

NIA ENWL010

Value of Lost Load to Customers

Customer Survey (Additional Interviews)
Report on Revised Results

8 February 2019



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GLOSSARY

Abbreviation	Term
CE	Choice experiment
DNO	Distribution network operator
DPCR	Distribution price control review
EHP	Electric heat pump
EV	Electric vehicle
GB	Great Britain
LCT	Low carbon technology
NIA	Network Innovation Allowance
MW	Mega Watt
Ofgem	Office of gas and electricity markets
PV	Photovoltaic (solar panel)
RIIO-ED1	Electricity distribution price control 2015 to 2023
SME	Small to medium enterprise
VoLL	Value of Lost Load
WSC	Worst-served customer
WTA	Willingness to accept
WTP	Willingness to pay

1 EXECUTIVE SUMMARY

1.1 Introduction

This report serves as an addendum to the main findings of the VoLL study, as reported in the phase 3 report, published on the [VoLL webpage](#) on 5 October 2018. This addendum summarises the results of analysis associated with additional surveys that were conducted after completion of the main quantitative study. This document should be considered in conjunction with the customer survey (phase 3) key findings report and its supporting technical appendices.

The purpose of conducting additional surveys was to supplement/strengthen data collected in the original study to facilitate:

- Robust analysis of objectively-defined ‘worst-served’¹ customers – in the main study, only 74 respondents who completed the ‘unplanned’ outage exercises could be verified as meeting Ofgem’s definition of a worst-served customer (WSC). These respondents were all served by Electricity North West’s network, where the availability of fault data enabled objective classification.
- Sufficient sample sizes for SME sub-group analysis – In the main study, 615 SME respondents took part and while this was sufficient to provide robust results at the overall level, the ability to break down the results for sub-group analysis was limited.

The additional completed survey quota was comprised of the following:

- 100 domestic customers from the Electricity North West region, classified as ‘worst-served’. This definition was based on objective fault data, as opposed to customers’ self-expressed service experiences
- 200 SME customers recruited by phone and invited to complete the questionnaire online
- 200 SME customers recruited from commercial research panels and invited to complete the questionnaire online.

The questionnaire developed for the main survey was used as the vehicle to obtain responses from the additional WSC and SME sample, but the following modifications were introduced to maximise the robustness of the data:

- Only willingness-to-accept scenarios (WTA) for ‘unplanned’ outages were tested in the choice experiments (CEs). The main study, supported by previous research² established that WTA was the most relevant way to represent VoLL. Therefore, the opportunity was taken to show more WTA scenarios per respondent (12 instead of nine) while maintaining a practical length to the questionnaire by omitting willingness-to-pay (WTP) scenarios.
- The secondary ‘mitigation methods’ CE was omitted because sufficient data had been collected in the main study. Removal of this exercise shortened the overall questionnaire, making the fieldwork easier and quicker to implement.

¹ The [Ofgem definition \(regulatory instructions and guidance Annex A - Glossary\)](#) of worst-served customers for RIIO-ED1 is: customers experiencing 12 or more higher voltage unplanned interruptions over a three-year period, with a minimum of three higher voltage unplanned interruptions in each year.

² London Economics, 2013, The Value of Lost Load (VoLL) for Electricity in Great Britain.

In the analysis, the same model forms as those in the main study were used to estimate VoLL from the CE responses.

1.2 Summary of key findings

Domestic 'worst-served' customers³

- The VoLL for WSCs (£13,736) is largely the same as VoLL for the average domestic customer served by Electricity North West's network (£14,080), as estimated in the main study. This figure is lower than the value of £17,481 MW/hr for all domestic customers, GB-wide.
- Because VoLL for this group is no different from the average customer, there is no case for changing the estimate of overall domestic VoLL obtained from the main study (**£17,481 MW/hr**).

The objectively-defined WSC sample is less affluent (about two thirds of average income), making a case for an adjustment to reflect this when considering this group. The rationale for adjusting WTA by household income for low income groups has been academically validated⁴ and indicates that objectively-defined WSCs have a VoLL almost one third higher than the average for all domestic customers, served by the Electricity North West network, when income is taken into account.

SME customers

- The overall SME VoLL, now based on a larger WTA sample (1,003 versus 615), is not significantly different from the estimate of **£47,560 MW/hr** measured in the main study. However, there is a directional finding that this value could be slightly higher than originally reported (with an average of £50,584 MW/hr based on the larger SME sample).
- SME LCT users have a very low VoLL compared to the average for SME customers (only a quarter of the value). Differences in the profiles of LCT users versus non-users suggest that the difference in VoLL is unlikely to be a result of using LCTs but more a reflection of the different types of business that are likely to use LCTs.
- At the top level, the effect on VoLL, relative to SME customers' experience of any kind of power cut is minimal. However, experience of planned power cuts increases VoLL by ~30%, while experience of unplanned power cuts generally lowers VoLL (by around 10%).
- SMEs in the sector groups of: utilities and manufacturing & construction express a much higher VoLL than the average (+46% higher). A high VoLL is also evident in the sector group containing admin, education, health and the arts (+52%). In contrast, SMEs in accommodation and information have a very low VoLL (-54%).

It is important to note that for all VoLL estimates from this research respondents were asked to consider the impact of outages *occurring at the most inconvenient time for them*. This approach effectively measures 'maximum VoLL' rather than 'average VoLL' as is typical in other research, with the likely result that values will be generally higher.

Appendix 4.3 summarises the times of day and days of the week that respondents identified as the worst time for an outage to occur when, as a consequence, VoLL would be highest.

³ Objectively-defined according to the RIIO ED1 definition based on actual consumption (refer to Section 2.1).

⁴ Adjustments to WTA estimates associated with the distribution of income are referenced in Appendix 4.5 of this document and discussed fully in Appendix 6.6 of the VoLL customer survey (phase 3) key findings report.

2 'WORST-SERVED' DOMESTIC CUSTOMERS

2.1 Objectively defined 'worst-served' customers

The additional sample of domestic WSCs was drawn only from Electricity North West's region, to ensure compliance with the RIIO-ED1 definition⁵. In common with the approach used in the main survey, these respondents were identified from Electricity North West's network data.

In the main GB-wide survey approximately one third of respondents that were categorised as worst-served had self-identified as such on the basis of having experienced 15 or more outages in the preceding three years. The results of this subjective sample are viewed with caution as, without access to fault data from other DNOs, it was not possible to definitively verify if these respondents met the criteria of the RIIO-ED1 or DPCR5⁶ definitions.

The objectively-defined customers are also distinguished from another subjectively-defined sample who, when asked how the DNO should prioritise future investment, simply stated they wanted an improvement in service⁷.

Because the objectively-defined WSCs were all from the Electricity North West region, the relevant comparison should be made against the overall VoLL for Electricity North West customers, rather than the GB sample. Figure 2.1 summarises the key results.

Figure 2.1: VoLL estimates for worst-served domestic customers

	N	WTA	Lower	Upper	VoLL	Lower	Upper
Total GB sample (main study)	3,381	£7.87	£7.30	£8.44	£17,481	£16,209	£18,753
ENWL total (main study)	969	£6.46	£5.39	£7.52	£14,080	£11,752	£16,409
ENWL worst-served (main + additional study)	174	£6.19	£0.79	£11.58	£13,736	£1,755	£25,718

Setting the VoLL for WSCs against total Electricity North West customers gives an index value of **96** (£13,736/£14,080). This index value, coupled with the fact that two results are not statistically significantly different from one another, indicates that the VoLL of this segment is no different from the general customer population.

Because there is no difference in WSC VoLL from the average customer, there is no case for changing the estimate of overall domestic VoLL obtained from the main study (**£17,481 MW/hr**).

Although the VoLL for WSCs is similar to the overall Electricity North West domestic customer VoLL, the survey results show that WSCs are less affluent than others. The

⁵ The [Ofgem definition \(regulatory instructions and guidance Annex A - Glossary\)](#) of worst served customers for RIIO-ED1 is: customers experiencing 12 or more higher voltage unplanned interruptions over a three year period, with a minimum of three higher voltage unplanned interruptions in each year.

⁶ The [Ofgem definition \(regulatory instructions and guidance Annex A - Glossary\)](#) of worst served customers in the Distribution Price Control Review 5 2011-2015 (DPCR5) definition is: customers experiencing 15 or more higher voltage unplanned interruptions over a three year period, with a minimum of three higher voltage unplanned interruptions in each year.

⁷ The specific option offered to respondents was to 'Improve supply reliability levels where the benefits to customers outweigh the distribution company's costs to make these improvements.'

research identifies an average reported annual income of £22,456 for Electricity North West WSCs versus £30,489⁸ for all Electricity North West customers and this result is statistically significant. It indicates that WSCs are more likely to live in lower income households.

As a result, when adjusted for income, VoLL for all Electricity North West is almost unchanged at £14,213; however, the adjusted VoLL for Electricity North West WSCs is significantly higher at £18,650 (**almost one third higher** than the total Electricity North West sample) as shown in Figure 2.2 below.

The rationale for adjusting WTA for an equitable comparison, in low income groups, has been academically validated and the approach is documented in Appendix 6.6 of the VoLL customer survey (phase 3) key findings report.

Figure 2.2: VoLL estimates for 'worst-served' domestic customers adjusted by income

	N	VoLL	Index
Total sample	3,381	£17,481	-
Electricity North West total	969	£14,213	100
Electricity North West 'worst-served'	174	£18,650 ⁹	131

⁸ The average reported annual income for the total GB sample = £30,221.

⁹ £13,736 x (£30,489 / £22,456)

3 SME CUSTOMERS

3.1 Sample profile

Figure 3.1 shows the profile of the SME sample by sector is broadly in line with national statistics.

Figure 3.1: SME target profile versus sample profile

	Nationally representative	Sample (n=1,003)
Agriculture, forestry and fishing	5%	3%
Mining and quarrying	1%	2%
Manufacturing	5%	5%
Construction	11%	8%
Wholesale and retail trade	18%	16%
Transport and storage	3%	2%
Accommodation and food service	6%	4%
Information and communication	7%	5%
Finance and insurance	2%	3%
Real estate	4%	2%
Arts, entertainment and recreation	3%	4%
Professional, scientific and technical	17%	12%
Education	2%	2%
Human health and social work	6%	4%
Administrative and support service	8%	7%
Public sector	17%	21%
Private sector	83%	78%

3.2 Overall SME results

The effect of incorporating data from the 400 additional SME interviews into the model is to increase the overall VoLL estimate for SMEs from £47,560 MW/hr (as reported in the main VoLL phase 3 report) to £50,584 MW/hr.

This value is for the baseline scenario of ***an unplanned outage, of one-hour duration, once every three years, occurring at a time that would be most inconvenient.*** The difference between this new figure and the value obtained in the main study is not statistically

significant¹⁰, suggesting that the result obtained from the larger sample does not make a case for changing the VoLL for all SMEs. However, it does suggest that, directionally at least, the VoLL for SMEs could be higher.

The VoLL results for different frequency and duration of outage are summarised in Figure 3.2 below. The comparable results from the main study are given in the appendices.

Figure 3.2: SME VoLL by frequency and duration of outages (unplanned)

						Confidence interval (95%)	
SME WTA unplanned		WTA	Lower	Upper	VoLL	Lower	Upper
Once every 3 years	1 hour	£170	£165	£175	£50,584	£49,006	£52,162
2-3 times every 3 years	1 hour	£178	£172	£183	£52,920	£51,291	£54,549
4-6 times every 3 years	1 hour	£285	£277	£293	£84,859	£82,522	£87,197
7-14 times every 3 years	1 hour	£323	£315	£332	£96,250	£93,645	£98,855
15+ times every 3 years	1 hour	£397	£387	£408	£118,311	£115,201	£121,421
Once every 3 years	6 hours	£272	£263	£280	£80,839	£78,316	£83,361
2-3 times every 3 years	6 hours	£284	£275	£293	£84,571	£81,968	£87,175
4-6 times every 3 years	6 hours	£456	£443	£468	£135,614	£131,878	£139,350
7-14 times every 3 years	6 hours	£517	£503	£531	£153,817	£149,654	£157,981
15+ times every 3 years	6 hours	£635	£619	£652	£189,073	£184,103	£194,043
Once every 3 years	12 hours	£311	£301	£321	£92,543	£89,655	£95,430
2-3 times every 3 years	12 hours	£325	£315	£335	£96,816	£93,836	£99,796
4-6 times every 3 years	12 hours	£522	£507	£536	£155,249	£150,972	£159,526
7-14 times every 3 years	12 hours	£592	£576	£608	£176,087	£171,321	£180,854
15+ times every 3 years	12 hours	£727	£708	£746	£216,447	£210,758	£222,137
Once every 3 years	2-3 days	£390	£377	£402	£115,951	£112,333	£119,569
2-3 times every 3 years	2-3 days	£408	£395	£420	£121,305	£117,571	£125,039
4-6 times every 3 years	2-3 days	£654	£636	£672	£194,518	£189,159	£199,877
7-14 times every 3 years	2-3 days	£741	£721	£761	£220,628	£214,656	£226,600
15+ times every 3 years	2-3 days	£911	£887	£935	£271,196	£264,067	£278,325

¹⁰ A range of £49,006 to £52,162 at the 95% level of confidence versus £45,289 to £49,830 in the previous study results. The overlap, with £49,830 > £49,006 indicates that they are not significantly different, but the result is border-line.

3.3 Results by SME sub-group

Results at sub-group level are fairly consistent when compared to the results from the main study. Groups with similar VoLL values in both sets of results, relative to the overall average VoLL, are:

- Rural and urban
- Those identified as off-gas¹¹
- Those who have experienced any power cut (planned or unplanned).

The extra sample has allowed additional groups to be included in the modelling.

Analysis by sub-group is shown in Figure 3.3.

The main points to note are:

- SME LCT users were found to have a very low VoLL, around a quarter of the average (index value 26), though the difference is less pronounced when outages become more frequent. Further analysis to contextualise this result reveals that LCT users had experienced more outages than non-LCT users, but the impact was less severe. There are pronounced differences in the profiles of these groups, therefore, the unexpectedly low VoLL is unlikely to be influenced by LCTs alone. The study reveals that current LCT users are more likely to be in administrative/professional sectors and public companies, non-LCT users in utilities/manufacturing and a range of 'other' sectors.
- When questioned about the DNO priorities for future investment:
 - SMEs wanting to improve reliability in worst-served areas, have a higher than average VoLL, but the difference is much less than observed in the main study (index value of 106 versus 134 in the main survey)
 - In the additional sample, those wanting to maintain bills at current levels along with retention of existing levels of supply reliability show slightly higher relative VoLL when compared to the main study (index values of 110 [billing] and 94 [reliability] versus 96 and 81 respectively).
- The overall effect on VoLL relative to whether SME customers have experienced any kind of power cut (planned or unplanned) is minimal. However, when analysed by the type of outage, for those with experience of planned power cuts, VoLL is higher than average (index 128), while it is lower for those with experience of up to three unplanned power cuts (index values 86-89). However, there is a notable increase in VoLL of almost 60% above the average for those experiencing four or more unplanned outages. Intuitively this might be anticipated but the index value of 158 is based on a relatively small sample of 124 respondents and should therefore be treated with caution.
- There are significant variations in VoLL across SME sectors. The groups of: utilities, manufacturing, construction¹², retail and transport express VoLL 46% higher than the average. The sector group containing admin, education, health and arts have a VoLL even higher at 52% above the average. SMEs in the sector group of accommodation,

¹¹ As in the main study, this group needed an adjustment to their % bill to correctly reflect electricity-only consumption

¹² It has been noted in another study (CEPA, 2018, study on the estimation of the value of lost load of electricity supply in Europe, ACER/OP/DIR/08/2013/LOT 2/RFS 10) that the construction sector is potentially a large outlier with regarding to VoLL. Although the sample sizes here are not sufficiently large to test for this, directionally there is no evidence in this study to conclude this – the VoLL based on only 57 respondents from the construction sector is close to the overall SME average.

information, finance, professional and technical express a much lower VoLL, 54% below the total SME average.

- There is a notable difference in the VoLL of the public and private sectors, with private companies expressing VoLL around 10% higher than the average and public sector organisations showing a significantly lower VoLL (index 37), more than 60% lower than the SME average.

When calculating VoLL, the annual consumption figure used at the overall SME sample level was modified at sub-group level to reflect the relative rate of consumption for that particular group, compared to the total sample. This means that WTA obtained for one group (the money to compensate for an hour's outage) does not convert to annual VoLL in the same way as another group.

For example, SMEs in rural areas have a consumption ratio of 0.83 compared to the total sample (that is, they use about four fifths of the electricity consumed by the average SME customer); for those in urban areas the ratio is 1.05. If these two groups had given the same WTA value, the rural group would have the higher VoLL ($WTA/0.83$), because the amount of compensation they wish to receive is relative to less electricity consumed and therefore, proportionally greater £/MWh.

The impact of this adjustment is most noticeable in Figure 3.3 where those who have experienced no power cuts (either planned or unplanned) are compared with those that have. Here the WTA value for a one-hour outage is higher for the 'no power cuts' group (£186 versus £161) but the subsequent VoLL is lower (£49,472 versus £54,999). This reflects the respective consumption ratios of 1.12 ($= £186/1.12$) versus 0.87 ($£161/0.87$) for each group, converted into KWh.

However, these consumption ratios should be considered with an element of caution, due to the introduction of GDPR after the main study but before this additional survey work. To ensure GDPR compliance, respondents who were unable or unwilling to share actual consumption data or provide consent to obtain this data could not be excluded from taking part in the survey. As a consequence, most of the additional sample could not be identified for the purpose of establishing their actual consumption data and stated consumption was not requested from SME customers. The ratios used in the modelling are therefore based on data from respondents who completed the main study.

Customers with recent experience of power cuts were asked to provide an assessment of the impact on their business. Those reporting a moderate to high impact expressed VoLL around 10% higher than the average. VoLL was around 10% below the average when there was little or no impact (index value 92). This suggests a logical order, but these values are based on perception only.

Figure 3.3: SME VoLL (WTA) by sub-groups

SME WTA unplanned	n	WTA	Lower	Upper	VoLL	Confidence interval (95%)		Index vs total	
						Lower	Upper	Main + additional	Main only
Total	1003	£170	£165	£175	£50,584	£49,006	£52,162	100	100
Rural	202	£198	£182	£214	£71,433	£65,635	£77,232	141	144
Urban	699	£160	£154	£166	£45,453	£43,792	£47,115	90	92
Electricity North West	712	£175	£169	£182	£40,160	£38,744	£41,576	79	100
Off-gas	483	£218	£211	£225	£54,283	£52,627	£55,939	107	103
LCT users	254	£32	£22	£41	£13,081	£9,320	£16,842	26	
No power cuts (either planned or unplanned)	391	£186	£177	£195	£49,472	£47,120	£51,823	98	80
Power cuts (either planned or unplanned)	596	£161	£155	£168	£54,999	£52,639	£57,359	109	108
Impact of power cut – low	283	£125	£118	£133	£48,796	£45,918	£51,675	96	89
Impact of power cut – medium	209	£164	£149	£179	£51,613	£46,884	£56,342	102	77
Impact of power cut – high	116	£190	£171	£208	£60,396	£54,547	£66,244	119	116
Want to keep bills constant	312	£185	£175	£195	£55,868	£52,880	£58,857	110	96
Want to keep reliability	249	£145	£135	£154	£47,783	£44,652	£50,913	94	81
Want to improve worse served	202	£183	£168	£198	£53,859	£49,554	£58,165	106	134
Want to improve supply	230	£134	£126	£142	£33,033	£30,998	£35,069	65	69
Winter	707	£122	£117	£127	£30,957	£29,711	£32,204	61	40

SME WTA unplanned		n	WTA	Lower	Upper	VoLL	Confidence interval (95%)		Index vs total	
							Lower	Upper	Main + additional	Main only
Summer		287	£229	£217	£240	£81,628	£77,540	£85,717	161	164
Experienced planned power cut		302	£157	£147	£167	£64,611	£60,459	£68,764	128	122
Experienced four or more unplanned power cuts		124	£191	£177	£206	£80,081	£73,844	£86,319	158	
Experienced two or three unplanned power cuts		240	£131	£120	£142	£44,852	£41,094	£48,610	89	
Experienced one unplanned power cut		197	£179	£168	£190	£45,163	£42,422	£47,905	89	
Experienced no unplanned power cuts		397	£175	£167	£182	£43,325	£41,499	£45,150	86	
Sector Group	Utilities, manufacturing, construction, retail, transport	296	£177	£165	£189	£73,703	£68,846	£78,561	146	
	Accommodation, information, finance, professional	189	£63	£58	£68	£23,045	£21,064	£25,026	46	
	Admin, education, health, arts	209	£171	£155	£188	£76,763	£69,390	£84,136	152	
	Other services	141	£229	£209	£249	£48,083	£43,892	£52,273	95	
	Other	243	£234	£221	£247	£64,497	£60,940	£68,053	128	
Public		259	£43	£36	£50	£18,839	£15,774	£21,905	37	
Not public		725	£198	£191	£204	£55,544	£53,712	£57,376	110	

3.4 VoLL and LCT users

Unexpectedly, SMEs who identified themselves as LCT users stand out as having extremely low VoLL (74% below the average total SME value). Intuitively, it might be expected that the greater electricity dependency of LCT users would lead to a relatively higher VoLL. This is not reflected in these results and the unexpected finding is even more apparent when analysed by specific LCT.

The VoLL for those with electric vehicles (EVs) and electric heat pumps (EHPs) is not significantly different from zero when valued on the baseline scenario of a *one-hour outage occurring once every three years*.

Figure 3.4: SME VoLL (WTA) by LCT usage for a one-hour outage once every three years

Once every three years						Confidence interval (95%)		Index vs total
SME WTA unplanned	n	WTA	Lower	Upper	VoLL	Lower	Upper	
Total	1003	£177	£172	£183	£52,727	£51,054	£54,400	100
LCT users	254	£32	£22	£41	£13,081	£9,320	£16,842	26
Electric vehicles (EV)	116	~0	-	-	~0	-	-	~0
Solar panels (PV)	144	£62	£46	£79	£28,536	£21,071	£36,001	56
Heat pumps (EHP)	175	~0	-	-	~0	-	-	~0

LCT user sub-groups only start to register values when more frequent outages are tested, as indicated in Figure 3.5. The VoLL for all LCT users is still around 20% below the average; it is noticeably low for those with EHPs and lower still for EV users. Only those with PVs show a higher than average VoLL.

Figure 3.5: SME VoLL (WTA) by LCT usage for a one-hour outage, 4-6 times every three years

4-6 times every three years						Confidence interval (95%)		Index vs total
SME WTA unplanned	n	WTA	Lower	Upper	VoLL	Lower	Upper	
Total	1003	£285	£277	£293	£84,859	£82,522	£87,197	100
LCT users	254	£164	£149	£179	£68,124	£61,929	£74,320	80
Electric vehicles (EV)	116	£57	£40	£74	£29,516	£20,747	£38,285	35
Solar panels (PV)	144	£206	£179	£233	£94,407	£81,943	£106,870	111
Heat pumps (EHP)	175	£131	£110	£152	£51,502	£43,156	£59,848	61

The noticeably lower values of VoLL for LCT users is unexplained and further investigation is recommended as customers' specific levels of resilience were not identified in the survey. It

could be hypothesised that the lower VoLL reflects less dependence on electricity supplied from the grid and for these customers, outages only take on a value when they become too frequent. However, there is no suitable information from the survey to corroborate this.

An important point to note when interpreting these findings is that LCT users in the SME sample may not have the same characteristics as non-LCT users. It is probable that these differences in characteristics are the key drivers behind the lower VoLL. This is illustrated by comparing the profiles of those who identify their companies as LCT users with those who do not. This reveals a number of significant differences.

Figure 3.6: SME profiles by LCT usage versus non-LCT usage: significant differences¹³

		LCT user	Non-LCT user
Total sample size		266	741
Impact of power cut – low		40%	25%
Impact of power cut – medium		34%	16%
Want to keep bills constant		24%	35%
Want to keep reliability		35%	24%
Experienced planned power cut		54%	24%
Experienced four or more unplanned power cuts		20%	10%
Experienced two or three unplanned power cuts		31%	21%
Experienced one unplanned power cut		15%	22%
Experienced no unplanned power cuts		20%	45%
Sector group	<i>Agriculture, mining, utilities, manufacturing, construction, retail, transport</i>	30%	27%
	Accommodation, information, finance, real estate, professional, technical	35%	18%
	Admin, education, health, arts	20%	13%
	<i>Other services</i>	13%	16%
	Other	11%	27%
Public		37%	14%
Not public		63%	83%

¹³ Significant at the 95% level of confidence. Non-significant differences that have been included for reference are shown in italics.

These results suggest that LCT users have more experience of power cuts but are also more likely to state that the impact of an outage on their organisation is low to moderate. A larger proportion of LCT users are in the public sector and are more prevalent in the main sector groups encompassing accommodation, information, finance, etc. Around a quarter of non-LCT users are categorised as 'other' and therefore more diverse in terms of the represented sectors.

The conclusion is that early adopters of LCTs are generally from SME sectors that are more tolerant of outages. This is significant and may be influential in the lower VoLL observed for this group. However, sector-specific differences could also contribute to a lower VoLL among LCT users.

4 APPENDICES

4.1 Potential WTA/WTP order effect

In the main study, exactly half the respondents were presented with the willingness-to-pay (WTP) exercise of the CE before the WTA exercise. The other half saw the WTA exercise before the WTP questions. This is a well-established approach designed to eliminate order bias. The VoLL estimates derived from the main study represent an average value independent of any possible order effect.

As outlined in Section 1.1, this additional survey sample was asked only to consider scenarios framed in a WTA context. The potential effects of this adjustment to the original approach are as follows:

Domestic customers

Examination of the main study results reveal that those who saw WTP first gave a higher WTA value than respondents who were presented with the WTA scenarios first.

For the total main survey sample, where the overall sample WTA was £7.87 for a *one-hour outage once every three years*, those who saw WTP first gave a WTA value of £9.12, compared with only £7.00 for those who saw WTA first. This observation may suggest that customers develop a higher expectation of the level of compensation they should receive when first questioned about what they would be prepared to pay to avoid outages. The difference in the result is statistically significant at the 95% level of confidence.

On this basis, it could be argued that analysis of VoLL values for the additional sample should be adjusted to reflect that they were derived within a WTA context only and were therefore subject to this order effect. That is, they are equivalent to the results for respondents in the main study that saw WTA scenarios before WTP scenarios.

On the other hand, it could be argued that the WTA is a more difficult question for respondents and that showing WTP first has allowed respondents to locate a meaningful estimate of the value they attach when subsequently framed as WTA.

The values for the 'total sample' and the 'Electricity North West total' in Figure 4.1.1 represent a 50/50 combination of WTP first/WTA first; the 'worst-served' results represent a 21/79 combination of WTP first/WTA first¹⁴. If it is assumed that an adjustment factor of 0.86 (the ratio of £7.87/£9.12 WTA values for the whole sample) applies to those who saw WTP first and 1.24 (the ratio of £7.87/£7.00 WTA values for the whole sample) to those who saw

¹⁴ That is, 37 'WTP first' respondents and 37 'WTA first' in the main study, plus 100 'WTA first' respondents in this additional survey.

WTA first, the values for WSCs should be adjusted by a combined factor of 1.215 ($[0.86 * 21 + 1.24 * 79]/100$).

Alternatively, if seeing WTP is thought to be the more considered value, the factors are calculated and applied in reverse, giving values of 1.16 (£9.12/£7.87) for those who saw WTP first and 0.89 (£7.00/£7.87) for those who saw WTA first. This gives an alternative combined factor of 0.947 ($[1.16 * 21 + 0.89 * 79]/100$).

These factors were applied to the latest results to show the potential range of values that would result, (shown in Figure 4.1.1 below). An alternative approach would have been to weight the mix of respondents (see SME approach in next paragraph) but the small sample sizes for WSC suggested that the results would not be reliable.

Figure 4.1.1: Unadjusted and adjusted VoLL estimates for ‘worst-served’ domestic customers

ENW worst-served (main + additional study)	N	WTA	Lower	Upper	VoLL	Lower	Upper
Unadjusted	174	£6.19	£0.79	£11.58	£13,736	£11,755	£25,718
Adjusted for WTA first (1.215 x unadjusted)	174	£7.52	£0.96	£14.07	£16,687	£12,132	£31,243
Adjusted for WTP first (0.947x unadjusted)	174	£5.86	£0.75	£10.97	£13,008	£11,132	£24,355

SME customers

A similar result is observed for SME customers, together with the same arguments as to whether WTP first is the more considered value for WTA. Those in the main study who saw WTP scenarios first gave a WTA value of £167 compared to £117 for those who saw WTA first. The WTA for the total sample in the main study was £160 and the difference between the two is statistically significant at the 95% level of confidence. In the new combined sample of 1,003 respondents, the ratio of those who saw WTP first to those who saw WTA first is 33/66; therefore, the data was weighted at the respondent level to reflect a 50/50 split. This weighting approach was applied instead of the factor approach used for WSCs, because the larger sample sizes for SMEs make this approach more robust.

Figure 4.1.2 shows the results from the main study and for the main + additional studies. If the data is not weighted in this way, the VoLL is not significantly different from the results from the main study (the upper and lower values overlap); if it is weighted, the result is significantly higher than the main study.

Figure 4.1.2: Unadjusted and adjusted VoLL estimates for SME customers

SME	N	WTA	Lower	Upper	VoLL	Lower	Upper
Main result (main study only)	615	£160	£152	£167	£47,560	£45,289	£49,830
Unadjusted (main + additional study)	1003	£170	£165	£175	£50,584	£49,006	£52,162
Adjusted (50/50 WTA/WTP wgt)	1003	£177	£172	£183	£52,727	£51,054	£54,400

A final view on potential WTA/WTP order bias

There are arguments for inflating or deflating the WTA estimates according to whether respondents saw WTP scenarios beforehand or not. However, the more adjustments that are made to the original model estimates, the more difficult it becomes to defend those estimates. Given the relatively wide confidence intervals around the WSC values and the relatively small variations around the SME values, it was concluded that the unadjusted results for the main + additional sample should be used. This approach has been independently validated and the academic critique is presented in Appendix 4.5.

4.2 Mean values versus median values

Throughout the study, the WTA values used to calculate VoLL have been based on mean model utility values with the top and bottom 2.5% values removed to reduce the influence of outliers. As a further general test of the stability of the results overall, the analysis was repeated using the median values. Figures 4.2.1 and 4.2.2 compare the values derived by the two methods and demonstrate that the results are very stable. There are no significant differences between values derived from the two methods.

Figure 4.2.1: Domestic VoLL values based on mean utility values versus median utility values

Domestic (total)	N	WTA	Lower	Upper	VoLL	Lower	Upper
Mean	3,381	£7.87	£7.30	£8.44	£17,481	£16,209	£18,753
Median	3,381	£7.49	£6.62	£8.35	£16,626	£14,704	£18,548

Figure 4.2.2: SME VoLL values based on mean utility values versus median utility values

SME (total)	N	WTA	Lower	Upper	VoLL	Lower	Upper
Mean	1,003	£170	£165	£175	£50,584	£49,006	£52,162
Median	1,003	£180	£170	£190	£53,561	£50,677	£56,446

4.3 SME results from the main study

The tables below show outputs from the main study suitable for comparison with the results from this additional work.

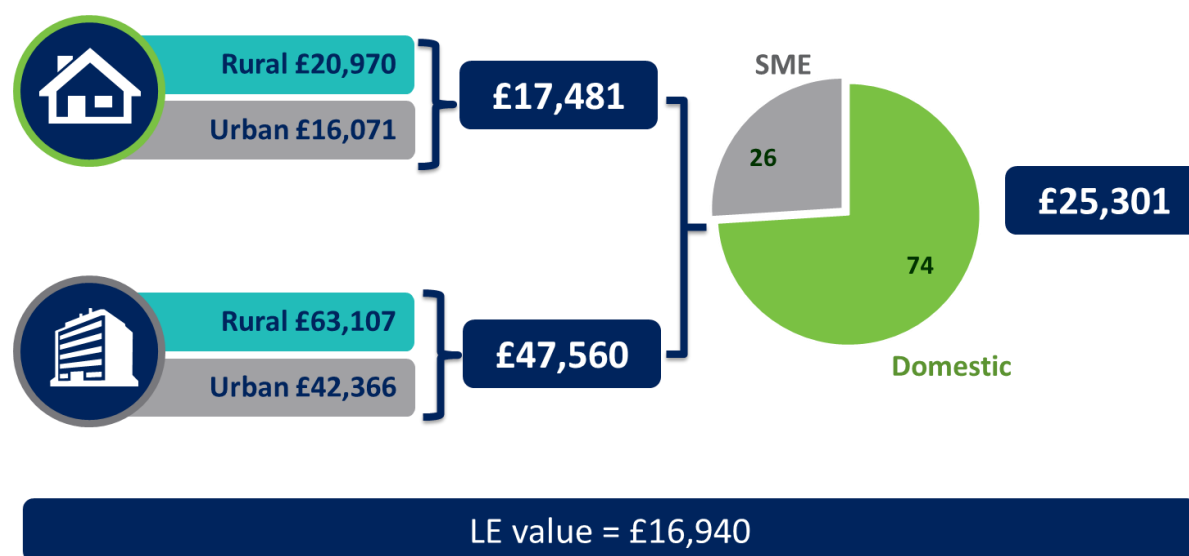
Figure 4.3.1: SME VoLL by frequency and duration of outages (unplanned) – Figure 6.5 main report

SME WTA unplanned		WTA	Lower	Upper	VoLL	Confidence interval (95%)	
						Lower	Upper
Once every 3 years	1 hour	£160	£152	£167	£47,560	£45,289	£49,830
2-3 times every 3 years	1 hour	£160	£152	£167	£47,560	£45,289	£49,830
4-6 times every 3 years	1 hour	£294	£282	£305	£87,382	£83,967	£90,798
7-14 times every 3 years	1 hour	£306	£295	£318	£91,219	£87,684	£94,754
15+ times every 3 years	1 hour	£416	£401	£431	£123,778	£119,291	£128,265
Once every 3 years	6 hours	£255	£243	£268	£76,005	£72,377	£79,633
2-3 times every 3 years	6 hours	£255	£243	£268	£76,005	£72,377	£79,633
4-6 times every 3 years	6 hours	£469	£451	£488	£139,646	£134,188	£145,105
7-14 times every 3 years	6 hours	£490	£471	£509	£145,778	£140,129	£151,427
15+ times every 3 years	6 hours	£665	£640	£689	£197,810	£190,640	£204,981
Once every 3 years	12 hours	£292	£278	£306	£87,009	£82,856	£91,163
2-3 times every 3 years	12 hours	£292	£278	£306	£87,009	£82,856	£91,163
4-6 times every 3 years	12 hours	£537	£516	£558	£159,865	£153,616	£166,113
7-14 times every 3 years	12 hours	£561	£539	£582	£166,884	£160,417	£173,351
15+ times every 3 years	12 hours	£761	£733	£788	£226,450	£218,241	£234,659
Once every 3 years	2-3 days	£366	£349	£384	£109,018	£103,814	£114,222
2-3 times every 3 years	2-3 days	£366	£349	£384	£109,018	£103,814	£114,222
4-6 times every 3 years	2-3 days	£673	£647	£699	£200,302	£192,473	£208,131
7-14 times every 3 years	2-3 days	£702	£675	£730	£209,096	£200,994	£217,199
15+ times every 3 years	2-3 days	£953	£919	£988	£283,729	£273,444	£294,014

Figure 4.3.2: SME VoLL (WTA) by sub-groups – Figure 6.9 main report

SME WTA unplanned	n	WTA	Lower	Upper	VoLL	Confidence interval 95%		Index vs total
						Lower	Upper	
Total	615	£160	£152	£167	£47,560	£45,289	£49,830	100
Rural	118	£217	£184	£249	£68,452	£58,201	£78,703	144
Urban	489	£152	£144	£160	£43,885	£41,680	£46,090	92
Electricity North West	325	£186	£175	£198	£47,466	£44,561	£50,371	100
Off-gas	316	£152	£144	£161	£49,056	£46,406	£51,706	103
No power cuts (either planned or unplanned)	239	£147	£137	£157	£38,167	£35,648	£40,686	80
Power cuts (either planned or unplanned)	376	£153	£143	£163	£51,341	£47,981	£54,701	108
Impact of power cut – low	161	£114	£101	£127	£42,375	£37,455	£47,296	89
Impact of power cut – medium	149	£131	£113	£150	£36,629	£31,458	£41,801	77
Impact of power cut – high	68	£146	£126	£166	£48,005	£41,454	£54,555	101
Want to keep bills constant	188	£144	£132	£155	£45,823	£42,297	£49,349	96
Want to keep reliability	141	£124	£109	£139	£38,564	£33,832	£43,296	81
Want to improve worse served	116	£233	£196	£269	£63,896	£53,833	£73,958	134
Want to improve supply	161	£131	£119	£142	£32,919	£30,044	£35,793	69
Winter	319	£73	£66	£81	£19,099	£17,079	£21,119	40
Summer	287	£229	£216	£241	£77,843	£73,572	£82,115	164
Experienced planned power cut	185	£232	£215	£248	£58,227	£54,077	£62,377	122

Figure 4.3.3: Group-level VoLL combined to give a single overall VoLL – Figure 2.3 main report



4.4 Time of day and day of week when outages have the greatest impact (=highest VoLL)

The table below shows that for domestic WSCs, over half identify weekdays between 09:00 – 21:00 as the most impactful/inconvenient time for an outage. Two thirds of the total WSC sample identify this 12-hour period as most inconvenient when weekends are also taken into account. The lower numbers who report greatest impact in the early morning and late evening may reflect the higher incidence of older customers (53% of WSC are aged 60+ versus 28% for the total population), with correspondingly lower proportions of full-time employment.

Figure 4.4.1: Domestic worst-served – timing of highest VoLL (total sample)

Time of day	Day of week		
	Weekday (Monday to Friday)	Weekend (Saturday or Sunday) or bank holiday	Total
Early morning (6:00am – 9:00am)	13%	3%	16%
Day time (9:00am – 3:00pm)	20%	3%	24%
Afternoon to evening (3:00pm – 9:00pm)	31%	11%	42%
Late evening (9:00pm to midnight)	8%	3%	11%
Night time (midnight to 6:00am)	4%	3%	7%
Total	76%	24%	100%

For SMEs, two thirds identify 09:00 – 15:00, as being most inconvenient; however, this is divided fairly evenly between weekdays and weekends. The high proportion indicating the weekend as the most inconvenient period may reflect that about half of the SME sample are in sectors that are likely to operate at weekends and for these customers this may be one of the busiest periods (retail, accommodation, food, small service sector companies).

Figure 4.4.2: SME – timing of highest VoLL (total sample)

Time of day	Day of week		
	Weekday (Monday to Friday)	Weekend (Saturday or Sunday) or bank holiday	Total
Early morning (6:00am – 9:00am)	4%	6%	11%
Day time (9:00am – 3:00pm)	35%	29%	65%
Afternoon to evening (3:00pm – 9:00pm)	8%	9%	17%
Late evening (9:00pm to midnight)	2%	2%	4%
Night time (midnight to 6:00am)	1%	2%	3%
Total	51%	49%	100%

4.5 Justification for additional sampling and integration of results with the main study

Professor Iain Fraser, School of Economics University of Kent

This report is the final part of a wider study examining the Value of Lost Load (VoLL) to electricity consumers in Great Britain (GB) by Impact Research for Electricity North West.

The specific aims of this project (customer survey – additional interviews) were:

- Provide more robust analysis of worst-served customers (WCS); and
- Increase the sample size of SMEs such that sub-group analysis could be conducted.

To achieve these aims further survey work was undertaken with a focus on WSC and SMEs. The survey data collected employed a modified version of the earlier survey instrument. Specifically, given the specific focus on only collecting willingness-to-accept (WTA) estimates all willingness-to-pay (WTP) questions were dropped, along with an additional part of the study examining mitigation methods. To maintain consistency with the earlier research the same statistical model specification has been used to examine all of the additional survey data.

Overall the results in terms of estimates of WTA compensation for an unplanned outage appear to be consistent with those presented in the main body of the research. It is also the case that the estimates reported here and in the main report can be considered upper bounds in terms of the magnitude of VoLL because of the way in which the questions have been framed and the type of valuation exercise employed. For this reason it is to be

expected that reported estimates are somewhat higher than those previously reported in the literature.

In terms of specific results reported in this new research, although there are some small differences in point estimates of WTA reported in these new samples compared to the main study, there is not sufficient statistical evidence to claim any meaningful difference for either the WSC and SME samples. It is noted that the SME estimate from the larger sample is a little higher.

In terms of specific issues, there are some interesting details that emerge.

- The average income of the WSC is significantly lower than that of the overall household sample. Therefore, there is a possible case for adjusting the estimate of VoLL for this sub-sample but the resulting difference with the total sample is not significant. The appropriateness of adjustments to WTA and WTP estimates associated with the distribution of income are discussed in Appendix 6.6 of the VoLL customer survey (phase 3) key findings report.
- Another possible adjustment considered relates to the order of the discrete choice experiment questions in the main survey: WTP followed by WTA or WTA followed by WTP. This report examines how the order in the original survey impacted estimates of VoLL and what this would imply for the estimates obtained from the additional survey data. These results are reported. However, as there is no obvious reason to assume that a specific order is to be preferred, the adjustments made to the estimates of consumer VoLL are simply reported for completeness. This is a sensible approach given the general level of confidence placed in WTA estimates.
- It is also the case that both mean and median of VoLL have been examined as the nature of the underlying distribution of WTA estimates is such that simply relying on single point estimates can result in a misleading interpretation of results. Importantly, as demonstrated in this report, the use of the mean or median of the WTA distribution has only a marginal effect on the resulting estimates of VoLL.
- The new SME results provide an interesting insight into sub-group differences in VoLL especially for companies that employ low carbon technologies (LCTs). The additional insights provided on the updated SME sample indicate that the additional survey work was warranted.