

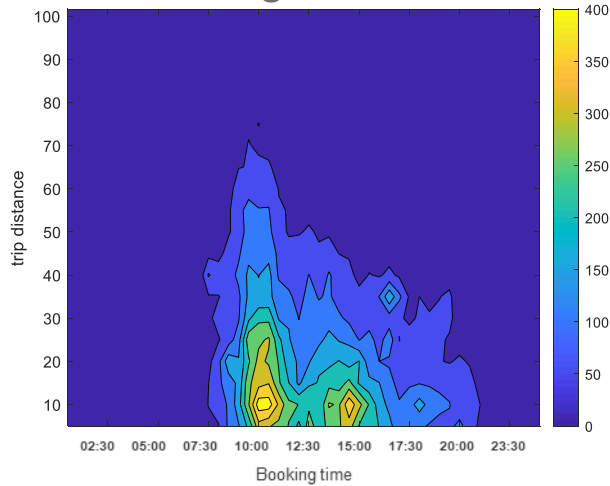
A Multi-Service Business Model for V2G Flexibility

E-Flex V2G Project Results

Roberto Moreira – Dimitrios Papadaskalopoulos – Alicia Blatiak - Goran Strbac



Bookings start time



Bookings end time

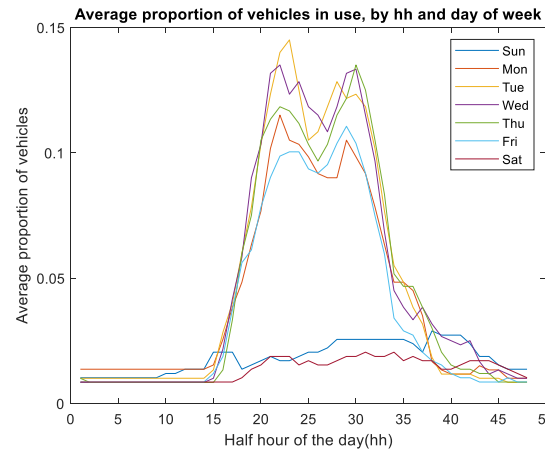
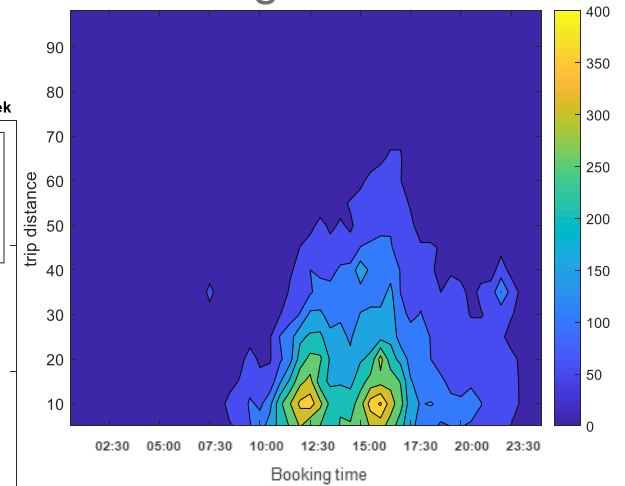
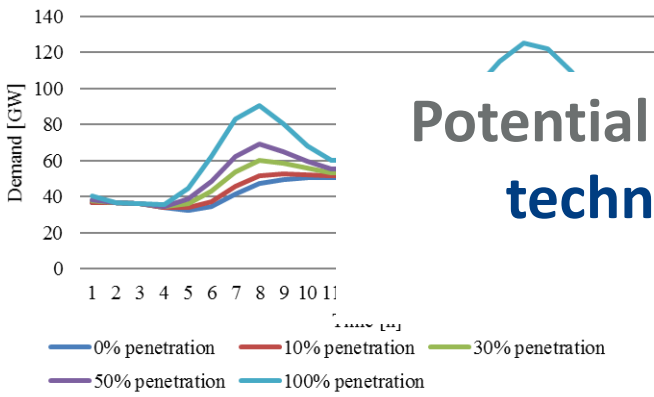


Figure 1 Day of the week profiles, with average proportion of vehicles in use

- Multi-Service Business Models with multi-market participation
- Imperial College responsible to design adequate Commercial Strategies for V2G capabilities that maximise its business case;
- E-Car Clubs with V2G capability;

System challenges with net-zero carbon Networks

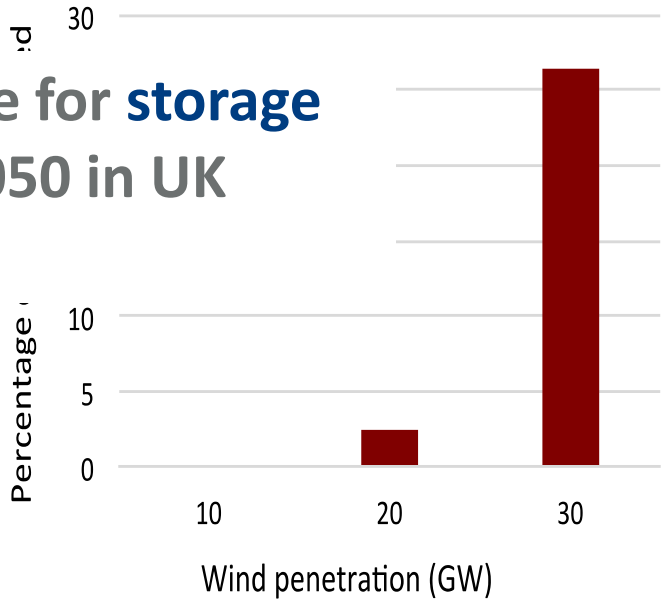
Capacity challenges with electrification of other energy sectors



Potential market volume for storage technologies post 2050 in UK
+£8bn/year



Balancing and need for flexibility



Applications / services for demand-side flexibility & storage

Energy price arbitrage

- Participate in day-ahead energy market to seize arbitrage opportunities;

Frequency regulation services

- Providing primary/secondary/tertiary frequency regulation services;

Contribution to system adequacy

- Reducing the need for peaking plants – e.g. through capacity markets – and network capacity;

Network support

- Reduce the need for network reinforcement – both in distribution and transmission networks;

Supporting low carbon generation mix

- Flexibility supports meeting carbon targets while reducing LC generation;

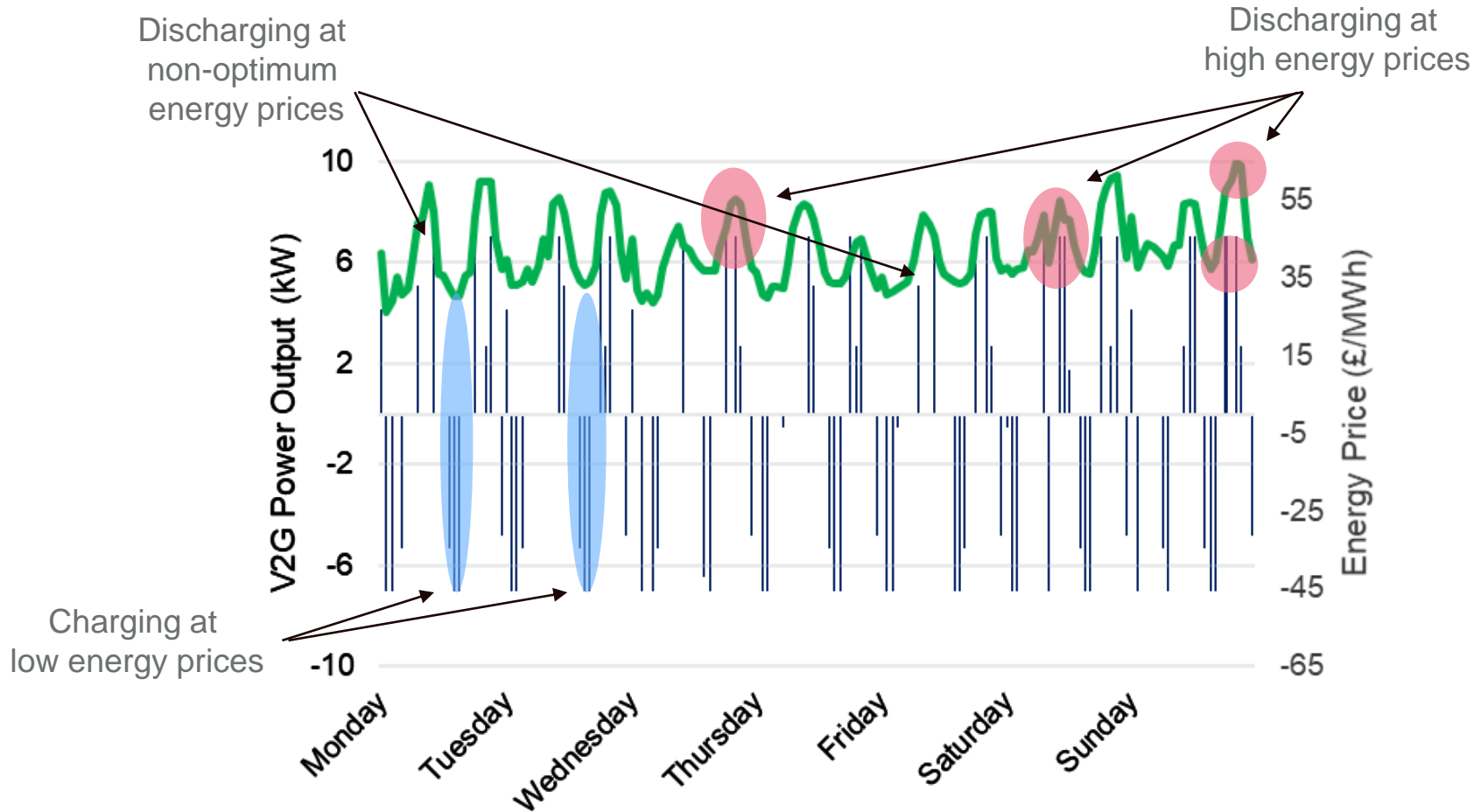
Ancillary services

- Provide necessary system ancillary services such as reactive power support, black-start, security of supply, losses minimization, etc;

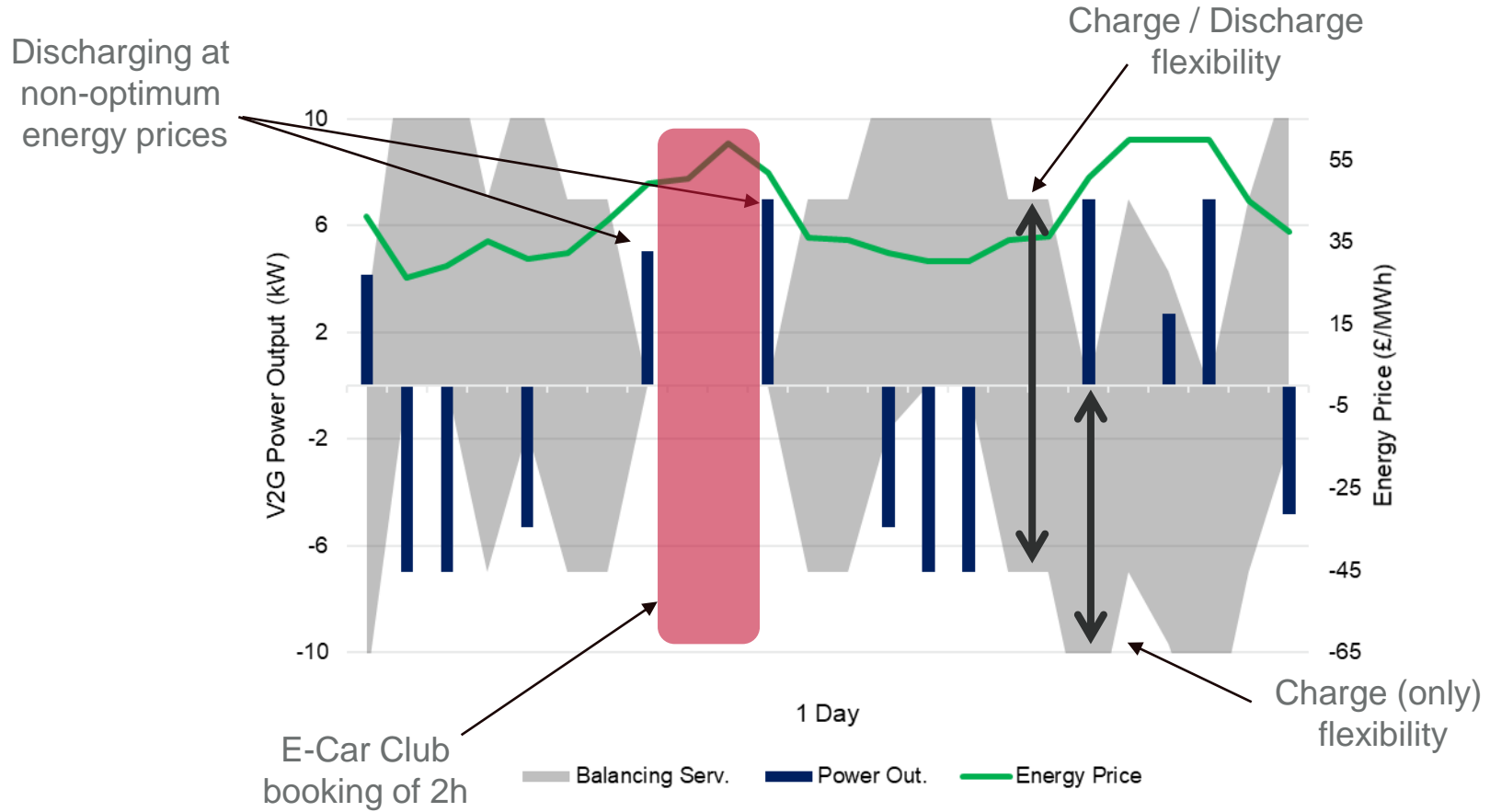
Option value

- Providing flexibility to deal with uncertainty;

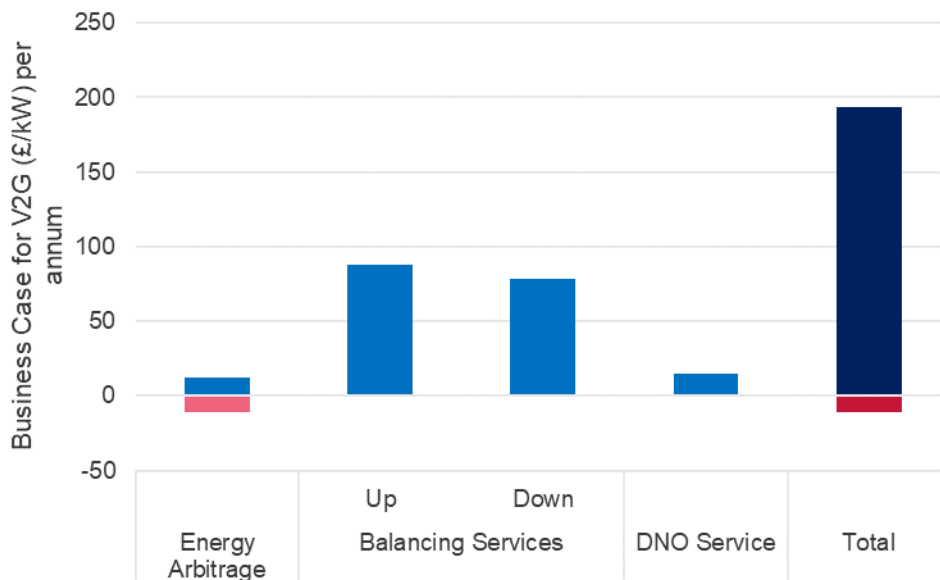
V2G Power Output



V2G Power Output (cont.)



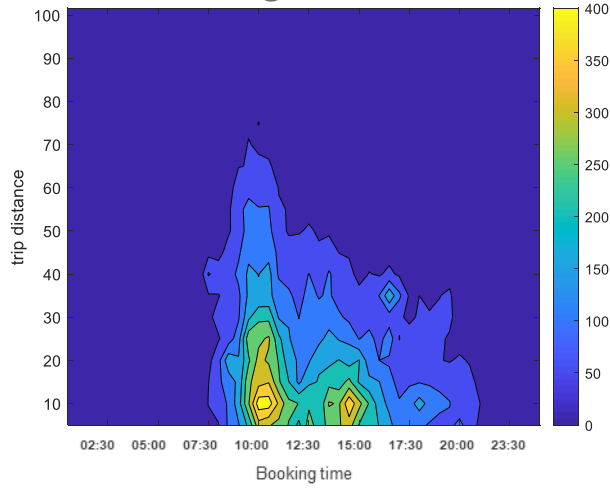
Business Case for V2G Capability



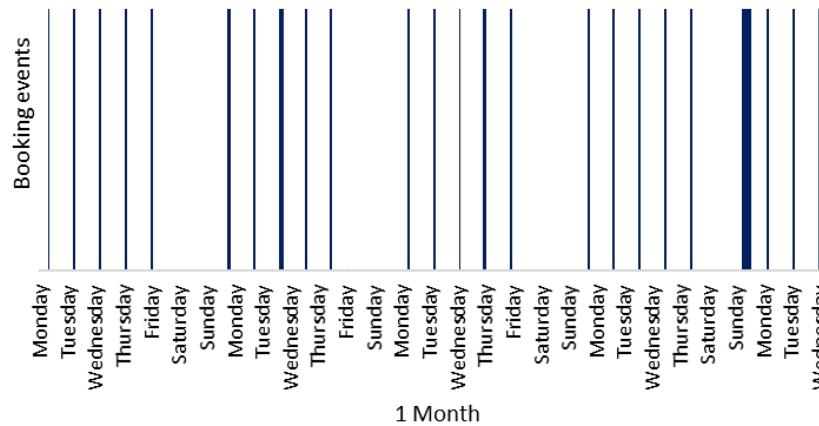
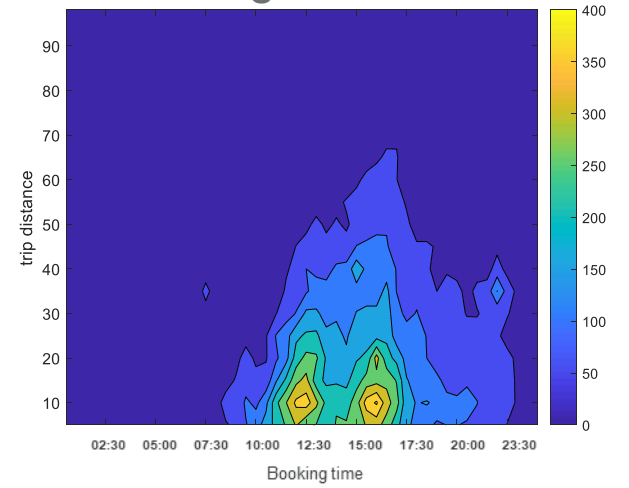
- Business case for single EV (deterministic results) up to 200 £/kW
- Value of EV flexibility is concentrated in balancing market participation (i.e. frequency regulation services); In a future low carbon energy mix, the value of balancing services is expected to double!

Next Steps

Bookings start time



Bookings end time



Further reading

Strbac G, Pudjianto D, Aunedi M, Papadaskalopoulos D, Djapic P, Ye Y, **Moreira R**, Karimi H, Fan Y et al., 2019, Cost-Effective Decarbonization in a Decentralized Market The Benefits of Using Flexible Technologies and Resources, *IEEE POWER & ENERGY MAGAZINE*

Ye Y, Papadaskalopoulos D, **Moreira R**, Strbac G et al., Investigating the Impacts of Price-Taking and Price-Making Energy Storage in Electricity Markets through an Equilibrium Programming Model, *IET Generation, Transmission & Distribution*

Papadaskalopoulos D, **Moreira R**, Strbac G, Pudjianto D, Djapic P, Teng F, Papapetrou Met al., 2018, Quantifying the potential economic benefits of flexible industrial demand in the European power system, *IEEE Transactions on Industrial Informatics*

Pudjianto D, Papadaskalopoulos D, **Moreira R**, Strbac G, Djapic P, Teng F et al., Flexibility Potential of Industrial Electricity Demand: Insights from the H2020 IndustRE project, The 11th Mediterranean Conference on Power Generation, Transmission, Distribution and Energy Conversion

“An analysis of electricity system flexibility for Great Britain”, (2016) BEIS

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/568982/An_analysis_of_electricity_flexibility_for_Great_Britain.pdf

“Can storage help reduce the cost of a future UK electricity system?” (2016) BEIS, Scottish Government

<https://www.carbontrust.com/media/672486/energy-storage-report.pdf>

“Roadmap for flexibility services to 2030” (2017) the Committee on Climate Change

<https://www.theccc.org.uk/wp-content/uploads/2017/06/Roadmap-for-flexibility-services-to-2030-Poyry-and-Imperial-College-London.pdf>

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