THE INNOVATION INTERFACE

Business model innovation for electric vehicle futures.

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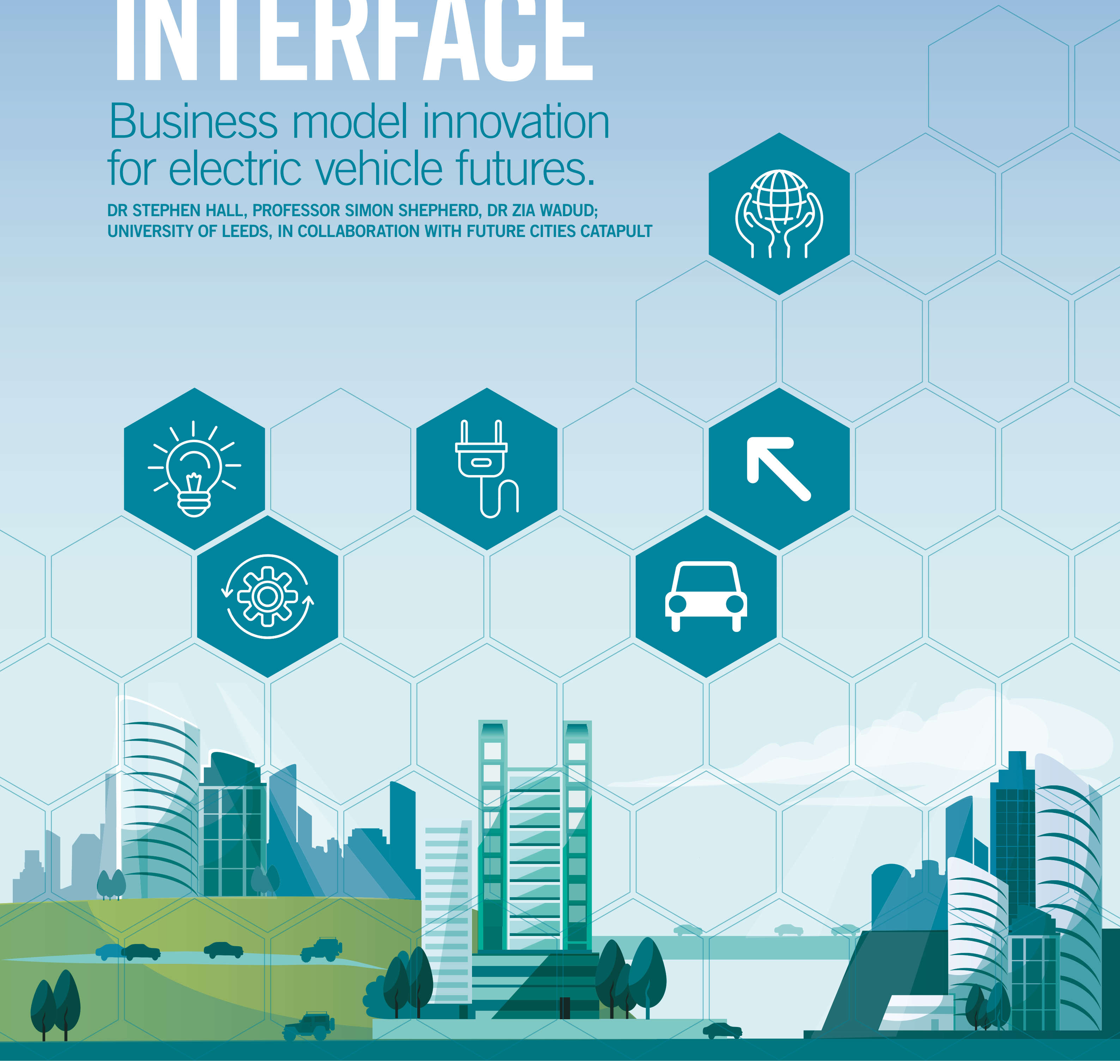

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Executive summary

There is huge potential to link electric vehicles, local energy systems, and personal mobility in the city. By doing so we can improve air quality, tackle climate change, and grow new business models. Business model innovation is needed because new technologies and engineering innovations are currently far ahead of the energy system's ability to accommodate them. This report explores new business models that can work across the auto industry, transport infrastructure and energy systems.

New e-mobility business models can link three important sectors that have previously operated in isolation from one another; the auto industry, energy systems and transport infrastructure. It is vital that new e-mobility business models are investigated, as recent research shows current city level policies are having little effect on electric vehicle uptake[i]. New e-mobility business models have to work across the boundaries of these three large systems. We call this the 'Innovation Interface', where new products, services and commodities are offered by new partnerships between cities, the energy system, and the auto industry.

This report presents ten business models that work at the Innovation Interface. Some offer more benefits to the energy system, some are most positive for the auto industry, and others link together city transport infrastructures more effectively.

This report compares each business model archetype in detail to explore implications for users, regulation, technology, and city systems. Each business model is scored for its ability to fulfil business model innovation needs across the Innovation Interface.

This research is organised around four questions:

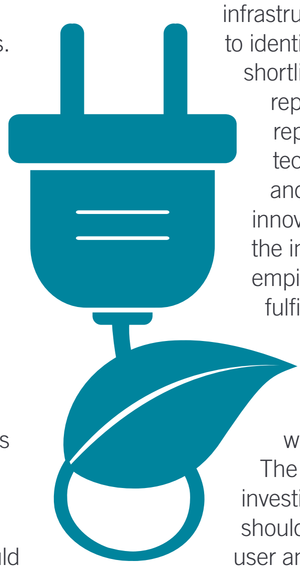
Question 1	**What are the business model innovation needs of different stakeholders?**
Question 2	**What are the business model archetypes that meet these needs?**
Question 3	**What are the implications of these business models for these stakeholders?**
Question 4	**How well does each model catalyse the Innovation Interface?**

E-mobility in cities

The e-mobility transition will be shaped city by city, it is affected by the infrastructures and transport systems of each city, and each city will find different e-mobility business models suitable to their needs. Section 1.1 of the report explores several driving forces which motivate cities to take a lead in e-mobility transitions. These include the health of citizens, the economic development benefits of urban decarbonisation, and the opportunity to better optimise local energy resources. These internal drivers are complemented by top down initiatives which promote e-mobility.

From the top down, successive EU[2] and UK[3] white papers have stressed the need for cities to provide alternative fuel infrastructures. This has translated into EU and UK grant schemes for cities such as the Plugged in Places scheme[35]. At the international scale (and prior to the UK's vote to leave the EU) Directive 2014/94/EU[4] on the deployment of alternative fuels infrastructure, would have driven all city regions to provide appropriate publicly accessible charge points.

In short there are a series of health, environmental, and economic drivers for increasing the uptake of e-mobility in cities. However, to date the focus has been on public policy and subsidy as opposed to independent business models which link city transport systems with the energy system and auto industry. While national level subsidy policies have claimed to be successful , research by the RAMSES Cities project has found that in the UK, city level policies to increase EV uptake have not been effective[1].



What we did

We conducted 21 semi structured interviews across the auto industry, energy utilities, city governments, and charge infrastructure providers. These interviews were used to identify business model innovation needs and to shortlist 10 business model 'archetypes' 2 of which represent current business models, and 8 which represent new business model archetypes which are technically possible but require further investigation and comparison. We then used two business model innovation workshops conducted in 2016 to investigate the implications of each of these models. We used this empirical work to analyse how well each archetype fulfilled the innovation needs of each sector, and how well it catalysed the Innovation Interface.

It is important to note that this research investigates the needs of system stakeholders which they feel will accelerate e-mobility uptake. The private users were not part of the empirical investigation due to resource constraint. Further work should explicitly investigate the innovation needs of the user and the ways in which both private and commercial sectors can engage with new business models.

Answering Question 1

Question 1 for this research was: 'what are the business model innovation needs of different stakeholders? The nine business model innovation needs we found were:

The Auto Industry needs

1	A coherent and accessible charge network, giving buyers certainty and reducing range anxiety
2	New routes to market/use models for e-mobility
3	Clarity on energy infrastructure capabilities to better design the next generation of charge capacity and management

The Energy System needs

4	Better optimisation of intermittent generation and EV Charging
5	Tariffs to reward flexibility and response and new aggregator businesses/functions
6	The ability to anticipate and respond to network stress

City Governments need

7	A coherent and accessible charge network
8	Better partnerships with energy system stakeholders
9	Integrated service approaches to mobility

Answering Question 2

Question 2 for this research was: 'what are the business model archetypes that meet these needs'? The complete report investigates the potential for 10 business models to meet the innovation needs of stakeholders. The 10 business models investigated are not an exhaustive list and were drawn primarily from participant suggestions in the interview phase.

The 10 Business models identified were:

1. **The Current Archetype:** In the current archetype, private individuals and companies purchase electric vehicles and buy electricity from a utility with (at best) a static time of use tariff (ToUT). This archetype represents the current system and locks out many smart services, energy and transport benefits.
2. **The Smart Utility:** This archetype is similar to the Current Archetype but uses smart meters to aggregate electric vehicles to better serve energy markets and help consumers avoid peak power prices. Here, little is done to find new routes to market for auto makers, but energy innovation is enabled.
3. **The EV White Label:** In this archetype a partnership is forged between the auto industry and energy utilities which creates a specially branded EV tariff. Private and commercial customers buy both the vehicle and the electricity from the same company. This means the vehicle manufacturer can take responsibility for both battery warranty and energy service provision, but little is done to encourage smarter transport choices.
4. **The Mobility Utility:** In this archetype consumers buy mobility as a service from utility companies, bundling energy and transport services. The need to buy an electric vehicle is replaced by a regular energy and mobility bill. This means the vehicles can be used as an energy system resource.
5. **The Municipal Mobility Utility:** In this archetype the city sets up a utility to both provide energy and mobility as a service. Here local renewable energy optimisation is possible. The model is similar to the national Mobility Utility, but much more local optimisation of energy is possible.
6. **Public Charge: Current Archetype:** This is the current way provide public charge points are provided. It is often grant dependent and has led to patchy coverage and inconsistent standards of service and technology.
7. **Public Charge: Municipal Lead Utility:** Here the city owned utility takes control of the charge infrastructure provision across a city. EV charging can be linked with local energy priorities and local infrastructure can be better managed.
8. **Car Share Compound:** In this archetype the electric vehicles are stored in a car share compound. The compound can serve high use locations such as transit stations and, when not in use, the compound vehicles can provide energy services.
9. **Rapid Charge Hubs:** This archetype looks and feels like a 'petrol station of the future' where drivers can charge cars in less than 20 minutes while accessing other services such as retail options.
10. **E-Mobility Service:** Here the city's transport body rolls electric vehicle hire into the wider integrated mobility package of the city.

Answering Questions 3 and 4

Questions 3 & 4 in this research were: 'What are the implications of these business models for these stakeholders?' and 'How well does each model catalyse the Innovation Interface?'

Each archetype meets different business model innovation needs to different degrees. We found that the business model archetypes that strongly catalyse innovation are often complex, rely on several revenue streams across different systems, and require deeper commercial trials. We classified each archetype in terms of how well they met the needs of stakeholders across the auto industry, energy systems, and city infrastructures. (Table ex1).

By analysing each archetype in expert focus groups we found each has different implications for users, system regulation, technologies and wider systems. Issues of consumer trust, data protection and driver convenience were highlighted in the user implications. From a system regulation perspective there are serious questions over how consumers can be protected given more complex tariffs, and how consumers can be protected given more complex tariffs, and how to avoid new business models 'cherry-picking' consumers. From a technology perspective, ICT integration and data access are key concerns, along with battery degradation protection. From a systemic perspective there are clear gains to be had in optimising energy systems and reducing transport pollution; but there is still uncertainty over knock on effects of storage on traditional energy markets.

Table ex1. Comparative analysis of business model innovation potential.

Business Model Archetype	AutoIndustry & Cities: Coherent and accessible charge network.	Auto Industry: New routes to market/use models	Auto Industry: Clarity on energyinfrastructure capabilities	Energy System: Better optimisation of intermittent generation and EV charging	Energy System: Tariffs to reward flexibility and response and new aggregator businesses functions	Energy System: Ability to anticipate and respond to network stress.	City Governments: Better partnerships with energy system stakeholders	City Governments: Integrated service approaches to mobility	Net Strength* of Business Model as an Innovation Interface Catalyst
1. Current Archetype with static ToUT	-	-/+	+	+	+	-	--	-	Weak
2. The Smart Utility	-	-/+	++	+	++	++	--	--	Weak/Moderate
3. The EV White Label	-	+	+++	+	+++	++	--	-	Moderate
4. The Mobility Utility	-/+	+++	+	++	+++	++	+	+	Strong
5. The Municipal Mobility Utility	++	++	++	+++	++	+++	+++	-/+	Strong
6. Public Charge Current Archetype	-	-/+	--	-	-	+	+	-	Weak
7. Public Charge Municipal Lead Utility	++	-/+	++	+++	-	++	+++	-	Moderate/Strong
8. Car Share Compound	--	+++	-/+	++	--	+++	+	+++	Moderate
9. Rapid Charge Hubs	+++	-/+	-/+	--	--	--	-/+	-/+	Weak
10. E-Mobility Service	+++	++	+	+	-/+	++	+	+++	Strong

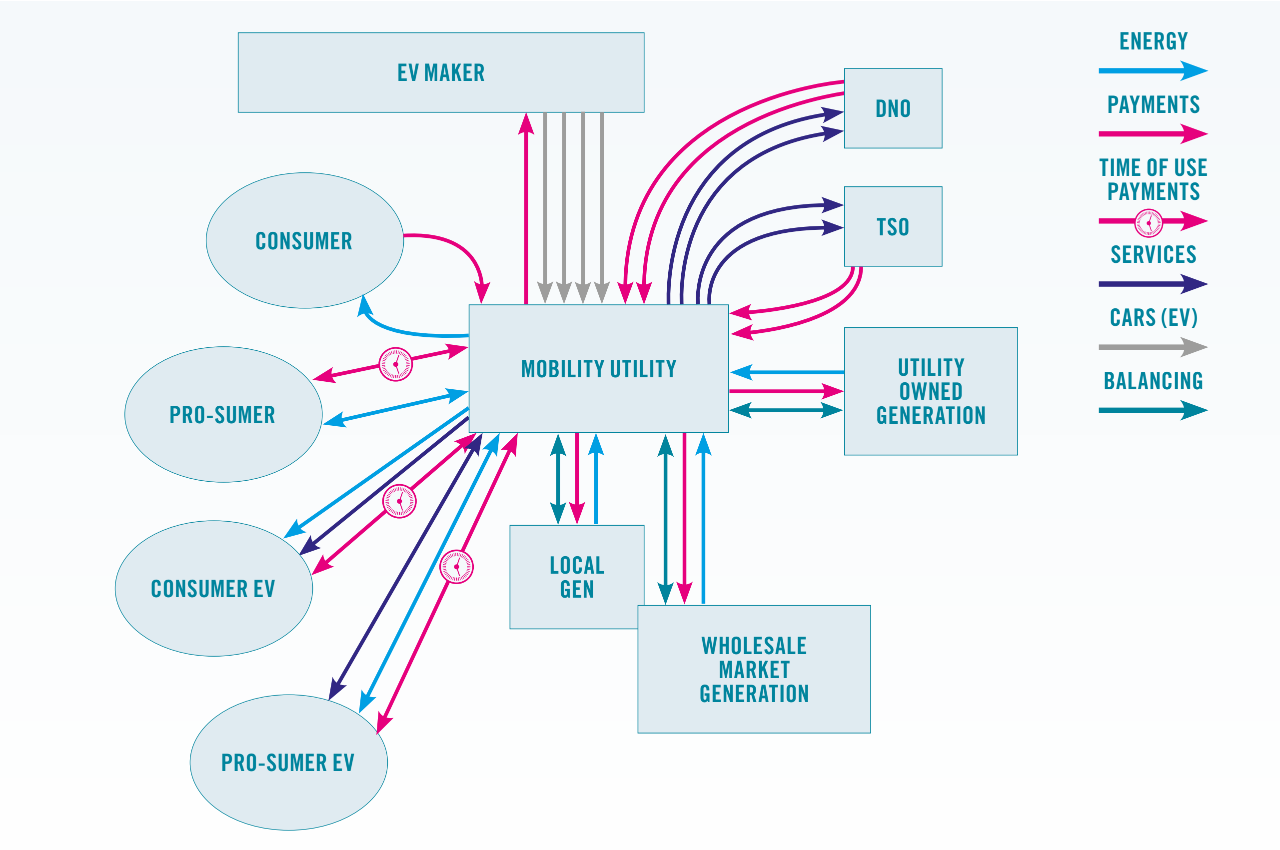
**Weak = 0 net positives. Weak/Moderate = 1-5 net positives. Moderate = 6-9 net positives. Moderate/Strong =10-12 net positives. Strong = 12 or higher net positives.*

We found that the archetypes that meet the most business model innovation needs are the municipal and national 'Mobility Utility' archetypes, and the 'E-Mobility Service' archetype. In the full report an archetype diagram is presented for each business model, here we reproduce the strongest three. These archetype diagrams show the flows of energy and payments in the system, where services are offered between parties, and where energy system balancing (ensuring sufficient supply) is done. Each archetype diagram is introduced with a paragraph or key attributes.

The Mobility Utility

In this archetype the private and commercial EV users no longer purchase the vehicles but lease them through the electricity utility via special tariff. As the utility now owns both vehicle and battery, it can optimise electricity market functions against battery degradation concerns. Vehicle to grid and vehicle to home services both become available via two way power flow. The utility can optimise for grid services or vehicle to building consumption. The EV manufacturers benefit from a new route to market for low-emission vehicles, utilities secure new revenue streams, cities benefit from enhanced EV uptake and may be able to engage more effectively with users aggregated under single utilities with further incentives. Distribution Network Operators and the Transmission System Operator (DNOs and the TSO) can be more closely involved in contracting new services with the utility.

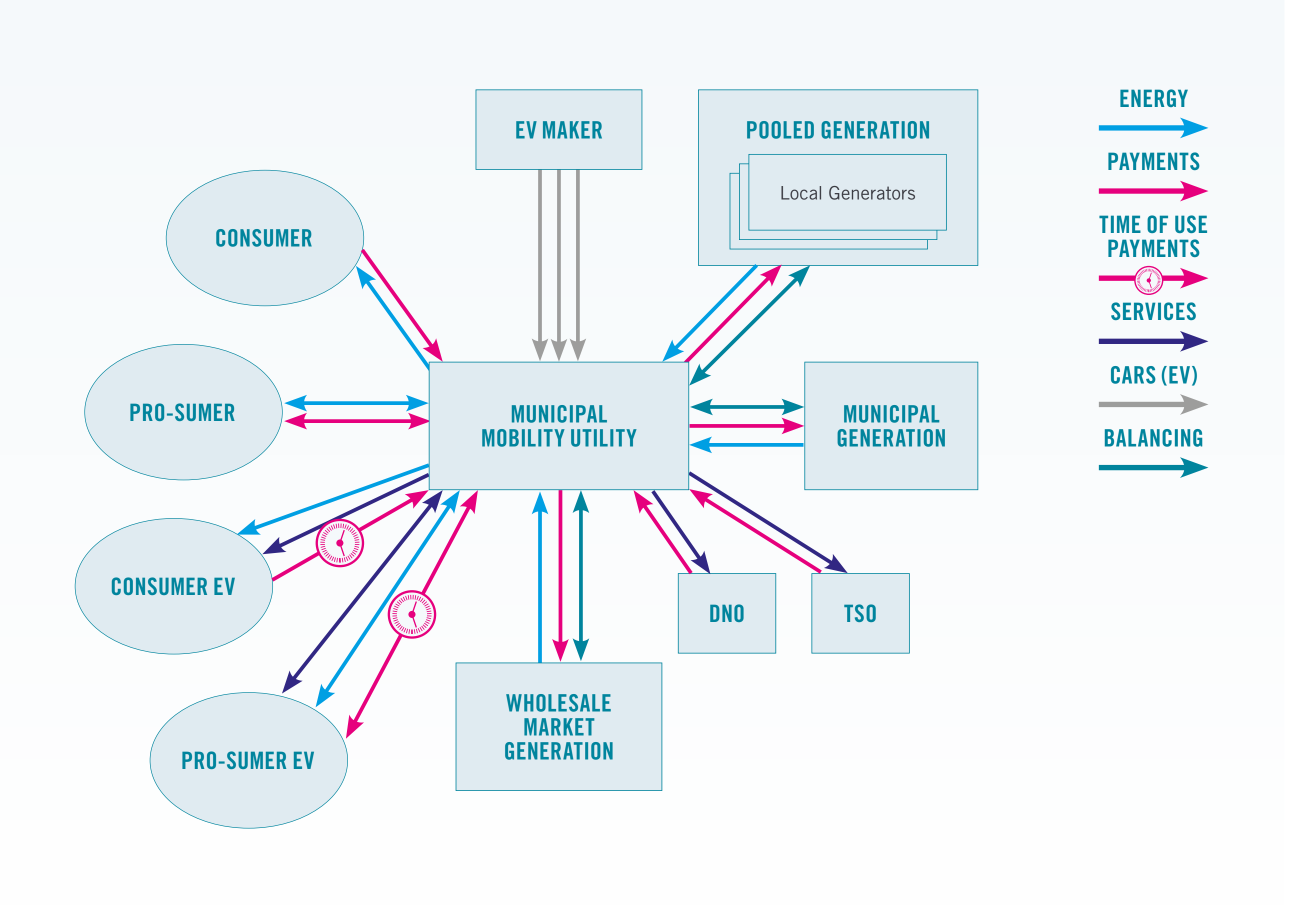
Figure ex1: The Mobility Utility



The Municipal Mobility Utility

In this archetype the private and commercial EV users no longer purchase vehicles but lease them through the municipal utility via special tariff. Municipal utilities service predominantly one geographical area, and have controlling interest in the company. As the municipal utility now owns both vehicle and battery, it can optimise electricity market functions against battery degradation concerns. Vehicle to grid and vehicle to home services both become available via two way power flow, the utility can optimise grid services or home/building consumption. The EV manufacturers benefit from a new route to market for low-emission vehicles. Distribution Network Operators (DNOs) and the Transmission System Operator (TSO) can be more closely involved in contracting new services with municipal utility. The municipal utility can also pool and sleeve local generation from municipal assets such as energy from waste plants and CHP units. This provides new routes to market for decentralised generation. Operating on a defined geography, the municipal utility can better engage with the DNO to take a strategic view on network re-enforcement needs caused by EV penetration.

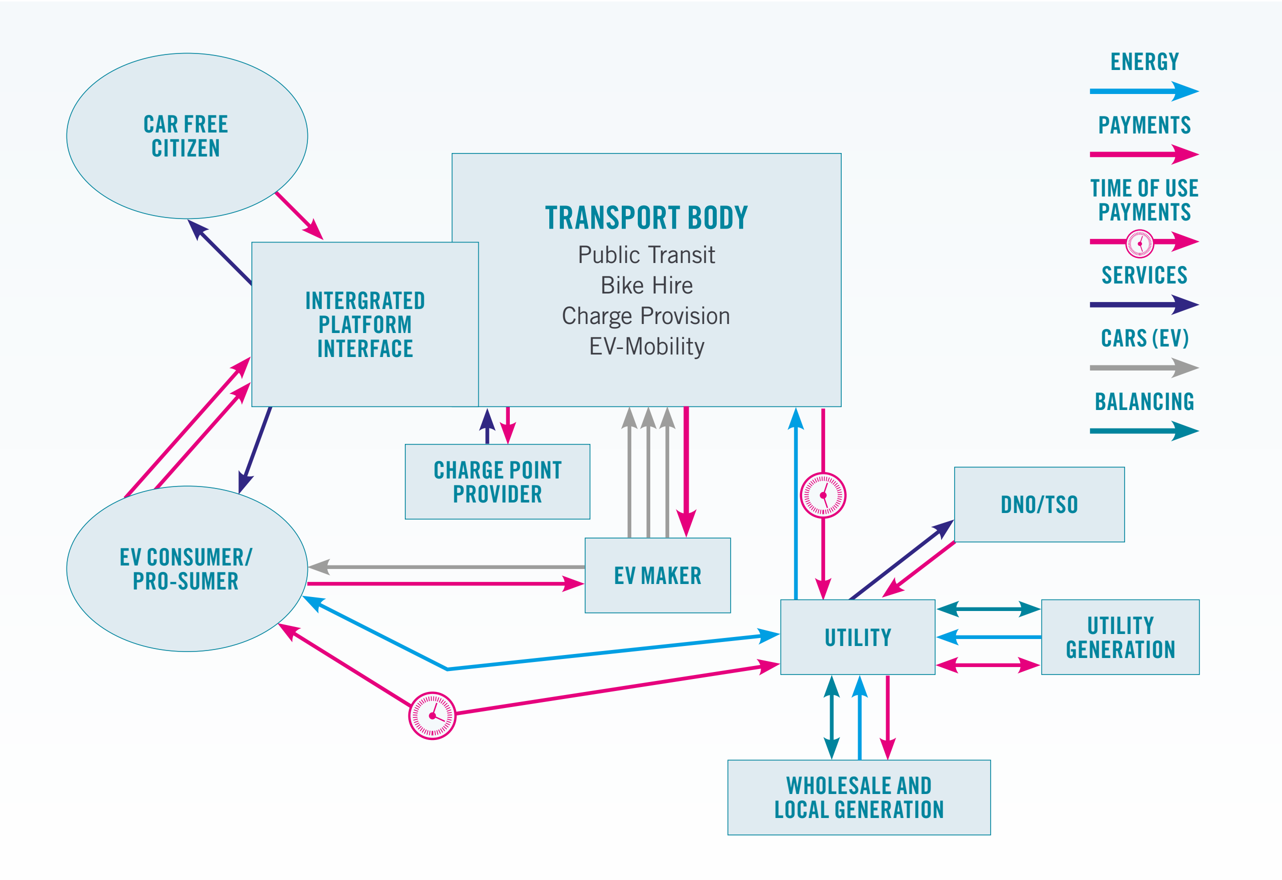
Figure ex2: The Municipal Mobility Utility



E-Mobility Service

This archetype is built on a full mobility option for citizens, including access to an electric vehicle for those who do not own a car. Electric vehicles form part of an integrated mobility package. This package is a multi-modal mobility service offer, managed by the local transport authority. Citizens sign up to have all mobility charged against a mobility account. This is similar to a car club, but is incorporated into the wider transit offering of the city. This combines the convenience of integrated ticketing such as TFL's Oyster Card and the flexibility of short term vehicle hire. Vehicles are in a variety of compound and on street locations such as in the Paris Autolib scheme. The integrated platform can also serve private EV drivers by providing charge points throughout the city. Thus, one mobility service provider caters to private and shared vehicles, and would have a load control offer to an electric utility or grid/system operator. There is little optimisation of local generation however, as the utility remains nationally focused.

Figure ex 3: E-Mobility Service



These archetypes perform well across the majority of business model innovation needs. These innovative business models demonstrate the importance of new routes to market and use models in allowing for new energy system services and mobility services.

What we recommend

To capture the benefits of the e-mobility transition, new business models need to be nurtured. These archetypes represent just some possible future models. We recommend the following actions are taken to encourage and support business model innovation across the auto industry, energy systems, and city infrastructures. The aim is to facilitate the e-mobility transition, reduce air pollution, tackle climate change, provide new energy services and grow new, smart business propositions. These recommendations are expanded in section 5.

Energy Tariff Innovation

All innovative business model archetypes investigated rely on some form of tariff experimentation by energy supply utilities. We found recent energy system regulations that restricted the number of tariffs utilities could offer, have hampered the development of electric vehicle specific offerings. Though this tariff cap is likely to be removed, there remain further barriers to tariff experimentation that are related to market size and sunk costs of metering infrastructure. To derive the greatest benefit from electric vehicles, new 'challenger' utilities may benefit from developing vehicle specific tariffs, or bundling vehicle energy with other mobility services. This may have regulatory impacts and leads to recommendation #1.

Recommendation #1

Pursue tariff experimentation and scope regulatory effects of mobility service bundling

Principal Agents: Energy supply utilities, Ofgem.

Infrastructure stress

The majority of archetypes proposed also have the technical ability to anticipate and respond to stress on the physical distribution network, i.e. the neighbourhood scale. Where EV consumers are smart meter enabled the EV charge can be interrupted if stress on the local network is anticipated. However, doing so through the smart meter implies a relationship with the smart meter data hub which is one level removed from the direct control of Distribution Network Operator companies. While most of the proposed models show a positive impact on the distribution network, this is either because current periods of network stress coincide with high energy prices, therefore time of use tariffs are compatible with using the grid within limits, or because the archetype offers better data for network planning. It may be the case that managing network stress through commercial innovation (i.e. within the energy bill of the EV consumer) may be over complex, and regulatory standards may be a more effective option.

Recommendation #2

Investigate a common technological standard for EV charger interruption with Distribution Network Operator access

Principal Agents: British Standards, Planning Authorities and UK Parliament.

Access to charge infrastructures

During the course of this research almost every participant in interviews and focus groups accepted that for those with access, home and workplace charging will make up the vast majority of electric vehicle charging and this is supported by real world use data. However the same data demonstrates most consumers find it 'very' or 'quite' important that an accessible on street or public option is available. This relates to our four 'public charging' archetypes, where electric vehicle drivers find new ways of accessing on street provision. There is an over provision of publicly accessible charge infrastructure in some UK cities and a substantial under provision in others. This is largely due to the current archetype of public charge point provision being grant dependent. Recommendation #3 deals with this by mandating appropriate levels of public provision in UK cities.

Recommendation #3

Define minimum standards of access and provision for public charging coverage

Principal Agents: Department for Communities and Local Government/Department for Transport. Also Core Cities group, Transport for the North, Transport for London.

Energy market regulation

The ability of the energy consumer to switch their supplier to get a better deal has underpinned energy market design for the past two decades. This has led to a requirement that all private customers should be able to switch supplier within 3-4 weeks. However, as new micro generation, storage, and smart home/vehicle solutions become available, there is increasing attention on whether the installation cost of these technologies can be incorporated into energy bills. If these solutions are to be financed on energy bills, this implies a long term relationship with a single bill provider. This means it is unlikely the consumer could switch supplier in the 3-4 week period enshrined in system regulation. This problem is particularly acute for the 'mobility' archetypes (mobility utility, municipal mobility utility) where the electricity bill is part of a wider mobility package. The 'Mobility as a Service' offering may roll the vehicle energy into a wider payment scheme, but where vehicles are charged at any private dwelling or on a commercial customers premises, this will either require a new dedicated meter, an on-board meter, or have to engage with market switching regulations. Recommendation #4 explores the possibility of amending the switching requirements to allow for business models that would benefit from a longer term relationship with the consumer.

Recommendation #4

Regulatory reform of supplier switching mechanism to enable longer contracts for EV power supply.

Principal Agents: UK Parliament, Department for Business Energy and Industrial Strategy, Ofgem.

Closer city partnerships

This research highlights key benefits cities may derive from a transition to electric vehicles and the business model archetypes that may achieve this. Some of these archetypes, such as the Rapid Charge Hubs, Car Share Compound, Municipal Mobility Utility, and the Mobility as a Service model, would benefit from close co-ordination with land use and transport planning functions. This would ensure new mobility options do not undermine wider urban mobility strategies or detract from transit or active mode use. Further, the city can play a key role in actively convening stakeholders around new infrastructure provision such as rapid charging, where that option fits the needs of that city. This leads to recommendation #5:

Recommendation #5
The city to act as a partnership broker
Principal Agents: Combined Authorities, Local Enterprise Partnerships.

The city utility

The 'Public Charge: Municipal Lead Utility' and 'Municipal Mobility Utility' archetypes analysed in this report both require city governments to set up a utility company by gaining energy supply licenses. These archetypes have the potential to use locally generated energy more efficiently and provide a reliable market for intermittent renewable energy. The current missing piece is a series of geographically focussed utilities, a gap which municipalities may fill. This could lead to more holistic transport and energy planning across cities. This leads to recommendation #6, for cities to closely investigate the business case for establishing such a utility.

Recommendation #6
Cities to analyse business case for establishing a supply utility.
Principal Agents: City Councils, Combined Authorities.

Our conclusions

New business models that span the Innovation Interface will be important to e-mobility transitions. Without new business models the e-mobility transition may struggle to reach enough citizens to make meaningful contributions to air quality improvements and greenhouse gas reductions from transport. This report identified 9 business model innovation needs across three systems; vehicles, energy, and cities. Our analysis has showed how 10 business model archetypes, current and future, may fulfil these 9 innovation needs. It was discovered that new business model archetypes at the Innovation Interface fulfil different stakeholder's needs in different ways and with various levels of complexity. From new mobility as a service offerings, to ancillary energy market services using aggregated EV batteries, new value pools are emerging. These value pools can be captured by the adoption of the archetypes explored in this report. From this analysis 6 recommendations were made which span policy, regulatory and commercial stakeholders. By exploring e-mobility transitions from a business model archetype perspective, we can see that cities can play a key role. Using this suite of business model archetypes is one way city governments can scope and select the right business models to match their particular mobility and energy needs.

Four future research needs were identified. The first is a deeper investigation of the regulatory effects of energy and mobility service bundling. The second is the need to scope the size of the value pool for each of the business models archetypes proposed. By quantifying the potential revenues from each archetype the largest commercial opportunities can be identified. Thirdly, more work is needed on the role of metering in linking the vehicle to the energy-system. For this work we have assumed fixed meter points, this assumption should be challenged, as efforts to introduce on-board metering would extend the business models available in the e-mobility transition. Finally and most importantly, the user element of the e-mobility transition requires further investigation to appreciate the appeal of new business model archetypes to consumers.

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Contents

The Innovation Interface: Business model innovation for urban e-mobility

"…in the future, better energy management goes hand in hand with better mobility management in cities."

(Source: vehicle manufacturer, 2016)

1.0 Introduction

This report compares business models that can integrate energy systems, transport infrastructures, and electric vehicles in order to accelerate e-mobility transitions. Linking these systems can improve air quality[6], decarbonise our economy[8], reduce oil dependency[7], and grow new businesses in the UK[8]. We start from the perspective of the city. It is in cities and at the city-region scale through which most journeys are made, where the impacts of poor air quality are felt, and where there is the most potential for maximising smart energy solutions. Cities also operate key infrastructures in the 'e-mobility' transition; the transition from fossil fuel powered transport, to zero emission electric mobility.

At the same time, cities do not control *all* the relevant parts of this transition. Electric vehicles are international propositions, the same electric vehicles are available across continents. Similarly, energy systems are mainly national markets, designed to balance demand across a country.

Energy systems, city infrastructures and electric vehicles; each with a different geography, their own incumbent companies, and mix of private and public stakes, will define e-mobility transitions. These systems must converge to make e-mobility transitions a reality. This report uses a business model archetype perspective to show where these systems can interact by sharing value propositions and revenue models, by building new partnerships around common goals, and by leveraging cutting edge technologies. It is important to do so, as current electric vehicle policies in UK cities are not achieving statistically significant improvements in EV adoption[1].

This report calls the interaction between the three systems above the 'Innovation Interface' where new partnerships need building between stakeholders to form new business models.

This report is structured in six parts. Part one comprises this introduction, and investigates why cities are a key player in e-mobility transitions. Section one also provides a high level snapshot of low emission vehicle scenarios, and responds to a call for more comparative analysis of business model innovation in the space. Part two describes the methods of this study. Part three analyses each constituent system of the Innovation Interface, the auto industry, the energy system, and transport infrastructures. Part three also draws on empirical work from this study and the wider literature to distil key business model innovation needs for each system constituent. Part four sets out a series of comparable business model archetypes and analyses how each business model archetype fulfils the innovation needs identified in part three. Part four also assesses likely implications of each archetype on vehicle users, system regulation, technologies, and energy and transport systems. Part five analyses this work and proposes 6 recommendations to accelerate the e-mobility transition. Part six concludes this report.

1.1 E-mobility in cities

While each city will find particular approaches to accommodate more electric powertrain vehicles, there are a series of common incentives that are pushing cities to better accommodate e-mobility and search for new business models which can accelerate the transition. These broadly break down into citizen health concerns, low carbon opportunities in economic development, and climate change commitments.

Recent research suggests that poor air quality causes up to 40,000 premature deaths each year in the UK[104]. By replacing diesel fuelled vehicles in both the private and commercial fleet, electric vehicles can improve air quality[9]. In the UK, new air quality management zones and new powers given to local authorities over road user charging[10], mean that cities have both the regulatory incentive and financial tools to catalyse the e-mobility transition for air quality benefits. Similarly the recent devolution of health spending to the Greater Manchester area, demonstrates how new opportunities for pursuing health co-benefits can be envisaged by linking budgets at the city scale, a move which has been costed for active modes[11] and may be applicable to e-mobility[12].

Findings from the urban economic development community demonstrate that basic amenities such as environmental quality can be just as powerful a determinant of inward investment as traditional economic development policy[13], and that urban carbon control strategies are becoming a key part of the economic development discourse in some cities[14]. Further, cities are marketing themselves as low-carbon entrepreneurs, and using ecological indicators as key tools for attracting mobile households and business[15]. Finally, in terms of economic localisation and resource resilience, research has shown the manifold economic benefits of climate action in cities[16]. This body of work is demonstrating the benefits to wider urban economies of low-carbon urban development pathways, of which low emission vehicles are a key enabler.

Electric and alternative fuelled vehicles are a key pillar in the Committee on Climate Change's technology options for UK decarbonisation[17]. However the climate benefits of electric powertrain vehicles are sensitive to the carbon intensity of grid electricity[18,19]. Cities can play a key role in maximising the local use of renewable energy for reasons of both environmental and economic efficiency[40]. Electric vehicles, are capable of storing electricity generated by intermittent renewables during off peak times, and present the opportunity to link distributed clean energy with electric vehicles at the city scale. This can provide new markets for local energy generators, reduce the carbon intensity of urban mobility and further increase air quality benefits by reducing the amount of fossil energy being used to charge vehicle batteries.

UK cities have powerful motivations to facilitate the e-mobility transition, yet lack the energy system expertise or oversight to strategically incorporate e-mobility infrastructures into the city. Similarly, decarbonisation targets of cities are driving a concerted effort to better understand what urban managers can do to facilitate e-mobility transitions[20,21].

From the top down, successive EU[22] and UK[23] white papers have stressed the need for cities to provide alternative fuel infrastructures. This has translated into EU and UK grant schemes for cities such as the Plugged in Places scheme[35]. At the international scale, and prior to the UK's vote to leave the EU, Directive 2014/94/EU[24] on the on the deployment of alternative fuels infrastructure, would have driven all city regions to provision appropriate publicly accessible charge points.

There are then, a series of health, environmental, and economic drivers for increasing the uptake of e-mobility in cities. Much activity from cities to date has been focussed on public policy and subsidy for on street charging as opposed to independent business models which link city transport systems with the energy system and auto industry. Before going on to investigate the needs of cities, the auto industry and energy system, it is useful to reflect on the potential size of the transition and why business model innovation will be a critical enabler.

1.2 How many and by when? Scenarios for low emission vehicle uptake.

There have been multiple scenarios produced to help us understand how many electric and low-carbon vehicles might be on the road by when. Most scenarios try to forecast uptake based on policy and technology, but do not consider business models, which are a key enabler to bring both policy and technology together in ways that can offer coherent value propositions to consumers and wider systems. This research does not work to any particular uptake scenario for battery and plug in hybrid electric vehicles (BEV and PHEV, respectively). However these scenarios are helpful in contextualising the impacts the electric vehicle fleet may have on the Innovation Interface as they demonstrate the likely size of the value pool for each business model. As such, we undertook a snapshot analysis of the various scenario work that has been done to date. We use this to present a series of scenario assumptions that underpinned this research. Importantly, section 1.4 demonstrates that at current UK growth rates, ultra-low emission vehicles will not keep up with the Committee on Climate Change's mitigation needs from the transport sector for the 5th carbon budget.

1.3 At the Global scale

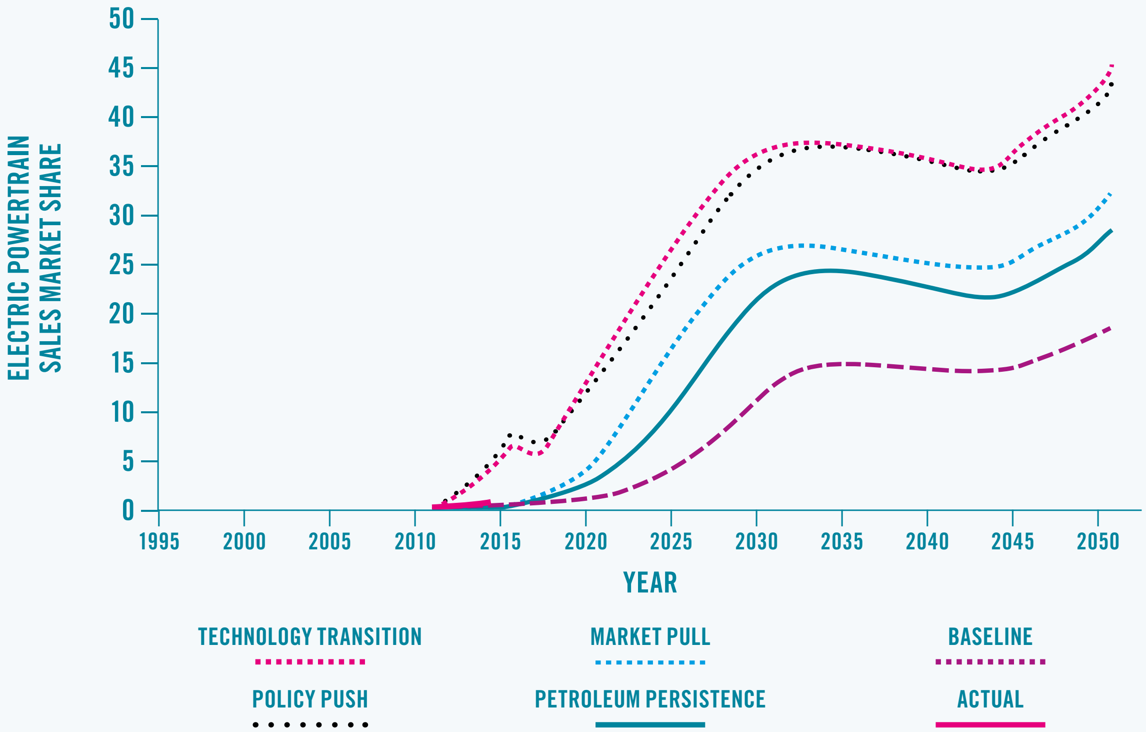
The OECD/IEA Technology Road Map[25] sets out a *'Blue Map'* scenario which investigates a combined EV/PHEV share of sales world-wide of 50% by 2050. This assumes optimistic technological and policy development, and that manufacturers begin to increase the range and types of vehicles on offer. Strict regulations on emissions are also in place. *"By 2030, sales of EVs are projected to reach 9 million and PHEVs are projected to reach almost 25 million. After 2040, sales of PHEVs are expected to begin declining as EVs (and fuel cell vehicles) achieve even greater levels of market share. The ultimate target is to achieve 50 million sales of both types of vehicles annually by 2050*[25]." This implies a global share of total sales in the order of 20% for PIHVs and 7.5% for EVs by 2030. More recent analysis shows the trajectory to 2050 is positive[26] but that continued policy drive is required to sustain annual average sales growth (from 66% through 2020 to 39% through 2025)[26]. In common with the IEA, independent scenarios by BNEF[27] envisage similar rates of uptake and regard the mid 2020's as the point at which EVs are expected to reach cost parity; accelerating fleet transitions.

1.4 At the European scale

The latest modelling work at the EU level investigates five scenarios with market shares ranging from around 15% to 45% by 2050 as shown in figure 1[28]. Once again the key period is between 2020 and 2030.

A 2010 Mckinsey study[29] assumes higher rates of electric powertrain penetration of up to 95% with the differing mixes of the electric Vs Hybrid mix. In common with other cited studies[25,28,27] the critical years for adoption occur in the 2020s.

Fig. 1: Full electric powertrain (PHEV, BEV, FCV) market share under the assumed scenarios.



Source: Pasaoglu et al, (2015) adapted

1.5 At the UK scale

Element Energy[30] forecast that if EV uptake in the UK achieves the pathway targets set by the Committee on Climate Change there will be 13.6 million EVs on the road in 2030, and that around 6 million of these will be battery EVs. Element Energy developed pathways to the CCC's high uptake scenario which seeks 100% share of sales by 2050. Based on Element Energy's analysis, a national rapid charging network representing around 20,000 units over 2,100 sites would be required in 2030 to meet the needs of EV owners. This translates into approximately one fast charger for every 300 battery EVs. The report also looks at infrastructure options to take forward this high uptake from 2030-2050, highlighting the need for rationally located and accessible charging points. Actual sales data shows electric powertrain (battery EV and plug-in hybrid EV) sales as 1.3% of all new vehicle registrations in the year to date June 2016[31]. The previous year the total sales were 1% of new registrations. At current growth rates ultra-low emission vehicles will struggle to meet the CCCs requirements from the transport sector for the 5th carbon budget.

1.6 Scenario assumptions

There is significant uncertainty over the likely penetration of electric vehicles; uptake is affected by consumer attitudes, oil prices, falling costs for alternative vehicles and myriad other concerns. However it is useful to operate with some basic assumptions. Firstly we assume that without substantial and sustained growth of electric vehicle sales it is unlikely that climate change targets will be met[32]. Secondly it is clear that the critical dates for adoption are in the 2020s, as early adopters are augmented by 'aspirant', 'mass market' and 'fleet' market segments[30]. Thirdly, though adoption rates may struggle to hit climate targets, business as usual trends still represent vehicle numbers in the hundreds of thousands growing to millions, and this serves as the main value pool for the business model archetypes proposed in Section 4. Finally, there is clear potential to think more systemically about the links between: the vehicles, the infrastructures they require, and how the electricity that powers them is sourced and managed.

1.7 Business model innovation as the catalyst

Electric vehicles are unlikely to reach their full potential unless new business models emerge that forge new relationships between private drivers, fleet managers, city managers, energy providers, the auto industry and central government. Much attention has been paid to the various public subsidy and policy options for electric vehicles[33,34]. These are spread across infrastructure grants and subsidy such as the UK Government's Plugged in Places[35] scheme, or extend to subsidy of vehicle purchase alongside marketing information. They also include targeted grant programmes such as city infrastructure provision in the UKs 'Go Ultra Low' Scheme[36].

The purpose of this work is to look beyond public subsidy, to determine how new business models can emerge that better capture the different value propositions offered by linking vehicles, energy systems and transport infrastructures. Only by looking closely at the value propositions in the space, and demonstrating how these value propositions can be captured by different stakeholders, is it possible to understand what needs to change to allow electric vehicles to reach their potential in the UK market.

Business model innovation is an important new area of study for those seeking transformational change across large systems[40,37]. Examples of business model innovations research on EV adoption do exist. In particular Beeton and Meyer[44] curate an international overview of alternative business models which interrogate existing examples such as Tesla's self-owned recharging network, and the Autolib case in Paris. Beeton and Meyer also present four potential future business model innovations; the free floating city electric car, plug in company cars, all electric subscription, and electric leasing. This work demonstrates the potential to link EV's closer with the energy system under energy service business models, a concept that has been investigated in a technological and regulatory sense by other research[57,38]. The purpose of this analysis is to use these broad definitions, to explore possible business models for the UK context, in which the particular institutional form of the energy system, auto industry, city governance and travel patterns define which business model innovations are possible.

This is a timely analysis, as recent work by Nesta and Accenture in partnership with Future Cities Catapult, investigated the potential for city initiatives across the Northern Powerhouse[ii] to catalyse technology, innovation and entrepreneurship . This report argued that cities must engage with new business models 'in a way that allows for disruptive entry'. Recommendation number 1 from this work was for cities to 'undertake collective analysis of emerging business models'; in order to strengthen performance in technology, innovation and entrepreneurship, city regions would:

> **'…conduct periodic reviews of emerging business models and future technologies (e.g. Mobility as a Service, autonomous vehicles, FinTech, Blockchain, etc.) to understand where regulatory barriers and gaps might limit adoption and innovation or create unfair advantage in established markets. Going a step further, the process should bring together traditional market players, new entrants and citizens to jointly work out solutions, and create regions where these solutions can be tested and refined.'[39, p.16.]**

This work directly answers this call by taking a 'Business Model Archetype' approach. This approach has been developed researchers at the University of Leeds[40] to facilitate comparative analysis of business models in complex socio-technical systems. Clear comparison of innovative business models allows stakeholders to identify the regulatory, user, commercial and public policy implications of each model, and understand each model's potential to foster new companies and achieve market entry. This is important in large technical systems like energy, infrastructure, and vehicles because they are characterised by high barriers to entry, long payback periods, and institutional inertia. They also have knock on effects on system integrity, climate change and public health. To address these issues the research is structured around four questions which were developed iteratively with research participants and project partners:

Question 1	**What are the business model innovation needs of different stakeholders?**
Question 2	**What are the business model archetypes that meet these needs?**
Question 3	**What are the implications of these business models for these stakeholders?**
Question 4	**How well does each model catalyse the Innovation Interface?**

[ii]The Northern Powerhouse is a coalition of six city regions in the North of England, comprises 16m people and 7.2m jobs, and in 2015 the region generated an economic output of around £290bn of Gross Value Added (GVA), about one fifth of the UK's total. http://www.transportforthenorth.com/pdfs/NP/Overview-NP-Independent-Economic-Review.pdf

2.0 Methods

To answer the four research questions we constructed a qualitative, expert-led methodology backed up by extensive secondary data analysis. Our empirical data was collected in two phases.

Phase 1 aimed to answer questions 1& 2 by investigating the innovation needs across key stakeholder groups and identify new, emergent, or latent business model needs across the auto industry, energy systems, and transport infrastructures. City governments and charge infrastructure providers were grouped into 'transport infrastructures' as these two bodies are key stakeholders in retrofitting e-mobility into existing transport systems. The critical stakeholder of the two is 'city governments' who often commission the charge providers for public charge infrastructures. This phase comprised 21 semi structured interviews with 26 individuals across: city and regional government, energy suppliers, infrastructure providers, vehicle manufacturers, public policy professionals and sector regulator. The sample comprised: 3 interviewees from city and regional government, 3 vehicle manufacturers, 2 auto industry and public partnerships, 3 charge infrastructure providers, 3 energy system suppliers/infrastructure providers, 2 academics, 2 energy system regulators, 2 fleet managers, and 1 central government department. Interviews were conducted as semi-structured 'elite' interviews using purposive and snowball sampling to access key individuals from across the electricity, urban infrastructure and vehicle markets space. This process generated 123,000 words of interview transcript which was iteratively coded in NVIVO 10, resulting in categorisation into 7 key nodes:

- Business model identification
- Drivers and barriers
- Infrastructure constraint
- Innovation systems
- Public policy
- Technological disruption, and
- Recommendations.

It was this method which identified both business model innovation needs and categorised business model archetype suggestions from interviewees.

Phase 2 of this method drew on the interview data to generate 10 'business model archetypes' which synthesised business model suggestions of interviewees and also drew on business models drawn from the wider literature, notably[41,42,43&44]. The generation and comparison of business model archetypes in the energy space is being pioneered by the University of Leeds[45] and has been recognised as a useful tool for the exploration of the systemic effects of new value propositions in large systems[36,37]. The 10 generated archetypes were then subjected to two sequential expert focus groups designed to a) refine the business model archetypes themselves and b) understand the implications of each archetype for vehicle users, regulation and public policy, technological development, and wider systemic effects.

Focus group #1 comprised: 1 energy supplier, 2 city managers, 1 future cities catapult member, 3 academics, 1 charge point provider and 1 infrastructure operator. Focus group #2 built on the recommendations and learning from focus group 1, refined the archetypes and comprised: 2 officers of the energy regulator, 3 vehicle manufacturers, 3 academics, 2 charge point providers, 2 energy suppliers, 2 fleet managers, 1 government department, 2 independent energy systems experts, 1 member of Future Cities Catapult, and 1 auto industry body, Sub groups of participants covering energy, infrastructure, public policy, cities, and vehicles were managed to achieve balance across groups. Each group was given 20-30 minutes per archetype to explore the implications across the four categories given.

One stakeholder group not represented in the empirical phase was the private user. This is because achieving robust data from private users requires larger statistical approaches which were beyond the resource of this research project. However user implications were front and centre of the archetype implication analysis. It should be noted however that user implications were drawn from system experts who each have their own perspectives on the 'user' group. Results are structured in two parts. Section 3 draws on both phases 1 & 2 of the research to identify business model innovation needs. Section 4 presents the business model archetypes that can respond to these needs.

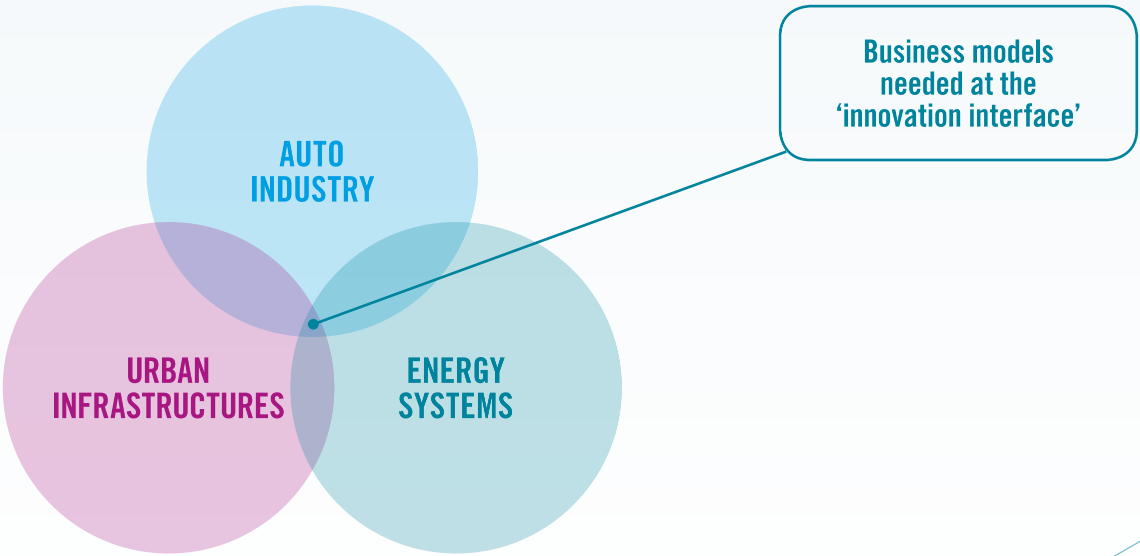
3.0 Socio-technical systems and the 'Innovation Interface'

The generation of innovative business models is a step beyond product or technical innovation. Business model innovation is a response not only to technological change but also to societal preferences, institutional rule systems, resource pressures etc. Various schools of thought have emerged that suggest different ways of studying how innovations are adopted into complex systems. The Sectoral Innovation Systems approach investigates the 'set of products and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products'[47] The analysis often concerns relations between firms and consumers. The 'Innovation Ecosystems' approach similarly pays attention to wider drivers but is often utilised with some form of biological analogy[48]. Building on these ideas, a 'Socio-Technical Systems' school of thought has emerged which includes to inter-firm dynamics but also places wider societal pressures, technological lock in[49], resource constraints[50] and the user environment[51] as key units of analysis[52].

A further development in this field has been a [co]-evolutionary turn[53,54], which understands transitional change in socio-technical systems as shaped by longer run dynamics. Each of these approaches shows us how innovations do not emerge in a vacuum in which 'superior' technologies supplant inferior predecessors or contemporaries. The co-evolution of user behaviours, institutional rule systems, resource scarcity, and critically business models, may not automatically select the best or most 'efficient' technologies for system transitions.

Where business model innovation has been studied in the past, the work often investigates only one socio-technical system; related examples are found in the electricity system[40] the auto industry[55] the urban mobility system[56]. With few notable exceptions[57,41,43] this single sector focus holds back analysis of business models that must straddle several large socio-technical systems. E-mobility transitions depend on new business models that sit at the interface of three socio-technical systems: the auto industry, energy systems, and transport infrastructures. We call this the 'Innovation Interface' figure 2:

Figure 2. Electric vehicle business models at the 'Innovation Interface'.



New e-mobility business models will have to catalyse innovation across these three large socio-technical systems. Two of these systems have developed iteratively over time, vehicles and transport infrastructures have manifestly co-evolved to incorporate each other's innovations, however energy (or more specifically electricity) systems, have largely been absent from the co-evolution[58] of user practises, technological innovation and business models between vehicles and urban infrastructures.

> **"The innovation from transport comes from the automotive industry who traditionally are able to isolate themselves from the energy going into their vehicle and in fact they can draw a very, very clear line and they define, there is a specification for a liquid fuel that is very clearly defined and that's the interface between oil and automotive and neither one of them necessarily has to straddle that line particularly."**
>
> (Source: Auto industry and public partnership manager, 2016, emphasis added)

> **"I think, you know, working with the energy infrastructure, so, sort of, like, National Grid is, the energy sector for me is, obviously it's a very new sector for us, […] there are so many different parts of that, you have aggregators[iii], you have the infrastructure and then obviously you have the providers, and that's probably a too simplistic view, but working with all of those is key."**
>
> (Source: Vehicle Manufacturer, 2016)

Similarly, from the energy systems side, the suppliers and providers have little experience of the auto industry:

> **"The main difference is that really utility companies are about commodity sales. It's electricity in various shapes and forms to retail and big B[usiness] to B[usiness] customers and it has been the sort of mainstream thinking. Everything is geared to that. Now the integration of electric vehicles is actually quite a different proposition because it's an added value proposition. It's quite different also from the perceptions of the products like electric cars are much more openly out of a say, say a hero products. […] the radical change in the energy systems from centralised, production […] to something which is much more distributed, that has prosumers rather than consumables and technology could go a long way to that requiring a much higher degree of integration and digital integration which is not necessarily in the, how should I put it, original DNA of utility companies."**
>
> (Source: Energy Supplier, 2016)

From the cities perspective, their traditional role of transport infrastructure provision is broadening to the linking of transport infrastructure with energy systems, but engaging with wider energy system effects is not currently top of the agenda:

> **"…I think there's been an awful lot to do. So, you know, some of the questions that you've got around, kind of, even electrical vehicles and you know, we haven't even got… you know, haven't, kind of, really got to that yet […] at the moment, the we are tinkering around the margins, I mean, great, take the [city name] Park and Ride, we've got a few charging points there, which is great. If actually every single car on that car park wanted to charge, it wouldn't be able to happen would it? Because the grid wouldn't support it and then that… so, at what point do we start to really worry about that?"**
>
> (Source: City Government Officer, 2016)

Each constituent system in this Innovation Interface is aware of a pressing need to find new business models that fulfil various needs that cannot be addressed alone. However no comparable business model set yet exists. As such what follows is a summary characterisation of each system and an identification of the main business model innovation needs drawn from the research sample and the wider literatures.

3.1 Business model innovation needs in the auto industry

The automotive industry is an international system comprising original equipment manufacturers (car companies) alongside component supply chains, retail outlets, financial services and aftersales. Business model innovation is possible in each element of this system[59], however the basic construction of vehicles on an assembly line producing all steel, monocoque chassis cars, has driven the industry to rely on ever increasing economies of scale[60]. These economies of scale drive automotive business models to require high unit sales for new models. As such, new model ranges must appeal to a relatively high number of potential customers.

While there have been transformative safety[61,62], and ICT[63] innovations over recent decades, the basic internal combustion powertrain has been subject to more incremental innovation. However there is substantial pressure for the auto-industry to reduce local pollutants[64] and increase fuel efficiencies due to international environmental regulation[65]. The regulations are those which require manufacturers to meet new car CO_2 emissions standards of 95 g CO_2/km BY 2020[65].

[iii]Aggregators are brokers which bundle small consumers into larger single units and trade flexible demand, generation or storage.

These regulations allow battery electric vehicles to be zero rated in tailpipe emissions, which leads to a strong incentive for vehicle manufacturers to develop battery electric vehicles as part of their wider fleet offering. The economies of scale required for monocoque chassis construction have led the industry to simple replacement of an ICE powertrain with a battery electric powertrain in existing all steel designs, albeit with some light-weighting. These designs currently dominate the marketplace[iv] and ranges in the mid-section of the market are approximately 120miles maximum, leading to issues of buyer range anxiety[66].

In order to retail such vehicles the manufacturers were clear that customers wanted to know there is a rational network of public charge points available, and that network is accessible:

> **"…what's interesting, is that even though we can prove, as it were, that the vast, vast, vast majority of charging is actually done at home, the main worry, if you talk to anyone about actually buying an electric car, is about range anxiety. So, they want to know that if they do need it, there's a charging point somewhere near them, wherever they are."**
>
> (Source: Vehicle Manufacturer, 2016)

> **"…we have to put the infrastructure in place based on what is on the market now because that is what the customer wants. If we delay the infrastructure until we know certainly what they want; nobody will buy the cars."**
>
> (Source: Charge Infrastructure Provider, 2016)

During the course of this research almost every participant in interviews and focus groups accepted that for those with access, home and workplace charging will make up the vast majority of electric vehicle charging and this is supported by real world use data[67,68]. However the same data demonstrates most consumers find it very or quite important that a more accessible on street or public option remains available. The first identified business model need from the auto industry is to be able to show new EV buyers that a coherent and accessible public charge infrastructure is available.

Business model need #1 Auto industry: A coherent and accessible public charging network

Another business model barrier from the manufacturer's perspective is the ownership of the dealer network which, if outside the manufacturer's control, must be persuaded to install the necessary hardware, infrastructure and sales skills to support the new electric powertrain vehicles.

> **"…the OEMs will have a hard enough job to get the retailers to invest in selling the electric cars, because they're obviously all going to need to upgrade all their retail outlets with charging equipment and other essential equipment to support EVs. Most retailers are franchise retailers, the OEMs do not own any of them. So they have to convince them to invest in their premises to do it. So this means they are going to them and saying, they need to invest in many 10's of £1000's to install this charging equipment to sell these cars. So that's our first stumbling block."**
>
> (Source: Vehicle Manufacturer, 2016)

This is raised here to demonstrate that there are business model and infrastructure needs within the auto industry that are important to e-mobility transitions. However the dealer network is part of the auto industry and business model needs within systems are not part of this analysis. This work is concerned with those needs that require some engagement with the Innovation Interface.

Another clearly signalled business model innovation need, which came from all parties, was questioning the ownership model of the vehicle, and approaching new ways of consumers accessing vehicles:

> **"…Autolib' [Parisian car hire scheme] they have a feeling that it is quite possible that they're creating a generation of people, who are quite happy with a non-ownership model. Now, when you talk to people in the industry they say "Oh, yes, but once they have children and things like that, they will want to own a car." And that may also be true, it might be too early to tell. But certainly, in a lot of big cities, I think these car sharing schemes having taken off much more than anybody ever expected, and this is why the car companies are now getting into that as well."**
>
> (Source: Auto industry academic, 2016, emphasis added)

> **"…what the OEMs are exactly are aiming for is e-mobility[v] because they want to sell some of the e-mobility packages. They don't want to sell them a car."**
>
> (Source: Charge Infrastructure Provider, 2016)

[iv] https://www.goultralow.com/choose-your-electric-car/

[v] In this case the interviewee is referring to e-mobility as a service, i.e. without up front vehicle purchase.

There is a thriving lease and personal contract purchase culture in new vehicle ownership in the UK[69]. However most of these are models of long term personal ownership or some form of hire payment by which the car is solely accessible by one individual. There have been some moves away from this model, particularly in the growth of car clubs in UK cities, which are driving further EV sales by adopting electric vehicles faster than the conventional market[70]. This rise in non-ownership models of use, favours the electric vehicles due to relatively short duty runs per hire, though functionality is restricted by access to charging[71], (dealt with by business model need #1). As such further proliferation of non-ownership models present a new route to market for mobility type solutions and benefit the auto industry by introducing new potential consumers to e-mobility as well as facilitating additional sales[70,72].

The second identified business model need from the auto industry is to find new routes to market for electric vehicles through mobility and other non-ownership models.

Business model need #2 Auto industry: New routes to market/use models

On top of the existing concerns over reliable public charging, and seeking new routes to market for vehicles, there are further concerns over how the next generation of electric vehicles will affect energy systems:

> **"…..we're looking at the wall-box that we'll be offering with the car, there'll will be mulitple versions. There will be an AC wallbox and a DC wallbox to give the customer an option of faster charging where their power supply permits. For DC, you will need to have three-phase. Less than two per cent of UK domestic properties have got three phase installed. And if you want it fitted, it can be incredibly expensive, probably about three and a half to four thousand pounds to have the fitted, dependant on your installation situation and DNO. Plus on top of this you''ve got the cost of a more expensive DC wall-box. Which is another barrier to the growth, of this faster charging home network. But with all of these big EVs coming out, that are ninety to hundred kilowatt hours, we need to find a way to enable this and make it more affordable. We've got to find a way of actually working with the energy providers, government, etc, to try and actually free that up and get more power in to the homes in a more affordable manner."**
>
> (Source: Vehicle Manufacturer, 2016)

> **"I have an electric van that I sell, as well, and I think if you're looking at what city, sort of, city planners are doing with trying to reduce CO_2 emissions in cities, I can see a point where they start banning vans going in for deliveries, and that will force a big electrification of, car derived vans, small van deliveries, which is great, but is the electricity industry there to support it? And for me, that's not a 15, 20 year issue, that's the next five years, and I'm just wondering whether those timings are all going to align well enough to best support businesses who want to move to putting 100 electric vehicles on…"**
>
> (Source: Vehicle Manufacturer, 2016)

The first quote from a manufacturer demonstrates the need to think beyond the energy requirements of current mass market electric vehicles with circa 24kWh battery packs and 110 mile range, towards vehicles with 60kWh battery packs and 200 mile range. The second quote demonstrates the link between urban mobility policy and the other two innovation sectors, with a specific question over the capacity of energy infrastructures. The auto industry is innovating quickly, with mass market offers in the 60kWh 200+ mile range imminent from both Tesla and Nissan, and announcements from premium vehicle manufacturers promising even higher power requirements and range offers.

> **…[re. charging network] The more successful you make the network by scaling it; the more people will buy electric cars and therefore the more capacity you will need. So it's quite ... It's not what we expected… It's not the position we expected to be in but we are in it. And we have to figure it out. Because otherwise the [electrical] capacity will become the constraint factor of the growth of sustainable transport.**
>
> (Source: Energy Supplier and Infrastructure Provider, 2016)

The third identified business model need from the auto industry is a requirement for much greater foresight and clarity as to whether energy systems are able to accommodate the electric vehicles already under development with high power requirements, and to accommodate the power needs of expanded fleets. Expert interviews showed no such clarity and this may hamper the development of new models.

Business model need #3 Auto industry: Clarity on energy infrastructure capabilities

There are three business model needs identified for the auto industry at the Innovation Interface. Firstly there is a lack of a clear, interoperable and accessible public charge solution, which consumers may underutilise, but still value highly to ameliorate range anxiety. The second is new routes to market for electric powertrain vehicles to capitalise on new ownership/service models of auto [e]-mobility. The third is a reduction of the uncertainty over the ability of the energy system to cope with new battery sizes and higher fleet penetrations. Any suite of new business models at the Innovation Interface should accommodate these needs to satisfy the 'Innovation Interface' problem.

Summary

Business model innovation needs from the **Auto Industry**:

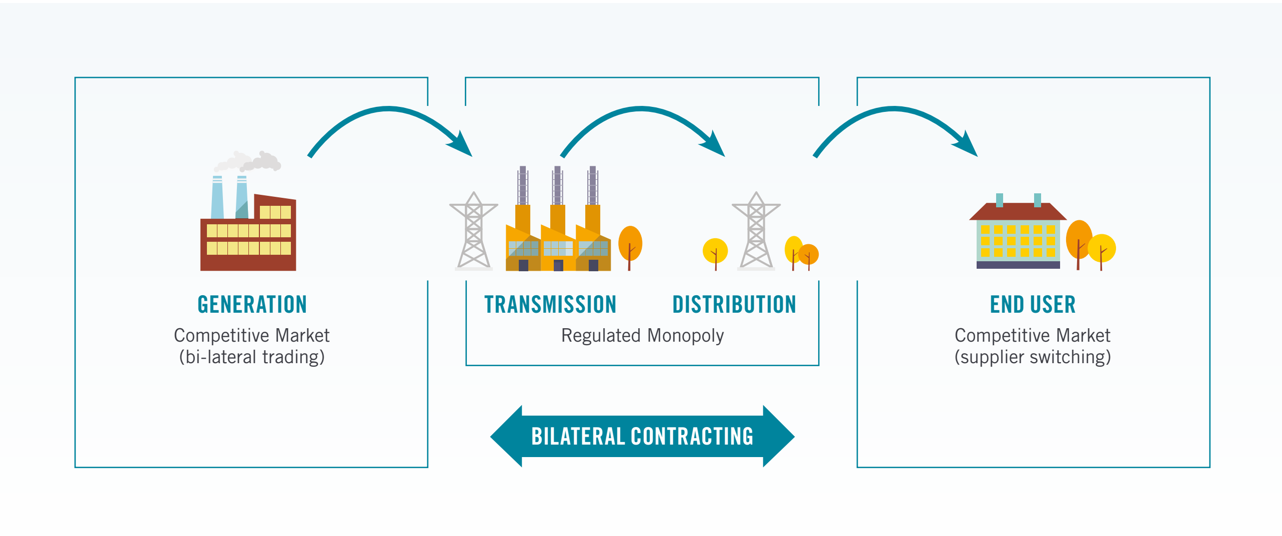
1	Reliable and visible public charging
2	New routes to market/use models
3	Clarity on energy infrastructure capabilities

3.2 Business model innovation needs in the energy system

Most electricity systems are 'centralised' systems, built on a model of high capacity plant, connected to national infrastructure networks which step down voltages to useable levels for electricity to be used in homes and businesses. This model has served most modern economies very well for almost a century. Electricity is an energy carrier: unlike gas, oil products, or solid fuels, it cannot be stored. Electricity systems have therefore been built to meet demand instantaneously, supply must match demand at any period and system frequency must remain within constant design limits. The addition of battery storage to this system does not change these parameters, it only offers more flexible ways of fulfilling them. This very briefly describes the physical characteristics of the system. Beyond the hard technologies of the electricity system, an institutional structure maintains infrastructure and balances different sources to meet demand. This institutional structure can take several forms. Pre-1930's most European nations relied on municipal corporations to run electricity systems . These city electricity companies were progressively nationalised in many European countries to form state monopolies which owned the entirety of the network. These nationalised utilities built much of the transmission system and larger generation plant which is currently reaching the end of its useful life.

The move toward privatisation and market liberalisation throughout the 1980's and 90's across many infrastructure systems[74] led to the separation of several functions of this system into competitive markets for generation and supply (retail), and regulated monopolies for transmission and distribution networks. This is a 'liberalised and unbundled' market structure, as shown in figure 3:

Figure 3: The electricity system



Business model innovation across the energy system is gathering pace as the international roll out of smart metering[75, 76], smart grids[77] and decentralised generation technologies[78] are undermining the incumbent business models of existing large utilities[79]. These technological innovations are leading to business model innovation in energy supply markets[40], as new companies and citizen groups seek to exploit the value propositions offered by smart metering, net metered renewables, and decentralised energy systems. These tensions between the centralised system model with its institutional inertia, and the technological and commercial innovations of a decentralised future, are leading to significant uncertainty over the pathways the energy sector may take in the transition towards a low carbon future[80].

Recent work[40] has demonstrated clear potential for decentralised renewable generators to receive a better deal in wholesale markets by balancing supply and demand on a local geography. With the addition of electric vehicle storage, a new demand sink is possible that could act as a guaranteed consumer of decentralised and intermittent energy sources. This is important because intermittent generators need to recover revenues from the power they produce. This is not always possible with high amounts of intermittent generation on the system, as the recent increase in negative price periods on the wholesale market shows[81]. To maximise the use of existing renewable capacity which is intermittent by nature, and ensure new capacity continues to be built, a controllable storage resource such as an EV battery would be an important system component. One interviewee described this optimisation of proximate intermittent supply and controllable EV demand as 'localised energy systems':

> **"…where you can keep the balance locally and use the asset that you have with the help of storage in order to keep more localised balance in that area and this is let's say a business model. […] They own electric vehicles. […] from the business point of view they share all the resources inside the community. So this is another way to use electric vehicles.**
>
> (Source: Energy Infrastructure Provider, 2016)

Another interviewee looked ahead to the use of electric vehicle batteries to act as a 'building block' in a future energy system with more intermittent generation.

> **"If you actually start moving towards a distributed system, with a very large percentage of renewable energy and you have new consumers like electric vehicles or in fact like a vehicle may become a building block in terms of storage then essentially the new business is based on arbitrage of a lot of uncertainty due to the fluctuation in renewable generation…"**
>
> (Source: Energy Supplier, 2016)

There is clear potential for electric vehicles to store decentralised renewable energies during the diurnal charge cycle, providing a reliable demand for low carbon power[82]. Building a charge business model and electricity tariff around this optimisation would ensure both the least expensive and the most carbon efficient electricity sources are used to power EVs[83].

Business model need #4 Energy System: Better optimisation of intermittent generation and EV Charging

Business model innovation in the energy system is ultimately reflected in the types and rates of tariffs available to consumers. In the electric vehicle space there has been very little innovation around new tariff structures, notwithstanding tariffs from Ecotricity and British Gas[vi] which have been marketed as beneficial to EV users. This is a problem, because there is real potential for electric vehicles to overload local electricity networks and add to the volume of generating plant required in the UK energy system if better management of the charge cycle is not adopted by EV users[84, 85].

> **"At the moment I think one of the challenges is the electricity market is somewhat limited in terms of the tariff structure [...] actually we don't have a particularly sophisticated opportunity to reward behaviour or reward the sort of behaviour we might want from charging vehicles. It's actually constrained to time of use tariffs, sophisticated time of use tariffs I believe are actually quite restricted at the moment in the UK because of the market regulations."**
>
> (Source: Manager, Auto Industry Public Private Partnership, 2016)

[vi] In this case the interviewee is referring to e-mobility as a service, i.e. without up front vehicle purchase.

However, if managed charging is adopted it can move from an expensive burden on the energy system to a net positive. In the UK, active charge management could reduce grid investment needs by up to £2.2bn[84], and generate up to £66m per year from frequency response service provision to National Grid[86]. Smart time of use tariffs would enable consumers to be rewarded for flexing behaviour. These tariffs need a smart meter which can reward consumers for charging at different times of day to avoid peak pricing. Time of use pricing is in its infancy for electric vehicle charging and the British Gas Tariff was the only time sensitive EV specific tariff at time of writing. There is real uncertainty over the potential for time of use tariffs to shift demand[87,88]. At the same time there is significant consensus emerging that without smart charging solutions, and innovative tariffs to reward customers for accepting them, the energy system will become a serious constraint to the expansion of the electric vehicle fleet, particularly if 7kW and above home chargers start to replace the current 3kW chargers as standard[84].

Put simply, if more EV drivers return home in the early evening and start charging with large chargers, all at the same time, more generating plant and much more power infrastructure will be needed. With current tariff structures, every household will incur some of this cost, whether they choose an electric vehicle or not. This is because domestic and small commercial consumers pay for electricity infrastructure at a flat rate across all bills[89] and current tariffs are unable to allocate the marginal cost of new generating plant to EV consumers, or accurately bill those consumers using the most expensive electricity, i.e. that at system peak.

"…the more work we do in this space, the more you become very acutely aware of the fact that the effect of the EVs on the grid is, in fact, not only quite high; it's actually going to make things worse and there isn't any mechanism to stop that from happening."

(Source: Energy Supplier, 2016)

If new 'smart' tariffs are needed, then business model archetype comparison is needed to be clear about the revenue and value flows that run through the electricity system which can remunerate or incentivise consumers to adopt smart charging and respond to price signals or comply with regulatory standards.

"…Flexibility is all very well, but it's not actually the purpose of the consumer to be flexible, it's something that's if they are prepared to be, then they should potentially get some reward for that…"

(Source: Officer of the regulator, 2016)

"…looking at the proportions that are going to be coming on line, I think the requirements at National Grid the biggest problems are going to be the ability for Grid to balance. So the ability to have quick response will have a much higher value going forward, and that's where there will be value and that's where storage is going to be interesting. So I think for those customers who have an electric vehicle and they can use it, not to sell it back, but to use it to avoid the higher costs which will be coming as a result of these additional services."

(Source: Energy Supplier, 2016)

The price signals for smart charging fall into two categories, those which shift demand to capture lower wholesale prices, and incentives that exist to remunerate provision of additional or 'ancillary' services. Many of these ancillary energy services are critical for the future security, affordability and decarbonisation of the electricity system. Further, these ancillary services are critical to the e-mobility transition as they: effect the upstream emissions of mobility, maintain the cost differential between electric Vs petrochemical mobility, and they define the viability of the system that delivers energy to the vehicle. It is therefore important to understand what these 'ancillary' services are and who needs them. Table 1 separates system flexibility values (value pools) for electric vehicles and briefly describes how electric powertrain vehicles can capture them.

Table 1: Energy market service possibilities for electric vehicles.

Value Pool	Value recipient	EV duty	Technology needs	Tariff needs
Frequency response services[vii]	Transmission System Operator	Reduce or cease charging in response to signal from TSO	Standardised protocol for communication between charge points and aggregator management systems to support frequency response requirements.[86]	Currently done through bi-lateral contracting, consumers likely to require this rolled into bill as opposed to a separate service.
Reserve services[viii]	Transmission System Operator	Reduce or cease charging in response to signal from TSO	Standardised protocol for communication between charge points and aggregator management systems to support reserve service requirements.	Currently done through bi-lateral contracting, consumers likely to require this rolled into bill as opposed to a separate service.
Reactive Power Services (Voltage)	Transmission System Operator	Reverse power flow from vehicle into the grid for voltage management	The two way power flow is (vehicle to grid) already possible in CHAdeMO vehicles and is being trialled in the UK[x]. However ICT systems and supporting infrastructure still require standardisation[90].	Currently done through bi-lateral contracting, consumers likely to require this rolled into bill as opposed to a separate service.
Avoided grid reinforcement and fault protection[xi] (not an open market and scheme/geography specific)	Distribution Network Operator	Reduce or cease charge demand in response to DNO signal.	Currently technically possible but needs standardisation.	Currently bi-laterally agreed outside retail market. Needs aggregator for EV's. May be better mandated than incentivised
Peak Tariff Avoidance[xii, xiii] (not strictly an ancillary service, though customers responding directly to wholesale price signals can be helpful to mitigate peaks)	Consumer	Reduce or cease charging, or reverse power flow to power home appliances at times of peak pricing.	Smart meter enabled home, ideally half hourly settled.	Clear and timely signals on price peaks, possible supplier automation.
Intermittency storage[xiv]	Generators through suppliers	Schedule charging to better match intermittent renewable generation.	Smart meter enabled home, certainly half hourly settled. Better generation side communication.	Would enable suppliers to offer better rates to intermittent generators in the knowledge that demand sink exists.
Portfolio Imbalance[xv]	Suppliers	Act as demand sink or demand reducer at times when suppliers position is 'long' or 'short' between wholesale and retail markets.	Smart meter enabled home, certainly half hourly settled.	Requires careful orchestration if mixed with other ancillary services from different market players with different incentives.

[vii] http://www2.nationalgrid.com/uk/services/balancing-services/frequency-response

[viii] National Grid (2016) http://www2.nationalgrid.com/uk/services/balancing-services/reserve-services

[ix] National Grid (2016) http://www2.nationalgrid.com/UK/Services/Balancing-services/Reactive-power-services

[x] http://utilityweek.co.uk/news/nissan-launches-first-vehicle-to-grid-storage-trial/1242532#.V5i4Ak0UXDc

[xi] UK Power Networks, Poyry Smarter Network Storage Low Carbon Network Fund Electricity storage in GB: SNS4.13 – Interim Report on the [x] Regulatory and Legal Framework. Accessed June 2016, Available at: http://poyry.co.uk/sites/www.poyry.co.uk/files/smarter-network-storage-lcnf-interim-report-regulatory-legal-framework.pdf

[xii] Thumin, J., (2014), Investigating the potential impacts of Time of Use (TOU) tariffs on domestic electricity customers, Report to Ofgem, Centre for Sustainable Energy, Available at: https://www.ofgem.gov.uk/ofgempublications/87361/toutariffsandclustering-reportvfinal160414.pdf.

[xiii] House of Commons Energy and Climate Change Committee [ECCC] (2016a) 'Oral evidence: Low Carbon Network Infrastructure, HC 613: Tuesday 12 January 2016'. http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/energy-and-climate-change-committee/low-carbon-network-infrastructure/oral/26779.html

[xiv] Mwasilu, F., Justo, J.J., Kim, E.K., Do, T.D. and Jung, J.W., 2014. Electric vehicles and smart grid interaction: A review on vehicle to grid and renewable energy sources integration. Renewable and Sustainable Energy Reviews, 34, pp.501-516.

[xv] Energy suppliers can use demand response or vehicle to home/grid to ensure their contracted supply volume is consistent with their actual provision to avoid charges in the balancing and settlement code. https://www.elexon.co.uk/wp-content/uploads/2011/10/BSC-Ops-Headline-Report-reporting-on-May-and-June-2016.pdf

Though these values are available for capture, on a per vehicle basis, the value of these ancillary services are negligible from both an energy bill and a household mobility spend perspective. Average household electricity bills in 2016 were £624, and transport fuels £1196[91]. Recent research[86] suggests the combined upper limit of the value of frequency response services to National Grid to be a maximum of £92 per electric vehicle by 2030 excluding vehicle to grid services. Separate analysis[92] shows that providing demand side balancing services may remunerate consumers by up to 18% of their e-mobility fuel bill. The same work shows provision of vehicle to grid services could theoretically provide much more remuneration, effectively enabling neutral or negative running costs for minimal battery degradation, however infrastructure costs for individual households or very small fleets, significantly undermine the cost benefit case. In sum, demand response is available to all EV owners whereas higher value vehicle to grid services favour those with access to a captive vehicle fleet in a single location.

However, it is unlikely that any of the energy system actors would contract for services with individual EV owners:

> **"...if you are looking for new opportunities and business models and you will find here that it is does require a certain capacity in order to participate on this market, to offer frequency services. So that definitely it is the role of the aggregators to offer these services.**
>
> (Source: Energy Infrastructure Provider, 2016)

What is being described is a need for an entity to bundle electric vehicle services from multiple owners into a single aggregated unit which can offer services at a meaningful capacity to different players in energy markets around the values in Table 1. However, 'aggregators' are usually commercial to commercial relationships that operate outside of the electricity supply bill on a bilateral basis. To operate this model at a householder and small commercial level it is likely that transaction costs and 'hassle factor'[93] involved would prevent consumers from establishing a relationship with a separate aggregator. As such it is likely that these services would have to be part of the energy supply contract and be operated by special tariff.

At time of writing, utility companies have been severely restricted in the amount of tariff innovation they are able to offer due to the Ofgem ruling restricting suppliers to offering only four tariffs to domestic consumers[xvi].

> **"I think there is a limitation in terms of the UK market in that actually the number of tariffs that you can create is limited and I think that is a slightly mis-conceived policy drive where essentially electric vehicles weren't on the horizon but that is actually biting us back now because we are limited in terms of the number of tariffs you can create [...] essentially the new business is based on arbitrage of a lot of uncertainty due to the fluctuation in renewable generation and we have actually very few tariffs available or essentially fixed tariffs is not really helpful."**
>
> (Source: Energy Supplier, 2016)

This piece of energy regulation has severely restricted the smart tariff offer and constrained business model innovation in this market. This was also highlighted by the Competition and Markets Authority investigation into energy markets[94].

The need for better tariffs to reward charging during off-peak periods, and the need for ancillary service participation to be rewarded through the consumer's electricity tariff, demonstrates a clear business model innovation need for tariffs to reward flexibility and response and new aggregator businesses/functions.

Business model need #5 Energy System: Tariffs to reward flexibility and response and new aggregator/business functions

One critical theme that emerged from the interviews was the need to find business models that could better match vehicle charging with the needs of the distribution network. The table above defines a suite of value opportunities that accrue to consumers, suppliers, generators and the transmission system operator, only one 'avoided grid reinforcement and fault protection' accrues to the distribution network operators; the companies responsible for the majority of electricity infrastructures in towns and cities, the lower voltage network (fig3). The auto industry concerns detailed above, over the ability of the energy system to cope with higher charge loads affects this network closely. The My Electric Avenue[84] project addressed this issue, finding that high levels of EV penetration would lead to serious infrastructure stress. However this was using 3kW chargers, the next generation of 7kW home charging will significantly reduce the threshold at which network stress exceeds limits, needing expensive re-enforcement:

[xvi]Since January 2014 all licensed energy ssuppliers have had to restrict tariff offerings to domestic consumers to four core tariffs under the Electricity suppliers Licence: Standard Conditions - Consolidated to 10 May 2016. This code is available at: https://epr.ofgem.gov.uk//Content/Documents/Electricity%20Supply%20Standard%20Licence%20Conditions%20Consolidated%20-%20Current%20Version.pdf

> **"So for home charging, you know. Clearly there's a number of issues that come out. First it's scale. You'll get a clustering effect of vehicles in certain neighbourhoods and networks. A sort of panel effect, when one house gets one, another house wants to get one too. So you've got a local problem in terms of infrastructure; can that local infrastructure manage the demand at the same time?"**
>
> (Source: City Government Officer, 2016)

Similarly, larger commercial fleets can be severely constrained.

> **"…the challenge that we've had is that it is very difficult to supply sufficient power for a significant number of vehicles at any one time. In terms our own fleet we have been kind of restricted on most sites two or three electric vehicles, sometimes up to five. But where we've got opportunities in terms of suitability of fleet transition to have say 10 12 even 20 electric vans operating from one site. We've not been able to do that because we haven't got sufficient power at those sites to facilitate the charging of the vehicles, even on slow charger overnight. To overcome that we would need huge investment…"**
>
> (Source: City Government Officer, 2016)

While the ancillary services market is nationally operated, and somewhat blind to geography, the DNO value in table 1 'avoided grid reinforcement and fault protection' is very sensitive to geography and can only be remunerated on a scheme by scheme basis, and often requires the addition of expensive network monitoring software. Grid constraints can be on higher voltage lines serving several communities, or at the sub-station level:

> **"I think the step forward, in terms of city planning, is a really interesting one. When we spoke to the National Grid, they said there are two issues. One, it's not an issue of total demand, which is the traditional question we get from journalists, it's a question of managing peaks, but it's worse than that. It's also about managing street by street, house by house"**
>
> (Source: Vehicle Manufacturer, 2016)

Under current arrangements DNOs can only expect residential and small commercial suppliers to shift demand in response to a supplier managed Time of Use (ToU) tariff[68]. These tariffs discourage charging when wholesale prices are high. This often in tandem with periods of network stress, but this parallel may not continue in the future. This raises the question whether DNO level smart charging should be mandated at certain vehicle penetrations as opposed to trying to manage it through the retail contract. If flexible demand for network stress issues are to be rewarded on consumer bills, a very fine grained, real time geographical dataset is required. If it is going to be mandated, more static vehicle registration data could be used to target LV feeders, substations and other parts of the low voltage network that may be at risk. The challenge is to find business models for EV charging that are not blind to this issue and can forge new partnerships between electricity suppliers, vehicle users, and the distribution network, that can anticipate network stress on the community level i.e. street by street. This leads to the final business model innovation need for an ability to anticipate and respond to network stress.

Business model need #6 Energy System: Ability to anticipate and respond to network stress

There are then, three clear business model innovation needs from the energy system stakeholders in the E-Mobility transition. The first is the need to better link vehicle charging with intermittent renewables output so as to provide a preferable route to market for intermittent renewables, preferably on a regional basis[45]. The second is the need for new tariffs that can aggregate and reward consumers for flexing demand in response to system stress, infrastructure constraint, or price spikes/troughs. The third is for business models with some geographical focus, which can anticipate and respond to network stress. Any suite of new business models should reflect these needs to catalyse the Innovation Interface.

Summary

Business model innovation needs from the **Energy System**:

4	Better optimisation of intermittent generation and EV Charging.
5	Tariffs to reward flexibility and response with aggregator businesses/functions.
6	Ability to anticipate and respond to network stress.

3.3 Business model innovation needs for city governments.

Section 1.1 describes a series of health, environmental, and economic drivers for increasing the uptake of e-mobility in cities. Here we investigate the business model needs of city governments, the de-facto transport infrastructure provider across the majority of the network.

For almost a century the urban mobility system has evolved largely to accommodate private car transport[95]. A post-war boom in auto-mobility infrastructure was driven by Keynesian infrastructure idealism and steady growth in private vehicle purchasing[97]. These trends were reflected in a parallel turn to auto-mobility accommodation across urban planning as a discipline[98].

Often referred to as the 'predict and provide paradigm', this led to an 'auto-mobility lock in'[99] which led to today's urban and transport planners having to retrofit active modes and sustainable transport interventions to a car dependent urban form.

> **"…cars are mental really, they were a solution to a problem that we had 45-60 years ago. But somehow we have let a solution to a problem become a driving force in how we design cities and how we live."**
>
> (Source: City Government Officer, 2016)

Efforts to retrofit sustainable modes into car oriented cities have been labelled variously: Predict and Prevent, New Realism, a New deal for transport[100] and 'Smarter Choices[100,101]. Each of these national policy programmes set the tone for local authority decision making, because the UK was reactive to a fundamentally centralised transport investment and planning environment[101]. Through these policy paradigms a common cost benefit analysis was adopted for transport schemes which aimed to assess economic, environmental and social impacts of transport schemes[102].

Whilst New Labour began the process of devolution of transport policy and funding to city regions, it was under the 2010 Coalition government that devolution gathered pace. For infrastructure, the most significant devolutions of power and funding where around transportation. Some integrated transport authorities were consumed into new combined authorities, and infrastructure prioritisation at the local scale became much more focussed on economic development potential as opposed to travel time savings across a network[103].

After this substantial devolution of infrastructure spending, there has also been the introduction of new air quality management zones overseen by Defra and new powers given to local authorities over road user charging[104]. This has become a further call on the newly devolved infrastructure funds, as targeted transport schemes are most likely to deliver air quality and carbon reduction improvements across cities (see section 1.1).

To summarise UK cities now have much more control over both transport policy and capital spend. There is a substantial institutional knowledge base around road and parking provision, active modes delivery, public transport operation and investment and land use planning. In parallel there is comparatively no institutional understanding over the energy system. This has left city managers unable to engage strategically with the key infrastructure underpinning the e-mobility transition.

Until recently this institutional separation was acceptable, as most transport infrastructures do not place substantial stress on energy systems. However, in order to facilitate e-mobility transitions, there must be careful management of where to place charging infrastructure in terms of consumer demand, optimised against where there is sufficient capacity on the network to accommodate this demand without requiring substantial re-enforcement works.

In common with Auto Industry need#1, cities also require a coherent and accessible charge network if they are to support the e-mobility transition, fulfil their Transport Body role as infrastructure providers across all transport modes, capture air quality benefits, and reduce the greenhouse gas emissions associated with the vehicle fleet. However, where the auto industry has little control over the public charge network[xvii], Cities and the various Integrated Transport Authorities, Transport Bodies and Highways Authorities have all the necessary powers to implement a coherent charging infrastructure. However, 'it is currently challenging to construct a profitable business case for publicly available EV charging investments for several reasons. These include high initial investment costs, low and uncertain near-term demand for publicly available charging, and commercial charging competing with home charging'[105].

> **"…Well, the business model is just as bad whichever way you do it. Whether you deploy them on the streets. You know, battery chargers or … whichever way. You know the business model doesn't work."**
>
> (Source: Energy Supplier and Infrastructure Provider, 2016)

Throughout the research, in the focus groups and across the interviews, there was broad consensus that the revenue returns from charging are unlikely ever to justify the capital investments required. This has led public charge infrastructure to become grant dependent, which in turn has resulted in a fragmentation of provision across UK cities:

> **"So in the plugged in places scheme that was from 2010 to 2013, there were eight regions of the country that received quite large amount of funding for infrastructure. Scotland, Northern Ireland, North East, Midlands, Manchester, London, South East, Milton Keynes. However Yorkshire didn't get anything and that is why there isn't a lot of charging infrastructure in Yorkshire. Because they didn't receive that funding five years ago and that's not all, West Yorkshire didn't do anything strategically for them. In fact I'm not aware of any publicly available. Well, it's limited now there is a few."**
>
> (Source: City Government Officer, 2016)

Under the 'Go Ultra Low' Cities scheme this concentration of effort on exemplar cities has further fragmented provision of public charge infrastructure, being awarded to exemplar and leading cities as opposed to being used to fill gaps in already uneven provision[106]. Prior funding had specified publicly funded charge points should be free at the point of use, however, recognising the need to recoup some revenue there has been a recent move to pay to use:

> **"So OLEV, Office for Low Emission Vehicles, last summer they funded a huge amount of rapid charger installs, and one of the conditions of their funding was that that rapid charger would be, I'm not quite sure of the exact wording, but it would be able to operate on a pay to use basis, and thereafter, all of the sentiment and noise that has come out of OLEV is that they are fully committed to the pay to use market, whereas formerly, prior to the summer 2015, charge points were still installed on a free to use funding model, which, the stipulation was for three years after you'd installed. So that's why the market, you know, that's one of the reasons why the market will be pay to use, but in the meanwhile there are various anomalies which prevent, sort of, commercial applications."**
>
> (Source: Charge Infrastructure Provider, 2016)

There is a substantial drive across public policy to identify revenue streams to build a 'sustainable business case' for charge point provision that is not dependent on centralised grant making. However, some have recognised the likelihood that user charging may never present a sufficient business case and are looking to other valuation methods. Recent research is:

> **"…looking for alternative ways to create an alternative business model which is why we're looking at social and environmental accounting, we're looking at different ways of valuing the different types of benefit that come from the introduction of electric vehicles and therefore the provision of public charging infrastructure."**
>
> (Source: Charge infrastructure provider, 2016, unique to above)

In common with auto industry need #1 the clear business model need at the city infrastructure scale is a coherent and accessible charge infrastructure and any business model archetype addressing this need will need to find new revenue streams or a deeper public case for investment to support the use of taxation based capital on charge infrastructure.

Business model need #7 City Infrastructures: A coherent and accessible public charging network

A further issue identified by city based interviewees was the strategic foresight they had over the urban energy systems.

> **"…that whole process in terms of engaging with the grid is very difficult. They are not very kind of user friendly in terms of their approach. You have a map and you sort of say, how much will it cost to put something there and they will come back and give you a fee. And then you say, how much will it cost to put it there and I will come back and give you a fee. But you know they've got the knowledge to say, how much is it to point A, they could just turn round and say actually you could put it there. But because of our knowledge of the grid and where the supply is and so on. You are much better just putting it here, but they won't do that. And you can't submit a suite of sites; how much to put one in point A? How much to put one in point B? How much to put one in point C? and you have to spend a lot of money to get to the point where you could make those decision. That actually point C was better all along, whereas if you could just have that a bit more flexible engagement and discussion with them, it would help…"**
>
> (Source: City Government Officer, 2016)

[xvii] Notwithstanding the Tesla model.

Both the expansion of charge point provision and the expansion of EV captive fleets needs closer partnerships to enable more strategic deployment of charge infrastructures. Further, in relation to the business model need #4 'Better optimisation of intermittent generation and EV Charging' cities also benefit from better optimised local renewables, both economically and environmentally[107]. This requires close co-operation with or indeed participation in the generation and supply elements of the energy system. Better optimisation of local renewables was a key motivating factor for the establishment of 'Bristol Energy'[108], and has been a feature of recent city/utility partnerships across the UK[109].

The business model innovation need that emerges here is for better partnerships with, or direct participation in, the energy system by cities to enable strategic foresight over both change infrastructure development *and* the distributed generation landscape across the city.

Business model need #8 City Infrastructures: Better partnerships with energy system stakeholders

The final business model innovation need identified in the city infrastructures space related to the ownership models active in e-mobility transitions.

> **"I really think we should try and look at building society around selling mobility rather than selling cars [...] you basically purchase travel rather than purchase the means of travel. And then I think that can inform a better style of urban planning and urban design. So instead of having these kind of central point and everyone moves inwards and moves outward sort day after day. You could also have less in the centre and perhaps have more sort of hubs. And so people don't have to travel as far or don't all need to travel in the same direction. And you know develop better sort of public rail and green spaces around those"**
> (Source: City Government Officer, 2016)

> **"I think there's general movement away from car ownership across the UK towards, you know, multi mobility where people will start to, not only rent a vehicle but even rent it per use. Because that does start to make a lot more sense if you've got a sufficient number of cars and sufficient... relatively easy accessibility to ... somebody with a smartphone application can book it"**
> (Source: City Government Officer, 2016, unique to above)

Linking new forms of vehicle use with wider mobility packages across the city, and mobilising better integrated transport needs has been the focus of some recent studies on smart city futures[110] and in particular by the UK's Transport Systems Catapult[111]. Highlight the potential for Mobility as a Service, or MaaS business models, to link low carbon vehicle pools with other multi-modal transport options under single interface systems. In order to realise this potential, new data flows on energy system performance, user needs, charge point availability and mass transit access must be available on an integrated platform. The business model need identified is for city infrastructure system providers to find service approaches to mobility that can capture this opportunity.

Business model need #9 City Infrastructures: Integrated service approaches to mobility

There are then three business model innovation needs at the Innovation Interface for city infrastructure providers. None of these can be realistically achieved without new business model offers at the Innovation Interface.

Summary

Business model innovation needs from City Governments:

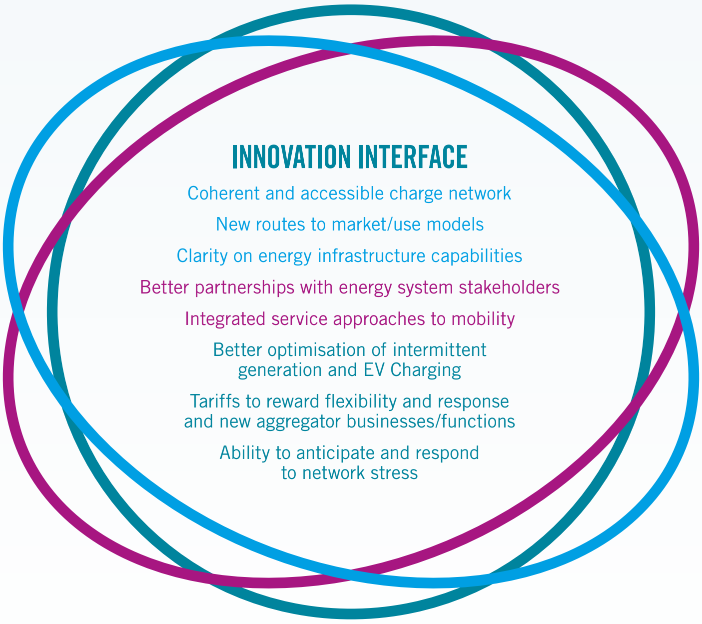
7	Coherent and accessible charge network*
8	partnerships with energy system stakeholders
9	Integrated service approaches to mobility.

**NB, The need for a coherent and accessible public charge network is shared by both the auto industry and city governments. For this reason the rest of the analysis incorporates need #7 into need #1.*

3.4 Business model innovation needs

This section has answered question one by identifying nine business model innovation needs that each individual system is unable or unlikely to provide for itself. These needs are driving a search for new business models that bring in new partners and more complex value propositions than the e-mobility transition has yet experienced. Figure 4 summarises these needs.

Figure 4: Summary of business model needs at the Innovation Interface for e-mobility.



4.0 Business model innovation across systems, an archetype approach

Section 3 described three socio-technical systems that physically intersect but have different business model innovation needs. In this section, ten business model archetypes are presented which fulfil these business model innovation needs to different degrees. For each business model archetype, the key attributes around vehicle ownership, charge access, and electricity provision are summarised. This summary is similar to that which the focus group participants of phase 2 were given in the business model innovation workshops. Focus group participants were provided with this information along with an archetype diagram, to investigate the implications of each business model on users, technologies, regulation and markets, and wider systems. For both city infrastructure providers and the auto industry, a more coherent and consistent charge network is needed. Both parties require this provision, irrespective of preferred use rates, as such, this business model need is combined in the need fulfilment tables below.

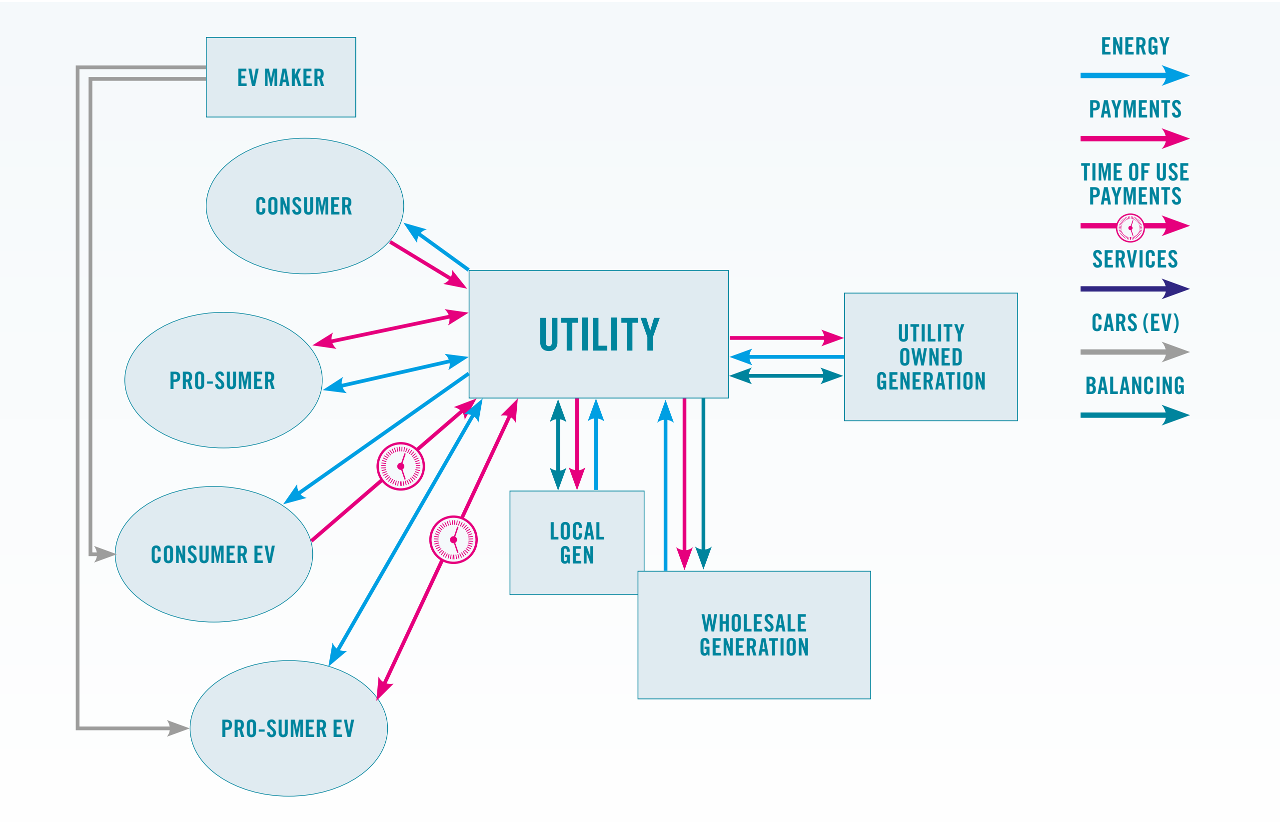
The implications drawn from workshop participants are summarised for each archetype, a table of attributes is then synthesised from this data to demonstrate how strongly each archetype fulfils each business model innovation need identified in section 3.

The archetype diagrams presented show the flows of energy and payments in the system, where services are offered between parties, and where energy system balancing (ensuring sufficient supply) is done. Each archetype diagram is introduced with a paragraph or key attributes. These diagrams are intended to aid comparison between business models and demonstrate how small shifts in technology availability, institutional relationships, and value flows, can deeply affect e-mobility transitions.

4.1 The Current Archetype with Static Time of Use Tariffs (private and commercial use)

This archetype represents the current system. Here private and commercial consumers purchase the vehicle and can switch to an energy tariff that is cheaper outside of peak times. These electric vehicle time of use tariffs (ToUTs) have been made available by suppliers such as British Gas and are enabled by smart meter installation. The city is largely absent, there is a marginal positive impact on electricity infrastructures as consumers shift demand to off-peak times in response to pre-set peak charges. There is a small advantage for utility companies in accessing a new market.

Figure 5: The Current Archetype with Static Time of Use Tariff (private and commercial use)



Implications

Users

Focus group participants were clear that this archetype gives some control over managing the cost of charging EV's by amending peak charge periods. The new time of use tariffs are accessible, but details in actual savings are uncertain and rely on user understanding and behaviour change. Users may be charged more if limited change in behaviour leads to peak time charging. There was also concern that though tariffs are differentiated, the user benefits would be small compared to savings in liquid fuel, and therefore fail to modify habitual re-charging. The tariff structure was thought to be *"theoretically fine"* but participants pointed out that *"the cost differential needs to be high enough to justify behaviour change"*.

Regulation and Governance

An equity issue in this archetype was highlighted which is applicable to others below. The issue is that of 'cherry-picking' EV consumers and offering them smarter tariffs with cheaper electricity due to their higher load. *"Equality issues arise when offering cheaper tariffs to those who can afford EVs"* participants reflected that making time of use tariffs EV only in the first instance does exclude those in energy poverty from the opportunity to shift load and thus save money. The city was seen to be relatively absent as a policy or regulatory actor in this archetype.

Technologies

While time of use tariffs in this archetype are static, they do still require smart meters[xviii]. It was observed that profiles of uses, times of operation, pricing signals, and the consumer market interface still require development, though the smart meter rollout is seen to make this simpler. This archetype's technology needs are minimal and indeed do not utilise the full functionality of smart meters, the EV's themselves, or optimise distributed generation.

Energy and Transport Systems

A clear benefit was seen to be the potential to realise CO_2 benefits by moving charging away from higher emitting peak load generation. In this archetype there is little opportunity for distribution network operators to manage geographically specific constraints. From a system perspective this archetype was considered to be *"not innovative/smart. If profile shift and 'peak' becomes at a different time the whole thing may need re-aligning again"*. It was highlighted there is some potential for load levelling, leading to lower investment in peak generation, but this was not strongly signalled.

Table 3: The Current Archetype with Static Time of Use Tariff (private and commercial use) business model innovation needs analysis: +++ strong positive ++ moderate positive, + weak positive, -/+ no effect, - weak negative, -- moderate negative, --- strong negative

Business model innovation Need	Need fulfilment	Comments
Coherent and accessible charge network.	-	Slight negative, better home charge tariffs reduce demand for public charging.
New routes to market/use models	-/+	No effect, This is the current archetype so even though it may expand it will not present any 'new' routes to market, only a replication of the current situation
Clarity on energy infrastructure capabilities	+	Some amelioration of charge peak possible due to demand shift.
Better optimisation of intermittent generation and EV Charging	+	Some shift away from peak times may provide more load for intermittent renewables during demand troughs.
Tariffs to reward flexibility and response and new aggregator businesses/functions	+	The time of use tariff in this archetype is enabled by a smart meter but is for a fixed daily period therefore only captures the value of lower off-peak prices and not deeper ancillary services.
Ability to anticipate and respond to network stress.	-	Continued existence of this tariff takes market share from smarter solutions with more granularity.
Better partnerships with energy system stakeholders	--	Market structure maintained with little link between cities and energy infrastructures.
Integrated service approaches to mobility	-	Slight negative as incentivises further private auto-mobility.

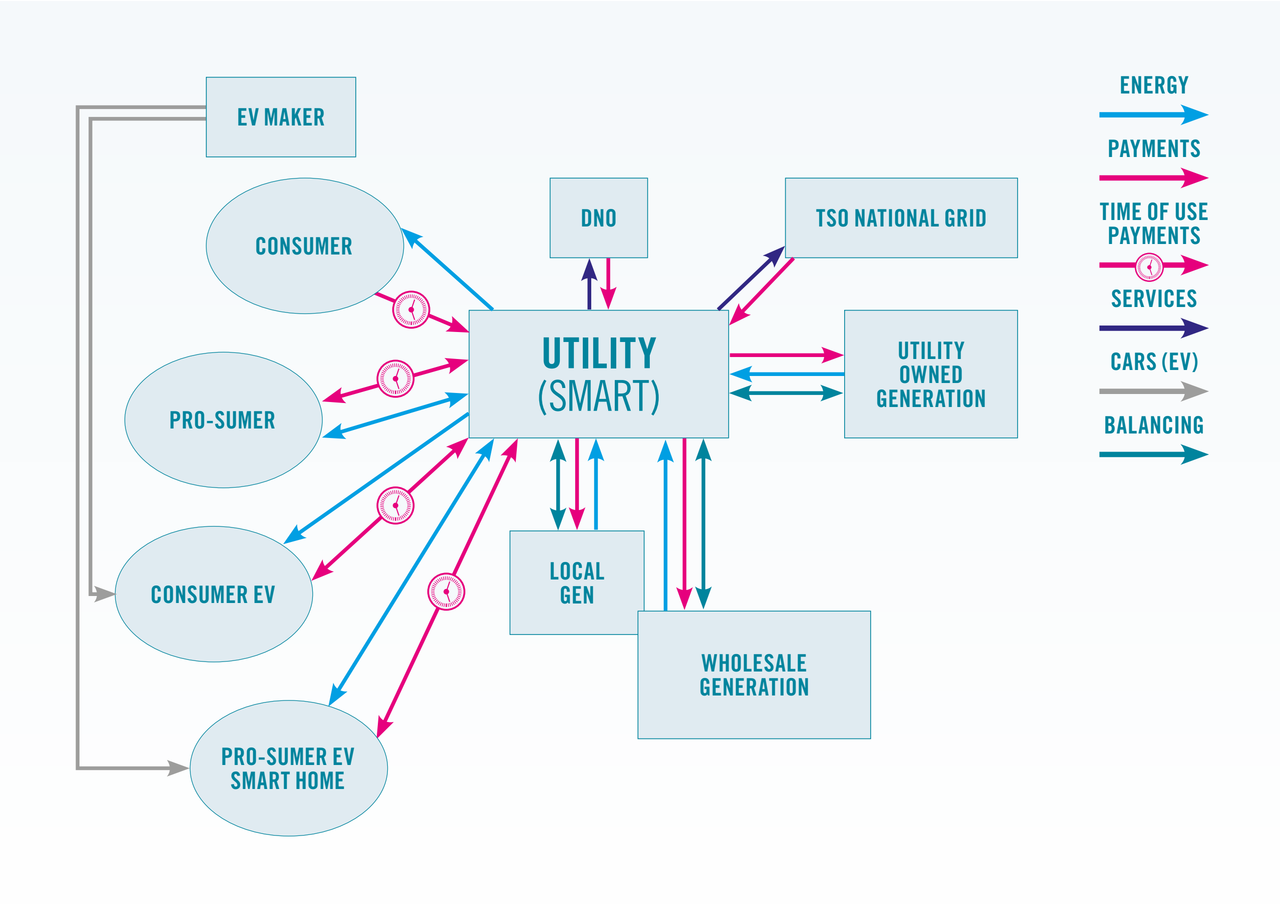
The current archetype with static time of use tariffs may require high differentiation in prices, but does not utilise full smart meter functionality and has limited benefits for the auto industry or cities. It does have the potential to smooth peaks, but in terms of catalysing the Innovation Interface it is a weak proposition.

[xviii]Older, analogue time of use meters have been used for EV tariffs in the past but with the mandated roll out of smart it is unlikely these will be pushed by utilities into the future.

4.2 The Smart Utility (private and commercial use)

In this archetype, private and commercial consumers purchase the vehicle and switch to an energy tariff that requires a smart meter. The utility can manage charging to ensure vehicle is optimised for different outcomes; charged with renewable/low carbon/local energy, charged for cheapest price etc. The utility can also interrupt or dial down charging for reasons of distribution network stress, to balance its supply position, or for ancillary services to National Grid. Power flow remains one way but is managed. TSO services lead to new revenues, DNO signals can be responded to if granularity of data exists. Domestic or commercial load unaffected beyond EV charge. Cities remain largely absent.

Figure 6: The Smart Utility



Implications

Users

The predominant user implication identified by both focus group participants and interviewees was the uncertainty over when the vehicle would be fully charged when needed. It was noted that the *"user* [was] *completely dependent on utility provider"*. Related to this concern was the ability of consumers to manually override, the foresight they would have on price penalty for this, and how much users could understand a complex tariff. A further concern was the possibility for inequitable charging; how for example are benefits shared when only a proportion of the fleet needs to respond to a price signal? This was part of the wider question over *"how does driver share requirements with* [the] *utility so utility can manage charging?"* There is clearly scope *"for demand shifting opportunities, setting timers mechanically on devices, e.g to charge EV at set times."* While the primary relationship remains with the supplier there may be scope for built in DNO overrides. This was the first archetype where consumer data management was discussed as a real concern, given the aggregation of state of charge data, indicators of home occupancy and mobility patterns, there is a need for clear communication of data protection measures. This archetype also requires users to commit to half hourly settlement and may expose them to high price peaks for overriding utility control or failing to time shift demand.

Regulation and Governance

In this archetype, focus group participants questioned *"how can the city overall benefit from an improved load management process, and how to support/be an active agent?"* The archetype is largely responding to EV load and is *"not* [an] *overall energy/city view".* As this is a national utility proposition, granularity and uptake at the city scale would be uncertain. There were questions over the ultimate responsibility for charging, i.e. *"who would be responsible if* [it] *fails?"* Again the question of equity of access was raised, this time in a regulatory format, being how can non EV-users benefit? In a system management vein it was questioned whether off-peak could become the new peak, as EV users shift demand. Public understanding of tariffs was discussed along with data security again being raised and concerns were voiced over the ability of the regulator to adapt quickly enough to new offerings in the space.

Technologies

To operate this archetype there is a *"need for bi-directional information flow, not only [from the] smart meter but also from vehicle to utility provider, [defining] when/how much does it [the EV] need to charge."* Clearly a successful roll out of smart meters is necessary, as is the ability for the smart meter data hub (operated by DCC[xix]) to manage key granular data. Whilst the tariff may enable DNO response, it was raised that there is still *"no monitoring of real time loads"* to gain real network foresight, and the direct access infrastructure for DNOs is still not being consistently applied in charge installations in the home. Concerns were also discussed over how the change in battery size may need very long charge times at home and require charging beyond off-peak periods or change in behaviour patterns such as charging over days of the week. The predominant issue raised here was that while the tariff may enable active network management through smart charging, there is still no real time foresight on that network management. To derive full benefit, more infrastructure needs installing at low-voltage sub stations than necessarily in the home. In terms of vehicle to grid this archetype could accommodate two way power flow, however the utility would have no foresight on vehicle warranty[xx], battery ownership arrangements or EV mileage and battery condition.

Energy and Transport Systems

In this archetype distribution network operators saw more opportunity for network management, but cautioned this is still through the supplier hub which DNOs do not have control over. Nor do DNOs have the real time network monitoring data to provide signals or constraint at sufficient granularity. This archetype would mean a widening of the ancillary services market for fast frequency/voltage response/demand balancing, but may reduce market value of these services due to over availability. There is limited interaction with urban infrastructures, but more EVs, would increase public charge network requirements in all cities. The rush hour and electricity demand peaks are sequential, meaning more EVs would impact the system differently if mobility patterns change, i.e. more home working. For the Taxi/private hire fleet time of use tariffs may be less desirable as they may not be able to access off-peak prices due to their duty cycle. For commercial fleets such tariffs can be particularly useful as they may enable more meaningful peak price avoidance in large sites, i.e. reducing TRIAD costs[xxi].

Table 4: The Smart Utility business model innovation needs analysis: +++ strong positive ++ moderate positive, + weak positive, -/+ no effect, - weak negative, -- moderate negative, --- strong negative

Business model innovation Need	Need fulfilment	Comments
Coherent and accessible charge network	-	Slight negative, better home charge tariffs reduce demand for public charging.
New routes to market/use models	-/+	No effect
Clarity on energy infrastructure capabilities	++	Strong and dynamic amelioration of charge peak possible due to demand shift. More options for EV drivers. Still no direct view from auto industry into energy system.
Better optimisation of intermittent generation and EV Charging	+	In this model users could specify a charge schedule likely to match higher renewable generation. However, without switching to a dedicated renewables tariff this would not guarantee low carbon power.
Tariffs to reward flexibility and response and new aggregator businesses/functions	++	The time of use tariff in this archetype is enabled by a smart meter and can respond dynamically to wholesale price fluctuations OR ancillary services through demand side response. Still no two way power flow from EV, mainly due to battery degradation concern as opposed to technical limitation.
Ability to anticipate and respond to network stress.	++	While no real time monitoring in place, the sharing of half hourly data that would result from signing up to this tariff would provide DNOs with much better load foresight and network planning.
Better partnerships with energy system stakeholders	--	Market structure maintained with little link between cities and energy infrastructures.
Integrated service approaches to mobility	--	Negative as further deepens incentives to further private auto-mobility by making private EV miles ever cheaper.

[xix]The Department of Energy and Climate Change (DECC) granted Smart DCC Ltd a licence in September 2013 to establish and manage the data and communications network to connect smart meters to the business systems of energy suppliers, network operators and other authorised service users of the network. Source: https://www.smartdcc.co.uk/about-dcc

[xx]Research into ancillary services often excludes vehicle to grid services due to warranty and battery degredarion concerns of EV manufacturers[83]

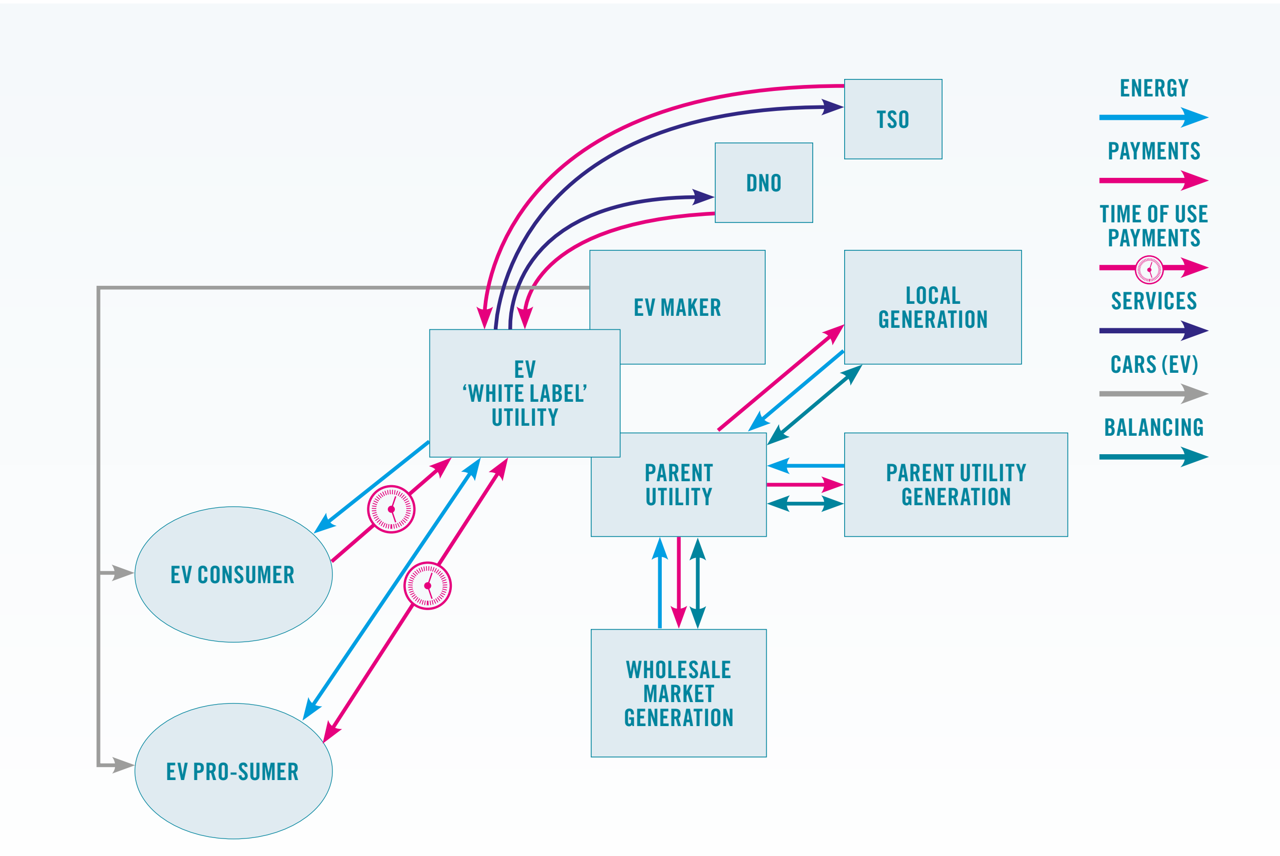
[xxi]http://www2.nationalgrid.com/UK/Industry-information/System-charges/Electricity-transmission/Transmission-Network-Use-of-System-Charges/Transmission-Charges-Triad-Data

This archetype predominantly strengthens the energy systems link to vehicle infrastructures and provides a new offer to an emerging market segment of EV drivers. Through better use of smart meter functionality this archetype can ameliorate, if not solve, distribution network issues, offer new ancillary services and better reward user flexibility. In terms of catalysing the Innovation Interface this archetype is stronger than the current archetype, but remains weak/moderate as the Auto Industry and Cities' business model innovation needs are not fulfilled.

4.3 The EV white Label (private and commercial use)

In this archetype the private or commercial EV user purchases the vehicle and is offered an electricity tariff branded by the EV maker. In these 'white label' relationships the energy utility manages compliance with energy market regulations and trading, while the white label company structures a tariff to optimise for different outcomes such as lowest cost, best grid management, vehicle to grid etc. The utility does not own vehicle or battery but the vehicle manufacturer partner might, it can optimise electricity market functions against battery degradation concerns, but must do so with consent from the private or commercial owner. Vehicle to grid and vehicle to home services both become available via two way power flow, the energy utility in partnership with the vehicle manufacturer can offer battery condition guarantees to users in the same way other parts are covered by guarantee. The energy utility can optimise grid services or home/building consumption. The EV manufacturers benefit from an added value offering for low-emission vehicles, utilities secure new revenue streams, cities benefit from enhanced EV uptake and may be able to engage more effectively with users aggregated under single utilities with further incentives. DNO and TSO more closely involved in contracting new services with the white label utility.

Figure 7: The EV white Label



Implications

Users

The first suggested user benefit of this archetype was that consumers may trust vehicle manufacturer's more than utility companies to optimise the vehicle for energy market participation. Given the relatively low value of the vehicle energy in relation to the purchase price, focus group respondents also explored the potential for vehicle retailers to cross subside electricity as an extended sales model[xxii]. If the vehicle manufacturer is responsible for vehicle to grid discharge and battery warranty there is a clear incentive to protect the user's battery when also contracting for ancillary services. It was still noted that drivers need certainty of supply. There was some concern over how to communicate benefits to consumers, particularly at point of vehicle sale when user would have to agree to half hourly metering and charge interruptions. Focus group participants felt the *"off the shelf package"* might be attractive from a customer point of view and this white label relationship could also install the EV charge point. A critical question was *"Do you* [users] *still have contract with energy utility for home and a separate OEM one for EV charging or one supplier for all?"*. This raised the question of EV specific or 'on-board' metering which could separate domestic and mobility consumption. This also led to further exploration of bundled service packages such as a telecoms company offering calls, broadband and mobility miles.

Regulation and Governance

In terms of consumer switching these tariffs may cause some disruption to the retail market, white label suppliers would still have to comply with switching rules, but tariff comparison would become more complex. Regulatory issues may arise around cross subsidy of tariffs and 'free' miles. This model also raises concerns over barriers to market entry for other businesses such as aggregators, whose access to potential consumers may be constrained under this model. This model was seen as potentially diffusing the need for on street or public charging which may only be used for 'top up' as users begin to understand and trust vehicle range. Most importantly however, focus group participants found the concept of dual metering difficult and questioned the viability of running two meter points at the same property and the complexities of regulating a mobile meter point in the vehicle. Given the complex services involved it would be difficult to compare tariffs for consumers and difficult to determine whether one tariff may be cheaper than another. This prompted discussion of the need to present very clear data to the customer.

Technology

In this archetype the full range of ancillary services highlighted in table 1 are made available to aggregated consumers under the vehicle manufacturers white label. It was also noted that as auto industry white labels grew there would be a clear route for second life battery use that remained under manufacturer control. For this model to be viable the car needs to communicate with the energy supplier to manage state of charge and fulfil user requirements.

Energy and Transport Systems

The proliferation of this archetype into even a moderate proportion of the future EV fleet could see the auto industry becoming a substantial owner of distributed storage resource and competitive participant in the ancillary services market. This may support the network but also disrupt it, as other forms of virtual power plant aggregation are pushed out of the market. There is still little mechanism for DNOs to communicate network stress to utilities, white label or otherwise. Questions that remained unanswered were around who leads the partnership OEM or Utility – and how benefits are distributed.

[xxii]Extended sales models including fuel already exist in the £500-£1000 range; https://www.skodafreefuel.co.uk/About/TermsAndConditions/SummerOffer2016 for an EV £500-1000 of free fuel would account for a substantial element of an average drivers annual needs.

Table 5: The EV white Label business model innovation needs analysis: +++ strong positive ++ moderate positive, + weak positive, -/+ no effect, - weak negative, -- moderate negative, --- strong negative

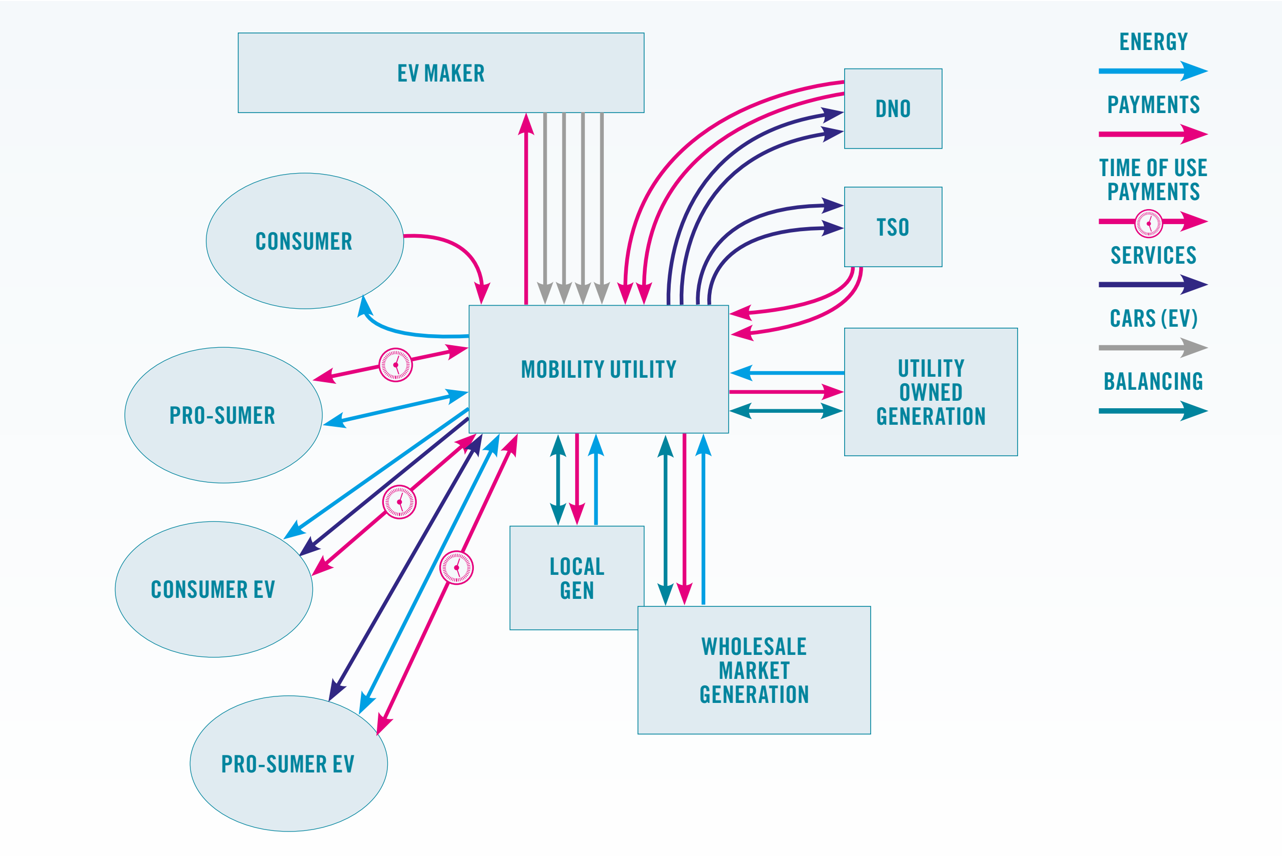
Business model innovation Need	Need fulfilment	Comments
Coherent and accessible charge network	-	Slight negative, better home charge tariffs reduce demand for public charging.
New routes to market/use models	+	Small positive as white label supply and extended energy sales may provide competitive advantage to first mover OEMs.
Clarity on energy infrastructure capabilities	+++	This archetype provides vehicle manufacturers with a direct view on the energy system and insight over future constraints, price effects, and environmental performance.
Better optimisation of intermittent generation and EV Charging	+	In this model users could specify a charge schedule likely to match higher renewable generation. However, without switching to a dedicated renewables tariff this would not guarantee low carbon power. White labels could optimise for cost or carbon, consumer choice dependent.
Tariffs to reward flexibility and response and new aggregator businesses/functions	+++	The bi-directional tariff in this archetype is enabled by a smart meter and can respond dynamically to wholesale price fluctuations and the majority of ancillary services. The white label supplier would have predictable, responsive and bi-directional load at their command and the ability to reward customers for flexibility.
Ability to anticipate and respond to network stress.	++	While no real time monitoring is in place, the sharing of half hourly data that would result from signing up to this tariff would provide DNOs with much better load foresight and network planning.
Better partnerships with energy system stakeholders	--	Market structure alters slightly but still with little link between cities and energy infrastructures.
Integrated service approaches to mobility	-	Negative as deepens incentives to further private auto-mobility, though may benefit car club arrangements.

This archetype effectively brings together many of the business model innovation needs of both the auto industry and the energy system. The foresight given on energy systems needs and capabilities by entering into a white label contract would be a significant step change for the auto industry. Offering a dedicated tariff may also lead to competitive advantage over other manufacturers/retailers of electric vehicles. In this archetype the energy system gets access to new flexible load in partnership with a vehicle manufacturer that can shoulder the responsibility for battery degradation through extended warranty. The business model innovation needs of the city are not fulfilled however, as this archetype has little to offer in terms of the publicly accessible network, does not open the city to new partnerships, and promotes further private ownership over mobility models. In terms of catalysing the Innovation Interface this archetype has a moderate effect.

4.4 The Mobility Utility (private and commercial use)

In this archetype the private and commercial EV users no longer purchase the vehicles but lease them via the electricity utility via special tariff. As the utility now owns both vehicle and battery, it can optimise electricity market functions against battery degradation concerns. Vehicle to grid and vehicle to home services both become available via two way power flow. The utility can optimise for grid services or vehicle to building consumption. The EV manufacturers benefit from a new route to market for low-emission vehicles, utilities secure new revenue streams, cities benefit from enhanced EV uptake and may be able to engage more effectively with users aggregated under single utilities with further incentives. DNOs and TSOs can be more closely involved in contracting new services with utility.

Figure 8: The Mobility Utility



Implications

Users

Focus group participants discussed the reduction of consumer risk this model offered as a positive for users adopting a new technology, particularly in the form of upfront purchase price barriers. Though EV leases are already available, neither desk research, focus group participants nor interviewees could identify any current lease offer able to accommodate vehicle to grid services. There were concerns over how transparent users would find a bundled energy and vehicle tariff, particularly in terms of how different this would be to a conventional lease agreement. Linking vehicle access to the energy bill under a single service would limit or disable consumers' ability to switch supplier.

Regulation and Governance

The main implication identified was the need for this model to operate outside of the rule that consumers can switch tariffs within 28 days. This is because longer term contracting is likely necessary for the utility to take on the credit risk. Interviewees identified that utilities, at least retail utilities, prefer to be asset light and would find taking on this larger credit risk problematic, though it was noted meter provision is often outsourced as the vehicle provision could be. The utility would need to undertake close scrutiny of individual properties for suitability and safety. In contrast to the white label model, focus group participants questioned whether consumers trust utilities enough to *"hand over mobility to them"*. There were serious questions over whether vehicle provision is compatible with existing market regulations and license codes.

Technologies

The highlighted implications for technology in this archetype were similar to the smart utility archetype but with the added concern over battery degradation due to vehicle to grid/home services (this would be an issue for all archetypes with a vehicle to grid element). The need for the car to be able to share state of charge and battery degradation data with the utility was highlighted as an ICT interface not currently commercially viable. At the utility end it was highlighted that significant billing and ICT systems would need to be invested in for this to be operable.

Energy and Transport Systems

This model gives the utility clear foresight on the effect of EVs on the consumers load profile and this data can be shared with DNOs for network management. There is also a pre-aggregated EV base for the utility from which to offer ancillary services and tune supply positions in the electricity market. Participants felt this model has high potential to support the market for renewable power as a guaranteed off-peak load would exist for intermittent renewables. In this model cities could engage with utilities to better understand geographic penetration of EVs and better plan charge infrastructure provision.

Table 6:The Mobility Utility business model innovation needs analysis: +++ strong positive ++ moderate positive, + weak positive, -/+ no effect, - weak negative, -- moderate negative, --- strong negative

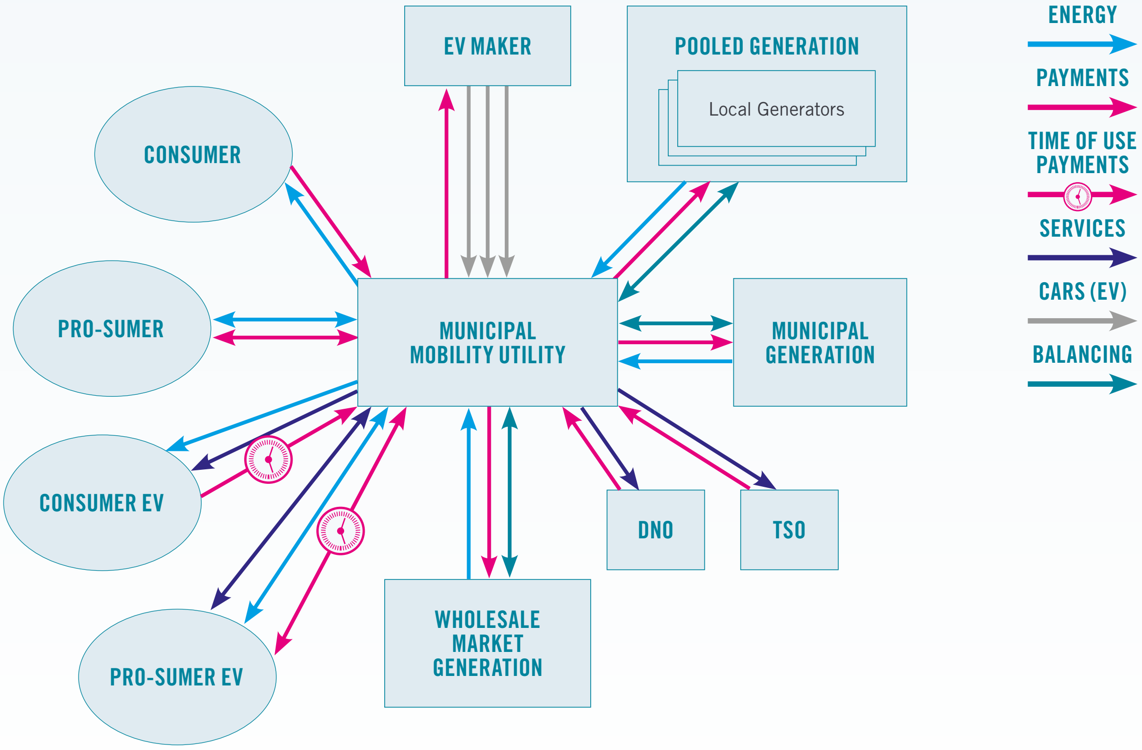
Business model innovation Need	Need fulfilment	Comments
Coherent and accessible charge network	-/+	Better home charge tariffs reduce demand for public charging. However utilities could partner with cities where uptake is high to better plan networks.
New routes to market/use models	+++	This would create an entirely new route to market for EV manufacturers in selling batches of vehicles to utilities.
Clarity on energy infrastructure capabilities	+	This archetype provides vehicle manufacturers with little direct view on the energy system, however as the vehicle is being managed by energy utilities there is a higher likelihood of strategic co-ordination.
Better optimisation of intermittent generation and EV Charging	++	In this model users could specify a charge schedule likely to match higher renewable generation and use the certainty of demand provided by EVs to offer better terms to distributed generators.
Tariffs to reward flexibility and response and new aggregator businesses/functions	+++	The bi-directional tariff in this archetype is enabled by a smart meter and can respond dynamically to wholesale price fluctuations and the majority of ancillary services. The mobility utility would have predictable, responsive and bi-directional load at their command and the ability to reward customers for flexibility.
Ability to anticipate and respond to network stress.	++	While no real time monitoring is in place, the sharing of half hourly data that would result from signing up to this tariff would provide DNOs with much better load foresight and network planning.
Better partnerships with energy system stakeholders	+	Market structure alters slightly in favour of new partnerships with mobility utilities at the city level. Likely in cities with high penetration.
Integrated service approaches to mobility	+	This is a departure from outright ownership and may normalise buying miles from a supplier. However it is unlinked to other transport infrastructures and cars remain at the sole disposal of the bill payer.

This archetype fosters a closer relationship between the auto industry and energy systems as new routes to market are provided for vehicle manufacturers, and energy suppliers acquire new, flexible load which can access the ancillary services market. The utility can better optimise distributed and intermittent renewables as this new flexible load can guarantee a destination for off-peak renewable generation. Though the auto industry gets little foresight on the energy system the urban infrastructure element is most disadvantaged as few of business model needs are fulfilled in this area, though note the small positive impacts of new partnership possibilities. As an Innovation Interface catalyst, this model is strong, though would constitute a substantial transition for utilities.

4.5 The Municipal Mobility Utility (private and commercial use)

In this archetype the private and commercial EV users no longer purchase the vehicles but lease them via the municipal utility via special tariff. Municipal utilities service predominantly one geographical area, and have controlling interest in the company. As the municipal utility now owns both vehicle and battery, it can optimise electricity market functions against battery degradation concerns. Vehicle to grid and vehicle to home services both become available via two way power flow, the utility can optimise grid services or home/building consumption. The EV manufacturers benefit from a new route to market for low-emission vehicles. DNOs and TSOs can be more closely involved in contracting new services with municipal utility. The municipal utility can also pool and sleeve local generation from municipal assets such as energy from waste plants and CHP units. This provides new routes to market for decentralised generation. Operating on a defined geography, the municipal utility can better engage with the Distribution Network Operator to take a strategic view on network re-enforcement needs caused by EV penetration.

Figure 9: The Municipal Mobility Utility



Implications

Users

Once again the trust of the user was cited as an important element for users. Some focus group participants felt users would be more likely to trust municipalities with data flows, vehicle lease and managing services *"Trust higher than with electricity co's"*. Users were thought to be *"not used to buying electricity or a car from your LA but the opportunity to move away from the big six must be attractive."* Following this discussion focus group participants reflected this model was clearly capable of *"creating more incentives for integrated city objectives"*. Wider user impacts were thought to be the *"same as [the] mobility utility but + target driven objectives (air pollution/ health impact)"*. There is the "opportunity to link to local targets eg air quality improvement and feel part of local improvements rather than national machine". One concern was whether this model operated on a city scale could achieve sufficient market penetration to achieve both economies of scale and sufficient load to participate in ancillary services markets.

Regulation and Governance

A clear barrier raised in the focus group was the new financial risk this model presented for the municipal provider. There were questions over the ability of cities to operate this model, indicative responses were: *"can cities get organised to do this. Most cities not set up to offer municipal utility function. Already heavy funding cuts. Cities Vs Regions vs National Suppliers, what is best grouping to balance objectives with costs?"* Other concerns at the city scale revolved around legal, financial and political implications: How to politically manage this model? Neutrality when selecting partners, 'good' or 'bad' energy providers. Others felt the *"organisational cost to municipality needs to be offset against their goals, e.g. air quality to justify this model."* This raised discussion over the ability of cities to implement polluter pays taxation on the most polluting vehicles. At the national regulatory scale questions were raised about the need for *"regulatory changes to facilitate leasing via special electricity supplier tariff."* Referring to consumer switching rights there was *"again* [the] *need to change rules to enable contract with domestic customers.* [This] *will impact on switching and risk of less competitive pricing in the future."*

Technologies

Focus groups reflected that from a technology perspective this archetype *"shouldn't be any different to mobility model"* [above]. Discussion here focussed around the potential to maximise benefits by linking the air quality benefits of EVs with further air quality and decarbonisation goals through distributed generation optimisation; *"Needs linking to decarbonisation of electricity supply. Could source a supplier of renewably generated electricity and make massive improvements to air quality."* And this model could: *"develop smart tech that facilitates easy access to vehicles, particularly short term hire/one off use or low mileage journeys at an affordable or immediate/ on demand basis."* Finally questions were raised over how complex the billing systems would need to become to make this model work.

Energy and Transport Systems

On a systemic level an interesting trade-off appears in this model, described by focus group participants as a *"tension with sustainable transport – cities want uptake of bikes/walking/busses, not necessarily cars."* And *"tension between council investing in electric cars whilst also public transport need."* However, just as a city scale promotion of leased EV's may conflict with sustainable transport/active modes policy it may also *"be used as incentive system for other energy efficiency public policies and cross sectoral measures"*. While this archetype can balance local generation by 'sleeving' power to the EV batteries, there may still *"be insufficient local generation within municipal region to balance with and wider reliance on national grid so still at risk of higher/ lower costs"*. Critically in this model the DNO liaison with local energy master planners is more realistic, as DNOs can engage with a more meaningful geography to manage network constraint through smarter charging: *"opportunity to work with DNO at local level now"*. Again it was highlighted that *"this model would allow emission standards to be better set at a municipal level creating a significant reduction in emissions and then improved public health."* In terms of integrating charge infrastructure and transport planning participants described the opportunity to affect *"change in planning/highways to create space for car hubs/charging."* There were also seen to be *"Wider benefits [of using] own generation from renewables as not for profit. Coordination of larger scale sources/demand possible."* Finally, participants envisaged there would be *"potential synergies with car clubs/shared EV ownership* [though see E-mobility service] *below. It was also highlighted that "circular use of energy – localises consumption,* [with] *potential savings but also potential rebound effects."*

Table 7: The Municipal Mobility Utility business model innovation needs analysis: +++ strong positive ++ moderate positive, + weak positive, -/+ no effect, - weak negative, -- moderate negative, --- strong negative

Business model innovation Need	Need fulfilment	Comments
Coherent and accessible charge network	++	Better home charge tariffs reduce demand for public charging. However tariffs could be linked to municipal charge infrastructure and some cross subsidy achieved from lease agreements.
New routes to market/use models	++	This would create an entirely new route to market for EV manufacturers in selling batches of vehicles to utilities. Though this is not maximally positive as the value pool would be single city by single city until multiple versions of the archetype emerged with possible common procurement.
Clarity on energy infrastructure capabilities	++	This archetype provides vehicle manufacturers with little direct view on the energy system, however as the vehicle is being managed by municipal energy utilities there is a higher likelihood of strategic co-ordination, both on a system level and at the distribution network level.
Better optimisation of intermittent generation and EV Charging	+++	In this model the municipal utility identifies a consistent route to market for local generation which can access embedded benefits from local use of power[xxiii]. Charging can be managed for least cost or most environmental benefit. Local renewables can be optimised across the city.
Tariffs to reward flexibility and response and new aggregator businesses/functions	++	The bi-directional tariff in this archetype is enabled by a smart meter and can respond dynamically to wholesale price fluctuations and the majority of ancillary services. The municipal mobility utility would have predictable, responsive and bi-directional load at their command and the ability to reward customers for flexibility. There is some possibility that scale of operation could be smaller than the Mobility Utility due to geographic focus.
Ability to anticipate and respond to network stress.	+++	While no real time monitoring is in place, the sharing of half hourly data that would result from signing up to this tariff would provide DNOs with much better load foresight and network planning. Further, the tighter geographic focus and co-ordination of benefits brings the city closer to the distribution network operator and new strategic partnerships can emerge to better manage the network.
Better partnerships with energy system stakeholders	+++	Here the city has become a fully licensed utility with full access to ancillary services, the ability to sign power purchase agreements with distributed generators, and has the ability to plan long term, city scale energy strategy.
Integrated service approaches to mobility	-/+	This is a departure from outright ownership and may normalise buying miles from a supplier. However it is unlinked to other transport infrastructures, cars remain at the sole disposal of the bill payer, and there may be some conflict with wider active modes and mass transit policy.

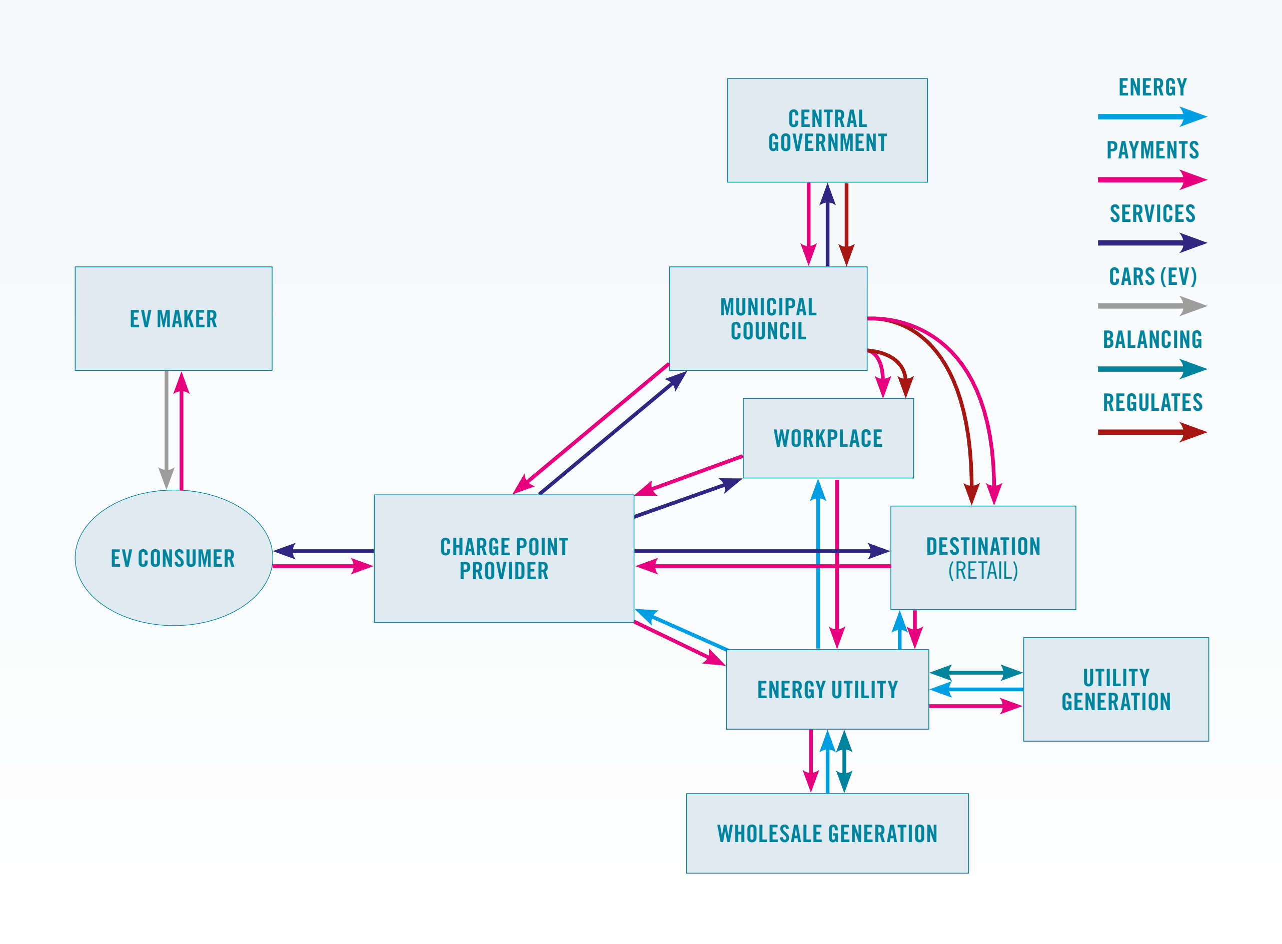
In this archetype there is clear potential to address many of the business model innovation needs identified in section 3. In particular the ability to optimise local distributed generation and embark on a strategic relationship with the distribution network operator is a strong positive. However, while this archetype performs well, it does require significant institutional change and political commitment. It also requires municipalities to acquire a range of sophisticated energy market skills which are currently scarce even at national utility scale. New billing, metering, optimisation and dispatch functions would have to evolve alongside a vehicle leasing function. In terms of catalysing the Innovation Interface this model is strong, but is accompanied by higher complexity and requires new regulatory and political mobilisation.

4.6 Public Charge Point Current Archetype

This is the first of the business model archetypes to address the public charge function beyond domestic and private fleet charging. The previous archetypes have focussed predominantly on private users in the home or small business. The remaining archetypes are more concerned with the public charging or mobility service realm. This archetype represents the current situation in which charge point providers are commissioned by municipalities, workplaces and retail outlets to install charge infrastructure. Destination charging (retail, entertainment venue, workplace etc) can operate on a commercial to commercial basis. Most on street or parking garage charging however has been supported by grants from competitive funds. Charge providers buy electricity from a licensed utility and sell charge time or parking. These installations are often supported by direct public grant or spatial planning regulations on developers. The cost of installation, often due to grid constraints, is limiting the business model's expansion. Research respondents suggest it is unlikely that charge time payments alone will be sufficient to roll out a coherent public network. Charge points are becoming smarter, and under aggregation may be able to offer frequency response or respond to load constraint, subject to negotiation between utilities and DNO/TSO. Using charge constraint may however undermine customer experience at rapid charge locations.

[xviii]Extended sales models including fuel already exist in the £500-£1000 range; https://www.skodafreefuel.co.uk/About/TermsAndConditions/SummerOffer2016 for an EV £500-1000 of free fuel would account for a substantial element of an average drivers annual needs.

Figure 10: Public Charge Point Current Archetype



Implications

Users

While this current archetype has generated a search for new business models, it has been and is instrumental in providing *"increased trust in e-mobility"*. It was highlighted from charge point providers that *"many workplace and destination charging business models do work* [on a commercial to commercial basis] *as they have a business model positive to host"*.

Regulation and Governance

It was broadly accepted that on street or public parking charge infrastructure is unlikely to cover costs outside very large utilisation areas. Outside London there is a need for consistent public sector contribution. There was very little discussion around the regulatory and governance challenges of this archetype as they were already familiar with the majority of expert focus group participants.

Technologies

Technology implications of the current archetype are largely already known, however it was highlighted in the interview phase that many public charge points are becoming obsolete and require replacement/upgrading or now require maintenance which is difficult when they have been historically free to use.

Energy and transport systems

There was little discussion from a systemic perspective due to the relatively low impact of this archetype on energy or transport systems at the city or regional level. Interviewees noted the existing charge provision at public parking sites is unlikely to be able to expand to meet the needs of a growing fleet without substantial grid re-enforcement.

Table 8: Public Charge Point Current Archetype business model innovation needs analysis: +++ strong positive ++ moderate positive, + weak positive, -/+ no effect, - weak negative, -- moderate negative, --- strong negative

Business model innovation Need	Need fulfilment	Comments
Coherent and accessible charge network	-	Continuing with the current model is likely to perpetuate ad-hoc, grant dependent installation of public charge networks and cluster destination charging around self-selecting businesses. This exacerbates the 'post-code lottery' effect, leading to over provision in some areas and under provision in others.
New routes to market/use models	-/+	No effect
Clarity on energy infrastructure capabilities	--	Divergent expectations and real provision across cities means car dealers and manufacturers will have to deal with patchy provision and uncertainty over what the customer can access in different cities.
Better optimisation of intermittent generation and EV Charging	-	Persisting with this model is unlikely to incentivise better intermittent optimisation and may 'crowd out' smarter solutions from entering the market.
Tariffs to reward flexibility and response and new aggregator businesses/functions	-	Smart or responsive load management is likely to be hardwired or unavailable under the current archetype. There is little potential for customers to be rewarded for flexibility i.e. accepting charge interruptions.
Ability to anticipate and respond to network stress	+	Future public charging can be enabled with hardwired control but the mechanism through which DNO's might signal network stress, and charge providers respond, is unclear in this model.
Better partnerships with energy system stakeholders	+	Here the city or the host of destination charging is likely to pay through their existing commercial utility contract for the power drawn by EV's. This may lead to new tariff offers but is not a strong incentive for new partnerships.
Integrated service approaches to mobility	-	Continued provision of this archetype assumes further private car ownership. simply a substitution from liquid fuels to EV

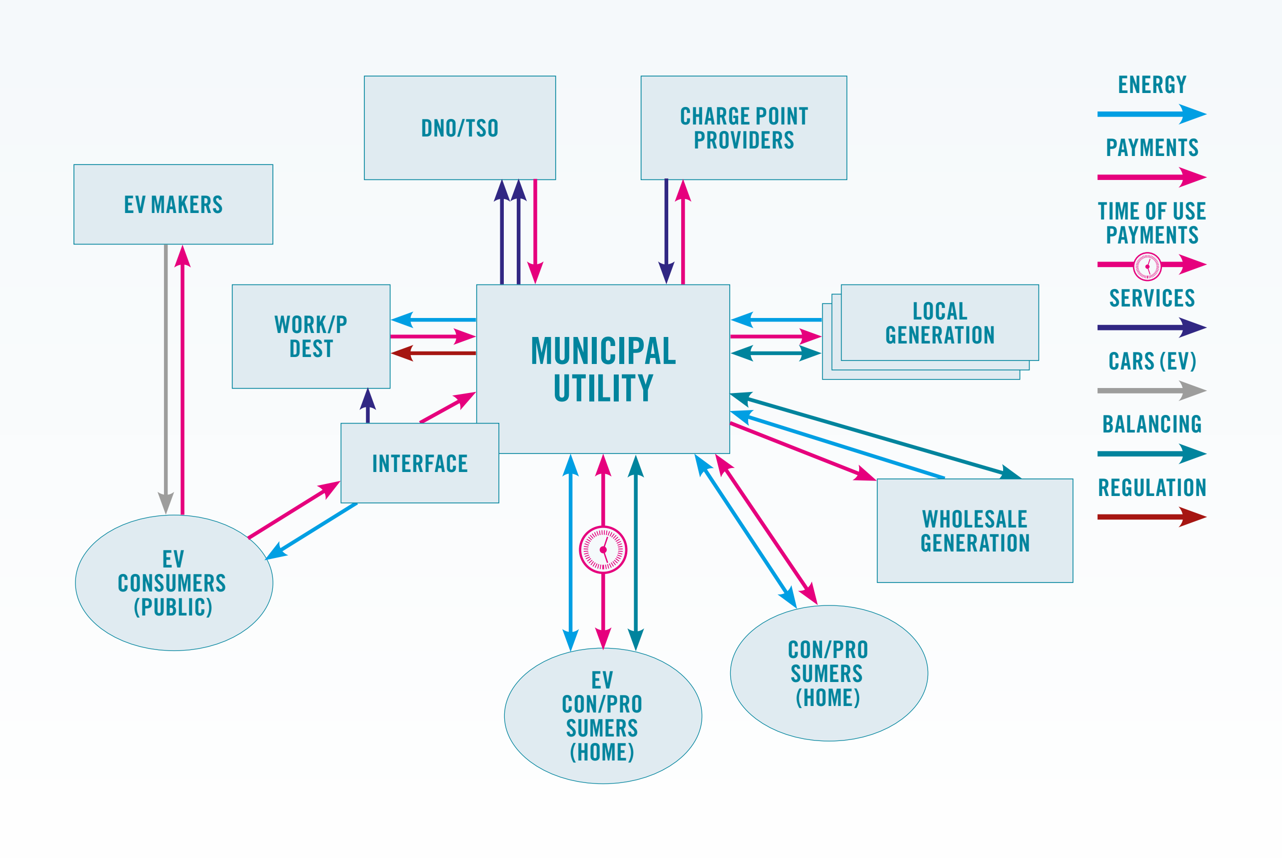
The current public charge archetype has helped cities learn how to site, maintain and best promote public charging. Current low utilisation rates of some on street infrastructure coupled with the need to begin levying a fee for EV charging, means utilisation rates may decrease further. Interviewees and focus groups agreed the business case for public charging is poor. With such patchy provision, it is unlikely this model will bring together the new revenues, partnerships, ancillary services of energy tariff structures that would fulfil the business model needs outlined in section 3. As a catalyst for the Innovation Interface this archetype is weak.

4.7 Public Charge Point: Municipal Lead Utility

This archetype is similar to the municipal mobility utility minus the lease element. Instead the municipal utility is fully licensed electricity supplier that also acts as the strategic infrastructure planner, energy utility, and charge point manager (or procurer) for a city charge infrastructure. Here the charge point providers are commissioned by municipalities to provide on street, workplace, and retail outlets which are accessed via a common interface. The municipality is the licensed utility and can sell electricity, charge time, or parking. The municipal utility can cross subsidise charge infrastructure from profits on domestic and commercial tariffs in the city.

More options are available to manage grid constraints, including demand side management of proximate loads that are supplied by the municipal utility. Charge points are becoming smarter and under aggregation may be able to offer frequency response or respond to load constraint, subject to negotiation between utilities and DNO/TSO. Customer experience may be undermined at more rapid charge locations. Local daytime charging can be 'pooled and sleeved' from local generation such as solar and EFW plants, to EV charge loads, thus capturing 'embedded benefits'. This is a 'smart city' type approach, but requires significant local expertise.

Figure 11: Public Charge Point: Municipal Lead Utility



Implications

Users

Focus group participants envisaged very little perceptible change on the user side for this model beyond the accessibility and coherence of the charge network. It is likely the network would be accessed by existing RFID cards or contactless technology. In terms of behaviour change little is expected, though consumers may need to give permission for the municipal utility to dial down charging in response to infrastructure stress or wholesale energy price spikes.

Regulation and Governance

All of the regulatory tools and governance precedents were thought to currently exist for this archetype to succeed; subject to barriers being overcome for the growth of municipal utilities in general[45].

Technologies

In terms of technologies required, focus group participants felt most already existed but had not been brought together in this constellation in the UK before. The key opportunity is for municipalities to strategically plan the publicly accessible charge network for user utility alongside network availability. However, there remains the gap of the DNO being able to directly monitor EV impacts of multiple low voltage feeders.

Energy and Transport systems

Here, the ancillary service market can be accessed during longer periods as charge points are utilised throughout the day and home charging predominantly undertaken at night.

Table 9: Public Charge Point: Municipal Lead Utility business model innovation needs analysis: +++ strong positive ++ moderate positive, + weak positive, -/+ no effect, - weak negative, -- moderate negative, --- strong negative

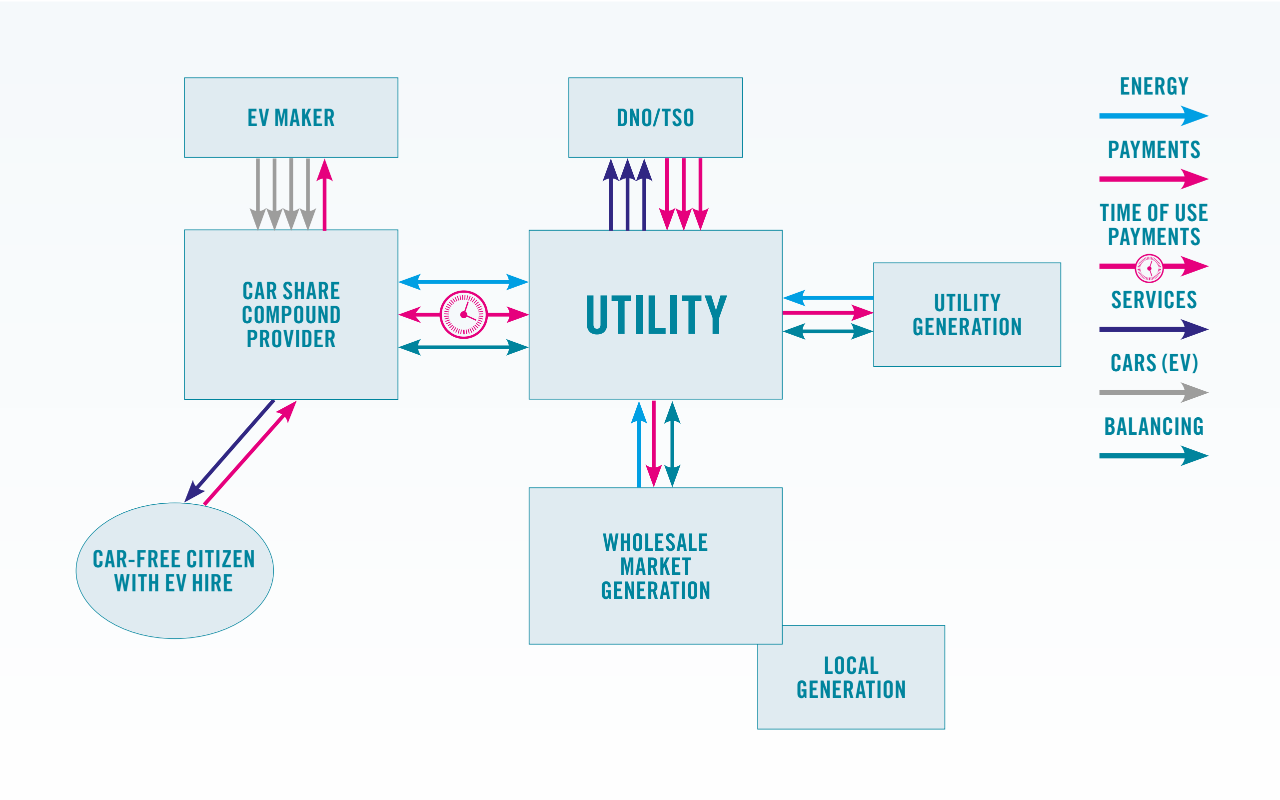
Business model innovation Need	Need fulfilment	Comments
Coherent and accessible charge network	++	Taking closer control of the charge infrastructure across a city would generate much more certainty over charge access for users and a clearer view on whole system costs. Some form of tax based public revenue is still likely to be required.
New routes to market/use models	-/+	No effect
Clarity on energy infrastructure capabilities	++	If this archetype were to proliferate based around good practise standards for charge access and strategic planning with the distribution network operators it would give some reassurance on energy system capabilities without requiring deep auto industry involvement.
Better optimisation of intermittent generation and EV Charging	+++	Additional daytime flexible load obtained through aggregated public charging would further strengthen the municipal utilities position in optimising local decentralised generation.
Tariffs to reward flexibility and response and new aggregator businesses/functions	-	Smart or responsive load management at public charge stations is more likely than individual customer reward as charge customers would be transient. The technological option exists, but constructing a fee/tariff structure to capture this for the user may be too complex.
Ability to anticipate and respond to network stress.	++	Future public charging can be enabled with hardwired control but the mechanism through which DNO's might signal network stress, and for charge providers to respond, is unclear in this model. However close integration of charge infrastructure planning and network management would ameliorate the need for real time monitoring and response.
Better partnerships with energy system stakeholders	+++	Here the city has become a fully licensed utility with full access to ancillary services, the ability to sign power purchase agreements with distributed generators, and has the ability to plan long term, city scale energy strategy.
Integrated service approaches to mobility	-	Continued provision of this archetype assumes further private car ownership.

In this archetype the municipal utility is able to extend the capture of renewable loads to daytime generation as well as night-time storage, as EV's are plugged in to their public charge network throughout the day. With a reliable load, local renewables can be sleeved to proximate storage and avoid negative price periods which undermine their business models. Being able to do so through the night into domestic and commercial premises, then operate the same method during the day, gives the utility more opportunity to match local supply with demand. This archetype links urban infrastructure provision and energy systems closely and has a strongly positive effect on that element off the Innovation Interface, the auto industry gains a small positive advantage through greater certainty over visible and accessible charge provision for EV buyers. In terms of a catalyst for the Innovation Interface this archetype is moderate/strong.

4.8 Smart Car Share Compound

In this archetype EV drivers do not own the car and access the vehicle from compounds in high demand locations. This model is particularly suited to urban areas with denser commercial and domestic land use and individual parking is at a premium. With multiple cars in one location, owned by the car club/share provider, the provider can benefit from a smart tariff from the electricity utility which can offer vehicle to grid services and bulk charge during off-peak periods when cars are also in lower demand. Grid reinforcement needs may be significant as compounds or parking towers may be in areas of high demand with already stressed grids. The car share provider would receive the benefits of flexibility and be able to pass this on as price completion to users.

Figure 12: Smart Car Share Compound



Implications

Users

For this archetype focus group participants variously underlined the availability and reliability benefits of a compound based EV mobility model, but also cited the more distributed street by street approach as more convenient in the conventional car club sense: *"Less convenient than the car clubs from a consumer perspective"*. One of the biggest barriers of car clubs is the distance to the nearest car." Planning EV compound location around transit hubs was suggested as a useful way to encourage integrated low carbon transport, but other focus group participants questioned whether this would be sufficient to make the model viable. Autonomous vehicles were also discussed as a potential solution, to the distance to the hub problem. From the user perspective the need for substantial charging behaviour change is absent as vehicle state of charge is managed by the compound provider; *"no hassle to you"*.

Regulation and Governance

For this archetype focus group participants highlighted land use planning pros and cons from different angles. The availability and cost of land in central/highly trafficked locations was questioned, as was the potential for multiple co-located vehicles to add to congestion.

In terms of energy system governance the electricity contract is commercial to commercial, and as such little regulatory oversight or planning would be required if this archetype were to emerge.

Technologies

The compound concept elicited most interest from the energy system stakeholders in the focus groups, largely due to the wider range and depth of services that become available with multiple high capacity batteries available on one site. Opportunities were highlighted around peak shaving, renewable energy integration, the ability to work closely with the DNO on relatively few, large sites, and the ability to enter the ancillary services market without substantial aggregation.

Energy and Transport Systems

This archetype clearly performed well in its integration with the energy system and focus group participants saw potential to link integrated transport solutions together, particularly 'last miles' solutions from transit hubs to workplaces and venues in this model. For the distribution network operator function, a compound may require re-enforcement, however smarter solutions would be available as load is geographically aggregated i.e. not spread across many low voltage feeders.

Table 10: Smart Car Share Compound business model innovation needs analysis: +++ strong positive ++ moderate positive, + weak positive, -/+ no effect, - weak negative, -- moderate negative, --- strong negative

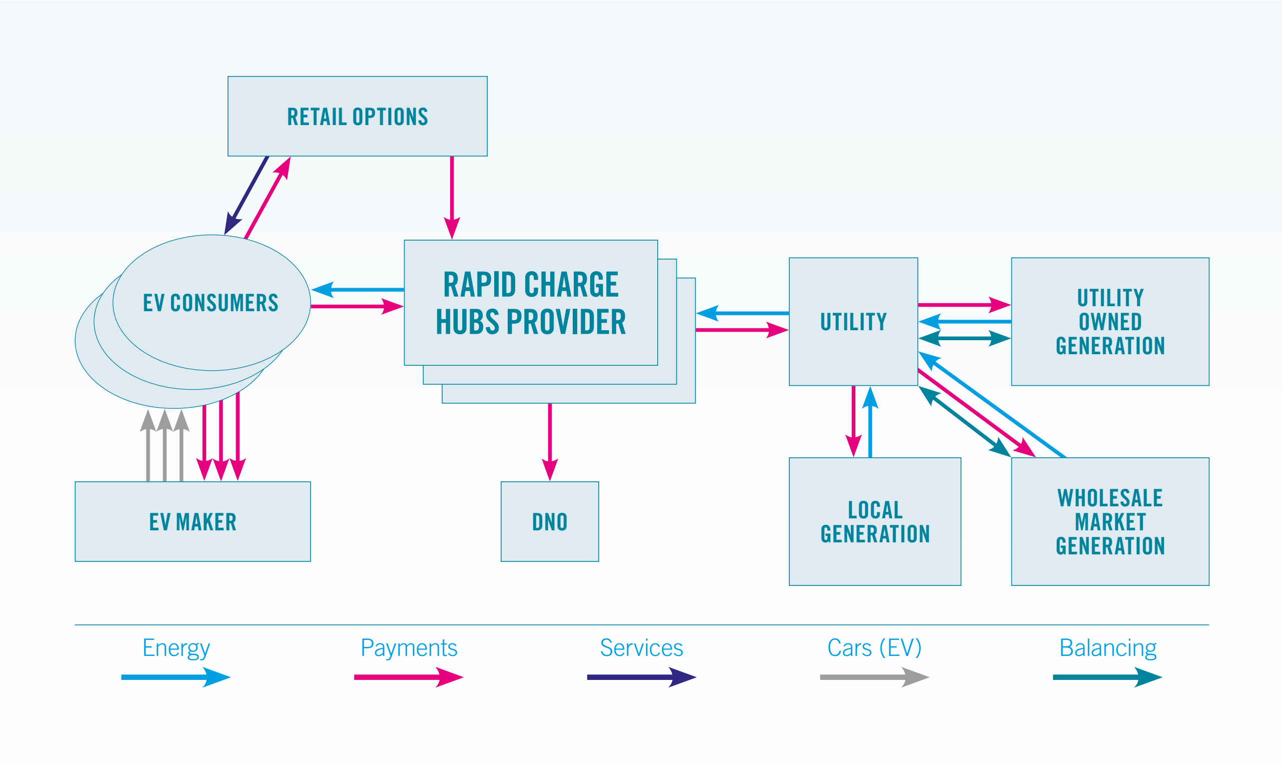
Business model innovation Need	Need fulfilment	Comments
Coherent and accessible charge network.	--	This model would substantially reduce the need for public accessible charging by replacing the private charge need with a pre-charged hire vehicle.
New routes to market/use models	+++	Highly positive as a new route to market, particularly for smaller, mass market models, is created by the compound buying multiple vehicles.
Clarity on energy infrastructure capabilities	-/+	No effect
Better optimisation of intermittent generation and EV Charging	++	Night and daytime flexible load obtained through aggregated compound charging. This would provide fewer, larger storage sinks for intermittent and decentralised low carbon generators. Decision on what values to optimise for (low-carbon, price, speed of charge) would determine potential.
Tariffs to reward flexibility and response and new aggregator businesses/functions	--	While this archetype enables e-mobility it may undermine the value of domestic and small commercial aggregated flexibility by constructing a large flexible grid resource which is better able to capture ancillary services. This would undermine utilities drive to aggregate EV storage in homes and businesses due to a weaker price signal.
Ability to anticipate and respond to network stress.	+++	Any compound with multiple electric vehicle batteries charging in tandem would place stress on the network, but it would do so in fewer larger locations where more creative grid management can be delivered. DNO works in partnership with both compound company and energy provider to hardwire constraint solutions.
Better partnerships with energy system stakeholders	+	Here the city is closely involved with the land use planning impacts of this scheme. However, largely this is a commercial charge hub. The city may reap air quality benefits but is less involved in the energy management of the archetype.
Integrated service approaches to mobility	+++	This is a clear move away from personal ownership and provisions the city with an integrated 'last miles' option, breaking down barriers to transit use and offering alternatives to personal vehicle purchase.

By aggregating vehicles in compounds this archetype offers substantial potential for most ancillary energy services. Though it does not incentivise new flexible tariffs or new public charging, it ameliorates the need for them by offering a different service model. Auto makers achieve a new route to market in terms of bulk sales, and this model offers the electric vehicle driving experience to a new market segment. The city realises a new service based element to mobility that does not require on street charge installation, and depending on the ownership of the compound this could encourage new partnership with the energy providers. In terms of catalysing the Innovation Interface, this archetype is moderate as it engages with business model needs across all three stakeholders.

4.9 Rapid Charge Hubs

Here private and commercial customers own the vehicle and pay for rapid charging at a hub similar to a traditional re-fuelling station. There are retail opportunities available during the 10-20 minute wait necessary for recharge on a rapid charger. The retail concessions somewhat offset the cost of the infrastructure. The presence of several rapid charge points in a single location would lead to a large load on a small geography and would likely require distribution grid upgrades. There is little foreseen potential for vehicle to grid or electricity market services such as demand response, because the duration of charge will be of primary concern. Whilst this business model would be a significant innovation in the urban landscape it does not enable multiple smart city options due to its high one directional power requirements.

Figure 13: Rapid Charge Hubs



Implications

Users

Focus group participants and interviewees consistently referred to the rapid charge archetype as a convenience based archetype for users, particularly in terms of *"certainty of charge and reduced location anxiety"* i.e. being able to find a charge station. It was considered "great for the user = availability and visibility" but it was felt there would be potential for confusion if the charger had to step down power at peak demand times, such that smarter charging may be ruled out in favour of charge speed. Participants and interviewees cited the *"opportunity for additional [mainly retail] services while charging. Retail e.g. supermarkets can benefit. New role for convenience stores?"* Though most saw home charging as remaining dominant, rapid charge stations may act as supporting or top up if needed. Of importance to city managers was the ability of this archetype to enable those without off street charging to participate in the EV market.

Regulation and Governance

Given that the electricity tariff end of this archetype would be a commercial to commercial relationship, with consumers paying for charge 'at the pump', the energy market regulation implications were felt to be low. There is also precedent for this in the Ecotricity rapid charge network currently operating in most motorway service stations in England. The main regulatory concern was the sharing of the cost of the DNO connection which may be prohibitive.

Technologies

On the network capacity issue the main technological need identified by both focus group participants and interviewees was the need for active management systems. Though users may not accept long interruptions they may accept shorter ones of less than 1 minute to manage the high peak of circa 10 EVs starting a rapid charge at once. One DNO representative suggested this could substantially reduce the re-enforcement need as the worst case scenario would be greatly reduced. In this archetype there was broad consensus in the focus groups that a hardwired DNO response would be required to prevent overload. However, having to deal with a network of rapid charge station in tens or low hundreds would be less complex than doing so household by household. There was significant discussion about the possibility to link solar generation with rapid charge hubs and also allow battery storage to ameliorate network stress and provide ancillary services. This was a gap in the investigated archetypes and is considered below under 'hybrid' approaches.

Energy and Transport Systems

The main message back from both focus groups and interviewees was that though the rapid charge station archetype would be a significant innovation in the city infrastructures, it would not enable a high degree of smarter services or fulfil business model innovation needs in the energy system. This is because the main value proposition to the customer is as rapid a charge as possible. Interrupting or even reversing this charge while customers wait is likely to be unacceptable. Where urban air quality may benefit from inner city drivers switching to EVs, safe in the knowledge a rapid charge station is available, the energy system may lose out on the potential for better balancing and smarter services.

Table 11: Rapid Charge Hubs business model innovation needs analysis: +++ strong positive ++ moderate positive, + weak positive, -/+ no effect, - weak negative, -- moderate negative, --- strong negative

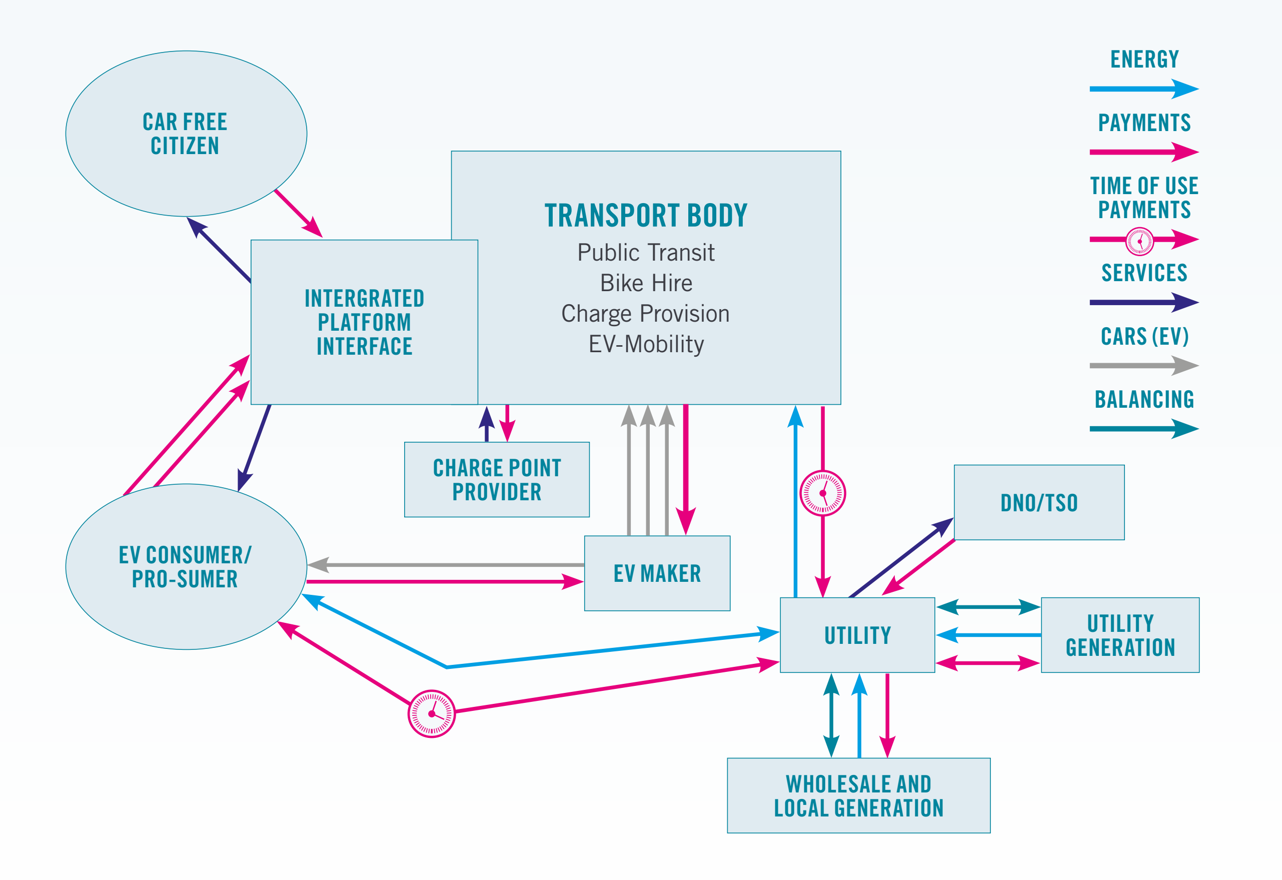
Business model innovation Need	Need fulfilment	Comments
Coherent and accessible charge network	+++	Highly visible, rapid charging, on a relatively familiar 'filling station model' would give more certainty to buyers. Also the captive retail demand of charging customers provides new revenue opportunities.
New routes to market/use models	-/+	No effect
Clarity on energy infrastructure capabilities	-/+	This model has the potential to both encourage the development of larger battery, faster charge vehicles, and simultaneously further stress energy networks, ultimate impact is unclear for this need.
Better optimisation of intermittent generation and EV Charging	--	Consumers likely to charge during peak travel hours which overlap with peak electricity pricing. Rapid charge electricity is therefore likely to be higher carbon and higher price than domestic slow charging.
Tariffs to reward flexibility and response and new aggregator businesses/functions	--	This model may undermine the need for smarter and more flexible tariffs as consumers use a convenient solution more frequently. Home charging likely not abandoned, but other options may reduce use.
Ability to anticipate and respond to network stress.	--	Likely to exacerbate network stress and lead to substantial re-enforcement.
Better partnerships with energy system stakeholders	-/+	Effect depend on ownership of the rapid charge hubs.
Integrated service approaches to mobility	-/+	Has the potential to allow EV mobility solutions to penetrate where no off street charge infrastructure available, but may also re-incentivise private vehicle ownership in those areas.

This archetype would be an innovative addition to urban e-mobility infrastructures and would only require slight behaviour changes (increasing wait times at re-fuelling/ charging points). This archetype's proliferation would also open up e-mobility to those without off street private charging. Conversely the range of ancillary market services available, and the opportunity to better utilise intermittent renewables is negatively affected. In terms of catalysing the Innovation Interface this is a weak archetype, but does present cities with a useful option for bringing in new EV drivers in inner cities.

4.10 E-Mobility Service Archetype

This archetype is built on a full mobility option for citizens, including access to an electric vehicle for those who do not own a car. Electric vehicles form part of an integrated mobility package. This package is a multi-modal mobility service offer, managed by the local transport authority. Citizens sign up to have all mobility charged against a mobility account. This is similar to a car club but is incorporated into the wider transit offering of the city. This combines the convenience of integrated ticketing such as TFL's Oyster Card and the flexibility of short term vehicle hire. Vehicles are in a variety of compound and on street locations such as in the Paris Autolib scheme. The integrated platform can also serve private EV drivers by providing charge points throughout the city. Thus, one mobility service provider caters to private and shared vehicles, and would have a load control offer to an electric utility or grid/ system operator. There is little optimisation of local generation however, as the utility remains nationally focused.

Figure 14: E-Mobility Service Archetype



Implications

Users

The initial reaction from focus group participants on user implications was to question demand. There was extended discussion over whether fully integrated city standardised options are preferable to multiple private offerings now that many inter model transactions can be dealt with via contactless card technology: *"Why is this necessary? Why isn't this just using your credit card?"* The second issue highlighted was the need to shift the behaviour of drivers to being 'car free' though there was some discussion over whether going car free was more to do with new urban lifestyles as opposed to a shift in the behaviours of existing car owners.

Regulation and Governance

There was close discussion in focus groups over the complexity of adding another layer of governance to mobility provision in the city. Participants pointed to existing route mapper services offered by Google, which will plan integrated journeys. Some discussion in focus groups centred around how an integrated platform could use surge pricing to incentivise mode shift at peak times. *"If you have an integrated view at city scale you can manage more effectively through tools such as surge pricing."* Other discussion focussed on whether a single service could crowd out further mobility service provider options: "[is] *competition facilitated or restricted by government intervention in a single model?"* There were very few systemic issues discussed on the energy system side, when questioned by facilitators participants responded that this was due to the utility maintaining a national role. There was one suggestion to link with a municipal utility approach as this would present a fully integrated model, but this option was not formally explored in the focus group sessions; see 'hybrid approaches' below.

Technologies

Reflections on technological implications focussed on the single interface possibility and utilisation of the *"Internet of things"*. The system integration was seen to be more of an ICT issue as opposed to fundamental technology barrier. The possibility of linking such an urban solution to driverless cars was raised; in particular this was thought to get away from the individual insurance problem, though it was remarked other car clubs already manage this. The need for an accessible single platform to enable this archetype to work was raised again.

Energy and Transport Systems

The focus group participants saw the greatest benefit in linking up EV drive with other mass transit options such as park and ride. The ability to charge EVs at park and ride sites as opposed to bringing them into the city to worsen congestion was multiply cited. There was less discussion over the potential energy system links, though it was recognised that the city owned EV's (the car club vehicles) should be able to offer some ancillary services when aggregated.

Table 12: E-Mobility Service Archetype business model innovation needs analysis: +++ strong positive ++ moderate positive, + weak positive, -/+ no effect, - weak negative, -- moderate negative, --- strong negative

Business model innovation Need	Need fulfilment	Comments
Coherent and accessible charge network	+++	Taking closer control of the charge infrastructure across a city would generate much more certainty over charge access for users and a clearer view on whole system costs. Some form of tax based public revenue is still likely to be required. In this model charge infrastructure can become part of an integrated infrastructure package.
New routes to market/use models	++	As the city buys multiple vehicles to serve 'car free' citizens the auto makers realise a new route to market, particularly for smaller city cars.
Clarity on energy infrastructure capabilities	+	If this archetype were to proliferate based around good practise standards for charge access and strategic planning with the distribution network operators it would give some reassurance on energy system capabilities without requiring deep auto industry involvement. However, the desire for faster home charging remains problematic.
Better optimisation of intermittent generation and EV Charging	+	There is little link with local energy sources here, there may be some benefit from aggregated flexibility on other distributed load connection costs.
Tariffs to reward flexibility and response and new aggregator businesses/functions	-/+	No effect
Ability to anticipate and respond to network stress.	++	Future public charging can be enabled with hardwired control but the mechanism through which DNO's might signal network stress, and for charge providers to respond, is unclear in this model. In this model the city only has oversight over the public network.
Better partnerships with energy system stakeholders	+	The city will be able to offer new flexible load to the supplier and gain some foresight over use of the public network. However new relations with the DNO limited to public charge point connection and management.
Integrated service approaches to mobility	+++	This archetype is built on a full mobility provision for citizens. The option to avoid a private vehicle purchase is more realistic, particularly for those whose car use is infrequent but essential.

This archetype is based around using EVs as a low-carbon, air pollution reducing addition to existing transport options in the city. By integrating the car as a mode in a wider transport offering, citizens can access electric vehicles without needing a long term hire/lease or a large private purchase. In terms of the fulfilment of business model innovation needs this archetype satisfies more of the auto industry and urban infrastructure needs than it does energy system needs, since the utility remains relatively passive. It is particularly weak in terms of capturing the benefits of distributed generation optimisation. In terms of catalysing the Innovation Interface this archetype is strong, but other archetypes perform better across energy system needs.

4.11 Potential for hybridity

Both the interview and focus group phases of this research highlighted the potential for each of these business model archetypes to be amended or hybridise with others to capture different value propositions. However, due to the resources available not all archetypes mentioned could be constructed and interrogated. While there is clearly potential for multiple hybridisation, three specific possibilities were alluded to more than once. Though these 'hybrid' archetypes were not subject to full investigation and no focus group work was done to define possible implications, it is useful to list them below as each one ads something to those formally investigated above.

1. **Rapid charge hubs and battery storage.** Here the constant high power demand from a rapid charge hub would be balanced against battery storage. As the rapid charge hubs may require substantial distribution network upgrade, some of this cost could be avoided by using a battery to smooth peaks in demand. The sizing of the battery would be relative to the infrastructure costs it could defray, plus the batteries ability to store off-peak priced electricity and deliver this to vehicles during periods of higher wholesale prices. This addition would take the rapid charge hubs from a moderate performer in terms of the Innovation Interface to a strong performer, however solutions may need to be modular to suit conditions at each rapid charge hub.
2. **The Auto Utility.** In the 'EV White Label' archetype above, the auto industry partners with an existing licensed utility to manage electricity market services and deliver electricity to the vehicle. However, there is no legal barrier to car manufacturers or retailers from the auto industry acquiring a licensed utility of their own to sell electricity[xxiv] to new EV consumers. Arguably this model would bring battery degradation and warranty concerns 'in house' and give the auto industry much better visibility on energy system requirements and more insight over the technical limitations of the system the vehicles rely on. In terms of catalysing the Innovation Interface this may fulfil more business model needs on the energy and vehicle side but does little to engage with the needs of cities.
3. **E-Mobility Service + Municipal Mobility Utility.** There is clearly potential to link the final 'E-Mobility Service' archetype to the Municipal Mobility Utility archetype. The first is a transport and transit focussed offer while the Municipal Mobility Utility is more focussed on the energy offer. By combining the two at the city scale all of the business model needs of the parties may be met. The auto industry gains new routes to market and can engage with a utility close enough to the distribution system to forge meaningful strategic partnerships. Ancillary energy services and distributed generation optimisation are possible, and there are new partnerships available to the city in the energy space as well as a 'car free' mobility service offer. This archetype would strongly catalyse the Innovation Interface but it would also require a great many new functions to be ceded to municipalities in terms of citizens' auto-mobility and energy needs as well as more familiar services such as transit, waste and highways.

Each of the above hybrid archetypes demonstrates the potential for further business model innovation beyond what has been interrogated by the formal empirical methods in this study.

[xxiv] And usually gas to ensure dual fuel customers are captured.

4.12 Business model archetype performance at the Innovation Interface

This section has investigated the operation and implications of ten business model archetypes at the Innovation Interface between the auto industry, the energy system, and city infrastructures. Table 13 below summarises and compares how each archetype performs across the business model innovation needs of the three sectors.

Table 13: Business model archetype comparative analysis.

Business Model Archetype	AutoIndustry & Cities	Auto Industry	Auto Industry	Energy System	Energy System	Energy System	City Governments	City Governments	Net Strength* of Business Model as an Innovation Interface Catalyst
	Coherent and accessible charge network.	New routes to market/use models	Clarity on energyinfrastructure capabilities	Better optimisation of intermittent generation and EV charging	Tariffs to reward flexibility and response and new aggregator businesses functions	Ability to anticipate and respond to network stress.	Better partnerships with energy system stakeholders	Integrated service approaches to mobility	
1. Current Archetype with static ToUT	-	-/+	+	+	+	-	--	-	**Weak**
2. The Smart Utility	-	-/+	++	+	++	++	--	--	**Weak/Moderate**
3. The EV White Label	-	+	+++	+	+++	++	--	-	**Moderate**
4. The Mobility Utility	-/+	+++	+	++	+++	++	+	+	**Strong**
5. The Municipal Mobility Utility	++	++	++	+++	++	+++	+++	-/+	**Strong**
6. Public Charge Current Archetype	-	-/+	--	-	-	+	+	-	**Weak**
7. Public Charge Municipal Lead Utility	++	-/+	++	+++	-	++	+++	-	**Moderate/Strong**
8. Car Share Compound	--	+++	-/+	++	--	+++	+	+++	**Moderate**
9. Rapid Charge Hubs	+++	-/+	-/+	--	--	--	-/+	-/+	**Weak**
10. E-Mobility Service	+++	++	+	+	-/+	++	+	+++	**Strong**

**Weak = 0 net positives. Weak/Moderate = 1-5 net positives. Moderate = 6-9 net positives. Moderate/Strong =10-12 net positives. Strong = 12 or higher net positives.*

It is important to note that some business models service all or many of the needs of one constituent of the Innovation Interface while leaving others unfulfilled. Some are stronger on the energy systems side, some better fulfil city infrastructure needs, while some are most beneficial to the auto industry. It should also be noted that those that perform best are also the most complex value propositions that require the co-ordination of many revenue streams across different systems. They are 'complex value business models' in that they rely on the production of financial, developmental, social and environmental benefits which accrue to different parties, across multiple spaces and times, and through several systems.[40]

Because these value propositions are complex and their ultimate financial sustainability is uncertain, it will not hold that the strongest catalyst of the Innovation Interface will necessarily become the dominant paradigm in the e-mobility transition or even a substantial player. For example, in the interviews with city managers the rapid charge hubs were generating the most interest:

> **"Well I mean we are aware of the sort of opportunities in terms of things like development of different solutions, things like the charging hubs which I've mentioned. I would love it if we could establish a series of charging hubs across the city."**
>
> (Source, City Government Officer, 2016)

> **"…the people who don't have off-street charging and would need to have some kind of on-street facility. If you look at that group alone; you can see it is one in ten drivers. The demand for that will exceed the need for public infrastructure for drivers that have home charging. So it's a whole other user group with a whole other set of needs and they're likely to want more petrol station type models."**
>
> (Source: City Government Officer (unique to above), 2016)

Similarly, though the Mobility Utility performs strongly in terms of the Innovation Interface, it is a substantial transition for utilities to adopt. It means a move away from selling commodities to selling a bundle of services, goods and commodities:

> **"…you have a new set of propositions that need to be developed to actually make this work and it's very, very different from just commodity sales."**
>
> (Source: Energy Supplier, 2016)

It is possible that those archetypes that perform best in the e-mobility transition are those which fulfil some but not all business model innovation needs, and are in relative terms simpler to operate, it is beyond the scope off this report to predict which these may be. However, given the benefits to catalysing the Innovation Interface, it is important to explore where and how this might be facilitated. In the next section we present our recommendations for various constituents in the e-mobility transition.

5.0 Barriers and recommendations

Section 4 shows that the national and municipal 'Mobility Utility', and 'E-Mobility Service' archetypes have the greatest capacity to fulfil the business model innovation needs across the three systems. However, as each business model need is fulfilled a further level of complexity is added in terms of either the user interface, market regulation, technology needs, or at the energy or transport system level. It is quite possible that less effective but simpler archetypes could gain market share in the short to medium term, as co-ordinating all the actors across the Innovation Interface may prove complex.

Each archetype however faces different barriers to adoption. From phases 1 & 2 of the empirical work, some common barriers emerged which apply to more than one archetype. These barriers are synthesised below and from each a recommendation is made which is designed to enable the operation, or further exploration of the archetypes investigated in this report.

5.1 Energy Tariff Innovation

In their recent review of energy markets the Competition and Markets Authority found tariff simplification rules by Ofgem have limited suppliers to four core tariffs and constrained innovation the energy system[94]. Interviewees across government and industry expected the CMA to recommend the tariff cap be lifted, which the CMA did in June 2016 and Ofgem is expected to follow this recommendation at time of writing. Section 3.2 demonstrated the need for energy utilities to develop new tariff offerings for EVs which better reflect wholesale pricing and pass market signals onto consumers. However the current size of the electric vehicle market can preclude offering a new tariff, as national utilities often require substantial market size relative to their existing portfolio:

> **"…We did actually offer an EV tariff back in 2011. […] but it's something that has previously been looked at. Whether it actually got sold to any significant amount of customers or not is a very different question and I don't know on that one. It is always that question, you can offer something, but until it's a mass market…"**
>
> (Energy Supplier, 2016)

Incumbent suppliers require large market sizes to justify the creation of new tariff, this is compounded by the fact that existing suppliers have an element of incumbent 'inertia' in switching domestic and small commercial consumers over to smart meters to enable these smarter tariffs. Some 'challenger' suppliers, new utilities in the market, have elected to go 'smart from the start' and do not have legacy infrastructure to switch over, the same energy supplier respondent felt these challenger suppliers may be more able to create smart EV tariffs.

"…what will happen when that [smart metered EV tariff] becomes possible? Because I think you get early adopters who are doing it, who both already have a proper smart meter and are aware enough of the implications because they will get a better deal at this stage. You know, when there's not that much take-up and therefore it's pricing it through. They will be small numbers and probably offered by a limited number of smaller suppliers who don't already have massive customer portfolio of customers who don't do that. The systems will have been designed, future designed as it were…"

(Energy Supplier, 2016)

The recommendation is for energy supply companies, particularly challenger utilities to use this opportunity to pursue tariff experimentation with new partners in the auto industry or in the city. This research discovered a clear need for new tariffs to reward flexibility and response from consumers. By partnering with either the auto industry or cities, energy supply utilities will identify a route to market for new tariffs which has the potential to meet the customer numbers needed to make the offering sustainable.

This opportunity is particularly salient to new utilities which do not have legacy 'dumb' meter infrastructure or high hurdle rates for initial consumer numbers for new tariffs, meaning they can build flexible tariffs from the start. Tariff flexibility is relevant to all archetypes, but particularly relevant to those suited to challenger utilities, such as the Mobility Utility, Municipal Mobility Utility, and potentially the EV white Label Archetypes.

The extension of the smart tariff in the 'mobility utility' archetype also envisages the electricity and vehicle payment being rolled into one. This service bundling has not yet entered the market and there may be specific regulatory concerns about the bundling of the two services. The proliferation of electric vehicles is likely to lead to questions for the electricity sector regulator to scope the impacts of bundled service provision. Our sample also highlighted the increase in data protection needs when bundling EV services into an electricity bill. This should also be a focus for regulators when assessing tariff experimentation with EVs.

Recommendation #1

Pursue tariff experimentation and scope regulatory effects of mobility service bundling

Principal Agents: Energy supply utilities, Ofgem.

5.2 Infrastructure Stress

The majority of archetypes proposed also have the technical ability to anticipate and respond to stress on the physical distribution network, i.e. the neighbourhood scale. Where EV consumers are smart meter enabled the EV charge can be interrupted if stress on the local network is anticipated. However, doing so through the smart meter implies a relationship with the smart meter data hub which is one level removed from the direct control of Distribution Network Operator companies. Whilst most of the proposed models show a positive impact on the distribution network, this is either because current periods of network stress coincide with high energy prices, therefore time of use tariffs are compatible with using the grid within limits, or because the archetype offers better data for network planning. It may be the case that managing network stress through commercial innovation (i.e. within the energy bill of the EV consumer) may be over complex, and regulatory standards may be a more effective option.

The 'My Electric Avenue' project demonstrated the potential for demand response to be hardwired into vehicle charge points which respond to signals from monitors on low voltage sub stations[84]. This project showed that hardwired DNO intervention in the charge cycle is acceptable to customers over a 15 minute rolling period. The hardwiring of demand response with no remuneration through the electricity tariff is important, as many of the archetypes above cannot instantly signal and respond to distribution network stress, and rely on consumer behaviour. While ancillary services to National Grid and price responsive tariffs can be rewarded through consumer bills, it is likely DNO level demand response needs cannot, due to their scale and diversity. As such a hardwired, non-rewarded[xxv] option that operates to a common standard may partially meet business model needs #3 and #6; the auto industry's need for better clarity on energy system capabilities (customers unlikely to overload local network) and also the energy system's need for anticipation of and response to network stress. This could be achieved by mandating charge sockets installed after a certain date meet a British or International standard for charge interruption[112]. This same demand response capability would also enable many of the ancillary energy services identified in table 1. This may be done through local planning regulation for the socket installation or through a wider 'CE' approach which would expand coverage across the European Economic Area[xxvi].

Recommendation #2

Investigate a common technological standard for EV charger interruption with Distribution Network Operator access.

Principal Agents: British Standards, Planning Authorities and UK Parliament[xxvii].

[xxv] The term 'non-rewarded' means the specific demand response of charge interruption would not be remunerated to individual consumers but would benefit consumers across a DNO geography in lower network charges.

[xxvi] https://www.gov.uk/guidance/product-safety-for-manufacturers

[xxvii] It is unclear at the time of writing whether the UK will remain subject to the rules of the European Economic Area and this would affect the geographic reach of any developed standard.

5.3 Access to charge infrastructures

During the course of this research almost every participant in interviews and focus groups accepted that, for those with access, home and workplace charging will make up the vast majority of electric vehicle charging and this is supported by real world use data[113,114]. However the same data demonstrates most consumers find it 'very' or 'quite' important that a more accessible on street or public option remains available. The first identified business model need from the auto industry is to be able to show new EV buyers that a coherent and accessible public charge infrastructure is available.

There is an over provision of publicly accessible charge infrastructure in some UK cities and a substantial under provision in others. This is largely due to the current archetype of public charge point provision being grant dependent. Recent moves to recoup some revenues by making charge points 'pay to use' as opposed to free will recoup some value, however charge point providers were clear that in many locations outside London the public charge solution only works where there is a *"business model positive to the host"* that goes beyond the sale of units of power (such as footfall or staff retention). For public charge points the business model positive to the host, i.e. the city, is air quality improvement, decarbonisation, and economic development. As there is very little data on real world air quality improvements from e-mobility transitions, and substantial difficulty in measuring and re-allocating health savings, it is recommended that public EV charging provision becomes a responsibility of municipal transport authorities. To do so a set of minimum standards for alternative fuel infrastructure should be agreed by major cities in the UK in the first instance. Prior to the UK's vote to leave the EU, Directive 2014/94/EU[115] on the on the deployment of alternative fuels infrastructure, would have driven all city regions to provision appropriate publicly accessible charge points. However the vote to leave the EU has left the future of some standardization mandate uncertain. If citizens, cities, and the auto industry are going to benefit from public charging infrastructure provisioned across all cities, minimum standards should be adopted that reflect the needs and demands of each city. Recent work by Element Energy for Birmingham and Liverpool City Councils'[20,21] has demonstrated the potential for rationalizing charge infrastructure across individual city geographies (albeit for captive fleets), and mandating similar strategic planning for the publicly accessible network is an important next step to ensure the current divergence of provision across "winner/loser" cities does not continue.

Recommendation #3

Define minimum standards of access and provision for public charging coverage

Principal Agents: Department for Communities and Local Government/Department for Transport. Also Core Cities group, Transport for the North, Transport for London.

5.4 Energy market regulation

One of the most important elements of energy system liberalisation was the ability of the consumer to switch their electricity supplier within a 3-4 week period. The competition created by consumer choice is a cornerstone of current market regulation. However, as new micro generation, storage, and smart home/vehicle solutions become available, there is increasing attention on whether the installation cost of these technologies can be incorporated into energy bills. If these solutions are to be financed on energy bills, this implies a long term relationship with a single bill provider. This means it is unlikely the consumer could switch supplier in the 3-4 week period enshrined in system regulation[116,117]. One of our interviewees put it thus: *"essentially, there's no point investing 20k into a customer that is going to change [switch] in the next six months, so you would be looking much more to create a partnership essentially with the customer."* However such partnerships are not possible within current system legislation. Critically, the functioning of the Innovation Interface may depend on new permissions being made by the regulator to allow a bundled service contract over several years in a single dwelling. This may require benchmarked price control as the consumer may have no option to switch supplier for circa 10 years depending on initial investments. These conditions have hitherto been enshrined in EU law, however the UK's vote to leave the EU provides the opportunity to re-assess the blanket switching requirement for domestic consumers, and could do much to catalyse the Innovation Interface and e-mobility transitions.

"I think there's a question about, well who would OFGEM require to provide this if it was going to be done through your electricity bill, because at that point we need to start to say, right I'm going to have my electricity bill from company X, I'm now going to sign a contract and you would have an ability to have a contract which will bring through even more problems because OFGEM is seemingly going down the route where they want to remove any ability to stop it switching. So then you've got a big credit risk on that, but then you would have say, unless every supplier can offer it you will then be constraining the market because if you have it with one supplier and you want to move to someone else who doesn't offer you that, well then you're stuck because you wouldn't be able to send the car back, or no one is going to accept that you probably a huge exit fee and all that sort of thing."

(Source: Energy supplier, 2016)

This problem is particularly acute for the 'mobility' archetypes (mobility utility, municipal mobility utility) where the electricity bill is part of a wider mobility package. The 'Mobility as a service' offering may roll the vehicle energy into a wider payment scheme, but where vehicles are charged at any private dwelling or on a commercial customers premises this will either require a new dedicated meter, an on-board meter, or have to engage with market switching regulations.

Recommendation #3

Regulatory reform of supplier switching mechanism to enable longer contracts for EV power supply.

Principal Agents: UK Parliament, Department for Business Energy and Industrial Strategy, Ofgem.

5.5 Closer city partnerships

The recent work by Nesta and Accenture in partnership with Future Cities Catapult called for the comparative analysis of new business models undertaken above, it also highlighted cities unique role in facilitating and brokering new partnerships around critical infrastructures and digital innovation[39]. For the Innovation Interface to operate effectively, cities should lead and convene new partnerships with the auto industry, the energy sector and the charge infrastructure supply chain to identify the business models that suit their needs.

Archetypes such as the Rapid Charge Hub, the Car Share Compound, and the Municipal Lead Utility (public charging), would benefit significantly from closer partnerships between the host city, charge infrastructure providers, and the energy industry.

This report is the first comparative analysis of electric vehicle business models across these sectors in the UK, and builds on a growing literature[105,118,119,44] that explores how different business models and value propositions can capture different benefits. Cities across the UK have the institutional capacity in Combined Authorities[39] to convene stakeholders across the Innovation Interface to select, pilot and scale out new e-mobility business models such as mobility as a service models. In particular cities have the ability to co-ordinate surge pricing and public transport links with mobility service models. This partnership with urban transit and active modes provision is critical, as recent work suggests shared mobility options may do more to reduce transit ridership numbers than reduce car ownership[120].

Recommendation #5

The city to act as a partnership broker

Principal Agents: Combined Authorities, Local Enterprise Partnerships.

5.6 The city utility

The final recommendation from this work is for cities in the UK to undertake a close analysis of the benefits of setting up a municipal utility to support e-mobility business models. This will include detailed analysis of whether the air quality, carbon reduction, economic development and transport benefits of setting up an energy utility are a sufficient to justify following Nottingham, Bristol, and other city councils' actions in entering energy markets to serve their citizens[121,40]. Much of the focus of these new municipal utilities has been on reduction of fuel poverty and offering fairer tariffs. However for Bristol in particular there is wider ambition to link sources of local generation with local demand. As demonstrated throughout the comparison of business model archetypes, the opportunity to more effectively achieve this local balancing via vehicle batteries as storage is an opportunity for further decarbonisation, economic development, and is can deepen air quality improvements beyond EV adoption alone. It is only with a geographically focussed utility that this balancing is most effective[40]. Given the cities' drivers on air quality, carbon reduction and opportunities in the green economy, this municipal utility model may make sense for more than the first few pioneer councils. The possibility to link mobility as a service models with municipal utility models at the city scale could rapidly catalyse the Innovation Interface.

Recommendation #6

Cities to analyse business case for establishing a supply utility.

Principal Agents: City Councils, Combined Authorities.

5.7 Avenues for further research

Several questions were raised by this research which were beyond the scope and resource of the project, but which warrant further work.

The first is a need for more attention to the regulatory effects of energy and mobility service bundling. Specifically the regulatory effects of service bundling of mobility and energy payments. There is little work on the potential consumer impacts of service bundling. As metering devices become more able to separately account for various appliances and services, the distributional and competitive impacts of such tariffs need to be appreciated to ensure fair access.

There is also a need to scope the size of the value pool for each of the business models archetypes proposed. The purpose of this work was to explore which archetypes may exist and what their implications are, by quantifying the potential revenues from each archetype under various scenarios, researchers will be able to demonstrate where the largest commercial opportunities arise.

Further work would also investigate the role of metering in linking the vehicle to the energy-system. The archetypes above assume a fixed meter point, this assumption should be challenged, as efforts are ongoing to produce standardised requirements compatible with on-board metering, but these are unlikely to take effect in the short term[122]. Further research should explore the business model innovation opportunities of on-board metering with regard to extending the possible business models available in the e-mobility transition.

Finally and most importantly, the user element of the e-mobility transition requires further investigation. To appreciate the appeal of new business model archetypes to consumers, researchers should use these archetypes and others like them to explore consumer reactions to mobility service packages, intelligent energy services, and different configurations of public charge infrastructure. This will move research beyond what innovative business models are possible, to define which are likely based on current preferences.

6.0 Conclusion

This report has identified the Innovation Interface as an important concept in the e-mobility transition. Without new business models and new partnerships between the auto industry, energy system, and city infrastructures, the e-mobility transition may struggle to reach enough citizens to make meaningful contributions to air quality improvements and greenhouse gas reductions from transport. Without new business models the technical potentials of storage supported local energy systems, and mobility oriented transport systems could be missed entirely.

This report identified 9 business model innovation needs across three systems – vehicles, energy and cities. Our analysis has shown how 10 business model archetypes, current and future, may fulfil these 9 innovation needs and synthesised expert opinion on their implications for users, system governance, technical needs, and systemic effects. It was discovered that new business model archetypes at the Innovation Interface fulfil different stakeholder's needs in different ways and with various levels of complexity. The operation of most of the above archetypes will require new partnerships, commercial relationships and consumer behaviours as well as the deployment of new technologies. This report has investigated how revenues, energy, vehicles, and services are allocated across different models. No one model is capable of meeting all of the business model innovation needs at the Innovation Interface. Indeed some of the weaker models in terms of catalysing innovation may succeed because they are simpler to operate in an already complex marketplace. However, for policy makers, system regulators and city governors, it will be important to be very clear on which business models are emerging, what their effects might be and how public institutions can respond to them to capture the optimal mix of environmental, social and economic benefit. For utilities, and the auto industry, the business model archetypes presented in this report offer new opportunities to exploit as yet uncaptured values in the e-mobility transition. From new mobility as a service offerings, to ancillary energy market services using aggregated EV batteries, new value pools are emerging; value pools which can be captured by the adoption of the archetypes explored in this report.

From this analysis 6 recommendations were made which span policy, regulatory and commercial stakeholders. The adoption of these recommendations would remove some of the barriers to these new business models and catalyse the Innovation Interface. These business models are not an exhaustive list, new models may emerge in the UK. Equally, international differences between auto industries, energy markets, and city infrastructures will require further archetype creation and comparisons in non-UK contexts. From this work it is clear that new business model archetypes will emerge to facilitate the e-mobility transition, and they have real potential to grow new businesses, better manage existing infrastructures, and deliver economic and environmental benefits across cities.

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