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The Value of Lost Load

Electricity supply interruptions have financial and social impacts on customers that vary by season, time of day, customer type and customer load. Understanding the value of lost load (VoLL) is important for distribution network operators (DNOs) when determining network planning and investment strategies. This will become increasingly important as customers become more reliant on electricity in the low carbon future.

Background

At present in Great Britain (GB), a single uniform VoLL is used to provide an overall estimate of the value given to loss by domestic and business customers. This single measure is used to evaluate what customers would be prepared to accept to avoid a supply interruption of average duration.

A VoLL of £16,000/MWh was established for RIIO ED1 by Ofgem and this figure is used to represent the economic measure of a supply interruption: It acts as a price signal for the adequate level of supply security in GB and is a useful guide for determining how much money should be spent to deliver security of supply.

Previous research has identified that VoLL varies significantly among three distinct customers groups: residential, small/medium enterprises (SMEs) and large industrial/commercial (I&C) customers. This research has shown that VoLL varies considerably within each of these groups, across many customer segments, for example there are significant differences between rural and urban customers, those in vulnerable circumstances and users of low carbon technologies. While this divergence is recognised, it is not reflected in the current single VoLL model.

Project overview

This project investigated if the current single VoLL, applied to domestic and SME customers is appropriate to guide investment decisions in electricity networks as GB moves towards a decarbonised economy. To explore this question, we sought to gain a much more comprehensive understanding of the value that specific types of customers place on their electricity supply. A key objective of our project was to deliver new understanding and practical models that will allow DNOs to better and more efficiently serve the various segments of their customer base.

The project was funded by the Network Innovation allowance (NIA) and involved an extensive programme of engagement with a diverse range of customers from across GB. It commenced in October 2015 and the conclusions and recommendations were published in September 2018.

Research approach

We worked with a wide range of stakeholders during this project. Key stakeholders included government bodies, such as the Department for Business, Energy and Industrial Strategy (BEIS), Ofgem and Citizens Advice.

We also consulted key stakeholders who are likely to support or be in contact with customers during a supply interruption. This critical phase of research provided a better understanding of the unique perspective of organisations such as hospitals, care homes, local authorities, educational establishments and charitable organisations. This information was used to inform our research approach.

Before embarking on the large scale survey, working with our project partner, Impact Research, we conducted a piece of qualitative research with customers to identify what they believe are the most appropriate characteristics of supply interruptions. These were then incorporated into our questionnaire. This phase of research involved a series of focus group meetings with an engaged customer panel who were selected to represent key customer groups from across our region. These included: urban and domestic customers, those fed by relatively poorly performing networks and classified as 'worst-served' and SME representatives from a cross-section of organisations with a range of consumption profiles. We also carried out a number of face-to-face interviews to ensure that we consulted customers who are more difficult to reach, such as those with vulnerabilities.

We then conducted over 6,000 surveys across GB to understand how VoLL is assessed by different domestic and SME customer groups and how this might change in the future. Participants were selected on the basis of geographic and demographic quotas to include the most diverse range of customers, with different needs and expectations. Around 5,000 interviews were completed with domestic customers and 1,000 with businesses.

The current single VoLL estimate is averaged across domestic and SME customers. We did not consult I&C customers, given that they are more able to influence the security of their supply by demand side response, self supply and other types of protection/resilience strategies.

Why do we need a better understanding of VoLL?

Modern network management systems allow DNOs to view the number and segmentation of customers fed from specific assets. This visibility coupled with a detailed understanding of VoLL by customer segment could be harnessed to calculate the VoLL that should be applied in a given investment decision on a specific asset. Understanding the relative VoLL for every individual asset on the network will allow much greater efficiency in future investment decisions, and ensure investments are more fully informed by customer need. Figure 1 simply demonstrates the benefits of adopting a segmented matrix, using the example of two comparable feeders, serving the same number of domestic customers.

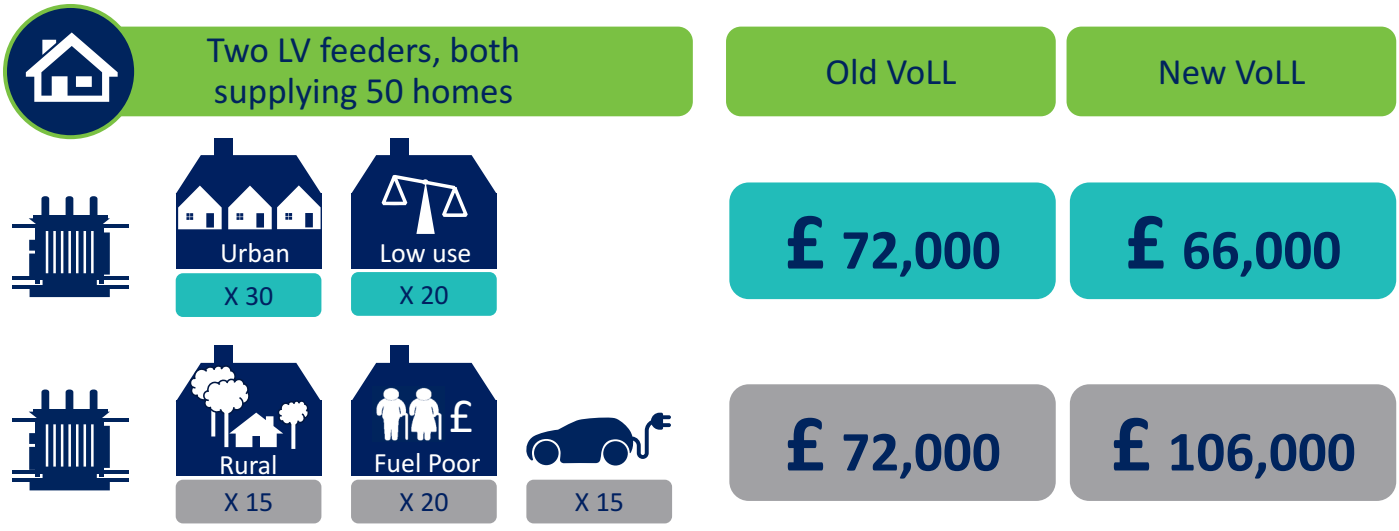
When considering an investment decision using the existing single VoLL, the net present value (NPV) on each feeder for a ten-hour interruption, occurring once every five years, is £72,000. The column illustrating the calculation using a 'new VoLL' model, which reflects the mix of customer types, provides a very different set of results. By applying the more sophisticated VoLL calculation, the NPV for the first feeder is around 8% lower at £66,000, whereas it is almost 50% higher (at £106,000) on the second feeder.

This simple example demonstrates that an investment to mitigate the cost of failure for the asset on the second feeder can be justifiably prioritised over the first because of the greater needs of, and impact on, the customers served. This more sophisticated calculation demonstrates how DNOs might better target finite resources to deliver greatest value.

Application of a revised segmented VoLL is attractive because it does not involve a significant change in 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 strategies, which focus on the impact of decisions.

Figure 1: Example of VoLL application: single VoLL vs VoLL varied by customer type

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



Measuring VoLL

The survey included a 'stated preference choice experiment' which is widely accepted as the most robust technique for measuring metrics such as VoLL. This involved asking customers to trade off scenarios which presented different levels of supply reliability and support, in exchange for a hypothetical payment or penalty.

The choices made by respondents inferred their willingness to pay (WTP) higher prices for a better service, or their willingness to accept (WTA) compensation for a loss in service. This approach is generally considered to provide more objective measures of WTP and WTA than direct questioning. A 'multinomial logit' econometric model was used to convert the choice experiment results into £/MWh VoLL figures and confidence intervals. This is a standard limited dependent variable estimation method and is a recognised and well-established method for choice experiment modelling.

In common with previous studies, we found that the WTA measurement of VoLL produced a much larger estimate than the comparable WTP for both the domestic and SME segments.

Figure 2: Overall VoLL in £/MWh among domestic and SME segments

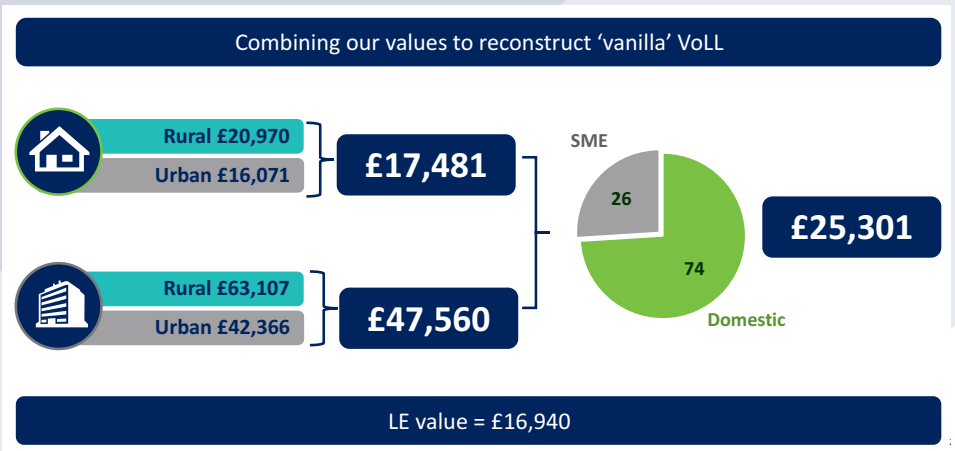
VOLL measure	Domestic	SME
Willingness to pay (£/MWh)	£2,000	£17,500
Willingness to accept (£/MWh)	£17,500	£47,500

The WTP value for domestic customers is comparable to the figure reported by London Economics (LE) who conducted the last major study into VoLL for electricity in GB for Ofgem and DECC in 2013 (£2,000 versus £2,000).

The WTA figure is regarded as the most appropriate estimate for valuing security of supply for electricity as it indicates consumers' inconvenience if the reliable service they already enjoy is interrupted. The domestic WTA value revealed in this research was notably higher than in the 2013 study (£17,500 v £12,000). This is likely to reflect a number of factors including a difference in the frequency of interruptions used to set the context of the choices. We presented this as once every three years, reflecting current average industry service performance, rather than once every 12 years, as in the 2013 study. The higher values may also reflect increasing customer needs and expectations and the effects of inflation.

Figure 3 shows the overall VoLL when the results for the two main customer types are combined in a weighted average, in the same manner as the LE study. This final figure of £25,301 MWh compares to LE's 2013 figure of £16,940. The LE figure of £16,940 would now be closer to £18,500, if adjusted for inflation.

Figure 3: Group-level VoLL combined to give a single overall VoLL



Differences in VoLL by customer type

This research provides robust evidence that the existing 'vanilla' VoLL fails to reflect the significant variation that exists in the financial and social impact of supply interruptions across different customer types.

Figure 4 highlights that VoLL is substantially higher for less affluent groups, particularly those classified as 'fuel poor'. When adjusted to reflect income, the VoLL of customers with vulnerabilities is also well above the average. This finding is significant and demonstrates that Ofgem's focus on identifying and tackling consumer vulnerability in the energy market is justified. It is also higher in the 30-44 age group, which is likely to reflect the greater impact of interruptions on families with children. VoLL was predictably higher than average for customers without a mains gas supply, where electricity is the primary source of energy.

Figure 4: Domestic customers with higher than average VoLL (>£17,500/MWh)

Domestic segment	VoLL £/MWh	% variation of average domestic WTA (rounded to 0.05)
Fuel poor*	£32,500	+ 85%
Electric vehicles (EV)	£21,500	+ 25%
Rural	£21,500	+ 20%
Low income groups*	£20,500	+ 15%
Aged 30-44	£20,000	+ 15%
Vulnerable*	£19,500	+ 10%
Experienced no planned or unplanned power cuts	£19,000	+ 10%
Off gas network	£18,500	+ 5%

** WTA figure adjusted for income*

Figure 5: Domestic customers with lower than average VoLL (<£17,500/MWh)

Domestic segment	VoLL £/MWh	% variation of average domestic WTA (rounded to 0.05)
Experienced large scale, lengthy supply interruption in last 12 months	£12,000	- 30%
Urban	£16,000	- 10%
Experienced no unplanned power cuts	£16,000	- 10%

Similar differentiation was found in the VoLL of business customers. However, given the diversity of the SME sample relative to their size, economic activity and consumption profiles, additional surveys are proposed to support these findings.

Figure 6: SME customers with higher than average VoLL (>£47,500/MWh)

Domestic segment	VoLL £/MWh	% variation of average domestic WTA (rounded to 0.05)
Rural	£68,500	+ 45%
Experienced power cuts	£51,500	+ 10%
Off-gas	£50,000	+ 5%

Figure 7: SME customers with lower than average VoLL (<£47,500/MWh)

Domestic segment	VoLL £/MWh	% variation of average domestic WTA (rounded to 0.05)
Want to improve supply	£33,000	- 30%
No experience of power cuts	£38,000	- 20%
Want to keep reliability	£38,500	- 20%
Urban	£44,000	- 10%

VoLL £/MWh figures shown are rounded to nearest 500

Impact of a low carbon future on VoLL

A key objective of our study was to investigate potential changes in VoLL in a low carbon future in which customers will be increasingly dependent on a reliable electricity supply.

We found that the VoLL of domestic customers using LCTs is ~10% higher than the average for domestic customers. VoLL for heat pump users is almost 15% over the average and this rises further for users of electric vehicles who have a VoLL of almost 25% above the average.

This is a significant finding and has important implications for future network investment strategies and design policy as it suggests that VoLL is set to increase in line with the projected uptake of LCTs.

Domestic segment	VoLL £/MWh	% variation of average domestic WTA (rounded to 0.05)
All domestic customers	£17,500	
Current domestic LCT users	£19,000	+ 10%
Current domestic customers with PV	£18,000	+ 5%
Current HP users	£20,000	+ 15%
Current domestic EV users	£21,500	+ 25%

Customer strategies to mitigate VoLL

The study suggests that optimising customer communications strategies might provide a financially efficient means of mitigating the impact of supply interruptions over other support mechanisms. For instance, making a phone call directly to a domestic customer's land line appears to be around three times as important in mitigating the impact of a power cut than providing updates on social media. However, this isn't reflected in the responses of 18-29 year olds, where there were significant differences in the value placed on the support mechanisms tested. This implies that effective communications and support strategies will need to evolve to reflect future needs and expectations.

This learning has potentially wider implications and could be influential in informing future customer compensation strategies. This is discussed further in the conclusions and recommendations report published on the VoLL webpage.

Conclusions

The results of this survey provide evidence that a single uniform VoLL may no longer be appropriate. This most recent research and modelling allows a much more representative VoLL model to be established. This more sophisticated approach will significantly improve efficient targeting of investments and ensure those investments are based on a much richer and more representative understanding of customers' needs.

It demonstrates the different impacts of supply interruptions across a range of domestic and SME sub-groups. The range of values is almost double when considering the lowest to highest estimates reported.

The current universal VoLL undervalues the needs of certain customers, for example those dependent on LCTs, off-gas customers and the fuel poor. Similarly, it over-represents the needs of other customer groups.

The findings are likely to have an impact on our social obligations and influence how we adapt our response to customers on our priority services register and our solutions for addressing fuel poverty.

We have developed a simple VoLL calculation tool to demonstrate how a more sophisticated approach could be applied to provide a better understanding of the relative needs of customers when making investment decisions. This will help to meet some of our long-term challenges to deliver an affordable, secure and sustainable electricity supply.

Next steps

We are carrying out further research to provide clarity on the factors responsible for the relatively low VoLL expressed by customers served by poorly performing networks. In addition, given the diversity of the SME sample, further research is proposed to deliver more insight into VoLL across a range of different business sub-segments.

To aid the practical implementation of a differentiated VoLL, it is recognised that more research is needed to explore issues around the fairness and legitimacy of an alternative model. This model would need to maintain equitable DUoS charges at a low level, but allow for more sophisticated investment decisions, influenced by divergent customer need and dependency. Given the importance of these findings and their implications, further collaborative work is planned with Citizens Advice, particularly to assess the impact on those living in fuel poverty.

Further research is also planned to better understand VoLL at local and community level. This will consider the duration and scale of interruptions and how VoLL changes during large scale events which affect wide areas and large numbers of customers.

Finally, more detailed analysis is planned to determine the optimum level of complexity required in the VoLL calculation/decision-making tool and a practicable mechanism for implementation at scale. This analysis will also assess the stability and variability of key VoLL drivers over time. This will involve consultation with key industry stakeholders to consider the regulatory implications and practicalities of national implementation.

To find out more about our VoLL project visit: www.enwl.co.uk/voll