FROM INSIGHT TO INFLUENCE

# Value of Lost Load to Customers (VoLL2)

Methodology Statement

Prepared for ENWL

Prepared by Impact

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electricity north west

Bringing energy to your door

# Contents

## Version history

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| 1 | | Impact | Draft | |

## Approval

| Name | Role | Date |
|---|---|---|
| Tracey Kennelly | Innovation Customer Delivery Lead | 08 May 2019 |
| | | |

## Glossary

| Abbreviation | Term |
|---|---|
| DNO | Distribution network operator |
| DPS | Data privacy statement |
| ECP | Engaged customer panel |
| GB | Great Britain |
| HB | Hierarchical Bayesian |
| MNL | Multinomial logit |
| SME | Small and medium enterprise |
| VoLL | Value of lost load |

# Foreword

In Great Britain (GB) a single, uniform Value of Lost Load (VoLL) is used to evaluate 'disbenefit' 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) has demonstrated that VoLL is now notably higher than observed in the previous major GB study in this area, conducted by London Economics for Ofgem, in 2013. 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 will theoretically 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 is recognised that further detailed analysis is required to explore the requisite level of sophistication needed in a credible decision making tool, and the appropriate mechanism for practicable 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 on the basis of the entire community, rather than the individual, ie assessing the overall impact of a large-scale outage affecting a significant number of people versus that of a smaller, more localised interruption. 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 will comprise two distinct pieces 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). The scope and objectives associated with both elements of this study are summarised in the VoLL2 registration document, which was published on the project webpage in October 2018.

This report specifically focuses on the customer research element of the project (Phase B), and documents:

- The methods that will be utilised to engage with customers
- The scope and objectives of the analysis and research activities
- The anticipated research learning and outcomes.

The 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 commenced in November 2018 and will be conducted over an 18-month period. The customer research forming Phase B of this study will culminate in:

- An understanding of the impact on VoLL in different scenarios that will inform smarter decisions by DNOs 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
- An evaluation of perceptions on fairness and the efficiency of an alternative model; and an assessment of potential social impacts and costs, as assessed by key customer groups and stakeholders.

This methodology statement is supported by two accompanying addenda, published on the VoLL 2 webpage.

- *Methodology statement addendum A: literature review*
- *Methodology statement addendum B: peer review.*

# 1 Background

## 1.1 Why further understanding of Value of Lost Load is important: the problem

The previous VoLL study conducted by Electricity North West (ENWL010) identified the need for additional analysis of the survey data, before practical steps can be taken to implement a differentiated VoLL. This additional research needs to determine the necessary level of sophistication required in a decision making tool and the appropriate mechanism for efficient implementation, at scale.

In addition, ENWL010 identified the need for further evidence from empirical customer research around the impact of different scenarios. This includes the 'multiplier' effect on VoLL of scale and duration, in the context of an interruption impacting the entire community rather than the individual. This analysis will facilitate smarter decisions based upon the value of investment to prevent or minimise the severity of unplanned interruptions, versus the ability to mitigate VoLL by deployment of support mechanisms to manage the consequence and minimise disruption.

Finally further investigation is needed to provide more nuanced understanding of perceptions around the socialisation of investment costs informed and prioritised by customer need. This study will deliver an understanding of when, if ever, this is considered fair and/or acceptable. The research will consider differences in attitudes across a range of customer segments and establish views on the perceived consequences of implementing a revised VoLL model.

## 1.2 Project objectives

### 1.2.1 Phase A – Strategy

The aim of this phase of the research is to explore the practicalities and regulatory implications for implementation of an alternative, segmented VoLL model and its applicability. Full details are available in the NIA Project Registration and Project Eligibility Assessment Document.

### 1.2.2 Phase B – Customer

The aim of this phase is to gain insight into the multiplier effect and socialisation of cost arising from a revised model through empirical research. Specifically, it seeks to:

- Quantify the impact of scale and duration of an outage on VoLL

- Deliver an understanding of the societal value of investment to prevent an event versus that of managing the consequence of the event
- Determine the increased sense of equity and DNO service provision that can be achieved through implementation of a differentiated VoLL model
- Measure societal acceptance of a differentiated VoLL model, segmented by customer need
- Substantiate which segments are perceived by society to have the greatest need
- Quantify the likely effects of a differentiated VoLL investment model on society, now and in the future.

### 1.3 Project success criteria for Phase B – Customer

The project success criteria of Phase B are:

- Evaluation of potential social impacts of implementation of a future differentiated VoLL model by key customer and stakeholder groups
- Delivery of an understanding of the societal value of investment to prevent an event versus that of managing the consequence of the event
- A practical demonstration of how the VoLL model can help DNOs to more effectively plan investment levied in areas where the consequence of asset failure are much higher, in a manner which delivers greatest value to the DNO, and benefits those most impacted but which is fair to all.

### 1.4 Potential for new learning

The following new learning is anticipated from the project overall:

- How to use differentiated VoLL to guide investment decisions for Electricity North West and other DNOs
- How the VoLL segmentation tool translates into the quantification of network impacts in decision making, eg in setting reliability incentive rates, quantification of network risk and definition of cost-benefit analysis
- An understanding of what fairness means to society, in the context of socialised costs and divergent investment, based on an improved awareness of customer needs
- An understanding of the preferred practical scale of implementation given current data etc
- An understanding of how the alternative VoLL model could inform investment decisions to accelerate the uptake of low carbon technologies
- A clearer understanding of how VoLL is likely to change over time in the context of investment decision making on long-lived assets.

## 2 Summary of the approach for Phase B – Customer

This phase of exploratory customer research will address the following questions to support the practical application of the VoLL segmentation:

- What is the impact of a large event involving a significant number of customers on VoLL versus a smaller, localised supply interruption?
    - When assessing the aggregated impact at community level, can this change be simply summated ie is the relationship linear or nonlinear?
    - How does VoLL change over the duration of an event? For longer interruptions over 12/18 hours does the rate of increase in VoLL per customer decelerate or plateau?
- How should investment models account for relatively low VoLL if values are influenced by greater resilience, brought about through customer's own proactive mitigation (eg medically-

dependent), or higher levels of tolerance as a result of repeated exposure to supply interruptions (eg worst-served).
- Are all customer segments able to accurately signal their true VoLL? What are the societal consequences if specific customer groups are unable to effectively signal true VoLL because the wider impacts are not necessarily recognised, ie costs which are not directly borne by the customer but are picked up by society elsewhere?
- What are the unintended consequences, from a societal perspective, of replacing one imperfect model with one that recognises divergence but may also be imperfect?

The method utilised to achieve this will encompass five key stages of customer and stakeholder engagement:

- Stage One: Desk research and stakeholder engagement
- Stage Two: Qualitative exploration
- Stage Three: Quantification
- Stage Four: Implementation scale analysis
- Stage Five: Validation

Full details of these stages are provided in subsequent sections of this document.

# 3 Stage One: Desk research and stakeholder engagement

The first stage of research commenced with a comprehensive literature review covering published work relating to existing research on the 'multiplier' effect and the impact of longer duration interruptions, and on cost socialisation and investment prioritisation.

A literature review typically covers current knowledge including substantive findings, in addition to theoretical and methodological contributions to a particular topic. The review drew on a broad range of sources from GB and internationally. This is documented in Methodology Statement Addendum A: Literature Review and published on the Value of Lost Load 2 webpage.

The best methods of evaluating fairness and the efficiency of alternative investment models are explored in this document, which will be subject to peer reviewed by Professor Iain Fraser of the University of Kent. This critique will evaluate the method's ability to provide accurate and robust results and achieve the requisite project objectives. The critique will also identify any required amendments or enhancements. The methodology statement will be revised as required based on this feedback.

The method will be shared with key stakeholders including expert industry advisors and customer advocates, who will provide further feedback, challenge the approach and highlight any wider implications or considerations which have not been included in the methodology. This engagement will take the form of in-depth interviews, led by Electricity North West and supported by Impact. Key feedback will be documented as an addendum to the method and the revised methodology, incorporating the feedback will be published on the project webpage.

The customer research questions to be explored in the study will be considered as part of, and finalised following the stakeholder engagement.

The study will inform smarter investment decisions and as such, stakeholders that are likely to benefit from the learning will be engaged throughout the project to help shape the research and ensure the findings are of maximum utility. It is anticipated that expert advisors will be engaged at several stages during the project and the project team will be available to answer questions from these stakeholders throughout the life of the project.

# 4 Stage Two: Qualitative exploration

This qualitative phase of research will be conducted with engaged customer panels (ECPs) and take the form of directed focus group meetings. These have been proven, in previous studies, to be a suitable platform to explore complex concepts and encourage informed discussions. A number of in-depth interviews will also be conducted with representatives of more 'difficult to reach' customer groups.

This initial stage of direct customer engagement will explore initial perceptions of the VoLL multiplier, relative to scale and duration, in addition to attitudes concerning fairness and cost socialisation.

A key objective will be to identify how to contextualise and explain VoLL, the potential multiplier effect and cost socialisation concepts in a manner that ensures research participants (particularly those responding in the subsequent quantitative customer survey stage) are able to sufficiently comprehend the subject matter and provide an informed opinion.

Contextualisation is particularly important for this research because of concerns about customers' ability to envisage how they would react during low-probability large scale, long-duration outages, which are outside the experience of most. These concerns are highlighted in the literature review that accompanies this document, specifically in the Royal Academy of Engineering report[1]. Careful survey design is required to ensure that respondents are supported in thinking deeply about the context of a major disruption; specifically all of the effects this would have on them and the wider community, before expressing their opinions.

Three domestic ECPs will be convened, including but not limited to segments, defined in the previous study has typically having low, average and high VoLL. The ECP will also be represented by urban and rural participants, and include representatives of a community which has experienced a major incident. These will be supplemented by in-depth interviews with hard–to-reach or vulnerable customers including those with medical dependency.

Customers with vulnerabilities will be proactively engaged with the aim that a small number have the opportunity to attend each ECP group meeting. If insufficient numbers are able to attend, they will instead be engaged by telephone interview or face-to-face if preferred. Up to 6 interviews will occur and participants will be offered a financial incentive to take part in the research.

An ECP of small to medium enterprise (SME) customers will also be convened across a range of industry sectors, specifically those heavily reliant on electricity, and therefore exhibited a relatively high VoLL in the earlier study. In common with previous research, larger industrial and commercial customers will be excluded as they are likely to have robust resilience capabilities and the ability to access mitigation in the event of a supply interruption.

Approximately ten customers, representative of each segment, will be recruited to reflect an appropriate balance of demographics such as age and gender. Each group will meet at least twice. Customers will be incentivised to aid recruitment and to encourage the subsequent attendance of reconvened focus groups. SME representatives will be offered a slightly higher payment than domestic customers in recognition of the challenges of recruiting participation from this group and the higher value they place on their time. This payment will be weighted, with a higher value payment being offered at the second meeting to help with retention.

Members of the ECP will be educated about the research objectives to enable them to provide informed responses. This will involve developing a range of communication materials that will

[1] 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.

provide context and clarity to scaffold the research, in order to attain the intended learning outcomes.

To achieve this, a professional, independent moderator will ask the ECP semi-structured questions relating to a predefined list of topics. This will provide the moderator with the flexibility to question participants further on issues arising through open discussion and encourage the natural evolution of the ECP's understanding and engagement. This is consistent with the approach successfully deployed in the initial VoLL study (ENWL010).

The qualitative research will:

- Evaluate customer reactions to the outcomes and implication of the VoLL study, explore views on the low, medium and high VoLL assignment of specific customer segments
- Evaluate customer perception of potential benefits/disadvantages of DNOs adopting an alternative approach to investment prioritisation
- Assess reactions to the likely impact of a lengthy, large scale outage (perceived or experienced) and explore how this might differ relative to a short, localised outage
- Further explore various mitigation strategies and views on their relative appropriateness to understand the drivers of perceived fairness
- Explore the perceived ability of customer segments to signal their true VoLL
- Test and refine a survey instrument for use in Stage Three of the research, including how to best conceptualise a 'large scale interruption'.

In-depth probing will identify areas of misunderstanding and the cognitive process involved in completing the exercises. This evaluation of proposed key elements of the survey and its supporting materials will maximise comprehension and ultimately, the quality of survey responses.

Due to the sensitivity of the subject matter these issues will be explored independently amongst segmented groups of customers who are more likely to have shared experiences. It is expected that this strategy will highlight differences in the collective perspective of unique customer types eg rural communities; however, the various groups will also be actively encouraged to consider how their needs might align and differ from others in society.

To ensure strategic alignment, a deliberative workshop will be convened in parallel with the ECPs to facilitate meaningful engagement with key stakeholders (including customer advocates and representatives from other DNOs). The pool of stakeholders participating will be supplemented with feedback from specialists who are well positioned to debate the wider societal consequences of a differentiated VoLL model and how this would be implemented in practice. This approach will provide an educated and engaged pool of stakeholders who are able to challenge and discuss the merits of a more sophisticated decision making tool, reflective of divergent customer needs, when making investment decisions.

# 5 Stage Three: Quantification

A large-scale quantitative survey will be conducted using a combination of research methods, including face-to-face, online and online with telephone support. This approach will maximise response numbers, particularly from hard-to-reach groups such as vulnerable customers. The survey instrument will be tailored to fit the response method but the content will be similar for all methods.

The survey instrument will be designed by Impact in conjunction with Electricity North West to ensure that it is able to robustly address the objectives of the research set out in Section 1.2.2. The design will build on the learning transferred from Stages One and Two.

The draft survey instrument and supportive communication materials will initially be introduced to the ECP to test and refine its content. It will then be subject to further refinement following a robust

pilot, conducted with an appropriate sample of domestic and SME customers, before it is rolled out more widely.

A large scale, quantitative survey will then be conducted amongst a representative sample of 2,000 GB customers. This is expected to include approximately 1,500 domestic customers and 500 SME representatives and will be administered via a mixed approach of online, face-to-face and telephone. This is expected to be conducted over summer 2019.

The survey sample will include domestic customers covering a variety of rural and urban locations. Demographic quotas will be set in relation to age, gender and social grade to ensure results are representative of the total population. Quotas will also be set for energy consumption and customers off main gas networks.

The survey design will ensure it can be completed in the least possible time to deliver the required outputs, and we expect it to take no longer than 20 minutes on average.

Customers will be presented with a series of detailed supply interruption scenarios with examples of how each might impact them individually and demonstrate the extent of potential impacts on the wider community.

The survey will comprise a trade-off exercise between the various scenarios, and Hierarchical Bayesian (HB) techniques will derive utility values for each attribute level.

The proposed attributes include but are not limited to:

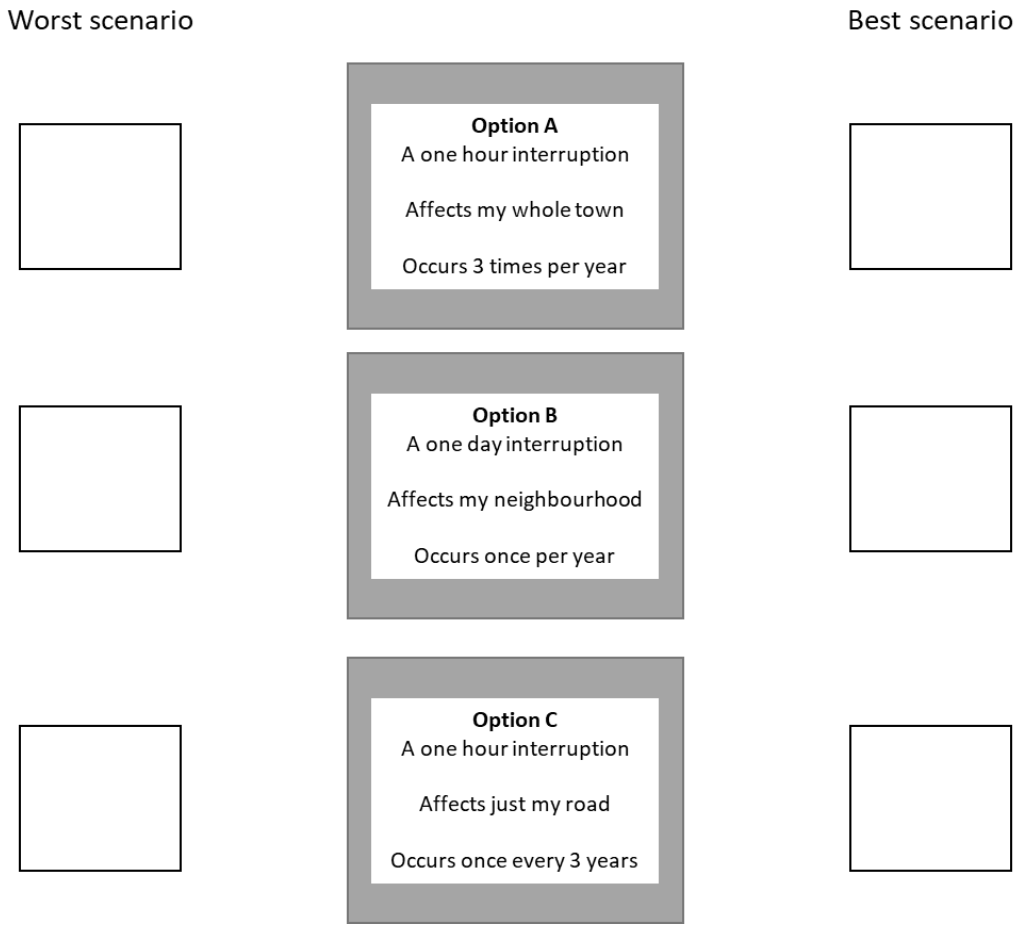
- Length of interruption (20 minutes, 1 hour, 4 hours, 1 day, 3 days). This is in line with the interruption durations tested during the previous VoLL research.
- Scale of interruption (my road, my immediate neighbourhood, my entire town). This may be expanded to cover a larger area (for example county, DNO region, GB) depending on feedback from participants in the qualitative engagement as to how equipped they would be to provide a considered response
- Frequency of interruption (once every three years, once a year, three times per year).

The attribute levels to be tested will be co-designed/influenced by feedback from the key project stakeholders engaged in Stage one. These will be evaluated during the qualitative design stage - for example, when describing the scale of interruption, it will be necessary to determine if this should be referenced as the number of houses or streets impacted, the geographical area or an alternative (such as the distance to a local shop that is not impacted). It will also be important to understand how the regional scale and magnitude used to define outage characteristics varies among rural and urban customers.

Participants will be asked to choose which option they think is the worst scenario and which is the best. They will see multiple iterations which will be analysed in order to produce a rank of best to worst case scenario. The current base case will be included in these options to determine its ranking, in the scenario in figure 5.1 the base case is option c. After initial review, peer reviewer Professor Ian Frasier suggested the inclusion of an additional attribute around socio-economic context. This could take the form of average income in the area, or proportion of property owners versus renters. However careful consideration is needed to ensure that respondents are not overloaded by the decisions being made, and therefore this could sit better outside the exercise. This will be reviewed and customer feedback sought in the qualitative phase.

An example of how this would appear in the survey is shown below in Figure 5.1.

*Figure 5.1: An example of the exercise which participants will see*




Customers will be asked to articulate their views on the personal and societal impact of a range of events and the choices they might make as a result. This will be recorded through a mixture of open and closed questions that will accompany the exercise. To encourage respondents to give careful thought to the impact of large scale outages, appropriate visual material and other prompts will be used to help them to envisage the extent of such events. An example of a prompt for the geographical impact of an outage is given below, which may be expanded to cover large geographical areas dependent on feedback in the qualitative phase.

*Figure 5.2: Visualisation of different levels of geographical impact*


With this approach, respondents see only a few scenarios, but are required to give much more detailed and considered responses on factors such as: how they believe they would be impacted, and whether knowing that the wider community is also affected reduces their perceived direct, personal impact. The intention here has been to depart from conventional choice-based scenarios to

encourage a more 'holistic' customer view of the impact of large scale outages, which in turn will prompt more comment.

The trade-off exercise will be subject to academic review by Professor Iain Fraser of the University of Kent prior to roll out, to ensure the instrument is sufficiently robust to deliver the desired outputs.

The survey will also capture sentiment concerning current and alternative future investment models and robustly measure the level of public support for a change from the status quo and more specifically, where prioritisation informed by customer need and expectation is justified. This element of the study will assess customers' willingness to pay extra on their bills to subsidise additional support for vulnerable customers and other groups.

The survey will also deliver an understanding of how different customer types determine which groups are most in need and/or deserving of additional support or investment. An example of this is those who own an electric vehicle. While they may not be deemed worthy of additional support from the majority of the general public, those who are intending to invest in electric vehicles may be more likely to support this additional investment as they could see a direct benefit to themselves. A mixture of closed and open questions will be used, with closed question allowing participants to select from a list of pre-defined responses for quantification purposes. Open questions will provide more nuanced learning by offering participants the opportunity to explain the rationale for their answers.

# 6 Stage Four: Implementation scale analysis

Detailed analytics will be undertaken to understand the multiplier effect ie variations in VoLL at community level with duration and scale. The analysis will deliver a better understanding of social impacts/perceptions of fairness associated with the implementation of a differentiated VoLL model and may reveal unintended consequences and social costs.

# 7 Stage Five: Validation

Once results are available, a workshop session will be held at which key stakeholders will be invited to review and challenge the results, and finalise the design of the VoLL decision making tool. Stakeholders will be asked to provide feedback on how this data should be used to inform improved decisions between supply interruption measures and impact mitigation measures if a disruption occurs.

# 8 Customer protection requirements

In accordance with the requirements of the Electricity Network Innovation Allowance Governance Document, this research will comply with Electricity North West's publically available data privacy and sharing policy

Electricity North West, Impact Research or any other project partners or project supporter will not visit a premises of any customer for sales or marketing activities in connection with, in the context of or otherwise under the guise of this project.

This document outlines the proposed customer engagement plan and summarises how Electricity North West and its project partners will interact with, or impact upon relevant customers where any form of engagement is undertaken as part of the project. All customer research activities will be conducted in strict compliance with Electricity North West's Data Protection and Acceptable Usage Policy, NIA governance and in accordance with the professional standards set out in the Market Research Society Code of Conduct.

Impact Research will be responsible for provision of customer consent forms and for obtaining explicit consent before undertaking any form of customer research, as part of this project. These activities will be subject to a project specific Data Protection Impact Assessment, which will be published on the project website prior to any form of engagement

All customer engagement will have regard to the implementation of the smart meter roll-out to ensure that the research does not impede the implementation of the roll-out in any way.

# 9 Analysis

## 9.1 Modelling stated preferences

The approach proposed for this work deliberately avoids direct measurement of the Value of Lost Load in monetary terms. Suitable monetary values were established in previous research[2] and the focus of this research is to establish a VoLL *modifier*, suitable for longer outages on a broader geographical scale than those tested in the main VoLL study. This approach will therefore enable some translation of the previously established monetised values to understand the multiplier when individual values are extrapolated across a range of customer types, across a large community.

Statistical models will be developed from the rank data provided by the trade-off exercise. These will take the form of paired choices as the dependent variable, inferred from the rankings of each combination of attributes given by respondents. This is preferable to converting the rank information into some artificial metric scale value and allows the form of typical choice-based models to be followed.

### 9.1.1 HB analysis

A Hierarchical Bayes (HB) approach will be the main method used to analyse the discrete choice exercises. This is designed to estimate values for individual respondents and is derived from the commonly used Multinomial Logit (MNL) model. Compared to more traditional aggregate MNL models, the HB approach has the potential to draw out differences in the VoLL of different sub-groups of customers more clearly.

### 9.1.2 Multinomial logit (MNL) model

The MNL model is a widely-used general model of choice behaviour that is based on the premise that consumers attach a 'utility' to each of the options available to them and that they choose the option with the highest utility. The model relates to probability of choice and the utility function represented in the model will therefore have a systematic component (representing, for example, the features of the options that appeal to or deter the consumer) and a random component:

$$Uj = Vj + \varepsilon$$

Where: $Uj$ = Utility of option j
$Vj$ = The systematic component of the choice of option j
$\varepsilon$ = The random element of the choice of option j

If the random component is assumed to have an extreme value 1 exponential distribution[3], the model takes the following basic MNL form:

$$Pj = \frac{\exp(Vj)}{\sum_1^k \exp(Vk)}$$

[2] VoLL Report ENWL010.
[3] $Prob(\epsilon) = \exp\,(-\exp(-\varepsilon))$

Where: $Pj$ = Probability of choosing option j
$Vj, Vk$ = Utility function for each option

It is a necessary assumption in the MNL model that the odds of choosing alternative j over alternative k should be independent of the choice set for all pairs j, k (the independence of irrelevant alternatives).

The data underlying this model is panel data, where all choices that were presented to respondents are stacked in the form of paired choices. Thus if a respondent ranked combinations X, Y, Z in order 1, 2, 3, there would be three pairs: X preferred to Y, X preferred to Z and Y preferred to Z. There is an implicit assumption of consistency of ranking – that is, if X is preferred to Y and Y is preferred to Z, then X will always be preferred to Z. It can be argued that logic inconsistencies that might be observed in choices between actual paired comparisons better reflect uncertainty about or indifference to certain attribute values. However, the assumption here is that such inconsistencies are likely to be minor, given the relatively simple trade-offs (only three attributes and no monetary attribute).

To allow for non-linear progression in the weight that customers give to each attribute, 'dummy coding' will be used to represent each attribute level. This will deliver a set of utility values for each respondent, for each attribute level. Thus the utility function will take the form of:

$$Vj = a_0 + a_{i2}.A_{i2} + a_{i3}.A_{i3} + a_{i4}.A_{i4} + a_{i5}.A_{i5} + b_{i2}.B_{i2} + b_{i3}.B_{i3} + c_{i2}.C_{i2} + c_{i3}.C_{i3}$$

Where: $Vj$ = The systematic component of the choice of option j
$a_0$ = Model constant (grand mean)
$a_{i2} - c_{i3}$ = The model coefficients for each level of attributes A to C
$A_{i2} - C_{i3}$ = The 'dummy (0, 1) values for each level of attributes A to C. Level 1 of each attribute is coded as zero throughout and has no coefficient.

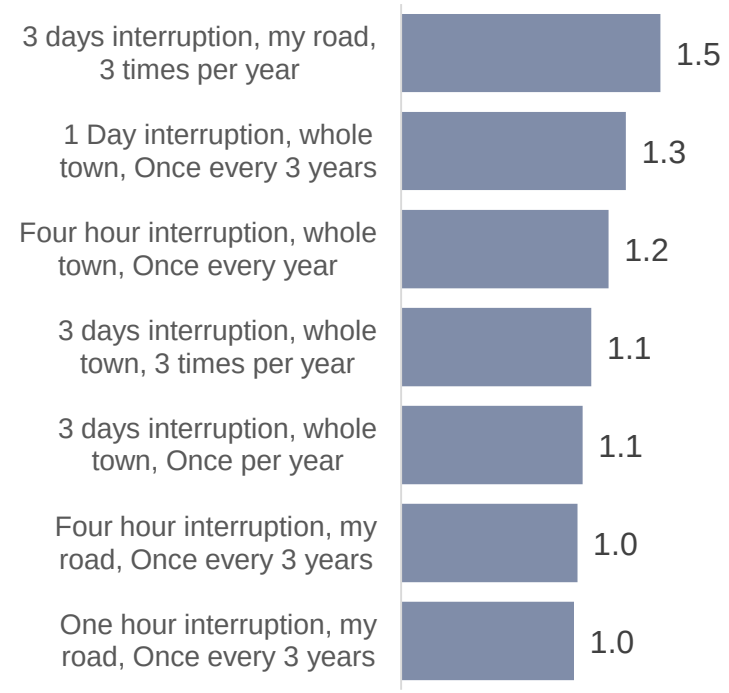
This specific example assumes the following:

- Length of interruption (20 minutes, 1 hour, 4 hours, 1 day, 3 days)
- Scale of interruption (my road, my immediate neighbourhood, my whole town)
- Frequency of interruption (once every three years, once a year, three times per year).

### 9.1.3 Outputs from the models

The coefficients estimated from the above model indicate the part-worth utility of each attribute level. For each attribute combination these can be added together and compared to the base combination, which is defined as a one hour interruption, 'my road', once every three years. This corresponds to the base combination used in the main VoLL study.

*Figure 9.1: Example output of utility ratio values*




This example would indicate that the VoLL for three days of interruption, 'my road', three times per year would be 50% higher than the standard VoLL.

### 9.2 Socialisation of costs

Another objective of this research is to capture customers' willingness to support resources being prioritised towards vulnerable customers and other groups. This is most effectively achieved by quantifying their willingness to pay extra on their bills in order to fund those resources.

A Contingent Valuation approach[4] will be used in which respondents are presented with an increase to their annual bill and asked how acceptable this would be if the additional amount was used to prioritise assistance for vulnerable groups during large scale outages. The increase will be drawn from the centre values of a table of possible increases (eg +£0 to +£20 in £2 increments). If a respondent replies that this sum is acceptable, they will then be asked to consider the next highest increase; if they say it is unacceptable, they are shown the next lowest increase.

In this way a measure of average willingness to pay can be established. This will serve as a direct measure of customers' support for vulnerable groups.

Results from all the analysis conducted will be peer reviewed Professor Iain Fraser of the University of Kent ahead of publication.

## 10 Implementation of findings

This research will build on the previous study to provide a better understanding of the distribution and scale of the benefits of a differentiated VoLL. The research will consider how an alternative model might impact affordability and quality of outcomes for different groups of customers. This will inform Electricity North West and other DNOs in their investment decisions.

[4] Also referred to as the Gabor Granger method.

# 11 Dissemination of findings and lessons learned

The outputs from Phase B – Customer will comprise:

- A final report documenting findings from all phases of research
- A peer review of results by Professor Iain Fraser of the University of Kent
- A presentation of key results suitable for innovation dissemination events
- The ability to factor values, derived from the multiplier effect of scale and duration in the VoLL calculation tool.

These outputs will be published and disseminated via appropriate channels to key stakeholders and will also be shared on the project webpage.