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European Commission

Science for Environment Policy

Understanding degradation of battery life-time is key to successful vehicle-to-grid systems

Electric vehicles (EVs) could play a role in future power supply, but face issues surrounding the longevity of their batteries. This study reconciles two recent contradictory results on the effects of vehicle-to-grid (V2G) technology on battery life-time, and shows that V2G — a process via which EVs would exchange energy with the power grid to provide ancillary services, such as supplying power during peak periods, and helping to regulate grid frequency — could actually extend the lifespan of commercial lithium-ion batteries[1].

EVs are predicted to make up one third of the global car fleet by 2040[2], and with this increased use comes the prospect of V2G. However, battery[3] cells only have a finite number of charge cycles, which could affect the longevity of vehicle batteries and make the system — as currently modelled — economically unviable.

Clean, sustainable mobility is a focus for the European Commission — as part of the 'Europe on the Move' package[4], recent initiatives aim to increase the availability of electric charging points across Europe, and to encourage the deployment of zero- and low-emission vehicles[5].

Vehicle-to-grid systems could assist in the push for clean mobility and green energy. Through reciprocal energy exchange, EVs could help energy-distribution networks with peak shaving (reducing demand on the grid by charging their batteries during off-peak periods and discharging during peak), regulating system frequency, and spinning reserves (a reserve capacity linked to the grid to meet surges of demand). V2G could also provide financial incentives to consumers by helping them avoid peak tariffs (buying power during off-peak periods (at lower cost) and storing it for use as needed), and support regions lacking sufficient energy storage, back-up and peak supply services.

Two recent studies explored different elements of V2G: one experimental study tested the impact of reciprocal energy flow on commercial lithium-ion batteries in maximising a car owner's profit (i.e. selling as much cell capacity as possible during a peak one-hour period), while the other simulation-based study tested the idea of using V2G as a tool to adjust a cell's rest conditions in order to improve its longevity. Despite testing very similar commercial batteries, each reached a different conclusion — the former that V2G would be detrimental to cell performance, potentially shortening battery lifetimes to less than five years and increasing their capacity loss by 75% over an 18-month period, and the latter that intelligent V2G could actually reduce the capacity and power fade of an EV battery by up to 9.1 and 12.1% respectively.

However, the researchers involved have now collaborated on a study to successfully reconcile their results and provide clarity on how EV battery life can be reliably extended. They confirmed that the viability of V2G is governed by battery degradation: as lithium-ion batteries age and undergo charge cycles they lose both charge capacity and power capability, which in turn causes a battery-powered vehicle to become less efficient and able to travel shorter distances between charges. Current V2G pilot-studies model batteries without considering their degradation — a factor with important economic, regulatory, and policy implications for consumers, manufacturers, and policymakers alike.

Continued on next page.

1. Lithium ion batteries cost on average about 200 €kW/h. But their costs could decrease rapidly, by at least 50% in 2030 and up to 75% in 2040, due to mass production of electric vehicles — according to a recent report from the EU's Joint Research Centre: *Li-ion batteries for mobility and stationary storage applications*

2. *Electric Vehicle Outlook 2017* – Bloomberg New Energy Finance's annual long-term forecast of the world's electric vehicle market. Executive summary, July 2017: https://data.bloomberglp.com/bnef/sites/14/2017/07/BNEF_EVO_2017_ExecutiveSummary.pdf

3. For more information about future battery technology see SfEP's Future Brief: *Towards the battery of the future*

4. *Europe on the move: Encouraging clean and sustainable mobility*. European Commission: https://ec.europa.eu/transport/sites/transport/files/mobility-package-factsheet-iii.pdf

5. The New European Driving Cycle tests show that the wide range of current EVs can travel from 100 to 632km on one battery charge. These figures vary according to weather, traffic and driving style.

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The study shows that, while current V2G models would be detrimental to the lifetime of an EV battery, 'optimised' or 'smart' V2G systems — designed to work more responsively and efficiently, and to rely on prognostic battery degradation models to limit the amount of energy that could be traded — would be viable, profitable, and capable of extending battery life even beyond the case in which there is no V2G.

A V2G system as currently represented in pilot studies is unviable, say the researchers; they instead call for smart infrastructure and business models that accurately consider how lithium-ion batteries degrade, in order to better manage their vehicular use and support a shift towards clean mobility and carbon reduction. They highlight a number of priority policy, regulatory, and research areas that must progress for a smart V2G system to thrive and expand as a future grid service — an area that requires ongoing research and innovation. Such innovation includes innovative battery research and real-time testing, new compensation models for EV owners, investment in relevant infrastructure and technology, establishing a free market for grid services, and the development of accurate, battery-specific prognostic models for how cells degrade over time. V2G could also help to mitigate the effects of climate change, by reducing levels of polluting carbon and promoting clean, eco-friendly mobility (although it should be noted that these qualifiers of 'clean' and 'sustainable' also depend upon the source of the electricity itself – for example renewables versus fossil fuels).