3 Years of Electricity – Understanding Development of the EV Market (2014-2017)

Abstract

This paper explores the development of the Electric Vehicle (EV) market both locally (UK) and Globally with a view to understanding current trends and driving factors, as well as how these factors will change in the short to medium term (3-5+ years). Understanding driving EV market factors and market development will be vital in underpinning the infrastructure that supports Town Centre Planning from 2020-2040. This paper will not make recommendations; however, the data may be useful for bodies wishing to compile local or regional EV strategies/policies and provide a brief overview of and introduction to EV ecosystems.

Introduction

Electric Vehicles (EVs) have grown in prominence from the start of the 21st century, with projects such as the Tesla Roadster in 2008 changing perception of EVs from vanity projects or gimmicks to 'real-world' useable vehicles.

Despite this, initial take up was slow due to 3 key limiting factors:

- Range Anxiety
- Cost
- Attractive/Realistic Vehicle Models

Lack of investment, infrastructure and knowledge being provided to members of the public were also key issues, but surveys seem to indicate that in spite of this the terms above are what really hold people back, and I'll explain them below as they are likely to recur throughout this paper.

Range Anxiety – The fear that an Electric Vehicle doesn't have enough charge to reach its destination and will leave the user stranded.

Cost – Due to the initial battery technology and manufacturing costs, vehicle prices were extremely high compared to fossil fuel alternatives.

Attractive/Realistic Vehicle Models – Whilst a 'shallow' factor, many motorists complain that EVs looked too 'sci-fi' and unattractive[1], or weren't practical for everyday usage.

[1] Linklater, D. *Stuff (motoring)*, https://www.stuff.co.nz/motoring/97760520/car-question-19-why-do-electric-vehicles-have-to-look-so-silly (accessed January 8, 2018)

Fast forward to 2017 and electric vehicles are on the rise. Infrastructure such as EV charging networks are being expanded massively, vehicle manufacturers are prioritising EVs over petro-fuel vehicles for the first time, legislation is finally starting to support EV ownership over petro-fuel ownership and industries such as freight and shipping are now looking to switch to EVs due to the significant savings in running costs.

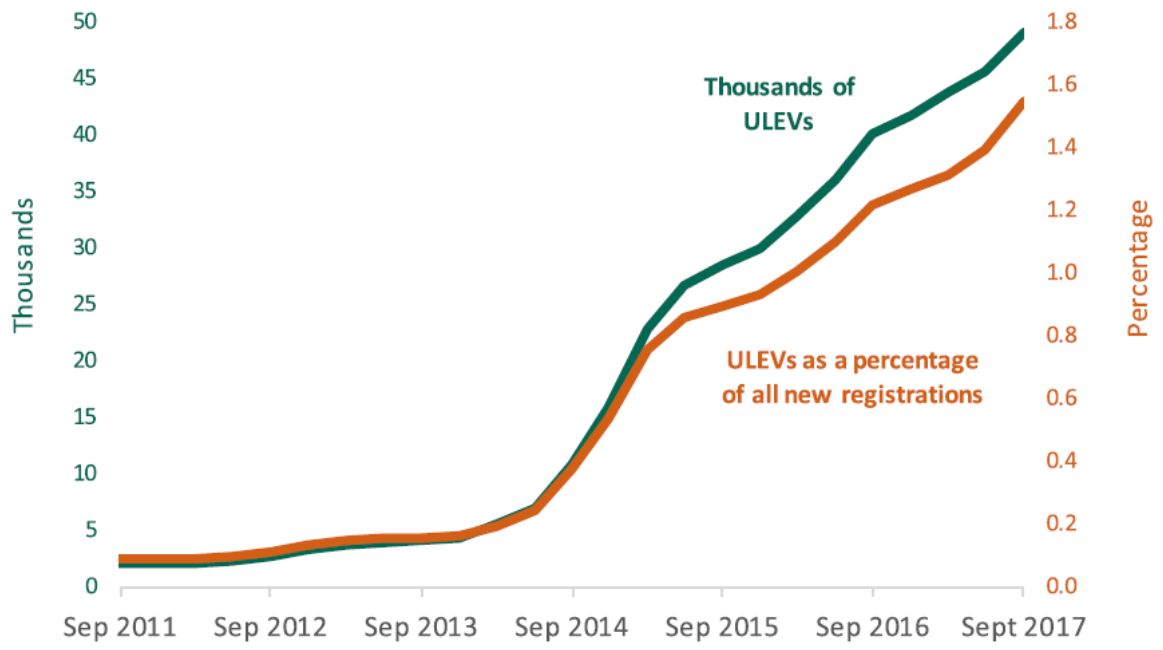
Manufacturers and industry leaders are even already working on fleets of electric autonomous vehicles which can be publicly or privately owned and leased throughout the day as ridesharing services.

All of this seems to point to an electric future, but where does it leave us now? And what should be the focal points for Local Government Authorities (LGAs) focussing on promoting EV usage?

EVs 2014-17

Vehicle Registrations

Before analysing what the next 3 years will look like in the auto manufacturing world, we need to look backwards and see how the industry has developed over the past three, specifically looking at the time period from 2014-2017.



Growth in Ultra Low Emission Vehicle (ULEV) ownership in the UK has skyrocketed in the last 3 years and continues to increase at an exponential rate. At the end of 2015 there were just over 50,000 ULEVs registered on UK roads, from January to November 2017 alone, there were over 42,700 [2]registered. Whilst this still only accounts for 1.8% of all vehicles on the road, it's up from 1.4% in 2016 and 1% in 2015. In 2014, only 3 years ago, ULEV accounted for only 0.4% of vehicles on the road. This represents 350% growth over 3 years.

[2] *Department for Transport: Vehicle Licensing Statistics*, https://www.gov.uk/government/statistics/vehicle-licensing-statistics-july-to-september-2017 (accessed January 3, 2018)

Figures in the UK are relatively low when compared to successful European economies like Norway, Where in June 2017, 52% of new cars purchased were EVs[3], up from 37% in January of the same year.

Legislation

UK

2017 saw the UK pass the first deeply meaningful piece of legislation promoting EV usage, banning the sale of all Petrol or Diesel vehicles by 2040[4]. Whilst this sets 2040 as a deadline, it's more probable that a huge shift in transport mode occurs between 2020-2030, due to broader market pressures, especially from China.

China

As the largest single market in the world as well as being the most progressive country in terms of transport electrification, it's no surprise that China's Ministry of Industry and Information Technology holds significant influence in the motoring world.

When they announced a new piece of legislation requiring all automakers to have Zero Emission Vehicles (ZEVs) accounting for 10% of new car sales[5] it was unclear how automakers would react.

By the close of 2017 all major manufacturers have announced plans to either replace existing products or expand product lines to include ZEVs – specifically EVs.

Manufacturer Investment

2017 has also seen something sorely missing from previous years, a commitment from the auto manufacturing industry as a whole to producing ULEVs, specifically with a focus on EV production. Historically, EVs have been 'niche' products; with manufacturers producing either unattractive 'sci-fi' offerings or premium luxury vehicles (see below).

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[3] Lambert, F. *Electrek*, https://electrek.co/2018/01/03/electric-car-market-share-norway-tesla-record-deliveries/ (accessed January 3, 2018)

[4] Swinford, S. *The Telegraph: 'Diesel and Petrol car ban…'*, http://www.telegraph.co.uk/news/2017/07/25/new-diesel-petrol-cars-banned-uk-roads-2040-government-unveils/ (accessed December 21, 2017)

[5] Perkowski, J. *Forbes: 'How China is Raising the Bar…'*, https://www.forbes.com/sites/jackperkowski/2017/10/10/china-raises-the-bar-with-new-electric-vehicle-rules/#2f7b660c77ac (accessed January 8, 2018)

In 2017 the most popular vehicle in the UK (according to DfT registration figures) remains the Ford Fiesta, a low-mid budget vehicle with an attractive sporting chassis; regrettably at the start of 2017 there was little in the EV world to rival this.

Fast-forward to December 2017 and all major auto manufacturers are now either expanding or replacing their existing product lines to cater for electric vehicles whilst phasing out petroleum/diesel vehicles; notable examples include General Motors, Nissan, Daimler and Volkswagen. VW for example have committed to investing $84bn in both electric cars and battery technology[6].

This provides consumers with the familiarity of suppliers and also product models that they are familiar with, but with a new drivetrain that your everyday motorist wouldn't notice. Essentially, this removes cognitive consumer bias about buying an 'electric car' [7]as the electrified models of existing cars look identical.

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[6] Lambert, F. *Electrek: 'VW announces…'*, https://electrek.co/2017/09/11/vw-massive-billion-investment-in-electric-cars-and-batteries/ (accessed January 8, 2018)

[7] Liao, F. *Taylor & Francis Online: 'Consumer Preferences for Electric Vehicles'*, http://www.tandfonline.com/doi/full/10.1080/01441647.2016.1230794 (accessed January 8, 2018)

Vehicle Costs

Understandably, one of the major roadblocks to widespread EV adoption is cost. Most EVs sit in a price range that is only affordable to Middle/Upper socio-economic classes.

Manufacturers, industry leaders and legislators have tried to extol the long-term operational cost savings of owning an EV such as:

- Free charging initiatives
- Less maintenance required
- Government sponsored buying schemes[8]
- Tax relief schemes

However, in spite of these, motorists are still put off – yet again, this is down to consumer psychology. For the majority of consumers it's hard to feel the benefit of long-term operational savings without seeing upfront tangible cash savings.

On the other hand, there's a comparably higher capital expense when purchasing a base-level EV compared to buying a petro-fuel equivalent. The table below shows the cash cost of EVs and their petro-fuel counterparts to consumers:

Manufacturer	Model	Fuel Type	Cost	% Cost Variance
Volkswagen	Up!	Petrol	£ 8,525	
	e-Up!	Electric	£ 24,985	193%
Nissan	Pulsar	Petrol	£ 13,060	
	Leaf	Electric	£ 26,490	103%
BMW	3-Series	Petrol	£ 25,850	
	i3	Electric	£ 33,340	29%
Ford	Focus	Petrol	£ 19,915	
	Focus Electric	Electric	£ 31,680	59%

Electric vehicles require an obviously considerable capital investment compared to their petro-fuel counterparts. In the table above, EVs cost on average 96% (purchase price) more than petro-fuel vehicles.

However, these figures don't take into account purchasing grants available from Central Government as well as the lifetime costs of running an electric vehicle against running a petro-fuel vehicle. The table below shows the lifetime running costs of a Nissan Leaf (one of the best-selling UK EVs) against the Nissan Pulsar balanced against the initial capital investment.

[8] *GOV.UK: 'Low-emission vehicles…'*, https://www.gov.uk/plug-in-car-van-grants (accessed 20 December, 2017)

	Nissan Leaf	Nissan Pulsar
Purchase Price	£ 26,490.00	£ 13,060.00
Government Grant	-£ 4,500.00	£ -
Fuel	£ 1,848.60	£ 8,626.80
Road Tax[9]	£ 1,092.00	£ -
MOT[10]	£ 429.00	£ 429.00
Maintenance[11]	£ 780.00	£ 5,421.00
Total Lifetime Cost	£ 26,139.60	£ 27,536.80

Figures show that over the average lifespan[12] of a car, there is actually a minor saving when making the switch to electric. Regrettably, these savings are often overlooked in light of the 'sticker price' and more work needs to be carried out to help 'bust' the myth that EVs are more expensive.

Charging/Refuelling Psychology

I mentioned Range Anxiety earlier on and it does remain one of the biggest obstacles for many when buying an EV; however, unfortunately, the mentality non-EV owners have towards charging is usually flawed.

Petro-Fuel Refuelling

Petro-fuel motorists are used to a refuelling method which has been tried and tested for almost a century.

DRIVE UNTIL FUEL LOW – ADD MORE FUEL AT DESIGNATED REFUELLING STATION – CONTINUE JOURNEY

This is what I'll refer to as 'reactive refuelling'. Motorists don't often refuel unless they have a large journey ahead of them, or they're low on fuel.

This is largely due to infrastructure. Petrol stations are often out of the way, and fuel is expensive; therefore refuelling is avoided or 'put off' as much as possible due to the inconvenience and cost of continuous refuelling.

However, despite the relative inconvenience, motorists are used to it and it doesn't require a change in habits.

EV Recharging

Conversely, EV charging methodology requires 'proactive refuelling', whereby if a battery has run down from 100% to 83%, you would recharge it if for no other reason than you can.

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[9] *GOV.UK: 'Vehicle tax rates'*, https://www.gov.uk/vehicle-tax-rate-tables (accessed January 4, 2018)
[10] *GOV.UK: 'Getting an MOT'*, https://www.gov.uk/getting-an-mot/mot-test-fees (accessed January 4, 2018)
[11] DJS Research Ltd. *DJS Research: 'Survey finds average Brit spends £700… on car maintenance'*, http://www.djsresearch.co.uk/AutomotiveMarketResearchInsightsAndFindings/article/Survey-finds-average-Brit-spends-700-a-year-on-car-maintenance-03172 (accessed January 4, 2018)
[12] *Society of Motor Manufacturers and Traders (SMMT): 'Average Vehicle Age'*, https://www.smmt.co.uk/industry-topics/sustainability/average-vehicle-age/ (accessed 23 December, 2017)

The reason EV refuelling (charging) is so easy is due to infrastructure. Whilst infrastructure in 2014 was sparse, in 2017 there are now a variety of charging speeds, manufacturers and mapping systems all designed to make charging as accessible as possible for motorists.

Manufacturers are liaising with employers and car park operators to install charging points as aside from at home or on a driveway; this is where cars spend 95% of their time[13]. So instead of having to head to a designated refuelling point in an inconvenient location, your car will charge/refuel whilst you're at work, or doing your shopping.

The current methodology for EV recharging is as follows:

DRIVE – PARK – CHARGE

This is an objectively more streamlined process than petro-fuel refuelling.

Whilst motorists commonly express range anxiety about running out of charge on the way to recharge, as the average journey length in the UK is 7 miles [14]it's unlikely that this would be the case provided motorists follow the methodology above.

Infrastructure

From 2014 to 2017 the market has seen huge investments in infrastructure and charging technologies. Nissan forecast that in the UK EV charging stations will outnumber petrol stations by 2020.[15]

Companies like VW subsidiary 'Electrify America' have pledged to roll out thousands of charging stations[16]; however, success is still contingent on motorists changing their refuelling habits from a petro-fuel mentality to an EV mentality.

In the meantime, in Europe, Ionity have partnered with Shell to deploy ultra-fast EV chargers at petrol stations [17]which will provide a familiar experience to petro-fuel motorists who are still getting used to EV ownership. A clever interim measure until consumer mentality shifts.

Public Transport

Another market development in 2017 was the push to get away from private vehicle ownership and push towards both public transport and ride-sharing models. As such, providers of these services have worked with cities across the world to begin implementing strategies to help electrify fleets and reduce harmful emissions.

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[13] Morris, D. *Fortune: 'Today's Cars Are Parked…'*, http://fortune.com/2016/03/13/cars-parked-95-percent-of-time/ (accessed January 8, 2018)
[14] *Department for Transport: 'Road Use Statistics…'*, https://www.licencebureau.co.uk/wp-content/uploads/road-use-statistics.pdf (accessed January 4, 2018)
[15] Murray, J. *The Guardian: 'Electric Vehicles…Nissan'*, https://www.theguardian.com/environment/2016/aug/04/electric-vehicle-charge-points-to-outnumber-petrol-stations-by-2020-say-nissan (accessed January 8, 2018)
[16] Lambert, F. *Electrek: 'VW's… to install "2,800 charging stations"…'*, https://electrek.co/2017/12/19/vw-electrify-america-charging-stations-workplaces-appartments/ (accessed December 19, 2017)
[17] Lambert, F. *Electrek: 'Ionity…partners with shell to deploy chargers at petrol stations'*, https://electrek.co/2017/11/27/ionity-ultra-fast-electric-car-charging-network-partners-with-petrol-stations-chargers/ (accessed November 27, 2017)

UBER

In the second half of 2017, ride-hailing tech firm UBER committed to electrifying its whole London fleet by 2020, offering purchasing incentives to its drivers and adding a surcharge to customer fees to help fund the project.

This means that the 40,000 UBERs currently operating in London will switch to EVs or Hybrid vehicles by 2020[18]. In the longer term, the company has stated that by 2025, 100% of its London fleet must be fully electric or PHEVs (Plug-in Hybrid Electric Vehicles) which typically run for 40 miles on electricity before switching to a petrol engine.

Buses

Buses have seen a huge amount of investment in 2017 and technology is finally in a place where Electric Buses are viable as an alternative to conventional petro-fuel fleets. Headlines include:

- US firm Proterra developed an all-electric bus with a range of 1,100 miles on a single charge[19]
- VW committed $1.7bn to development of electric buses[20]
- 12 Major Cities across the world committed to only buy all-electric buses from 2025[21]
- Shenzhen in China set the new standard for EV switchover by electrifying all public transport with a fleet of 16,000+ electric buses

Whilst the development of bus technology is amazing, wider concerns about grid drain and town planning and infrastructure remain larger barriers to the success of shifting motorists from private to public transport and reducing harmful emissions.

EVs 2018-2021

With all the developments across the EV market from 2014-2017 and the rate of technological growth, it's hard to fully anticipate where we'll be in 3 years' time or what the technology will look like. Whilst this is exciting, it also introduces a degree of fallibility to any long-term policies or strategies focussing on EV technology.

That being said, some industry leaders have unveiled their plans for product development and the section below will review some of these and how they may impact the market and motorists as a whole.

Charging Technology

One of the largest complaints from petro-fuel users when asked why they wouldn't switch to EVs is range anxiety and the perceived inconvenience of recharging an electric vehicle.

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[18] Vaughan, A. *The Guardian: 'Uber…electric cars from 2020'*, https://www.theguardian.com/technology/2017/sep/08/uber-london-hybrid-fully-electric-cars-2020-vehicles (accessed January 3, 2018)

[19] Lambert, F. *Electrek: 'All-electric… 1,100 miles on a single charge'*, https://electrek.co/2017/09/19/all-electric-bus-travels-record-1100-miles-on-a-single-charge/ (accessed January 3, 2018)

[20] Lambert, F. *Electrek: 'VW plans…'*, https://electrek.co/2017/10/12/vw-electric-truck-buses/ (accessed January 8, 2018)

[21] Lambert, F. *Electrek: '12 major cities…'*, https://electrek.co/2017/10/23/electric-buses-12-major-cities-pledge-2025/ (accessed January 8, 2018)

Whilst the reality is EV charging is really no less inconvenient (perhaps even slightly more convenient) than conventional refuelling, manufacturers have taken this point on board and are developing new charging technologies.

Industry leaders including Continental and Qualcomm are currently trialling a new charging method of wireless induction charging [22]which works in a similar method to smartphone wireless charging.

This means that rather than having to stop and charge, EV users will be able to charge while they drive, thanks to strips of electrified highway – whilst there are few *in situ* tests[23], the idea of electrified highway or even electrified parking bays would be a huge improvement in convenience for both petro-fuel and EV users.

Battery Technology/Vehicle Costs

Battery manufacturing has long been the primary cost pushing the price of EVs up, and capital cost, as stated earlier is one of the largest put-offs to first time EV buyers.

2017 saw landmark investment in mass manufacturing of EV batteries as well as the creation of the world's largest factory, the Tesla Gigafactory. The impact of being able to mass manufacture these batteries is huge, with analysts predicting a 30% decrease in battery costs [24]in the first year of operation.

Other electronics manufacturers are also investing in the EV battery market, with industry leaders like Bosch investing €20bn [25]in battery manufacturing.

Whilst it's impossible to know the real-world capital cost implications on EVs, by lowering the price tag, manufacturers are removing one of the biggest obstacles for EV adoption and so we can predict higher EV take-up over the next 3 years (and beyond).

Bi-Directional/Vehicle-to-Grid (V2G) Charging

Another new technology being trialled by several major car manufacturers is bi-directional charging or V2G charging.

At its simplest, the technology allows a car to act as a portable battery to power a house or to put electricity back into the grid at peak times.

This technology feeds into a larger growing trend for households to have a battery pack fitted which saves energy and acts as an automatic backup in the event of power cuts or strain on the grid – this technology is already seeing growth, especially in the US and Chinese markets.

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[22] Weintraub, S. *Electrek: 'Continental…car charging ecosystem'*, https://electrek.co/2017/12/13/continental-ev-charging-wireless/ (accessed December 13, 2018)
[23] Fagan, A. *Scientific American: 'Israel Tests Wireless Charing Roads for Electric Vehicles'*, https://www.scientificamerican.com/article/israel-tests-wireless-charging-roads-for-electric-vehicles/ (accessed January 9, 2018)
[24] Trefis Team. *Forbes: 'Gigafactory…cost reductions'*, https://www.forbes.com/forbes/welcome/?toURL=https://www.forbes.com/sites/greatspeculations/2014/03/11/gigafactory-will-cost-tesla-5-billion-but-offers-significant-cost-reductions/&refURL=&referrer=%20-%20384305ca2ebe (accessed January 8, 2018)
[25] Lambert, F. *Electrek: 'Bosch…'*, https://electrek.co/2017/12/15/bosch-investment-battery-cells-production/ (accessed January 8, 2018)

Long-term feasibility is yet to be quantified; however, with rapid growth in improvements to battery technology, it's likely that this technology will become more prominent in coming years.

Current companies investing in V2G technology include Continental and Honda[26].

Solar – The Missing Link

Following the growing number of EV chargers across the UK, one of the emerging considerations is what impact a full EV society (by 2040) will have on the grid.

Analysts predict that the grid, as it is now, would not be capable of supporting peak electricity increases from motorists arriving home after 17:00.

One way many countries are currently relieving grid strain is through solar farming, the use of undeveloped green areas to capture solar energy for either self-contained storage to release peak-time pressures, or to be fed back into the national grid. Examples include the Tesla battery solutions across Polynesia, Puerto Rico and Australia[27].

However, it's important to note that harvesting solar energy is not confined to unused green spaces and even urban developments, car parks, rooftops and roads can be used to capture solar energy and convert it into electricity.

China has recently developed a transparent concrete [28]which they are using to pave roads containing solar panels underneath, effectively converting whole roads into giant solar panels.

Use of solar energy also promotes a fully green vehicle cycle, relying on environmentally friendly means of electricity consumption rather than charging an emission free vehicle with electricity generated by fossil-fuels.

Land Freight

One of the biggest developments in the EV market during 2017 was Tesla's announcement of the Tesla Semi, the first mass manufactured fully electric truck (18-wheeler).

Estimates predict that the decreased operating costs will save freight companies $250,000 (£184,925) for every million miles travelled.[29]

As of 2016, land freight in the UK accounted for over 19.2 billion kilometres[30]; this translates to potential savings of up to £2.2bn a year for freight companies.

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[26] Lambert, F. *Electrek: 'Honda is working on bi-directional charging…'*, https://electrek.co/2017/12/07/honda-bi-directional-charging-technology-electric-vehicles/ (accessed January 8, 2018)
[27] Jenkins, E. *Fortune: 'Tesla…'*, http://fortune.com/2017/12/26/tesla-australia-battery/ (accessed January 9, 2018)
[28] Fitzgerald Weaver, J. *Electrek: 'China is building solar roadways…'*, https://electrek.co/2017/12/21/china-solar-roadways-transparent-concrete-solar-cells-charge-cars/ (accessed December 21, 2017)
[29] Dent, S. Engadget: *'Tesla electric Semi's price is surprisingly competitive'*, https://www.engadget.com/2017/11/23/tesla-semi-electric-truck-price/ (accessed January 9, 2018)
[30] *Department for Transport: 'Domestic Road Freight Statistics…2016'*, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/627597/domestic-road-freight-statistics-2016.pdf (accessed January 9, 2018)

Reservations for Tesla semis have been huge, with many large shipping and delivery firms making huge pre-orders. It's reasonable to assume that due to the savings to service providers, EV Freight will see much greater growth over the next 3 years.

EVs – Underpinning Autonomous Vehicles (AVs)

Autonomous driving used to be the stuff of science fiction but is drawing ever closer. Levels of autonomous driving have already been achieved and are rated on a 1-5 scale created by SAE International[31].

Full autonomy (where no driver is required) begins at Level 4. Currently, manufacturers of autonomous vehicles are capable of producing Level 3 autonomous vehicles. It's not unlikely that by 2021 manufacturers will have reached Level 4 at least.

Underpinning autonomous vehicles is electric charging technology, particularly wireless technology, which would allow a car to drive itself home, or to pick a passenger up, or even to park without having to worrying about it running low on battery.

AV Ridesharing and the End of Private Ownership

Another huge change which some analysts predict will be as revolutionary as the creation of the internet is the concept of AV Ridesharing.

AV Ridesharing is the concept that there will be a fleet of unmanned autonomous vehicles which will be able to be hailed by customers through an UBER like app interface with fleets being owned by either large-scale organisations, such as UBER or Addison Lee, or privately where a car owner can set their car to act as a fleet vehicle for the day and return to its owner at a specified time.

Addison Lee in particular are working with Greenwich Council as part of the MERGE Greenwich study[32] to analyse how an AV ridesharing service could provide an easy-to-use cost-effective service whilst complimenting public transport alternatives. Initial MERGE studies predict that 34% of driver's journeys in London could be replaced by AV ridesharing as soon as 2025.

If these ridesharing schemes become popular enough, it's possible that we could actually witness a large decrease in private vehicle ownership due to the diminished need to own a car. However, for this to happen AV technology needs to reach Level 4 or ideally Level 5, ridesharing needs to go mainstream, public transport requires infrastructure prioritisation and policy makers will have to create holistic strategies to synergise conflicting interests and create a harmonious transport ecosystem.

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[31] *SAE International: 'Automated Driving…'*, http://www.sae.org/misc/pdfs/automated_driving.pdf (accessed January 8, 2018)

[32] *The Engineer: 'Autonomous vehicles ride-sharing to merge with public transport'*, https://www.theengineer.co.uk/autonomous-av-avs-transport/ (accessed January 8, 2018)