WE OWN AND OPERATE $3.0 BILLION OF CAPITAL ASSETS

HEAD OFFICE
14 CARLTON STREET
TORONTO, ONTARIO
M5B 1K5

674,201 RESIDENTIAL CUSTOMERS

757,000 CUSTOMERS

44 LARGE USERS WITH MONTHLY DEMAND OVER 5000 KILOWATTS

81,492 GENERAL SERVICE CUSTOMERS WITH MONTHLY DEMAND OF 0-5000 KILOWATTS

1,480 EMPLOYEES
Toronto Hydro's Service Area

- 15,560 Kilometres of Overhead Wires
- 16,900 Primary Switches
- 60,440 Distribution Transformers
- 176,500 Poles
- 161 Municipal Substations
- 12,920 Kilometres of Underground Wires
In Ontario, 70% of electricity is generated by Ontario Power Generation. This provincially-owned organization has generating stations across the province that produce electricity from hydroelectric, nuclear and fossil fuel sources.
Transmission

Once electricity is generated, it must be delivered to urban and rural areas in need of power. This happens through high voltage transmission lines that serve as highways for electricity. There are approximately 30,000 km of transmission lines in Ontario and the majority are owned by Hydro One.
Distribution
Toronto Hydro is responsible for the last step of the journey: distributing electricity to customers in Toronto.
Climate Change Adaptation

Mitigation

Adaptation

Emergency Management

Source: thestar.com

Source: news.nationalpost.com
Climate Change Adaptation

- **Vulnerability Assessment Phase 1**
- **Vulnerability Assessment Phase 2**
- **Roadmap Development**
- **Roadmap Implementation**

System Resilience Enhancements

Timeline:
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
Climate Change Adaptation

July 2013 – Extreme rainfall (126mm in 2 hrs)

325,000 customers impacted
Flooding of station control equipment

news.nationalpost.com
Climate Change Adaptation

December 2013 – Ice storm
300,000 customers impacted
Tree limbs falling on power lines
Climate Change Vulnerability Assessment

- Engineers Canada’s Public Infrastructure Engineering Vulnerability Committee (PIEVC) Engineering Protocol

- Consortium: AECOM, City of Toronto, Clean Air Partnership, Engineers Canada, Risk Sciences International…

- NRCan funding

- Available at: www.pievc.ca

**Phase 1**
- Pilot case study
- Current climate only
- Small portion of distribution system
- Completed Sept 2012

**Phase 2**
- 2010-2050, 20 climate parameters
- Entire distribution system
- Completed June 2015
## PIEVC Phase 2

### Table ES-1: Climate Parameters and Probability of Occurrence

<table>
<thead>
<tr>
<th>Climate Parameter</th>
<th>Annual Probability (Historical, Projected 2030’s and 2050’s)</th>
<th>Probability of Occurrence Study Period (2015-2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Maximum</td>
<td>25°C: 66 per year, 84 per year, 106 per year</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>30°C: 16 per year, 26 per year, 47 per year</td>
<td>100%</td>
</tr>
<tr>
<td>High Daily Avg. Temperature</td>
<td>30°C: 0.07 per year, N/A, 1.2 days per year</td>
<td>~100%</td>
</tr>
<tr>
<td>Heat Wave</td>
<td>3 days max temp over 30°C</td>
<td>0.88 per year; &gt;1 for both</td>
</tr>
<tr>
<td>High Nighttime</td>
<td>Nighttime low &gt;23°C: 0.70 per year; 7 per year, 16 per year</td>
<td>~100%</td>
</tr>
<tr>
<td>100 mm in &lt;1 day + antecedent</td>
<td>0.04 per year; extreme precipitation expected ↑, percentage unknown</td>
<td></td>
</tr>
<tr>
<td>15 mm (tree branches)</td>
<td>0.11 per year; &gt;0.13 per year, &gt;0.16 per year</td>
<td></td>
</tr>
<tr>
<td>25 mm ≈ 12.5 mm radial</td>
<td>0.06 days per year; &gt;0.07 per year, &gt;0.09 per year</td>
<td></td>
</tr>
<tr>
<td>70 km/h+ (tree branches)</td>
<td>21 days per year; N/A, 24 to 26 per year</td>
<td></td>
</tr>
<tr>
<td>90 km/h</td>
<td>2 days per year; N/A, &gt;2.5 per year</td>
<td></td>
</tr>
<tr>
<td>120 km/h</td>
<td>~0.05 days per year; likely ↑, but % unknown</td>
<td></td>
</tr>
<tr>
<td>Lightning</td>
<td>Flash density per km km²</td>
<td>1.12 to 2.24 per year per km²; Expected increase, % change unknown</td>
</tr>
<tr>
<td>Snowfall</td>
<td>Days w/ &gt;10 cm: 1.5 days per year; Trend decreasing but highly variable</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>Days w/ &gt;5 cm: 5 days per year; Trend decreasing but highly variable</td>
<td>100%</td>
</tr>
<tr>
<td>Frost</td>
<td>229 frost free days, 249 frost free days, 273 frost free days</td>
<td>100%</td>
</tr>
</tbody>
</table>
PIEVC Phase 2

PIEVC Phase 2 Climate Change Risk Map by 2050
4. High Temperature Maximum Above 40 C
City of Toronto
Vulnerability Assessment Adaptation Opportunities

- Infrastructure strengthening
- Capacity planning
- Inspection and maintenance programs
- Data collection and quality
Ongoing System Resilience Enhancements
Capital & Maintenance Programs

Rear Lot Conversion

Overhead Infrastructure Relocation

Tree Trimming Standards

City of Toronto Strategic Forest Management Plan 2012-2020
Ongoing System Resilience Enhancements
New Technologies

Breakaway Connectors

Stainless Steel Submersible Transformers

Solid Dielectric Submersible Transformers
Roadmap Development

- Multi-disciplinary team
- Looking at data, analysis tools, investment programs, standards,…
- Develop initiatives to help make system more resilient
Roadmap Development

Adapting to Climate Change
State of Play and Recommendations for the Electricity Sector in Canada

4 Sector Perspectives and Practices on Adaptation

B. Bridging the Gap: Tools to Integrate Adaptation into Investment Planning

1. CEA’s Climate Change Adaptation Management Planning Guide
2. Engineers Canada’s Public Infrastructure Engineering Vulnerability Committee’s Protocol
**Roadmap Development**

- Climate data validation
- Asset lifecycle
- Equipment specifications
- Capital and maintenance programs
- Planning data, tools, guidelines
- Design practices
- Construction standards

<table>
<thead>
<tr>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>Q1</td>
</tr>
<tr>
<td>MAJOR EQUIPMENT TECHNICAL SPECIFICATIONS REVIEW</td>
<td>UPDATE SYSTEM PLANNING GUIDELINES TO INCLUDE CLIMATE CHANGE</td>
</tr>
<tr>
<td>ASSET IMPACT STUDY</td>
<td>INDUSTRY REVIEW</td>
</tr>
<tr>
<td>LOAD FORECAST IMPACT/SENSITIVITY</td>
<td>CAPITAL PROGRAM REVIEW</td>
</tr>
<tr>
<td>REVIEW ASSET RENEWAL</td>
<td>MAINTENANCE PROGRAM REVIEW</td>
</tr>
<tr>
<td>VALIDATE CLIMATE DATA</td>
<td>ANALYTICAL TOOLS REVIEW</td>
</tr>
<tr>
<td>RISK MAPS</td>
<td>LIGHTNING MAPPING</td>
</tr>
<tr>
<td>OVERHEAD LINES EXITING STATIONS</td>
<td></td>
</tr>
<tr>
<td>MONITORING RELIABILITY</td>
<td></td>
</tr>
</tbody>
</table>
Validate Climate Data

CEA’S CLIMATE CHANGE ADAPTATION MANAGEMENT PLANNING GUIDE

2.2 Determine Future Projections:

To adapt to climate change impacts the expected changes must first be understood. Much of the existing infrastructure that is climate sensitive was designed using statistics on past climate and risk that may not be representative of future climate risks. Climate conditions are projected to change on an ongoing basis for the foreseeable future. To plan for future conditions they must be understood.
CEA'S CLIMATE CHANGE ADAPTATION MANAGEMENT PLANNING GUIDE

2.2 Determine Future Projections:

To adapt to climate change impacts the expected changes must first be understood. Much of the existing infrastructure that is climate sensitive was designed using statistics on past climate and risk that may not be representative of future climate risks. Climate conditions are projected to change on an ongoing basis for the foreseeable future. To plan for future conditions they must be understood.
Load Forecast Impact/Sensitivity

- Station Load Forecast report is prepared annually
- Used for the purpose of evaluating station bus capacity adequacy
Load Forecast Impact/Sensitivity

- Station Load Forecast report is prepared annually
- Used for the purpose of evaluating station bus capacity adequacy
Major Equipment Specifications

- Technical Specifications for Major Equipment
- Codes, Standards and Regulations typically use historical values.
- Review specifications, investigate impacts of climate projections and revise as necessary.

4.1.3 As the transformer enclosure may be subjected to flooding or to high water tables, the transformer including its terminations shall be capable of continuous unattended operation while continuously submerged under a head of 3 m (10 ft) of water. Manual operation of certain accessories may require that the water level be lowered below the top of the transformer prior to operation.
Risk Maps

• Risks maps were completed at a high level
• Narrow down to asset level to be more useful to planning teams
Risk Maps

Transformers at End of Life for 2016 - 2020

Expected EOL
- 2016 (437)
- 2017 (283)
- 2018 (301)
- 2019 (306)
- 2020 (355)
Risk Maps

Transformers at End of Life for 2016 - 2020

Expected End of Life for Transformer

- **EOL from Aging**
- **EOL from Heat**
Lightning Mapping

- Lightning strike data over the last 20 years has been mapped across the city
- Correlation with system outage information will continue in 2017
Independent Studies

Industry Review

- Review practices of major utilities in Canada and USA
- Paper review on industry best practices

Asset Impact Study

- Transformers vs temperature
- Poles vs climatic loads
- Overhead conductors vs climatic loads
- Underground cables vs extreme rainfall
- Overhead conductors vs temperature
Roadmap Development

- Climate data validation
- Asset lifecycle
- Equipment specifications
- Capital and maintenance programs
- Planning data, tools, guidelines
- Design practices
- Construction standards

<table>
<thead>
<tr>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>Q2</td>
</tr>
<tr>
<td>MAJOR EQUIPMENT TECHNICAL SPECIFICATIONS REVIEW</td>
<td></td>
</tr>
<tr>
<td>ASSET IMPACT STUDY</td>
<td>INDUSTRY REVIEW</td>
</tr>
<tr>
<td>VALIDATE CLIMATE DATA</td>
<td>REVIEW ASSET RENEWAL</td>
</tr>
<tr>
<td>RISK MAPS</td>
<td>LIGHTNING MAPPING</td>
</tr>
<tr>
<td>LOAD FORECAST IMPACT/SENSITIVITY</td>
<td>CAPITAL PROGRAM REVIEW</td>
</tr>
<tr>
<td>ANALYTICAL TOOLS REVIEW</td>
<td>MAINTENANCE PROGRAM REVIEW</td>
</tr>
<tr>
<td>MAJOR EQUIPMENT TECHNICAL SPECIFICATIONS REVIEW</td>
<td>ASSET IMPACT STUDY</td>
</tr>
<tr>
<td>VALIDATE CLIMATE DATA</td>
<td>REVIEW ASSET RENEWAL</td>
</tr>
<tr>
<td>RISK MAPS</td>
<td>LIGHTNING MAPPING</td>
</tr>
<tr>
<td>LOAD FORECAST IMPACT/SENSITIVITY</td>
<td>CAPITAL PROGRAM REVIEW</td>
</tr>
<tr>
<td>ANALYTICAL TOOLS REVIEW</td>
<td>MAINTENANCE PROGRAM REVIEW</td>
</tr>
<tr>
<td>MAJOR EQUIPMENT TECHNICAL SPECIFICATIONS REVIEW</td>
<td>ASSET IMPACT STUDY</td>
</tr>
<tr>
<td>VALIDATE CLIMATE DATA</td>
<td>REVIEW ASSET RENEWAL</td>
</tr>
<tr>
<td>RISK MAPS</td>
<td>LIGHTNING MAPPING</td>
</tr>
<tr>
<td>LOAD FORECAST IMPACT/SENSITIVITY</td>
<td>CAPITAL PROGRAM REVIEW</td>
</tr>
<tr>
<td>ANALYTICAL TOOLS REVIEW</td>
<td>MAINTENANCE PROGRAM REVIEW</td>
</tr>
<tr>
<td>MAJOR EQUIPMENT TECHNICAL SPECIFICATIONS REVIEW</td>
<td>ASSET IMPACT STUDY</td>
</tr>
<tr>
<td>VALIDATE CLIMATE DATA</td>
<td>REVIEW ASSET RENEWAL</td>
</tr>
<tr>
<td>RISK MAPS</td>
<td>LIGHTNING MAPPING</td>
</tr>
<tr>
<td>LOAD FORECAST IMPACT/SENSITIVITY</td>
<td>CAPITAL PROGRAM REVIEW</td>
</tr>
<tr>
<td>ANALYTICAL TOOLS REVIEW</td>
<td>MAINTENANCE PROGRAM REVIEW</td>
</tr>
</tbody>
</table>
Disclaimer

The information in these materials is based on information currently available to Toronto Hydro Corporation and its affiliates (together hereinafter referred to as “Toronto Hydro”), and is provided for information purposes only. Toronto Hydro does not warrant the accuracy, reliability, completeness or timeliness of the information and undertakes no obligation to revise or update these materials. Toronto Hydro (including its directors, officers, employees, agents and subcontractors) hereby waives any and all liability for damages of whatever kind and nature which may occur or be suffered as a result of the use of these materials or reliance on the information therein. These materials may also contain forward-looking information within the meaning of applicable securities laws in Canada (“Forward-Looking Information”). The purpose of the Forward-Looking Information is to provide Toronto Hydro’s expectations about future results of operations, performance, business prospects and opportunities and may not be appropriate for other purposes. All Forward-Looking Information is given pursuant to the "safe harbour" provisions of applicable Canadian securities legislation. The words "anticipates", "believes", "budgets", "could", "estimates", "expects", "forecasts", "intends", "may", "might", "plans", "projects", "schedule", "should", "will", "would" and similar expressions are often intended to identify Forward-Looking Information, although not all Forward-Looking Information contains these identifying words. The Forward-Looking Information reflects the current beliefs of, and is based on information currently available to, Toronto Hydro’s management. The Forward-Looking Information in these materials includes, but is not limited to, statements regarding Toronto Hydro’s future results of operations, performance, business prospects and opportunities. The statements that make up the Forward-Looking Information are based on assumptions that include, but are not limited to, the future course of the economy and financial markets, the receipt of applicable regulatory approvals and requested rate orders, the receipt of favourable judgments, the level of interest rates, Toronto Hydro’s ability to borrow, and the fair market value of Toronto Hydro’s investments. The Forward-Looking Information is subject to risks, uncertainties and other factors that could cause actual results to differ materially from historical results or results anticipated by the Forward-Looking Information. The factors which could cause results or events to differ from current expectations include, but are not limited to, the timing and amount of future cash flows generated by Toronto Hydro’s investments, market liquidity and the quality of the underlying assets and financial instruments, the timing and extent of changes in prevailing interest rates, inflation levels, legislative, judicial and regulatory developments that could affect revenues, and the results of borrowing efforts. Toronto Hydro cautions that this list of factors is not exclusive. All Forward-Looking Information in these materials is qualified in its entirety by the above cautionary statements and, except as required by law, Toronto Hydro undertakes no obligation to revise or update any Forward-Looking Information as a result of new information, future events or otherwise after the date hereof.
Questions

Rob McKeown, P.Eng.
Standards and Policy Planning
Toronto Hydro-Electric System Limited
rmckeown@torontohydro.com