Value of Lost Load: Preliminary Survey of Values for Alberta

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Summary: Preliminary VOLL Guidance for Alberta's Power Market

Parameter	Preliminary Guidance	Why?
Price Cap	**~$2,000-$6,000/MWh**, Starting toward the lower end and potential to phase in higher cap over time as more DR and customer participation is activated	• The price cap should balance the design goals of limiting exposure to extreme price events, runaway economic withholding, and consistency with current framework (goals advanced by a lower price cap) while maintaining ability to compete for imports with neighbouring jurisdictions, ensuring reliability, activating DR participation, and maintaining investment signals (goals advanced by a higher price cap) • Much higher values in the range of a true VOLL can be justified on economic theory (see below), but prices at that high level have substantial downsides (exposure to extreme price events and systemic financial risks in the event of sustained outage when nothing practically can be done to address the event once it begins, given limited scale of DR participation expected) • A range of ~$4,500-$6,000/MWh can be informed by highest prices realized in SPP & CAISO markets during extreme events (if Alberta prices cannot rise to this level, it will not attract imports if reliability events occur simultaneously) • Further, the price cap should be at least high enough to provide room for operational response to outages when they occur, and for customers/businesses to self-select into lower levels of reliability via voluntary curtailments. In Alberta, some DR can activate at ~$200-500/MWh, and industrial tariffs indicate more responsiveness to avoid peak transmission tariffs in a range of ~$12,000/MWh • Overall, suggest to consider higher price cap over time if more DR begins to participate in AESO markets, and if there is indication that more DR would participate at higher strike price levels
VOLL to be Used in Calculating ORDC	Point estimate roughly **$32,000/MWh**, with a substantial uncertainty range of approximately **$12,000-50,000/MWh** Alberta-specific survey approach may provide more evidence (but likely to fall in this range)	• VOLL relevant for informing the quantity, price cap, and ORDC parameters of new ancillary service products that may be introduced. Concept of VOLL times the probability of lost load (POLL) informs the most cost-effective quantity of reliability to maintain for customers across different situations and system conditions (e.g. most important reserves should have the highest price cap, same as energy; while the least critical reserves with may have a lower price cap) • Sector-specific VOLL values derived from LBNL tool (using survey-based approach, with some adjustments to Alberta context, but no survey of Alberta customer VOLL is available) • For C&I customers with high VOLL, the parameter is capped by the cost of backup generation and the typical outage rates experienced as consistent with Alberta SAIDI metrics. Customers with higher VOLLs are assumed to already have backup generation • Final value reflects a weighted average of VOLL parameters for customers likely to be curtailed in such an event. If residential customers are most affected, the number is toward the lower end of the range. If C&I are most affected or interruptions are proportional to load share, then the number is toward the higher end

Detailed Development

Alternative Approaches to VOLL Estimation

Approach Category	Specific Approach	Used By	Description
Stated Customer Preference Survey	• Willingness to pay (WTP) • Willingness to accept (WTA) • Direct cost questionnaire	• MISO, ERCOT • Great Britain (for residential and commercial customers) • Australia	Use of surveys to estimate a customer's WTP and WTA directly—several examples of use in electricity regulation
Revealed Customer Preference	• Interruptible contracts • Demand-curve estimation • Mitigation investments (backup generator sales)	Not used by the RTO/ISOs examined here, but common in academic literature	Use of real-world sales data to determine expenditures customers incur to ensure reliable generation (e.g., backup generators, battery storage systems) as VOLL proxy
Macroeconomic Approach	• Retail electricity price • GDP indicators • CGE modeling • Production functions	• Great Britain (for industrial customers) • EU countries	Use of macroeconomic data and observable expenditure data to estimate VOLL (i.e., GDP, energy consumption, cost of leisure time). Can be simplistic estimate of GDP divided by energy use or based on more complex economic modeling using production functions with energy use as an input
Benchmarking	Compare VOLL and price cap values to those developed by other ISO/RTOs	Used across RTOs to inform market design parameters including VOLL and the price cap	Comparison of VOLL estimate and price caps can be used to: (a) inform conceptual approach and sanity check resulting values; and (b) for jurisdictions with substantial levels of import/export, ensure pricing is competitive for imports during reliability events
Meta Study	Meta study	Not directly used for official VOLL estimate but likely used in development of estimates	Use of academic literature to provide insight into VOLL estimates

Sources and Notes: Table adapted from the following sources: Gorman. "The quest to quantify the value of lost load: A critical review of the economics of power outages". *The Electricity Journal*. October 2022; Sergici, et. al. "A Literature Review of Value of Lost Load Estimates and Development of an Interim Value for ERCOT". December 15, 2023.

Strengths and Weaknesses of VOLL Estimation Techniques

Approach	Relevance to Alberta	Strengths	Weaknesses
Stated Customer Preference Survey	This is a common approach amongst independent system operators and has been accepted by other stakeholder forums	• Most direct incorporation of customer preferences • Considers duration/timing of outages • Flexibility to consider scenarios with advanced warning, socioeconomic aspects • Allows incorporation of jurisdictional specifics to impact estimations	• Demanding on time and budget • Potential for interview biases • Respondent reliability highly variable based on their experience with outages
Revealed Customer Preference	Provides an upper bound for VOLL estimate as all customers *could* purchase a backup generator	• Directly indicates a customer's actual response to an outage event • Data is often up-to-date (generator sales, etc.) • Provides a clear upper-bound for VOLL as all customers can buy backup power systems if they value it	• Limited consideration of duration/timing of outages • Difficult for residential customers to quantify expenses associated with an outage • Limited consideration of jurisdiction-specific characteristics • It is difficult to determine the "average VOLL" because most customers opt not to buy backup generation equipment
Macroeconomic Approach	Provides a point of comparison and valuable for calculating the aggregate customer loss from outages	• Few variables that are easy to obtain using public sources • Multiple variations on the approach that can lead to a straightforward point estimate	• No consideration given to timing/duration of outage, advanced warning, etc. • Simplistic estimations can skew causal impact of energy on macroeconomic indicators (e.g., Not all GDP-creating processes rely on energy production)
Benchmarking	Valuable to consider tradeoffs of setting a higher VOLL in comparison to neighbouring jurisdictions	• Provides real world comparison to other similar energy markets • Valuable to consider tradeoffs in particular for price caps of neighbouring jurisdictions	• Not specific to Alberta context • Relies on other jurisdictions utilizing quality VOLL estimate
Meta Study	Valuable to leverage quality studies completed by economists studying VOLL in a variety of geographies and for different customer classes	• Provides valuable point of comparison • Can provide insights on the underlying reasons for variations in VOLL estimates	• Not specific to Alberta context • Not always completed with market design principles in mind

Sources and Notes: Table adapted from the following sources: Gorman. "The quest to quantify the value of lost load: A critical review of the economics of power outages". *The Electricity Journal*. October, 2022; Sergici, et. al. "A Literature Review of Value of Lost Load Estimates and Development of an Interim Value for ERCOT". December 15, 2023.

VOLL Estimates Used by Other RTOs

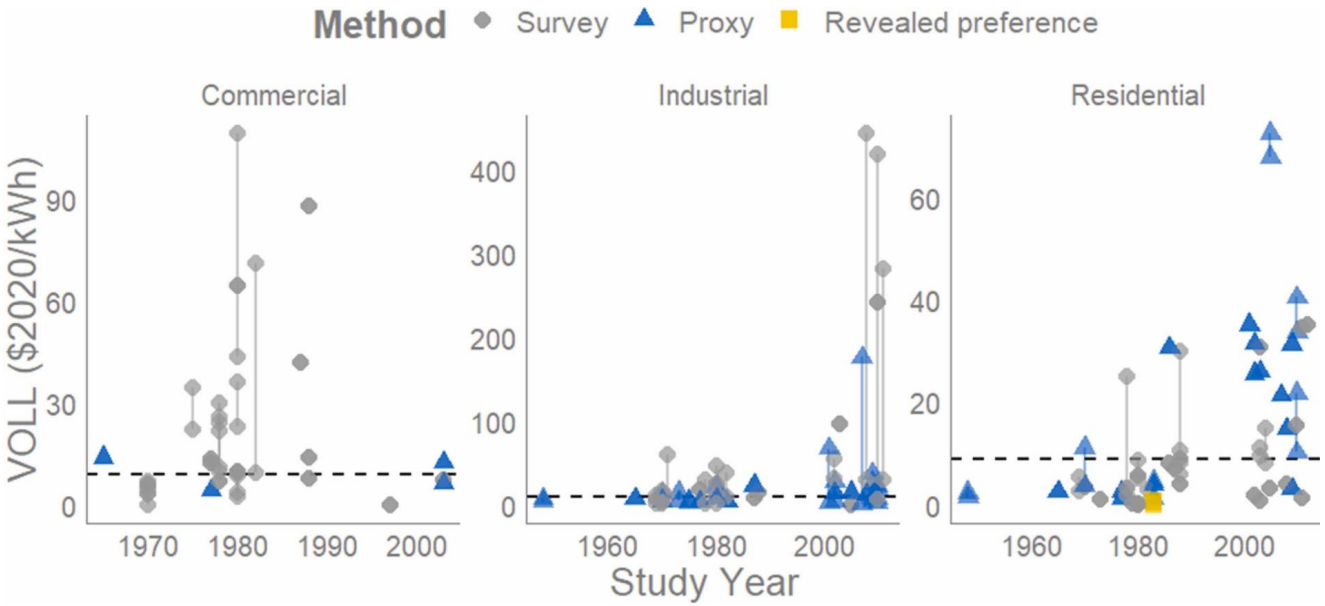
Region	Estimation Type	VOLL Estimate *(2024$CAD/MWh)*	Notes
MISO (Proposed)	Stated Customer Preference Survey	• Price Cap: **$13,700/MWh** • VOLL: **$47,800/MWh** (used in the construction of the ORDC slope)	• Calculations indicate that the true VOLL should be between $18,000/MWh CAD and $47,000/MWh CAD but MISO opted for $13,700/MWh CAD because it will "generate appropriate pricing signals without being excessively punitive" • MISO utilizes a meta study completed by the Lawrence Berkely National Laboratory (LNBL) which relies upon stated preference surveys completed across the United States • Prior VOLL of $4,900/MWh CAD had been criticized as too low by the IMM
ERCOT	Stated Customer Preference Survey	• Price Cap: **$7,100/MWh** • VOLL: **$34,200/MWh** (interim value) • Currently completing stated preference survey for final VOLL	• ERCOT commenced a proceeding to update their VOLL based on comments from their independent market monitor that the current VOLL was too low • In December 2023, they released an interim VOLL estimate of $34,000/MWh CAD with a caveat that the true VOLL could be in the range of $27,000/MWh CAD to $95,000/MWh CAD • VOLL was used to set the price cap in the energy market, but price cap was decoupled from VOLL due to impacts of Winter Storm Uri • VOLL is now used for reliability studies and system planning
Australia	Calibration to reliability standard for MPL Stated Customer Preference Survey for VCR	• Price Cap (MPL): **$15,500/MWh** • VOLL (VCR): **$26,100/MWh**	• VOLL was acknowledged as a separate concept from the price and renamed "Market Price Limit" (MPL) in 2010 • Market Price Limit estimation technique is not based on inherent value of lost load, rather it is set to ensure Australia can meet its reliability standard of 0.002 EUE • Value of Customer Reliability (VCR) is separate from the Market Price Limit and used for cost benefit analyses, reliability analyses, and setting transmission and distribution reliability standards among other things
Great Britain	Stated Customer Preference Survey and Macroeconomic Approach	• VOLL: **$29,500/MWh**	• VOLL is calculated using a combined approach of a stated preference survey for residential and commercial customers, and the macroeconomic (proxy) approach for industrial customers • Single estimate is calculated using a weighted average of the estimates for each customer class

Sources and Notes: All values presented in 2024 $CAD/MWh and rounded to the nearest hundred. The price cap in MISO is referred to as VOLL but MISO acknowledges it is lower than what they actually expect the VOLL to be. See London Economics. "The Value of Lost Load (VoLL) for Electricity in Great Britain". July 2013; Australian Energy Market Commission. "National Electricity Amendment (NEM Reliability Settings: VoLL, CPT and Future Reliability Review) Rule 2009". May 28, 2009; MISO. "Scarcity Pricing White Paper: Value of Lost Load and Operating Reserve Demand Curve". March 2024; Sergici et. al., "A Literature Review and Value of Lost Load Estimate and Development of an Interim Value for ERCOT". December 15, 2023; Australian Energy Regulator. "2023 Values of Customer Reliability Annual Adjustment". 2023; Australian Energy Regulator. "Values of Customer Reliability: Final report on VCR values".

VOLL Estimates in Academic Literature

- VOLL Estimates from academic literature vary significantly both between the same customer class and between different customer classes
- Commercial and industrial customers tend to have higher VOLL than residential customers
- Values in the chart only show academic estimates and exclude energy regulation approved estimates

VOLL is higher for commercial and industrial customers
(All values in 2020 USD)



Commercial
Median = $14,000/MWh
75th percentile = $7,000/MWh
25th percentile = $30,000/MWh

Industrial
Median = $20,000/MWh
75th percentile = $12,000/MWh
25th percentile = $75,000/MWh

Residential
Median = $10,000/MWh
75th percentile = $5,000/MWh
25th percentile = $22,000/MWh

Sources and Notes: Median, 25th percentile, and 75th percentile estimates are visually extracted from the figure, they are not exact values. See Gorman. "The quest to quantify the value of lost load: A critical review of the economics of power outages". *The Electricity Journal*. October 2022.

Indicative Range of Potential VOLL and Price Cap Values for Alberta

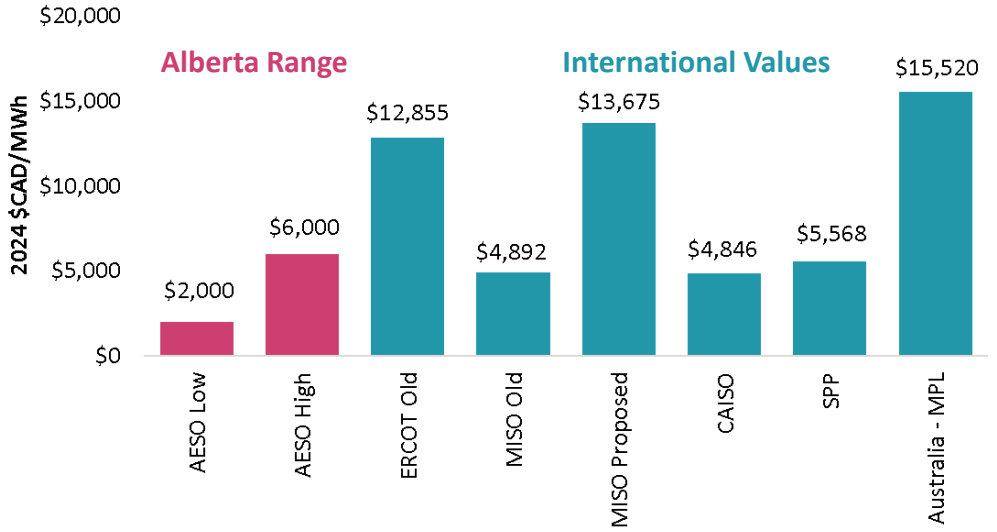
Approach	Estimate (2024 $CAD)	Description	Implications for the REM
Stated Customer Preference Survey	Res: $11,642/MWh Small C+I: $172,408/MWh Large C+I: $92,642/MWh Aggregate: $108,606/MWh	• Uses the LBNL ICE Calculator with certain inputs calibrated to Alberta • Similar method as used by MISO and ERCOT • Aggregate value calculated by weighting customer type by their annual consumption	• Provides estimates calibrated based directly on customer preferences • Estimates are too high to be used for the price cap in Alberta given limited DR participation and implications for customer risk exposures in extreme events
Revealed Customer Preference (Backup Gen)	Res: $29,053 - $55,849/MWh C+I: $25,500 - $49,057/MWh Aggregate: $26,203 - $50,400/MWh	• Calculated based on the cost of installing a backup generator for the hours it is likely to be used • Utilizes SAIDI stats from Fortis as a proxy for Alberta as a whole	• Highest values that potentially could be considered relevant for bulk system reliability - reflects the reality that all customers *could* buy a backup generator if they desired higher reliability (and would do so as a means to avoid distribution-related outages) • Informs the high end of the range for the VOLL estimate to be used in the construction of the ORDC or inform AS price and quantity
Revealed Customer Preference (Ind. Tariff)	$11,901/MWh	• Calculated using the highest possible cost for 1 MWh of energy for a transmission customer • AESO sees curtailment from some industrial customers during periods when rates reach this peak	• Informs the low end of the range for the VOLL estimate to be used in the construction of the ORDC or inform AS price and quantity
Macroeconomic Approach	GDP approach: $4,643/MWh	• GDP approach calculated using simple macroeconomic approach of dividing GDP by consumption	• Not recommended as relevant in electricity market context (GDP-based concepts more relevant in comparing economic competitiveness between economies to attract business, e.g., comparing average prices)
Benchmark	SPP Price Cap: ~$5,568/MWh CAISO Price Cap: ~$4,846/MWh MISO Price Cap: $13,675/MWh (Proposed)	• MISO uses separate estimates to produce the ORDC price cap vs. the slope of the ORDC • Both SPP and MISO ORDC price caps are significantly lower than most VOLL estimates in academic literature	• Useful in setting the price cap as it provides information on the level of price cap needed in Alberta to attract imports over other jurisdictions
Aggregate Recommendations	**VOLL: $12,000-$50,000** **Price Cap: $2,000-$6,000**	• **VOLL:** Low end of range based on the industrial tariff estimate and the residential stated survey approach; high end range based on the revealed preference approach for commercial and industrial customers • **Price Cap:** Low end of range is based on balancing considerations of attracting imports of neighbouring jurisdictions while limiting exposure to extreme price events; high end of range based on ensuring price cap greater than SPP or CAISO who could compete for imports against Alberta	

Sources and Notes: The revealed preference and proxy approaches are primarily based on calculations from the AESO internal team. The MISO proposed ORDC is capped at a lower value of $8,205/MWh CAD but the LMP price cap is set at $13,675/MWh CAD with the difference between the values being due to other components of LMP such as congestion and losses. CAISO and SPP do not have explicit price caps, but prices references in the table are based on the highest LMPs over the past 5 years. See SPP. "SPP Operating Reserve Market Overview". 2019; MISO. "Scarcity Pricing White Paper: Value of Lost Load and Operating Reserve Demand Curve". 2024.

Indicative VOLL and Price Cap Values for Alberta

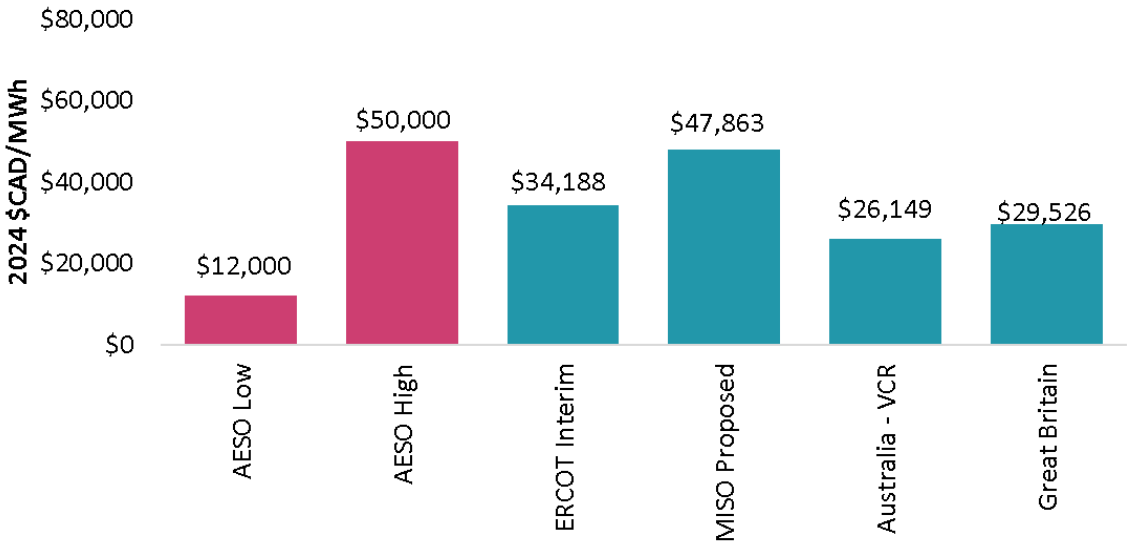
Preliminary survey indicates a price cap in the range of $2,000/MWh - $6,000/MWh (potentially beginning at the lower end, and increasing if/when more DR activation is observed at higher prices) and the VOLL used to construct inform ancillary service parameters of price, quantity or ORDC be set in the range of $12,000/MWh - $50,000/MWh

Price Cap



Indicative Alberta Values	Informed By
$2,000 - $6,000/MWh (2024$ CAD)	• High end of range based on price caps used by other jurisdictions (namely CAISO and SPP) • Low end of range based on design principles of the REM and the existing price cap

VOLL for AS Parameters & Benefit-Cost Analysis



Indicative Alberta Values	Informed By
$12,000 - $50,000/MWh (2024$ CAD)	• Range based on the stated customer preference approach for residential customers and revealed preference approach (i.e. backup generation cost) for C+I customers • Aggregate value calculated assuming outages occur on a load-weighted basis

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