ONTARIO CLIMATE CONSORTIUM

Assessing Climate Change Vulnerability in Ontario's Electrical Transmission Sector

2017-2018 Ontario Regional Adaptation Collaboratives Webinar Series

December 5, 2017

NODELCORP

RSI RISK SCIENCES INTERNATIONAL

ieso Independent Electricity System Operator

Toronto and Region Conservation for The Living City

Ontario Climate Consortium

The OCC was established in 2011 as a centre of expertise providing research and analysis services to municipalities, conservation authorities, and the broader public sector.

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Project Context

Chart 1
Electricity Infrastructure Investment from 2010 to 2030
(2010 $ billions)

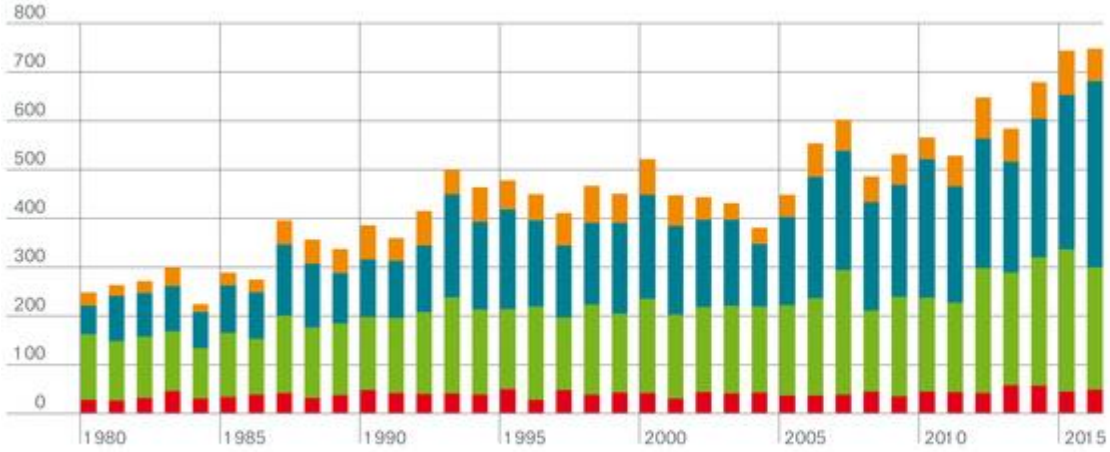
Source: The Conference Board of Canada.

Major Transmission Projects Under Development Across Ontario

Source: Ontario Long-term Energy Plan (2017)

Project Context, cont'd

Worldwide Natural Catastrophes – 1980-2015



Source: Munich Re (2016).

The Expert Panel on Climate Change Adaptation

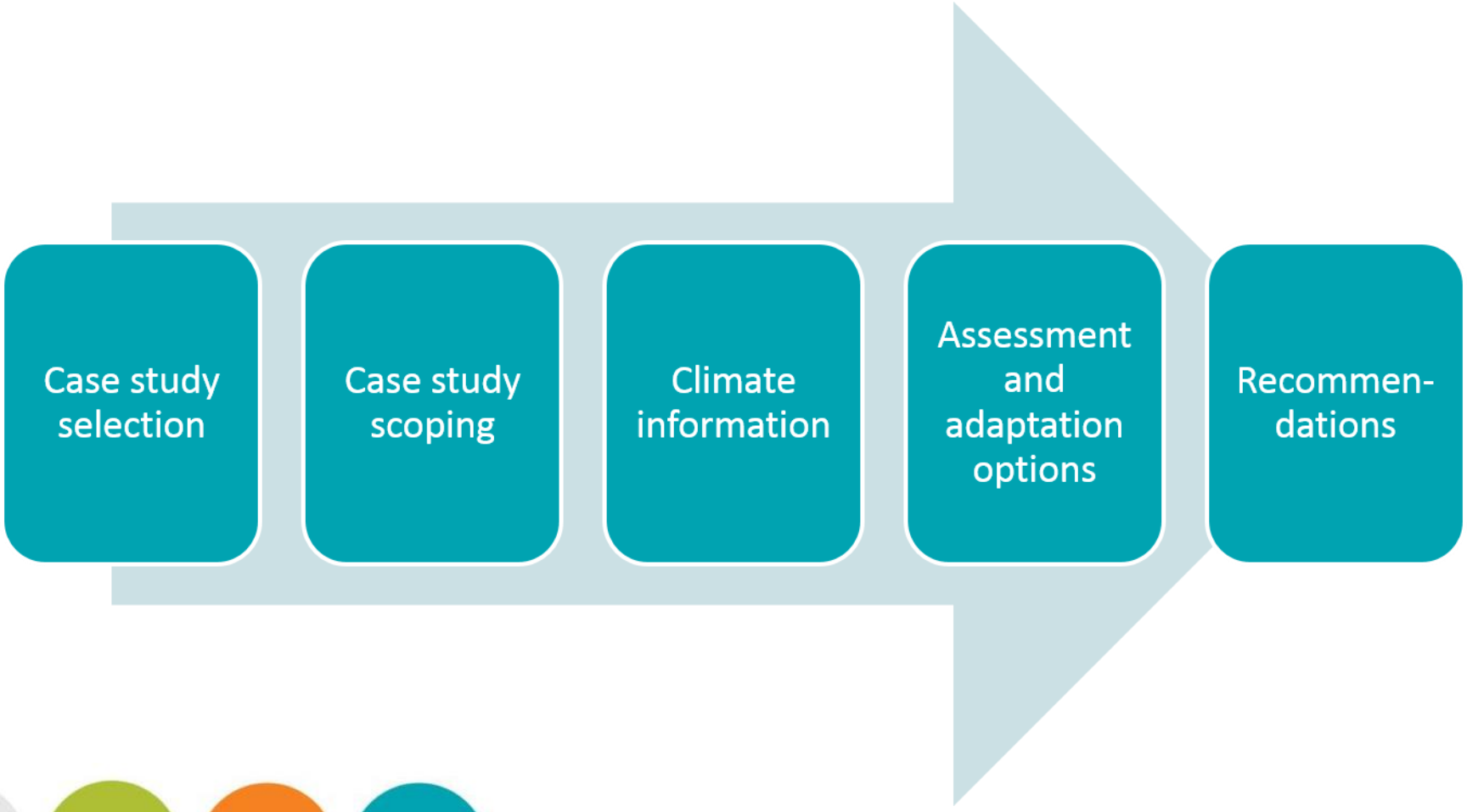
Report to The Minister of The Environment

November 2009

Recommendation 9

The Ministry of Energy and Infrastructure should request the Independent Electricity System Operator, in accordance with its responsibility for maintaining the reliability of the electricity grid in the province, to complete a climate change risk assessment of the Province's electricity grid and to propose adaptive actions. This should be carried out in partnership with other energy agencies in Ontario such as the Ontario Power Authority, Hydro One and local distribution companies, and should be completed by the end of 2012.

Project Overview



Case Study Selection & Scoping

Major transmission station in GTA + Connected Circuits
Infrastructure components included in study

Above ground station components

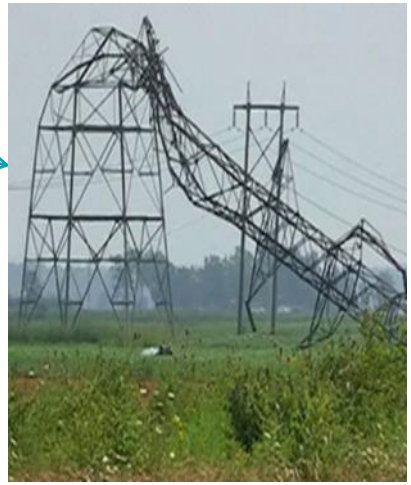
Above ground circuits

Below ground station components

Case study scoping

Climate parameters considered in study

Tornadoes and other high wind events



Extreme rainfall

Ice storms

Extreme heat

Summary of Climate Parameters

Climate Element	Threshold	Probability – Historical	Probability – Future
Ice Storms	24 mm	20%	>30%
	29 mm	<7%	~10%
			~1%
Tornadoes			~0.3%
Other high intensity wind (HIW)	120 km/h +	est. ~40%	est. ~40%
"Large Scale" wind storms	110 km/hr	20%	>30%
	120 km/hr	<7%	10%
Extreme Temperatures	35°C	100%	100%
	40°C	25%	100%

% chance over 35 years

New Research?

NB: *These are figures developed for this particular study. Extreme caution is indicated for use or application in other cases.*

Assessment Results

General Observations

Built-in redundancy through design and O&M procedures, acute events not likely to significantly affect delivery of services from case study location

- 4 high risks identified; 87 "*special cases*"
- Climate projections of small-scale extremes a challenge

Climate Parameter	Results
Ice accretion	• System-wide vulnerability, particularly on 230 kV segments
High intensity wind (HIW)	• Convective winds >120 km/h • Debris impacts • Localized extreme wind events (e.g., microbursts)
Extreme heat	• Potential high risk associated with line sag over transportation corridors

Assessment Results

Weather variables deserving more attention

- High winds (HIW, incl. tornadoes)
  - Direct loading *and* debris impact
- Ice storms (e.g., 29 mm radial)
  - Lower than E ON, but still possible

High-Impact/Low-Probability

- ~1 to 10% over 35 years

  but very high severity

"rare" ≠ "impossible"

Assessment Results

Extreme Heat – line sag over transport corridors

- *Not* equipment operation concern
- *40°C* daytime highs projected 2050s

Adaptation Response: Emergency Management vs. Asset Hardening

Consistent with initial discussions & Lit. Review

- Deterministic
- Robust system design

PIEVC Risk Workshop Results

Heterogeneity of electric power system a challenge for determining tolerance thresholds

Continuous, iterative consultation and interdisciplinary teams are *critical*

Adaptation **planning** more than asset "hardening"

- Responses to climate change include planning, operations, monitoring and maintenance

Triple Bottom Line: Objectives and Process

- An add on to the risk assessment framework that allows various alternative adaptation approaches to be reviewed in the context of economic, social and environmental factors

TBL Key Discussion Questions

- What are the features of the power transmission system in the Toronto region that lead to high system wide resiliency to changing climate?
  - Redundancy
  - Over-design
  - Others?
- Do other areas of the provincial transmission system share these features?
- If no, disregarding economics for the moment, would overall system wide performance be improved by incorporating some or all of the Toronto area features?
- What do you think the ballpark cost of adopting these features would be?

Triple Bottom Line Module - Potential Adaptation Options

Alternative	Description
1	Northern community supplied by single circuit 115 kV line; Twinning, Redundant Design
2	Northern community supplied by single circuit 115 kV line; Enhanced Design, Asset Hardening.
3	Northern community supplied by single circuit 115 kV line; Low Voltage Redirection
4	500 kV transmission corridor carrying supply from major nuclear facility; Asset Hardening
5	Northern communities supplied by 115 kV transmission; Twinning, Redundant Design
6	Northern communities supplied by 115 kV transmission; Local Generation

It's a Question of Balance

What would you say is the correct **balance** between social, environmental and economic considerations in assessing the contemplated changes?

Social	Environmental	Economic
(%)	(%)	(%)
33.3	33.3	33.3
20	20	60
10	10	80
Other	Other	Other

Triple Bottom Line Results

Scenario % Economic Emphasis		TBL Score (Maximum = 100 points)					
		Alternative					
		1	2	3	4	5	6
	90%	21	70	76	83	21	46
	80%	27	72	77	82	27	49
	70%	32	73	77	81	32	52
	60%	37	75	78	80	37	56
	50%	42	76	78	79	42	59
	40%	47	78	79	78	47	62
	30%	52	79	79	78	52	66

Triple Bottom Line Results

Alternative 4 the priority when economic factors weighted highest

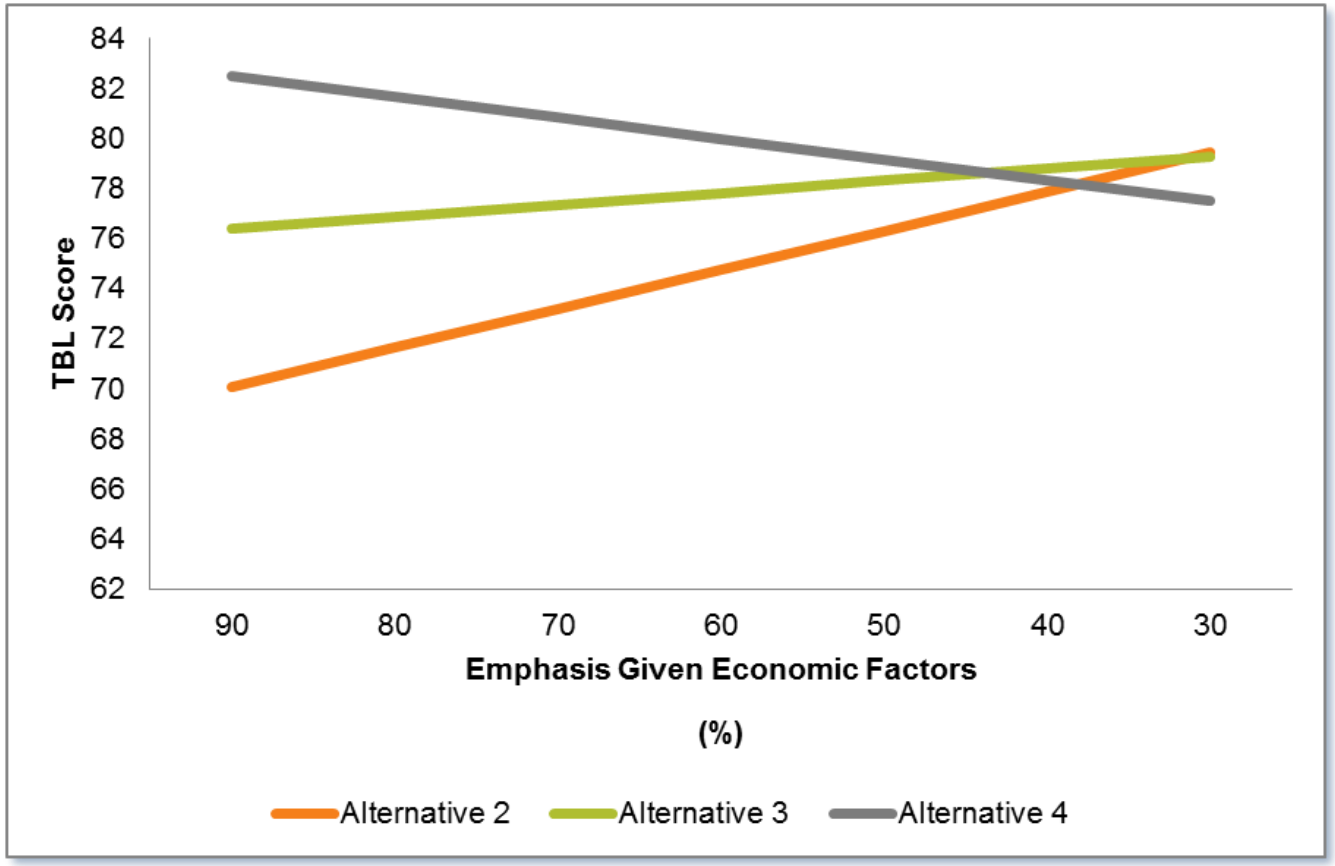


Figure 2 - TBL Sensitivity Analysis. Adjusting Economic Emphasis for most promising alternatives

Recommendations

- Improved monitoring, recording, study of high impact climate parameters
  - Important event types (ice, wind) are ones w/ poor historical records & CC projections
- Forensic assessment of various component types – climate load resilience *unknown*
  - E.g., "*four-wire bundles*" 500 kV lines

Recommendations

- Survey transmission system-transportation system crossings
- Increase availability of long-term historical climate data
- Improve early warning systems
- Conduct a more in-depth triple bottom line assessment

Questions?

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