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Vehicle to Grid Technology: Commercialisation Pathways





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Graeme Cooper, Project Director in National Grid's EV division, says that owners of EVs become much more conscious of their energy usage and as a consequence are more alive to the environmental impact. "This social movement is strange. It almost makes the government's 2040 target irrelevant."

Logic dictates that an abundance of electric vehicles (EVs) on our roads will ramp up the need for power capacity nationally and internationally. The grid will come under significant strain, but new technologies can, and I believe will, respond by developing solutions to the challenge of integrating decarbonised transport aspirations into the industry frameworks.

Larger scale and domestic storage solutions (batteries or more innovative proposals currently in development) will inevitably be part of the equation, but it would be remiss to ignore the possibilities provided by Vehicle-to-Grid (V2G) (or at least Vehicles-to-Building / Vehicles-to-Home, commonly termed V2X), by which we already have the technology to allow charged vehicle batteries to provide additional system security services to the grid at times of high demand, directly or by reducing the demand of a home or an office.

For a change, the challenges are perhaps less technical, and more legal and commercial. Can we get to the point of accessing these valuable benefits from privately owned vehicles in a way that the population can be comfortable with, and where the benefits of such access are sufficient and properly shared?

V2G technology is expected to play a part in balancing energy demand, but the commercial relationships that bind market participants, including vehicle owners, technology providers and automotive manufacturers are yet to be defined. How is risk going to be apportioned or shared? Who gets to own the data and exploit it commercially? How will proactive prosumers and passive customers use and engage with the technology?

These are just a few of the questions and concerns that were raised during a roundtable dinner at CMS London. I take comfort from the pathway that renewable energy has carved, cutting through the scepticism and pessimism to become the leading force for change in the sector. As with renewables, there are practical and ethical imperatives that are likely to drive V2G/X forward.

The roundtable dinner was attended by senior figures from across the industry, it generated some distinctive and thought-provoking insights, which are captured in the following report. We hope that you find this informative and we look forward to ongoing dialogue on this engaging and essential subject for the Energy Transition.



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What is Vehicle to Grid?

All forecasts agree that the number of EVs will increase globally over the coming years. The potential challenges that the rapid rise of EVs poses have been well documented. Powering an increasing number of EVs on the roads may become a challenge for system operators and network owners, but the vehicles themselves might also be part of the solution.

V2G could be a key building block to unlock the wider potential of this emerging area, by addressing some of the issues presented by EVs and providing additional benefits, for example avoiding the need for electricity network reinforcement and / or significant additional generation capacity to facilitate the mass roll-out of EVs.

V2G allows the energy stored in each EV battery when plugged in to be used by allowing the export of the electricity stored within it to a consumer's home or the wider electricity network, rather than simply to power the EV itself. Such export can provide services such as:

- Price arbitrage for various market participants;
- Greater energy security in the event of power outages; and
- Additional revenues, for example by participation in electricity balancing markets and providing ancillary services, such as frequency response or reserve.

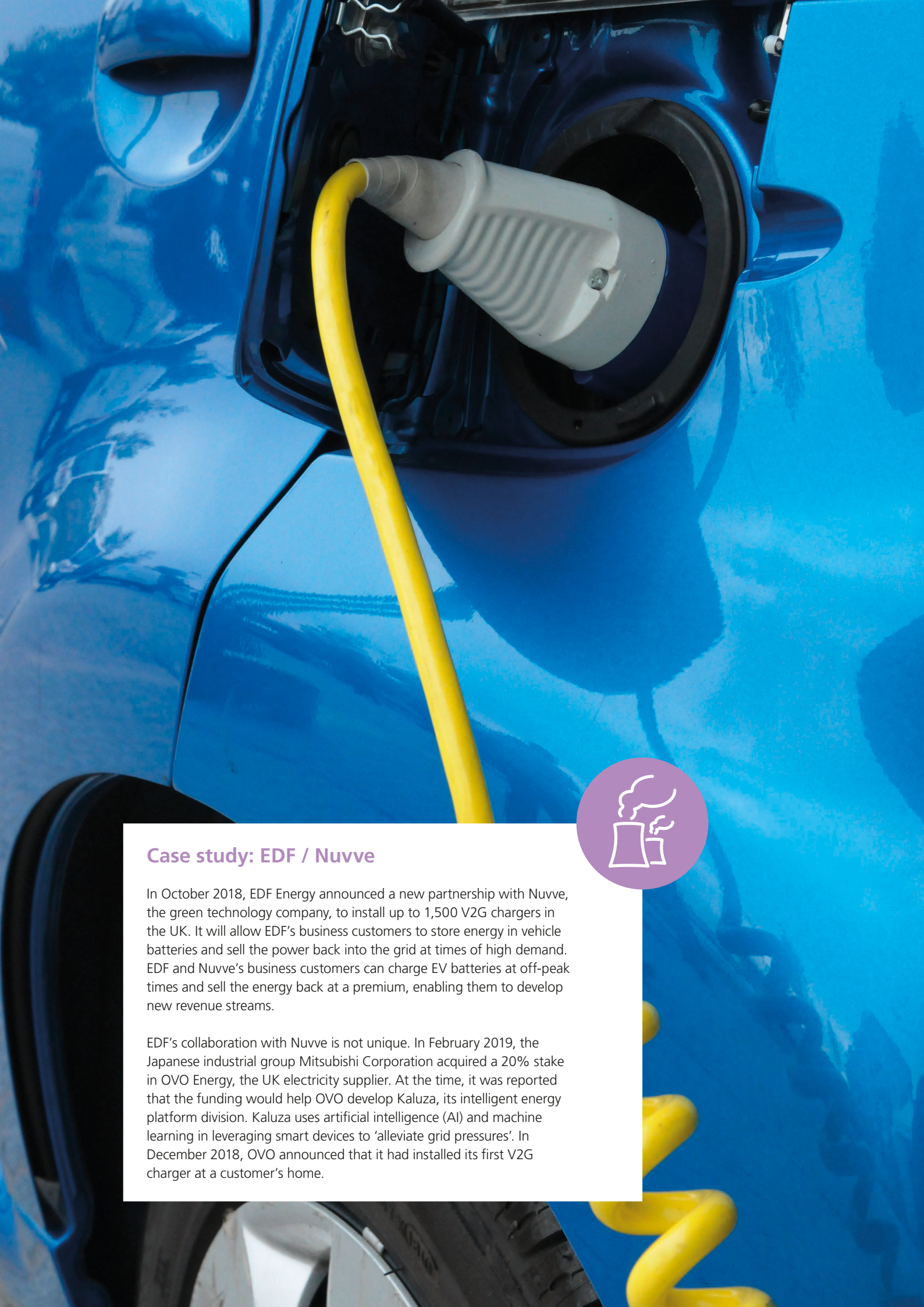
Whilst each EV battery has a small capacity, in combining EVs together, this can quickly result in an abundance of flexible storage potential.

V2G technology means that EVs should be able to target all the revenue streams that stationary storage projects currently access, as well as some additional benefits. However, the exact formulation of the revenue mix will depend on the value of the services to be provided, the circumstances of the relevant EV customer, the V2G scheme in which they are participating, as well as the jurisdiction where all this takes place, due to local regulations that may impact what can and can't be done.

V2G can take a range of forms dependent on a variety of factors, including:

- Where the V2G services are provided, for example whether the EVs are connected at home, work or when using destination or other charging points;
- To whom the services are being provided, for example, directly to an electricity network operator, to the EV customer's electricity supplier or Original Equipment Manufacturer (OEM), or via an aggregator; and
- When and the duration of the V2G services provided, for example on a schedule or whenever the relevant EV is available.

V2G is still a nascent technology at present. A recent study by **Everoze** and **EVConsult** assessed where the value of V2G lies and what the challenges are. The report considered 50 global V2G projects – mainly located in North America, Western Europe and Asia (principally Japan) – the vast majority of which only comprise 50 or less charging points. However, wider uptake will be required in order to assess the full potential for the technology.



Case study: EDF / Nuvve

In October 2018, EDF Energy announced a new partnership with Nuvve, the green technology company, to install up to 1,500 V2G chargers in the UK. It will allow EDF's business customers to store energy in vehicle batteries and sell the power back into the grid at times of high demand. EDF and Nuvve's business customers can charge EV batteries at off-peak times and sell the energy back at a premium, enabling them to develop new revenue streams.

EDF's collaboration with Nuvve is not unique. In February 2019, the Japanese industrial group Mitsubishi Corporation acquired a 20% stake in OVO Energy, the UK electricity supplier. At the time, it was reported that the funding would help OVO develop Kaluza, its intelligent energy platform division. Kaluza uses artificial intelligence (AI) and machine learning in leveraging smart devices to 'alleviate grid pressures'. In December 2018, OVO announced that it had installed its first V2G charger at a customer's home.

Taking theory and putting it into practice

Conceptually, the V2G idea makes a great deal of sense. Effective energy storage in EV batteries will negate the need for unnecessary investment in additional generation or network capacity. It will in turn reduce the burden on the taxpayer and allow more renewable generation to be used independently of the weather and so address decarbonisation aims.

EVs could be an effective network balancing solution. Vehicles spend the majority of their time standing immobile, so why not use stored, unneeded energy to feed back into the grid at times of peak demand?

The classic win-win scenario is hard to dismiss, but V2G proliferation faces a number of obstacles, not least potential customer apathy, an incomplete regulatory picture and undeveloped approaches to commercial arrangements and monetisation.

Will V2G be a genuine game changer in the move towards decarbonising the economy? **National Grid's Future Energy Scenarios report** in July 2019 sees only 2% of EVs participating in V2G by 2030, whereas smart charging could shift up to 47% of EV demand at peak. Industry participants are unanimous on the absolutely critical role that smart charging will play, but are less convinced on the necessity of V2G.

Inevitably, the V2G concept will face stiff competition from other solutions such as static battery storage providers. But while scepticism is always healthy, V2G is well placed to garner support. Munir Hassan, Head of the CMS Energy Group, believes that V2G will find a place in the market if there is consumer demand for it, if it is profitable and if government provides support for it. Where Original Equipment Manufacturers (OEMs), energy utilities, vehicle owners or aggregators can prove its commercial and financial value, then V2G can achieve true market acceptance.

Balancing and stabilising the grid

The energy arbitrage problem is to become especially acute given that petrol and diesel are currently by far the dominant forces in transport in the UK. But with EVs poised to take over the road transport market, it creates a huge challenge for system operators, network owners and other market participants to live up to.

This is further complicated by the world turning its sights on renewable energy sources. This important energy evolution is dependent on the availability of effective electricity storage with wind and solar energy, for example, not able to provide a continuous source of power; wind turbines can stand idle on tranquil days, while solar panels are redundant at night and feeble in cloudy conditions.

During these periods, particularly at times of peak demand, nations could depend on energy storage to feed in additional capacity and enhance service reliability. V2G could be an effective solution which would deliver additional energy security to consumers or indeed even allow them to go “off grid”.

OVO Energy and Imperial College’s 2018 report **A Blueprint for a Post-Carbon Society** indicates that effective grid balancing will pay off economically and environmentally. Under the report’s ‘Future Survival’ scenario, it estimates that V2G charging could cut the cost of decarbonisation by £3.5bn per year. It states: ‘These huge savings come from reducing the investment requirement in network infrastructure and allowing for greater uptake of cheaper renewable energy like wind and solar.’



Addressing the obstacles

The path to V2G ubiquity is testing. As we have seen in other industries, when it comes to switching suppliers, consumers tend to be resistant to change. Consumers are often sceptical when it comes to new technologies, especially when they struggle to understand the practicalities and the economics, let alone the benefits of the proposed changes. More data and case studies will be imperative in proving that V2G can deliver the desired results.

Currently V2G chargers are expensive to produce and supply, though a maturing market and additional economies of scale will reduce costs. The risk of obsolete technology is one that will be important to address from a consumer perspective – no-one wants to invest in the “mini disk” of V2G technology.

The potential for battery degradation caused by regular V2G use has also been raised as a concern, yet a report in 2017 by the University of Warwick indicated that smart use of V2G could actually extend a battery’s life.

Further research will be essential in providing comfort to and building trust with OEMs and consumers. Addressing concerns that V2G might affect a vehicle’s warranty will be essential. Nissan has already taken steps to address this in its EV warranty packages.

V2G also faces stiff competition from stationary energy storage. Pivot Power, for example, is working with the National Grid to develop a 2GW network of grid-scale batteries and rapid EV charging stations across the UK.

With such movements, is there still space for V2G? Stationary storage requires substantially more capital investment, given that V2G depends on pre-existing vehicles that can double up as grid balancing facilitators. “Vehicles will play a role in the ecosystem,” says Andreas Atkins, Head of Electricity Vehicle Strategy for Property at Centrica Mobility Ventures. “Vehicles are always going to be plugged in for a long time, whether we are talking about vehicles as part of a fleet or a car that sits at the airport or at your workplace.”

An added complication is that meters will be required to track the import and export of energy through the V2G product, and it is not yet clear whether the current generation of smart meters will be sufficient for this task.

Another stark fact is that vehicle ownership is in decline. Laurence Kalman, Partner in the Commercial / Technology team at CMS says: “There is the broader issue of how we consume mobility and the role of V2G in that. The way people view mobility is changing. Younger generations are not buying cars in the same way that they used to.” With fewer privately-owned vehicles in circulation, it could be that V2G will be primarily applicable to the commercial fleet segment, particularly given that vehicle fleets face higher aggregate costs and are more exposed to tariff variations. So maybe it is wider societal change rather than monetary benefits which will drive V2G uptake forward.

In isolation, the domestic customer may struggle to see the value in V2G. Consumers are known to be apathetic towards modest savings and a recent **report** predicts that even consumers with a “full energy network” comprising a home battery, smart hot water tank, PV system and V2G-enabled EV can only expect savings of £300 through increased solar consumption. Historically, only a small number of domestic customers have routinely changed energy suppliers to make savings, though according to Energy UK, the trade body, there was a significant increase in switches in 2019, in part thanks to the raising of the price cap in April. Daniel Saunders, Investment Director in the Transport & Energy division at Octopus Investments says: “How much value is there for the consumer? People don’t switch contracts for a £200 saving and changing supplier can go wrong. There’s a hassle factor. Does legislation need to push [V2G] through?”

Nevertheless, understanding and predicting consumer plugging-in and charging behaviour will be vital. One issue is the unpredictability of domestic life. Consumers will want to have the confidence that their EV will have

enough charge for an emergency dash to the hospital or a last-minute rush to the shop for milk. They will need to know that participating in V2G only depletes the battery charge to a certain level – and one which they have some say over. The consumer interface – via apps or otherwise – will need to be easy to use and seamless to override to address such concerns.

Dalia Majumder-Russell, Senior Associate in the Energy team at CMS suggests there needs to be greater clarity on where the risks are going to lie: “What kind of a business model do we want to see develop? Do the aggregators take the risk or do they push that onto the consumer? If barriers exist for consumers now, how are we going to overcome them?”

New commercial ventures suggest that the private consumer sector will still have a place in the market. Moixa, the smart battery business, is working with Honda to develop smart charging and V2G services. Its GridShare platform aggregates home energy storage systems, EV batteries and other small loads. With electricity being an increasingly precious commodity, this kind of model that leverages V2G technology and other energy sources could be incredibly effective. Indeed, such technology that allows for invisible, remote and even automatic control of the provision of V2G will be crucial if this subsector is to take off.

Customer engagement: considerations for developing a consumer base

Commercially viable and scalable V2G services may depend on:

- Manufacturers and suppliers providing a free or lower cost V2G charger;
- A monthly fee to be levied to cover costs of participating and the coordination of V2G services;
- Supply of free electricity as an incentive to reduce the overall cost of the EV; or
- Delivery as part of an overall mobility offering from the OEM.

Incentives will also be crucial to ensure that the EV is plugged in at the desired times.



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Putting ethics and the environment first

Consumer and business choices are now much more attuned to environmental and ethical factors. There is a strong financial argument for engaging with V2G, but there is also the positive decarbonisation impact created by EVs and V2G. Tom Pakenham, Director of Electric Vehicles at Kaluza and OVO, says that the ability to go “off grid” needs to be part of the conversation: “There is strong demand for islanding and self-sufficiency. People are engaging with solar power across the UK and this is driving forward different behaviours.”

It is a powerful sell to end-users at a time when people are being flight shamed and disparaged for poor attitudes towards climate change. Exploiting private solar panels and storing this energy within an EV battery would be attractive to those that want to reduce their carbon footprint.

The current social and ethical movement should not be underestimated in assessing the overall impact of EVs and V2G technologies. Graeme Cooper, Project Director in National Grid’s EV division, says that owners of EVs become much more conscious of their energy usage and as a consequence are more alive to the environmental impact. “This social movement is strange. It almost makes the government’s 2040 target irrelevant.” The government has pledged to outlaw the sales of new petrol and diesel cars and vans in 2040, though there are suggestions that these targets may be revised to make them more ambitious.

V2G: overcoming the barriers

The V2G proposition needs to overcome:

- Customer apathy;
- Whether sufficient financial incentives can be created for the private consumer to engage with the market;
- An evolving but incomplete regulatory environment;
- An uninformed public that is yet to understand the commercial, ethical and environmental reasons for V2G use;
- Further technological innovation may be required to allow for ease of access and use;
- Concerns about battery degradation and the interactive with the vehicle’s warranty;
- Competition from stationary battery storage and other flexibility solutions;
- Declining vehicle ownership and the move to autonomous / connected vehicles;
- Uncertainties over who owns the V2G charging event and the data associated with it; and
- Uncertainty over which parties will be driving V2G roll-out and the commercial arrangements that sit behind it.



Waiting for regulatory certainty

Technological advances and innovation are always a step ahead of regulation. Regulators, through no fault of their own, are constantly chasing the market's own evolution. In the case of EVs and V2G, the government and regulators need to unlock the full potential in the market. The classification of V2G end-users are not yet clear and Louise Dalton, Senior Associate in the Energy team at CMS, questions whether they will be treated as consumers or, particularly when aggregated as energy generators by regulators and legislators. The additional regulatory burden of the latter approach could be a significant disincentive to V2G market participants and customers.

Even where a conscious decision has not been made, perverse incentives may encourage certain behaviours (e.g. generation licensees not being subject to final consumer levies).

For regulators, this creates an unenviable task. They must balance national energy demand, climate change obligations, transport strategies and broader economic challenges in the context of the ever-changing energy market. There will always be competing political interests in decarbonisation and what that means for customers.

Yet with multiple entities having an interest or responsibility for energy supply and decarbonisation of transport, it is natural that there will be diverging priorities. Achieving consensus on V2G, the role of various market participants and its contribution to grid balancing and decarbonisation is a tough ask.

Competing protocols

Currently there are only a limited number of EVs that are V2G enabled. Warranty packages need to be developed for EVs, taking into account the vehicle's use of V2G technology and its use as an energy storage facility.

Industry alignment around simple charging technology still remains out of reach. Reuters called it Plug Wars: the battle for electric car supremacy in January 2018. The Combined Charging System (CCS) is favoured by European car manufacturers, while Nissan, Mitsubishi and other Japanese manufacturer vehicles are charged by the CHAdeMO system. Its reminiscent of the battle between VHS and Betamax for videotape ascendancy back in the 1980s, but the picture is even more opaque. Tesla, the EV market disruptor, has its own supercharger system.

Developing a V2G technology across the spectrum is especially complex because Tesla has no plans to support it and V2G is only expected to be rolled out for the CCS protocol in 2025. CHAdeMO is currently the only standard that can enable V2G.

Some form of protocol convergence or wider support for the V2G concept will be required for it to be an option for all makes of EV.



Data capture and monetisation

For those that are part of the V2G value chain, one of the primary objectives will be to capture the data from both the charging and discharging events and wider consumer behaviours. Indeed, capturing the data and monetising it may be even more lucrative than any revenues that stem from utilisation of the vehicles' V2G capabilities. "The two most valuable aspects are not the actual energy supply and the vehicle, but the ownership of the customer and the data," says Daniel Saunders of Octopus Investments.

Participants in the V2G sphere will almost certainly compete for ownership of the customer and the data they create. "Who will own the charging event?" asks Daniel Brown, Policy Manager at the Renewable Energy Association. Energy utilities, aggregators, automotive manufacturers, V2G technology suppliers, CPOs or other market participants will be in the frame.

Given the trust that consumers have in many automotive brands, it is likely that OEMs will be at the forefront of customer and data ownership. In this instance it will be imperative that customers and end-users understand the value of their own data and how it can be used for the greater good. Where it can be leveraged for decarbonisation and increased safety, for example, customers are more likely to buy in.

This inevitably creates further complexities as to who has access to the data created through V2G services and what the parameters are around exploitation and monetisation of the data. Naturally, the EU General Data Protection Regulation (GDPR) will be part of the conversation.

Further, as with any such technology, there remain concerns around security of the data, in particular cybersecurity concerns around cloud-based technologies.

Experts in the field, including our roundtable participants, indicate that there needs to be a convergence of metering and data ownership to facilitate effective V2G operations. "The ownership of metering and data are two different worlds and universes. They have to come together to make V2G have any sense," says Ben Willis, Strategy Manager at RWE Generation UK.

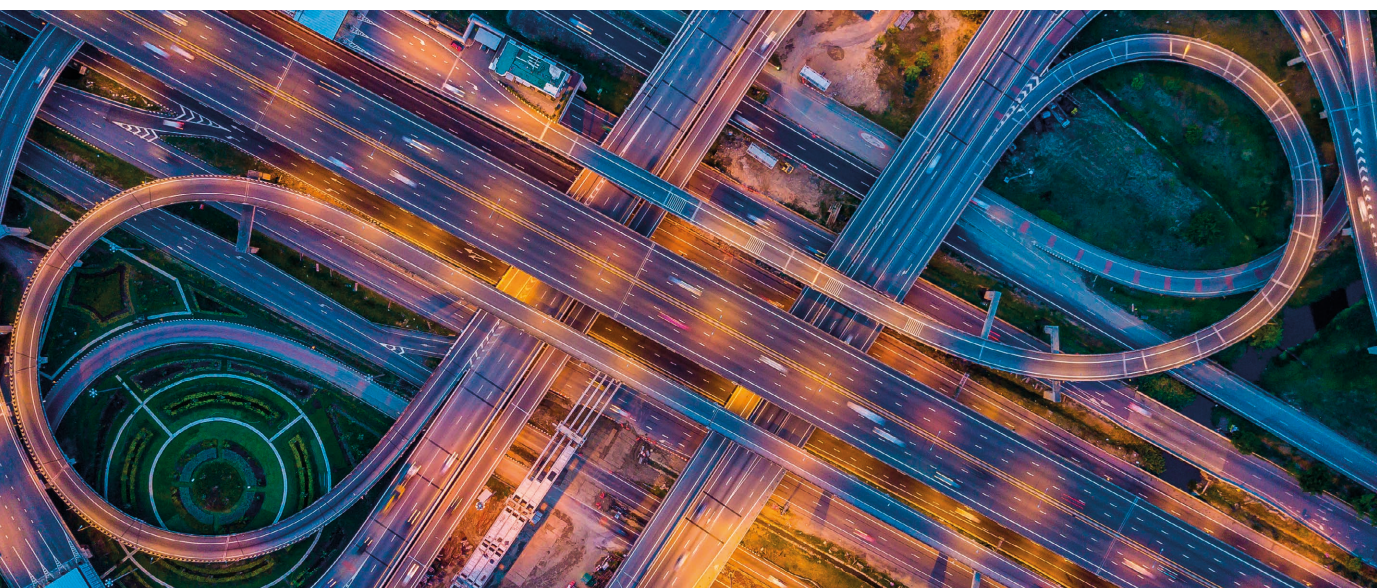


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Conclusion

Undeniably the world of transport is changing. While fully automated vehicles may take a while longer to become mainstream, how consumers think about a car will change much sooner. The automotive and energy sectors need to work together to expedite industry modernisation and regulation must evolve to facilitate data capture, smart charging and V2G proliferation.

V2G could become an important factor in grid balancing and the provision of additional capacity, and it may provide significant financial benefits to those that embrace it. Yet the concerns and obstacles to its growth are plenty. Commercial arrangements must be locked down and clear, risks have to be mitigated and financial incentives need to be evolved. Our decarbonised future depends on it.



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