



The future

The Value of Lost Load (VoLL)

Methodology Statement

29 July 2016



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APPROVAL

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GLOSSARY

Abbreviation	Term
CE	Choice experiment
CEP	Customer engagement plan
DECC	Department of Energy and Climate Change*
DNO	Distribution network operator
DPS	Data Protection Statement
ECP	Engaged customer panel
EHP	Electric heat pump
EV	Electric vehicle
GB	Great Britain
HEV	Hybrid electric vehicle
LCN Fund	Low Carbon Networks Fund
LCT	Low carbon technology
NIA	Network Innovation Allowance
Ofgem	Office of Gas and Electricity Markets
PSR	Priority service register
PV	Photovoltaic
RIIO-ED1	Electricity distribution price control 2015 to 2023
RIIO-ED2	Electricity distribution price control 2031 and beyond
SIC	Standard Industrial Classification
SME	Small and medium enterprise
VoLL	Value of Lost Load
WTA	Willingness to accept
WTP	Willingness to pay

* DECC and the Department of Business, Innovation and Skills (BIS) merged on 14 July 2017 to create the Department for Business, Energy and Industrial Strategy (BEIS)

DEFINITIONS OF TERMS

Term	Definition
Business sector SIC code	The United Kingdom Standard Industrial Classification of Economic Activities (SIC) will be used to classify businesses by the type of economic activity in which they are engaged for analysis purposes.
Business size	For the purposes of this research, small and medium enterprise (SME) size has been defined in line with the European Commission (Enterprise and Industry) classification as follows: Micro – 1-10 employees (turnover of less than £2 million pa) Small – 11-50 employees (turnover of less than £10 million pa) Medium – 51-250 employees (turnover of less than £50 million pa).
Dependency	<p>An understanding of customer impact will primarily inform the way in which dependency on the continuous availability of electricity supply is defined. Research will categorise respondents who indicate that an electricity outage eg of a one-hour duration, would have a 'very large impact' on them (based on the time of year in which they answer the question) as having a heavy reliance, in response to the following question:</p> <p>How much of an impact do you think it would have on your household's/organisation's day-to-day activities?</p> <ul style="list-style-type: none"> • No impact • Slight impact • Moderate impact • Large impact • Very large impact (Heavy reliance)
Electricity usage	<p>For domestic customers, the uSwitch usage classification of low, medium and high users will be adopted for analysis purposes. The definition utilises consumption, type of accommodation, time spent at home and usage of heating and appliances to classify consumers. It is based on consumer perceptions. An additional question relating to the type of meter installed at the property will be asked for analysis purposes. An average 'low user' is defined in terms of energy usage of 2,000 kWhs of electricity a year. An average 'medium user' is defined as using 3,100 kWhs of electricity a year. An average 'high user' is defined as using 4,600 kWhs of electricity a year.</p> <p>SME customers' usage classification will be based on consumption data from their bill; these customers will be encouraged to refer to recent bills to promote response accuracy.</p>
Fuel poverty	This research uses Energy UK's definition of a fuel-poor household as one which needs to spend more than 10% of its income on all fuel use to heat its home to an adequate standard of warmth. In England, this is defined as 21°C in the living room and 18°C in other occupied rooms.

Term	Definition
Geographical classification	<p>The 2011 Rural-Urban Classification of Local Authority Districts and other higher level geographies will be used to classify survey participants into geographical categories as follows:</p> <ul style="list-style-type: none"> • Mainly rural (rural population including hub towns $\geq 80\%$) • Largely rural (rural population including hub towns 50-79%) • Urban with significant rural (rural population including hub towns 26-49%) • Urban with city and town • Urban with minor conurbation • Urban with major conurbation. <p>This geographical classification will be coded automatically from postcode information collected in the survey. These six categories can then be aggregated to rural versus urban (the classification used in the London Economics study for Ofgem and the Department of Energy and Climate Change (DECC)).</p>
LCT users	<p>In this study, current low carbon technology (LCT) users will be classified as such by virtue of owning and/or operating electric vehicles (EVs), photovoltaic (PV) systems or electric heat pumps (EHPs). Hybrid electric vehicles (HEVs) do not form part of the definition; however, HEV owners will be included in the overall survey sample.</p>
Maximum Import Capacity and Maximum Export Capacity	<p>Maximum Import Capacity (MIC) and Maximum Export Capacity (MEC) are the maximum agreed amounts of electricity permitted to flow to (MIC) or from (MEC) a business or industrial customer's connection points via the network.</p>
Off-gas	<p>Properties which are off the gas grid ie do not have a mains gas supply.</p>
Power quality	<p>Power quality is determined by the electrical network's ability to provide a clean and stable power supply to consumer's premises and devices. Synchronization of the voltage frequency and phase allows electrical systems to function in their intended manner without significant loss of performance or life.</p>
Profile class	<p>Profile class is used to indicate likely electricity consumption throughout a 24-hour period. The Use of System Charging Statement utilises profile codes 1-8 linked to metering systems to indicate how consumption is measured for non-half hourly metered customers:</p> <ul style="list-style-type: none"> 00 Half-hourly metered supply (import and export) 01 Domestic unrestricted 02 Domestic Economy Meter of two or more rates 03 Non-domestic unrestricted 04 Non-domestic Economy 7 05 Non-domestic, maximum demand (MD) customers with a peak load factor (LF) $<20\%$ 06 Non-domestic, MD customers with a LF between 20 and 30% 07 Non-domestic, MD customers with a LF between 30 and 40% 08 Non-domestic, MD customers with a LF $> 40\%$. <p>Accurate classification data is likely only to be available for supplies in the Electricity North West region.</p>

Term	Definition
Service performance	Reliability (supply interruptions) and availability (time without power) are the two key industry measures of service performance . These are measured in units known as Customer Interruptions and Customer Minutes Lost.
Supply interruption impact	The impact of loss of supply will be defined in terms of financial and social impacts to customers in this study.
Vulnerable customers	<p>This study references Ofgem’s definition of vulnerability which defines a customer as vulnerable when his or her personal circumstances and characteristics combine with aspects of the market to create situations where he or she is:</p> <ul style="list-style-type: none"> • Significantly less able than a typical consumer to protect or represent his or her interests in the energy market; and/or • Significantly more likely than a typical consumer to suffer detriment. <p>These personal circumstances may include, but are not limited to:</p> <ul style="list-style-type: none"> • Disability • Chronically sick (physical or mental illness and dementia) • Reliance on essential medical equipment and/or stair lift/hoist • Pensionable age • Blind or partially sighted • Deaf or hearing impaired • Difficulty with reading or writing • Having an unstable income or being unemployed • Caring for someone else in the household • Experiencing a sudden change in circumstance • Having English as a second language or speech difficulties • Having an infant in the household. <p>Customers classed as vulnerable may or may not be included on a priority service register (PSR).</p>
Worst-served customers	<p>Defined by Ofgem as those customers who experience, on average, at least five higher voltage interruptions per year ie 15 or more over a three-year period. The additional requirement for this classification is a minimum of three higher voltage interruptions in each qualifying year.</p> <p>In this survey, customers in the Electricity North West area classified as worst-served will be identified. Those outside the region will be asked to indicate their perceived frequency of interruptions and this information will be used to classify them.</p>

FOREWORD

This report seeks to re-examine the existing model used by distribution network operators (DNOs) to place a value on the loss of electricity supply to customers. Electricity North West and its project partner, Impact Research, will conduct extensive customer and stakeholder engagement to understand how the Value of Lost Load (VoLL) is assessed by different customer segments and how this might change in a low carbon future.

The research aims to deliver a comprehensive assessment of customer impacts associated with the loss of electricity supply, the relative importance of various supply interruption characteristics eg duration, how these components are valued by specific customer groups and how this might change with the adoption of low carbon technologies (LCTs). It will also examine if VoLL could be influenced by adopting different approaches to managing outages.

At present in Great Britain (GB), a single VoLL is used to evaluate what customers would be willing to pay to avoid a supply interruption of average duration. The value of loss can be expressed as a customer damage function relative to the duration, season, time of day and notice of an outage. Previous research has identified that VoLL varies significantly among three distinct customer groups: residential, small/medium commercial and industrial enterprises (SMEs) and large commercial/industrial users. The value may also vary considerably within each of these groups, for example, between rural and urban residential customers. The existing single VoLL is aggregated to provide an overall estimate of the value given to loss across all customer segments.

Modern network management systems allow DNOs to view the number and segmentation of customers fed from a specific asset to calculate the VoLL that should be applied in a given investment decision. Understanding the relative VoLL components at a much more granular level could allow greater efficiency in future investment decisions driven by customer need.

This project will investigate if the current single uniform VoLL, applied to all customer segments, remains appropriate as GB moves towards an economy increasingly reliant on electricity, driven by the decarbonisation agenda. Extensive customer research will build on previous studies in this area, to determine if a revised VoLL model would benefit customers.

This project is funded by the [Network Innovation Allowance](#) (NIA), introduced as part of the RIIO-ED1 price control, which provides an allowance for RIIO network licensees to fund projects that have the potential to improve network operation and maintenance and to deliver financial benefits to the licensee and its customers.

This research project commenced in October 2015 and will be conducted over a 28-month period. It will culminate in a comprehensive assessment of how VoLL should be defined across a range of customer segments and ultimately inform a potential revised model to help DNOs better plan their network investment and customer strategies.

This document supersedes the original VoLL methodology statement (version 1), published in February 2016 on the project [webpage](#) and incorporates refinements to the approach following consultation with key stakeholders, who were engaged to assess support for the VoLL project and shape its direction. This revised methodology statement is accompanied by three new addendums which are all published on the project webpage:

- *Methodology Statement Addendum A: Literature Review*
- *Methodology Statement Addendum B: Peer Review*
- *Methodology Statement Addendum C: Stakeholder Consultation.*

1 BACKGROUND

1.1 Definition of the Value of Lost Load

Electricity supply interruptions ('lost load') have financial and social impacts on customers.

The Value of Lost Load (VoLL) is defined as:

“A measure of the economic value given to an amount of electricity that is prevented from being delivered to consumers (ie is 'unserved') as a result of a planned or unplanned outage of one or more components of the electricity supply chain.”¹

This measure of economic value can take a number of forms:

- The amount that customers are willing to pay in order to avoid an outage
- The amount they wish to be compensated in the event of an outage
- The actual financial cost they incur as a consequence of an outage.

1.2 Why measuring VoLL is important: the problem

Improving or maintaining reliability of supply to customers requires significant and continuous investment in distribution assets. Supply interruptions have financial and social impacts on customers, which vary by season, time of day, customer load and customer type. Previous research into VoLL has identified such differences. However, it is still the practice to use a single uniform VoLL based on existing customer energy usage and assigned value. Existing research identified a range of possible values (£4,300 to £22,000/MWh) to use as an incentive for operators to reduce lost load. Ofgem settled on a value of £16,000/MWh but recognised that this could be changed in the light of further research².

As GB decarbonises heat and transport, customers will become more reliant on electricity for their energy needs and hence it is likely that the VoLL will change. This future VoLL is important in informing issues such as network reliability standards, design policy for LCT-intensive networks and service standards. VoLL may also have significantly different values across the various segments of the customer base; for example, rural customers compared to urban, and worst-served customers compared to those with a history or expectation of an average or below average number of interruptions. Understanding VoLL by segment will be an important factor in forming DNO policies and investment plans for RIIO-ED2 and beyond.

While VoLL is reflected in various incentive rates such as Ofgem's Interruption Incentive Standards, it may not necessarily follow that incentive rates should also be segmented. Differential VoLL values may be more appropriate in investment decisions where relative customer needs can be considered.

1.3 Measuring VoLL: best practice

Unlike large commercial/industrial users, SMEs and domestic electricity customers are less able to influence the reliability of their power supply by resilience planning, either from paying for additional network assets or installing standby generation to provide an alternate source of supply during an outage. Large commercial/industrial users are more able to signal their VoLL by entering into balancing contracts and flexible energy demand/supply agreements eg demand side response and short-term operating reserve. These customers may have widely varying assessments of VoLL but, importantly, are able to effectively influence the security of their supply. As such, this class of customer will not be included in the research and this approach has been endorsed by key industry stakeholders.

¹ Electricity Authority – Te Mana Hiko, 2012, Investigation into the Value of Lost Load in New Zealand – Summary of Findings.

² Ofgem, March 2011, Strategy for the next transmission price control – RIIO-T1: Outputs and incentives, Supplementary Annex, p 42.

The customer engagement methodology designed to measure VoLL in this study has been developed to incorporate learning from previous research in this area, undertaken in a number of countries and utility sectors, most notably for Ofgem and the Department of Energy and Climate Change (DECC) in 2013³. This study observed how the value can vary by season, time of day, customer load and customer type eg urban/rural and worst-served. The *Methodology Statement Addendum A: Literature Review* published on the project [webpage](#) demonstrates how this historic body of work has established a guide on how current VoLL can best be measured via customer surveys.

The biggest challenge for this project, and possibly its most significant contribution to understanding VoLL, is how to measure likely changes in the way customers assign value in the future, particularly in relation to the adoption of LCTs. Increase in customer use, and hence dependency on electricity, is a critical factor in influencing future VoLL and therefore long-term decision-making in investment planning. The method for making this calculation is described in Section 2.3.

1.4 Project objective

The aim of the project is to quantify VoLL to customers by customer segment, now and in the future. This will be achieved by answering the following research questions:

- What is the impact on customers of lost load?
- What is the value of this impact, expressed as the financial and social cost to customers in £ per kWh?
- How does this vary by customer type and supply interruption components eg duration?
- How can Electricity North West and key stakeholders mitigate the cost of lost load to customers?
- How will this vary with LCT adoption?

1.5 Project success criteria

The research will deliver the following outputs:

- An understanding of customer impact, how value is defined and how this might be influenced eg better communications
- A credible segmentation and future VoLL model by key customer groups to guide investment decisions
- A demonstration of how these values would help Electricity North West and other DNOs to better plan their network investment strategy
- Guidance on customer compensation strategies.

2 SUMMARY OF THE APPROACH

The method will encompass three phases of customer and stakeholder engagement to acquire a comprehensive understanding of VoLL over time and by customer segment.

2.1 Phase 1: Understanding the problem

Phase 1 comprised the following activities:

- Review of published literature on the measurement of VoLL. This literature has identified the best methods of evaluation among customers and established methods of VoLL calculation drawing on previous international work. The review is published in the *Methodology Statement Addendum A: Literature Review*.

³ London Economics, 2013, The Value of Lost Load (VoLL) for Electricity in Great Britain, Final Report for OFGEM and DECC.

- A peer review of the proposed methodology, the key findings of which are published in *Methodology Statement Addendum B: Peer Review*.
- Consultation with key stakeholders (DECC and Citizens Advice) to outline the approach and integrate feedback into the proposed method. The research may also be shaped to reflect feedback from other parties with a vested interest. The findings and recommended modifications to the research approach, derived from stakeholder engagement, are published in *Methodology Statement Addendum C: Stakeholder Consultation*.

2.2 Phase 2: Refining the approach

Phase 2 will comprise focus groups and depth interviews with a cross-section of customers, and with stakeholders likely to be in contact with or support customers during a supply interruption. This includes, but is not limited to: domestic customers, SMEs (with a focus on sectors heavily reliant on continuous electricity provision), hospitals, educational institutions, local authorities, care homes, British Red Cross, Age UK and communications companies. Customers interviewed will include those who have recently endured high impact, low probability events such as the storm/flood damage which affected North West England in winter 2015/16. These customers will be able to discuss recent experiences of a supply interruption and the impact on their household or business.

This research will explore:

- How reliability of supply is defined by customers
- How customers and businesses prepare, if at all, for supply interruptions
- Differing expectations for planned outages versus unplanned interruptions associated with faults
- How different customer groups value reliability of electricity supply in different ways
- The financial impact of lost load (particularly to SME customers and service organisations). This will consider customer perception around costs associated with their own resilience measures, insurance cover for loss resulting from outages and uninsured losses
- The social impact of lost load (particularly in relation to domestic customers) including the impact on communications and vital services
- Expectations around communication and support from Electricity North West and other stakeholders during a supply interruption and the extent to which enhanced support would mitigate their assessment of VoLL. Optimised customer communications could provide a financially efficient means of mitigating power loss compared with network reinforcement
- Key attributes of supply interruptions such as frequency, duration, time of day and financial impact
- How customer and stakeholder views may change with future decarbonisation of heat and transport
- How VoLL might vary in relation to the scale of a supply interruption and the number of customers experiencing the loss of supply within a community. For example, where a major incident such as severe flooding affects a large population. This research will consider the extent to which VoLL varies when demand on vital services increases to support entire communities
- If there is a 'tipping point' in the VoLL for customers, when measured against investment in reinforcement to improve network resilience to mitigate against lost load.

An engaged customer panel (ECP) representing domestic and SME sectors will be convened. Focus groups are proven to be a suitable platform to explore complex concepts and encourage informed discussions. Each issue will be investigated by engaging with separate groups of customers, likely to have shared experiences eg SMEs and worst-served customers.

Individual interviews will be undertaken with difficult-to-reach groups eg vulnerable customers. Key stakeholders will also be interviewed individually to understand the unique position between Electricity North West and the stakeholders' own customers.

A statistically robust pilot will be conducted with the ECP and a wider audience of domestic customers and SMEs to review the survey instrument and any supporting materials before it is rolled out more widely.

2.3 Phase 3: Measuring VoLL

A large-scale quantitative survey will be conducted to provide insight into the following research questions:

- Does VoLL vary by customer segment and what are the relative value assignments of these segments?
- How will VoLL vary with LCT adoption?
- How would the level of incentives tested for demand side response in other Low Carbon Networks (LCN) Fund trials compare to future VoLL?
- Which segments, if any, would support a strong VoLL and hence potentially higher investment?
- How does the scale and duration of an interruption affect VoLL? Is there a tipping point at which investment to mitigate against supply interruptions becomes the most financially viable option to customers, particularly during extremely infrequent, lengthy and widespread outages?

The survey will include a stated preference choice experiment (CE), identified in the literature review as the most robust technique for measuring VoLL. This will involve asking customers to trade off different levels of supply reliability and support in exchange for a hypothetical financial incentive or penalty. The worst-served customer sample will be key to this element of the research, having a poorer experience of supply interruptions than the average customer and thereby a more informed opinion.

VoLL will be measured both in terms of customers' willingness to accept (WTA) compensation for lost load and willingness to pay (WTP) for avoidance of lost load. This is based on previous research which has demonstrated quite different results from these two approaches, with WTP values being notably lower than WTA values. This is largely the result of customers' belief that they have an intrinsic entitlement to a good/service when the good/service may be described as a 'public good' such as security of the electricity supply. When consumers are accustomed to receiving a service for which they pay, they typically expect greater compensation to offset the loss of that service than they are willing to pay to retain it. This is because individuals perceive a sense of ownership or property rights for something they already have (in this case a secure electricity service). Psychologically, the loss from giving something up feels greater than the gain from retaining it and avoiding the loss.

Literature published by influential institutions such as the Council of European Energy Regulators⁴ suggests that it is realistic to ask survey respondents to make hypothetical trade-offs in relation to their current behaviour and experience. However, there is likely to be greater uncertainty if respondents are asked to consider VoLL specifically in relation to future LCT adoption. This is because respondents will be required to take further steps to make considered decisions in a trade-off exercise. Initially, this will require the assimilation of projected changes in electricity use before respondents can imagine their expectations in a future with greater reliance on LCTs and electricity in general.

⁴ Council of European Energy Regulators (CEER), Dec 2010, Guidelines of Good Practice on Estimation of Costs due to Electricity Interruptions and Voltage Disturbances, Ref: C10-EQS-41-03.

The survey will use the same method (CE) to derive VoLL with all respondents. However, for half of the respondents, the questions presented will be phrased in terms of current electricity usage; for the other half, they will be phrased in terms of future usage with a greater presence of LCTs. The introduction to the exercise will vary according to whether respondents are being asked to consider the current or future context.

Investigation of the potential variation of VoLL in relation to LCTs will not be confined solely to comparisons of the results for the current and imagined future contexts. VoLL for *current* users of LCTs can be compared with VoLL for current non-users of LCTs; additionally, VoLL for high users of electricity can be compared with VoLL for low users. The potential change in VoLL as consumers increase their LCT usage and electricity consumption in the future can be inferred from both of these comparisons.

A pilot survey will be used to test and evaluate how optimum results can be achieved using this approach.

Following completion of the main survey and analysis, the original ECP will be re-convened to evaluate the findings. The role of the ECP will include an evaluation of the customer engagement outcomes and their implications for the VoLL project.

3 PHASE 1: LITERATURE REVIEW

The initial phase of this project involved a comprehensive literature review covering published work relating to the measurement of VoLL and specifically, the methods considered most suitable for that calculation. This is documented in *Methodology Statement Addendum A: Literature Review* published on the project [webpage](#).

A literature review typically covers current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic.

This review drew on the comprehensive work undertaken by London Economics for Ofgem and DECC in 2013⁵ which made extensive use of stated preferences (what people say they will do) when measuring VoLL for domestic and SME customers.

4 PHASE 1: INTERVIEWS WITH KEY STAKEHOLDERS

The results from this research should make it possible to predict future changes to VoLL as LCTs are adopted onto the network. It was recognised that stakeholders that are likely to make use of the information and adopt any new values must be engaged in the early stage of the project to help shape the research in order for the findings to be of maximum utility.

It is anticipated that these stakeholders will be engaged at several stages during the project. An initial, depth interview was conducted with individual stakeholders to help develop this methodology, ensure their views on the proposed approach were understood, and that any concerns they had regarding the method, results and subsequent implementation were captured. This feedback has been used to refine the approach to ensure the objectives of the main research phases of the project reflect and fully align with the wider industries' required outputs. Stakeholder feedback is documented in *Methodology Statement Addendum C: Stakeholder Consultation* published on the project [webpage](#).

On completion of the project, the stakeholders will be provided with advanced notice of the summary results and the implications for implementing a revised VoLL model.

⁵ London Economics, 2013, The Value of Lost Load (VoLL) for Electricity in Great Britain, Final report for Ofgem and DECC.

The project team will be available to answer questions from these stakeholders throughout the life of the project.

5 PHASE 2: CUSTOMER ENGAGEMENT TO GUIDE SURVEY DESIGN

To measure VoLL accurately, the customer survey must encompass all of the main factors that adversely impact customers as a direct and indirect result of lost supply. To ensure that no elements are missed, exploratory research will be conducted among key customer groups who have specialist requirements, or suffer lost load more frequently than average. This engagement will be influential in establishing customer experience of negative impacts associated with the loss of supply.

5.1 Engaged customer panel

An ECP will be convened ahead of the main customer survey (data collection stage). The ECP will comprise four focus groups, each representing a key customer segment:

- Urban domestic
- Rural domestic
- Worst-served customers
- SMEs (particularly from industries heavily reliant on electricity).

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 twice before the start of the quantitative research and once after the customer survey analysis has been completed. The ECP will explore the key objectives as outlined in Section 2.2.

The scope of the ECP meetings will be designed to explore these considerations and meet the research objectives shown in Figure 5.1.

Figure 5.1: ECP meetings

ECP Meeting	Date	Research objective
Meeting 1	April 2016	<ul style="list-style-type: none"> • Introduce Electricity North West, its role as a DNO in the electricity industry and its relationship to National Grid and suppliers • Establish customer perception and impact of VoLL on their household/business
Meeting 2	May 2016	<ul style="list-style-type: none"> • Evaluate draft survey instrument, in particular the attributes and levels to be used in the choice-based conjoint, with regards to effectiveness and accuracy of data collection

The draft materials for the customer survey research will be developed between meetings 1 and 2. These materials will incorporate the factors identified as adversely impacting customers as a result of lost supply and will be evaluated by the ECP during meeting 2 and further refined before launching the survey instrument (see Section 8.2).

5.2 Customer and stakeholder depth interviews

In addition to the ECP, up to 20 depth interviews will be conducted with difficult-to-reach customers and relevant stakeholders. These will include:

- Vulnerable customers currently listed, or eligible to be listed, on the priority services register (PSR)
- Off-gas customers
- Key stakeholders such as hospitals, care homes, local authorities, educational institutions, charities such as British Red Cross and Age UK and communications companies who are in contact with and/or are actively involved in supporting customers in the event of a supply interruption
- SMEs particularly reliant on electricity such as hotels
- Customers affected by large-scale supply interruptions.

The topics covered in the depth interviews will be similar to those discussed in ECP meetings 1 and 2. Individual interviews will be conducted by phone or face-to-face, depending on participants' preferences. These one-to-one interviews are likely to be more convenient for vulnerable customers, who may be unable to travel long distances or be too geographically dispersed to attend a focus group. Key stakeholders will be interviewed individually, to understand the unique position between Electricity North West and their customer base. Relevant customer insights will be integrated in the design and administration of the customer survey.

6 PHASE 2: CUSTOMER SURVEY INSTRUMENT DESIGN

The main customer 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 difficult-to-reach groups such as vulnerable customers. The full breakdown of the target sample is detailed in Section 8.1. The survey instrument will be tailored to fit the response method; however, the content will be similar for all methods.

The survey instrument will be designed by Impact Research in conjunction with Electricity North West to ensure it is able to robustly address the objectives of the research set out in Section 1.4. The draft survey will then be introduced to the ECP to test and refine its content. The survey instrument will be used to provide answers to the following research questions:

- Does VoLL vary by customer segment and what are the relative value assignments of these segments?
- How will VoLL vary with LCT adoption?
- How would the level of incentives tested for demand side response in other LCN Fund trials compare to future VoLL?
- Which segments would support a strong VoLL and hence potentially higher investment?
- How does the scale and duration of an interruption affect VoLL? Is there a tipping point at which investment to mitigate against infrequent, lengthy and widespread interruptions becomes the most financially viable option to customers?

To ensure the survey is not too onerous to complete, thus maximising potential participation among all customer segments, it is expected to take no more than 30 minutes and will include the following sections:

- Demographic information such as age and gender, vulnerability, business type, geographical location, electricity consumption (including use of LCTs), energy affordability and home working
- Experience and perception of unplanned and planned interruptions, including frequency and duration
- Satisfaction with supply reliability and customer service ie the DNO's handling of and communication strategies during the power cut
- Context of the interruption/s, for example, localised fault or outage caused by severe weather events, including storms and flooding

- Stated preference scenarios, where respondents will trade off varying levels of reliability of supply in exchange for a hypothetical financial incentive or penalty.

The ECP will be influential in refining the draft survey instrument, particularly the stated preference scenarios. The scenarios will include several key factors that contribute to customer perception of VoLL. All participants in the survey will be presented with key attributes and a series of trade-off choices.

The analysis of this decision-making process will inform the understanding of the levels of acceptability for each key attribute, such as loss of supply at a specific time of day. The levels within this attribute might be early morning, middle of the day, late afternoon, evening and overnight. The ECP will utilise a deliberative approach to establish the optimal list of attributes and levels, based on their experiences and expectations of planned and unplanned interruptions. The instrument will be revised as necessary, based on ECP feedback, before being piloted and peer reviewed prior to the main customer survey phase.

This well-established approach to survey design allows for the comprehensive testing and refinement of the instrument before the main survey phase (see Section 8). Any required adjustments highlighted at the pilot stage will ensure that the survey instrument is thoroughly optimised before the actual customer survey takes place.

7 PHASE 2: CUSTOMER SURVEY PILOT

A statistically robust pilot will be conducted with the ECP and a group of customers to review the survey instrument and any supporting materials before it is rolled out more widely. This is a direct learning from previous customer engagement projects and ensures that the final survey instrument can be correctly understood and will provide accurate and relevant data.

The sample sizes planned for the pilot survey provide the opportunity to ask half of all respondents to make their choices in the context of a future scenario, with greater dependence on electricity, framed specifically around the use of one of three possible LCTs:

- An electric vehicle (EV)
- A photovoltaic (PV) system
- An electric heat pump (EHP).

The remaining respondents will relate choices to their current experience only. This approach should elicit a realistic estimation of the potential future shift in VoLL. However, this will only be possible if the pilot survey sample demonstrates that respondents can imagine the LCT future with sufficient clarity. Pilot responses will be analysed to assess customers' ability to imagine the future scenario.

Stratified random sampling will be used to ensure that a cross-section of current LCT users is included in the main customer survey. However, it is recognised that this may be challenging in terms of recruitment.

7.1 Sample size and method

All ECP members (up to 40 customers) will be approached to participate in the pilot and their feedback will be utilised to further refine the key components (attributes and levels) of the stated preference exercise, where customers will trade off varying characteristics of supply reliability in exchange for a hypothetical financial incentive or penalty.

As the ECP will have been previously educated about VoLL and its background and context, its members are likely to give more considered responses than typical customers. Therefore, 700 pilot interviews will be conducted with previously unengaged customers to thoroughly test the survey instrument.

These interviews will comprise 600 domestic and 100 SME customers. Among the domestic sample, 300 interviews will be conducted with customers from Electricity North West's region, with a focus on the key customer groups of interest (as referenced in Section 8.1).

The composition and administration of the pilot will reflect that of the final survey. The majority of domestic and SME quantitative interviews will be conducted online. Respondents from outside Electricity North West's operating region are expected to administer the survey online. The majority of these surveys will be completed by a panel of online respondents who are familiar with and regularly participate in online surveys of this nature. Customers located within Electricity North West's distribution region are expected to take part online through a self-completion method or alternatively be guided through the survey with the assistance of a professional interviewer. This assistance will either be provided over the telephone or face-to-face. Surveys will be specifically offered in this manner when targeting vulnerable, fuel-poor and worst-served groups of customers.

7.2 Actions from the pilot

The final survey instrument will be reviewed and refined following feedback from the pilot before launching the customer survey. It is not envisaged that major amendments will be required following the pilot. However, should this be the case, a further pilot will be conducted to test the updated instrument prior to launching the full survey.

A peer review of the survey instrument will be undertaken to evaluate its ability to provide accurate quantitative research and to achieve the research objectives. The peer review of the survey is intended to maintain standards of quality, improve performance and provide credibility.

8 PHASE 3: QUANTITATIVE SURVEYS

8.1 Sample selection

A total of 6,000 surveys will be completed, split between customers from Electricity North West's operating region and from other GB DNOs. This will include 5,000 interviews with domestic customers and 1,000 interviews with SMEs.

An understanding of customer impact will primarily inform the way in which dependency on the continuous availability of electricity supply is defined. Survey analysis will identify SMEs which are heavily dependent on a continuous and reliable supply of electricity. The approach for classifying SMEs as being heavily reliant will be assumed from the survey responses in the form of a customer-driven perception measure. The approach will also be subject to the peer review of the survey instrument.

Existing research has categorised respondents who indicate that an electricity outage of one hour duration would have a 'high impact' on their organisation's business as usual operations, as having a heavy reliance. Customers are likely to quantify the impact on their organisation in different ways eg productivity, and be influenced by any mitigation already in place to enhance the organisation's resilience.

The interviews will be conducted in two phases, winter 2016/17 and summer 2017 with 50% of each customer type being completed in each phase.

The challenge of engaging with willing survey respondents, because of seasonal commitments, will be reflected in the winter fieldwork taking place up to 21 December 2016 and recommencing after 3 January 2017. This will prevent detrimental impact on the study over the Christmas and New Year period.

The online survey will include a nationally representative sample of 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.

A minimum number of 300 surveys will be conducted with domestic customers within each DNO region. Following consultation with key stakeholders and agreement of the methodology, DNOs will be sent written notice of proposed engagement with customers in their operating regions before the pilot phase of customer survey fieldwork. They will also be issued with the project methodology statement and invited to provide feedback on the research.

Respondents from outside Electricity North West’s operating region are expected to administer the survey online. Customers located within Electricity North West’s distribution region are expected to take part online through a self-completion method or alternatively be guided through the survey with the assistance of a professional interviewer. The assistance of a professional interviewer will either be provided over the telephone or in a face-to-face interview where this is appropriate.

The 1,000 interviews with SMEs will be conducted across GB via the online survey approach, with 500 interviews per fieldwork period.

To guarantee sufficient data from key customer groups and to permit detailed sub-analysis, a statistically robust sample size will be achieved for each of the following subgroups in the Electricity North West region and at an aggregated GB level:

- Worst-served customers
- Customers affected by large scale supply interruptions during adverse weather in either winter 2015/16 or winter 2016/2017
- Vulnerable customers
- Customers in fuel poverty
- Off-gas network customers
- LCT users
- Geographical rural and urban classifications
- SMEs in a range of sectors and of various sizes
- Low, medium and high dependency customers
- Low, medium and high users of electricity
- Home workers.

It is expected that identification of some customers falling into these subgroups will be naturally apparent in the national survey sample; in which case, their data will also be included in the subgroup analysis.

The proposed sample structure for domestic customer interviews is outlined in Figure 8.1 below. This includes key customer groups of interest.

Figure 8.1: Quantitative sample structure for domestic customer interviews

Domestic sample structure	Recruitment/survey method	Incidence (where known)		Total interviews	
		North West	Rest of GB	North West	Rest of GB
Gender					
Female	Online, F2F and telephone	51%	51%	1530	1530
Male	Online, F2F and telephone	49%	49%	1470	1470

Domestic sample structure	Recruitment/survey method	Incidence <i>(where known)</i>		Total interviews	
		North West	Rest of GB	3000	3000
				North West	Rest of GB
Age					
18 – 29	Online, F2F and telephone	21%	21%	630	630
30 – 44	Online, F2F and telephone	25%	25%	750	750
45 – 59	Online, F2F and telephone	25%	25%	750	750
60+	Online, F2F and telephone	29%	29%	870	870
Socio-economic group					
A	Online, F2F and telephone	19%	23%	570	690
B	Online, F2F and telephone				
C1	Online, F2F and telephone	30%	31%	900	930
C2	Online, F2F and telephone	21%	21%	630	630
D	Online, F2F and telephone	30%	25%	900	750
E	Online, F2F and telephone				
Population density					
Rural	Online, F2F and telephone	11%	18%	330	540
Urban	Online, F2F and telephone	89%	82%	2670	2460
Region					
Electricity North West	Online, F2F and telephone			Minimum 3000	
Scottish and Southern Energy	Online				Minimum 300
SP Energy Networks	Online				Minimum 300
Northern Ireland Electricity	Online				Minimum 300
Northern Powergrid	Online				Minimum 300
Western Power Distribution	Online				Minimum 300
UK Power Networks	Online				Minimum 300

Domestic sample structure	Recruitment/survey method	Incidence (where known)		Total interviews	
		North West	Rest of GB	3000	3000
				North West	Rest of GB
Faults					
Worst-served	Online, F2F and telephone in region, GB online	20%		600	Natural fall out
Experienced large scale, lengthy supply interruption in last twelve months	Online, F2F and telephone in region, GB online			150	Natural fall out
Sensitivity					
Vulnerable	Online, F2F and telephone in region, GB online	31%		930	930
Fuel poverty	Online, F2F and telephone in region, GB online	17%		510	510
Off-gas	Online, F2F and telephone in region, GB online			Minimum 300	
LCT users	Online, F2F and telephone in region, GB online	Estimated 5%		Target (boost) 350	

The [Standard Industrial Classification of Economic Activities](#) (SIC) will be used to classify businesses by the type of economic activity in which they are engaged, for recruitment and analysis purposes. The SIC includes large industrial and commercial customers which are outside of the scope of the VoLL project, therefore the incidence of business sectors outlined in Figure 8.2 below will not be strictly enforced. The sample structure will be used to ensure that an appropriate spread of business sectors is represented within the GB SME sample.

Figure 8.2: Quantitative sample structure for SME customer interviews

SME sample structure	Recruitment/survey method	GB Incidence	GB Interviews
Agriculture, Forestry and Fishing	Online, F2F and telephone in region, GB online	3%	28
Mining and Quarrying; Electricity, Gas and Air Conditioning Supply; Water Supply; Sewerage, Waste Management and Remediation Activities	Online, F2F and telephone in region, GB online	1%	5
Manufacturing	Online, F2F and telephone in region, GB online	5%	51
Construction	Online, F2F and telephone in region, GB online	18%	177
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	Online, F2F and telephone in region, GB online	10%	97
Transportation and Storage	Online, F2F and telephone in region, GB online	5%	51
Accommodation and Food Service Activities	Online, F2F and telephone in region, GB online	3%	34
Information and Communication	Online, F2F and telephone in region, GB online	6%	63

SME sample structure	Recruitment/survey method	GB Incidence	GB Interviews
Financial and Insurance Activities	Online, F2F and telephone in region, GB online	2%	16
Real Estate Activities	Online, F2F and telephone in region, GB online	2%	19
Professional, Scientific and Technical Activities	Online, F2F and telephone in region, GB online	15%	147
Administrative and Support Service Activities	Online, F2F and telephone in region, GB online	8%	82
Education	Online, F2F and telephone in region, GB online	5%	50
Human Health and Social Work Activities	Online, F2F and telephone in region, GB online	7%	69
Arts, Entertainment and Recreation	Online, F2F and telephone in region, GB online	5%	50
Other Service Activities	Online, F2F and telephone in region, GB online	6%	60

8.2 Survey approach

The customer survey will mostly be conducted through online panels of respondents, pre-registered and open to research of this kind. This cost-effective approach provides for the targeted selection of customers as set out in Section 8.1. Other benefits of the online approach are that the stated preference scenarios and associated educational materials can be viewed on screen to inform the trade-off decisions; and the survey can be completed at a time and place convenient to the participant.

A tailored survey approach will ensure the best responses from the key customer groups being interviewed.

These customers will be approached by phone or face-to-face and offered an incentive to the value of £15 to participate in the survey. These methods have consistently been proven to obtain a higher response rate than online recruitment alone and will ensure samples that are statistically robust for the required analysis. Additionally, the presence of an interviewer enables customers to ask questions or clarify survey content as necessary.

Following formal acceptance of the VoLL customer engagement plan (CEP), the subgroups described in Section 8.1 will be identified and targeted from Electricity North West's customer database. Although it would be preferable to approach customers in these groups GB-wide, this would require other DNOs to provide customer information to Impact Research. This is likely to be problematic for a number of reasons and impractical within the constraints of time and budget allocated for this project. Therefore, targeting a representative sample of customers from all segments within Electricity North West's region will be sufficient to draw conclusions about the application of VoLL to these subgroups nationwide.

8.3 Seasonal variation and timings

Customer perception of VoLL is likely to vary by the season in which a supply interruption occurs, as indicated by previous research. Customer experience will be affected differently dependent on daylight hours and whether heating is required, as discussed in the literature review. Seasonal perception of VoLL is also expected to vary among users of different LCTs ie users of EHPs, EVs and PV systems.

It is recognised that VoLL is likely to vary by season, and it is also accepted that only a proportion of customers interviewed might be expected to have recently experienced a

supply interruption. However, conducting surveys in two phases will help to identify any changes in perception of VoLL resulting from the season in which the interviews take place and how such changes vary within each segment dependent upon recent experience of an outage.

Previous research has identified that planned interruptions are generally more acceptable to customers during warm summer months but are extraordinarily disruptive in winter. By comparing customer perception of VoLL over summer and winter, the extent of the seasonal impact will be quantified. While it may be more challenging to gauge perception of VoLL based on past events, these experiences will be influential when survey respondents are considering future, hypothetical situations in the trade-off exercise (see Section 8.4).

For the purposes of this research, it will be sufficient to control the seasonal variation in the analysis by collecting survey data across two seasons (winter and summer) and deriving average values of VoLL across these likely extremes in perception. Any seasonal considerations will be controlled in the scenarios presented, for example, by presenting attributes that relate to heating and lighting requirements at the time of the interruption. The most consistent and therefore ideal approach will be to develop attribute definitions that are the same for any time of the year, even if their impact will differ by season. Irrespective of whether a customer completes a survey in summer or winter, they will be presented with scenarios that include variables relating to all four seasons.

It is possible that respondents will find it more straightforward to provide VoLL perceptions relative to the season during which they complete the survey. For example, customers may find it more difficult to consider the impact of fewer hours of daylight, or several hours without heating in winter, when responding to these scenarios at the height of summer. However, conducting interviews during the two seasonal extremes will ensure the analysis is sufficiently robust to determine the scale of any changes in perception of VoLL by season.

8.4 Past experience of supply interruptions

Past experience of supply interruptions is an influencing factor on VoLL perception. The type of bias this might introduce will be explored with the ECP and measured in the customer survey. The customer survey data will be analysed according to experience of supply interruptions.

Experience of supply interruptions can broadly segment customers into five groups:

- Customers who have historically experienced very few, if any, supply interruptions
- Customers who have had repeat exposure to supply interruptions
- Customers who have experienced supply interruptions of a relatively lengthy duration
- Customers who have experienced supply interruptions of a relatively short duration
- Customers who have experienced prolonged and large scale supply interruptions as a consequence of severe weather events ie storms and flooding.

Worst-served customers comprise the second and third segments described above. Although they are described as one group, it will be interesting to understand how VoLL perception varies between the two types of worst-served customer and this will be included in the results analysis.

8.5 Measuring customer perception of VoLL

Choice experiments (CEs), as referenced in the literature review, will be integrated into the customer survey instrument. This section is likely to be one of the longest to complete and will demand concentration and the complete engagement of the participant. The CE design for this research will be broadly similar to the approach taken by the London Economics study for Ofgem and DECC. However, this research does not propose to cover all the attributes included in that study for two reasons:

- It is not necessary to capture the same granularity of detail for attributes where a robust measure of variation was achieved in that study
- Omitting some of these variations will provide capacity in the design to include other attributes not previously tested.

The attributes and levels included in the CE reflect the learning obtained through:

- *Methodology Statement Addendum A: Literature Review* – relating to the measurement of VoLL
- *Methodology Statement Addendum B: Peer Review* – the independent peer review of the method by Professor Ken Willis of Newcastle University
- *Methodology Statement Addendum C: Stakeholder Consultation* – regarding the intended approach to measuring VoLL
- Feedback from the ECP.

The original VoLL methodology statement (version 1) proposed the omission of time of day/day of week attributes. However, the peer review conducted by Ken Willis concluded that care must be taken to avoid part-whole bias; therefore, these specific attributes will be included to scale the WTP and WTA findings observed in this study against those generated in the London Economics study.

The levels associated with the key attribute of duration and amount to pay or accept will also be similar to those tested in the London Economics study. That is, durations of up to one hour and up to four hours and domestic one-off payment/incentive values of £1, £5, £10, £15 (for SMEs these will be replaced with bill reductions/payments to the value of 1%, 5%, 10% and 15% of the annual bill, to reflect the greater diversity of electricity consumption in this group).

Although similar, the levels associated with duration utilised by London Economics will be optimised to reflect current DNO reliability performance measures and more realistic interruption scenarios, such as the inclusion of short duration interruptions of up to three minutes, given the prevalence of these across modern distribution networks protected by automated systems.

In addition to the core set of attributes included in the London Economics study; other measures will be included in the CE to represent means by which VoLL could be reduced through communication and customer support during supply interruptions:

- Level of additional assistance for vulnerable customers
- Communication channels through which notification and information about the power cut can be proactively given
- Quality of information provided.

A full list of attributes and levels to be tested in the CE is included in Section 13. Figure 8.3 below gives an example of the choices that will be shown in a WTA trade off. Each scenario will be divided into two screens to keep the exercise manageable for respondents.

Figure 8.3: Example of how a CE scenario (WTA) could look to respondents

Screen 1

Below are descriptions of two power cuts involving different scenarios. Please select the one that most accurately reflects your view on the amount of money you would expect to receive to accept this situation. Please remember this is only a hypothetical situation and payment:

	Option A	Option B	
Type of power cut	Unplanned	Unplanned	Not sure
Advance warning of the power cut	No notice	Less than 24 hours' notice	
Frequency of power cuts	15 or more power cuts in a three year period	7-14 power cuts in a three year period	
Duration of the power cut	Up to 1 hour per power cut	Up to 12 hours per power cut	
Time of day	Early morning (6:00am – 9:00am)	Day time (9:00am-3:00pm)	
Day of week	Bank Holiday	Weekend	
The one-off amount you receive for this happening	Payment to you: £10	Payment to you: £15	
Please make your selection here:	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Screen 2

You selected the following option with a payment to you of £15:

Type of power cut	Unplanned
Advance warning of the power cut	Less than 24 hours' notice
Frequency of power cuts	7-14 power cuts in a three year period
Duration of the power cut	Up to 12 hours per power cut
Time of day	Day time (9:00am-3:00pm)
Day of week	Weekend

Below are possible types of support that you could receive during the above power cut, please choose the support option you prefer:

	Support A	Support B	
Quality of information provided	Confirmation that your electricity is back on	A justified reason for the power cut	Not sure
Proactive information about the power cut	Nominated friend, family member or colleague who can be sent updates instead of, or in addition to us contacting you	Nominated friend, family member or colleague who can be sent updates instead of, or in addition to us contacting you	
Assistance for customers vulnerable during the power cut	Sending a mobile unit that allows you to charge mobile phones and tablet devices	Sending a mobile catering van to provide hot food and drinks	
The one-off amount you receive for this happening	No extra payment to you	£2 extra payment to you	
Please make your selection here:	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

The inclusion of a 'no choice' option in the form of a 'not sure' response avoids forcing a choice with an inherent bias effect on the results.

In the WTP scenarios, respondents will be shown 'The one-off amount you pay to avoid this happening' instead of 'The one-off amount you receive for this happening'.

The scenarios will be constructed using established statistical design principles. Each respondent will be asked to make two separate choices within each scenario:

- The most acceptable power cut option, if any, presented in a WTA or WTP trade off
- The most acceptable support option, if any, presented in a WTA or WTP trade off.

Each exercise will comprise 12 scenarios for each respondent⁶. Half of these will present WTA and the other half WTP, with the order of these randomised. Full instructions for completion of this questioning technique will be included before the exercise and the respondents' ability to complete this element of the survey with relative ease will be evaluated during the pilot.

As the focus of the study is on future VoLL, it is important that values are not overtly anchored to customers' current experiences. Therefore, the current situation will not be explicitly represented in the scenarios. However, prior to the CE, respondents will be asked how they perceive their current service in the context of the characteristics that will be tested in the CE. This will encourage them to evaluate the attribute levels and establish a personal benchmark. They will be allowed to respond 'not sure' in all cases.

8.6 Evaluation of results

Section 5.1 outlines the objectives of the initial ECP meetings in phase 2 of the project.

Where possible, the original ECP will be re-convened after the survey analysis has been completed to evaluate the findings.

Due to the length of time between the first phase of ECP consultation and the scheduled survey analysis, reconvening all the original panellists may not be practical, as many factors may contribute to attrition.

The role of the ECP will include an evaluation of the customer engagement outcomes and their implications for the VoLL project. Figure 8.4 denotes the timing and research objective of the meeting.

Figure 8.4: ECP final meeting

ECP Meeting	Date	Research objective
Meeting 3	Nov 2017	Review, interpret and contextualise the research findings.

9 CUSTOMER ENGAGEMENT PLAN

In accordance with Sections 4.6 to 4.10 of the Electricity Network Innovation Allowance Governance Document a customer engagement plan (CEP) and data privacy statement (DPS) were submitted to Ofgem and formally approved on 14 April 2016. These documents specify how Electricity North West and its project partners will interact with, or impact upon,

⁶ All these elements of the design are consistent with the London Economics, 2013 report for Ofgem and DECC, pp4-9.

relevant customers where any form of engagement is undertaken as part of the project. These documents are published on the project [webpage](#).

10 ANALYSIS

10.1 Modelling stated preferences

Statistical models will be used to examine respondents' decision-making processes and quantify the influence of each attribute in their choice between a pair of scenarios in the CE. This produces a measure of the value placed by customers on each attribute. The ratio of each non-monetary attribute to the monetary attribute gives an inferred WTP or WTA value.

Comparison with other studies will be limited to specific attributes common to this and previous research, where direct comparison is possible. As indicated in the peer review, there is a danger of 'part-whole' bias resulting from only some of the attributes being the same across studies. This can be addressed by scaling WTP or WTA findings against a strong common attribute, such as duration of outage.

Further detail on this process is provided in Appendix B of the literature review.

10.2 Segmentation by customer groups

The WTP and WTA values will be estimated for each respondent. This allows the responses to be grouped in two ways:

- By predefined customer subgroup, including:
 - LCT users
 - Vulnerable customers
 - Worst-served
 - Home workers
 - Geography (urban/rural)
 - Profile class (likely only to be available in the Electricity North West region)
 - SME customers' MIC and MEC (likely only to be available in the Electricity North West region).
- As clusters of individuals with similar preferences as expressed in the CEs.

This second part of the analysis could identify new subgroups within the predefined subgroups or across the wider survey population.

Vulnerability

The analysis will assess VoLL in the context of the DNO's social responsibility to its vulnerable customers by examining the value placed on the loss of supply within this customer segment. Variations in VoLL among customers categorised with different definitions of vulnerability, based on information voluntarily provided in the survey, may be identified. These results are expected to be influential in the DNO's policy decisions aligned to social obligations and customer vulnerability strategies.

Affordability

Analysis will distinguish the VoLL of customers who need to spend more than 10% of the household income on fuel to heat their home to an adequate standard. The revised VoLL model will inform investment strategies to ensure the interests of fuel-poor households are

protected. These customers will be mainly identified by means of customer profiling questions at the start of the survey⁷.

10.3 Forecasting LCT adoption and other future behaviour

The survey will include questions designed to elicit each respondent's view about the future adoption of LCTs. These will be introduced with an appropriate explanation about the anticipated increase in reliance on electricity driven by the decarbonisation agenda.

Two approaches will be used to estimate the potential VoLL of future adopters:

- Some respondents will be asked to imagine a future where they rely much more on electricity generally and also specifically because of their personal adoption of a defined LCT. This sample will be instructed to respond to the CE within this future context
- VoLL values derived for *current* users of LCTs and high consumers of electricity will be applied to non-LCT users, responding in the context of future adopters.

The first approach offers the potential for an accurate representation of VoLL, provided survey respondents are able to clearly imagine and realistically comprehend the future impacts of LCTs. However, it is anticipated that non-users of LCTs may find it difficult to imagine or accept the extent of anticipated future LCT adoption and, consequently, society's increased demand for and dependence on a reliable electricity supply. It is therefore critical that participants are provided with effective education materials in the quantitative research.

The second approach has the advantage of using values that are derived from actual experience, but it assumes that future adopters will have the same values as current LCT users and high consumers of electricity. These may not be valid assumptions, given that there may be differences in VoLL for users of multiple and single LCTs. It is also impossible to quantify the extent to which future users may offset EHP and EV demand with distributed generation, such as PV and energy storage systems.

To increase the likelihood that participants have seriously considered the future LCT scenario and the impact on their household or business, it is proposed that tailored education materials are placed at the start of each section of the survey, rather than more lengthy reading material being provided beforehand.

Early adopters

One way of identifying how VoLL might change with the adoption of LCTs is to compare the responses of current LCT users with those of comparable customers who are not yet users of these technologies. The VoLL for customers with EVs, PVs or EHPs will be compared with the VoLL of customers with a similar demographic profile who currently do not use these technologies.

11 IMPLEMENTATION OF FINDINGS

11.1 An opportunity to improve DNO investment models

It is anticipated that the outputs from this research will significantly revise a DNO's current models of cost-benefit analysis. The research will deliver a set of VoLL estimates that reflect the varying needs of different customer groups far more accurately than the single-value approach currently used. This will enable DNOs to make targeted investment decisions

⁷ For example, "Which of these best represents your total household income before tax and other deductions, either per month or per year? (Show income bands)" and "On average, how much is your average spend, either per month or per year, on gas and electricity? (Show spending bands)"

based on an accurate assessment of the cumulative VoLL on specific networks, comprised of a range of customer segments, thereby ensuring investment is driven by relative customer need.

The application of a revised segmented VoLL will be attractive because it does not involve a significant change to the way that DNOs assess the benefits of lost load mitigation. Rather, it allows them to refine their models to produce a more precise method for prioritising investment.

11.2 Understanding customer perceptions of cost mitigation

Objective four of this research, as referenced in Section 1.4 considers: 'How can Electricity North West and key stakeholders mitigate the costs of lost load to customers?' The Royal Academy of Engineering suggests that 'there are a number of relatively low cost measures that can be taken to mitigate economic and social costs of [electricity] shortfalls.'⁸

These include:

- Improved communication with customers, both in content and technology
- Improved planning and phasing of outages, particularly in the avoidance of peak load times
- Demand side response
- Use of communities and social networks to mitigate impacts.

This study provides the opportunity to explore customer perception around the acceptability of such measures and to examine how VoLL could vary relative to individual circumstances. For example, VoLL may be influenced by a customer's familiarity with and preference for different communication channels.

It is expected that the research will identify distinct customer groups who vary in their VoLL, and may also respond differently to various DNO strategies intended either to reduce lost load or mitigate its effects. The results of this research will be published and disseminated via appropriate channels to key stakeholders (see Section 12).

The final report will focus on the following topics:

- Marketing and the management of customer expectations regarding supply interruptions
- Effective customer communication channels during and after supply interruptions, and prior to planned interruptions
- Local asset replacement in worst-served areas
- Changing Electricity North West's investment strategy in relation to asset refurbishment and replacement
- The wider implications for Ofgem and GB DNOs in planning their future investment strategy.

12 DISSEMINATION OF FINDINGS AND LESSONS LEARNED

Following successful completion of this project, the fundamental driver in the adoption of a revised VoLL model will be the dissemination of findings to all key electricity industry stakeholders in an appropriate manner. There will be several reporting deliverables to share the results of the analysis and demonstrate achievement of the following success criteria:

⁸ Royal Academy of Engineering, Nov 2014, Counting the Cost: the Economic and Social Costs of Electricity Shortfalls in the UK, A Report for the Council for Science and Technology, p3.

- An understanding of customer impact, how value is defined and how this might be influenced eg better communications
- A credible segmentation and future VoLL model by key customer groups to guide investment decisions
- A demonstration of how these values would help Electricity North West and other DNOs to better plan network investment strategies
- Guidance on customer compensation strategies.

The project findings, lessons learned and implementation recommendations will be shared as follows:

When	Criterion	Required evidence
Phase 1	Literature review, research approach and CEP	Publish the draft methodology statement by February 2016 and the refined approach by July 2016
	Draft the CEP and DPS	Send the CEP and DPS to Ofgem, for approval, by February 2016
	Inform DNOs of the project aims and customer impact	Circulate methodology statement to DNOs by end August 2016
Phase 2	Executive summary of ECP and key customer depth interviews	Publish executive summary of ECP and key customer depths interviews by August 2016
	Peer review of proposed survey instrument	Publish peer review of pilot survey instrument by September 2016
	Executive summary of pilot survey	Publish executive summary of pilot survey analysis by November 2016
Phase 3	Interim summary of customer survey and VoLL model analysis	Publish interim analysis from model by end October 2017
	Final survey report including lessons learned	Document detailed quantitative research findings by December 2017
	Peer review of quantitative research findings	Publish peer review of findings by January 2018
	Conclusions and recommendations	Submit the final report to Ofgem for publication on the ENA learning portal by January 2018
Stakeholder updates	Annual NIA progress report	Submitted to Ofgem annually
	Update reports to key stakeholders and Electricity North West's executive leadership team	Quarterly email updates sent directly to stakeholders throughout project at key project milestones Dissemination events held for key stakeholders as appropriate

All key learning documents will be published on the project [webpage](#).

13 APPENDIX: CHOICE EXPERIMENTS ATTRIBUTES AND LEVELS

Service attribute	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Type of power cut	Planned	Unplanned					
Advance warning of the power cut	7 to 14 days' notice and a reminder 12 to 48 hours before we switch off your electricity	14 days' notice	7 days' notice	48 hours' notice	Less than 24 hours' notice	No notice	
Frequency of power cuts	1 power cut in a three year period	2-3 power cuts in a three year period	4-6 power cuts in a three year period	7-14 power cuts in a three year period	15 or more power cuts in a three year period		
Duration of the power cut	Up to 3 minutes per power cut	Up to 1 hour per power cut	Up to 4 hours per power cut	Up to 8 hours per power cut	Up to 12 hours per power cut	Between 12 and 24 hours per power cut	Major storm/flooding event causing the loss of power for two to three days
Time of day	Early morning (6:00am to 9:00am)	Day time (9:00am to 3:00pm)	Afternoon to evening (3:00pm to 9:00pm)	Late evening (9:00pm to midnight)	Midnight to 6:00am		
Day of week	Weekday	Weekend	Bank Holiday				
Assistance for customers vulnerable during the power cut	Home visits to offer help and advice at any stage	A welfare pack to help you cope with the power cut. This might include items such as: a blanket, hand warmer, baby bottle warmer, hot flask, analogue telephone, battery powered candle or wind up torch	Generator - If you rely on electricity for medical equipment or have other needs, we may be able to provide a partial supply to keep essential equipment and appliances running and keep your lights on	Sending a mobile catering van to provide hot food and drinks	Sending a mobile unit that allows you to charge mobile phones and tablet devices	None	
Proactive information about the power cut	Nominated friend, family member or colleague who can be sent updates instead of, or in addition to us contacting you	Phone call(s) made directly to your mobile or landline	Short message service (SMS) sent to your mobile phone	Automated text-to-speech message (A computer-generated spoken voice update sent to your landline phone)	Social media (Twitter, Facebook etc.)	Public address/ tannoy system	No proactive updates

Service attribute		Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Quality of information provided		A justified reason for the power cut	Accurate information about when the power is expected to be restored	Number of properties affected by the fault	The region(s) affected by the power cut	Advice on what to do during a power cut (e.g. what to do about alarms, freezers, specific equipment)	Confirmation that your electricity is back on	No information provided
Domestic Customers	The one-off payment you pay to avoid this happening	Cost to you: £1	Cost to you £3	Cost to you: £5	Cost to you: £7	Cost to you: £10	Cost to you: £12	Cost to you: £15
	The one-off amount you receive for this happening	Payment to you: £1	Payment to you: £3	Payment to you: £5	Payment to you: £7	Payment to you: £10	Payment to you: £12	Payment to you: £15
	Additional support payment	No extra cost to you	Extra cost to you: £1	Extra cost to you: £2	Extra cost to you: £3			
	Additional amount received with support	No extra cost to you	Extra cost to you: £1	Extra cost to you: £2	Extra cost to you: £3			
SME Customers	The one-off payment you pay to avoid this happening	Cost to you: 1% of annual bill	Cost to you: 3% of annual bill	Cost to you: 5% of annual bill	Cost to you: 7% of annual bill	Cost to you: 10% of annual bill	Cost to you: 12% of annual bill	Cost to you: 15% of annual bill
	The one-off amount you receive for this happening	Payment to you: 1% of annual bill	Payment to you: 3% of annual bill	Payment to you: 5% of annual bill	Payment to you: 7% of annual bill	Payment to you: 10% of annual bill	Payment to you: 12% of annual bill	Payment to you: 15% of annual bill
	Additional support payment	No extra cost to you	Extra cost to you: 1% of annual bill	Extra cost to you: 2% of annual bill	Extra cost to you: 3% of annual bill			
	Additional amount received with support	No extra cost to you	Extra cost to you: 1% of annual bill	Extra cost to you: 2% of annual bill	Extra cost to you: 3% of annual bill			