Assessing the Impact of Energy Shocks on Consumer Tariff Choice and Distribution Network Planning

Matthew Deakin[1], Cheng Wen[2], Mohammad S. Rafaq[3], Paraskevi Vatougiou[4], Shandelle Steadman[5]

[1]Newcastle University, [2]Leeds University, [3]Coventry University , [4]Heriot-Watt University , [5]Cranfield University

Introduction and Problem

Distribution network planning depends on methods for predicting peak demand of substations so that congestion can be managed. For decades, consumers have been modelled effectively using industry-standard techniques (e.g., using Elexon classes).

If a majority of households in future have EVs and heat pumps, there will need to be widespread upgrades to distribution networks. Automated home energy management systems can reduce bills and support grid resilience *and* address this network capacity problem.

It is envisioned that these **consumers will have choice in the flexibility they are willing to provide.** If this is the case, **there is a potential risk for distribution networks planners** if there is a shift *away* from flexible provision over a relatively short period of time. This could have a substantial impact on costs of LV infrastructure [1].

We are interested in the following question: what could the impact of an energy system 'shock' (large changes to the energy system or society) have on consumer willingness to allow a third-party to control their largest demands (e.g., heat pumps and EVs)?

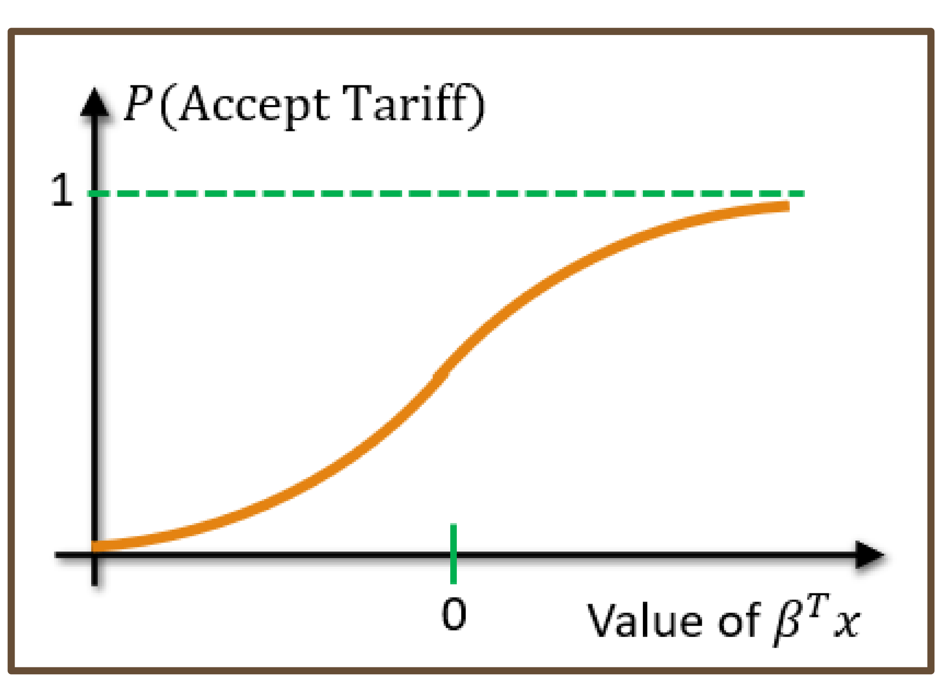
Proposed methodology

It is proposed to explore this using three steps:

1. Identify **'energy system shocks'** (e.g., armed conflict, sharp changes in wholesale prices) that may affect willingness to accept 3rd party control.
2. Build a **consumer model** to map those energy system shocks to changes in the probability of accepting a 'smart' tariff (e.g., a V2G program).
3. Map these **probabilities to peak demand** using conventional EV/heat pump/demand models.

The results focus on step (2.) (the consumer model). We propose a logit model, depending on consumer "Characteristics" $\beta \in R^m$, such that

$$\Pr(\text{Flex}) = \frac{1}{1+e^{-\beta^T x}}$$



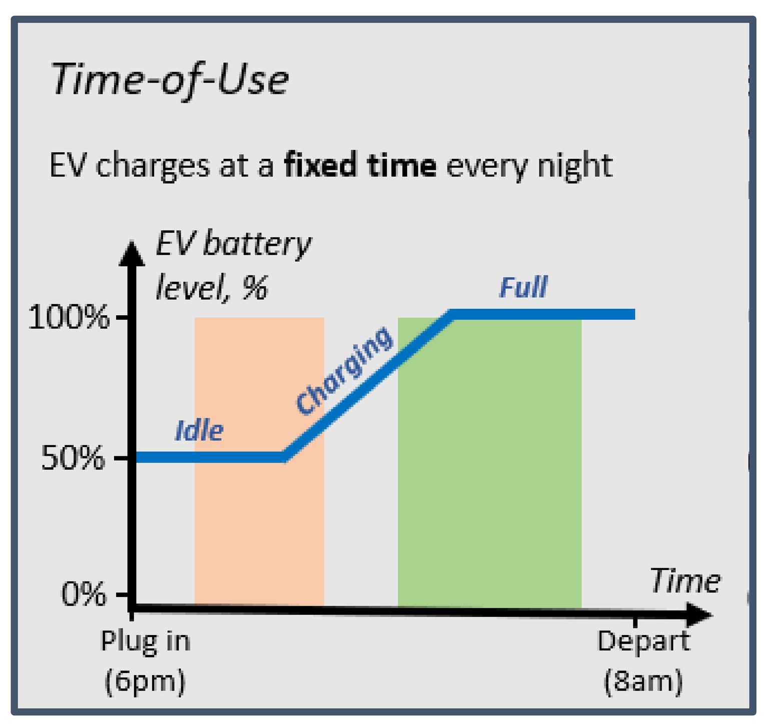
Preliminary Results

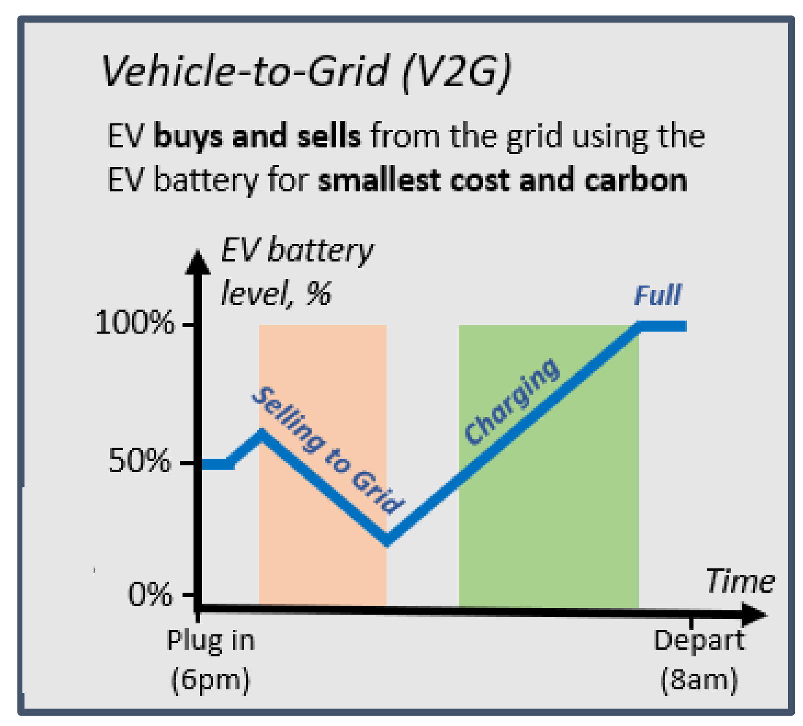
A Choice Experiment has been used to build the consumer model, using a binary stated preference survey experiment, with 994 consumers. Fifty characteristics are included within characteristics parameter β ($m = 49$).

The Average Marginal Effect of some of these parameters in β include:

- EV vehicle-to-grid reduces uptake by 17%;
- Cost savings increase uptake by 0.06%/£-yr;
- Carbon savings increase uptake by 0.16%/% saving-yr
- The lowest trust in supplier reliability has 14.32% lower uptake than the most trusting.

For example, if a widespread cyberattack reduced benefits of flexibility by £100/yr and all consumers in a previously fully-trusting neighbourhood dropped to no trust, the average effect would be (approximately) $6.0 + 14.3 = 20.3\%$. Modern EV chargers are 7 kW, and so (per-house) the demand might then increase by 1.4 kW. This is close to the same level as current per-household 'after diversity maximum demand', and so could cause congestion.





Conclusions and Future work

- Consumer choice considering smart tariffs will introduce risks in positive and negative senses
- A consumer model has been proposed, using logistic regression, to model flexible tariff uptake
- A "Choice Experiment" questionnaire has been used to determine model parameters.

Future work

- Developing 'system shock' models (in x) to pass into the consumer model, and, peak demand modelling
- Exploring impacts with DFES scenarios

References and Acknowledgement

[1] Low voltage network study. BEIS, August 2022. https://www.gov.uk/government/publications/low-voltage-network-capacity-study

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