Assessment of Customer Impact of Last Resort Arrangements for Distributors to Manage Specific Consumer Connected Devices.

A key consideration for the implementation of managed EV charging is the expected experience of customers during operation of a system. There is considerable nervousness over obtaining the correct balance between limiting EV charging with the potential risk of impacting uptake rates, and ensuring our local electricity networks remain reliable and cost-effective.

A challenge to achieving a view of customer impact is that each network area is bespoke in terms of the capacity, topology, number of customers and behaviour of those customers.

In order to quantify the customer impact a modelling exercise was carried out as part of the Smart E V Network Innovation Allowance Project.

Modelling Specifics

The modelling simulates the operation of a managed EV charging system. The salient details of the analysis are:

- Twelve months of monitoring data at 10-minute resolution for six feeders with varying available capacities;
- Eighteen months of EV charging data at 1-minute resolution (time stamps for start/end charging);
- Analysis was conducted on the phase with highest demand;
- Comparison of loads against either the fuse rating or cable rating (whichever is lower);
- EV charging demand profiles were randomly added to the feeder monitoring data to simulate future demands with various EV penetrations;
- Where the total expected feeder load was greater than the fuse or cable rating a managed charging event was created;
- Each event is an indication of the amount of demand needed to be controlled. The required demand reduction was evenly spread across all customers that were charging at that particular time (e.g. if 10kWh was required and five customers were charging during that time interval, the experience of each customer would be a demand curtailment of 2kW. If that event lasted for half an hour, the amount of energy curtailed per customer would be 1kWh);
- An analysis was conducted over a 12 month period to ascertain the number of events, the average amount of energy curtailed per event (kWh) and the maximum amount of energy curtailed during the most severe event (kWh)
- It was not possible to determine voltage excursions in this first pass analysis. The analysis is based upon overload alone.

Notes on Modelling Accuracy

The modelling conducted is considered to be the best available in light of the real-world data sources used; however, it is intended as a guide to the degree of customer impact of managed charging. This section briefly describes some of the more significant assumptions and limitations of the modelling:

- Only the feeder has been modelled and not the distribution transformer (which typically supplies multiple feeders – usually between one and six). Using managed EV charging for distribution transformer constraints is also desirable for DNOs;

- The charging rates have been extrapolated from 3.5kW to 7kW using a very basic assumption of double the demand and half the duration.

Nonetheless, the modelling presents the first view using real data at 10-minute resolution of how networks will cope and how managed EV charging could be used by DNOs. This is a significant step forward from using averaged data where it is difficult to understand the inter-day variation of demand.

Results

Six low voltage feeders were modelled with different characteristics in terms of number of customers and network capacity. EV charging profiles were added to the feeder demand and any overloads were classified as managed EV charging events. The table below describes:

- Max Feeder Utilisation (%): the maximum demand recorded for each feeder expressed as a percentage of the network capacity (feeder rating or able rating – whichever is lower);
- EV penetration (%): the percentage of customers with EVs;
- Number of managed charging events: over the twelve month modelling period, the number of distinct managed charging events. Overloads in two or more consecutive 10-minute time periods are classed as one event;
- Average duration of event (mins): the average duration of managed charging events seen by each customer. This is different to the average duration of events as only a proportion of customers are charging their vehicles during each event. The modelling was conducted at 10-minute resolution, hence the minimum duration is 10 minutes;
- Average deferred energy (kWh); this represents the average amount of energy displaced by each managed charging event. For example, a 7kW charger curtailed by 20% for 20 minutes would be equal to 0.47 kWh (7 x 20% x 20/60);
- Maximum energy deferred (kWh): during the most severe managed charging event, the greatest amount of energy deferred.

On analysis of the results below, if we consider Circuit 2, which the modelling suggests would experience four overloads a year with a 50% EV penetration. Per year, a customer could expect to have 0.92kWh (4 events x 0.23 kWh) of charging delayed by 18 minutes on average. For perspective, an EV owner covering 10,000 miles a year would require around 3,000 kWh of energy to re-charge their vehicle.

Considering recharging an EV after a 50-mile round trip, with a 7kW charging rate, the vehicle would be fully re-charged after approximately two hours. With managed charging to save four potential power outages, on these four occasions, the re-charge time would be extended by two minutes.

When penetrations of EVs reach 100%, the analysis shows that the number of breaches rises dramatically, often above 200 events per annum, although the average amount of deferred energy per event remains low.

Table 1: Modelling result figures for a year of data

Circuit Identifier	Customers On Feeder	Max Feeder Utilisation at present (%)	EV Penetration (%)	Number of Managed Charging Events	Average duration of event (mins)	Average deferred energy per customer per event (kWh)	Maximum energy deferred (kWh)
Circuit 1 (Suburban	14	70	58	4	10	0.08	0.17
			100	23	15	0.55	2.02
Circuit 2 (Suburban)	44	52	50	4	18	0.23	0.45
			100	207	25	2.02	3.29
Circuit 3 (Suburban)	24	18	69	1	10	0.06	0.06
			100	194	18	0.10	0.15
Circuit 4 (Rural)	22	71	17	5	30	0.75	1.45
			100	251	23	0.1	1
Circuit 5 (Urban)	55	68	17	10	24	0.65	2.35
			100	256	32	1.03	11.64
Circuit 6 (Rural Substation)	200	47	23	4	19	0.35	1.04