Value of Lost Load (VoLL) 2

Joint DNO Workshop
1 October 2019

Jonathan Booth, Head of Asset Management

Paul Auckland, Head of Economic Regulation

Tracey Kennelly, Project Manager

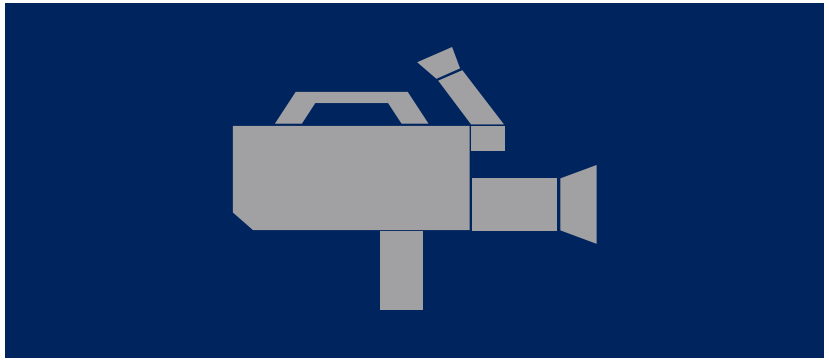
Robbie Urwin, Sam White, Anuj Nayyar – Frazer Nash Consultancy

Housekeeping

Mobile phones

Breaks

Fire alarms



Workshop will be recorded

Agenda

Plenary session 10.30am – 11.30am	**Introduction, objectives of today's workshop**	**Project background and high level findings**	**Understanding current uses of VoLL in ED1**
	Paul Auckland *Head of Economic Regulation*	Tracey Kennelly *Project Manager*	Jonathan Booth *Head of Asset Management*
11.30 – 11.40am	**Break**		
Plenary session 11.40am – 12.30am	**Overview of the proposed modelling approach**	**Implementation options**	**Implementation challenges for a variable VoLL**
	Frazer-Nash Consultancy	Frazer-Nash Consultancy	Frazer-Nash Consultancy
12.30 – 1.00pm	**Lunch**		
Open discussion 1.00 – 2.00pm	**Open forum discussion around structured questions**	**Wrap up – opportunity to get involved**	
	Electricity North West		

Introduction – Paul Auckland

Welcome	Introduction	Objectives of today

Opportunity to learn from shared experience

Capture parallel studies in related work areas to establish an emerging view

VoLL – background

The **social** cost of supply interruptions to customers in £ per MWh

VoLL has existed since 1990
2013 - London Economics **~£17k/MWh** average value (excluding I&C)

VoLL varies considerably across domestic and SME customer segments

A single average figure is used to provide an overall value for a given asset / decision

Ofgem used a figure of ~£16k/MWh for RIIO ED1

Original Electricity North West research

Quantify VoLL by customer segment now and in the future

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?

How does this vary by supply interruption components?

How can DNOs mitigate the cost of lost load?

How will this vary with LCT adoption?

6,500 surveys with a wide range of customers across GB in winter and summer
5050 with domestic customers – 1450 with SMEs

Using our results to replicate LE's value (main study)

Combining our values to reconstruct 'vanilla' VoLL

Rural £20,970

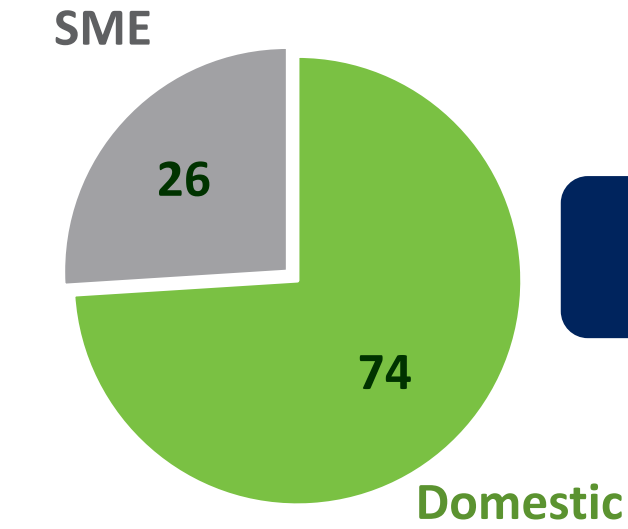
Urban £16,071

£17,481

Rural £63,107

Urban £42,366

£47,560



£25,301

LE value = £16,940

New estimation of VoLL

10 hour LV feeder fault occurring once every five years, over a period of 40 years

Two LV feeders, both supplying 50 homes	Old VoLL	New VoLL
Urban X 30, Low use X 20	£ 72,000	£ 66,000
Rural X 15, Fuel Poor X 20, X 15	£ 72,000	£ 106,000

VoLL calculated for each household by applying a weighted combination of values for each household characteristic

VoLL is increasing over time
Some differences in research approach vs earlier study

Values notably higher than those observed in the last major study by London Economics in 2013

Project developed a statistical model to capture granular impact of an interruption

VoLL estimates expressed relative to an outage at the **worst possible time** rather than the average

Higher VoLL estimate reflects variations in attributes tested by LE & ENWL

Demonstrates increasing customer needs & expectations

Increase in overall VoLL WTA estimates (£/MWh)

London Economics (2013) = £16,940

Electricity North West (2018) = £25,300

How does VoLL vary with the duration of interruptions?

VoLL for domestic and SME customers increases relative to frequency and duration of an unplanned outage

Domestic (unplanned) *VoLL in MW/h by frequency and duration of outage*

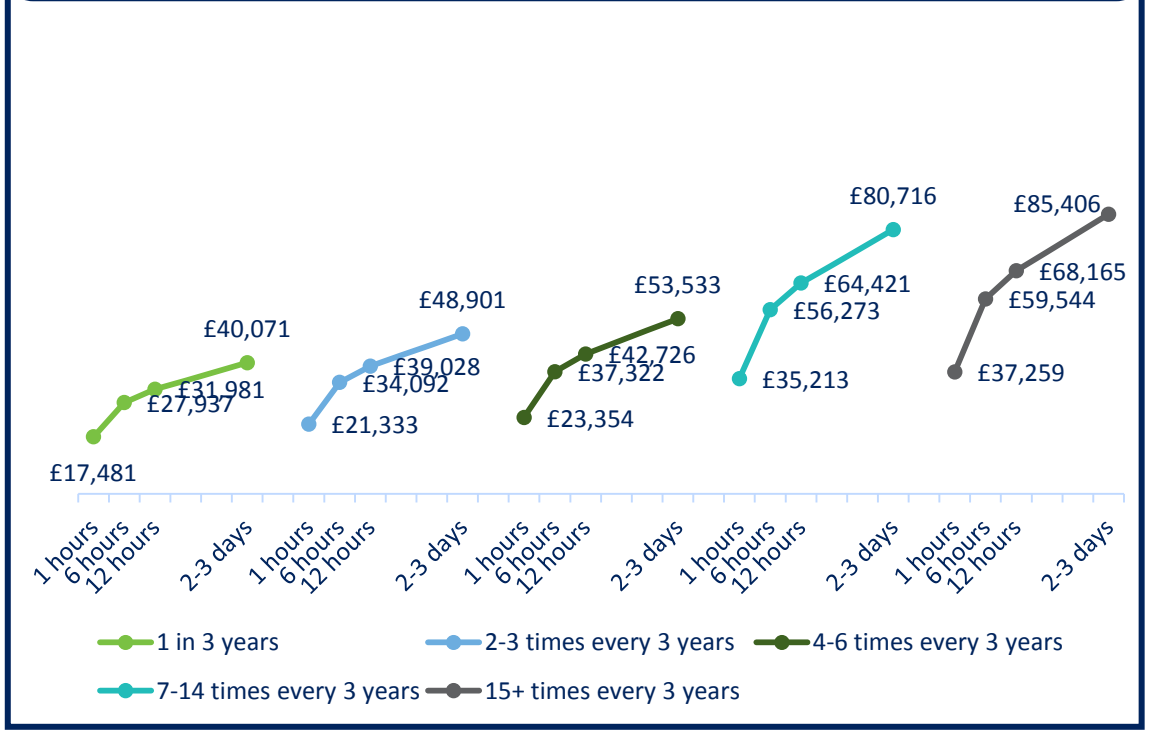
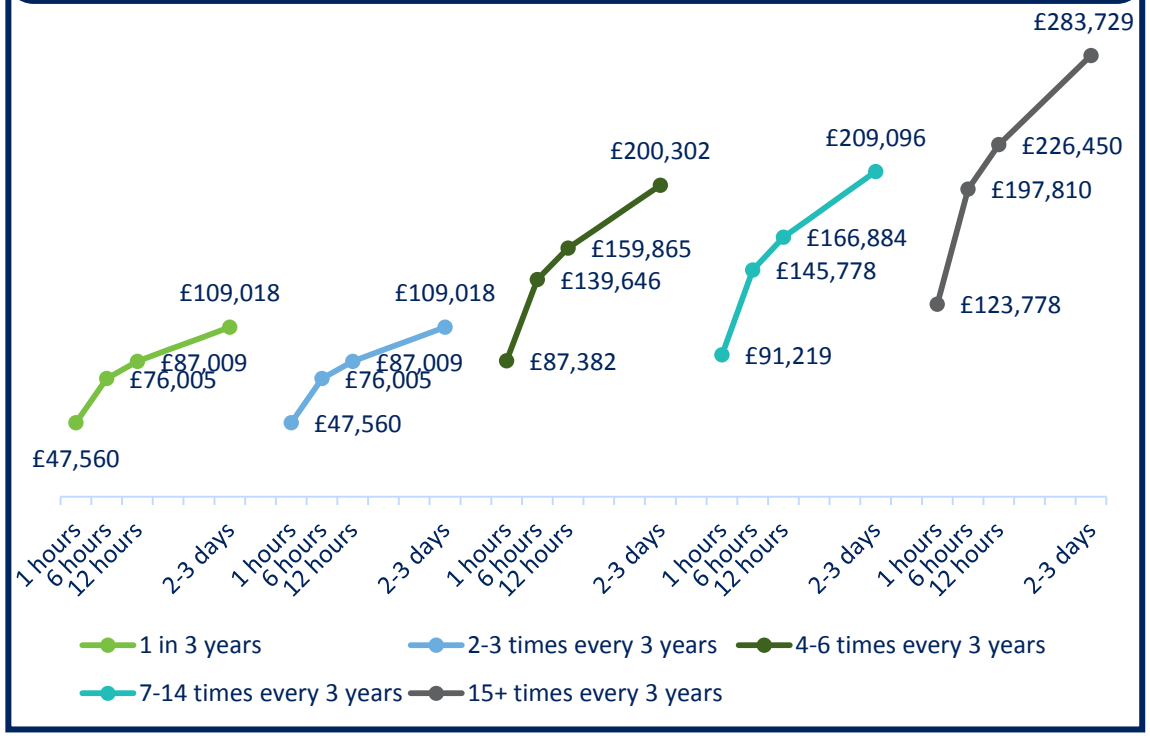


Fig 1: ***SME*** *VoLL in MW/h by frequency and duration of outage (**unplanned**)*



Findings and dissemination

Interim findings disseminated at LCNI conference in Telford	Findings disseminated at Ofgem's network output measures (NOMs) cross-sector working group	Electricity North West innovation and learning event	Affordability and sustainability advisory panel workshops
December 2017	February 2018	July 2018	July 2018
Ofgem's reliability, safety and environment working group	Project factsheet available to industry stakeholders at the LCNI conference	VoLL will be presented at the LCNI conference in Glasgow	All key findings available on our website www.enwl.co.uk/voll
September 2018 and May 2019	October 2018	October 2019	Ongoing

Summary of original findings

Existing approach undervalues the needs of certain customers

Not reflective of those dependent on LCTs

Fuel poor are hugely under represented

Others are over represented potentially driving inefficient investments

A revised VoLL model will provide an effective tool that all DNOs can use without the need for new data flows

Segmentation model enables DNOs to make decisions more reflective of actual customer needs

VoLL2 summary

New research questions for VoLL 2

Having established key factors contributing to VoLL and empirical research as to their relative strength, we need to look at the practicalities of implementation

At what scale should a more complex VoLL function be applied?	Over what time period should VoLL be considered?	How to differentiate between embedded and transient factors?	How to incorporate scenario forecasting and associated uncertainty?
Establish the optimum degree of complexity of a new model Range from GB level through to individual MPAN	Today's VoLL, tomorrow's, lifetime of the asset/network under consideration?	Establish the stability/variability of factors that influence VoLL and the Level of detail at which variables might be combined, relative to network parameters	What is the art of the possible with regard to currently available data & systems?

VoLL 2 – Customer research
Establishing a VoLL modifier and perceptions on fairness

VoLL2 will gather further empirical evidence

			
How is VoLL best extrapolated to a population Study will examine relative value HILP events involving many customers vs localised outages	How VoLL is influenced by the greater resilience of certain customer types / communities	The ability of customers to signal VoLL, where social costs are not recognised or borne by the customer	Perceptions of fairness Unintended consequences of a model that recognises divergence

Project timeline

Overview

ENWL022

Value of Lost Load (VoLL) 2

18 month project

Benefits

- Credible assessment of VoLL by key customer segments
- Improved strategies to mitigate impact of lost load
- More efficient investment decisions
- Targeted customer compensation strategies
- Transferrable to other DNOs

Project supporters

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Impact Research

Timeline (strategic analytics element of project only)

Go live **Nov 2018**	Analytics literature review / proposed approach **Sep 2019**	Complete analysis & model build **Oct 2019**	Develop visualisation Tool **Oct 2019**	Strategic analysis recommend-ations **Oct 2019**	Dissemination of findings **Nov 2019**	Closedown **May 2020**

Overview – Matrix currently using VoLL
Early view on potential application in RIIO-ED2

Matrix where current vanilla VoLL is used	Areas where notional VoLL is used	Areas where VoLL concept not currently used
Setting IIS incentive rate Calibrating CBA model to evaluate benefits of investment Tailoring network performance factor in Common Network Asset Indices Methodology (CNAIM)	Worst served customer regime	Guaranteed Standards regime Customer service and/or satisfaction measures

VoLL – Calibration of IIS

Annual CI and CML incentive rates for RIIO-ED1		
DNO	**CI incentive rates £m**	**CML incentive rates £m (11/12 prices)**
ENWL	0.35	0.86
NPgN	0.24	0.58
NPgY	0.34	0.83
WMID	0.37	0.90
EMID	0.39	0.96
SWALES	0.17	0.40
SWEST	0.23	0.57
LPN	0.34	0.83
SPN	0.34	0.82
EPN	0.53	1.29
SPD	0.30	0.73
SPMW	0.22	0.54
SSEH	0.11	0.27
SSES	0.44	1.08

Customer number for GB	**29,184,812**
09/10 cost from licence	
£/mwhr	16000
£/kWhr	16
Average consumption (kWhr) per customer per year	
For year	10,912
VoLL	
£/mwhr	17,600
£/kWhr	17.6
Total amount willing to pay for year without electricity	192,045
Per minute	**£0.37**

Latest GB average CML (without storms)	41
Total amount willing to pay per minute without electricity (ENS to CML incentive rate)	£0.37
Implied **VoLL** per customer interrupted	£14.98

Condition Based Risk Management (CBRM)

Main driver of asset replacement programme

Condition Based Risk Management (CBRM)

Regulatory position “to maintain underlying asset condition & performance and hence maintain network risk”

CNAIM: Determining CoF – Network Performance (LV & HV)

The *Customer Sensitivity Factor* is already a component of the CNAIM and is used to reflect circumstances where customer impact is increased due to customer reliance on electricity (eg vulnerable customers)

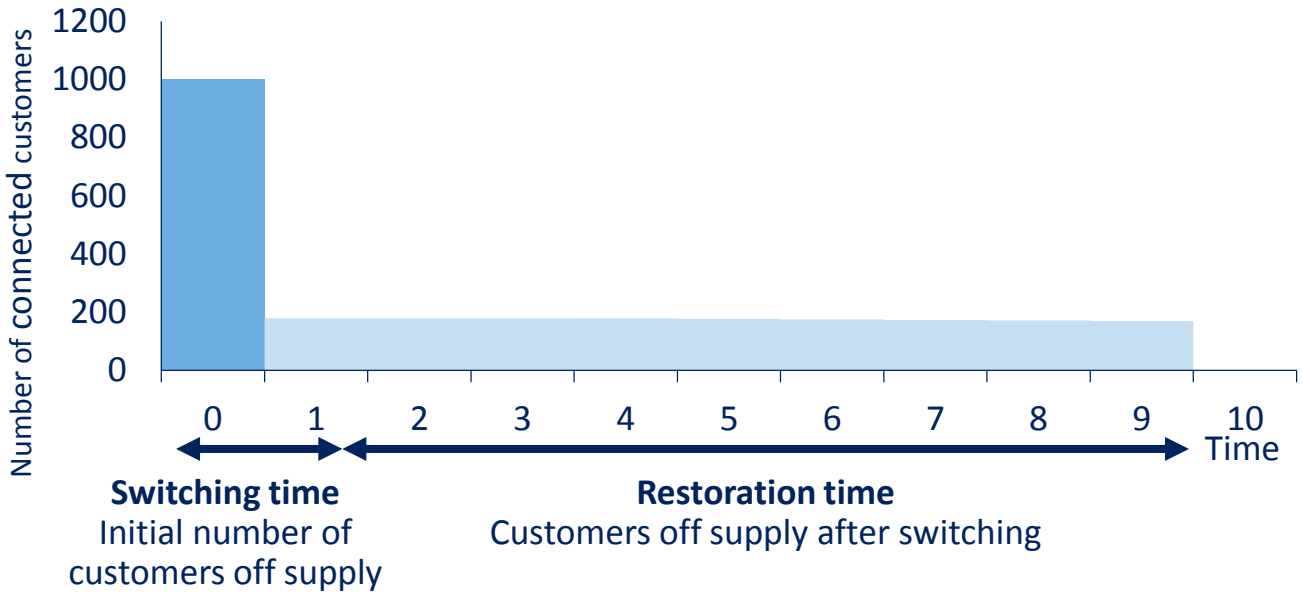
Financial + Safety + Environmental + Network Performance = Current CoF

For LV and HV assets, a **'Reference Network Performance Cost of Failure'** appropriate to the Asset Category is initially applied.

The resulting value can then be modified for individual assets in two ways:

Directly - based on the ratio of customers connected to an individual asset, to the equivalent figure used in the average value; and/or

Via the application of a **Customer Sensitivity Factor** to reflect particular customer characteristics (if appropriate)



Eq 38: Reference Network Performance Cost of Failure = ((load at risk in T1 x duration of T1) + (load at risk in T2 x duration of T2) +(load at risk in T3 x duration of T3)) x % of failures that result in an unplanned outage x probability of further coincident outage x **VoLL**

VoLL and cost benefit analysis

VoLL is one step removed from the standard CBA model although it underpins elements of the societal costs included within the assessment tool

For ED1	For ED2
Represented two out of the eight 'societal costs' within the CBA tool (v4)	It is likely that the current CBA will need to be updated for ED2. With regards to VoLL:
Standard VoLL represented in the form of CIs and CMLs	Should a disaggregate VoLL be utilised within a standard CBA?
To establish the CI and CML values the VoLL was converted considering a number of DNO factors	Given that VoLL is proxied by CI and CML does the conversion method and underlying factors need updating?
CI and CML reflected a value representative of DNOs differences but essentially grounded in single VoLL	How would the conversion method interact with a disaggregated VoLL?

Worst served customer regime

In RIIO-ED1 Ofgem definition for a WSC is:
One who experiences 12 or more higher voltage unplanned interruptions over a three-year period, with at least three higher voltage interruptions each year

A use-it-or-lose-it allowance to improve network reliability for customers who have a significantly poor service

DNOs must demonstrate that they have delivered a set level of service improvement to these customers in order to receive the funding

Notional VoLL is used in ED1 price for worst served customers (WSCs) and WSC schemes to report activity volumes and expenditure incurred due to schemes commissioned under the WSC mechanism

The CV19 work sheet requires the reporting of direct costs, volumes of schemes and asset changes related to investment for WSCs & WSC schemes. This includes number of customers interrupted in reference period and number of customers interrupted post scheme completion

Ofgem

Ofgem's current view in the development of aspects of VoLL within the regulatory regime for ED2

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Bringing energy to your door

Break

Restart at 11.40am

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Bringing energy to your door

Value of Lost Load (VoLL) 2 Workshop

Robbie Urwin, Sam White, Anuj Nayyar

1st October 2019

SYSTEMS AND ENGINEERING TECHNOLOGY

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Bringing energy to your door

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Introduction

- Frazer-Nash tasked by ENWL to explore the implementation of an alternative segmented VoLL model (work commenced August 2019)
- This workshop is an industry consultation on the practicalities and regulatory implications for the implementation of such a model
- The aim of the workshop is to:
  - Share the proposed approach
  - Explore the practicalities of implementing a more disaggregated VoLL model
  - Discuss the practicality and appropriateness of the approach with respect to investment decision support models and the calibration of regulatory incentives
  - Discuss and share best practice

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Agenda

1. Modelling Approach Overview
   a) Explanation of the Impact Research Customer Survey
   b) Proposal for how to derive a VoLL model
   c) Details on the required inputs for the VoLL model (VoLL Indicators)

2. Model Implementation Options
   a) Geographical Fidelity
   b) Data Granularity

3. Open Discussion

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Modelling Approach Overview

The Customer Survey (Impact Research)

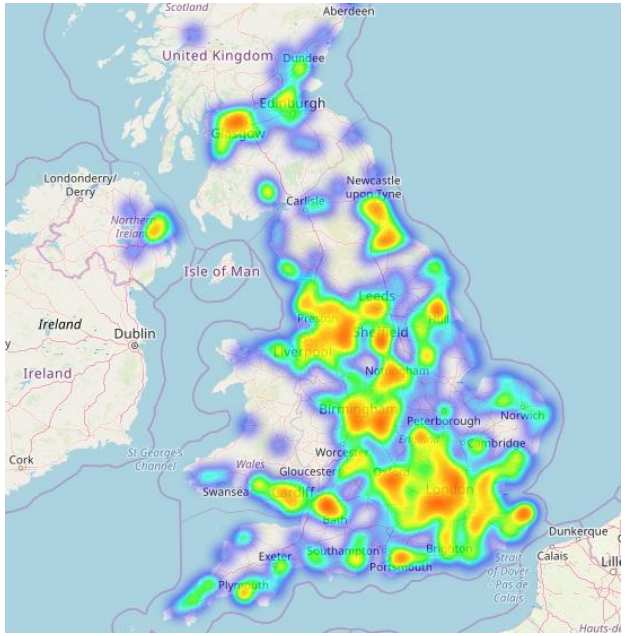
- Variable VoLL to be derived from choice experiment data
- Collected from a customer survey conducted by Impact Research
- 6,500 customers surveyed
  - 5,000 domestic
  - 1,500 SME
- Customers presented with various trade-off scenarios
- Hierarchical Bayes analysis then used to calculate VoLL

WTA	Option A	Option B	
Frequency of power cuts/s (over a three-year period)	7-14 power cuts	4-6 power cuts	Not sure
Duration of the power cut/s	More than 6 hours per power cut	6 hours per power cut	
The amount you receive for this happening	Payment to you: 15% of your annual electricity bill	Payment to you: 5% of your annual electricity bill	
Please make your selection here	○	◉	○

An example trade-off scenario presented to customers in the survey. Customers were asked to select the option that most accurately reflected their view on what they would expect to receive in such a situation.

VoLL Indicators

- VoLL Indicators: The key characteristics of a customer that most influence how they value loss of electricity supply
- For each respondent, the customer survey catalogues:
  - Domestic or SME
  - Age
  - Gender
  - Rurality
  - Income
  - Vulnerability
  - Fuel Poverty
  - Electricity Consumption
  - Electricity Supply Reliability
  - Gas Supply
  - Low Carbon Technology (LCT) Adoption
    - Electric Vehicles (EV)
    - Heat Pumps (HP)
    - Photovoltaics (PV)
- Analysis of the survey results can be performed to determine which of these attributes are the most significant VoLL indicators



Locations of survey respondents. Orange and red areas have a greater density of respondents.

VoLL Estimation for Customer Segments

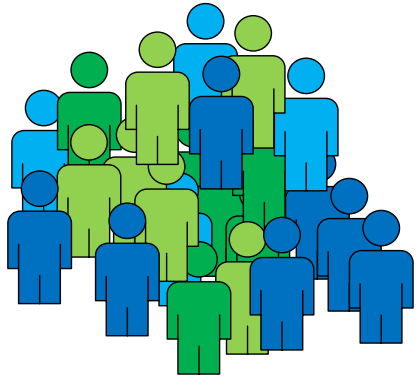
SIMPLIFIED EXAMPLE – JUST CONSIDERING RURALITY AND EV OWNERSHIP

Rural, Non-EV Owner

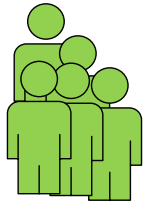
Rural, EV Owner

Urban, Non-EV Owner

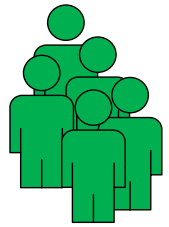
Urban, EV Owner



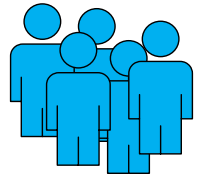
Survey Population



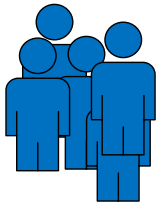
Rural, Non-EV Owning Segment



Rural, EV Owning Segment



Urban, Non-EV Owning Segment



Urban, EV Owning Segment

- VoLL can be estimated for the entire survey population
- VoLL can also be estimated for samples of the survey population that represent different customer segments (so long as the sample contains 200+ customers)

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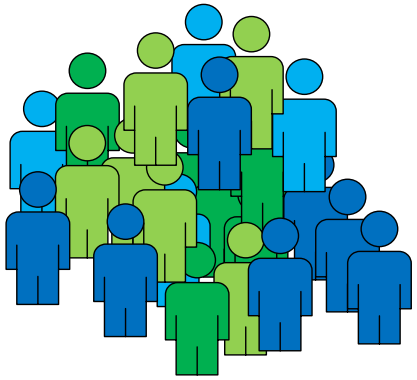
VoLL Estimation for Sample Populations

Rural, Non-EV Owner

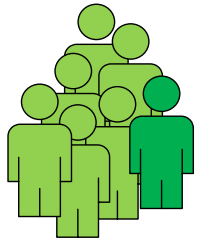
Rural, EV Owner

Urban, Non-EV Owner

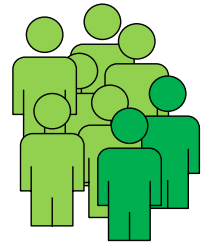
Urban, EV Owner



Survey Population

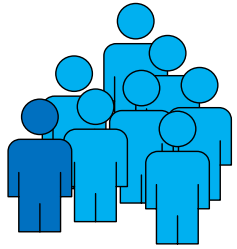


Rural
5% EV Owner

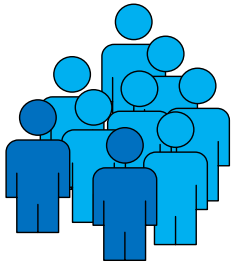


Rural
10% EV Owner

Rural
20% EV Owner



Urban
10% EV Owner



Urban
15% EV Owner

Urban
20% EV Owner

- VoLL can also be estimated for sample populations containing a mix of customer segments (more representative of ‘real’ populations)

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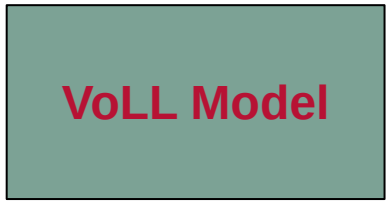
The VoLL Model

- A VoLL model can be trained using millions of different sample populations drawn from the customer survey
- The model can then be used to predict the VoLL for **ANY** sample population for which the VoLL indicators are known
- For example this could be:
  - The households in a Lower Super Output Area (LSOA – approx. 1500 population)
  - The households in a radius around a distribution substation
  - The households known to be served by a primary substation

Rural
8% EV Owner



18,450 £/MWh

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VoLL Indicator Estimation

- In order to estimate the VoLL for any given sample population it is therefore necessary to estimate the VoLL indicators for this population
- The process of down selecting the most important VoLL indicators is still being undertaken
- Exactly which attributes are chosen will depend on
  - The significance of the attribute as a VoLL indicator
  - The availability of data at a suitable granularity
- However it is highly likely to include:
  - Fuel Poverty
  - EV Ownership
  - Rurality
- Possible sources of the data required to estimate both these and the other attributes is provided on the next slide

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VoLL Indicator Estimation

VoLL Indicator	Data Source	Granularity	Indicator Likelihood	Damage Function
Age	ONS	LSOA	Low	TBC
Gender	ONS	LSOA	Low	TBC
Rurality	ONS	LSOA	High	TBC
Income	ONS	LSOA	Medium	TBC
Vulnerability	PSR	Household	Medium	TBC
Fuel Poverty	ONS	LSOA	High	TBC
Consumption	ONS / DNO Databases	LSOA / Household	Medium	TBC
Supply Reliability	DNO Databases	Household	Medium	TBC
Gas Supply	CSE	Postcode	Medium	TBC
EV Adoption	DNO Databases / National Charge Point Registry	LSOA / Primary Substation / Charge Point Locations	High	TBC
HP Adoption	DNO Databases	LSOA / Primary Substation	Medium	TBC
PV Adoption	DNO Databases	LSOA / Primary Substation	Low	TBC
SME Locations	ONS	Local Authority	High	TBC

ONS = Office for National Statistics, PSR = Point Service Register, DNO = Distribution Network Operator, CSE = Centre for Sustainable Energy

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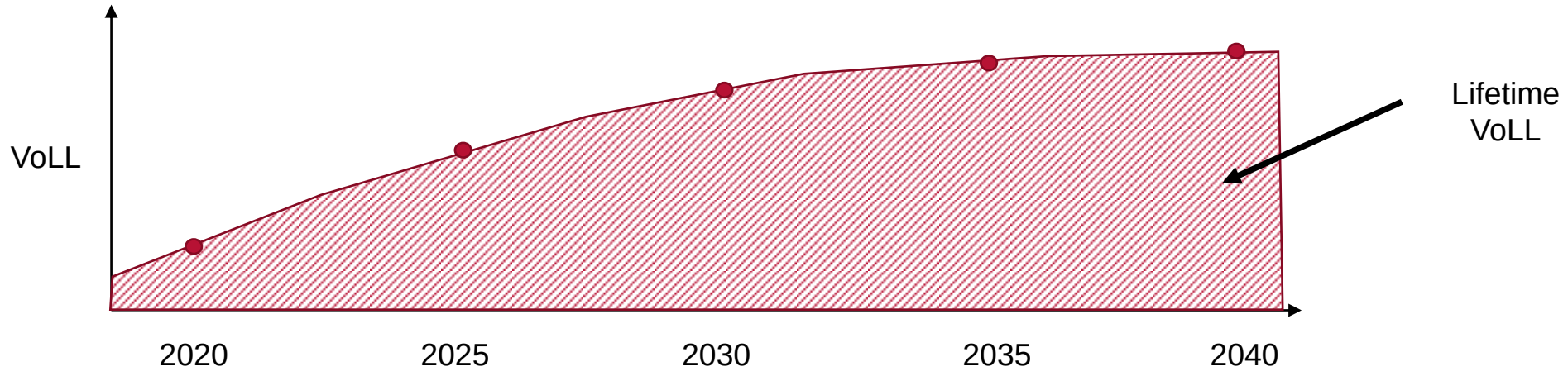
Future Scenario VoLL Estimation

- The VoLL model can be used to make predictions for any set of VoLL indicator values
- These VoLL indicators could represent a sample population in the present OR a hypothetical sample population in the future
  - For example the VoLL model could be used to make estimates of VoLL for a forecast scenario with greater EV penetration
  - It would then be possible to use such estimates to calculate the ‘lifetime VoLL’ of an asset



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Modelling Assumptions

1. Only VoLL attributes collected in the Impact Research customer survey have been considered as candidate VoLL Indicators
2. The Impact Research customer survey contained a representative sample of the UK population
3. Estimates of VoLL derived from the Impact Research customer survey are 'correct'

   (*is there a need to periodically repeat the customer survey to keep the VoLL model up to date with the current value customers are attributing to their security of supply?*)
4. The model coefficients calculated for individual survey respondents using Hierarchical Bayes techniques are independent and can be used to derive VoLL estimates for sample populations (this is a statistical assumption, but common practice)
5. Estimates of VoLL do not account for businesses with 250+ employees
6. Estimates of VoLL will be adjusted for low income customers, based on the principle that the value of an additional pound of income may be higher for a low income recipient than a high income recipient (the same assumption was made by Impact Research in their analysis)
7. Overall VoLL is calculated as a load-share weighted average across domestic and SME customers (the same assumption was made by both Impact Research and London Economics)

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Model Implementation Options

Implementation Options

- The model could be implemented with varying degrees of:
  - Geographic Fidelity – i.e. How to identify the sample population?
  - Data Granularity – i.e. How detailed should the VoLL indicator data be?

A: Geographic Fidelity

1. LSOA
2. Point and Radius
3. Freeform Polygon
4. List of Households
5. Asset Database

B: Data Granularity

1. LSOA
2. Household

- We will consider a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis for each option and identify a preferred option(s).
- See SWOT slide hand-out to record your views – to be discussed at open discussion session

Critical Success Factors

- What attributes are essential for a successful VoLL model?
  1. Solution accuracy – how accurately is the solution able to calculate VoLL?
  2. Solution practicality – how practical is the solution for integration with investment decision support models and the regulatory incentive schemes?
  3. Implementation practicality – how practical is it to collect the necessary data and implement the solution?
  4. Cost – how costly is the solution?

- Potential discussion points:
  - What are the implications of this approach for: CBA?, CNAIM?, IIS?
  - What do you think is an appropriate level of granularity for the model data?
  - Would you rather have access to the VoLL model as a tool (i.e. a web application) or as a dataset (i.e. spreadsheet or database)?
  - How available do you believe the discussed data sets to be?
  - How could you foresee such a model being utilised for forecast distribution scenarios?
  - Do you foresee any additional challenges with the implementation not already discussed?

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A.1: LSOA

- Lower Super Output Area (LSOA) are geographical areas designed to contain a population of around 1500 residents
- They are areas of consistent size whose boundaries do not change
- LSOA boundaries were developed by ONS, and a wide range of data is available at this level
- VoLL could be provided for each LSOA, nationwide, in a tabulated data format (i.e. spreadsheet)
- However it would be for each DNO to determine how to map from LSOA polygons to a sample population of interest (which is unlikely to map directly to network distribution parameters)
  - Although guidelines on how to do this could perhaps be published

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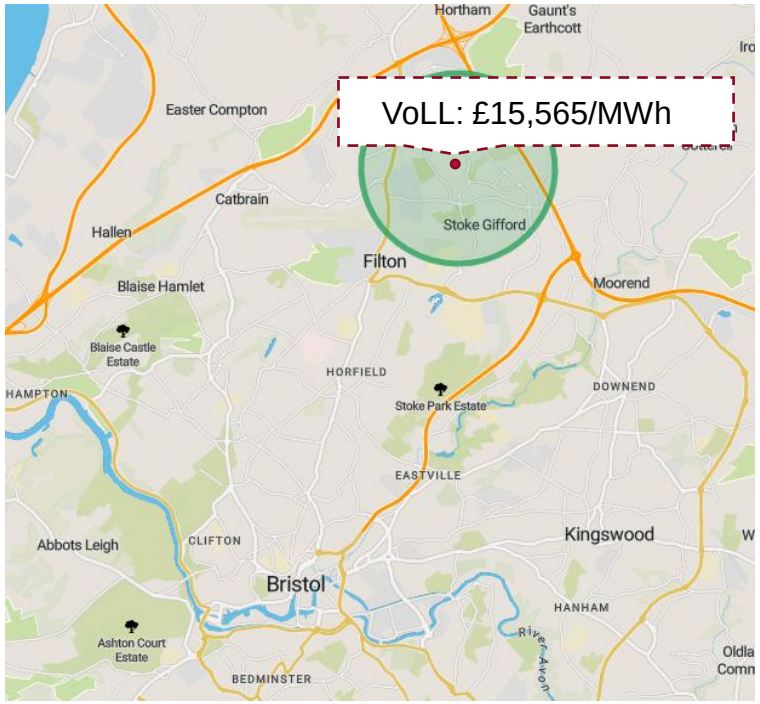
A.2: Point and Radius

- Alternatively, VoLL estimates could be provided for the households in any area defined by a point and a radius
- This could be implemented as a web application, including a point and click and/or text entry user interface
- This has more flexibility than rigidly defined LSOAs, you could for example estimate the VoLL for a substation in this way (if you assume that it serves all households within a fixed radius)

Enter Latitude …

Enter Longitude …

Enter Radius …



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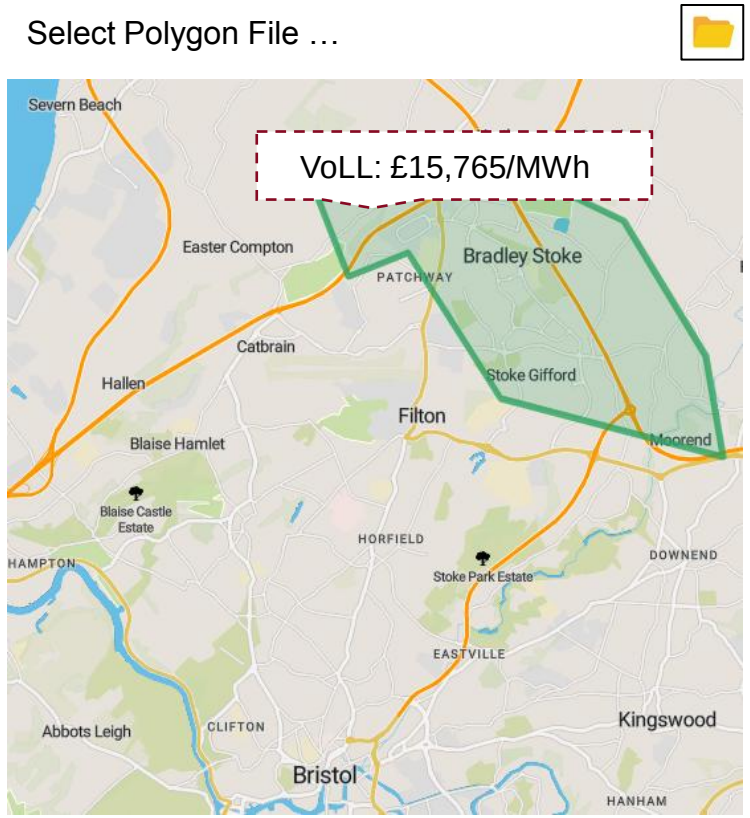
A.3: Freeform Polygon

- VoLL estimates could also be provided for the households in any area defined by a freeform polygon
- Again this could be implemented as a web application, including a point and click and/or polygon file upload user interface
- This is similar to the point and radius option, but gives you more flexibility in the shape of the sample population area



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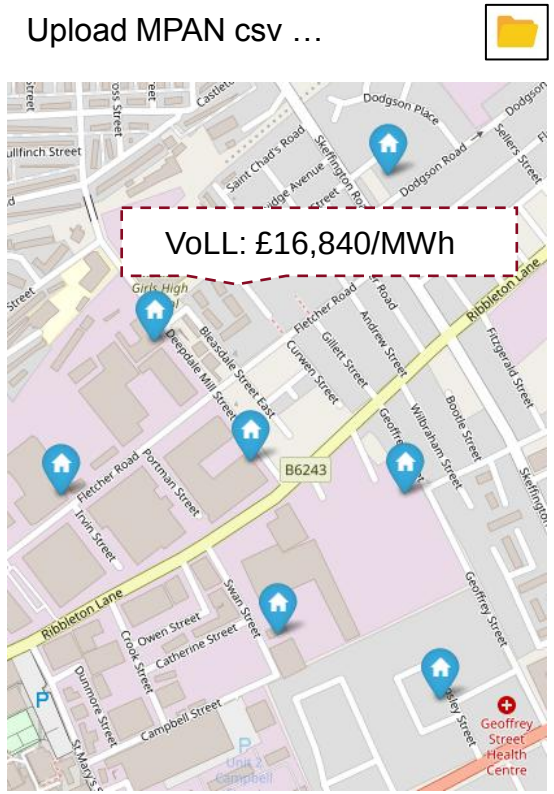
A.4: List of Households

- Another option, which offers further fidelity, is to define the sample population by directly providing a list of households – potentially by Meter Point Access Number (MPAN)
- Estimations of VoLL indicators can be made directly for each household and aggregated to provide the overall VoLL indicators for the sample population
- Note however that this option provides far more utility if the underlying VoLL indicator data is at a household level
- Again this could be implemented as a web application whereby household MPANs (or household locations) are uploaded and an estimate of VoLL returned



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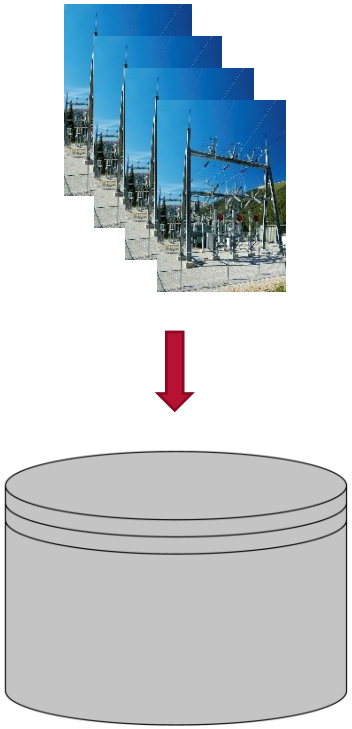
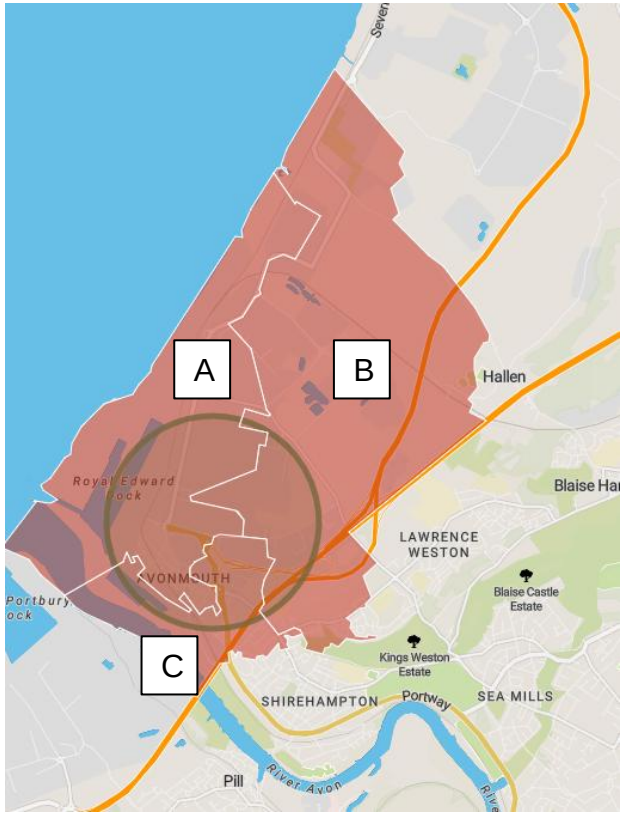
A.5: Asset Database

- A database could be developed that contains the VoLL for all network assets nationwide (i.e. all distribution substations, primary circuits, primary substations etc.)
- This would need to be developed by deriving the households served by each asset from DNO data
- VoLL indicators could then be estimated for each household
- The aggregated VoLL for this population would be the ‘asset VoLL’
- Of all the options this perhaps requires the most upfront effort to implement
- However it could be the option that is simplest for DNOs to utilise once it has been deployed



B.1: LSOA Data Granularity

- Many UK datasets are available at an aggregated LSOA level, meaning that this is the most straightforward option
- However it is unlikely that the sample population of interest directly correlates to an LSOA
- For example if you were trying to estimate the proportion of Fuel Poor households within the radius of an asset (the green circle in the figure)
  - The proportion of Fuel Poor households in the different LSOAs might be
    - A = 6%
    - B = 18%
    - C = 14%
  - It could be calculated that radius is 50% A, 30% B and 20% C
  - A weighted average Fuel Poverty would therefore be
    - (0.5*6) + (0.3*18) + (0.2*14) = 11.2%
- Equally if you were trying to estimate the Fuel Poverty for a single household (i.e. for approaches A.4 or A.5), you would have to assume that the Fuel Poverty number applies to all households within the LSOA
- These are clearly estimates, but it *may* be sufficiently accurate and practical for the purposes of the VoLL model



B.2: Household Data Granularity

- It may be possible in some (if not all) cases, to gain access to datasets that provide estimates of VoLL indicators at a much more granular level than LSOA
- This could be:
  - Output Area (OA)
  - Postcode
  - Household
- For some demographic datasets this level of granularity can be bought (i.e. the Experian Mosaic dataset, ~£20k / year)
- For other datasets (Electricity Consumption and Supply Reliability) whether or not this is possible depends on what the DNOs can provide
- The practicality of obtaining such data sets, and the utility it would provide for the model is up for debate
- The requirement and overhead in keeping this data up to date should also be considered

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Lunch

12.30pm – Afternoon session starts at 1.00pm

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Open discussion

What are the implications of this approach for: CBA?, CNAIM?, IIS?

What do you think is an appropriate level of granularity for the model data?

Would you rather have access to the VoLL model as a tool (ie a web application) or as a dataset (ie spreadsheet or database)?

How available do you believe the discussed data sets to be?

How could you foresee such a model being utilised for forecast for forecast distribution scenarios?

Fairness & equity - could a variable VoLL align with the GS regime or drive CSAT measures?

Scale and duration: How to value the wider societal costs of High Impact Low Probability (HILP) events

Do you foresee any additional challenges with the implementation not already discussed?

Questions

Thanks for your time and contribution

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Thank you for your time and attention