



# 2016 Maine Resource Integration Study – Steady State Results

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*Planning Advisory Committee*

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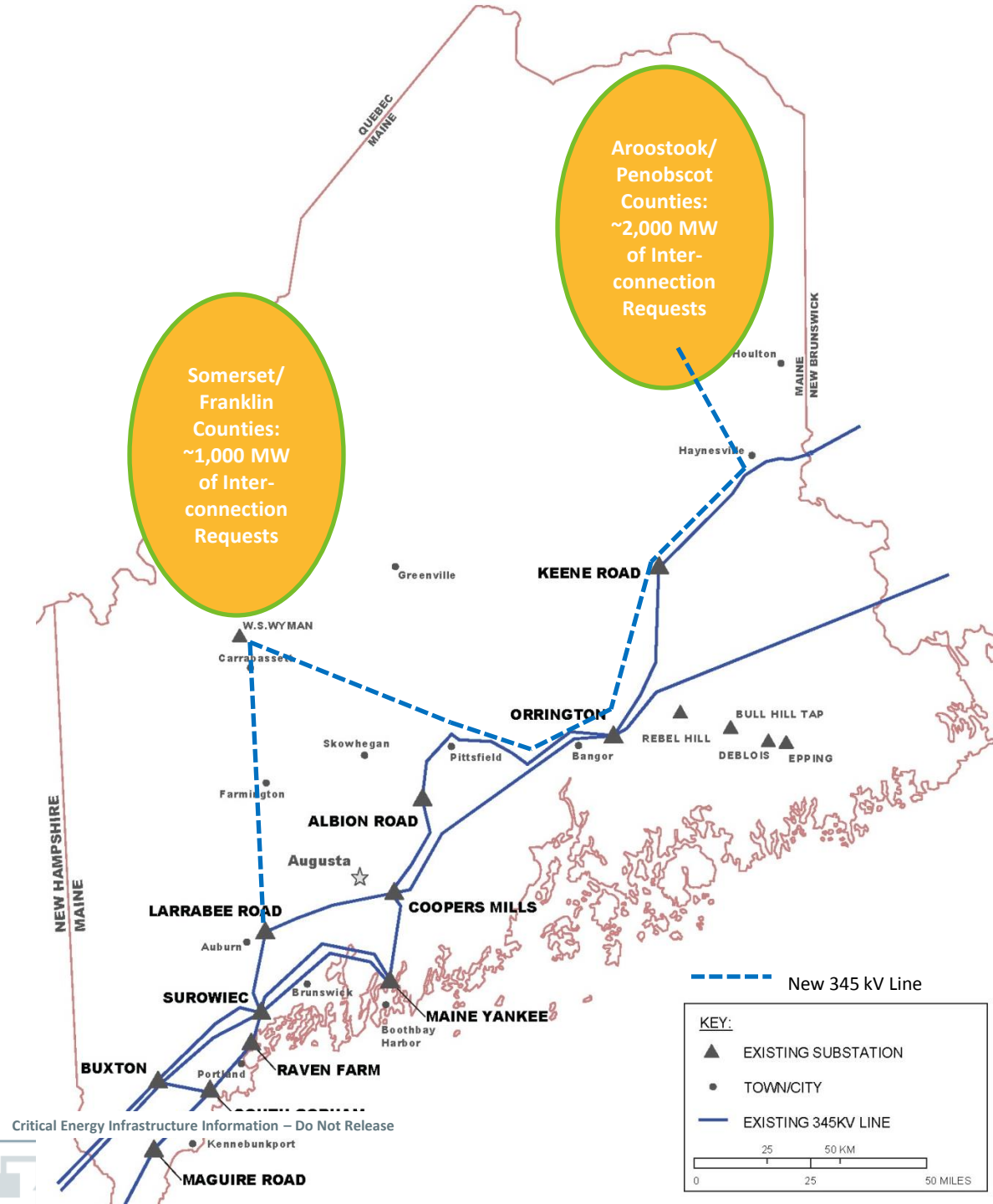
SYSTEM PLANNING

# 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 2016 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

# 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



# Testing

- Steady State Thermal (Northern, Western & Combination)
  - N-1
  - N-1-1
- Steady State Voltage
  - N-1
- Inverter-Based/Weak Grid Issues
  - Reactive Support
  - Low Short Circuit Ratio
- Stability Testing
  - Local and some remote (BPS impact) testing
  - Use real queue generation data to the extent possible

Completed  
Analyses

Next  
Steps

# Steady State

## Summer Peak Load Base Case Conditions

Interface Flows (MW)	Generation Dispatch (MW)	
New Brunswick-New England = 1049	Belldune	480
Orrington South = 1359	Mactaquac	290
Surowiec South = 1494	Bayside	170
Maine- New Hampshire = 1922	Coleson Cove	300
	Pt. Lepreau	705
	Mckay Hydro	33
	Jimmy Owl	26
	Stetson	57
	Dundee	33
	Rollins	27
	Passadumkeag	40
	MIS	310
	Oakfield	148
	Pisgah	9
	Bull Hill	34
	Bucksport	0
	Kibby	132
	QP333 Wind	185
	VERSO Cogen AEC	165
	Rumford Power	277
	Newpage Cogen	110
	Record Hill	51
	Sappi Somerset	97
	Westbrook Energy	539
	Yarmouth 4	623

# N-1 THERMAL TESTING



# Steady State N-1 Thermal Results

- Thermal transfer analysis for each interconnection area:
  - Northern Maine
    - 4 Potential Configurations (with no Western Injection)
  - Western Maine
    - 4 Potential Configurations (with no Northern Injection)
- Thermal transfer analysis for a combination using a configuration from each area
  - With simultaneous injections in both the North and the West
- All N-1 thermal transfer analyses used Short Time Emergency ratings

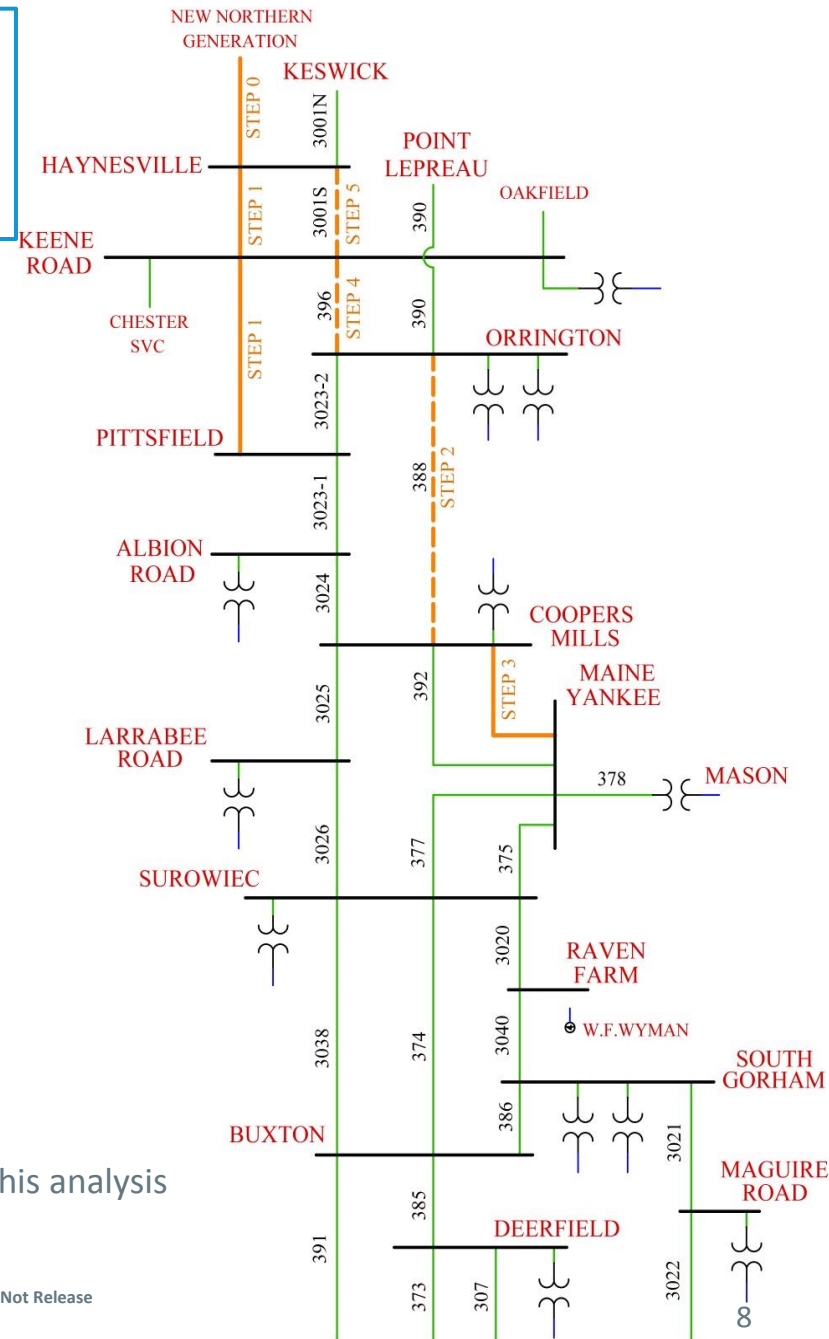
# New Northern Gen.

## Option 1 - Interconnect at Haynesville, Keene Road, and Pittsfield\*\*

(New Gen. to Haynesville to Keene Road to Pittsfield)				
Step	Add New Line(s) or Upgrade the Listed Existing Line	Next Most-Limiting Element	Limiting Contingency	Available MW Injection*
0	Add New Connection to Haynesville (S.3001 Interconnection)	S.396 (Orr.-Keene Rd)	Orrington K390-1 Breaker Failure	132
1	New Lines (Pittsfield-Keene Rd & Keene Rd - Haynes.)	S.388 (Orrington-Coopers)	Any Albion Road Stuck Breaker	368
			S.3023-1 (Albion-Pittsfield)	390
2	S.388 (Orrington-Coopers)	S.392 (Coopers-ME Yankee)	S.3025 (Coopers-Larrabee)	422
3	Build Parallel S.392 (Coopers-ME Yankee)	S.396 (Orr.-Keene Rd)	New Line (Pittsfield-Keene Rd)	508
4	S.396 (Orr.-Keene Rd)	S.3001S (Keene Rd-Haynes.)	New Line (Keene Rd-Haynes.)	720
5	S.3001S (Keene Rd-Haynes.)	S.3038/374 (Buxton-Surowiec)	S.3040 (South Gorham-Raven)	992

\*In order to compare options on an incremental basis, no re-dispatch north of Maine-New Hampshire was conducted in this analysis

\*\*The approximate locations of Haynesville & Pittsfield are shown on the map on slide 3

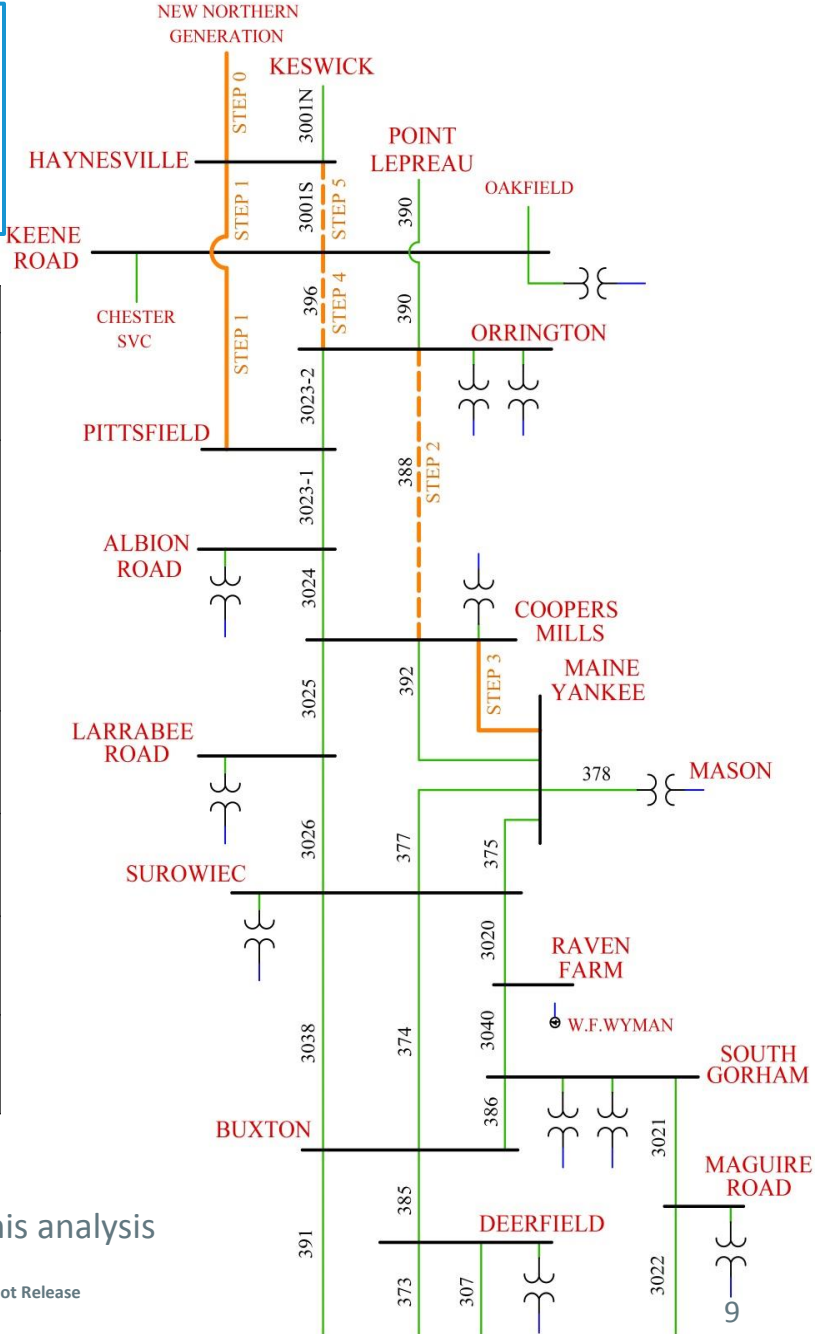




**New Northern Gen.**  
**Option 2 - Interconnect at Haynesville**  
**and Pittsfield. Bypass Keene Road.**

(New Generation to Haynesville to Pittsfield)				
Step	Add New Line(s) or Upgrade the Listed Existing Line	Next Most-Limiting Element	Limiting Contingency	Available MW Injection*
0	Add New Gen. (Haynesville/S.3001 Interconnection)	S.396 (Orr.-Keene Rd)	Orrington K390-1 Breaker Failure	132
1	New Line (Pittsfield-Haynes.)	S.388 (Orrington-Coopers)	Any Albion Road Stuck Breaker	369
			S.3023-1 (Albion-Pittsfield)	391
2	S.388 (Orrington-Coopers)	S.392 (Coopers-ME Yankee)	S.3025 (Coopers-Larrabee)	422
3	Build Parallel S.392 (Coopers-ME Yankee)	S.396 (Orr.-Keene Rd)	New Line (Pittsfield-Haynes.)	581
4	S.396 (Orr.-Keene Rd)	S.3001S (Keene Rd-Haynes.)	New Line (Pittsfield-Haynes.)	820
5	S.3001S (Keene Rd-Haynes.)	S.3038/374 (Buxton-Surowiec)	S.3040 (South Gorham-Raven)	992

\*In order to compare options on an incremental basis, no re-dispatch north of Maine-New Hampshire was conducted in this analysis



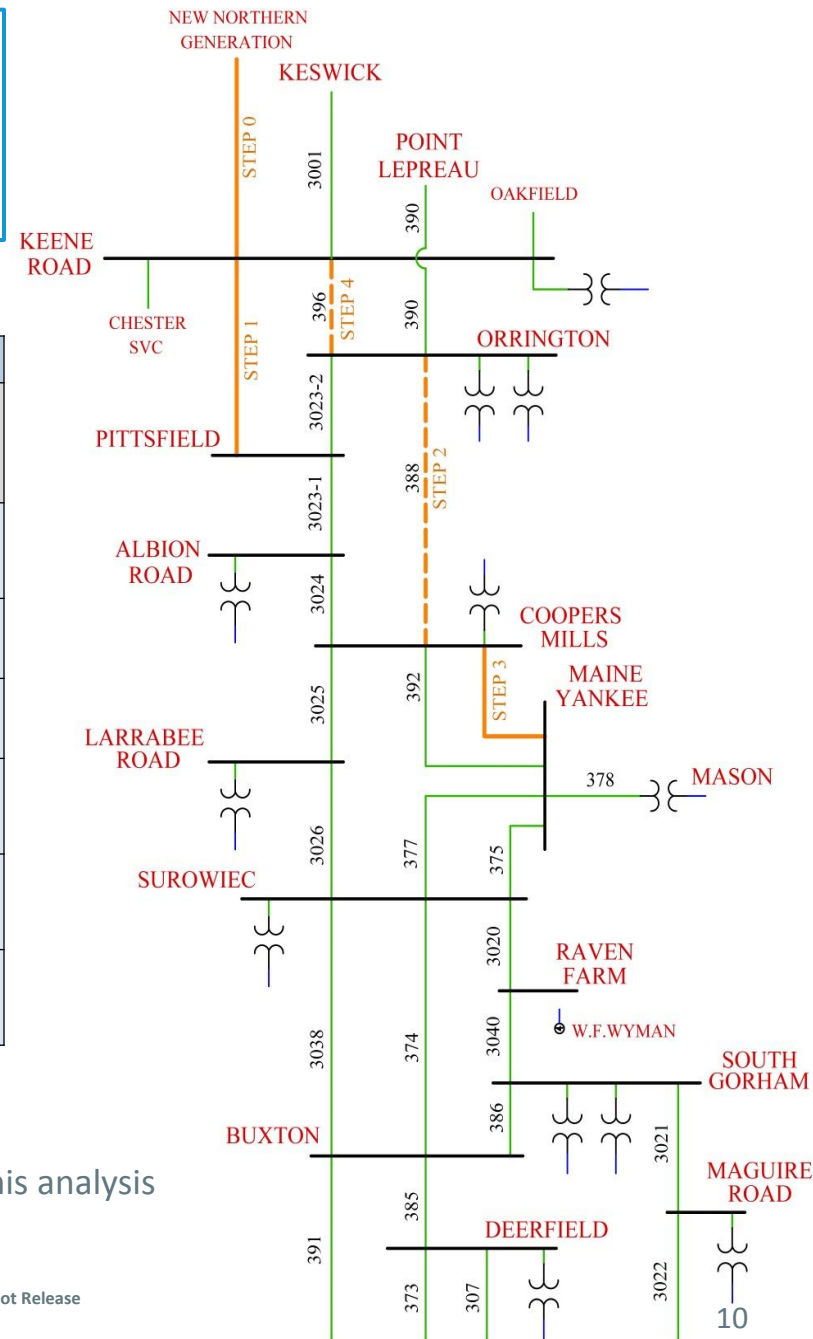
# New Northern Gen.

## Option 3 - Interconnect at Keene Road and Pittsfield. Bypass Haynesville.

(New Generation to Keene Road to Pittsfield)

Step	Add New Line(s) or Upgrade the Listed Existing Line	Next Most-Limiting Element	Limiting Contingency	Available MW Injection*
0	Add New Gen. (Keene Rd.-New Gen.)	S.396 (Orr.-Keene Rd)	Orrington K390-1 Breaker Failure	132
1	New Lines (Pittsfield-Keene Rd.)	S.388 (Orrington-Coopers)	Any Albion Road Stuck Breaker	371
			S.3023-1 (Albion-Pittsfield)	393
2	S.388 (Orrington-Coopers)	S.392 (Coopers-ME Yankee)	S.3025 (Coopers-Larrabee)	424
3	Build Parallel S.392 (Coopers-ME Yankee)	S.396 (Orr.-Keene Rd)	New Line (Pittsfield-Keene Rd.)	502
4	S.396 (Orr.-Keene Rd)	S.3038/374 (Buxton-Surowiec)	S.3040 (South Gorham-Raven)	995

\*In order to compare options on an incremental basis, no re-dispatch north of Maine-New Hampshire was conducted in this analysis



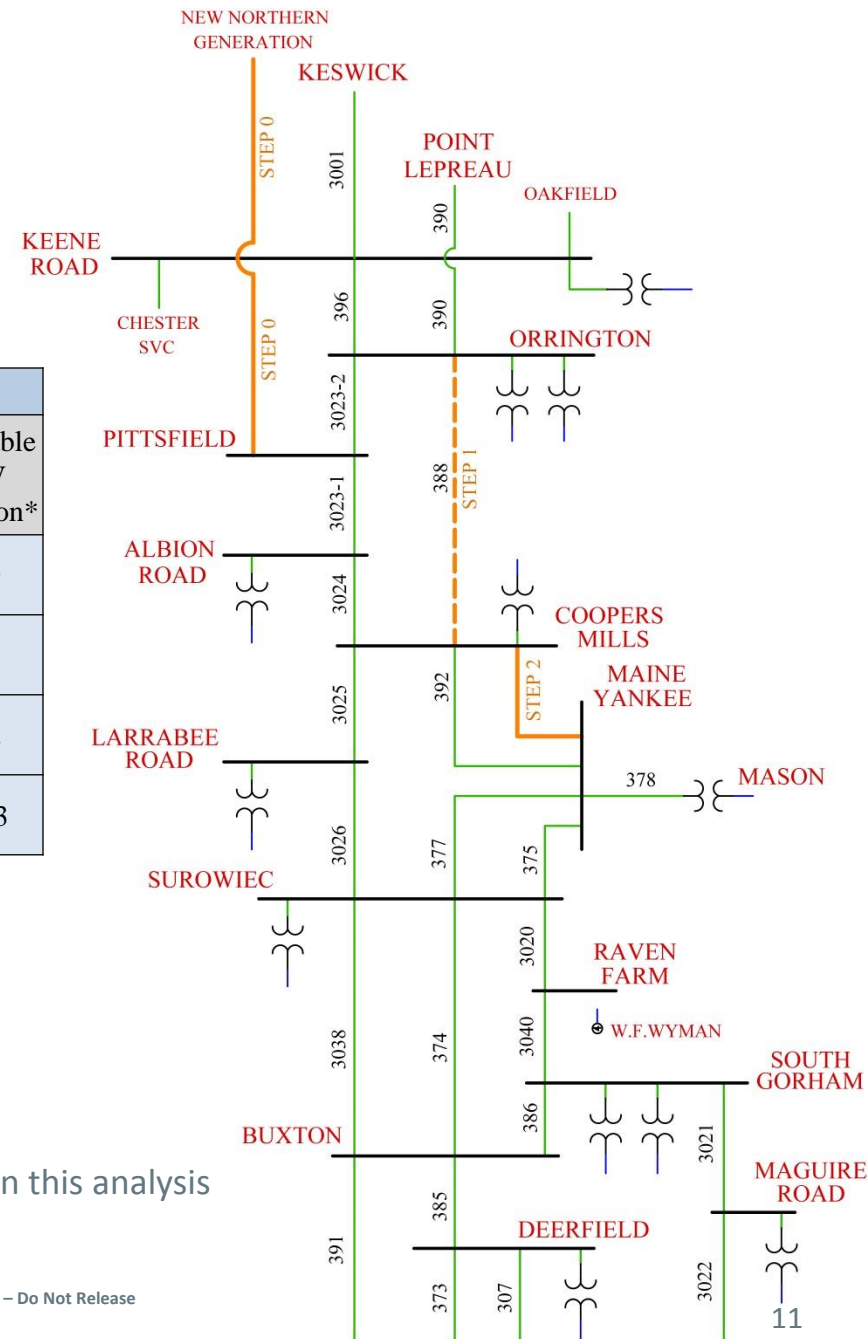
# New Northern Gen.

## Option 4 - Interconnect at Pittsfield. Bypass Haynesville and Keene Road.

(New Generation to Pittsfield)

Step	Add New Line(s) or Upgrade the Listed Existing Line	Next Most-Limiting Element	Limiting Contingency	Available MW Injection*
0	Add New Gen. (Pittsfield-New Gen.)	S.388 (Orrington-Coopers)	Any Albion Road Stuck Breaker	379
			S.3023-1 (Albion-Pittsfield)	401
1	S.388 (Orrington-Coopers)	S.392 (Coopers-ME Yankee)	S.3025 (Coopers-Larrabee)	432
2	Build Parallel S.392 (Coopers-ME Yankee)	S.3038/374 (Buxton-Surowiec)	S.3040 (South Gorham-Raven)	1003

\*In order to compare options on an incremental basis,  
no re-dispatch north of Maine-New Hampshire was conducted in this analysis

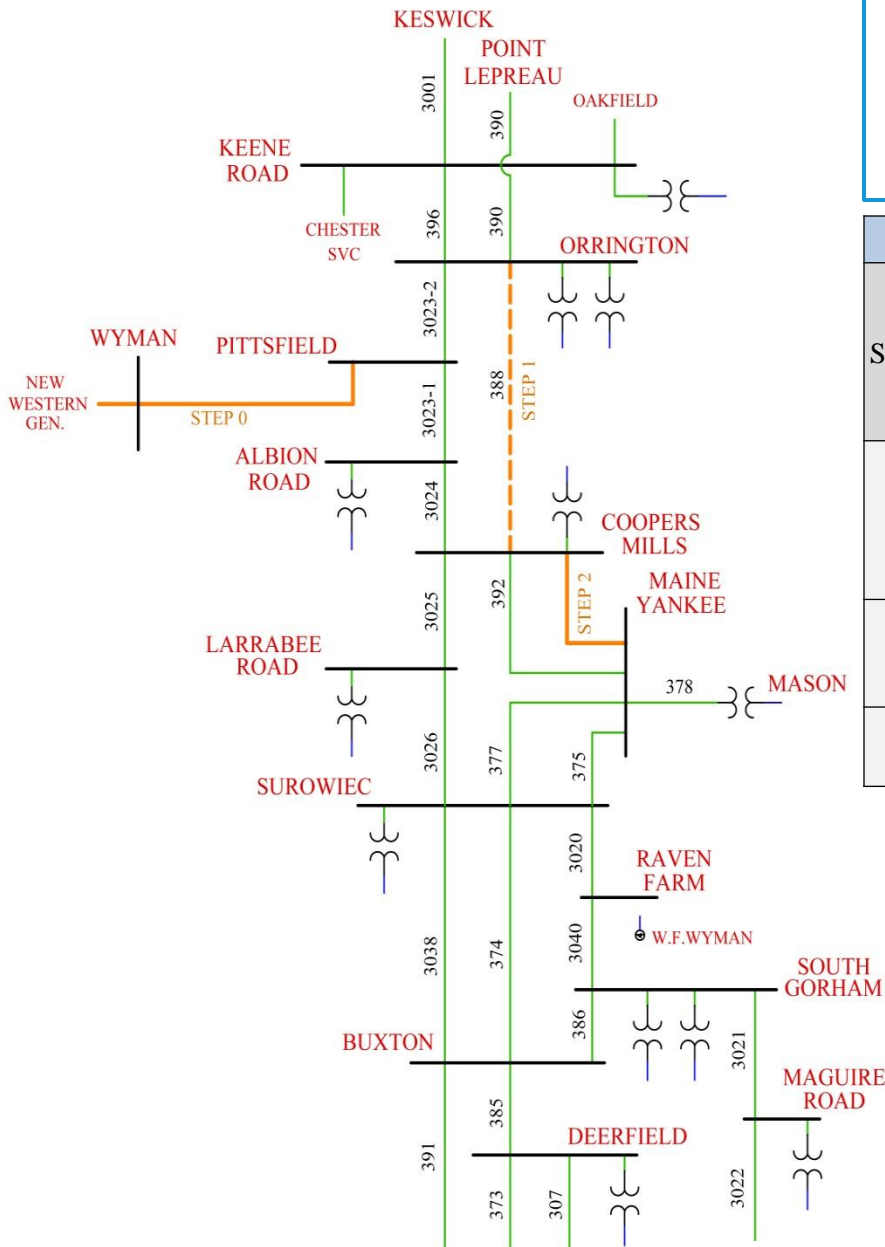


# Northern Results Comparison

Step	Add New Line(s) or Upgrade the Listed Existing Line	Option 1	Option 2	Option 3	Option 4
		Keene Road & Haynes. Interconnect	Keene Road Bypass	Haynesville Bypass	Haynesville & Keene Road Bypass
		Available MW Injections			
0	New Line to New Gen. (Keene Rd or Haynesville)	132	132	132	379
1	New Lines (Some Variation of Pittsfield to New Gen.)	368	369	371	
2	S.388 (Orrington-Coopers Mills)	422	422	424	432
3	Build Parallel S.392 (Coopers Mills-ME Yankee)	508	581	502	1003
4	S.396 (Orrington-Keene Road)	720	820	995	Note B
5	S.3001S (Keene Rd-Haynesville)	992	992	Note A	
Note A: With Haynesville bypassed (no longer tapping S.3001) thermal loading of S.3001S is no longer an issue					
Note B: With Haynesville bypassed (no longer tapping S.3001) and Keene Road also bypassed (creating direct path from Generation to Pittsfield) thermal loading on Sections 396 and 3001S are no longer an issue					

# New Western Gen.

## Option 1 – Interconnect at Pittsfield from Wyman Western Gen.



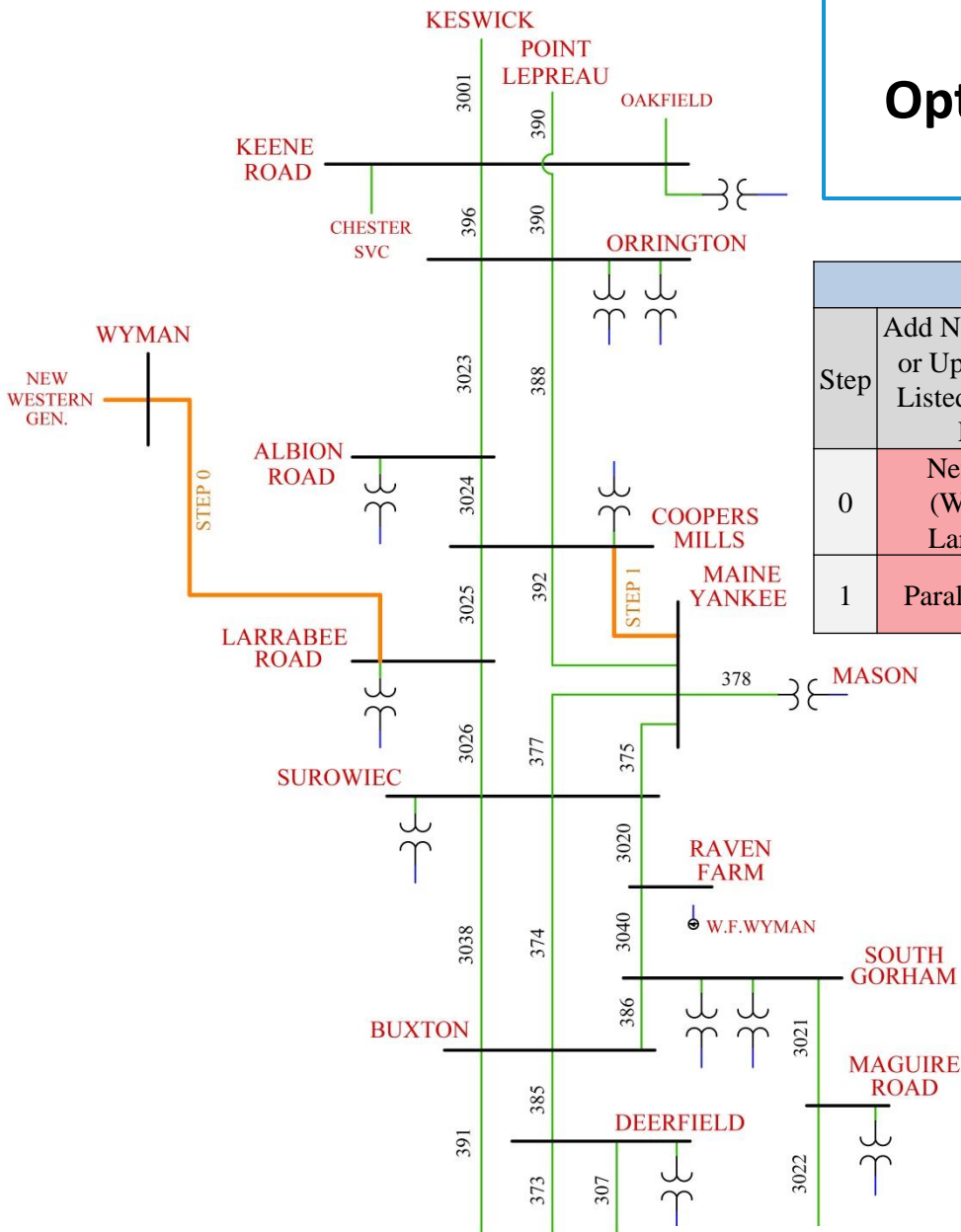
(Pittsfield to Wyman)

Step	Add New Line(s) or Upgrade the Listed Existing Line	Next Most-Limiting Element	Limiting Contingency	Available MW Injection*
0	New Line (Pittsfield-Wyman)	S.388 (Orrington-Coopers)	Any Albion Road Stuck Breaker	383
			S.3023-1 (Pittsfield-Albion)	404
1	S.388 (Orrington-Coopers)	S.392 (Coopers-ME Yankee)	S.3025 (Coopers-Larrabee)	433
2	Parallel S.392	S.3038 (Surowiec-Buxton)	S.3040 (S.Gorham-Raven)	1004

\*In order to compare options on an incremental basis, no re-dispatch north of Maine-New Hampshire was conducted in this analysis

# New Western Gen.

## Option 2a – Interconnect at Larrabee from Wyman Western Gen.



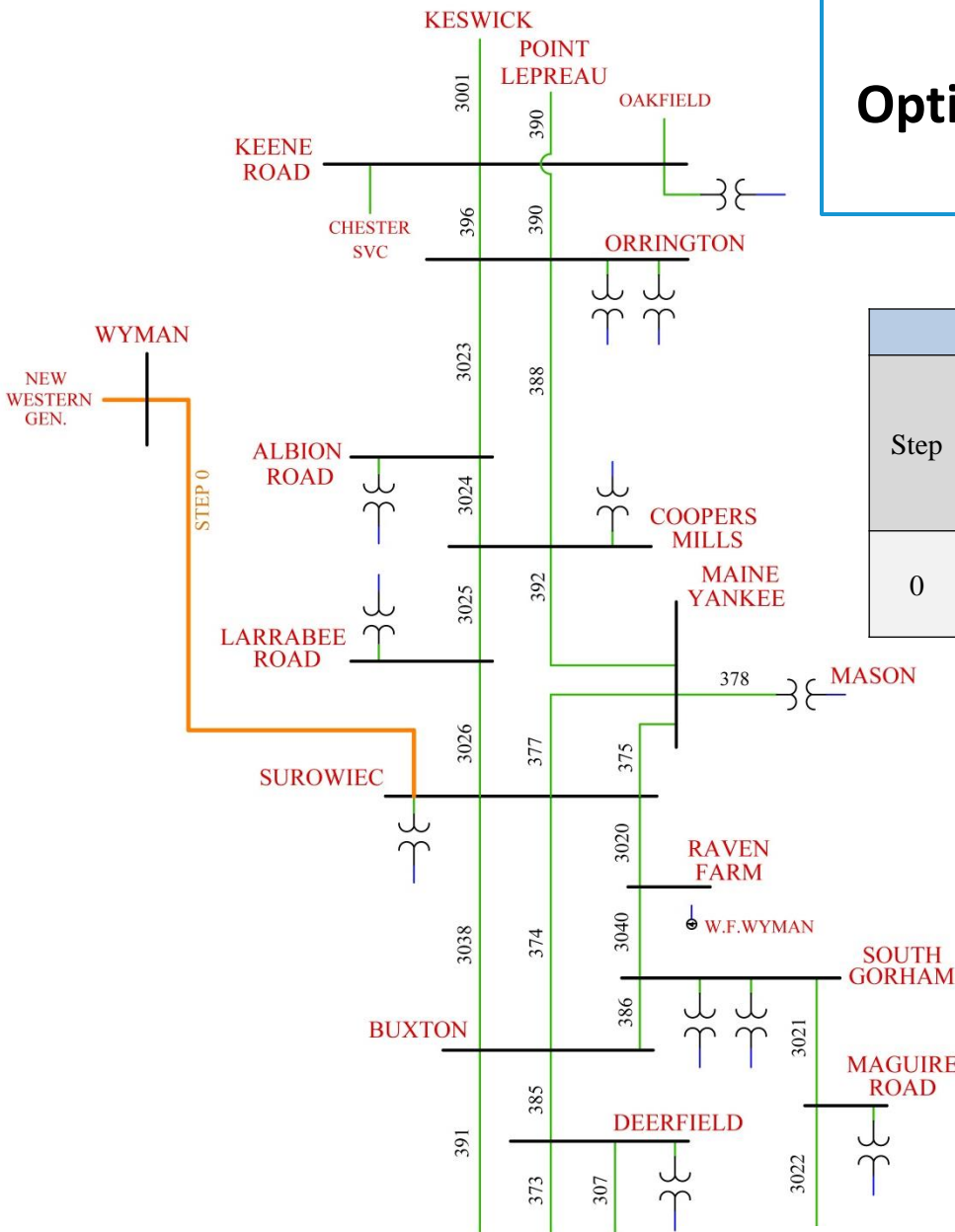
(Wyman to Larrabee)

Step	Add New Line(s) or Upgrade the Listed Existing Line	Next Most-Limiting Element	Limiting Contingency	Available MW Injection*
0	New Line (Wyman-Larrabee)	S.392 (Coopers-ME Yankee)	S.3026 (Larrabee-Surowiec)	660
1	Parallel S.392	S.3038 (Surowiec-Buxton)	S.3040 (S.Gorham-Raven)	1001

\*In order to compare options on an incremental basis, no re-dispatch north of Maine-New Hampshire was conducted in this analysis

# New Western Gen.

## Option 2b – Interconnect at Surowiec from Wyman Western Gen.



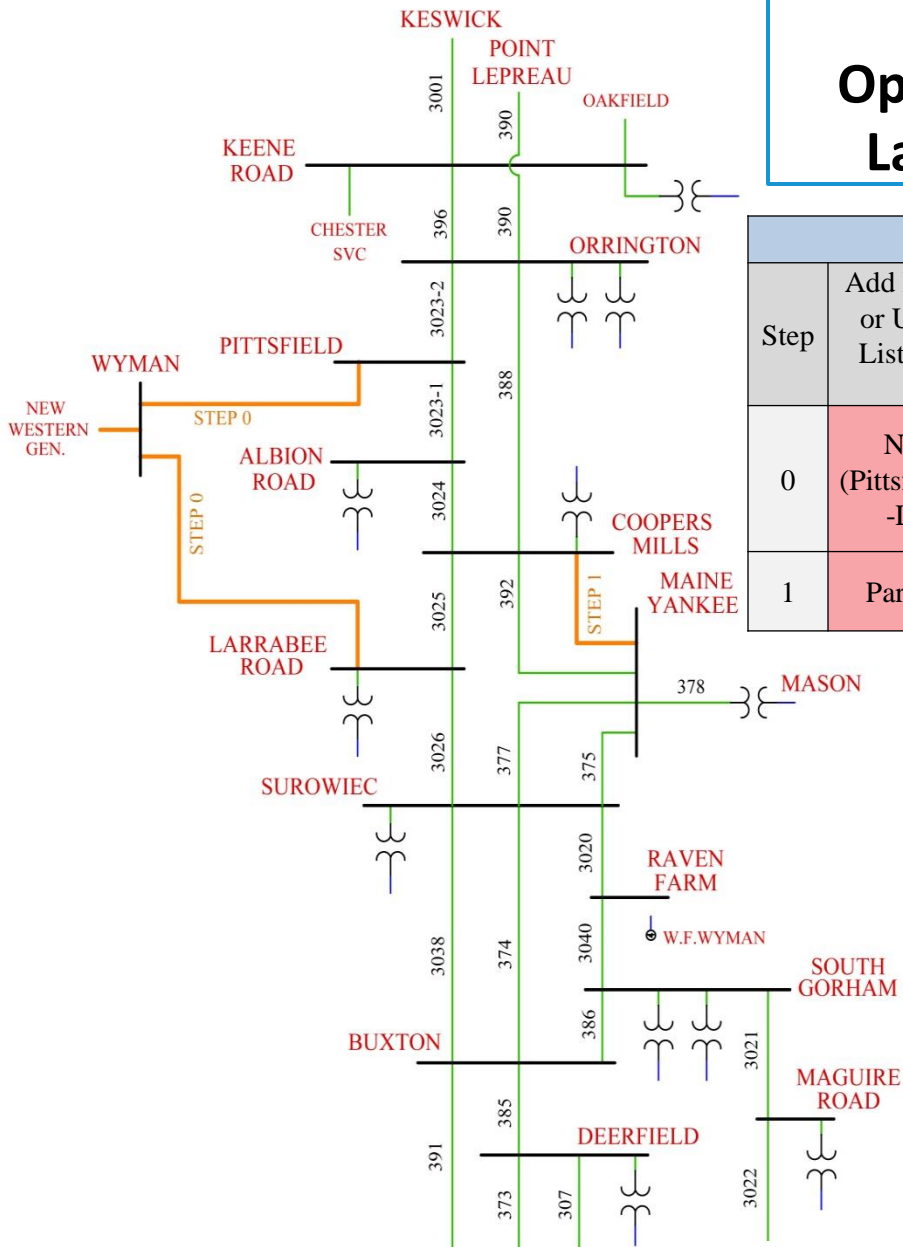
(Wyman to Surowiec)				
Step	Add New Line(s) or Upgrade the Listed Existing Line	Next Most-Limiting Element	Limiting Contingency	Available MW Injection*
0	New Line (Wyman-Surowiec)	S.374/3038 (Surowiec-Buxton)	S.3040 (S.Gorham-Raven)	984

\*In order to compare options on an incremental basis, no re-dispatch north of Maine-New Hampshire was conducted in this analysis



# New Western Gen.

## Option 3 – Interconnect at Pittsfield and Larrabee from Wyman Western Gen.



(Pittsfield to Wyman to Larrabee)

Step	Add New Line(s) or Upgrade the Listed Existing Line	Next Most-Limiting Element	Limiting Contingency	Available MW Injection*
0	New Lines (Pittsfield-Wyman-Larrabee)	S.392 (Coopers-ME Yankee)	Larrabee K3025/NEW Stuck Breaker	429
			S.3026 (Larrabee-Surowiec)	624
1	Parallel S.392	S.3038 (Surowiec-Buxton)	S.3040 (S.Gorham-Raven)	996

\*In order to compare options on an incremental basis, no re-dispatch north of Maine-New Hampshire was conducted in this analysis



# Western Results Comparison

Step	Add New Line(s) or Upgrade the Listed Existing Line	Option W1	Option W2a	Option W2b	Option W3
		Wyman to Pittsfield	Wyman to Larrabee	Wyman to Surowiec	Pittsfield to Wyman to Larrabee
		Available MW Injections			
0	New Line(s) <i>(Pittsfield-Wyman-Larrabee)</i>	383	660*	984	624*
1	S.388 <i>(Orrington-Coopers)</i>	433	Note A		
2	S.392 <i>(Coopers-ME Yankee)</i>	1004	1001	Note B	996
Note A: With the injection point below Pittsfield the thermal loading of S.388 is no longer an issue					
Note B: With the injection point below Larrabee Road the thermal loading of S.392 is no longer an issue					
*Larrabee K3025/NEW Breaker will be doubled as part of this Option					

# Northern and Western Combination

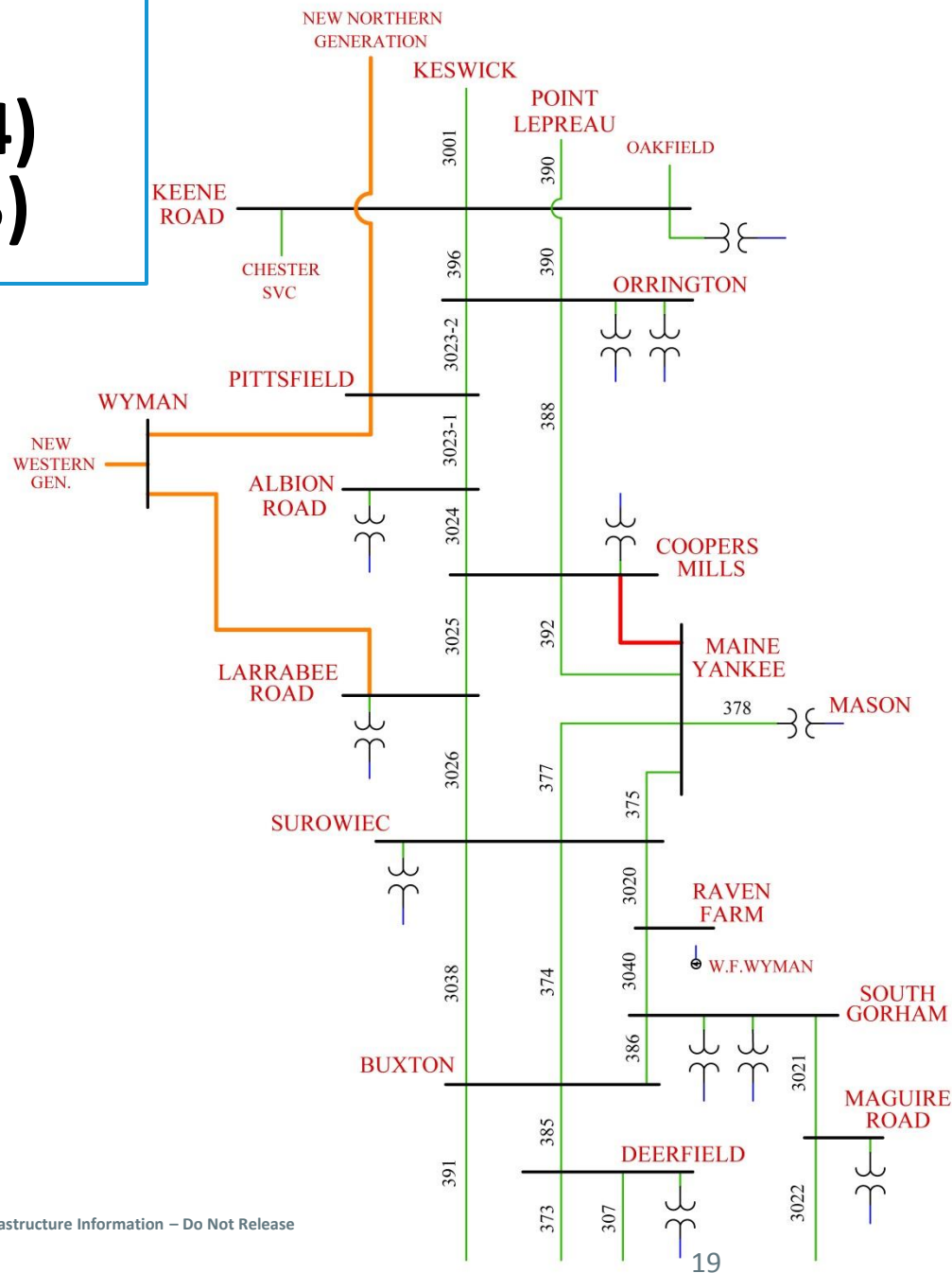
- The Northern Option 4 was chosen together with the Western Option 3 because this provided a complete new 345 kV path from Aroostook County down to Larrabee Road
  - Other combinations may be reviewed based on further testing

# Combination:

## Northern Option 4 (N4)

## Western Option 3 (W3)

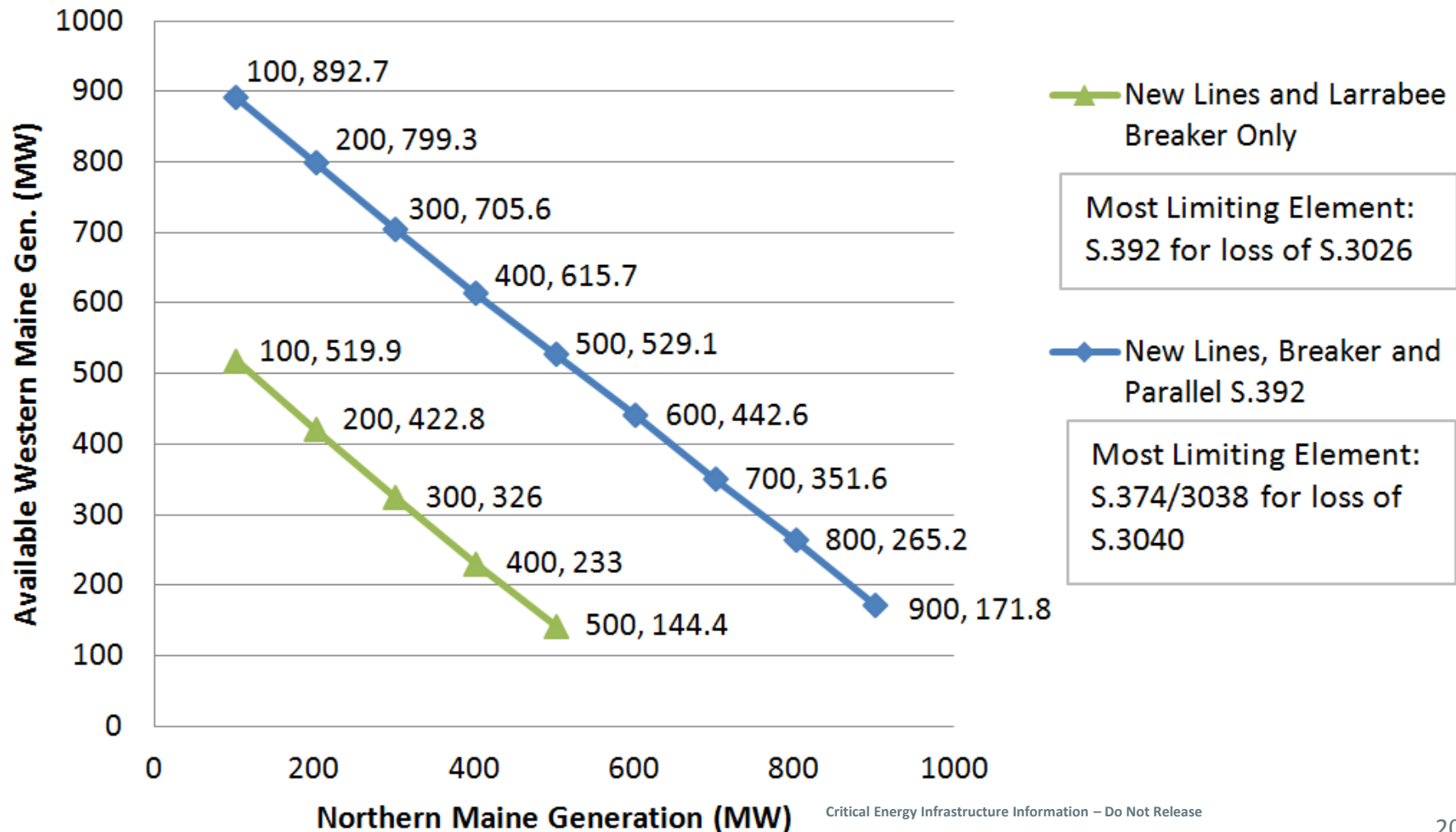
(Pittsfield to New Northern Generation) (Pittsfield to Wyman to Larrabee)		
Fixed Generation Added in the North (MW)	Available Injection from the West (MW)	
	Options N4+W3 + Additional Larrabee Breaker	Options N4+W3 + Additional Larrabee Breaker + New Parallel S.392
100	519.9	892.7
200	422.8	799.3
300	326	705.6
400	233	615.7
500	144.4	529.1
600	-	442.6
700	-	351.6
800	-	265.2
900	-	171.8



# Nomogram of Combination Analysis

North: Option 4 (Northern Generation direct to Pittsfield)

West: Option 3 (Pittsfield to Wyman to Larrabee)



# N-1-1 THERMAL TESTING

# Steady State N-1-1 Thermal Results

- Thermal transfer analysis for each interconnection area:
  - Northern Maine
    - 4 Potential Configurations (with no Western Injection)
  - Western Maine
    - 4 Potential Configurations (with no Northern Injection)
- Thermal transfer analysis for a combination using a configuration from each area
  - With simultaneous injections in both the North and the West

# N-1-1 Criteria Used

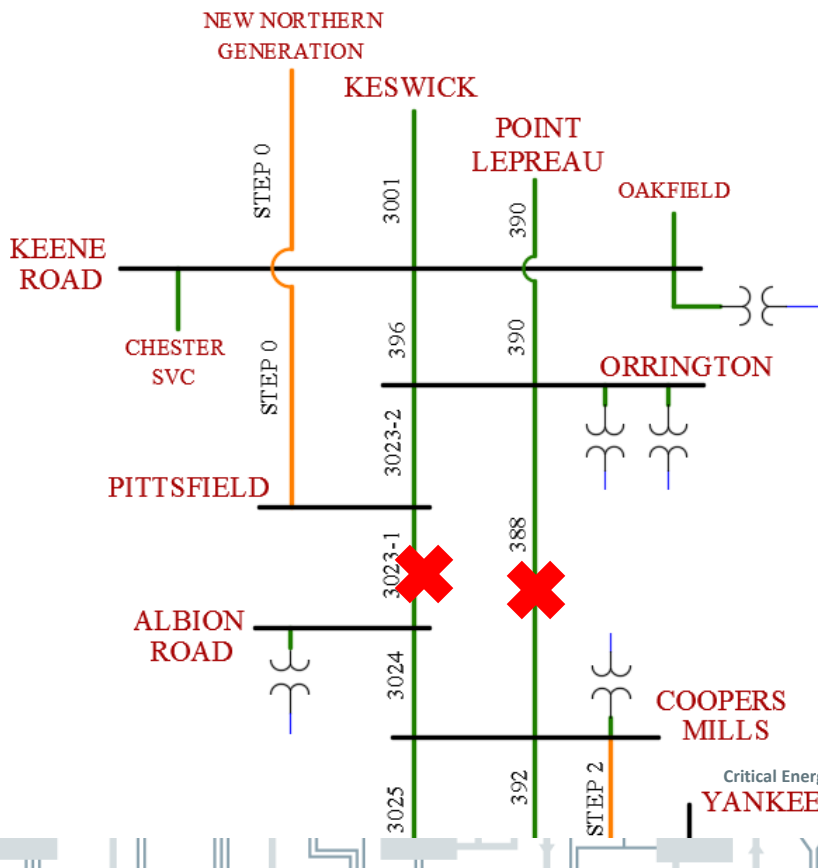
- Up to 1200 MW back down allowed:
  - New Brunswick
  - Existing Generation
  - New Generation
- Line Outages – All Maine 345kV Lines
- N-1-1 limits respect Long Time Emergency ratings

# Northern N-1-1 Thermal Results

First Level Outage	Contingency	Monitored Facility	LTE Rating	Option 1	Option 2	Option 3	Option 4
				Haynes. & Keene Road Interconnect	Keene Road Bypassed	Haynes. Bypassed	Haynes. & Keene Road Bypassed
				Available MW Injections			
LN_3023-1	Orrington K390/388 <i>(Several Contingencies)</i>	CMP_65_EM 115 BUCKSPORT 115 1	193	<b>345</b>	<b>344</b>	<b>345</b>	<b>346</b>

One line diagram for Option 4

Note that all 4 options were tested



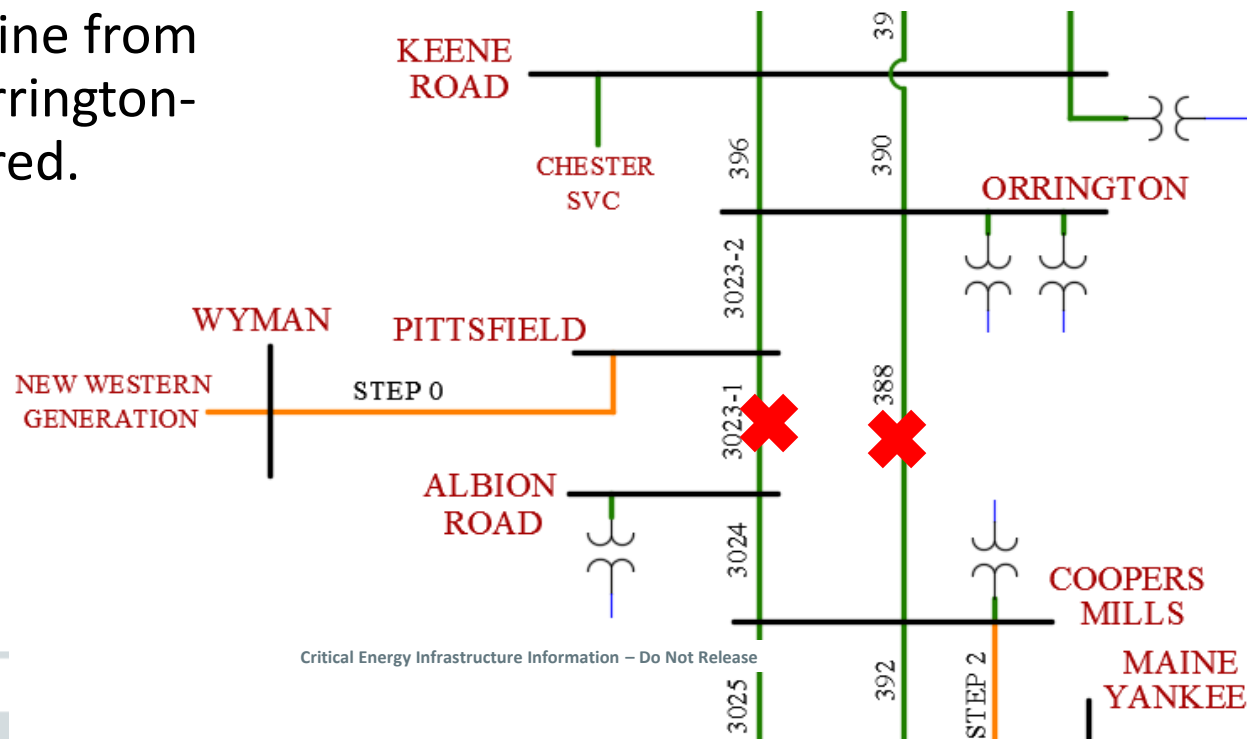
The N-1-1 Limit for all Options is approx 345 MW – additional upgrades defined in the N-1 analysis will not increase this limit. In order to increase this limit another line from Pittsfield or Orrington-South is required.



# Western N-1-1 Thermal Results – Option 1

The N-1-1 Limit for Western Option 1 is approx 345 MW – additional upgrades defined in the N-1 analysis will not increase this limit. In order to increase this limit another line from Pittsfield or Orrington-South is required.

First Level Outage	Contingency	Monitored Facility	LTE Rating	Option 1
				Pittsfield-Wyman
				Available MW Injection
LN_3023-1	Orrington K390/388 (Several Contingencies)	CMP_65_EM 115 BUCKSPORT 115 1	193	<b>344</b>

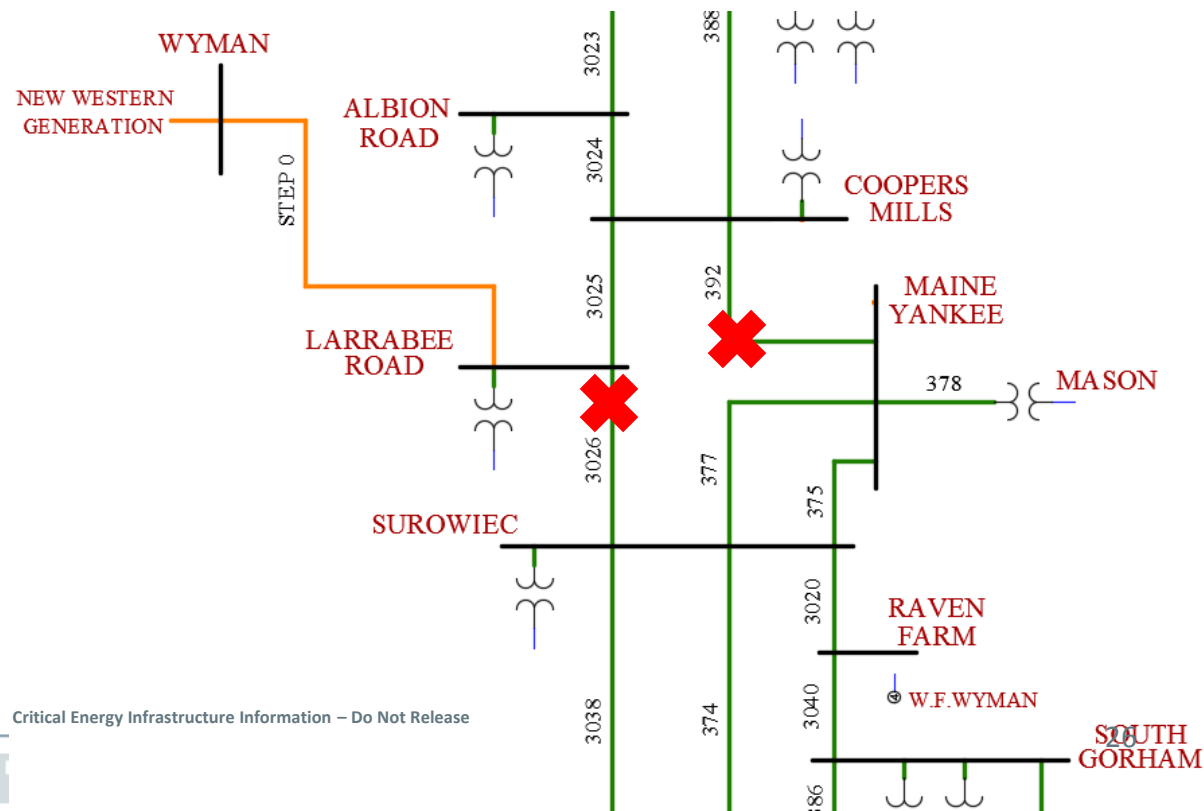


# Western N-1-1 Thermal Results – Option 2a

## (Step 0 Only)

The N-1-1 Limit for Western Option 2a modeling the addition of the new line from Wyman to Larrabee Road only. In order to increase the amount of generation to greater than 460 MW a parallel S.392 would need to be added.

First Level Outage	Contingency	Monitored Facility	LTE Rating	Option 2a
				Wyman-Larrabee
				Available MW Injection
LN_3026	LN_392	CROWLEYS 115 SUROWIEC 115 1 <i>(Several Elements Overloaded)</i>	226	<b>460</b>

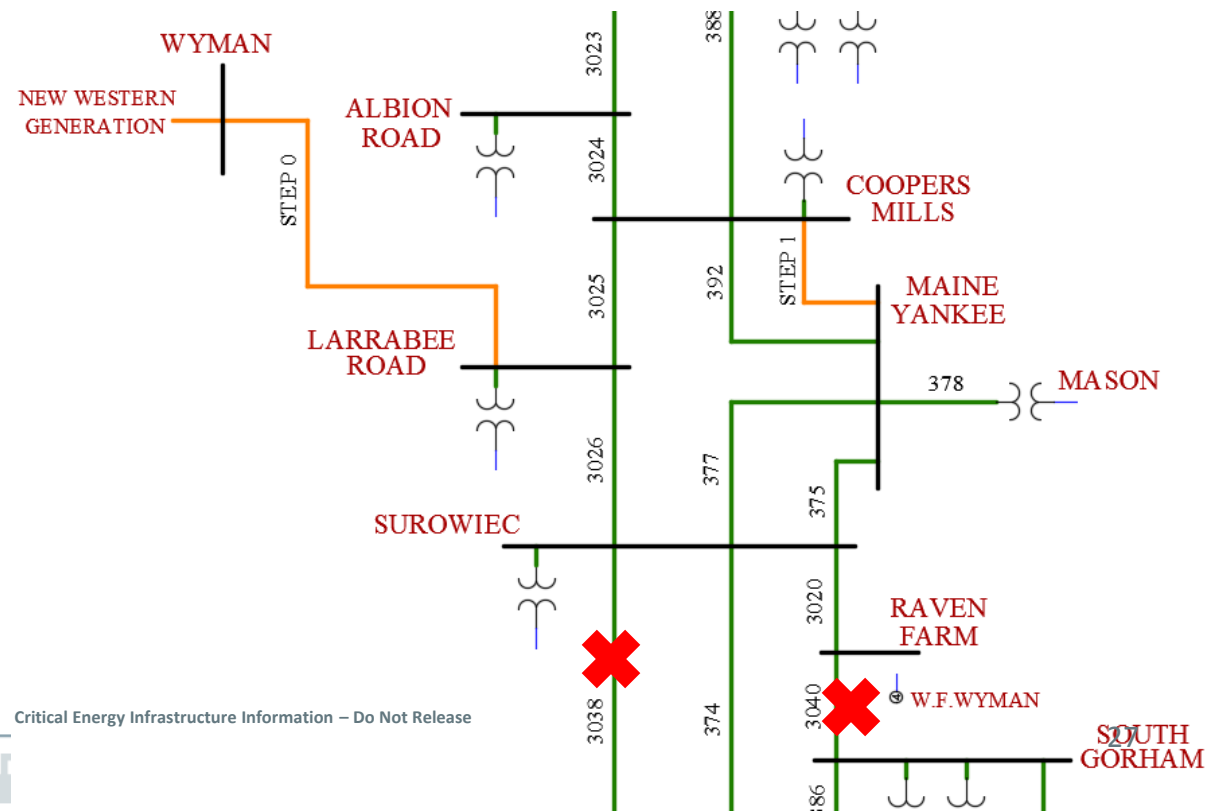


# Western N-1-1 Thermal Results – Option 2a

## (Step 0 & Step 1 Upgrades)

The N-1-1 Limit for Western Option 2a which includes a parallel S.392 the amount of generation is increased to 785 MW.

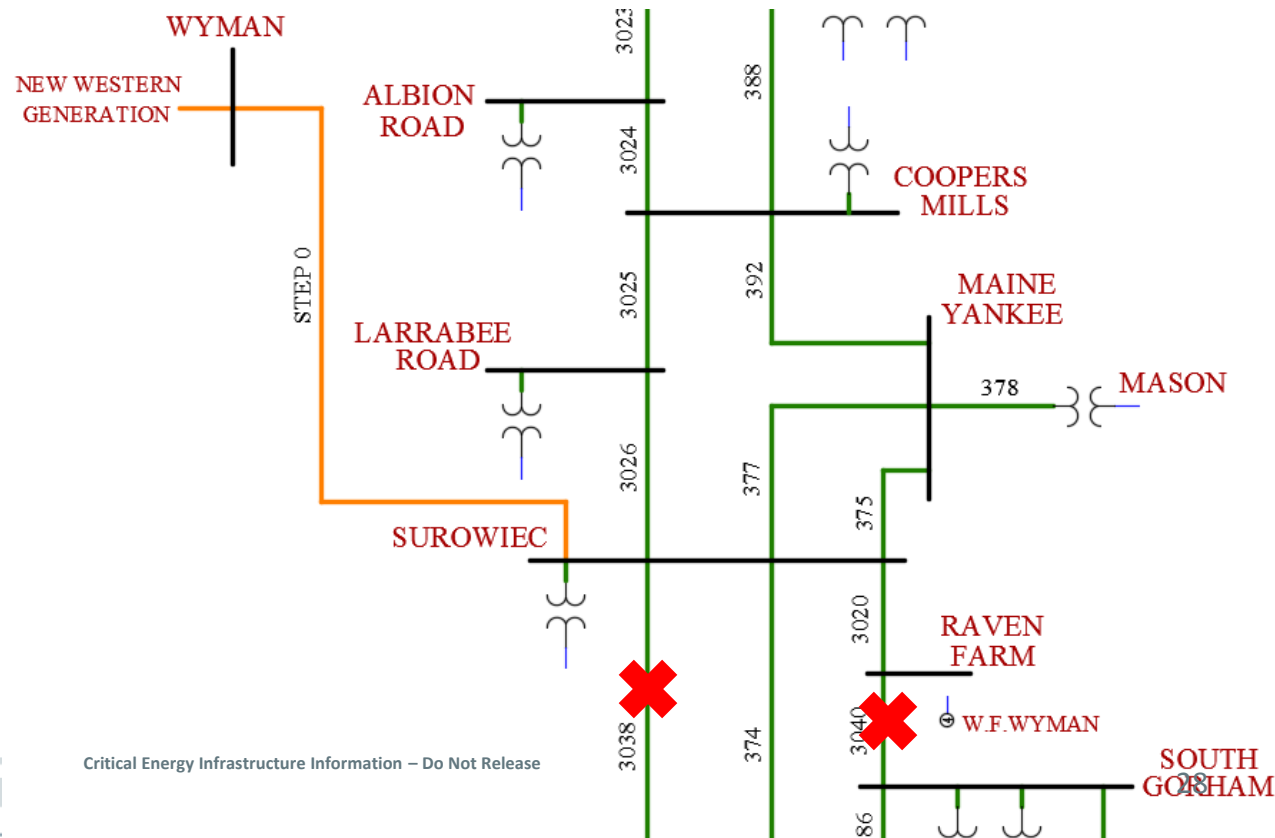
First Level Outage	Contingency	Monitored Facility	LTE Rating	Option 2a
				Wyman-Larrabee
				Available MW Injection
S.374/3038 (Surowiec-Buxton)	S.3040 (S.Gorham-Raven)	S.374/3038 (Surowiec-Buxton)	1429	<b>785</b>



# Western N-1-1 Thermal Results – Option 2b

The N-1-1 Limit for Western Option 2b is approx 866 MW.

First Level Outage	Contingency	Monitored Facility	LTE Rating	Option 2b
				Wyman-Surowiec
				Available MW Injection
LN_3038	LN_3040	SUROWIEC 345 BUXTON 345 1	1429	<b>866</b>

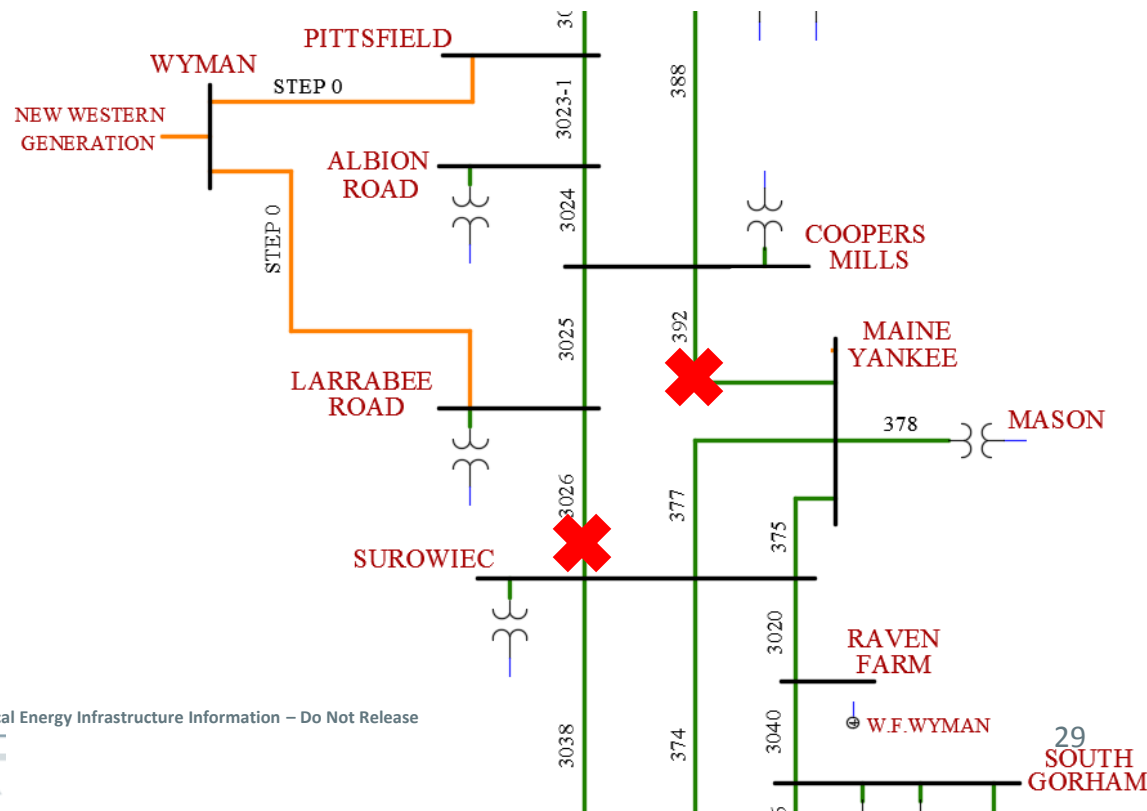


# Western N-1-1 Thermal Results – Option 3

## (Step 0 Only)

The N-1-1 Limit for Western Option 3 modeling the addition of the new lines from Pittsfield to Wyman to Larrabee Road only. In order to increase the amount of generation to greater than 446 MW a parallel S.392 would need to be added.

First Level Outage	Contingency	Monitored Facility	LTE Rating	Option 3
				Pitts.-Wyman-Larrabee & Larr.BKR
				Available MW Injection
LN_3026	LN_392	CROWLEYS 115 SUROWIEC 115 1 <i>(Several Elements Overloaded)</i>	226	<b>466</b>

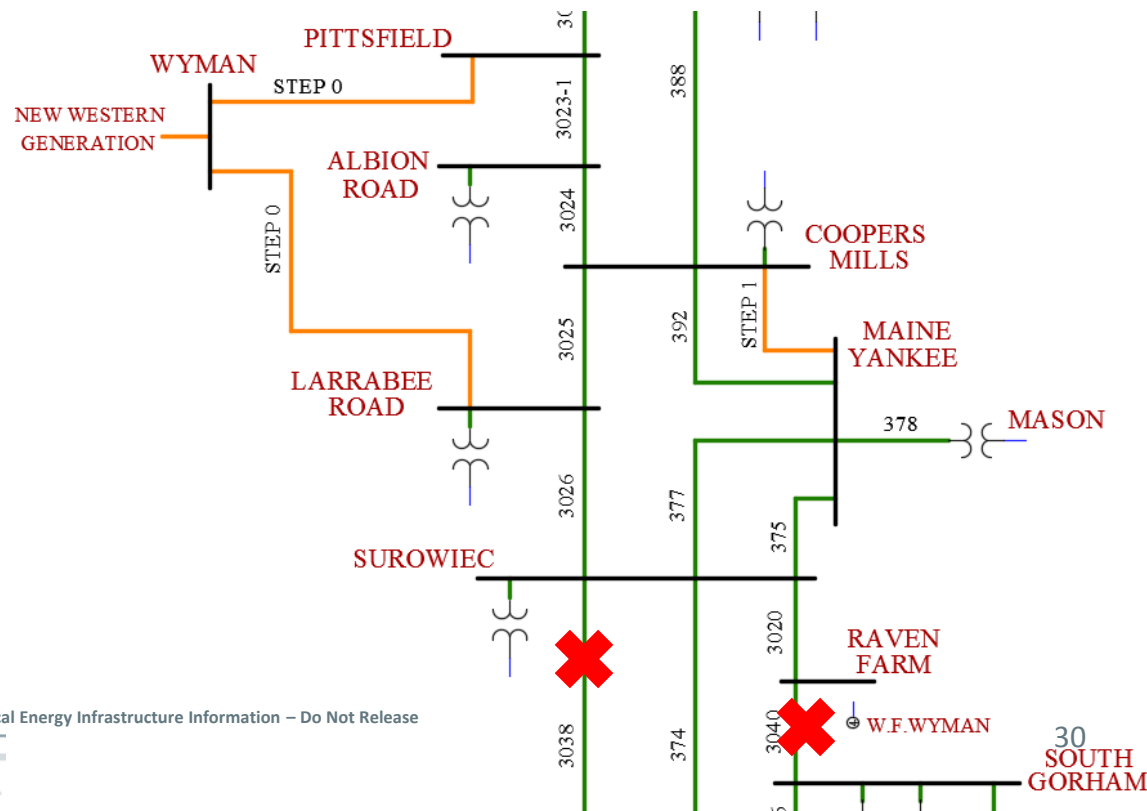


# Western N-1-1 Thermal Results – Option 3

## (Step 0 & Step 1 Upgrades)

The N-1-1 Limit for Western Option 3 which includes a parallel S.392 the amount of generation is increased to 841 MW.

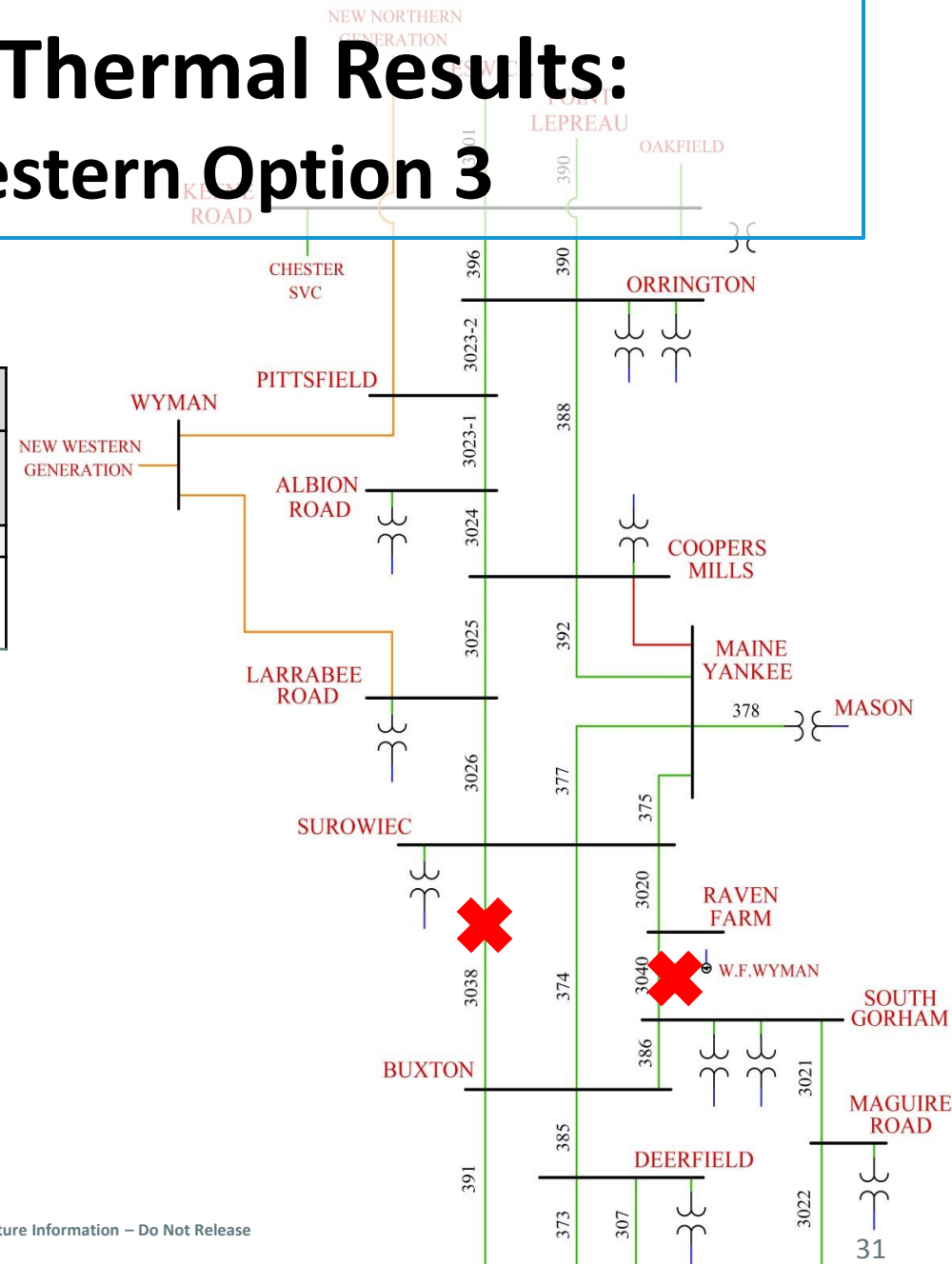
First Level Outage	Contingency	Monitored Facility	LTE Rating	Option 3
				Pitts.-Wyman-Larrabee & Larr.BKR
				Available MW Injection
S.374/3038 (Surowiec-Buxton)	S.3040 (S.Gorham-Raven)	S.374/3038 (Surowiec-Buxton)	1429	<b>841</b>



# Combination N-1-1 Thermal Results: Northern Option 4, Western Option 3

First Level Scenario	Contingency Name	Monitored Facility	LTE Rating	North, Option 4	West, Option 3
				Haynes. & Keene Road Bypassed	Pittsfield-Wyman-Larrabee
				Available MW Injection	
LN_3038	LN_3040	SUROWIEC 345 BUXTON 345 1	1429	<b>863</b>	

The N-1-1 Limit for the combination of Northern Option 4 and Western Option 3 is approx 863 MW (modeled in this case as 500 MW from the North and 363 MW from the West).



# N-1 / N-1-1 Results Comparison

Location		Option	Description	N-1 Analysis Results (MW)	N-1-1 Analysis Results (MW)
North		Option 1	Haynesville - Keene Road - Pittsfield	368	345
		Option 2	Haynesville - Pittsfield	369	344
		Option 3	New Gen. - Keene Road - Pittsfield	371	345
		Option 4	New Gen. - Pittsfield	379	346
West		Option 1	Wyman - Pittsfield	383	344
		Option 2a	Wyman - Larrabee Road	660	460
			Wyman - Larrabee Road + Parallel S.392	1001	785
		Option 2b	Wyman - Surowiec	984	866
		Option 3	Pittsfield - Wyman - Larrabee Road + BKR	624	446
			Pittsfield - Wyman - Larrabee Road + BKR + Parallel S.392	996	841
Combo	North	Option 4	New Gen. - Pittsfield	500	500
	West	Option 3	Pittsfield - Wyman - Larrabee Road+ BKR + Parallel S.392	529	363



# STEADY STATE VOLTAGE TESTING



# Steady State N-1 Voltage Results

- Voltage analysis for each interconnection area:
  - Northern Maine
    - 4 Potential Configurations
  - Western Maine
    - 4 Potential Configurations
      - (+2 sensitivities involving a parallel S.392)
- Voltage analysis performed using the MW injection values identified in the N-1-1 testing
- Very high-level indication of the quantity of reactive upgrades for steady state voltage issues
  - Reactive requirements will be further identified in stability testing

# Northern N-1 Voltage Results

Northern Option	Description	Injected MW	Keene Road Reactive Requirements (MVAR)
Option 1	Haynesville - Keene Road - Pittsfield	345	125
Option 2	Haynesville - Pittsfield	345	100
Option 3	New Gen. - Keene Road - Pittsfield	345	100
Option 4	New Gen. - Pittsfield	345	100

No injection was conducted for the Western Option(s) in this testing

# Western N-1 Voltage Results

Western Option	Description	Injected MW	Reactive Requirements (MVAR)
Option 1	Wyman - Pittsfield	345	100
Option 2a	Wyman - Larrabee Road	460	110
	Wyman - Larrabee Road + Parallel S.392	785	425
Option 2b	Wyman - Surowiec	865	550
Option 3	Pittsfield - Wyman - Larrabee Road + BKR	445	75
	Pittsfield - Wyman - Larrabee Road + BKR + Parallel S.392	841	450

No injection was conducted for the Northern Option(s) in this testing

# Combination N-1 Voltage Results

Location	Option	Description	Injected MW	Reactive Requirements (MVAR)
North	Option 4	New Gen. - Pittsfield	500	300
West	Option 3	Pittsfield - Wyman - Larrabee Road + (2) DBL BKR's + Parallel S.392	363	

# Next Steps

- Complete stability analysis
- Perform weak grid evaluations
- Present final results
  - End of 2016

# Questions

