Guidehouse

ONTARIO ENERGY BOARD

OEB Electricity Distribution Vulnerability Assessment and System Hardening

Proposed Component 3 & 4 Overview

Agenda

OEB Introduction **15 Minutes**	Kick-off meeting.
VASH Overview **15 Minutes**	Review each of the six components and timeline for Components 3 & 4.
Component 3 **75 Minutes**	Overview of the proposed value of lost load (VOLL) methodology and LDC options. Open discussion.
Component 4 **75 Minutes**	Overview of the proposed benefit-cost analysis (BCA) framework. Open discussion.

VASH Overview

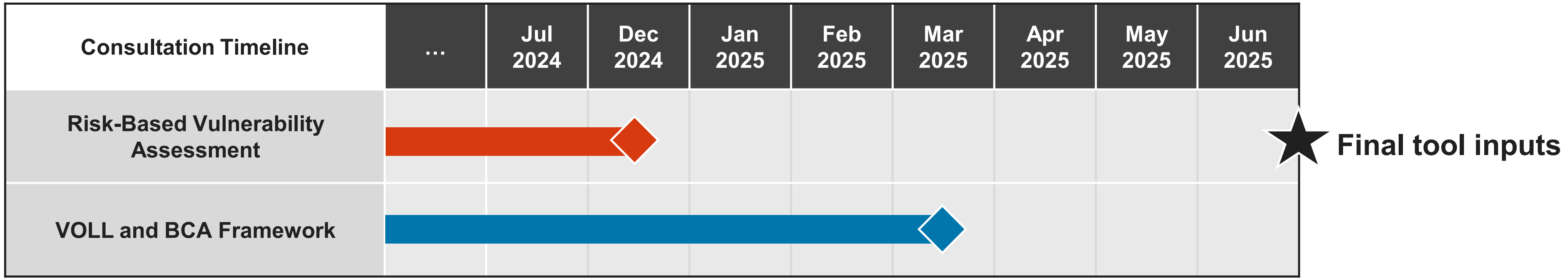
Project Components

Six components combine to inform the final ED VASH Report and are supported by a scan of 3-5 leading jurisdictions.

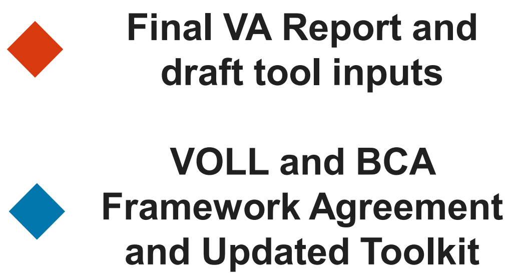
Component	*Definition*
1. Risk-Based Vulnerability Assessment	A risk-based Vulnerability Assessment that includes the probability/impact of events. The frequency and time-period of the Vulnerability Assessment should also be included.
2. Standardized Vulnerability Assessment Data Sources	The sources for any standardized input variables to be used in the Vulnerability Assessment (including, for example, the use of a common forecast or model that estimates how climate change is likely to alter the frequency and severity of adverse weather conditions; a common set of equipment impacted; etc.).
3. Value of Lost Load Methodology	A value of lost load methodology to quantify risk reduction value from the Vulnerability Assessment.
4. Benefit-Cost Analysis	A benefit-cost analysis to evaluate whether an LDC should pursue an investment based on the cost of the investment in comparison to the value of lost load mitigated and other applicable benefit streams.
5. DSP Integration Methodology	Methodology for incorporating System Hardening into an LDC’s system planning as an additional investment driver within their integrated system planning process.
6. Filing Requirement Updates	Recommend updates to the Chapter 2 and 5 Filing Requirements for Electricity Distribution Rate Applications or develop policies resulting from Report. The recommendations for the Filing Requirements should be included as part of Report.

VOLL and BCA Framework Deliverables and Timeline

The VOLL and BCA frameworks will be developed by the end of March 2025 with updates to the vulnerability assessment that incorporate Standard Option functionality.



Meetings	Objective
January	Solicit feedback on VOLL and BCA initial methodology proposal
February	Draft VOLL and BCA methodology



Component 3: Value of Lost Load Methodology

Value of Lost Load (VOLL) Overview

The value of lost load (VOLL) estimates a customer's willingness to pay for interruptions in electricity service. These may be expressed as $/unserved–kW (or –kWh) or $/CMI. The benefits from reductions in CMI through utility interventions are critical to a resiliency investment BCA and commonly leverage a VOLL.

VOLL Estimation Methods:

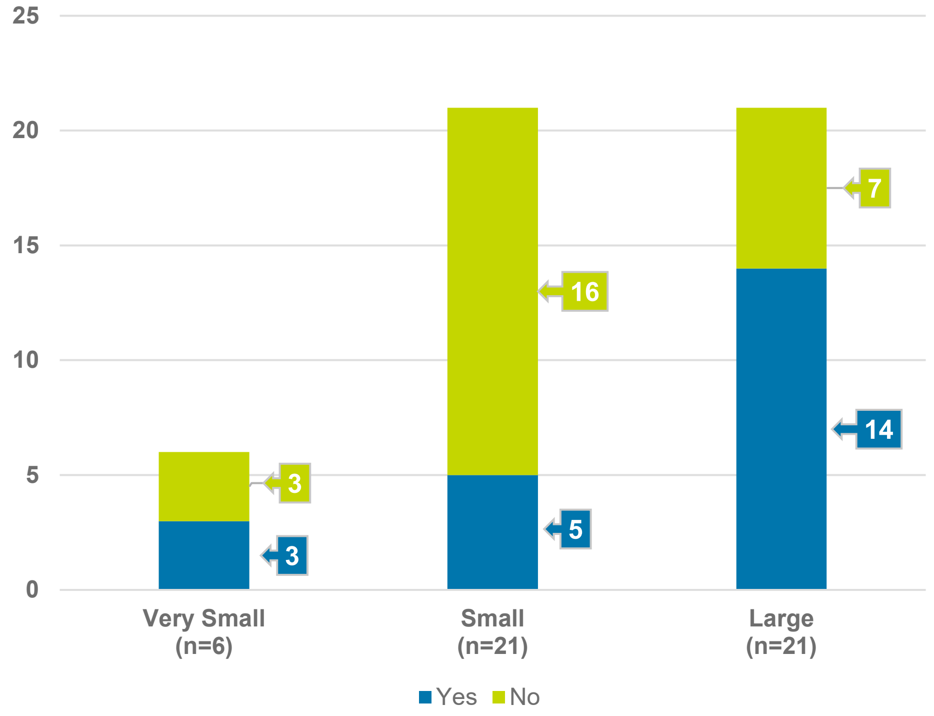
Method Category	Example Approaches	Example Jurisdiction
Proxy	- Retail Electric Prices - GDP Indicators - Production Functions	- EU
Survey	- Willingness-to-Pay - DOE ICE Calculator - Willingness-to-Accept	- MISO - ERCOT
Revealed Preference	- Interruptible Contracts - Demand Response Incentives	- IESO
Meta Study	- Combination of approaches from other categories	- Not used directly but may set boundaries.

Adapted from: Gorman, W. (2022). The quest to quantify the value of lost load: A critical review of the economics of power outages. The Electricity Journal, 35(8).

Value of Lost Load (VOLL) RPQR Survey Findings

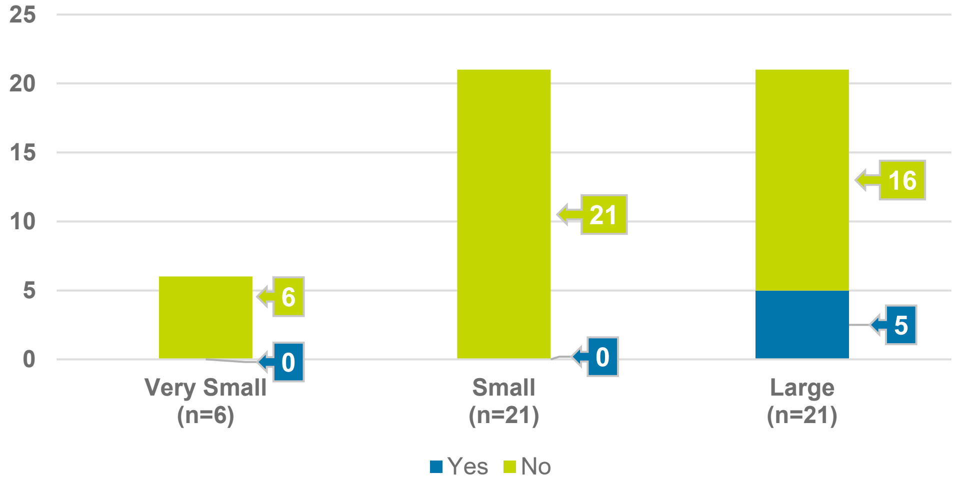
Incorporating Resilience in System Planning

22 out of 48 LDCs (46%) stated that they currently incorporate resilience into their system planning as one of the investment drivers



Incorporating Value of Lost Load (VoLL) in Cost Benefit Analysis

5 out of 48 LDCs (10%) stated that they currently use VoLL studies to evaluate the cost and benefits of their investment plans related to reliability or resiliency



LDC used sources for VoLL

Department of Energy
CEATI Value of Service
Options Analysis Report by 3rd Party
Calculation based on Customer Surveys

VOLL used by LDCs in previous Rates Applications

Five (5) LDCs have stated that they incorporate a VOLL into their resiliency planning:

- Two (2) LDCs that we know of have used VOLL values from US Department of Energy research or ICE calculator.

- Three (3) LDCs that we know of have developed their own values as follows:
    - $30 per kVA (peak load) as the event cost to represent the VOLL due to the initial period of the outage, and $15 per kVA (peak load) per hour to represent the VOLL value due to the increasing duration of the outage (mixed Residential, Commercial & Industrial)
    - $20 per kW as the event cost to represent the VOLL due to the initial period of the outage, and $20 per kW per hour to represent the VOLL value due to the increasing duration of the outage (mixed Residential, Commercial & Industrial)
    - VOLL range of $10-$30 per kWh to provide a low and high estimate of the risk borne by local customers

DOE ICE Calculator Comparison (*Converted to $2025 CAD*)

State	Res ($/unserved-kWh)	Small CI ($/unserved-kWh)	Med/Lg CI ($/unserved-kWh)	Total Weighted
New York	$5.28	$257.71	$114.37	$91.40
Illinois	$4.53	$199.90	$49.96	$56.45
Michigan	$4.92	$248.02	$55.12	$62.83
Composite	$4.94	$236.58	$70.21	$70.01

Value of Lost Load (VOLL) VASH Considerations

To maintain consistency with stakeholder feedback from the vulnerability assessment and continue to provide clear guidance allowing LDCs to accomplish VASH with minimal increased burden as well as maintain flexibility for those who desire it, the OEB is considering two VOLL Options.

VOLL Option	Summary	Rationale
Generic Option	LDCs may use the US DOE ICE Calculator[1] with LDC-specific inputs where applicable. *Option 2 (for discussion): The OEB procures a standard value*	The US DOE ICE calculator provides the ability to customize inputs to LDC specific variables such as outage history and customer characteristics. This resource is free to access and provides an acceptable estimate while significantly reducing research burden on LDCs.
Custom Option	LDCs may propose a VOLL using any industry recognized approach with accompanying methods and justification. VOLL should be proposed at the customer segment level.	Certain LDCs have previously conducted VOLL studies targeted at their customers. LDCs may wish to conduct new targeted studies.

[1]*https://icecalculator.com/interruption-cost*

Value of Lost Load (VOLL) Methodology Example

The OEB is considering that Guidehouse provide standard guidance to develop VOLL in $/CMI for three customer classes based on the US DOE ICE calculator[1]. Additionally, a description of methods and documentation to use external VOLL study values for resiliency events will be supplied.

Example Calculation of VOLL in $/CMI (Customer minutes of interruption)

Customer Class	Value of Unserved Load ($/kWh)	Annual Consumption per Customer (kWh)	Average Consumption per Minute (kWh)	Value of Lost Load ($/CMI)
Residential	$4.94	9,000	0.02	$0.08
Small Commercial	$236.58	15,000	0.03	$6.75
Large Commercial	$70.21	600,000	1.14	$80.14

$$VOLL = Value\ of\ Unserved\ Load * \frac{Annual\ Consumption\ per\ Customer}{Minutes\ per\ year}$$

Where:

Value of Unserved Load = Derived from the ICE Calculator for each customer class

Annual Consumption per Customer = Derived from LDC customer data

Minutes per year = 525,600

[1]**https://icecalculator.com/interruption-cost**

Outage Duration and VOLL Estimates

- The severity of event and subsequent outage duration may impact customers' willingness to pay for reduced minutes of interruption.
- VoLL values from ICE calculator may not reflect customer's willingness to pay for longer duration outages.
- The ICE calculator has been used across a variety of jurisdictions as a conservative VOLL estimate for resiliency investments, however, its values represent research focused on shorter duration outages.

Open Discussion – Component 3 (VOLL)

Stakeholder Feedback:

- TBD
- TBD
- TBD

Component 4: Benefit-Cost Analysis

Benefit-Cost Analysis (BCA): Baseline Risk

The benefit-cost framework outlines the applicable benefit and cost streams to be evaluated in developing a system hardening BCA ratio. Commonly, benefits of resiliency investments include avoided repair/replacement asset costs and VOLL (reduction in CMI) estimates in present value for the expected lifetime of equipment in the form of a risk buy-down.

Illustrative annual risk calculation:

$$\begin{aligned}&\text{Annual Asset Risk}\\&= \left(pRepair * Repair(\$)\right) + \left(pReplace * Replace(\$)\right)\\&+ \left(pRepair * Customers\ Interrupted * Repair\ Duration\ (\text{minutes}) * \$/C\,MI\right)\\&+ \left(pReplace * Customers\ Interrupted * Replace\ Duration\ (\text{minutes}) * \$/C\,MI\right)\end{aligned}$$

Where,

pRepair = Annual probability of an asset requiring repair
Repair ($) = Cost of asset repair including labor
pReplace = Annual probability of an asset requiring replacement
Replace ($) = Cost of asset replacement including labor
Customers Interrupted = Number of customers experiencing an outage due to an asset failure
Repair Duration (minutes) = Expected outage duration from repair failure
$/CMI = Value of lost load per minute of customer interruption by class
Replace Duration (minutes) = Expected outage duration for replacement failure

Benefit-Cost Analysis (BCA): Risk Mitigation Modes

Based on this proposed BCA framework, investments in system hardening and other resiliency risk mitigating activities can accrue benefits in three ways:

Reductions in annual asset failure and outage frequency (pRepair or pReplace)

Example: *Infrastructure system hardening may include increasing design standards, undergrounding segments, relocating assets, etc. These investments increase the robustness of vulnerable assets to a measured climate peril.*

Reductions in the number of customers impacted by an outage

Example: *Modernization investments such as improvements to grid situational awareness, IGSDs, sectionalizing, or battery storage. These activities improve the grid's ability to react to outage events in real-time.*

Reductions in the average customer duration of an outage

Example: *Non-infrastructure investments include storm preparedness and response activities as discussed in the RPQR working team activities.*

Benefit-Cost Analysis (BCA): Project-Level Risk Mitigation

Risk is compared between scenarios for the expected lifetime of an asset to determine investment benefits. Costs include incremental asset capital and O&M spend compared to a baseline scenario.

Project benefit calculation:

$$Project\ Benefits\ (\$) = \sum (PV(Asset\ Baseline\ Risk) - PV(Asset\ Mitigated\ Risk))$$

Where,

Asset Baseline Risk = Asset lifetime risk for the baseline scenario
Asset Mitigated Risk = Asset lifetime risk for mitigated scenario

Illustrative project cost calculation:

$$Project\ Cost = \sum (Asset\ Capital\ Cost + Asset\ O\&M\ Cost) + Program\ Parametric\ Cost$$

Where,

Asset Capital Cost = One-time cost at time of purchase above (or below) baseline
Asset O&M Cost = Ongoing annual cost of asset upkeep above (or below) baseline
Program Parametric Cost = Non-asset costs (e.g., admin, replaced asset removal)

Open Discussion – Component 4 (BCA)

Stakeholder Feedback:

- TBD
- TBD
- TBD

Your guides

Donald Lau
Manager, Electricity Distribution
Donald.Lau@oeb.ca
+1 416-440-7681

Zubin Panchal
Senior Advisor, Electricity Distribution
Zubin.Panchal@oeb.ca
+1 416-440-8113