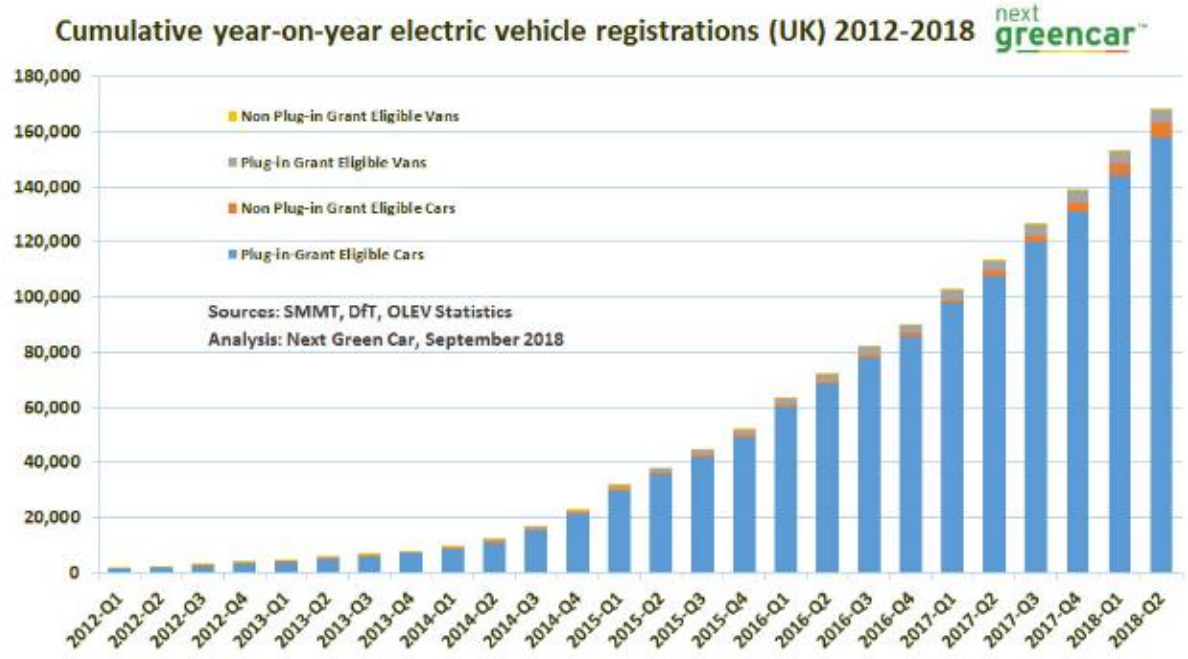
VIRTUE

ENERGY STORAGE SOLUTIONS

ELECTRIC VEHICLE (EV) MARKET OVERVIEW

From 2012-Q1 to 2018-Q2 the cumulative electric vehicle data shows a sustained and dramatic growth of the EV car and van market.

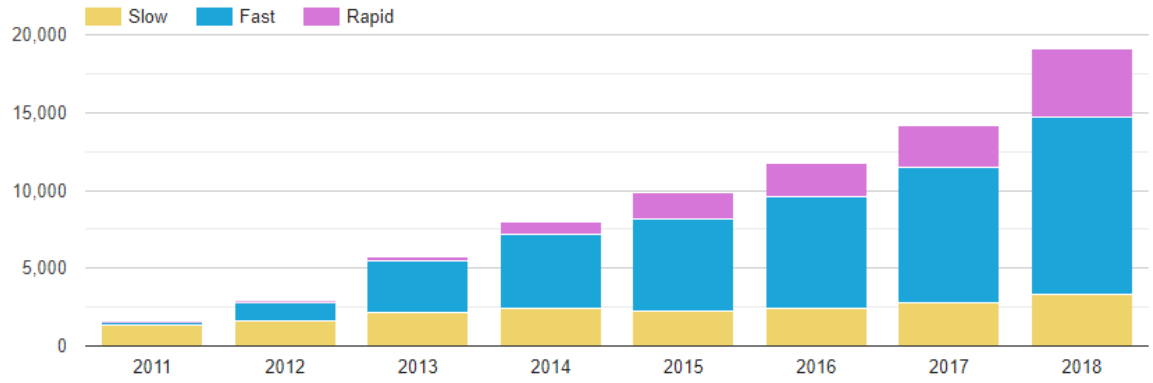
- In 2012-Q1 there was approximately 2,000 registered electric vehicles on the road in the UK
- This gradually rose to over 15,000 in 2014-Q3
- After 2014-Q3 there was an exponential increase in the number of EV's registered in the UK to almost 20,000 by the end of 2017
- 2018-Q2 reported close to 170,000 registered vehicles, the vast majority being plug-in grant eligible cars



Source: Next Greencar

As a result of sustained government and private investment, the UK network of EV charging points has also increased from a few hundred in 2011 to more than 8,208 charging locations, 13,171 charging devices and 22,381 connectors by April 2019. The proportion of charger types has also changed dramatically during that time with an increase in high power (rapid) units being installed across the UK. The number of slow chargers being introduced is decreasing, while the faster variants (fast/rapid) are increasing.

UK charging connectors by type 2011 - 2019



Source: Zap-Map Statistics

As of the most up to date data in April 2019, there are currently **1,458** rapid charging locations, 2,125 rapid charging devices, and 4,880 rapid charge connectors on the UK network.

With increasing demand for faster charging this number is going to increase considerably over the next few years. A rapid charger can charge a standard EV vehicle (23 – 30kWh) to 80% SOC in approx 30 minutes at 50kW output power. But rapid chargers are limited to areas where the supply is able to tolerate a sudden 50kW load, i.e. non – residential. Even medium commercial companies will struggle to charge more than 2 cars at the same time via rapid charging, purely due to the amount of power required.

EV batteries are also increasing in size, with new models such as the Hyundai Kona and Jaguar iPace being comfortably above the standard 23-30kWh at 64kWh and 90kWh respectively with ranges of 282 and 298 miles[1]. These brands are not alone in this evolution and although these industry-wide improvements should diminish range anxiety they further exacerbate the issues surrounding demand as a larger EV battery will need a proportional increase in energy from the grid.

Although the market is increasing at a fast rate, wider adoption of EV's is still limited by the following:

- **Range anxiety** – Electric vehicles are still limited by their range, and the vast majority see about 1/3rd of the range of standard fuel consuming cars. This is due to the amount of battery capacity that a manufacturer can fit into a vehicle (this is mainly dictated by cost and space).

- **Charging time** – In order to fill up a tank of fuel, you will be waiting no more than 2 -3 minutes. In order to charge a vehicle, you will be waiting, at an absolute minimum, 20 minutes, and more than

[1] https://www.nextgreencar.com/electric-cars/available-models/

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likely over 8 hours if you are charging at home. Charging time is affected by how fast a particular storage technology can be charged and how much power is available to charge.

- **Price** – EV's are considerably more expensive than their combustion engine counterparts which removes EV's from the low-level vehicle market.

Unfortunately, convenience is prized above all else in the UK, and these issues are all inconveniences.

To correct these issues manufacturers have to increase the capacity of the vehicles, increase the charging speed of the charging points, and reduce the cost of manufacturing.

THE FUTURE STRATEGY FOR ELECTRIC VEHICLES

We are already seeing manufacturers increasing the capacity of electric vehicles, however, in order to achieve the range of a standard petrol/ diesel engine vehicle a sedan/ saloon vehicle will need about 150kWh of energy storage and a hatchback may require around 90kWh.

Each car will therefore need 300kW and 180kW chargers respectively to charge them under 30 minutes (0% - 80% approx 20 minutes). If manufacturers go down this path, one that we believe to be necessary for wider adoption, a new and more significant issue occurs.

Charging these vehicles at the rate consumers require, even higher power chargers will be required which means that the local and national grid infrastructure will see a significant increase in burst demand. The onset of these high-power chargers will introduce multi–megawatt power swings at certain periods of the day, meaning the grid will require sudden available capacity.

In order to cope with this, the grid can do one of three things:

1. Introduce more capacity on the grid through generation (Nuclear, Wind, Solar etc) and consequently expand the networks capacity (more power lines larger/ more substations).
2. Introduce more flexible generation in order to deal with the spikes seen from chargers. This way during times where cars aren't being charged, there won't be over capacity on the grid, which would need balancing.
3. Introduce local storage to greatly reduce the demand spike by utilising stored energy to deal with the sudden ramp up of power.

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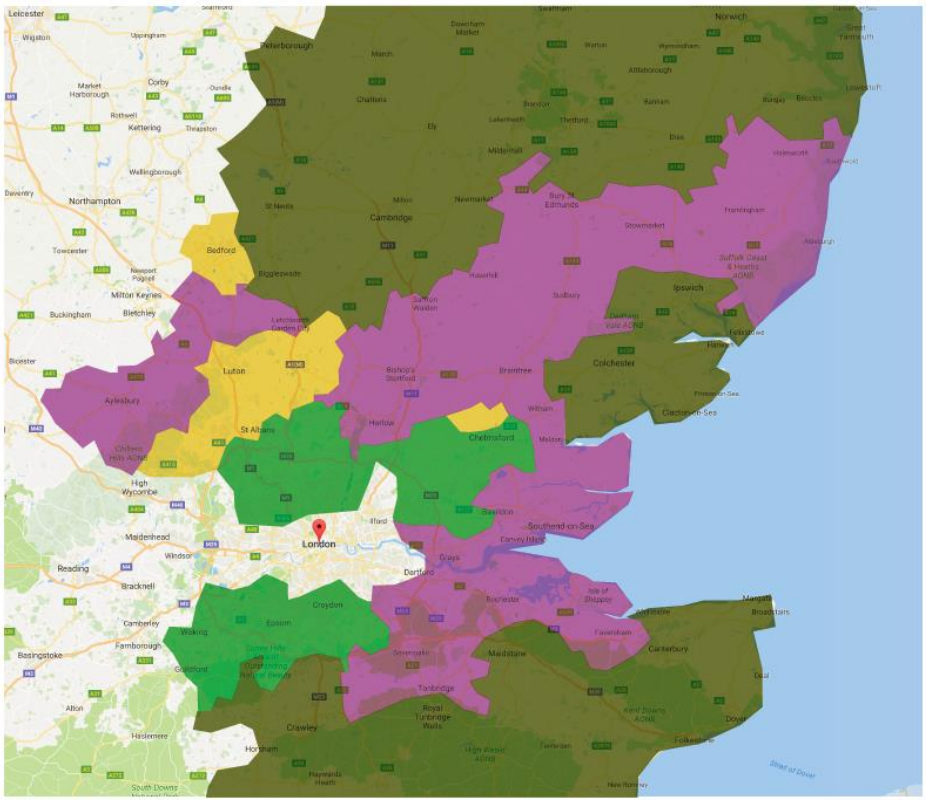
Option 3 is certainly the most cost effective for the network as option 1 & 2 require the local network and eventually the national network to be upgraded to handle the new capacity increase/ capacity potential.



Significant capacity available
This area of our network has capacity availaible for new connections.

Capacity available
There is some capacity available however, connections may be subject to an interactive queue with other schemes, or require some network reinforcement.

Highly utilised and or reinforcement required
Connections can be made but reinforcement may be required, or the connection offered may be at a higher voltage, or be some distance away from the proposed site.

Flexible Distributed Generation (FDG) zone
In line with our FDG stratagy, certain highly utilised areas of our network will be opened to receive applications for constrained connection offers. These will make use of appropriate active network management techniques to curtail generation when operational limits are, or could be exceeded.

A prerequisite to connection will be the establishment of an area monitoring and control system to restrict or turn off generation output as and when required.

If we look at figure 3 for UKPN grid limitations, we can see that the vast majority of areas are under heavy grid constraint, and large increases in demand in those areas would cause significant issues.

Local storage/ charging units also have the added benefit of being able to integrate with onsite renewable/ local generation, so that the charging process can occur at net zero carbon footprints.

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