Smart Meter Aggregation Assessment

Final Report – Benefits Reduction

Document Version 1.3

27 July 2015

This document is the second of the EA Technology reports on the assessment of aggregation and how it affects the ability of network operators to extract network benefits from the use of consumption information contained in smart meters. The first report assessed the relationship between data aggregation and customer anonymity; this second report was commissioned by ENA to assess the relationship between data aggregation and the reduction in DNO benefits.

It is intuitive that the DNO network benefits will reduce as the number of customer consumption profiles that are aggregated increases; EA Technology were commissioned to explore ways of quantifying this effect. It became apparent during the discussion between DNOs and EA Technology that developing a methodology to try to quantify this relationship was difficult because of the range of uncertainties which include the:

- characteristics of individual DNO networks
- present and future loading on existing networks
- headroom on existing networks
- penetration rates and clustering of LCTs
- roll out and penetration rates of smart meters
- systems and processes DNOs might develop and deploy to assess network reinforcement requirements

EA Technology developed their thinking in three areas, based on one DNO's business plan, where they felt it would be possible to quantify the benefit reduction: i.e. looped services, sections of urban feeders and sections of rural feeders and the report describes the methodology and results from these three areas.

The discussion between EA Technology and DNOs during the project increased the level of understanding of the issues and difficulties quantifying the effects amongst all parties.

The EA Technology findings are presented in the report, however, DNOs do have some concerns about the applicability of the methodologies across the entire GB network. For example, the EA Technology benefit assessment includes modelling of the unbundling of service connections; the extent to which this would be equally applicable to all DNOs is unclear as not all DNOs included service unbundling in their ED1 submissions. As such, the findings of the work have not been fully endorsed by DNOs. The work did however stimulate thinking which resulted in a number of alternative approaches being developed by DNO's and we plan to provide an overview of these methodologies at the stakeholder briefing on 4 August 2015.

Whilst there is a difference in the methodology the general results from the assessment have similarities in that they illustrate that there is a reduction in DNO benefits as the aggregation level increases.

REPORT

Smart Meter Aggregation Assessment Final Report - Benefits Reduction

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Executive summary

Background

This document summarises the findings of the study conducted by EA Technology on behalf of ENA to assess the relationship between smart meter data aggregation and the delivery of network benefits. A separate report was prepared to assess the relationship between data aggregation and customer privacy[1].

Consumer behaviour and electricity demand on the low voltage (LV) network are anticipated to change dramatically over the coming years, posing a significant challenge to electricity distribution network operators (DNOs). Having increased visibility of demands at the LV level via the roll-out of smart meters (SM) to all customers could be of material benefit to DNOs in assisting them manage their networks and plan reinforcement. In turn, the use of SM 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 (LCTs).

Under licence condition SLC10a DNOs are unable to access raw load profile data (time series demand data) from smart meters due to concerns over personal privacy issues with customers. SLC10a states that "Electricity Consumption Data which is obtained by the licensee and which relates to a period of less than one month ceases (through its aggregation with other Electricity Consumption Data or by means of any other process) to be data which is capable of being associated with a Domestic Customer at relevant premises".

As such, a previous report[1] was produced to examine the level of smart meter data that needs to be aggregated to protect customer anonymity and this report instead focusses on the evaluation of the reduction in LV benefits that will be realised as a consequence of DNOs not being able to make use of individual smart meter data to inform their network investment decision process.

The task of determining the reduction in network benefits as a consequence of smart meter aggregation is challenging due to the characteristics of LV networks, the range of demand on them, the range of headroom available, and the uncertainties of the penetration of LCTs in the future. Having discussed potential approaches with DNOs, a methodology based on one DNO's characteristics was developed by way of an example of a methodology that illustrates the reduction in DNO benefit as the number of consumption profiles are aggregated.

It is important to note that the content of each distribution company's business plan differed and the potential benefits from use of smart metering data was based on different scenarios, meaning that the analysis within this report does not necessarily translate directly to all other companies' business plans. There are differences in the structure of the electricity networks inherited by each company and the impact of LCTs on looped services in the DNO area example used in this paper is not reflected in all business plans where the focus is the impact on low voltage cables.

Therefore although this report has taken a sample methodology and extrapolated across all DNOs, there are alternative approaches that can be taken to the calculation of benefit reduction owing to different design philosophies in different DNOs. Indeed, other DNOs have subsequently proposed alternative methods of calculation outside of this report.

This study was based on the best available data and made use of the "Best View" RIIO-ED1 Business Plans put forward by the DNOs. Some of these plans took into account additional benefits (such as the efficient management of looped services) in comparison to previous smart meter benefits assessment work (e.g. the previous ENA work) and as such these plans were taken to be the latest, best data source for calculations. These RIIO-ED1 Business Plan figures have been used as the basis

[1] Smart Meter Aggregation Assessment Final Report. EA Technology, June 2015. Report 96240

for this work where the analysis has been focused on feeders that have a high proportion of domestic customers, and for this reason suburban and rural feeders have been selected for assessment.

This paper summarises the work to assess 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 at three different points on the LV network: looped services, branch level (on suburban networks) and feeder level (rural networks), all of them having a maximum of 4 customers each (Figure 1), the results of which are presented below (Table 1).

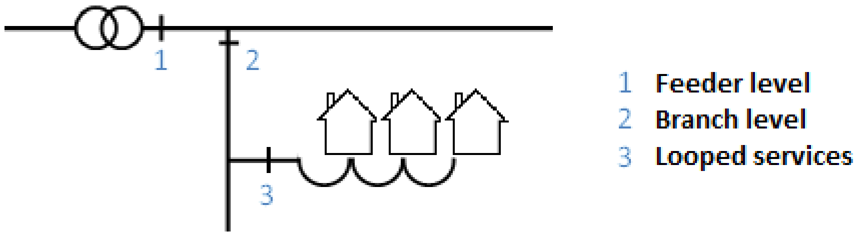

Figure 1 Analysed network sections

Table 1 Benefits assessment summary – Cumulative benefit reduction

Aggregation level	Can MD solve the problem?	Cumulative benefit reduction (£ million)	Visibility risk (%)
1	Yes	0	100%
2	Yes - partly	2 - 20	22%
3	No	58 - 60	20%
4	No	66 - 70	17%
5	No	> 70	15%

It is important to note that these benefit reduction figures have been calculated by EA Technology independently of previous studies, such as the ENA 2013 assessment referenced earlier. They contain elements that were not considered in previous assessments, such as benefits associated with looped services.

Table 1 shows that for those cases where the required aggregation level is 1 or 2, although DNOs cannot make use of individual smart meter half hourly data (HHD) due to potential customer's privacy restrictions, they can, for a high proportion of the cases, use maximum demand (MD) data to assist them in their planning decisions. If however the aggregation level is three or greater, the fact that individual customer MDs are not coincident means that this data cannot be used to base investment plans on. The decision as to which aggregation level to take will then rest on the acceptability or otherwise of the visibility risk (the risk of being able to derive an individual customer's demand profile) at each of these levels derived from the previous assessment on the relationship between data aggregation and privacy.

It is to be noted that Table 1 figures show a range of benefit reduction for each aggregation level to allow for a certain degree of flexibility considering that some of the looped services could have been double counted in the suburban and rural domestic feeder analysis.

Conclusions

Table 1 above and Figure 2 below show that a significant benefit loss occurs at an aggregation level of three and above and beyond an aggregation level of five the additional benefit loss becomes marginal.

Figure 2 also shows that the reduction in benefit has little degradation at 2 but significant reduction beyond this level.

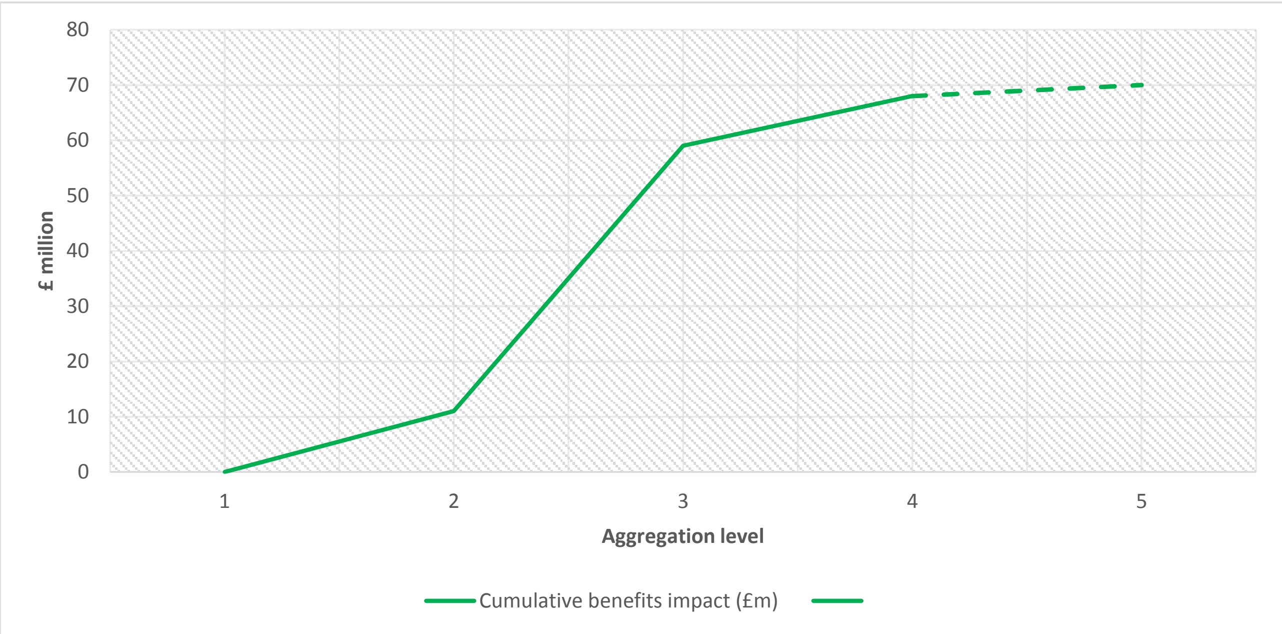

Figure 2 Cumulative benefits reduction for each aggregation level (£ million)

For ease of reading, Figure 2 has taken the central point of the ranges from Table 1 to be plotted, so as to give the likely benefit reduction rather than a best or worst case.

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1. Background & Introduction

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 (LCTs). Having been informed by the ENA work, DNOs have developed their "Best View" for ED1 Business Plans taking also into account the benefits associated with looped services[2]. These ED1 figures have been used as the basis for this work.

The roll-out of smart meters to all customers is one means by which this greater level of visibility may be achieved. However, it is to be noted that 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.

Although DNOs will receive non-aggregated (defined as attributable to an identifiable customer) load profile data, DNOs are obliged to anonymise the data (by aggregation or other means) as soon as possible and can only store and analyse the data in this anonymised manner. SLC10a states (in 10.A.5) that "Electricity Consumption Data which is obtained by the licensee and which relates to a period of less than one month ceases (through its aggregation with other Electricity Consumption Data or by means of any other process) to be data which is capable of being associated with a Domestic Customer at relevant premises".

As such, this 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.

2. Scope and Objectives

In order to ensure that the customer anonymity is preserved and at the same time DNOs obtain meaningful information, assessment of the cost-benefit for aggregating smart meter data was required. As such, the scope and objectives of this project are summarized in sections 2.1 and 2.2 below.

[2] Owing to the connection of LCTs, some looped services will undoubtedly need to be unbundled in GB as a consequence of thermal issues (voltage issues are not considered in this study), and a small number of DNOs allowed for these costs in their Business Plans. However, some who did not are still likely to need to unloop some services when LCTs connect over the course of ED1 (and beyond). Consequently, some DNOs will incur costs and these costs will represent a reduction in smart meter benefit as this reinforcement will fall into the IQI cost share mechanism in ED1. The extent to which this applies is dependent on the number of looped services in different DNO licence areas. Therefore, even though some DNOs did not allow for this in their Business Plans, it is still deemed to represent a reduction in smart meter benefit and so it is to be considered in this work.

2.1 Scope of project

The scope of this project was to analyse suburban and rural feeders that have a high proportion of domestic customers.

The study assessed the impact of today's load and future load at different points on the LV network (Figure 3) each of which were independently assessed:

1. Feeder level, taking into consideration all customers on the feeder
2. Branch level, taking into consideration all those customers on the spur
3. Looped services, between 2 and 4 customers connected on the same service cable

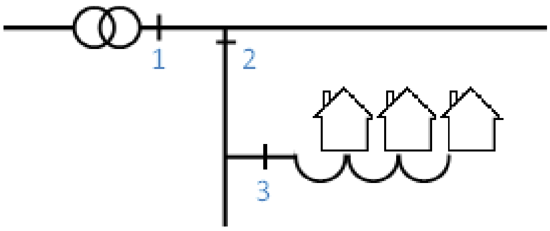

Figure 3 Analysed network sections

2.2 Objective of project

The objective of this project was to assess 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.

3. Analysis Overview

To determine the reduction in benefits that DNOs may experience if smart meter data cannot be analysed on an individual household basis, it was assumed that the maximum number of smart meter datasets that would need to be aggregated to maintain a high degree of customer's anonymity would be up to 4. This maximum aggregation level was based on the results presented in the Smart Meter Aggregation Assessment Final Report issued in June 2015[3].

This reduction in benefits assessed the financial effects at three different LV points on the network:

1. Looped services of 2, 3 or 4 customers (point 3)
2. Suburban domestic feeders with spurs having 2, 3 or 4 customers (point 2)
3. Rural feeders having 2, 3 or 4 customers (point 1)

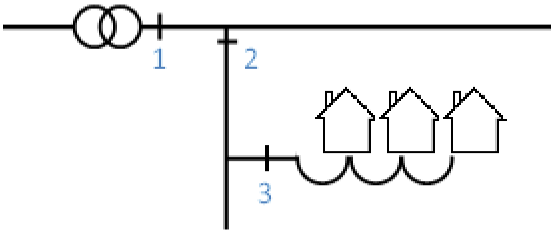

Figure 4 LV points of analysis that may have an effect on the reduction in DNO benefits

[3] Smart Meter Aggregation Assessment Final Report. EA Technology, June 2015. Report 96240

The data used to inform the analysis was derived from the following sources:

- DNOs Business Plan Assessments,
- Smart Metering Implementation Programme published by the Department of Energy and Climate Change (DECC),
- Low Carbon Network Fund projects: Customer Led Network revolution (CLNR) and My Electric Avenue (MEA),
- Information from the Transform Model.

4. Reduction in DNOs' benefits assessment

4.1 Looped services

This section shows the total costs that DNOs would require to invest for unbundling looped services of 2, 3 or 4 customers, with smart meters, due to LCT installations during the ED1 period.

The information used for this part of the analysis was taken from the DNOs Business Plan Assessments – "Best View" LCT Reinforcement Data, and in those cases where unbundling volumes and costs were required, these were taken from a DNO's network characteristics and extrapolated to explore the potential impacts on GB network benefits. This was deemed to be an appropriate way of illustrating the effects on network benefits from higher levels of aggregation although some DNOs have reservations regarding its applicability across the whole country and may prefer to use alternative illustrations.

4.1.1 Looped services analysis breakdown

First it was required to understand the number of Heat Pumps (HP) and Electric Vehicles (EV) that DNOs predicted to be installed, per licence area, between 2016 and 2023. Table 2 and following tables show the results presented by DNO, listed in alphabetical order and for ease of reading shortened versions of the full tables are presented below. Full analysis results can be found in Appendix I.

Table 2 HPs and EVs installation volumes per licence area

	2016	…	2020	…	2023
ENWL	2,415	…	17,921	…	15,545
NPgN	1,615		10,692		9,955
…	…		…		…
SSEH	9,538		45,453		62,882
SSES	16,500		89,264		154,307
…	…		…		…

The amount of looped services that the example DNO predicted that would be affected by HP and EV installations per year between 2016 and 2023 (Table 3) were used to expand the calculations to the rest of the DNO licence areas (Table 4) using this DNO yearly proportions and each licence area yearly HPs and EVs forecasted installation volumes.

Table 3 Forecasted volumes of looped services affected by HP and EV installations (example DNO)

	2016	2017	…	2022	2023
Looped services from example DNO	29	117	…	1,439	1,880

$$Proportion\ of\ HPs\ and\ EVs\ going\ into\ looped\ services/year = \frac{Forecasted\ looped\ services/year}{HPs\ and\ EVs\ forecasted\ installs/year}$$

Table 4 Forecasted volumes of looped services affected by HP and EV installations (14 licence areas)

	2016	2017	…	2022	2023
ENWL	29	117	…	1,439	1,880
NPgN	19	76		921	1,204
…	…	…		…	…
SSEH	113	425		5,738	7,605
SSES	195	812		13,066	18,662
…	…	…		…	…

Once this was known, the next step was to understand how many of the above looped services affected by HP and EV installations would also have smart meters installed[4] during the ED1period. For this it was necessary to first analyse the proportion of customers that will have smart meters installed in each licence area, per year between 2016 and 2023:

$$\%\ customers\ with\ SM\ installed\ per\ licence\ area\ per\ year\ = \frac{GB\ customers\ per\ licence\ area}{Aggregated\ SM\ installed\ per\ licence\ area}$$

These proportions of customers with smart meters installed, per licence area and per year were then multiplied by the affected looped services presented in Table 4, with the results shown in Table 5.

[4] Information regarding the yearly roll out of smart meters was taken from the Smart Metering Implementation Programme published by the Department of Energy and Climate Change (DECC), where it was predicted that 53 million gas and electricity smart meters will be installed in domestic and small non-domestic premises by 2020. Out of these 53 million smart meters approximately 60% of those will be electricity meters and 40% gas meters (split percentage figures were based on statistic records presented up to 2014 on the “Smart Meter Quarterly Statistics Report Q3 2014” from DECC).

Table 5 Forecasted volumes of looped services affected by HP and EV installations that will also have SM installed (14 licence areas)

	2016	2017	…	2022	2023
ENWL	6	48		1,439	1,880
NPgN	4	31		921	1,204
…	…	…	…	…	…
SSEH	23	174		5,738	7,605
SSEH	40	333		13,066	18,662
…	…	…		…	…
Total	**250**	**1,857**	…	**51,587**	**69,821**

In order to economically quantify the effect of unbundling all the looped services shown in Table 5 it was supposed that each licence area would have the same individual cost per looped service as the DNO taken as an example; this figure was £1,277. Therefore, the average cost of unbundling all possibly affected GB looped services with smart meters is presented in Table 6.

Table 6 Average costs for unbundling all looped services affected by HP and EV installations that will also have SM installed

Average cost of unbundling affected looped services (£million)									
2016	2017	2018	2019	2020	2021	2022	2023	Total (All DNOs)	Total per licence area
0.32	2.37	7.28	22.86	19.72	21.17	65.89	89.18	**228.80**	**16.34**

Thus far the calculations have shown what the total costs, by licence area, would be if DNOs were required to unbundle all the services. However, the reduction in benefits that DNOs would experience if smart meter data cannot be individually assessed is less than the £228.80 million figure as, in actuality, not all looped services would have to be unbundled. To evaluate how much less this would be it was assumed that all licence areas would have the chosen DNO's total predicted unbundling costs for the ED1 period example: £7.6 million, which for the 14 licence areas would amount to £106.4 million. This means that the reduction in DNO benefits would be the difference between £228.8 million and £106.4 million, equating to £122.4 million.

Finally it was necessary to evaluate the proportion of this reduction in benefits associated with unbundling looped services with 2, 3 and 4 customers. For this it was supposed that out of all the evaluated looped services, 65% would have two customers connected, 30% three customers and 5% four customers. These figures were arrived at in consultation with ENA members. The split of this reduction in benefits according to these percentage figures is shown in Table 7 below.

Table 7 Reduction in DNOs benefits by looped services

Number of looped customers	% of occurrence	Reduction in looped services benefits (£million)
2	65%	79.56
3	30%	36.72
4	5%	6.12

Hence it can be seen that if an aggregation level of two were selected, the total reduction in benefits attributable to unbundling of looped services would be £79.56m. However, if an aggregation level of four were instead adopted, the reduction in benefits would be the sum of the figures above, totalling £122.4m. These figures assume that DNOs cannot make use of maximum demand data from these customers to inform their investment plans. We address later (in section 5) how these figures change once MD data is considered.

4.2 Suburban domestic feeders with spurs having 2, 3 or 4 customers

Given the need to aggregate smart meter data, DNOs will not be able to have visibility of the loads on a suburban spur containing a small number of customers. For example, if an aggregation level of 4 was required, then DNOs would not be able to observe the smart meter data of customers on a spur containing three properties to assess whether the spur was at risk of overloading.

This section shows the total costs that DNOs would require to invest for upgrading spurs with 2, 3 or 4 customers, with smart meters on suburban domestic feeders, due to LCT installations during ED1 period.

The information used for this part of the analysis was taken from:

- 16 different suburban domestic feeders from Low Carbon Network Fund (LCN Fund) projects: Customer Led Network revolution (CLNR) and My Electric Avenue (MEA), and
- The Transform Model

4.2.1 Spurs having 2, 3 or 4 customers analysis breakdown

First of all it was identified, by visual inspection[5], the number of spurs that have 2, 3 and 4 customers on the 16 selected feeders (Table 8). It was found that 31% of the analysed feeders have spurs with 2 and 3 customers and 25% have spurs with 4 customers.

[5] The identification of the spurs with 2, 3 or 4 customers was done by inspecting the Geographical Information System (GIS) maps.

Table 8 Suburban domestic spurs having 2, 3 or 4 customers

				Spurs with 2, 3 or 4 customers		
Feeder ID	DNO	Feeder Name	Feeder Type	2 cust.	3 cust.	4 cust.
1	SSEPD	Marlow	Suburban Semi-det /detached	0	0	0
2	NPg	Wylam	Suburban Semi-det /detached	0	1	0
…				…		
15	NPg	Wooler St Mary, Feeder C	Suburban Semi-det /detached	1	0	0
16	NPg	Wooler Bridge, Feeder A	Sub. Terraced St	0	0	0
			Total	**5**	**5**	**4**
			Representation	**31%**	**31%**	**25%**

Afterwards data from the CLNR and MEA projects was examined to determine the number of customers per feeder. In conjunction with some generic information taken on these types of feeders from the Transform Model[6], the calculation of the LCT per customer ratio was derived and found to be equal to 9.4%.

The next step was to evaluate the likelihood of a customer on the spur having an LCT connection (Table 9). To obtain this the spurs with 2, 3 and 4 customers were divided into the total customers per feeder, and the result of this division multiplied by the likelihood of a customer having an LCT installation. It transpired that there is a 0.12% probability that a customer on a spur of 2 customers has an LCT connection, 0.06% probability that a customer on a spur of 3 customers has an LCT connection and 0.04% probability that a customer on a spur of 4 customers has an LCT connection.

Once again Transform Model information was used to estimate the number of domestic LV feeders in GB, found to be 530,377. This figure was then multiplied by the likelihoods of customers on spurs having LCT connections by 2023, given the number of spurs on suburban domestic LV feeders that will have LCT installations by the end of the ED1 period. This is shown in Table 10.

[6] The Transform Model provided information on (a) the average number of customers and number of circuits per substation feeder type (suburban semidetached/detached and suburban terraced) used to obtain the total number of customers in suburban feeders, and (b) the HP and EV volumes installed in suburban feeders by 2023.

Table 9 Likelihood of a customer on the spur having an LCT connection

	Spurs with 2, 3 or 4 customers			Total customers/ Feeder	Likelihood of a customer having an LCT installed	Likelihood of a customer on the spur having an LCT connection		
Feeder ID	2 cust.	3 cust.	4 cust.			Spurs 2 cust.	Spurs 3 cust.	Spurs 4 cust.
1	0	0	0	139	9.4%	0.00%	0.00%	0.00%
2	0	1	0	72		0.00%	0.39%	0.00%
…						…		
15	1	0	0	21		0.89%	0.00%	0.00%
16	0	0	0	9		0.00%	0.00%	0.00%
					Total	**1.8%**	**1%**	**0.6%**
					Average %	**0.12%**	**0.06%**	**0.04%**

Table 10 Spurs on suburban domestic LV feeders that will have LCTs installed by 2023

GB spurs with LCT installed		
Spurs of 2 cust.	Spurs of 3 cust.	Spurs of 4 cust.
611	324	200

In order to economically quantify the effect of upgrading the spurs with 2, 3 or 4 customers presented in Table 10 it was supposed that all GB suburban domestic feeders are underground and the cost for overlaying LV cable is £10k[7]. With this information it was possible to estimate the costs that DNOs would incur if they opt for upgrading these underground cables due to the LCT installations during the ED1 period. These costs are shown in Table 11.

Table 11 Anticipated DNO costs for upgrading suburban spurs with 2, 3 or 4 customers due to LCT installations during the ED1 period

DNOs maximum costs upgrading suburban spurs	
Aggregation level	Costs (£million)
2	**6.11**
3	**3.24**
4	**2.00**

[7] Transform Model costs for overlaying 150 metres of LV cable is estimated to be £30k. For the purpose of this analysis this was apportioned to 50 metres.

4.3 Rural feeders having 2, 3 or 4 customers

This section shows the total costs that DNOs would be required to invest for upgrading rural feeders with 2, 3 or 4 customers, with smart meters, due to LCT installations during the ED1 period.

Information used for the assumptions in this part of the analysis were taken from the Transform Model, including:

- Average number of customers and number of circuits per rural networks used to obtain the total number of customers in rural feeders
- HP and EV volumes installed in rural networks by 2023

4.3.1 Rural feeder having 2, 3 or 4 customers analysis breakdown

Firstly it was obtained from the Transform Model that there are 53,917 rural networks in GB, and it was assumed that half of them, 26,959, have few customers. From these feeders that have few customers it was also supposed that there may be a quarter each, 6,740 feeders, with 2, 3 or 4 customers.

To obtain the likelihood of a customer in those rural feeders having an LCT connection it was previously calculated, with information from the Transform Model, the LCT per customer ratio, which was found to be equal to 9%. This was multiplied by the estimated rural feeders that have few customers to derive the probability of an LCT being installed on these rural networks (Table 12).

Table 12 Likelihood of an LCT being installed in a rural network with few customers

	Customers on the feeder	Likelihood of an LCT being installed on these rural networks
Feeder 2	2	18%
Feeder 3	3	27%
Feeder 4	4	36%

In order to economically quantify the effect of upgrading the rural feeders with 2, 3 or 4 customers presented in Table 12 it was assumed that all rural networks in GB are overhead and the cost for re-conductoring the LV overhead line is £2k[8]. With this information it was possible to estimate the costs that DNOs would incur if they opt for upgrading these overhead lines due to the LCT installations during ED1 period. These costs are shown in Table 13.

Table 13 DNOs maximum costs for upgrading rural networks with 2, 3 or 4 customers due to LCT installations during ED1 period

DNOs maximum costs upgrading rural networks	
Aggregation level	Costs (£million)
2	**1.22**
3	**2.43**
4	**3.65**

[8] Transform Model costs for re-conducting 250 metres of overhead LV cable is estimated to be £10k. For the purpose of this analysis this was apportioned to 50 metres.

5. Reduction in DNOs' benefits assessment conclusions

This final part of the report summarises the reduction in benefits that DNOs may realise if smart meter data cannot be analysed on an individual household basis due to LCT installations on:

- Looped services
- Suburban domestic feeders with spurs having 2, 3 or 4 customers
- Rural feeders having 2, 3 or 4 customers

Results from sections 4.1, 4.2 and 4.3 have been collated and presented in Table 14 with the particular difference that it has been taken into consideration that some of the looped services could have been double counted in the suburban and rural domestic feeders analysis and therefore a lower (30% of total reduction in benefits) and higher (70% of total reduction in benefits) estimate band has been proposed for this reason.

Table 14 shows that the majority of the reduction in benefits is associated with an aggregation level of two[9] and the proportional increase in the reduction in benefits decreases with higher aggregation levels.

Table 14 Total reduction in DNOs benefits accounting for looped services, rural feeders and spurs of 2, 3 or 4 customers in suburban feeders without making use of MD data

Aggregation level	Reduction in benefits - lower estimate (£million)	Reduction in benefits - higher estimate (£million)
2	**81.76**	**84.69**
3	**38.42**	**40.69**
4	**7.82**	**10.08**

At this point of the analysis it would be beneficial for the reader to also compare the above figures with the visibility risks (median figures) obtained from the 330 correlation analysis results presented in the Smart Meter Aggregation Assessment Final Report issued in June 2015[10]. This is presented in Table 15.

It is to be noted that Table 15 shows the benefits impact for the aggregation of two customers reduced to between £2 and £20 million and the rest of the aggregation levels reduced accordingly. The reason for this reduction is the use of maximum demand (MD) data. All the analysis undertaken up to this point assumed that MD readings would only provide sufficient information to DNOs for planning their investment decisions when assessing one customer's consumption. Therefore, all these results were statistically derived assuming that for two or more customer profiles, MDs and times of MDs would not provide enough information to DNOs. Discussions with the ENA members during the latter stages of this work concluded, however, that MD data would assist DNOs, for a significant proportion of the cases, to make an informed decision regarding their investment plans for an aggregation level of two. It is difficult to precisely quantify the level of benefit associated with this. The ENA Steering Group used the best available information and their engineering judgement to estimate the level of reduction in benefits related to the aggregation of two customers to be in the range between £2m and £20m.

[9] Without making use of MD data

[10] Smart Meter Aggregation Assessment Final Report. EA Technology, June 2015. Report 96240

As such Table 15 shows that for those cases where the required aggregation level is 1 or 2, although DNOs cannot make used of smart meter half hourly data (HHD) due to potential customer privacy restrictions, they can, for a high proportion of the cases, use MD data to assist them in their planning decisions. If however the aggregation level is three or greater, the fact that individual customer MDs are not coincident means that this data cannot be used to base investment plans on. The decision as to which aggregation level to take (two, three, four or greater) will then rest on the acceptability or otherwise of the visibility risk (the risk of being able to derive an individual customer's demand profile) at each of these levels. I.e. an aggregation level of three has an associated risk of around 20% and if this risk is deemed suitable then the reduction in benefits is around £60m.

Table 15 Benefits assessment summary – Cumulative benefit reduction

Aggregation level	Visibility risk (%) (median correlation results)	Can MD solve the problem?	Cumulative benefits reduction	
			Estimate at 30% band (£million)	Estimate at 70% band (£million)
1	100%	Yes	0	0
2	22%	Yes – partly	2	20
3	20%	No	58.42	60.69
4	17%	No	66.24	70.77
5	15%	No	> 66.24	> 70.77

Table 15 above and Figure 5 below show that a significant benefit loss occurs at an aggregation level of three and above and beyond an aggregation level of five the additional benefit loss becomes marginal.

Figure 5 below shows that the reduction in benefit has little degradation at 2 but significant reduction beyond this level.

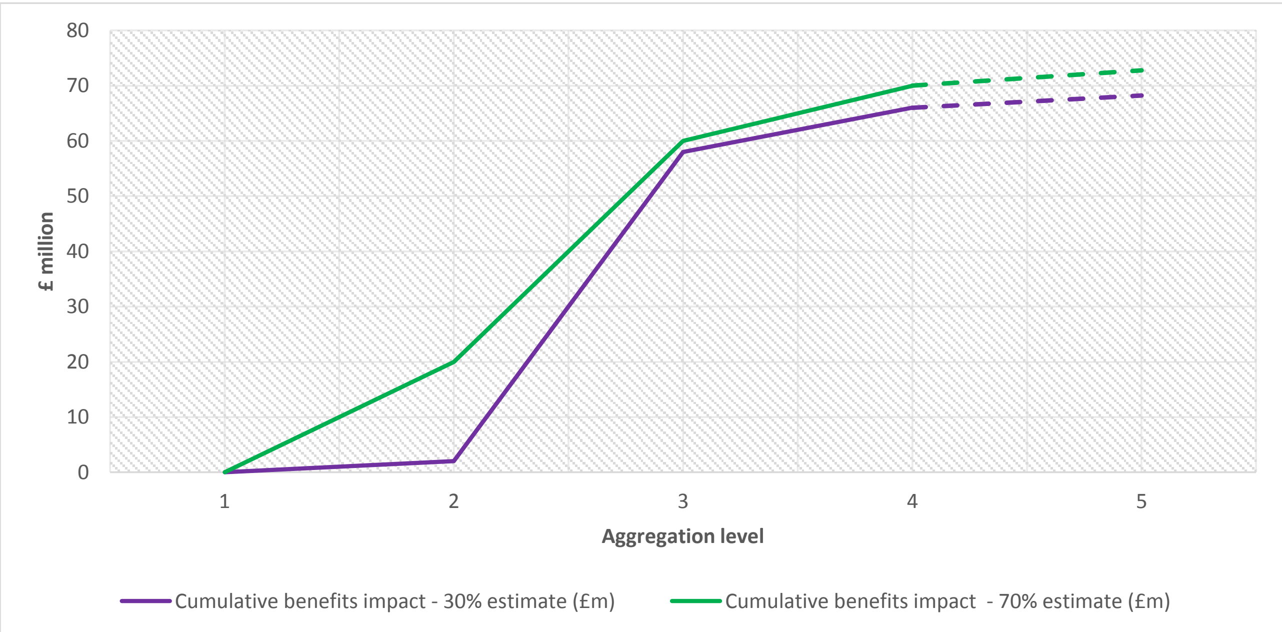

Figure 5 Cumulative benefits reduction for each aggregation level (£ million)

Appendix I Reduction in DNO benefits assessment supportive material

Looped services

Table 16 HP and EV installation volumes per licence area

	2016	2017	2018	2019	2020	2021	2022	2023
ENWL	2,451.00	3,200.00	4,216.00	5,600.00	17,921.00	29,263.00	14,144.00	15,545.00
NPgN	1,615.00	2,081.00	2,722.00	3,620.00	10,692.00	17,124.00	9,053.00	9,955.00
NPgY	2,487.00	3,205.00	4,190.00	5,539.00	17,255.00	27,880.00	13,874.00	15,244.00
SPD	19,724.56	22,478.06	16,531.44	17,056.53	21,324.11	25,453.00	27,757.84	33,296.62
SPMW	8,853.95	10,684.21	8,538.91	9,340.23	12,135.10	14,592.69	16,132.56	19,825.12
SSEH	9,538.00	11,627.00	14,064.00	25,880.00	45,453.00	50,822.00	56,402.00	62,882.00
SSES	16,500.00	22,200.00	29,710.00	52,495.00	89,264.00	107,912.00	128,424.00	154,307.00
EPN	18,958.41	21,231.48	26,597.96	38,484.22	42,536.59	51,475.51	66,493.04	66,797.56
LPN	3,794.38	4,226.35	5,645.48	8,978.23	9,931.55	12,150.32	15,952.95	15,577.74
SPN	8,756.78	9,701.34	13,450.98	22,638.30	24,564.36	30,625.37	41,418.94	39,186.89
EMID	3,057.11	4,255.61	6,009.04	15,787.98	25,349.90	27,996.37	36,120.50	45,596.03
SWALES	2,117.27	2,251.09	2,739.17	10,750.33	15,785.92	14,448.71	16,831.08	18,322.95
SWEST	2,244.00	3,019.00	4,091.00	13,615.00	22,222.00	24,191.00	32,349.00	40,353.00
WMID	2,703.76	3,754.21	5,284.16	14,039.54	22,540.32	24,875.72	32,098.34	40,435.55

Table 17 Forecasted volumes of looped services affected by HP and EV installations (example DNO)

	2016	2017	2018	2019	2020	2021	2022	2023
DNO	29	117	264	470	734	1,057	1,439	1,880

Table 18 Proportion of LCTs going into looped services (example DNO)

	2016	2017	2018	2019	2020	2021	2022	2023
DNO	1%	4%	6%	8%	4%	4%	10%	12%

Table 19 Forecasted volumes of looped services affected by HP and EV installations (14 licence areas)

	2016	2017	2018	2019	2020	2021	2022	2023
ENWL	29	117	264	470	734	1,057	1,439	1,880
NPgN	19	76	170	304	438	619	921	1,204
NPgY	29	117	262	465	707	1,007	1,412	1,844
SPD	233	822	1,035	1,432	873	919	2,824	4,027
SPMW	105	391	535	784	497	527	1,641	2,398
SSEH	113	425	881	2,172	1,862	1,836	5,738	7,605
SSES	195	812	1,860	4,406	3,656	3,898	13,066	18,662
EPN	224	776	1,666	3,230	1,742	1,859	6,765	8,078
LPN	45	155	354	754	407	439	1,623	1,884
SPN	104	355	842	1,900	1,006	1,106	4,214	4,739
EMID	36	156	376	1,325	1,038	1,011	3,675	5,514
WMID	32	137	331	1,178	923	899	3,266	4,890
SWALES	25	82	172	902	647	522	1,712	2,216
SWEST	27	110	256	1,143	910	874	3,291	4,880

Table 20 Assumed DNOs customers per licence area

	Total N˚ Customers (million)	Proportion of customers of the total GB customers
ENWL	2.4	8.1%
NPgN	1.6	5.4%
NPgY	2.3	7.8%
SPD	2.0	6.9%
SPMW	1.5	5.1%
SSEH	0.7	2.5%
SSES	2.9	10.1%
EPN	3.5	12.1%
LPN	2.3	7.8%
SPN	2.2	7.7%
EMID	2.6	9.0%
WMID	2.4	8.4%
SWALES	1.1	3.8%
SWEST	1.5	5.3%

Table 21 Smart meter aggregated installation volumes per licence area per year

	2016	2017	2018	2019	2020
ENWL	0.48	0.97	1.49	2.06	2.44
NPgN	0.32	0.65	1.00	1.38	1.63
NPgY	0.46	0.93	1.43	1.98	2.33
SPD	0.41	0.82	1.26	1.74	2.06
SPMW	0.31	0.61	0.94	1.30	1.54
SSEH	0.15	0.30	0.47	0.65	0.77
SSES	0.60	1.20	1.86	2.57	3.03
EPN	0.72	1.44	2.23	3.08	3.64
LPN	0.46	0.92	1.43	1.97	2.33
SPN	0.46	0.92	1.41	1.95	2.31
EMID	0.54	1.07	1.65	2.29	2.70
WMID	0.50	1.00	1.55	2.14	2.53
SWALES	0.23	0.45	0.70	0.96	1.14
SWEST	0.32	0.63	0.98	1.35	1.59
Total	**5.97**	**11.91**	**18.39**	**25.41**	**30.03**

Table 22 Percentage of customers that will have smart meters installed in each licence area per year

	2016	2017	2018	2019	2020	2021	2022	2023
ENWL	21%	41%	63%	87%	100%	100%	100%	100%
NPgN	21%	41%	63%	87%	100%	100%	100%	100%
NPgY	21%	41%	63%	87%	100%	100%	100%	100%
WMID	21%	41%	63%	87%	100%	100%	100%	100%
EMID	21%	41%	63%	87%	100%	100%	100%	100%
SWALES	21%	41%	63%	87%	100%	100%	100%	100%
SWEST	21%	41%	63%	87%	100%	100%	100%	100%
LPN	21%	41%	63%	87%	100%	100%	100%	100%
SPN	21%	41%	63%	87%	100%	100%	100%	100%
EPN	21%	41%	63%	87%	100%	100%	100%	100%
SPD	21%	41%	63%	87%	100%	100%	100%	100%
SPMW	21%	41%	63%	87%	100%	100%	100%	100%
SSEH	21%	41%	63%	87%	100%	100%	100%	100%
SSES	21%	41%	63%	87%	100%	100%	100%	100%

Table 23 Looped services that will have smart meters installed in each licence area per year

	2016	2017	2018	2019	2020	2021	2022	2023
ENWL	5.96	47.97	167.12	411.10	734.00	1,057.00	1,439.00	1,880.00
NPGN	3.93	31.19	107.90	265.75	437.92	618.53	921.05	1,203.95
NPGY	6.05	48.04	166.09	406.62	706.72	1,007.05	1,411.53	1,843.60
SPD	47.96	336.94	655.30	1,252.13	873.38	919.38	2,824.06	4,026.87
SPMW	21.53	160.15	338.48	685.67	497.02	527.10	1,641.31	2,397.63
SSEH	23.19	174.28	557.49	1,899.87	1,861.64	1,835.73	5,738.30	7,604.90
SSES	40.12	332.77	1,177.69	3,853.69	3,656.03	3,897.86	13,065.76	18,661.77
EPN	46.10	318.25	1,054.33	2,825.15	1,742.19	1,859.33	6,764.95	8,078.44
LPN	9.23	63.35	223.78	659.10	406.77	438.88	1,623.04	1,883.96
SPN	21.29	145.42	533.19	1,661.89	1,006.10	1,106.21	4,213.93	4,739.23
EMID	7.43	63.79	238.20	1,159.00	1,038.27	1,011.25	3,674.87	5,514.35
WMID	6.57	56.27	209.46	1,030.65	923.20	898.53	3,265.66	4,890.24
SWALES	5.15	33.74	108.58	789.19	646.55	521.90	1,712.38	2,215.96
SWEST	5.46	45.25	162.17	999.48	910.16	873.80	3,291.16	4,880.26
TOTAL	**250**	**1,857**	**5,700**	**17,899**	**15,440**	**16,573**	**51,587**	**69,821**

Table 24 Average cost of unbundling 1 looped service (example DNO)

	2016	2017	2018	2019	2020	2021	2022	2023	Total ED1
Example DNO yearly forecast unbundling costs (£k)	37.43	149.71	336.85	598.85	935.70	1,347.40	1,833.97	2,395.38	7,635.29
Example DNO yearly average cost for unlooping 1 service (£k)	1.29	1.28	1.28	1.27	1.27	1.27	1.27	1.27	
Example DNO average cost for unlooping 1 service (£k)	1.2777								

Table 25 **Forecasted average costs for unbundling all GB looped services affected by HP and EV installations that will also have SM installed**

Average cost of unbundling affected looped services (£million)									
2016	2017	2018	2019	2020	2021	2022	2023	Total (All DNOs)	Total per licence area
0.32	2.37	7.28	22.86	19.72	21.17	65.89	89.18	**228.80**	**16.34**

Suburban domestic feeders with spurs having 2, 3 or 4 customers

Table 26 **Analysed Suburban domestic feeders with spurs having 2 , 3 or 4 customers**

Feeder	DNO	Feeder Name	Type of Feeder	Spurs with 2, 3 or 4 customers			Total cust./ feeder	LCTs installed on these Suburban Feeders	Likelihood of a customer having an LCT installed	Likelihood of a customer on the spur having and LCT connection		
				2 cust.	3 cust.	4 cust.				Spurs 2 cust.	Spurs 3 cust.	Spurs 4 cust.
1	SSEPD	Marlow	Sub Semidetached/detached	0	0	0	139	13.05	9.4%	0.00%	0.00%	0.00%
2	NPg	Wylam	Sub Semidetached/detached	0	1	0	72	6.76	9.4%	0.00%	0.39%	0.00%
3	SSEPD	Whiteley	Sub Semidetached/detached	1	1	0	113	10.61	9.4%	0.17%	0.25%	0.00%
4	SSEPD	Chiswick	Sub Terraced St	0	1	2	374	35.13	9.4%	0.00%	0.08%	0.20%
5	SSEPD	Chineham	Sub Semidetached/detached	0	1	1	357	33.53	9.4%	0.00%	0.08%	0.11%
6	SSEPD	South Shields (Valley lane East SS)	Sub Semidetached/detached	1	0	0	62	5.82	9.4%	0.30%	0.00%	0.00%
7	NPg	South Gosforth	Sub Terraced St	1	0	0	57	5.35	9.4%	0.33%	0.00%	0.00%

Feeder	DNO	Feeder Name	Type of Feeder	Spurs with 2, 3 or 4 customers			Total cust./ feeder	LCTs installed on these Suburban Feeders	Likelihood of a customer having an LCT installed	Likelihood of a customer on the spur having and LCT connection		
				2 cust.	3 cust.	4 cust.				Spurs 2 cust.	Spurs 3 cust.	Spurs 4 cust.
8	NPg	South Shields (Cleadon Manor SS)	Sub Terraced St	0	0	0	54	5.07	9.4%	0.00%	0.00%	0.00%
9	NPg	Wooler Rampsey, Feeder B	Sub Semidetached/detached	0	0	0	74	6.95	9.4%	0.00%	0.00%	0.00%
10	NPg	Darlington Merlore, Feeder B	Sub Semidetached/detached	0	0	0	68	6.39	9.4%	0.00%	0.00%	0.00%
11	NPg	Darlington Merlore, Feeder D	Sub Semidetached/detached	0	0	0	80	7.51	9.4%	0.00%	0.00%	0.00%
12	NPg	Wooler Rampsey, Feeder A	Sub Terraced St	1	0	1	126	11.83	9.4%	0.15%	0.00%	0.30%
13	NPg	Harrowgate Hill, Feeder C	Sub Semidetached/detached	0	0	0	25	2.35	9.4%	0.00%	0.00%	0.00%
14	NPg	Wooler St Mary, Feeder A	Sub Semidetached/detached	0	1	0	154	14.46	9.4%	0.00%	0.18%	0.00%
15	NPg	Wooler St Mary, Feeder C	Sub Semidetached/detached	1	0	0	21	1.97	9.4%	0.89%	0.00%	0.00%
16	NPg	Wooler Bridge, feeder A	Sub Terraced St	0	0	0	9	0.85	9.4%	0.00%	0.00%	0.00%
			Total	**5**	**5**	**4**				**1.8%**	**1.0%**	**0.6%**
			%	**31%**	**31%**	**25%**				**0.12%**	**0.06%**	**0.04%**

Table 27 Suburban feeders LCTs per customer ratio

Total customers suburban feeders	LCTs installed in suburban feeders	LCTs/customer ratio suburban feeders
18,723,697.36	1,758,520.38	9.4%

Rural feeders having 2, 3 or 4 customers

Table 28 Rural feeders LCTs per customer ratio

Total customers in rural feeders	LCTs installed in rural feeders	LCTs/customer ratio rural feeders
1,182,316.07	106,653.12	9.0%

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