CeMoRe
Centre for Mobilities Research

The Politics and Practices of Low-Carbon Urban Mobility in China:

4 Future Scenarios

David Tyfield, Dennis Zuev, Ping Li & John Urry

A CeMoRe Report

June 2016

LOW CARBON
INNOVATION IN CHINA
中国低碳创新

Lancaster University

Tsinghua University

Dramatic and rapid reductions in greenhouse gas emissions are needed to stay within 2°C scenarios. How can the radical, global transformations in the systems that shape the production and consumption of energy be achieved?

Given the size of its emissions and economy, China is central to achieving this transformation. Its UN climate commitment has set ambitious targets for cutting carbon emissions. Innovation is crucial to achieving these targets, but this innovation must take place in and transform specific domains of society and everyday life. What could these futures look like – *socially* and *qualitatively*?

This document presents a set of four scenarios regarding possible futures of urban e-mobility in China.

It has been developed on the basis of evidence collected in the urban e-mobilities work package of the ESRC-funded project 'Low Carbon Innovation in China: Prospects, Politics and Practices',[1] a collaboration between researchers at the Centre for Mobilities Research (CeMoRe), Lancaster University and the Graduate School at Shenzhen, Tsinghua University.

As the title suggest, this project has examined contemporary low-carbon innovations, including in e-mobility, focusing on the specific issues of the parallel evolution of those innovations with a changing landscape of social power relations and (possibly everyday) social practices. This approach builds on conceptions of low-carbon transition as a matter of the transformation of entire socio-technical systems: where both the irreducible importance of social (never just technological) factors *and* their integration into complex, multi-factorial systems merit emphasis.

This perspective conditions a particular interest in forms and aspects of innovation beyond high-technology development along what are currently understood to be 'obvious' routes – though it also incorporates these innovations. But to understand the prospects of widespread adoption and development of these less high-profile and high-technology innovations, the importance of two further factors becomes clear.

First, the uptake and shape of innovations are conditioned by, and in turn condition, the differential enabling and disabling in society of particular agents, institutions and projects. For instance, the contemporary dominance of the system of social relations built up around the production and use of the steel-and-petroleum (internal combustion engine, ICE) car profoundly shapes the prospects of other competing mobility innovations.

Secondly, demand for specific forms of mobility is similarly shaped by the everyday practices of those who produce and use them, and how these fit (or not) into their daily lives. For instance, demand for a conventional car may be based on the need to travel long distances on highways for a daily commute or the need to transport children or shopping on the way.

As such, even if our interest is just the seemingly techno-economic issue of which mobility technologies will flourish and which will wither in the medium-term, this can only be meaningfully addressed by situating such innovation in this broader context. But, of course, doing so also immediately opens up questions about winners and losers in these social futures, how we normatively respond to these prospects and what, if anything, can be intentionally done to shape them.

Since late 2013 this project has thus examined these two issues of changing social power relations and everyday mobility practices and their parallel change as regards the adoption (or not) of e-mobility vehicles. Specifically, it has compared electric car (EVs) and electric

two-wheelers (E2Ws) in four significant but different locations – Beijing, Shenzhen, Shanghai and Shandong province – where this comparative lens offers a practicable window into these complex, multi-factorial and fast-evolving systems.

We have adopted a qualitative approach in this research, including over 40 in-depth interviews with producers, entrepreneurs, government, NGOs, academics and users, 7 focus groups with diverse users of e-mobility users, and qualitative observations of e-mobility on site over a total of nearly 3 months of fieldwork between 2013 and 2016. For more discussion of the project, please see the *STEPS Centre Working Paper 71*, available at: **http://steps-centre.org/publication/low-carbon-innovation-chinese-urban-mobility-prospects-politics-practices/**

Building scenarios of future Chinese e-mobility

This project thus takes a deliberately broad and systemic perspective, built on attention to the intrinsic openness and uncertainty of the emergence and transition at system level. This analysis, however, cannot lead to definitive and singular conclusions about the prospects of such low-carbon innovation. Instead, it enables the construction of a set of scenarios. These scenarios are not to be understood nor used as supposedly objective extrapolations of current trends, with measurable probabilities attached to each one. Inverting familiar expectations about the outputs of a rigorous scientific approach, any such confident singular prediction directly goes against the intrinsic and irreducible complexity and, hence, unknowability of the evolution at systems level to which the research precisely wants to draw attention.

So the scenarios are not predictions, but neither are they simply fictional speculations. Instead, they are constructed as sets of *plausible* future systems,[2] with each such scenario qualitatively possible, in terms of the possible *co*-emergence and interaction amongst the multiple elements that constitute them. And they are to be used primarily as devices to stimulate thought in the multiple parties and stakeholders that will inevitably shape what does in fact come to be the case; perhaps alerting these readers to issues (or relations between issues) they had not previously considered or eliciting a change in perspective regarding the issue in question.

They have been constructed in the first instance through an iterative process of internal peer review, drawing on the empirical evidence from our research regarding key and/or embryonic trends in e-mobility innovation today in China. These have been combined with consideration of major considerations across the multiple relevant scales (global, national, local) and institutional levels (state, business, civic and consumer) relevant to low-carbon system transition, as well 'mega-trends' also relevant to this question.

For instance, the latter includes issues such as: energy resources (e.g. peak oil) and energy transition; geopolitical concerns including a 'global war on terror'; the unknown effect of climate change and breaching other planetary boundaries; futures of employment and production of goods, value and knowledge; unforeseeable technological breakthroughs; and the trajectories of globalization and intra- and inter-national inequalities.

The scenarios were then discussed in depth at a workshop in Shenzhen (in March 2016)[3] involving over 40 key stakeholders, including entrepreneurs, representatives of major e-mobility and auto sector corporations, government, academia, NGOs (local and international) and students. This generated feedback that has since been incorporated into the scenarios that we present here. We repeat, however, that the goal of this document is to stimulate further interest and action regarding this key field of contemporary socio-technical change.

Key Findings: Embryonic Trends in Contemporary Urban Mobility in China

In general, we find a highly dynamic landscape of e-mobility innovation, characterized by ongoing deepening of conventional, ICE car-based mobility (and its problems) with a diverse set of mobility innovation niches, all of which are at present what innovation scholars have called 'hopeful monstrosities'.[4] In this situation, it is particularly unclear what a future urban e-mobility system will look like, since how these niches develop both individually and in combination, and towards growth and transition or stagnation and disappearance, cannot be reliably plotted.

Nonetheless, assisting projection of plausible futures, our research finds the following **specific major emerging social trends regarding urban (e-)mobility futures in China**, none of which are obvious through a lens that focuses on the simple technological replacement of the ICE car by the electric car. In each case, the item connotes a *question* regarding the unknown way in which that issue will develop, given that it is clearly currently in play and potentially significant for mobility system transition:

- Significant continuing challenges – social and regulatory, not just technological – for the rapid adoption of the plug-in EV as replacement of the 'car'
- The increasing importance of information communication technologies, internet connectivity, social media and data in mobility, including as a key consumer demand
- A possible generational shift, particularly in big cities, from intense socio-cultural aspiration and status competition regarding personal ownership of a big (foreign) car to greater interest in shared mobility and online connectivity that remains status-conscious
- Continuing growth in awareness (particularly regarding health) about environmental issues (e.g. air quality) together with ongoing emergence (or at least resilience) of a 'green public sphere' online and environmental action/activism
- Quantitative growth of small and/or '*disu*' (low-speed) EVs, together with qualitative dynamism in changing social status associated with these vehicles and E2Ws
- The importance of the parallel emergence and shaping of the (urban) 'middle class(es)' and their growing and changing demands for 'liveability' alongside persistent priorities of autonomy and private space
- Fluidity and a recent burst in dynamism in the levels and mechanisms of support for e-mobility, including new forms of corporate competition and changing priorities and initiatives for government support
- Ecological civilization, 'new normal' and the new Urbanization Plan (and, indeed, the 'Belt/Road' policy of external investment in a new Silk Road by land and sea) as top-level government projects signalling progressive shifts towards major green investment.

Together, then, these findings both draw on and illuminate how e-mobility transition and broader socio-technical, cultural and political change, including regarding future cities, are

inseparable. The former are thus a window onto the latter, which then in turn illuminate the former again: our specific focus here.

In particular, this process highlights as two key dimensions regarding future trajectories for e-mobility in China the questions of whether and how there will be convergence or divergence regarding:

- First, these diverse system niches of EVs, *disu*, E2W, public, car/ride-sharing, digital and self-propelled (conventional bicycles and walking) mobility; and
- Secondly, the diverse models of urban mobility and mobility (innovation) governance that currently exist around the country – an enormous country, lest we forget, with significant geographical, climatic, sociocultural, economic/industrial and local governmental diversity.

The four scenarios, thus, highlight different futures regarding these two key dynamics given possible interacting trajectories of the major trends listed above.

Four plausible scenarios of future urban e-mobilities in China

We take 2041 (25 years from now) as our date, between commonly used dates of 2030 and 2050 for much current forecasting work. A quarter of a century is also roughly half the period identified by Vaclav Smil as the necessary time historically for a transition in energy system through deployment of new innovations.[5] Hence, currently emergent trends will be significantly entrenched by then, but new and unforeseeable breakthroughs and developments will not yet have had time to have systemic impact.

As such, these futures may seem decidedly *un*futuristic, in technological terms, to some readers. Yet this is a deliberate decision of this analysis. For, recalling the primary aim of these scenarios, the priority here is to highlight the dramatically different *social* futures that are currently plausible system-level outcomes of the mass adoption of innovations *already* in evidence (however embryonic); and, hence, the political and strategic choices that are both available and inescapable.

Four scenarios are developed below, in no particular order of probability, or eve plausibility. Nor are they presented in any order of normative preference with none to be taken as 'ideal', either involving the definitive resolution of all contemporary challenges or without costs and trade-offs. They are:

S1: Slow people-centric e-mobility

S2: Hi-tech elite e-mobility

S3: 'BAU' (business as usual) digitized mobility

S4: Secure, splintered e-mobility

These may, in turn, be summarized in terms of four sociological 'archetypes', capturing what is most socially praised and aspired to in each scenario – what superlatives are strived for and are sources of socially-enabling status competition – with implications for the systems and practices of urban mobility in each case:

S1: 21st century sage – the most 'balanced', 'poised'

S2: Fast-living high-mobility innovator – the most elite, fastest, richest

S3: Influential celebrity – the most and best connected, the most 'friends'/ followers

S4: Responsible custodian – the most vigilant or prudent and loyal to their city

To get a more comprehensive sense of these four scenarios, however, we must explore in some detail the coevolution of multiple dimensions in their meso-level concrete detail. Specifically, in each scenario we explore possible parallel changes of 7 key system elements:

1. (Daily) mobility patterns and demand
2. Vehicle forms and their use
3. Industries, innovations and employment
4. Infrastructures and energy & resource systems
5. Regulations and governance (at multiple relevant scales)
6. Aspirations, values and status competition
7. Environmental impacts

The scenarios should thus be read 'in the round' as thought experiments regarding a new 'system logic' that may emerge from the messy and contingent combination of tendencies and trends already in evidence. We take each in turn.

The Scenarios

S1: Slow people-centric mobility

Life is slower.

There has been a sizeable and deliberate deceleration of life: first chosen by many, led by the urban knowledge-working middle classes, seeking a post-materialist and green 'liveability' focused on maximizing time; then progressively regulated as such.

But this is still within a capitalist market society that actually both circumscribes this new 'slowness' for many and prescribes familiar 'speed' for many more.

Hence, there is slower and reduced mobility, shifting to localization (and changing urban forms), more leisure and (online-mediated) civic activity but also highly environmentally- and socially-conscious mutual policing and snobbery.

System Elements	***Key Points***
(Daily) mobility patterns and demand	**Mobility is slower, smoother, less hurried and simply less** - China has passed 'peak stuff' and has moved to become globally leading in this regard, and wages are lower (especially for elite white collar workers) but more equal, if still far from evenly distributed. - Mobility is part of the day during which you can do what you were doing anyway, hence speed from A to B is not a priority. - Rush hours (and range anxiety) are a thing of the past, since there is no need to be in the office or leave at a certain time. - Distances travelled have diverged into shorter (given relocation of life and work, including increasing home-based working) and longer (given reliable, high-speed inter-city linkages for business trips across the country), with green gentrification of old city centres. - As China's population has 'grown old', the growth of demand for slow, smoother, safer and healthier mobility has also been significant, including from younger generations who are keen to keep elderly parents (-in-law) mobile so that *their* autonomy in turn is maximized.
Vehicle forms and use	**A shift to diverse ecologies of small electric vehicles and transit-oriented development** - EVs and *disu* have converged on small EV–based and transit-oriented development (ToD) systems (including walking and conventional bicycles for well-being), with multiple locally-relevant models of urban mobility around the country (and world). - 'Cars' have become increasingly unacceptable as 'big', 'decadent', 'selfish', 'backward' (and 'American') vehicles. - No personal ownership of vehicles, even bikes, is increasingly normal and unexceptional. - Integrated public/ quasi-private sharing multi-modal systems involving multiple vehicle forms. - E2Ws have continued to diversify into multiple forms and market niches.
Industries, innovations and employment	**Chinese mobility innovation, including social innovation, leads the world** - Chinese global leadership in both *disu*/connected vehicle systems and E2Ws via global innovation networks, locally adapted around the world. - Significant social innovation and voluntary civic activity, including in mobility and practices affecting demand for mobility and energy, creates multiple and locally diverse mobility systems.

	- New construction, maintenance and innovation jobs, albeit in a clearly two-tiered labour market: 'highly'-skilled knowledge work driving innovation of the new system including new infrastructures; and 'lower'-skilled work from job-*creating* and *capital*–substituting 'disruptive' (high labour, low capital) innovation, which creates new markets of newly affordable, high-quality services, and from the construction of those new infrastructures…
Infrastructures and energy and resource systems	**Significant new infrastructures effecting a major decarbonization** - … e.g. under-road, solar-powered inductive charging on expressways and city redesign towards more human-centric, liveable models, with many roads reclaimed for green spaces and old city centres developed into dense but green cities. - Growing (global) public investment in innovation leads to a parallel decarbonisation, incremental but significant cheapening of batteries and breakthroughs in batteries and battery recycling (towards water and salt as main ingredients), relieving pressure on Li resource competition.
Regulations and (local) governance	**Cars and acceleration of life are strictly limited** - 'No car' bans across all Chinese cities of over 100,000 inhabitants. Local and national public education campaigns and regulations penalize car ownership and parking, shifting attitudes and status competition starkly from cars to other modes and outlets, including display of green consumerism. - Speed limits of 20 mph across all cities with ubiquitous connectivity, but also clearly-marked 'off' buttons. - Deliberate knowledge-middle-class-led state control over accelerating mobilities, focused on trade-off of less accumulation and financial wealth for more time, interpersonal connection and broader distribution of system benefits. - Working hours (micro-measured by hours on work computer systems) are strictly limited to 40 per week with penalties, not overtime, for working longer (on any one job – a source of much snobbery and hypocrisy) and are self-policed via social media. - Diverse, local systems of mobility, governed by local government specialized to different characteristics and forms of Chinese cities, including industrial profiles and local demographics (e.g. working days, weekend consumption of places, tourism…).
Aspirations, values and status competition	**The modern Chinese sage** - Status is a matter of competition and pride in local and/or cosmopolitized connectivity, leisure time and use of the latest, smallest or lightest 'ecological footprint' and greenest technologies in the most 'balanced' (and 'Chinese', defined as '21st century-cum-ancient') way of life.
Environment	**Deep decarbonisation and local environmental sustainability measures** - Combination of deliberate slowing of mobility, innovation investment and switch to e-mobility/ToD leads to a trajectory of clear and sizeable reductions in GHG and improvements in air and environmental quality, though with significant challenges still ahead.

S2: Hi-tech elite mobility

Life is lived 'on the move' and has continued to accelerate … and to diverge.

E-mobility has emerged as a key industry and innovation, at the heart of a transformation of social life, and with China in the lead.

But it has also deepened social inequalities, with growing separation of the mobility rich and the mobility poor.

System Elements	***Key Points***
(Daily) mobility patterns and demand	**Always on the move** - People are always at work and expected to be mobile (even when sleeping, if necessary); personal service has become a norm for those who can afford it, to take care of the home. - Deepening divergence into a mobility rich (knowledge-working, green 'middle class') and mobility poor, with divisions increasingly cemented and little social mobility between 'green' and 'black' classes. - Middle classes live in new eco-cities and greened high-class housing compounds and travel at maximized speeds to wherever is needed, especially attractive, gigantic and greened CBDs. 'Black' classes live at lower elevations, in denser and poorer housing with worse environments. - Access to upper tiers of mobility services depend on both ability to pay and invitation to elite 'mobility clubs', self-policed through social media ratings (e.g. 'likes'). - Mobility poor are dependent on increasingly localized and isolated life/work (within both cities and in rural spaces) and evermore crowded and underfunded public transport or the lowest, cattle-class tiers of the 'big 3' mobility services.
Vehicle forms	**Elite EV systems… with a highly proscribed but still massive E2W niche** - There has been divergence of EV and E2W/*disu* towards elite, high-tech, smart, private, proprietary and steeply-tiered EV mobility services (including semi-private small buses) amidst lives of accelerating, individualized pressure and increasing regulatory barriers to E2W/*disu.* - Adoption of EVs takes off as charging and parking problems dissipate amidst dominant models of use built on car-sharing, not personal ownership, and elements of autonomous driving. - 'Chinese Tesla' (Faraday Future), Tesla and Apple – that latter two both now in coalition with Chinese partners – as dominant oligopoly. - E2Ws/*disu* are increasingly cemented as 'low quality' (*di suzhi*) and/or 'rural' vehicles and banned from many roads in big cities, but remain essential forms of auto-mobility for many, including as '2nd' vehicles for middle-class families.
Industries, innovations and employment	**Global corporate knowledge-economy concentration, centred in China** - Telecoms, grid and 'BAT' giants have progressively merged into an oligopoly of 3 mega-systems, each offering increasingly steeply-tiered mobility services, with little personal ownership of 'cars' - Chinese EV and e-mobility brands ascendant, with significant praise and support from government. The Chinese innovation system more broadly takes the shape of an enormous (in absolute terms) iceberg, mostly below the 'surface' level of global competitiveness but with a singularly steep and high peak above the surface. Hence there are several unquestionably global-leading brands that afford growing global connotations of 'Chinese' as 'top quality technology', but with this disguising –even as it is built upon – the overwhelmingly larger system 'below' the surface. - Continued knowledge economy job contraction and corporate concentration, but now involving Chinese companies based in China's major

	megacity regions of Silicon Delta (硅三角，*guisanjiao*), Silicon Capital (硅京，*guijing*) and Silicon River (硅江，*guijiang*) as major global players. - Deepening dynamics of technological un(der)employment, including in knowledge white-collar professions, creates mass reserve of labour and hence counter-dynamics of innovations that draw on cheap 'unskillled' and 'semi-skillled' (if, in fact, possibly highly educated) workers, including in services (in the home, care etc..), document work and private security, amidst fears of a growing unemployable 'rabble'. - Concentration squeezes out other innovation and funding for it, including increasing philanthropic and scholarship support for a commercialized higher education system that elicits intense global educational competition for access to top 10 universities (3 in China, 3 in US, 2 in EU, 1 in India, 1 in Singapore) that also entrenches privilege between generations, and real estate competition for the 'best' school places (leading to the best universities, and then the best "knowledge jobs" in a shrunken and steeper job market).
Infrastructures and energy and resource systems	**Unlimited growth of high-speed, high-tech, smart mobility infrastructures** - Continued growth of *gaosu* (high-speed) road network, including underground and elevated urban expressways, and with increasing regulation that only (comparatively expensive) autonomous/connected vehicles may use them: a 'super'-motorway (*zhaogao*) on which cars are both the only form of traffic *and* the only *drivers*. - Disruption of mobility on the *zhaogao* is seriously disruptive (potentially stranding millions in a single incident) and hence subject to intense security measures. - Autonomous driving (AD), with a human back-up driver, is permitted only on designated main roads. AD without any passengers is only permitted for licensed cars and when going directly from one passenger to an identified next one within 500 metres, all monitored remotely by the police. - All mobility (including walking, via smartphones) is tracked and big data monitored (as are smart houses/Internet of Things) to maximize system efficiency and further 'innovation', but by multiple competing mega-corporate systems, not unified state oversight. - Coal plants are moved further and further away from big cities and there is slow installation of CCS (carbon capture and sequestration), while there is a clean energy transition in cities to (thin film) solar PV, starting with those who can afford it.
Regulations and (local) governance	**Green but socially regressive regulation** - Green taxes and personal carbon budgets serve primarily to benefit the wealthy as green technologies are expensive, acting as de facto regressive tax cuts; hence greening is a step up in quality of life for richer 'middle class' sections of society, but a step down for poorer sections who are instead decarbonized through abandoning advantages of fossil-fueled mobile lives. - E2Ws/*disu* are now strictly policed, including with automatic immobilizers through Bluetooth chips on many main roads or by full movement tracking and remote surveillance and criminal prosecution. E2Ws thus become *de facto* the choice of the poor and the criminal. - Convergence on single megacity model as dominant, with 2nd, 3rd, 4th… tier Chinese cities officially aspiring to follow suit and attract top 'global talent', including through major renovation projects and city redesign to make city centres as easily and enjoyable 'consumed' as possible.
Aspirations, values and status competition	**The fast-living high-mobility innovator** – Competition is intense and aims to be the most elite, fastest, richest, smartest and most (globally) mobile.
Environment	**Environmental improvements, but erratic and unequally distributed** - Air quality improves but slowly and with big cities first: continuing and deeper divergence of urban/rural, including in environmental quality and health risks.

S3: BAU digitized mobility

Life has become increasingly inter-connected but dependent on small-time 'entrepreneurialism' (*chuangye*) for day-to-day survival in a broader social and environmental climate of unease.

And e-mobility has never successfully emerged, plagued by problems at every step.

Instead there remains a 'business as usual' (BAU) mobility system of (a lot more!) largely private ICE cars… and so gridlock.

But cars have become smart homes, incorporating a lot more interconnectivity and digitization: the focus of socio-technical change more generally.

System Elements	***Key Points***
(Daily) mobility patterns and demand	**Highly individualized lives, competing for networked opportunities** - Intensely competitive lives are dependent on high connectivity, managing vast networks of fleeting contacts and individual work projects, but via digital not physical co-presence. - Hence an increasing shift from physical to digital mobility – and deepening problems of obesity generating intense health concern more generally. - Housing is progressively greened, if slowly and unevenly, based on slow roll-out and personal purchase of expensive hi-tech innovations while the shift to 'smart homes' often increase energy demand in 'rebound' effects. - Cities remain zoned, leading to long commutes for most of those who have 'regular' employment. - Private car ownership remains dominant, with sharing tried but rejected on a grand scale as it proves unreliable when most needed: as the spectacular immobility (*da geqian*) of Spring Festival 2024 proves to many, when across Chinese mega-cities, the tiny number of available cars leaves hundreds of thousands unable to catch flights or high-speed trains on time, and so stranded. - Instead car-sharing simply replaces taxis and undermines public transport, leading to greater demand for private cars. - Digitization/ informationalization/ automated driving (in the limited form of negotiating slow-moving traffic on highways and automated parking) means congestion becomes considered less of a problem as one can still be productive and even 2+ hour 'carmageddon' commutes are adapted to.

Vehicle forms	**Hybrid cars trump plug-in battery EVs**
	
	- The plug-in electric car proves more problematic with each step forward:
	  - high-profile risk events and daily encounters of EV failure (ring-road breakdowns, from which rescue can take many hours) & frustration
	  - battery and charging explosions and fires, and persistent fears about 'radiation'
	  - persistent issues of battery breakdown
	  - rapid depreciation of batteries and financial risk in purchase
	- Meanwhile ICE hybrid improvements and new 'clean'/'green' sources of liquid hydrocarbon fuels lead to persistently low oil/gas prices and increasingly competitive life-cycle GHG emissions profiles vs. EVs, without all the frustration of the new and never-maturing technological system.
	- Cars become increasingly adapted for 'living in', not just travelling, and personalized – a highly personal and jealously protected space. And indeed an increasing number of people are *de facto* living in their cars since, with personal carbon budgets, houses are too expensive to maintain.
	- Cars can also be rented out easily via digital platforms while not in use, hence as P2P income-generating assets.

Industries, innovations and employment	**Innovation is concentrated in digitized information systems, not in mobility systems** - No global EV technological breakthroughs (e.g. battery) emerge due to systemic innovation under-investment and continued proprietary US/German/Japanese tech leadership and consumer preferences in China. Many successful Chinese firms offer cheaper and high-quality versions, but never take the technological or innovation lead, while local protectionism prevents consolidation of these Chinese firms. - Instead there is convergence in the market on cut-throat and low-margin (hence low innovation) competition amongst a small number of JVs of Chinese and foreign companies offering a *range* of vehicles (rather than mobility services) on micro-hire purchase schemes. - The informationalization of life generally, including of mobility, is instead the priority of innovation; and benefits the hybrid more than the pure EV. - Hence technological unemployment is mitigated by both new instalment and services of 'smart' living for urban middle-classes. But also, inseparably, by ICT-enabled growth of the 'gig economy' and micro-hiring platforms for all personal assets, dividing classes amongst: the wealthy and secure; the middling, modestly asseted and 'wheeling and dealing'; and the unskilled, unasseted and heavily policed.
Infrastructures and energy and resource systems	**Infrastructures for smart interconnectivity… and cars, not EVs** - Tesla's building of gigafactory elicits spike in Li demand and price, starting years of resource competition, conflict, smuggling and controversy. - Adequate charging infrastructures are never built given expense, disruption, persistent objections of landlords and property management (*wuye*) (vs. stuttering EV demand), irresolvable diversity of standards etc… - But smart energy infrastructures are increasingly built, and personal energy use is increasingly regulated by smart meters. - Conventional roads and city sprawl grows, but with digital infrastructures increasingly embedded, while new infrastructures for 'green hydrocarbons' are also rolled out, locking in new dependence.
Regulations and (local) governance	**Personal carbon budgets, monitored at every step** - Individualized carbon budgets condition further individualized opting for digital over physical mobility wherever possible. - E2Ws and *disu* are increasingly regulated to stasis: E2Ws peak and even fall, leaving only small-distance logistics as users (admittedly a booming sector), as individuals either shift *up* to hybrid cars or back down to bicycles/public transport to avoid financial penalties of their ownership and use. - Unified government databases monitor personal carbon budgets, which can be (micro-)traded; individualized mobility tracking affords monitoring of mobility carbon budgets too; and e.g. stop/start hybrid engines allow minimization of GHG emissions even in congestion (and no worse than EVs), while carbon budgets sensitize drivers to actual life-cycle emissions of EVs, not just tail-pipe differences.
Aspirations, values and status competition	**The influential entrepreneur celebrity** - With connections so important for life opportunities amidst intense competition, individualized financial security is achieved through being the most and best connected, with the most 'friends'/ followers.
Environment	**Rebound effects, slow environmental improvements and worsening environmental risks** - EV emissions prove *worse*, specifically for health as PM2.5 (and then PM1.5, which emerges as even more important to health, affecting metabolism), than ICE/hybrid. - Rebound effects of deepening digitization and more cars with slow low-carbon innovation mean air quality and GHG emissions fall only slowly, intensifying competition and the *zeitgeist* of anxiety regarding worsening extreme weather events and health fears.

S4: Secure, splintered e-mobility

This scenario emerges through a one-off or deepening shock (perhaps geopolitical, perhaps digitized) that effects a 'sobering', hunkering down and diminution of personal expectations of improving livelihoods.

In the aftermath, people are highly security conscious and privilege forms of organization and socio-technical innovations that enable relatively small-scale, person-to-person trust-based systems alongside megacity-based systems of state protection.

Hence there is a turn away from both accelerating and ever-deeper global interconnectivity and fossil fuels, and to technologies (of mobility) that afford personal control, maintenance and tinkering in ways that are also sensitive to local networked inter-dependence and system security.

System Elements	***Key Points***
(Daily) mobility patterns and demand	**Personal responsibility for local (i.e. metropolitan) system resilience** - Life is reshaped by privileging local system resilience and integrity in forms of primarily localized, city-based trust in the context of global security fears: environmental and socio-technical. - Cities and regions are increasingly differentiated into regionally significant and secure megacities (now around 60% of China's population, the vast majority of whom are now urban residents for at least two generations with no remaining *laoxiang* connections) and the rest. - There are in/out formal classifications of residents of an urban 'burgher' class, as evolution of the *hukou* system, who are expected to take strong personal responsibility for metropolitan security, as 'networked-individuality', while those without this status are formally excluded and policed. - Hence a splintering divergence of *worlds* into higher-tech urban vs. rural or (what are now called at international level) '*non*-developing countries', with small e-cars and E2Ws respectively as dominant vehicles. - The shift to 'networked-individuality' amongst this urban burgher class includes shared mobility 'clubs', but where this is built on highly security-conscious and individually and privately owned (not corporate or government) networks and local private-public partnership (PPP) entrepreneurialism not globally concentrated sharing platforms. - Home/work/leisure are increasingly relocated within smaller distances into 'new villages' (*xincun*), reducing commutes and overall mobility, even as mobility and autonomy within city limits (and to/from city centres) is carefully and robustly defended and preserved. - Private or quasi-private transport preferred, but owning and running vehicles is expensive.
Vehicle forms	**Shift from cars to EV-*disu* small electric cars… and bikes** - Cars are widely rejected, as both expensive to own and fossil-fuelled (i.e. both not 'green' and dependent on insecure global systems of provision). - Instead EV-*disu* small electric cars come to dominate, as also expensive, but increasingly affordable, and run on reliable local electricity. - E2Ws increasingly diverge into two types: expensive, trackable and allowed vs. cheap and banned and/or exported. - Autonomous driving is rejected as too dangerous following the 'mass hack' terrorist attack of cars in Los Angeles, 2028 and countless car bombs. - Localization and privileging of personal health and vigour as a collective responsibility leads to partial resurgence of the bicycle, with local factories.

Industries, innovations and employment	**Global-local champions of security innovation** - The electric car is a market and industry that emerges through merger of Chinese *disu* private brands with global auto majors (largely familiar from early 21st C) and a handful of Chinese auto majors, creating multi-located networked 'local champions' that then dominate their local markets (e.g. Pearl River Delta-Osaka-Ruhr-Texas-São Paulo vs. Shanghai-Seoul-Southern California-Mumbai-Northern England…). - IP (and profits) are owned by these auto majors, hence not concentrated in China, but with China a crucial market and node in new e-car system. - Globalization undergoes a 'phase shift' from accelerating fluid mobility in all directions to 'lumpy' mobility amongst distinct ('neo-Hansa') networks of global cities, while rural peripheries become increasingly remote. Essential inter-city trade becomes increasingly the preserve of non-urban classes as adventurers and risk-taking merchants (e.g. on the new Silk Roads through unstable regions) amidst diminishing other opportunities for them. - Digitization continues but making extensive use of intra-nets and deliberately limited connectivity, firewalls etc… into smaller, more stable and limited-access digital networks, with local government permission needed to contact to the global internet. - Growth in employment emerges in reshaping city regions for greater system resilience and security, including local factories and (urban/ urban-peripheral) farms. - Cheap, lower-tech E2Ws remain resilient only as an export business to the 'non-developing' countries and rural areas.
Infrastructures and energy and resource systems	**New local public-private infrastructures of distributed provision and surveillance** - Personal and public charging infrastructures increasingly but unevenly built by local governments in PPPs with local enterprises and philanthropists. - Local government- and civic-sponsored shifts to distributed renewable energy grids – but not highly interconnected or 'smart' ones everywhere. - Distributed system infrastructures for networked-individual P2P mutual policing and surveillance: you are 'on grid' in the metropolitan region. - Intense competition for key resources outside city regions, especially in regions that become increasingly constrained to primary sectors and are owned by megacity-based corporations and institutions, deepens geographical disparities of urban and rural, developed and not, 'safe' and not.
Regulations and (local) governance	**Strict regulation by devolved city governments** - Increasing devolution of (mobility) governance, including innovation and security, to metropolitan regions within strong national security policies. - Increasing local penalties for pollution and national regulations for system autonomy from global energy markets add to the ('burgher') shift to electric vehicles from ICE cars, but at different rates and to different models in different city regions. - Congestion is also strictly regulated at city level, to allow for rapid disaster response, and only local vehicles are allowed on major roads. - Charging infrastructures, especially private ones, require guards to secure access against extortion from petty criminals and aggrieved and excluded non-city-registered residents blocking them. - E2Ws face increasing regulation as a 'security hazard' leading to diminishing interest in major urban centres.
Aspirations, values and status competition	**The responsible custodian of the complex urban system** - The priority for the Chinese (and global) burgher ('middle') classes, with their lower expectations, is city-based security, with dangers 'outside'. - Emphasis is placed on vigilant and responsible personal action, particularly vis-à-vis local others with whom you are interdependent, including whom one interacts with (online) and/or whom one invites into mobility clubs, with a view to local complex system resilience.
Environment	**Accelerating but highly urban-localized environmental improvements** - Air quality and GHG emissions have improved slowly, then dramatically with the 'shock', followed by incremental-but-accumulating-and-accelerating improvements as mobility and energy use is reduced and shifted to renewables-cum-electricity

Discussion

These four scenarios are radically different, not only in terms of how and why urban mobility takes place but also regarding the broader socio-political character of Chinese (and, likely, global) society with which mobility systems co-evolve. There remains a high degree of diversity and variation in the plausible futures for Chinese e-mobility. We summarize these differences in Table 1 below, showing how the four scenarios comprise a full spectrum of values for these variables.

Table 1: Differences in Key Dimensions across the 4 Scenarios

	Key Dimensions	**S1**	**S2**	**S3**	**S4**
Low-carbon mobility	*Depth of transition to e-mobility vs. the 'car'*	High	High	Low	Medium
	Decarbonisation of mobility	High	Medium	Low	Medium
	Digitization of mobility	Medium/ Low	High	High	Medium/ Low
Global social changes	*Pace of life*	Slower (progressively)	Faster (progressively)	Faster (but stuck)	Slower (after shock)
	Chinese global innovation leadership	High	High	Lower	Lower
Convergence or Divergence	*Of electric cars (EV) with E2Ws and/or* disu *vehicles*	Convergence on small *disu*	Divergence to socially stratified e-mobility	Convergence to stagnation of all e-mobility	Divergence to adoption of small EVs vs. rejection/ export of E2Ws
	Of local models of governance of mobility (innovation)	Divergence to multiple locally-relevant models	Convergence on new mega-city model 'best practice'	Convergence on sub-optimal muddling through	Divergence into multiple city regions and city/rural disparities

Moreover, in terms of which vehicles will dominate Chinese city streets in 30 years' time, these could yet be big or small, connected or not, ICE or plug-in (or self-propelled) and largely familiar to us in 2016 or completely unfamiliar (see Figures 1 and 2).

For instance, while the ICE car falls at varying rates in three of the scenarios, in one it continues to grow, ultimately constrained, if not undone, only by insoluble gridlock. Similarly, regarding the smaller vehicles (E2Ws and '*disu*') at which Chinese low-carbon mobility innovation currently excels and is the global leader: in some scenarios these continue to grow in systemic significance and contribution to China's economy, while in others they are proscribed and abandoned.

Yet there are also significant similarities across all four, as one would indeed expect given the common evidence base from which they were all constructed. In particular, all involve:

- significant *social* and *systemic* change
- the shaping and dominance of a 'middle' or 'burgher' class (ranging from 10% to 40% of population)
- more or less digitization, albeit of vastly different kinds and trajectories; and
- continuing urbanization and city governance, also of very different forms.

Similarly, and of no less importance, is how none of them foresee the simple replacement of the 'car' by the 'electric car'. And it also seems a robust conclusion across all four that no future system in the medium-term will resolve all contemporary social and environmental challenges associated with contemporary mobility.

Figure 1: Chinese E2W and *disu* sales across the 4 scenarios (annual sales)

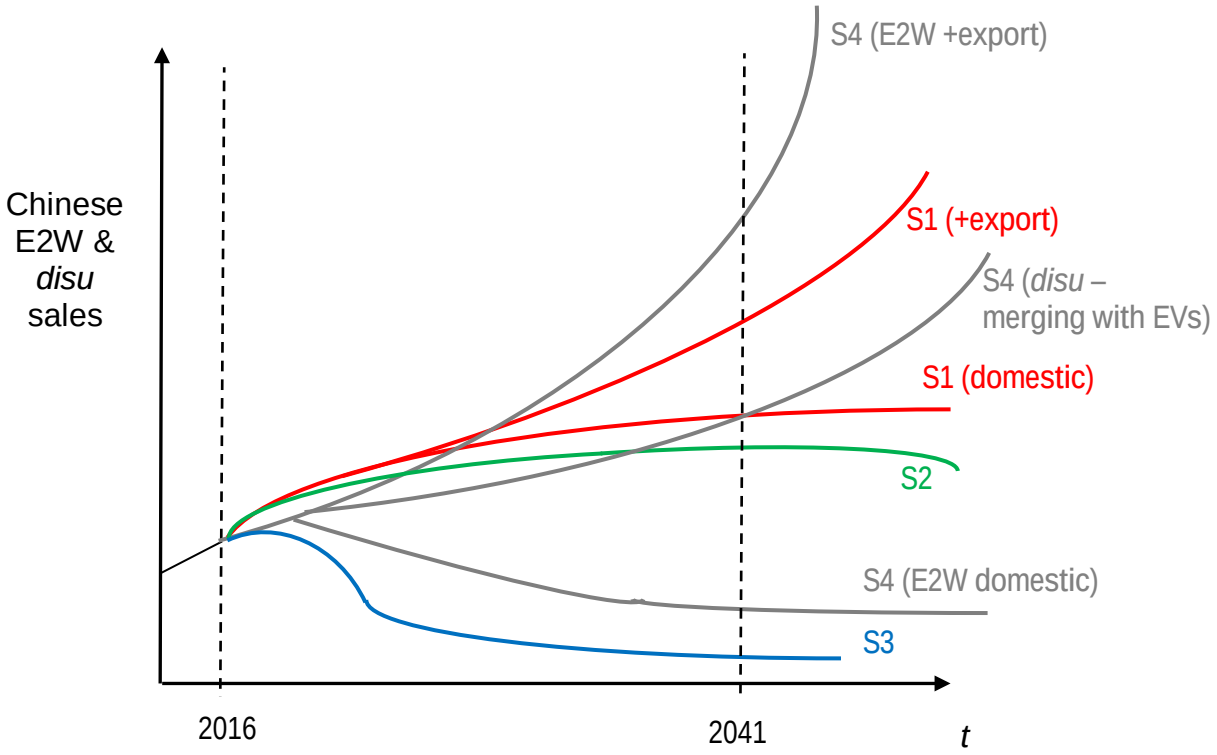
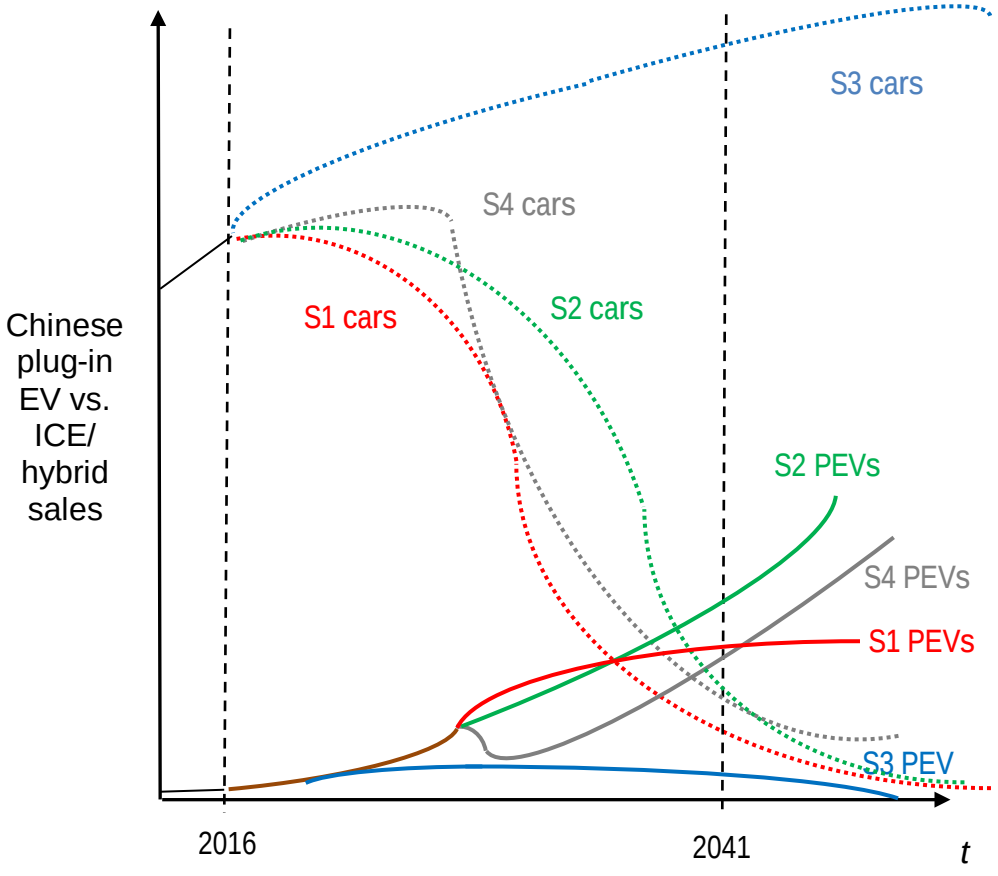


Figure 2: Chinese plug-in EVs vs. ICE/hybrid cars (annual sales)



Conclusions

Together, then, this analysis elicits three major conclusions:

"What is the preference of government?"
This is obviously a key question, not only for a socio-technical transition demanding coordination of the scale of e-mobility, but also in any case in China, given continuing levers of government over the structure of the political economy and the automotive, ICTs and electricity sectors. What these four scenarios illustrate, however, is how there is, at present, no simple answer to this question.

Different tiers of government (from central to local), different ministries and different SOEs – and indeed other stakeholders, including (new) private businesses – are currently all competing to become dominant or pivotal players in future e-mobility systems. There is thus no single dominant imaginary of the future currently guiding a unified national industrial policy. E-mobility in China is thus at present an arena of considerable dynamism and it is possible, if not likely, that the players driving and most supported by government policy in what finally emerges as an e-mobility transition will be new and surprising players.

Multiple different cities, overlapping scenarios
Secondly, just as the four scenarios are not to be read as definitive futures, nor should they be seen as necessarily mutually incompatible. Indeed, distinct recognizable elements of all four could subsist together and feed into each other's dynamics, even as there are clear limits to this compatibility. This is a particularly important eventuality to consider once we again acknowledge the diversity of China's cities and regions.

For instance, a slow mobility system (≈S1) could take root in tourist locations (e.g. Sanya in Hainan or Hangzhou's West Lake) and 'hi-tech' or university areas (e.g. Zhongguancun), but as quasi-elite and exceptional environments alongside a more generalized S2 system in the most developed megacities and a S3 system in (still very populous) 3rd, 4th and 5th tier cities and regions. In such circumstances, the small pocket of S1 could be precisely what attracts 'global talent' to China's top cities and innovation zones, driving broader S2 adoption in these places (e.g. helping turn a few domestic manufacturers of small *disu* vehicles into (key divisions of) new e-mobility global giants); while this also draws policy attention from the rest of country, which is thereby abandoned to S3.

We do not yet know *what*, or *who*, the 'EV' is
Most importantly, though, the scenarios and the extent of qualitative and irreducible uncertainty they illustrate highlights perhaps the most important lesson for contemporary efforts – of business strategy and policy – at an expedited low-carbon mobility transition; namely that we do not yet know *what* the 'electric vehicle' is nor *who* it is, in terms of which industries, corporations and national/regional innovation systems will dominate it, and how it will be used, by which consumers, to service what demands in everyday life.

This thus points to two key lessons: first, those engaged with e-mobility would do best to relinquish any ideas they have of the electric car as a familiar car-based system just powered by electricity rather than liquid fossil fuels; and, secondly, with so much of the socio-technical system still in flux but embryonic, the social futures of urban mobility, in all their qualitative complexity, are now there to be shaped, and with China as a key global site of this process.

Our hope is that these scenarios help to stimulate a broader consideration of the profound social, economic and cultural changes that will accompany e-mobility innovation, whichever mobility future in fact emerges.

David Tyfield
Dennis Zuev
Ping Li
John Urry

June 2016

Endnotes

[1] We gratefully acknowledge the funding of the UK's Economic and Social Research Council (grant ES/K006002/1) for this work.
[2] See e.g. Wilkinson, A., R. Kupers and D. Mangalagiu (2013) 'How plausibility-based scenario practices are grappling with complexity to appreciate and address 21st century challenges', *Technological Forecasting and Social Change* 80: 699-710.
[3] The event was held just before the untimely death of our inspiring colleague and friend, John Urry. We note here our immeasurable thanks to him for his contributions to this work and our gratitude that he could join us for that crucial event.
[4] See e.g. Mokyr, J. (1991) *The Lever of Riches*, Oxford: Oxford University Press.
[5] See Smil, V. (2010) *Energy Transitions*, Santa Barbara, CA: Praeger.

We gratefully acknowledge use (non-commercial) of the following images in the report:
https://commons.wikimedia.org/wiki/File:Service_bicyclette_hangzhou_zhongguo.jpg
https://vimeo.com/143864537
https://commons.wikimedia.org/wiki/File:Nitin03.jpg
https://en.wikipedia.org/wiki/Airport_Expressway_(Beijing)
https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcSv4hA7aENcwbA9ehOZ_z4iplfvL0YQaZ2XBRXS2de62e0zCDe61A

LOW CARBON
INNOVATION IN CHINA
中国低碳创新

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 project is available at:
http://steps-centre.org/project/low-carbon-china/
Twitter: @**Lowcarbonchina**

The Centre for Mobilities Research (**CeMoRe**) at Lancaster University has been a globally-leading centre for the new and fast-growing research field of mobilities since it was established in 2003. Mobilities encompasses the analysis of the global, national and local movements of people, objects, capital, information and material things combining together to engender the economic and social patterning of life.

For more information about research and events, visit:
www.lancaster.ac.uk/fass/centres/cemore/
Twitter: @**cemore4mobs**

Correct citation: Tyfield, D., Zuev, D., Ping, L. and Urry, J. (2016) *The Politics and Practices of Low-Carbon Urban Mobility in China: 4 Future Scenarios,* CeMoRe Report, Lancaster University