Electric-Bikes and Energy Demand in China

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Low Carbon Mobility transition in China and the role of low-tech

China represents a test-case of global significance regarding the challenges of urban mobility transition. On the one hand, China as the world's largest car market, and with significant further growth predicted, is globally central to 'greening' mobility. On the other, the growth of a (fossil-fuelled) urban mobility system has been a central feature of the immense changes that occurred in China since 1978. Yet in both respects the need for an urban mobility transition is 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 21st century, namely electric vehicles (EV). At the same time, the much lower-technology electric two-wheeler (E2W) has emerged as globally significant and dominated by small Chinese firms and their Chinese customers.

Moreover, the current landscape of low-carbon mobility transition in China is comprised of multiple geographical "strongholds" where particular forms of e-mobility innovations dominate. In Shenzhen in the Pearl River Delta EV taxi fleets have been actively promoted by local government as a part of the high-tech city self-presentation. Shenzhen is the home of the most successful national EV manufacturer BYD and many battery manufacturing companies, as well as now global ICT brands such as Huawei, Tencent and ZTE.

Hangzhou in Zhejiang province, renowned for its bottom-up entrepreneurialism, is a stronghold for vehicle sharing; It is the location of the world's largest bike-sharing scheme and several successful car-sharing ventures.

The less prosperous province of Shandong is characterized by the production and use of low-speed electric vehicles (LSEVs). While Shanghai, as the world's largest city (by population) and the home of arguably China's strongest 'carbon capital' state-owned enterprises (SOEs) including in internal combustion engine (ICE) cars, is where two-wheelers are prominent. City centre congestion makes electric scooters and bicycles the most efficient mode of transportation within Shanghai.

The question of future e-mobility in China thus involves how negotiation, competition and combination across these niches will take place. We explore this process here from the perspective of electric bikes (E2W). But how are we to understand and analyse this process? It is clear that a key element of a system transition concerns the dynamic growth in demand for the socio-technical assemblage at its core; in the process also giving this shape and substance. Meanwhile, the importance of demand is largely ignored by a policy orthodoxy, including in China, that focuses on (high-)technology–push approaches.

Moreover, the 'demand' for mobility of various modes results from complex nexuses of embedded social practices relating to the everyday life of people and organizations. The growth of E2W mobility, if it is to emerge to a system transition, must be part of the growth and spread of a range of existing or new social practices. It is this issue of the changing social practices and system transitions that we are

examining in research on Low Carbon China (http://steps-centre.org/project/low-carbon-china/).

But how are we to study this in real time, when everything depends on everything else and future trajectories of elements are themselves so uncertain? Or, in other words, where are the sources of system dynamism in this process and how can they be identified?

Our research partly on the streets of China has attempted to answer these key questions by taking dynamic power/knowledge relations and technologies as key theoretical lens (see Tyfield et al. 2014). This presents a perspective in which innovation – in the broadest socio-technical sense of adoption and demand and not just production and supply – as a pivotal practice of transformation of power/knowledge technologies that may then, in turn, condition further innovation. Where positive feedback loops emerge, a 'power momentum' of transition can be identified, albeit provisionally and fallibly and needing further investigation.

Regarding demand the transformation of social practices with changing profiles of demand for consumption can be traced in real-time starting from specific innovations. And demand for *energy*, more broadly, also emerges as a key aspect of this process in terms of the enabling of power/knowledge relations that enable/disable access to energy for use in specific projects and by specific constituencies in their dynamic momentum of growth, reproduction, emergence and maintenance. This is what we have elsewhere called the 'powering of power' (Tyfield 2014).

In the following sections we discuss politics, practices and prospects of e-bike use in China. We first consider the wider picture of the current politics (i.e. power/knowledge relations) of e-bikes before turning to two brief examples of more detailed analysis, e-bike taxis in Shenzhen and issues of charging. In subsequent writing we report on interview and focus group material that begins to examine broader shifts in social practices and how E2Ws may be significant within such shifts. If this were the case then they could shift from niche to regime to use the language of socio-technical transitions. So we draw here upon transitions and social practice formulations in order to interrogate the fascinating case of e-bikes in China of which there are currently over two hundred million.

E-bikes in Chinese cities

The situation with E2Ws in China and their role in low-carbon transition is still not very clear (Ling et al 2016). E2Ws arguably remain the most visible element of Chinese low-carbon mobility transition, even in big cities. Manufacturing E2Ws is also a growing, although highly fragmented, domestic industrial sector – the largest e-bike industry in the world – with over 200 million on China's roads, though growth is forecast to slow down (Navigant research, 2015); a decline partially attributed to the growth of low speed electric vehicles (Liu Jian, 2016).

There have been few studies, limited to a few cities, on the role of E2Ws in mobility transition, yet some of these studies suggest that E2Ws are often used together with a car (Ben Dror, 2014) or can be a stepping stone to a car purchase (Fishman and Cherry, 2015) rather that its long-term replacement. Importantly, however, E2Ws

have significantly changed the traffic landscape of the Chinese cities and have provided increased mobility for lower income populations and possibly also the rising middle class(es) (Cherry et al 2016). E-bikes thus do seem to have potential to replace other motorised modes (Fishman and Cherry, 2015).

A key barrier is socio-cultural. In China a car is still seen as the second-most important family investment (after the house) and E2Ws are often associated with low *suzhi* (personal quality) population (i.e. associated with the status (display) of lower income, uneducated, rural migrants or workers). As such, the broader impact of the E2W depends to a great extent on its capacity to move 'up' market and challenge these social associations. Similarly, regarding prospects of exports, Fishman and Cherry (2015) note that to compete with motorcycles in other Asian markets e-bikes need substantial performance and price incentives. China has already implemented an important E-bike lithium-ion battery standards and sizes, which aims to improve lithium battery quality and technology. E-bike manufacturers also cannot establish factories only based on lead-acid battery technology (interview with Consultancy).

Yet the E2W is highly resilient. Regulation of electric two-wheelers has undergone attempts to ban them in several cities, since they are seen as dangerous and unruly (see comparison of two cases in Wells and Lin, 2015). Yet many of those bans have been lifted given the importance of E2W-based mobility for continued economic development, e.g. given long-distance commutes to the newly built residential areas. E2Ws are also commonly used for short trips – to work and for delivering and picking up children from school – even by parents who have cars. E2Ws have also provided an essential tool for many services in big cities, being now the mainstay of delivery companies, including fast food (such as *Elema*, promoted by Chinese e-commerce giant Alibaba) and express deliveries. With the growth of the Internet and online consumption in China, the fleet of electric two wheelers used for this sort of deliveries is only likely to grow. In the context of costly parking provisions and aggravating congestion, it seems likely that E2Ws will remain a preferred mode of transportation in the city centres for many specific purposes and sources of demand for mobility.

There are questions, however, regarding E2Ws' "low-carbon" status and environmental impact. One of the main issues related to questioning the "low-carbon" status of E2Ws (vs. EVs) is the battery use and its recycling since currently most of the E2Ws use lead-acid battery. Li-ion battery is becoming more popular and cheaper, however, and this also makes the E2W lighter, thereby opening up new (and higher status) markets as a complementary tool for the solution of the 'last mile' problem, especially for the daily commuters who use cars or subways. Other objections concerning the GHGs emitted from the electricity generation are also less significant than for EVs, being lighter vehicles. While from a transitions perspective the E2W also represents a popular individual mobility option with unquestionable demand, unlike the EV, which remains utterly dependent on government subsidies. Moreover, the E2W has substituted for motorcycles and has led to improvement of air quality and reduction of noise pollution (Wells and Lin, 2015).

As such, E2Ws, along with and in competition with LSEVs, are a potential niche for developing and strengthening Chinese low-carbon innovation capacity. Their

widespread use in China provides multiple companies with an excellent testing ground and revenue to develop their R&D departments and expansion into other world markets (Tyfield et al 2015). Indeed, some of the Chinese E2W manufacturers already demonstrate their priority markets in Europe rather than China, evidencing a differentiation and strengthening of the sector.

Maya Ben Dror made a pioneering study on e-bike use and diffusion in Beijing (2012). She discovered that the majority of the e-bike users in Beijing shared similar rationale: they wanted improved transport performance and achieving this at a lower cost. Another element to this was opportunity to have a reasonably inexpensive private vehicle, hence for *auto*-mobility. E-bike power is considerable: it can carry more cargo, more people and travel longer distances at minimal cost for the user. This differentiates the e-bike from the bicycle, since it has become a more solid tool in facilitating individual mobility and individual freedom – partially allowing or improving ambulant occupations or life-style. As with any personal item the ownership is emphasized by details and accessories, decorating the seats, attaching various features for more comfort. It is no longer a crowd of unidentified two-wheelers. The individual signaturing is also important as the bike and/or battery theft is also rife. One of the reasons why shabby or unmaintained e-bikes are so visible on Chinese streets is practical: old e-bikes are less attractive to thieves.

Gendered effects are also significant. The e-bike has become a mobility alternative that considerably alleviated the load of women in their everyday mobilities. There is very high adoption potential especially among women (Chiu and Tzeng, 1999). Giving excellent education to children is one of the priority tasks in the family and this may entail longer journeys to school of choice, generally for mothers. However transporting children to school is not always carried out by women - grandparents play a tremendous role as well (seeding LSEV demand, especially in colder climates). Nevertheless, gender differences could be distinguished in terms of preference of particular types of e-bike. According to one of the e-bike dealers interviewed in Hangzhou, while men prefer bulky, solid and more powerful scooters with bigger and softer seats, women often preferred lighter models with a back seat that was more convenient for carrying children. At the same time young women preferred the new slim models equipped with Li-ion battery pack that could be easily carried home for recharge. These bikes also were normally easy to pedal – physical exercise while going to work was one of the reasons why women chose pedelec instead of a scooter. And, indeed, an emerging theme in e-bike research is that although e-bikes provide lower level of physical activity than traditional bikes they still achieve a level necessary for health enhancement and provide enjoyment experience (Fishman and Cherry, 2015).

The study of e-bike diffusion in Beijing has revealed that e-bike development unlike other transport technologies, has been largely driven by demand. The reason for not buying a car was also a very practical one: Beijing and many other Chinese cities already had a developed infrastructure for accommodating bikes, such as bike lanes and bike parking lots, while as a car-owner one would face the serious problem of the lack of parking space. Since Beijing's inner core city is also comprised of narrow alleys (*hutongs*), it is much easier to navigate them on an e-bike than a car. Several interviewees in fact did own a car, but avoided using it due to operational costs and parking problems; perhaps buying it just for 'face', as befits their status. According to

one of the interviewees during a focus group organised in Beijing she had to deal with an identity problem being a car-driver who hates e-bikes, and e-bike rider who hates cars: an apt analogy for China's conflicted attitude to contemporary urban mobility more generally.

Several studies of e-bikes in China (Ben Dror 2012, Weinert et al. 2008) agree that E2Ws have a future in second and third tier cities, as a form of private transport, while large cities that have resources to construct efficient public transit systems may benefit from reducing motorized two-wheeler use. However, as Wells and Lin (2015) suggest the forces required to create a new mobility regime are not present and economic and political power of traditional ICE car mobility remains substantial. This creates a policy stalemate in which the bottom-up 'mushrooms' of E2W auto-mobility may spread.

Indeed, one large city outlier to these expectations of tiered adoption of e-bike penetration is Shanghai (where e-bikes were first manufactured and are more widespread than in Beijing). Why some large cities ban and others don't is a question that does not have a definite answer. Sometimes this can be explained by insufficiently developed public transportation system (Beijing) or image issues (Shenzhen, Guangzhou) or political will of its authorities. Conversely, urban sprawl has made e-bikes essential transportation, saving the large residential districts outside of big cities (such as Shanghai) that were designed for car-users but house residents who cannot afford a car (Lohry 2014). Without e-bikes these residential areas would remain ghost-towns and e-bikes allowed new migrants to deal with the increased commuting distance from suburban areas to city centres (Zhang et al. 2013).

But the e-bike isn't just a potential replacement of the car. Cherry and Cervero (ref), studying Kunming and Shanghai, demonstrated that the e-bike is not a transitional vehicle between bike and car, but is a mobility alternative to public transportation – again pointing to the importance of auto-mobility. During summer months Shanghai residents prefer e-bikes because it is not only fast but also "refreshing", while in winter different practices make riding more comfortable: putting on helmets and putting a wind-breaker e-bike duvet in front, which also often hides children who are traveling with their parents. These considerations, however, point to the significant gap in existing studies regarding e-bike mobility in Chinese cities from the perspective of social practices employed by e-bike users; which to some extent has led to misunderstanding and clumsy regulation (Wells and Lin, 2015) on the part of the authorities.

E-bike mobility as a unique type of movement involves a cluster of practices. These practices include the fuelling and maintenance of the movement: charging, repairing, keeping the bike intact when interacting with other vehicles and users. For instance, some of the questions that are considered day-to-day by users includes: How to keep balance with e-bike (it is much heavier)? How to keep yourself dry, fresh (you obviously sweat less – in Austria there was software developed that would analyse the trajectory that you take and analyse the energy you would lose)? How to save energy (your own and that of the bike)? – What about the wind power? There are windier places and less windy places in each city. How to earn money from ownership (deliveries, riding, sharing)? How to move faster without impeding safety

(using bike lanes or pavements)? How to navigate? Balancing and dodging may be the next valuable skills for riding self-balancing devices and e-bikes.

One of the objectives of this study was to get a glimpse of e-bike users and observe their practices. In the following section we will provide a detailed analysis of e-bike rickshaws or informal transportation that uses e-bikes in Shenzhen, one of the cities with strict anti-e-bike regulation.

E-bikes solving the "last mile" problem in Shenzhen

Shenzhen is famous for being a rather successful example in adopting EVs for taxi fleet and e-buses for its public transportation, but also for enforcing the ban of e-bikes as a part of its low-carbon and high-tech city image management. There are not so many e-bikes to be seen on the streets of Shenzhen as one would see in Shanghai or Hangzhou. But in *Futian* district which is a part of central zone in Shenzhen the traffic scene was similar to any other "normal" Chinese city with plenty of e-bikes around and in all directions. Every metro exit has a line or rather a group of e-bikers who would invite to have a ride to all the people coming out, especially in the late evening hours. This kind of informal motorized taxi is considered illegal (*heiche*) but is nothing new and only some years ago all these two-wheeled taxis were all motorcycles. With motorcycle ban in many cities the practice of informal two-wheeled taxi service did not disappear. It became the e-bike taxi (see photo 1).

Photo 1. *E-bike rickshaws "heiche", are waiting at the metro station "Science Park", one of the city centres of high-tech city of Shenzhen in South China, close to the quarters of Tencent, one of the Chinese software giants.*

E-bikes are strictly prohibited in the city centre(s) of Shenzhen, but not outside city centre(s[1]) in the fringe areas. *Daxin* metro station is an excellent example – it is 30 minutes away by metro from the centre of Futian district. It has four exits and each exit has sometimes about ten e-bikes ready to take you away. "Where do you want to go?" is the typical question of the e-bike-rickshaws as you . The rain is not a hurdle to their business as they have custom-made umbrellas and umbrella mounts on their vehicles.

After some period of observation there was spotted a group of e-bikers on duty every evening at the entrance to one of the hotels and the idea to have a focus-group interview with them came very naturally. This was the group which could be interested in earning some money and after a few conversations a contact with *laoda* (informal leader as he was called by his colleagues in this little group – for the experience he had and a very confident way he spoke) was established. He was not interested in earning money but wanted to talk about various things. *Laoda* explained, that the major contingent of their customers at the late hour is prostitutes or girls that worked in karaoke bars, KTV bars. They knew him very well and he knew them, so he had a stable clientele every day. He said that this is what he did for living, nothing else.

Apart from the *zhuanxing*, or specialized e-bike rickshaws, there is another group, which does this kind of e-bike taxiing to supplement their more stable income. The specialized ones, mostly young men in their twenties, said the main reason for doing this kind of job was 'freedom': no schedules to follow, no supervision, reliance on yourself. The second group had a stable job during the day, which also often involved deliveries or sales and in the evening they would go out to work as transportation providers for a few hours. One of the interviewees had a day job but was still working at 2am. The work is often in the late hours, when public transportation stops and taxis are expensive.

But what is freedom? What is the attraction of risking your only working tool in the city that built its fortune largely on manufacturing done by migrant workers? Laoda responded:

> *It is easy to find a job in Shenzhen, factories have a lot of jobs. But there you have to work for somebody, the schedule is set for you, here I have freedom. Many of us had stable jobs, but many quit them. Here you depend on yourself, you go out when you want, because if you don't go to work you don't eat. You can't really earn a lot and save, but you can earn enough, eat meat, eat well you understand?*

But freedom is still relatively limited in Shenzhen, as rickshaws have to look out for traffic police, e-bike thieves and reckless taxi-drivers. Traffic police can expropriate the bike if they catch the rider with the scooter in "no-go" areas (close to city centres). It is easy to identify "no-go" areas in central districts where no e-bikes can be seen. The police, however, are not very active in the evening, so informal transportation is synchronized with the darkness and lack of formal transport. E-bike theft is ubiquitous, so there are few practices for e-bike users to safeguard their

[1] Shenzhen has multiple city centers

possession. First of all is not to park the bike with many other bikes, but rather in an isolated place, so it is visible. The second is not to have a flashy new bike – "as long as it can ride, it is OK" – so the e-bike often is seen as a pragmatic mobility tool, not a tool for making a personal statement. And finally another danger is roads, especially main roads that are unavoidable on most journeys. As our interviewees noted, however, they face a double risk: not just of an accident that will likely be worse for them but also of default blame for it; hence further evidence of the deep-seated prejudice towards e-bikes.

In Shenzhen, this prejudice is enforced by car drivers and taxi-drivers position, that these are low quality people (migrants), who need some kind of affordable transportation. But as the photo 2 shows, e-bikers in Shanghai are very different in the sense that they feel equal to car-drivers and even show their advantage by lining up in front of the cars and starting off first at the green light, not sticking close to curbs as in Shenzhen. In short, then, while both pursuit of auto-mobility and the dangers of use unites the patterns of adoption of E2Ws across China, the diverse local political economies and cultural geographies of its cities leads to very different status and associated practices, and hence demand. It is far from clear which, if any, of these will prevail in a new mobility system.

Photo 2. *E-bike riders dominate the street in Shanghai. E-bikes create different mobility order on the streets of Shanghai, as is very visible on this photo, they do not follow the rule of lining up after each other, but they instead make a row occupying the space in front of the cars, in front of the pavement and even a part of the opposite lane.*

Charging batteries

As already noted, one of the main themes in the interviews which works against e-bikes is their safety. It includes the contribution to road accidents and potential accidents related to electricity use and charging. There is a lot of debate in China about development of EV charging infrastructure, involvement of major state companies and minor enterprises. And in many ways while charging for EVs is a

major hurdle dependent on massive public/private infrastructure build and investment, that E2Ws do not depend on this is a major advantage.

In any case, e-bikes are relatively ignored by the government and there is little talk about e-bike charging infrastructure, so it seems that consumers also have themselves to invent a solution for charging. As one may expect in contemporary China, there are multiple entrepreneurial manufacturers producing fast e-bike "yellow" chargers (see photo 3). These are portable charging station, produced by a factory in Zhejiang province, and, in this case, a part of a bike-repair shop. You can come up, drop a one yuan coin and get enough charge for your battery to arrive at home. Waiting time is approximately 10 minutes which gives enough charge for a few kilometres. Yellow chargers in Hangzhou (the capital of Zhejiang) are often placed near shops, where owners agreed to provide electricity on agreement of sharing the returns. As one of the shop owners admitted, the charger is not for profit but rather to provide convenience to the riders, who may also get attracted to buy a few things while waiting. However these chargers have been criticized by professional e-bikers, as they are good only for a short charge, and not good for Li-ion batteries. Serious e-bike riders shun them in order not to damage the capacity of the battery. But it remains the case that there are no designated places for charging e-bikes apart from fast yellow chargers on the streets.

Photo 3. *Yellow e-bike charger on the street.*

Instead, charging thus normally happens at work, then it costs nothing, or at home, then it costs very little, often by carrying the battery inside to a conventional socket, depending on the mass and easy removal of the battery from the bike. But this can be dangerous. Living in high-rise blocks, people commonly hang wires from their apartments to charge the bike overnight in any weather conditions – rain or cold. These cables often intertwine with each other and it becomes a rather messy knot of cables. In 2014 after a major fire in a residential district of Zhengzhou (capital of Henan province) was caused in this way killing 5 people, the government introduced new regulations obliging construction of a dedicated bike-shed for charging e-bikes

on the premises of the apartment block.[2] As is always the case, however, implementation of such rules is another matter, and is dependent on landlords investing in housing for tenants who may have little leverage. The extent to which charging E2Ws remains a widespread hazard, fuelling public animosity or concern about them, is thus unclear.

Another option is the charging practices of e-bike rickshaws, which differ from normal users in being based on battery swap. As Laodo noted "we don't charge when we work, we have an extra or two batteries at home and we swap them when the battery is dead." But this method also conditions the e-bike use. No-one among interviewees in Shenzhen would travel more than fifteen km one way, because it means 30km return trip. So e-bikes service a particular district, and they have to stick close to home, because this is where they swap their battery. The battery becomes the primary element that limits the range of informal e-bike transportation service; in fact a situation similar to the EV taxi in Shenzhen, which refuse longer journeys (even lucrative trips just to the city airport) due to the technical limitations.

In short, the current hotchpotch of practices of charging E2Ws remains a key barrier to the domestication of the E2W system and its broader acceptance and adoption.

Conclusions

E2Ws have proven extremely popular forms of e-mobility in China. Regarding prospects of an E2W-based transition of urban mobility system, however, examining the power relations and practices of their current use and adoption reveals a number of key enablements and hurdles. On the one hand, their appeal is built upon a mass demotic demand for auto-mobility and 'freedom' that is ubiquitous, across all strata of society and enduring, being sedimented in the current structures of China's liberalizing and individualizing political economy. Conversely, however, persistent challenges regarding their safety in use and the associated issue of their marks as symbols of personal 'quality' and class remain. Yet both of these key challenges are highly dynamic.

As one expert reported, e-bikes are here to stay, some manufacturers interviewed also had optimistic forecasts about growing adoption of e-bikes by middle class and white collar workers, who will use foldable e-bikes to avoid traffic jams in city centres. This optimism was however secured by primarily targeting e-bikes for European markets, though there is already some evidence of this model in Shanghai. Meanwhile, China is still searching its way to regulate and 'domesticate' e-bike mobility. It is possible, however, that growing governmental attention to another "irregular" electric vehicle – the low-speed EV – may be better placed than the EV to service the key demand of the growing 'middle classes' and to provide an important niche for boosting economic growth and urbanization plans, a so-called process of urban-rural unification (Fang and Zhu, 2015)

In future writing we will connect these different e-mobilities briefly examined here to issues of system transition and changing social practices.

[2] http://politics.people.com.cn/n/2014/0825/c70731-25528546.html

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