REPORT

Smart Meter Aggregation Assessment Final Report - Executive Summary

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Executive summary

Background

This document summarises the content of the full Smart Meter Aggregation Assessment Final Report produced by EA Technology on behalf of the ENA to assess the relationship between data aggregation and privacy. A further report is being prepared to assess the relationship between data aggregation and the delivery of network benefits.

Consumer behaviour and electricity demand on the low voltage (LV) network are anticipated to change dramatically over the coming years due to electrification of heat and transport, decarbonisation of electricity production and widespread take-up of micro-generation, posing a significant challenge to electricity Distribution Network Operators (DNOs). Having increased visibility of demands on the LV network via the roll-out of smart meters to all customers could be of material benefit to DNOs in assisting them manage their networks and plan reinforcement. In turn, the use of smart meter data will benefit end customers as a consequence of DNOs being able to make more informed decisions and hence invest more efficiently in the network. Previous ENA work has shown the likely benefits to be £27.9m over ED1 and a further £41.3m over ED2, although this is dependent upon the realisation of the forecast increases in Low Carbon Technologies (LCT).

Under licence condition SLC10a DNOs are unable to access raw load profile data (time series consumption data) from individual smart meters due to concerns over personal privacy issues with customers. This project has been instigated to investigate the relationship between aggregation and anonymity. A second project has been instigated to evaluate the reduction in financial benefits as a consequence of DNOs not being able to make use of individual consumption profiles from individual smart meters to inform their network investment decision process and/or if anonymity concerns result in aggregation levels that prevent access to sufficiently granular consumption data.

This paper summarises the work to assess the level of aggregation required to achieve a high degree of anonymity. It is important to note that aggregation on its own cannot ensure anonymity; for example the aggregate of consumption profiles from customers A, B and C subtracted from the aggregate of consumption profiles from customers A, B, C and D will produce the consumption profile for customer D. This simple example illustrates that whilst aggregation can help provide anonymity, DNOs will need to build controls into their IT systems and/or business processes to preclude the possibility of aggregated data being abused. Hence, the objective of this work was to establish the relationship between the number of consumption profiles aggregated and the likelihood of being able to establish the consumption profile of an individual customer from this aggregated profile.

Establishing an individual profile from an aggregated profile

This section describes the methodology adopted and the results obtained from the studies performed to assess the possibility of being able to recreate an individual consumer consumption profile from a profile formed by aggregating different numbers of consumption profiles.

To model this it was necessary to establish some typical LV demand profiles representative of individual household load consumption. For this EA Technology used a well-established model which simulates over a 24 hour period the use of domestic appliances within UK dwellings. This model, called the CREST model[1], was used to create individual household half hourly load consumption data, representative of ten real feeders with the number of customers on each feeder ranging from 9 to 124.

[1] Centre for Renewable Energy Systems Technology at Loughborough University - http://www.lboro.ac.uk/research/crest/

These modelled profiles were aggregated, at feeder level, and validated against the feeder monitoring data from the Northern Powergrid Customer Led Network Revolution project (CLNR)[2].

Once the profiles were confirmed as being representative of real LV networks, they were subject to consecutive aggregated customer privacy studies using three different methods of analysis:

- **Method 1 – Visual inspection:** graphically compared the aggregated half hourly profiles. Aggregation was undertaken in increased order from 2 customers up to the total number of customers on the feeder and the optimum aggregation value to preserve anonymity was one that visually showed appreciable differences to the previous aggregated profile but aggregated profiles thereafter showed a lower degree of graphical variations.

- **Method 2 – Correlation analysis:** investigated how correlated an additional profile was to a group of aggregated profiles. The correlation coefficient between profiles was used to numerically quantify the similarities between profiles and to calculate the extra differentiation that the addition of a further profile could add into the group.

- **Method 3 – Clustering analysis:** used a K-means clustering approach that determined the average number of customers with household load profiles similar to that of the group, and how likely an individual customer load profile could be estimated from the aggregated group load profile.

These methods were assessed considering typical conventional network loads under balanced load conditions and results from each methodology were considered. The review concluded that the visual inspection method provided less objective results than the correlation analysis, while the clustering analysis offered less granular comparisons than the correlation analysis.

For these reasons the correlation analysis was the chosen methodology to be taken forward for the detailed analysis, examining 330 different future load cases and assessing the effects of LCT and uncertainties associated with customers' phase connectivity which affects load balance on the network.

These 330 analyses were obtained from 33 LCT penetration scenarios analysed over 10 different feeders. The LCTs considered for the analysis were: photovoltaics (PV), Heat Pumps (HP) and Electric Vehicles (EV) – both fast and slow charging points. The 330 analysed cases covered situations with domestic customers without any LCTs and included several combinations of increasing LCT penetration up to a maximum number of customers with LCT loads[3] and analysing winter/summer seasonal variations on both suburban and rural feeders.

In the following table the visibility risk is presented as a key metric in the evaluation of suitable aggregation levels. Visibility risk is defined as the likelihood of an individual customer consumption profile being derived from the aggregated group load profile. In other words, if someone had access to the aggregated profile, what would be the probability of deriving one individual profile from it. Hence the lower the visibility risk the greater the customer privacy. The visibility risk has been calculated as the median of the 330 results obtained from the analysed cases and results are presented in Table 1.

[2] Northern Powergrid feeders were deemed to be appropriate for the analysis having already been investigated for their national representation on the Low Carbon Network Fund (LCN Fund) project and having had monitoring systems fitted in place which allowed the simulated load consumption data to be validated against real feeders.
[3] Based on DECC's Credit Purchase scenario projections for 2020 - this scenario bears the closest resemblance to the uptake of LCTs expected by DNOs in the RIIO-ED1 period following the results of stakeholder engagement activities undertaken by all DNOs.

Table 1 Visibility risk for each aggregation level

Aggregation level	Visibility risk (%) (median correlation results)
1	100%
2	22%
3	20%
4	17%
5	15%

Figure 1 below shows that an aggregation level of two reduces the visibility risk by approximately 80% and very little improvements for increasing levels of aggregation happen thereafter.

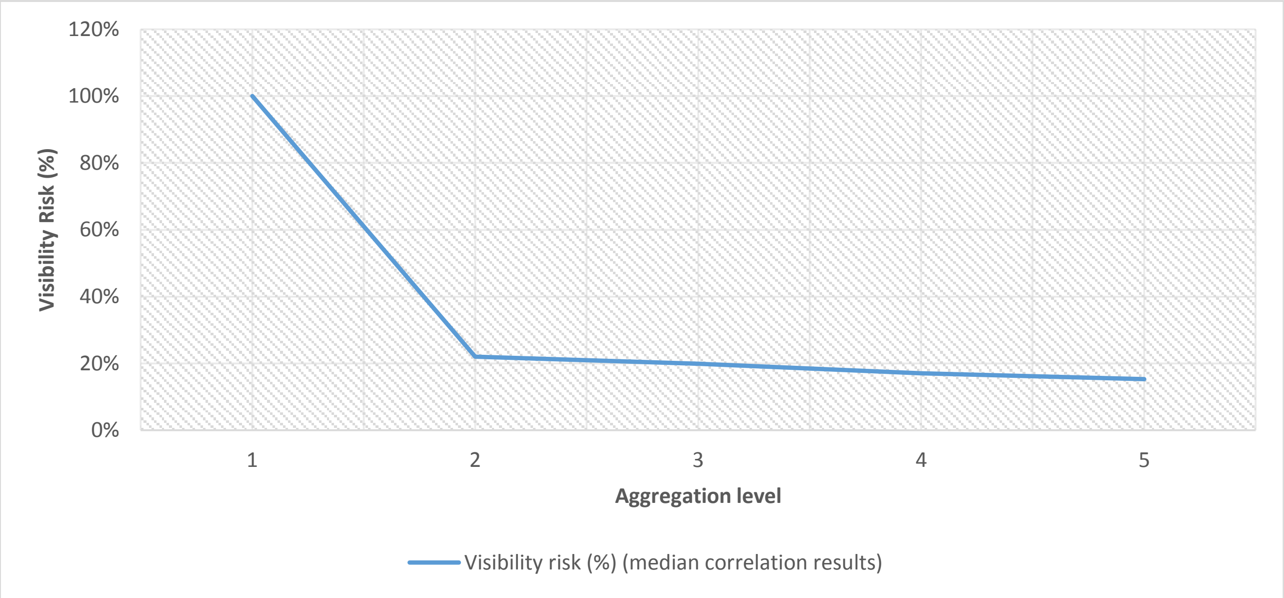

Figure 1 Visibility risk for each aggregation level

The detailed analysis shows that aggregating two consumption profiles reduces the possibility of being able to establish an individual customer's consumption profile from 100% to 22%, and that further aggregation would provide only a marginal reduction in visibility risk. Hence aggregation of two profiles, coupled with the development and implementation of DNO IT systems and/or business processes, to address the inherent flaws in using aggregation to ensure anonymity, is proposed as being the approach to meet the requirements of SLC10a.

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