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V2GB – Vehicle to Grid Britain Contributing to the Decarbonisation of Power and Transport

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Director – Element Energy

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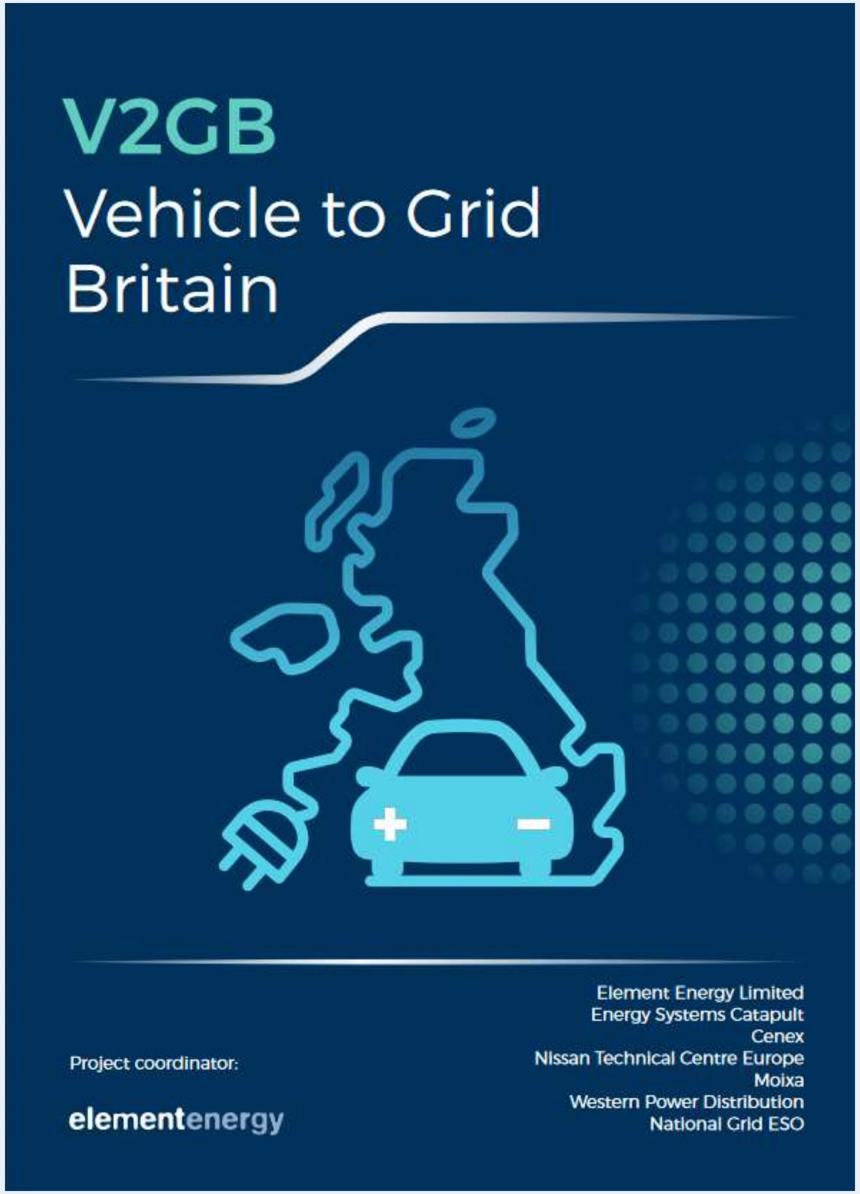

V2GB – Vehicle To Grid Britain
Contributing to the decarbonisation of power and transport

LCV 2019

Element Energy Ltd

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Element Energy, a consultancy focused on the low carbon energy sector

- Element Energy is a **specialist energy consultancy**, with an excellent reputation for rigorous and insightful analysis in the area of low carbon energy
- We consult on both **technical and strategic issues** – our technical and engineering understanding of the real-world challenges support our strategic work and vice versa
- Element Energy covers all major low carbon energy sectors:

Energy Networks

Smart Energy Systems

Carbon Capture and Storage

Hydrogen

Low Carbon Transport

Built Environment

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Vehicle 2 Grid Britain – Exploring the feasibility of V2G in Britain

How viable is V2G in Britain?

The project and its objectives

- V2GB is an Innovate UK funded project assessing the techno-economic viability of V2G in Britain.
- Dedicated work packages are set up to investigate
  - The **long term** demand for V2G type services in the GB electricity system
  - The **early opportunity and revenues** that V2G could capture
  - The **business models and value chains** which are best suited to capture the value of V2G

The project partners

- The study is conducted by a consortium of partners covering the whole V2G supply chain, among them a car OEM, the British transmission system operator, a distribution network operator, and an aggregator
- Specialised consultancies and a research organisation add to the analytic expertise of the consortium

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Scaling up V2G in Britain: from niche application to mass market

- **Revenue streams:** How are revenues streams changing over time? Which revenue stream will be dominant and drive viability?
- **Costs:** What are the main cost components? What is the potential for cost reduction? What reductions must be achieved to reach economic viability?
- **System value of V2G:** How can V2G contribute to decarbonisation of power and transport? How do increased renewable generation and competition from alternative flexibility providers affect the system value of V2G?

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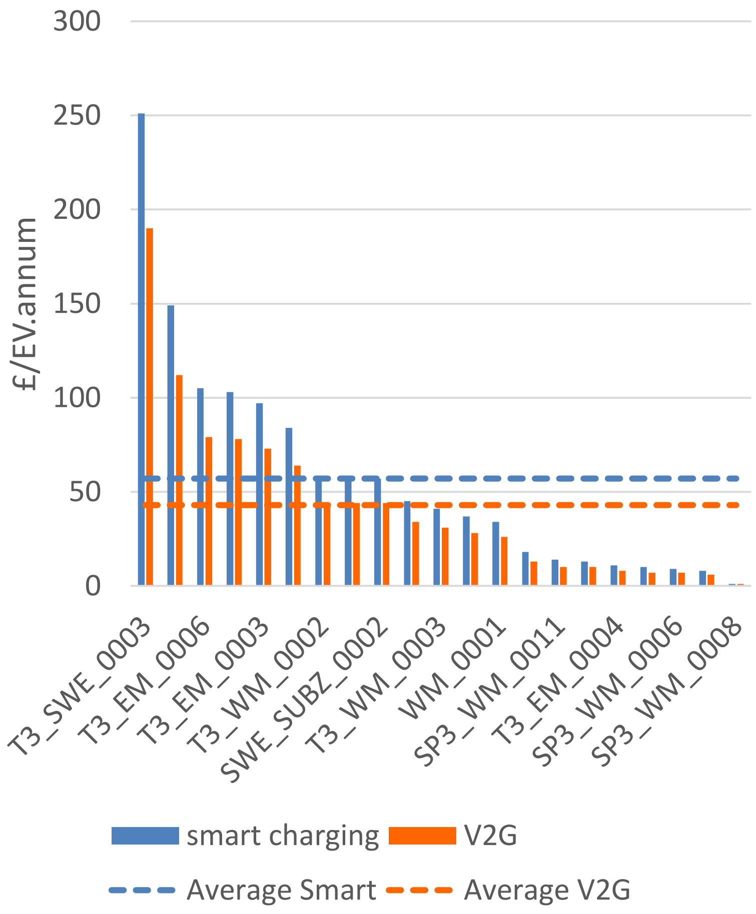
DNO REVENUES 2030 – Potentially Valuable….
….but time and location sensitive

Revenue variation across 21 zones

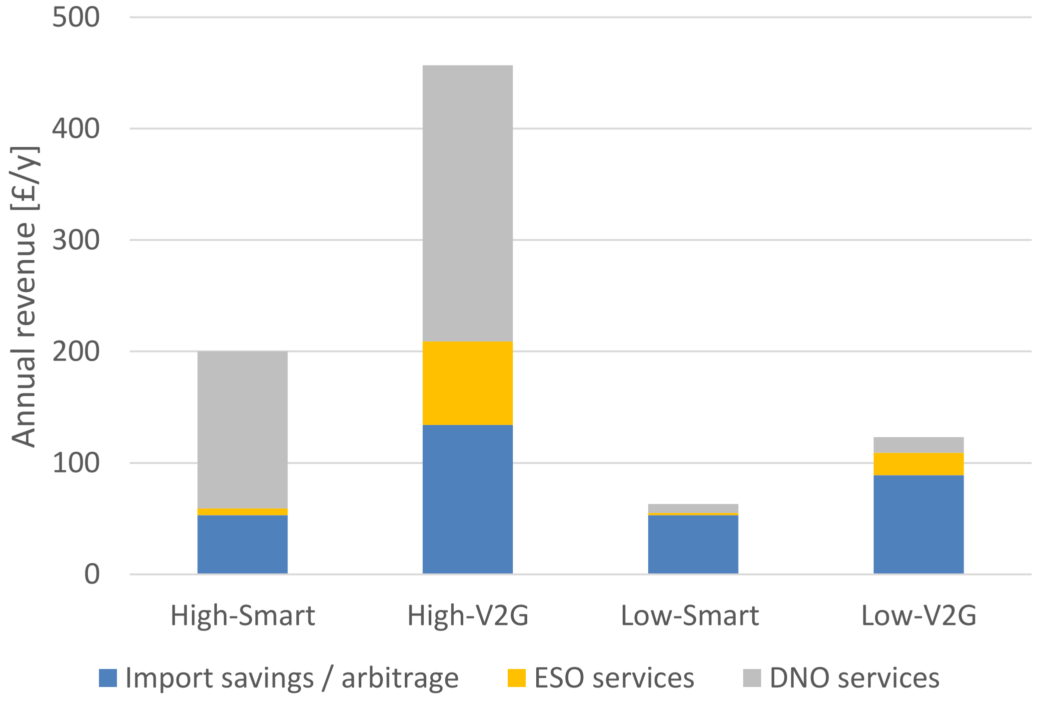


Notes

- All based on WPD published data on active congestion management zones. Based on Gone Green 2024 scenario.
- Using average utilisation rate of service in particular zone (as specified by WPD)
- Reason for difference between regions is expected call rate (number of hours per day, days per week, seasonality of calls etc).
- Note these 21 zones represent a small fraction of all WPD areas i.e. these are only zones where congested is expected (out of 100's)
- Most zones expected to have zero market value for congestion.
- Revenues for V2G are incremental, i.e. in addition to those for smart charging
- Daily charging requirement 6.6kWh; export limit 5kWh

REVENUES 2030

Revenue stack in 2030



Insights

- DNO service highest potential value, but limited number of zones, most zero value
- Daily arbitrage has sustained value – for smart this emerges from simple tariff structure; for V2G, concern is battery degradation

Notes

DNO services: Based on average utilisation from all 21 of WPD active congestion zones (these being a small fraction of all WPD areas). High: average of 5 most highly utilized zones. Low: average of 5 least utilized zones (most areas have value of zero – no congestion expected)

ESO revenues: Based on CENEX WP 2 data (lower FFR value, £5/MW/h), extrapolated to 2030 by estimating future FFR demand and EV capability to provide it (through V2G and smart charging); High: high plug in rates; Low: low plug in rates[1].

Import savings / arbitrage: Using whole system energy dispatch model, accounting for marginal production costs, as well as capacity savings in dispatch model.

High: unconstrained V2G scenario (*); Low: constrained V2G scenario; assuming V2G is used to offset domestic demand

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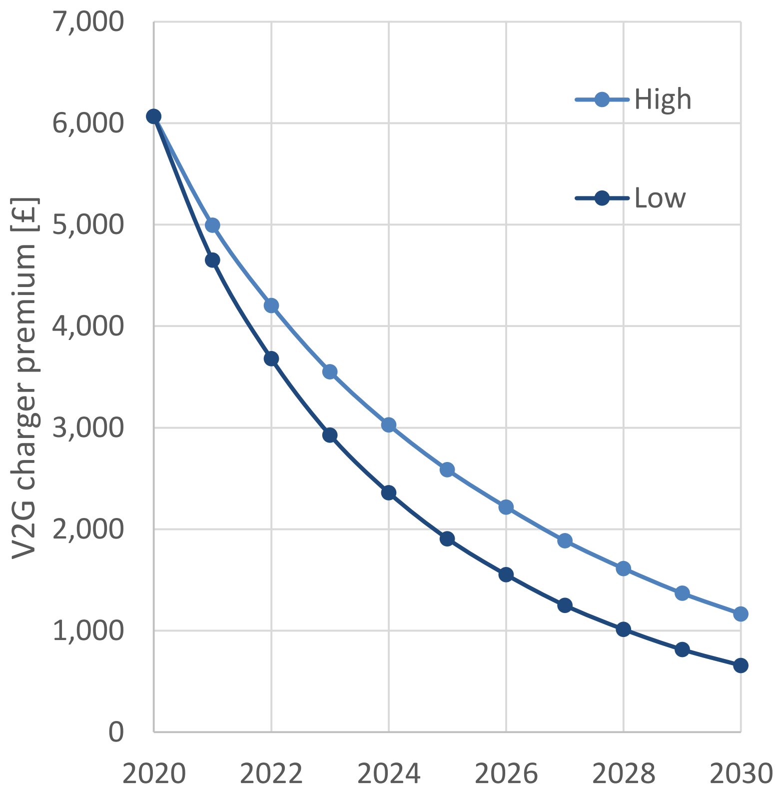
Cost reduction of V2G hardware

Cost-down trajectory for V2G charger



Notes

Costs based on 7kW charger

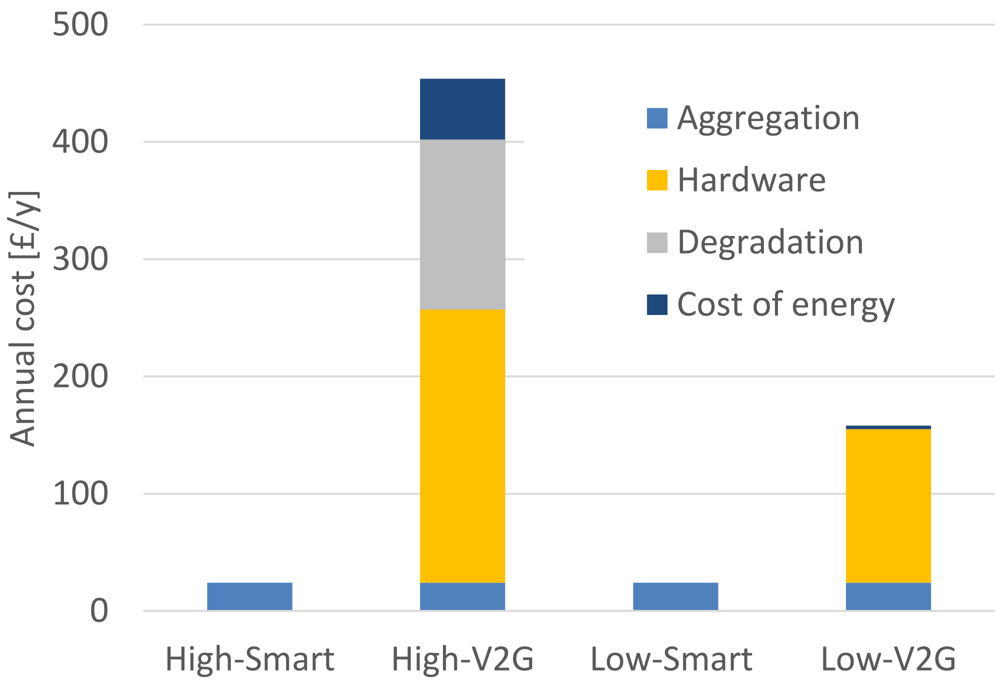
- Learning rates based on those achieved in proxy technologies (low kW residential solar inverters);
  - High: 11% learning rate
  - Low: 15% learning rate
- Using IEA global EV rollout projection
- High cost in 2030: £1160 on-cost
- Low cost in 2030: £660 on cost
- Further cost reduction through use of new technologies (GaN)

Notes

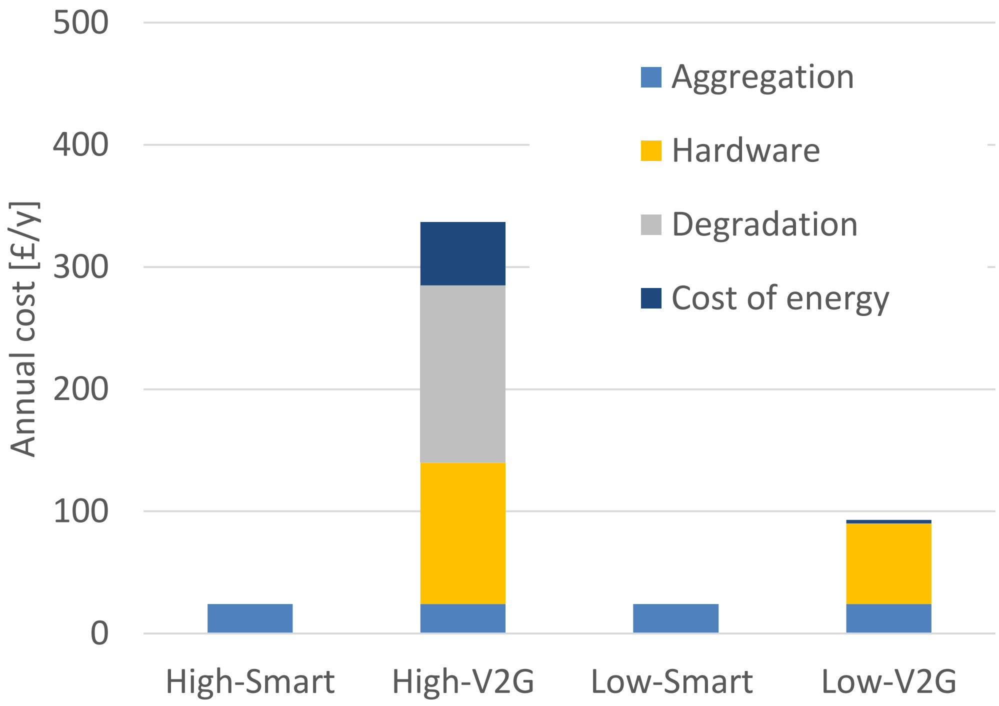
- Figures cross-checked and align with a bottom-up estimate based on key component costs.
- Top down (learning rate) and bottom up (component level) give similar projections to 2030.

COSTS 2030

Annual cost with simple 5 year capital depreciation



Annual cost with simple 10 year cap. depreciation



Notes

- **Cost of energy:** cost of energy to provide DNO service; assuming 85% full roundtrip efficiency, residential electricity price of 15p/kWh; negligible in "low" scenario due to low discharge in least utilised congestion zones[1]
- **Aggregation service cost:** £24/EV/y (from Moixa)

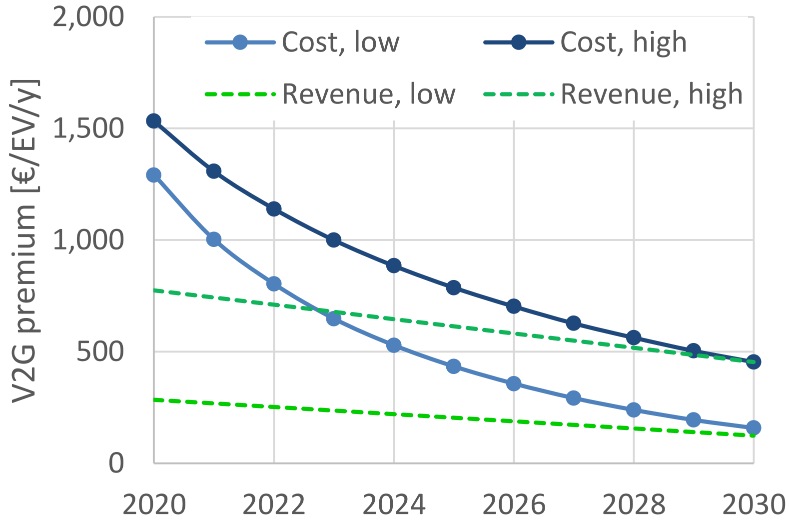
Notes continued

- **Degradation:** based on total throughput of 4500kWh/annum; assuming EV battery cost of £120/kWh, remaining capacity of 90% at end of 8 year warranty, 15,000 miles/y; 0.25kWh/mile.
- Degradation "low" assumes there is no issue with degradation

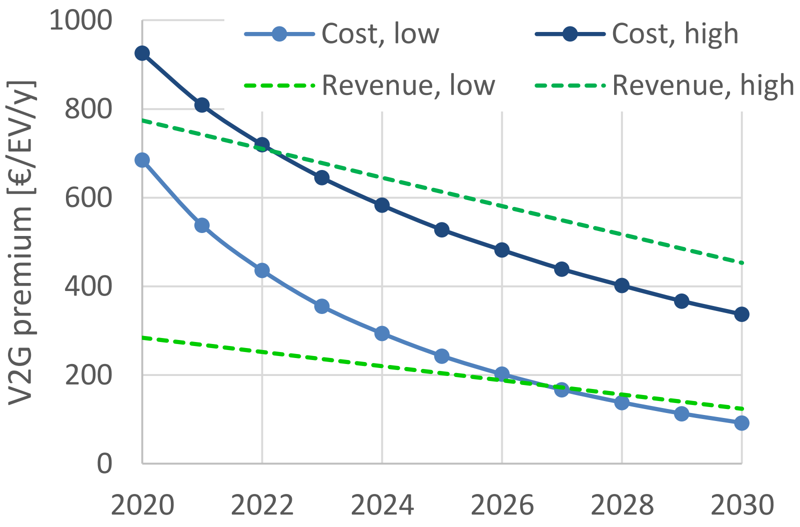
1) Cost estimate is conservative, since discharge for DSO service and discharge for arbitrage might be aligned and thus no additional discharge might be required

Cost reduction of V2G hardware is essential to make business models feasible

Cost vs revenues of V2G 5y lifetime



Cost vs revenues 10y lifetime



Conclusions: likely to achieve viability by 2030, provided the following:

Costs:

- Critical that commercial model able to annualise cost over long life, with low discount rate.
- Degradation almost as important as hardware in annualised costs
- Hardware costs must come down to allow economic viability beyond unusual edge cases

Revenues:

- High revenue case mostly reliant on DSO revenues in congested areas –time and location sensitive; most WPD areas **not** expecting congestion.

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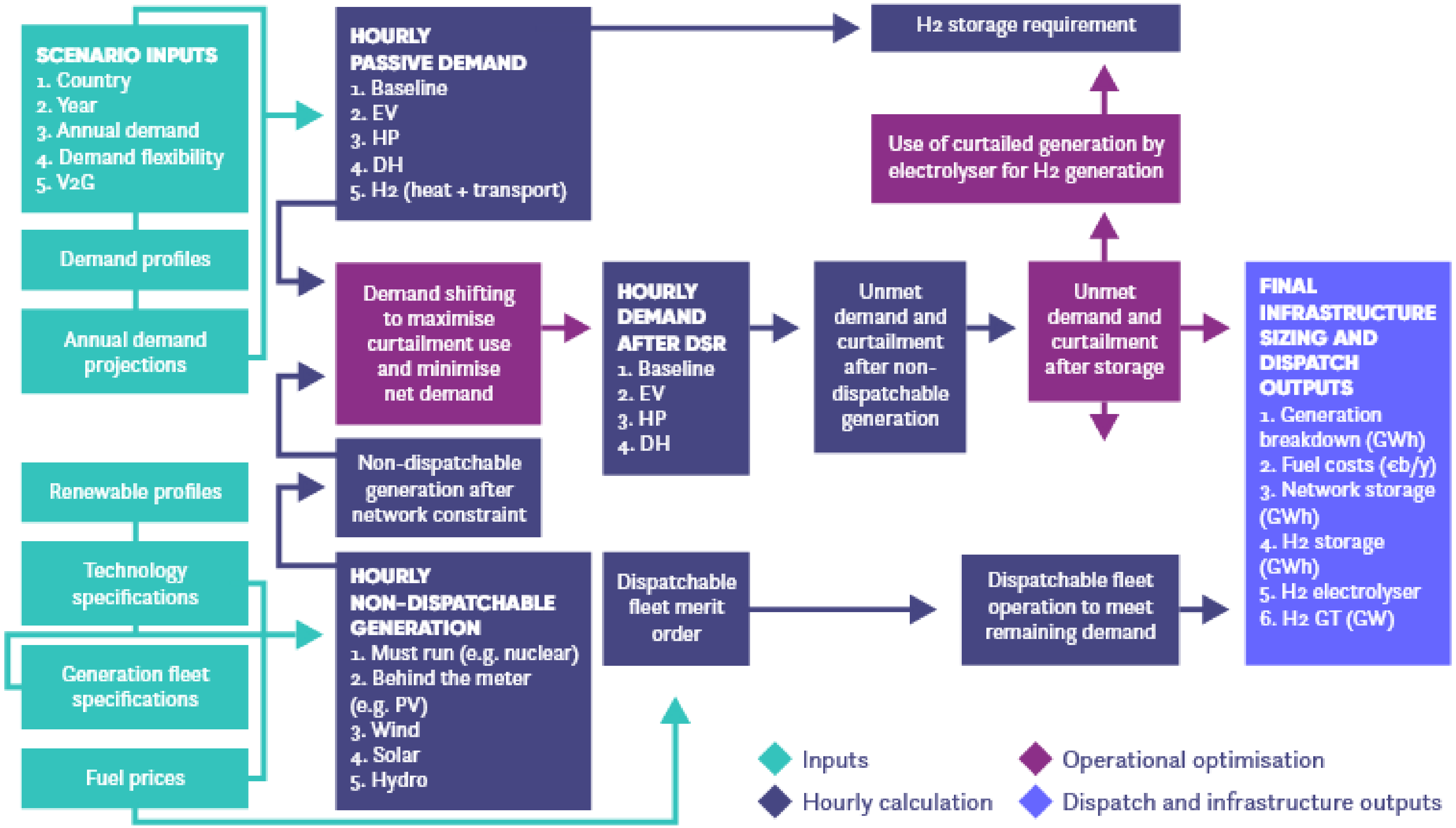
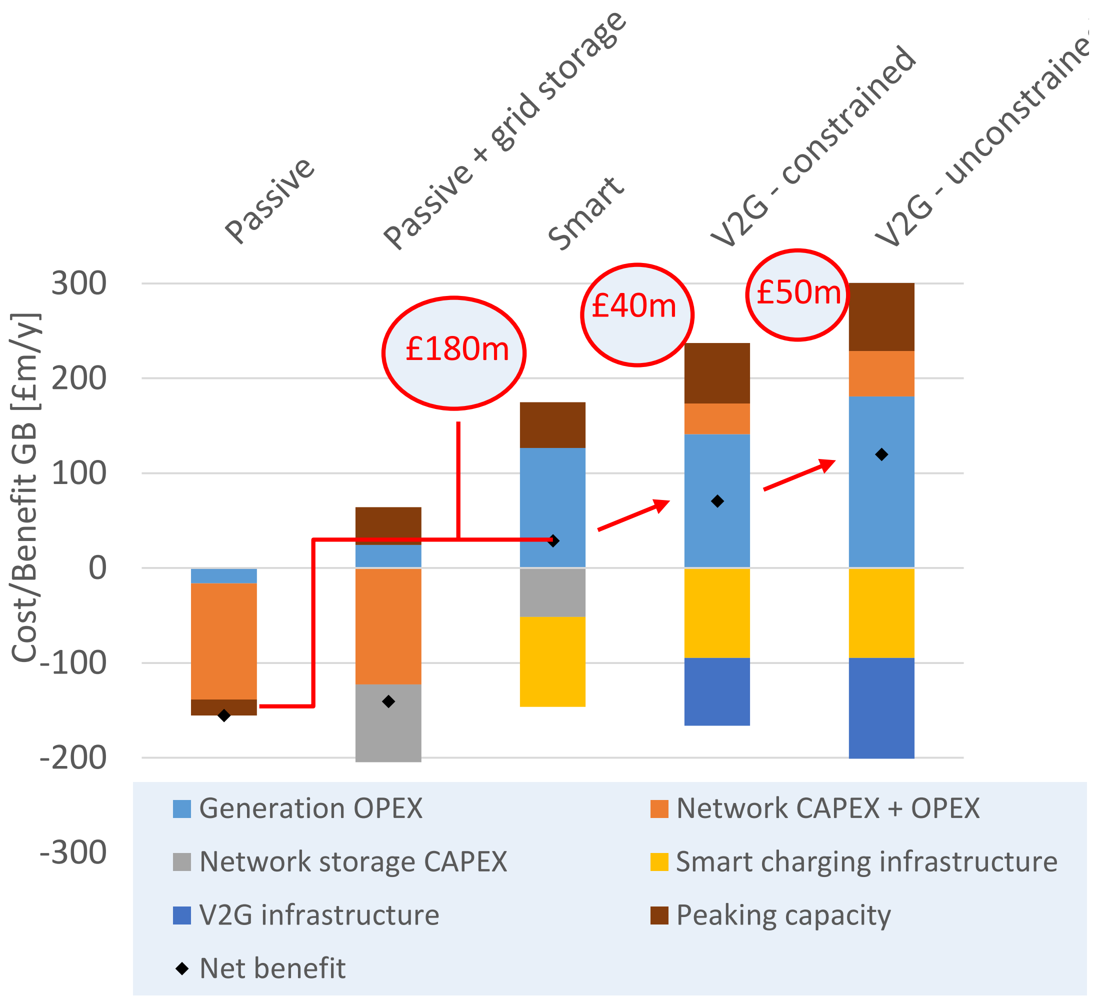
Multi-sectoral hourly dispatch model for system adequacy in low carbon system – price maker evaluates competition between technologies.



Whole system value dispatch modelling in 2030

System costs and benefits of smart charging and V2G in 2030 (4M EV; ca 1M V2G)



Clear system value of smart charging over passive

- Most significant value to the system is associated with smart charging (relative to passive)
  - Passive charging uses up significant network capacity.
  - Regulation could change to encourage smart charging as a minimum.
  - Smart charging supports cost avoidance (networks) as well as operational efficiencies

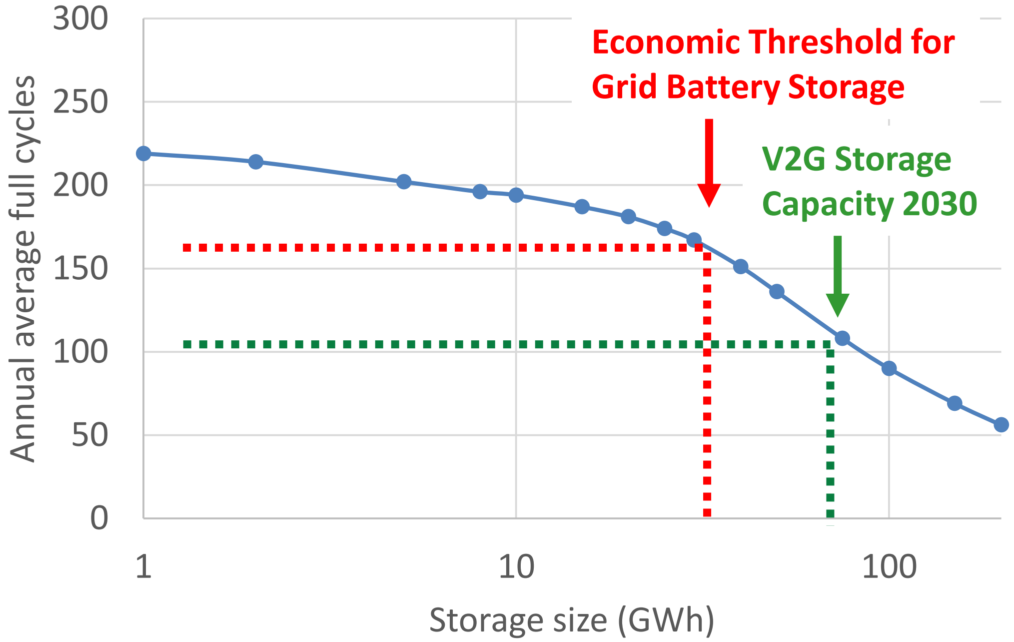
V2G deployed until marginal savings = marginal cost

- Constrained scenario limits battery utilization to + 2000kWh/annum for V2G
- Unconstrained (to level where marginal savings = marginal cost) results in ca. 4000kWh/annum

2030 UK system configuration taken from ENTSO-E Global Climate action scenario.
which does not consider the profile of EV charging but adds it as a flat block to the demand profile

Flexibility is key to supporting high levels of VRES penetration: the two sectors must grow together to be sustainable

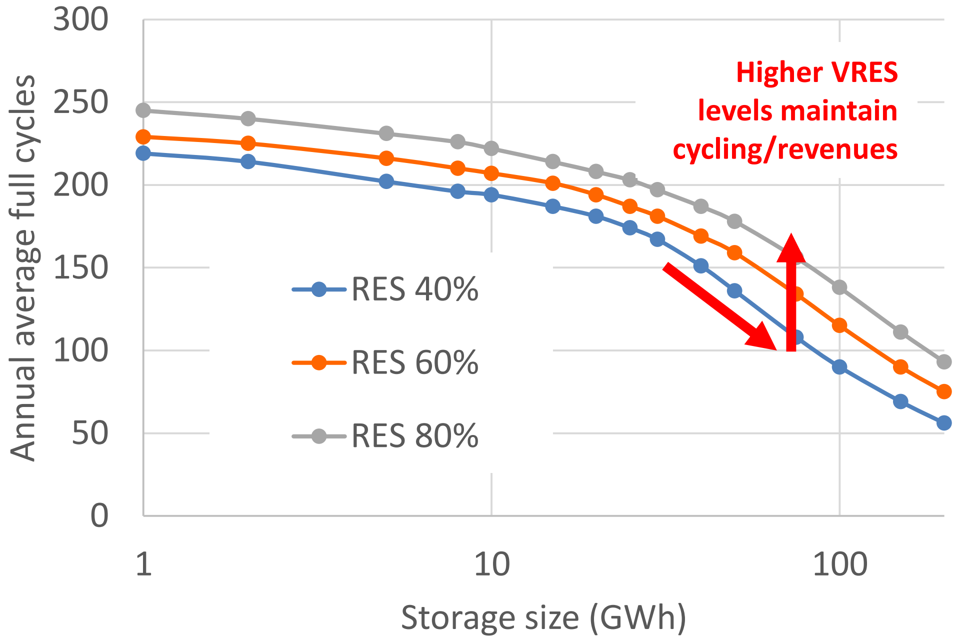
Reducing marginal value of storage



In a grid where supply and demand capacities do not vary, marginal value of deployment reduces.

V2G could provide a huge storage resource at low cost

Increasing VRES and Flexibility



Flexibility capacity can grow sustainably in a grid where VRES is increasing.

It will limit curtailment of VRES and requirement for dispatchable generation

Left hand chart shows the potential storage capacity if 100% of the EV fleet was using V2G chargers; it is assumed that 80% of the fleet is plugged in at any time and 50% of the EVs battery capacity is available for V2G