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EV Uptake in the Transport Fleet: Consumer Choice, Policy Incentives & Consumer-Centric Business Models

Seven Key Takeaways

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This document summarises seven key takeaways from the Oxford Institute for Energy Studies' third workshop on the impact of disruptive change in the transport sector, titled 'EV Uptake in the Transport Fleet: Consumer Choice, Policy Incentives and Consumer-Centric Business Models', held late last year. Participants included experts from the electricity, oil, auto, mobility, finance and technology sectors.[1] The context for the Workshop is the importance of three key factors influencing the uptake of Electric Vehicles (EVs) in the transport fleet: government incentives, consumer choice, and consumer-centric business models. The workshop focused on specific urban transport modes (light passenger and small freight vehicles, and electric buses) and a timeframe of the next 20 to 30 years.

The sessions were organized to address the following main questions:

- What types of government incentives are most effective and efficient in "nudging" consumers towards engaging with decarbonized transport, including EV adoption?
- How are consumers responding to policy and commercial incentives to adopt Electric Vehicles (EVs) and electric mobility? What determines consumer choice?
- What are the requirements of a consumer-centric business model for EVs? What has been the experience to date, and what are the policy or commercial barriers to the growth of consumer-centric models?
- Are there any misalignments between existing EV support policies and consumer preferences, or between EV utilization business models and consumer choice?

The workshop resulted in seven key takeaways:

1. **A lack of policy coordination between national governments and local authorities could slow the pace of the EV transition.**
2. **Governments have largely favoured 'carrots' rather than 'sticks' in designing policy incentives to promote EV uptake – but their targeting has differed in advanced and emerging economies.**
3. **Timelines for EV incentive schemes need to be consistent with the minimum timelines required for auto manufacturing supply chains to adapt.**
4. **Interoperability is a key component of government policies to promote EV uptake, but could also slow innovation around new business models.**
5. **The design of EV uptake policies needs to take consumer choice into account, while also promoting consumer education.**
6. **Fleet-based business models provide an opportunity to rapidly scale up EVs in an economy.**
7. **EV uptake policies in advanced economies need to adopt 'whole systems' or 'circular' approaches to mitigate externalities beyond the boundaries of their own societies.**

[1] **OIES is grateful to the speakers and participants for bringing valuable insights to the debate. Readers can also access key takeaways from 2017 and 2018. Takeaways summarised by Anupama Sen, Senior Research Fellow & Executive Director on the OIES Electricity Research Programme.**

1. A lack of policy coordination between national governments and local authorities could slow the pace of the EV transition.

National targets on EV penetration are set by national governments, although they are guided by multilateral institutions and 'umbrella' agreements. For instance, electromobility targets in EU countries are broadly guided by the European Commission[2] with national governments free to adopt their own pathways towards meeting them. National policies aim to catalyse coordination between the automotive industry and Original Equipment Manufacturers (OEMs), battery suppliers, fuel suppliers, capital markets, and infrastructure providers (see Figure 1).

However, much of the responsibility for the implementation of targets ultimately falls to local government or local authorities that act as the main interface with stakeholders 'on the ground' – i.e. the local residents and businesses that must accept and adapt to change. **The pace of the EV transition is therefore being driven in large part at the local level, making efficient coordination between national and local levels of government imperative to meeting targets**.

Local authorities[3] face some coordination-based barriers in this regard. First, they typically carry out consultations with local residents and businesses prior to implementing national EV uptake policies, which may sometimes result in the tempering of initial expectations on the pace of rollout of electric mobility. An example relates to the implementation of *Low Emission Zones* (LEZs) – following stakeholder consultations, the originally planned boundaries of LEZs sometimes need to be altered to consider local business requirements. This potentially creates divergence between expectations and outcomes unless there is effective coordination at all levels of administration.

Second, coordination is required around the numerous sources of funding available to support the local transitions. For instance, the UK's *Road to Zero*[4] strategy provides for various government grants towards promoting EV uptake among consumers and towards charging infrastructure; and until recently, local authorities could draw directly only upon on one scheme (the On-Street Residential Charge Point scheme) providing 75 per cent of the required funding for on-street charging, with the remaining 25 per cent needed to be sought elsewhere.[5] Coordination between national and local policy is also required in relation to the introduction or amendment of fiscal incentives that are likely to impact localised EV uptake – for example, changes in tax incentives for company-owned EVs could potentially influence company fleet-based EV uptake – fleets being a key driver of EV penetration in the transport sector.

A third area of coordination relates to the provision of EV charging infrastructure, on which there are a range of views on the role of local authorities. There is a strong preference in some countries for local authorities to partner with third parties (e.g. private companies) to enable this – for instance, a *Park and Charge* scheme is being trialled in the UK where local district council car parks are provided for use as overnight charging hubs by residents that don't have off-road parking. The scalability of projects can be a barrier here – local authorities mainly have the capacity to administer small or medium-scale projects

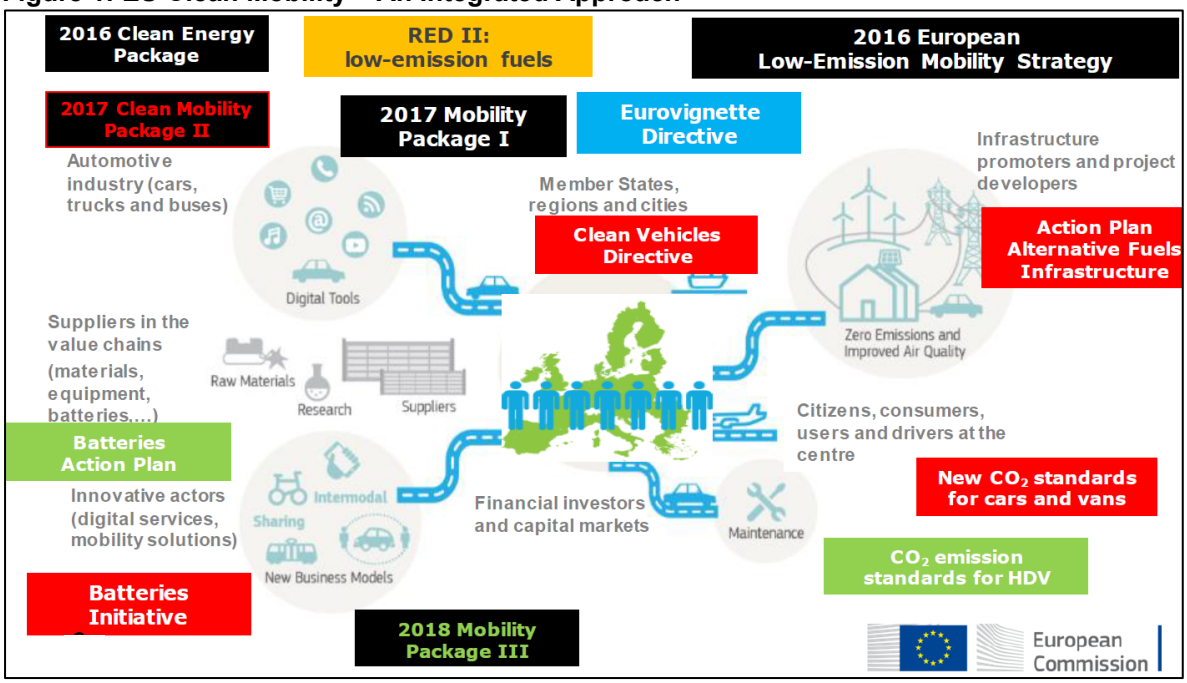
[2] The *Clean Energy Package*, *Clean Mobility Package*, and *Low-Emission Mobility Strategy* for instance set out fleetwide targets across the EU for achieving percentage reductions in tailpipe emissions as well as percentages of Zero-and-Low-Emission-Vehicles (ZLEVs) in the fleet, through to 2030.
[3] Used interchangeably with 'local government'.
[4] This aims for at least 50 per cent and as much as 70 per cent of new cars and as many as 40 per cent of new vans in the transport fleet to be zero-emissions by 2030.
[5] Funding under the scheme was recently increased.

and may wish to run these projects in areas which have the most promising potential to catalyse changes in consumer behaviour, whereas third-party private developers may not always find a scalable business case in these areas.

Fourth, local authorities must balance the implementation of national EV uptake policies with their own objectives for reducing traffic congestion in cities and towns. For example, national incentives geared towards promoting EVs as a replacement for Internal Combustion Engine Vehicles (ICEVs) among car owners could have potential long-term negative impacts on mode share – by moving people away from public transportation and incentivising greater private vehicle uptake. Some local authorities have been motivated into designing local schemes to better align national and local policy incentives – for example, the UK's *Workplace Charging Levy* will utilise funds from parking charges levied on company parking spots in city locations to improve local public transportation.

Finally, local authorities are often viewed as a 'unitary mass' – whereas they are a set of separate city and district-level institutions with remit over a number of different yet related policy areas. Thus, in addition to vertical coordination, promoting rapid EV uptake calls for a unified approach in terms of horizontal coordination at the local government level, towards EV and infrastructure rollout, which is also in alignment with other policies on local infrastructure planning, environmental management, and the behaviour of local residents and businesses.

Figure 1: EU Clean Mobility – An Integrated Approach



Source: European Commission

2. Governments have favoured 'carrots' over 'sticks' when designing incentives to promote EV uptake – but their targeting has differed in advanced and emerging economies.

In general, governments appear to have adopted policies favouring the provision of incentives to promote the uptake of EVs among consumers ('carrots'), rather than instituting bans on ICEVs ('sticks'). These incentives can be compared across advanced and emerging economies in terms of three broad metrics: the **approach** adopted towards their implementation, their **effectiveness** on promoting EV uptake across consumers, and their longer-term **sustainability**.

First, looking at the **approach**, the types of incentives and their target consumer base have varied in advanced and emerging economies. Governments in advanced economies (e.g. the Nordics, UK, France, and some US states) have announced future dates for ending new sales of petrol and diesel vehicles, and simultaneously provided upfront incentives aimed at making EVs (or zero emission alternatives) the 'natural vehicle of choice' for *passenger vehicle owners*. For example, in California which is considered one of the more advanced markets for EVs, a US-wide $7,500 tax credit for an EV has been supplemented by a state 'clean vehicle rebate' of $1,500 for a PHEV or $2,500 for a BEV, as well as non-fiscal incentives such as exclusive vehicle lane access for EV owners.

In contrast, if we look at an emerging economy – e.g. India, EV incentives have been targeted at *electric two and three wheelers, electric taxis and electric buses* rather than at private passenger vehicles, as the focus is to promote shared EVs, and modes that have high shares in terms of passenger kilometres carried. Incentives are primarily aimed at bringing down the capital costs of EVs, through federal and state tax exemptions and upfront purchase incentives. For instance, Delhi has had the highest tax exemption on EVs, up to nearly 30 per cent on the ex-factory price – these tax exemptions are at least partly met through Delhi's *Air Ambience Fund*, which is made up of a surcharge on diesel sales in the city. These measures are supported by other non-fiscal incentives, such as special 'green' license plates, a waiving of commercial permit requirements (e.g. for electric taxis or other commercial transport) and road taxes, and tax deductions on loans for EVs.

Second, looking at the **effectiveness** of incentives in promoting EV uptake, in advanced economies although incentives have increased EV uptake they may have also created income-based inequities in EV ownership. For instance, a survey of EV consumers in California concluded that high-income households which are a smaller proportion of consumers, accounted for a larger proportion of EV purchases relative to middle-income households.[6] Further, while high-income households could access all EV incentives, their price elasticity of demand for EVs was low – i.e. they would have purchased EVs in the absence of incentives. Similarly, evidence from the UK indicates that households with more than one private vehicle are more likely to be willing to purchase a Battery Electric Vehicle (BEV) than those with a single vehicle – the EV used as the "main" vehicle (e.g. for daily commuting) and other vehicles used less frequently (e.g. for longer journeys).[7] Incentives in advanced economies therefore appear to be more important for EV uptake among lower-income consumers, although they are not explicitly targeted towards these households (for instance, via 'income caps' for access to incentives).

In contrast with this, in emerging economies – again taking India as an example – incentives are explicitly targeted instead towards those modes of transport which contribute the *maximum amount of passenger kilometres travelled*, as well as in which new models can be quickly introduced alongside the requisite charging infrastructure – namely, the two and three wheeler, and bus segments.[8] There is

[6] For details, see https://its.ucdavis.edu/research/publications/?frame=https%3A%2F%2Fitspubs.ucdavis.edu%2Findex.php%2Fresearch%2Fpublications%2Fpublication-detail%2F%3Fpub_id%3D3042

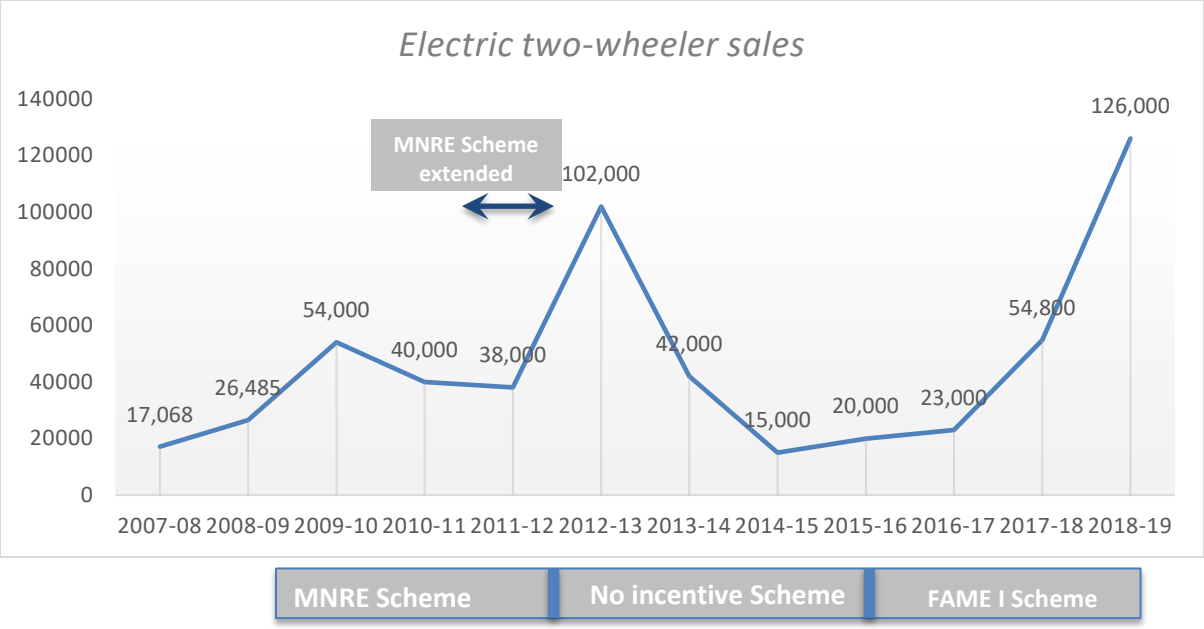
[7] For details, see https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/464763/uptake-of-ulev-uk.pdf

[8] The creation of charging infrastructure around these is seen as less onerous e.g. buses can be charged in depots.

also an upper cap on the prices of EVs for which consumers can access subsidies, to ensure that resources are not disproportionately allocated towards wealthier private EV owners.

The final metric to look at is the **sustainability** of incentives and here advanced and emerging economies face the same issue – namely, that EV sales tend to spike towards the end of the incentive period, and then drop off sharply, indicating that the market is heavily dependent on incentives. This has been seen in India, for instance (Figure 2). California's *Clean Vehicle Rebate* has to be continually funded through drawing from the general budget, which in turn requires a sanctioning process, leading to gaps in funding that may diminish the longer-term effectiveness of the incentive.

Figure 2: Impact of Incentives on India EV (2W and 3W) Sales



Source: Rocky Mountain Institute (RMI) India; using commercial TW sales data[9]

Note: Sales spike before the end of the MNRE incentive scheme, sharply drop after it, and pick up upon the reintroduction of incentives via FAME I.

A key question in relation to the sustainability of incentives is: what is the critical mass or the threshold volume or "tipping point" that would trigger the EV market into long-term, self-sustaining growth?

In the absence of a clear answer (which may be different for different markets) an option being suggested/explored by researchers – in California, for instance – to sustain EV incentives, is to fund them through cross subsidies such as *feebates*, a mechanism already being used in France and Sweden. This involves imposing fees on vehicles with high emissions and utilising the proceeds to fund rebates for lower emission vehicles. These fees have to be continuously balanced with the rebates, and thus adjusted upward each year as more EVs are sold and higher fees need to be imposed on ICEVs. In emerging markets like India, where feebates may not provide the required scale of funding, incentives have been tied with efforts to catalyse local industry and supply chains for EVs in the hope of triggering sustained market development – for instance, EV models have to meet a specified *local content*

[9] 'MNRE' refers to an incentive scheme for the purchase of EVs administered by India's Ministry of New and Renewable Energy. 'FAME I' refers to the first phase of a flagship incentive scheme for EVs titled 'Faster Adoption and Manufacture of Hybrid and Electric Vehicles' launched by India's Ministry of Heavy Industries and Public Enterprises.

requirement to qualify for fiscal incentives. In China, there is a policy effort to shift the subsidies provided for EV purchases, towards infrastructure charging service providers.

3. Timelines for EV incentive schemes need to be consistent with the minimum timelines required for auto manufacturing supply chains to adapt.

Auto manufacturers, or Original Equipment Manufacturers (OEMs), are at the heart of the nexus between government, industry, and consumers. OEMs must meet progressively tighter regulatory standards on improving the fuel efficiency of vehicles (usually set for 5-year periods by regulators in different countries) and on emissions reduction [10] while developing the technological powertrain necessary to meet governments' EV targets, and also meeting the needs and expectations of consumers. As emissions targets have tended to be technology-neutral, OEM strategies involve developing a range of electric technologies for different types of customers, often with more than one model for each technology type – with the expectation that the market will determine which of these models are then dropped and which ones are continued. There are also indications that models which are available at an affordable price point tend to be over-subscribed, leading to waiting periods for delivery. Given global climate change mitigation goals, regulatory standards have tended to move much faster relative to adjustments in consumer expectations and purchasing behaviour – therefore fiscal and monetary incentives continue to be important in supporting EV uptake among consumers. The planning of OEM supply chains requires a minimum of around three years in the case of repurposing existing technologies; but this could be longer in the case of developing entirely new technologies.

The time periods of policy incentives are sometimes inconsistent with OEMs' supply chain planning timelines – sales data appears to show that in many countries, **EV purchases tend to spike upwards towards the end date of an incentive scheme and then to drop off if there is no clarity over whether schemes might continue in the longer-term** (see Figure 2). There is a need for greater coordination between incentive schemes administered by governments and OEMs' supply chain planning, in order for the industry to have the lead time to bring models onto the market. Manufacturing supply chains for two and three wheelers (e.g. in India) appear to be an exception to this – with models made available in the market much sooner following the announcement of incentive schemes. However, the introduction of localisation (or local content) criteria as a condition for accessing incentives, alongside other existing regulations, could prove a barrier to scaling up EV uptake. Taking the example of India [11], where the auto manufacturing industry has needed to make significant investments to leapfrog from 'Euro 4' to 'Euro 6' efficiency standards, the addition of local content criteria for models to qualify for incentive schemes has led to some pushback around the need for long-term policy consistency on these schemes.

Alternative business models are emerging among OEMs, based on the integration of EVs into the electricity sector (and their participation in the wholesale electricity market) via partnerships with third party aggregators that often involve the integration of their software into EVs at the manufacturing stage; on battery-swapping; and also based on releasing the residual value of the battery for use in grid-scale electricity storage. These are arguably yet to be brought to scale at a global level.

[10] OEMs are fined/penalized if they do not meet these standards.
[11] The auto industry in India contributes around 50 per cent to manufacturing GDP and 6 per cent to total GDP.

4. Interoperability is a key objective of government policies to promote EV uptake, but could also slow innovation around new business models.

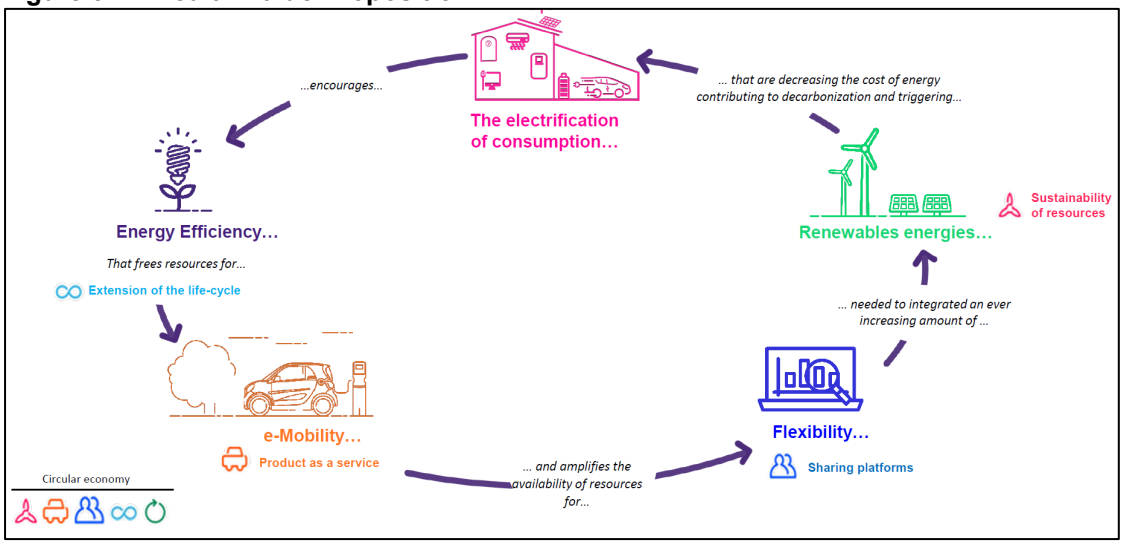
A key element of "consumer centric" policies relates to making the infrastructure for EV uptake widely and easily accessible.[12] In this vein, many government EV uptake policies envision "interoperability" between different EV charging networks – such that EV drivers would remain unconstrained by access to charge points and charging services across different spaces/borders. However, this vision potentially conflicts with efforts by emerging industry players around the scalability of charging infrastructure, by developing business models around innovations that are specific to their companies. In other words, while government policies may be aiming for *standardisation*, private companies may need (at least initially) to base their business models on *specialisation*.

For instance, in many jurisdictions the business of charge point and smart charging operators is based around the specific equipment that they provide, in addition to the accompanying services, on the premise that there is a value to be unlocked from using EVs as grid assets. For example, new business models around *Vehicle-to-Grid Integration (VGI)*[13] essentially involve technology platforms which can be installed in vehicles, enabling the utilisation of EVs to integrate renewables into the electricity grid through smart charging. Services can be provided by these EV 'aggregators' either locally – i.e. on-site, to fleet owners/operators – or to network operators at the distribution level if there is congestion, or at the transmission system level to help balance the grid. Most EV aggregators also have partnerships with retail electricity supply companies (e.g. in the UK, California, and France) wherein EV owners can take advantage of cheaper charging tariffs from these suppliers at specific times of the day or night. Another version of this model is for aggregators to facilitate the participation of EVs in the (electricity) frequency regulation market, based on which EV owners receive market payments which then contribute towards lowering the cost of ownership of their vehicle. In a sense, these models substitute the need for large investments in grid-scale storage, and potentially minimise the need for grid reinforcements by making better use of local resources.

Business models are likely to continue to evolve as the markets and regulations around EVs and their integration into the electricity system also change. For instance, there is an ongoing debate over which agent in the system would have primacy over a customer's usage patterns – the charge point service operator, or the Distribution Network Operator (DNO). The implications of the latter option for charging service providers are that charging equipment may need to be designed more uniformly and specifically for the jurisdiction (or country) in question, potentially impacting innovation. In India, for instance, distribution utilities have indicated that they would want specific chargers and communication protocols to be followed. There are also ongoing debates over the ownership of the data generated from customers' EV usage. Given that the market for EVs has arguably yet to reach maturity in many jurisdictions, business models that are based on a single value-generating proposition could end up cannibalising themselves. Therefore, companies are also looking at 'circular value propositions' which identify a wider range of revenue streams that can be encompassed within an EV business model (see Figure 3).

[12] For example, a driver of an ICEV can refill at any petrol station.
[13] Based on unidirectional charging of vehicles from the grid.

Figure 3: "Circular Value Proposition"



Source: Enel X

5. The design of EV uptake policies needs to take consumer choice into account, while also promoting consumer education.

Evidence appears to show that in some countries[14] EV sales drop sharply when incentives are withdrawn, indicating that economic incentives on their own may be insufficient to promote EV uptake at the desired pace. Consumer preference is a key element of EV uptake among households. For instance, survey research from four northern European countries indicates that mobility accounts for the largest proportion of households' carbon footprints; yet, people are least likely to volunteer to decarbonise mobility as this involves significant disruptions to their lifestyles.[15]

Consumer preferences also change over time – the early adopters of EVs were likely to be enthusiastic consumers with higher disposable incomes, and to have more than one private vehicle, whereas in the current context governments require a large proportion of middle/low-income consumers in their economies to opt for EVs (including as their sole vehicle purchase)[16] in order to drive up to the scale of uptake needed to meet policy targets (see Figure 4). Low and middle income consumers are also more dependent on incentives, and therefore while the planned phaseout of subsidies (e.g. the federal tax credit in the US) may not have much of an impact on the sales of high-end EVs, it may for other models.

The "consumer-centric" marketing strategies that most OEMs have hitherto appeared to follow are to build on the *status quo* that drivers have become accustomed to – by designing EVs that give consumers as close an experience as possible to driving an ICEV. In other words, "to balance policy aspirations and visions with something that most people can use so that you get scale." There is some debate over whether being "overly consumer-centric" in this manner might impede the achievement of

[14] For instance, looking at EV sales data in California and India.
[15] Dubois et al. (2019) "It starts at home? Climate policies targeting household consumption and behavioral decisions are key to low-carbon futures," *Energy Research & Social Science,* 52 (June, 2019), pp. 144-158.
[16] This does not hold universally – for instance, survey research from India showed that consumers also purchase EVs as a first vehicle.

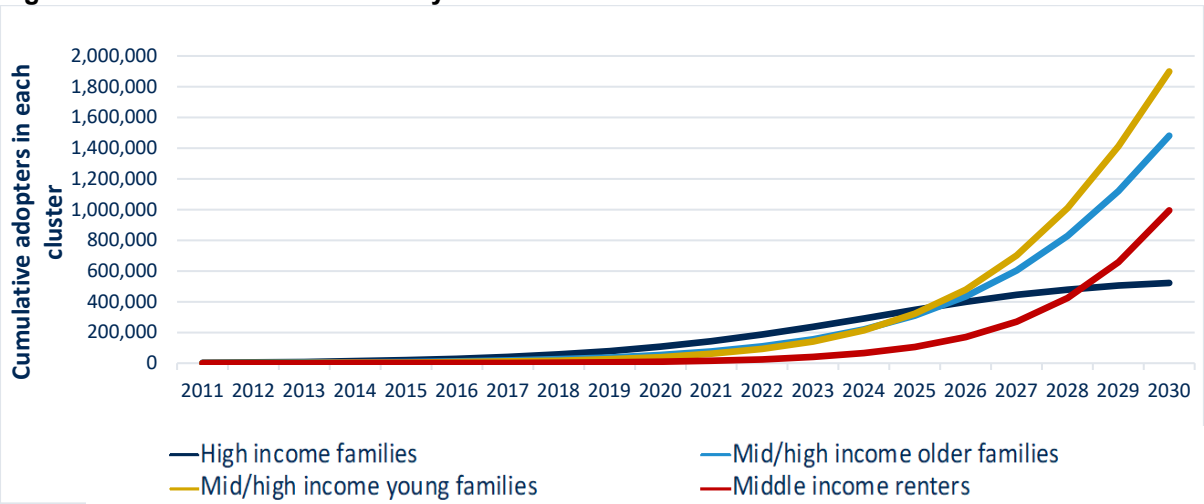
EV targets, as it potentially prompts false comparisons.[17] Comparisons with ICEVs over specific metrics such as 'range' risk missing the point and also expose a lack of education around EV technologies and usability. Consumers tend to "buy much more than they need" – for example, a consumer may prefer to purchase an EV capable of a 'longer range' even when the data shows that the average daily commute is quite low.[18] This may then require a vehicle with a larger battery, thus adding to the cost of an EV, which could act as a disincentive to purchase.

Range anxiety of this kind can be managed through other means. For instance, through better consumer education as part of government policy packages – for example, China's New Electric Vehicle policy reportedly has a consumer education component. Dealerships also need to be trained to deliver accurate information to consumers, particularly to assuage any concerns around "a new technology with a potentially unknown residual value". In China, new electric car manufacturers (such as *Nio*, for instance) have focused their businesses heavily on marketing and after-sales services – offering the buyers of their cars a 'lifestyle experience' based around an upmarket club membership which includes managing the charging of the car through a network of battery-swapping stations with quick turnaround times. Arguably, such 'holistic' models are yet to achieve commercial profitability. Another way of managing consumer range anxiety is through creating higher visibility around the availability of EV infrastructure – especially as its utilisation continues to be very low even in many European countries.[19] In India, for instance, distribution utilities are concerned about the visibility of charging points, which essentially provide them with an additional stream of revenue.

As climate change mitigation deadlines grow nearer, will governments move to enact policies which override consumer choice? Past attempts to nudge consumers into making environmentally desirable choices through explicit policy intervention have provoked public outcries (e.g. efforts to introduce carbon taxes in France were met with *Gillet Jaunes* protests) – but not least because their larger objectives are possibly not communicated clearly to the public. Another suggested route to achieving some alignment between policy targets on EV uptake and consumer preferences may be to "bind consumer decisions within certain scripted technologies" which effectively moves consumers towards making more environmentally sustainable decisions around mobility – for e.g. by preventing rebound effects.[20] In other words, policies could be designed around "providing constrained choices within the boundaries of sustainability."

[17] To emphasise this point, participants at the workshop evoked a famous Henry Ford quote: "if I ask my customers what they wanted, they would say a faster horse."
[18] In England for instance, 58 per cent of car driver journeys are under 5 miles. See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/823068/national-travel-survey-2018.pdf
[19] For instance, as suggested in the workshop, EV home charging infrastructure could be marketed as akin to "having a petrol station in your house".
[20] Consumers who purchase EVs to reduce their carbon footprint may inadvertently overconsume in other ways, potentially offsetting the carbon savings gained through switching to electric mobility.

Figure 4: Characteristics of EV Buyers in California



Source: Lee et al. (2019)[21]

6. Fleet-based business models provide an opportunity to rapidly scale up EVs in an economy.

Recent data from auto trading platforms in the UK has shown that the number of consumers searching for second-hand EVs tends to significantly exceed the number of units available for sale. This indicates a demand for EVs which is not being fulfilled. The sale of EVs to high-income consumers is one method towards making them commercially available to the wider population, including low-income consumers, as these sales catalyse the development of infrastructure and markets, and EVs eventually find their way into the second-hand vehicle market. An alternative, potentially faster route to scaling up EV uptake is through fleets –i.e. businesses purchasing EVs for commercial operations and taking advantage of scale economies to introduce them into their fleets. These EVs, contingent on their turnover period within the business,[22] are eventually released into the second-hand EV market, becoming available for purchase to wider consumers.

Fleet purchases of EVs may be made for reasons in addition to economic motivations, for instance as part of corporate social responsibility practices. Decisions on EV purchases for fleets are likely to be made by fleet managers or their equivalents in firms – and are therefore likely to be more 'rational' in comparison with private individuals EV purchase decisions.

The economics of fleets and their contribution to rapid EV uptake will vary across different markets – for example, roughly 50 per cent of all cars sold in the UK are fleet vehicles (or company cars) therefore with a higher potential to impact the EV market.

Fleets can be defined in terms of all vehicles employed within business organisations, irrespective of ownership structure, and they are subject to significant variability, based on the size of the business.

[21] Lee, J.H., Hardman, S.J. and Tal., G. (2019) "Who is buying electric vehicles in California? Characterising early adopter heterogeneity and forecasting market diffusion", *Energy Policy, Vol. 55, September, pp. 218-226.*
[22] The period after which they are replaced.

Smaller firms are unlikely to have dedicated fleet managers who can monitor EV developments; middle-sized firms tend to carry out analyses based on Total Cost of Ownership (TCO) to work out the economic viability of EVs in their fleets; however, large firms (e.g. logistics providers) tend to think more strategically about EV acquisition as part of their fleets, engage in longer-term scenario modelling, and participate actively in EV trials, especially as they may be affected by LEZs in the cities across which they operate. Larger firms also tend to renew their fleets in shorter time periods (typically around 3-5 years) than smaller firms, and ideally, the alignment of EV incentives and targets for uptake with these turnover periods would boost the market for second-hand (and more affordable) electric vehicles. EV uptake by smaller firms could also be boosted through the intervention of intermediaries – for e.g. companies leasing EVs to smaller firms instead of the latter making direct purchases.

Fleet based business models can therefore potentially help scale up EV uptake via the second-hand car market, but also face some barriers. One such barrier relates to how to incentivise and treat EVs in 'grey fleets' – namely, when businesses (such as smaller firms) rely on their employees' private cars to conduct their business activities. A second barrier relates to regulations around access to grants and incentives for fleet-based businesses – for example, in some jurisdictions businesses have to purchase an EV with a battery pack that will do at least 100 miles, in order to qualify for a grant, which makes the upfront cost of the vehicle prohibitively expensive. This is particularly the case for fleets engaging in last-mile deliveries where journeys amount to tens rather than hundreds of miles on average. Finally, a significant barrier to scaling up EVs in the second-hand market pertains to the residual value of second-hand EVs, which is strongly influenced by their mileage, which in turn is connected to battery degradation. A lack of clarity around this value may put off EV consumers in second-hand car markets, and although technically, with advancements in battery technologies, this may actually be a non-issue, more needs to be done by the industry to use easy-to-understand metrics around battery usage and life, for the benefit of consumers.

7. EV uptake policies in advanced economies need to adopt 'whole systems' or 'circular' approaches to mitigate externalities beyond the boundaries of their own societies.

An emerging issue in relation to the EV transition is the pressing need to incorporate equity and social justice within it, as societies among the advanced economies continue to decarbonise. Research has shown that a singular focus on the decarbonisation of transportation within a society via promoting EV uptake can sometimes create negative externalities. One example of this is evident in the effect of incentives on EV uptake among high versus low income consumers and arguably the creation of an 'elitism' in transport, privileging one form of transport over others. For instance, data published in 2019 by the Congressional Research Service claims to show that US federal tax credits for EV purchases tend to be claimed by high-income consumers. For 2016, 78 per cent of claimants filed returns with adjusted gross income (AGI) of $100,000 or more, and such returns accounted for 83 per cent of the amount claimed. In comparison, of all returns filed, about 17 per cent have AGI above $100,000.[23] Rebound effects from 'consumer-centric' business models are another example of an externality – when consumers purchase an EV, they may offset the reduction that it brings about in their carbon footprints through increasing other types of carbon consumption. Research on household attitudes and behaviour towards decarbonization in selected European countries shows that people were least likely to tolerate

[23] For details see https://crsreports.congress.gov/product/pdf/R/R45747

more aggressive reductions – the more revolutionary or meaningful the action (i.e. giving up a car), the less likely a household was to prefer it.[24]

Externalities can also occur beyond the boundaries of a decarbonizing society in advanced economies – for instance, recent research on 'whole energy systems justice'[25] has shown that Western Europe is decarbonizing precisely because a lot of the social and environmental costs can be pushed onto other, largely lesser-developed, countries. For instance, polluting ICEVs that are displaced from the large European economies as a result of transport decarbonization have been found to end up in Eastern European and African nations.[26]

Figure 5: Whole systems energy justice impacts of European Low Carbon Transitions

Spatial

Macro scale (global)	• Mineral extraction processes • Transportation of materials • Labor conditions • Global supply chains	• Rising energy demand • Impact on other countries' policies	• Rising global waste • Geopolitical issues
Meso scale (national)	• Increase in subsidies leading to raised taxes • Carbon footprint of installations • Diversion of funds from other sectors	• Inequality of benefits • Increased vulnerability and inequality	• Waste • Costs of disposal • Recycling of old materials
Micro scale (local)	• Disruption of ecosystems • Diversion of funds from other sectors • Loss of local jobs in old systems • Health risks to workers in factories	• Local pollution • Exposure to local risks • Urban-rural divide	• Legacy of local pollution
	Production/ distribution stage	Consumption stage	Disposal/ recycling stage

Temporal

Source: Sovacool et al. (2019)[27]

[24] See Sovacool, BK, A Hook, M Martiskainen, and LH Baker, "The whole systems energy injustice of four European low-carbon transitions," *Global Environmental Change 58* (2019) 101958.
[25] Ibid.
[26] Ibid.
[27] Ibid

The social justice aspect of the EV transition relates therefore not just to the EV *per se*, but to all stages across the life-cycle of its production and use, from the extraction of minerals and procurement of materials for battery production, to waste disposal and recycling.[28] Given the disconnect between policies to enable a rapid transition to EVs and the pace of change and adaptation in consumer behaviour, research suggests that building *multiscalar policy mixes* in a number of areas (i.e. not just transport, but also energy, food, buildings, and appliances, among other things) may be necessary– in other words, sustained and coordinated policy mixes rather than just single policies.

In emerging markets, the transition to EVs one could argue inherently adopts a 'whole systems' approach as the primary motivation underpinning the adoption of policies to promote electric mobility is often not decarbonization, but rather improvements in urban air quality, energy security (e.g. in India, the push for EVs in transport is in conjunction with the need for a proportionate future reduction in oil imports), the desire to "leapfrog" to sustainable levels of economic growth, and the creation of local manufacturing supply chains and employment. As discussed earlier in these takeaways, EV incentives in emerging market economies also tend to be targeted towards both high and low-income consumers. Whatever the context, policymakers need to be perpetually aware of the political economy and energy justice elements of low-carbon mobility.

[28] An oft-cited example of this angle of the debate is the adverse consequences of rapidly rising demand for lithium and cobalt in on the working conditions of mining workers of the Democratic Republic of Congo – although this is also likely to be exacerbated by poor governance and economic institutions within the country.