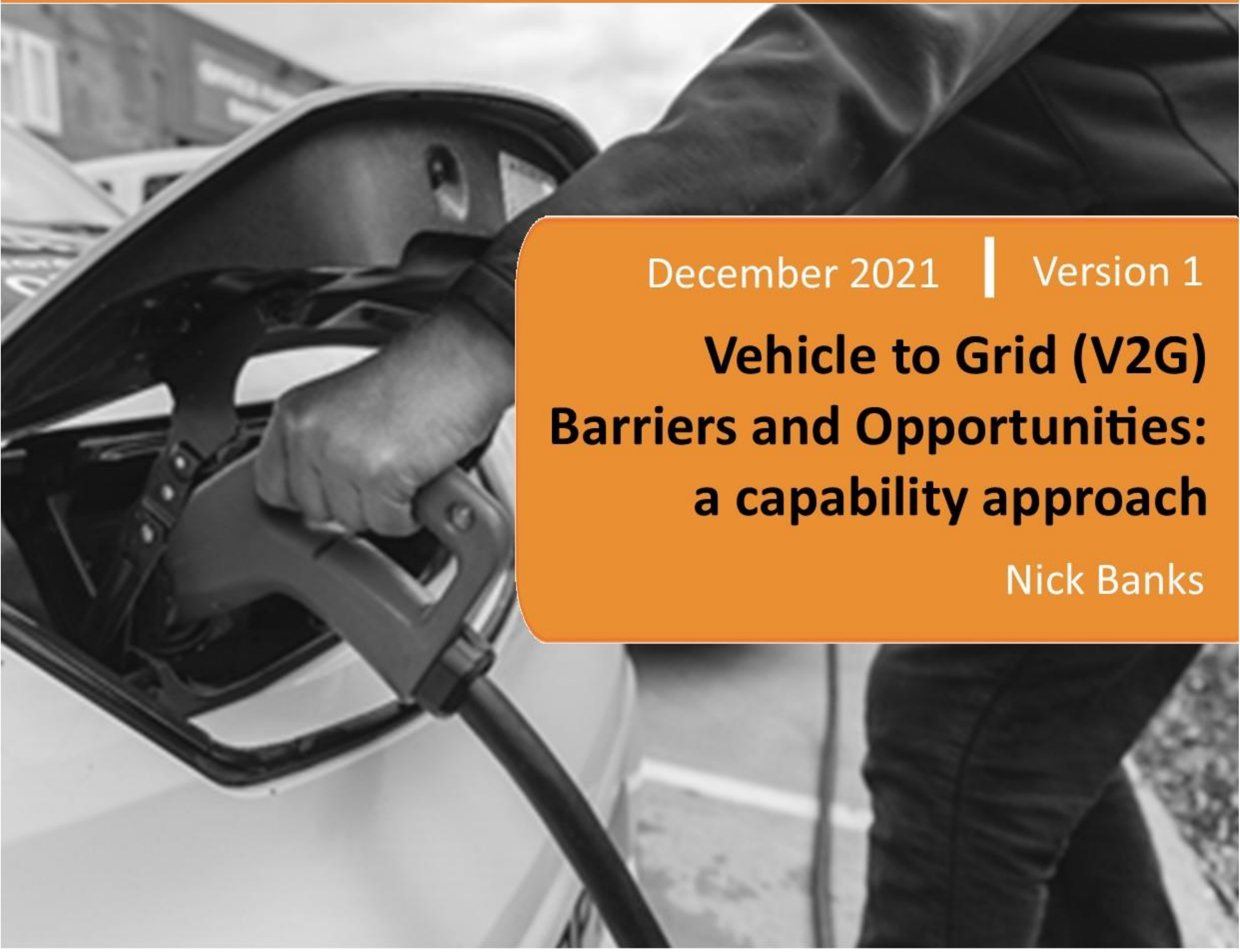
LEO Local Energy Oxfordshire



December 2021 | Version 1

Vehicle to Grid (V2G) Barriers and Opportunities: a capability approach

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Report Title:	V2G Barriers and Opportunities: a capability approach
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Version:	Final draft	Date:	21-12-21
Workpack*:	WP6	Deliverable:	6.1.9
Reviewed by:	Filiberto Fele (Oxford University), Sarah Darby (Oxford University) , Paige Mullen (NuVVe), James Dixon (Oxford University), Paul Gambrell (Oxfordshire County Council)		
Date:	21/12/21		
Signed off by:	Nick Banks		
Date:	21/12/2021		

Can be shared (Y/N):	Internally	Yes	Publicly	Yes

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1 Vehicle to Grid in a nutshell

Vehicle-to-Grid (V2G) technology is still in early stages of development but offers many possibilities for Smart Local Energy Systems by virtue of its ability to supply flexible demand and generation services that can potentially help with the management and balancing of low voltage electricity networks as well as balancing services for the National grid.

V2G can take charge from the grid or from distributed energy resources (such as a rooftop solar array), store the energy for a limited period and then discharge, either back to the site, to the local network or, indeed, to the motor in the vehicle.

Optimising charge and discharge cycles allows the creation of network services, the ability to take full advantage of time-of-use tariffs (based on wholesale markets for electricity) and to charge at times of low carbon intensity of grid supply and discharge at times of high carbon intensity.

Figure 1: Nuvve vehicle to grid chargers deployed as part of the Invent project in San Diego, California USA. Source: Nuvve

One recent study concludes that V2G assets are well placed to support local distribution grids and improve utilisation of existing network capacity, which could lead to avoided or postponed reinforcements. In addition V2G could be used to support network congestion management, so that instead of installing redundant assets it is possible to enhance existing asset utilisation. In the case of a component failure, V2G can also supply electricity for a limited time to avoid overloading the network[1].

Project LEO is testing V2G's ability to provide flexibility services as part of its trials. This briefing note captures some of the main learnings around the barriers and opportunities for deployment of V2G charging infrastructure captured from LEO experience with the technology thus far.

[1] The Drive Towards a Low Carbon Grid: Unlocking the value of vehicle-to grid fleets in Great Britain. Nissan, Eon and Imperial College London (July 2021). Report here.

1.1 Benefits

V2G or V2X[2] can deliver economic, social and environmental benefits. These include:

- As a battery asset, V2G allows access to a broad range of flexibility markets including the national markets for balancing services and frequency response fault recovery[3].
- V2G, at scale, could improve network resilience.
- V2G, at scale, can help with mitigation of constraints caused by too much distributed generation or demand.
- V2G charging and discharging cycles can be optimised around reducing the carbon content of electricity supplies. Also, charging and discharging cycles can be optimised for battery longevity.
- As a backup source of power, V2G can be useful in maintaining critical electricity dependant services for vulnerable households when there are interruptions to mains supply.
- V2G can optimise use of behind the meter solar on-site generation.
- Like other EVs, V2G EV can potentially offer lower cost transport per mile than conventional ICE alternatives and a new source of income from sales of exported energy [4]– potentially particularly benefitting low income households[5].
- Revenue from sales of V2G flexibility services can reduce the total cost of ownership of an EV, enhancing their cost-competitiveness with ICE vehicles.
- In common with conventional EVs, V2G offers reductions in local air pollution from tailpipe emissions.

These benefits are discussed further below.

1.1.1 V2G allows vehicles to participate in multiple flexibility and balancing markets

Like other batteries, a V2G battery can deliver flexibility services to local networks. Because of short ramp up times batteries are well suited to services where very quick response is needed - e.g. for stabilising the frequencies on the network in the event of a fault and also during normal operation. But they can also be used for DNO procured services that need scheduling days, weeks or even months in advance such as Sustain Peak Management[6].

Connection of V2G at low voltage level does not limit it to provision of DNO services. In the UK, V2G using domestic vehicles connected at the low voltage level have successfully trialled supplying grid

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[2] V2X – the capacity of the battery management system and chargepoint to discharge either to the grid or other circuit such as the behind-the-meter electricity supply point to a domestic distribution board.

[3] Batteries are well suited to frequency response services. In particular the market for National Grids Dynamic Containment service is thought well suited to Vehicle to Grid applications. National Grid's frequency response pages are here.

[4] Noting that Octopus Agile Export tariff reached £2.38 per kWh during September 2021. See: https://www.energy-stats.uk/octopus-agile-outgoing-export/

[5] But noting that early adoption of EVs is low in low income households at the moment - whilst capital cost of EVs remains higher than ICE vehicles and the second hand market for EVs is still in its infancy. However EVs are expected to reach price parity with ICE alternatives in the next few years. It should also be noted that where the costs of grid reinforcement triggered by connection of EVS to networks are socialised, all households including low income households will see their bills go up but clearly only those with the EV or V2G EV will benefit.

[6] SSEN's description of the various types of service needed by DNO's is found at: https://www.ssen.co.uk/SmarterElectricity/Flex/

services, from those operating on a timescale of minutes to hours such as the Balancing Mechanism[7], and timescales of milliseconds to seconds, such as Dynamic Containment[8]. Therefore, V2G batteries can be used in different ways in different markets for flexibility and balancing services[9] and consequently there are multiple ways of working with V2G technology to create different value propositions.

Static batteries are capable of delivering all balancing and flexibility network services but are particularly well suited to delivering network services requiring virtually instantaneous to short term responses. This makes them well suited to ESO markets for managing frequency issues such as Dynamic Containment and for local network requirements for pre and post fault services.

Unlike weather dependent sources of flexibility, batteries can also be reliably scheduled to deliver services weeks and months in advance. V2G batteries are no different to static batteries but must be managed differently because there is no 100% certainty that the batteries will be connected to the network at any particular time (when they may be needed to provide a service)[10]. Instead, the aggregator must forecast the likely number of V2G batteries available based on previous experience and knowledge of driver behavioural patterns.

A further difference to static batteries is that V2G batteries must also be managed so that there is sufficient charge for the EV to be used for its primary function - i.e. as a vehicle.

1.1.2 Mitigating network constraints allows more DER to be connected at LV levels

As with other sources of flexibility, smart charging EVs and V2G EVs can potentially mitigate network constraints at individual household or community levels through facilitating connection of distributed energy resources (e.g. rooftop solar) at low voltage levels. V2G EV's in particular can facilitate more demand for example using V2G to artificially increase headroom and allow more heat pumps onto the network.

1.1.3 Carbon benefits

V2G can deliver carbon reductions by smart charging and discharging depending on the carbon intensity of grid electricity and availability of low carbon electricity either produced from a DER (e.g. from a solar roof) or from renewable electricity generators connected to high voltage parts of network (solar farms, on shore and offshore wind).

1.1.4 Benefits for vulnerable households

V2G can potentially play a role in providing emergency back-up power services in vulnerable households where power failure would interrupt supply of critical services such as powering medical

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[7] For example, see WPD's Energy Nation project: https://electricnation.org.uk/

[8] ESO's frequency response services are now being brought together as Dynamic Containment: https://www.nationalgrideso.com/industry-information/balancing-services/frequency-response-services/dynamic-containment

[9] The ways in which different Distributed Energy Resources (flexibility assets) including small batteries can be deployed in different markets for flexibility and ESO balancing services are described in Project LEO report, Value Chain for Flexibility Providers at: https://project-leo.co.uk/wp-content/uploads/2021/06/LEO-D2.8-Value-Chain-for-Flexibility-Providers-v2.1-LEO-cover.pdf

[10] Although we should note that no power plant or storage asset has an availability factor of 100%.

equipment, lifts and hoists, and keeping medicines refrigerated. It is thought that there is huge potential here both for vulnerable households and for others as outages become more common place with electricity use rapidly increasing in the next few years.

1.1.5 Benefits for low income houses

As with other EVs, V2G enabled electric vehicles have much lower running costs than vehicles with Internal Combustion Engines (both maintenance and fuel costs)[11]. Capital costs of EVs versus ICE vehicles are expected to reach parity or become lower in the next 5 years[12]. In addition, because of the potential income that can be generated from sale of flexibility services to the DNO and the ESO[13], V2G ownership has a potential role to play in transport poverty and in improving energy equity.

1.1.6 Air quality benefits

By enabling additional revenue flows from sales of flexibility, financial aspects of ownership of electric vehicles are improved therefore further encouraging uptake of EV's. Wider ownership of EVs creates social and health benefits. For example, cuts in local air pollution.

1.2 Challenges and issues

However, installing V2G is not without its issues and challenges. These include:

- V2G chargepoint hardware is currently relatively expensive versus conventional charging stations,
- More complex chargepoint connection processes versus conventional EVs. This can result in greater connection cost,
- EV chargepoint installation can be difficult and expensive,
- V2G benefits depend on extended and specific plug in times,
- Extended plug in times have equity implications,
- V2G services are unlikely to be feasible when delivered through public chargepoint infrastructure,
- Policy and regulation do not always recognise distinct V2G benefits,
- At this time, V2G is only deliverable through a limited number of vehicle types linked to specific charging standards (primarily, CHAdeMo) though this is thought to be changing soon with a requirement to switch to European standards[14].

These challenges and issues are discussed further below.

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[11] Going electric: how everyone can benefit sooner. Green Alliance (2019) https://green-alliance.org.uk/resources/going_electric_how_everyone_can_benefit_sooner.pdf

[12] See, for example, Deloitte Electric Vehicle report (2021): https://www2.deloitte.com/uk/en/insights/focus/future-of-mobility/electric-vehicle-trends-2030.html

[13] CENEX estimates that between £150 and £400 is available to the customer from V2G value streams over and above standard smart charging savings depending on the amount of time the vehicle is plugged in and able to discharge. The upper rate is only achievable if the vehicle is plugged in around 75% of the time. See CENEX report for Innovate UK, A fresh look at V2G value propositions. June 2020. Available at: www.cenex.co.uk/app/uploads/2020/06/Fresh-Look-at-V2G-Value-Propositions.pdf

[14] However, there is no agreed European standard using Type 2 or CCS charging ports yet.

1.2.1 V2G chargepoints are relatively expensive versus conventional smart charging

V2G charging infrastructure (chargepoints) is more expensive than conventional smart chargepoints at this time. Much of this cost is associated with the specialised inverter required to convert DC power from the battery to AC for grid supply – i.e. a 10 kW AC/DC converter is required on your driveway. However, if vehicle manufacturers designed the onboard converter that allows installation of an AC chargepoint for one-way charging to *allow bidirectional power flow*, then V2G would be possible using the exact same smart charge points as are used for smart one way charging[15].

OVO's recently concluded trial of V2G found that the average cost of V2G hardware and installation is currently around £3,700 higher in the UK than for a regular smart EV charger. Trial participants in the OVO study said that bringing this figure down to around £1,000 extra would encourage uptake, as the payback period would then be five years at most[16].

1.2.2 EV chargepoint installation can be difficult and expensive

As with conventional EV chargepoint installation, V2G charging infrastructure can be extremely expensive to retrofit to sites if the local network or site electrical systems need to be reinforced or substantially upgraded, or streets and hardstanding have to be dug up to accommodate cables and conduits. Including civil works to separately earth the chargepoint and run cable beneath a driveway. A residential V2G chargepoint installation in LEO cost around £6.5k excluding VAT.

1.2.3 More complex connection processes

Because V2G sends power back into the network, the DNO must analyse any impacts on the local network and design the connection appropriately. The DNO process to design, electrify and commission the connection of generation and storage assets connected at medium and low voltage parts of the network (such as V2G batteries connected at low voltage levels) is called G99[17]. G99 can take weeks to months to process[18] and, depending on the DNO, G99 can also be charged for. Costs can vary from a few hundred pounds up to thousands.

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[15] Conventional smart chargepoints cost around ~£300 versus around £3000 for V2G chargepoints.

[16] See EDIE story on the trial at: https://www.edie.net/news/8/-World-s-largest--V2G-trial-finds-that-motorists-could-cut--725-off-monthly-electricity-bills/

[17] A V2G electric vehicle is considered as both a demand and a generator by DNOs. The generator application for connection will depend on the power export capacity of the V2G and what generation or storage devices are already connected at the designated charging point. It is likely that V2G will be > 16 A/phase and therefore G98 is not applicable **and G99 should be used**. The current situation is that installers follow one of two generation application processes and sets of forms, which are as follows below:

- Where the total of all generation, fixed storage and the power export capacity of the V2G is < 50 kW 3-phase or 17 kW single-phase, the G99 Simplified Application Form A1-1 can be used.
- Where the total of all generation, fixed storage and the power export capacity of the V2G is > 50 kW 3-phase, the connection application should be made using the Standard Application Form.

In addition, the installer should complete forms associated with a standard Electric Vehicle (EV) charge point, such as the ENA EV installation form ("Application Form for the Installation of Low Carbon Technologies"). The DNO may also request further information, such as a photograph of your electric meter and consumer unit.

From: www.energynetworks.org/assets/images/Resource%20library/G98%20Single%20Summary%20Guide%202020.pdf

[18] However recently developed industry wide policy is intended to streamline the process, removing the requirement for a full G99 application for installations below < 50 kW 3-phase or 17 kW single-phase.

Subject to the conclusions of G99, a requirement for local network reinforcement may be triggered with the cost of this payable by the customer. Where local network reinforcement has already taken place and the G99 indicates that the new connection will make use of that reinforcement then some DNOs will require the customer to retrospectively pay a contribution towards the reinforcement[19].

1.2.4 V2G benefits depend on extended and specific plug-in times

V2G charging and discharging for best results from the network point of view may not always coincide with vehicle-owners' travel patterns, preferred charge and discharge times and availability of low cost or low carbon electrical generation. For V2G to deliver maximum value to the householder or fleet operator it should be plugged in and capable of charge and discharge for as long as possible and, particularly for V2G, the EV should be plugged in at weekday peak times (approx. 4 to 7pm) and over the weekends[20].

Because V2G only has substantial benefits over conventional smart charging when plugged in around 70% of the time, the technical case for V2G in helping manage network constraints is strengthened where chargepoints installed in the home are complemented by chargepoints installed at the workplace or other public locations such as shopping centres. It is also possible to imagine value propositions for V2G which incentivise charging and discharging at public locations. For example, if the V2G battery, whether at home or at the workplace is discharging into another or the same part of the network with a network constraint (and the V2G flexibility therefore has value at home and at the second location) it would be helpful for the business case if the value of the workplace flexibility could be returned to the V2G EV owner. Another value proposition would be for the public chargepoint location owner, e.g. a shopping mall, to incentivise charging and discharging at specific times by offering time of use tariffs or by linking a scale of parking charges to time of day.

1.2.5 The requirement for extended plug-in times has equity implications

The extended plug-in times currently required to make the business case for V2G to stack up versus conventional smart charging EV require secure off-street parking with associated chargepoints. But this has equity implications as lower income groups generally have less access to off street parking. For example, lower income groups live disproportionately in private rented accommodation and in social housing. Evidence presented in SSEN's EV strategy suggests that around 22% of owner-occupier households in England do not have secure off-street parking. But this rises to 52% of the private-rented sector and 75% of households in local authority housing[21]. Therefore, it is likely that households on lower incomes will have less access to secure off-street parking and will be less able to participate in the V2G or smart charging EV offer. Given the financial benefits of owning and operating a smart charging EV this is a potential source of inequity in the energy transition. Creative business models and value propositions are required to address this potential source of inequity.

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[19] As an indication, the reinforcement charge incurred in the domestic V2G connection installation undertaken in LEO was around £1300.

[20] Significant revenues over conventional smart charging are only achievable if the vehicle is plugged in around 70% of the time. See CENEX report, Understanding the True Value of V2G. Available here

[21] Accelerating a Green Recovery: Proposals to deliver the world's most extensive electric vehicle charging network by 2025. SSEN. 2020. Available here

1.2.6 V2G services delivered through public charging infrastructure need careful design

Public chargepoints are unlikely to be capable of delivering V2G network services because there is no guarantee that a V2G vehicle will be connected at the time required to deliver the flexibility event. In addition, public chargepoints will be primarily used for charging not discharging into the local network hence only demand turn up services are likely to be feasible at public chargepoints. Demand turn up is deliverable by both V2G and conventional smart charging. Also, public chargepoints are, by definition, not able to generate benefits for a specific privately owned site (i.e. a residence or an organisation's premises). However, if V2G EVs are able to take charge from public charge points during the day (or from chargepoints installed at workplaces) they are more likely to be sufficiently topped up to provide network services from discharge during weekday teatime peaks or at weekends. So public chargepoints do have a role to play in indirectly facilitating V2G network services.

We should also consider that each type of EV infrastructure has a specific purpose to serve. Some places people park for a long time so only need to charge slowly or could pass energy back to support the grid. Examples include the home, workplaces, airports, long term parking, lamp post charging, community charging hubs and park and rides. At other times, charging is needed quicker, such as at a shopping centre or along the motorway. V2G is most adapted to places with longer dwell time and new business models to increase utilization, such as overnight parking at a shopping centre with V2G and rapid or fast charging during the day will lower prices for all while allowing for more options for customers to charge based from their needs.

1.2.7 Policy and regulation do not always recognise distinct V2G benefits

Policy and regulation have not entirely caught up with the need to provide a framework that encourages and enables V2G operations. Current DNO policy for connection of V2G to local networks does not recognise the flexibility it can bring: it can be viewed only as a technology that could exacerbate network constraints rather than resolve them.

1.2.8 V2G is only deliverable through a limited number of vehicle types

Only certain vehicles (and therefore charging standards) are V2G compatible at this time. The limited vehicles that are available are all Japanese using the CHAdeMo standard. This standard is due to be phased out over the next couple of years and replaced with vehicles using European charging standards.

The Nissan Leaf is by far the most common V2G compatible model currently purchased but an increasing number of V2G compatible EV models are under development by other manufacturers as the global standard of 15118 continues to develop and prototypes are released for V2G testing.

2 A Capability approach to understanding barriers and opportunities

Building on work by CSE's Smart and Fair research programme[22], LEO is developing a capability framework to think about how households, businesses, communities and local energy systems can adopt and integrate flexibility technologies and practices.

2.1 Actor, community and system capabilities

Large-scale actors have participated in markets for energy services for many years, but with the advent of distributed renewable supply and storage, smart metering and cheap internet connected monitoring and control systems, participation is now open to small-scale domestic and business customers, at least in theory. This means the formation of new relationships between actors who are learning new roles, for which they will need capabilities: the ability, suitability and willingness to contribute to, and benefit from, local energy systems. Communities too must learn to act collectively and in new ways if they are to fully benefit from the SLES opportunity. Required capabilities for participation by individual, organisational or community actors fall into domains:

a) technical e.g. possession of a generation asset;
b) economic e.g. financial resources to invest in assets;
c) lifestyle/operational e.g. ability to shift demand without detriment;
d) skills and motivation e.g. digital skills;
e) social capital e.g. sharable skills and insights, normative approval.

The energy system as a whole must also be able to host or integrate a SLES by possessing capabilities such as a conducive planning, policy and regulatory environment, market platforms where services can be traded and sufficient actors of particular types to supply liquidity, competition and necessary services.

We use this capability framework to think about what capabilities of different types are required to adopt a V2G Electric Vehicles and associated charge points. Consideration of required capabilities naturally lends itself to identification of the barriers and opportunities for V2G.

2.2 Intervention strategies

The capability approach also helps identify two types of intervention strategies to overcome barriers:

1. 'Fit strategies' are strategies to adapt the V2G offer to work better with existing capabilities as these are clustered and geographically distributed. The onus for change is on the V2G offer rather than the Energy Markets, SME, household or community that is adopting the technology.
2. 'Transform strategies' are about changing the capabilities of households and communities in order to facilitate V2G adoption. The onus for change is on the capabilities of the community, household or business.

[22] https://www.cse.org.uk/projects/view/1359

In practice, it is likely that a blend of fit and transform strategies will be most effective in stimulating adoption. This approach has been used in developing policy to facilitate adoption of V2G amongst fleet managers[23].

[23] See report on the Vehicle to Grid Oxfordshire project at https://www.tsu.ox.ac.uk/research/v2go/

3 Capability framework

Domain	Capability Category	Required capabilities to adopt V2G	Barriers to possession of requisite capabilities	Opportunities and recommendations for gaining requisite capabilities
Actor level Householder, SME, Organisation	Technical Technical characteristics of appliances and equipment in the building, structure and layout of the building and curtilage, characteristics of the electricity supply to the site	**Secure parking adjacent to a chargepoint** The site must have space for secure parking of EV(s) close to accessible chargepoints. Secure parking is particularly important for V2G where benefits over conventional smart charging are only realised if the car is plugged in and able to charge and discharge. The greatest revenue potential is when a car is connected at strategic times, such as peak periods and for around 70% of the time.	Overall, it is estimated that around 60% of English households have secure off street parking. The Oxfordshire EV strategy estimates that around 66% of households in Oxfordshire have access to secure off-road parking in some form leaving some 34% of households likely to be parking their vehicles in the streets. Trailing cable from the home across the pavement to connect the EV parked in the street creates a trip hazard, even with a cover, and therefore contravenes the Highways Act (1980). Guidance from local authorities prohibits this method of home charging[24]. Consequently, home charging for households with no off street parking will be problematic without a practical solution[25]. Availability of secure parking also poses an equity issue. Around 22% of owner occupier households in England do NOT have secure off street parking. This rises to 52% of the private-rented sector and 75% of households in local authority housing. Lower income households are more likely to live in private rented accommodation or in social housing. Therefore, it is likely that households on lower incomes will have less access to secure off street parking and will be less able to participate in the smart charging and V2G offer. Given the financial benefits of owning and	On street and public charging infrastructure supports V2G indirectly by creating opportunities for charging throughout the daytime so that there is always sufficient charge remaining in the battery to deliver V2G services. Also, EV ownership is encouraged where street and public charging infrastructure is developed[30]. The local planning system can also be leveraged to encourage installation of both regular smart charging and V2G infrastructure in new build and historic buildings. Local authorities can further influence install rates by requiring chargepoints to be installed on their own estates[31]. Influencing retrofit of EV charging infrastructure into existing housing and buildings is beyond the direct reach of the planning system but can be encouraged indirectly through provision of grants, awareness raising etc. Other solutions for facilitating EVs and V2G where there is no off street parking have been explored in the City and County Council's Go Ultra Low Oxford project[32]. The clear winner is a cable gulley. A cable gulley removes this issue and is relatively easily and cheaply installed[33]. Local planning rules, policies and practices should be developed that facilitate this kind of low cost but effective solution.

[24] See, for example, guidance from Haringey council here

[25] The barriers and solutions to tackling on street charging provision are discussed in Oxfordshire's EV strategy

[30] A list of options for charging EVs where there is no access to off street parking is found in Appendix B of Oxfordshire EV strategy found here.

[31] Local plans should include policies that require any newly constructed homes or non-residential buildings to have associated parking spaces equipped with chargepoints. Importantly, also, newly constructed parking space that is NOT allocated to a specific dwelling or non-residential building should also be equipped with chargepoints. This kind of provision has found its way into some local plans including the Oxford City Council local plan. This has the following requirements: Policy M4: Where additional parking is to be provided in accordance with Policy M3, planning permission will only be granted for new residential developments if a) provision is made for electric charging points for each residential unit with an allocated parking space; and b) non-allocated spaces are provided with at least 25% (minimum of 2) having charging points installed. Permission will only be granted for non-res development that includes parking spaces if a min of 25% of spaces have charging points.

[32] Go Ultra Low Oxford: https://www.goultralowoxford.org/

[33] Key learnings from the Go Ultra Low Oxford On-street (O-GULO) project demonstrate that installing electrical on-street EV charging infrastructure is complex, time consuming and costly to install and manage. Costly electrical/data connections and maintenance create a challenging business case for investment and limited choice for local authorities and consumers. Learnings suggest avoiding on street electrical infrastructure by creating off-road fast charging hubs and can support better use of infrastructure and makes a stronger case to attract private investment. Also, the potential to provide safe access to charge an EV with a home charger using a 'cable gully' as piloted in the O-GULO project may help us to support on-street EV charging at mass scale, simply and cost effectively.

			operating a smart charging EV this is a potential source of inequity in the energy transition. The Office of Zero Emission Vehicles (OZEV) grant for chargepoints[26] is only payable for installs where there is secure off street parking[27]. The parking requirements also stipulate that arrangements that involve cables placed over public land, including pavements will not be permitted. This grant scheme will cease from March 31st 2022[28]. OZEV further administers a grant accessible by local authorities to pay for on street parking infrastructure – the On-Street Residential Chargepoint Scheme (ORCS)[29]. However, this grant is not to be used for: • the installation of chargepoints for the primary use of EV car clubs, taxi fleets or other commercial undertakings – given the residential focus of the scheme or • the installation of chargepoints connected to an individual's domestic electricity supply – hence it will not fund installation of cable gulleys to individual homes.	A simple cheap solution to allow vehicles to be charged and discharged when parking on the street clearly addresses some equity issues associated with EV (and V2G) ownership. Where households do not have access to off street parking, an electric vehicle car club where the vehicle is charged (and can discharge) in a designated publicly accessible bay could offer a further solution. However, there is currently no grant scheme to subsidise installation of chargepoints for car club schemes. Some local authorities, including Oxford City and County council are actively developing policy to address on street charging issues[34].
		V2G compatible vehicle type Make and model of EV must have ability to discharge to chargepoint.	Only a limited number of vehicles are currently capable of discharging vehicle to grid. At present the CHAdeMO standard is the only commercially available standard for V2G[35]. Vehicles equipped with a CHAdeMO connector are largely limited, at present, to the Nissan Leaf, a four door family car and the	Many producers of EVs have stated that their new EV models will be V2G compatible. The V2G-compatible EVs will be equipped with 'CHAdeMo' charging ports and include models from Mitsubishi, Nissan and Toyota. However, other brands are researching the potential of V2G, and it's likely to be available in more cars soon using other European charging standards[37].

[26] Payable for up to 75% of the cost of the smart chargepoint install up to a maximum of £350.
[27] Guidance on eligible parking arrangements are found here.
[28] Overview of the scheme including dates when it will finish is found here.
[29] On-Street Residential Chargepoint Scheme guidance for local authorities is found here.
[34] The Oxfordshire EV strategy has the following policy: Policy EVI 6: Recognising that lack of off-road parking may be a significant barrier to EV take-up, Oxfordshire County Council will promote a hierarchy of solutions to EV charging for residents, businesses and shared vehicles without access to off-road parking, which prioritises off-street charging hubs, and other solutions which avoid generating additional street clutter or surrounding maintenance and management challenges.
[35] It is thought that over the next couple of years all EVs sold in Europe will use the European Type 2/CCS charging standard. Thus CHAdeMo is thought to be a "dying proposition". Pers. Comm. Paul Gambrell, Oxfordshire County Council EV strategy lead.
[37] What Car magazine article on this topic found here.

		At present, the CHAdeMO standard is the only commercially available standard for V2G. This has been adopted by the Nissan range of V2G capable EVs including the Nissan Leaf	Nissan eNV200 which is an electric van (which can also be configured as a large family car). Therefore, in selecting sites to approach with the V2G offer, Nuvve described how they were largely limited to organisations owning a fleet of Nissan Leafs - installation of six V2G chargepoints at Oxford Brookes University will only allow Nissan Leafs. and a handful of other CHAdeMO compliant vehicles to connect to the CHAdeMO standard charger. In the short term, this may create an issue for EV driving members of staff who do not own a Leaf who may effectively be locked out of using the chargepoint service to charge their vehicles without the use of an adapter[36].	Adapters for converting CHAdeMo to type 2 standard connectors exist and cost in the region of £400. However, these will only allow charging from a V2G chargepoint - they do not allow discharge from the car to the chargepoint. This is because the battery management system of the vehicle itself must be designed to deliver V2G charge and the adapter does not deliver this capability. New vehicle standards that will allow V2G are in development and supported by almost all major vehicle manufactures.
		Chargepoint comms protocol is compatible with V2G and is readable by the aggregator	OCPP[38] is the protocol used most commonly for comms between the smart charging EV charge point and an aggregator for charging (noting that CHAdeMO is the standard allowing the connection between the charge point and the vehicle).	OCPP 2.0 does officially allow V2G (and the older one, 1.6, doesn't stop it happening, it just communicates negative charge quantities).
		Cost-effectively installed power cable and conduit from consumer unit to chargepoint. The building should be technically suitable for installation of cable, conduit and charger without excessive cost and disruption.	Installation of chargepoints can be disruptive and particularly expensive where further civil works are involved such as where hard standing must be dug up to lay cable conduit. Long cable runs out to chargepoints in secure parking areas where the cable should be buried are more likely in commercial fleet scenarios and where parking areas are shared communally such as parking provision for residents of flats. In domestic retrofit situations cable can be attached to walls and usually run beneath floorboards. In new build situations cost and disruption can be avoided if provision for cable runs (i.e. conduit) is built into the design for future use.	Where possible all parking spaces allocated to a residential building or commercial building (or to be shared between all building users) should be fitted with buried cable conduit into hardstanding and pavement so that chargepoints not installed at the time of the build or renovation can be retrospectively installed at least cost without the need to dig up hard standing. The electric vehicle chargepoint regulations 2021 are still being consulted upon[39].
		Building's wiring has capacity for additional chargepoint circuits.	The household consumer unit must have capacity to accommodate the new chargepoint circuit. The energy demand of the household including the newly installed chargepoint must not exceed, with diversity factored in, the rated capacity of the "cut out" fuse - usually 60 amps.	The recast Energy Performance in Buildings directive published in 2018 states that all new and thoroughly renovated residential buildings with more than ten parking spaces must be equipped with the appropriate pre-wiring for a charging point to be installed in each space. The same rule applies to commercial buildings; only the requirement is for just

[36] Tesla manufacture an adapter for CHAdeMo to type 2 standard. This costs around £400.
[38] More detail on the Open Charge Point Protocol available at: https://www.openchargealliance.org/
[39] The impact assessment for these regulations is found here.

		Spare terminal on household consumer unit or building distribution boards and sufficient capacity on the mains supply cut out fuse to accommodate chargepoint (s).		20% of spaces to be pre-wired. There will also need to be at least one physical charging point present in these car parks, however residential properties will need wiring present. The directive also requires the Member States to lay down requirements for the installation of a minimum number of charging points, for all non-residential buildings with more than 20 parking spaces, by 1 January 2025, and to simplify the deployment of recharging points in buildings, such as in permitting and approval procedures. Whilst the UK is no longer a member of the EU, these measures are supported in the Governments Energy White Paper: "we are taking action on introducing new building regulations to require electric vehicle chargepoints in all new homes and in non-residential buildings". Upgrades to wiring, distribution boards and consumer units triggered by renovation should anticipate that further EV chargepoint circuits may be added in due course. Also, wiring in new builds should have sufficient capacity and specifications to permit further chargepoints to be added later.
		Feeders, substations and other infrastructure (e.g. fuses) must have sufficient capacity to accommodate V2G loads and generation (i.e. discharges)	Vehicle to Grid discharge to the local network may exceed threshold levels. Where it is found that the V2G connection will potentially cause thresholds to be exceeded the DNO will require that the local network to be reinforced. At present, some part of this cost will be charged to the customer and this could be extremely expensive. The domestic V2G installation undertaken in LEO incurred an additional charge of £1300 to pay for local reinforcement. Interestingly, the reinforcement had already taken place and hence this cost was charged to the household retrospectively. The charge was also "pseudo" socialised – all those benefitting from the locally reinforced network were incurring a request for a contribution to the reinforcement cost - but only where their new required connection capacity necessitated or made use of the reinforcement.	The SSEN ED2 business plan makes a number of provisions to reduce the costs to customers of connection of EVs and heat pumps to the network where those connections could trigger a requirement for reinforcement. They do this in two main ways: 1. Flexible connections Flexible connections allow generators and demand assets to connect to the network ahead of required reinforcement. SSEN currently provide the ability for generation only customers at higher voltage levels but now wish to provide this option to demand customers and develop an offering on LV flexibility. Hence this measure allows early connection but is not a direct route to reducing connection costs. 2. Socialise the costs of Low Carbon Technology connection In SSEN's connections strategy they commit to fully fund the elements of reinforcement or changes to service arrangements that are required to facilitate the connection of all EV's and Heat Pumps to existing premises as well as other demand increases[40]. This is in line with Ofgem

[40] SSEN state that funding reinforcement costs incurred by LCT connection will "ensure that there is a just and fair transition for all to Net Zero and we expect the cost of that to amount to approximately £22m in costs that would have been paid for by our connections customers". SSEN's ED2 connections strategy is found at: https://ssenfuture.co.uk/wp-content/uploads/2021/06/A_13_ConnsStrategy_MICROSITE.pdf

			.	guidance and is considered to a mechanism to promote net zero goals in a fair way. Consequently the costs of reinforcement due to LCT connection will be recovered from DUoS charges on the energy bill. Costs to the individual requiring the connection are thus minimised (where there is a need to reinforce) removing a cost barrier to acquisition of EVs and other power hungry but low carbon technologies (such as heat pumps). However, because DUoS charges are included in the cost of a unit of electricity[41], which all, including low income households, pay, this method of cost recovery could be seen as regressive in that as low income households are much less likely to own or operate a V2G EV (yet still pay for the infrastructure allowing others to connect) An alternative to reinforcement is through creation of flexibility on the network at the connection point. Flexibility to allow a V2G connections could be achieved through: • Sequencing charge times of V2G and any other battery assets connected to the same part of the network • Modulating the load drawn. It is possible to control level of power drawn by the chargepoint • Installing generation or load limiting devices to give assurance to the DNO that discharge or demand thresholds will not be breached[42]. • Managing generation and demand behind a single MPAN or connection point so that there is no net impact on the network (offsetting)
	Economic and financial capabilit	**Particularly for V2G capable EVs, the household or business must have significant financial resources to afford both the car and associated**	Capital costs of EVs and associated charging infrastructure are more expensive than fossil fuelled alternatives.	V2G capable vehicles are no more expensive than regular electric vehicles. However, the relatively high capital cost of an EV and, particularly for V2G, associated additional chargepoint infrastructure costs plus the additional costs of the G99 process and any network reinforcement that may be triggered means that particularly high capital

[41] DUoS and TNUoS charges currently constitute about 23% of the unit price of domestic electricity. See Quick Guide to DUoS and TNUoS charges here.

[42] SMETS 2 smart meters are equipped with Auxiliary Load Control switches capable of switching off individual smart appliances (or chargepoints). These could be operated automatically via the internet to provide assurance to the DNO that charge and discharge to the local network can be controlled within set levels to avoid creating network problems. In addition, devices designed to limit exports onto the network can be installed according to the G100 protocol. G100 states that "as the cost of generation continues to reduce, many Customers are now seeking to increase the amount of generation installed within their premises to offset their import requirements. Where the DNO has assessed that an increase in generation export capacity will require costly or time-bound upstream reinforcement, some Customers may choose to restrict the net export from their connection rather than wait for or contribute to the reinforcement. A typical ELS may be used in the following scenarios:
• Over-sizing the generation and limiting the peak output
• Increasing flexibility of on-site demand at times of peak output
• Guaranteeing a defined export limit.

		incrementally more expensive chargepoint infrastructure.	At present, for some models, a V2G EV or regular EV will be several thousand pounds more expensive than for an ICE equivalent vehicle[43].	and administrative costs for the technology will tend to rule out lower income groups from acquiring the technology in the short to medium term. If only those on higher incomes can access the technology and therefore access the benefits that V2G releases then an inequity is perpetuated and deepened. Some local authorities recognise this danger and are developing policies to counteract it by, for example, ensuring that an inclusive public charging network is created, options for home charging where there is no off street parking are explored and where alternative ownership arrangements such as EV car clubs are facilitated[44]. Increasing both financial and non-financial incentives for retail and fleet purchasers of electric vehicles. A significant proportion of new vehicles go into the fleet market first before entering the second-hand market to further support transport decarbonisation. A plan for the evolution of the plug-in grant schemes beyond 2023 as part of a strategic incentive package would give businesses confidence to electrify large fleets and industry the confidence to invest. Car club vehicles may also provide a more affordable alternative to private EV ownership, with the potential to give wider access to clean vehicles, and support reductions in private vehicle ownership in line with the aims of Connecting Oxfordshire. Electric car clubs and the chargers needed to power them are therefore included as a valuable measure to improve social inclusion in Oxfordshire's EV ready future. Car share vehicles are often parked for long periods of time before they are checked out and can be very well suited for V2G.

[43] Going electric: how everyone can benefit sooner. Green Alliance (2019) https://green-alliance.org.uk/resources/going_electric_how_everyone_can_benefit_sooner.pdf

[44] Oxfordshire Electric Vehicle strategy contains the following policies:
Policy EVI 1: The Councils will collaborate to enable and encourage deployment of public EV chargepoints in Oxfordshire towards meeting predicted demand by 2025 in line with national targets and with reference to European directives. Importantly, a key action following from the policy recognises the potential for differential access to EV technology to become a source of inequity: "The Councils will use their best endeavours to enable a geographically and socially inclusive EV charging network which promotes equal access to EV charging for those in rural and remote locations and areas of deprivation based on available evidence of EV charging need".

		Sufficient financial resources particularly for V2G because of the relatively high capital cost of V2G chargepoint versus conventional smart chargepoints.	At present, an installed V2G chargepoint costs around £5000 versus around £1000 for a conventional smart chargepoint[45] - V2G chargepoints are approximately £4000 more expensive than conventional smart chargers. The Office of Zero Emission Vehicles (OZEV) has a grant scheme to subsidise the costs of chargepoint installations in domestic property[46]. However, only one V2G chargepoint make is eligible for the scheme[47] – the Indra 170911A202. Therefore, unless the V2G install uses this make / model they will not qualify for the grant. V2G may also incur further connection fees including those incurred by the G99 process and any socialised cost of reinforcement of the local network that may be triggered by the installation.	The relatively high costs of V2G chargepoint will also discourage V2G ownership versus conventional smart chargers amongst all groups. A recent study has found that the incremental cost of a V2G chargepoint over a conventional one needs to drop to around £1000 before the payback period comes in at around 5 years. Around 5 years was considered an acceptable period for an investment of this type amongst the householder V2G owners in the trial[48]. However, EVs are much cheaper to run than ICE alternatives and V2G offers potential income streams from sale of flexibility services to DNO and national markets. Some models estimate that these are anywhere between £150 and 400 per annum depending on tariff and value stacking arrangements[49]. Therefore, V2G technology in particular, offers a means of addressing transport poverty if those on lower incomes are able to access the technology.
		Ability for organisations and households to take on significant financial risk where returns from the investment in V2G technology are uncertain.	The case for investment in the V2G technology is uncertain: no-one knows the expected value of flexibility at a site in one year's time, for example. Alternatively, the DNO may take a decision to reinforce a part of the network that formerly was served by procuring flexibility – thus the demand for flex services at that point of the network will change and an investment in a flex asset may no longer make sense. Consequently, only organisations with the ability to absorb certain levels of risk are likely to adopt the technology at present – struggling SMEs are less likely to participate in a V2G offer. Therefore, this capability will tend to be associated with larger organisations who have access to greater financial resources and also the in-house resources to make risk assessed investment decisions. The consequence of this is that in equity issues apply amongst SME's and organisations as well as in the domestic sector.	It is suggested that investors in V2G develop value propositions and business models which: • Value stack as much as possible working with local and national markets for flexibility • Risk assess revenue streams from flexibility based on thorough appraisal of the business plans and investment programmes of the DNO – in particular considering which parts of the network will remain designated as Constraint Managed Zones and which will be slated for reinforcement over what time period • Also consider projected load analysis based on data feeding into local area energy planning • Consider local authority Local Plans and infrastructure planning and energy strategy • Understand other, non-financial value streams that result from investment in V2G – e.g. reputational benefits.

[45] The Electric Vehicles (Smart Charge Points) Regulations 2021 Impact Assessment published 14/07/2021 found here.
[46] The Electric Vehicle Homecharge Scheme Guidance for Customers is found here.
[47] The current OZEV listing of eligible chargepoint makes and models is found here.
[48] See the Project Sciurus Trial Insights: Findings from 300 Domestic V2G Units in 2020 here.
[49] CENEX estimates that between £150 and £400 is available to the customer from V2G value streams depending on the amount of time the vehicle is plugged in and able to discharge. The upper rate is only achievable if the vehicle is plugged in around 75% of the time. See CENEX report for Innovate UK, A fresh look at V2G value propositions. June 2020. Available at: www.cenex.co.uk/app/uploads/2020/06/Fresh-Look-at-V2G-Value-Propositions.pdf

				In addition, local authorities should develop the capacity and skills to work with smaller companies and organisations to enable this tier of smaller actors to understand the risks, challenges and benefits of participating in local energy systems and flexibility markets.
	Digital capability includes connectivity digital confidence	**Actors must own devices capable of hosting the V2G app plus possess digital confidence and skills to use it.**	V2G users control charging schedules using an application hosted on smartphone, tablet, desktop computer. Therefore, the user must own a devices and have the knowledge and confidence to use the V2G apps. The evidence suggests that ownership of smart devices is not equally distributed across all demographic groups. For example, surveys of smart phone ownership by age group[50] indicate that while ownership amongst age bands, 16-24; 25-34; 35-44 is approaching 95% plus, those aged 55-64 have only 87% ownership and only 65% of those aged 65+ have a phone that is smart. We can conclude that the oldest age groups are less likely to possess the requisite technology and have the associated digital confidence to use the app. Issues with digital confidence are compounded by the complexity of key concepts such as time-of-use tariffs and the innovative notion that the home's electricity use can be met by an battery parked on the drive.	Although digital confidence and ownership of the requisite devices (ie smartphones, tablets and personal computers) is now extremely widespread across all age groups bar the 65 years plus category the degree to which this capability will pose some sort of barrier to many in this older group is perhaps not to be underestimated. However, it is also notable that the CENEX study identifies "retired professionals" as a priority segment to work with as they are considered highly suited to V2G by virtue of their driving patterns (high levels of plug in time) and other characteristics including environmental motivations[51].
		Ownership of a smart meter	A smart meter records half hourly energy consumption and energy export data and is therefore essential if the EV is to take advantage of Time of Use tariffs (charging when energy prices are low), and, potentially, to offer verification and settlement of flex services (charging and discharging in response to local and national system needs). Although all energy suppliers are obliged to offer a smart meter it is not mandatory[52] and the offer can be declined. Smart Energy	Investment in V2G and smart charge points should trigger acquisition of a smart meter and this is the optimal way forward for households as the smart meter allows use Time of Use tariffs and therefore the timing of battery charging can be cost optimised. Where the boundary point meter is a half hourly meter or where a SMETS smart meter is configured for half hourly settlement, Elexon Code Modification P375[56] allows for the meter embedded within the chargepoint to be used in verification and settlement in the Balancing

[50] See Statista survey of use of smartphones by age group here.
[51] "The Retired Professional has a high-income background and is socially and environmentally conscious. They have PV on their home and are interested in the synergy with their midsized EV and off-street home V2G charger. The EV is used mostly for short or medium journeys during the day and is plugged in when not in use". Understanding the True Value of V2G found here
[52] See Ofgem smart meter pages: https://www.ofgem.gov.uk/information-consumers/energy-advice-households/getting-smart-meter
[56] Elexon's P375 pages are found at: https://www.elexon.co.uk/mod-proposal/p375/

			GB[53], the government agency promoting smart meters, finds clear demographic trends in interest in smart meters: younger people, those in rented accommodation and those with prepayment meters are most likely to be supportive of smart meters. The oldest age groups are the least likely to be interested in owning a smart meter[54]. However, it is not thought that non-ownership of a smart meter will prevent adoption of V2G technology because in all likelihood, adoption of V2G of a smart chargepoint will trigger install of a smart meter for those not already owning one. BEIS or Ofgem could develop a process that encourages this[55].	Mechanism. However, the embedded meter must also provide half hourly data and be compliant P375 Code of Practice 11 specifications[57]. There is a much better business case for investment in V2G over conventional smart charging EVs where there is access to National Grid balancing and capacity markets therefore P375 is considered game-changing in that it allows smaller assets (with integrated asset meters such as V2G chargepoints) to more easily participate in the Balancing Mechanism via aggregators. Depending on the configuration of the circuit and protocols established with the energy supplier, it may also be possible to demonstrate delivery of a Balancing Service on the SMETS Meter via P344 as a Supplier Serviced Metering System without the need of an Asset Meter. Should that not be possible the Virtual Lead Party (i.e. provider of a service to the Balancing Market) would have to look at any clashes with other services available and in use by a customer to determine if P375 is a viable option at individual sites. LEO has not yet developed a position on whether the metering arrangements agreed for participation in the Balancing Mechanism under P375 should also apply to DNO procured flex services. Finally, just to note that it also possible to capture many of the financial benefits of charging in off peak periods with the economy 7 and economy 10 tariffs. Analysis by CENEX shows that nearly all of the financial benefit delivered by half hourly ToU tariffs is also captured by Economy 7[58]. These tariffs do not require a smart meter - but do require ownership of an E7 meter.
		Cyber secure, robust, low latency digital connectivity between the chargepoint and the internet.	There is a general preference for a wired connection between the chargepoint and the router however running network cable to chargepoints may prove problematic or expensive. The connection must also be cyber secure.	Wi-Fi is alternative to network cable but evidently this kind of connection is less stable. Wherever possible wired connections should be enabled. This may entail running data cables in the same or adjacent conduit to the power cables. Cable runs arranged like this require

[53] Smart Energy GB
[54] The 2019 Outlook report is found here
[55] It is proposed that BEIS/Ofgem establish a process which strongly encourages consumers who are going to install, or already operate, a chargepoint to have a smart meter installed; and that this process could be triggered by the installation of a chargepoint and include notifying the consumer's energy supplier. See Proposal 10 of the Electric Vehicle Energy Taskforce report to OLEV, Energising Our Electric Vehicle Transition (2020), found here.
[57] Modification P375 'Metering behind the Boundary Point' was approved by Ofgem on 24 February. It will allow data from Asset Meters fitted at units behind the boundary point to be used in Settlement, from 30 June 2022.
[58] See CENEX report, Understanding the True Value of V2G. Available here

			The connection must also be low latency – particularly for some network services. The GB smart meter system facilitates secure comms of most applications required for the energy market (such as smart tariffs etc.), but the latency for some applications is too high (~10-15 secs) for rapid response needed for V2G to provide services such as dynamic containment. ESO’s current requirements for Dynamic Containment is <1 second. On the island of Ireland, it’s now < 0.1 seconds.	special arrangements so that the data cable signal is not impacted by the electromagnetic field created by the power cable. When commissioning the chargepoint householders should be reminded of the necessity to keep Wi-Fi routers switched on at all times. Also that charging will be interrupted if the chargepoint is not connected to the internet. To enable V2G to participate in fast response network services such as dynamic containment control systems may have to bypass the smart meter and communicate directly through the internet connected chargepoint.

	Work practices, personal and behavioural factors (alignment of lifestyle and practices, relevant skills and supportive motivations)	**Capability to have the EV plugged in for extended periods. Extended plug in times will only be compatible with particular work practices and householder driving patterns**	For V2G to optimise financial benefits by providing flex services to local and national markets the EV should be plugged in for as long as possible: the plug-in rate is a key driver for value captured from V2G. Average plug-in rates currently appear to be low (around 30% of time plugged in). In the case of a high plug-in rate driver archetype (75% of time plugged in) a 7kW V2G charger could capture annual revenues of around £436 - four times that achieved with the average plug in rate. Nearly all of this value would be from providing services to National Grid ESO Operator (SO), mainly Firm Frequency Response[59].	Domestic and non-domestic customers for V2G technologies should be segmented using a broad range of technical, demographic and attitudinal criteria. Once segmented, estimates of plug in times for each segment should derived allowing prioritisation of which segments are most suited to V2G. For example, Cenex has identified a list of 16 domestic customer "archetypes" (i.e. segments) and 18 commercial archetypes which are believed to be representative of current and future customers for V2G[60]. Each archetype was assessed for their applicability for V2G, resulting in the following short list of archetypes that provide high applicability to V2G and significant potential scale in the UK: • Council fleet - Pool cars • EV Car clubs • Company car park • The Retired Professional • The Eco-Professional • The Run-around (EV as 2nd Car) The findings of the CENEX study were somewhat compromised through having to work with a relatively small sample which did not allow for a robust assessment of charging patterns for each segment to be derived. Consequently, all segments were merged to generate a "combined" plug in profile. There is an opportunity to develop this work by: • Working with a much larger dataset to allow plug in profiles for each segment to be derived • Develop mappable indicators for each archetype so that the distribution of actors most suited to V2G can be derived • Overlay the actor map layer with a network state layer showing existing and forecast network constraints and designated Constraint Managed Zones.

[59] See recommendations and conclusions of Vehicle to Grid Britain report found here.
[60] See CENEX report, Understanding the True Value of V2G. Available here

		Positive attitudes to risk and innovation	V2G technology is still under development. DNO markets for the flexibility services that it can provide are non-existent or not widely available. Consequently, the business case for investment in V2G EV may be marginal. Therefore customers should have the capability to absorb financial risk and to recognise and value non-financial benefits such as V2G's environmental benefits. They will also need to have trust in the system provider and back-office services and any aggregator. Knowing others who have taken up the offer can build trust and understanding of how the service can fit with lifestyle. This includes overcoming anxieties about not having sufficient charge to make essential journeys. One dimension of capability to participate in a SLES is wishing to do so: i.e. having a set of values, attitudes and motivations which predispose a householder or business to become aware of benefits of participation and to be eager to participate when the opportunity arises[61]. In general, the motivations of so called "early adopters" of an innovative practice or technology will have different motivations than those who will adopt later as the practice becomes more mainstream. Typically, early adopters will not be primarily motivated by financial incentives and will have different attitudes to risk from the mainstream.	Developments of Rogers' innovation theory[62] are helpful here in thinking about how the priorities, motivations and capacities of early adopters may differ from the other segments in the innovation adoption curve that constitute the mass market and which follow on from the innovators and early adopters - the "early majority" and the "late majority". For example, early adopters tend to be higher social status, have greater financial liquidity and are more educated than the early majority. This translates to different attitudes to risk and scepticism around the benefits of adoption of the new technology or practice[63]. Innovation theory therefore suggests that encouraging participation in SLES will require different messaging and engagement strategy depending on which of these groups are being engaged. Also, that to create widespread participation in SLES at the grid edge the messaging and communication channels deployed must shift from what is effective for early adopters to what is effective for the early and later majority. There is an opportunity here to apply social marketing theory to create value propositions and communications strategy for different social and SME groupings. The could usefully draw on innovation theory. CSE's capability lens has taken this approach.
		Knowledge and skills	It is the joint responsibility of industry and government to ensure consumers and businesses are well-informed about the energy and mobility choices they make. As recently highlighted in a CENEX report, education around the benefits and value of V2G can make a significant difference to uptake rates of the technology.	Increasing knowledge, understanding and experience of EVs can help break down the barriers to EV ownership, challenge perceptions, and give people the encouragement and reassurance they need to make the shift to a cleaner vehicle. Awareness of available EV charging infrastructure is also a factor in driving EV adoption. The Councils have opportunities to use their existing online presence to signpost current and potential EV drivers toward existing sources of information on

[61] A "sociotechnical" perspective emphasizes that there is continual interaction between one's technical and material conditions (how the house or business is designed and equipped and hence technical capability) and one's lifestyle, attitudes, values, motivations and priorities. For example, adoption of solar technology and a battery will tend to support a set of attitudes to the environment and renewable technologies which are used to justify the adoption decision. So possession and use of particular technology will tend to develop and reinforce a particular worldview and associated set of attitudes. A cohesive set of attitudes rooted in particular worldview and value system will in turn tend to encourage particular technology choices, practices and behaviours. One's social world shapes one's technical world and one's technical world shapes one's social world.

[62] Wikipedia entry for innovation theory: https://en.wikipedia.org/wiki/Diffusion_of_innovations

[63] These demographic distinctions can be mapped to "psychographic" or lifestyle segmentations and also geodemographic segmentation systems such as ACORN or MOSAIC. LEO has access to the ACORN database via Oxfordshire County Council. The mapping group is currently considering how ACORN can be used in planning SLES.

			Empowering consumers through awareness campaigns and technology demonstrations will help accelerate EV, V2G and smart charging adoption to the benefit of consumers and the wider electricity system…	chargers, and to use resources from their projects to promote EVs and a cleaner transport choices.
		Corporate and personal values are supportive of V2G	Adoption of V2G technology offers environmental and social benefits in addition to financial benefits. Where the incremental financial benefits of V2G over unidirectional EV charging or conventional ICE vehicles may be small or non-existent, the environmental and social value achieved with V2G may be sufficiently motivating to drive adoption both amongst households and amongst organisations and SMEs. In the domestic sector, possession of bio spheric and socially altruistic values seem better aligned with non-financial benefits of V2G (doing one's "bit" to reduce carbon emission and play a role in the drive to net zero). These values are more strongly expressed in some socio-economic and demographic groups than others and are perhaps in the minority. However, other value systems focussed around more "extrinsic" goals (wealth, social recognition, power) can also be linked with acquisition of V2G technology if the offer is framed in the right way. Distribution of corporate environmental values tends to be associated with some types of organisation more than others. These values will sometimes be expressed in strong environmental policies, a culture of corporate social responsibility finding its way through to strategic investment decision-making and procurement rules or guidance (such as considering the environmental impact of the selection of fleet vehicles). Non-domestic actors which do not have a strong corporate social responsibility ethos may have other priorities that can nonetheless be aligned with acquisition of V2G technology - such as a desire for lower running costs of the fleet or the desire to self-consume as much site based solar generation as possible.	Multiple segmentations of households are available (ACORN[64], MOSAIC[65]) categorising households using a mix of variables: • demographic (e.g. age and life stage) • lifestyle and social (e.g. newspaper readership, hobbies), • financial e.g. (income) • attitudinal (e.g. attitudes to the environment) and • technical variables (e.g. the built form of the house) Implicit in these segmentations are assessments of the segment's attitudes, worldview and value orientations. Whilst some segments have stronger intrinsic value systems (valuing activities and approaches which more strongly look out to the biosphere, wider society and others, others have value systems which are more extrinsic, deriving value from success in comparison to others (e.g. wealth, social recognition, pleasure and achievement). In between the extremes are values that overlap emphasizing security, friends and family and local community. On the whole, the non-financial benefits of V2G (e.g. facilitating connection of low carbon energy generation) seem to have a better alignment with intrinsic values but extrinsic values can also be leveraged e.g. by framing ownership of V2G as a symbol of social success or by emphasizing how the local network will be more resilient and secure as a result of mass V2G adoption. There is an opportunity to frame the V2G offer in multiple ways to target specific segments of the population. Just as with households, SMEs and public sector organisations also have practices and patterns of decision making often reinforced by a sense of what the organisation stands for – i.e. its culture and values. Organisational decision making around energy efficiency and energy using technologies (such as electric vehicle fleets) have been found to be linked to the size of the organisation and its sector[66]. Large retail organisations will think and act differently to small retail organisations or to a large local authority.

[64] ACORN segmentation here
[65] MOSAIC segmentation here
[66] See DECC report, What are the factors influencing energy behaviours and decision making in the non-domestic sector? DECC, 2012. Found here

				This suggests a segmentation of the non-domestic sector is also possible where some types of SME or organisation will be much more responsive to the V2G offer than others. Different values can be seen amongst early adopters of EVs vs. the mass market. Successful business models could tailor value propositions to target specific customer segments who highly value the social and environmental benefits as they may require the least monetary compensation. Gaining a better understanding of which customers value what costs and benefits and by how much may enable cost reduction methods and targeted business models[67].
		Capability of vulnerable householder to switch to EV and to V2G in particular.	Electric Vehicles and V2G offers multiple benefits to all customers however a number of specific barriers to adoption by vulnerable householders have been identified[68]. These include: • High up-front costs of Electric Vehicles which can be increased further if the vehicle needs to be modified to accommodate disabilities. As EV's are relatively new to the market there is, as yet, little developed capacity for modification of vehicles. And where it does exist it is likely to be very expensive at this stage • Accessibility and usability of chargepoints - the design of chargepoints can make them difficult to use, particularly for those in wheel chairs. Also uncertainty about where and when they may be able to charge is a key barrier for many drivers with a mobility impairment. • EV range is well documented as a barrier to EV uptake in the general population. Drivers with a mobility impairment are likely to be more risk averse than able bodied drivers and are more likely to be affected by EV range anxiety. Being able to travel independently is key, and so journeys are often subject to a higher level of planning and preparation than for able-bodied drivers.	There a number of benefits for vulnerable householders to switch to Electric Vehicles and to V2G or V2X in particular. Many of these are the same benefits that apply to all – much lower maintenance and running costs for example. However there are number of aspects of EV ownership which are particularly beneficial to vulnerable householders: • Those with off street parking can charge at home. Through thoughtful siting of the domestic chargepoint this can be considerably easier for a household with mobility issues than navigating the refuelling process at a petrol station. • Often, vulnerable or disabled householders spend considerable time at home. This means that a V2G EV is likely to be plugged in and available for charge and discharge for longer periods of time than typical. Therefore the EV is likely to be able to maximise revenues from participation in local and national markets for flex. Revenue from participation in flex markets can be up to £400 per year depending on the location of the vehicle[69]. • V2X combined with longer plug in times and long periods at home consuming electricity[70] and adoption of a Time of Use tariff means the system can charge when electricity is cheap and discharge to the site when electricity is expensive and still needed. • SSEN's Equal EV research program is also considering for V2G can also offer valuable back up power supply to those on the priority service register for whom interruption of the power

[67] Vehicle to Grid Britain. Report to OLEV and BEIS. October 2019. Element Energy and others. Found here

[68] Outline of the Equal EV aims and objectives is found here. For review of barriers and recommendations for overcoming them see also SSEN Equal Electric Vehicles research programme. Literature review and engagement findings report prepared by Impact (June 2021).

[69] CENEX finds that average revenue generation from V2G is in the region of £150-200 per year, with customers with a high plug in rate achieving in the region of £400 per year. CENEX report here.

[70] Vulnerable households using critical life support devices can consume very large amounts of electricity.

				supply could be life threatening - e.g. those households that are dependent on critical life support devices.
Community level capabilities	Technical	**Technical capability for a critical number of households and businesses to aggregate their flexibility using monitoring and control systems and smart equipment.**	Communities of geography can be connected to the same part of the network that has an existing or forecast network constraint. Therefore, by acting together to flex their energy demand and generation, the community can head off network constraints, tackle faults, reap financial rewards and create the headroom at the low voltage level for more Distributed Energy Resources to be connected. Technical barriers to this are possession of the requisite smart technologies and control systems. Given: a) the cost of distributed generation (solar panels)[71], the price premium of ownership of smart appliances, smart charging electric vehicles and other smart home technology (e.g. smart thermostats) b) that smart technologies generally function better in well insulated, well-constructed homes c) that electric vehicle ownership is facilitated by ownership of off street parking - a drive or a garage and that these are generally associated with larger properties (not flats) in comparatively better of areas It is likely these technical capabilities will be associated with better off communities. Numerous studies have shown this[72]. This raises an equity issue – how can we ensure that lower income communities can also access the benefits of coordinated control of smart appliances, electric vehicles and equipment in a smart local energy system?	There is ongoing work amongst partners to design these systems for monitoring and control and interaction with the flex market IT architecture described above. The Low Carbon Hub is investigating working with two systems: A Smarter Grid Solutions (SGS) product used for monitoring, scheduling, control and dispatch of larger-scale assets. The SGS products are targeted at both DSO and asset owners / aggregators and offer different mixes of monitoring and control functions, integration with energy markets and DSO operational systems such as the WSC described above. LCH is considering the use of the SGS 'Strada' product to monitor, schedule and control its larger generation and storage assets such as Sandford Hydro, Ray Valley Solar, Rosehill battery and other larger solar installations. The Rosehill battery has started to be integrated into the SGS scheduler – the software to dispatch it via the SGS system is currently being written. Low Carbon Hub also have an 'Internet of Things' solution under development using open-source data standards for monitoring and controlling small-scale grid edge assets - primarily demand side response (DSR) assets such as smart appliances or heat pumps (the Peoples Power Station). There is an opportunity here to make use of the SMETS2 functionality of smart meters which includes four auxiliary load control switches and an inbuilt comms hub that connects a Home Area Network (HAN). This allows connection of energy displays, smart appliances and gateway devices which can send data to the internet. Thus, the auxiliary load control switches and the HAN can be used to control enabled devices in the home in response to signals from the DNO or a third party such as an aggregator or a flex market platform configured to control assets. Further work is needed to understand if and how these SMETs capabilities can be integrated with the system architecture envisaged for PPPS2.0.

[71] Identifying trends in the deployment of domestic solar PV under the Feed-in Tariff scheme. DECC 2012. Found here.
[72] See a general review of this topic in, The justice and equity implications of the clean energy transition, Carley and Konisky. Nature Energy, Vol 5, August 2020, 569–577. Available here.

	Economic	**The community as a whole has sufficiently high income levels that adoption of V2G technologies by a critical number of households is possible without recourse to business models requiring quick paybacks.**	As discussed above, the additional cost of Vehicle to Grid over conventional smart charging versus the additional revenues that are achievable (through participation in capacity market and the Balancing Mechanism) do not make a compelling business case for V2G. The chargepoints cost around £5000 installed versus around £1000 for conventional smart chargers. There are also the additional costs of signing off the new connection through the G99 process plus any reinforcement costs that are triggered. In the case of the LEO domestic V2G install, this additional reinforcement cost was around £600. These additional V2G costs over conventional smart charging extends simple payback beyond the 5-year threshold usually considered the limit that most businesses and households will use in their decision-making around the value of investments. As the technology develops the prices of V2G chargepoints will come down but, in the short term, it is likely that non-financial arguments for adoption of the technology will form a strong component of the motivation for adopting V2G. These motivations will include environmental motivations and sustaining corporate reputation social responsibility for non-domestic actors.	We should expect that V2G will be most popular in high income communities with businesses and organisations which have low carbon policies and environmental management systems. Businesses, in particular, will be, in sectors where there is a strong incentive to have low carbon procurement policies as part of Corporate Social Responsibility and brand building. These tend to be businesses in sectors which have operations which are public facing – e.g., retail. Where the business case for V2G is not compelling from a financial perspective for individual actors a community could come together to fund a community asset or support other community-level benefits from sale of their aggregated flexibility. This is an interesting possibility where the value of flexibility to an individual actor may be so small as to be inconsequential (perhaps negative once transaction costs are factored in - the aggregated value may become enough to create change. This idea has been mooted in relation to funding the installation and maintenance costs of a publicly accessible electric vehicle chargepoint on Osney island.

	Skills and knowledge	**The community has individuals and organisations (such as schools or businesses) embedded within it that understand the value of V2G, will actively spread messages about to others in the community and can lobby and fundraise effectively for low carbon systems to be installed**	Diffusion of Innovation theory holds that early adopters of innovative low carbon technologies such as V2G have a critical role to play in facilitating the spread of technologies to the main stream - the early majority. To do this, ideas and information must cross a communications “chasm” so that information about the innovation breaks out of the social space occupied by the early adopters and finds its way to the early adopters. This may entail reframing the benefits of the innovation (e.g. away from environmental benefits, instead emphasizing cost saving or lifestyle benefits instead). Early adopters of the technology should also be considered opinion leaders, should be trusted and considered knowledgeable by non-adopters. Quantitative study of the dynamics of communication between adopters and non-adopters of low carbon technology finds two key communications barriers: 1. Where adopters do not spread messages beyond their wealthy clustered social networks, thus restricting diffusion and limiting the seeding of information amongst those in the community that they are loosely acquainted with 2. Where non adopters in the community, who most trust word of mouth and interpersonal communications to get their information have low connectivity to adopters[73].	To catalyse and facilitate the mobilisation of adopters to share information with non-adopters in their social networks the industry could identify on line opinion leaders, for example Instagram influencers. Local champions for the V2G technology could be identified and encouraged to become active on local social media channels - for example: • Facebook groups convened around managing / enjoying local community resources (e.g. Friends of XXX park) • Website forums for discussing and sharing local community issues • Street level What's App groups.

[73] Social networks and communication behaviour underlying smart home adoption in the UK. Vrain, E and Wilson, C. Environmental Innovation and Societal Transitions Volume 38, March 2021, Pages 82-97. Available here.

	Social Capital Bridging, bonding and linking social capital. Also social norms	**Possession of forms of social capital allowing the community to:** • **Spread messages about the technology** • **coordinate its activities and** • **bring in external sources of help and funding** • **lobby for change (e.g. installation of a public on street EV chargepoint)**	A community is more capable of acting collectively to bring about low carbon projects if it has certain forms of "social capital"[74] that allow members of the community to: • communicate with one another in a trusted way to speed transmission of innovative ideas and practices. These could be ideas about electric vehicle ownership and smart charging possibilities[75]. • coordinate their efforts with members of the community beyond their immediate family and friendship group - e.g. neighbours and people that live in the community but are unknown to them. This is so-called "bridging" social capital, • lobby power centres for change (e.g. local politicians), to reach out to external sources of funding, expertise and to connect with other communities that are trying to achieve similar objectives. This is so called, "linking" social capital. It is also helpful if the community has "norms" for low carbon activities and empowerment – "this is the kind of thing people who live round here do". Evidently, distribution of requisite bridging and linking social capital is not uniform across society. Nor are strong social norms for low carbon lifestyle and adoption of associated technologies. There are underlying geographical, demographic, infrastructural and cultural factors which shape the quality and quantity of social capital and shared norms in a community. Distribution of social capital has implications for energy equity: • Very low income communities have been found to have less dense social networks (bridging social capital) – this is likely to slow the spread of ideas and information about a low carbon innovation[76]. • Low income communities are less engaged in local planning and policy processes – they tend to have less "linking" social capital[77].	Low Carbon Hub have found that their efforts to catalyse installation of an electric vehicle chargepoint at Osney Island have depended on the community possessing "linking" type social capital. There are a small number of key individuals in the community who understand the benefits of electric vehicles would like to see a public chargepoint installed. This small number of individuals have reached out to Oxford City Council to help realise the installation. This has resulted in ongoing discussions and the creation of a strong working relationship between particular low carbon staff and the Osney Island community representatives. Referring to the relationship between themselves and the Osney community, LCH staff stated: "People were picking up on the idea that there was some kind of kind of capability that you could have to receive collaboration [i.e. for the local community to work with external agencies]. Yeah. So you might say they've got that in spades". This again raises the question of how to create "linking" social capital where there is insufficient at the moment. LCH have done extensive work in developing tools which engage communities, including low income communities, in the process of creating a value proposition for low carbon projects in their area. The work considers the community's capabilities and records their priorities, barriers and opportunities also. This work and the LEMAP mapping tool allows a community to begin to assess its technical and economic resources and its various forms of social capital so that a plan can begin to be developed which makes the most of the communities capability. The approaches trialled in LEO can be integrated with the local area energy planning processes also in development and supported I SSEN's business plan for ED2. There are also regulatory or policy mechanisms available to ensure that chargepoints are not only installed in better off, "low hanging fruit" type communities. For example, SSEN support universal provision of EV chargepoints and argue that leaving provision of public chargepoints entirely in the hands of private companies opens the ways to transport equity issues. Private companies will tend to focus on installation of chargepoints where it is most financially advantageous to them. Rural areas and areas where there is low ownership or use of EVS will tend to be deprioritised.

[74] Definitions of different form of social capital are here

System level capabilities	Technical	**Digital, data and operational** **The local DNO should have IT and OT systems capable of understanding local network conditions and procuring and dispatching flexibility**	It is well documented that there needs to be much greater visibility of the low voltage parts of the network to manage it to deliver flexibility and greater connection of low carbon assets at the grid edge.	SSEN are seeking to create a "local network function" in their Control Rooms to manage demands, as well as a dedicated low voltage flexibility procurement / dispatch team to manage the growing need for requests for flexibility at this level. These will allow the DNO to secure and utilise contracts for services such as smart charging and vehicle to grid (V2G) from customers either via third parties or directly[78].

[75] The ability of actors within a community to talk to one another about the merits of an energy innovation (such as a device that could automatically control electricity demand to create energy services) has been shown to increase the likelihood of adoption of particular energy innovations fourfold. See McMichael and Shipworth (2013) The value of social networks in the diffusion of energy-efficiency innovations in UK households, Energy Policy, Volume 53, 2013, Pages 159-168, here

[76] See Larsen, L. Harlan, S.L, Bolin, B., et al. Bonding and Bridging: Understanding the Relationship between Social Capital and Civic Action. Journal of Planning Education and Research. 2004;24(1):64-77. Available here

[77] Levels of participation are correlated with income and occupation. See Pattie, C., Seyd, P. and Whiteley P. (2004) Citizenship in Britain Cambridge: Cambridge University Press p.86

[78] SSEN's EV strategy is accessible here

		Aggregators and DNO's must be able to offer monitoring and control systems that drive down transaction cost for numerous small assets	For a given amount of flexibility, the transaction costs of monitoring and controlling small assets are disproportionately higher than for a smaller number of larger assets. Thus, for the market to function with aggregated smaller assets, systems must be developed which simplify interactions and automate monitoring and control. This can bring down transaction costs and facilitate interaction with the Neutral Market Facilitator platform and associated SSEN back-office systems, which are designed to manage a limited number of transactions per flex event, not thousands. At present, with existing DNO systems, the cost of monitoring flex provision from V2G is considered too high and the manual systems needed to procure flex from scattered stationary batteries are considered too "clunky". An indication of the technical issues that must be resolved in configuring an IoT-based system for monitoring and control is found with metering arrangements for LCH's solar array on the roof of a small block of flats at Rose Hill. To meet the needs of the CAVA system, the smart meter must be reprogrammed to return data of greater granularity (better than hourly) and with greater regularity than at present. In addition, the data must be transposed into the open standard format (MQTT) to be usable on LCH's IoT platform. Meeting these needs has proved problematic. LCH's proposed solution is to install a second meter configured to meet their needs. The second meter may also be able to offer some control functionality over the array - sending the power to either a battery, on site for self-consumption, or to the network.	LEO is aware of the SMETS2 functionality of smart meters which includes four auxiliary load control switches and an inbuilt comms hub that connects a Home Area Network (HAN). This allows connection of energy displays, smart appliances and gateway devices which can send data to the internet. Thus, the auxiliary load control switches and the HAN can be used to control enabled devices in the home in response to signals from the DNO or a third party such as an aggregator or a flex market platform configured to control assets. Further work is needed to understand if and how these SMETs capabilities can be integrated with the system architecture envisaged for PPPS2.0. LCH have begun working on the data architectures that will allow Smart and Fair Neighbourhoods (SFNs) to be configured to provide flex services by coordinating demand-side response in households and possibly schools. Firstly though, the proof of concept of DSR using open standards and IoT platforms must be demonstrated.
		Network state. For V2G to have added value and to capture potential revenues for provision of local flex services there should be an existing or forecast network constraint.	While passive EV charging may worsen congestion on distribution networks, where possible deployment of V2G should be focussed in areas where the DNO has acute congestion issues and will reward Smart and V2G charging for congestion avoidance[79] and local system balancing.	There could be an opportunity for Smart and V2G charging to generate significant revenues where it is in a DNO congestion management zone. Using estimates of revenue from this nascent market, where congestion is acute and sustained, the value per EV could be £250/EV year or more. The opportunity will be geographically restricted and the most valuable opportunities are expected to be time limited as they will compete with network upgrades.

[79] Recommendation from Vehicle to Grid Britain report which is accessible here.

	Economic and Financial	**Accessible market platform allowing flex trades on local and national markets.**	V2G requires an aggregator able to stack and trade value from the various services that it can provide, e.g. national balancing services to ESO but also local DSO flexibility services. Hence the local energy system should ideally interact with a number of market platforms and markets.	Given the unpredictability of EV driving patterns, a move towards procuring ancillary or flexibility services closer to actual delivery or accommodating real-time provision of services – in contrast to guaranteeing provision in advance over a long pre-defined time window – should be considered. Thresholds for minimum bid size, and the means by which contributions of EV aggregators is measured and validated will also determine overall success in boosting participation.
		Local Flexibility Market DNO market for battery friendly flex services	V2G offers the means to tackle network stresses via delivery of flexibility services. Hence V2G installation as part of a SLES is facilitated where there is a market for flexibility services. The market for flexibility services is created because existing or forecasted network constraints are most cost-effectively dealt with via flexibility rather than reinforcement in particular parts of the network.	Stationary and EV batteries can also deliver the range of local flex services that DNO's are likely to wish to procure. Because of very fast ramp up times V2G will be suitable for fault rectification but, given uncertainties about when V2G is plugged in and ready to go, planned fault rectification following planned maintenance on the system is probably better suited to an EV battery.
		National market for flexibility Services (balancing mechanism, capacity market)	Participation in national markets for flexibility, in particular the market for Dynamic Containment is very important to the viability of Vehicle to Grid Business models: local markets for flexibility are unlikely to be sufficient in most locations. However, the current testing and participation regime for Balancing Services (mainly FFR) results in prohibitively high costs for domestic DSR and V2G[80]. The new industry code, P375, is an important first step in removing some of this verification and settlement cost for smaller assets.	V2G, like all battery systems, is good at providing some specialised services such as provision of reactive power[81] and Balancing market services requiring near instant response such as Fast Frequency response and Dynamic Containment. There is a need to find solutions which can boost number of entrants in DSR markets by driving down costs of participation. The new Elexon code P375 is one such, allowing embedded metering in chargepoints to provide Balancing Mechanism compliant data – allowing distributed V2G chargepoints behind a boundary meter to participate in the Balancing Mechanism. Participation in national flex markets is critical to the viability of V2G business models at present.
		Supportive Tax Regime for purchase of new and second hand EV' including rules on VAT	Tax-based incentives applied to new and used EV purchases have the benefit of helping alter consumer behaviour without being dependent on available public funds.	. Grants for zero emission vehicles for both new and used vehicles should be retained in the short term with a clear plan for replacing them with a tax regime that rewards the cleanest vehicles on our roads with 0% VAT for EV purchases and a VED regime that disincentivises consumers from choosing cars with higher emissions over their lifetime, with the benefit of removing the upfront cost of grants to the public purse.
	Policy and Regulation	**Publicly accessible data showing precise location of network constraints and historic reinforcement where the cost is socialised and must**	It is difficult for V2G suppliers and aggregators to build business models and create value propositions without knowing the location of network constraints and the value of flexibility in specific parts of the network. Such data allows identification of sweet spots where aggregators and V2G service providers can	SSEN and other DNOs are beginning to make available data (e.g. constraint heat maps) to allow aggregators to develop business models for targeting specific communities and businesses with a Demand Side response and V2G offer. This approach is now baked into the SSEN EV strategy and to the ED2 business plan.

80 Vehicle to Grid Britain

81 This is particularly valuable in parts of the network where there are high levels of electrical resistance - at the LV level in general and particularly in long cable runs in rural areas. The system must be capable of rewarding these services.

		be repaid if triggered by a new connection.	make their offer. It also identifies parts of the network that are likely to go underserved by chargepoint infrastructure or where additional support is needed to ensure that V2G opportunities are accessible to all.	In the medium term, the DNO's and local Authorities need to establish processes to agree and plan a public charging infrastructure. This should inform local markets for flexibility and hence business models for V2G.
		DNO has simplified or cheaper connection approval processes for V2G	The G99 application is the DNO process for managing connection of small generation assets up to 17kW for a single phase and 50kW for three phase to the LV network[82]. V2G in discharge mode is considered generation and therefore must complete the G99 application. As such, NuVVe submits a load profile which captures intended charge and discharge times at the site, "to give them an idea of what the power flows will be at what time of day". The G99 also collects all the detail of the circuits to be installed (electrical line diagrams), generation harmonics, type tested device information. The connections team will use the information to determine whether it is safe to connect the battery to the network or whether a network constraint will result. The G99 process is often the first-time detailed analysis will have been undertaken of the network state in that particular part of the network. The G99 application process takes 45 days but can take much longer if issues are encountered requiring further investigation. Costs vary from free up to around £2000 if no upgrades or reinforcements are required.	SSEN and other DNOs have been working with the Energy Networks Association to update the connection forms for EV chargers to incorporate V2G chargers. This should make it far simpler and easier to connect by removing the need for a lot of the additional forms typically needed. Once the new forms go live in 2021 they can be used where the total aggregated capacity of generating/storage equipment on site is 17kW (single phase) or 50kW (3-phase), the V2G charge point is fully type tested and registered in the ENA Generation Type Test Register, and an electrical schematic of the installation and site layout showing location of the charge point is attached. If the connection meets this criterion then the G98 and G99 forms are no longer needed i.e. the connection process will be administered using a standard EV/HP connection form. This should make the connection process quicker and cheaper which will remove cost and improve V2G business models.
		Supportive local DNO connections policy recognising the flexibility that V2G can bring to the network and therefore be used as a means of tackling rather than exacerbating network constraints	At present, Nuvve typically will not pursue installations of V2G into parts of the network with a known network constraint. This is because existing SSEN processes for assessing impacts on the network assume the worst-case scenario and ignore the flexibility V2G can bring versus standard smart EV charger connections. Review of the SSEN EV Connections pages suggests that the charging cycle of V2G is treated in the same way as standard smart charging EV connections whilst the discharge cycle is managed through the G99 protocol applied to all low voltage storage and generation. Consequently, installation of EV chargers (regardless of whether they are "smart" or not) can trigger a requirement for a potentially	That existing connection procedures discourage V2G connection in parts of the network with an existing or predicted network constraint is paradoxical because the connection of battery storage under smart control is a means of tackling network constraints not exacerbating them. In addition, Nuvve wishes to add network flexibility services to the value stack of their V2G offer to increase the revenue flow to their customers and to create a greater value pie from which they can take a slice as an aggregator providing a network service. It is recommended that DNO processes assessing viability of connection are changed to factor in the types of flexibility that V2G can bring to network management.

[82] SSEN's G99 pages: https://www.ssen.co.uk/G99Application/

			expensive network upgrade or reinforcement. Reinforcement is paid for by the "first mover" i.e., the entity that triggered the requirement for the upgrade must shoulder the entirety of the bill despite the benefits of the upgrade being shared by all connected to the upgraded part of the network. Clearly, a requirement to upgrade the network can be difficult to accommodate within a viable business model or in a commercial offer.	A principal reason why DNO's must assume worst case scenario loading and discharge onto the network from V2G's when analysing where load thresholds may be breached is that, unlike the chargepoint operator, they do not have any direct control over loading and discharge. However, for very large generation connections they do have systems that have this capability known as Active Network Management[83]. ANM gives the DNO assurance that a generator cannot exceed generation thresholds and thereby cause problems on the network. The same kind of control and assurance could be provided by the Auxiliary Load Control switch[84] or Home Area Network auxiliary load control switch[85] that are integrated with the SMETS2 smart meter. SSEN's EV strategy recognises the potential for V2G flex and the need to adapt policy (including connections policy) as this technological trend develops. For example, SSEN have asked Government and Ofgem to work with industry to set out clear standards covering when domestic EV charging can be managed to support wider system security. BSI produced some standards (PAS 1878 and 1879) which outlined how grid stability should be a key element of any standard, and SSEN would like to see that enshrined and built upon moving forward.
		Local area energy planning services and local planning policy	At present, local authority planning policy (as documented in Local Authority Local Plans) is primarily concerned with new development, transport infrastructure and in ensuring that planning rules around development in conservation areas are enforced. Consequently, retrofit with smart technologies of non-LA owned buildings and housing stocks are often only addressed in ad-hoc strategies and (partially) funded by stop-start Government programmes. A workshop with planners from various Oxfordshire local authorities in March 21 also found there is often poor	Where DNO's are embedded or working closely with Local Authorities there is an opportunity to ensure that flexibility offered by V2G (or V2X) is built into local area energy plans from the earliest stages. SSEN is supportive of this approach, calling for Government and Ofgem to ensure that Local Area Energy Planning is integrated in RIIO-ED2 business plans for 2023-2028. They argue, for example, that LAEPs can deliver efficient investment in EV infrastructure through identifying where there is need, and developing robust, data-driven evidence for rolling out charge points[88].

[83] Active Network Management (ANM) is a system that allows network operators to control and alter the output of generators connected to their network. An ANM system generally consists of three pieces of hardware: a central 'brain' that sits in the network operators control room and has the ability to send instructions to generators to change their output; a monitoring piece of equipment that sits somewhere on the network, sending network information (such as power flows and available capacity) to the central system; and a control piece of equipment that sits at the generation site and enacts the instructions sent by the central 'brain' i.e. reduce/increase output. The primary benefit of installing an ANM scheme is that it will allow generators to connect to the network quicker (sometimes years ahead of schedule), and generally at a lower cost.

[84] Auxiliary Load control Switch. Large domestic loads like storage heaters or heat pumps can be connected and controlled independently of the customer's main supply. An ALCS inside a smart meter can switch the electricity supply to the devices connected to it on or off based on an agreed switching pattern. It works in the same way as traditional Economy 7 meters, providing a scheduled period of power to connected devices. Subject to an agreement made between supplier and customer this could also support ad hoc commands allowing switches to respond to wider network conditions such as periods of excess renewable generation. See BEIS leaflet detailing how the ALCS could be used in demand side response here.

[85] Similar to an ALCS (Auxiliary load control switch), a HCALCS allows large domestic loads, such as electric vehicles chargers, to be controlled independently of the main power supply. However, rather than being integrated with the meter directly, the switch is remotely connected via the Home Area Network. This provides more flexibility, avoiding the need for new wiring back to the meter when a new load is connected

[88] See SSEN report, Accelerating a Green Recovery available at: https://www.ssen.co.uk/ev/

			communication between DNO's and planning functions in local authorities. The report found that: "In common with the planning profession as a whole, the group as a whole also seemed to have a reasonably low awareness of the role of DNO's, the relevance of grid capacity to renewable energy and EV rollout and how planning authorities and DNO's could work more closely together. Greater engagement between the DNO and Local Planning Authorities (LPAs) at forward planning stage could help anticipate, plan for and overcome issues of grid capacity. This engagement should explicitly consider the interrelationships between spatial planning and grid planning, and between local planning policies and existing and future grid constraints. This could include scenario planning, with scenarios developed to match the council's intended spatial strategy, their renewable energy and EV policies and the outputs from climate emergency action plans"[86]. In other words, this planning workshop identified a clear need for the Local Area Energy Planning approaches being developed by Energy Systems Catapult[87].	In their ED2 business plan SSEN have a commitment to create processes which help local authorities develop local area energy plans (called, Local Network planning). This LNP, activity will help local authorities and local enterprise partnerships understand the uptake of LCTs in their areas. More importantly, the LNPs provide the local distribution network with network constraints and capacity information to aid Local authorities as they develop their Local Area Energy Plans (LAEPs) and Local Heat and Energy Efficiency Strategies (LHEES)[89]. This approach will also include SSEN providing dedicated support for LAEP process – an SSEN representative tasked with working with LA planners. Energy Systems Catapult also call for DNO's to assist Local Authorities in planning for EV charge point rollout (on street, destination and forecourt infrastructure) as EV provision so clearly needs to align with spatial planning and local transport policy. This will require Local Transport Notes and alignment with the National Planning Policy framework[90]. There is an opportunity for LEO to begin to explore what the terms of reference for collaborative working between LAs, DNOs and other local stakeholders on LAEP's might look like. CSE propose that SSEN and LEO to set up a joint workshop with LA forward planners to explore greater and deeper engagement at plan making stage and a more nuanced understanding of how their plans intersect, exploring issues around grid capacity planning, renewable energy and electric vehicle rollout.
		Rules on what tenants can do in commercial buildings	Leasing and rental agreements between tenants and landlords of commercial buildings can often be a barrier to installation of chargepoints.	Where EVs are introduced into commercial buildings, lease agreements should allow installation of V2G infrastructure.

[86] Project Leo workshop 1 - Enabling and facilitating smart energy systems within the existing planning system. Workshop outputs. CSE report to Project LEO August 2021.
[87] Energy Systems Catapult Local Area Energy planning pages here.
[89] See page 100 of SSEN ED2 draft business plan at: https://ssenfuture.co.uk/wp-content/uploads/2021/06/SSEN-ED2-Draft-Business-Plan-Website.pdf
[90] See proposal 19 of the Electric Vehicle Energy Taskforce report, Energising our Transition to Electric Vehicles available here.

	Skills	**The system needs to have sufficient V2G trained electrical contractors available to install the chargepoint equipment.**	Not surprisingly, the LEO experience of installing the domestic V2G chargepoint was that there were very few electrical contractors with experience of doing this specific type of installation. For the market to grow at the rates required technical colleges and vehicle manufacturers must ramp up their training offers in this area.	The Institution of Engineering and Technology (IET) have produced a code of practice for installing EV chargepoints. The latest edition (the 4th) has a separate section for V2G chargepoints[91]. As an alternative to specialist V2G chargepoint installation training, if vehicle manufacturers designed the onboard converter that allows installation of an AC chargepoint for one-way charging to allow bidirectional power flow, then V2G would be possible using the exact same smart charge points as are used for smart one way charging. Therefore no additional specialist training would be required.

91 https://shop.theiet.org/code-of-practice-for-electric-vehicle-charging-equipment-installation-4th-edition