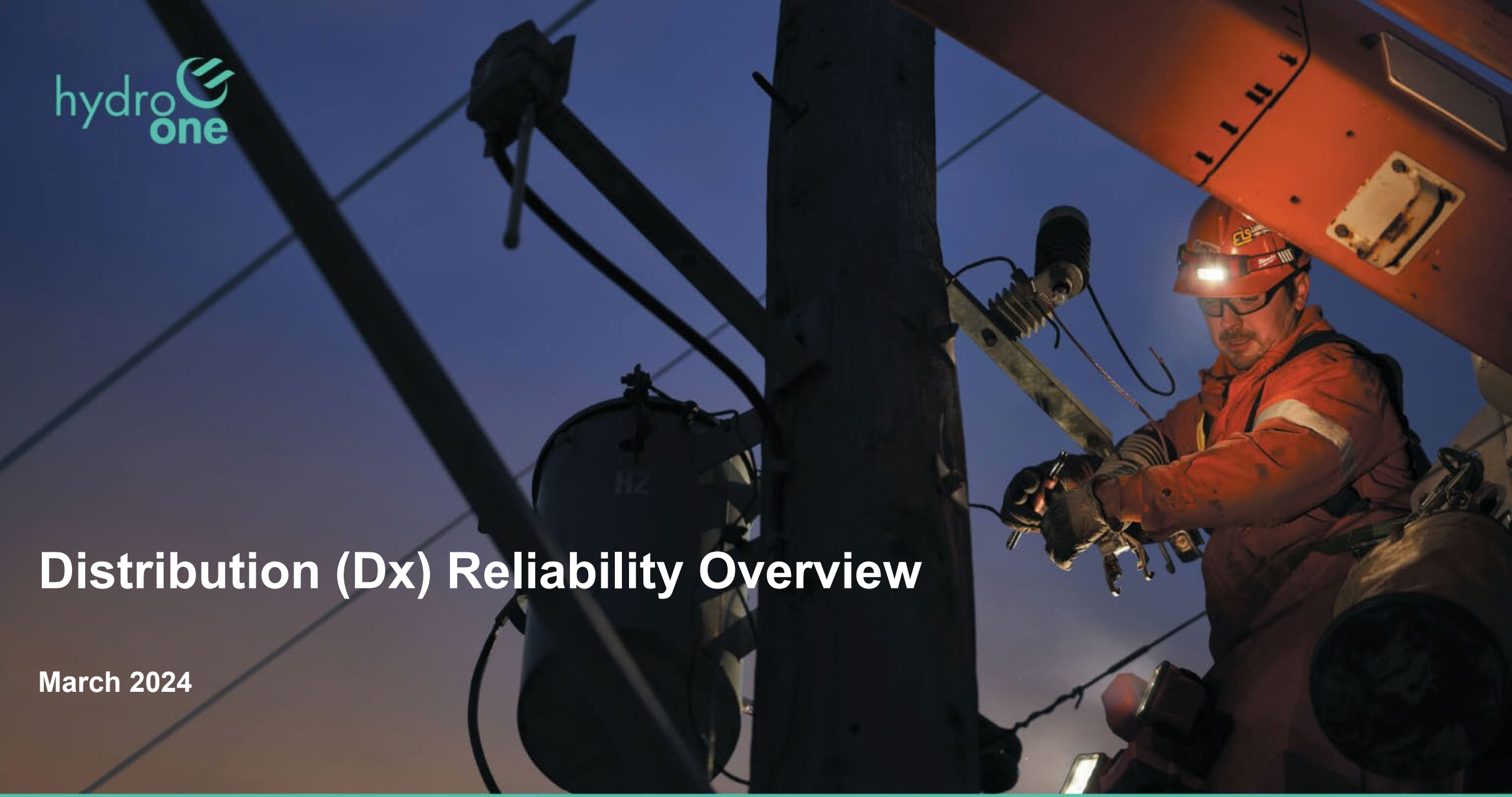


# Distribution (Dx) Reliability Overview

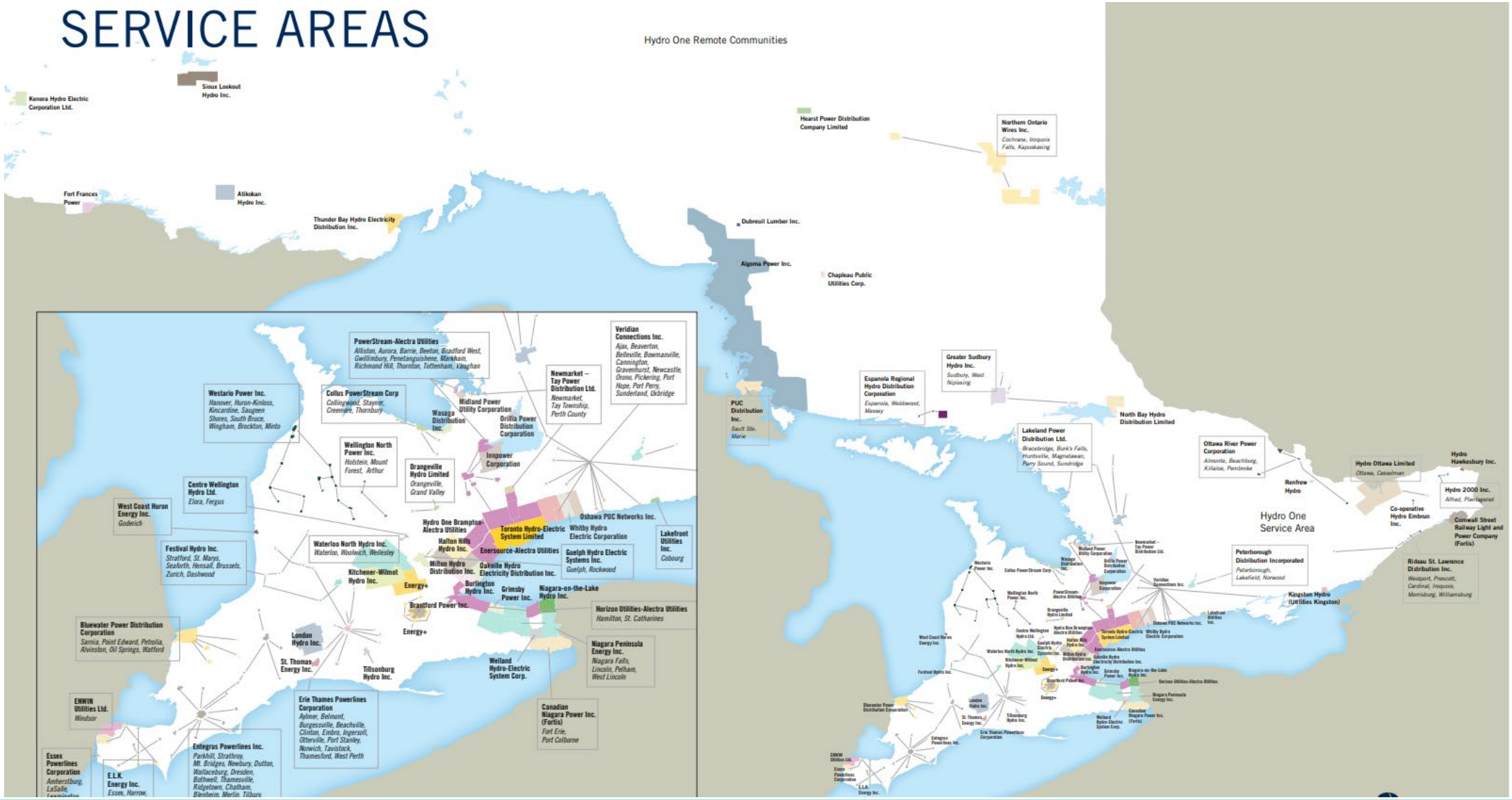
March 2024

# Agenda

- Introduction - Service Area, Performance Metrics
- Hydro One's Historical Dx Reliability
- Embedded LDC Supplying Reliability
- Feeder Level Reliability
- Improving Distribution Reliability
- DER Impact To Dx Reliability

# Introduction

# Hydro One Distribution Service Area



# Dx Reliability - Performance Metrics

- Dx Reliability - provide reliable power supply to distribution system and end customers.
- Common key performance indicators (KPI's) used for Dx Reliability:
  - System Average Interruption Frequency Index (SAIFI)
  - System Average Interruption Duration Index (SAIDI)
  - Customer Average Interruption Duration Index (CAIDI)
    - SAIDI/SAIFI
- Key KPI's for Dx utilities
  - Mandated by Regulator
  - Customer-driven

# Distribution Reliability - Performance Metrics

- System Average Interruption Frequency Index (SAIFI)

$$SAIFI = \frac{Total\ Customers\ Interruptions}{Total\ Number\ of\ Customers\ Served}$$

- System Average Interruption Duration Index (SAIDI)

$$SAIDI = \frac{Total\ Customer\ Hours\ Interruptions}{Total\ Number\ of\ Customers\ Served}$$

- Customer Average Interruption Duration Index (CAIDI)

$$CAIDI = \frac{Total\ Customer\ Hours\ Interruptions}{Total\ Customer\ Interruptions}$$

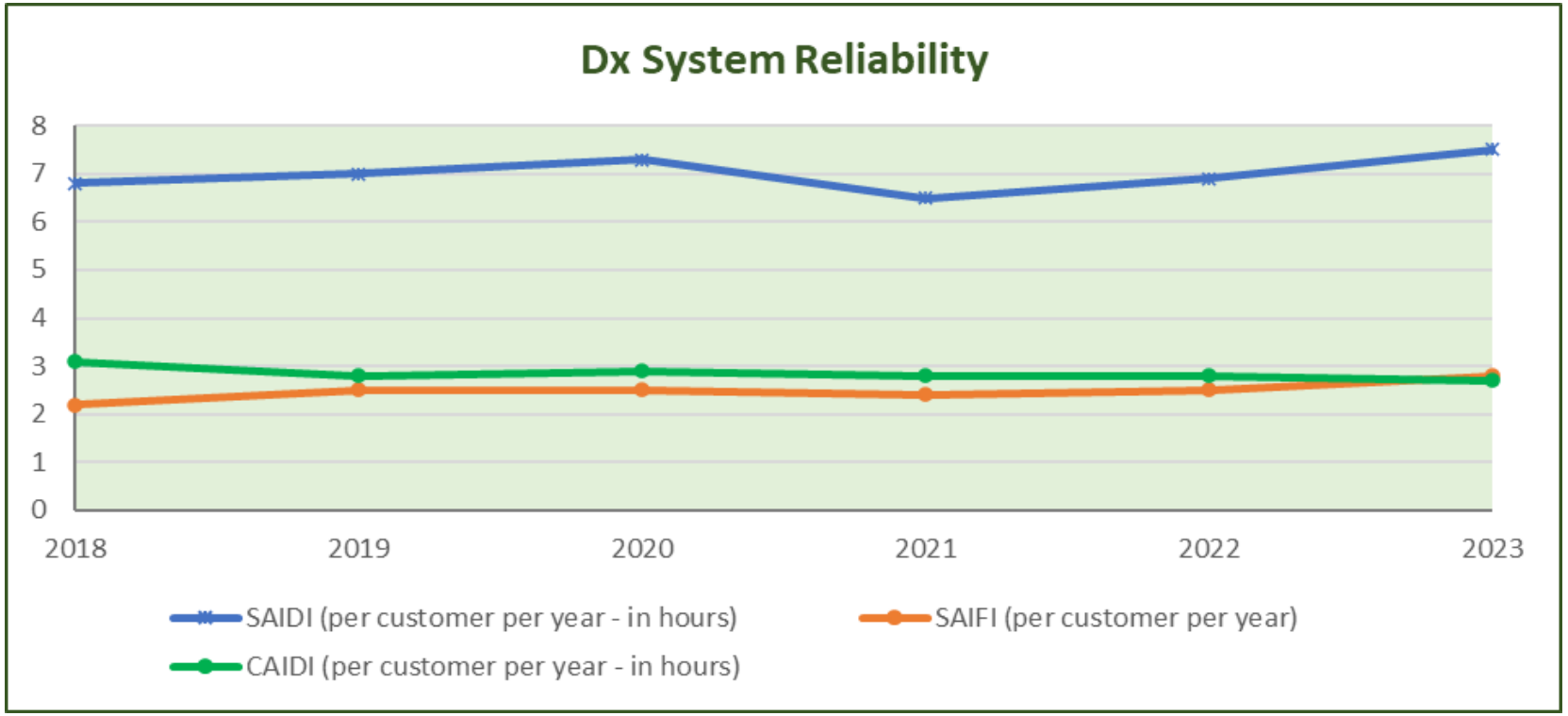
$$= \frac{SAIDI}{SAIFI}$$

# Hydro One's Historical Dx Reliability

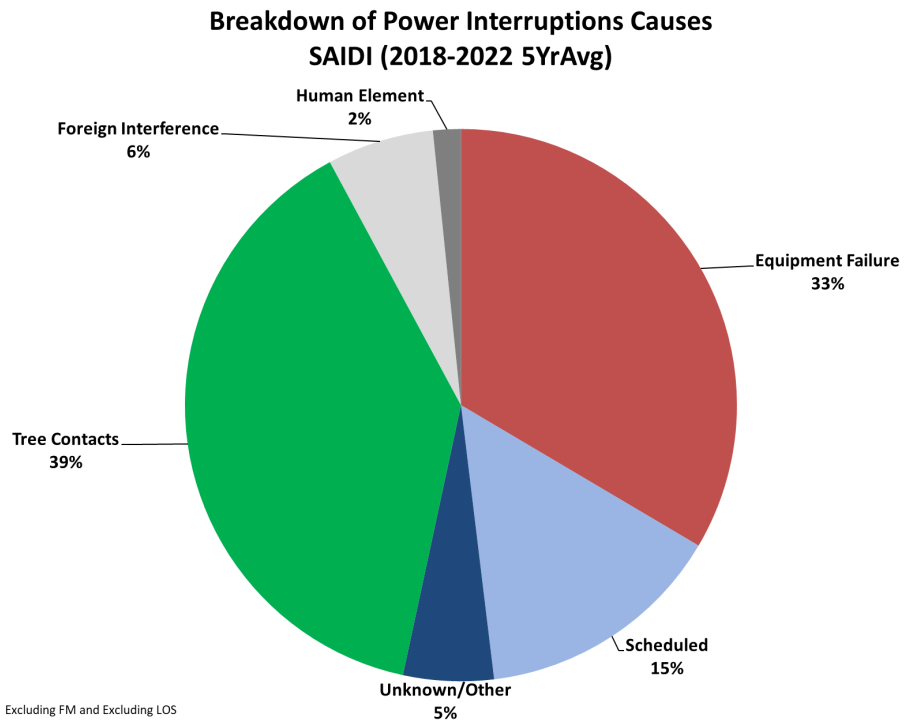
# Hydro One's Historical Distribution Reliability

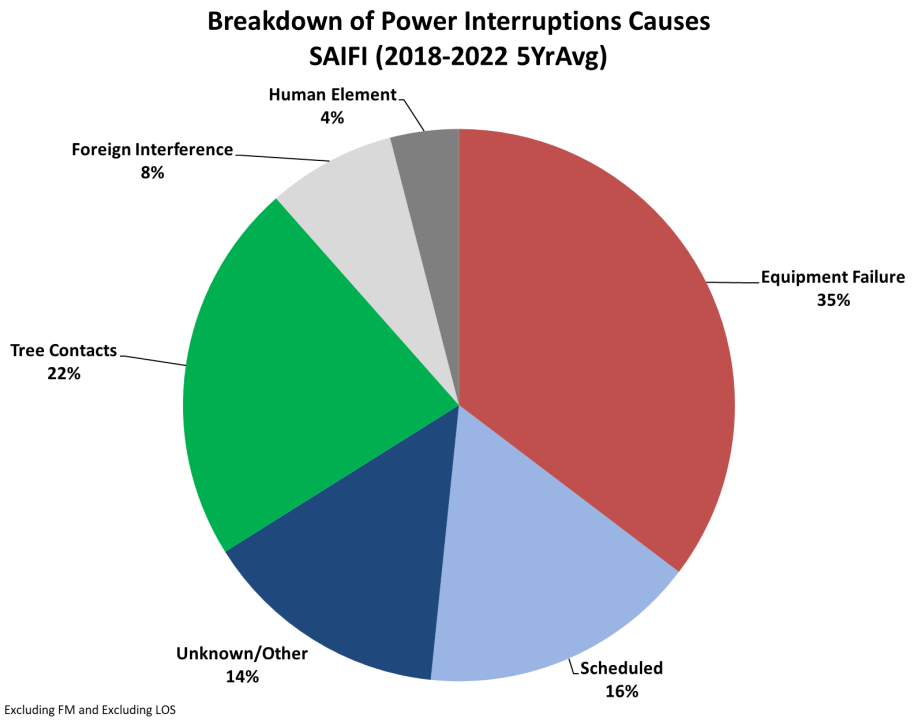
| System Reliability | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|
| SAIDI (Excluding LOS and Excluding FM) | 6.8 | 7.0 | 7.3 | 6.5 | 6.9 | 7.5 |
| SAIFI (Excluding LOS and Excluding FM) | 2.2 | 2.5 | 2.5 | 2.4 | 2.5 | 2.8 |
| CAIDI (Excluding LOS and Excluding FM) | 3.1 | 2.8 | 2.9 | 2.8 | 2.8 | 2.7 |

Notes: All metrics exclude LOS (Loss of Supply) and FM (Force Majeure)



# Hydro One Distribution Reliability by Causes




- Major Interruptions Causes are **Tree Contacts** and **Equipment Failure**.

# Embedded LDC Supplying Reliability

# Embedded LDC Reliability

- Hydro One is **uniquely positioned**: serves every LDC in the province through Transmission (Tx) delivery points or Distribution (Dx) supply points.
  - Many LDCs are embedded in Hydro One's Dx service territory. Examples:

| Customer Name |
|---|
| Alectra Utilities - Enersource Hydro Mississauga Inc. |
| Alectra Utilities - Horizon Utilities Corporation |
| Alectra Utilities - Hydro One Brampton Networks Inc. |
| Alectra Utilities - PowerStream Inc. |
| Atomic Energy of Canada |
| Bluewater Power Distribution Corporation |
| Burlington Hydro Inc. |
| Canadian Niagara Power Inc. [Port Colborne ] |
| Centre Wellington Hydro Ltd. |
| Chapleau Public Utilities Corporation |
| COLLUS PowerStream Corp. |
| Cooperative Hydro Embrun Inc. |
| E.L.K. Energy Inc. |
| Eastern Ontario Power Inc. |
| Energy+ Inc. [Brant County] |
| Energy+ Inc. [Cambridge North Dumfries] |
| Entegrus Powerlines Inc. (Chatham-Kent) |
| Entegrus Powerlines Inc. (Middlesex) |
| Erie Thames Power Lines Corporation (ERTH) |
| Espanola Regional Hydro Distribution Corp. |
| Essex Powerlines Corporation |
| Festival Hydro Inc. |

# Embedded LDC – different supplying ways

**Different types of connection in terms of supplying LDC**

*Through*

- Transformer Station (TS) direct supply using M feeder breaker
  - Express, Direct, Dedicated
- M-class feeders (downstream reclosers or switches)
  - Hybrid Feeder: feeds both LDC and H1 customers
- Distribution Station (DS) direct supply using F feeder breaker
  - Express, Direct, Dedicated
- F feeders (downstream reclosers or switches)
  - Hybrid Feeder: feeds both LDC and H1 customers

Ties, Switching and Back-feeding poses huge amount of challenges to reliability analysis.

# Feeder Level Reliability

# Feeder Level Reliability

Hydro One is a uniquely positioned utility in Ontario:

- Feeder-level interaction with both LDC's and Hydro One end customers
- Hydro One's Dx Asset Management Department manages distribution-level assets and investment planning.
- Several programs to track/monitor reliability at feeder level as well, such as Dx Modernization Program within Dx Investment Plan.
  - Example: **Worst Performing Feeder (WPF) Program**
    - Track individual feeders' performance relative to overall performance
    - Worst performing feeders addressed as part of Dx Investment Plan

# Improving Distribution Reliability

# Primary Contributors Affecting Dx Reliability

- Weather
- Vegetation Exposure
- Investment Planning and Dx Planning
  - Sustainment Work and New Build
  - New Technology/Modernization
- Geographic size of Network
- Restoration Practices
  - Examples: Isolation, Sectionalizing, Back-Feeding, etc.

# Initiatives to Improve Dx Reliability

- Dx Asset Mgmt./Investment Planning
  - Dx Modernization (ie. SCADA Switches, FLISR, CFCI)
  - Battery Energy Storage Solutions (BESS)
  - System Reconfiguration and Tie Lines
  - Worst Performing Feeders Program
  - AMIO (revenue metering) Integration
- Forestry
  - Optimizing tree trimming cycles
- System Operation/Control
  - Planning outage optimization
  - Advanced Distribution Management System

# DER Impact to Dx Reliability

# DER Impact to Dx Reliability

- Several types of DER connected to Hydro One's Dx System. Examples:
  - Wind
  - Solar
  - BESS
    - Grid-scale
    - Behind-the-meter
- DER impact on Distribution Reliability
  - Mainly limited to the distribution system level.
  - For remote areas, use of BESS as non-wires solution to improve reliability
  - Outages due to DER have occasionally been observed.
    - Transfer trip where DER issue causes the M-class feeder breaker to trip

# DER Impact to Dx Reliability

- Hydro One has invested in various types of ‘Non-Wires Alternatives’ like Battery Energy Storage Systems (BESS)
  - Battery storage system for replacing a feeder.
  - Battery storage system for replacing a section of circuit.
  - Batteries at the customer side (behind meter)
- BESS deployment and reliability benefit tracking
  - BESS have been deployed at select customer locations with poor CEMI/CELID (Customer Experiencing Multiple Interruptions and Long Interruption Duration).
  - Percent of total grid interruption duration mitigated by BESS: ~75%

DER’s impact to system reliability is managed via our Technical Interconnection Requirements (TIR), Connection Impact Assessments (CIA), and Business Process Documents (BPD). This combines engineering and operation practices to ensure our grid is reliable with the addition of DER.

# DER Integration: Engineering Challenges & Solutions

The issues identified below have been studied and preventative measures have been included in the TIR. DER Engineering challenges & solutions encountered by Hydro One are below:

- Reverse power flow impacts on station transformers:

  ***Solution***: TS transformers were replaced as part of a work management program, but flows needed to be managed closely in real time by Operators. DS transformers are not to be loaded above 60% of nameplate rating.

- Phase Balancing of single phase DER

  ***Solution***: Conduct study to connect DER to highest loaded phase. Possibly re-balance lateral distribution taps.

- Capacity (thermal, voltage, transformer and short circuit)

  ***Solution:*** The capacity requirements are outlined in the TIR and enforced via the CIA process. Hydro One has a Distributed Energy Resource Management System (DERMS).

- Power Quality issues due to insufficient Var support:

  ***Solution:*** Some wind farms were required to add additional capacitance at their station. The wind farms also need to govern their output to handle inertia on start up.

# DER Integration: Operational Challenges & Solutions

The issues identified below have been studied in depth and preventative measures have been included in the TIR. DER Operational Challenges & Solutions encountered by Hydro One are below:

- DER islanding:

  ***Solution***: All DER must have their own under-voltage protections. Transfer Trip is the primary solution for utilities to ensure disconnection, for DER > 1MW.

- Reconnection of Feeder with DER during momentary interruption:

  ***Solution***: Distributed Generator End Open signal from DER to utility breaker ensures that the DER is disconnected and allows auto-reclose of the feeder breaker to supply all other customers. DER's can reconnect to the system 15 minutes after the feeder has been restored.

- DER on alternate supply with no Transfer Trip during planned outages:

  ***Solution: "***50% rule" is implemented, which states that a DER can remain connected to an alternate feeder with no transfer trip, if the output of the DER is <50% of the feeders minimum loading.

# Thank you

For more information, please contact us at John.Penaranda@HydroOne.com; James.McGowan@HydroOne.com