases and particulates in Beijing were consistently, 'more than 16 times the World Health Organization's recommended upper limit' (FT 2014). Similarly, US Embassy measurements of the 'air quality index' (AQI) between June 2013 and May 2014 in five major cities (Beijing, Shanghai, Guangzhou, Chengdu and Shenyang) show that, in all, measurements are regularly in excess of 'very unhealthy' levels, sometimes twice or even three times (in Beijing and Chengdu) these levels.[8] By marked contrast with GHG levels, this is an environmental 'crisis' that is palpable to everyone every day (FT 2014, quoting a WHO representative in China).

City rush hour traffic is increasingly faced with gridlock contributing further to the problems of air pollution as journeys take longer and the efficiency of emissions decreases. This has been mitigated to some extent by various regulations, usually at municipal or provincial level, mandating improvement in emission standards (e.g. Winebrake *et al.* 2008; Gallagher 2006); as well as limiting the number of cars allowed on the road in various ways (such as licence plate auctions in Shanghai and Guangzhou; in Beijing, daily limitations on vehicles based on their registration number along with a restricted lottery for new licence plates). There has also been a significant expansion of public transport, especially subway systems which have boomed across China in recent years (Economist 2013). Yet congestion continues to worsen, and not just in the country's top and second tier cities (e.g. provincial capitals) but increasingly across the country.

[7] E.g. http://www.ft.com/cms/s/0/cdea72f6-c494-11e2-9ac0-00144feab7de.html; http://www.ft.com/cms/s/0/d85d5066-9e03-11e3-b429-00144feab7de.html

[8] http://www.ft.com/cms/s/0/cdea72f6-c494-11e2-9ac0-00144feab7de.html

This worsening congestion is due to the equally rapid urbanisation of China, another epochal change in Chinese society and one inseparable from the political priority of economic growth. China's urban population now outnumbers its rural population for the first time.[9] It is thought that by 2030, one billion people, or nearly 70 per cent, will live in cities, adding a further 350 million urban dwellers to the current urban population (MGI 2009). The central government has announced ambitious plans to build 400 new cities by 2030, and so far the plans for establishing car-free eco-cities have been unsuccessful, being largely projects of land speculation for new elite suburbs (de Jong *et al.* 2013; Baumler *et al.* 2012; Chien 2013). Instead, these new Chinese cities are being organised around fast transport and extensive movement (between urban zones) for work, family life and leisure. Existing urban infrastructures are also being redesigned around the car system and its 'smooth passages', for instance with the elimination of bicycle lanes and of old, narrow streets in traditional areas. The expansion of new cities also raises key issues, both environmental and political, regarding land use change – in a country that already suffers from dramatic shortages of usable, non-polluted arable land – and land requisition (Chen 2013; see also WP4).

Finally, there is the issue of access to the key resource for automobility, oil (Urry 2013). China has recently experienced the 'peaking' of its own oil supplies and is increasingly scouring the world for new sources at precisely the moment when what remains is mainly 'tough oil', both geologically (deep water, shale, tar sands) and/or politically (Russia, Libya, the Persian Gulf, Nigeria). On this score, therefore, American car intensity would seem impossible to be realised within China since it would entail some 970 million cars in China and the consumption of 102 per cent of current world oil output (calculation using IEA 2011 and Winebrake *et al.* 2008: 216).

As such, China cannot *first* create a twentieth century automobility system and *then* deal with the ensuing problems of 'success'; what Beck (2008) would call the challenges of 'first' and 'second' or 'reflexive' modernity, respectively. Rather, as a matter of its 'compressed modernity' (Chang 2010), it has to confront the challenges of *both simultaneously*. This confers upon the Chinese challenge of urban mobility its final, and greatest, significance – namely its dynamism. This, in turn, is inseparable from the extraordinary geopolitical and political economic rise of China. Just as the emergence of the existing automobility system was inseparable from the early/mid-twentieth century emergence of American hegemony, it is worth considering whether we are today witnessing in China the transition to a new model of urban mobility that may involve similarly profound and global transformations in global political economy and society.

The greening of China's urban mobility is of urgent global significance. There are various ways of decarbonising travel, including shorter journeys, greater use of slow modes, the substitution of corporeal travel with digital connections, and the building of higher density and more closely connected forms of work, leisure and housing. These alternatives and options are indexed by a broader focus on (land-based) *mobility* (and demand through interlinking social practices) rather than through the analysis of *transport* (Sheller and Urry 2006).

Nevertheless, the dominant policy narrative in China today focuses on decarbonising *car* travel through electrification. Faced with such a hugely difficult, complex and multi-layered challenge, it is not surprising that evidence of a significant 'low-carbon transition' is lacking, and this despite significant government and corporate support, especially for electric vehicles (EV). The EV thus represents a necessary *starting point* for analysis of current mobility innovation in China. But it does not thereby necessitate assuming the same technology-focused perspective as that of the policy supporting it.

[9] See also data from the World Bank: http://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS

Indeed, as we will show, its trajectory to date and its prospect can only be understood by exploring broader questions of social practices and power relations.

2. Electric Vehicles, Mobilities and Power

2.1 Prospects

The future of urban mobility, especially in China, undoubtedly requires significant low carbon innovation. Crucially, this is also acknowledged at the highest levels of government, as well as within business, both private and state-owned enterprises (SOEs). Indeed, low-carbon mobility is understood as a significant, once-in-a-generation opportunity for China to develop innovations of global stature in this key economic sector. In particular, the EV has been imagined as the route towards Chinese breakthrough, 'overtaking round the corner' in the language of Science Minister (and former Audi executive) Wan Gang, into the global automotive oligopoly. This is, of course, an intensely competitive industry with very high barriers to entry from proprietary technologies and tacit knowledge capacities of global (supply chain) management, innovation and branding (with the latter also a key substitute in recent decades for meaningful investment and innovation in non-ICE vehicles). The EV has thus been invested with intense hopes in China to be a key pillar of the broader project of squaring globalised economic growth and continued one-party-state government through global innovation leadership (Zhao 2010). The EV has become the key policy priority regarding China's programme of low-carbon mobility transition.

Table 2.1: Ten Best-selling Passenger Car Brands in China, March 2014

Brand	***Number of cars produced***
FAW-Volkswagen (VW)	155,600
Shanghai (SAIC)-VW	151,800
SAIC-GM-Wuling	143,600
Shanghai-GM	140,700
Changan	105,100
Beijing-Hyundai	95,000
Dongfeng-Nissan	82,700
Changan-Ford	72,300
Dongfeng-PSA	60,000
Great Wall	56,400

Source: ChinaAutoWeb.[10]

This is particularly so given the present state of the automotive industry in China. While considered of such importance, regarding economic capacity and international political economic prestige, the industry is dominated by joint ventures between major Chinese SOEs and foreign automotive transnational corporations (TNCs), with these JVs dominated by the latter (see Tables 2.1 and 2.2).

This pattern is to be found across numerous indicators, including national sales figures for different brands (see Tables 2.1 and 2.2) as well as innovation statistics such as value production per employee and ratio of new model production (Winebrake *et al.* 2008: 227). Similarly, analysis of Chinese patents granted between 1985 and 2005 to automotive TNCs in the Fortune Global 500 and Chinese companies in the country's top 500 industrial enterprises shows the dominance of the former, absolutely and relatively (Chen 2008). Moreover, this is apparent in comparison between JVs and the TNCs that are party to them, indicating how little technology transfer has taken place (Chen 2008). One senior

[10] http://chinaautoweb.com/2014/04/best-selling-new-cars-in-march-2014/

Chinese car executive from a major auto SOE interviewed in 2009 argued that they, 'hardly get any core technologies and key parts through', their JV and are, 'enslaved' by this dependency.[11]

Table 2.2: Top 20 Best-selling Sedans, Hatchbacks and Coupes in China, March 2014

Rank	***Models***	***Manufacturers***	***Sales***
1	Volkswagen Lavida (sedan)	Shanghai-Volkswagen	32667
2	Volkswagen Jetta	FAW-Volkswagen	27928
3	Volkswagen Sagitar	FAW-Volkswagen	26585
4	Volkswagen Passat	Shanghai-Volkswagen	26387
5	Nissan Sylphy	Dongfeng-Nissan	26261
6	Buick Excelle	Shanghai-GM	26220
7	Volkswagen Santana	Shanghai-Volkswagen	24409
8	Chevrolet Cruze	Shanghai-GM	22351
9	Volkswagen Bora	FAW-Volkswagen	21090
10	Chevrolet Sail (hatchback)	Shanghai-GM	20167
11	Hyundai Elantra Langdong	Beijing-Hyundai	18167
12	Volkswagen Magotan	FAW-Volkswagen	18098
13	Buick Excelle GT	Shanghai-GM	17687
14	Audi A6	FAW-Volkswagen	15800
15	Toyota Camry	GAC-Toyota	15723
16	Volkswagen Golf	FAW-Volkswagen	15316
17	Hyundai Verna	Beijing-Hyundai	14998
18	Honda Crider	GAC-Honda	13320
19	Toyota Vios	FAW-Toyota	13280
20	Changan Eado	Changan	13255

Source: ChinaAutoWeb[12]

In this context, and in the related political context of techno-nationalism, the apparent opportunities presented by the EV have proven decisive in setting the policy agenda. Moreover, the seeming need for significant government support to develop a viable EV system appears to play to another supposed strength of the Chinese political economy. For instance, a shift to the EV involves considerable challenges of coordination (Tyfield 2013), such as the construction of infrastructures for charging batteries before there is any consumer demand for such vehicles. The absence of such vehicles eliminates incentives for the private provision of charging services. Similarly, while there is a clear consensus in China in favour of pursuing EV innovation, other nation-states capable of mounting such an initiative are aligned with automotive companies that see the ICE, not the EV, as their priority and advantage (Germany, Japan), or have political economies not inclined to a strong programme of industrial policy (UK), or both (US). See Schamp, 2014 on the possible exception of France. By contrast, government at all levels in China, central, provincial and municipal, have developed sets of policies to support national and/or local 'champions', both SOE and private, in developing and commercialising EVs (see Box 1).

[11] This evidence was gathered as part of the ESRC Project 'UK-China Networks of Low Carbon Innovation' (2007-2010)

[12] http://chinaautoweb.com/2014/04/best-selling-new-cars-in-march-2014/

In 2010, EVs were declared a 'key strategic industry for the next 5 years', and RMB100 billion (£10 billion) of government support was announced. Targets of producing 500,000 EVs by 2015 and 5 million by 2020 were announced. To encourage demand, a 0 per cent sales tax was introduced, along with subsidies of RMB 60,000 from central Government, which was matched by some cities (notably Shenzhen, home of the company BYD). Furthermore, a programme focusing on the 'electrification' of mobility within 25 major pilot cities was also introduced. The rules for subsidising EV sector are stipulated by the *Beijing Demonstration and Application of New Energy Passenger Car Manufacturer and Product Administration Rules*. According to the list announced by Beijing, six EV models will be subsidised with subsidies ranging from RMB63,000 to RMB108,000. The six EV models on the list are DENZA and E6 made by BYD; Roewe E50 made by SAIC Motor; ZINORO made by Brilliance Auto; E150 EV and C70GB made by Beijing Automotive Group; and iEV4 made by JAC Motor.

Box 2.1: Summary of National NEV policies in China

NEV (New energy vehicle) refers to the vehicles not using conventional fuels (petrol, diesel) as power sources for vehicles. According to different sources, there are three main types of NEV: HEV (Hybrid Electric Vehicle), EV (Electric Vehicle) and FCEV (Fuel Cell Electric Vehicle). According to the different battery types, it also can be divided into three types: nickel-metal hydride battery NEV, lithium battery NEV and fuel cell NEV.

There are four main reasons for China to develop NEVs: (1) Climate change; (2) Energy Security; (3) Catch-up (Corner Overtaking, “弯道超车”); and (4) Green Industry (Strategic Emerging Industries, “战略新兴产业”). These four priorities are reflected in the following policies, affecting EV innovation and development.

1. Planning

No.	*Name*	*Year*
1	The Eleventh Five-Year Plan for National Economic and Social Development (中华人民共和国国民经济和社会发展第十一个五年规划纲要)	2006
2	National Medium- and Long-term Science and Technology Development Plan (2006-2020) (国家中长期科学和技术发展规划纲要)(2006-2020 年)	2006
3	China's auto industry revitalisation plan (汽车产业调整和振兴规划)	2009
4	Decision of the State Council on Accelerating the Fostering and Development of Strategic Emerging Industries (国务院关于加快培育发展战略性新兴产业的决定)	2010
5	The Twelfth Five-Year Plan for the National Economic and Social Development (中华人民共和国国民经济和社会发展第十二个五年规划纲要)	2011
6	The National Twelfth Five-Year Plan for Science and technology development (国家“十二五”科学和技术发展规划)	2011
7	The Twelfth Five-Year Plan for Industrial Technology Innovation (“十二五”产业技术创新规划)	2011
8	The Twelfth Five-Year Plan for Science and technology Development of Electric Vehicle (电动汽车科技发展“十二五”专项规划)	2012
9	Energy Saving and New Energy Auto Industry Development Plan (2012-2020) (节能与新能源汽车产业发展规划)(2012-2020 年)	2012

Box 2.1: Summary of National NEV policies in China (cont.)

2. State major science and technology R&D projects

Period	State major R&D projects
Eighth Five-Year (1991-1995)	key technology R&D of the core components of electric vehicle
Ninth Five-Year (1996-2000)	National clean car projects
Tenth Five-Year (2001-2005)	R&D of electric vehicles are included in the national “863” plan
Eleventh Five-Year (2006-2010)	the '863' major projects of new energy vehicles

After twenty years development, China has set up a 'three vertical and three horizontal' R&D Layout of NEV at present. “Three vertical and three horizontal”(三纵三横) refers to three “vertical” technologies (whole car technologies of HEV, EV and FCEV) and three “horizontal” technologies (key technologies i.e. Multi-power Drivetrain Control System, Drive motor and Power battery).

3. Application demonstration project

No.	Name	Year
1	“1000 NEV for 10 Cities” demonstration projects (十城千辆节能与新能源汽车示范推广应用工程)	2009
2	Notice on the expansion of energy-saving and new energy vehicles demonstration to public services (关于扩大公共服务领域节能与新能源汽车示范推广有关工作的通知)	2010
3	Official letter on strengthening safety management in the demonstration of energy-saving and new energy vehicles (关于加强节能与新能源汽车示范推广安全管理工作的函)	2011
4	Notice on further improving the energy-saving and new energy vehicles demonstration and pilot work (关于进一步做好节能与新能源汽车示范推广试点工作的通知)	2011
5	Notice on the continuation of popularization and application of new energy vehicles (关于继续开展新能源汽车推广应用工作的通知)	2013

4. Regulations

No.	Name	Year
1	Automobile industry development policy (汽车产业发展政策)	2004, 2009
2	The comprehensive programme of work in energy saving and emission reduction (节能减排综合性工作方案)	2007
3	Rules on the Production Admission Administration of New Energy Automobiles (新能源汽车生产准入管理规则)	2007
4	New energy automobile manufacturing companies and product access management rules (新能源汽车生产企业及产品准入管理规则)	2009
5	Electric Vehicles Initiative Joint Action Plan (电动汽车发展共同行动纲要)	2009
6	Provisional administration of financial assistance funds for promotion of energy-efficient product in “Energy-saving products benefit people project” (“节能产品惠民工程”高效节能产品推广财政补助资金管理暂行办法)	2010

Box 2.1: Summary of National NEV policies in China (cont.)

7	Rules for promotion of energy-saving cars (1.6 litres or less) in “Energy-saving products benefit people project” (“节能产品惠民工程”节能汽车(1.6 升及以下乘用车)推广实施细则)	2010
8	Notice on implementing NEV private buyer subsidy pilot project (关于开展私人购买新能源汽车补贴试点的通知)	2010
9	Notification on adjusting energy automobile promotion subsidy policy (关于调整节能汽车推广补贴政策的通知)	2011
10	Guidance on promoting internationalization of emerging strategic industries (关于促进战略性新兴产业国际化发展的指导意见)	2011
11	Guidance on speeding up the popularization and application of new energy vehicles (关于加快新能源汽车推广应用的指导意见)	2014
12	Implementation plan for government agencies and public institutions to buy new energy vehicles (政府机关及公共机构购买新能源汽车实施方案)	2014

In seeing the associated business opportunities within China, there have also been some high-profile international investments in various New Energy Vehicles (NEVs). The battery company BYD, which has entered the automotive sector specifically targeting the EV, has been a particular beneficiary with investments from world-renowned US investor Warren Buffett. More recently, BYD entered into a JV with Daimler to turn out the new energy vehicle DENZA, which will be subsidised by the city government of Shenzhen.

Technologically, developing EVs is eminently sensible. In terms of energy efficiency, EVs are the 'best' technical solution, consuming no energy when free-wheeling or at rest and offering up to 90 per cent energy efficiency as compared with 37 per cent for the ICE. This figure may improve further through the development of regenerative breaking (Sperling and Gordon 2009: 23).[13] Furthermore, electrically powering urban (auto) mobility currently appears to be the only viable technological option for zero-emission but mechanically propelled mobility. Even the most sceptical of projections, such as from the ICE-dominated car industry itself, foresee EVs as the 'eventual' technology of choice given constraints of emissions and future oil supplies.

Yet, in terms of the EV as an agent of low-carbon transition, there are serious questions regarding their emissions especially in China. Nationally, over 70 per cent of electricity is generated by coal, and in many areas (particularly in the North and North-East) the percentage is much higher. As much of this coal is, in turn, of low quality and burned in low efficiency power stations, the emissions associated with EV mobility even exceed those of conventional ICE mobility in some regions of China (Earley *et al.* 2011). For instance China has six interprovincial power grids, where North, North-East and East are highly carbon dependent (from 88 per cent to 98 per cent) and North-West, Central and South are less high carbon, due to hydro- or wind- power resources which make between 22 per cent and 30 per cent of the generation mix (Huo *et al.* 2010). Inner Mongolia has huge renewable energy resource potential which could power the needs of the growing car demand within the region. EIA and International Energy Agency projected that coal will be used for around 80 per cent of electricity by 2030, while

[13] There are various forms of EV, including full battery EVs (BEVs), hybrid EVs (HEVs, which use an electric motor to supplement an ICE) and plug-in hybrids (PHEVs). The battery too can take on different specifications, with lithium batteries currently the favoured option – over conventional lead acid batteries and hydrogen fuel cells (FCEV) – for reasons of mass and power capacity, even as this remains a relatively expensive option.

Chinese institutes project that the share of coal can be reduced to the still very high figure of 72 per cent by 2030 (Huo *et al.* 2010).

In many regions of China, therefore, EV mobility would substitute dispersed emissions in urban centres with point source emissions, possibly further afield. To be sure, this may have significant advantages regarding other forms of localised air pollution (such as SO_x, NO_x and particulates) as well as greater energy efficiency. But it would achieve little as regards a 'low-carbon' transition unless the electricity grid is significantly decarbonised (see Urban and Geall 2014 on solar energy).[14] Moreover, despite the favourable conditions listed above, the EV so far remains a relative failure in China (see Table 2.3 and Figure 2.1). Against the target of 500,000 by 2015, fewer than 12,000 alternative fuel vehicles of any description (i.e. including HEVs) had been sold by the end of 2012. And most had been purchased in programmes of government procurement for municipal taxis. Amongst automotive SOEs presented with government targets for developing what are unprofitable EVs, the result has often been half-hearted engagement at best, and positive foot-dragging at worst (Wang 2013a). Similarly, municipal targets for EVs and charging infrastructure have been widely missed, with none of the cities involved in the programme meeting targets at the end of the Five-year plan in 2012. Nor has there been any dramatic upswing since then.

Table 2.3: 2012 Sales Ranking of Chinese-Built Pure-Electric Cars

Model	***Sales***
1. Chery QQ3 EV[15]	5,305
2. JAC iev (J3 EV)	2,485
3. BYD e6	2,091
4. Zotye TD100 EV	845
5. BAIC E150 EV	644
6. SAIC Roewe E50	238
7. Zotye 5008 EV	142
8. Zotye M300 EV	134
9. Changan CX30 EV	100
10. Chery Riich M1 EV	90
11. Shanghai-GM Springo	11
Total:	12,085

Source. China Auto Web[16]

This lack of progress is partly due to the large number of EV policy initiatives, for these do not add up to a coherent national industrial policy framework (*Cf* Nolan's (2004) classic comparison of Chinese and Japanese industrial policy). Rather, EV policy reflects the divergent interests and struggles amongst

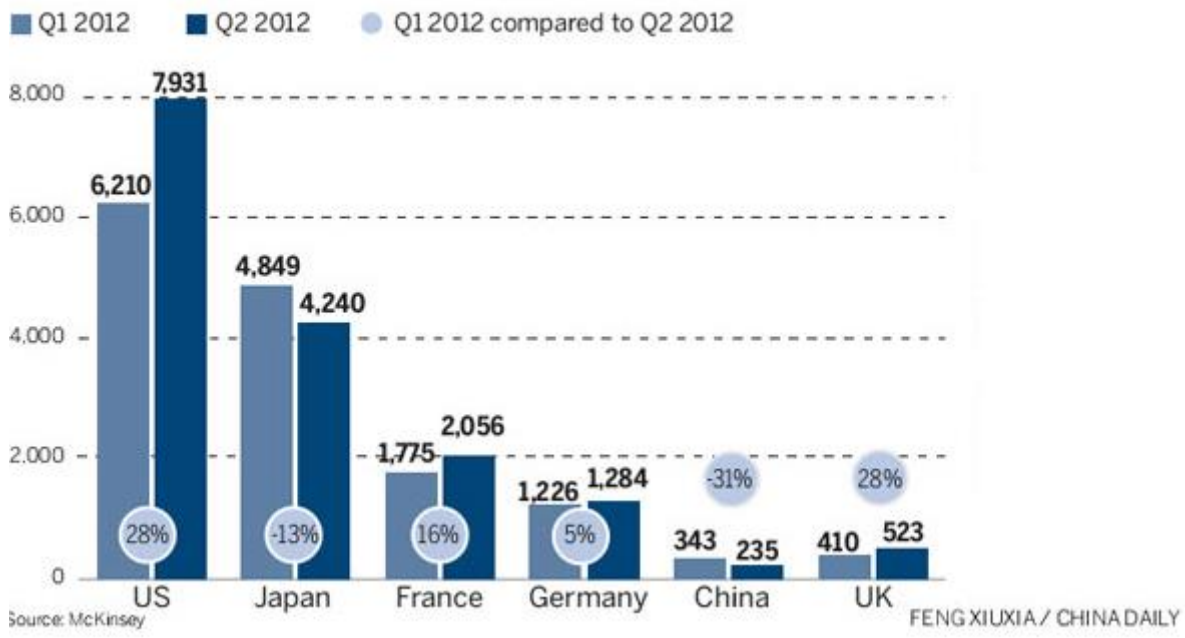
[14] Hence, a successful EV-based low-carbon transition hinges on transition in both electricity and automobility systems. This brings new alliance building, which is already in evidence in China. For instance, at the time of finalizing this Working Paper a deal was announced between Tesla and China Unicom to develop charging infrastructure. See Tyfield (2014b).

[15] Interestingly the leading e-vehicle in China is Chery QQ which is allegedly mock design of Chevrolet-Spark.

[16] http://chinaautoweb.com/2013/03/chinese-ev-sales-ranking-for-2012/

tiers of government and ministries characteristic of policy in China more generally. For instance, the 'Energy Saving and New Energy Auto Industry Development Plan (2012–2020)' issued in 2012, was discussed for a lengthy period. One reason for this is that the Ministry of Science and Technology (MOST) and the Ministry of Industry and Information Technology (MIIT) hold different opinions. MOST gives priority to the development of electric vehicles, while MIIT tends to 'walk on two legs, i.e. energy-saving cars (including ICE cars) and new energy vehicles. In July 2011, Wen Jiabao published an article in *Qiushi Journal* that pointed out that the direction and goal of NEV development is vague and needs to be made clear as soon as possible.[17] In order to get rid of local protectionism, the newly issued 'Guidance on speeding up the popularization and application of new energy vehicles' requests the formulation of a national unified NEV promotion directory in July, 2014.

Figure 2.1: Sales of Electric Cars in Q1 & Q2 2012



Source: China Daily[18]

Globally, EVs have had a hard time in recent years. Wang reports:

> The US sales targets for two high profile products, the GM Volt and Nissan Leaf, were also missed by wide margins in 2012. Even the profits made by Tesla Motors in the first quarter of 2013 were overshadowed by the gloom of a series of bankruptcies including [high-profile international companies] Fisker Automotive, battery-manufacturer A123 Systems, and electric car company Better Place.
> (Wang 2013b)

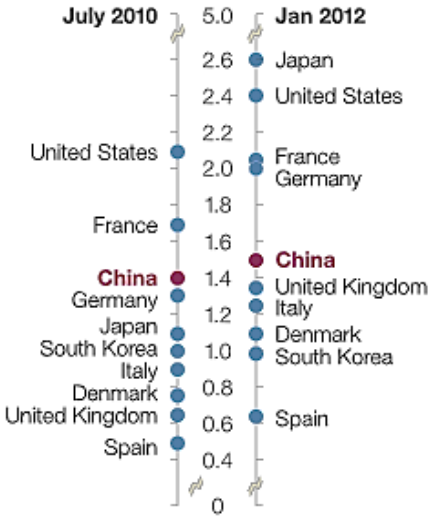
Thus there is little prospect that a Chinese EV industry will emerge in the next few years that would be capable of standing on its own without significant government support; nor of one that will

[17] http://finance.people.com.cn/stock/BIG5/15188749.html

[18] http://www.chinadialy.com.cn/business/2012-10/23/content_15838891.htm

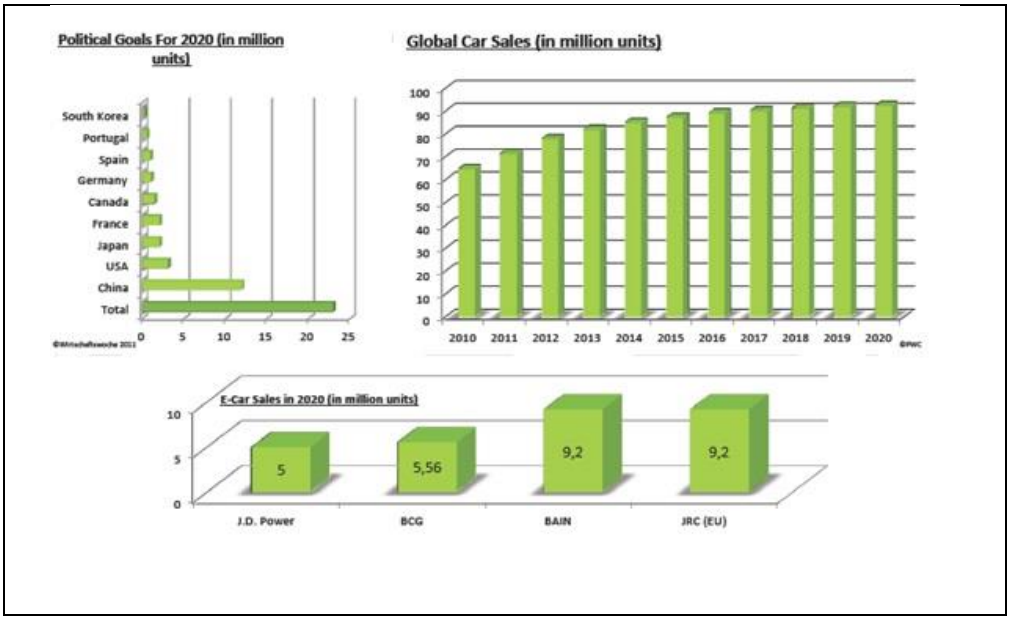
dramatically and suddenly disrupt the global car industry or the dominant model of urban automobility.

Figure 2.2: China's Falling Ranking on the McKinsey Electric Vehicle Index[19]



Source: McKinsey and Company (2012)[20]

Figure 2.3: Global EV Sales in Context



Source: Chandrasekar 2010 for Castellan AG (2010)

There are particular problems in China. While the US too will fall far short of its (more ambitious) goals of 1 million EVs by 2015, it still has produced three times as many vehicles as China. Moreover, even

[19] McKinsey's Electric Vehicle Index measures development of the e-vehicle production sector, and is rated from 5 (very developed) to 0 (non-developed). Here we observe that China was outpaced by some of the developed countries in terms of production, but it is still a leader in production among developing nations, and although outpaced it still maintained slight growth.

[20] http://www.mckinsey.com/insights/energy_resources_materials/recharging_chinas_electric-vehicle_aspirations

as the Chinese overall car market has boomed (racing to the top slot globally) and the US market slumped in 2009 and is slowly recovering, Chinese competitiveness in EVs has fallen behind. According to McKinsey and Company data, China in 2010 occupied third position in the world production of e-vehicles, but by 2012 it had been outpaced by Japan and Germany, even as it has the most ambitious targets (see Figures 2.2 and 2.3).

This is not to say, however, that the prospects of EVs in China are of marginal significance. Rather, the point is that the prospects of the EV do not seem to fit the expectations of current imaginaries of policy and business strategy. In order to see how the EV could still be significant, we must therefore investigate the specific problems of EVs within China. These may be divided into those regarding 'producers' and those relating to 'users' or 'consumers'.

The key technological issues remain those regarding the battery, its design, cost, mass and integration into the vehicle (Watson *et al*. 2011). As the price of the battery is the key determinant of the (high) price of the EV, this is also an issue with significant implications for issue of consumer demand. Indeed, from this user perspective, its high price remains the main barrier to significant market interest in EVs in China, though even the highest subsidies are not overcoming this barrier, as in Shenzhen where only 600 EVs were sold in 2011 (Kreiger *et al.* 2012)**.** In response to this problem, major EV companies such as BYD are, with local state support, exploring new financial models to mitigate cost (see Box 2.2). However, it is too early to say whether these are proving successful.

Box 2.2: BYD's Experiments with Battery Leasing in Shenzhen

On November 4, 2012, BYD launched its new solution for promoting electric public transportation for the taxi and bus market in Shenzhen. This initiative is called 'Zero vehicle purchase price, Zero costs, Zero emissions, and is supported financially by the China Development Bank. The scheme aims to ease the financial pressure on taxis and pay the full amount upfront for the purchase of electric vehicles, thereby providing a feasible path to speed up public transport electrification. According to the scheme, which is specifically targeting the public transit operators/companies, customers can choose one of three optional operating models, as summarised in the following table.[21]

Model	**Financing Body**	**Lease Period**	**Ownership**
Financial Lease	Finance Company	A complete electric vehicle operational life cycle (e.g. five years)	During the lease period, the financial organisation owns the electric vehicle. The taxi company pays the lease in instalments. After the lease period ends, the taxi company owns the vehicle.
Operational Lease	Third party vehicle lease company	A complete electric vehicle operating life cycle (e.g. five years) or a shorter period (e.g. one year)	During this lease period and after it ends, the vehicle lease company owns the vehicle. The taxi company and the vehicle lease company sign an operational lease contract for the lease.
Buyer'sCredit	The Taxi Company		The taxi company has ownership of the vehicle. The taxi company pays monthly instalments to the financial institution.

[21] http://smartenergyuniverse.com/electric-vehicle/7821-byd-launches-zero-vehicle-purchase-price-zero-costs-zero-emissions.

Box 2.2: BYD's Experiments with Battery Leasing in Shenzhen (Cont.)

The document initiating the policy explains the concept of 'Zero Cost' by comparing the costs over five-year between an ICE fuel taxi and BYD's all-electric cab in Shenzhen city, taking into account the higher costs of the latter and interest on multiple payments. On this basis, it was concluded that savings of RMB 326,000 over this five year period were possible.[22] Furthermore, it was concluded, if enough miles are done, 'the vehicle payment will be entirely offset'. BYD also emphasised the 'Zero Emission' feature of its

renewable-energy vehicles by stating that, 'an e6 electric taxi saves 14,120 litres of fuel per year, with 32 tonnes fewer CO_2 emissions', and '169 million litres of fuel could be saved, with CO_2 emissions reduced by 38.62 million tonnes per year', if all Chinese taxis were to be replaced with its electric vehicles. Currently, this policy is only available to the Chinese market.[23]

Conversely, from the producer perspective, Chinese firms remain at a global competitive disadvantage regarding these issues, notwithstanding the global leadership of firms such as BYD in battery technology (Kreiger *et al.* 2012). Yet it is precisely the promise of global leadership that generated the intense focus upon the EV within Chinese policy. As such, geopolitical issues regarding international collaboration, let alone open global markets for such technologies and related engineering services, remain sensitive. Yet, by examining the broader global market scene, more interesting futures for the Chinese EV emerge as real possibilities. In particular, the only clear 'success' story in the (global) EV sector to date, the US manufacturer of luxury electric sports cars, Tesla, presents intriguing opportunities in China. The potential impacts of Tesla on the EVs prospects in China are not obvious. As a luxury vehicle, making its high price (the US price tag is US$70,000–US$93,400)24 a virtue and a deliberate mark of its distinction and desirability, Teslas are already far beyond the reach of the vast majority of putative car buyers in China. Moreover, not only does Tesla not qualify for Chinese EV production subsidies, not manufacturing in China, but it also faces steep import taxes that effectively double the already high price. Nevertheless, Tesla hopes its S model, and generally its entrance into the Chinese market, will help to 'catalyse EV adoption in China'.25 Tesla (Tuosule) will follow its existing corporate strategy of direct sales in China and started to take orders in March 2014 from the Chinese super-rich keen to display what is currently amongst the most desired of cars in Chinese cities.

That the Tesla S Model is effectively a toy for the super-rich does not, itself, mean it is of little significance for a broader system transition. On the contrary, it is precisely as a prestige product that this EV has secured the steady market demand that is eluding other more 'conventional' EVs (the Nissan Leaf, Chevy Volt or BYD's E6). Similarly, it was as a rich man's (and woman's!) (Urry 2007: 113) speed machine that the first cars emerged at the end of the nineteenth and early twentieth centuries (Urry 2007; Dennis and Urry 2009). But the impact of Tesla on the EV in China may be even more direct. In particular, bolstered by its undoubted market demand (globally), Tesla has been able to launch a

[22] In Shenzhen, for example, the BYD e6 taxi, after subtracting the RMB 60,000 government subsidy and RMB 60,000 local subsidy, the actual price is about RMB 180,000. A Shenzhen taxi travels an average of 450km per day and operates for 353 days a year (taxis on average have a one-day service each month). It is estimated that the average ICE fuel taxi consumes about 9 litres of petrol per 100km, and the price of petrol is 8 RMB per liter. But the e6 pure electric taxi consumes 26 kw per 100km, and the average price of electricity is RMB 0.66. So each electric taxi saves RMB 247 per day, RMB 7,166 per month. If the hire car runs for 5 years, and the total saving over 5 years is deducted from the higher cost of the vehicle and the interest on multiple payments, it can save RMB 326,400. This will be the profit in the operation of the pure electric vehicle.

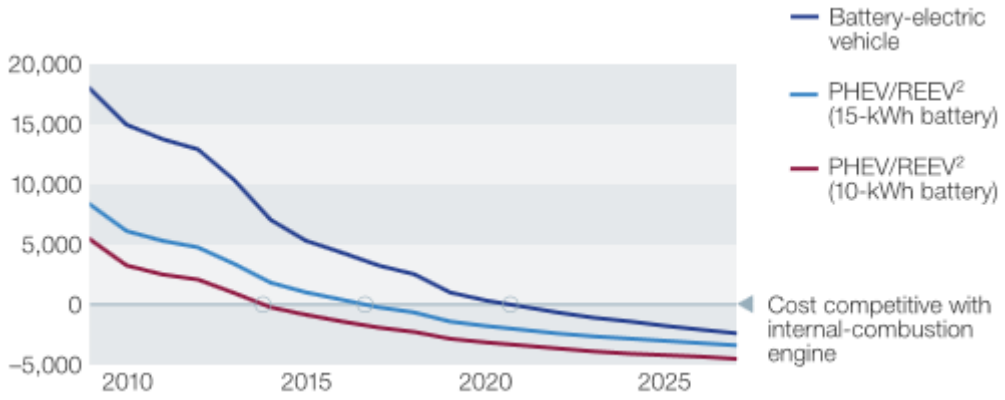
[23] http://www.businesswire.com/news/home/20121108007021/en/Free-Phones-Free-Taxis-BYD-China-Development#.UzRApYXwr08

[24] http://www.teslamotors.com/models/design

[25] http://www.dailytech.com/Tesla+Motors+Wants+in+on+Chinas+EV+Subsidies/article34319.htm

strategy focused on tackling this key techno-economic barrier of the cost of the battery, building a 'Gigafactory' in the US (Economist 2014e). If successful, this could even make the EV a real competitor to budget ICE models, ending the vision of the EV as a luxury product, a goal to which Tesla itself is orientated.[26] And Tesla's intervention builds on (if perhaps accelerating) existing trends of reducing prices for EV batteries as reflected in falling prices for new EVs (Figure 2.4). With a cheap battery the low-carbon technology would quickly become affordable to the mass consumer (or at least a much broader base capable of affording a 'normal' car), leading some to compare Tesla to the revolutionary impact of the shift to mass production of the Ford Model T, computer memory chips and solar panels (on which see Urban and Geall 2014).

Figure 2.4: Annual (Projected) Total Cost in China (RMB) of Various EVs



Source: McKinsey and Company[27]

However, as these historical examples also testify, it is not just the leading (eponymous even) company that benefits from such transitions in manufacturing and prices. This may be particularly important for China for, as Breznitz and Murphree (2011) and Zeng and Williamson (2007) have argued, not only is leadership in research and development (R&D) and technological innovation unnecessary for the subsequent achievement of market success[28] but, to the contrary, copying and improving existing products through novel combinations, greater personalisation and reduced price have proved a key competitive strength of Chinese business in recent decades, and a major source of its ongoing economic growth.

Moreover, this process of 'disruptive innovation' itself (Christensen 1997; Tyfield *et al.* 2010) and the resulting revenues combine to create emerging trajectories in such firms that afford the R&D and hi-tech innovation that would otherwise be out of their reach. This, for instance, has been the route taken by what are now global brands, such as Huawei, Haier, ZTE and Lenovo (see also Bound *et al.* 2013 on China as an 'absorptive state'). As such, while the prospects of Tesla remain a matter of its own strategic fortunes, any dramatic reduction in battery expense will also be to the advantage of multiple Chinese 'followers' with major repercussions for developing EVs within China.

Furthermore, various considerations speak to the possibility that Chinese firms may be particularly enabled within such competition. First, expanding the EV depends upon the steady supply of graphite,

[26] In 2014 Tesla has also opened its patents, potentially very good news for Chinese EV producers. http://www.businessweek.com/articles/2014-06-12/why-elon-musk-just-opened-teslas-patents-to-his-biggest-rivals

[27] http://www.mckinsey.com/insights/energy_resources_materials/recharging_chinas_electric-vehicle_aspirations

[28] Though some research base is helpful (Bell and Pavitt 1993), a research base that China is also undoubtedly building.

which is mostly mined in China. Yet, as with rare earth metals, China is unwilling to increase its rate of extraction and has in fact downscaled due to environmental impacts.[29] It may be assumed though that the resulting scarce resources will be made available to Chinese firms on favourable terms.

Secondly, and more fundamentally, the barriers to EV uptake are not merely a matter of the cost (of the battery). Instead, within a broader socio-technical system transition, they reflect a number of concerns from potential consumers. These concerns include: a lack of safety following some high-profile fires; charging worries given limited cruising range (especially when coupled with gridlocked congestion) and inadequate charging infrastructure; and a simple lack of consumer appeal or cachet especially compared to the top-class foreign ICE cars that could be purchased for similar amounts. Hence, even with a lower price the EV may continue to lack popular credibility as a practical mobility solution[30] Yet the significance of Chinese disruptive innovators in EVs may be particularly significant in tackling these social and consumer issues, given their focus on and advanced understanding of Chinese society, in ways with which Tesla will struggle to compete.

Figure 2.5: Low-Speed Vehicle, Produced by Shifeng Factory in Shandong

Source: www.shifeng.com

One particularly interesting development is to be found within the province of Shandong, South-East of Beijing. In 2014 over 20 automakers in Shandong produced more than 128,000 so-called 'low speed' (*disu*) EVs, of which 125,000 were sold according to ChinaCarTimes, figures that are in marked contrast with the stalling fortunes of EV sales.[31] These low-speed vehicles are certainly low-cost, tackling this key issue for the majority of Chinese consumers. But they are also an important aspect of the growth of China's homegrown e-vehicle industry, and a high-tech shift of gear for the manufacturing landscape of a province not at the forefront of China's industrialisation to date. The electric cars, often the result of tinkering by small garages and an example of '*shanzhai*' (or 'knock-off') innovation (see Figure 2.5), are priced at around RMB30,000 (US$5000). They are thus very attractive to rural customers who both can afford little more than this and, conversely, have a personal garage (while urban populations seeking a similar-sized car may still prefer pricey high-carbon cars such as the Smart or a Mini).

[29] http://www.wallstreetdaily.com/2014/03/22/graphite/

[30] http://www.forbes.com/sites/ninaxiang/2014/03/18/will-teslas-china-story-lose-its-charge/

[31] http://www.techinasia.com/china-shandong-becomes-hub-for-electric-vehicles/

In the light of this bottom-up entrepreneurial success, as with Tesla, the growth of revenues is affording the funding of R&D relations between these small, new companies and both elite Chinese research institutions (such as Shanghai Jiaotong's Automotive Engineering Department) and more high-profile and 'hi-tech' businesses, such as Shenzhen's electric bus company, Wuzhoulong. These small producers, with few overheads and little in the way of established innovation capabilities and management structures are also able to experiment with a range of products. Thus Shifeng not only produces an EV that resembles the Mercedes Smart, but also non-electric trucks and farm vehicles.

In summary, the EV sector in China is characterised by at least three distinctive niches, each being associated with a particular political economic geography. First, and most obviously, there are the traditional ICE companies, particularly the major SOEs and their JVs, who are seeking to launch their new energy efficient vehicles in programmes that are dependent upon the state and, as such, are doing so often with little enthusiasm or internal corporate dynamism. This model is epitomised by Shanghai (Huang 2002; Huang 2009). Second, there are emerging private automotive companies (such as BYD, Geely and Chery), that are focusing more heavily on developing the EV and are relatively unencumbered by existing success in producing ICE cars. These companies are in turn often situated in locations known for their entrepreneurialism and comparatively free-market political economies, such as Zhejiang, Sunan or (archetypically) Shenzhen. As such, these companies are also based in locations without a major national automotive SOE so that, while private, these companies are effectively local champions and receive considerable local government support. Finally, there is the set of small, 'no-name' companies engaged in indigenous, mass-production of small, low-speed, low-cost and 'no name' EVs. This is epitomised by the emerging complex of innovating companies within Shandong.

This geographical diversity is to be expected in a country the size of China. This diversity of experiments, some apparently more successful than others at present, is also potentially a significant advantage for the development of what may in time emerge as a viable and self-sustaining innovation trajectory of EV transition, especially as the diversity also incorporates a range of levels of engagement with, and/or protection from (Smith and Raven 2012), the global car industry. Similarly, the *combinations* among these models (through alliances and collaborations) could be pivotal. For instance, even as current model of EV innovation is not succeeding in Shenzhen, the city itself remains an important site of innovation in China, particularly with regard to the cognate domain of ICTs. Indeed, the actual successes in ICT (*viz.* Tencent, Huawei) simply serve as both challenge and goal to the current stasis in EV innovation, further motivating its development in Shenzhen, especially given its status as China's 'Silicon Valley' (Sum 2004).

Here, Shenzhen's significance in EV innovation rests on the socially-effective and performative effects of its reputation as the first and the most successful special economic zone (SEZ) in China and an experimentation ground for Chinese 'catch-up'. It is a twenty first century megacity built from scratch based upon global trade, entrepreneurship and innovation. In 2010 the first forty electric crossover e6's manufactured by BYD Auto appeared in Shenzhen as taxis. Shenzhen was also the first city in China to develop the world's largest electric bus fleet. In 2011 200 BYD buses were delivered to the city to serve at the Universiade and they remained as part of this city's transportation afterwards according to a previous agreement between the City Government and BYD. Nevertheless, the private EV has been coming rather slowly into Shenzhen's urban landscape, despite subsidies from central government.

Geographical diversity is also a crucial factor as regards the consumer appeal of the EV, as well as the levels of pollution associated with electricity production, discussed above. This is a matter both of differing socio-economies and associated transport geographies (including distances to travel, levels of congestion, quality of roads and so on) and climate. For instance, in cold climates during winter,

taxis need to use energy from the battery in order to heat the car to a temperature that customers will find comfortable. Yet this can considerably reduce the range of the vehicle, with commensurate anxieties about being caught in congestion (and 'stranded on the ring road') and/or time lost through the need for recharging. The converse is equally true of hot climates regarding air conditioning, though it is easier to open the windows in this case.

Another key issue for potential users, both personal and taxis, that depends significantly on the geography of cities, including forms of housing and standards of infrastructure, is charging (see Box 2.3). For instance, in the densely populated megacities of the country's East and South where most of the Chinese population live in (often tightly packed) flats, models for home-charging that presume the domestic garage of American suburbia, something surprisingly evident even in models of EV mobility on show at BYD's headquarters, are inapplicable.[32] But in this respect, again, the Shandong '*disu*' model appears particularly appealing. For whereas even automotive upstarts, let alone the ICE majors, are envisaging the EV as a car just with a different engine, the Shandong model is constructing new forms of vehicles. These both take advantage of the benefits of e-mobility to afford new capabilities for mobility (rather than forcing them to fit into a pre-existing model of automobility), and do so in ways that are compatible with the constraints imposed by existing forms of local socio-economic life. The prospects of EVs in China may thus disproportionately depend on the fortunes of small companies currently making relatively cheap and low standard vehicles, rather than those emerging from the giants of the Chinese automotive sector. This possibility seems particularly plausible given one final consideration affecting producers, users and governments seeking to tackle the coordination of EV transition (Tyfield 2013) which is that it is an open question as to what technologies actually constitute the electric vehicle. This parallels how the technological assemblage that today constitutes what is conventionally called the car was itself once a 'hopeful monstrosity' (Mokyr 1991; Law 1991).

The most significant innovations of automobility in recent years have not concerned the engine and its decarbonisation, but rather a set of changes that are increasingly digitising the car, rendering it primarily an electronic and not a mechanical artefact (Sheller 2013; RAEng 2010). This includes: the development of changes as seemingly superficial as improved in-car entertainment systems; increased real-time connectivity; GPS and satnav; integration into 'intelligent transport systems'; sharing and deprivatisation (with reliable access) of vehicles and/or improved coordination of (personalised but public) intermodal travel enabled by web 2.0 applications and fob locks; self-driving vehicles famously produced not by a car major but an internet giant, Google.

Moreover, the integration of these new capacities is technically easier within EVs than for ICEs (Sperling and Gordon 2009). Whereas conceptualising the EV simply as a new type of 'car' thus (mis)directs attention to the efforts of existing car companies with all their competitive advantages. Therefore, we can see that there is currently the strong possibility that the future giants of the EV sector will not only be companies that we have not yet heard of today, but also companies that are not associated with the 'car', notably Google, either alone or in new corporate alliances with existing automotive majors (*cf* Mercedes and Swatch regarding Smart in the 1990s (Truffer and Dürrenberger 1997) (see Box 2.3). Future corporate alliances, possibly between such companies, may well be key milestones in the future trajectory of the EV in China. But, as this indicates, a clearer understanding of these prospects demands also that we consider the changing power relations associated with EV innovation.

Box 2.3: EV Charging

One of the crucial elements in the transition to new mobility system is the new energy supply infrastructure.

[32] We will be exploring these issues and their social practice dimensions further in the project fieldwork.

There are various diverse practices that are relevant to EV charging and technologies of charging are also in the process of development. One can charge the battery at a dedicated spot (at varying speeds), swap the battery for a new, charged one or charge the vehicle at home.

Dedicated infrastructure for the use of EVs (charging points or battery exchange spots) has not drastically changed in China and entrance of new "cool" models like Tesla S as well as of low-speed electric vehicles is problematic regarding the place where the owner could charge the car (as in most cases even middle class Chinese do not have private garages and live in apartment blocks). One may think that it is the infrastructure that comes first which is then followed by the EV use. The case from Bristol, UK shows, however, that even a rather developed infrastructure need not stimulate strong growth of EVs, at least in the next 10 years.[33] Hence, the growth of e-mobility in China is not something that can be achieved overnight.

The practice of battery switching was promoted by the Israeli-based company Better Place which wanted to cooperate with China Southern Grid (CSG) in this direction. CSG, the world's largest utility company, planned to install 2,300 battery switch stations by the end of 2015. But since Better Place went bankrupt in 2012, the plans for implementing this practice in China have died out. At the same time, battery switching can be a complex issue in China as a country with low-trust culture, associated with its still nascent civil society and public sphere. But where one player was lost, another appeared: ABB, the Swiss/Swedish automation technology group has teamed up with Shenzhen Daimler New Technology Co to expand China's EV charging network to be the largest in the world within the next six years so making the new Denza EV a practical alternative to traditional ICE cars.

Another technology being developed but that still has rather limited prospects is wireless (inductive) EV charging.[34] As of early 2014, there is only one commercial wireless charging system available for PEVs, an aftermarket system offered by Evatran and Bosch, and only available in North America. Currently, automakers are reticent about their plans for wireless EV charging and most of the EV charging systems are in the pilot phase. By 2015-2016, however, models with built-in wireless charging capability will be available from several major automakers. Within a decade, wireless charging could be the main way of charging EVs. Navigant Research forecasts that wireless charging equipment for light duty vehicles will grow by a compound annual growth rate (CAGR) of 108% from 2013 to 2022, reaching annual sales of slightly less than 302,000 units in 2022.[35]

Widely available wireless charging of mass-produced EVs in China may seem hard to imagine in the near future. But the trend towards innovative mobilities has been announced by the top managers of some of the leading global automakers. Volkswagen (the foreign company that has the longest history and is the best-sold foreign brand in China) declared that the increasingly intensive networking of cars with their surroundings and automatic driving would be the key topics for the intelligent mobility of the future.[36]

This is another sign of carbon capital reorganizing itself and seeking alliance with digital (IT) capital. What we yet have to see are the declarations of low carbon and IT capital alliances.

2.2: Politics

The political issues regarding EV transition in China are multiple and complex, involving issues of industrial and innovation policy (including, for different industries, ICE cars, EVs, electronics and ICTs, oil/gas/(gasified) coal, infrastructure and construction), environmental politics, and rapidly changing social power relations at the ground level of society, including issues of consumerism, social distinction and intersubjective class definition. All these in turn can be seen to have significant implications at the

[33] http://www.bbc.co.uk/news/uk-england-bristol-23353996

[34] http://www.navigantresearch.com/research/wireless-charging-systems-for-electric-vehicles

[35] Wireless Charging Systems for Electric Vehicles http://www.navigantresearch.com/research/wireless-charging-systems-for-electric-vehicles.

[36] http://www.smart-mobilitymanagement.com/the_automobile_waves_goodbye_to_the_past_and_welcomes_digitalisation_56424-en-422-186520.html

landscape level (Geels and Kemp 2013) of state power and legitimacy as well as international political economy, globalisation and the international division of labour of innovation. These issues are considered here only insofar as they play back *into* the possible prospects of mobility transition but which cannot necessarily be taken as given and exogenous, rather than *themselves* in dynamic co-production with developments at the socio-technical regime level (Tyfield 2014a), as well as in relation to the rapidly deepening ICE automobility regime. In analysing this field, we can usefully (if imperfectly) divide it up, as above, into issues of (EV-system) producer and user perspectives (including their respective interaction with, and constitution of, the 'state' in both cases). The striking picture that emerges in both cases, however, is one of both considerable tensions and, more importantly, *significant dynamism and change* in power relations. For each perspective, therefore, we discuss both existing limits and problems and evidence of emerging or embryonic power shifts that are associated with EV innovation and system transition.

Producers

From the perspective of the producers of EVs, these dynamic political landscapes may be characterised by various challenges. At the national level there is that of techno-nationalism within the context of a deeper engagement with a changing globalisation. The specific manifestation and political geography of this tension is manifest through fragmented authoritarianism and its geographically diverse devolution of decision-making power into what has been termed 'local state corporatism' (Oi 1992).

More concretely, there are three overlapping dimensions. There is first the distinction between regions with powerful automotive SOEs and those with private companies (or none at all). Second, there is the extent to which regional, provincial and local industrial policy privileges the [central party-]state or markets and private enterprise, and thence the openness to global business. And third, we can examine the localised power of carbon interests *vis-à-vis* other industrial sectors, notably electronics and/or what has been termed digital capital. Along each dimension, Shanghai may be identified with the former, Shenzhen with the latter. These may also be treated *prima facie* as the two most important locations regarding analysis of EV innovation and they are the two sites upon which this project will focus.

However, the sheer size and diversity of China means that there are also important hybrids and other combinations along the spectrum that each of these dimensions represents, which any comprehensive snapshot of contemporary China would need to grapple with, notably in Chongqing, Wuhan, Zhejiang, Liaoning/Jilin (Dongbei) and Beijing. Focusing on the prospects of EV transition in China, the task here is not so much this comprehensive analysis but rather to avoid overlooking developments that may also be pivotal (perhaps in collaboration with efforts in Shenzhen or Shanghai, as above), as in Shandong as analysed above.

Regarding these three locations, therefore, some key political challenges to EV innovation within China can be seen. On one hand, the tight connections amongst state-led industry, a powerful incumbent SOE ICE-automotive industry and carbon [state-]capital raises serious questions about the extent to which, for all its stated goals of prioritising EVs, state policy actually supports EVs, not just in the abstract, but *in competition* with ICE cars (Cohen 2010). In fact, the biggest and most powerful SOEs have in recent years become increasingly autonomous (with links to the state that are mediated through the state's professionalised share-holding administration, State-owned Assets Supervision and Administration (SASAC)) and managed by professional managers seeking profit maximisation, rather than national political goals (Naughton 2007). However, as Jiang (forthcoming) and Zhao (2010) detail, this greater autonomy of the SOEs from the party-state has to a great extent simply flipped over the relations of influence, rather than created arm's-length institutional relations. With senior Party figures still passing through senior management positions on their rise through the ranks, and with great fortunes of personal wealth to be made, often through borderline or even outright corruption, the

situation today is one of state capture by these SOEs, rather than corporate capture by the party-state (Dickson 2008; Tsai 2007). The politics of EV transition are thus intimately related to the broader socio-political challenges of a powerful cadre-capitalist class (So 2003). There iis the related endemic problem of corruption, now the focus of a high-profile crackdown that has included China National Petroleum Corporation, the operations of the foreign-owned automotive parts industry and ongoing investigations into all the major telecommunication companies, that these have spawned. In these circumstances the chances of national policy being drafted, let alone implemented, at the cost of existing powers – which means carbon state-capital – seem slim indeed. This may be a particular issue in Shanghai.

Conversely, privileging its indigenous and private electronics firms, prizing its reputation as China's Silicon Valley (Sum 2004) and running a trade policy that is the most open globally in China suggests issues of a high-carbon power lock-in are likely to be less significant in Shenzhen. However, lacking the connection to Beijing via strong SOEs of national importance, the flipside of this is that Shenzhen (in the southern province of Guangdong, where it is said 'the mountain is high, the Emperor is far') has comparatively little influence over national state policy for EVs. Yet Shenzhen does possess some important advantages. Indeed, ever since 1978, it has stood as the totemic city of 'reform and opening up', the shining example, leading the way for the rest of China to prosperity through increasing marketisation, global trade and investment and, most recently, high rates of innovation. This framing of Shenzhen in the contemporary Chinese political imagination, further entrenched by Deng Xiaoping's 'Southern Tour' to Shenzhen to restart the reform process in 1992, yields the significant advantage of affording the city political leeway from Beijing to experiment with market reform, international collaboration (the only automotive JV with more than 50 per cent foreign ownership is in Guangdong) and, now given policies of *zizhu chuangxin*, innovation (particularly in hi-tech) that would be much harder for most other cities or provinces in contemporary China.

Finally, Shandong is a coastal province but one not as wealthy as the key industrial areas of the Pearl River and Yangtze deltas to the south and the Beijing-Tianjin-Bo Hai region to the North. In recent years, it achieved some notable successes in several forms of 'alternative' or 'bottom-up' (and, as it happens, low-carbon) innovation, including not just the low-speed vehicles described here but also solar thermal power and agriculture (Tyfield *et al.* 2014; Urban and Geall 2014; Ely *et al.* 2014). Lacking both powerful SOEs and core industries, *and* emerging private hi-tech companies with national or global brands, however, Shandong's influence upon national industrial policy is weaker than Shenzhen's, while it is also relatively unencumbered by the tensions of a powerful local lobby for carbon [state-]capital. Thus in recent years, accepting that its innovations will not receive the attention and support of national policy (as low-tech, apparently unpromising, low-cost and low-prestige), its priority has been to protect the emerging niches of innovation within the province from onerous regulation, particularly from policies associated with high-tech innovation. In particular, Shandong has been working to ensure its low-speed vehicles are not classified as electric vehicles and so forced to comply with regulations of such things as safety and road licensing that would penalise them off the road. At the same time they offer few advantages in return with regard to forms of government support for research, development, demonstration and deployment (RDD&D) (since national government research funding is not likely to back projects relevant to the development of these technologies) that these vehicles have found success so far without.

In all cases, therefore, the fragmented authoritarianism of China's EV innovation policy and the diversity of its political geographies presents significant challenges, in terms of what amounts to something of a trade-off between influence over central government policy for support of RDD&D of EVs and autonomy from what remains the more powerful coalition in Chinese automotive politics, namely carbon state-capital. Together with the local state corporatism, this also has the broader effect on Chinese industrial policy for the automotive sector of hampering an effective *national* strategy,

most notably in terms of continuing to prevent the rectification of the overcapacity and profusion of Chinese car firms through the concentration of the Chinese car industry into a few globally-competitive companies, given local protectionism, that has been the official policy aim since at least the 1990s (Gallagher 2006). China thus also presents the starkest example of the challenges of e-mobility innovation niche protection through (infant industry) industrial policy, as described by Smith and Raven (2012); namely the challenge of not constructing structures of power relations that simply lock-in permanent industrial uncompetitiveness, subsidies and, possibly, graft. As such, the fragmentation of power relations contributes to the key government grievance regarding the car industry and a continuing issue for the attempted hi-tech EV transition, namely the continuing domination of the foreign JV partners.

These deep-seated political challenges, however, also condition a situation of considerable dynamism in each respect even as the domination of SOEs, and of the state-capitalist model of development more generally, remains entrenched. First, there is the growing success of Chinese businesses in creating just the kind of global and hi-tech brands for which the government, and broader population, hope. These, however, are not in the car industry or indeed any of the sectors of heavy industry that are dominated by the increasing number of massive SOEs that feature in the Fortune Global 500 of the world's biggest firms (by revenue). Rather, they are in ICTs and electronics and are quintessentially identified with the more global and entrepreneurial provinces of the South and South-East, specifically Guangdong (which includes Shenzhen) and Zhejiang. Moreover, even as recent years (notably, of turbulence and crisis in the global economy) have seen, there have been moves towards trade protectionism and tightening of requirements for foreign investment or competition in China (Hout and Gemawat 2010), this has also included a redoubled state commitment to engage with the global economy (WB/DRC 2012), including moves to liberalisation of finance and the RMB, both trends that appear to be continuing under the new Xi/Li administration. Moreover, there are signs of a renewed top-level commitment to SOE reform.[37]

Furthermore, the new administration is also tackling the entrenched power of the 'cadre-capitalist' class, responding to growing popular outrage against corruption. While the success of this campaign is an open question, this situation does point to a new touchiness if not fragility in power relations; and considerable anxiety amongst this class, given the ever-higher penalties if caught, resulting in growing movement in corporate-state relations and hence the potential for significant, rapid or volatile change in the power of specific industries. In all these respects, therefore, there are intriguing signs of a greater influence of private, globally-focused and innovative hi-tech firms over state policy and of emerging openings in the stranglehold of incumbents over industrial and innovation policy.

Moreover, fragmented authoritarianism itself is both proving a potential strength (not just a weakness) and is changing. Oh (2013), in his case study of success of Hyundai's joint venture in Beijing, reveals the essentially dual-structure of Chinese politics in dealings with auto manufacturers. Fragmented authoritarianism in this case means that while central government is involved in 'big' world trade battles it enables local governments to regulate locally the demands on global businesses that may be willing to invest there. Local governments can manipulate consumer purchases and thus promote locally based Joint Ventures, offering shortcuts to facilitate new foreign businesses where it suits them. While national government establishes global links through membership of the World Trade Organization (WTO), regional (sub-national) governments maintain significant leeway in their dealings. But both national and sub-national levels seem to be following the same goal. For instance, it was

[37] E.g. Sinopec has recently announced efforts to realize the mixed ownership management by attracting social and private capital. The move is seen as a prelude to a new round of the mixed ownership reform (http://www.sasac.gov.cn/n1180/n1566/n1881407/n1881422/15718895.html).

Beijing Government's decision to select a particular brand (Hyundai) when renovating the taxi fleet (Oh 2013), the result being the rapid rise, from market entry, of this brand in China.

Secondly, as Mertha (2009) details, a 'fragmented authoritarianism 2.0' is emerging in which government bodies are downsizing to afford a more streamlined and efficient form of governance, while also 'consulting' (whether officially or through monitoring) a broader community of stakeholders through the growing proliferation of social media (see Tsang 2010 on 'consultative Leninism'). This change in governance is particularly useful for a responsive form of governance suited to a fast-changing field, such as that regarding innovation. And indeed, in Shenzhen, EV policy is now primarily administered through a 'leadership team' (*lingdao xiaozu*) comprised of senior local cadres.[38] In short, then, while the incumbent politics of EV production are stacked in favour of high-carbon SOEs, the emergence of both critical immanent challenges to this structure of power relations and significant 'external' experiments showing increasing success together present a dynamic picture of potential instability and/or transition.

Users

Regarding user politics, a similar conclusion emerges. An essential aspect of the extraordinarily rapid current *construction* of an automobility socio-technical system in China, is that the car has become the number one consumer aspiration.[39] This is all the more the case as cars are increasingly affordable for growing numbers of Chinese. Nor is this simply a matter of consumption choice. Rather, in a country characterised by 'individualization without individualism' (Yan 2010) in which the domains of (jealously protected) increasing personal autonomy reside squarely in the economic (as opposed to the civic) sphere, consumerism is of heightened social and political significance. It is primarily through the consumption practices of oneself and one's family that contemporary Chinese can exercise their individual freedom, cultivate a sense of individual identity and put it and their material success upon display and hence claim a certain social status.

Moreover, focusing on economic success or freedom conditions the adulation of a particularly unlimited and conspicuous form of wealth. As Zavoretti (2013) mentions in her ethnographic study of class distinctions among urban Chinese, by spending money on a fancy article, the consumer proves his high quality (*suzhi*) as a person, something that was generally considered to add an important symbolic and moral value to economic prosperity (Anagnost 2006).[40] It is no surprise, therefore, that China is increasingly seen as one of the most discriminating of national markets regarding the power of brands (Economist 2014c). In the relative absence of socio-political freedom, the bodily experience of the consumption of *mobility*, or the freedom of autonomous movement, appears to offer a strong sense of personal freedom (*cf* Paterson 2007). In these circumstances of personal affective investment, the car assumes an almost unrivalled position. There is a strong preference for big, expensive, foreign (particularly German), gas-guzzling cars that epitomise the extravagant modern, Western lifestyle to which many Chinese aspire. The conventional fossil-fuel car is thus currently a key element in the forming of the social identity of the Chinese middle class (Zhou and Qin 2010). And given the importance of this stratum of society for broader regime legitimacy, this suggests serious obstacles to policies that would penalise the petrol-powered car in support of an EV alternative. Indeed, the car appears so irresistible that even policies seeking to reduce car numbers and to mitigate its effects can have potentially negative unintended consequences. For instance, large cities such as Shanghai or

[38] http://www.sz.gov.cn/zfgb/2009/gb678_1/200912/t20091218_1396126.htm

[39] See Nielsen (2011), and 'Chinese car sales trail consumer aspirations', http://www.scmp.com/article/494103/chinese-car-sales-trail-consumer-aspirations

[40] The discourse of suzhi and its connection to green-thinking requires particular attention which will be examined during fieldwork in China, 2014-2015. We return to this theme below, in section 3.2.

Beijing have long attempted to implement measures to decrease the impact of the carbon-based transport. In order not to let all the cars on the streets on the same day in Beijing, cars only with odd numbers on the number plate are allowed on one day, and the following day those with even numbers are permitted to travel. For those who could afford it, however, the response has been to buy a second car, and hence to increase overall car numbers and travel (Time 2014).

The reception of the EV is tied up not just with consumer politics but also with those of mobility more generally, and these matter profoundly to systems of government of modern market(ised) societies (Bærenholdt 2013), which would certainly include China. Automobility and the promise (at least) of fast, personalised transport is a crucial aspect of the functioning of such societies, again privileging (the imaginary of) the car as freedom in ways that add further support to the consumer politics and affective pleasures of the car.

This dynamic also plays out through the process identified by Elias (1995), in which socio-technical advances (archetypically the car) call forth a concomitant 'civilization' of the population.[41] Drivers in control of huge, fast and lethal machines are forced to change their behaviour, and in turn their dispositions and attitudes thus mitigating the intensified dangers of cars; as are other 'road users' and pedestrians. Today in China, this is clearly in process, as high death and injury rates are eliciting such changes in personal identity. A civilized person thus becomes (defined as) one who knows how to drive or manoeuvre through the new urban environment, while the uncivilized 'bumpkin' is the person who puts themselves and others in danger through undisciplined movement. Again, therefore, we see the car as a crucial element of changing social relations of the 'conduct of conduct' within contemporary Chinese society (Dean 2010).

Together, then, the prospects of the widespread rapid adoption of EVs do not appear promising. Indeed, the situation appears to evidence one of entirely separate spheres of evolving 'normal' consumer aspiration for mobility on the one hand, and of 'low carbon' EV mobility innovation on the other. The prospects of an EV sociotechnical transition would need these to co-evolve and to converge. This is after all what happened regarding the growth of ICTs and of web 2.0 innovations and services that developed in co-evolution with the formation and shaping of China's urban middle class.

Yet the politics of mobility consumption are dynamic and may be subject to rapid change. Indeed, the social meaning of the middle class, with which these issues are intimately bound, is far from settled and is affected by considerable tensions. In particular, the two key issues with which the car is increasingly associated in China are significant problems, and not experiences of freedom on the open road as in multiple icons of mid-twentieth century American culture, integral elements of the American Dream and US hegemony (Paterson 2007). These two issues are air pollution and daily gridlocked congestion. In both cases, this poses serious challenges to the construction of a middle class identity of hoped-for (moderately well-off - *xiaokang*) prosperity and increasing quality of life in which the car retains its centrality.

Rather the car is increasingly associated with trade-offs that tarnish, and so threaten, the entire social vision, now formalised in the new top-level political discourse of the 'Chinese Dream', of contemporary Chinese modernity and progress. For instance, a recent study by Sandow (2011) in Sweden shows that the long or painful commuter experience is directly linked to personal unhappiness and a loss of family cohesion (which was also highlighted in Putnam 2000). This could have far-reaching consequences in undermining the popular imaginary and common sense upon which the current Chinese political

[41] Though we may put a more Foucauldian spin on this argument by adding the scare quotes to 'civilization' that Elias would leave out, showing this is a matter of knowledge politics and social definition and not of objective progress.

economic order is built. Americans and Europeans did not face such trade-offs in their rise to middle class prosperity in the mid-twentieth century. As a result, significant shifts, including in government policy to accommodate these tensions, might be expected.

Thus faced with the challenges of air pollution and congestion, the car serves to sensitise Chinese urban residents to issues that may problematise further entrenchment of the existing automobility system. This is particularly so for the emerging middle class, as it is this group that has the existing resources, incentive and leverage to demand improvements in their quality of life, such as in their environment. Similarly, when owning a car means that one must set off to work very early or very late, it becomes apparent that what is valued is not the car *per se* but the personalised mobility that it supposedly promises but rarely delivers.

In these circumstances, then, a new openness may be emerging to multiple possible alternative models of urban mobility. This includes a growing willingness to experiment with forms of mobility, including intermodal travel, where cars will no longer dominate the urban landscape and commuters could use a scheme of inter-connected personal vehicle-public transportation. According to the IBM commuter pain index survey constructed in 2011[42] residents in both Shenzhen and Beijing are ready to switch to public transport under certain conditions, such that it is less crowded, low carbon, and/or fast.

This is further bolstered by important generational changes in China. In 2014, those now in their mid-twenties or younger have grown up exclusively in a post-'89 China. This generation are called 'strawberries' (*caomei*) by disparaging elders, because they enjoy pleasurable, hedonistic lives of high materialistic expectations, but are delicate and not robust enough to do hard work (Lin and Sun 2010). Yet, whatever the merits of such a characterisation, they are also more open to experiment with digital technologies and have greater awareness of developments and forms of life elsewhere in the world (hence affording comparison with, say, European or Japanese standards of air quality or urban mobility). They thus might be said to have expectations that are increasingly 'post-materialistic' (*Cf* Inglehart 1997). This has generated a new Chinese social phenomenon of the bourgee, 'bourgeois bohemians' or *xiaozi* class, who may not yet be able to afford the (expensive) EV models available but could be latent users, using or willing to use an EV (of some description) for short-range trips, if only as a novelty or as a part of their Westernised outlook (see Wang 2009).

A further important element in this dynamic picture concerns the specific enabling of this group by the still-emerging digital innovations and web 2.0 social media. China now has more regular users of the internet, and increasingly the mobile internet, than any other country (some 600 million by 2012, or more than the US, India and Japan (numbers 2–4 in global rankings) combined).[43] This has helped create several giant Chinese firms (Baidu, Alibaba, Tencent, ZTE, Huawei), including those offering services that overseas companies offer elsewhere but which are banned within China (Weibo, WeChat/WeiXin, Renren *Cf* Twitter, WhatsAp and Facebook respectively). Moreover, the specific group within Chinese society most enabled by these digital communications is the young, urban, educated (and largely male) class from the 'strawberry' generation. Interestingly, marketing research shows that three-quarters of the online population obtain news about cars from the Internet.[44] This is a generation focused on hi-tech software/media innovation (Keith *et al.* 2013). Yet the increasing digitisation of mobility, in which the very technologies that constitute the 'EV' remain an open question, presents interesting possibilities regarding how this generation – as users *and* potential innovators or both together; *and* as it ages and changes in priorities and resources – could contribute

[42] http://www-03.ibm.com/press/us/en/pressrelease/35359.wss and Time, March 24 (2014).

[43] http://www.census.gov/population/international/data/idb/rank.php

[44] http://www.mrweb.com/drno/news6174.htm

to a significant migration to EVs, although this would *per se* do little to reduce congestion. In other words, while the politics of EVs as currently conceptualised in policy and business imaginaries seem a failure, the trajectory of sociotechnical innovation leaves open the prospects of a more broadly conceived e-mobility transition.

Similarly, enabled by social media, it is this constituency that is particularly empowered in the crucial political arenas of environmental and mobility politics, even as the Xi administration has launched the latest of recurrent clampdowns on online activity. This is particularly the case given the specific nature of these two fields of political contention. On the one hand, contestation about the environment is hard to portray as simply 'anti-China' (anti-CCP) and is amongst the more tolerated arenas of protest, while the environmental movement continues to grow, especially from 'recruits' amongst the online, urban generation (Geall 2014). On the other, with mobility so important to a functioning market society and to regime legitimacy, the politics of automobility, congestion and parking is crucial to the most powerful class of Chinese citizens, namely the new middle class of car owners (Tyfield 2014a). To this we may also add the twist of Tesla, the most desirable (and foreign) car in the world today, now selling to the Chinese super-rich and so transforming the dynamics, regarding EV transition, amongst the elite cadre-capitalist class as well (Want China Times 2014).

This leads to the final point regarding a broader tension at the heart of contemporary Chinese politics. We have discussed above how the government of modern market societies places a particular imperative upon accelerating individualised mobility (Virilio 1986; Foucault 2009; Rosa and Scheurman 2009). In committing itself to unbroken economic growth and the liberalisation that this entails, the CCP is also committed to this imperative. Yet, the corollary of increasing automobility is the increasing empowerment of drivers of their cars, a group that is empowered on grounds that bear no relation to their membership of, or even ideological sympathy for, the monopoly of legitimate organisation of the CCP. On the contrary, this quintessentially middle class group are likely to have personal ambitions that are materialistic and individualistic, rather than political or statist.

In short, mobility politics in China are constructing power relations that are quintessentially 'liberal', in the sense of privileging government through the consumption of individual freedoms (Rajan 2006; Foucault 2010) although this does not in any way entail power relations supportive of democratic forms of government (Tyfield 2014a). And this is increasingly the political constituency on which the broader legitimacy of the regime itself rests. Mobility politics thus incorporates tensions constitutive of the emerging middle class in China, what this identity is coming substantively to mean inter-subjectively, while this in turn makes the reception of EV mobility innovation a crucible for the key political tension between regime legitimacy and this class's demand for the globally most advanced (2.0-connected, futuristic, clean, mobility-efficient but also affordable) innovations.

In exploring this dynamic terrain of shifting socio-technical power relations, therefore, we can approach the key sociological question of the prospects for transition to low-carbon mobility in China, and the possible qualitative characterisation of such emerging societies. In order to do this, however, we must turn to the concrete practices of mobility regarding EVs and their hesitant adoption.

2.3 Social Practices

In seeking to identify emerging complexes of potentially automobility-regime-disrupting socio-technical change, we direct attention to emerging *practices* of electro-mobility. This section briefly restates the theoretical case for the importance of social practices. And it then illustrates this with initial empirical findings that provide a snapshot of (considerations regarding) the *questions* relevant to subsequent research.

In assuming the lens of social practices, we follow the insights regarding socio-technical transitions developed as 'practice theory' (Shove and Walker 2007; Shove and Walker 2010; Shove *et al.* 2012). This perspective builds on seminal debates in social theory (such as Giddens and Bourdieu) that sought to identify social practice as a primary locus for social action, thereby squaring the perplexing circle of the structure-agency debates of the 1970s and 1980s. In more recent developments, subsequent social theorists (Schatzki 2001; Reckwitz 2002; Warde 2005) have focused more on issues of technology and culture in processes of social ordering and interaction (Spaargaren 2011). Practices are defined by Reckwitz as:

> a routinized type of behaviour which consist of several elements, interconnected to one other: forms of bodily activities, forms of mental activities, 'things and their use', a background knowledge in the form of understanding, knowhhoveow, states of emotion and motivational knowledge.
> (Reckwitz 2002: 249; quoted in Spaargaren 2011: 817).

These relatively persistent entities are then inhabited and/or performed by individuals, rather than placing the (rational) agent (or, indeed, a non-human social structure) as ontologically primary. Practices are thus the 'site of the social' (Schatzki 2001), and they provide an analytical window into the evolution of social life and social order. As such, a phenomenologically more compelling account of social action may be constructed, in which the greater part of such activity is not presumed to be rational, cognitive, individualist but habitual, social and practically or culturally rational (Fischer 2003). Moreover, such practices tend to cluster or 'hang together' (Schatzki 2001; Shove and Walker 2014) in complex assemblages, forming a nexus, such that alterations or innovations in one practice may have (non-linear, unpredictable) repercussions upon others.

As regards socio-technical systems transition, practice-focused analysis has shown itself adept at illuminating such processes and, in particular, key reasons for the relative *failure* of any low-carbon transition to emerge despite some significant policy initiatives (Spurling *et al.* 2014; Watson 2012). In particular, both the two major considerations above, *viz*. the priority of social practices over individual rational agency (and non-human structure alike) and their complex embeddedness and inter-relations with other practices, directly problematise existing policy orthodoxies regarding the driving of low-carbon transition through policies that presuppose individualist models of changing attitudes, behaviour and choice (Shove 2010, for a critique of the 'A-B-C' model).

McMeekin and Southerton explain that, whereas from this mainstream perspective the emphasis lies entirely on encouraging 'sustainable' (consumer) choices and, in particular, associated with new green *technologies*:

> Significant challenges and opportunities arise from potential shifts in the practices within which new technologies are absorbed; indeed, *the absorption of technologies into practices must be amongst the most significant forces in changes to practices as performances and entities*. This reinforces how important it is to look beyond the purchase of new products into *how those products are actually used and embedded within existing nexuses of practices*, and what the *ecological impacts are of those practice nexuses*. (Emphasis added)
> (McMeekin and Southerton 2012: 358)

As such, while individual changes in behaviour and consumer choice

> […] are an important source of change for sustainability transitions, their significance can only be understood in the context of stabilised practices and social relations. Moreover, they will

> only matter in sustainability transitions if they play some part in reconfiguring collective practice, such that the new ways of participating in the practice become stabilised and recognisable in the practice as entity.
> (McMeekin and Southerton 2012: 352).

A practice-focused perspective explores the embedding of innovations within everyday life, and where practices are viewed as social, habitual, systemically-situated and system-performative (Watson 2012).

This perspective is particularly useful for exploring transitions of mobility Understanding the transition of mobility systems, or lack thereof, demands analysis going beyond mobility as travel from A to B, framed in the economistic terms of the supposed priority amongst users of (technologically-assisted) maximum efficiency and minimum travel-time (Schwanen *et al.* 2011). On the contrary, mobility is understood as a social practice in its qualitative richness and complexity; for example, as in the *practice* of car-driving (Laurier *et al.* 2013; Sheller and Urry 2003). And, furthermore, mobility sits within a complex nexus of practices that construct the habituated expectations of and *demands* for specific forms of mobility (Shove and Walker 2014). For instance, it is the practices of commuting long distances to work, doing a supermarket shop on the way home, *alongside* dropping the kids at school that creates the practice of the school run in the car (Pooley *et al.* 2011).

This project, however, lies in exploring whether and how novel and dynamic assemblages of *power relations* are emerging through the specific e-mobility innovations in China. As such, while building on practice theory, and its engagement with socio-technical systems analysis (Watson 2012), our focus on practices departs in important ways from much of the work deploying this framework. In particular, our concern here is to explore practices through the same strategic-power-relational perspective used above. This serves as an analytical window through which to explore over an 'extended present' how reception, consumption and use or not of these socio-technical innovations is transforming everyday life (collective identities, expectations, norms of adequate performance) and thence the power relations constitutive of socio-technical formations and underpinning possible further transformation.[45]

This further theoretical step is taken to impart dynamism to analyses of (nexuses) of social practices by reading them as performative and as mediating and mediated by strategic power relations. This then affords analysis of real-time systemic change and avoids more challenging problems that face a classically 'practice theory' perspective that treats social practices as ontologically primary within a 'flat' social ontology.

There are two key problems here: first, how to abstract intelligibly from the sheer complexity of the nexus of practices, in which changing any individual element or practice has entirely unpredictable effects regarding associated practices; and secondly, the impossibility of exploring future practices, given that one has no grounds to extrapolate from existing empirical patterns into an unknowable future nexus of practices that will feature both practices not yet in existence (or perhaps not even conceivable) and the disappearance of other, current practices (as described by Shove 2012).[46]

Our concern is to explore the various ways e-mobility innovations are received, adopted and embedded within changing social practices. This calls for a system–situated approach where groups of both actual and potential users (who may currently be non-users or opposing groups) are included in the fieldwork, thus allowing for a broad range of logics of innovation adoption to be considered. For

[45] This may be described, using the terminology introduced in CLR1 (Tyfield *et al.* 2014) following Flyvbjerg *et al.* (2013), as the exploration of everyday phronesis insofar as this relates to urban mobility.
[46] These problems for practice theory will be explored in greater depth in a later paper.

instance, by users we will mean not only actual owners of EVs, but also mediated users including e-car designers, e-taxi drivers and service workers, as well as imaginary users (such as prospective buyers, aspiring consumers) and non-users (e.g. ICE car-owners who are not willing to shift to EVs). In all cases, the key question concerns who, as identified sociologically by their practices, is *enabled or disabled* (empowered or disempowered) by the adoption of the innovation and how? This may then be further operationalised in terms of simple questions that may easily be posed to lay users of EVs as well as the managers, policymakers and EV experts who will all be our research subjects and that revolve around the key issue of, 'why do you use (or not) the EV?' There are six dimensions here, which illuminate different but crucial aspects of the transformation of power relations associated with e-mobility innovation.

- First, there are questions of *collective identity and subjectivity*, central concerns from a Foucauldian perspective in terms of the mutually-constitutive encounter of people and systems of power relations. Hence, what social identities are assumed in choosing specific mobility practices? And what identities are constructed and shaped in such a process?
- Second, and related, there is a cluster of issues concerning *emotion and affect.* Are there any emotions of pride or shame in being the user of different kinds of mobility-system including EVs? Do people feel more stressed and anxious, more relaxed, more enjoying the quietness of EVs, as opposed to the 'speed' of ICEs?
- Third, issues arise concerning conceptions and practices of *quality of life and well-being*. Does the innovation (or its absence) enhance quality of life and how? What is lost or sacrificed, and what gained, by adopting the innovation? What practices in daily life are valued, perhaps anew, as a result?
- Fourth, there are questions of *changes in social practices per se*. For instance, how has or how would the adoption of a different vehicle alter daily rhythms, relationships and knowledge about traffic, work, home, friendship, romance, consumption/shopping, leisure and so on? Will it make a difference if this vehicle is hired rather than owned?
- Fifth, what *connections and relations to others* have been formed (and/or broken) as result of mobility practices? What is the quality and intensity of these connections? Are people engaged with or in new coalitions?
- And finally, how has the innovation transformed *aspirations and attitudes*, especially regarding the broader system of mobility innovation, such as the direction policy is or should be taking for innovation, mobility, environment and so on?

In the rest of this section we provide some initial examples to illustrate this framework and its insights. We focus upon four key issues of contemporary urban EV mobility practices in China: charging; demand; social elites; and gender. In each case, what emerges is the distinctively privileged position of social elites regarding EV consumption, with potentially far-reaching implications for viable innovation trajectories of transition to electro-automobility (see Birtchnell and Caletrío 2014, on elite mobilities).

<u>Charging</u>

Charging will be a crucial daily practice in the life of an EV owner or user, and, as such, it illuminates many of the issues just listed. First, given the range of most existing EV models, it may be difficult to travel from A to B, complete the errands that necessitate the journey (at least according to given social-practice definitions and purposes of 'worthwhile' or 'necessary' mobility) and return home without recharging. This is likely to generate new affective contours in the lives of EV owners, notably in terms of the novel phenomenon of 'range anxiety', which may add to the existing stress of driving and sitting in traffic; and may be prove all the more intense given the gridlocked traffic of China's megacity ring roads.

Second, with regard to changing practices, because even fast[47] recharging (at a dedicated station) takes a considerably longer time than has become customary and 'normal' than filling a tank with liquid fuel, this time has to be spent by the driver doing something else. Where home charging infrastructure is possible, problems are diminished, even taking into consideration the fact that 'slow' charging takes longer still, as charging can be done during the night or when the vehicle is not in use. Even the *possibility* of access to home charging is highly limited in Chinese cities, where the vast majority of people live in high-rise apartments and parking is a problem. As discussed above in Box 2.3, another possible technological option for charging is battery swapping. However, this also faces serious challenges in terms of practices as well as infrastructure and expense (see RAEng 2010, discussing the technology in the UK context). For instance, interviews (in 2013) with EV engineers at one major Chinese car company revealed that battery swap had been investigated by this company. But in the low-trust culture of contemporary Chinese society, it was concluded that drivers would not adopt this option, not least given the huge expense and importance of the battery to the very functioning of the vehicle.

The problem of charging *en route* or 'elsewhere' thus remains predominant. Practices of charging and their interweaving with other practices that are valued and/or the efficient use of time are thus a key locus for the viability of the EV, as, therefore, is the possible social redefinition of what are deemed to be 'valued' and 'efficient' social practices. One emerging solution is the construction of charging stations, often offering free parking and spaces specially reserved for EVs, at places of work and of consumption, such as shopping malls, fitness centres, office buildings and educational facilities. However, this depends upon the new or re- design of appropriate spaces, which, even in a country with as much construction as contemporary China, is necessarily a slow and limited process that cannot reliably provide charging infrastructure in the case of journeys to places unknown to the driver. The establishment of routines, however, where such parking-charging spaces *are* reliably available could well be expected to 'ripple' (Spurling *et al.* 2014: 5) through transformations in other social practices and daily schedules, as well as create experienced discourses of 'improved quality of life' associated with EVs. Indeed, one may well expect the provision of charging services to elite EV-driving customers to be particularly propitious for the convergence of these positive feedbacks, the provision of high-end and hi-tech new buildings and infrastructures, housing elite work or consumption spaces (to occupy the driver during charging) and offering parking that is *less* competitive as being reserved for a small number of vehicles, the drivers of which can also thereby completely avoid wasting time at a petrol station. In turn, one can speculate that this would create new senses of social identity and identification with consuming a specific form of (EV) mobility.

Finally, regarding changing connections with others (overlapping with issues of quality of life), initial ethnographic data from Shenzhen shows how EV taxis have changed the daily rhythm of the taxi drivers, as well as creating a new niche of service workers who charge batteries and undertake repairs.[48] Making a virtue of necessity, these drivers have taken to meeting up together for lunch, while the battery undergoes charging in the middle of the day. While initially frustrated by the loss of working

[47] There are 'normal', 'fast' and 'rapid' charging speeds which take different times for the battery to be fully charged. The major technical (and hence economic) challenge here is that faster charging leads to a quicker degradation of the battery. Given the expense of the battery, a rapid depreciation of the battery poses serious problems for the economic viability of the EV. See also Box 2.3.

[48] Li Ping, interview data collected as a part of the study in Shenzhen in December, 2013.

time, and hence fare income, these drivers have come to value this break and the time they spend with colleagues, who are increasingly also friends and thereby forming a new strategic coalition.[49]

Distance and demand

In coming to deal with range anxiety, especially for drivers of lower-end EVs, one may also expect changes to habits of planning movements with consideration of charging stations available on the way, clearly something that would also be facilitated by the incorporation of services and/or ICTs providing (possibly real-time) information about the proximity and availability of charging facilities through satellite navigation (SATNAV). This may then also manifest in such practices changing mobility patterns, with reduced distances or more carefully monitored routes.

But practices of vehicle *purchase* may also be affected by EVs. For instance, in Beijing, the primary practical benefit of buying an EV is not the contribution to a pollution-free sky but that one does not have to wait for the highly valued number plate which is provided automatically rather than through competitive lottery. In a city where 1.4 million people applied for license plates in just one month[50] and driving schools are the size of universities, this is a big time-saver and, assuming one can afford the car itself, a cost-saver too.

Similarly, resale prices for cars are a key consideration in the Chinese market for private cars. Hence one reason why EVs have not taken off is not only the high initial price itself but also the expectation that second-hand values may be much lower than for similar petrol or diesel cars. It is not unreasonable to imagine that within a relatively short period of time battery capacity will be much improved. Indeed, it is being speculated that within 18 months electric cars may have 25 per cent longer range and at a lower price as volume increases will lower production costs. Any initial technology of an EV and its battery are likely to be dramatically improved and, therefore, an anxiety associated with EV ownership is that the vehicle will quickly be worthless. Moreover, this has a reflexive twist on market conditions, in that (akin to deflationary spirals) potential customers may rationally postpone the decision to buy such a vehicle given the significantly improved quality and value of the technology for only a short delay, but with the result that market demand remains absent and tomorrow never actually arrives.

In both respects regarding practices of vehicle purchase it again appears that the wealthy are in a relatively privileged position regarding the potential of experimenting with EV mobility (Bhidé 2009, on the importance of 'venturesome consumption'). In the first instance, this stems from the ability to reap the savings of avoiding the licence plate lottery (or perquisites regarding similar schemes in other major cities) through being able to afford the upfront costs (and associated risks) of the EV. In the second, there may be an ability to absorb what may be the 'sunk' cost of buying a car that cannot be reliably resold. Indeed, for elite customers, this may simply not be a problem. Rather, the consumer pitch for the sale of an elite EV as a flashy toy and not a dependable vehicle and investment, whose very purpose is to signal the owner's 'nowness' and conspicuous consumption with a capacity to burn money, transforms the problems of purchasing the EV-as-normal-car into precisely its attraction.

The most obvious exception to these issues would arise where the EV is simply not purchased at all, but is provided within car-sharing schemes. Evidently, these too would open up key questions regarding changing social practices along the six dimensions above. And, indeed, car-sharing schemes are emerging in many of China's major cities, notably in Hangzhou were the Kandi car-sharing has

[49] This offers a significant line of further inquiry regarding other mobility-related technology interventions and their possible impacts on sociability or unsociability. Such as the combination of ubiquitous smart phones and wifi availability which has led to (many) people always being online, thus never having a break or only having a break when the wifi signal is weak.

[50] Sky News, April, 2013 https://www.youtube.com/watch?v=5DnQA69vwWc

achieved a high-profile nationally, and which we will be exploring in detail in fieldwork. However, competing with taxis, which are reliable, familiar and cheap, and also contending with emerging powerful cultures of personal vehicle ownership (see above) as well as a civic culture of mutual mistrust, settled practices of urban mobility in Chinese cities present significant challenges for EV car-sharing (Shaheen and Martin 2011; Wang *et al.* 2012).

Elites

The EV as elite and luxury consumer technology thus emerges as a key aspect of its prospects from a practice perspective. This may well have global repercussions. In 2012 China was counted as the world's largest market for luxury cars[51] and indeed the second largest market for luxury goods after Japan. It is little wonder, therefore, that the Shanghai Motor Show 2014 for the first time featured the fastest e-vehicle, Detroit Electric SP01, to be sold in China, as well as the first Porsche electric-fuel hybrid Panamera and an e-Rover (*Roewe*), the British brand acquired by SAIC. Similarly, the first seven Tesla S model sedans were sold in Shanghai in April 2014 to large business owners, elite customers with fearsome purchasing power.[52] The EV as *the* luxury vehicle is thus fast becoming cemented within the Chinese consumer imagination.

However, in the process, expectations regarding a high-end driving experience must also change. In particular, lacking the characteristic noise of roaring engines, luxury EVs are engaged in marketing campaigns to transform the silence of these vehicles from an effete absence signalling a childish toy or amusement to the new signifier of the technologically avant garde, and a highly gendered (i.e. masculine) 'grown up' and serious machine: a 'man's car' (See Figure 2.6).

Gender

This thus leads to the final issue we mention here, namely the gendering of electro-automobility (Urry 2004), a key dimension of the emerging common sense meaning and practices of EV automobility. On the one hand, the growth of the number of women drivers in China is a key current trend. On the other, as we have seen, this does not mean that a gender neutral or gender equal conception of EV (practices) is likely to emerge. Doubtless, the emerging practices of EV adoption, use and promotion are taking on specific gender aspects, just as they did with the emergence of automobility in the early twentieth century, notwithstanding the importance of women as early adopters and engineers of the motorcar (Urry 2007).

Moreover, this is not just a matter of marketing, nor even imagined practices of EV mobility; *per* the flashy 'male' Tesla sportscar as opposed to the tidy, nimble and small 'female' car (the family's second car) for short trips to the shops, the school run or family weekend entertainment.[53] Rather, here one has to view issues of safety, aesthetics, technical knowledge and (possibly even self-assisted) repairs through the prism of socially-imputed gender differences and the performativity of gender (Butler, 1999). We may note, however, that in both of the cases (male and female), it is again as a consumer technology of the wealthy, in particular, that this co-production of the meaning of EV and (twenty first century 'modern' Chinese) gender emerges most clearly, hence precisely as images of the acme of successful masculinity and femininity, and so *not*, currently, as an item for mass (or even 'middle class',

[51] http://www.wantchinatimes.com/news-subclass-cnt.aspx?id=20130210000044&cid=1102

[52] http://www.wantchinatimes.com/news-subclass-cnt.aspx?cid=1102&MainCatID=11&id=20140426000003

[53] The changes in power relations in the family or between men and women that occur due to the intervention of a new technology (particularly related to mobility) will be considered in a dedicated article.

'respectable' etc.) consumption and mobility. The interaction between elite and emerging middle class practices and conceptions is thus a key arena in which socio-technical change may develop.

There is also an emerging alternative model of e-mobility within China that appears to hold greater promise for mass e-mobility and this is the electric 2-wheeler to which this paper now turns.

Figure 2.6: The Gendering of Elite E-Automobility - Shanghai (June 2014)

Source: Dennis Zuev

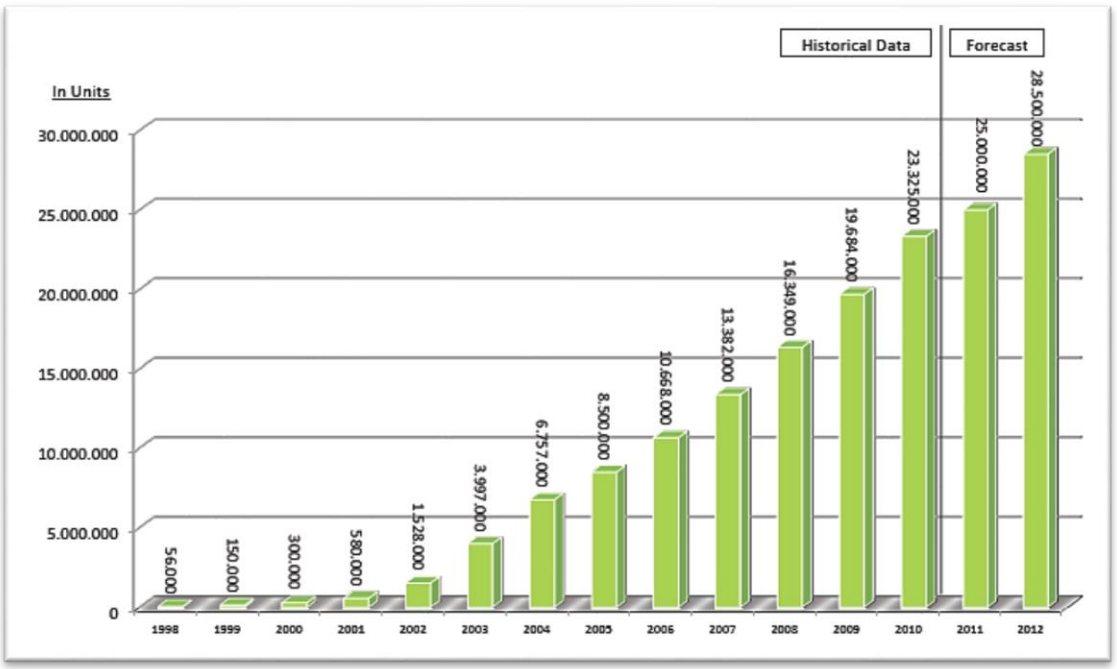
3. Electric 2-Wheelers, Mobilities and Power

3.1 Prospects

Moving from the EV, we have already considered above one potential innovation, namely *disu* vehicles. However, a more striking case is presented by electric two-wheelers. The current situation regarding E2Ws in China contrasts with the EV in many respects. Most obviously there is their enormous spontaneous and bottom-up market demand, with some 120 million on the roads by 2010 (Weinert *et al.* 2008) and strong growth since then, and this in the almost complete absence of government support (and certainly of high-level programmes of industrial policy). Moreover, with China accounting for 92 per cent of the global market in E2W sales (Navigant Research 2013), and with most Chinese citizens choosing domestic Chinese brands, this is also a real opportunity for Chinese global industrial leadership.

We consider first the successes and opportunities of the E2W, specifically regarding their prospects for a *broader socio-technical system transition of urban mobility* in China, before turning to challenges and obstacles. As above, it is useful to divide these areas into issues seen from 'user' and 'producer' perspectives. In the former case, sales of E2Ws in China have been spectacular (especially in contrast with the stuttering of EV demand) (see Figure 3.1). The global light electric vehicles (LEV) sector is witnessing robust growth and is the fastest-growing segment of the overall electric vehicles market, with E2Ws in turn the most popular LEVs (IDTechEx forecast 2013).The highest growth rates are, in turn, registered in China where their annual sales are projected to reach nearly 130 million by 2025 (IDTechEx forecast 2013). Until recently e-bike sales were concentrated within the EU, Japan and China. However, during the past few years almost every society has bought the Chinese E2Ws, and in certain cases in rather large volumes (Analysis of Chinese Electric Bicycle/Pedelec Exports in 2013).

Figure 3.1: E2W Annual Sales in China



Source: Chandrasekar for Castellan AG (2010).

This prospect of Chinese global leadership must, however, be set against the different technologies (or types of E2W) and standards placed upon E2Ws around the world. Currently, throttle-controlled E2Ws are in high demand worldwide, these being effectively e-scooters. The Western European market, however, is one of the few markets to have mandated pedal-assist e-bicycles. While China's battery market is largely lead-acid based, lithium-ion batteries are most common in Western European and North America. This is because the quality and range are important enough to justify the higher cost, especially since the e-bike appeals to a different consumer base. In the global North, for instance, E2Ws are emerging as expensive (costing thousands of pounds) and stylish, servicing cycling enthusiasts and leisure cyclists looking for an extra boost up a steep hill. Conversely, in China, the huge appeal of the E2W hinges on the access to a motorised mobility that is cheap (e.g. from as little as hundreds of RMB, or tens of pounds, with also low fuel costs via cheap electricity), speedy (maximum speeds of 40–50 km/h), and 'nimble' (able to weave through congested streets and onto and off pavements).

In China's fast-expanding cities, where citizens face daily demands for mobility of increasing distance and where public transport is struggling to keep up with growth of demand (the current boom in metropolitan subway construction, for instance, notwithstanding (Economist 2014c), such a cheap option is potentially transformative for the vast majority who cannot afford a car. Moreover cars will often be stuck in the gridlock which the E2W can wind its way through it.

Moreover, the E2W is not only of much greater appeal and relevance to the massive Chinese market, but also to similar demands of much of the rapidly developing global South (see Sengers and Raven 2014). Such South-South trade and technology transfer may be of greater global impact than the more limited prospects of the E2W in the global North, with perhaps even important 'reverse innovation' implications in the medium-term (Immelt *et al*. 2009; von Hippel and Chen 2009).

The appeal of the E2W to Chinese urban residents is thus clear. However, from the producer perspective too, there are clear successes and strengths in China. The first e-bicycles only appeared in Shanghai in 1995, manufactured by Shanghai Cranes Electric Vehicle Co. based in the Pudong section of Shanghai (symbolically still a relatively undeveloped part of the city but now the central financial district of China). The company derived from a venture-capital arm of the Shanghai Government that had been investing in electric-drive technology in a bid to lead a new national electric-automobile R&D programme. When Shanghai lost the automobile research bid to Guangzhou in 1994, Shanghai's EV team turned to E2Ws, a type of vehicle that had begun to appear in Japan the year before. Due to the lack of intellectual property protection (in marked contrast to the IP-intensive model of innovation in the EV sector), the Cranes model spread relatively rapidly. As a result, there are now approximately a staggering eight hundred brands produced by registered and unregistered manufacturers in China, largely clustered in Zhejiang and Jiangsu provinces and Shanghai.

This has created a hugely fragmented, but also highly competitive, industrial structure. And whereas the high costs of EV innovation mean that the similar (if less remarkable) fragmentation of the Chinese car industry has strong negative implications for such innovation, the comparatively low costs of E2Ws means that this competition is not at the expense of a growing capacity of successful firms to innovate. Indeed, competition is driving the search for the security of monopoly super-rents that innovation offers, and along trajectories that pay the utmost attention to the demands of (potential) customers. Whereas the EV is thus driven by a top-down imaginary or grand plan of e-automobility (as basically a 'car' with a different engine), the E2W is developing in an active and recursive response to existing and changing consumer demand. With significant revenues and profits, R&D programmes are also affordable for at least the more successful firms without government subsidy, again in marked contrast to the EV.

Large Chinese E2W companies are expected to face fierce competition from, and even be pushed aside by, established motorcycle and auto parts making companies, including those from overseas. In particular, businesses from other Asian countries, such as Taiwan, Japan and South Korea, are deemed to have huge growth potential owing to the presence of strong supply chains for nearly every LEV or LEV component in these geographical areas (Market Publishers Report 2014). But China too is developing supply chains and industrial capabilities for end-consumer products that particularly service Chinese (or even more localised) market demands, so their incumbency in these markets is no small advantage.

As such, the E2W industry in China is potentially another key example of the emerging strengths and capacities of the Chinese 'national innovation system' as an 'absorptive state' (Bound et al. 2013) and a 'disruptive' innovator (Breznitz and Murphree 2011; Zeng and Williamson 2007; Tyfield *et al.* 2010). Indeed, the E2W is potentially a classic case of such disruptive innovation, where this is correctly understood not just as a techno-boosterist buzzword for 'tech' innovation *per se* but as involving the *social redefinition* of existing technologies by developing, 'cheaper, easier-to-use alternatives to existing products or services often produced by non-traditional players that target previously ignored customers' (Willis *et al.* 2007: 1; Christensen 1997) and/or their use in novel contexts and combinations. In the first instance, therefore, a disruptive innovation may offer *lower* functionality than existing products according to established social definitions of what the product 'is' or 'does' as in the case of the E2W rather than cars, whether powered by petrol or electricity. But by offering them at lower cost and possibly with new combinations of functions, a new market is opened that may in time, as the disruptive innovation itself improves, disrupt the established market. The classic case here is the digital camera, which while originally not so functional as film-based cameras has almost entirely come to replace them.

Disruptive innovation is thus intrinsically a *socio*-technical innovation. It also resonates with a consistent insight of innovation studies (including multi-level perspective (MLP) literature) regarding the likelihood that transition may well involve innovations that appear peripheral, small or otherwise unpromising from the perspective of the incumbent regime (Elzen *et al.* 2004). But the most important consideration regarding E2Ws, from the perspective of their prospects in driving a broader system transition, is their potential for socially redefining the very idea of the 'car', and hence of 'automobility' itself.

Several of China's E2W disrupters, such as Lüyuan, were explicitly founded as a route towards the future construction of other EVs and are already experimenting with further forms of vehicle (such as 3-wheelers; Tyfield *et al.* 2010). The form of these larger vehicles is open to radical redesign, since an electric drive train removes the engine and transmission of an ICE around which the rest of the car is assembled. And developing EVs from E2Ws enables innovators to explore disruptive possibilities rather than start from the current design of what is a car. This potential is particularly shown with the growing practice of *shanzhai* or 'knock-off brands'. This involves the tinkering by small garages of existing cars to convert them to electric vehicles (Wang 2011). This is widespread within Chinese cities and is focused upon small vehicles, often 3-wheelers.

Moreover, most firms are Chinese (including along the supply chain) and many are engaging in programmes of R&D and RDD&D. There is, thus, a significant potential for E2Ws to catalyse a broader shift in the international division of labour of innovation in this key industrial sector of urban mobility. Indeed, with Chinese companies emerging as major global players, the dynamics of international collaboration and technology transfer (i.e. the *key* issues of contemporary techno-nationalist innovation policy in China) would open up the potential for more even-footed cooperation based on mutual benefit as opposed to the current uneven *quid pro quo* of market access for technology transfer. This game-changing innovation is now attracting the attention of established car companies.

At the Shanghai Expo in 2010, GM-SAIC displayed its EN-V bubble car (Economist 2010), which is not easily classified as either an EV or an E2W since it involves two people sitting side-by-side but it has only two parallel wheels which gyroscopically raise the vehicle up into a balanced position once the engine is turned on.

Finally, a remodelled system of urban automobility built around the smaller 2 or 3-wheelers that emerge from these new disruptive socio-technological trajectories would have potential to address not just the fossil fuel emissions of the existing ICE automobility system but also other key challenges, notably the space constraints involved in congestion and parking (and charging).

In short, the prospects of E2Ws are high. But its success in terms of broader system transition hinges on the capacity to upscale from and move beyond a *viable, if important,* niche. There are several important issues here. First, in terms of environmental impact and low-carbon credentials (as above regarding EVs) there is the crucial question of the extent to which the E2W as a form of e-mobility will actually reduce GHG emissions and not just displace them to point sources generating the electricity. However, the E2W as a smaller, lighter vehicle is much more energy efficient than the EV and more than the most efficient ICE cars. Crucial questions regarding the Jevons or rebound effect, in which the greater efficiency of mobility and energy leads to greater overall consumption of energy and resources, also remain.

This points to further questions regarding the demands of contemporary socio-economic life for accelerating corporeal mobility (Rosa and Scheurman 2009; Virilio 1986) and the importance of broader social transformations of mobility and the possible place, and meaning, of E2Ws within such a system. But the more dramatic shift from the ICE car to E2W could open up these crucial questions better than the lock-in to the 'car' system which the imaginaries of the current programme of EV innovation presupposes.

In terms of environmental risks and harms another key challenge for E2Ws in China arises from the question of waste, especially given the current technical cheap option of lead-acid batteries. Just as decarbonisation depends upon transitions in other sectors, so too does the need for a dedicated infrastructure for low-carbon recycling of disused and discarded batteries from e-vehicles, including E2Ws (Cherry 2007). China is already one of the leaders in informal e-waste recycling, often resulting in significant damage to the environment. So in a classic example of the challenges of compressed modernity (Han and Shim 2010), the afterlife of e-mobility components is already important and not something that can simply be left to be 'cleaned up later'. If lead acid batteries could be replaced, E2Vs could be regarded the most environmentally sustainable motorised vehicle in China (Cherry 2007). As for now (Chun 2013), fewer than one-third of lead-acid batteries are properly recycled, with official recycling companies not receiving all material for recycling. A lot gets illegally recycled in much more hazardous and polluting ways. This also has international and geo-political aspects. China has sought to implement a 'Green Fence' programme of stopping e-waste imports which currently cause much environmental pollution within China, especially in the South (see Urry 2014 on offshoring waste more generally).

This leads to a second key challenge, namely the question, also raised for EVs, of the geographical diversity of China and the resulting E2W markets. This diversity is climatic (differing challenges from weather to which the E2W driver is exposed), economic (differing levels of income, consumer expectation and demands for mobility), urban (different challenges of traffic, quality and design of roads and bicycle lanes, and daily distances) and socio-cultural (practices and norms of mobility, including consumer identities and practices of individual or family mobility). There is also a crucial political geography, in terms of diverging policies not just of support but also of penalty and regulation, including their outright ban in many cities (see below). Together, these various factors, and the

commensurate geographical diversity of conventional car mobility (and support thereof (Cohen 2010)), also construct widely diverging exposure to risk, safety (of the E2W driver and others, both drivers and pedestrians) and accidents. However, this geographical diversity and the fragmented market are also potential strengths of the E2W, especially as many diverse models and innovations come to assemble, combine and converge. Again, therefore, the longer-term significance of the E2W may lie in regions and cities not currently at the forefront of Chinese socio-economic development.

This can be seen by considering the three case-study locations of Shanghai, Shenzhen and Shandong Province. Shanghai is the original home of the E2W and it remains a key industrial and consumer hub. The continuing domination of the car and regulations policing the E2W pose serious challenges to the growth of E2W beyond a niche and any E2W-based transition must be able to become widespread in established mega-cities such as Shanghai. In Shenzhen, too, the E2W faces serious obstacles, including a municipal ban, on many of the major arterial routes.[54] There is also industrial competition of the (local-government championed) EV. However, the regional industrial successes of ICTs, and both the massive local workforce of migrant labour seeking cheap auto-mobility as well as the comparatively large population of young, professional but not wealthy, and innovation-hungry consumers willing to experiment with new forms of mobility, all point to the importance of Shenzhen in developing E2Ws. With relatively lower levels of urbanisation, income and automotive industry support and high levels of 'tinkering', Shandong is a promising location for E2W development but under conditions that may not allow for easy translation of innovation success to other locations. This, in turn, could significantly diminish the broader significance of such innovation, since transitions require movements out of the geographies of the niche itself (Smith 2007).

In each case, the prospects of growth of the E2W beyond niche status towards a broader regime shift will depend on the trajectories of convergence and assemblage of this disruptive innovation with others, including digitisation. This process, which will be explored in fieldwork, depends on the protection of the E2W niche where this is conceptualised in terms of empowerment of producers, consumers and other relevant stakeholders and not just 'shielding' and 'nurturing' (Smith and Raven 2012). In short, this involves some transformation of power relations affected and effected by the uptake and shaping of E2Ws (Tyfield 2014a).

3.2 Politics

The political or power aspects of current E2W niche(s) in China reveal both important problems and tensions, as well as the potential for these to engender a dynamism and processes of system change. This is true in terms of politics and coalitions and the political enabling of both producers and users/consumers. While of similar dynamism, then, to the situation for the EV, clear differences also emerge.

With regard to policies affecting E2W innovation, first, there is the relative absence of development of E2W, technologies notwithstanding. Certainly, the E2W has nowhere near the level of concerted government support of EVs, and it is largely neglected and seen as an irrelevance, if not an embarrassment, to the hi-tech techno-nationalist imaginaries of such policies. Indeed, given the potential global leadership of this distinctively Chinese industry, the almost total neglect of the E2W within industrial policy is anomalous and intriguing. It may largely be explained by the continuing grip of hi-tech and car-centric imaginaries over policies of innovation-led 'catch-up' and 'modernity'.

From the perspective E2Ws themselves, the key question facing such a system change revolves around the status of this novel vehicle form, and hence the right of users to drive them, with or without a

[54] http://news.ifeng.com/mainland/detail_2012_04/01/13602800_0.shtml

licence or even at all. Official national determination on this point was only reached in 2004, when the National People's Congress amended the national road safety law to give E2Ws the right to use roads and, importantly, bicycle lanes. However, the issue of the access of E2Ws rests with more local tiers of government and hence has important implications for the diverse geography of its prospects across China. Developing E2Ws involves a new politics of space which will determine which machines can go in which places, at what speed and what kinds of infrastructures get constructed or indeed reconstructed.

The experience of riding E2Ws has been ambivalent in China. On the one hand, they have enjoyed advantage over ICE motorcycles, which have been banned in many cities (as in Chengdu or, for two-stroke engines, Shanghai (Weinert *et al.* 2008)). Moreover, the legacy of the bicycle infrastructure with dedicated lanes for two-wheelers has facilitated E2W growth. This helps to explain their comparative success in China as compared with other Asian countries. This is the case even as some bicycle lanes have been re-designed out of existence as roads are expanded for cars. The implementation of bye-laws also matters here. Regardless of official rights to use bicycle lanes or not, the speed and agility of E2Ws means that their riders take advantage of many available passages and routeways and they are difficult to police.

Yet E2Ws have faced bans or restrictions in many (including major) Chinese cities, such as Beijing, Fuzhou and Shenzhen. These rules have been introduced on various grounds. Environmentally, E2Ws are restricted on grounds of the pollution caused by their lead batteries (and handling thereof). The most common objections, however, revolve around public security and/or road safety. On one hand, as quick, nimble and silent, they are portrayed as hazards to public security in terms of their capacity to facilitate theft (creeping up behind someone before speeding off), and their ability to swing round corners, without warning, into the paths of other larger, more robust vehicles or vulnerable pedestrians. Conversely, on the other, their *slower* speeds as compared with conventional traffic and their unpredictable trajectories are blamed for disrupting traffic flow, hence causing increases of road accidents in the context of China's already poor record of road deaths and injuries.

These political discourses of E2Ws as a major security risk are redoubled by the fact that owning and driving them is unlicensed. In classic Foucauldian fashion, concerning the crucial politics of the government of urban circulation, therefore, the E2W is the focus of discourses of a 'dangerous' and 'undisciplined' mobility. The E2W is thus not merely officially penalised but is subject to a broader popular contestation of meaning. On the one hand, there are attempts to control and thereby legitimise specific E2W practices and the freedoms of mobility that it affords, while delegitimising others. Hence in Shenzhen E2Ws registered with the city's E2W industry association will not be included in the municipal ban. E2Ws used in emergency repairs of public road facilities, postal services and delivery services are also exempt from the ban.[55] In these cases, therefore, responsible E2W use is contrasted with undisciplined and dangerous e-riding. Yet, on the other, these struggles of meaning are not uncontested. Indeed, regarding the issue of licensing for driving E2Ws, the central government in 2009 set out to introduce a licence[56] but such was the opposition of consumers and producers, that these plans were abandoned before coming into effect. This manoeuvring has continued, with alternative strategies being pursued since then. In 2011 the new regulation of lead-acid production led to the closure of several producers, with battery shortages slowing down E2W's growth. Moreover, the Chinese government now requires E2W manufacturers to obtain licenses, leading to some consolidation in the market during 2011 and 2012.

[55] http://www.shenzhen-standard.com/2012/10/09/traffic-police-to-expand-bicycle-restrictions/
[56] http://english.peopledaily.com.cn/90001/90782/90872/6835037.html

The governance of mobility is thus a key aspect of contemporary E2W innovation in China, profoundly affecting the possible empowerment of E2W system stakeholders (Tyfield 2014a; Smith and Raven 2012). Again, this may be analysed from both producer and user perspectives. Regarding the former, perhaps the most important issue concerns the political audience and lobbying power of the E2W industry (and its supply chain and related services). As above, regarding the EV, this raises issues of industrial politics regarding private *versus* state-owned enterprises, and domestic *versus* foreign (whether by international collaboration, technology transfer or JV). In the case of E2Ws, however, with no notable and powerful SOEs and a highly localised and fragmented industry, set alongside the generally low opinion of government regarding them and their low prestige, the industry is considerably weaker even than the EV lobby (let alone the incumbent ICE automotive sector). Catering overwhelmingly to local or national demand, and with little to offer major auto TNCs and their own business strategies and strengths, the current prospects of, or interest in, cooperation from such parties further diminishes the standing of E2W manufacturers, at least so far.

As we have seen above, with regard to SAIC-GM, this is not the whole picture. And the continuing economic success of the E2W firms, as well as the potential for collaboration with partners from other important and powerful sectors (notably digital and web-based mobility services), means that this is a potentially fast-changing scene. The potential for the E2W industry to be disruptive, not just socio-technologically but also politically, contesting power relations and structures of the Chinese mobility system is still very much alive.

From the user perspective, there are considerable challenges but also openings in terms of shifting power relations with crucial themes of socio-political change in contemporary Chinese society interacting in complex and, as yet, undetermined ways. Three seem particularly important, namely: the politics and meaning of 'low carbon mobility'; the changing socio-cultural politics of social stratification; and broader issues of government and 'governmobility' (Bærenholdt 2013).

While undoubtedly a more promising prospect for low-carbon mobility than the EV, the actual environmental sustainability of any E2W-based system transition remains open, if not problematic. Certainly, for a mobility system to emerge that meaningfully addresses the overlapping problems of contemporary automobility, the E2W must be reconceived in the context of a much broader system change. This would involve, for instance, re-imagining forms of ownership (with a shift to personalised but quasi-public transport), the nature, experience and purpose of mobility itself (such as the practices associated with time spent on the move) and of the social practices which necessitate demand for mobility (including rezoning and redesign of cities). Alternative forms and technologies of mobility would also have to play crucial roles in any such emergent system including, presumably, the regular non-electric bicycle. Such transformations would, no doubt, involve considerable socio-technical innovation and novel combinations of technologies, including ICTs, the very shape and technologies that comprise the E2W being precisely as uncertain as that of the EV, with even the possibility of their convergence. Yet, these challenges notwithstanding, it is also possible that the E2W, lacking the burden of comparison with the hugely powerful imaginary of the car, could provide greater openings for such tinkering and system-changing socio-technological recombination. And, by readily enabling lived experiences of less gridlocked and quicker movement, this could well emerge, like the existing success of the E2W, through demand from the bottom-up. This could be seen if it were adopted on a large scale by experimental, urban, self-consciously 'sophisticated' and 'venturesome' young people (Bhidé 2009).

For such new fashionable practices to emerge, the social meaning of the E2W must confront some serious challenges. Just as the prospects of the EV are conditioned and largely constrained by the intensely affective politics of meaning associated with mobility consumer choices in contemporary China, so too a singular challenge for the E2W concerns its current symbolism and social connotation.

Notwithstanding its huge success, and following the discussion above concerning the disciplining of responsible urban movers, the key issue is the extent to which the E2W is and becomes sedimented as a poor person's vehicle. This would prove a major factor in whether the E2W becomes a consumer choice that replaces the (higher-carbon) car or the (lower-carbon) bicycle, and especially whether it is merely a stage on the way to being able to afford a car. This consideration will profoundly shape the trajectory of socio-technical development and possible combinations with other technologies that this innovation may take.

The discourse of the 'undisciplined' E2W movement is crucial and also marks a crucial difference to that associated with the EV. For on one telling of the E2W narrative, the very source of their mass consumer appeal, which establishes them as an important niche, could readily be turned against their further growth and disruption at the system level. This centres on defining them as the choice of the poor and 'uncivilized', who are enabled by these fast and cheap vehicles without having been appropriately schooled in the ways of the city and safe traffic flow. Such a potentially powerful discourse is particularly enabled by important and inter-connected developments within contemporary Chinese urban society.

First, there is the enormous migration of rural Chinese residents to urban centres in search of work, prosperity and an experience of urban modernity, and upon whose labour much of the Chinese economic miracle rests. This 'blind flow' is of over 200 million people (UNDP 2013; Nyiri 2010). They have travelled especially to the industrial and commercial centres of the Pearl River Delta, Yangtze and Bo Hai regions, though also, since the downturn of 2008 and the relocation of industries inland, increasingly to more local centres of second and third tier cities. This has created a massive social constituency that features clearly in the imaginations of all Chinese, no matter what their own class designation. This massive population is also the source of a constant flow of people who are new to modern urban life and hence unaccustomed to the rules and informal mores of how to move through that milieu. Hence, they can be viewed as clumsy and obstructive.

Second, this phenomenon resonates with and performs a key contemporary discourse of *suzhi*, or personal 'quality' (Anagnost 2006; Anagnost 2008). Concerned with the growing concentration of non-urban residents in cities, the Chinese Government has over recent years adopted an official discourse of 'civilizing' citizens through education and personal development (Nyiri 2010), policing and disciplining the 'crude' habits of the rural-to-urban newcomer, such as spitting or urinating in the street or wayward movement. The concept *suzhi* came to denote this official direction of the new citizens that to some extent imposes a new moral order. These politics of *suzhi* operate in the realm of late socialist governmental logics, manifesting the desired growth of an urban (and urbane) middle class alongside poverty eradication via policies of 'harmonious society' that seek to mitigate the threat to social stability of a vast growth of urban inequalities. These two projects of governance thus work hand-in-hand to condition the *suzhi* as 'common sense' (Anagnost 2008: 513). In this context there is clear potential for associating the E2W with those lacking *suzhi*.

Third, this is especially the case with the household registration system of *hukou*. Conferring upon all Chinese nationals an official status as either urban or rural, and with drastically divergent rights of access to public services attached to these, the *hukou* system institutionalises 'one country, two societies' based upon the accident of birthplace rather than, say, colour of skin, religion or officially attributed political stance (Whyte 2010). As such, while constantly in the process of reform but never actually abolished, it served not so much to exclude the mass migration to China's cities – a catastrophic eventuality given the dependence of the political economy on these workers – so much as permanently placing them in a grey area of questionable legality, reduced rights, enduring insecurity and institutionalised inequality (Nyiri 2010).

The implications of this system for the politics of E2Ws are far-reaching. To the extent that E2Ws may be associated with such insecure migrants (holders of rural and/or extra-local *hukou*), then E2Ws are identified with a class of urban residents facing much greater obstacles in becoming 'respectable' members of urban society. Hence, positive and self-confirming feedback loops between the 'dangerousness', or simple 'untidiness' or 'dirtiness', of E2W *drivers* and their road behaviour and the meaning of the E2W as a consumer item are clear. Moreover, facing forms of social and economic exclusion, such E2W drivers could find themselves confined to living within specific urban areas such as the rural villages absorbed into sprawling urbanisation or *chengzhongcun*, including in Shenzhen (Wang *et al.* 2009). These villages are increasingly distant from the fast-developing and gentrifying downtown areas. Thus E2Ws could become visible only in poorer, urban peripheries and/or as the cheap choice for the longer commutes faced by these workers as a result. Finally, and possibly of most importance, is how the *hukou* system provides an institutionalised, and self-confirming, basis for discrimination and social stratification regarding mobility choices that delegitimise or otherwise denigrate the E2W as 'backward' and 'common'.

Such a trajectory of the cultural politics of E2W, however, is not set in stone. Indeed, there is the possibility that innovation trajectories of the E2W could introduce hugely consumer-attractive, but still comparatively inexpensive, vehicles, in a disruptive fashion. This consumer pitch and shift upmarket could, for instance, arise through the combination of E2W technologies with digitisation and new electronics, which are of course globally-competitive sectors in China, and hence create products (such as the GM-SAIC gyroscopic vehicle) with a futuristic and highly desirable 'wow' appearance. Positive feedback loops between consumer choice and social distinction could thus emerge, involving a self-conscious green identity, a 'middle class' urbanity and technological sophistication, as well as patriotic support for a Chinese technological and industrial global success story.

This leads to the further consideration, of E2Ws and the government of mobility. As discussed above, circulation is a key aspect of state control and management in market societies. Yet the tension is all the greater in contemporary China given the dominant political imperative of state-party monopoly of control. Here, then, the enabling of the freedoms of mobility of the population, and the potential *disruption* to the governmental imperative of circulation, that the E2W and its risks respectively represent assumes a political importance extending far beyond the issue of urban transport. Rather, by providing 'dangerous', 'disruptive' mobility to urban masses, the threat to public security posed by E2Ws takes on a more profound sense which is possibly greater even than the challenges arising from the remaking of power relations built on the car. This stems from the much greater democratic openness of this form of mobility to groups that are most definitely not current winners within Chinese society. Rather, they bear its harshest costs. In these circumstances, the current penalising and regulation of E2Ws – its potential for a transformative global industry notwithstanding – becomes more intelligible, and conversely the political-structural challenges to expanding E2W-mobility becomes starker.

Yet the socio-technical re-assemblage of the E2W as a digitally enhanced device is of potentially key significance. For a Foucauldian perspective alerts one to the possibility that the key technological issue for a mobility transition may well not be in the technologies of mobility *per se*, but rather in how these interact and coordinate amongst themselves and the power-knowledge technologies they must integrate for this to be possible. The technological characterisation of e-mobility and the role of digital ICTs are again, therefore, seen to be crucial open questions. But the internet in China has grown prodigiously and with far-reaching socio-economic, and even political, effects without fundamentally upsetting the political constitution of the state (indeed, entrenching and enabling it by some of the more compelling and recent accounts (MacKinnon, 2011)). So it is possible to imagine E2Ws enabled by web-2.0 real-time connectivity that would afford both maximum efficient mobility and freedom of movement *as well as* its policing, state oversight and disciplining through responsible mobility. In such

circumstances the very success of the E2W as a mainstream mobility choice would go hand-in-hand with its redefinition away from, and to the exclusion of, mass mobility and towards its association with markers of social distinction. In exploring these possible developments, however, we turn briefly to the transformation of practices, or techno-practice assemblages,that may themselves involve forms and arenas of innovation.

3.3 Social Practices

The questions of social practices here are both similar and different to those regarding EVs. On the one hand, the theoretical framework and so types of questions remain the same. Hence, again we will be introducing examples regarding changes in identity or subjectivity, affect, quality of life, practices (of mobility *per se* and the surrounding demand for mobility), interpersonal connections and attitudes. On the other, though, the issues regarding E2W are substantively and notably different. This reflects the differing problems facing the mainstreaming of these two mobility technologies in terms of their socio-technical convergence on (what is thereby constructed as) the 'respectable middle (class) common-sense' regarding mobility. In the case of EV, what is emerging is the challenge of downward convergence from elites; in the case of E2W, from the 'masses' upwards.

For instance, the key question of battery-charging is less prominent with E2W, for several reasons. Practically, charging is much easier in that batteries can simply be removed, carried inside an apartment and plugged in. This is a singular benefit regarding prospects of system transition, avoiding the 'Catch 22' public good problem of charging infrastructure construction. The ability of E2Ws to weave through traffic considerably reduces range anxiety, as gridlock is not an issue. This does not render charging practices unimportant or uninteresting but their importance as regards system transition and empowering the E2W niche is significantly less.

In its place, though, arise several other key issues, reflecting the challenge of upscaling the niche from its mass and basic appeal to something much more system disruptive. Four issues are considered here: weather and climate; demand for mobility; safety and carrying capacity; and questions of social distinction.

First, conventional E2Ws, such as bicycles and motorbikes, are open to all weathers. The ubiquity of these forms of transport around the world, in both heat (and humidity) (South East Asia) and cold (Copenhagen and Amsterdam as cycling cities) shows that this is not an immoveable obstacle to the use of such vehicles. But climate clearly conditions mobility practices, in combination with other practices, and is likely to be reflected in geographically differentiated ways. Practices of clothing, for instance, clearly matter here. These in turn are both matters of simple practicality (body temperature, protection from rain, tight enough not to get caught in wheels, safety) and of symbolism and social distinction (brands or shapes of helmet if one is worn at all, the biker's leathers with skull back patch, the serious cyclist's luminous lycra). But so too are the various social practices that necessitate various kinds of movement.

For instance, a key consideration here would be the practices of work and the condition (bodily, sartorial, relaxed or 'buzzing') in which one must (be seen) to arrive at work ready for work. Can one change and shower at work? Or is the mobility itself a (key part of) the work, such as courier, postal/delivery worker, or even peripatetic service worker (such as higher-end estate agents, who routinely drive clients around prospective flats in Chinese mega-cities). The two obvious social groups that adopt the E2W interestingly could have utterly different demands from their work practices, but both of which fit with the E2W as currently conceived. For instance, those seeking simply a cheap form of transport (whether for a commute to the factory, construction site or office), clocking in on-time could prove the decisive consideration, while one's presentation may be less of a concern for the

performance of the job. Conversely, for young venturesome consumers they may well be employed in jobs that allow remote or home-working online, hence avoiding the worst weather.

Shopping for food is another key social practice (Shove and Walker, 2014). The ability to experiment with E2W mobility may interact with the ability to undertake grocery shopping. This is divided between small local stores and, often very large, out-of-town supermarkets, with the latter increasingly the choice of those able to shop there, because of concerns about food safety (Yan 2012). Also important here is whether the shopper is buying food for a week or just for the next meal? Or for one person or a family? Finally, ordering food online is now increasingly common in China (in big cities at least) with E2Ws often used for the deliveries. (The term '*zhai*' (宅) has become popular in Chinese conversation, describing someone who stays at home and does most things online, including buying groceries.)

There are also key issues around the practicalities of movement on a E2W, e.g. of carrying capacity and road safety. The E2W's potential use will be shaped by whether it is imagined as a risky mobility practice, and who it is aimed at. This could happen in both directions: seen as risky, it may well put off many, such as families (especially with young children who can only perch precariously upon it weaving through the traffic); conversely, the very riskiness may also attract others (e.g. young single men), or at least not put them off to the extent that it is compatible with, or over-ridden by, other considerations such as its style and low cost. This is thus a matter of identity (as with Mods and scooters in 1960s Britain); effect (the experience of rapid, exposed movement); quality of life (the enjoyable thrill of mobility and its risks); connections (E2W clubs, contacts made in parking spaces); various social practices (as above); and attitudes regarding municipal regulations of such vehicles, or one's environmental credentials and virtue and its social importance.

The final issue, of novel forms of social distinction, thus runs through them all. How, in short, is the E2W being constructed as desirable and a form of status display (high or low)? Such a question relates to issues of changing road behaviour and 'civilizing', as in the conjunction of the discourse of *suzhi* with Elias's process of 'civilization' through exposure to 'decivilizing' new dangerous technologies (Elias 1995). And how do these processes interact with other socio-technical innovations (including of mobility practices), such as the integration of real-time ICTs or the wearing of head-phones while riding along?

Similarly, questions of the routes chosen and way-making arise here. An E2W rider may well choose to take different routes from those of the conventional car (including the EV), thereby enabling the user getting to know a city's back streets. This, in turn, could have varied, but potentially profound, implications. An alternative picture of *their* city could be assembled by users, as compared with the grand boulevards and ring-roads that are icons of contemporary Chinese urban planning imaginaries. This image may be positive (vital, human, historical) or negative (dirty, unsafe, backward), or a combination of the two that would give E2W consumers of the city a more real sense of it and especially of its beauty and ugliness, its greatness and problems (Urry 1995).

This in turn could develop profoundly different visions for what an attractive city life could be as an alternative to that projected by official policies and construction projects. Visions, may be those of groups empowered in parallel with the construction of their mobility option of choice, hence as key elements in the broader transition of socio-technical regimes (Certeau's classic on the tactics of 'Walking in the City' (Certeau 1984)).

4. Conclusion

In this paper the framework for analysing the prospects of e-mobility system transition in China was introduced, comparing socio-technical innovation in systems organised around EVs and around E2Ws. Deploying the lens of social practices to explore, in turn, evidence of changing power relations capable of driving and shaping such a system transition, it has been shown that the contemporary Chinese situation of low-carbon mobility innovation can be usefully analysed through two markedly contrasting narratives and potential trajectories.

On one hand, the EV is the focus of intense political and business effort and the target of techno-nationalist industrial policy, conceiving of this as a singular opportunity for Chinese innovation and economic catch-up more generally. On the other, the E2W is almost entirely neglected by policy, and indeed subject to attempts to penalise and regulate it off the roads and pavements. Again, on one hand, the EV remains a dramatic flop, with little evidence of its formation even as a significant socio-technical niche, much less one threatening system transition. While on the other, the E2W, for all its unwelcome regulatory attention, has flourished, creating China as the key global market and industry in this sector.

Finally, the prospects of success for the EV seem to lie in its deployment as an elite vehicle, and hence its likely limited adoption by less-wealthy but aspirational drivers. The prospects of an E2W transition, conversely, hinge on its capacity to build on and transform its current success as a cheap form of mass-mobility into a viable and attractive option that rivals the (high-carbon) car, and not just the (near-zero-carbon) bicycle. This is thus a question of its potential move up market, including through it being assembled as a system, together with not only new battery-types but also with the latest and most consumer-attractive digital and 'app' economy.

In both cases, this reveals a situation of both geographical diversity and considerable dynamism, political and social as much as obviously related to innovation, technology and industry, even while the most high-profile efforts of electric car innovation continue to struggle to make a significant impact. The prospects of e-mobility urban transition hinge on the emergence of new powerful coalitions supportive of, and in parallel actively constructing, visions of such system change. This in turn involves the construction of new social practices that materialise and normalise such commitments into every-day life. The dynamism described here is precisely this process at work in contemporary China, but as the comparison of EV and E2W highlights, the system to which it is moving remains open and unclear.

Seeking, thus, to identify clear evidence of emerging self-sustaining feedback loops of changes in social practices, power relations and socio-technological innovations, this project will continue to compare the EV and E2W niches. It will focus upon developments occurring within three crucial sites, of Shanghai, Shenzhen and Shandong. And while the two models of low-carbon innovation envisage different futures for Chinese urban mobility and involve conflicting social groups and interests, political actors, social institutions and mobility-discourses, it will also be seeking evidence of their alignment into a broader systemic 'common sense'. This thus involves consideration of key social factors such as: the social distinctions of income, urban/rural differences, gender and generation; the potential development of new social practices that may render one or other niche or system more or less likely to gain traction; the ways in which new systems rarely simply replace old systems but grow up alongside and at some point take over (mobile telephony as opposed to landline phones).

As examples, thus, of different possible futures for Chinese low-carbon society more generally, we hope thereby to illuminate not just possible routes to a more climate-resilient society within China and around the world more broadly, but also to do this in ways that open up the crucial qualitative and social issues associated with these essentially political, and not merely technological, decisions.

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