



# 2016/17 Maine Resource Integration Study – Study Results

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*Planning Advisory Committee*

Al McBride

SYSTEM PLANNING

# Agenda

- Briefly review the objectives of the Maine Resource Integration Study
- Present the latest list of Interconnection Requests that have been identified as potentially eligible to participate in the cluster
- Present the results of the steady state, stability and PSCAD analysis

# Study Objectives

- Identify potential transmission infrastructure that could be used **to interconnect** queued generation in Maine
  - Quantify generation that could interconnect with new transmission
- The Maine Resource Integration Study is focused on the assessment of new 345 kV AC transmission circuits that could connect to the areas with the largest quantity of requested new generation interconnections
  - [Scope](#) presented to the March 2016 PAC meeting
  - [Initial Steady State Results](#) presented to the September 2016 PAC
  - [Additional Steady State Results](#) presented to the November 2016 PAC
  - [Preliminary Stability Results](#) presented to the February 2017 PAC

# Link to Interconnection Queue Clustering

- The Tariff changes for the proposed interconnection clustering methodology received the support of the NEPOOL Participants Committee at the February meeting
- The proposed methodology will be triggered when more than one Interconnection Request requires common new transmission line infrastructure to interconnect
- Clustering approach will have two phases
  - Phase 1 will be a Regional Planning Study that is presented to the PAC
    - It is proposed that this Maine Resource Integration Study will be used as the regional study for the first cluster(s)
  - Phase 2 will be a Cluster System Impact Study where more than one project will be studied together and will share the costs for certain upgrades

# CLUSTER ELIGIBLE INTERCONNECTION REQUESTS

# Eligible Interconnection Requests

- The following Interconnection Requests are currently being considered in the Maine Resource Integration Study and have been identified as potentially eligible to participate in a subsequent Cluster System Impact Study (CSIS)
- This does not reflect the final list of Interconnection Requests that will be ultimately identified as eligible to participate in a subsequent CSIS
- The final eligibility to participate in such a subsequent CSIS will be determined by the final clustering rules, as approved by the Commission and the status of each Interconnection Request at the time of the finalization of the Maine Resource Integration Study

# Eligible Interconnection Requests, continued

QP417

QP458

QP459

QP460

QP461

QP462

QP470

QP471

QP571

QP572

QP573

QP574

QP576

QP577

QP578

QP589

QP590

QP591

QP593

QP594

QP621

QP626

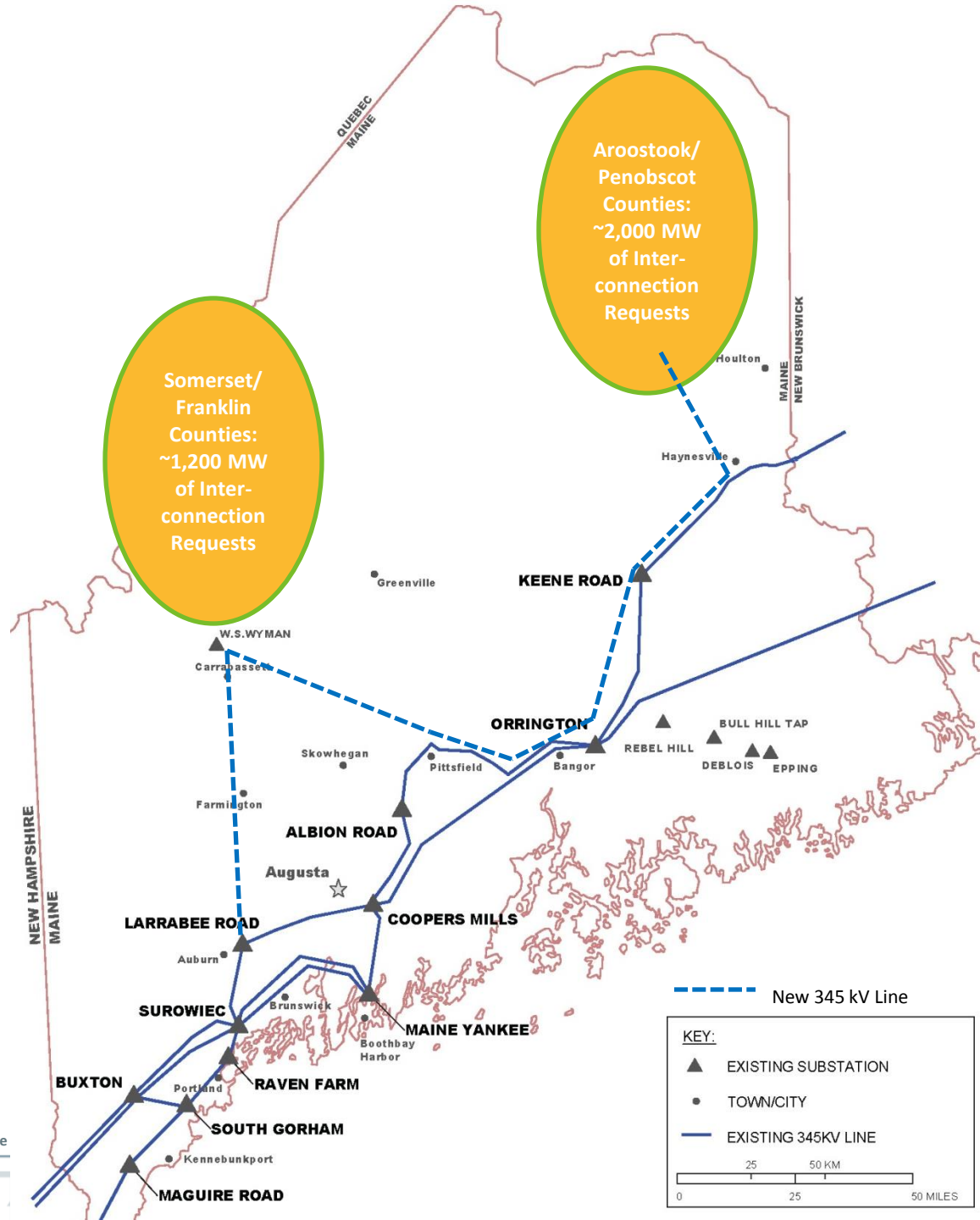
# DEVELOPMENT OF UPGRADE CONCEPTS

*Review of Steady State and preliminary Short Circuit Ratio and Stability Testing*



# Initial Conceptual Transmission Upgrades

- Analysis of new 345 kV transmission in parallel with the existing network
- Evaluations include interconnecting with, or bypassing, existing lines and substations



# Summary of the Evaluation of Alternatives

(Review the presentations referenced on Slide 3 for further details)

- Four alternative configurations were evaluated to interconnect resources in Western Maine
  - A radial connection to Larrabee Road 345 kV with a parallel 392 line was identified to provide the best N-1 and N-1-1 steady state performance and was compatible with Northern Maine infrastructure concepts
- Four alternative configurations were evaluated to interconnect resources in Northern Maine
  - Analysis showed the need to bypass Orrington South to avoid:
    - Interactions with existing special protection systems and other equipment
    - Post-contingent flows through New Brunswick that would required prohibitive upgrades
    - N-1-1 limitations
  - All four options showed the need for additional 345kV infrastructure travelling south to Maine Yankee to meet N-1-1 requirements

# Investigation of Increasing the Surowiec South Transfer Capability

- Investigated increasing Surowiec South from 1,600 MW to 2,200 MW
  - The increased flow was simulated in the study by (partially) dispatching against Yarmouth 4
  - The remaining re-dispatch was performed by turning down existing Western Maine generation when adding the new proposed Western Maine resources
- Note that this increase in Surowiec South required a significant amount of stability and voltage testing to confirm achievability
- This increase in Surowiec South transfer capability could be used by both Western and Northern Maine proposed resources

# Western Option: Radial to Larrabee Road & Parallel 392 Thermal Summary

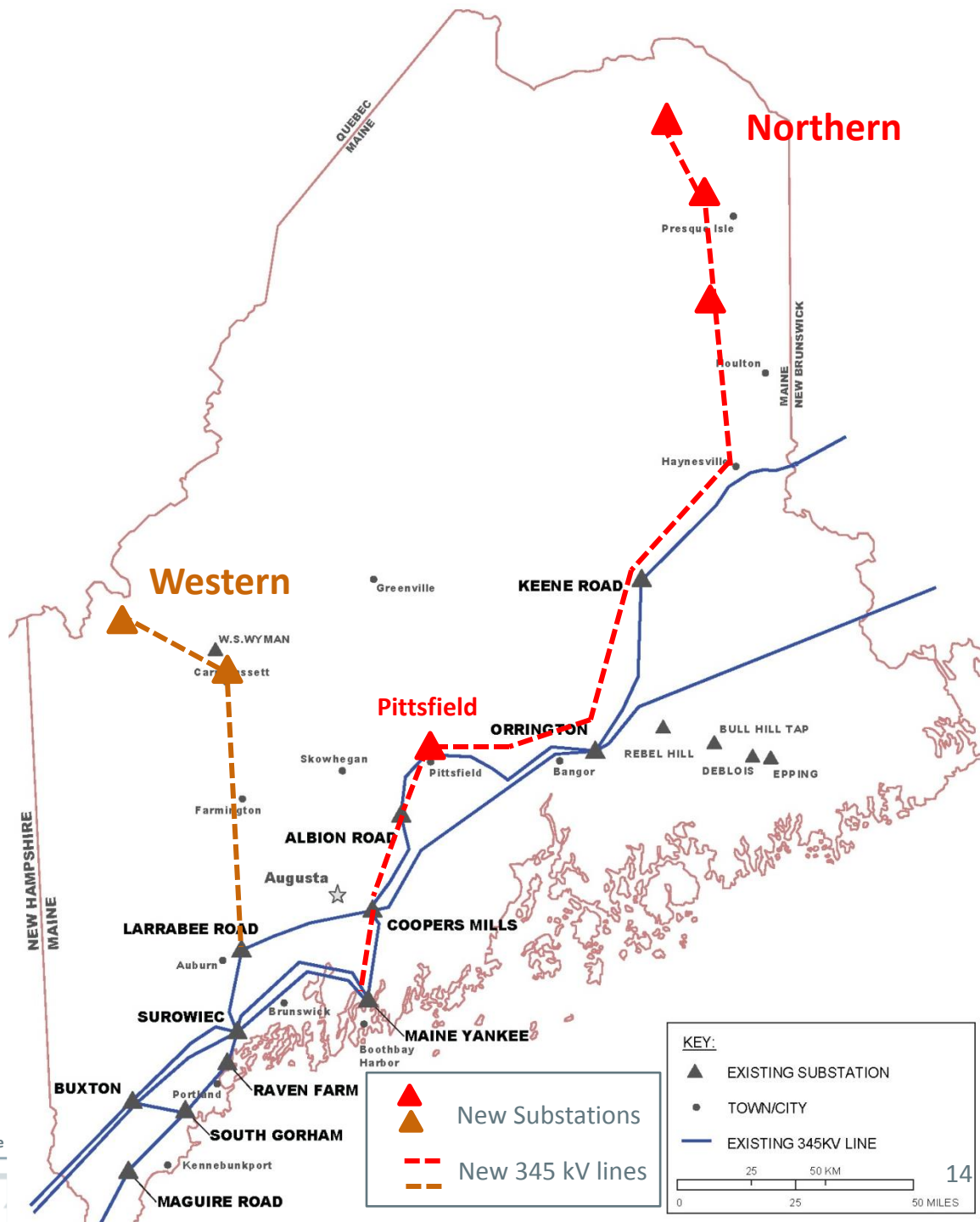
- When dispatching against Yarmouth 4 and existing Western Maine resources – no N-1 or N-1-1 thermal violations were identified for the addition of up-to 1,200 MW of new resources in Western Maine
  - From a thermal perspective, the radial to Larrabee Road 345 kV with a parallel 392 line can accommodate up-to 1,200 MW
  - Additional reactive upgrades are required, which are described later in this presentation

# Northern Option Radial to Pittsfield with additional Parallel to Coopers Mills & Parallel 392 Thermal Summary

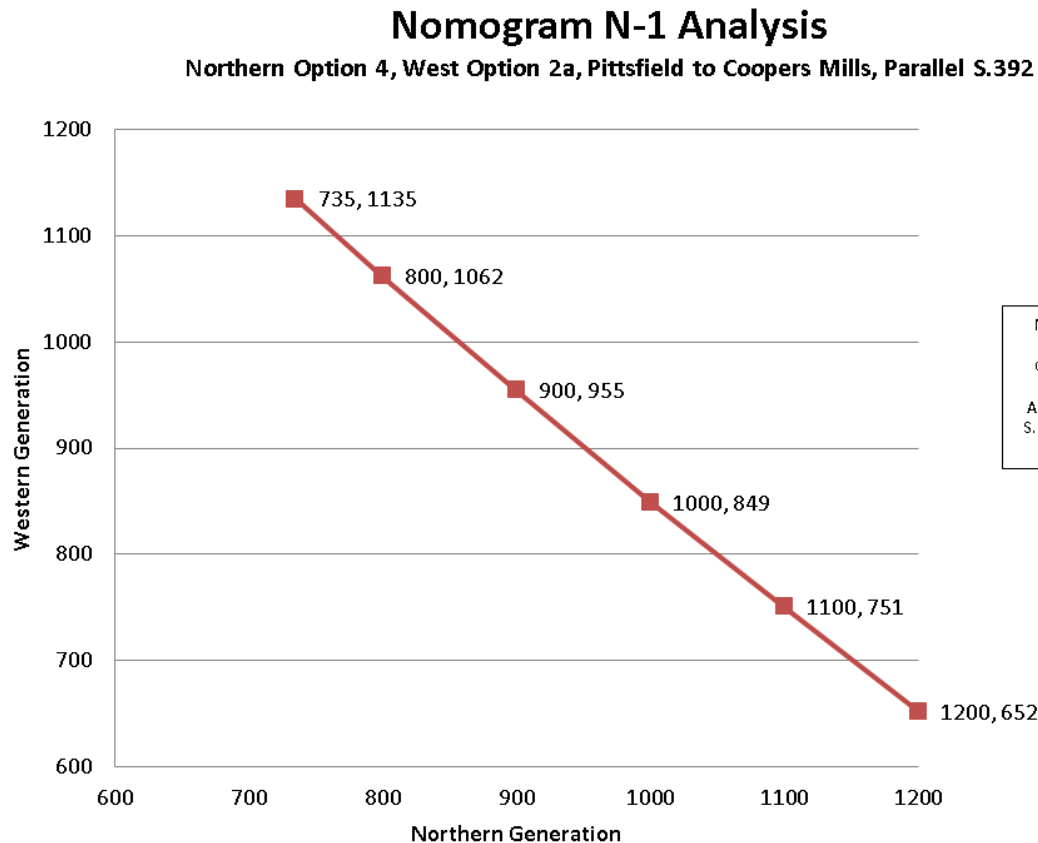
- When dispatching against Yarmouth 4 and existing Western Maine resources – no N-1 or N-1-1 thermal violations were identified for the addition of up-to 1,200 MW of new resources in Northern Maine
  - From a thermal perspective, the radial to Pittsfield 345 kV with Pittsfield-Coopers & Parallel 392 can accommodate up-to 1,200 MW
  - Additional reactive upgrades are required, which are described later in this presentation

# Resulting Transmission Upgrade Concepts

- Radial to Pittsfield with additional Parallel to Coopers Mills & Parallel 392
- Radial to Larrabee & Parallel 392



# North/West Combination – Simultaneous Injection Capability



These combinations were  
Also all acceptable under  
The tested N-1-1  
Conditions

Northern Generation  
Fixed, Western  
Generation Adjusting

All Scenarios Limited By  
S.84 Overload caused by  
the loss of S.259

# Redispatch Consideration under the Network Capability Interconnection Standard

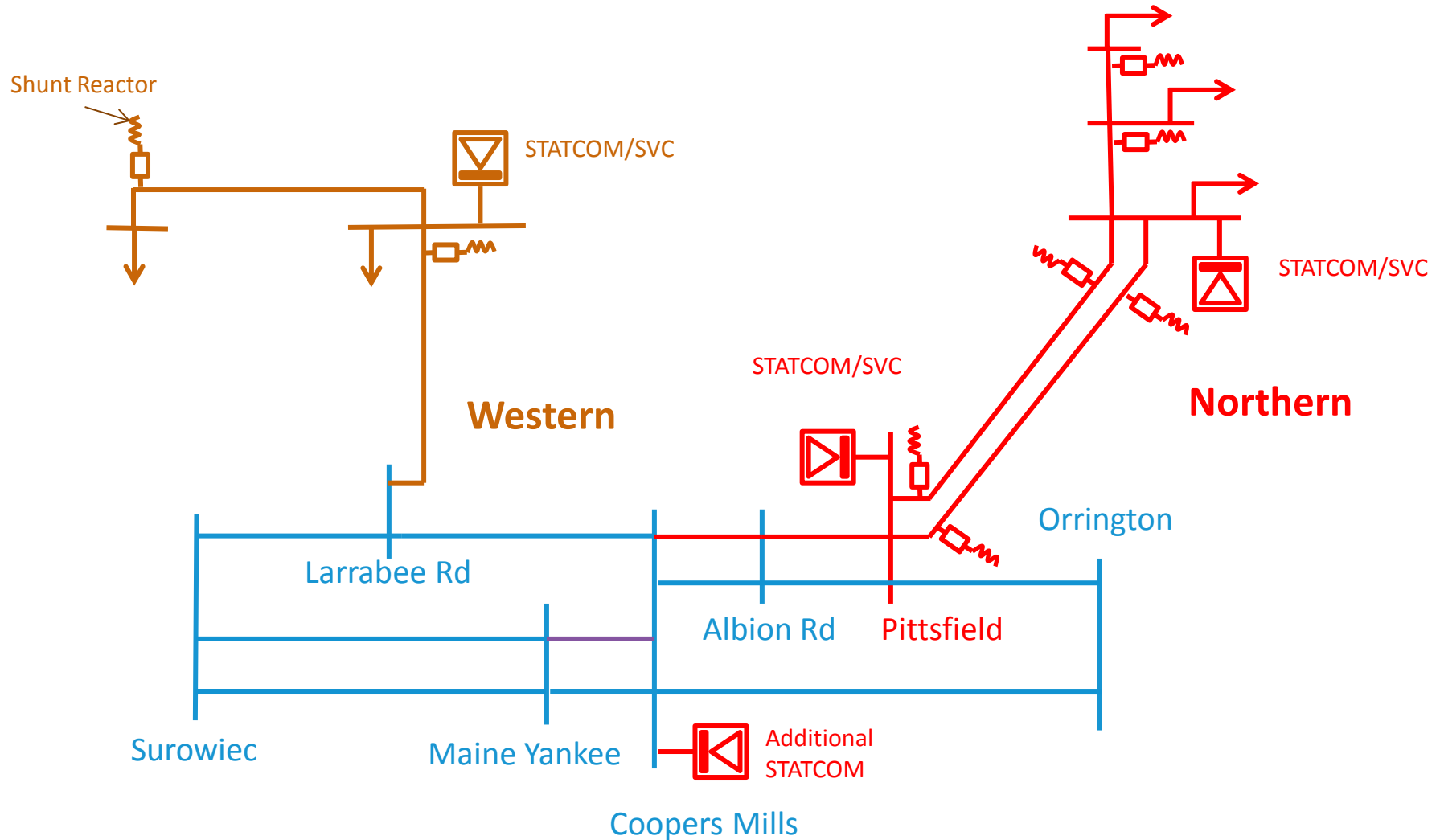
- In the presence of a constraint, other resources can be re-dispatched when injecting a new resource under the Network Capability Interconnection Standard
- The Northern and Western injections share some downstream thermal constraints and ultimately the Surowiec South interface constraint
- With the upgrades identified, the Northern and Western injections will have ability to re-dispatch against each other for simultaneous injections that would otherwise be beyond those, for example, shown on the previous slide



# Preliminary Stability and Short Circuit Ratio (SCR) Testing

- Preliminary stability and SCR testing indicated the need for the following upgrades:
  - To accommodate up-to 1,200 MW, the Northern connection from Aroostook County to Pittsfield should be double circuit
  - One Statcom/SVC with the Western projects
  - Two Statcom/SVCs with the Northern projects
  - Expansion of the existing Statcom at Coopers Mills
  - Shunt reactors with each transmission line element
  - Synchronous condensers with the Northern projects (and possibly with the Western projects)
- Comprehensive stability testing, short circuit ratio analysis and some PSCAD testing was conducted to size the reactive device upgrade sizes

# Conceptual Transmission Upgrades with Placement of Reactive Upgrades



# DETAILED DEFINITION OF TESTED QUEUE POSITIONS UNDER STUDY AND REACTIVE DEVICE UPGRADES

# Queue Positions Included in Detailed Testing

- Northern Resources

- QP458 & QP459
- QP460, QP461 & QP462
- QP470

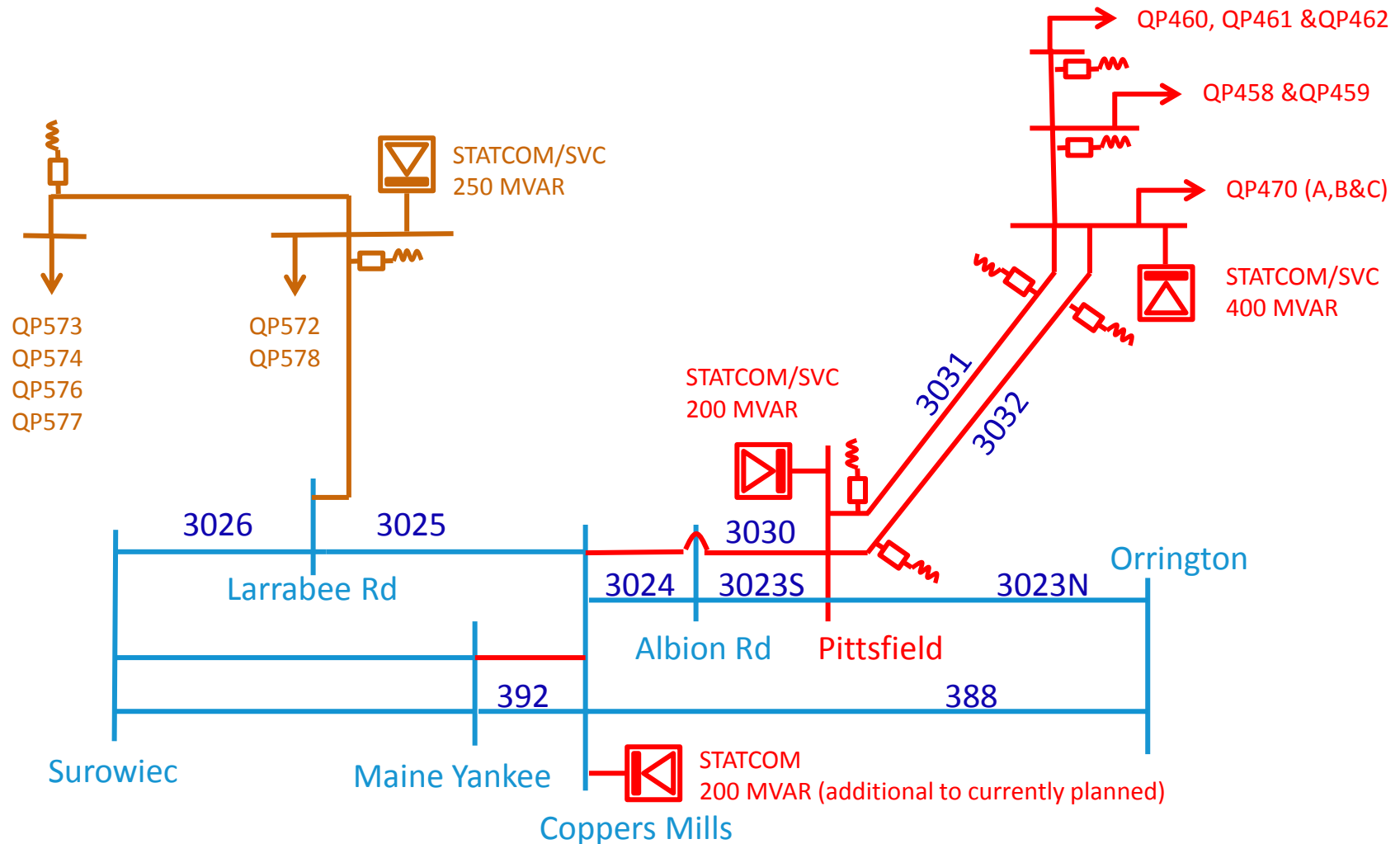
**1118 MW**

- Western Resources

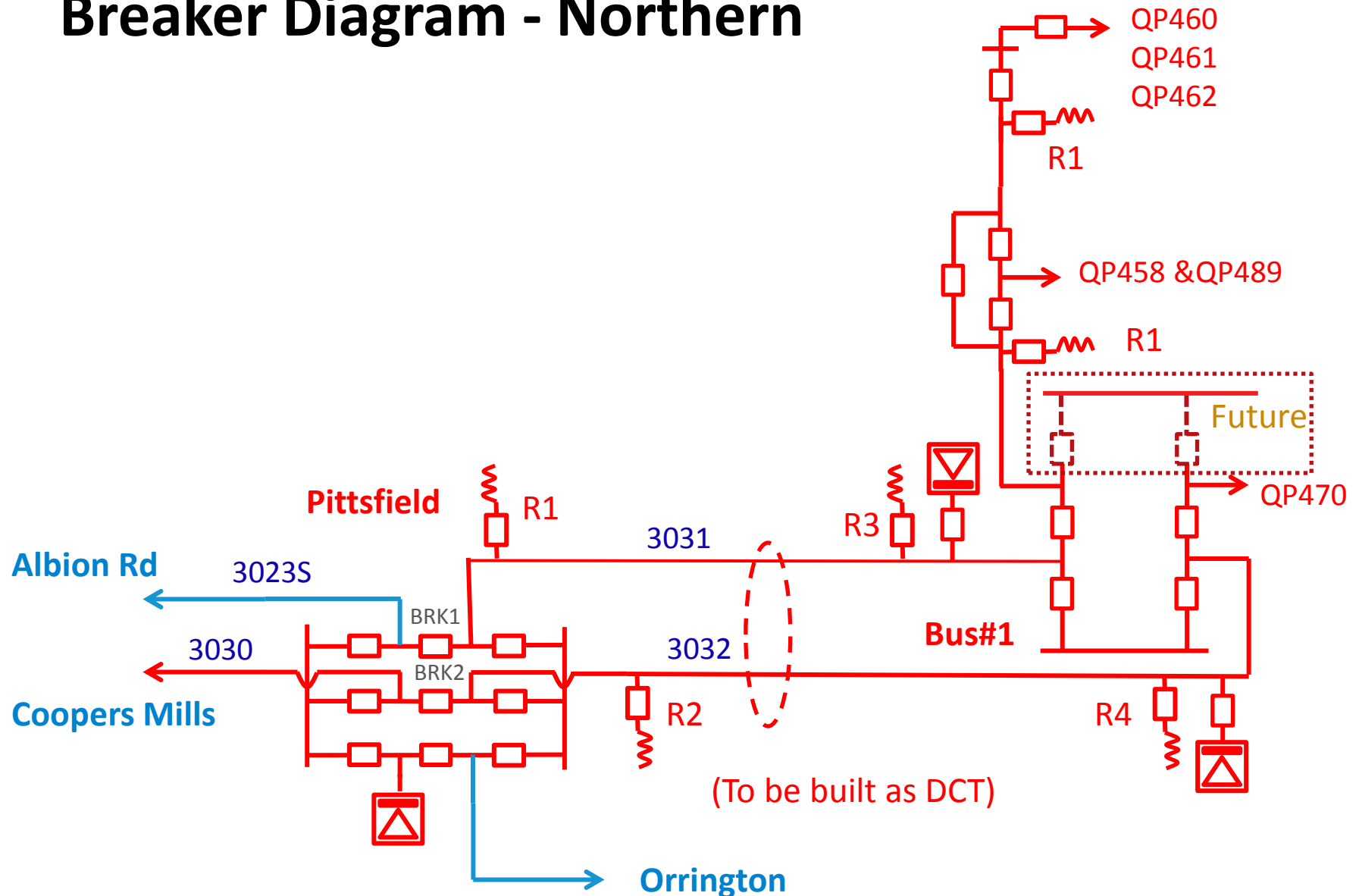
- QP572
- QP573 & QP577
- QP574 & QP576
- QP578

**777 MW**

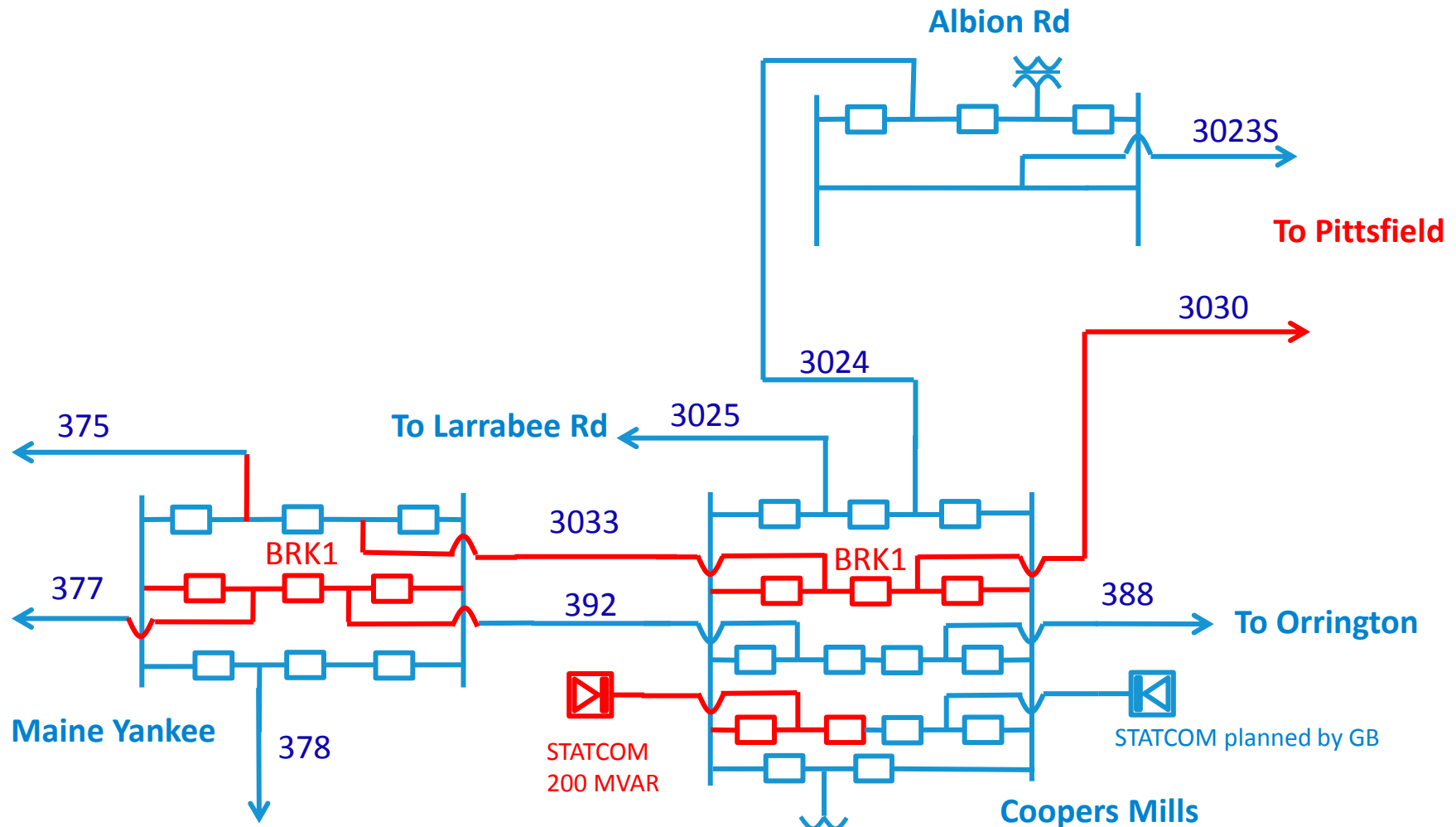
# Proposed Transmission Upgrades

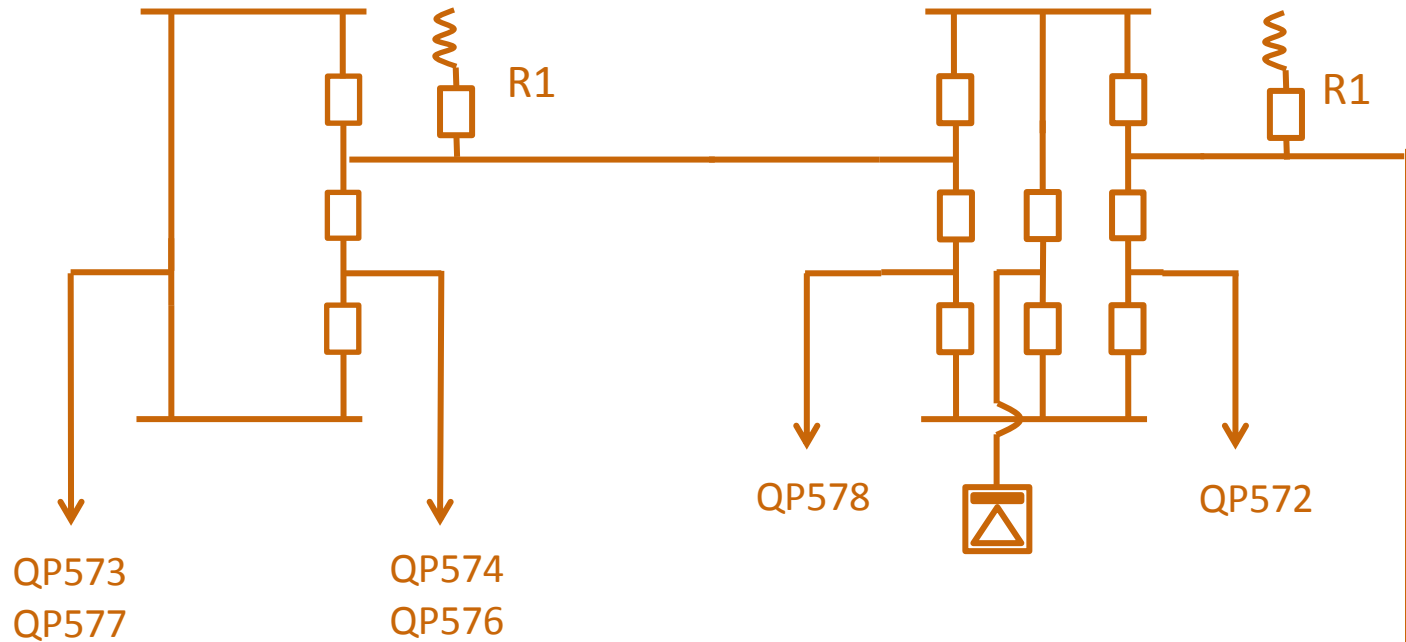


# Breaker Diagram - Northern

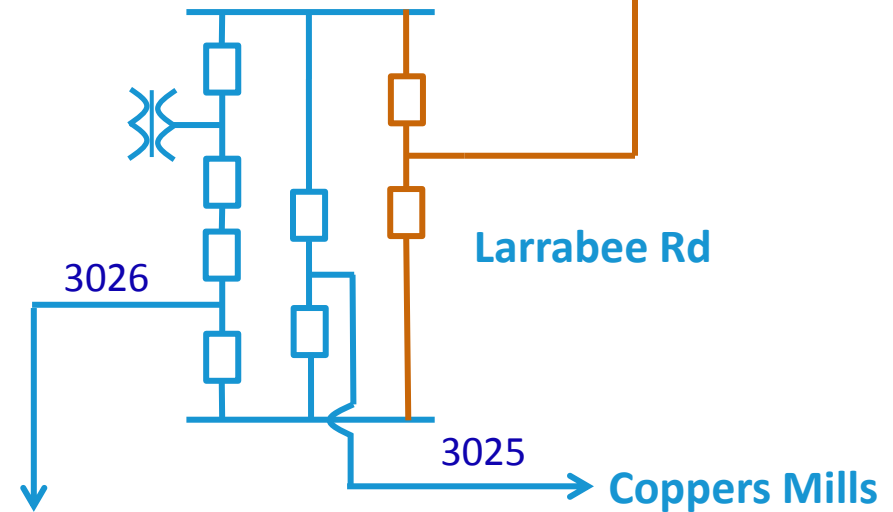


# Breaker Diagram – Northern, continued





# Breaker Diagram Western



Surowiec



# DETAILED TESTING RESULTS

## *PSCAD Screening*

# Objectives of the PSCAD Screening

- Examine weak grid issues for the Northern and Western injections
- Evaluate any transient overvoltages caused by the interconnection
- Identify potential for sub-synchronous control interactions (SSCI) between the Northern wind turbines and the existing series capacitors on the 3023N and 388 lines

# Base Cases Evaluated in PSCAD

Case ID	Description	Note
LL21_SSCI	All-lines-in	For SSCI screening
LL21_WG	All-lines-in	For weak grid assessment
LL21_WG_3023Noos	Line 3023N OOS	
LL21_WG_3023Soos	Line 3023S OOS	
LL21_WG_3025oos	Line 3025 OOS	
LL21_WG_3026oos	Line 3026OOS	
LL21_WG_388oos	Line 388 OOS	
LL21_WT30	All-lines-in	For transient overvoltage evaluation
LL21_WT30_3023Noos	Line 3023N OOS	
LL21_WT30_3023Soos	Line 3023S OOS	
LL21_WT30_3025oos	Line 3025OOS	
LL21_WT30_3026oos	Line 3026 OOS	

- Multiple contingencies were evaluated at Pittsfield, Orrington and Larrabee Road

# PSCAD Screening Conclusions

- PSCAD study supports that the proposed transmission upgrades are viable to interconnect two resource clusters
- Weak grid issues were identified for the Northern resources, which can be mitigated by adding one 60 MVA synchronous condenser (SC) at each wind plant (5 SCs in total)
- No sustained or undamped SSCI oscillations were observed even when the Northern interconnection is operated radially with the nearby series capacitors on the 3023 and 388 lines
- Transient overvoltages (TOVs) occurred in both areas and some nearby 345kV buses
  - Care should be taken for certain line-out conditions that lead to the Northern interconnection being connected radially to the series capacitor of the 3023N line after a second contingency
    - In those line-out conditions, the terminal voltage of the series capacitor could reach up to 1.48pu (RMS)

# DETAILED TESTING RESULTS

*Steady State and Stability Testing of the Proposed Solution*

*(Solution as described above with the inclusion of the Synchronous Condensers at the Northern Resources)*

# Steady State N-1 Testing

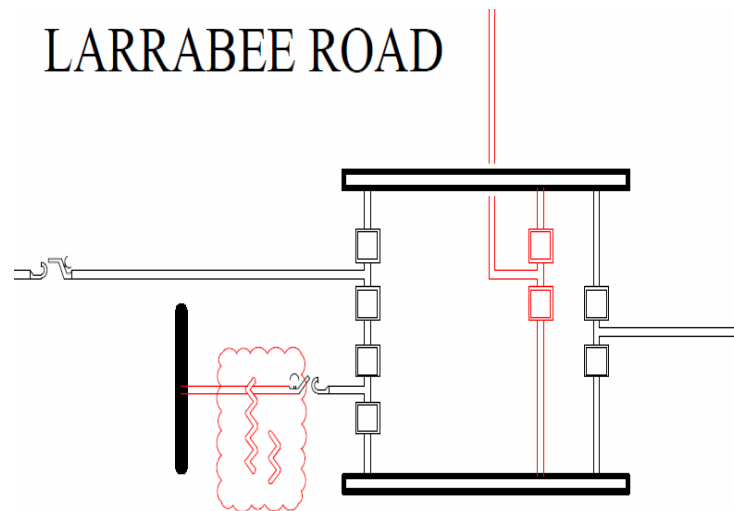
- N-1 Thermal and Voltage Testing
  - 6 Base Cases
    - Peak Load Dispatches 1 and 2
    - Shoulder Load Dispatches 3 and 4
    - Minimum Load Dispatches 7 and 8
  - Contingencies Tested
    - 345 kV and 115 kV Maine contingencies (845)
    - 345 kV New Hampshire contingencies (80)
    - Selected 345 kV New Brunswick contingencies (13)

# Steady State N-1 Thermal Results

- Steady state N-1 testing indicates, with the full simultaneous injection of both the Northern and Western resources, the need to increase the thermal capacity of two existing system elements:
  1. Larrabee Road T1 345/115 kV Transformer
  2. 115 kV Section 207 (Maine Yankee – Bath)

# Upgrades Driven by Steady State N-1 Thermal Results

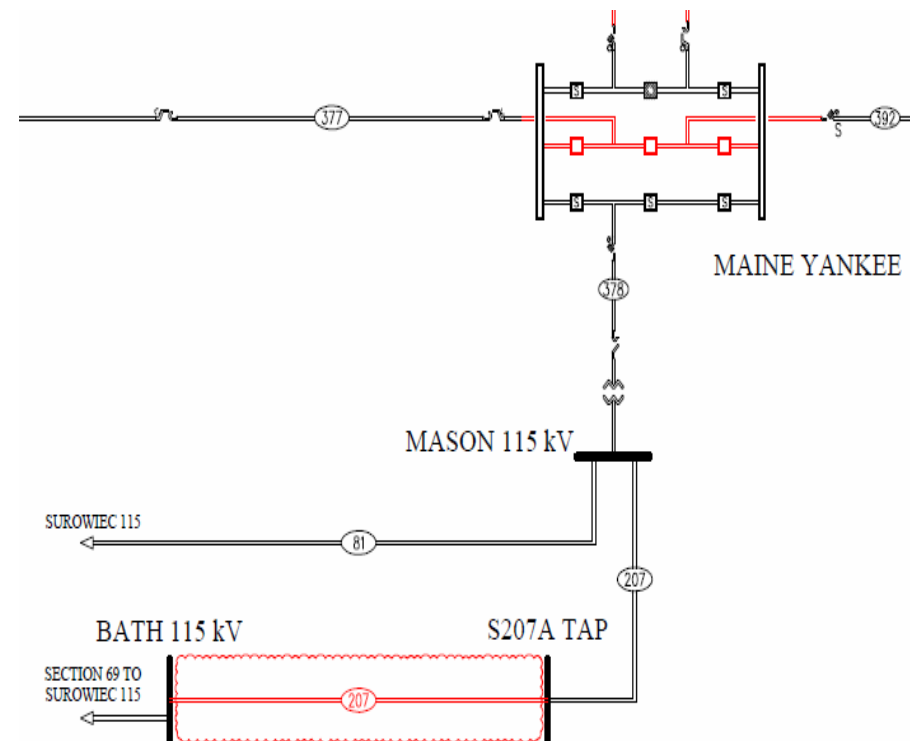
- Larrabee Road T1 345/115 kV Transformer
  - Limiting Contingency - 345 kV Section 3026 (Larrabee Road – Surowiec)
  - Post-contingency loading exceeds 597 MVA STE rating
  - 103% of STE for Peak Load Dispatch 1
  - Loss of one of two 345 kV lines at Larrabee Road with north to south transfers at limits





# Upgrades Driven by Steady State N-1 Thermal Results

- 115 kV Section 207 (Maine Yankee – Bath)
  - Limiting Contingency – 345/115 kV DCT 377/81
    - 345 kV Section 377 (Maine Yankee – Surowiec)
    - 115 kV Section 81 (Mason – Surowiec)
  - Post-contingency loading exceeds 105 MVA STE rating
    - 101% of STE for Peak Load Dispatch 1
  - Heavy north to south transfers



# Steady State N-1 Voltage Results

- High voltage at 345 kV Series capacitor on Section 3023
  - Additional review will be required to determine if upgrades are required
- Results of the steady state N-1 voltage analyses indicate that the transmission upgrades proposed with the Maine Clusters do not present an adverse impact on system voltage performance

# Steady State N-1-1 Testing

- N-1-1 Thermal and Voltage Testing
  - 4 Base Cases
    - 2 Peak Load Dispatches
    - 2 Minimum Load Dispatches
  - N-1-1 Scenarios Included:
    - 22 Initial Facility Outages
    - All N-1 contingencies
  - Peak load N-1-1 testing included re-dispatch of the following resources after initial outage
    - New Brunswick
    - Maine Cluster generation
    - Bangor area generation
    - Southern New England

# Steady State N-1-1 Thermal Results

N-1-1 Thermal Analysis of Peak Load Dispatch 1				
Initial Outage	Limiting Contingency	Limiting Element	LTE Rating (MVA)	Re-dispatch (MW)
Section 375	DC_377_81	115 kV Section 207 (ME Yankee - Bath)	103	1240
Larrabee Rd T1 345/115 kV	BF_SRW_166 -1			>1630

- Steady state N-1-1 testing indicates the need to increase the thermal capacity of 115kV Section 207 (ME Yankee – Bath)
  - The re-dispatch of generation required to resolve overloads of 115 kV Section 207 exceeds the 1,200 MW criteria between contingencies
- Required capacity of Section 207 (BPS element) - 163 MVA LTE rating
  - Maximum loading under N-1-1 conditions was 158% of the existing 103 MVA LTE rating
  - Driven by the Section 375 outage and DCT 377/81

# Steady State N-1-1 Thermal Results

- The re-dispatch of generation assumed the upgrade of the Larrabee Road T1 345/115 kV transformer
- Analysis showed that all other Cluster related thermal overloads can be resolved with generation re-dispatch

# Upgrades Driven by Steady State N-1-1 Voltage Results

- Sizing of the proposed Western reactor
  - Increase the size from 40 to 70 MVAR and split into two 35 MVAR banks
  - Driven by high 345 kV voltage within Western resources for outage of multiple reactive devices
    - Limiting N-1-1 scenario - local STATCOM outage and local reactor contingency
    - Limiting system condition - Minimum Load Dispatch 7 (resource clusters in Maine offline)
- Other Reactors:
  - Pittsfield: 2 x 65 MVAR
  - North (main substation) S/S : 2 x 65 MVAR
  - North (mid) S/S : 1x 30 MVAR
  - North (most northerly) S/S : 1x 30 MVAR
  - Western S/S: 2x 35 MVAR
  - Western (most westerly) S/S : 2 x 35 MVAR

# Upgrades Driven by Steady State N-1-1 Voltage Results (cont'd)

- Design of the proposed Northern STATCOM
  - Split the proposed 400 MVAR STATCOM into two 200 MVAR STATCOMs and relocate them from the 345 kV Northern bus onto each of the 3031 and 3032 Lines
  - Driven by high 345 kV voltage within Northern Cluster for outage of multiple reactive devices
    - Limiting N-1-1 scenario - Northern reactor outage on Section 3032 and Hammond 3031 breaker failure contingency
    - Limiting system condition - Minimum Load Dispatch 7 (resource clusters in Maine offline)

# Stability Testing: BPS Base Case Setup

- BPS Testing
  - 2 Base Cases:

Generation Dispatch	ME_C_D1	SEMA_D2
Cluster 1 Generation	50%	50%
Cluster 2 Generation	50%	50%
<b>Interface Transfers (MW)</b>		
Orrington-South	1375	1193
Surowiec-South	2200	1890
Maine-New Hampshire	2000	1710
NNE Scobie + 394	3650	3195

- An additional ME\_C sensitivity dispatch was simulated w/ Northern Pass Transmission (NPT) in service



# Stability Testing: Normal Contingency (NC) and Extreme Contingency (EC) Base Case Setup

- NC/EC Testing
  - 4 Base Cases:

Generation Dispatch (MW)	LL_D3	LL_D4	LL_D5	PK_D5
Cluster 1 Generation	1118	795	1118	1118
Cluster 2 Generation	0	777	777	777
Interface Transfers (MW)				
New Brunswick-New England	1050	1050	1050	1050
Orrington-South	1375	1375	1080	1375
Surowiec-South	2200	2200	2200	2200
Maine-New Hampshire	2000	2000	2000	2000
NNE Scobie + 394	3650	3650	3650	3420
East-West	3500	3500	3500	3500
New York-New England	-1200	-1200	-1200	-1200

- An additional LL\_D5 sensitivity dispatch was simulated w/ Northern Pass Transmission (NPT) in service

# BPS Contingency List

- BPS Testing
  - Contingencies Tested

Number of ACT Faults by State	
Maine	
Emera	9
CMP	41
New Hampshire	
Eversource	28
National Grid	4
Massachusetts	
National Grid	67
NSTAR	101
Eversource	8
Vermont	
VELCO	4
Rhode Island	
National Grid	16
Connecticut	
Eversource	41
United Illumination	24
Total:	<b>343</b>

# Local NC and EC Contingency List

- Local NC/EC Testing
  - Contingencies Tested

Number of Local Faults by Station	
<b>Albion 345 kV</b>	
NC	1
EC	1
<b>Concord 345 kV</b>	
NC	1
EC	0
<b>Coopers Mills 345 kV</b>	
NC	5
EC	4
<b>Hammond 345 kV</b>	
NC	1
EC	0
<b>Larrabee 345 kV</b>	
NC	2
EC	0
<b>Maine Yankee 345 kV</b>	
NC	2
EC	2
<b>Orrington 345 kV</b>	
NC	3
EC	5
<b>Pittsfield 345 kV</b>	
NC	8
EC	3
<b>Surowiec 345 kV</b>	
NC	2
EC	2
Total:	<b>42</b>

# Remote EC Contingency List

- Remote EC Testing
  - Contingencies Tested

Number of SNE Faults by Station	
K Street 115 kV	
EC	2
Millbury 345 kV	
EC	1
Mystic 345 / 115 kV	
EC	3
N. Cambridge 345 kV	
EC	1
Wachusett 345 kV	
EC	1
W. Medway 345 kV	
EC	2
Total:	10

# Stability N-1 Simulations

- Stability N-1 tested a total of 1,289 fault/contingency combinations:

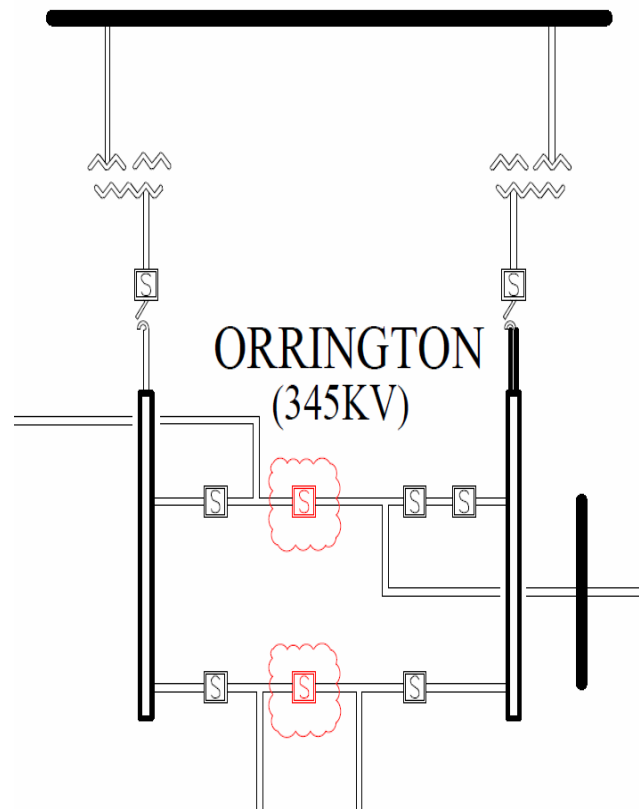
Fault Type	Number of faults	Simulated Dispatches								Number of Simulations
		ME_C_D1	SEMA_D2	ME_C_D1_NPT	LL_D3	LL_D4	LL_D5	LL_D5_NPT	PK_D5	
Local NC/EC	42				X	X	X	X	X	210
SNE	10				X	X	X	X	X	50
BPS	343	X	X	X						1,029
Total:										1,289

# Stability N-1 Results

- BPS testing showed no reclassifications
  - The new Pittsfield substation will be BPS
- All Local NC testing acceptable
- Two ECs failed and require Independent Pole Tripping on Orrington 345 kV breakers:
  - K390/388
  - K396/3023
- All SNE EC testing acceptable

# Upgrades Driven by Stability N-1 NC/EC Results

- Upgrade two Orrington 345 kV breakers to IPT



# Stability N-1-1 Testing

- Targeted analysis performed to screen for acceptable performance given allowable 1,200 MW generation/import reduction between the first and second contingencies
- 345 kV Line Outages tested:
  - 388, 3023N, 3030, 3033, 375, 3025, 3026, 3038
- With the allowable re-dispatch, all scenarios resulted in acceptable system response
  - 388 and 3023 outages required the most reduction in generation between contingencies to secure case



# PREVIEW OF OVERLAPPING IMPACT DELIVERABILITY

*Ability to meet the Capacity Capability Interconnection  
Standard*

# Expected Ability to Meet the Capacity Capability Interconnection Standard (CCIS)

- The availability of Capacity Network Resource Capability (CNRC) “headroom” on the Surowiec-South interface is a primary factor in the ability of the proposed resources to meet the CCIS
  - Surowiec-South already had approximately 200 MW of CNRC headroom
  - Surowiec-South is being increased by 600 MW
  - Assuming no increase in the upstream Orrington-South interface, and assuming no local constraints other than Surowiec-South, there would be room for approximately 800 MW of additional CNRC north of Surowiec-South
- Note that this is not the definitive determination of the ability to meet CCIS
  - Definitive evaluation takes place within the Capacity Network Resource (CNR) Group Study as part of Forward Capacity Market (FCM) qualification
- Note that wind resources are qualified for the FCM as intermittent resources
  - (Expected) output over specified (reliability) peak hours in each season
  - Typically, on-shore wind resources are qualified with summer capacity at approximately 15-20% of their nameplate capability

# Next Steps – Targeted for June PAC

- Transmission Owners prepare cost estimates
- Calculate associated cost allocations
- Issue Draft Report for Comment

# Questions

