Review of Summer 2018 Operations

Market Operations Fall 2018 Awareness Session

Kyle Russell
System Operations

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Agenda

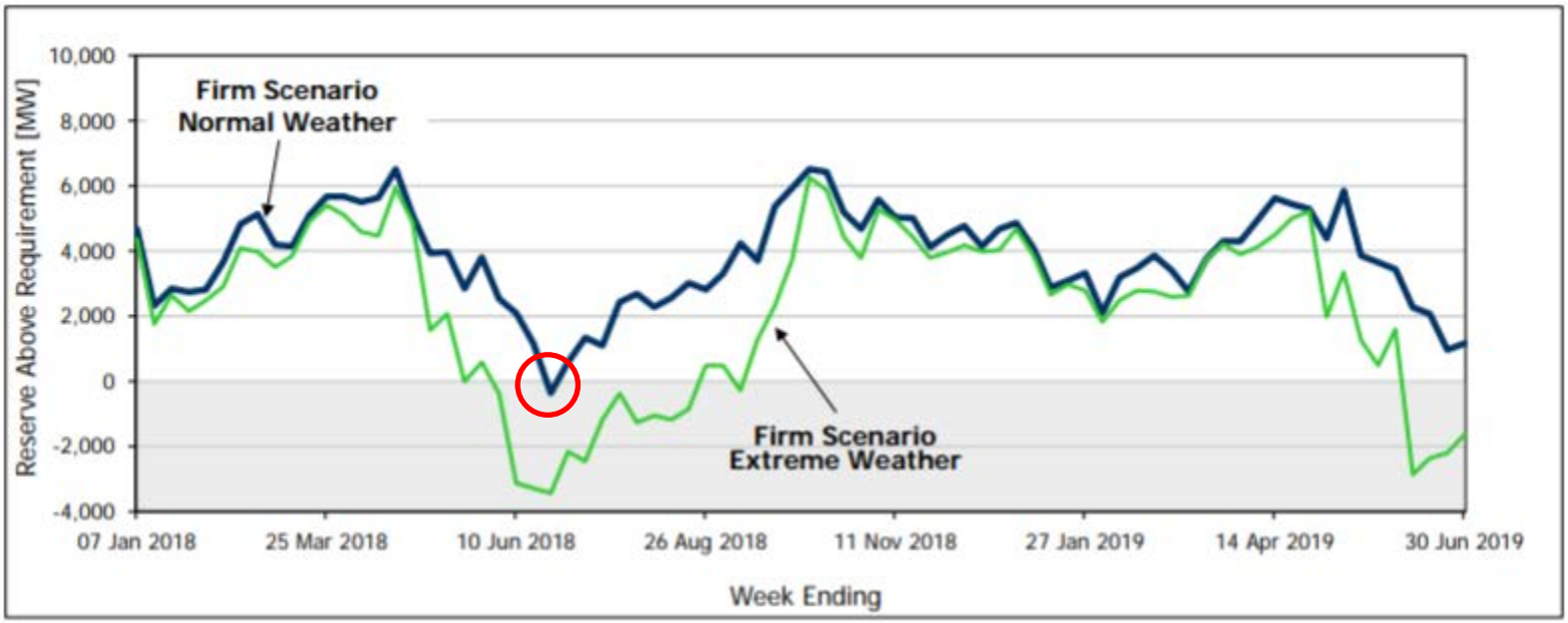
- Review of Summer 2018
  - Planning
  - Operations

- Significant Event Review
  - Loss of Pickering B Nuclear Generating Station
  - Ottawa Area Tornado's

REVIEW OF SUMMER 2018

Planning for Summer 2018

- Week ending June 24 adequacy shortfall identified in 18-month outlook (2017 Q4)

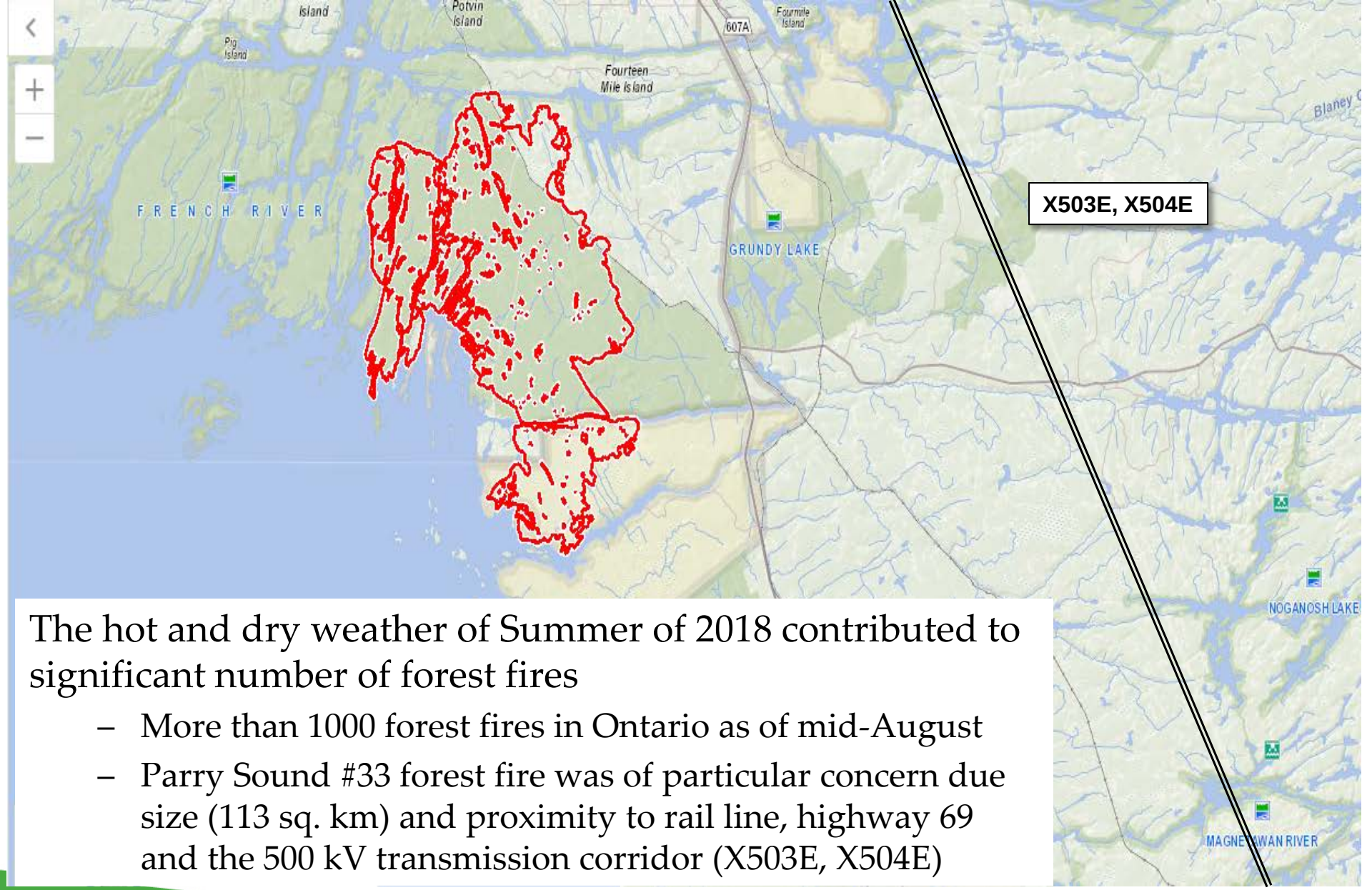


Planning for Summer 2018

- As part of the quarterly outage planning assessment process, the summer 2018 outage plans had to be adjusted to mitigate generation and transmission adequacy concerns as a result of:
  - Multiple nuclear unit outages
  - High demand forecast in 18 month outlook
- Planning goal leading into the summer:
  - Priority was to ensure that adequacy and operability is maintained
  - No major impact on nuclear maintenance and refurbishment plans

Operations During Summer 2018

- Ontario experienced an hot and humid summer in 2018:
  - Daily maximum temperature exceeded 30 degrees Celsius in the GTA for 29 days between May and September, compared to 14 days during the same period last year
  - Outage approvals were based on normal weather forecasts
  - Ontario demand exceeded the 18-Month Outlook's normal weather demand forecast on 9 separate weeks
  - The summer peak Ontario demand of 23,240MW was observed on September 5th, representing the third year in a row that Ontario has set a September peak



The hot and dry weather of Summer of 2018 contributed to significant number of forest fires

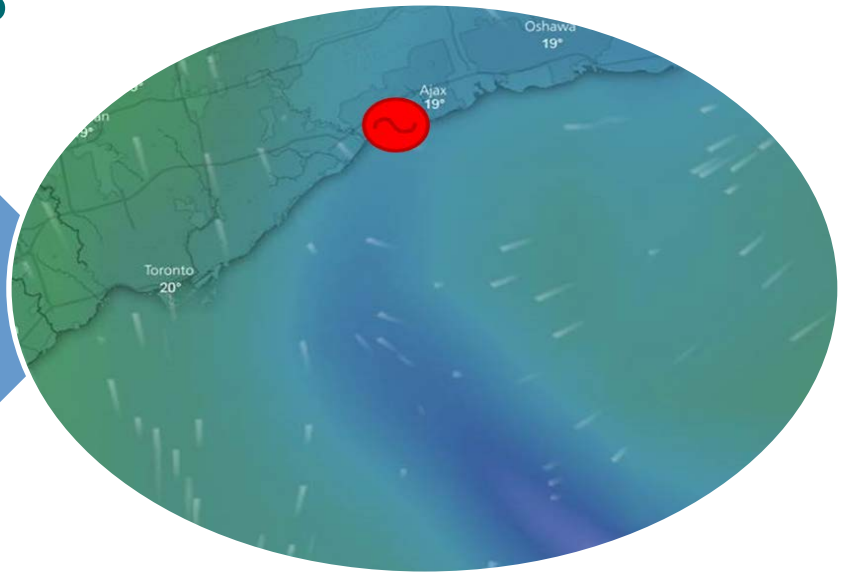
- More than 1000 forest fires in Ontario as of mid-August
- Parry Sound #33 forest fire was of particular concern due size (113 sq. km) and proximity to rail line, highway 69 and the 500 kV transmission corridor (X503E, X504E)

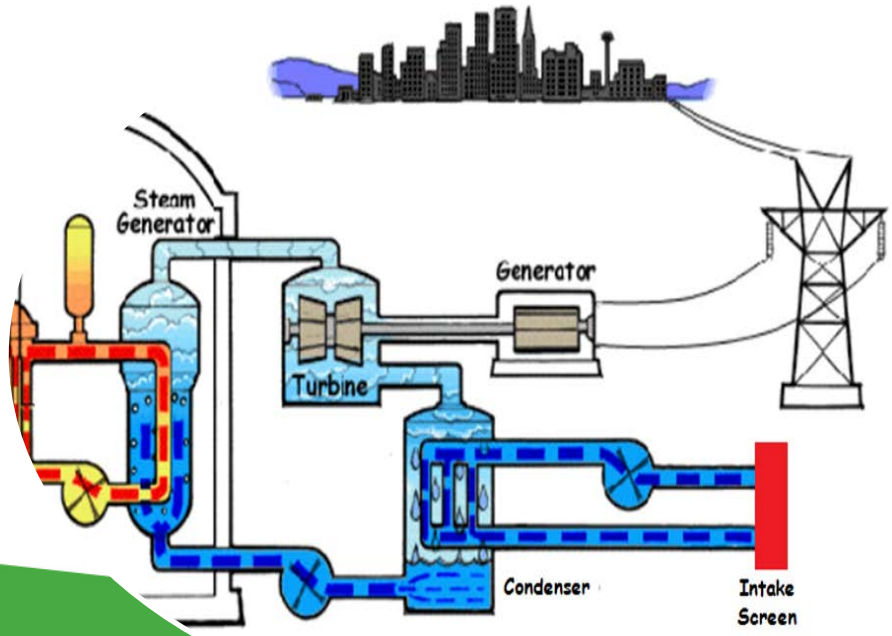
Significant Event Review

LOSS OF PICKERING B GENERATION STATION

Loss of Pickering B Units

Storm and funnelling winds pushed algae and debris towards the Pickering Nuclear Station.





-Sunday July 22nd blocked intake screens reduced flow to the CCW pumps

-CCW pumps tripped to prevent intake screen collapse

-Turbines tripped almost immediately resulting in ~2000MW generation loss

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Event Response

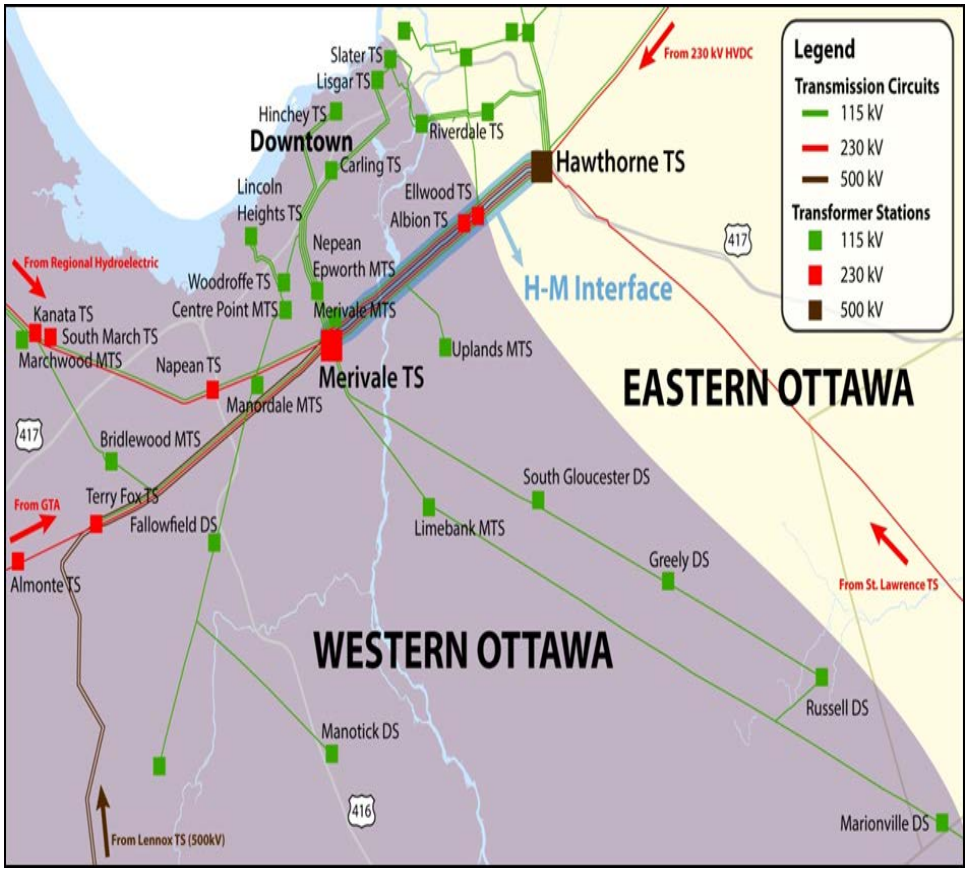
- Restored load/supply balance by activating generation reserves and assistance from our neighbours
- Studied and implemented new system limits
- Communicated event through our Emergency Preparedness processes
- Staff immediately started working with MP's to develop a valid operating plan for the rest of the week:
  - Deferred planned maintenance work
  - Committed additional generation to ensure grid resilience

Significant Event Review

OTTAWA AREA TORNADOES

Ottawa Area Overview

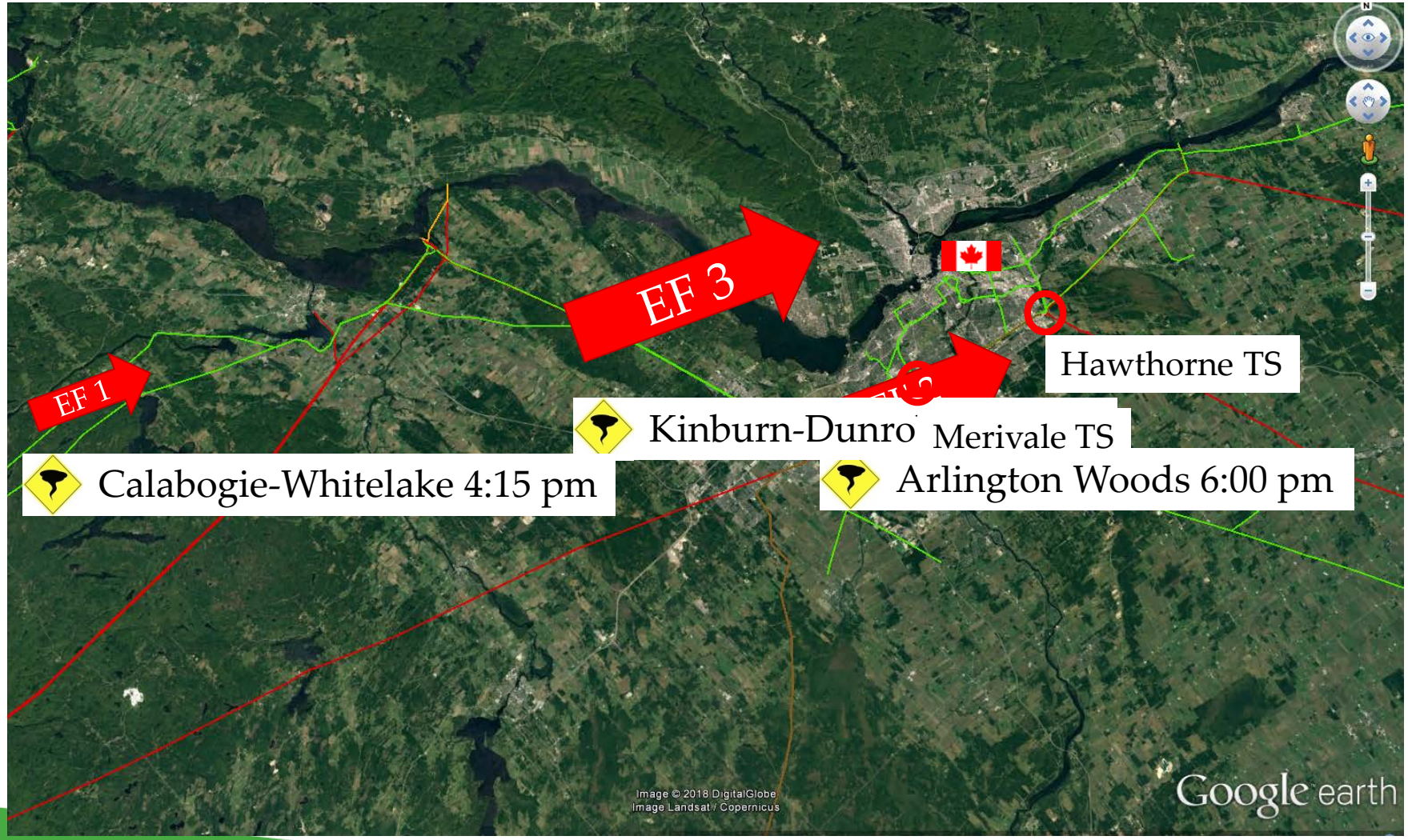
- Merivale TS and Hawthorne TS are the two main transformer stations in the Ottawa area.
- Merivale TS supplies western Ottawa and Hawthorne TS supplies eastern Ottawa (including Parliament Hill).



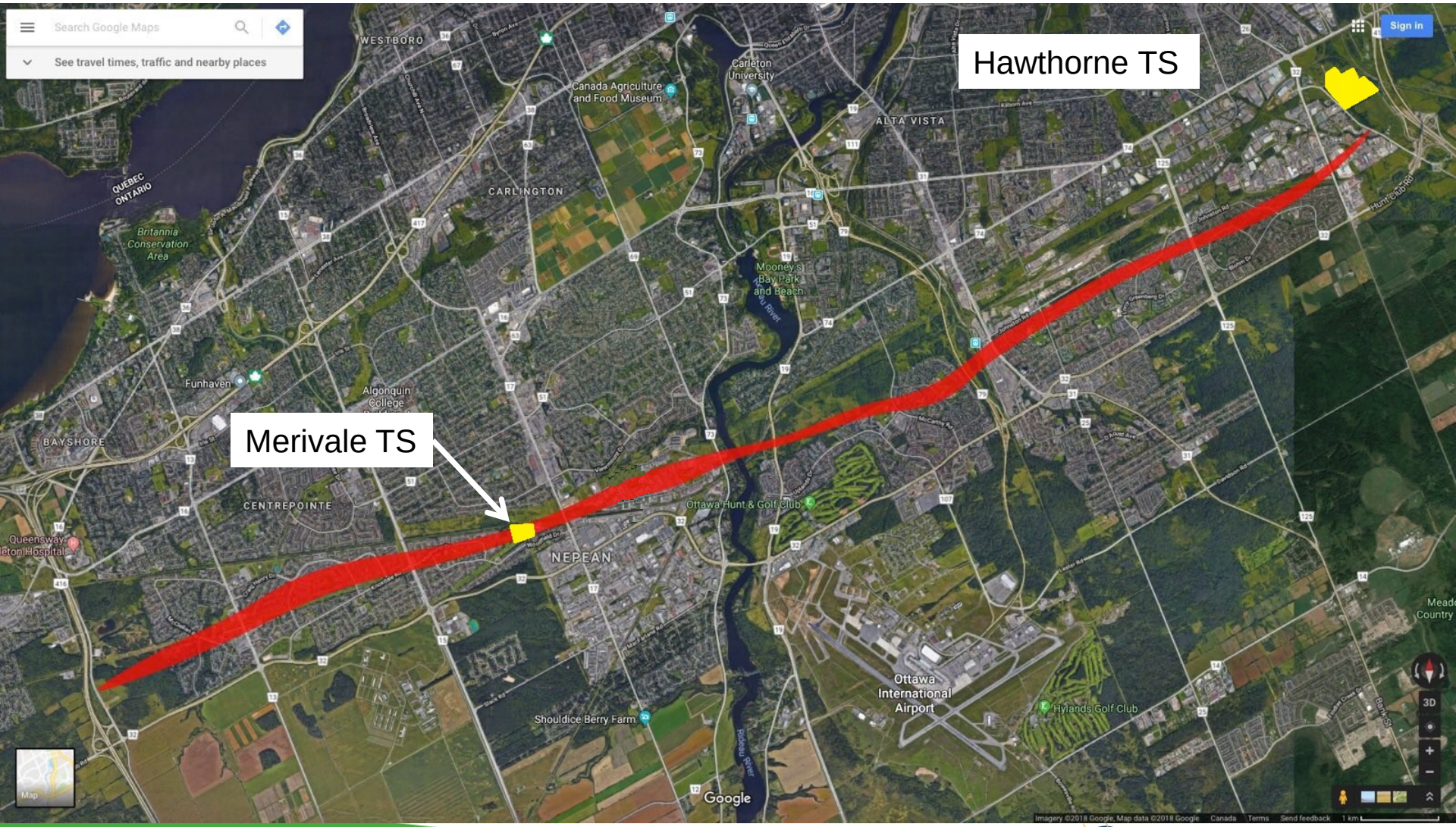
Event Review - September 21, 2018

- Forecast of thunderstorms, hail, heavy rainfall, winds in excess of 100 km/hr, and potential for isolated tornadoes
- Minor circuit and generator trips began shortly after 16:00 EST
- Shortly before 17:00 EST, Merivale TS was directly hit by a tornado ('the event')

September 21, 2018



Path of Tornado



Security Camera Footage – Merivale TS

Images – Merivale TS

Event Response

- Implemented new safe posture system limits to prepare for another major transmission loss in the Ottawa area.
- Communicated event through established channels
  - Notified the nuclear plants of the grid disturbance and informed them of potential reductions
  - IESO informed key participants (including government) through our Emergency Preparedness processes
- While Hydro One and Hydro Ottawa worked around the clock with focus on restoring the equipment, the IESO helped coordinate transmission restoration and provided restoration system limits

Event Review – "The Numbers"

- Merivale 115 kV and 230 kV Switchyards were lost as a result of the tornado:
  - 5 busses
  - 2 autotransformers
  - 12 transmission circuits
  - 33 breakers
- A total of over 600 MW of load was lost, approximately 200,000 customers were without power
- Five days later, all customer power was restored
- The recovery/rebuilding effort continued for many weeks

Next Winter and Summer Operations Outlook

Operations Awareness Session
November 19, 2018

Bilal Muhammad, P. Eng.
Market Forecasts and Integration, IESO

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Executive Summary

- Outlook for reliability remains positive for the Winter 2018-19
  - Sufficient capacity and energy supply, with no anticipated reliance on support from external jurisdictions
  - Reserves are above the requirement
  - Quarterly outage assessment identified no operational concerns
  - Surplus Baseload Generation (SBG) conditions continue to be managed through existing market mechanisms.
- New adequacy criteria for outage approval process applicable to outages that end after May 1 2019.

Agenda

1. Winter 2018-19 outlook –Adequacy
2. Winter 2018-19 outlook – System Security
3. Summer 2019 outlook – Adequacy
4. New adequacy criteria for outage approval process

Winter 2018-19 outlook – Adequacy

Forecast peak demand (Source: 18-month outlook, October 2018 - March 2020)

Season	Normal Weather Peak (MW)	Extreme Weather Peak (MW)
Winter 2018-19	**21,334**	22,261

Summary of Available Resources

Description	Winter Peak 2019 Firm Scenario
Installed Resources (MW)	36,843
Total Reductions in Resources (MW)	10,092
Demand Measures (MW)	795
Firm Imports (+) / Exports (-) (MW)	-500
Available Resources (MW)	**27,046**

- Sufficient available reserves (5,712 MW) during Winter 2018-19.

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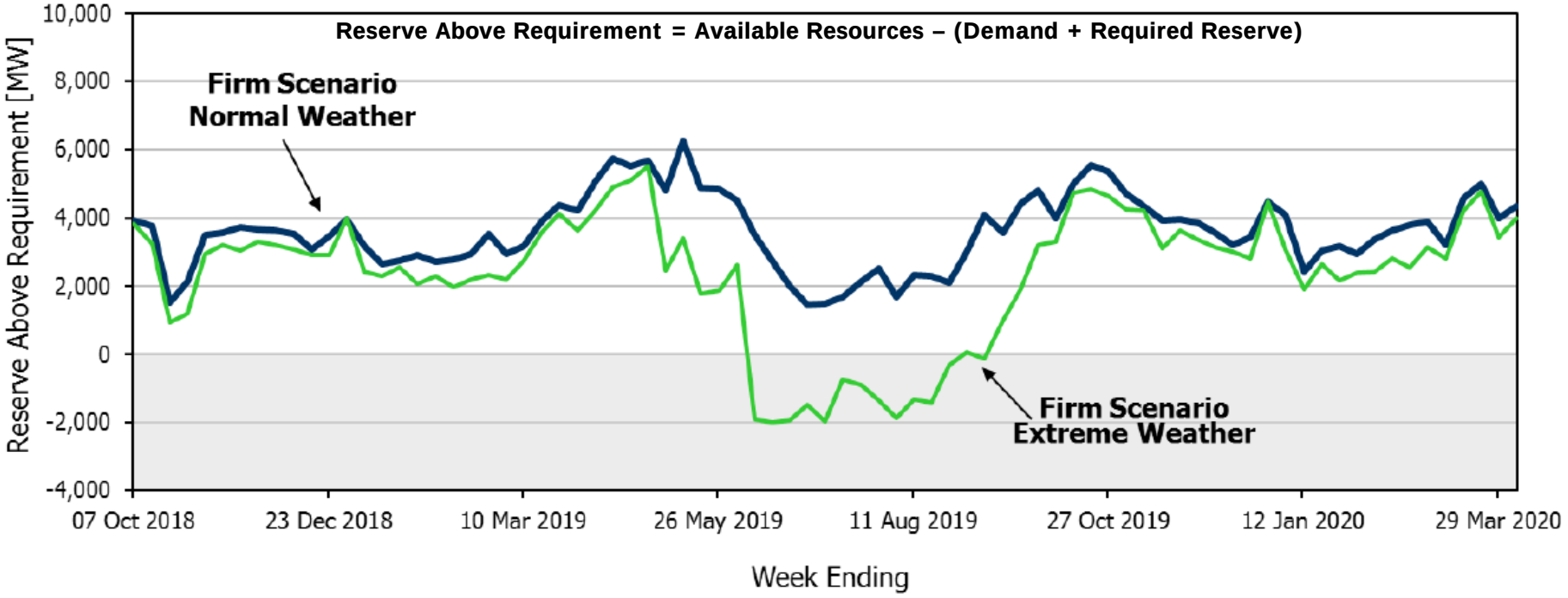
Winter 2018-19 outlook – Adequacy (cont.)



(Source: 18-month outlook, October 2018- March 2020)

- Reserve Above Requirement is positive for Winter 2018-19; no anticipated reliance on support from external jurisdictions.

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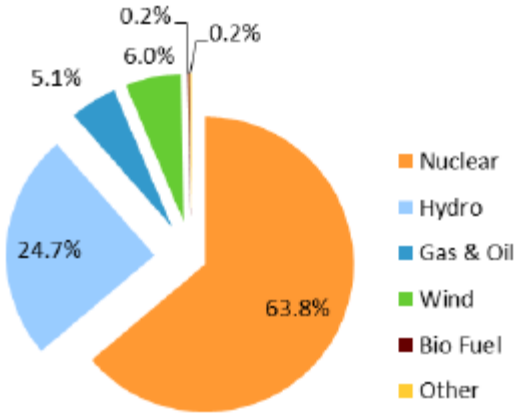
Winter 2018-19 outlook – Adequacy (cont.)

- Gas units are tested under the unit readiness program to ensure that they are available and operable when needed to:
  - **supply** forecasted demand;
  - **prevent** an emergency operating state; and/or
  - **mitigate** possible generation shortfalls



Production by Fuel Type
(October 1, 2018, to March 31, 2019)

- The IESO also meets with pipelines companies and natural gas suppliers as part of the Gas Electric Coordination forum.

Agenda

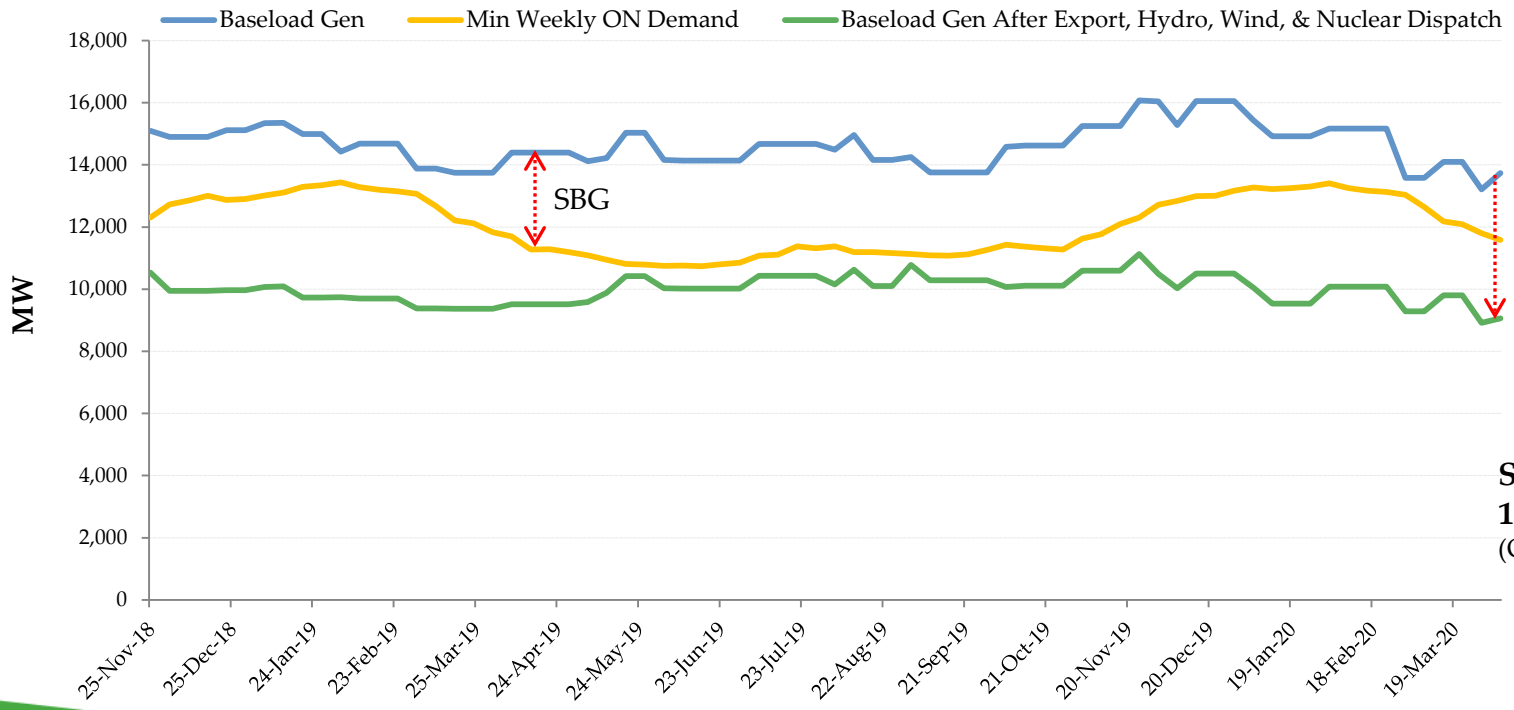
1. Winter 2018-19 outlook – Adequacy
2. Winter 2018-19 outlook – System Security
3. Summer 2019 outlook – Adequacy
4. New adequacy criteria for outage approval process

Winter 2018-19 outlook – System Security

- System security studies are conducted as part of the quarterly outage assessment process to highlight any operating concerns and system constraints.
- Outage approval is based on satisfying the adequacy, system security, and re-preparation criteria.
- Q3-2018 quarterly outage assessment looked at outages during the period of October 2018 - March 2019.
- No adequacy or security concerns were identified in the quarterly outage assessment for the Winter 2018-19.

Winter 2018-19 outlook – System Security (cont.)

- High SBG conditions to be managed through existing market mechanisms.



Source:
18-month outlook
(Oct 2018- Mar 2020)

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Agenda

1. Winter 2018-19 outlook – Adequacy
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3. Summer 2019 outlook – Adequacy
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Summer 2019 outlook – Adequacy

Forecast peak demand (Source: 18-month outlook, October 2018 - March 2020)

Season	Normal Weather Peak (MW)	Extreme Weather Peak (MW)
Summer 2019	22,068	**24,485**

Summary of Available Resources

Description	Summer Peak 2019 Firm Scenario
Installed Resources (MW)	36,787
Total Reductions in Resources (MW)	11,480
Demand Measures (MW)	567
Firm Imports (+) / Exports (-) (MW)	0
Available Resources (MW)	**25,874**

- Reserve Above Requirement under extreme weather is negative; support from external jurisdictions may be required.

Agenda

1. Winter 2018-19 outlook – Adequacy
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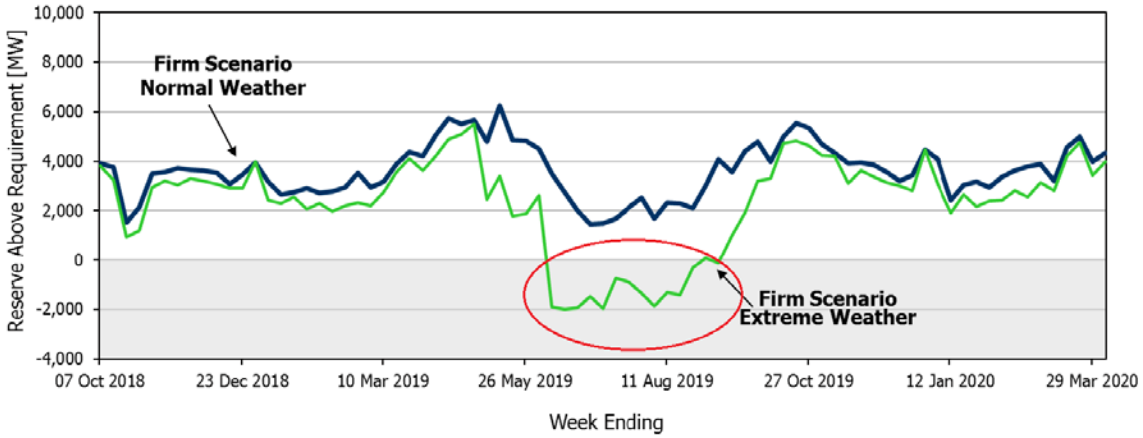
4. New adequacy criteria for outage approval process

New Adequacy Criteria for Outage Approval Process

- Outage approval criteria is changing
  - Existing criteria is based on resource adequacy forecast under normal weather assumptions.
  - New criteria is based on using the extreme weather forecast for outage approval; it will be applicable to outages that end after May 1st 2019.
  - New criteria is expected to shift outages to periods with high Reserve Above Requirement.



Source: 18-month outlook
(October 2018- March 2020)

Summary

- Outlook for reliability remains positive for the Winter 2018-19
  - Sufficient capacity and energy supply, with no anticipated reliance on support from external jurisdictions
  - Natural gas storage levels expected to be adequate; gas-fired generating units tested for unit readiness
  - No operational concerns identified in the quarterly assessment for Winter 2018-19.
- Reserve Above Requirement for Summer 2019 using the extreme weather forecast is negative; we may need support from external jurisdictions.
- The new adequacy criteria for outage approval process is expected to help shift outages to periods with high Reserve Above Requirement.

Questions?

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Interconnected Operation

Ahmed Rashwan P.Eng. – Engineering Manager, Power System Limits

November 19th 2018

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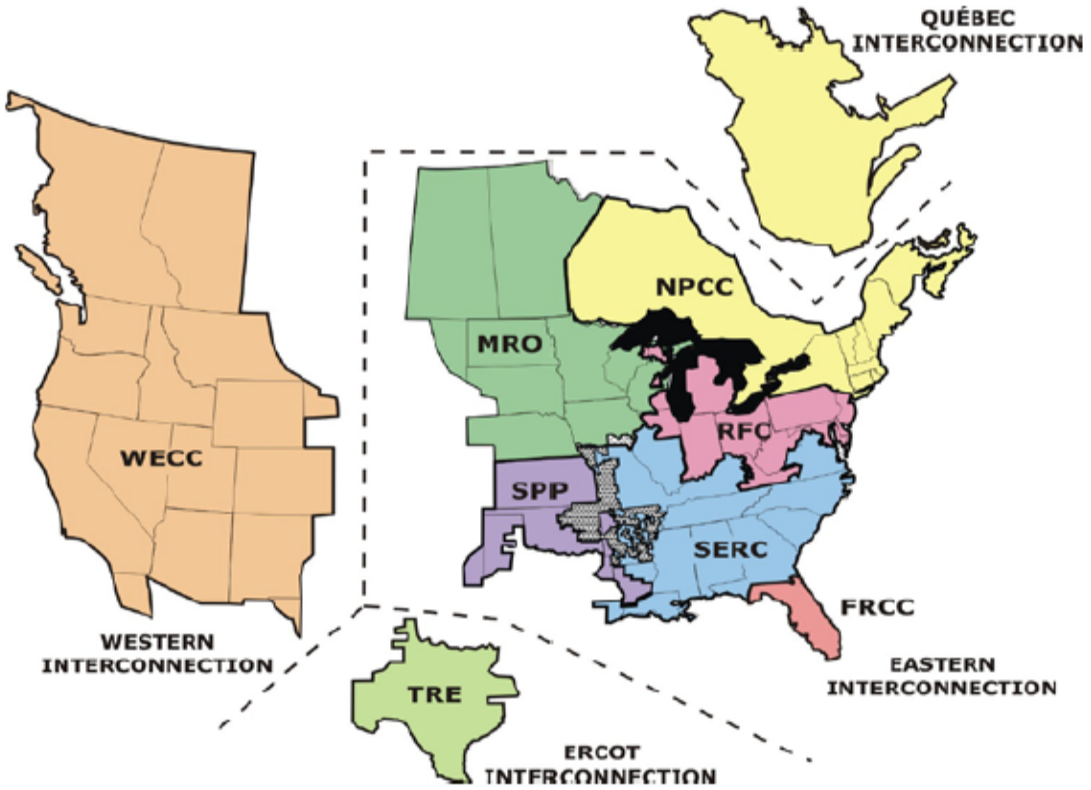
Agenda

- Interconnected Grid Operation
- Benefits and Challenges
- Intertie Planning
- Current Operation

North American Interconnections

- There are 4 Synchronous Interconnections in North America.
- Ontario is part of the Eastern Interconnection.
  - Largest interconnection
  - Thousands of generators
  - 750 GW peak demand
- There are eight Regional Reliability Organizations.
  - Ontario is part of the Northeast Power Coordinating Council (NPCC)

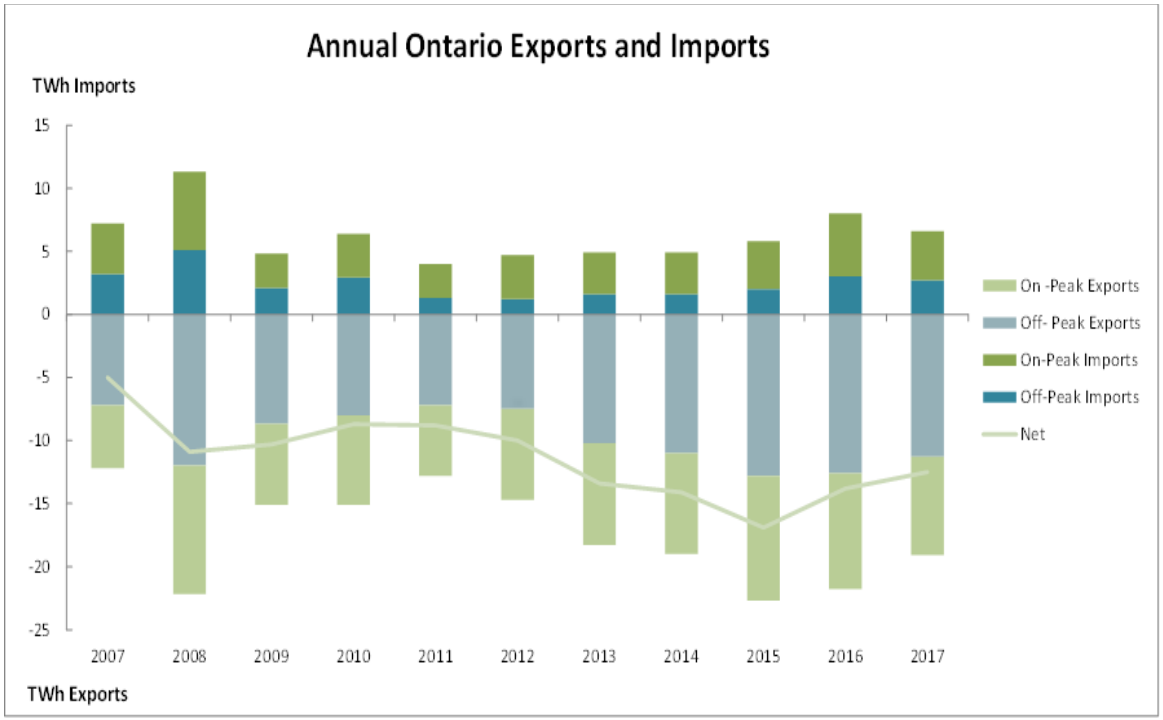


Ontario is well interconnected

- 13 synchronous interties with Manitoba, Minnesota, New York and Michigan
- Two High Voltage Direct Current (HVDC) ties and nine radial connections with Quebec
- Ontario has 5,200 MW of import and export intertie capability, after factoring in internal constraints and loop flows

Economic Benefits of Interconnections

- Competition leads to lower prices for energy, operating reserve and capacity from increased competition for supply
- Provides opportunities to generators, who can sell surplus energy and extra capacity outside Ontario



Reliability Benefits of Interconnections

Balance normal load and generation fluctuations, especially useful when Ontario flexible resources are scarce

Help keep **nuclear generators online** during surplus baseload generation and have them ready for the next peak period

Enhance the system's ability to **withstand and recover** from major disturbances

Operating reserve support between Control Areas, helping to achieve quicker post-event recovery

Allow for **assistance** during energy emergencies

- e.g. 251 MW emergency support by Ontario to New England in Sept 2018.

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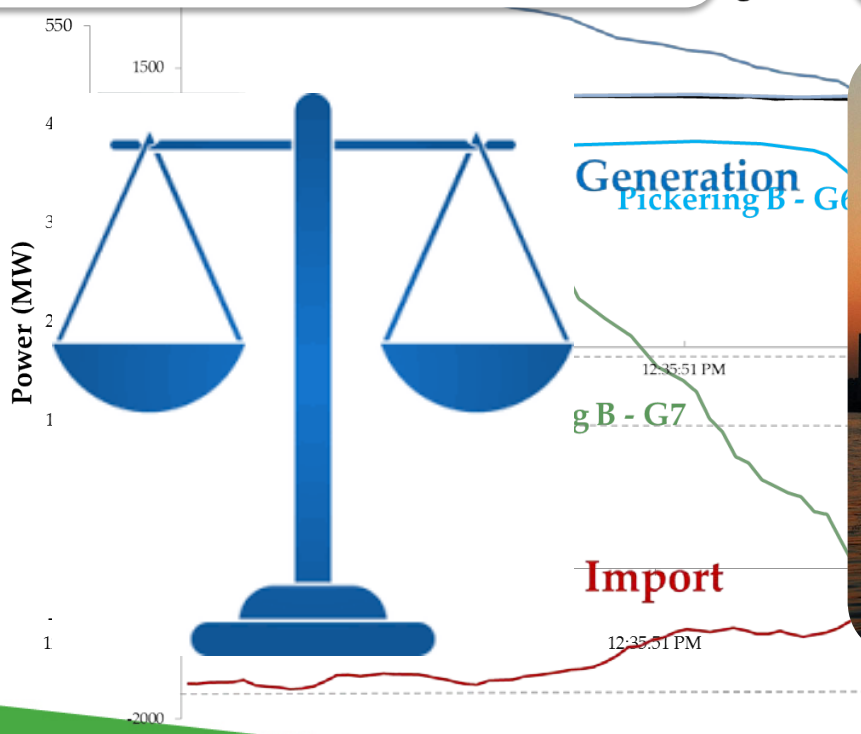
Pickering B GS Event- Jul 22, 2018

Activation of reserve In Ontario and in other jurisdictions rebalanced the system in two minutes

Without the Interconnection, Ontario load would have been interrupted



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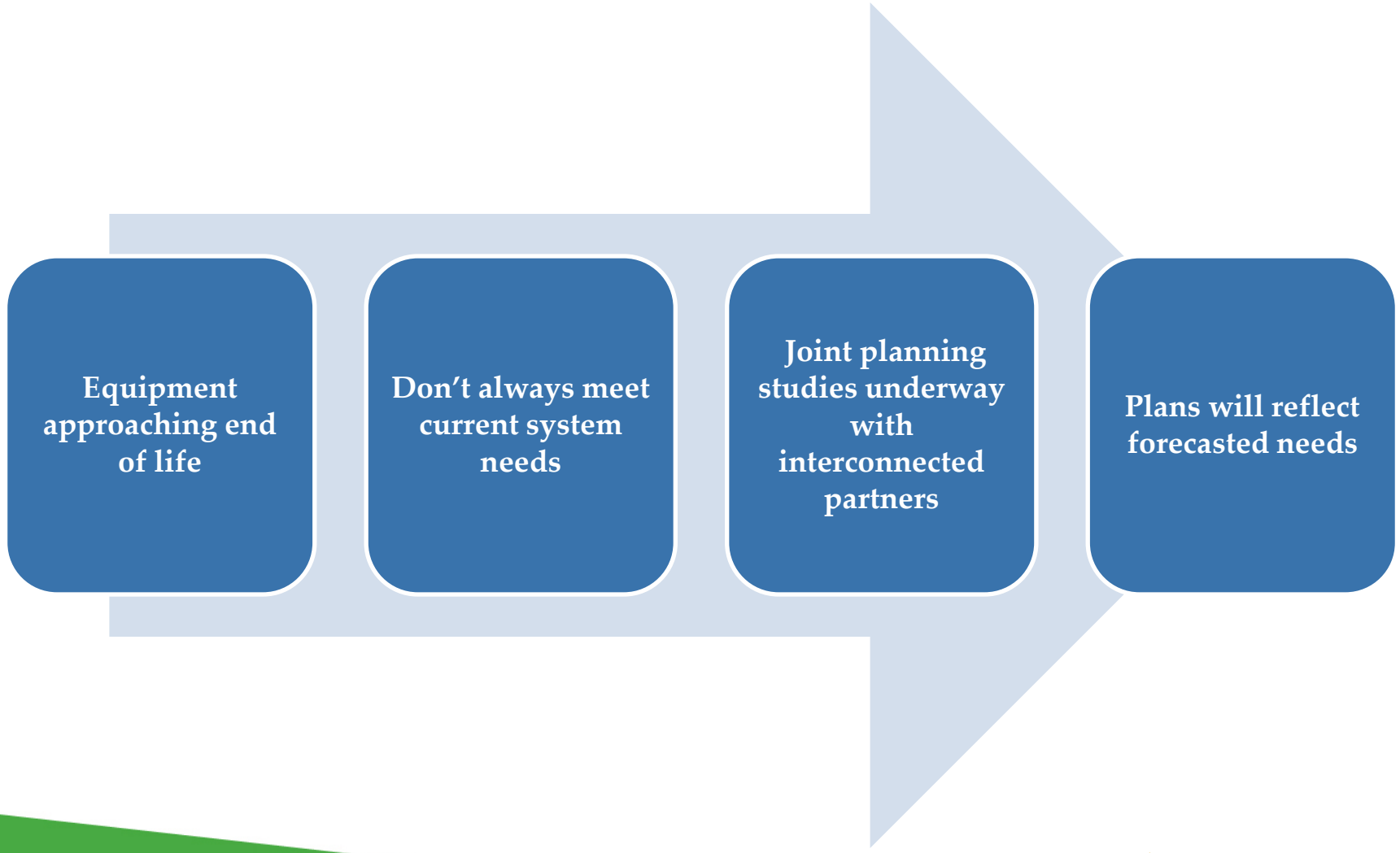
Interconnection Challenges

- Widespread power outages
  - A fault in one Area can be felt across the Interconnection;
  - If not properly isolated, faults could result in major blackouts;
  - Planning and operation coordination is critical.
- Parallel (Loop) Flows
  - Unplanned power flows across multiple jurisdictions if not controlled;
  - Introduce market inefficiencies or equipment overload;
  - Phase-shifting transformers (PS) are used to control intertie flows.

Intertie Planning



Current Operational Challenges - St. Lawrence Intertie

- The PS on one intertie with NY failed in April, 2018 - it takes four years to replace.
- Reduction to Ontario intertie transfer capability with NY and at times to Quebec imports
- Decreased internal transfer capability in Ontario and NY.
- Requires enhanced planning and coordination
  - Complex power system analysis required
  - Continuous dialogue with OPG, Hydro One, NYISO, NYPA and River Board
  - Maintenance outages to transmission are more impactful
  - Up to 700 MW of imports and local generation will need to be reduced in ON
  - NYISO will need to reduce their imports from Quebec and their local generation
  - The remaining intertie at St. Lawrence may need to be disconnected to improve internal limits in NY and in ON.

Interconnected Operation - Summary

Interconnected system operation has many benefits and challenges

Ontario has intertie equipment approaching end of life; replacing them requires several years - Planning work underway

In the meantime, operational plans are in place to manage immediate challenges and maintain system reliability

Questions?

2018 OPERABILITY ASSESSMENT

Mauro Facca, P.Eng.
Senior Manager – Performance, Applications and Integration

November 19, 2018

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What is an Operability Assessment?

An Operability Assessment is a study of the IESO's ability to **effectively** and **reliably** operate the power system **into the future** based on our real-time operating experiences.

Assessment Objective: Recommend changes to power system design or market mechanisms, processes and/or tools to address operability **concerns**

What major changes are expected in future?

- Increased penetrations of Distributed Energy Resources (DERs)
  - Reduce power system transfers and grid demand
  - Inverter-based DERs behave differently than traditional synchronous generators
- Long-term outages and retirement of nuclear generators
  - Reduce power system support responses after a transmission fault

Distributed Energy Resources (DERs) are generators or controllable loads connected to distribution systems

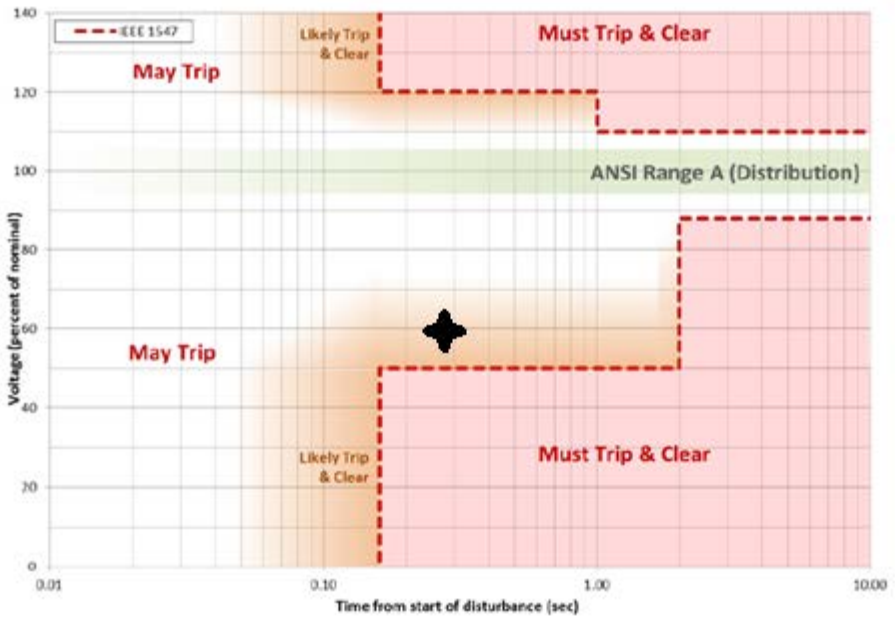
Why did we do this assessment?

- We have already seen instances of reduced power system responds after a fault
  - Observed as part of our regular monitoring required by NERC balancing standards
- New knowledge from other system operators:
  - 2016 California Bluecut forest fire caused a transmission fault; triggered an unexpected 1200 MW solar generation loss
  - 2017 California Canyon forest fire caused two transmission faults; triggered an unexpected 900 MW solar generation loss

Distributed Energy Resources - Limitation

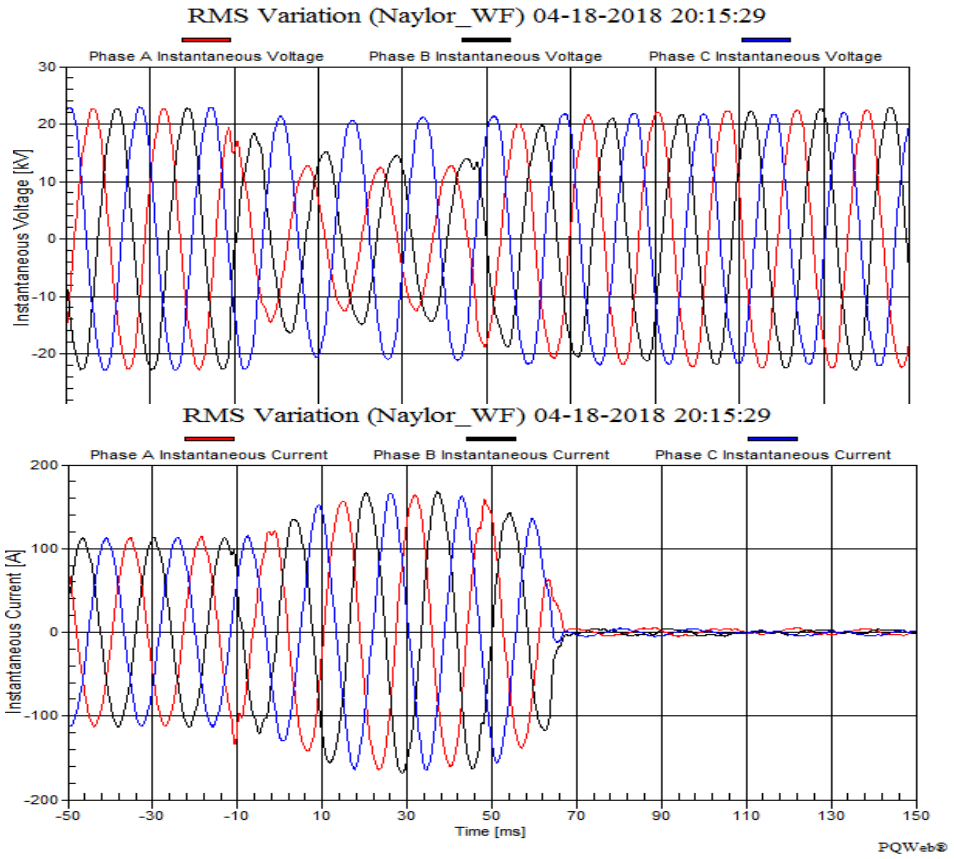
- Voltage Ride-Through Capabilities – Performance during and after a fault

Figure 1: IEEE Standard 1547 Voltage Sensitivity



Distributed Energy Resources - Limitation

- DER trip example



What did we study?

- Developed study conditions/scenarios that incorporated the following items:

	2025
DERs – IESO driven FIT and LRP projects	All inverter-based projects in-service at high outputs
Pickering NGS	Retired
Bruce and Darlington NGSs	Up to 4 units will be out of service for long-term outages
Low grid demands	As low as 8500 MW

- Studied how the power system responds during and just after a transmission fault

What power system responses were assessed?

- **Single Largest Contingency** - A large number of DERs may trip following a transmission fault, resulting a new single largest contingency that needs to be respected

- **System Inertia** - High penetration of DERs will lower the system inertia of the IESO-controlled grid

- **Primary Frequency Response** - High penetration of DERs will lower frequency response provided by Ontario

What did we find?

- Under certain system conditions, ¾ of DER production in Ontario will trip due to the effects of a transmission fault
  - The sudden loss of a single Darlington unit is typically Ontario's 'Single Largest Contingency' (SLC) today
  - If the fault occurs at Darlington, a Darlington generator and DERs will trip, causing a new and very large SLC for Ontario

What did we find?

- We will have sufficient traditional rotating generators (i.e., hydro-electric and/or nuclear) to support System Inertia and Primary Frequency Response after a transmission fault

What do we need to do?

1. Change settings on inverter-based DERs:
   - Work with the Ontario Energy Board (OEB) to modify the Distribution System Code (DSC) by adopting the new Canadian Standards Association rules on DER performance
   - Engage local distribution companies and DER owners

DER size (MW)	Percentage of total installed capacity (%)	Number of DER facilities
≥ 10	50%	134
≥ 5.0	66%	192
≥ 1.0	67%	204
≥ 0.5	76%	721
<0.5	24%	3721

What do we need to do?

2. Consider increasing occasionally Operating Reserve as an interim measure
   - Needed when loss of DERs is SLC for a transmission fault
3. Investigate Transmission solutions, if needed
4. Continue regular monitoring of how the system responds to transmission faults
   - Quarterly for primary frequency response
   - Annually for system inertia

2018 Operability Assessment – Next Steps

- Collaborate with OEB, LDCs and DER asset owners to investigate implementation of DER related recommendations
  - *What does this mean to DER asset owners?*
    - Likely to be an OEB implementation plan with direction from IESO and coordination from LDC
    - No reduction of output capability
    - Likely to require just a change in settings/controls
    - Likely no change in equipment
    - Less interruptions due to transmission and distribution faults
- Issue 2018 Operability Assessment report in Q1 2019

Questions

Connection Assessment for Behind-the-meter Generation and Storage

Samuel Jager, Connection Assessments, IESO

November 2018

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Terms of reference:

'LDU'

- Load displacement generation or storage unit(s) that are strictly for the needs of the customer; and installed within a load facility directly connected to the transmission system

'Behind The Meter'

- *Connected on the customer side of the wholesale revenue meter registered with the IESO*
- *No dedicated revenue meter registered with the IESO*

Objectives

- When and who applies for an IESO connection assessment for an LDU
- The rationale for the IESO's requirements when approving connections of LDU(s)

Connection Assessment and Approval (CAA)

- Applicable to new or modified facilities
- To preserve the reliability of the transmission system
- System Impact Assessments (SIAs), and Expedited System Impact Assessments (ESIAs) performed by the IESO
- Customer Impact Assessment (CIA) performed by the transmitter

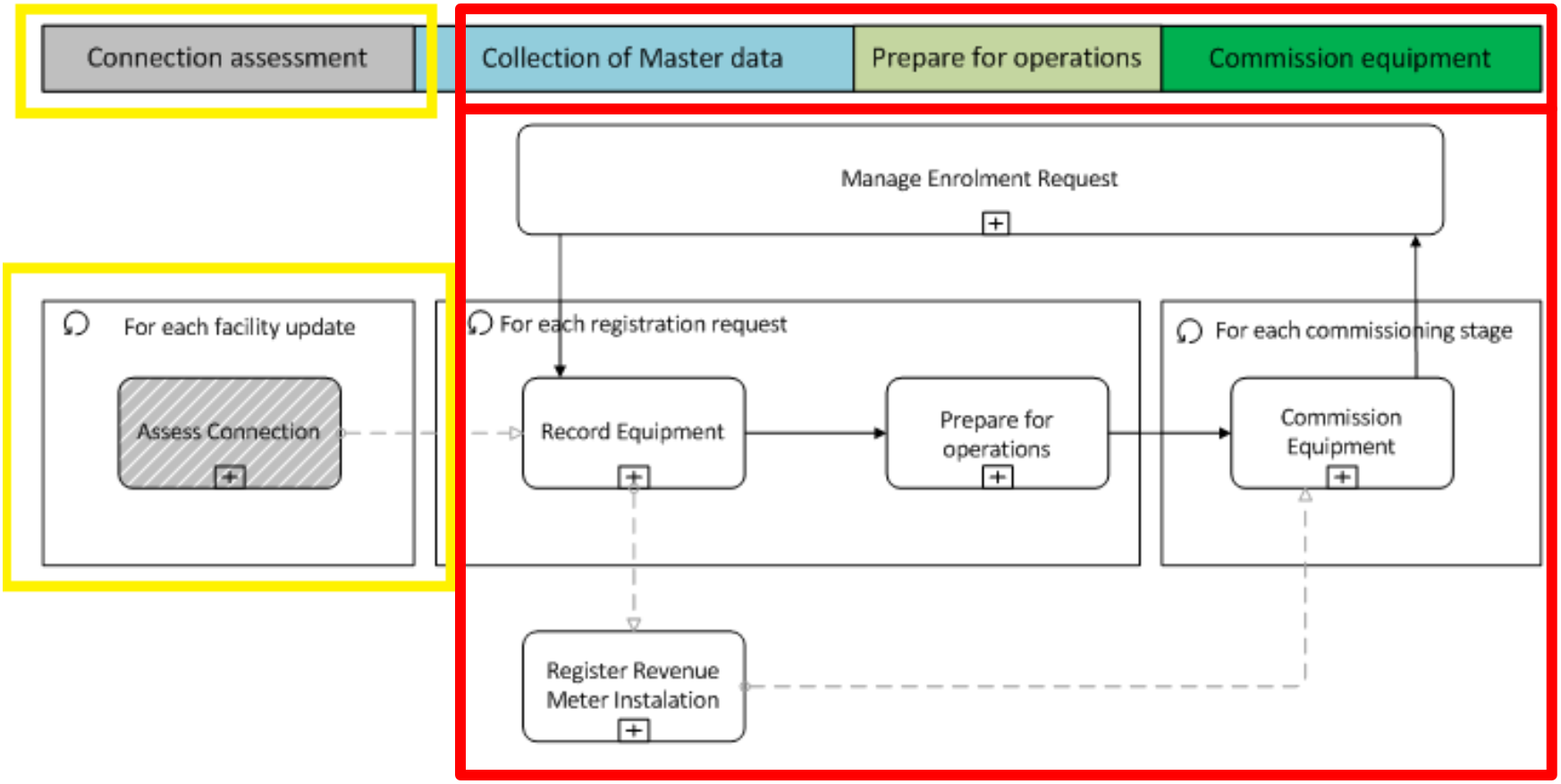
CAA Process Overview

- SIA/CIA application
- SIA agreement
- Draft SIA report
- Final SIA report and Notification of Conditional Approval
- CIA agreement with the transmitter
- Draft CIA report by transmitter
- Final CIA report by transmitter

Who applies for the SIA?

- Market Participants installing LDUs must apply for the SIA and CIA for projects of any size (MW)
- Distribution customers should contact their distributor for generation or storage projects
- An SIA is required for changes to the mode of operation of generation or storage unit(s) – i.e. to participate in IESO markets and services

CAA and the Market Registration Process



Rationale for IESO's requirements

- LDU connections are increasing
- Ensure LDUs do not trip for voltage and frequency excursions caused by system-wide events
- Prevent wide-spread tripping of inverter based units including LDUs for single system events and avoid severe impact on the transmission system.
- Unintentional injection of electricity and poor power factor may cause unmanageable MW flows and voltages

Connection Requirements

- LDUs must follow requirements in Appendix 4.2 of the Market rules for:

  Off-nominal frequency, speed/frequency control and voltage ride-through

- Load facilities with LDUs must continue to meet power factor requirements in Appendix 4.3
- Unintentional injection must be minimized
- Maximum facility load allocation must not be exceeded

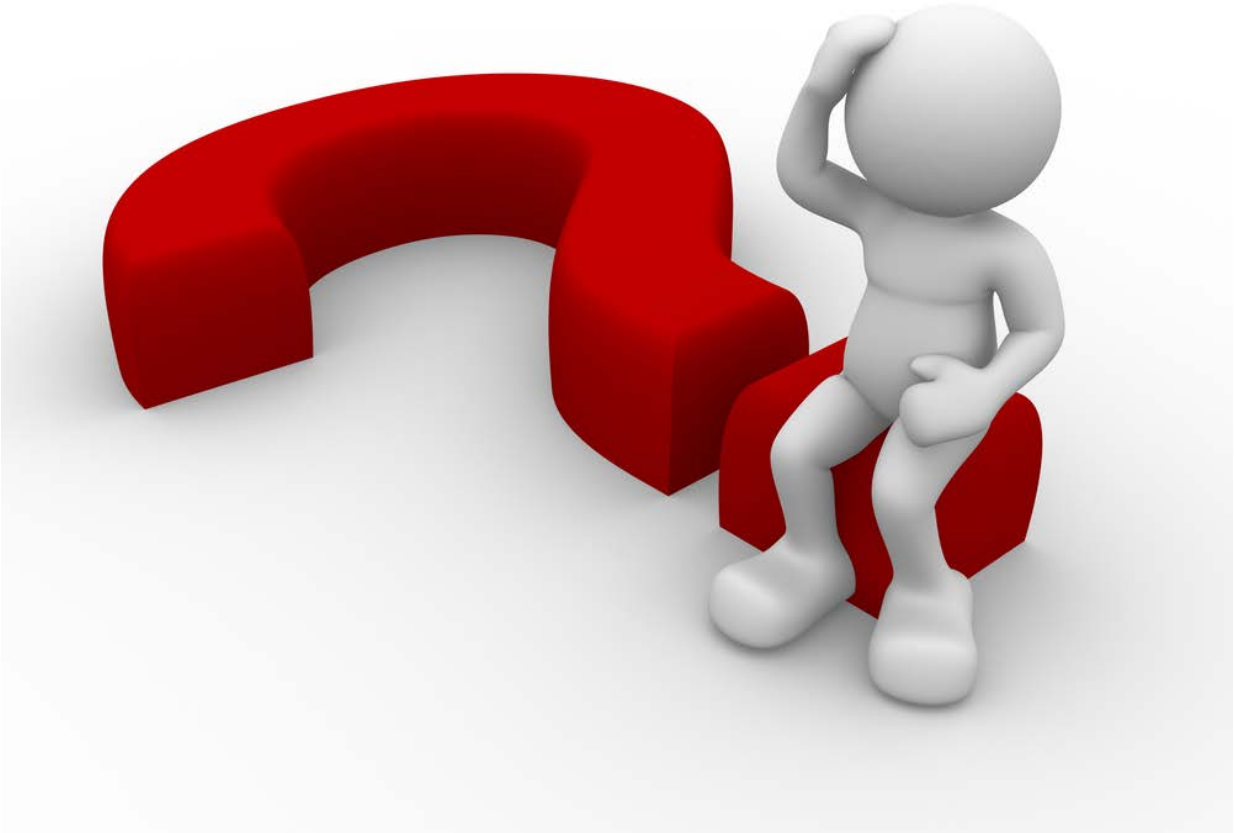
Additional Connection Requirements

- Short circuit capability
- Protection changes
- Telemetry
- Generation and storage units connected to the distribution system follow the distributor's requirements

Looking forward

- Bulletin and website update clarifying connection assessment requirements and who applies
- Distribution System Code (DSC) under review
- Questions or concerns: Please email us at connection.assessments@ieso.ca.

Questions?



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