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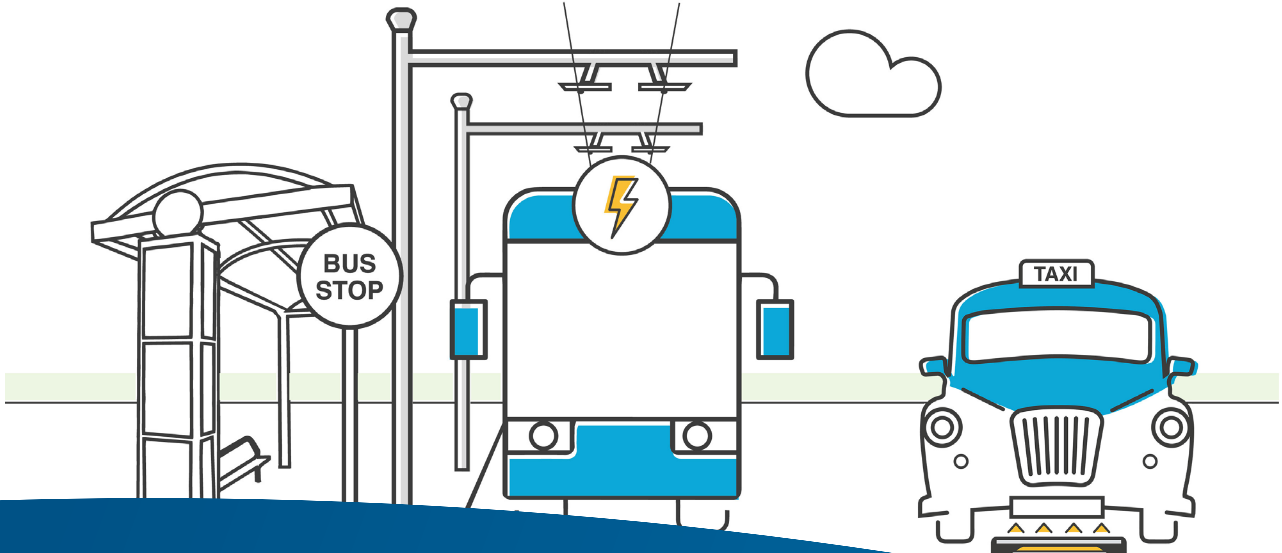


An Introduction to Innovative Electric Vehicle Charging Infrastructure

Cenex Insight - August 2021

Vehicle-to-Grid technology could solve some of the expected challenges to EV charging

EV Charging Challenges

EV chargepoints are a relatively new technology and even advocates of the industry will admit that further innovation is needed in order to meet the diverse needs of all EV drivers. While not often a problem at the moment, innovation is key to overcoming the future challenges presented by a move to mass market for EVs.

Current challenges include:

- Supply and demand must be balanced at all times to keep the national electricity network (grid) functioning. As demand increases from electric vehicle charging, grid management is required to maintain a constant supply.
- Electrification of long range and/or heavy vehicles, where the cost of a vehicle with a sufficiently large battery to meet the required range or payload makes it difficult for drivers/operators to economically justify the switch to electric vehicles.
- Public charging currently requires charging posts and cables. These add to street clutter and create safety (slip, trip and fall) hazards. It is likely a matter of time before the first legal cases following injury to a member of the public and therefore alternative approaches are required.
- Vulnerable drivers, such as drivers with disabilities can find plugging into existing charging infrastructure difficult, meaning that adoption rates for EVs within these segments are much lower than average.

In each area, innovations are required to support the continuing electrification of transport. In order to tackle these challenges, Cenex is currently exploring a range of innovative charging technologies, including:

- Vehicle-to-Grid
- Wireless charging
- Pantograph charging
- Using existing street furniture
- Pop-up chargepoints

Vehicle-to-Grid

Vehicle-to-Grid (V2G) is a system whereby plugin electric vehicles, when connected to a V2G charger, can provide bi-directional flows of energy and data.

This technology enables EV batteries to charge, store and discharge electricity when necessary.

V2G is still in the trial phase, but R&D projects by Cenex suggest it is close to mass market rollout. However it requires costly, bespoke hardware on the chargepoint and the vehicle.

By controlling the power and timing of charging and discharging of the vehicle battery, customers can optimise the electric resources available.

Revenue generation

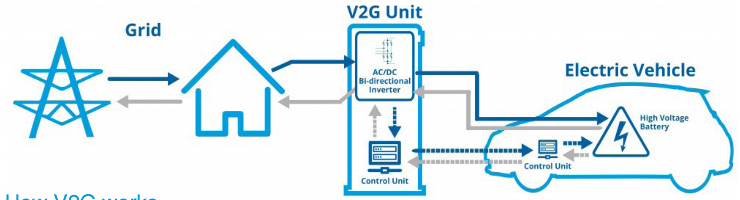
V2G allows customers to use an EV as an energy storage asset for financial reward by discharging to the grid or premises during expensive peak times and charging during cheaper periods. Users could earn, on average, £400 per year, and up to £700.

Resilience

The concept of V2G expanded rapidly in Japan as a means of ensuring electricity supply following the 2011 earthquake and tsunami and ensuing blackouts. V2G could be used to provide resilience in areas susceptible to power outages, or as an alternative to polluting back-up generators.

Personal Net Zero

V2G allows users to optimise self-consumption of energy generated by on-site renewable energy technologies such as solar PV panels. The EV battery can charge at peak generation, and discharge it to the premises in place of grid electricity.



How V2G works

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Vehicle-to-Grid

Enhanced Battery Management

Preserving the health of an EV's lithium-ion battery is vital. Limiting battery degradation can be realised by maintaining an acceptable capacity and power over its lifetime, prolonging its usable lifetime. Based on current evidence, V2G could extend the life of an EV battery by about 10%.

Benefit to Society

Mass V2G deployment can deliver widescale environmental and societal benefits. Based on avoiding curtailment of renewable generation alone, this could equate to savings of 6 megatonnes of CO2e per year, and avoided network upgrade costs could equate to approximately £180 per household, meaning lower bills and improved quality of life.

Wireless Charging

Wireless charging (also known as inductive charging) is a type of wireless power transfer which uses electromagnetic induction to provide electricity to a device, in this case an electric vehicle.

Wireless charging will allow vehicles that drive long distances or have heavy duty cycles to extend their range without increasing the battery capacity.

In addition, wireless charging removes the need to ‘plug in’ and eliminates the ‘slip, trip and fall’ hazard created by trailing cables from kerbside EV charging.

There are two forms of wireless charging:

Static

EV charging takes place while the vehicle is stationary, in locations like taxi ranks, junctions and by traffic lights. It relies on resonant magnetic induction to transfer energy between a pad mounted on the floor, and another pad connected to the underside of the vehicle.

The base charging pad is typically around a metre square, with a smaller receiver pad on the vehicle. The typical distance between pad and receiver is 150–300 mm and transmission efficiencies generally range from 80-95%.

Once the two pads are aligned, charging can take place at a range of powers – current systems range from 3.3 kW up to 20 kW. At the higher end, this equates to about 20 miles additional range for every 20 minutes a vehicle is connected and charging.

Static demonstrators are underway, including a project for wireless charging of electric taxis, led by Cenex in Nottingham, UK. A series of wireless charging pads installed at a taxi rank enable frequent bursts of charge when the vehicles are stationary in the queue – as the queue moves forwards, the taxi aligns on the next pad and charging recommences.

This will make the taxi rank cleaner and greener for passengers, offer better service availability and

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Wireless Charging

reduce any ‘range anxiety’.

Dynamic

In this case, EV charging takes place while the vehicle is moving. Dynamic wireless charging would likely be best suited to key transport routes such as ring roads, motorways and bus/delivery routes where vehicles are regularly travelling across the same stretches of road.

The primary coils are embedded in the road surface and the secondary coil (receiver) is mounted on the vehicle (as with Static). Dynamic systems have been tested with a much wider range of air gaps (from 7.5 – 500 mm) and achieve experimental efficiencies of 70-90%.

Cenex is working with Coventry City Council and Western Power Distribution to understand the possibility of using the technology to support electrification of buses and goods delivery; as well as model the impacts on the electricity network.

Pantograph Charging

Pantographs are a suitable charging solution for buses and heavier vehicles, using overhead charging infrastructure. There are two main variations:

Conductive pantograph charging

This consists of an overhead charging unit which will typically be installed at bus stops or depots where the bus is stationary for a short period of time. The unit charges a battery fitted to the top of the vehicle. This has some of the same barriers as inductive systems as it can add to journey times and will be expensive to install multiple units on a single bus route. Finally, it adds to street furniture which is not always desirable or feasible in some areas.

In-motion pantograph charging

This involves charging vehicles directly from overhead wires. As a wired solution it doesn't suffer from the efficiency losses associated with inductive charging. However, it does add to street furniture and requires significant installation and maintenance costs.

Existing Street Furniture

As a number of existing street furniture assets require power sources, some technology developers have begun investigating the feasibility of utilising any 'spare' capacity at these supplies in order to enable EV charging without the need for additional street furniture. Two key examples are:

Lamp Posts

This approach integrates EV charging into street lights/lamp posts. The charging hardware typically acts as a simple plug, with the intelligence for control and billing located in a separate 'smart cable'. Retrofitting a charging device into lamp posts makes this more cost effective than the installation of free-standing on-street charging equipment.

However, in many locations the lamp posts are not located in an appropriate location for vehicle parking or may be at the rear of a walkway rather than by the road, making these systems less feasible. In addition, where the street lighting systems is reasonably modern and designed for LED lighting, there may be minimal spare capacity available for this approach.

Broadband Cabinets

This is a newer innovation, currently being trialled by Virgin Media through a joint project with Cenex called VPACH. Broadband cabinets typically have a much larger power supply than is required for the cabinet, as well as existing cable routes running through roads and pavements.

The theory is to include passive EV charging provision as part of general installs and maintenance to the broadband systems, thus minimising cost and disruption associated with the groundworks. These systems typically aim to provide passive provision for around ten 7 kW AC chargers, utilising load management to optimise the number of chargers which can be operated from the available supply.

Pop-up Chargepoints

Pop-up chargepoints feature a mechanism by which the chargepoint can sit flush to the pavement surface when not in use or, in some cases, while charging is underway.

These solutions are, for the most part, at a ‘close to market’ stage of development, with many suppliers currently engaging with local authorities and landowners to deploy units on a trial basis.

They are designed for residents who do not have access to off-street parking (estimated between 22% and 32% of UK residents), and are intended for overnight charging so the street clutter of a chargepoint and trailing cables is removed during the day when pavements are busiest.

The pop-up chargepoints will typically be operated via a mobile phone app, which cordinates billing and other user information.

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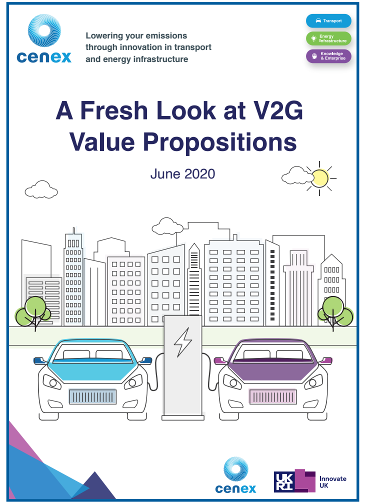
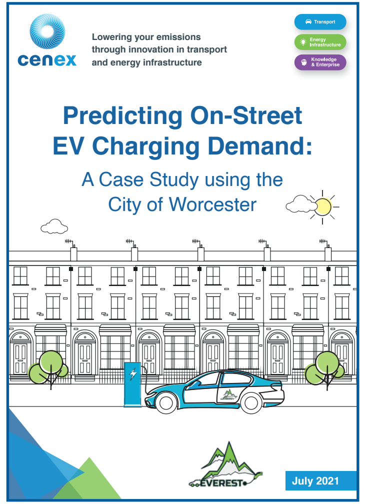
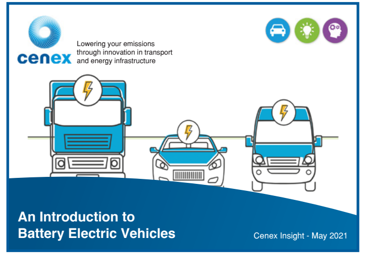
Further Reading



A Fresh Look at V2G Value Propositions
www.cenex.co.uk/app/uploads/2020/06/Fresh-Look-at-V2G-Value-Propositions.pdf



Predicting On-Street EV Charging Demand
www.cenex.co.uk/app/uploads/2021/07/final-EVEREST-Report.pdf



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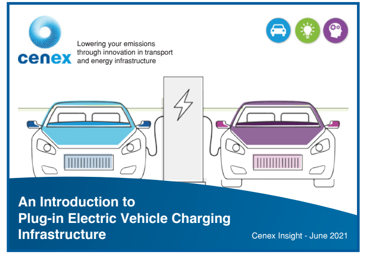

An Introduction to Plug-in Electric Vehicle Charging Infrastructure
www.cenex.co.uk/resources/an-introduction-to-plug-in-ev-charging-infrastructure/

Wireless Charging for Electric Taxis
www.wicet.co.uk

Introduction to Low Emission Road Transport - Future Learn Course
www.futurelearn.com/courses/introduction-to-low-emission-road-transport

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