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Value of Lost Load (VoLL2) Multiplier Effect

Customer Survey - Key Findings Report

6 May 2020

VERSION HISTORY

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1	26/03/20	Impact	Draft	Initial peer reviewed
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APPROVAL

Name	Role	Date
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GLOSSARY

Abbreviation	Term
BWS	Best-Worst Scaling
CVM	Contingent valuation method
DNO	Distribution network operator
EV	Electric Vehicle
GB	Great Britain
LCT	Low carbon technology
MNL	Multinomial logit
NIA	Network Innovation Allowance
Ofgem	Office of Gas and Electricity Markets
PSR	Priority Services Register
RIIO-ED1	Electricity distribution price control 2015 to 2023
SEG	Socio-economic group
SME	Small to medium enterprise
VoLL	Value of Lost Load
WTP	Willingness to pay

FOREWORD

In Great Britain (GB) a single, uniform Value of Lost Load (VoLL) is used to evaluate the 'dis-benefit' to customers of a supply interruption of average duration. It can be expressed as the value that customers would be willing to pay to avoid an interruption or what they would be willing to accept in compensation if they experience an interruption. A uniform VoLL assumes that all customers are impacted equally as a consequence of the loss of power and attach the same value to their supply reliability. Investment in electricity networks is thereby, at least partly, driven by a factor which currently fails to recognise any differentiation in customer need, or valuation of service.

Recent Network Innovation Allowance (NIA)-funded research conducted by Impact on behalf of Electricity North West (ENWL010)[1] has demonstrated that VoLL is now notably higher in real terms than the value established in the previous major GB study in this area, conducted by London Economics for Ofgem, in 2013[2]. This increase, as reported on the VoLL webpage, is thought to reflect a greater dependency on electricity and changing customer needs and expectations. The study also robustly concluded that a uniform VoLL significantly undervalues the needs of certain customer segments, most notably the fuel poor and early adopters of low carbon technologies; whilst others are over represented, driving potentially inappropriate investments. An output of the VoLL research is a new segmentation model, which in principle will enable Distribution Network Operators (DNOs) to make smarter investment decisions that are more reflective of divergent customer needs.

To move towards the practical implementation of a differentiated VoLL it was recognised that further detailed analysis was required to explore the requisite level of sophistication needed in a credible decision making tool, and the appropriate mechanism for practical implementation, at scale. ENWL010 also highlighted the need for further empirical customer research to test the impact of different scenarios. This includes the 'multiplier' effect on VoLL of scale and duration, when assessed by individual customers. That is, they may experience a different level of dis-benefit when an interruption effects the entire community, rather than just themselves as a private individual. This could reflect concern for the wider community or a perception that a major interruption is potentially more restrictive on how they and the DNO can cope with it.

This understanding will inform smarter decisions based on the relative value of proactive investment, aimed at preventing or minimising the severity of unplanned interruptions, versus the ability to mitigate VoLL by deploying appropriate support mechanisms to manage the consequence of an event.

This follow up project comprised two distinct elements of research: a strategic piece of statistical analysis and industry consultation to explore the practicalities and regulatory implications for implementation of an alternative, segmented VoLL model and its applicability (Phase A); and empirical customer research to provide insight into the multiplier effect and socialisation of cost arising from a revised model (Phase B). This report addresses Phase B.

[1] Value of Lost Load to Customers Customer: Survey (Phase 3) Key Findings Report (October 2018)
https://www.enwl.co.uk/globalassets/innovation/enwl010-voll/voll-general-docs/voll-phase-3-report.pdf
[2] London Economics, 2013, Estimating Value of Lost Load (VoLL, Ofgem

The methodology was designed by Electricity North West and its market research partner, Impact. It was set out in the VoLL2 Methodology Statement which encompasses five key stages of customer and stakeholder engagement:

- Stage 1: Desk research and stakeholder engagement
- Stage 2: Qualitative exploration
- Stage 3: Quantification
- Stage 4: Implementation scale analysis
- Stage 5: Validation.

This report and the analysis therein reference the key findings from the large scale quantitative study conducted in Stage 3[3]. This provided robust, statistically significant findings against the project objectives, with differences between key sub-groups highlighted to enable tailored implementation and actions from these findings.

The VoLL2 project is funded by the NIA, which was introduced as part of the RIIO-ED1 price control and provides an allowance for network licensees to fund research with the potential to improve network operation and maintenance, and to deliver financial benefits to the licensee and its customers. The project (ENWL021) commenced in November 2018 and was conducted over an 18-month period.

All documents relating to the project are published on the VoLL2 webpage.

1 EXECUTIVE SUMMARY

1.1 Introduction

This report details the results and analysis associated with Stage 3, the large-scale quantitative customer survey, of the VoLL2 project. Data collection took place during January and February 2020.

A total of 2,054 surveys were completed covering domestic and small to medium enterprise (SME) customers from across the whole of GB including 911 respondents from within Electricity North West's operating region. A total of 1,545 of these surveys were conducted with domestic customers and 509 were completed by a broad sample of SME customers.

Details of the research approach are set out in the VoLL2 Methodology Statement which also comprehensively explains the background of the VoLL2 project and the analysis protocols utilised.

1.2 Summary of key findings

The objective of this phase of the research was to find answers to three key questions:

1. What is the impact of a large event involving a significant number of customers on VoLL versus a smaller, localised interruption?
2. How does VoLL change over the duration of an event? Specifically, for longer durations over 12 hours, does VoLL per hour increase, stay the same, or reduce?
3. What are customer views surrounding the socialisation of costs? Specifically are customers willing to pay, through bill increases, for investment to reinforce areas where low carbon technology (LCT) uptake may be high versus those living in fuel poverty?

The findings from the customer survey are summarised below.

[3] Impact Research, 2019, Value of Lost Load to Customers (VoLL2), Methodology Statement, ENWL

The impact of large events

This was measured in terms of length of interruption, frequency of interruptions experienced, and the geographical scale of a particular interruption.

The research found that length of interruption was the biggest factor in determining VoLL. For interruptions that last more than 6 hours, a 24 hour interruption (+18 hours) has about twice the impact and a 3 day interruption (+66 hours) has about six times the impact that a 12 hour interruption (+6 hours) has. This implies that the VoLL per hour is lower beyond the 12 hour point, but then remains constant.

This effect is the same irrespective of whether customers are domestic or SME and is consistent across most other sub-groups. There were small differences amongst male respondents and those with low bills, who place slightly more value on the impact of long interruptions. Among SMEs, medium sized companies in mixed urban/rural areas register the lowest impact from long interruptions, while small companies (<10 employees), those that own electric vehicles (EVs) or hybrid vehicles, and those with low bills perceive the highest impact.

The scale of an interruption does affect its perceived impact: town/village-wide and region-wide interruptions exhibit a multiplier effect relative to interruptions that are limited to individual properties or streets. The impact of a region-wide (eg the whole of the North West) interruption is as much as 40% to 60% higher when compared to an interruption ‘just at my property’. Domestic customers regard a local interruption in a similar way to ‘just my property’, whereas SMEs regard a local interruption as less important than one affecting ‘just my property’.

Among domestic groups, EV/hybrid users place greater importance on a supply interruption to their property or immediate locality and less on region-wide interruptions, which may reflect a focus on availability of convenient local charging points and the fact that the majority of charging currently occurs at home[4]. Young people (18-29) and high energy users place more importance on region-wide interruptions. In the case of the former, this may relate to having less experience of outages, which is known to correlate with higher VoLL[5]. For the latter, this may simply reflect a generally greater engagement with the importance of secure electricity supply, given their greater dependency.

Among SMEs, only those with high bills or with 10-49 employees regard interruptions at street/local streets level to be of equal or greater importance to an interruption at their property. These also attach a much higher importance to larger scale interruptions. Other SME groups attaching higher than average importance to larger scale interruptions include those in urban locations, those off gas and LCT users.

Frequency of an interruption only becomes an issue when it becomes more frequent than once a year; VoLL increases after this threshold.

The socialisation of costs

Customers were asked detailed questions about their willingness to pay socialised costs to enable power to be restored to vulnerable customers sooner when there is an interruption, and whether certain groups should be prioritised for power restoration if this cost were socialised.

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[4] Two thirds of EV owners in the study said that they charge mostly at home (domestic customers) or at work (SME customers)

[5] Counting the cost: the economic and social costs of electricity shortfalls in the UK: A report for the Council for Science and Technology (November 2014) https://www.raeng.org.uk/publications/reports/counting-the-cost. This stated that, “Experience of interruptions affects WTA.” This was also observed in ENWL010. The CST study also suggested that people tend to over-estimate the negative impact of a power cut (especially if they have no experience of one).

Customers were willing to pay more for some of these groups, including vulnerable customers, to be prioritised ahead of others. However, customers were also willing to pay more to have their own property or SME site restored before others. Vulnerable groups are generally prioritised above those who are fuel poor. The reasons for this are not completely clear but perhaps those who are fuel poor are considered to already receive public support and that the responsibility for supporting this group lies with the government and less so with themselves. The group of customers who have EV/solar power are considered to be lowest priority (unless the customer is themselves a member of this group).

Customers generally supported socialised costs that would enable DNOs to proactively identify customers eligible for priority services when an interruption occurs.

Some customer groups are willing to pay more than others, for example, those who use LCTs/EVs/solar panels have greater willingness to pay. This partly reflects a relationship with income[6] where, perhaps unsurprisingly, those with higher incomes and those who do not tend to struggle with paying bills are willing to pay more. However, other groups also express a higher willingness to pay for priority power restoration: the youngest consumers, those living in urban areas, those with children in the household, and those on the Priority Service Register (PSR).

Customers were also asked detailed questions that sought to uncover their views on how network costs should be socialised and specifically, whether they should be proportional to consumption as they are now, or based on a flat rate. Nearly half of respondents felt that proportional charging is fair, although almost all of the rest were ambivalent. More than half of respondents were ambivalent about whether it was fair that network charges do not reflect the different costs involved in delivering electricity to rural compared with urban customers.

However, when asked to choose the network management approach that they felt DNOs should take, the most popular was to ensure that all customers receive the same level of reliability. This is consistent with a similar finding from the original VoLL study[7]. Those aged 60+ were most likely to select this as the most important strategy, while LCT users were least likely to rate this as important.

Their top-ranked charging approach was that charges should encourage efficiency ie be based on a standard rate for everyone up to a certain limit, ensuring basic needs are covered, after which unit rates would increase, meaning that heavy users pay more than others. This seems consistent with an observation from the earlier ECP study[8], where although a number of participants accepted the value of using differentiated VoLL to prioritise investments, in practice they ‘expected that investment priorities would be determined by demand levels or the extent to which the equipment was inadequate’. Thus, prioritisation for certain groups is to be considered once the basic requirements that serve all customers were met first.

1.3 Conclusions

The results of this phase of the project demonstrate that large scale and lengthy interruptions have the potential to increase VoLL, when compared to shorter, limited scale interruptions. Consideration should be given to how a more tailored VoLL could help mitigate this increased disruption and impact.

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6 A higher proportion of LCT users are in the AB social groups: 33% of LCT users v 21%in the total domestic sample. However, there are no significant differences in reported income between LCT and non-LCT users

7 In that study, 29% of domestic customers said that ensuring ‘that all customers received the same level of reliability’, making it the second most important objective after ‘keeping customer bills constant’ (39%) and ahead of ‘focus on the worst areas of reliability and improve these’(19%) and ‘improve supply reliability levels…’ (14%)

8 ENWL, October 2019, ECP Report

Regarding the socialisation of costs and whether customers consider a variable model of VoLL to be fairer, the ability of customers to prioritise certain groups (vulnerable customers) over others (EV/LCT owners, those in fuel poverty) through a higher willingness to pay suggests that they would consider a variable model more desirable.

2 THE MULTPLIER EFFECT OF LARGE SCALE INTERRUPTIONS

2.1 Approach

This part of the research aimed to address the following questions:

- *How does VoLL change over the duration of an event? Specifically, for longer durations over 12 hours, does VoLL per hour increase, stay the same, or reduce?*
- *Does a 'multiplier effect' on VoLL exist when assessed on the basis of the entire community, rather than the individual?*

The approach was to test with customers, in a large online and face-to-face survey, a range of service levels from two key attributes previously tested in the main VoLL study conducted in 2018[9], namely length of interruption and frequency of interruption. This research involved presenting these attributes with longer interruptions (up to three days in length) and a new attribute representing the geographical scale of the impact.

A trade-off technique, 'Best-Worst Scaling' (BWS), was adopted to measure the relative importance attached to large scale interruptions, defined in terms of extreme length and varying from a single property to a whole DNO region. The decision was made not to include a price element, as per the main VoLL study, as the aim was to encourage respondents to give full consideration of what extreme interruptions would really mean to them in terms of how much worse these event are, when compared to short, relatively localised interruptions they are more likely to experience, without introducing the complexities of compensation/ability to pay associated with willingness to pay (WTP) studies.

The outputs indicated the extent to which the dis-benefit experienced by customers from an interruption of the type they are most likely to experience (eg in the 1 hour to 6 hour range) could be multiplied to represent the effect of longer interruption times and wider geographical spread.

Best-Worst exercise

The main component of the survey instrument[10] was a stated preference BWS exercise[11]. Respondents were presented with a series of scenarios and asked to trade off different levels of supply reliability and scale of interruption. These scenarios were constructed from the service attributes and levels shown in Figure 2.1. These were tested and developed at the qualitative stage of the research.

A 'type 3' randomised fractional factorial design (60 combinations) was used to create the scenarios; that is, a multiple choice between three options is offered in each scenario. This design was subject to dominant options being excluded, so that no one of these three options was clearly best or worst in any one scenario[12].

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9 https://www.enwl.co.uk/globalassets/innovation/enwl010-voll/voll-general-docs/voll-phase-3-technical-appendices.pdf

10 https://www.enwl.co.uk/zero-carbon/innovation/smaller-projects/network-innovation-allowance/enwl021---voll-2/

11 BWS is a specialised type of survey question that presents respondents with choices between alternative qualities of service. The way respondents choose infers the relative importance they place on different aspects of a service. This is considered to give more objective measures of the importance customers place on interruptions than any form of direct questioning. The potential advantage of this approach over a conventional single-response discrete choice model is the extra information given by the two best/worst responses in the one model.

12 The construction of an 'efficient design' (one based on maximum likelihood estimation) was attempted, but it proved impractical to produce a solution that avoided/minimised dominant options.

Figure 2.1: Attributes and levels tested in the BWS exercise

Attribute	Level				
	1	2	3	4	5
Length of interruption	Up to 1 hour	6 hours	12 hours	24 hours	3 days
Scale of interruption	Just my property	My street or several local streets	My town/ village and surrounding areas	The whole of [Name of REGION]	
Frequency of interruption	Once every three years	Once per year	Several times per year		

120 'sets' of 12 scenarios were created, with each respondent being shown one set, one scenario at a time. This number of scenarios was required to overcome the requirement that every scenario avoided showing a dominant option. An example of one such scenario is given below.

Figure 2.2: Example of a Best-Worst scenario

Which of these situations (A, B or C) would be MOST DISRUPTIVE for you and which would be LEAST DISRUPTIVE?

	Length of power cut	*Scale of power cut*	*Frequency of power cut*	MOST DISTRUPTIVE	LEAST DISRUPTIVE
Situation A:	3 days	My street or several local streets	Once every three years	○	○
Situation B:	24 hours	The whole of the ENW region	Once per year	○	○
Situation C:	6 hours	Just my property	Several times per year	○	○

2.2 Main findings

This section of the report details the analysis and results from over 2,000 respondents, a total of more than 48,000 data points[13]. Details of the model and outputs are given in the Appendix. The sub-sections that follow summarise the main findings derived from these models.

Figure 2.3 summarises the overall results for domestic and SME customers. All the results in this table are standardised against the disutility of moving from an interruption of up to 1 hour to an interruption of 6 hours. This provides a basis for comparing the impact of longer interruptions and the geographical scale of supply interruptions across customer groups.

The value of 100 for a 6 hour interruption versus a value of 0 for 'up to 1 hour' represents the model coefficient for this change divided by itself. All other results (eg a 12 hours interruption) are divided by the same model coefficient value for 6 hours versus 'up to 1 hour', to allow comparison of the magnitude of the dis-benefit associated with each level of interruption length, scale and frequency.

[13] 2,000 respondents x 2 responses x 12 scenarios

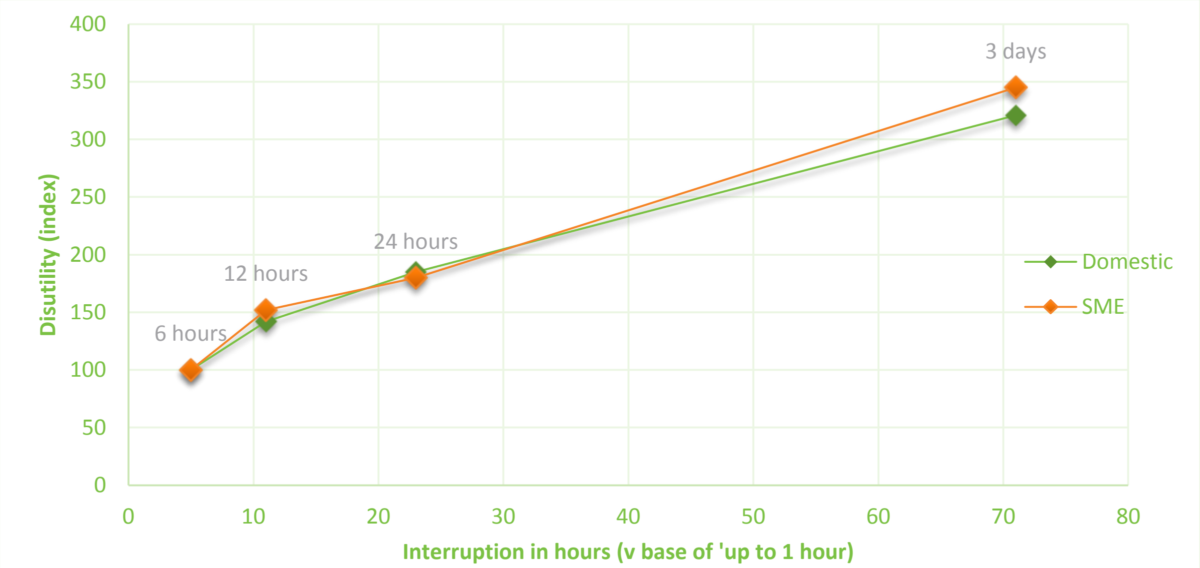
Figure 2.3: Results for total sample (indexed)

Attribute level		Domestic (all) N=1,545	SMEs (all) N=509
Length of supply interruption	Up to 1 hour (Base)	0	0
	6 hours	100	100
	12 hours	142	152
	24 hours	185	180
	3 days	321	345
Scale of interruption	Just my property (Base)	0	0
	My street or several local streets	7	-32
	My town/village and surrounding areas	18	35
	The whole of [REGION]	43	69
Frequency of interruption	Once every three years (Base)	0	0
	Once per year	22	39
	Several times per year	142	221

Length of supply interruption

These standardised model results from Figure 2.3 suggest that disutility increases at a reduced rate above a 12 hour interruption but then progresses steadily at that rate up to a 3 day interruption. This pattern, shown in Figure 2.4, is similar for Domestic and SME customers. It is also similar to the pattern observed in the earlier VoLL study, of which more is discussed in section 2.5.

Figure 2.4: The multiplier effect of large interruptions



Scale of supply interruption

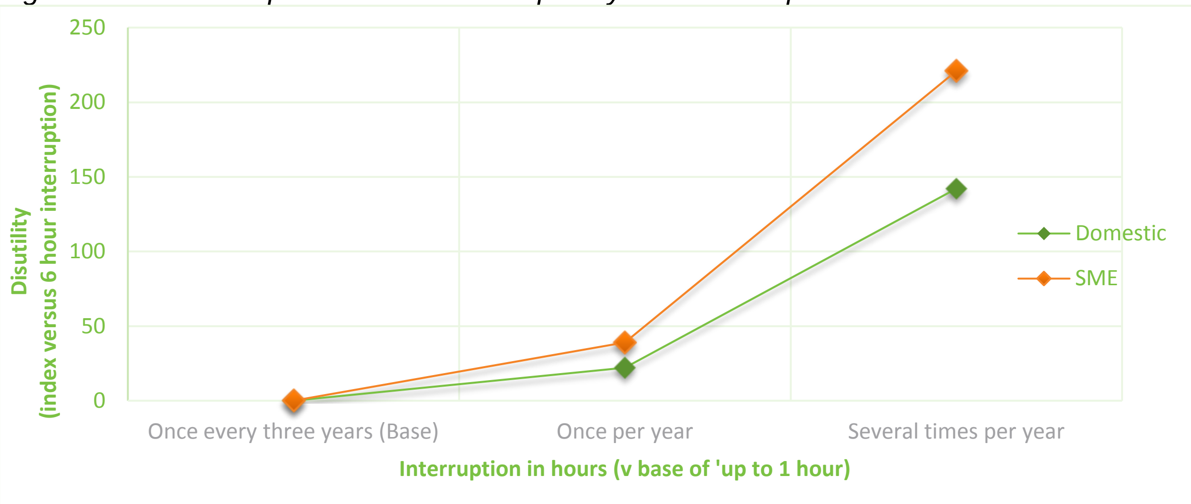
The standardised model results from Figure 2.3 and illustrated in Figure 2.5 suggest that disutility resulting from the scale of an interruption is different for Domestic and SME customers. Domestic customers register a relatively modest increase in disutility as the scale moves from ‘just my property’ to ‘my town/village/area’, where it then doubles if it moves to the whole of their region. SME customers show a similar pattern for town/village/area and whole region, but are least concerned if it occurs at the level of ‘my street / local’.

Figure 2.5: The multiplier effect of the geographical scale of an interruption

Frequency of supply interruption

Finally, the standardised results from Figure 2.3 shown below in Figure 2.6 suggest that disutility resulting from the frequency of an interruption is broadly similar for Domestic and SME customers, though more pronounced for the latter. Experiencing more than one interruption a year increases the disutility dramatically for both customer groups. This effect was also observed in the earlier VoLL study[14], indicating further similarity between the results of this study and the earlier work

Figure 2.6: The multiplier effect of the frequency of an interruption



[14] Electricity North West, NIA ENWL010 - Value of Lost Load to Customers , Section 2.5

2.3 Domestic: Length of supply interruptions

Figure 2.7 identifies domestic sub-groups that differ most notably in terms of the importance they place on the scale of supply interruptions. Generally there is relatively little difference between sub-groups, but the main points to note are:

- LCT users appear most sensitive to the longest interruption (3 days) and this is consistent for EV/hybrid and solar panel owners.
- Those who struggle to pay their bills, males and those aged 60 years or more all place higher weight on the longest interruption. Some of these are groups who may be concerned that they have limited options when coping with a long term interruption.
- Those who place relatively less importance on a long duration interruption include those on the lowest incomes, in an urban location and paying medium bills. These groups may also have limited options, but perceive it less strongly, some being a little more complacent with regard to long interruptions[15]
- Others who also show slightly lower sensitivity to a long interruption include the worst served[16], those in the AB socio-economic status group, females and customers with children at home.
- In all these cases, the importance attached to shorter interruptions is similar to the average, so the distinction is only for the most extreme.

[15] Counting the cost: the economic and social costs of electricity shortfalls in the UK: A report for the Council for Science and Technology (November 2014) https://www.raeng.org.uk/publications/reports/counting-the-cost, notes that, "The UK's history of high security of supply over the past four decades means that UK consumers are especially vulnerable to outages, as most will not have contingency measures in place." This was also evident in the qualitative engagement conducted with worst served customers as part of ENWL010[15]. Typically, urban customers who had never experienced an outage, or had done so very infrequently, were far less likely to have considered preparing for these eventualities

[16] Defined as those who claimed to have experienced four or more interruptions

Figure 2.7: Domestic sub-groups values for the length of supply interruptions

Sub-group	**n**	**Indexed (versus disutility of 6 hours versus up to 1 hour interruption)**			
		6 hours *(versus up to 1 hour)*	12 hours *(versus up to 1 hour)*	24 hours *(versus up to 1 hour)*	3 days *(versus up to 1 hour)*
Total Domestic	**1,545**	**-**	**42**	**85**	**221**
LCT user	177	-	36	80	251
Electric/hybrid vehicle	113	-	30	67	241
Solar panels	112	-	32	70	235
Struggle to pay bills	606	-	47	96	233
Males	739	-	40	91	231
Age: 60+ years	413	-	42	85	201
Worst-served	114	-	35	72	200
SEG: AB	345	-	33	77	200
Females	804	-	42	84	200
Children under 18 at home	395	-	32	75	200
MEDIUM electricity/gas bill	520	-	35	79	197
Urban location	307	-	33	78	195
Income <£15.5k	340	-	39	82	195

Domestic: Scale of supply interruptions

Figure 2.8 and Figure 2.9 identify sub-groups that differ most notably in terms of the importance they place on the scale of supply interruptions.

With reference to all the model outputs being standardised against the dis-benefit value of 100 for a 6 hour interruption versus a value of 0 for 'up to 1 hour' (see the beginning of this section 2.2), the results here represent the relative impact of increases or decreases in the scale of interruption on the same scale. For example, a value of 43 for an interruption that affects the whole region versus 'just my property' has a dis-benefit equivalent to 43% of the dis-benefit of going from an interruption of 'up to 1 hour' to a 6 hour interruption.

A negative figure, as observed for the whole region for owners of Electric/hybrid vehicles, indicates a *reduction* in dis-benefit (ie a positive benefit), relative to 'just my property', that is almost two thirds of the magnitude of the dis-benefit of a 6 hour interruption versus 'up to 1 hour'.

Groups placing higher than average importance on interruptions beyond their immediate property (see Figure 2.8):

- Those in the youngest age group (18-29 years) attach a much higher importance for all interruptions beyond their immediate property. Those in the next age group (30-44 years) also show higher importance to interruptions beyond their property, though this relates mainly to the local area only. Men also indicate a higher importance.
- High energy users and those with both electricity and gas show higher than average importance to all interruptions beyond their property.
- The results for all LCT user groups are not significantly different from zero, so are included here for indicative purposes only. EV/hybrid users appear to place high importance on an interruption that is beyond their property but confined to their near locality. This may be linked to the availability of charging points. This is reinforced by the observation that they place less importance on a region-wide interruption.

Groups placing lower than average importance on interruptions beyond their immediate property (see Figure 2.9):

- Older age groups and women attach lower than average importance to interruptions beyond their property.
- Groups such as those in the lowest income band and those on the PSR appear indifferent to the scale of interruptions. This may reflect a perception that their greater needs should be a priority
- Those in rural locations, off gas or worst-served all regard an interruption across their local streets as less important than for their property alone, which may be a function of their relative geographical remoteness and a greater level of self-reliance when responding to outages[17].

[17] 'Rural customers, who might be more likely to experience supply interruptions more frequently than urban customers, are less concerned because they are familiar with what to do and so are less anxious when interruptions happen. Rural customers often have torches and candles to hand or even own generators or alternative cooking equipment because they do not expect external support during supply interruptions', ENWL, October 2019, ECP Report, p14

Figure 2.8: Domestic sub-groups with higher values for the scale of supply interruptions

Sub-group	n	Indexed (v disutility of 6 hours versus up to 1 hour interruption)			
		Just my property	My street or several local streets	My town / village and surrounding areas	The whole of the region
Total Domestic	**1,545**	**-**	**7**	**18**	**43**
Electric/hybrid vehicle	113	-	*106*	*12*	*-68*
18-29 years	223	-	77	67	104
Income £15.5k-£24,999	304	-	40	39	65
High energy user	147	-	32	33	77
30-44 years	398	-	31	17	36
Electricity and gas in household	684	-	29	31	53
Males	739	-	28	33	49
Struggle to pay bills	606	-	27	8	45
Urban location	307	-	25	30	32
DE	378	-	17	18	21
Children under 18 at home	395	-	16	10	38

Results that are not significantly different from zero at the 95% level of confidence (one sample t-test) are shown in italics. Negative figures, highlighted in red, indicate less dis-benefit relative to the base level.

Figure 2.9: Domestic sub-groups with lower values for the scale of supply interruptions

Sub-group	n	Indexed (v disutility of 6 hours versus up to 1 hour interruption)			
		Just my property	My street or several local streets	My town/ village and surrounding areas	The whole of the region
Total Domestic	**1,545**	**-**	**7**	**18**	**43**
60+ years	413	-	*1*	10	28
Females	804	-	*0*	*3*	29
45-59 years	448	-	*0*	6	25
Worst-served	114	-	-6	14	30
Rural location	240	-	-12	*-2*	*3*
Off gas	138	-	-39	-15	*9*

Results that are not significantly different from zero at the 95% level of confidence (one sample t-test) are shown in italics. Negative figures, highlighted in red, indicate less dis-benefit, relative to the base level.

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2.4 SME sub-group analysis

SME: Length of supply interruptions

Figure 2.10 identifies SME sub-groups that differ most notably in terms of the importance they place on the length of supply interruptions. The main points to note are:

- Those with low electricity/gas bills are much more sensitive than other groups to interruptions of any length
- Owners of EV/hybrids also place more importance on all interruptions, but to a lesser extent
- Other groups who place slightly more importance on interruptions include small firms (fewer than 10 employees) and those off the mains gas network.
- Those sub-groups who place less importance on **interruptions are medium sized organisations, those with medium bills[18] and those in mixed urban/rural locations.**

Figure 2.10: SME sub-groups values for the length of supply interruptions

Sub-group	n	Indexed (versus disutility of 6 hours versus up to 1 hour interruption)			
		6 hours *(versus up to 1 hour)*	12 hours *(versus up to 1 hour)*	24 hours *(versus up to 1 hour)*	3 days *(versus up to 1 hour)*
Total SME	**509**	**-**	**52**	**80**	**245**
Low electricity/gas bill	124	-	103	148	397
Electric/hybrid vehicle	101	-	76	103	306
Fewer than 10 employees	211	-	51	88	273
Off gas	197	-	59	87	263
No electric/hybrid vehicle	408	-	46	74	229
Mixed urban/rural location	247	-	47	78	217
10-49 employees	128	-	52	68	208
Medium electricity/gas bill	182	-	35	64	202

[18] SME respondents reported their annual bill which was then classified as l0w (<£1,000 pa), medium (£1,000-£4,999) and high (£5,000+). For domestic respondents, who also reported the bill, the classifications were: low (< 800 pa), medium (£800-£1,199 pa) and high (£1,200+ pa)

SME: Scale of supply interruptions

Figure 2.11 identifies sub-groups that differ most notably in terms of the importance they place on the scale of supply interruptions. The main points to note are:

- Two SME sub-groups regard the impact of interruptions at street/local streets level to be less important than an interruption at their property, namely those with both electricity and gas, and those in the private sector. In reality, local interruptions are also likely to affect their property. It is noteworthy that those businesses in urban areas do not perceive a difference between an interruption at their property and one in their town/locality, so it is businesses in mixed or rural areas that drive this difference. This possibly reflects a relative sense of isolation in which their focus is primarily on their own property. A similar though less pronounced difference was observed for rural domestic customers
- Only those with high bills or with 10-49 employees regard interruptions at street/local streets level to be of equal importance to an interruption at their property. These SMEs also attach a much higher importance to larger scale interruptions.
- Other groups attaching higher than average importance to larger scale interruptions include those in urban locations and those who are off the mains gas network.
- The results for owners of EV/hybrid vehicles can only be considered as indicative, because the results are not statistically significant as a result of small sample sizes for this group. However, they give a directional hint that EV/hybrid vehicle users may place more importance on interruptions at their property and less on street/local street interruptions. This could reflect SMEs focussing on charging facilities on site and not regarding alternatives in the wider locality.
- All other appear indifferent to the scale of **interruptions.**

Figure 2.11: SME sub-groups values for the scale of supply interruptions

Sub-group	n	Indexed (versus disutility of 6 hours versus up to 1 hour interruption at 'just my property')			
		Just my property	My street or several local streets	My town/ village and surrounding areas	The whole of the region
Total SME	**509**	**-**	**-32**	**35**	**69**
High electricity/gas bill	143	-	*2*	*47*	127
10-49 employees	128	-	*24*	88	116
LCT user	127	-	*-93*	*130*	*93*
Urban location	157	-	*-5*	*26*	98
Off gas	197	-	*-3*	68	75
50-249 employees	170	-	*-84*	*29*	*72*
Electricity and gas	312	-	-54	*12*	68
Electric/hybrid vehicle	101	-	*-194*	*39*	*64*
Private sector	417	-	-37	34	58
Less than 10 employees	211	-	*-25*	*18*	*31*
MEDIUM electricity/gas bill	182	-	*-51*	*5*	*23*
LOW electricity/gas bill	124	-	*-103*	*-12*	*-8*

Results that are not significantly different from zero at the 95% level of confidence (one sample t-test) are shown in italics. Negative figures, highlighted in red, indicate a benefit, relative to the base level.

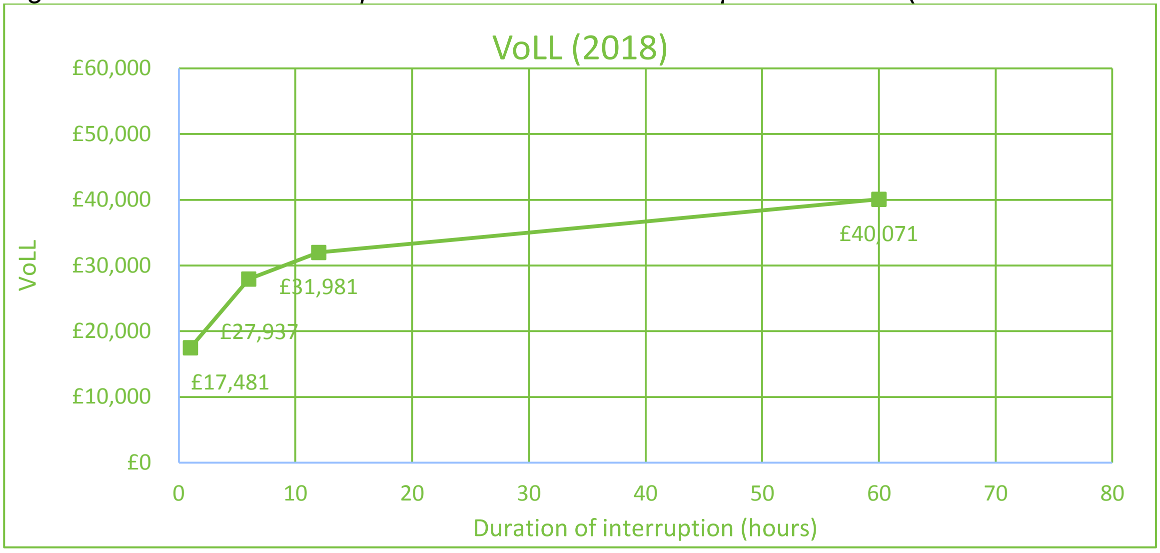
2.5 Applications for VoLL

The results reported in the preceding sections indicate the potential 'multiplier' effect that large scale interruptions could have on VoLL. It is important to note that to apply this to the established monetary values of VoLL, it must be assumed that the relationship between utility and value established in the previous VoLL study[19] will hold for these results so that they can be used to transform the standardised utility estimates into an equivalent monetary measure.

In the original VoLL study a relationship between VoLL and duration of interruption was established, as shown in Figure 2.12 below.

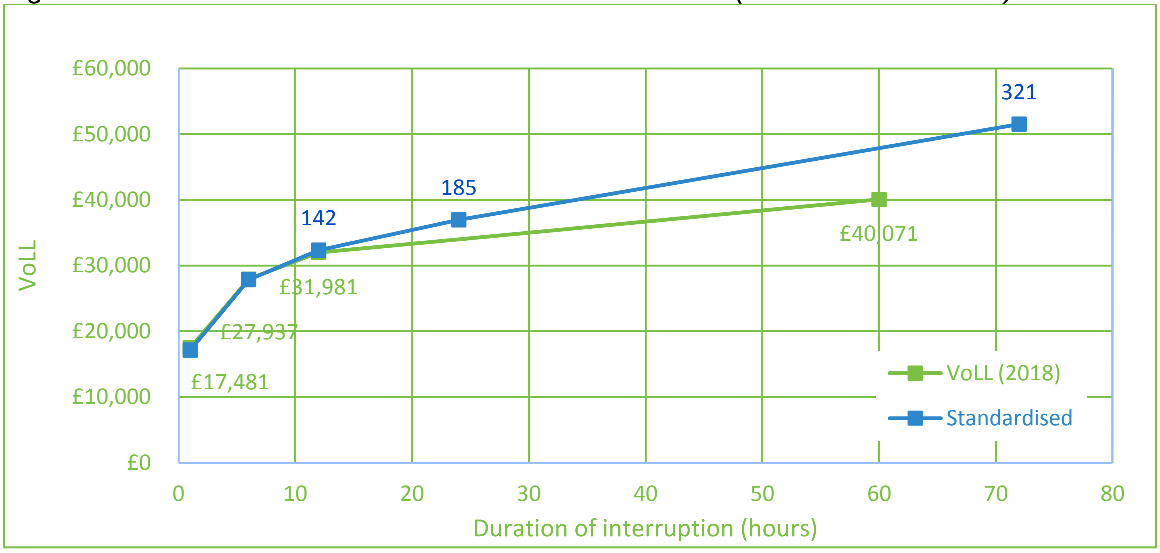
[19] Value of Lost Load to Customers Customer: Survey (Phase 3) Key Findings Report (October 2018) https://www.enwl.co.uk/globalassets/innovation/enwl010-voll/voll-general-docs/voll-phase-3-report.pdf

Figure 2.12: The relationship between VoLL and interruption duration (domestic customers)



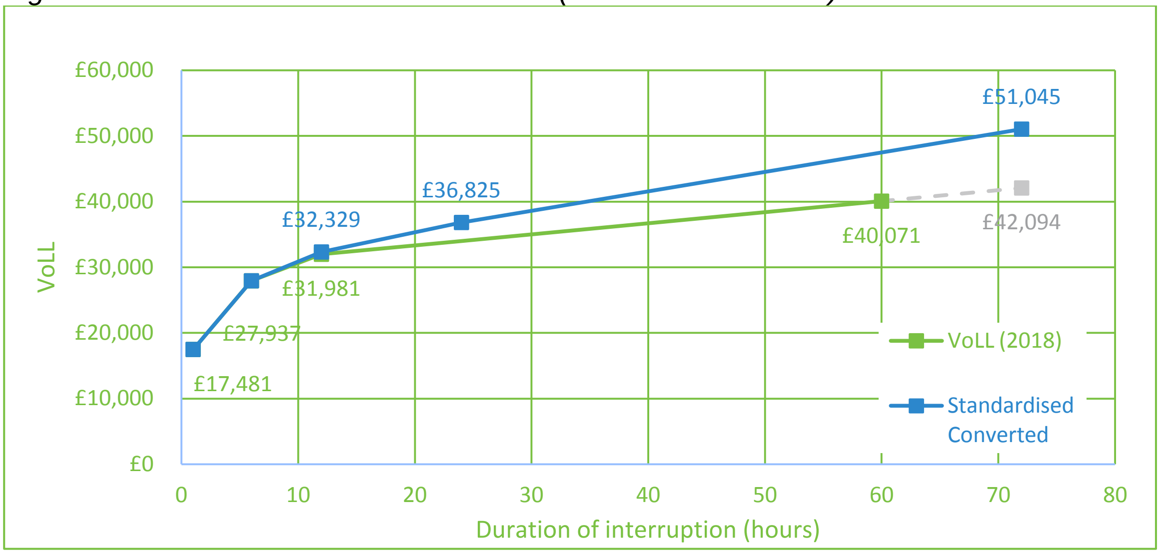
Taking the results from the current survey, the standardised values (indexed against the dis-utility of the change from 'up to 1 hour' interruption to 6 hours interruption) can be "overlaid" (fitted) onto Figure 2.12, as shown in Figure 2.13 below.

Figure 2.13: New standardised results overlaid on VoLL (domestic customers)



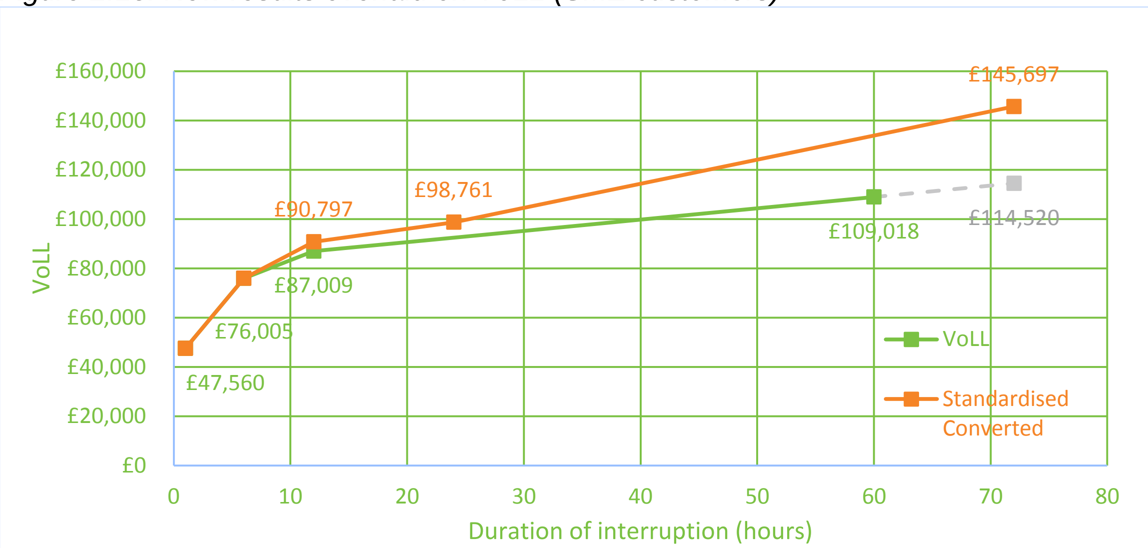
The standardised result of 100 for 6 hours versus 'up to 1 hour' is then assumed to be equivalent to a mean value £10,456 (this the £27,937 mean value for 6 hours minus £17,481 mean value for 1 hour), as taken from the earlier VoLL research. This conversion (£104.56 = 100 standardised units) is then applied to the other standardised values to give the values shown in Figure 2.14. In addition, the value of VoLL (2018) for a 3 day interruption (72 hours) is extrapolated from the 12 hours to 60 hours results to give an approximate comparator value.

Figure 2.14: New results overlaid on VoLL (domestic customers)



The implication here would be that the monetary value for VoLL progresses at a lower rate than the 'pure' multiplier effect measured in the current study. Figure 2.15 shows a similar relationship for SMEs, also suggesting a similarly lower value. However, in both cases the confidence intervals around these point estimates suggest that the difference is unlikely to be statistically significant[20].

Figure 2.15: New results overlaid on VoLL (SME customers)



[20] For example, in the earlier VoLL study, the estimates Domestic and SME VoLL for a 60 hour outage lay in the ranges of £37,154 to £42,987 and £103,814 to £114,222 respectively at the 95% level of confidence. If similar ranges are assumed for standardised converted values, then the differences in the central values would not be significant.

Finally, Figure 2.16 indicates the implied increase in VoLL when the scale of a 3 day interruption is beyond 'just my property'. As these figures are based on simple point estimates of VoLL, they should only be considered as indicative.

Figure 2.16: Potential Impact of large scale, 3-day service interruption on VoLL

3 day interruption in …	Domestic		SME	
	Standardised Value	Extrapolated VoLL	Standardised Value	Extrapolated VoLL
Just my property	321	£42,094	345	£114,520
Town / area	349	£45,766	380	£126,138
Whole region	364	£47,733	414	£137,424

2.6 The Multiplier Effect: Conclusions

The research shows that customers identify a multiplier effect for the dis-benefit of a large service interruption and that this relates both to the length of the interruption and the geographical scale of the interruption. Figure 2.17 summarises the implied multipliers that can be applied to the VoLL for a six-hour interruption (based on Figure 2.3).

Figure 2.17: Results for total sample (additive)

Attribute level		Domestic	SMEs
Length of supply interruption	6 hours	0.0	0.0
	12 hours	0.4	0.5
	24 hours	0.9	0.8
	3 days	2.2	2.5
Scale of interruption	Just my property (Base)	0.0	0.0
	My street or several local streets	0.1	-0.3
	My town/village and surrounding areas	0.2	0.3
	The whole of [REGION]	0.4	0.7
Frequency of interruption	Once every three years (Base)	0.0	0.0
	Once per year	0.2	0.4
	Several times per year	1.4	2.2

*For example, A six-hour interruption that only affected a customer's property, with a domestic VoLL of £42k based on the main VoLL study, implies a value of (£42k + £42k * (0.9 + 0.2) = £88k for a 24 hour interruption (0.9) that affected the town/village and surrounding areas (0.2)*

3 SOCIALISATION OF COSTS

3.1 Objective

A key objective of the research was to measure societal acceptance of a differentiated VoLL model, segmented by customer need. This was to be addressed by exploring customer views surrounding the socialisation of costs, and specifically, whether customers were willing to pay for investment to reinforce areas where LCT uptake may be high versus those living in fuel poverty.

The Contingent Valuation (CVM)[21] section of the main quantitative survey was designed to deliver an understanding of which groups are considered most in need and/or deserving of additional support or investment, according to electricity customers' willingness to pay for it through higher annual bills.

This was achieved by assessing the importance that domestic and SME customers place on restoring power after a supply interruption to different customer segments. The method evaluated their level of acceptance for a range of increases in their electricity bills, to enable DNOs to carry out faster or prioritised power restoration to each segment. Essentially it invited customers to express their willingness to pay for investment in specific areas of the network to support specific customer groups.

In this way, the CVM outputs were used as a proxy to assess customers' acceptance of investment prioritisation and consequently, perceptions around fairness of a variable model. This was considered the most appropriate mechanism for establishing perceptions on the basis that asking customers to respond directly to research of this type, which specifically refers to company investment decisions, is far too complex a proposition and introduces significant bias that would be unable to produce meaningful results[22].

Additional questions were also developed, in which customers were invited to prioritise investment in greater reliability of supply for different customer groups and to express views on fair charging.

All these topics are complex and can be difficult for customers to fully comprehend. The survey instrument was therefore subject to a robust pilot to review, endorse it, and to ensure these questions were supported by the optimum amount of education for comprehension and meaningful responses. The VoLL2 pilot survey report, published on the project webpage, outlines the results of the pilot study and resultant modifications. The questions presented in the main study therefore represent a balance between representing the topics with sufficient accuracy and relevance, while ensuring that customers have a good understanding of what they are being asked to assess.

3.2 Methodology

Each respondent was questioned in relation to five separate scenarios:

1. *If your electricity bill had to increase to ensure that adequate resources were available to* ***reduce the time it takes to restore power to vulnerable customers*** *(the elderly, sick and disabled), what level of increase would be acceptable to you?*

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[21] The Contingent Valuation method is a stated preference technique that is widely used to research consumer valuations. See ICF, *Improving willingness-to-pay research in the water sector*, 2017, p19.

[22] This was thoroughly evidenced in the earlier qualitative ECP research where it was apparent that customers struggled to understand the complexities, despite thorough explanations of how different customer groups rely on and value their supply and introducing questions about if and how this information should be taken into account when Electricity North West has to make difficult choices. Participants were unable to disassociate prioritisation about who benefits first from investment decisions with the notion of others losing out.

2. *How acceptable would you find an increase of £x on your annual bill to enable DNO to **prioritise restoring power to your household/business**?*
3. *How acceptable would you find an increase of £x on your annual bill to enable DNO to **prioritise restoring power to vulnerable customers** (the elderly, sick and disabled) **and other groups that would suffer more than most** during an interruption (residents in remote areas)?*
4. *How acceptable would you find an increase of £x on your annual bill to enable DNO to **prioritise restoring power to customers that use electricity to charge their electric vehicles or have solar panels**?*
5. *How acceptable would you find an increase of £x on your annual bill to enable DNO to **prioritise restoring power to customers living in fuel poverty** that would suffer more than most during an interruption?*

For each of the five scenarios, respondents were presented with an amount by which their annual bill would increase in order to reduce time to restoration of power or to prioritise power restoration to each of the customer groups in each scenario. The starting value for this initial bill increase was selected randomly from the list of possible values (a different scale was used for domestic and SME customers, to reflect the very different sizes of average annual bills).

Respondents were then asked how acceptable this increase would be. If they found the increase to be acceptable, respondents were presented with a higher amount, and asked about their level of acceptance to this new level. The process was repeated until respondents reached an amount they would not consider to be acceptable to them, or the maximum level in the list of possible values was reached; if respondents did not consider the initial price increase to be acceptable to them, the next level down was shown until an acceptable amount was found, or the lowest price point in the study was reached.

A total of 11 levels of annual bill increase were included for each scenario (see Figure 3.1 below). The 11 levels ranged from 50p to £20 for domestic customers. For SME respondents, the levels of increase were percentages of annual bill ranging from 0.5% to 10%. These were converted to monetary values using the actual bill information provided by the respondent. For the minority of SME customers who were unable to estimate their company's annual bill (n=60/509: 12% of SMEs), only the percentage value was shown.

The respondents were randomly assigned a starting increase between levels 4 and 8 (initial increase shown £6-£14 per year for domestic customers, 3-7% for SMEs).

Any respondents who were unwilling to pay any additional amount on their annual bill were assigned a zero value.

Figure 3.1: Levels of annual bill increase for domestic and SME customers

Level	Domestic customers	SME customers
1	50p per year	0.5% of annual bill
2	£2 per year	1%
3	£4 per year	2%
4	£6 per year	3%
5	£8 per year	4%
6	£10 per year	5%
7	£12 per year	6%
8	£14 per year	7%
9	£16 per year	8%
10	£18 per year	9%
11	£20 per year	10%

3.3 Analysis and results

The standard Turnbull methodology was used to calculate overall WTP as it accounts for any variation within the sample and is arguably a better estimator to use as a WTP proxy than a simple weighted average. A *'Turnbull Estimate'* is an established way of estimating a lower and upper boundary that respondents would be willing to pay.

The Turnbull method involves two steps:

1. Deriving lower and upper boundaries from the monetary values: The lower boundary is derived for each level by multiplying the level value (eg 50p) by the % of respondents who would accept the increase at that level. The upper boundary is derived by multiplying the value one level above (eg £2) by the % of respondents who would accept the increase at the lower (ie 50p) level. From this, an average lower value and an average upper value is calculated.
2. The average WTP is the mid-point of the average between the lower and upper boundaries.

The overall results from the five scenarios are shown in Figure 3.2 below:

Figure 3.2: Willingness to pay to support different customer segments

Respondent customer type	Scenario 1 Restore power to vulnerable customers sooner	Scenario 2 Prioritise your household/ business	Scenario 3 Prioritise vulnerable customers	Scenario 4 Prioritise EV or solar panel users	Scenario 5 Prioritise fuel poor customers
Domestic (n=1,545)	**£10.86** (£10.17-£11.54)	**£9.71** (£9.02-£10.39)	**£9.71** (£9.01-£10.41)	**£5.67** (£5.06-£6.28)	**£8.67** (£7.97-£9.38)
SME * (n=449)	**£169.95** (£153.44-186.46)	**£155.78** (£139.61-171.74)	**£143.74** (£127.62-159.86)	**£117.18** (£102.52-131.83)	**£136.26** (£120.77-151.75)
SME % increase	**4.2%** (3.8%-4.6%)	**3.8%** (3.4%-4.2%)	**3.6%** (3.2%-4.0%)	**2.9%** (2.5%-3.3%)	**3.4%** (3.0%-3.8%)

* Only those SME respondents who provided an estimate of their annual electricity bill were included in the analysis.
All figures in brackets are the low-high estimates produced by the Turnbull method. Figures in bold are the average.

The results in Figure 3.2 indicate a difference in WTP between reducing restoration time for vulnerable groups (scenario 1) and *prioritising* restoration (scenario 3). Domestic respondents were willing to pay an additional £10.86 to reduce the time it takes to restore power (scenario 1) but only £9.71 to give a priority to vulnerable customers (scenario 3). The same pattern applies to SME respondents (£169.95 versus £143.74: a 4.2% versus 3.6% increase). This suggests that respondents are in principle supportive of vulnerable groups when it comes to restoring power, but less so when that support could be detrimental to others' experience.

Respondents appear to be willing to pay a similar supplement (in the region of £10 for domestic and £150 for SMEs) to prioritise restoring power to their own household/business (scenario 2) as they are to prioritise vulnerable customers (scenario 3).

The WTP value for prioritising power restoration to customers living in fuel poverty (scenario 5) was lower than for vulnerable customers in scenario 3: £8.67 versus £9.71 for domestic; £136.26 versus £143.74 (3.4% versus 3.6%) for SMEs. This may reflect some respondents considering that these customers already receive support from government and that the responsibility for supporting this group lies with the government and less so with themselves.

There was considerably less WTP to support low carbon technology (LCT) users who are users of EVs or have solar panels installed (scenario 4). Here the average WTP is £5.67 for domestic (£5.09 for non-LCT users); £117.18 / 2.9% for SMEs (£94.86 / 2.4% for non-LCT users). This may reflect a perception that LCT users are generally more affluent and therefore not a priority group (see further discussion of this later in the section below.

3.4 Sub-group analysis

The results in Figure 3.3 below show the largest differences across customer sub-groups for each of the five scenarios. Note that no formal significance testing has been carried out for these Turnbull estimates. Additionally, given that the main purpose of the study is to understand the **differences in levels of prioritisation** and support offered to the different customer groups, WTP for SMEs will focus more on **percentage bill increase**, rather than a monetary value per se (although both are useful measurements): The monetary WTP value for SMEs is more a reflection of size of company eg an SME respondent who owns a larger company may appear to be willing to pay more than a smaller SME in financial terms, but the % increase they are prepared to accept may be **lower** than a business with a lower annual fuel bill.

Figure 3.3: Scenario 1 – Reduce the time it takes to restore power to vulnerable customers

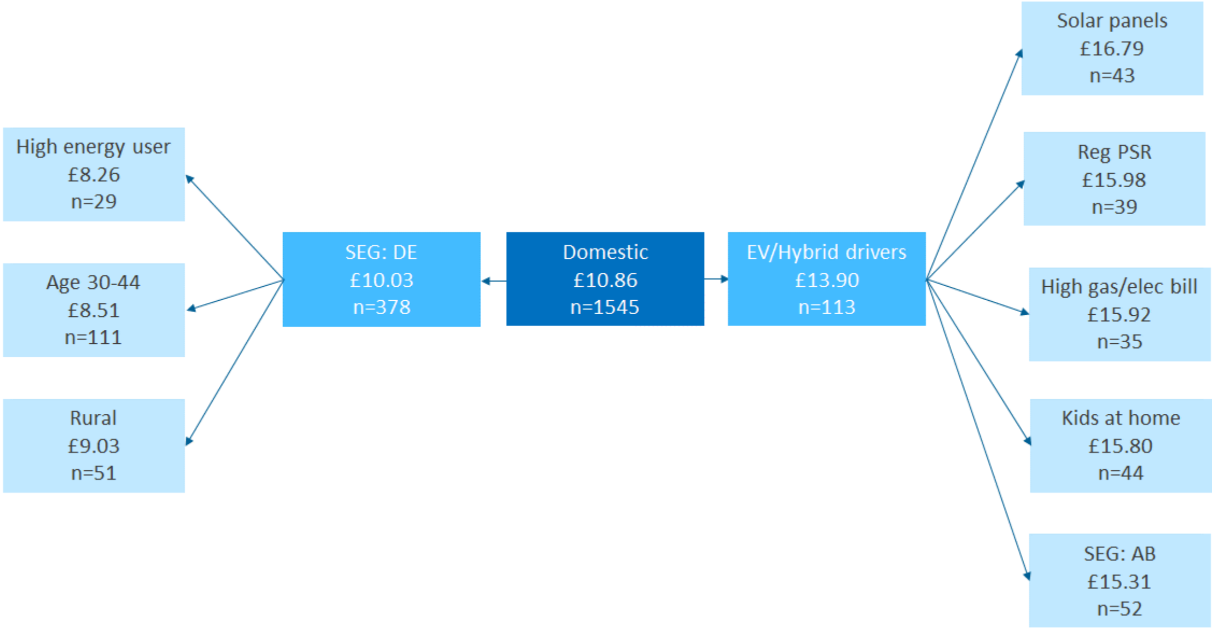
Domestic respondents	Base	WTP (£)	Difference from total
Domestic total	**1,545**	**£10.86**	**£0.00**
EV/hybrid vehicle user	113	£13.90	£3.04
LCT user	177	£12.85	£1.99
Solar panels	112	£12.73	£1.87
Age: 18-29	223	£12.12	£1.26
High utility fuel bills	424	£11.94	£1.09
Children under 18 at home	395	£11.81	£0.95
Urban location	307	£11.77	£0.91
Registered on PSR	185	£11.74	£0.89
Income £40k and over	355	£11.62	£0.76
Income <£15.5k	340	£10.15	-£0.71
4+ supply interruptions in 3 years	114	£10.11	-£0.75
SEG: DE	378	£10.03	-£0.83

Respondents who use low carbon technologies (EV/solar panels) have a greater than average WTP (this is true across all five scenarios). The younger population of respondents (18-29 years) appear to be more socially aware than other groups, and willing to pay an additional £12.12 per year to reduce the time it takes to restore power to vulnerable customers.

Perhaps unsurprisingly, WTP is reflective of financial circumstance; those in socio-economic segment DE, possibly having less disposable income, have WTP levels lower than average (although their average WTP is still £10.03).

The range in WTP levels increase greatly when drilling down further into the data eg considering those groups with highest and lowest WTP, as shown in Figure 3.4.

Figure 3.4: Scenario 1 – Sub-group WTP levels for domestic groups with highest and lowest WTP



Users of EV/hybrid vehicles who have children at home, for example, have a much higher WTP, whilst those who are classified as socio economic segment DE and who have high energy usage or who live in rural areas have a much lower WTP. One issue to consider here is the potential influence of income on *ability* to pay, which will partly contribute to WTP values. Analysis of VoLL in the earlier study showed that the value for EV/hybrid users could be reduced by a quarter when adjusted for income. However, those in rural areas remained much the same and high energy users had lower values still (reduced by about one sixth). If applied to these results, the adjustment would imply that EV/hybrid users are close to the average WTP once adjusted for income.

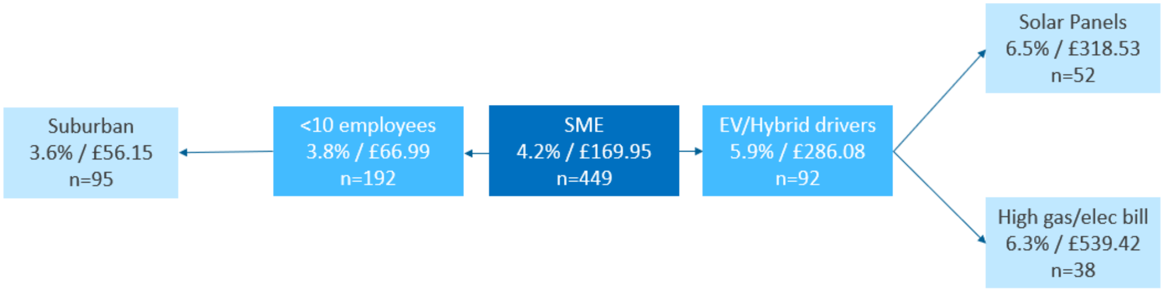
Figure 3.5: Scenario 1 – Reduce the time it takes to restore power to vulnerable customers

SME respondents	Base	WTP (%)	WTP (£)	Difference from total
SME total	**449**	**4.2%**	**£169.95**	**-**
EV/hybrid vehicle user	92	5.9%	£286.08	£116.13
Solar panels	78	5.7%	£265.50	£95.55
LCT user	116	5.4%	£242.05	£72.10
4+ supply interruptions in 3 years	53	5.0%	£239.59	£69.64
50-249 employees	147	4.7%	£292.49	£122.54
Urban location	140	4.6%	£217.94	£47.99
Low utility fuel bills	124	4.5%	£29.62	-£140.33
Medium utility fuel bills	182	4.0%	£105.17	-£64.78
Mixed urban/rural location	220	4.0%	£151.29	-£18.66
<10 employees	192	3.8%	£66.99	-£102.97

** SMEs with high utility fuel bills have a WTP % of 4.2% (on par with SME total). However due to its size, it has a much higher WTP value of £367.75 (almost £200 greater than the average), and therefore worthy of note.*

Those SME respondents using LCTs are happy to pay a higher % of their bill as a supplement in exchange for a reduction in the time it takes to restore power to vulnerable customers: EV/hybrid vehicle owners are prepared to pay 5.9% on top of their current annual bill. Companies with less fewer than 10 employees are prepared to pay an increase of 3.8%, suggesting that they may have other priorities such as maintaining the viability of the company and cash flow for example.

Figure 3.6: Scenario 1 – Sub-group WTP levels for SME groups with highest and lowest WTP



SME respondents who use an EV/hybrid vehicle and who also have solar panels installed are willing to accept an average annual bill increase of 6.5%, whilst those with fewer than 10 employees in mixed urban/rural areas are only prepared to pay on average an increase of 3.6%.

Figure 3.7: Scenario 2 – Prioritise restoring power to your household

Domestic respondents	Base	WTP (£)	Difference from total
Domestic total	**1,545**	**£9.71**	**-**
EV/hybrid vehicle user	113	£12.60	£2.90
LCT user	177	£11.90	£2.20
Children under 18 at home	395	£11.10	£1.40
Urban location	307	£11.07	£1.36
Registered on PSR	185	£10.94	£1.24
Age: 18-29	223	£10.91	£1.21
High utility fuel bills	424	£10.89	£1.19
Fuel poor	85	£8.87	-£0.84
Income <£15.5k	340	£8.69	-£1.02
Rural location	240	£8.55	-£1.16

Domestic customers who use an electric vehicle or a hybrid have a greater than average WTP (this is true across all five scenarios). Households with young dependents would be prepared to pay more than average for prioritisation of power to their household. The more urban the location, the greater the WTP to prioritise restoring power to their household.

As with the other scenarios, WTP is somewhat reflective of financial circumstance; those with lowest incomes, and possibly having less disposable income, have WTP levels lower than average (WTP £8.69 for respondents with an income of less than £15.5k).

Differences in WTP are more pronounced when looking at sub-groups of EV/hybrid users and those in rural areas as shown in Figure 3.8.

Figure 3.8: Scenario 2 – Sub-group WTP levels for domestic groups with highest and lowest WTP

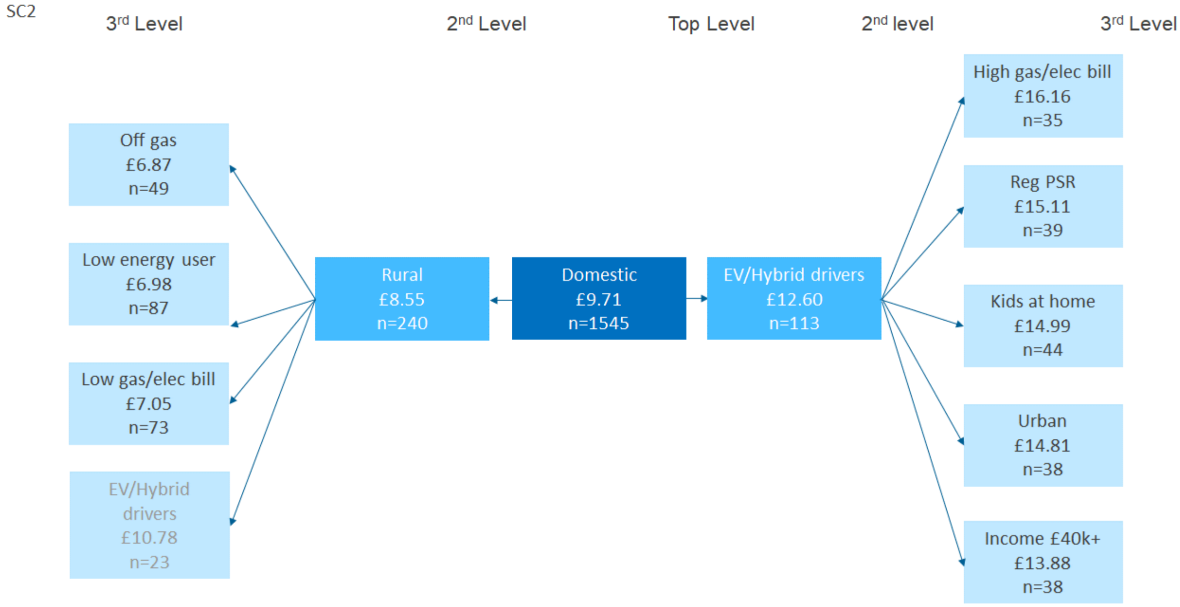


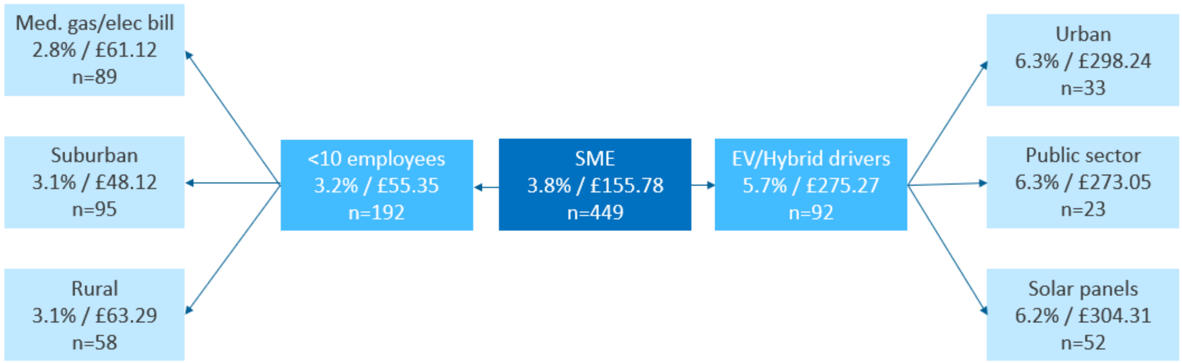
Figure 3.9: Scenario 2 – Prioritise restoring power to your property

SME respondents	Base	WTP (%)	WTP (£)	Difference from total
SME total	**449**	**3.8%**	**£155.78**	**-**
EV/hybrid vehicle user	92	5.7%	£275.27	£119.49
Solar panels	78	5.2%	£240.74	£84.96
LCT user	116	4.9%	£218.90	£63.13
50-249 employees	147	4.6%	£281.06	£125.28
Urban location	140	4.6%	£216.67	£60.89
Medium utility fuel bills	182	3.5%	£91.19	-£64.59
Rural location	87	3.5%	£123.79	-£31.98
<10 employees	192	3.2%	£55.35	-£100.42

** SMEs with high utility fuel bills have a WTP % of 4.1%. However due to its size, it has a much higher WTP value of £358.50 (more than £200 greater than the average), and therefore worthy of note.*

Those respondents who use an EV or hybrid vehicle, or other low carbon technologies would be prepared to pay proportionally more than other groups (5.7% increase in their annual bill) to prioritise restoring power to their household. Those SMEs in a rural location, or those with fewer than 10 employees have a lower WTP of 3.5% and 3.2% respectively.

Figure 3.10: Scenario 2 – Sub-group WTP levels for SME groups with highest and lowest WTP



For EV/hybrid vehicle users, the WTP % increases when the company is located in an urban area, is a public sector company, or a company with solar panels. Conversely, the WTP values decrease when companies with fewer than 10 employees are located in more rural areas.

Figure 3.11: Scenario 3 – Prioritise restoring power to vulnerable customers

Domestic respondents	Base	WTP (£)	Difference from total
Domestic total	**1545**	**£9.71**	**-**
EV/hybrid vehicle user	113	£12.66	£2.96
LCT user	177	£11.64	£1.93
High utility fuel bills[23]	424	£11.01	£1.30
Urban location	307	£10.70	£0.99
Children under 18 at home	395	£10.69	£0.98
Registered on PSR	185	£10.67	£0.96
Income £40k and over	355	£10.61	£0.90
Age: 18-29	223	£10.54	£0.83
Income <£15.5k	340	£8.84	-£0.87
SEG: DE	378	£8.73	-£0.98

As with other scenarios, respondents who use an electric vehicle or a hybrid have a greater than average WTP (£12.66). Those with higher fuel bills are willing to accept a bigger increase in their annual bill (an additional £11.01). WTP is also to some extent a reflection of income, financial security, and also location.

Differences in WTP become more pronounced when looking at sub-groups of EV/hybrid users and those in socio-economic segment DE as shown below.

[23] As indicated early, domestic respondents reported their annual bill which was then classified as low (< 800 pa), medium (£800-£1,199pa) and high (£1,200+ pa)

Figure 3.12: Scenario 3 – Sub-group WTP levels for domestic groups with highest and lowest WTP

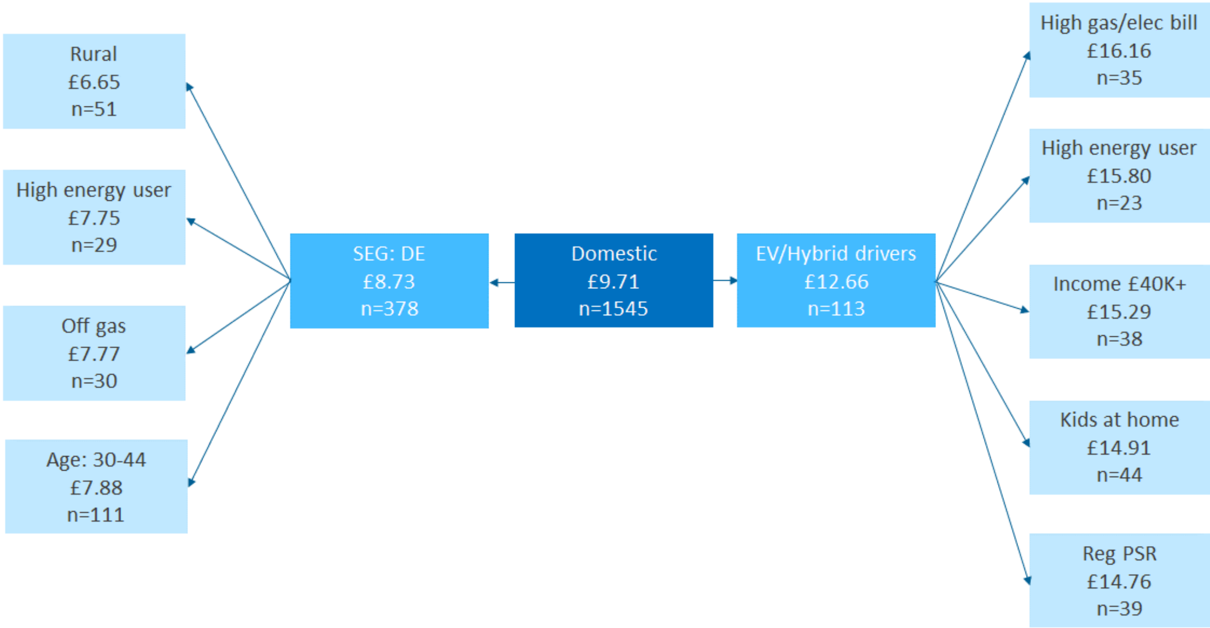


Figure 3.13: Scenario 3 – Prioritise restoring power to vulnerable customers

SME respondents	Base	WTP (%)	WTP (£)	Difference from total
SME total	**449**	**3.6%**	**£143.74**	**-**
Solar panels	78	4.8%	£224.77	£81.03
Electric/hybrid vehicle	92	4.8%	£233.48	£89.74
LCT user	116	4.4%	£195.94	£52.20
Urban location	140	4.1%	£195.32	£51.58
Public sector	75	4.0%	£179.55	£35.80
50-249 employees	147	3.9%	£238.76	£95.02
Low utility fuel bills	124	3.9%	£25.50	-£118.24
Mixed urban/rural	220	3.4%	£129.10	-£14.65
<10 employees	192	3.3%	£57.79	-£85.96
Rural	87	3.2%	£112.06	-£31.68

** SMEs with high utility fuel bills have a WTP % of 3.4%. However due to its size, it has a much higher WTP value of £299.96 (approximately £150 greater than the average), and therefore worthy of note.*

Those SME respondents who have solar panels installed, or make use of an EV or hybrid vehicle would be prepared to pay a larger percentage increase of their current annual bill to prioritise restoring power to vulnerable customers (4.8% increase). Public sector SMEs, those with greater numbers of staff, and those in more urban locations are also prepared to pay proportionally more – perhaps part of corporate responsibility and government legislation. This is in contrast to businesses with small numbers of employees, or those located in more rural areas, who have a lower than average % WTP.

Figure 3.14 includes some key sub-groups with the greatest WTP difference from the SME average of 3.6%. Users of EVs/hybrids have been used as opposed to those businesses with solar panels for sample size purposes:

Figure 3.14: Scenario 3 – Sub-group WTP levels for SME groups with highest and lowest WTP

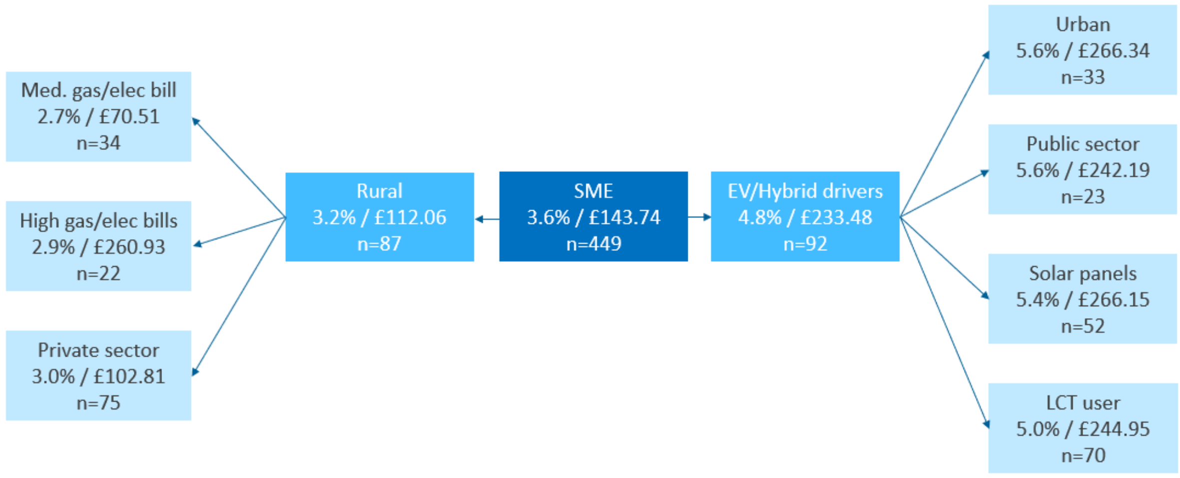


Figure 3.15: Scenario 4 – Prioritise restoring power to EV/solar panel users

Domestic respondents	Base	WTP (£)	Difference from total
Domestic total	**1,545**	**£5.67**	**-**
EV/hybrid vehicle user	113	£11.42	**£5.75**
LCT user	177	£10.15	**£4.48**
Age: 18-29	223	£7.52	£1.85
Children under 18 at home	395	£7.17	£1.50
Urban location	307	£7.14	£1.47
Registered on PSR	185	£6.97	£1.30
Age: 30-44	398	£6.75	£1.08
High energy user	147	£6.67	£1.00
Income £40k and over	355	£6.42	£0.75
Low energy user	555	£4.84	-£0.83
Age: 60+	413	£4.79	-£0.88
Rural location	240	£4.78	-£0.89
Age: 45-59	448	£4.68	-£0.99

This scenario, being more salient to EV users, brings about large differences between EV/hybrid users and other customers. Non-EV owning participants in the earlier ECP work generally perceived that EV owners are thought to be more affluent ("*people with electric vehicles, I would imagine, are quite affluent, because they're not cheap, electric vehicles"*) and as a result less deserving of prioritisation ("*So the impact if you're a poor person might be, I can't eat. The impact on someone with an electric vehicle might be… I can't drive to a very nice restaurant this evening!*")
Some sub-groups (eg 18-29, those with dependent children in the household) are a little more willing to accept an increase in annual bill to prioritise restoring power to this group, but these values are still lower than those observed in the other scenarios. This may imply that

the younger generation is more environmentally aware and recognise the wider environmental benefits of transitioning to a low carbon economy. Certainly other research[24] has indicated that those aged 18-29 were slightly more likely to actively engage with energy efficiency technologies and proactively seek out more efficient alternatives.

In the same vein, it might be that families with children at home may be more anxious about a future legacy for children which fails to address these environmental challenges. However, in the other research, those with children were most likely to approach energy efficiency from the view of saving money.

Figure 3.16: Scenario 4 – Sub-group WTP levels for domestic groups with highest and lowest WTP

WTP value increases for users of EV/hybrid vehicles who also have solar panels installed (WTP: £14.35). Those aged 45-59 living outside of urban areas are likely to place a lower priority on restoring power to those with EVs/solar panels (WTP: £3.89 for rural, £4.36 for mixed urban/rural dwellers).

[24] ENWL, 2020, ENW Vulnerable and non-vulnerable surveys, unpublished

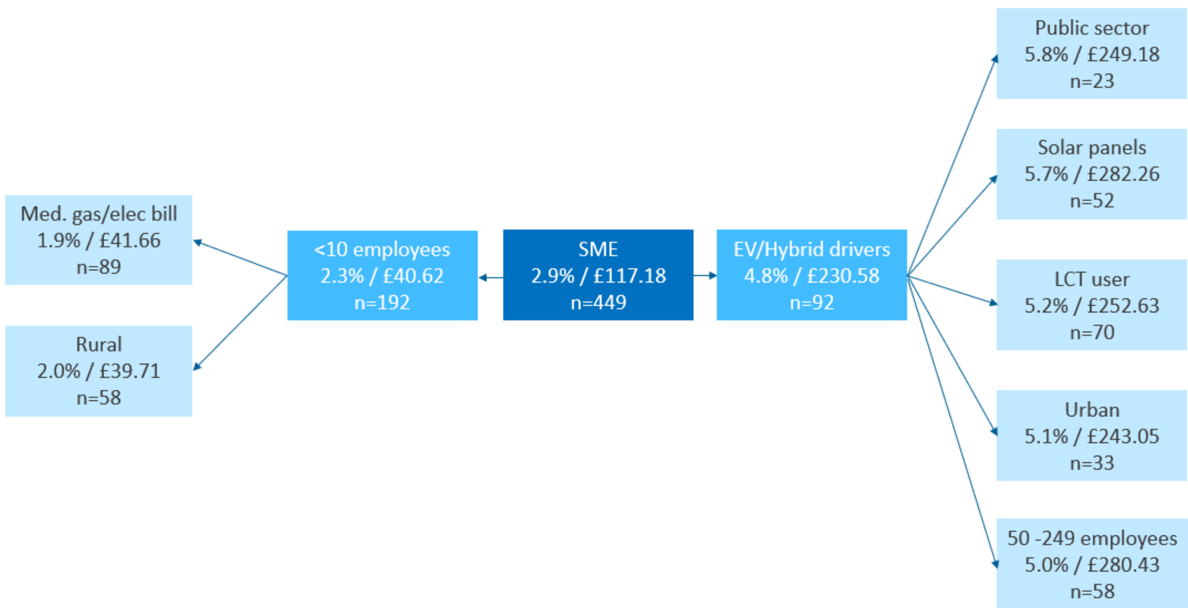
Figure 3.17: Scenario 4 – Prioritise restoring power to EV/solar panel users

SME respondents	Base	WTP (%)	WTP (£)	Difference from total
SME total	**449**	**2.9%**	**£117.18**	-
Electric/hybrid vehicle	92	4.8%	£230.58	£113.40
Solar Panels	78	4.6%	£212.98	£95.81
LCT user	116	4.2%	£188.64	£71.47
Public sector	75	3.8%	£167.42	£50.24
50-249 employees	147	3.7%	£226.48	£109.31
Low utility fuel bills	124	3.5%	£22.89	-£94.29
Urban	140	3.4%	£160.21	£43.03
Private sector	373	2.7%	£108.38	-£8.79
Medium utility fuel bills	182	2.6%	£68.85	-£48.33
Rural	87	2.5%	£87.47	-£29.70
<10 employees	192	2.3%	£40.62	-£76.56

** SMEs with high utility fuel bills have a WTP % of 2.7%. However due to its size, it has a much higher WTP value of £240.80 (approximately £125 greater than the average), and therefore worthy of note.*

Unsurprisingly, those SME respondents who make use of an EV or hybrid vehicle, or have solar panels installed would be prepared to pay a higher proportion on top of their current annual bill to prioritise restoring power to EV/solar panel users. Public sector businesses would be willing to pay an increase of 3.8% on their annual bill, perhaps due to government initiatives to fulfil social obligations to the community. Those in the private sector, in rural areas or those employing small numbers of employees are only willing to accept a small percentage increase on their bill.

Figure 3.18: Scenario 4 – Sub-group WTP levels for SME groups with highest and lowest WTP



For EV/hybrid vehicle users, the WTP % increases even further when the company is in the public sector (5.8%). Conversely, the WTP values decrease when companies with fewer than 10 employees are located in more rural areas (WTP 2%).

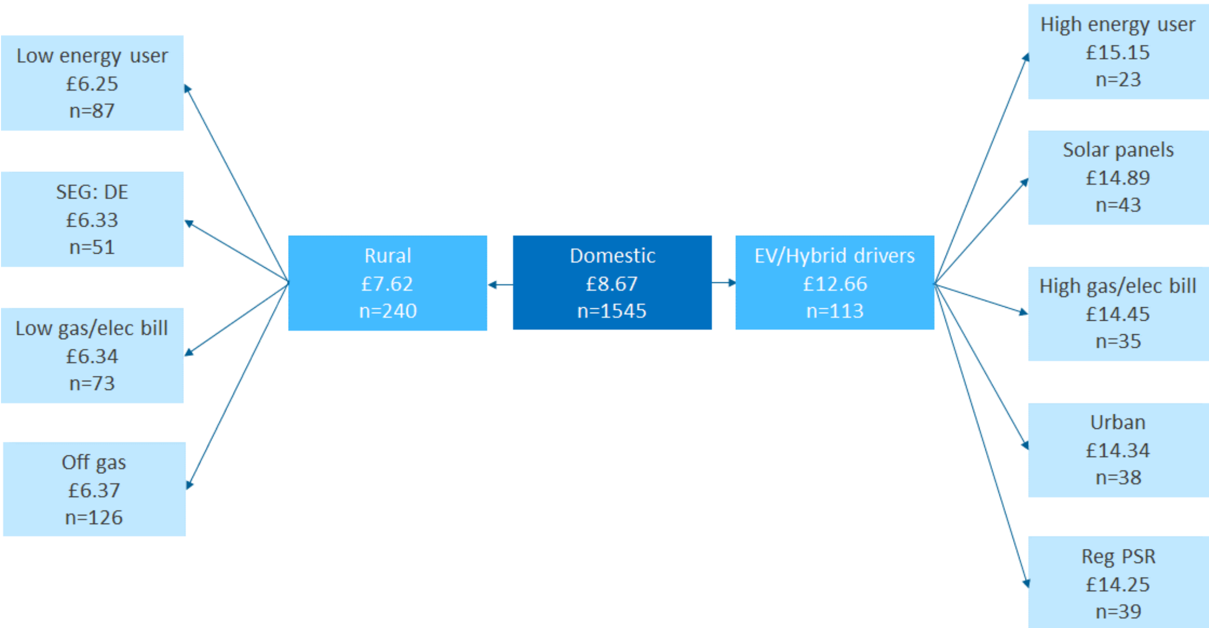
Figure 3.19: Scenario 5 – Prioritise restoring power to fuel poor customers

Domestic respondents	Base	WTP (£)	Difference from total
Domestic total	**1545**	**£8.67**	**-**
EV/hybrid vehicle user	113	£11.85	£3.18
LCT user	177	£10.93	£2.25
Urban location	307	£9.98	£1.30
Children under 18 at home	395	£9.87	£1.20
High utility fuel bills	424	£9.77	£1.10
Age: 18-29	223	£9.63	£0.95
High energy user	147	£9.52	£0.85
Registered on PSR	185	£9.44	£0.77
Rural location	240	£7.62	-£1.05

The patterns of results are similar to the other scenarios, with respect to the respondent sub-groups: Respondents who use an electric or a hybrid vehicle have a higher WTP (£11.85 versus £8.67 for total sample), as do households with young dependents and the youngest cohort. WTP also appears to be somewhat related to location and size of bill.

Differences in WTP are emphasised when exploring sub-groups of EV/hybrid users and those in rural locations in greater detail:

Figure 3.20: Scenario 5 – Sub-group WTP levels for domestic groups with highest and lowest WTP



Those in rural areas who have low energy usage, have low bills, are off gas, or are socio-economic status DE have WTP values of over £1 that are lower than the average for rural respondents (£7.62).

Figure 3.21: Scenario 5 – Prioritise restoring power to fuel poor customers

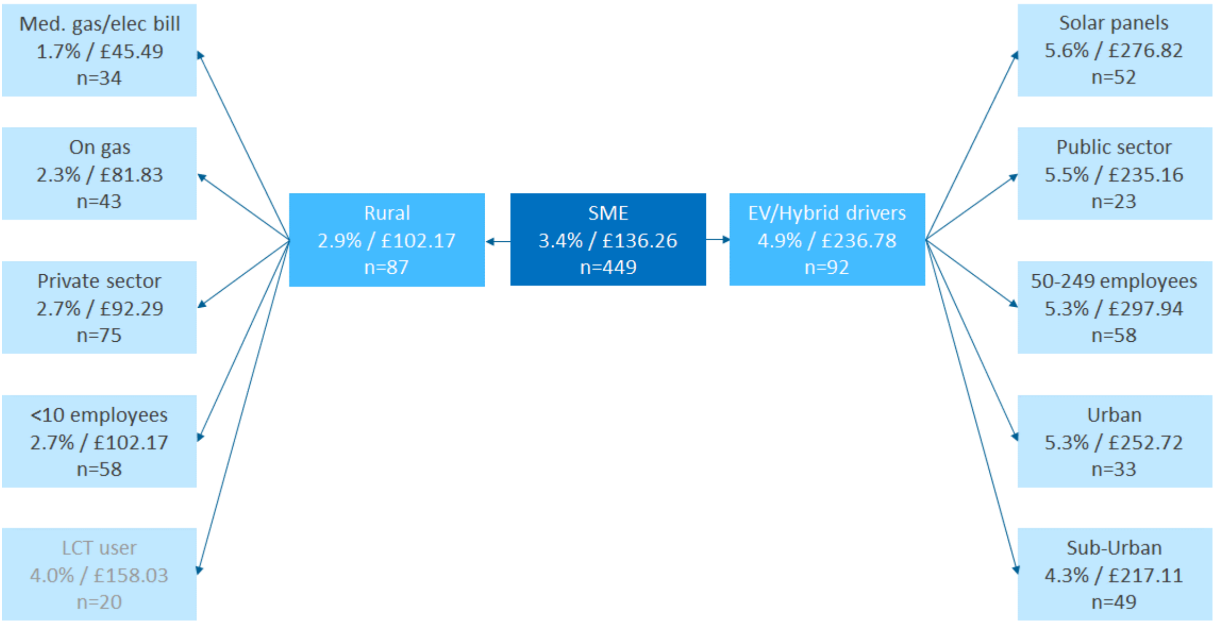
SME respondents	Base	WTP (%)	WTP (£)	Difference from total
SME total	**449**	**3.4%**	**£136.26**	**-**
Electric/hybrid vehicle	92	4.9%	£236.78	£100.51
Solar panels	78	4.6%	£213.73	£77.47
LCT user	116	4.3%	£190.57	£54.30
Low utility fuel bills	124	3.9%	£25.78	-£110.48
50-249 employees	147	3.9%	£239.60	£103.34
Urban location	140	3.8%	£182.14	£45.88
Public sector	75	3.7%	£165.95	£29.68
Medium utility fuel bills	182	3.1%	£81.00	-£55.26
<10 employees	192	3.0%	£52.02	-£84.25
Rural location	87	2.9%	£102.17	-£34.10

** SMEs with high utility fuel bills have a WTP % of 3.2%. However due to its size, it has a much higher WTP value of £285.63 (approximately £150 greater than the average), and therefore worthy of note.*

SME respondents who use an electric or hybrid vehicle, those with solar panels or using other low carbon technologies would be prepared to pay a higher percentage increase on their annual bill to prioritise restoring power to fuel poor customers. Public sector SMEs, those with greater numbers of staff, and those in more urban locations are also prepared to pay proportionally more – perhaps part of corporate responsibility and government legislation. This is in contrast to businesses with small numbers of employees or those located in more rural areas, which have a lower than average % WTP.

The following diagram explores in greater detail respondents with EVs/hybrids, and those SME respondents whose businesses are located in rural areas. A more striking difference in WTP emerges for these smaller groups:

Figure 3.22: Scenario 5 – Sub-group WTP levels for SME groups with highest and lowest WTP



Companies in rural areas, especially those with a moderate bill size, those in private sector and smaller companies are likely to have a propensity to accept a smaller proportional increase in their annual bill. This is in contrast to SMEs where the respondent drives an EV/hybrid vehicle and who has solar panels, whose business is in the public sector, or whose company is generally larger in size.

3.5 Summary of customers' willingness to pay for the socialisation of costs

The order of priorities is summarised in Figure 3.23 and Figure 3.24. The main observations to draw from this analysis are:

- There is consistent agreement across domestic and SME customers in terms of the order in which different groups of people have power restored to them, as defined by the five different WTP scenarios.
- Vulnerable groups are generally being prioritised above those who are Fuel poor – perhaps those who are fuel poor are considered to already receive support from government and that the responsibility for supporting this group lies with the government and less so with themselves. Those with EV/solar power are considered to be lowest priority.
- The scenario with greatest importance is 'getting power restored to vulnerable groups' – scenario 1 (although as soon as the term "priority" is mentioned, as in scenario 3, WTP generally decreases). This suggests that respondents are in principle supportive of vulnerable groups when it comes to restoring power, but less so when that support could be detrimental to their own experience. Evidence of this is that respondents were willing to pay similar amounts of money to prioritise getting power restored to their own household/business, as they are prioritising getting power restored to vulnerable groups.

Figure 3.23: Domestic customers: – Order of importance of each scenario

Order	Scenario	Description	% of 897 sub-groups who agree with the order
1	1	Scenario 1 – restore power to vulnerable customers sooner	97% (out of 897 sub-groups)
2	2	Scenario 2 – prioritise your household/ business	55% (40% rated as 3rd most important
3	3	Scenario 3 – prioritise vulnerable customers	56% (41% rated as 2nd most important
4	5	Scenario 5 – prioritise fuel poor customers	94%
5	4	Scenario 4 – prioritise EV or solar panel users	98%

Figure 3.24: SME customers: – Order of importance of each scenario

Order	Scenario	Description	% of 212 sub-groups who agree with the order
1	1	Scenario 1 – Restore power to vulnerable customers sooner	83% (out of 212 sub-groups)
2	2	Scenario 2 – Prioritise your household/ business	70% rated as 2nd most important
3	3	Scenario 3 – Prioritise vulnerable customers	58% rated as 3rd most important
4	5	Scenario 5 – Prioritise fuel poor customers	72%
5	4	Scenario 4 – Prioritise EV or solar panel users	84%

3.6 Supplementary socialisation questions

The following section relates to questions asked outside the BWS and CVM exercises that were designed to understand customer sentiment about the costs of prioritising certain groups, how these could be most fairly recovered, and which groups should be prioritised.

***Question*: Remembering that all of DNO customers pay for the operation and upkeep of its network and a small element of this cost covers support services, to what extent do you agree that [Name of DNO] should:**

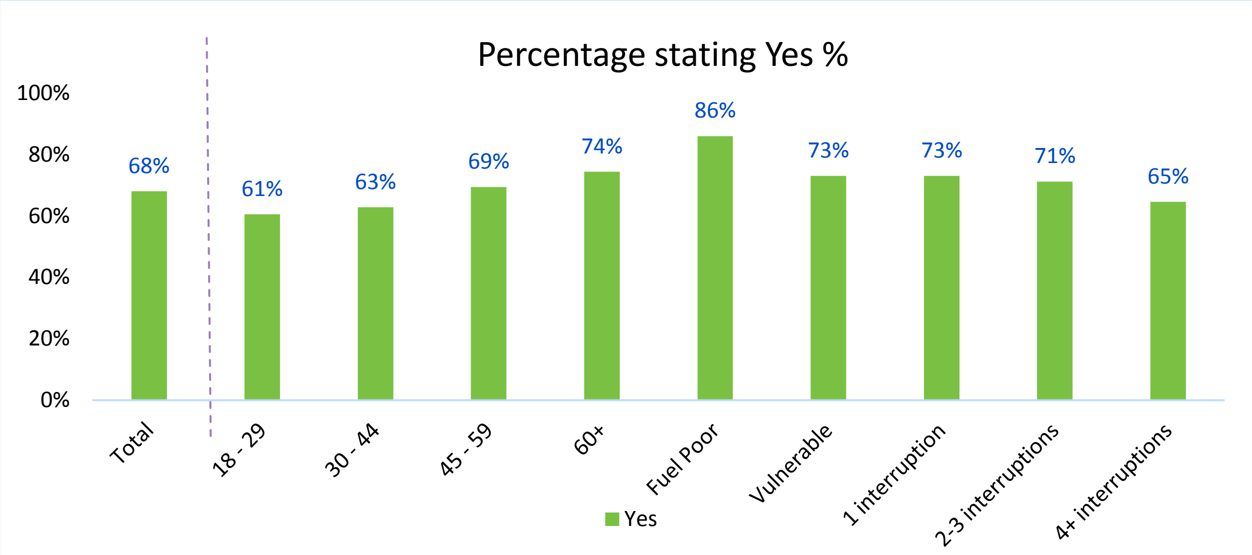
- *Contact vulnerable customers to offer practical advice and information updates during power cuts*
- *Prioritise repairs when vulnerable customers have power cuts – this means that other customers, that are experiencing an interruption, may be off for longer.*

In general, there is wide agreement (68% of customers) that vulnerable customers should be prioritised. This is consistent with the higher willingness to pay determined for these groups. Respondents felt that vulnerable customers should be contacted with updates, practical advice and information. This was particularly supported by those aged 60+ (76%) and females (71%), but other groups were more ambivalent especially those aged 18-29 (55%), those who heavily rely on electricity (60%).

***Question*: Do you believe that [Name of DNO] should allocate funds to identify customers that are likely to be vulnerable during an interruption, but are not already known to them and sign them up to the Priority Services Register, so everyone who is eligible for support during an interruption receives it?**

Support for PSR identification is dispersed across the age groups with those aged 45 and above being more likely than those aged 18-44 to support measures which increase the number of vulnerable people identified. Those identifying as vulnerable or fuel poor are, as expected, more supportive than average. Support decreases with the number of interruptions a person has experienced in the last three years.

Figure 3.25: Support for investment in PSR identification



Question: ***How fair is it that higher users of electricity pay proportionally more towards the upkeep, overall running and improvement of the network?***

Many people are unsure how fair the proportional charging for usage of the network is as 43% felt this was neither fair nor unfair versus 48% who believed this was a fair charging system when considering overall running and improvement to the network. Those aged 18-29 expressed particular ambivalence at 58%.

45-59 year olds were given to believing the charging structure is most unfair at 18% versus 13% in total. Other segments also stated that this charging system is unfair, in particular, those who hadn't experienced an interruption in the last three years (16%) versus those who had experienced an interruption (10%). This was also the case for those classified as having a heavy reliance on electricity – 32% of these customers believed this is unfair.

Those who felt this system is unfair stated that payments should be the same regardless of usage as different customer segments have different needs[25].

"High use may be because of low insulation/old houses or elderly needing more heat. They may not have extra income to afford higher rates"

"Because the service should be better prepared and supported to cope and manage with such incidents that we have been experiencing."

Those who felt this system was fair believed that those who use more electricity should pay more for the upkeep of the infrastructure.

"You are using more of the service it is only fair that you contribute a little more, also it is likely that in most instances the largest users have the greatest resources so are in a better position to pay a larger proportion of the costs"

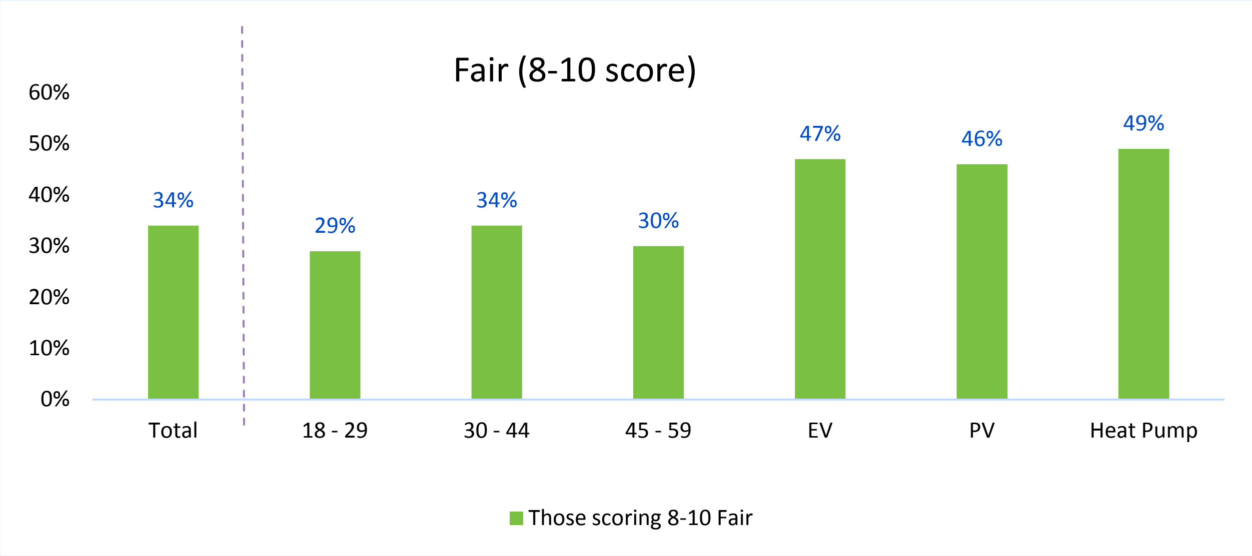
"Why should a pensioner living on their own pay the same as a large business organisation. The cost should be pro-rata according to their usage."

Question: ***How fair or unfair is it that charges do not reflect cost differences across the same region? For example, urban and rural customers pay the same towards their bill, when the costs for a network company vary between rural and urban networks.***

Generally, customers were unsure how fair or unfair this aspect of the charging system is with 55% of the total sample expressing ambivalence. Those aged 60+ were more likely to agree it is fair than the younger age groups. Not surprisingly, those had not experienced an interruption in the last three years were most likely (17%) to state that this is completely fair compared with those who had experienced an interruption (12%). This was also the case for LCT users, with 43% stating they felt this was fair versus non-LCT users at 32% with the overall average being 34%. Heat pump users in particular were most likely (49%) to state this was a fair system.

[25] Responses to the open-ended question 'Why do you say that?' which followed every scenario rating

Figure 3.26: Perceived fairness of within-region socialisation of cost



__Question__: Distribution charges cover all the costs of delivering a safe, reliable and cost-effective service. How important do you consider these investment priorities to be for distribution companies?

1. *Ensure that all customers receive the same level of reliability*
2. *Focus on worst areas of reliability and improve these*
3. *Improve reliability in areas with lots of customers in vulnerable situations or living in fuel poverty*
4. *Improve reliability in areas forecast to have large numbers of electric vehicles*
5. *Improve overall network reliability so that all customers can benefit from electric vehicles and low carbon technology in future.*

When asked to rank these different investment priorities (presented in random order), equality of reliability (1) came out as most important, followed by improving worst-served areas (2) and areas with many customers in vulnerable situations (3), followed by upgrading the network for LCTs in general (5) with improvements for EV users (4) being considered the least important.

Domestic customers are a little more supportive of the investment scenarios than SME customers, particularly with regard to improving worst-served areas (2) and improving areas with many vulnerable customers (3).

All those classified as living in urban regions are more likely to support investment into LCTs (5).

Those domestic customers who are aged 18-44 were a little more disposed to investment that prioritised high areas of EVs (4) (52% versus 48% for aged 45+). In contrast, those aged 45-60+ were notably less likely to support that scenario, though there were no age differences concerning LCTs for everyone (scenario 5).

Those in the DE social grade category and/or on the PSR place less priority on scenario 1 (reliability for all) and scenario 5 (LCTs for all) but do not give significantly different ratings to the other scenarios. This suggests that these groups want parity with scenarios that ensure that more vulnerable groups have equal priority.

1. Ensure that all customers receive the same level of reliability

This was considered most important for those aged 60+ at 95% versus 18-29 year olds of whom 75% rated this important versus 87% overall. Women also gave this higher priority than men. LCT users were least likely to rate this as important with 81% of domestic LCT users and 75% of SME LCT users agreeing versus 88% and 85% of the respective non-LCT users.

The importance placed on everyone receiving the same reliability is consistent with results from a similar question in the main study, where achieving the same level of reliability for everyone was ranked higher than focussing on the worst areas[26].

2. Focus on worst areas of reliability and improve these

Those who have a low reliance on electricity rated this higher (89% versus 87% of domestic customers). This may suggest that those with low dependency may not perceive there to be viable alternatives when service interruptions occur. The scenario was rated very highly by those aged 60+ but somewhat lower by those under 45 years. This may reflect a perception among older customers that they live in less well served areas, which correlates with their higher concern for scenario 3 (supporting vulnerable and fuel poor).

3. Improve reliability in areas with lots of customers in vulnerable situations or living in fuel poverty

Those aged 18-29 were less willing to consider vulnerable customers / fuel poverty as important compared with other age groups (72% versus 78% overall). Those who are considered worst served are least likely to rate support for those in fuel poverty as important at 69% (versus 81% overall).

4. Improve reliability in areas forecasted to have large numbers of electric vehicles

Generally there is a lot of consensus that investment to support EVs should be the lowest priority when considering other sub groups and regions. Unsurprisingly, LCT users were most likely to support this type of investment priority, but even for them it was not a top priority. More of those living in urban areas believed that investment in these areas was important versus rural dwellers.

Directionally, public organisations (56%) were more likely than private organisations (42%) to consider this investment priority as important.

5. Improve overall network reliability so that all customers can benefit from electric vehicles, and low carbon technology in future.

Generally, this measure had a similar rating across most groups: less important than scenarios 1 to 3, but higher than 4 (focus on EV users) as a statement relating to future LCT benefits for all customers. As part of this distinction of general LCT versus a focus on EV users, private organisations (68%) were more likely to consider investment into LCT areas as important, compared to public organisations (55%). Larger organisations gave higher than average priority to both LCT scenarios.

Figure 3.27: Investment Priorities (Domestic)

How important do you consider these investment priorities to be for distribution companies?					
% stating 'Important'	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5

[26] The question in the main study asked customers to identify the most important priority over the next few years for (1) Keep customer bills constant (2) Ensure all customers receive the same level of reliability (3) Focus on the worst areas of reliability and improve and (4) Improve reliability where the benefits to customers outweigh the costs to the DNO.

Among domestic customers, 38% chose (1), 29% chose (2), 20% chose (3) and 14% chose 4. Among SMEs, the priorities were less clear cut: 30% chose (1), 27% chose (2), 18% chose (3) and 25% chose 4.

or ‘Very important’	Ensure that all customers receive the same level of reliability	Focus on worst areas of reliability and improve these	Improve reliability in areas with lots of customers in vulnerable situations or living in fuel poverty	Improve reliability in areas forecast to have large numbers of electric vehicles	Improve overall network reliability so that all customers can benefit from electric vehicles and low carbon technology in future
Total	**87%**	**81%**	**81%**	**50%**	**68%**
Male	85% ↓	79%	78% ↓	50%	67%
Female	89% ↑	83%	83% ↑	50%	69%
18 - 29	75% ↓	73% ↓	72% ↓	52%	67%
30 - 44	81% ↓	74% ↓	78%	53%	66%
45 - 59	91% ↑	82%	82%	49%	70%
60+	95% ↑	90% ↑	86% ↑	47%	69%
SEG: DE	83% ↓	78%	80%	49%	63%
On PSR: Yes	81% ↓	82%	82%	49%	59% ↓
On PSR: No	89% ↑	81%	81%	50%	71% ↑
Children under 18 in household	84%	78%	78%	56%	72%
No children in household	89% ↑	83%	82%	48%	68%
LCT user	81% ↓	80%	79%	55%	72%
Non LCT user	88% ↑	81%	81%	49%	68%
Low reliance on electricity	89% ↑	84%	79%	52%	66%
Urban location	87%	79%	79%	50%	69% ↑
Worst served[27]	85%	76%	69% ↓	46%	62%

Figure 3.28: Investment Priorities (SME)

How important do you consider these investment priorities to be for distribution companies?					
% stating ‘Important’	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5

[27] Four or more interruptions experienced in the last three years

or 'Very important'	Ensure that all customers receive the same level of reliability	Focus on worst areas of reliability and improve these	Improve reliability in areas with lots of customers in vulnerable situations or living in fuel poverty	Improve reliability in areas forecast to have large numbers of electric vehicles	Improve overall network reliability so that all customers can benefit from electric vehicles and low carbon technology in future
Total	**83%**	**74%**	**71%**	**45%**	**66%**
Rural	85%	82%	74%	32% ↓	56%
Urban	83%	73%	72%	48% ↑	70% ↑
LCT user	75% ↓	69%	72%	64% ↑	72%
Non-LCT user	85% ↑	76%	71%	38% ↓	64%
Less than 10 employees	87%	79%	74%	37% ↓	64%
Between 10 and 19 + Between 20 and 49	80%	71%	63%	45%	65%
Between 50 and 99 + Between 100 and 249	79%	71%	74%	54% ↑	70%

***<u>Question</u>*: There are many factors that distribution companies could consider in running the electricity network to ensure charging is fair.**

Please rank the following charging priorities in order of importance, which you believe a distribution company should be taking into account with 1 being the most important and 9 being the least.

This question was developed as part of the extensive piloting prior to the main survey. The original approaches to this topic proved challenging for respondents. It was therefore found necessary to remove much of the education materials that were originally intended and ask this question at high level, using simple, one-line descriptions[28]. Figure 3.29 below summarises the responses.

Figure 3.29: Importance scores for fair charging factors

Statement	Rank	Importance score (Average)	Sub group analysis
Charges should encourage efficiency ie be based on a standard rate for everyone up to a certain limit, ensuring basic needs are covered. After which, unit rates increase, meaning large users pay more than others.	1	49% (3.8)	

[28] ENWL, 2020, VoLL Multiplier Report: 'This pilot demonstrated that a compromise must be reached between the type and quality of data required and the depth of engagement possible within a small section of a quantitative survey. In this case, the data quality is likely to be optimal using shorter descriptions and education materials to produce high-level prioritisation only. Providing more detailed education in this format with the aim of informing more granular prioritisation was apparently counter-productive as respondents became confused.'

Statement	Rank	Importance score (Average)	Sub group analysis
Charges should take account of the strain that a property puts on the network, ie large users of electricity, such as those who need to charge an electric vehicle, pay more.	2	45% (4.3)	Males see this as more important at 48% versus females at 40%.
Charges should change according to the time of day electricity is used ie charging more at peak times when the network is under greatest strain, and less at other times, to encourage people to use appliances when electricity is cheaper	3	40% (4.4)	This is considered more important for LCT users as 49% versus non-LCT users at 39%. Those living in a rural location were more likely to consider this important at 45% versus urban 39%. SMEs in particular find this more important with 47% versus 38% domestic sample.
Charges should take account of dependence on electricity	4	36% (4.4)	This was rated 2nd importance more by those classified as vulnerable (19%) and fuel poor (29%)
Charges should take account of customers' ability to afford to pay the electricity bill	5	35% (5.0)	This was higher for those in socio-economic status group DE (21%) and those classified as fuel poor (29%)
Charges should take account of businesses that could help the network respond to peaks in electricity demand by adjusting how they use or generate electricity	6	25% (5.4)	
Charges should be based on the value or size of your property (like non-metered water bills)	7	29% (5.4)	This was considered important by those classified as heavy reliance at 44% versus other reliance categories at 28%.
Charges should take account of the number of people living in a household	8	23% (5.7)	
Charges should reflect customers' positive contribution to a zero carbon economy	9	17% (6.3)	

3.7 Socialisation of Cost: Conclusions

The use of the WTP measures and subsequent questions on investment in reliability and fair charging indicate that customers support approaches that prioritise the needs of vulnerable customers and those who are currently poorly served. The needs of those who are fuel poor are seen as less of a priority and all these groups take precedence over the needs of LCT users, current and future.

However, this prioritisation must be in the context of *all* customers receiving adequate levels of investment. The general customer view appears to be that sufficient investment should be made to meet the particular needs of vulnerable customers and to this extent, a mechanism that enables this (ie variable VoLL) is supported. Yet this must not be at the expense of adequate investment for everyone else.

4 APPENDIX 1: STATISTICAL MODELS

4.1 Survey design

They key elements of the main survey are detailed below. The full customer questionnaire can be found on the project website.

4.2 Trade-off research

‘Main effects’ Multinomial Logit (MNL) model form

The ‘main effects’ model for both domestic and SME customers was:

P (Choice)$_i$ = β_{11}*(6 hours interruption,0,1)$_i$ + β_{12}*(12 hours interruption,0,1)$_i$ + β_{13}*(24 hours interruption,0,1)$_i$ + β_{11}*(3 days interruption,0,1)$_i$ +

β_{21}*(‘My street or several local streets’,0,1)$_i$ + β_{22}*(‘My town/village and surrounding areas’,0,1)$_i$ + β_{23}*(‘the whole of my region’,0,1)$_i$ +

β_{31}*(‘Once per year,0,1)$_i$ + β_{32}*(‘More than once per year’,0,1)$_i$

The base levels for each attribute were:

β_{10} = ‘Up to one hour interruption’
β_{20} = ‘Just my property’
β_{30} = ‘Once every three years’
No intercept was included as no alternative-specific bias was expected.

For the Best-Worst Scaling modelling, the analysis is essentially the same as for conventional Choice Exercises, with one modification: the design matrix is doubled up to incorporate two choices rather than one. The data set has as many rows as there are concepts * choice sets * respondents, as with any conventional Choice Exercise. Each row has a description of the concept (columns are effects-coded) plus a response variable indicating whether it was chosen or not. However, in Best-Worst modelling the tallness of the matrix is doubled by stacking beneath it a negatively coded matrix (all columns for effects-coded concept descriptions multiplied by -1) plus response indicators for the items selected as worst.

‘Main effects’ MNL model outputs

The model outputs for total domestic and SME, estimated using the Sawtooth HB/CBC package, are shown below.

Figure A.1: Model outputs for all domestic customers

		coefficient	se	t-Stat
Length	Up to 1 hour	0.00	0.000	-
	6 hours	-2.77	0.145	19.10
	12 hours	-3.91	0.138	28.39
	24 hours	-5.20	0.147	35.37
	3 days	-7.60	0.178	42.57
Scale	Just my property	0.00	0.000	-
	My street or several local streets	0.03	0.058	0.52
	My town/village and surrounding areas	-0.05	0.057	0.83
	The whole of my region	-0.39	0.066	5.86
Frequency	Once every three years	0.00	0.000	-
	Once per year	-0.37	0.057	6.46
	Several times per year	-1.95	0.083	23.59
	RLH	0.61	n=1545	

Figure A.2: Model outputs for all SME customers

		coefficient	se	t-Stat
Length	Up to 1 hour	0.00	0.000	-
	6 hours	-2.36	0.227	10.42
	12 hours	-3.14	0.221	14.19
	24 hours	-3.84	0.231	16.66
	3 days	-5.71	0.279	20.49
Scale	Just my property	0.00	0.000	-
	My street or several local streets	0.07	0.099	0.70
	My town/village and surrounding areas	-0.06	0.097	0.65
	The whole of my region	-0.40	0.109	3.70
Frequency	Once every three years	0.00	0.000	-
	Once per year	-0.51	0.107	4.78
	Several times per year	-2.25	0.152	14.82
	RLH	0.56	n=509	

All coefficients are of the expected sign and most are significantly different from zero at the 95% level of confidence (t-Stat >=1.96). The only exceptions are the scale levels between 'just my property' and 'the whole of my region'.

Standardisation of model outputs

To allow comparison of the model results across sub-groups and in relation to previous work on VoLL, the model coefficients were standardised against the disutility of '6 hours interruption' versus the base level of 'Up to 1 hour interruption'. This allowed interpretation of the results for large scale interruptions to be expressed in terms of a 'multiplier' against this base level of disutility.

The hierarchical Bayesian approach used in the model estimation produces coefficients at an individual respondent level. The estimation process begins with a standard Maximum Likelihood estimation based on the whole sample and finesses the results through a large number of iterations to arrive at a respondent-level estimate that aims to best fit the 12 responses given by each respondent.

A key step, described in the main report, was to standardise the model coefficients. All coefficients were divided through by the coefficient a 6 hour interruption versus a value of 0 for 'up to 1 hour' and multiplied by 100. This allowed the results for all customer groups to be compared on a common basis, namely the size of the dis-benefit relative to this base of 6 hours versus 'up to 1 hour' interruption.

The individual model estimates were used to derive standardised measures at the respondent level, with the intention of allowing more differentiation between sub-group results. The alternative was be to standardise the coefficients at the aggregate level, but this was considered likely to offer less differentiation.

Figures A.3 and A.4 compare the standardised results derived from the two approaches (standardisation of individual estimates versus standardisation of group aggregate coefficients). All mean values are based on results for individual respondents with the top and bottom 5% of values removed, so as to reduce the effect of outliers. This was important, as it was observed that the distribution of these results was generally skewed towards higher values. The standard error was calculated using the 'delta method'[29].

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[29] London Economics, 2013, The Value of Lost Load (VoLL) for Electricity in Great Britain, p17. $V(y/x) = V(y)/x^2 + V(x).y^2/x^4$, where V is variance and y and x are coefficients.

The general pattern is that the values based on individual respondents' coefficients emphasise the relative importance of the upper end of each attribute, relative to the values based on aggregate coefficients.

Figure A.3: Comparison of standardised results (total domestic, n=1,545)

		Based on total sample coefficients			Based on respondent level coefficients		
		Value	se	t-Stat	Mean Value	se	t-Stat
Length	Up to 1 hour	0			0		
	6 hours	100	-	-	100	-	-
	12 hours	141	8.3	17.05	141	49.2	2.86
	24 hours	188	10.5	17.90	187	52.9	3.53
	3 days	274	22.2	12.38	314	65.1	4.83
Scale	Just my property	0			0		
	My street or several local streets	-1	32.8	0.03	10	12.4	0.84
	My town/village and surrounding areas	2	34.1	0.05	14	12.2	1.13
	The whole of my region	14	45.7	0.31	38	14.2	2.66
Frequency	Once every three years	0			0		
	Once per year	13	5.3	2.52	18	6.6	2.71
	Several times per year	71	21.5	3.29	118	9.8	12.03

Figure A.4: Comparison of standardised results (total SME, n=509)

		Based on total sample coefficients			Based on respondent level coefficients		
		Value	se	t-Stat	Mean Value	se	t-Stat
Length	Up to 1 hour	0			0		
	6 hours	100	-	-	100	-	-
	12 hours	133	26.5	5.01	152	55.2	2.75
	24 hours	162	30.4	5.35	180	61.6	2.92
	3 days	242	57.0	4.24	345	75.4	4.58
Scale	Just my property	0			0		
	My street or several local streets	-3	100.0	0.03	-32	11.3	2.82
	My town/village and surrounding areas	3	135.9	0.02	35	11.4	3.10
	The whole of my region	17	143.4	0.12	69	12.6	5.47
Frequency	Once every three years	0			0		
	Once per year	22	11.8	1.83	39	6.6	5.92
	Several times per year	95	42.2	2.25	221	9.8	22.57

When the distribution of values based on individual respondents is examined, as shown in Figures A.5 and A6, it can be seen that there is a wide spread, sometimes with a skew towards the higher values. The median values approximate to the values based on aggregate coefficients, as summarised in Figure A.7.

The mean values derived on standardised individual respondent coefficients have been used for the main report, as they capture some of the skew in the distributions and are likely to bring out more distinct differences between groups.

Tests of significance: A one sample t-test shows that a t-Stat value of 1.96 or more indicates that the standardised value is significantly different from zero at the 95% level of confidence.

Figure A.5: Distribution of values (total domestic, n=1,545)

		Based on respondent level coefficients (percentiles)											
		Mean value	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
Length	Up to 1 hour	0											
	6 hours	100											
	12 hours	141	103	105	110	115	123	133	145	158	171	199	249
	24 hours	187	107	111	122	133	151	173	195	223	249	313	443
	3 days	314	128	144	179	211	241	274	309	341	441	675	933
Scale	Just my property	0											
	My street or several local streets	10	-258	-89	-27	-13	-7	-1	4	15	35	152	552
	My town/village and surrounding areas	14	-323	-82	-29	-14	-5	0	6	19	44	170	595
	The whole of my region	38	-397	-95	-26	-10	0	8	21	43	90	297	822
Freq-uency	Once every three years	0											
	Once per year	18	0	0	1	2	3	5	9	16	32	78	199
	Several times per year	118	4	7	11	19	35	57	87	132	218	455	862

Figure A.6: Distribution of values (total SME, n=509)

		Based on respondent level coefficients (percentiles)											
		Mean value	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%
Length	Up to 1 hour	0											
	6 hours	100											
	12 hours	152	105	108	112	118	123	130	140	157	182	271	438
	24 hours	180	110	114	124	133	145	158	175	196	225	315	515
	3 days	345	132	146	181	205	231	260	304	390	550	798	1,224
Scale	Just my property	0											
	My street or several local streets	-32	-1,489	-552	-61	-19	-9	-2	7	19	57	225	951
	My town/village and surrounding areas	35	-984	-240	-40	-14	-6	3	12	31	98	348	1956
	The whole of my region	69	-1,139	-389	-45	-11	-1	8	25	52	150	662	2358
Freq-uency	Once every three years	0											
	Once per year	39	0	1	2	3	6	10	18	34	61	188	429
	Several times per year	221	4	7	18	40	66	101	161	243	400	888	1,519

Figure A.7: Comparison of standardised results

		Domestic (n=1,545)			SME (n=509)		
		Based on total sample coefficients	Based on respondent level coefficients		Based on total sample coefficients	Based on respondent level coefficients	
			Mean Value	Median Value		Mean Value	Median Value
Length	Up to 1 hour	0	0		0	0	
	6 hours	100	100		100	100	
	12 hours	141	141	133	133	152	130
	24 hours	188	187	173	162	180	158
	3 days	274	314	274	242	345	260
Scale	Just my property	0	0		0	0	
	My street or several local streets	-1	10	-1	-3	-32	-2
	My town/village and surrounding areas	2	14	0	3	35	3
	The whole of my region	14	38	8	17	69	8
Frequency	Once every three years	0	0		0	0	
	Once per year	13	18	5	22	39	10
	Several times per year	71	118	57	95	221	101

5 APPENDIX 2: SAMPLE PROFILE

Figure A.8 depicts the profile of the sample surveyed in this study. Specific quotas were set to ensure a broadly representative profile of customers, while ensuring sufficient numbers of key groups such as the fuel poor and EV owners were consulted. The sample was also deliberately skewed to include a higher percentage of customers from within Electricity North West's operating region, to allow the robust analysis of VoLL across this region in isolation.

Figure 5.1: Sample profile

Segment	Real counts
Total	**2,054**
Domestic	1,545
SME	509
Male	739
Female	804
Other + not stated	0+2
18-29	223
30-44	398
45-59	448
60+	476
AB	345
C1	469
C2	350
DE	378
Urban	1,698
Rural	339
Electricity North West	911
Scottish and Southern Energy	154
SP Energy Networks	139
Northern Ireland Electricity	31
Northern Powergrid	153
Western Power Distribution	214
UK Power Networks	192
Other – IDNO	26
Unidentified	234
Electricity North West worst-served	66
Non-Electricity North West worst-served	845
Large scale interruptions	125
Fuel poor	85
Vulnerable	727
High vulnerable	34

Segment	Real counts
Off-gas	159
LCT	304
Electric vehicle	214
PV	194
Heat pumps	159

Weighting

To ensure the results of the research are representative of the GB population, the data was weighted to match the national profile in terms of gender, age, socio-economic status (domestic customers), company size, sector (SMEs) and region (all customers). An iterative Excel-based algorithm was applied to assign a weighting factor to each respondent. This ensured the incidence of any characteristic in the weighted sample profile fell within ±5% absolute difference and the individual respondent factor was less than or equal to 2.0. Where information was not available in relation to a particular characteristics, the factor was set at 1.0.

A comparison of the target nationally representative profile is shown against the unweighted sample profile in Figures A.9 and A.10 for domestic and SME customers respectively.

Figure 5.2: Domestic target profile versus sample profile

Segment	Nationally representative	Percentage
Male	49%	48%
Female	51%	52%
18-29	21%	14%
30-44	25%	26%
45-59	25%	29%
60+	29%	31%
AB	23%	22%
C1	31%	30%
C2	21%	23%
DE	25%	25%
Electricity North West	8%	44%
Scottish and Southern Energy	13%	7%
SP Energy Networks	12%	7%
Northern Powergrid	13%	7%
Western Power Distribution	26%	10%
UK Power Networks	28%	9%
Fuel poor	17%	6%
Vulnerable	50%	48%
Off-gas	15%	17%
Electric vehicle	3%	10%
PV	2%	10%
Heat pumps	1%	8%

Figure 5.3: SME target profile versus sample profile

Segment	Nationally representative	Percentage
Agriculture, forestry and fishing	5%	1%
Mining and quarrying	1%	1%
Manufacturing	5%	3%
Construction	11%	7%
Wholesale and retail trade	18%	7%
Transport and storage	3%	6%
Accommodation and food service	6%	2%
Information and communication	7%	5%
Finance and insurance	2%	6%
Real estate	4%	3%
Arts, entertainment and recreation	3%	4%
Professional, scientific and technical	17%	12%
Education	2%	11%
Human health and social work	6%	7%
Administrative and support service	8%	5%
Public sector	17%	15%
Private sector	83%	82%
Charity	3%	3%
<10 employees	54%	41%
10 to 49 employees	25%	25%
50 to 249 employees	21%	33%

6 APPENDIX 3: PEER REVIEW

A Review of:
Value of Lost Load (VoLL) 2 Project (Multiplier Effect)
Customer Survey (Stage 3)
Key Findings Report

24th April 2020 (Final Review)

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Overview of Activities

This report provides a summary of the review of a large-scale quantitative customer survey undertaken in Stage 3 of the VoLL2 project. At various stages of the project comments and reviews have been provided:

April 2019 - Electricity North West/VoLL 2 Methodology Statement/March 2019

The proposed survey design and statistical analysis were considered and commented upon.

September 2019 – Revised Methodology Statement and Draft Questionnaire

The revised methodology was considered along with the draft questionnaire. Comments and suggested changes were provided on both.

February 2020 – A statistical summary of main survey results were provided plus a further update to the Methodology Statement

Feedback on both documents was provided with a specific emphasis on clarification of survey design, implementation and statistical analysis.

March 2020 – Version 1 of the Final Report

Comments on Version 1 of the final report with a specific focus on clarification of results and the resulting conclusions being drawn.

April 2020 – Version 2 of the Final Report

Further comments seeking clarification on aspects of how the results have been interpreted and used to address the brief

April 2020 – Version 3 of the Final Report

Final examination of the report with an emphasis on clarity and accuracy of how the results have been reported and interpreted.

General Comments

The final version of the VoLL2 Report represents a significant piece of research. The report set out to address three main research questions:

1. What is the impact of a large event involving a significant number of customers on VoLL versus a smaller, localised interruption?
2. How does VoLL change over the duration of an event? Specifically, for longer durations over 12 hours, does VoLL per hour increase, stay the same, or reduce?
3. What are customer views surrounding the socialisation of costs? Specifically are customers willing to pay, through bill increases, for investment to reinforce areas where low carbon technology (LCT) uptake may be high versus those living in fuel poverty?

In terms of the three questions to be addressed there is no doubt that this research has achieved this. At the time of this review there still remains various questions regarding the interpretation of the results especially as they relate to specific user groups. However, from a methodological and statistical perspective Version 3 of the report is complete.

Specific Comments

In terms of my review of the project as a whole as well as the final report, I am pleased to note that Impact have always engaged in a positive manner to my many and varied questions and observations. As such the project and in particular the final report have been revised appropriately.

With a specific focus on the final report, Version 1 required various changes including the integration of a small section into the next section so as to improve the flow of the text, more clarity with regard to the design of the Best-Worst survey (BWS) instrument, presentation of and interpretation of the BWS results and how these could be compared with VoLL 1 results and in turn used to generate a multiplier effect. In addition, further clarification on the design, implementation and evaluation of the Contingent Valuation (CV) survey was required so as to ensure that the results could be considered robust. One important concern that was raised was in relation to how the BWS results had been standardised. It was suggested that more explanation was required in the text otherwise readers would be unable to understand how the econometric estimates derived from the BWS had been interpreted. Also a concern was raised about how willingness to pay (WTP) estimates from VoLL 1 could and might be used to infer values in this study.

I subsequently was sent Version 2 of the final report for comment. The revised version of the report was a step change in terms of quality of data analysis and reporting. In this case, my comments related to the results and how they had been interpreted. In particular, I noted a concern regarding the ability of the study to statistically claim a difference between the WTP estimates as the scale of lost load increased: either by time or geographical context. Version 2 of the report had introduced a clear explanation of how the BWS results had been normalised. This is important given that the results are presented and discussed with the data in this format.

Finally, I have had an opportunity to examine Version 3 of the final report. This version of the report has addressed the concerns that I previously had regarding the BWS analysis and how it is used to derive a multiplier. In Version 3 there is a clear statement regarding the results (see footnote 12) and the extent to which there is any change in value associated with lost load as the scale of the event increases, when compared to the results reported in VoLL 1. Overall, I am satisfied that the presentation of the methods used to collect the BWS and CV survey data are accurate and that associated statistical analysis is undertaken correctly.