SEM committee

Information paper

Calculation of a single Value of Lost Load within the Single Electricity Market

SEM-23-072

29 September 2023

EXECUTIVE SUMMARY

The Value of Lost Load (VoLL) is the average willingness to pay of electricity consumers to avoid an additional period without power. Disruptions to electricity supply can result in very high costs to society where they arise. Maintaining a high level of security of supply is also costly, and no system can ever be 100% secure. The economically efficient level of security of supply is where the marginal benefit of an additional unit of supply security is equal to the marginal cost of maintaining that level of supply of security[1]. VoLL provides a means by which the marginal benefits of additional security of supply can be measured. It allows a value to be placed on greater reliability of electricity supply by measuring the loss of socio-economic activity resulting from a unit of electricity not provided by the grid.

Article 2 of REGULATION (EU) 2019/943[2], also known as the Electricity Regulation (ER), defines the "*value of lost load*" as "*an estimation in euro/MWh, of the maximum electricity price that customers are willing to pay to avoid an outage*". The ACER Decision on the Methodology for calculating the Value of Lost Load, the Cost of New Entry, and the Reliability Standard indicates that the single VoLL used for the calculation of the Reliability Standard ($VoLL_{RS}$) must be based on consumer surveys of Willingness to Pay to avoid interruption to supply during typical load-shedding events.

The most likely interruption scenario across the SEM resulting from load-shedding (based on information provided to the RAs by the TSOs) would be in the evening during winter peak demand, with (at least in the first instance of load-shedding) no notice period and a duration of one hour. Based on consumer surveys carried out by Ipsos-MRBI in early 2022 relating to those specific interruption parameters, the Regulatory Authorities have calculated a $VoLL_{RS}$ of **€16,464/MWh**. This newly calculated 2022 $VoLL_{RS}$ compares directly with the 2022 VoLL of €12,533/MWh (inflated from the original value of €10,000 as published in AIP-SEM-07-484[3]). The

[1] CEPA study on the estimation of the Value of Lost Load (VoLL) of electricity supply in Europe, 2018
[2] REGULATION (EU) 2019/943
[3] https://www.semcommittee.com/publication/value-lost-load-market-price-cap-and-floor-decision-paper

new value of $VoLL_{RS}$, adjusted for inflation year on year, will be used from the T-4 2027/28 Capacity Auction onwards.

The RAs have additionally found that the maximum VoLL in the SEM is **€18,123/MWh**, based on consumer surveys of Willingness to Pay for an interruption scenario at midday during winter peak demand, in the event of no notice period and with a duration of one hour. According to ACER's interpretation of the ER the maximum value of VoLL ($VoLL_{MAX}$) is appropriate to use for setting technical bidding limits in the Day-Ahead Market and Intraday Market, and imbalance settlement prices. This new value of $VoLL_{MAX}$, adjusted for inflation year on year, will be used in the energy market from 1st October 2023 in the setting of technical price caps and Administered Scarcity Pricing.

The Reliability Standard is another adequacy parameter calculated using the Cost of New Entry (CoNE) of the Best New Entrant Reference Technology (an OCGT in ROI from the 2023 CEPA/Ramboll study[4]) and the $VoLL_{RS}$ as presented in this paper. A Reliability Standard based on this newly calculated $VoLL_{RS}$ and the CoNE ($LOLE_{RT}$ = 115,990 / (17,909 - 179)) would be **6.5 hours LOLE**, vs. the current security standard of 8 hours LOLE.

The SEM Committee has accepted the 6.5 hours as the output of the methodology and instructed the RAs to engage DECC in RoI and DfE in NI (including through the Joint Steering Group) on whether an alternative Reliability Standard should be set as a national competence instead of the default output of the ACER methodology.

Section 1 of this Information Paper relates the history of VoLL within the SEM and the requirements of the Electricity Regulation. Section 2 explores the design of the consumer survey and how it was tailored to the SEM. Section 3 describes the information gathered for different segments of the population. Section 4 describes how the "Willingness to pay" figures from the survey are converted to Values of Lost Load for each subsector and aggregated to produce a single VoLL. Section 5 relates how the resulting values (of $VoLL_{RS}$ and $VoLL_{MAX}$) are implemented within different areas of the Single Electricity Market across the island of Ireland.

[4] https://www.semcommittee.com/publications/sem-23-016-best-new-entrant-decision-paper

Table of Contents

List of Figures 4

List of Tables 4

Glossary of Terms and Abbreviations 5

1. Background 6

1.1 The Value of Lost Load in the SEM 6

1.2 Compliance with the Electricity Regulation 7

1.3 Transparency requirements of the Regulation 9

2. Design of the consumer survey 10

2.1 Requirements of the methodology 10

2.2 Tailoring the survey to the SEM 10

2.3 Key Survey Design Elements 11

3. Consumer Willingness to Pay to avoid interruption 15

3.1 Domestic Survey 15

3.2 Non-Domestic Survey 18

3.3 Business subsector breakdown in ROI 21

4. Single Value of Lost Load for the SEM 23

4.1 Sectoral VoLLs 23

4.2 Sectoral VoLLs for Large Energy Users in ROI 25

4.3 Single VoLLs 26

4.4 Selection of a central scenario 27

5. Implementation of the new VoLL 29

5.1 Areas of implementation 29

5.2 Implementation of $VoLL_{MAX}$ within the Energy Market 30

5.4 Implementation of the $VoLL_{RS}$ within the CRM 30

5.5 Calculation of a new Reliability Standard 30

5.6 Setting of a new Reliability Standard 32

Appendices (published alongside this paper)

Domestic Survey text

Non-domestic phone script

Ipsos-MRBI Report

List of Figures

Figure 1. Single VoLL for the calculation of the reliability standard (euros/MW) across Europe

Figure 2. Fixed CoNE and technology defining the RS (euros/MW/year) across Europe

Figure 3. Reliability standard as LOLE across Europe

Figure 4. Summary of Domestic Willingness to Pay to avoid interruption in ROI & NI

Figure 5. Average Domestic Willingness to Pay to avoid interruption during evening peak

Figure 6. Average Domestic Willingness to Pay to avoid interruption at midday

Figure 7. Domestic Willingness to Pay by contract type, age, social class, and vulnerability

Figure 8. Average Non-Domestic Willingness to Pay to avoid interruption during evening peak

Figure 9. Average Non-Domestic Willingness to Pay to avoid interruption at midday

Figure 10. Non-Domestic Willingness to Pay by market sector, contract type and MIC where available

List of Tables

Table 1. Summary of elements of VoLL survey design which needed to be tailored to the SEM

Table 2. Proposed sampling frame from Ipsos MRBI

Table 3. Timing of peak demand in ROI and NI

Table 4. Interruption scenarios utilised for the VoLL survey

Table 5. Breakdown of non-domestic ROI respondents by MIC

Table 6. Sectoral VoLLs across the range of scenarios surveyed

Table 7. High Willingness to Pay in Large Energy Users translates into low VoLL

Table 8. Single VoLLs based on weighted consumption during supply interruptions, for the scenarios which weighted VoLL the highest, with and without notice

Table 9. Comparison of existing VoLL vs new $VoLL_{RS}$ and $VoLL_{MAX}$

Glossary of Terms and Abbreviations

Abbreviation or Term	Definition or Meaning
ACER	EU Agency for the Cooperation of Energy Regulators
BNE	Best New Entrant
CEP	Clean Energy Package
CRM	Capacity Renumeration Mechanism
CRU	Commission for the Regulation of Utilities
ER	Regulation (EU) 2019/943 (Energy Regulation)
LEU	Large Energy Users
LOLE	Loss of Load Expectation
MDC	Mandatory Demand Curtailment
NI	Northern Ireland
OCGT	Open-cycle Gas Turbines
RAs	Regulatory Authorities
ROI	Republic of Ireland
RS	Reliability Standard
SEM	Single Electricity Market
TSC	Trading and Settlement Code
UR	Utility Regulator of Northern Ireland
VoLL	Value of Lost Load

1. Background

1.1 The Value of Lost Load in the SEM

The Balancing Market within the SEM operates with a technical price cap based on the Value of Lost Load (VoLL), which sets the upper limit for the Imbalance Settlement Price. The Administered Scarcity Price is also set as a percentage of VoLL. Within the Capacity Market VoLL also feeds into the determination of the Capacity Requirement and derating factors for different technologies.

A SEM consultation paper (AIP-SEM-07-381)[5] in 2007 indicated that the Trading and Settlement Code (TSC) requires the Regulatory Authorities to determine various administered prices, including the role of VoLL, which was described as follows: VoLL is defined in the Code as the value (in €/MWh) which "represents the end-customer's willingness to lose supply" and as the value that "consumers would place on a unit of non-delivered electricity."

AIP-SEM-07-381 acknowledged that the definition of VoLL in the TSC should theoretically be measured using customer surveys but in the absence of such data proposed an alternative derivation. A figure of €10,000/MWh for VoLL was derived as laid out in AIP-SEM-07-381. The subsequent SEM decision paper[6] confirmed that the VoLL would be set at €10,000/MWh for the initial calendar years 2007 and 2008 and would subsequently be uprated by applying the weighted average of the year-on-year increases in the Irish Harmonised Index of Consumer Prices (HCIP) (using a weight of two-thirds) and the UK HICP (using a weight of one-third) in the July of the preceding year by comparison with that a year earlier. CRM Detailed Design decision papers SEM-15-103[7] and SEM-16-022[8] confirmed this approach, while indicating that the VoLL calculation would be reviewed on a regular basis to ensure suitability. The most recently inflated value of VoLL, for the T-4 26/27 Capacity Auction held in March 2023, was €13,633/MWh.

[5] https://www.semcommittee.com/publication/aip-sem-07-381-voll-pcop-and-pfloor-consultation-paper
[6] https://www.semcommittee.com/news-centre/value-lost-load-market-price-cap-and-floor-decision-paper
[7] CRM Detailed Design Decision 1
[8] CRM Detailed Design Decision 2

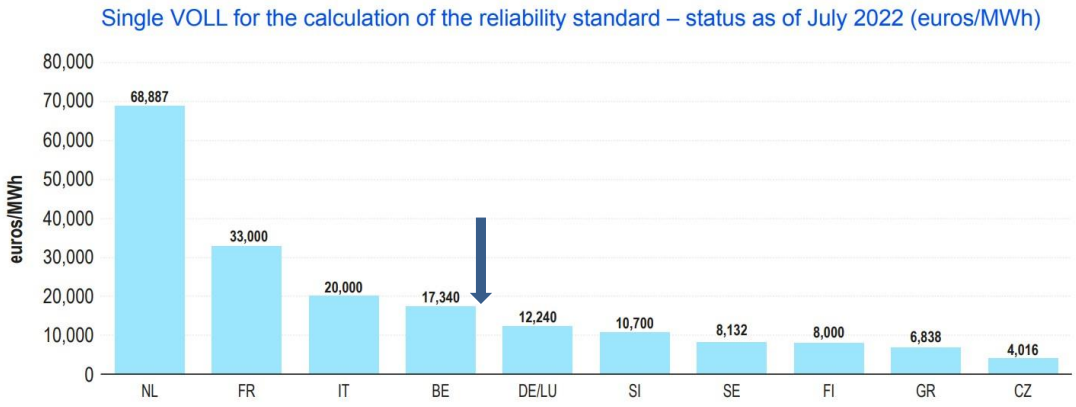
1.2 Compliance with the Electricity Regulation

The Electricity Regulation within the Clean Energy Package (CEP) seeks to harmonise the way that Member States calculate certain market parameters to assess resource adequacy when considering the introduction (or retention) of a capacity mechanism. SEM Committee information papers SEM-19-073[9] and SEM-20-089[10] lay out requirements for compliance with the CEP. Article 23 of the Electricity Regulation outlined the requirement for a new methodology to be developed to calculate VoLL. New methodologies were also required for the Cost of New Entry (CoNE) and the Reliability Standard (RS).

Pursuant to this requirement, ACER published a decision on the methodologies for calculating VoLL, CoNE, and RS in October 2020[11]. The decision indicates that the single VoLL, as "the maximum electricity price that customers are willing to pay to avoid a [supply interruption]", should be obtained by surveying a representative sample of consumers. An annex[12] to this decision listed the set of questions that the VoLL survey should cover.

The implementation of the new methodology is proceeding across Europe, although the resulting values show considerable variability, as shown in the following figures from a 2022 ACER report on Security of Supply[13].

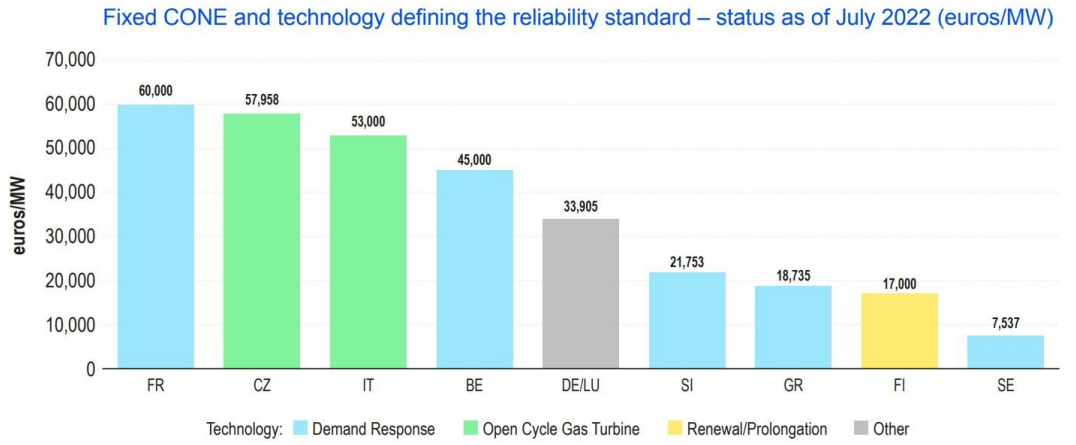
[9] Roadmap to Clean Energy Package Implementation (SEM-19-073)
[10] Updated Roadmap to Clean Energy Package Implementation (SEM-20-089)
[11] ACER Decision No. 23-2020 on the methodology for calculating the value of lost load, the cost of new entry, and the reliability standard
[12] ACER Decision No. 23-2020 Annex 1
[13] https://acer.europa.eu/sites/default/files/documents/Publications/ACER_Security_of_EU_Electricity_Supply_2021.pdf



Source: ACER based on NRA data

Notes: Germany and Luxembourg proceeded with a common calculation of the single VOLL as they belong to the same bidding zone. Calculations of the single VOLL for France and the Netherlands were concluded in 2022.

Figure 1. Single VoLL for the calculation of the reliability standard (euro/MW) across Europe, in comparison with the new $VoLL_{RS}$ of €16,464/MWh for 2022 (indicated by blue arrow). The current VoLL within the SEM is €12,533/MWh for 2022.

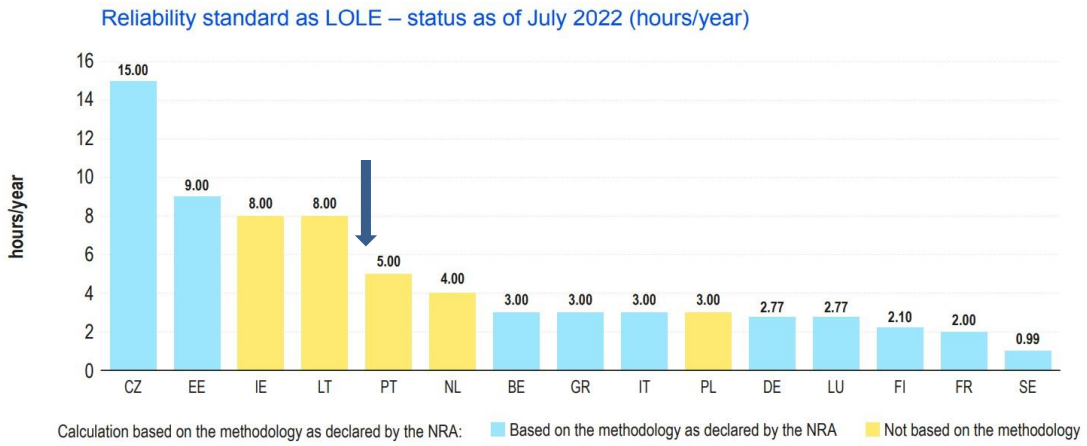


Source: ACER based on NRA data

Notes: When information was not directly available, the fixed CONE values were calculated based on the value of the reliability standard and the VOLL. For Germany and Luxembourg, the reliability standard is an average of relevant annual calculations for the years 2023-2031 and includes years when the resource defining the reliability standard is an open cycle gas turbine and years when it is demand response. For Slovenia, the minimum CONE value is presented.

Figure 2. Fixed CoNE and technology defining the reliability standard (euro/MW/year) across Europe. By comparison the equivalent Gross CoNE of the Best New Entrant in the recently published CEPA/Ramboll study[14] is €107,150/MW/yr for CY2022/23.

[14] SEM-23-016 Best New Entrant Decision Paper | SEM Committee



Source: ACER based on NRA data.

Notes: Implementation of the VOLL/CONE/RS methodology based on NRA declarations; the actual degree of compliance is not examined.

Figure 3. Reliability standard as LOLE across Europe, in comparison with the current Reliability Standard in the SEM of 8 hours LOLE or a Reliability Standard based on the new $VoLL_{RS}$ and CoNE of 6.5 hours (indicated by blue arrow).

1.3 Transparency requirements of the Regulation

This information paper meets the transparency requirements of the ACER methodology, to include publication of the following elements:

- Detailed information underlying the survey
- Sectoral VoLLs
- Weights (and protected consumers) for the single VoLL
- Single VoLL

Section 1 of the paper relates the history of VoLL within the SEM and the requirements of the Electricity Regulation. Section 2 explores the design of the consumer survey and how it was tailored to the SEM. Section 3 describes the information gathered for different segments of the population. Section 4 describes how the "Willingness to pay" figures from the survey are converted to Values of Lost Load for each subsector and aggregated to produce a single VoLL. Section 5 relates how the resulting values (of $VoLL_{RS}$ and $VoLL_{MAX}$) are implemented within different areas of the Single Electricity Market across the island of Ireland.

2. Design of the consumer survey

2.1 Requirements of the methodology

The RAs engaged Ipsos MRBI in 2021 to conduct a survey of a representative sample of consumers in ROI and NI in order to provide the data needed to determine VoLL for the SEM in accordance with the ACER methodology and the requirements of the CEP.

2.2 Tailoring the survey to the SEM

Ipsos MRBI provided the RAs with a draft consumer survey based on the template contained in the ACER methodology, but tailored to the SEM. The additional information required to tailor the questionnaire to the SEM included the list of energy suppliers in ROI and NI, identification of which suppliers provide dual fuel contracts information on billing periods and whether figures on annual consumption and energy spend would be available to respondents.

Element	Source of information	Decision
Treatment of respondents with incomplete data on energy spend, consumption & whether dual fuel contracts are in place	ACER methodology requires consumption to calculate Energy Not Served during interruption. Ipsos MRBI tender indicates respondents will be instructed to have access to bill during survey completion	Respondents must have complete data on electricity spend, consumption and whether dual fuel contracts are in place
Inclusion of customers on prepay meters	The percentage of domestic customers in NI on prepay meters at end June 2021 was 45% and 12% in ROI	Include domestic customers on prepay meters
Inclusion of questions on interruptibility or demand response	RAs are not aware of existing domestic schemes beyond very limited pilot schemes that have since ended	Include questions on interruptibility or demand response in non-domestic survey only
Inclusion of "if any" to questions regarding how much respondents would pay to avoid interruption	ACER Adequacy Working Group members have shared that "protest" responses answering zero for everything had created challenges in their calculations	Omit "if any" from the questions regarding how much respondents would pay to avoid interruption
Inclusion of question on kW power rating of electricity contract	Standard domestic connections are on 12kVA and dwellings which include farm machinery or light welding have 16kVA	Modify question to ask which of these two kVA contract respondents are on

Table 1. Summary of elements of VoLL survey design which needed to be tailored to the SEM

A summary of the elements of the survey design which needed to be tailored to the SEM is provided in Table 1.

2.3 Key Survey Design Elements

Sampling frame

The ACER methodology lays out the required minimum consumer segmentation for the consumer survey and subsequent calculation of VoLL, although aggregation is allowed to ensure meaningful results, given the available sample. This segmentation is as follows:

- **Household**
- **Commerce or service sector (tertiary)**
- Public service
- **Small-medium enterprise in the industrial sector**
- Large enterprise in the industrial sector
- Transport sector
- Other

ROI Active Enterprises by Sector (NACE)	%	No. of Interviews (approx.)
Services (Inc. financial and Insurance)	54.3	244
Distribution	17.2	77
Industry	6.8	31
Construction	21.7	98
Total	100	450

NI Businesses Operating by Sector (SIC)	%	No. of Interviews (approx.)
Services	56	78
Agriculture/Forestry and Fishing	23	32
Construction	14	20
Production	7	10
Total	100	140

Table 2. Sampling frame from Ipsos MRBI

The sampling frame for the non-domestic survey from Ipsos MRBI is included as Table 2. This sampling frame is based on absolute numbers of businesses from the CSO Business Demography data in ROI and the NISRA (Northern Ireland Statistics and Research Agency) Business Profile data. **Bold text** in the ACER-recommended consumer segmentation above indicates sectors which the sampling frame covers

sufficiently to allow robust statistically representative sub-analysis. The other sectors were surveyed but not at a sufficient level to allow robust sub-analysis and were aggregated into other sectors to ensure meaningful results.

For the purpose of calculating VoLL for the SEM, the lack of detailed coverage of public service and transport sectors was less of a concern given that much of these sectors would be exempt from load-shedding due to their status as priority customers in ESB Networks's DSO load-shedding plan[15]. However, while the subset of large enterprise/industry connected at 110 kV with backup generation holds similar status as priority customers, such customers are subject to Mandatory Demand Curtailment (MDC) and could be prioritised for disconnection in advance of emergency load-shedding if their demand is not curtailed in response to instruction. For this reason the RAs sought the inclusion of an additional "booster" sample from Ipsos MRBI to cover this area. This was intended to ensure that the sectors specified in the ACER methodology that would be sufficiently covered in the survey to allow robust sub-analysis would be:

- Household
- Commerce or service sector (tertiary)
- Small-medium enterprise in the industrial sector
- Large enterprise in the industrial sector

The remaining sectors would be covered, but not sufficiently to allow statistically representative sub-analysis. However, the RAs considered that this was acceptable given that consumers that fall into the Public Service or Transport categories are protected from load-shedding, so the VoLL associated with these sectors should either be considered not relevant to the calculation of the single VoLL or be weighted very lightly in the calculation.

Interruption scenarios

The ACER methodology requires that multiple inadequacy situations are explored. The survey template within the ACER methodology includes two demand peaks, Winter and Summer. Summer peaks are more relevant to hot countries with significant

[15] ESB Networks DSO Load-shedding Plan

air-conditioning however and the Summer peak in ROI and NI only corresponds to ~80% of the seasonal demand of the Winter peak[16]. For this reason, survey questions were restricted to the Winter peak only.

The main scenario is the Winter peak weekday evening, which describes the characteristics of supply interruption in the situations when Energy Not Served (ENS) is most likely to occur. However, the RAs also included a Winter peak midday scenario in order to fully capture the VoLL of industry, which may not be impacted to the same degree by supply interruption in the evening. The main calculation is carried out on the basis of the most likely, or central, scenario, which will be the Winter peak weekday evening. However, the sensitivity of the result to changes of the various supply interruption parameters (for example time, duration and pre-notification provided) was evaluated by adding other interruption scenarios to the survey.

The exact timing of the peak was selected based on an analysis of peak demand over the past five years. The table below shows the time of peak demand for the years 2016-2020.

Year	ROI Peak Demand (MW)	Date & Time	NI Peak Demand (MW)	Date & Time
2016	4761	21/11/2016 17:30	1649	14/01/2016 17:15
2017	4940	13/12/2017 17:30	1628	12/01/2017 17:15
2018	4914	04/12/2018 17:30	1652	10/01/2018 17:15
2019	5014	17/12/2019 17:30	1590	23/01/2019 17:15
2020	5348	07/12/2020 17:30	1562	06/01/2021 17:15

Table 3. Timing of peak demand in ROI and NI

Based on the data in Table 3 the peak demand in ROI corresponds to December 7th at 17.30 and the peak demand in NI to January 13th at 17.15. The surveys for ROI and NI were individualised based on these peaks.

The ACER methodology requires that the interruption scenarios reflect the most typical load-shedding events expected to take place in terms of duration and pre-notification.

[16] https://www.eirgridgroup.com/site-files/library/EirGrid/All-Island-Ten-Year-Transmission-Forecast-Statement-2019.pdf

The RAs referred to ESB Networks's approved DSO load-shedding plan referenced earlier, to the System Defense Plans for NI[17] and ROI[18], and to the draft Risk Preparedness plan for Ireland[19] to prepare the scenarios in Table 4. A Risk Preparedness Plan for the Electricity Sector in Northern Ireland is currently in preparation which will likely reflect similar scenarios to that of ROI. SONI and NIE load-shedding procedures were also assessed, and EirGrid and ESB Networks provided feedback on realistic scenarios.

Timing of interruption	Duration of interruption	Notice provided
Winter evening	1 hour duration	No notice
		1 hour notice
		12 hours notice
	4 hours duration	No notice
		1 hour notice
		12 hours notice
Winter midday	1 hour duration	No notice
		1 hour notice
		12 hours notice
	4 hours duration	No notice
		1 hour notice
		12 hours notice

Table 4. Interruption scenarios utilised for the VoLL survey

The likely scenarios that emerged based on these investigations consist of no pre-notification, 1 hour pre-notification and 4 hours pre-notification, and the most likely durations of supply interruption of 1 hour and 4 hours. The ACER template included additional durations of 2 minutes and 1 day but a 2-minute interruption is likely to have limited application from a load-shedding perspective and a 1 day interruption is more likely to be associated with unplanned or planned outages. For this reason the RAs excluded these additional duration parameters and based the survey on the interruption scenarios listed in Table 4.

[17] https://www.soni.ltd.uk/media/documents/System_Defence_Plan_Proposal_Northern-Ireland-Re-submission.pdf
[18] http://www.eirgridgroup.com/site-files/library/EirGrid/System_Defence_Plan_Proposal_Ireland-Re-submission.pdf
[19] https://www.cru.ie/wp-content/uploads/2021/08/CRU21098-Electricity-Crises-A-draft-risk-preparedness-plan-for-Ireland.pdf

3. Consumer Willingness to Pay to avoid interruption

3.1 Domestic Survey

The following is a summary of findings from the Domestic VoLL Survey carried out by Ipsos-MRBI. Additional detail is provided in the Ipsos-MRBI report included as an appendix to this paper, produced on the basis of extensive engagement with the RAs, from which the following section is excerpted. Please note that higher Willingness to Pay for a particular duration and notice scenario (€) does not translate directly to higher VoLLs, as the conversion to VoLL (€/MWh) takes account of consumption (section 4).

The VoLL Domestic Research was conducted online among a sample of 900 respondents in Republic of Ireland (ROI) and 350 respondents in Northern Ireland (NI), during January and February 2022. To be eligible to participate, respondents had to be mainly or jointly responsible for paying the household electricity bill and to know the amount paid for their most recent bill.

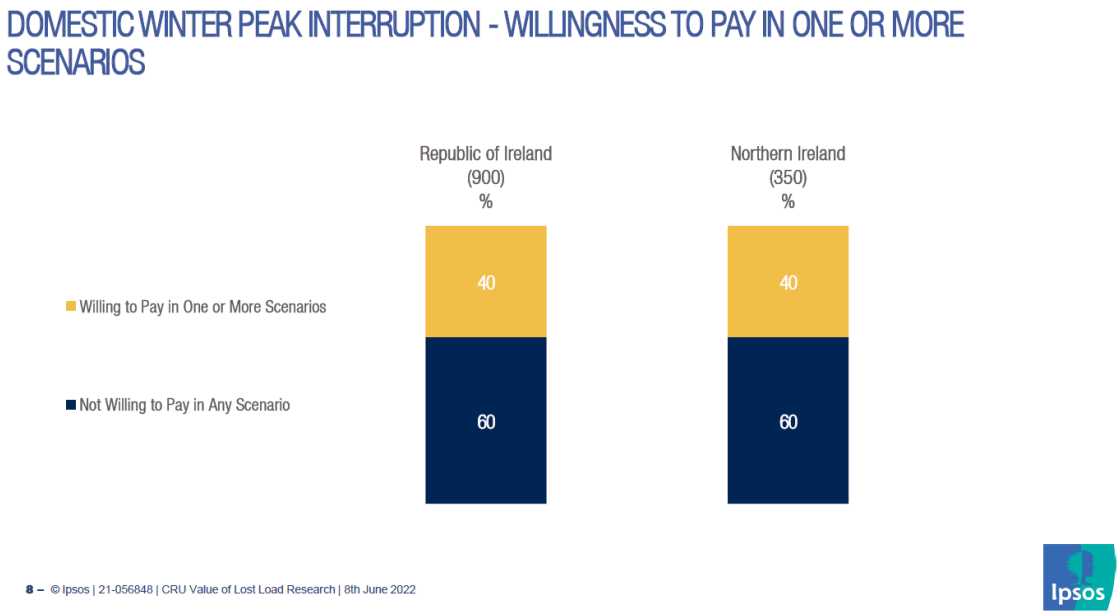


Figure 4. Summary of Domestic Willingness to Pay to avoid interruption in RoI & NI

Overall proportions of Domestic Willingness to Pay were the same for both ROI and NI (Figure 4), with 40% of respondents willing to pay to avoid interruption in one or more scenarios. Consideration was given as to whether zero answers should be included within Willing to Pay averages, at least for those respondents who were willing to pay in one or more scenarios. The decision was taken however to base average Willingness to Pay amounts only on those who said that they were willing to

pay for that particular scenario i.e. the initial "*Are you willing to pay to avoid interruption?*" enquiry was used as a filter question, flowing through to "*If yes, how much*?". In effect, the basic assumption for filtering the data from the survey was that lost load does have a value to consumers in the SEM.

Domestic research highlights are as follows:

- The data shows that bill payers are willing to pay more to avoid a 4 hour interruption than a 1 hour interruption, both in the evening and at midday (*although not 4 times as much*).
- The average amount domestic bill payers are willing to pay declines as the notice period increases.
- The highest average amounts that domestic bill payers are willing to pay to avoid an interruption are €18.37 in RoI and £15.36 in NI. In both jurisdictions this highest amount would be paid to avoid a winter 4 hour interruption to electricity supply, in the evening, with no notice.
- There are no statistically significant differences in the proportion of bill payers willing to pay to avoid interruption in RoI compared to NI across all scenarios, with the exception of a winter 4 hour midday interruption with no notice. In this scenario a significantly higher proportion of bill payers in NI (34%) were willing to pay than in RoI (29%)
- When it comes to demographics, those aged 18-34 are more willing to pay to avoid an interruption than any other age cohort, regardless of the scenario. In addition, the average amounts that respondents in this cohort are willing to pay are higher than for other cohorts, particularly in ROI. These patterns were also observed in the majority of scenarios in NI.

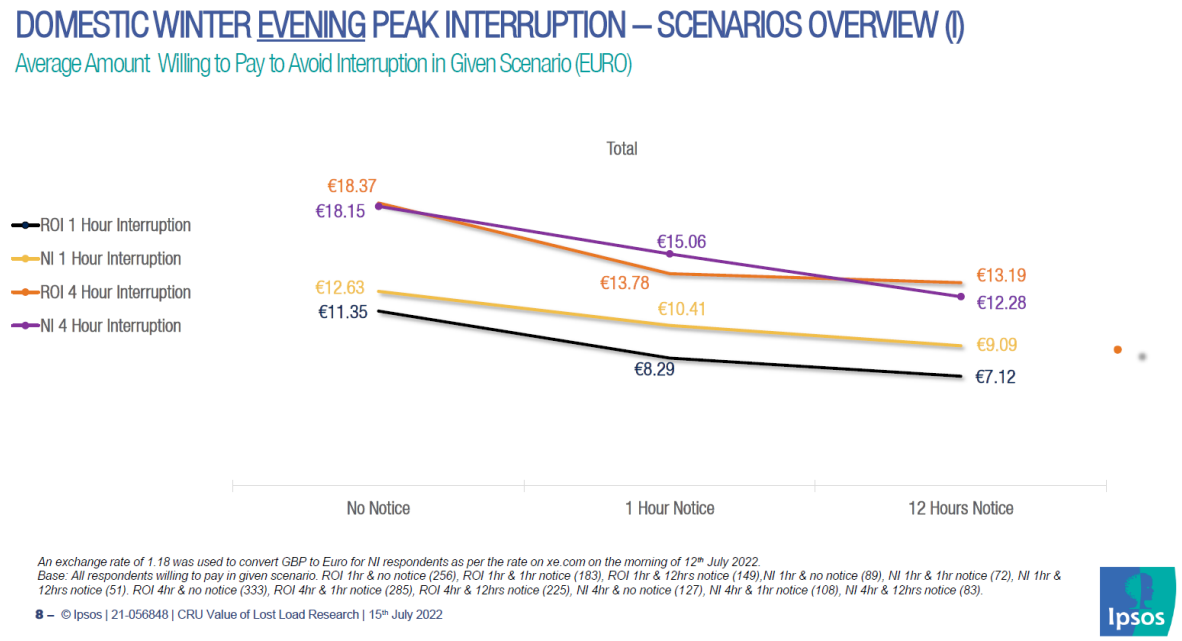


Figure 5. Average Domestic Willingness to Pay to avoid interruption during evening peak

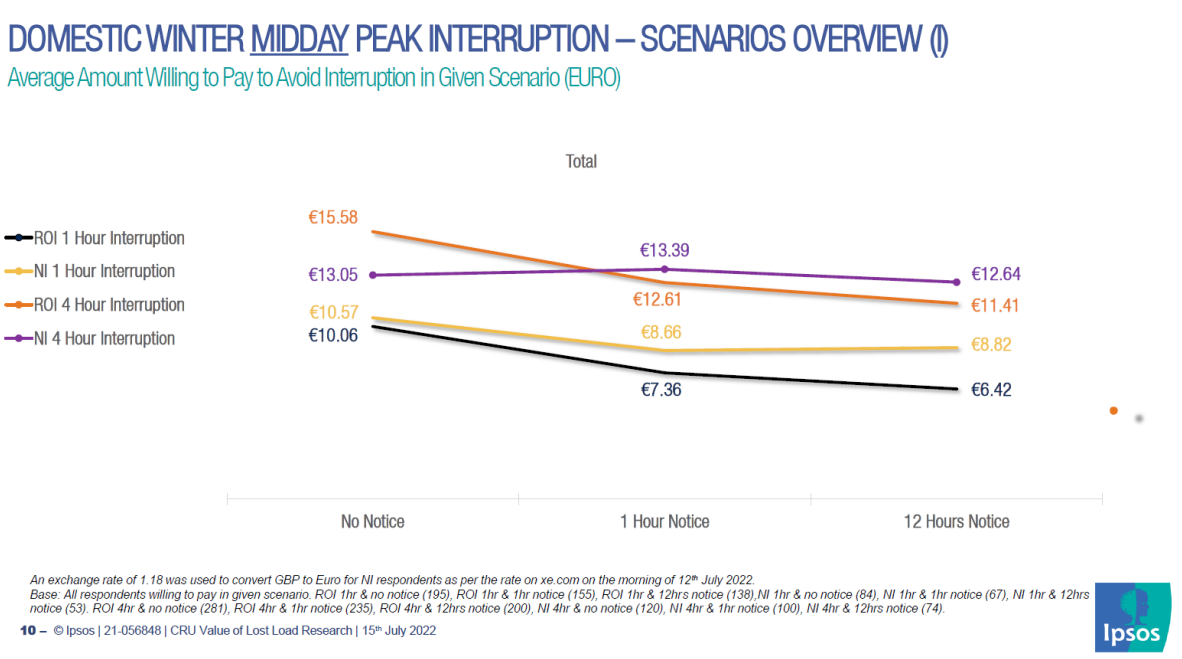


Figure 6. Average Domestic Willingness to Pay to avoid interruption at midday

The RAs requested that Ipsos-MRBI additionally include a graphical depiction of Willingness to Pay for each interruption scenario in relation to secondary variables surveyed. This approach serves to highlight any relationships between Willingness to Pay and supply contract type, age, CSO social class (based on occupation) and

vulnerability. An example of this breakdown is included in Figure 7, across the interruption scenario for which Willingness to Pay per hour is highest for the Domestic sector (evening peak with no notice for 1 hour). In this particular instance we see that younger people, the non-professional classes, and vulnerable customers are willing to pay more to avoid interruption, although the trends across various interruption scenarios are not fully consistent.

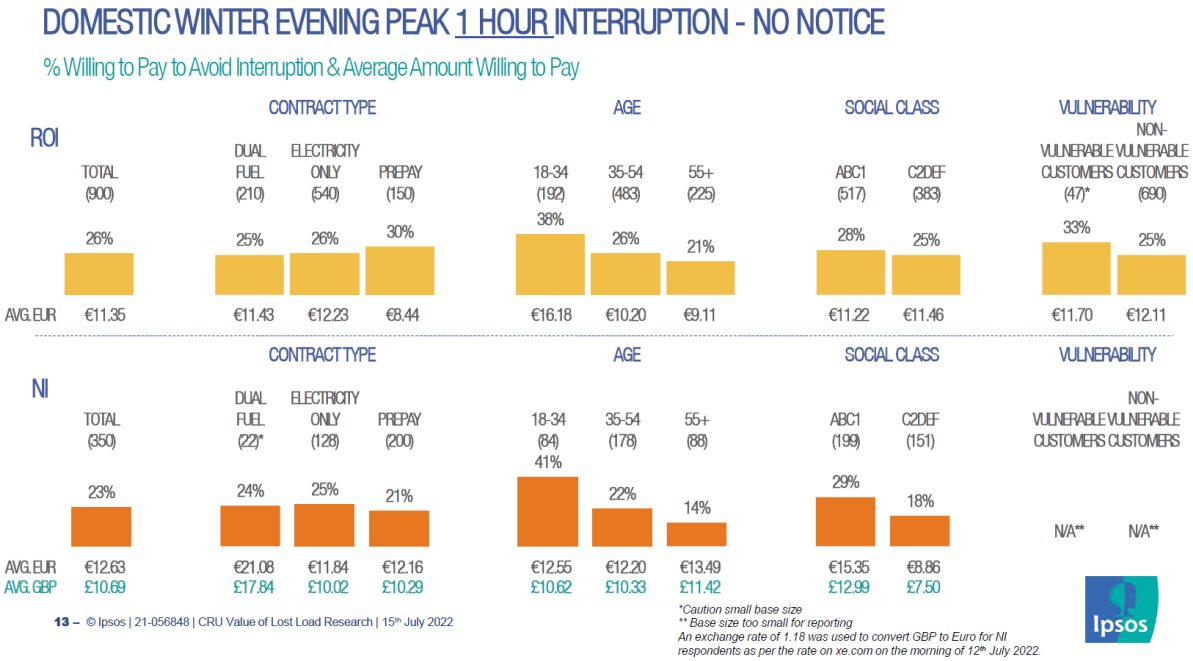


Figure 7. Domestic Willingness to Pay by contract type, age, social class, and vulnerability

3.2 Non-Domestic Survey

The addition of a sufficiently large booster sample for very large enterprise/industry to the Non-Domestic survey proved to be challenging. The initial approach was to target Large Energy Users (LEUs) in ROI and NI. While engagement with the MRSO in ESB Networks yielded a list of ~30 Large Energy Users in ROI, Ipsos MRBI indicated that the number of interviews likely to results from these leads would be insufficiently robust for analysis. The number of LEUs in NI was ~10 although many of these represented state-operated infrastructure. NIE Networks additionally indicated that these LEUs were informally excluded from load-shedding along with airports and hospitals. The RAs requested that Ipsos-MRBI prioritise seeking interviews with the LEUs in ROI, which would weight the sample towards this group to some degree even if insufficiently

robustly to constitute a separate category. The RAs additionally requested the inclusion of a question on kVA or Maximum Import Capacity (MIC) to facilitate classifying the commercial respondents by import scale post collection.

The following is a summary of findings from the Non-Domestic VoLL Survey. Additional detail is provided in the Ipsos-MRBI report included as an appendix to this paper, from which the following section is excerpted.

Non-Domestic Research was conducted using a mixed mode methodology (telephone and online) among a sample of 454 businesses in ROI and 145 businesses in NI, between January and March 2022. Overall proportions of Willingness to Pay diverged for ROI and NI in the Non-Domestic survey, with 51% of respondents willing to pay to avoid interruption in one or more scenarios in ROI in comparison with 41% of respondents in NI. As with the Domestic cohort, average Willingness to Pay amounts were based only on those who said that they were willing to pay for that particular scenario, the rationale for which was explored in Section 3.1.

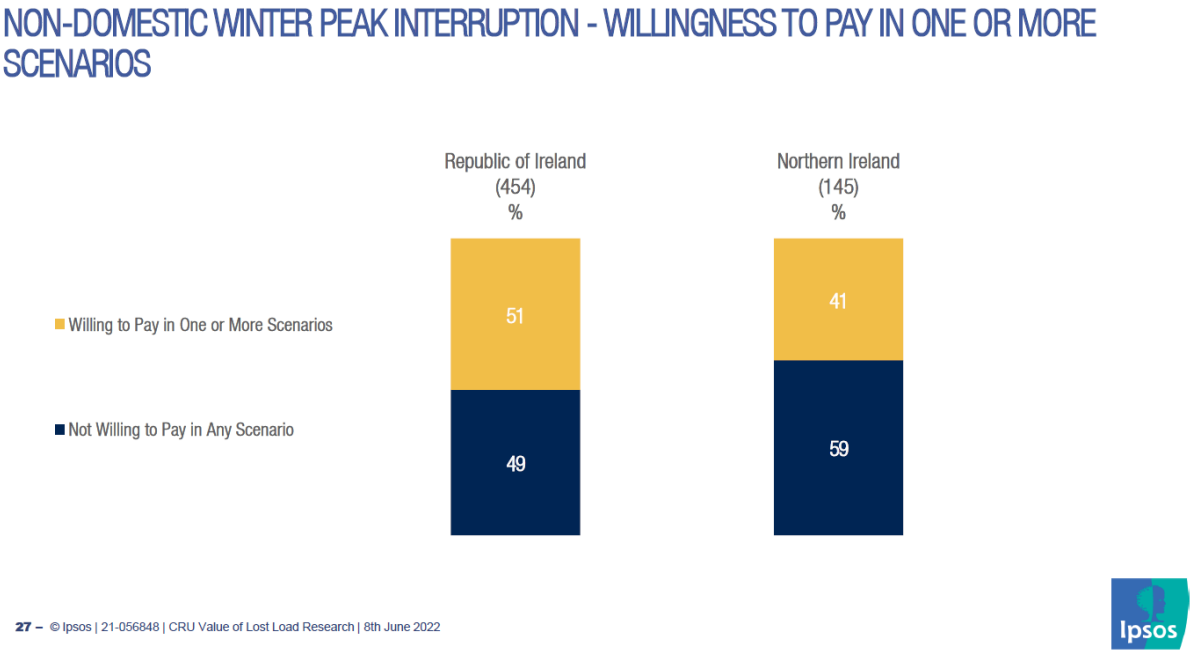


Figure 7. Summary of Non-Domestic Willingness to Pay to avoid interruption in ROI & NI

Non-Domestic research highlights are as follows:

- In line with the Domestic Research, non-domestic customers are willing to pay more to avoid a winter 4 hour interruption than to avoid a 1 hour interruption, either in the evening or at midday (*although not 4 times as much*).
- The average amount that non-domestic customers are willing to pay also decreased as the notice period increases.
- A winter midday 4 hour interruption with no notice results in the highest proportion of non-domestic customers being willing to pay to avoid interruption; 46% in ROI and 34% in NI, with small (50%) and medium (49%) businesses being more likely to pay for this scenario in ROI than large businesses (33%). The average amount paid to avoid this interruption in NI is higher than for any other scenario at £204.99. In ROI, a winter evening interruption with no notice results in the highest average amount that non-domestic customers are willing to pay, at €279.49.
- In ROI, large businesses are willing to pay significantly more than all other non-domestic cohorts to avoid interruptions to electricity supply, with the average amount that they are willing to pay peaking at €1,626.88 for a 4 hour evening interruption with no notice.

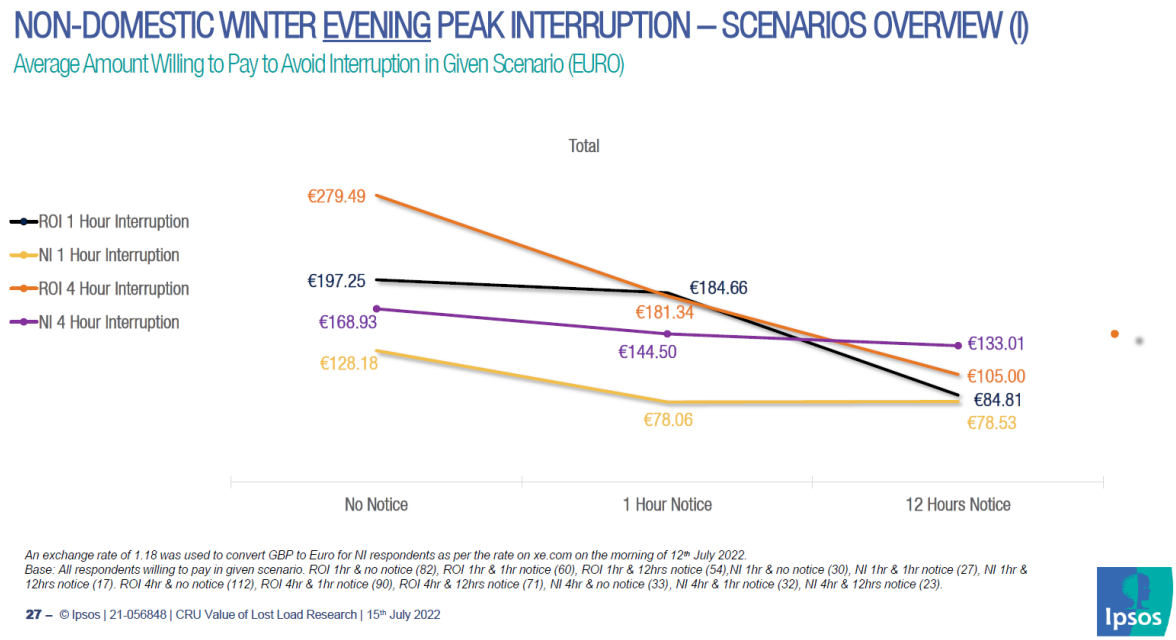


Figure 8. Average Non-Domestic Willingness to Pay to avoid interruption during evening peak

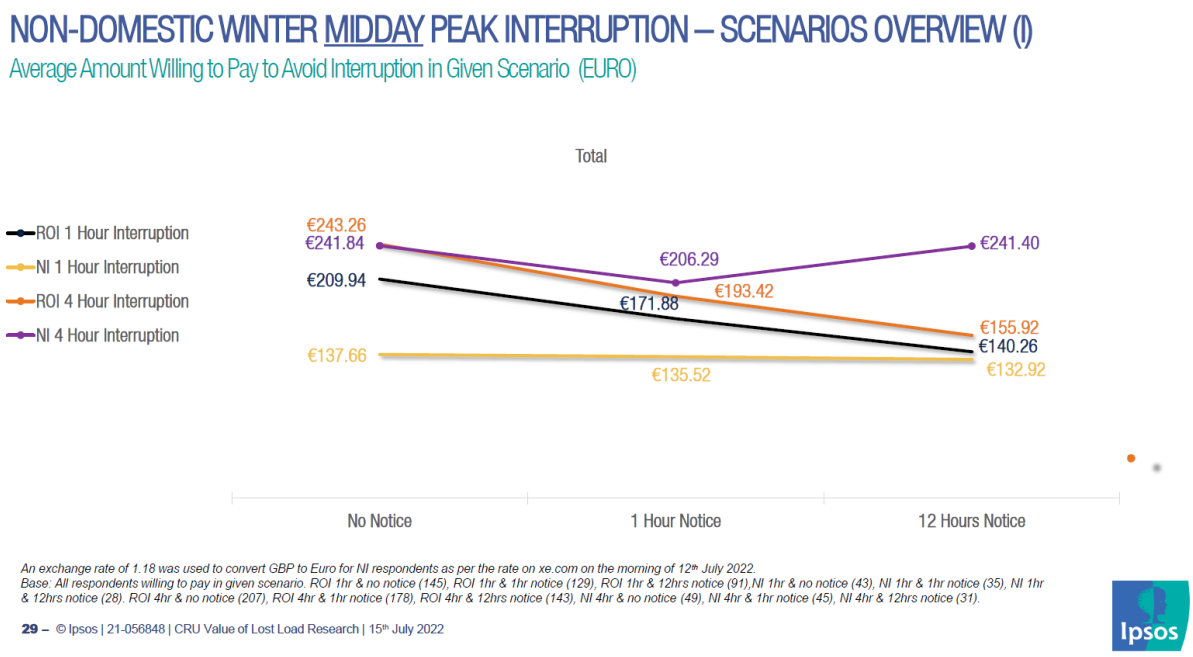


Figure 9. Average Non-Domestic Willingness to Pay to avoid interruption at midday

3.3 Business subsector breakdown in ROI

At the RAs' request, non-domestic respondents' answers to a survey question on kVA rating or MIC were used to classify ROI businesses into small, medium or large categories in ROI, based on ROI retail market categorisations as follows:

Business classification	**Maximum import capacity (MIC)**	# o**f respondents**
Small business electricity	1-9 kV	29
Medium business electricity	10-29 kV	132
Large Energy Users	30+ kV	53

Table 5. Breakdown of non-domestic ROI respondents by MIC

Ipsos MRBI opined that the base size for small business in ROI was low but could be included in the report with caution. For NI the majority of businesses answered "don't know" to questions on MIC so there was no grouping with a base size large enough for reporting (all in single figures). Annual and quarterly retail reporting carried out by UR groups non-domestic subsectors in NI by annual consumption bands (MWh) but again the majority of NI respondents answered "don't know" to the survey question on annual consumption so categorisation of NI businesses was not possible on this basis either.

An example of the breakdown across business and contract type is included here, for the interruption scenario for which Willingness to Pay per hour is highest for the Non-Domestic sector (midday with no notice for 1 hour). The resulting breakdown of Willingness to Pay in this instance across business subsectors in ROI illustrates that Large Energy Users would pay significantly more to avoid interruption. The actual survey responses for this scenario ranged from amounts of €0 - €15,000 per hour (values from raw data). Please note that higher Willingness to Pay (€) does not translate directly to higher VoLLs, as the conversion to VoLL (€/MWh) takes account of consumption (section 4).

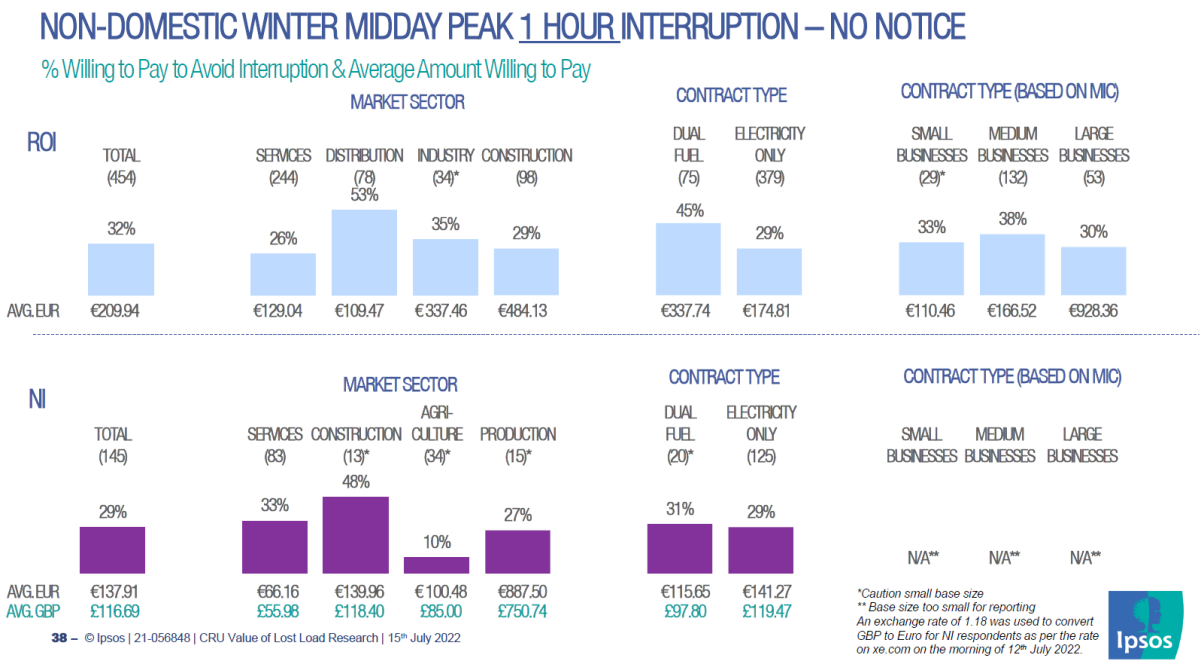


Figure 10. Non-Domestic Willingness to Pay by market sector, contract type and MIC (where available)

4. Single Value of Lost Load for the SEM

4.1 Sectoral VoLLs

The first step in converting average Willingness to Pay figures (€) from the consumer survey to VoLL (€/MWh) involved calculating the average consumption for each sector/subsector, for each interruption scenario, as follows:

$$\text{Average consumption per customer per interruption} = \frac{\text{Total sector consumption per interruption}}{\text{Number of customers in that sector}}$$

Total hourly sector consumption data for 2021 were obtained from ESB Networks's load profile models in ROI, and from NIE networks' load profile models in NI. Numbers of customers in each market segment were obtained from RA retail figures.

Willingness to Pay figures provided by the consumer survey were then converted to sectoral VoLLs as follows:

$$\text{Sectoral VoLL} = \frac{\text{Average willingness to pay per interruption}}{\text{Average consumption per customer per interruption}}$$

ROI and NI Sectoral VoLLs for each interruption scenario surveyed are shown in Table 6. Domestic Sectoral VoLLs ranged from €3,210/MWh to €20,140/MWh while Non-Domestic VoLLs ranged from €3,056/MWh to €21,140/MWh. In all cases VoLLs were highest in scenarios with one hour duration and no notice, midday in the case of the Domestic sector and evening in the case of the Non-Domestic sector, as high consumption levels inverted the relationship with Willingness to Pay (higher for the Domestic sector in evening and higher for the Non-Domestic sector at midday).

Timing	Duration	Notice period	Sector	ROI avg WTP (€)	NI avg WTP (€)	NI sect VoLL (€/MWh)	ROI sect VoLL (€/MWh)
Winter evening	1 hour duration	None	Domestic	11.35	12.53	17,540	11,138
			Non-domestic	197.95	127.35	14,002	21,140
		1 hour notice	Domestic	8.29	10.32	14,455	8,135
			Non-domestic	184.66	77.56	8,527	19,720
		12 hours notice	Domestic	7.12	9.01	12,617	6,987
			Non-domestic	84.81	78.03	8,579	9,057
	4 hours duration	None	Domestic	18.37	18.00	6,543	4,470
			Non-domestic	279.49	167.83	5,010	8,134
		1 hour notice	Domestic	13.78	14.93	5,427	3,353
			Non-domestic	181.34	143.56	4,286	5,277
		12 hours notice	Domestic	13.19	12.18	4,426	3,210
			Non-domestic	105	132.14	3,945	3,056
Winter midday	1 hour duration	None	Domestic	10.06	8.86	20,140	19,199
			Non-domestic	209.94	136.75	12,184	19,071
		1 hour notice	Domestic	7.36	8.59	19,527	14,046
			Non-domestic	171.88	134.62	11,994	15,614
		12 hours notice	Domestic	6.42	8.74	19,874	12,252
			Non-domestic	140.26	132.04	11,764	12,741
	4 hours duration	None	Domestic	15.58	12.94	7,339	7,310
			Non-domestic	243.26	240.24	5,538	5,638
		1 hour notice	Domestic	12.61	13.28	7,532	5,917
			Non-domestic	193.42	204.94	4,725	4,483
		12 hours notice	Domestic	11.41	12.53	7,106	5,354
			Non-domestic	155.92	239.81	5,529	3,614

Table 6 Sectoral VoLLs across the range of scenarios surveyed. Load lost during one-hour supply interruptions with no notice was valued the highest.

4.2 Sectoral VoLLs for Large Energy Users in ROI

A subsectoral breakdown was carried out for the Non-Domestic cohort in ROI, allowing sectoral VoLLs to be calculated for Small and Medium Business sectors, and Large Energy Users (LEU). As noted previously, higher Willingness to Pay (€) does not translate directly to higher VoLLs, as the conversion to VoLL (€/MWh) takes account of consumption. This effect is particularly pronounced in the case of LEU (MIC of >30 kV), illustrated in Table 7 across the interruption scenario for which Willingness to Pay per hour is highest for the LEU subsector (midday with no notice for 1 hour). Despite the LEUs being willing to pay €928.36 to avoid an interruption to their supply in comparison with the €10.06 of their Domestic counterparts, the VoLL for the LEUs, taking into account the very large consumption per customer, amounts to only €683/MWh in comparison with the Domestic VoLL of €11,146.

Sector	Subsector	Total sector consumption/ interruption (MWh)	Number of customers (2021 data)	Average consumption/ customer/ interruption (MWh)	Average willingness to pay zeros (€)	ROI Sectoral VoLL (€/MWh)
Domestic	**Total**	1123.017	2,143,255	0.000524	10.06	19,199
Non-Domestic	**Total**	3184.603	289,294	0.011008	209.94	19,071
	Small business	263.179	186,252	0.001413	110.46	78,173
	Medium business	298.518	101,113	0.002952	166.52	56,403
	Large Energy Users	2622.906	1,929	1.359723	928.36	683

Table 7. High Willingness to Pay in Large Energy Users translates into low VoLL

The decision was made to bring forward only the average Domestic and average Non-Domestic sectoral VoLLs from both ROI and NI for subsequent calculations of the single VoLL rather than including separate sectoral VoLLs for ROI business sectors, to ensure a consistent approach across both jurisdictions.

4.3 Single VoLLs

Sectoral VoLLs were combined into a single value within each jurisdiction by weighting them to reflect the applicable load-shedding process. The weights reflected the proportional share of total load-shedding, determined by respective sectoral consumption within the jurisdiction during the interruption period in question.

The ACER methodology does allow for the sectors or consumers who are price responsive, not subject to load-shedding, or protected from disconnection to be weighted at zero or excluded from the calculation. In the case of the SEM however, this would apply to subsectors within the Non-Domestic cohort, which is below the granularity of the data available for both jurisdictions. The resulting calculation to combine Domestic and Non-Domestic sectors in the case of ROI is as follows:

$$\text{Weighted RoI Single VoLL} = \left(\text{RoI Domestic VoLL} * \frac{\text{RoI Domestic consumption}}{\text{Total RoI Consumption}}\right) + \left(\text{RoI Non-Domestic VoLL} * \frac{\text{RoI Non-Domestic consumption}}{\text{Total RoI Consumption}}\right)$$

The same approach was applied to combine the two jurisdictional VoLLs into a Single VoLL for the SEM, again weighted by the respective consumption of each jurisdiction during the interruption period in question, as follows:

$$\text{Weighted Single VoLL for the SEM} = \left(\text{RoI Single VoLL} * \frac{\text{RoI consumption}}{\text{Total consumption in the SEM}}\right) + \left(\text{NI Single VoLL} * \frac{\text{NI consumption}}{\text{Total consumption in the SEM}}\right)$$

Table 8 shows the results of this exercise for the two scenarios which valued lost load the highest, returning a weighted single VoLL for the SEM of €16,464/MWh for the evening interruption scenario and €18,123/MWh for the midday interruption scenario. We also include two similar scenarios but which include a 1 hour notice period, returning a VoLL of €13,878/MWh for the evening interruption scenario and a VoLL of €15,004/MWh for the midday interruption scenario. As shown, weighted Single VoLLs for the SEM vary dramatically depending on the scenario and parameters for timing, duration and notice period provided.

Scenario	Single VoLL ROI (€/MWh)	Single VoLL NI (€/MWh)	Single VoLL SEM (€/MWh)
1 hour evening interruption, no notice	16,675	15,652	**16,464**
1 hour midday interruption, no notice	19,105	14,601	**18,123**
1 hour evening interruption, 1 hour notice	14,459	11,293	**13,878**
1 hour midday interruption, 1 hour notice	15,205	14,283	**15,004**

Table 8. Single VoLLs based on weighted consumption during supply interruptions, for the scenarios which weighted VoLL the highest, with and without notice

4.4 Selection of a central scenario

The methodology requires that a central scenario to determine $VoLL_{RS}$ is selected which reflects the most likely instance of expected energy not served. The RAs engaged extensively with the System Operators to determine the appropriate scenario, yielding the following information:

FOR IRELAND, the most likely scenario over winter peak:

a. LEUs (110kV and above) are most likely to be impacted by MDC (not disconnection) – 4hrs interruption with 1 hr notice
b. High Voltage (HV) and directly connected Medium Voltage (MV) customers may be similar to the LEU case from 23/24 onwards
c. Smaller customers (*Domestic, Small, and Medium Businesses according to the retail classifications*) are most likely to experience a no-notice interruption of 1hr up to 4 hrs.

Northern Ireland does not deploy MDC, which reduces the relevance of both a and b for the central scenario selection. The weighting applied to sectoral VoLLs on the basis of consumption dictates that central scenario selection should be carried out on the basis of c, as these customers account for the majority share of consumption (the TSO classification of “Smaller customers” which includes both the Domestic sector and the Small, and Medium Businesses according to the retail classifications). On the basis of this information the evening scenario with no notice and a one hour duration was selected. The rationale for this decision is as follows:

- **Timing**: demand is higher at the evening peak vs midday, e.g 6163MWh total consumption vs 5508MWh across the SEM for a 1 hour interruption based on

2021 data. While availability of wind and solar is variable across the day, overall there is a greater likelihood of load-shedding occurring in the evening rather than at midday.

- **Notice**: The SOs are in the process of developing mechanisms and protocols to directly notify customers in the event of an interruption to supply resulting from emergency load-shedding/demand control (e.g. communicating via text and email notification of MDC to LEU, communicating via social media, press statements, relevant phone apps or websites to homes and businesses) but at this time a mechanism to directly notify the majority of customers of emergency load-shedding is not in place. On that basis no notice has been selected as the most likely scenario at this time, particularly given the possible reluctance of the SOs to alert customers to a potential interruption which may not then come to pass.
- **Duration**: The appropriate selection between one hour and four hours of interruption is less obvious. Engagement with the SOs indicated a one hour interruption could potentially be associated with a no-notice scenario, while a four hour interruption is more likely to be associated with rota load-shedding, and advance planning. The RAs made the decision to utilise the one hour duration given the higher likelihood of a shorter unanticipated interruption.

The outcome of this decision is that the central interruption scenario (evening peak with no notice and one hour duration) produced a VoLL of €16,464/MWh for 2022.

5. Implementation of the new VoLL

5.1 Areas of implementation

The ACER methodology indicates that the single VoLL used for the calculation of the Reliability Standard ($VoLL_{RS}$) must be based on consumer surveys of Willingness to Pay to avoid interruption to supply during typical load-shedding events, as presented in this information paper. The RAs have calculated a $VoLL_{RS}$ of **€16,464/MWh** for the central (or most likely to produce load-shedding) scenario, which took place in the evening during peak demand.

ACER have provided their interpretation of the ER on the application of VoLL across various other areas. ACER guidance indicates, for instance, that when assessing the benefits of Security of Supply projects that the use of $VoLL_{RS}$ to define the value of the unshed load is also appropriate, i.e. VoLL determined by use of the central scenario most likely to result in load-shedding.

According to this guidance the maximum value of VoLL ($VoLL_{MAX}$) is appropriate to use for setting technical bidding limits in the Day-Ahead Market and Intraday Market, and imbalance settlement prices. RA findings are that the maximum VoLL that consumers were willing to pay in the SEM was **€18,123/MWh** for 2022. This corresponded to an interruption scenario at midday during winter peak demand, in the event of no notice period and with a duration of one hour, in contrast with the central scenario to determine $VoLL_{RS}$, which took place in the evening.

Capacity Year	Current VoLL	New $VoLL_{RS}$	New $VoLL_{MAX}$
2021/2022	€12,533/MWh	€16,464/MWh	€18,123/MWh
2022/2023		€16,546/MWh	€18,213/MWh
2023/2024		€16,877/MWh	**€18,577/MWh**[20]
2024/2025		€17,215/MWh	€18,949/MWh
2025/2026		€17,559/MWh	€19,328/MWh
2026/2027	€13,633/MWh	€17,910/MWh	€19,714/MWh
2027/2028	€14,933/MWh	€18,268/MWh	€20,109/MWh

Table 9. Comparison of existing VoLL vs projections for new $VoLL_{RS}$ and $VoLL_{MAX}$

These new values of $VoLL_{RS}$ and $VoLL_{MAX}$ for 2022 compare directly with an existing VoLL of €12,532.51/MWh for 2022. Projected indexation of the new $VoLL_{RS}$ and

[20] **2023/24 $VoLL_{MAX}$ to be applied in the Energy Market in the 2023/24 Market Year**

$VoLL_{MAX}$ to subsequent Capacity Years as per the decision in AIP-SEM-07-484[21] is shown in Table 9.

5.2 Implementation of $VoLL_{MAX}$ within the Energy Market

According to the ACER guidance, $VoLL_{MAX}$ which was determined at **€18,123/MWh** for 2022, should be applied in the following settings:

- Technical bidding limits in the Day-Ahead Market and Intraday Market
- Imbalance settlement prices

While the actual inflated $VoLL_{MAX}$ of €18,577/MWh to be used for the 2023/24 Market Year is communicated in Table 9 of this paper, the actual values for subsequent Market Years will typically be communicated to the Market Operators via the T-1 Capacity Auction Parameters Decision Paper for the year in question, i.e. the inflated $VoLL_{MAX}$ for the 2024/25 Market Year will be communicated via the T-1 2024/25 Capacity Auction Decision paper, and similarly for subsequent years. In the event that a T-1 Capacity Auction is not being held for a particular Capacity Year the value will be communicated directly to SEMO by the RAs.

5.4 Implementation of the $VoLL_{RS}$ within the CRM

$VoLL_{RS}$ calculated in accordance with the ACER methodology is being implemented within the CRM from the T-4 2027/28 Capacity Auction onwards. VoLL is inflated to the Capacity Year in question and provided to the TSOs by the RAs and feeds into the calculation of the Capacity Requirement and the Derating Factors for each Capacity Auction.

While VoLL itself is not consulted on as part of the parameter consultation for each Capacity Auction the multiplier used to determine Administered Scarcity Pricing does form part of the Capacity Auction Parameters Consultation (traditionally 0.25 of VoLL). As per the ACER guidance, and the previous section, it is appropriate to utilise the $VoLL_{MAX}$ in this case.

5.5 Calculation of a new Reliability Standard

A Reliability Standard is intended to reflect an appropriate trade-off between reliability and affordability i.e. between being able to meet demand, and the cost of meeting

[21] AIP-SEM-07-484 The Value of Lost Load, The Market Price Cap and Floor - Decision Paper

demand. The Reliability Standard in the SEM is expressed in terms of Loss of Load Expectation (LOLE), which is the number of hours per year that, statistically, a country's electricity production is expected to fall short of meeting its full demand. The Reliability Standard currently used for Ireland, and for All-Island calculations, including in particular the setting of volumes for the purposes of the Capacity Auctions, is 8 hours. For the purposes of the GCS Northern Ireland uses a Reliability Standard of 4.9 hours. If these Reliability Standards are exceeded, it indicates the system has a higher than design level of risk.

The Reliability Standard is calculated using the CoNE of the Best New Entrant (BNE) Reference Technology[22] (an OCGT in ROI) and the $VoLL_{RS}$ as presented in this paper.

According to the ACER methodology, the value of LOLE is set according to the following formula:

$$LOLE_{RT} = \frac{CONE_{fixed}}{VOLL_{RS} - CONE_{var}}$$

The values for these parameters are as follows:

- $CoNE_{fixed}$ corresponds to the Gross CoNE of the new BNE, an OCGT in ROI as per the 2023 CEPA/Ramboll study cited above. This value is €115.99/kW/yr or €115,990/MW/yr for CY2026/27.
- $VoLL_{RS}$ is the value presented in this paper, corresponding to €17,910/MWh for CY2026/27 (Table 9).
- $CONE_{var}$ was calculated by ESP consulting based on the Short Run Marginal Costs of an OCGT in ROI incorporating gas and carbon cost outputs captured during Plexos runs informing USPC determinations for the T-4 26/27 Capacity Auction. This value is €179/MWh for CY2026/27.

The formula yields the following:

$LOLE_{RT}$ = 115,990 / (17,909 - 179) = **6.5 hours**

This represents a decrease of 1.5 hours on the current security standard of 8 hours LOLE in the SEM. However, the impact of the Reliability Standard on the CRM

[22] https://www.semcommittee.com/publications/sem-23-016-best-new-entrant-decision-paper

Capacity Requirement calculation is relatively low in this range of RS values (i.e. less than 8 hours).

5.6 Setting of a new Reliability Standard

ACER have made clear that while the methodology focuses on calculating the RS pursuant to Art. 23(6) of the ER, setting the RS pursuant to Art. 25 of the ER is a Member State prerogative and goes beyond the methodology. From the ACER Decision on the Methodology for calculating the value of lost load, the cost of new entry, and the reliability standard: Annex I, Paragraph 66:

(66) "… *pursuant to Article 25(2) of the Electricity Regulation,* ***setting the RS is a Member State's prerogative that is beyond the scope of the RS methodology****. In that respect, ACER agrees with the views provided by ENTSO-E and the Member States during the consultation process …and reiterates that* ***the RS methodology focuses solely on calculating the RS and therefore does not encroach upon the Member States' right to set the RS****."* (emphasis added)

The SEM Committee has accepted the 6.5 hours as the output of the methodology and instructed the RAs to engage DECC in RoI and DfE in NI (including through the Joint Steering Group) on whether an alternative RS should be set as a national competence instead of the default output of the ACER methodology.