

# More than Money?

## Finding the True Power of Vehicle-to-Grid

*Chaired by Chris Cox, Cenex*



11:05

Keynote

**Dr Marco Landi**

Lead – V2G and EV  
Charging

**Innovate UK**



11:15

The True Power  
of V2G? Part 1

**Dominic  
McMahon**

Technical  
Specialist  
**Cenex**



11:25

Powerloop Project:  
Lessons Learnt

**Albena  
Ivanova**

Project Lead – Powerloop  
**Octopus Electric  
Vehicles**



11:40

The True Power of  
V2G? Part 2

**Sam Abbott**

Technical Specialist  
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Followed by Q&A

# Lowering your emissions through innovation in transport and energy infrastructure



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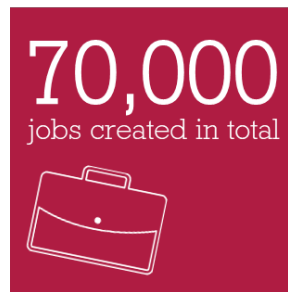
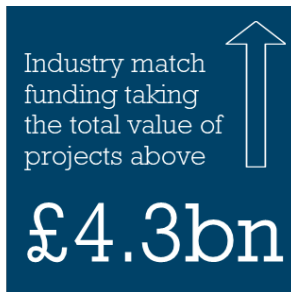
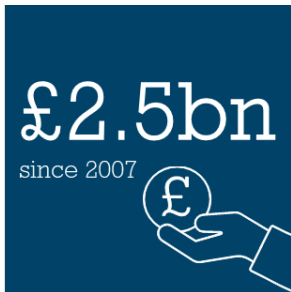


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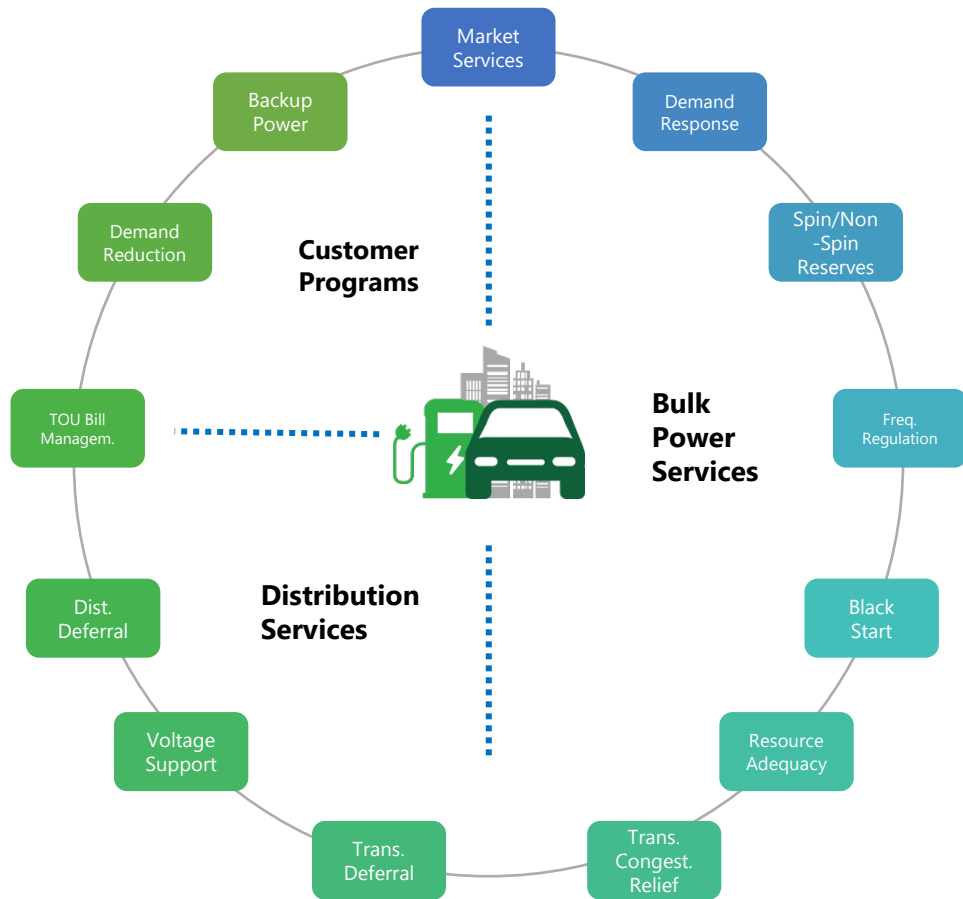
# Innovate UK



Innovate UK drives **productivity and growth** by supporting businesses to realise the potential of new technologies, develop ideas and **make them a commercial success**



# What is **Vehicle-to-Grid (V2G)**?



Vehicle to Grid (**V2G**) includes all technologies and systems that achieve a *tighter integration of EVs with the Power Grid*:

- EVs act as **controllable loads**, to smooth demand peaks  
(also referred to as *V1G* – can include Smart Charging)
- **Bidirectional energy transfer** means EVs can act as distributed storage, providing energy back to the grid
- EV drivers earn rewards in exchange for **grid services**

# iUK V2G programme: a world's first

Department for  
Business, Energy  
& Industrial Strategy

Office for Low Emission  
Vehicles

**UKRI** Innovate  
UK



KALUZA  
AN AWS COMPANY



ecotricity

[www.v2g-hub.com](http://www.v2g-hub.com)



VEHICLE TO GRID



Imperial College  
London



University of  
Salford  
MANCHESTER



e-on



octopus  
energy



UNIVERSITY OF LEEDS



19 HANGAR

GR Green  
Running



GenGame



elementenergy



Build Your Dreams

nationalgrid ESO



THE VIRTUAL FORGE®

POWERVAULT



energy  
saving  
trust



HONDA  
The Power of Dreams

NAVIGANT



regen  
transforming energy



Dependable Power through Innovation

GREATER  
LONDON  
AUTHORITY



BOROUGH COUNCIL



Grid Edge



Flexible Power Systems



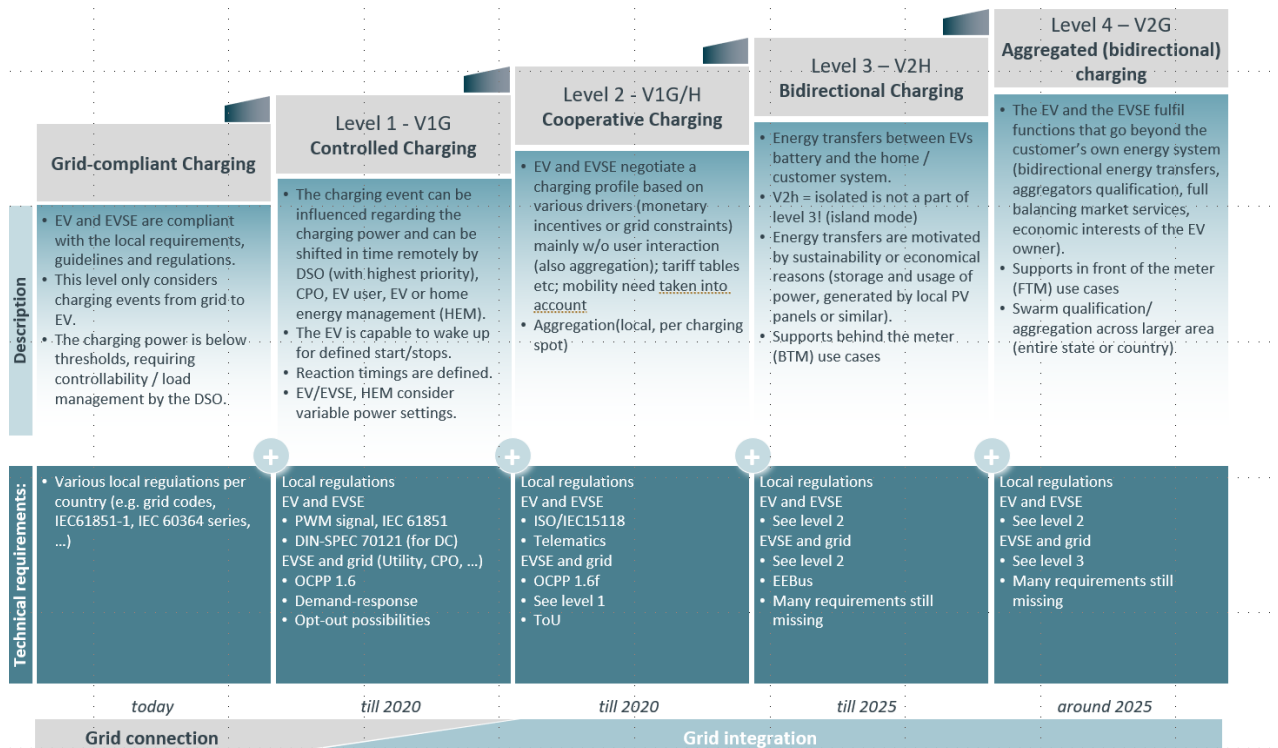
# V2G development pace is picking up

## Grid Integration Levels

Definitions after focus group survey



CHARIN





# V2G remains quite a 'hot' topic

## Global vehicle-to-grid trials go full throttle

December 3, 2019 · 0

### Volkswagen aims for terawatt scale V2G

MARCH 13, 2020 BY ALBAN THURSTON — LEAVE A COMMENT



The world's biggest power player – via €

Chief strategist Michael aiming to amass 35% of 2025, *Reuters* reports

By 2030 the total will be suggested.

"We can guarantee stored and this will be Jost. Grid balancing

VW announced last year its intention to launch Elli, its branded energy company, supported by a €30 billion investment in the next five years in e-mobility

The latest research painting the world with pictures of vehicle-to-grid technology around the globe.



## How V2G school buses could help power your home

A new vehicle-to-grid infrastructure project in America aims to bring cleaner air to schoolchildren while providing added stability for the grid

BY HEIDI VELLA — MARCH 17, 2020



Dominion Energy plans to connect 50 electric buses in Virginia with V2G infrastructure

## V2G project launched at London's Islington Town Hall by Honda and Moixa



VIGIL hails successful electric vehicle-to-grid trial in Birmingham

to act as



The V2G technology was trialled at two locations on Aston University's campus in Birmingham

Government-backed project assessed grid impacts of bi-directional EV charging at two sites at Aston University

## V2G is usually associated only with financial benefits

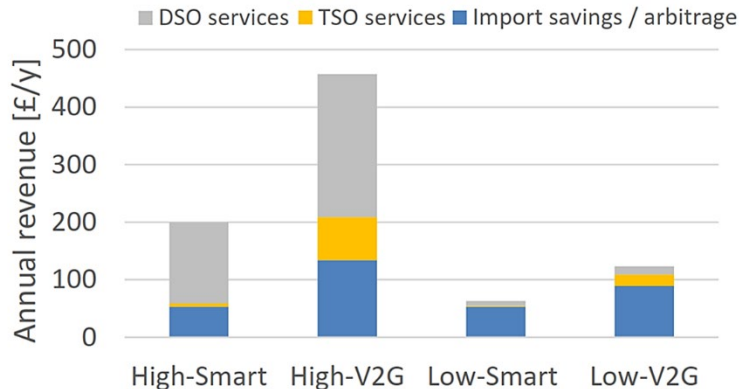
V2G was born as an **economically efficient** concept to maximize return on investment of expensive assets unutilized for most of the time




This translates into looking at V2G from two economic angles:

- Maximize revenue to participating users
- Maximize system level benefits

### Revenue stack in 2030

elementenergy



Scenario		Energy system benefit (£bn/yr)	
		Smart Charger	V2G
	<b>Burning platform</b> (assumes 50% participating vehicles)	0.1	0.15
	<b>Stepping stone</b> (assumes 50% participating vehicles)	0.5	1.4
	<b>Future survival</b> (assumes 80% participating vehicles)	1.1	3.5

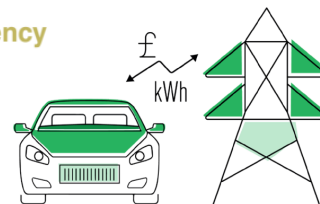
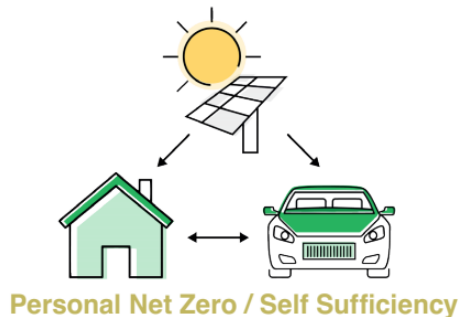
# Exploring **additional benefits** of V2G

The Cenex report contextualizes the revenue-generating V2G proposition by analysing a **wide range of V2G-related value propositions**, looking at:

- Potential customers
- Market attractiveness

## Who should read the report?

- Policy makers
- Business decision makers
- Researchers
- End-users



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**The True Power of  
V2G? Part 2**

**Sam Abbott**

Technical Specialist  
**Cenex**



Followed by Q&A

# The True Power of V2G? Part 1



*Dominic McMahon* Technical Specialist, Energy Systems & Infrastructure, Cenex



- What were we looking to achieve from this study?
- What did we learn from others?
- How did we decide on our value propositions?

# Purpose of the Study

“To identify and provide a simple evaluation of *alternative* value propositions in order to support the ongoing development of the V2G industry in the UK.”

# Our Preconceived Barriers



Evolving Energy Markets



Complex Value Chains



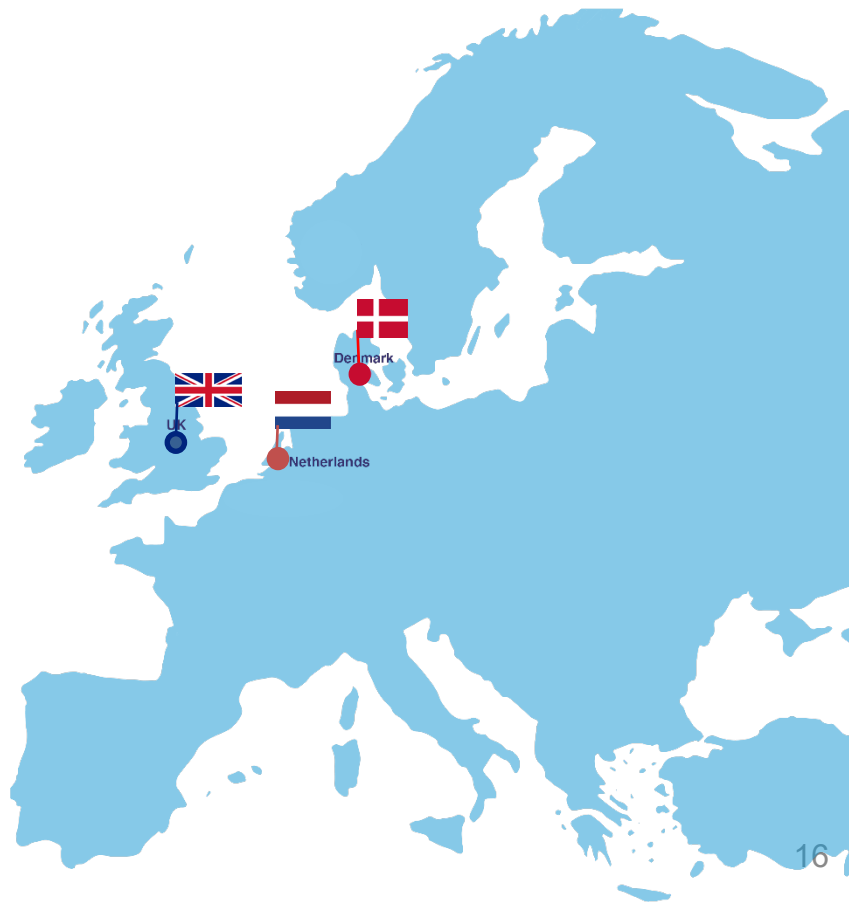
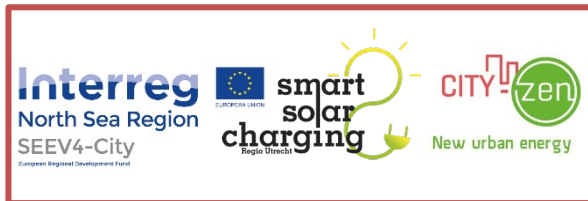
Regulation



Technology Maturity

















# Existing Projects Interviewed

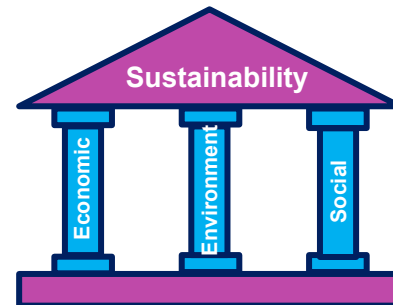
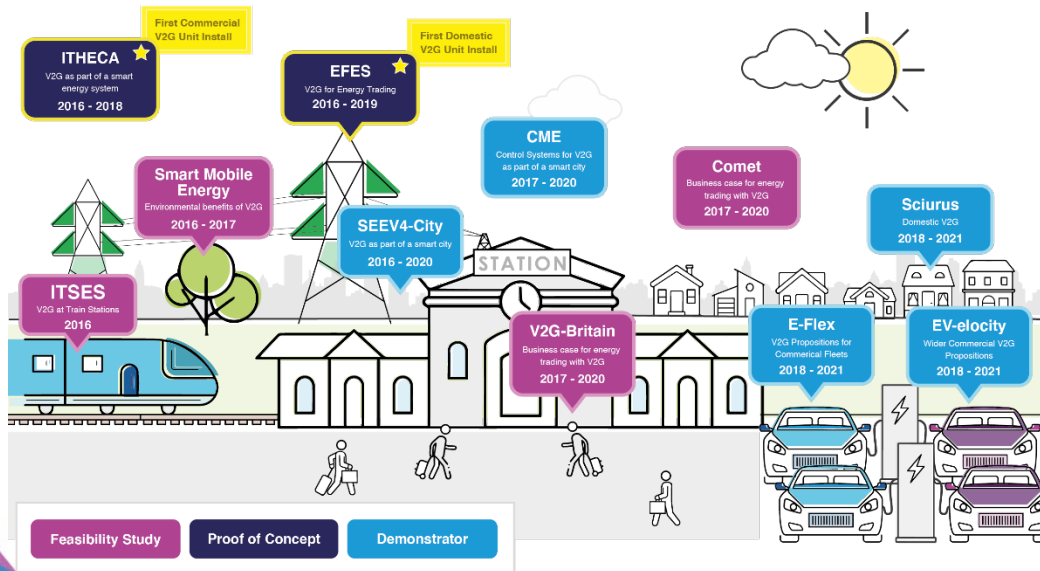




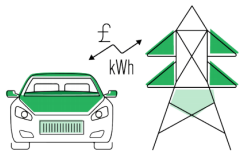
# Key Lessons from Existing Projects

Lesson	Barrier Category	Projects
Current UK market not set up for frequency services	Evolving Energy Markets	 
Evolving markets could make DSO services interesting	Evolving Energy Markets	  
Cost and time to gain DNO approval for installation is challenging	Regulation	  
Requirement for more OEMs to come on board to standardise V2G & Vehicle procurement delays	Technology Maturity	  
Keep systems simple and coordinated	Technology Maturity	
Accurate, transparent communication is key to gain customer trust	Complex Value Chains	 

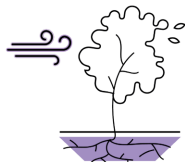
## A History of Cenex and V2G



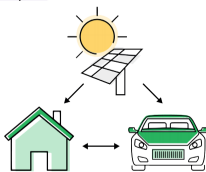
Five value propositions were studied:



**Revenue-Generating Energy Trading**



**Resilience**



**Personal Net Zero / Self Sufficiency**














**Benefit to Society**



**Enhanced Battery Management**

## Which of these value propositions were investigated by our interviewed projects?

			Existing V2G Project								
Value Proposition Name					e4Future	V2 Go!	V2Street				
Financial		Revenue-Generating Energy Trading	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Resilience				✓					✓
Non-Financial		Personal Net Zero / Self Sufficiency	✓	✓		✓			✓	✓	✓
		Benefit to Society	✓	✓	✓	✓	✓				
		Enhanced Battery Management									

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# Powerloop

Introducing the Octopus Vehicle-to-Grid bundle, bringing together the Nissan LEAF and Wallbox charger to save you money.

**Albena Ivanova**  
Octopus Electric Vehicles



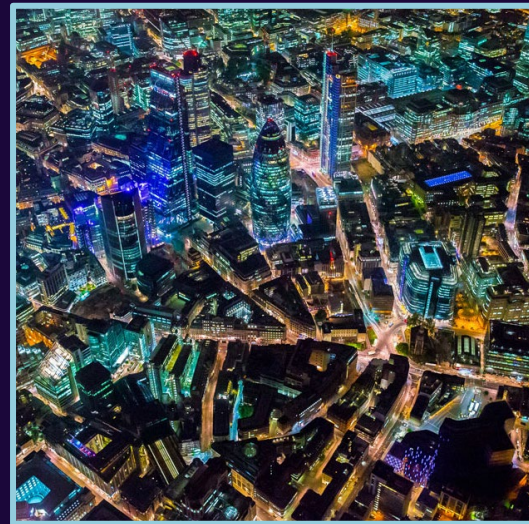
## What is Vehicle-to-grid (V2G)?



Excess electricity...

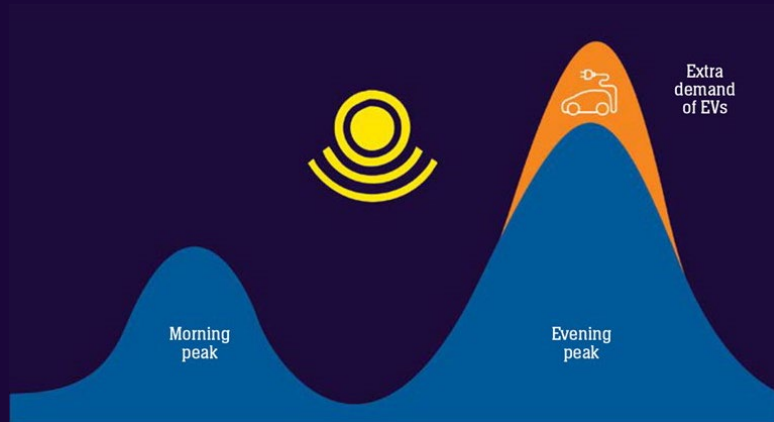


is stored in thousands of cars  
- and then discharged...

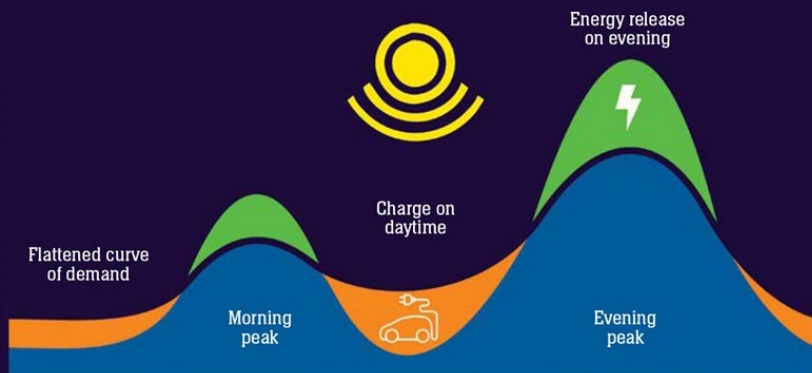


to power the UK at  
peak times

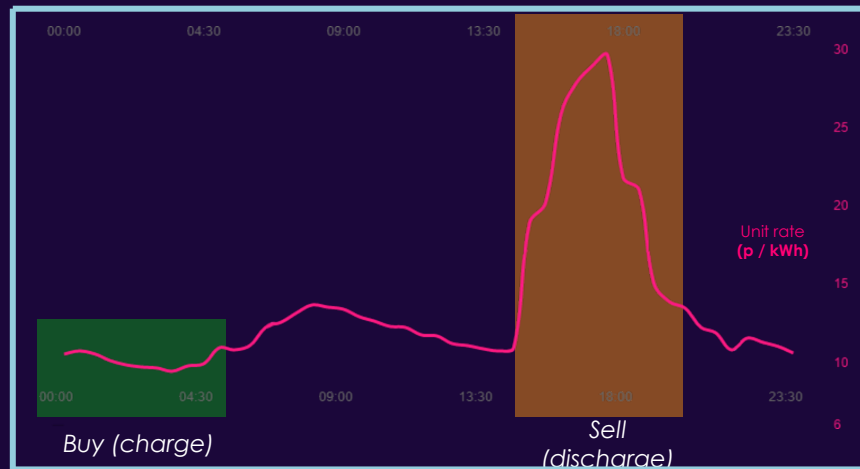
# Why is V2G valuable?



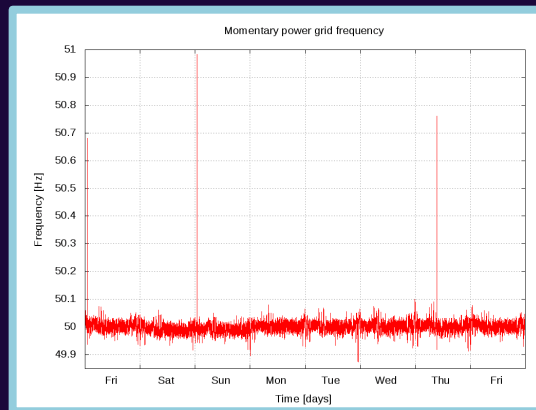
Without V2G



With V2G



Arbitrage – charging low and discharging high



Providing  
services to the  
National Grid  
and to the local  
grid operators



## What you get



A new Nissan LEAF



A free charger



A dedicated app  
to control charging



100% renewable  
electricity at home



£30 cashback  
every month\*



A smart meter  
installed for free



UK Power Networks  
working area

## How it works

1

Plug in before 6pm, and keep it plugged in until at least 5am the next day to complete the cycle

2

Use the app to tell us when you need your car and we'll schedule your sessions around you

3

Complete 12 cycles to get £30 cashback on your Octopus Energy account every month



# Insights, challenges, next steps

## Value proposition

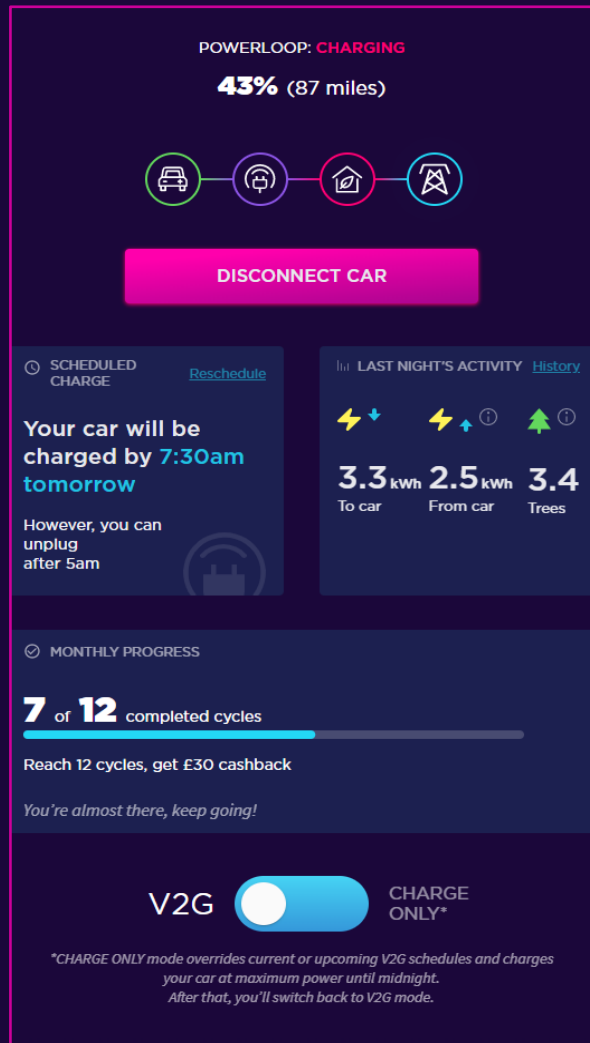
- Perception of bundle depends on type of customer and sustainability journey so far
- Educational aspect – importance of grid balancing

## Challenges

- DNO connection
- Export limitations

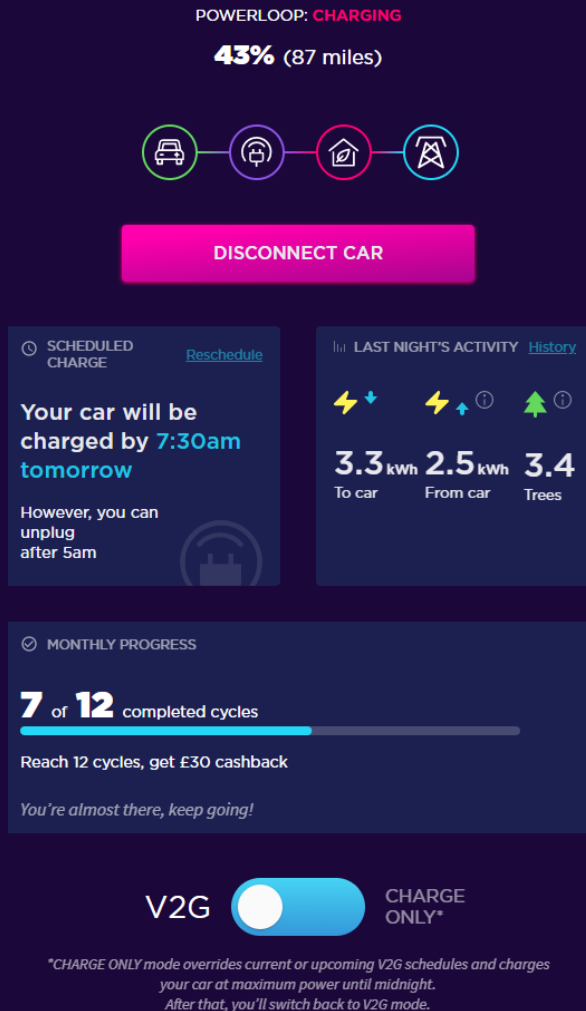
## Next steps

- Continuous recruitment
- Data collection and analysis



# Powerloop is unlocking V2G for drivers...

We are finding the **hardware**, building the **software** and creating the markets to demonstrate the feasibility and value in domestic V2G.





**Register your interest at**  
**[www.octopus.energy/powerloop](http://www.octopus.energy/powerloop)**

**Thanks for your time**

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# The True Power of V2G? Part 2

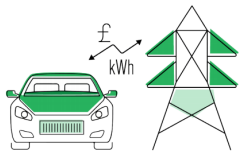


*Sam Abbott* Technical Specialist, Energy Systems & Infrastructure, Cenex

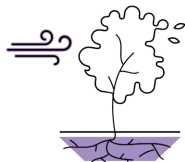


- How can V2G offer value to its stakeholders, what are the technical barriers, competing solutions and potential market sizes?
- The five value propositions identified in part 1 are explored further...

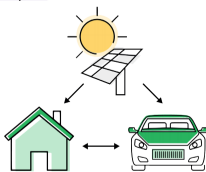
Five value propositions were studied:



**Revenue-Generating Energy Trading**



**Resilience**



**Personal Net Zero / Self Sufficiency**



**Benefit to Society**



**Enhanced Battery Management**

These five value propositions were assessed and scored based on four criteria:



### Consumer Focus Groups

How attractive is the value proposition to a small group of EV enthusiasts?



### Ease of Implementation

How complex is the system required to implement the value proposition and what barriers currently exist?



### Market Scalability

How large is the potential target market?



### Value Proposition Stability

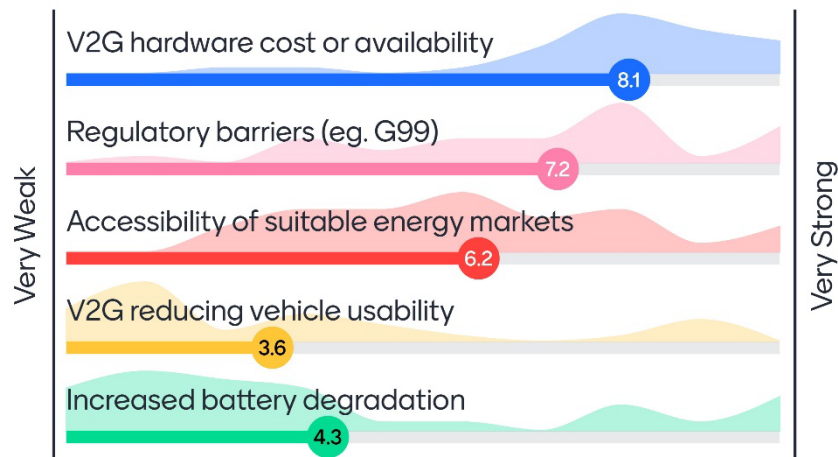
How likely and how great an impact could risks or opportunities have on any of the previous scores?



The competing solutions were also identified and discussed



## How strong are each of the following barriers to mass-market V2G adoption?

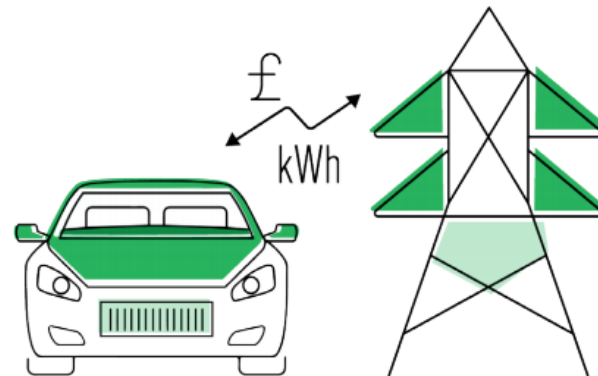


## Value Proposition 1:

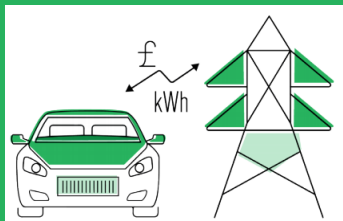
# Revenue-Generating Energy Trading

Revenue-generating energy trading is using the electric vehicle as an energy storage asset for **financial reward**.

The majority of existing V2G projects have tested this value proposition.



Most advantageous for vehicles with high “Plugged-in Not Charging” (PiNC) time.  
Average UK revenue generation from V2G estimated to be **£150 - £200 per year**.



## Revenue-Generating Energy Trading

Competing solutions:

- Domestic batteries
  - Grid connected batteries
  - Smart charging



+ Financial reward is an easy to understand proposition for customers.

- Risk of battery degradation with increased cycling for energy arbitrage.



+ Could potentially be applied to **any EV charger** where vehicles have **long dwell times** (high PiNC time).

- EVs with smaller batteries are less suitable operationally as the reserve State of Charge (SOC) % is higher.

+ Falling V2G prices will improve ROI scenario.  
**Cenex predicts V2G charger cost to fall to £1000 by 2030.**



- **Saturation of frequency response markets** reduces the revenue achievable.

? Emergence of **new V2G suitable markets** that present new opportunities (e.g. DSO services).



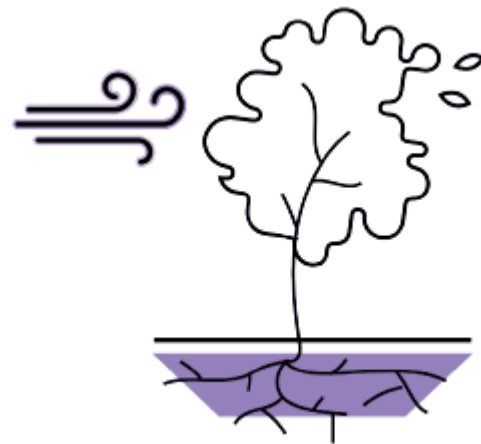
+ Scored highest of the five value propositions  
Unrealistic expectations of ROI term.

- Concerns over the increased capital cost of a V2G charger over a smart charger and erosion of the benefit with market saturation.

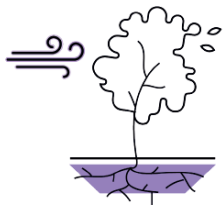
## Value Proposition 2:

# Resilience

The concept of V2G expanded rapidly in Japan as a **means of ensuring electricity supply** following the 2011 earthquake, tsunami and ensuing rolling blackouts.



A small UPS system with a 10-20 minute run-time costs £3,000 – £5,000. Cenex predicts **V2G hardware prices to fall below this level by 2025.**



## Resilience

Competing solutions:

- Traditional back-up diesel generators
  - Stationary UPS
  - Domestic batteries



+

Running V2G as an islanded energy system has **few technical or regulatory barriers**.



?

**Replacing a UPS for critical loads will be difficult** if there is any uncertainty of the availability of the fleet.

Deferring running of dirty back-up generators may be more feasible, but **any environmental or cost benefit will vary case-by-case** depending on the fleet size, operations and the site demand.



+

Whilst the number of applicable cases may be small currently, this will **increase as more fleets electrify**.

?

Using V2G for resilience may become more attractive when looking at **other countries** with growing EV uptake and **less reliable energy systems**.



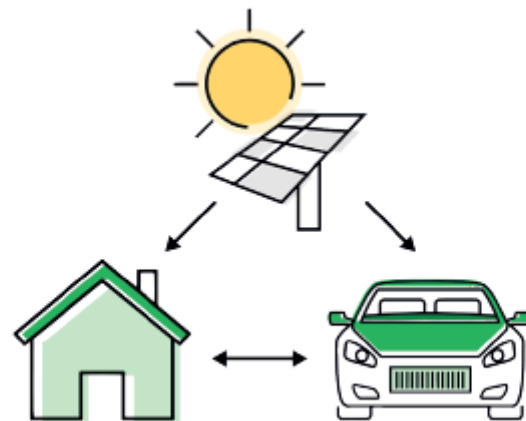
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**Number of applications** that would be suitable operationally are **limited**.

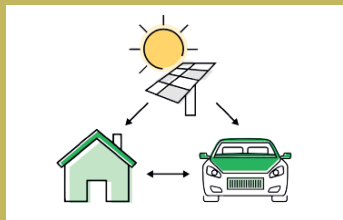
## Value Proposition 3:

# Personal Net Zero / Self Sufficiency

This **environmentally focussed** value proposition helps the user to optimise self-consumption of energy generated by on-site renewable energy technologies such as small-scale wind and solar PV.



Storing generation from a 4 kWp domestic solar PV system with an EV battery over a weekend with 6 hours of sun per day could save over **600 kgCO<sub>2</sub>e per year**.



## Personal Net Zero / Self-Sufficiency

Competing solutions:

- Stationary batteries
- Smart charging



- + **Already done commercially with stationary batteries.** Low-risk to extend this to V2G and already tested in demonstrators.



- + Large number of **existing domestic solar PV** installs
- ? Lack of **daytime vehicle availability** can limit number of applicable customers.
- Commercial **sites with high loads** always self-consume.



- + Increasing desire from public and enterprises to be **environmentally friendly**.
- ? Ofgem TCR could remove the behind the meter savings for on-site generation and therefore increase interest in V2G?



- + Domestic consumers agreed that V2G could make investment in solar PV more attractive; **“to store some of the excess rather than export it”**.
- ? What would be the impact on **battery degradation** and would it help at all if the vehicles are out when the sun is shining?

## Value Proposition 4:

# Benefit to Society

“Benefit to Society” is about engaging in V2G for altruistic reasons; doing your bit of the greater good of helping to solve **wider society’s environmental challenges**.



V2G could defer network upgrades of £5bn, or £180 per household.  
Reduced renewable curtailment could amount to a saving of 6 MtCO<sub>2</sub>e per year





## Benefit to Society

### Competing solutions:

- Stationary batteries
  - Grid connected battery storage
  - Smart charging



?

Optimising energy markets to best **use V2G to decarbonise grid** is complicated and depends on system operation. **Deferring DNO upgrade costs** using V2G may be simpler, but potentially possible through smart charging.



+

Applicable to most EVs, although dependent on use case.

+

Increase in **consumer interest** in technology that have an **environmental benefit** is increasing.



-

Greater competition from **grid connected batteries**

?

Ofgem proposing £25bn to reform energy networks



+

Generally supportive of the idea, especially if benefit could be realised at a community level.

?

"I'm not going to spend £5,000 out of the goodness of my heart".

## Value Proposition 5:

# Enhanced Battery Management

Preserving the health of an EV's lithium-ion battery is vital. Multiple benefits can be realised by maintaining an acceptable capacity and power over its lifetime.



Capacity fade can be reduced by 9.1% over a year through battery management. This could extend useable battery life by 10% giving an annual depreciation saving of £230.



## Enhanced Battery Management

Competing solutions:

- Vehicle battery management systems
  - Smart charging
  - New and improved battery technologies

+ Limited technical risks identified and few stakeholders required



? More Demonstration required to prove benefit over smart charging and increase consumer confidence.  
Uncertainty on how the business model would work.



+ Applicable to most EVs, although requires high PiNC time, and with few stakeholders.



+ If vehicle manufacturers endorsed V2G as means of protecting battery health, an instant market would be created.

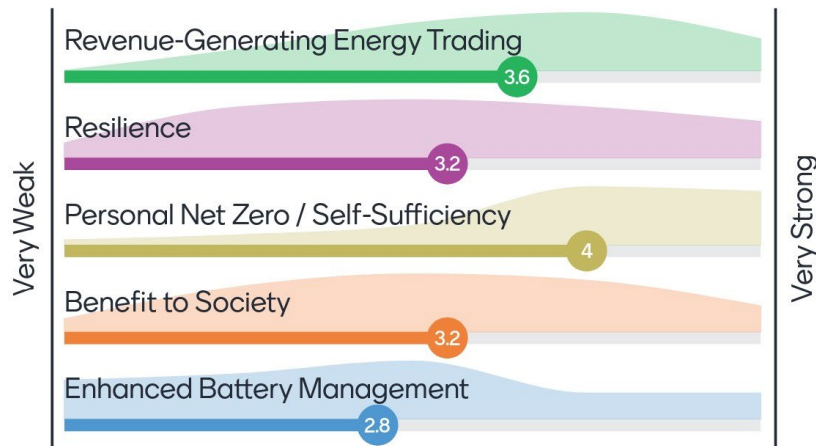
- Vehicle manufacturer BMS, trends to larger battery sizes, or developments in battery technology could negate need for management of battery health.

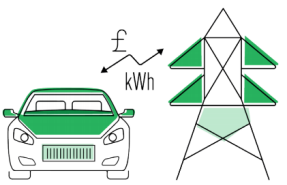


? Recognised the importance of battery health but sceptical over whether V2G can achieve this.

Unsure of benefit for customer for leased vehicles when lease term is much shorter than the battery lifetime.

## Give an overall rating to the five value propositions





**Revenue-Generating Energy Trading**




**Resilience**



**Personal Net Zero / Self-Sufficiency**



**Benefit to Society**



**Enhanced Battery Management**



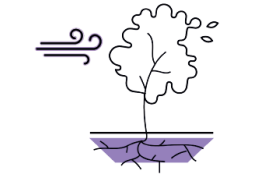
Strongest “Market Scalability” -

**Enhanced Battery Management**

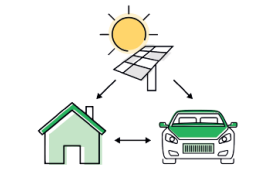




**Revenue-Generating  
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**Resilience**



**Personal Net Zero /  
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**Benefit to Society**



**Enhanced Battery  
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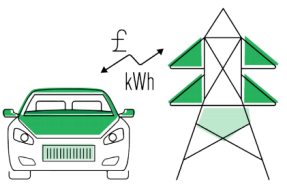


Strongest “Ease of Implementation”

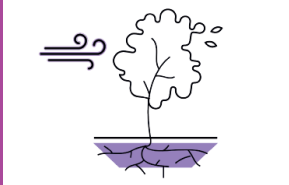


**Resilience**

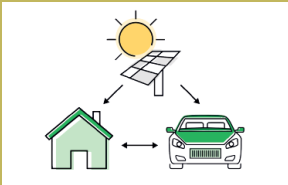
**Personal Net Zero /  
Self-Sufficiency**



**Revenue-Generating Energy Trading**



**Resilience**



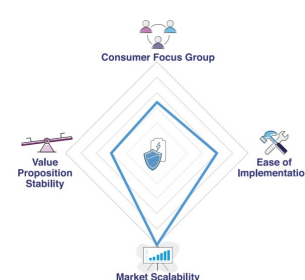
**Personal Net Zero / Self-Sufficiency**



**Benefit to Society**



**Enhanced Battery Management**



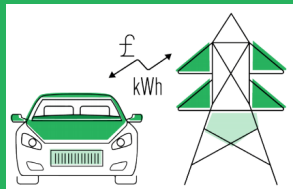
**Strongest “Stability”**

**Resilience**

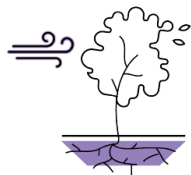
**Personal Net Zero / Self-Sufficiency**

**Benefit to Society**

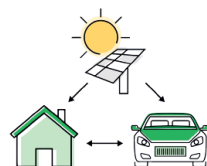




## Revenue-Generating Energy Trading



## Resilience



## Personal Net Zero / Self-Sufficiency



## Benefit to Society



## Enhanced Battery Management



Strongest “Consumer Focus Group” -

Revenue-Generating Energy Trading





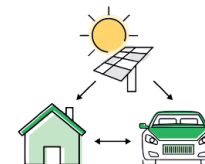
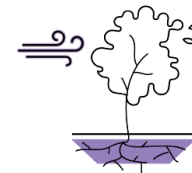
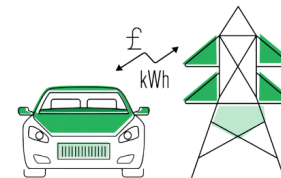
# Conclusions

Three recommendations

1. Know your “customer”.
2. Focus on the niche (then grow)
3. Communicate at the customer’s level

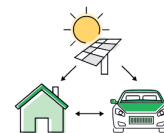
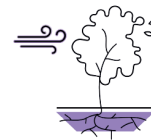
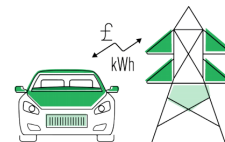
Other thoughts:

- V2G will compete with other technologies such as stationary batteries and smart charging
- **Value** does not necessarily mean financial reward.



# Recommendations

Stakeholder	Top recommendation
Existing projects	Refine language to make proposition appeal to niche customer segments
V2G manufacturers	Propositions should be designed around customer needs, not the product.
Vehicle manufacturers	Investigate idea of using V2G to prolong battery life and promote V2G compliant EVs
Investors / funders	Consider funding further trials focussing on alternative value propositions
TSO / DSOs	Reform energy markets to promote flexibility via V2G and streamline connection process
Policy Makers	Educate, create a V2G working group, or even enforce V2G?



To see all of the recommendations, please refer to the full report which is linked at the end of this presentation

## Thank you to our presenters:

11:05

Keynote

**Dr Marco Landi**

Lead – V2G and EV  
Charging

**Innovate UK**



11:15

The True Power of  
V2G? Part 1

**Dominic  
McMahon**

Technical  
Specialist  
**Cenex**



11:25

Powerloop Project:  
Lessons Learnt

**Albena  
Ivanova**

Project Lead – Powerloop  
**Octopus Electric Vehicles**



11:40

The True Power of  
V2G? Part 2

**Sam Abbott**

Technical Specialist  
**Cenex**



**Followed by Q&A**

Thank you for listening.  
Before you go, don't forget:

You can download a free copy of the full report here:

<https://www.cenex.co.uk/resources/...>

... visit the Powerloop project website here:

<https://www.octopusev.com/powerloop>

... or contact any of the presenters to find out more:

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**Innovate UK:** Neale Ryan ([Neale.Ryan@innovateuk.ukri.org](mailto:Neale.Ryan@innovateuk.ukri.org))

**Octopus EV:** Albena Ivanova ([albena.ivanova@octopusev.com](mailto:albena.ivanova@octopusev.com))