An Assessment of the Impact of Electric Vehicles on the Energy Storage Market and Associated Policy

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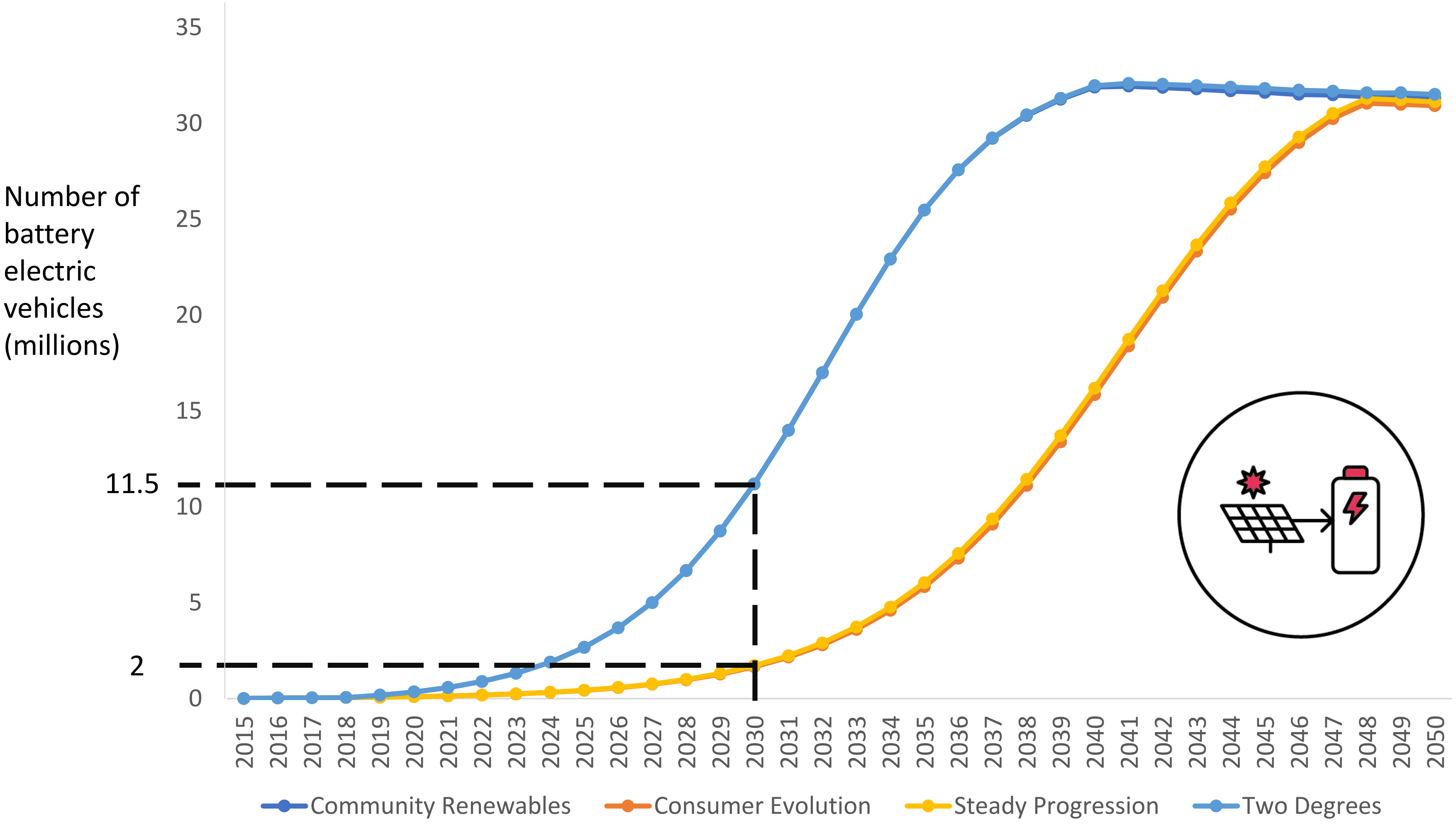
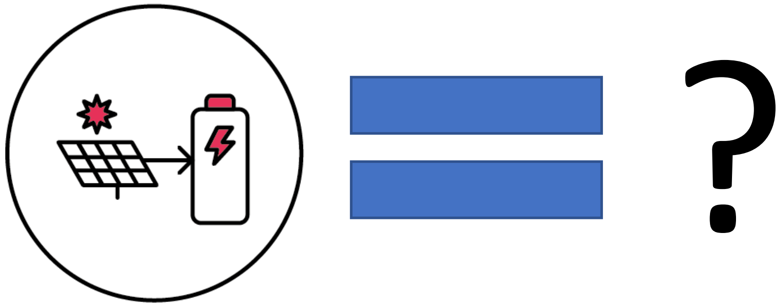
Acknowledgments: this work was undertaken at and funded by the University of Birmingham.
Susie Elks now works for the Energy Systems Catapult.

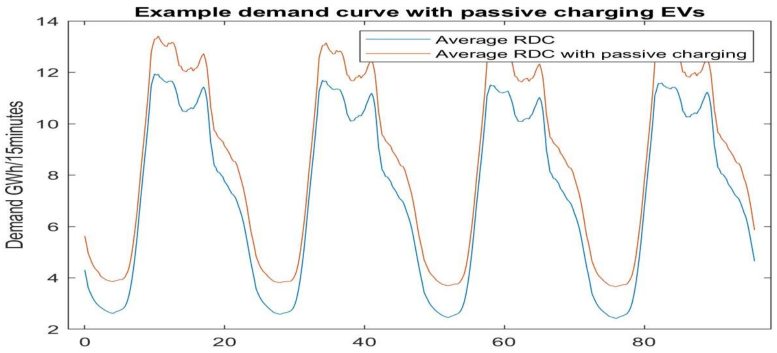
The search for flexibility



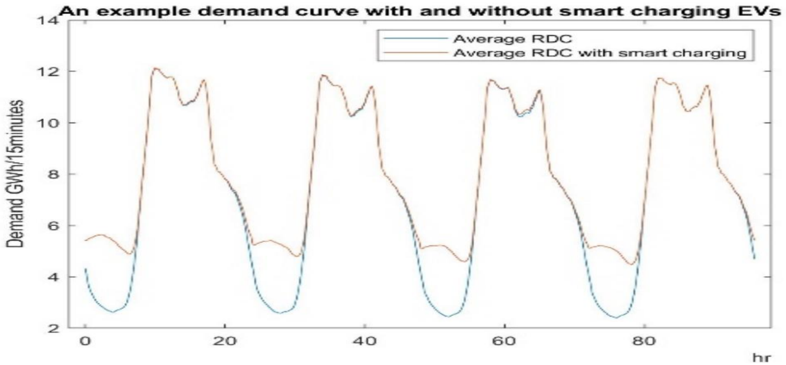


Potential Electric Vehicle Charging Patterns

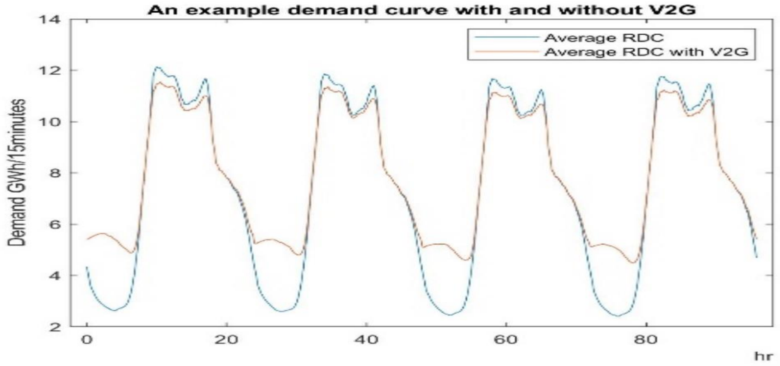
Passive Charging



Smart Charging

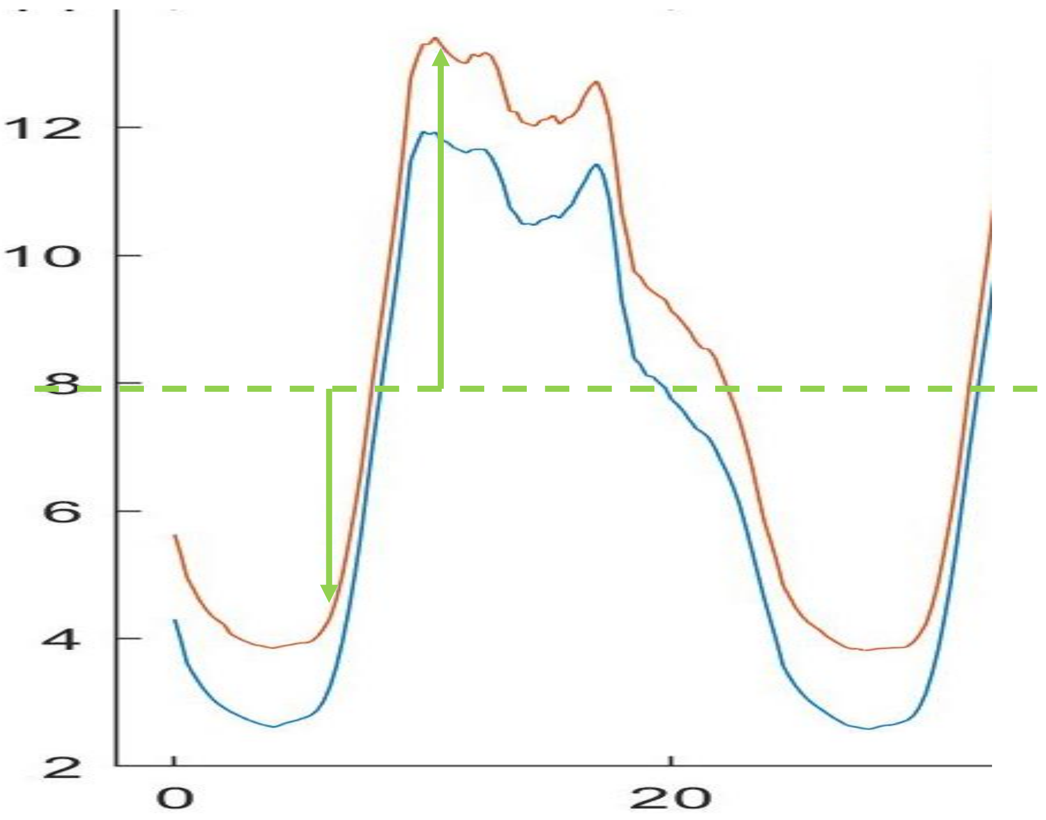


Vehicle to Grid



Modelling Approach- Indicators of Viable Energy Storage Capacity

	Potential Revenue Streams				
	Wholesale Energy Arbitrage	Balancing Mechanism	Capacity Market	Constraint Management	Frequency Response
Arbitrage Indicator	X				
Peak Indicator	X (scarcity pricing)		X	X	



Modelling the UK Energy System

2030

2050

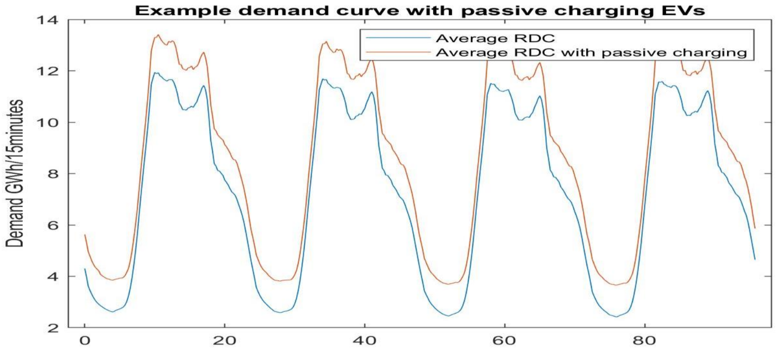
Consumer Power

Two Degrees

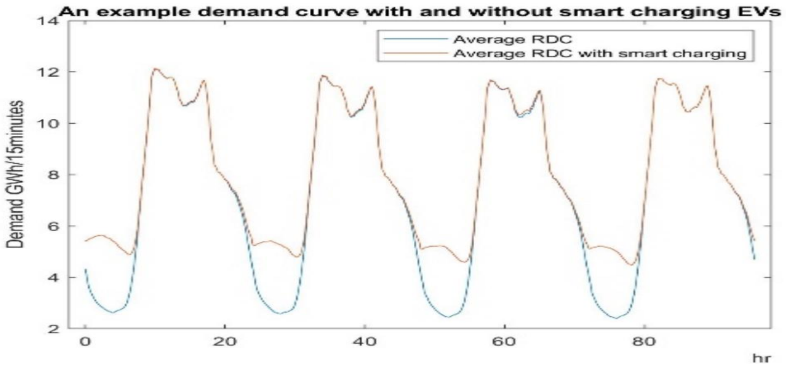
Slow Progression

Steady State

Passive Charging

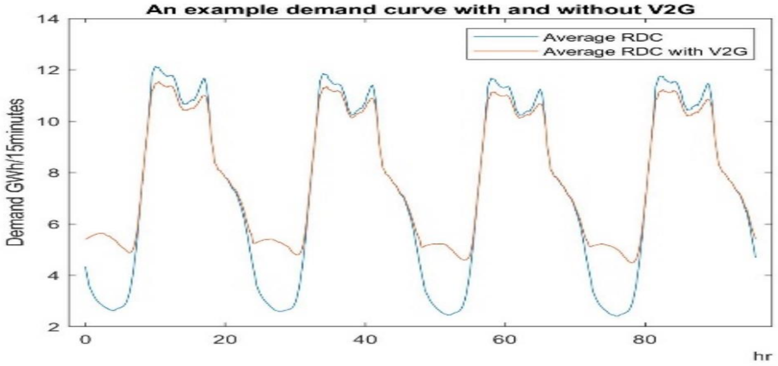


Smart Charging



Vehicle to Grid-1

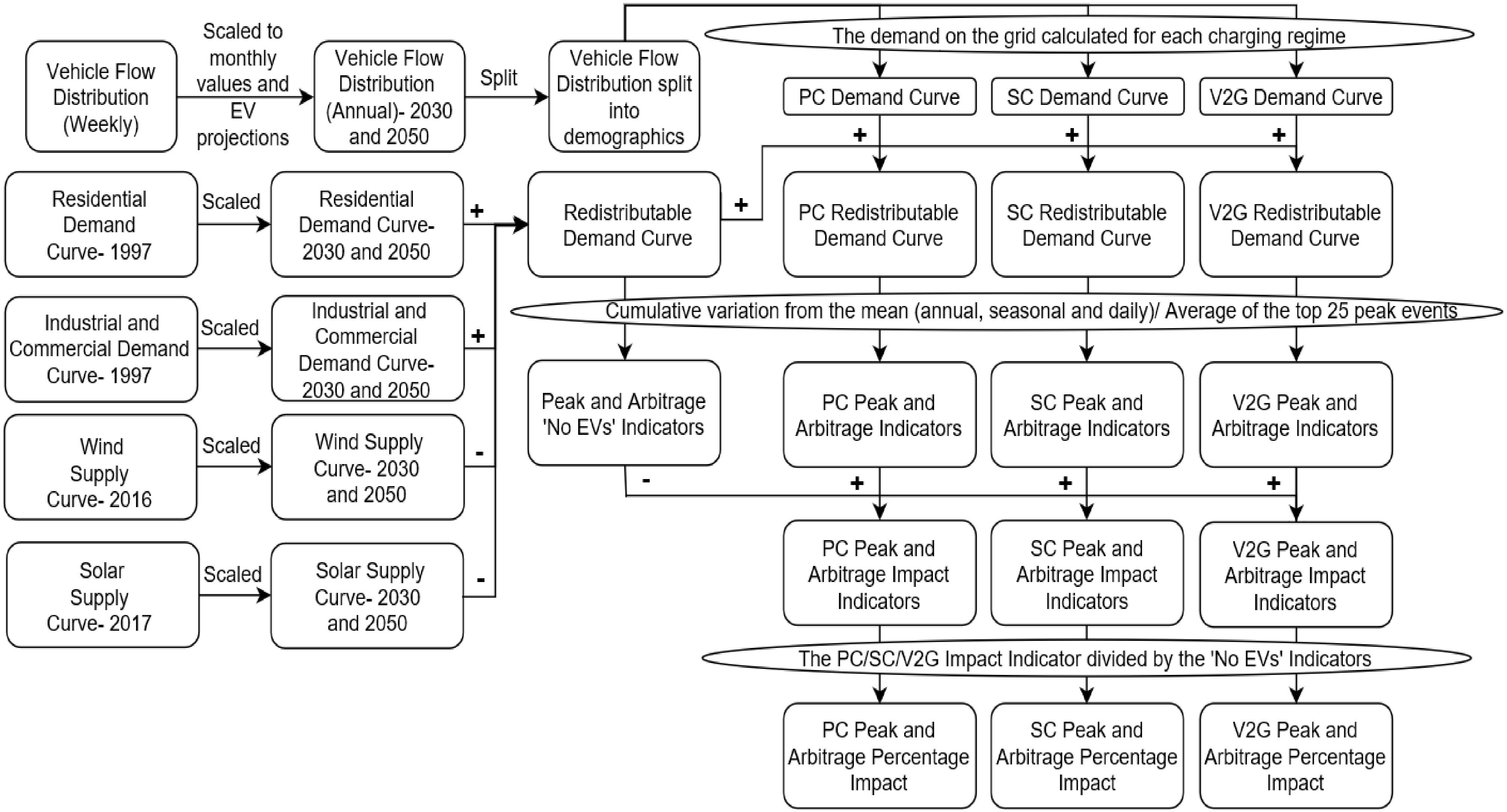
Vehicle to Grid-2



Intra-day

Intra-season

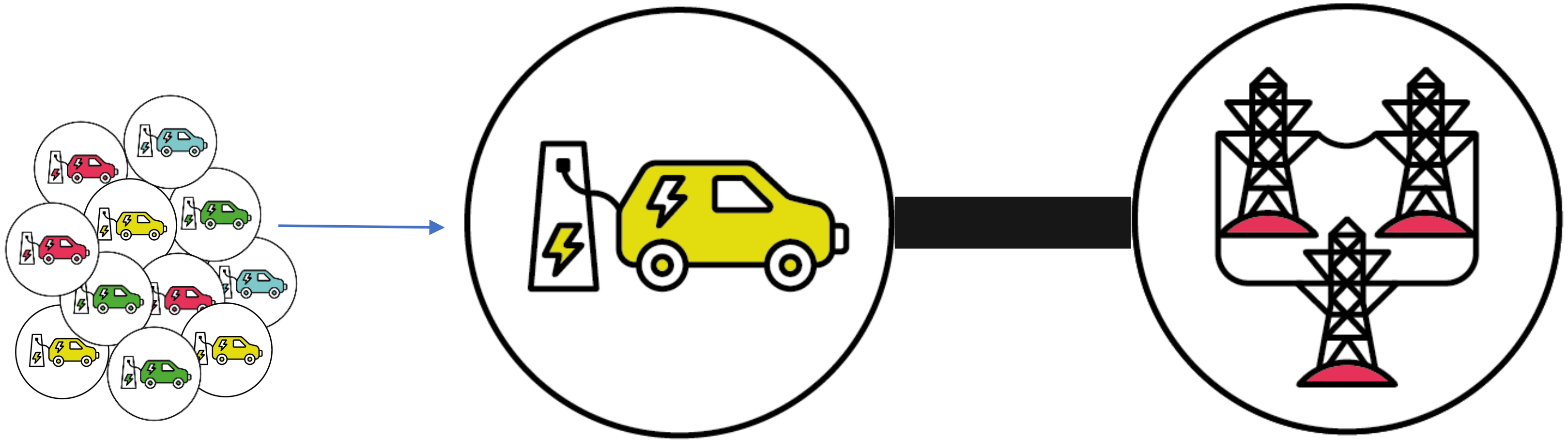
Modelling Annual UK Demand



Modelling Electric Vehicles- Vehicle Characteristics

	Scenario							
	2030				2050			
	TD	SP	SS	CP	TD	SP	SS	CP
EVs in the Population	30%	100%	16%	88%	6%	81%	10%	85%
Average Battery Capacity (kWh)	34.8	28.5	32.5	28.6	80	64	30.5	68.7
Collective EV Battery (TWh)	1.08	0.93	1.06	0.94	2.01	2.01	1.05	2.23
Charge Rate (kW)	5.8	4.7	5.4	4.7	13.2	10.6	5	11.3
Discharge Rate (kWh/100miles)	31.2	29.3	30.5	29.3	36	33.3	27.6	34.1

Modelling Electric Vehicles- Battery SoC



A collection of EVs is modelled as a single aggregate battery

With a single connection to the grid

When an electric vehicle battery is full, the aggregate connection to the grid should decrease.

To reflect this in the model, the population of EVs was split into ~100 groups of EVS with different driving patterns.

Each group had its own collective battery, therefore once this group's battery was full it stopped charging.

Assumption- the driving distributions were realistic and sufficiently granular

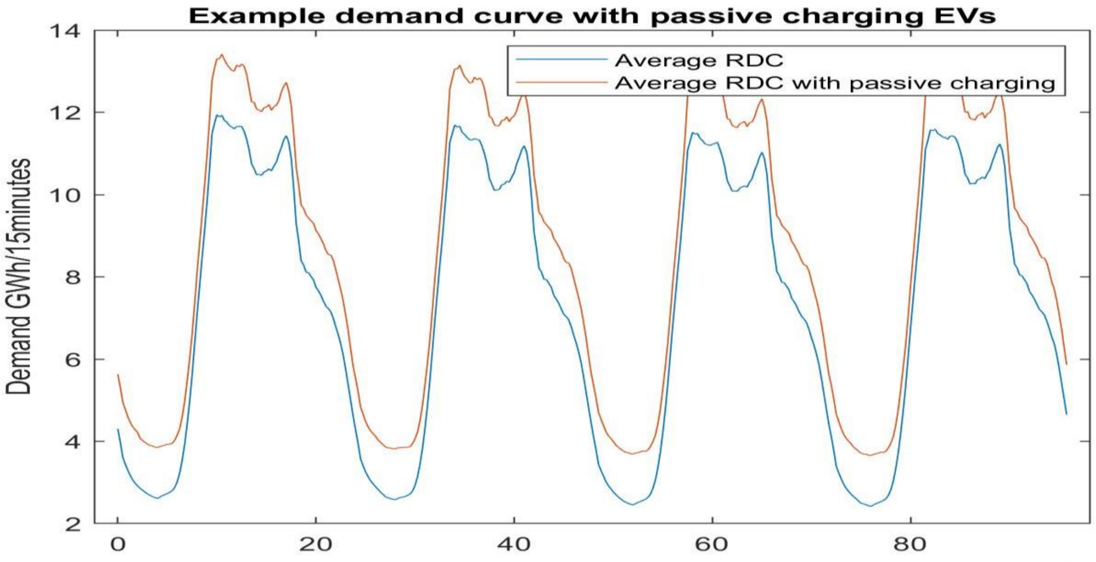
Modelling Electric Vehicles- Passive and Smart Charging

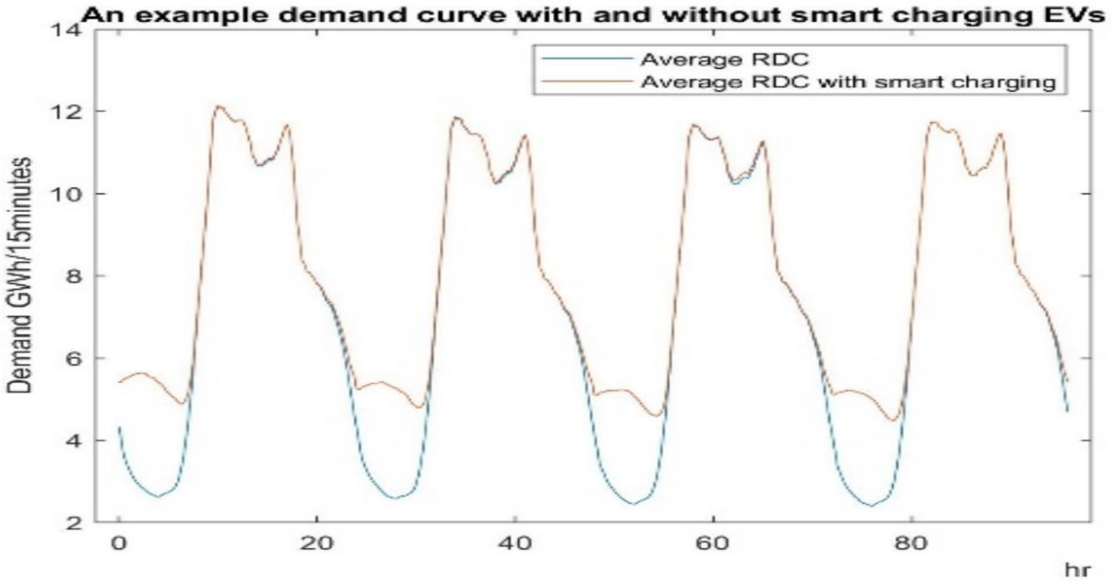
Covered Components:

- Vehicle characteristics
- Annual distribution of EVs on the road
- Modelling approach to capacity grid connection

Remaining Components:

- Number of EVs connected to the grid
- Passive charging
- Smart charging

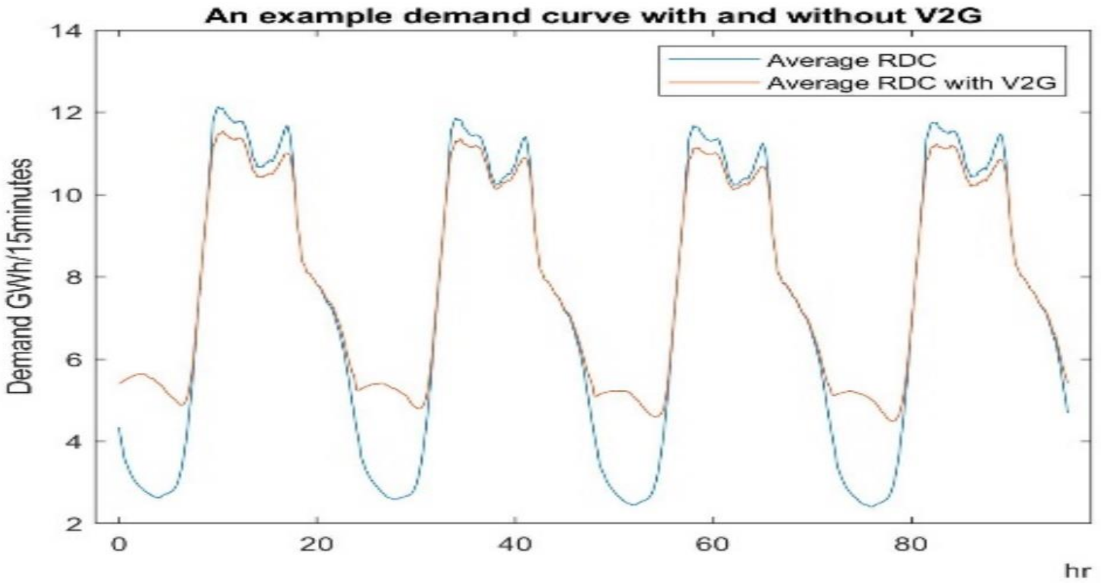




Scenario	2030				2050			
	TD	SP	SS	CP	TD	SP	SS	CP
PC	10%	10%	10%	10%	10%	10%	10%	10%
SC	43.5%	70.3%	81.5%	81.8%	5.0%	46.3%	85.7%	68.5%
V2G	46.5%	19.7%	8.5%	8.2%	85.0%	43.7%	4.3%	21.5%

Modelling Electric Vehicles- Vehicle to Grid Charging

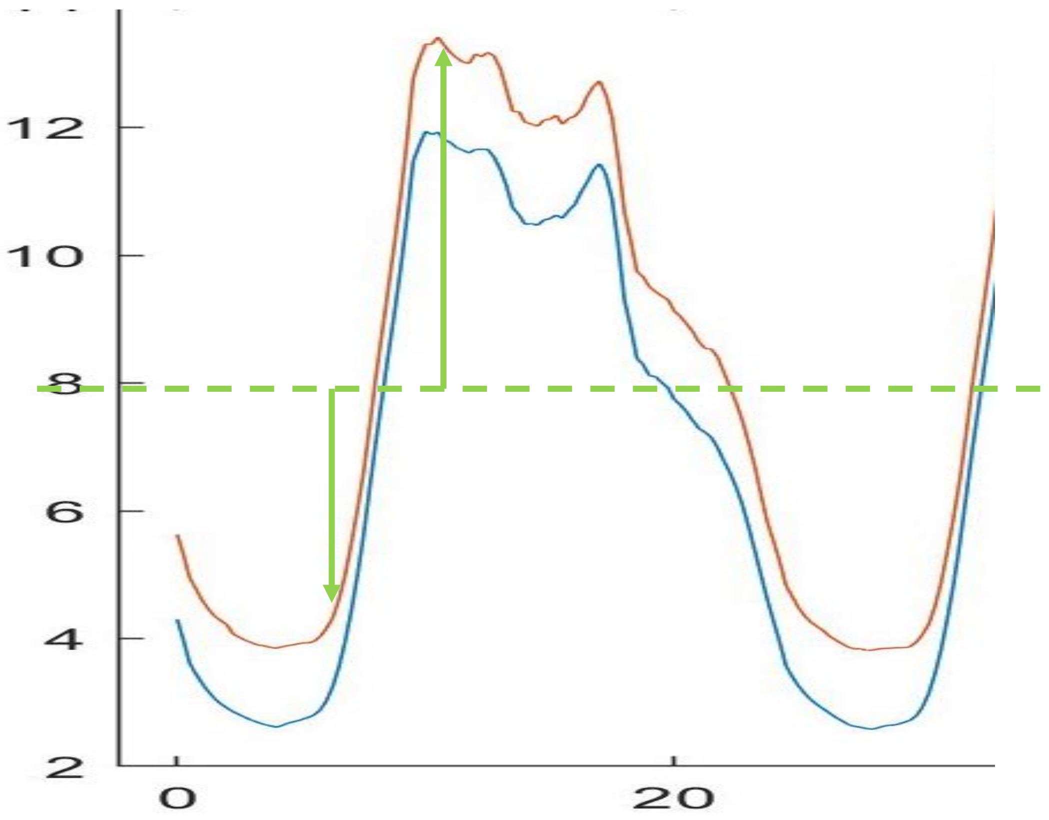
Scenario	2030				2050			
	TD	SP	SS	CP	TD	SP	SS	CP
PC	10%	10%	10%	10%	10%	10%	10%	10%
SC	43.5%	70.3%	81.5%	81.8%	5.0%	46.3%	85.7%	68.5%
V2G	46.5%	19.7%	8.5%	8.2%	85.0%	43.7%	4.3%	21.5%



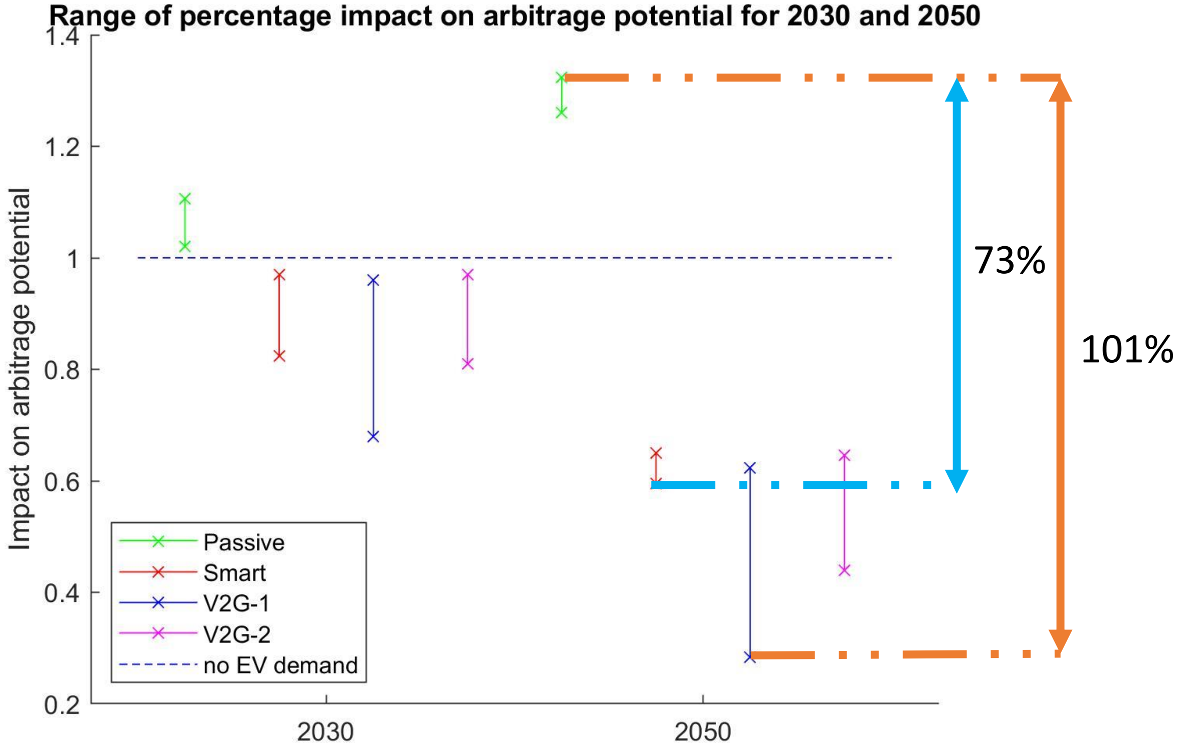
V2G Set-Up	Description	Proportion PC, SC and V2G	Percentage of the year V2G does not discharge to the grid	
			2030	2050
1	20% battery discharge each day, less than half the day max.	'Realistic Proportions'	71.3% to 93.5%	61.5% to 84.5%
2	Annual threshold; 50% battery discharge on max day, less than half the day max.	'Realistic Proportions'	95.7% to 99.5%	85.9% to 98.8%
3	10% battery discharge each day, less than half the day max.	'Realistic Proportions'	79.3% to 95.4%	61.7% to 87.7%
4	20% battery discharge each day, less than half the day max.	0.1,0.05,0.85	64.1% to 82.4%	54%
5	Annual threshold; 50% battery discharge on max day, less than half the day max.	0.1,0.05,0.85	93.1% to 98.1%	80.3% to 87.3%

Results- Potential Impact on Revenue Streams

	Potential Revenue Streams				
	Wholesale Energy Arbitrage	Balancing Mechanism	Capacity Market	Constraint Management	Frequency Response
Arbitrage Indicator	X				
Peak Indicator	X (scarcity pricing)		X	X	



Results: Arbitrage Potential

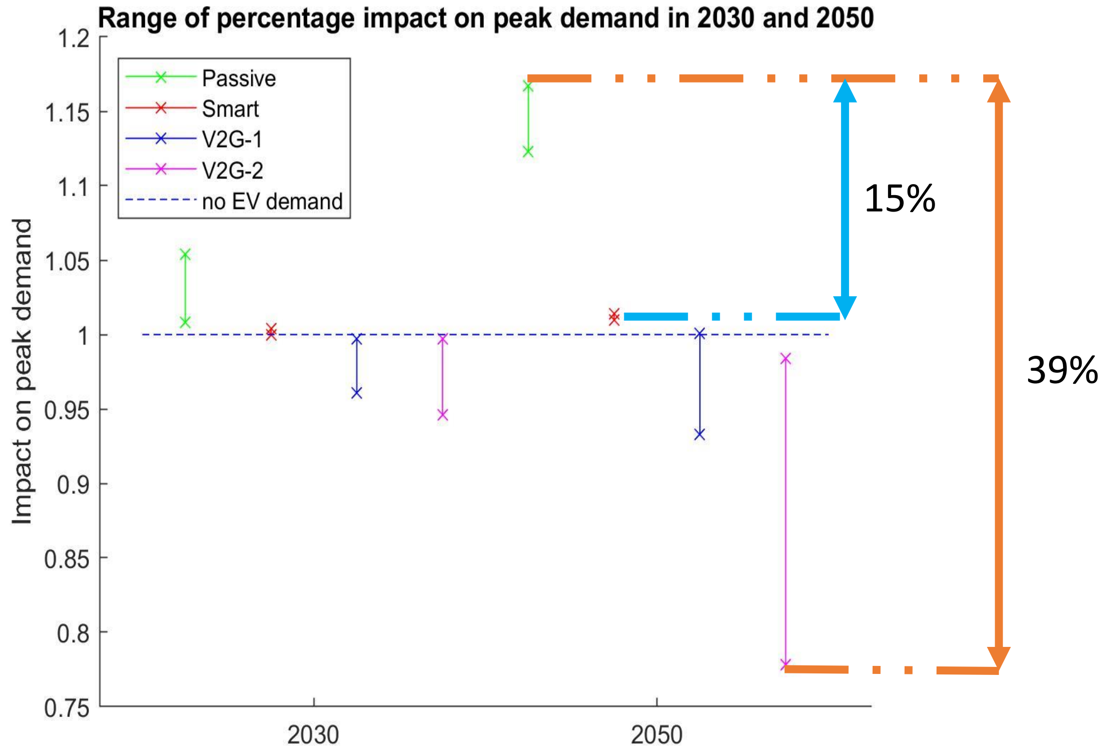


	2030		2050	
	Annual	Daily	Annual	Daily
Passive to Smart	3.7% to 19%	5.5% to 28.2%	43.9% to 49.2%	61.1% to 72.8%
Passive to V2G Set-Up 1	3.9% to 29%	5.8% to 42.9%	45.9% to 57.6%	63.8% to100.8%
Passive to V2G Set-Up 2	3.7% to 20.4%	5.5% to 29.3%	44.2% to 53.9%	61.4% to 88.4%
Smart to V2G Set-Up 1	0.2% to 9.9%	0.3% to 14.6%	1.9% to 11.3%	2.7% to 32%
Smart to V2G Set-Up 2	0% to 1.4%	0% to 1%	0.2% to 4.7%	0.3% to 15.5%

Points:

- Smart charging has significant impact
- Price differentials and volume altered
- Substantial uncertainty around the impact of V2G- potentially conservative assumptions
- Much larger impact on daily than annual

Results: Peak Demand Impact



	2030	2050
Passive to Smart	0.7% to 4.7%	11.3% to 15.3%
Passive to V2G Set-Up 1	1.1% to 9.2%	13.1% to 26.1%
Passive to V2G Set-Up 2	1.2% to 10.7%	14% to 38.9%
Smart to V2G Set-Up 1	0.3% to 4.4%	1.3% to 10.8%
Smart to V2G Set-Up 2	0.4% to 5.9%	2.6% to 23.6%

Points:

- Smart charging has significant impact
- Substantial uncertainty around the impact of V2G -potentially conservative assumptions
- Importantly, V2G has the additional potential to reduce peak demand

Results: Impact on Revenue Streams

<table>
<tr><th rowspan="2"></th><th colspan="5">Potential Revenue Streams</th></tr>
<tr><th>Wholesale Energy Arbitrage</th><th>Balancing Mechanism</th><th>Capacity Market</th><th>Constraint Management</th><th>Frequency Response</th></tr>
<tr><td>PC</td><td>26% to 32.3%*</td><td>Difficult to predict load</td><td colspan="2">Increase peak by 12%-17% by 2050</td><td>Likely to increase fluctuations</td></tr>
<tr><td>SC</td><td>-40.5% to -35%*</td><td rowspan="2">Potential supplier management</td><td colspan="2">Increase peak by 1% to 1.4%</td><td rowspan="2">National Grid (2015) found could provide 52% in 2030 (medium EV uptake scenario)</td></tr>
<tr><td>V2G</td><td>-71.6% to -35.4%*</td><td colspan="2">Reduce peak by 0% to 22.2%</td></tr>
</table>

*just the available volume reduction, not considering price differential reduction

Policy Implications

Resultant **uncertainty** in future ESS revenue and profit → **Reduction in investment** and increased cost of capital. → Impact on **technology and industry maturity**

The uncertainty arises from:

- Unknown EV take-up ✓
- Unknown EV charging preferences ✓
- Unknown V2G profitable operation ✓
- Potential widespread rapid charging ✗
- Disruptive transport business models ✗

- The potential transition ✓

Policy Implications

The case for maintain optionality:

- Flexibility is key to achieving major policy aims

Net Zero

World leader in new industries

Affordable energy

- Uncertainty over future EV capability

- EVs may not deliver assured system security

Peak Vehicle Usage

Market and Technical Integration

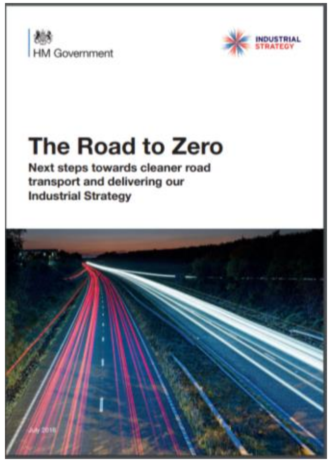
System Security Methodologies

Resulting Recommendations

Government must work to provide **market stability** for energy storage systems.

Reducing investment risk:

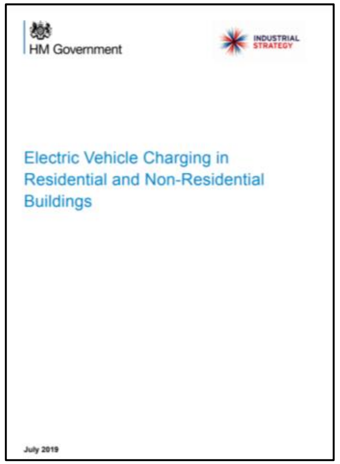
- Clear **policy roadmap** on EV charging
- Trials which show **consumer preferences** and reaction to incentives
- **Market stability mechanisms** for low carbon flexibility


HM Government

INDUSTRIAL STRATEGY

The Road to Zero

Next steps towards cleaner road transport and delivering our Industrial Strategy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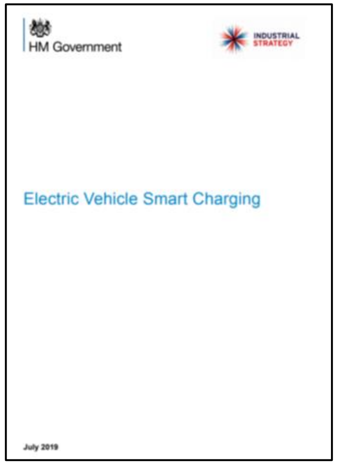
INDUSTRIAL STRATEGY

Electric Vehicle Charging in Residential and Non-Residential Buildings

July 2019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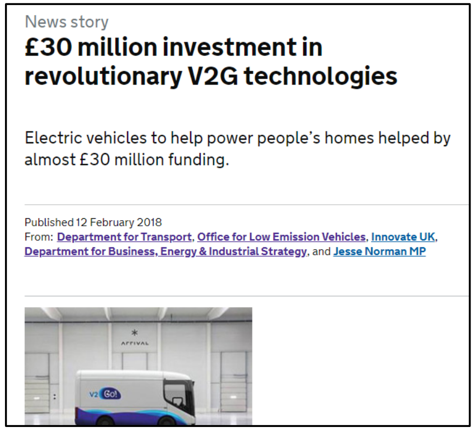
INDUSTRIAL STRATEGY

Electric Vehicle Smart Charging

July 2019


News story

£30 million investment in revolutionary V2G technologies

Electric vehicles to help power people's homes helped by almost £30 million funding.

Published 12 February 2018

From: Department for Transport, Office for Low Emission Vehicles, Innovate UK, Department for Business, Energy & Industrial Strategy, and Jesse Norman MP


Press release

Business Secretary to establish UK as world leader in battery technology as part of modern Industrial Strategy

Business Secretary Greg Clark announces the launch of the £246 million Faraday Challenge to boost expertise in battery technology.

Published 24 July 2017

From: Innovate UK, Department for Business, Energy & Industrial Strategy, and The Rt Hon Greg Clark MP

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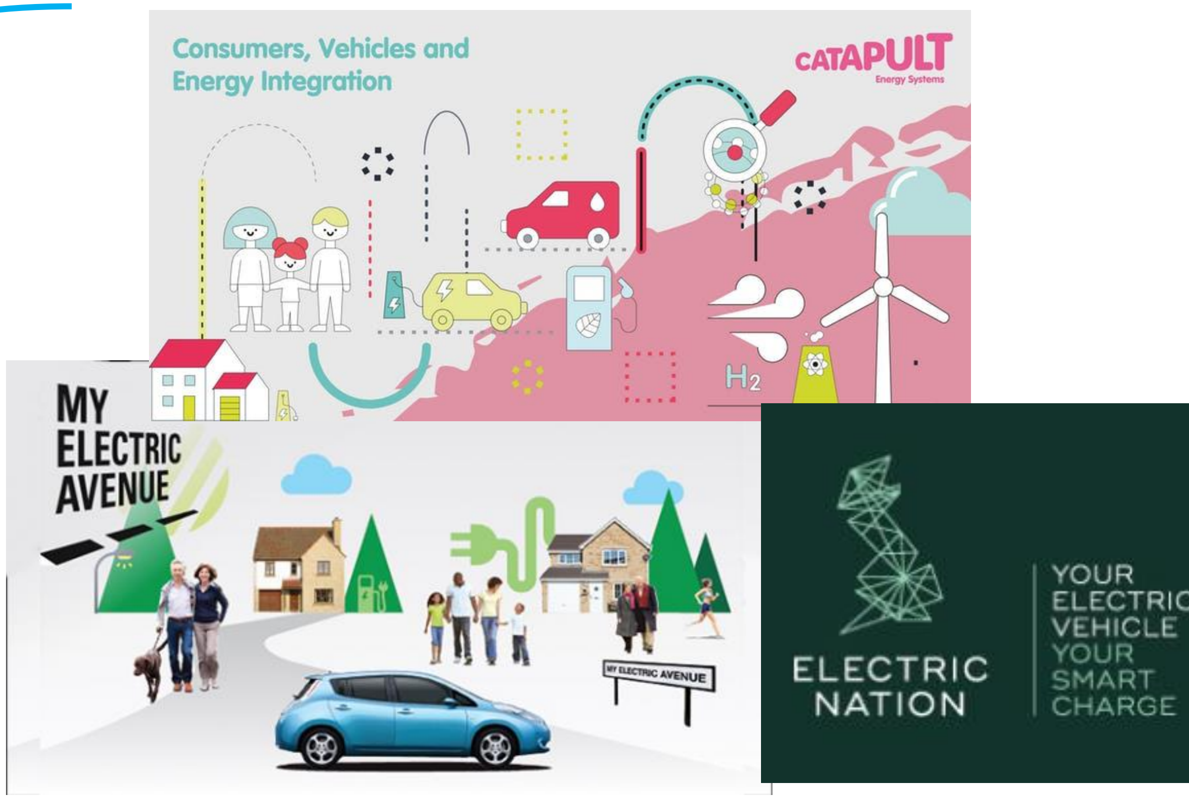

Resulting Recommendations

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Reducing investment risk:

- Clear **policy roadmap** on EV charging
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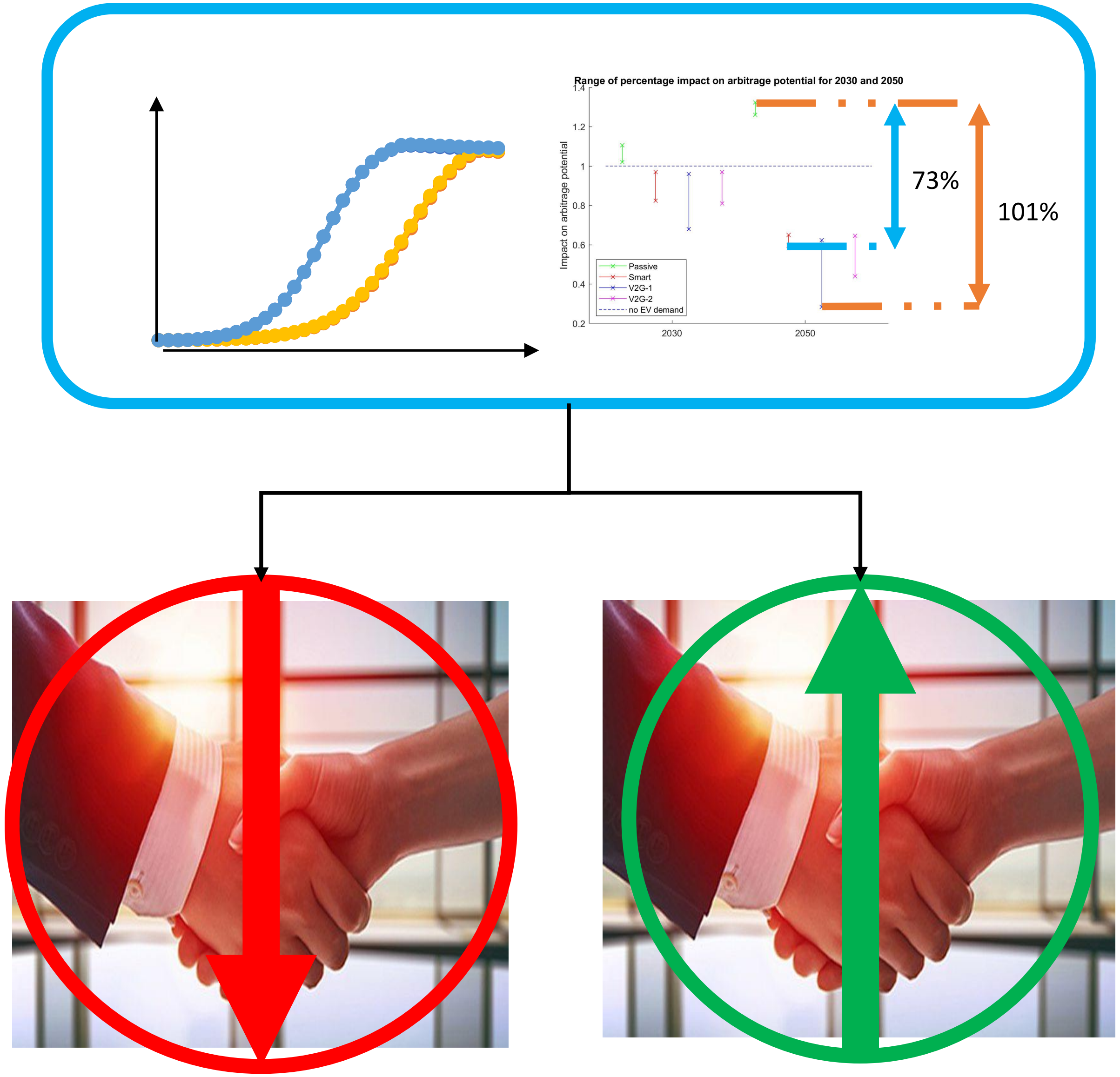
Conclusion

- Large variety of potential impacts from EV charging.
- Could prevent investment and optimal deployment of energy storage systems.
- Recommendation- To maintain optionality government must work to provide market stability for ESSs.



Thank you for listening

Susanna Elks- Energy Systems Catapult
Andrew Quinn- University of Birmingham