Opening of the B-22 Johnson to Morrisville 34.5kV Line

Loss and Reliability Impacts

October 21, 2010

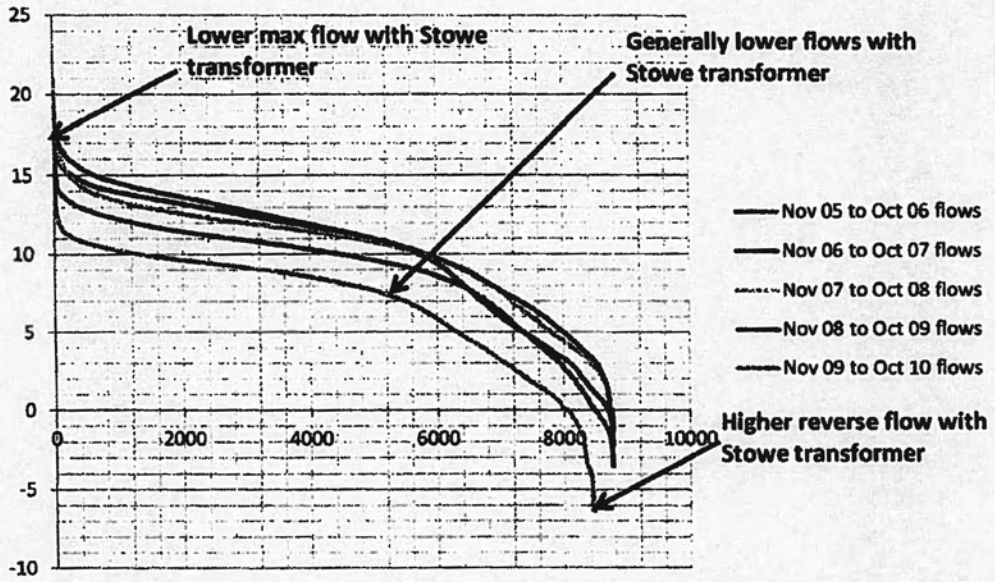
Operating Committee Meeting

Outline

- Historical B-22 flows
  - Before and after the Stowe transformer addition
- Factors that affect B-22 flows
- Analysis of the B-22 disconnection
  - Estimate of the loss impacts
  - Summary of the reliability impacts

Yearly Load Curves for B-22 Flows

- Flows after addition of Stowe transformer are lower (in service date of October 2009)



Comparison of Yearly B-22 Flows

- Flows after addition of Stowe transformer are lower (in service date of October 2009)

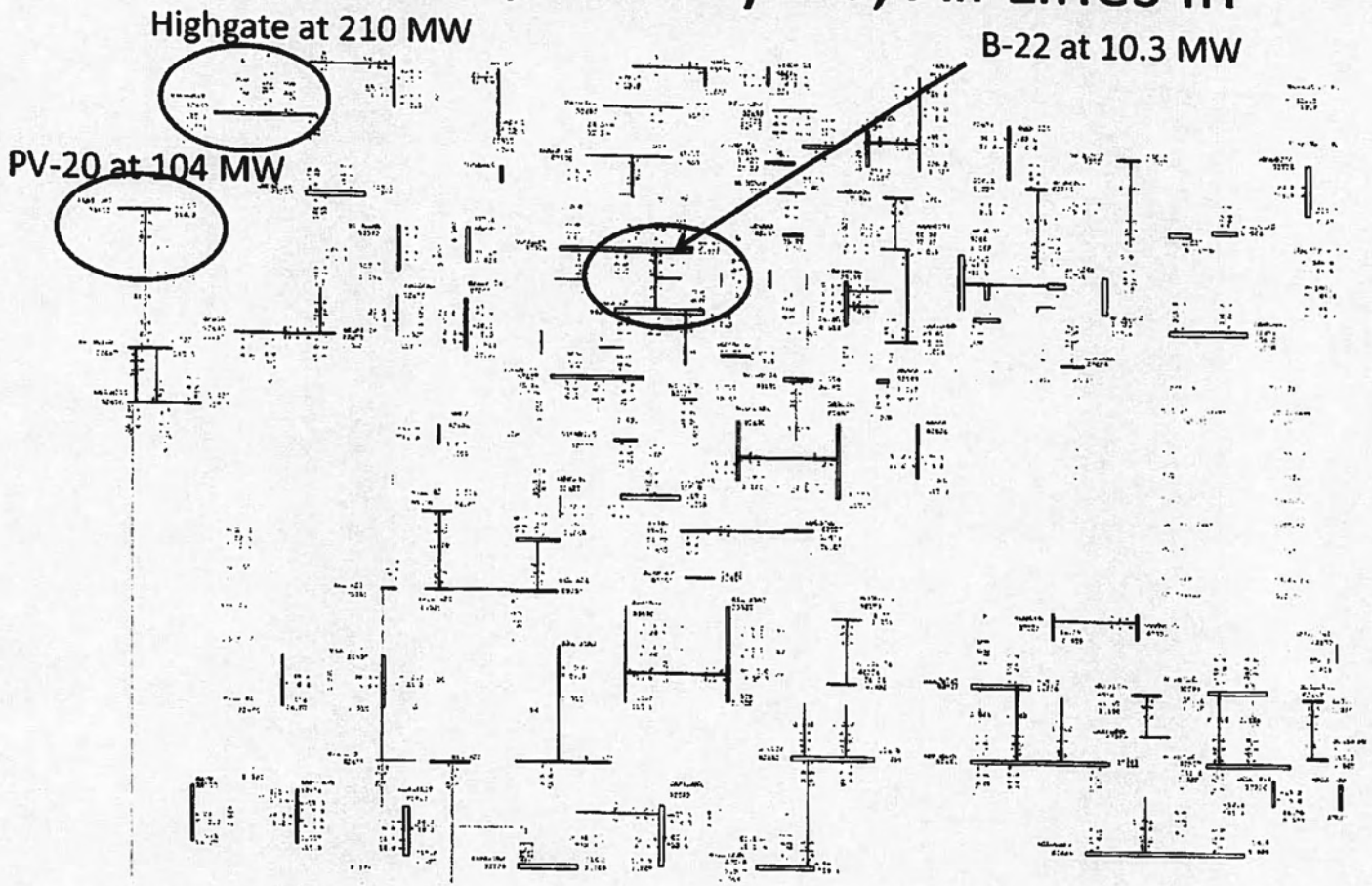
	05/06 flows	06/07 flows	07/08 flows	08/09 flows	09/10 flows
Average	8.94	10.11	10.25	10.82	7.06
Maximum	17.52	20.89	20.85	19.77	17.51
Minimum	-3.55	-2.16	-1.17	-1.41	-6.34
Median	10.07	11.49	11.21	11.57	8.39
	# of hours	# of hours	# of hours	# of hours	# of hours
Reverse flows greater than 1	109	14	3	4	243
Flows greater than 5	7365	7359	7792	7997	6310
Flows greater than 10	4502	5722	5793	5836	1336
Flows greater than 15	25	286	239	635	12
Flows greater than 17	4	22	61	66	2

Factors That Affect B-22 Flows

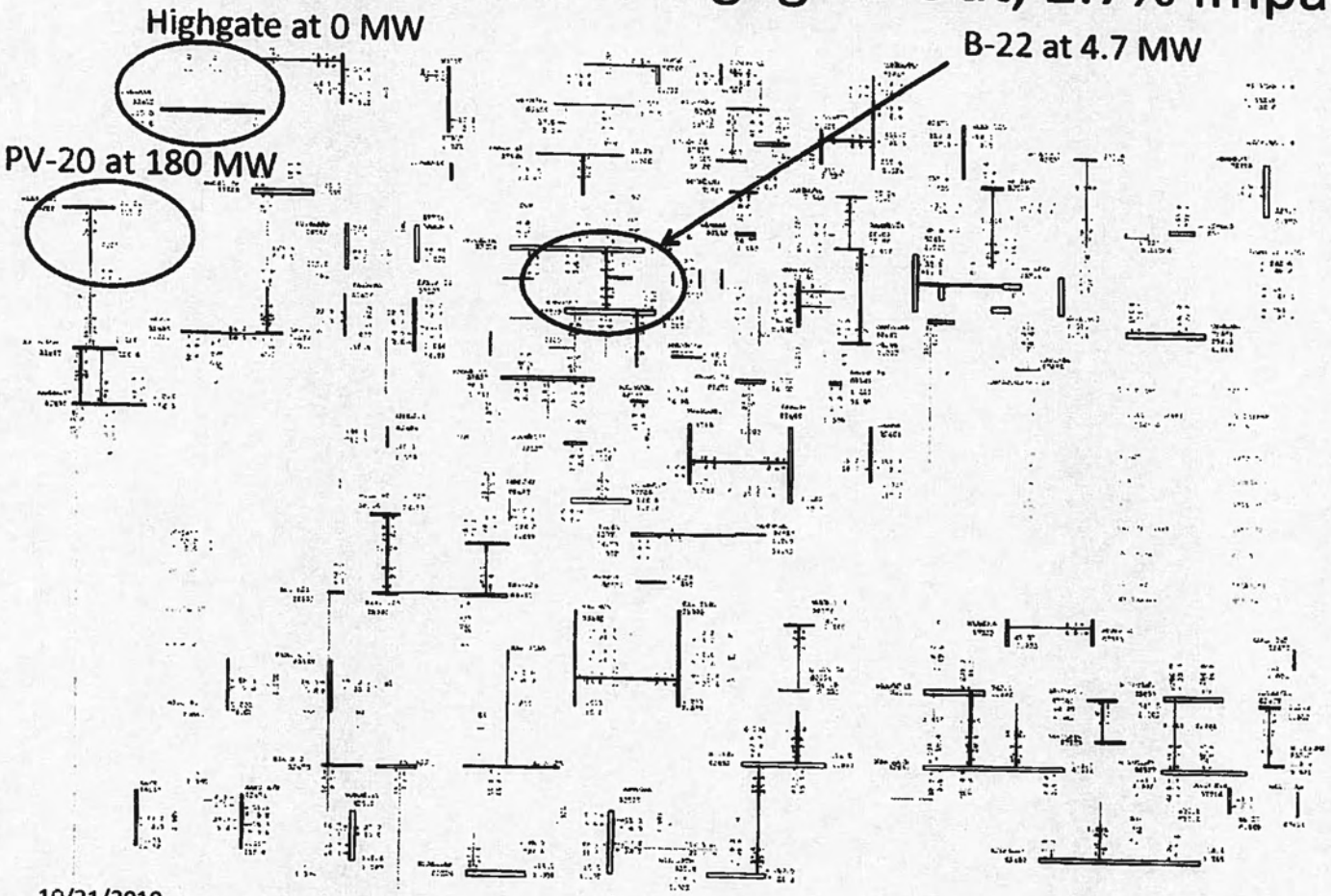
- Imports from Highgate
  - Average impact 3.4%
  - Maximum impact 6.1%
  - Minimum impact 1.2%
- Status of transmission lines
- Imports on state tie lines (PV-20, F-206)
- Generation and load balance north and south of the B-22 line

Historical flow changes over one hour		
Delta Highgate	Delta B22	%impact of HG on B22 flows
212.84	7.23	3%
190.27	7.17	4%
214.40	6.84	3%
213.01	7.67	4%
196.88	7.32	4%
214.89	9.12	4%
212.13	8.41	4%
209.61	7.19	3%
209.98	8.17	4%
184.04	7.29	4%
193.83	6.46	3%
208.16	7.65	4%
196.43	7.56	4%
189.85	6.60	3%
215.25	10.76	5%

1150 MW, Low Hydro, All Lines In



1150 MW, Low Hydro, Highgate Out, 2.7% Impact



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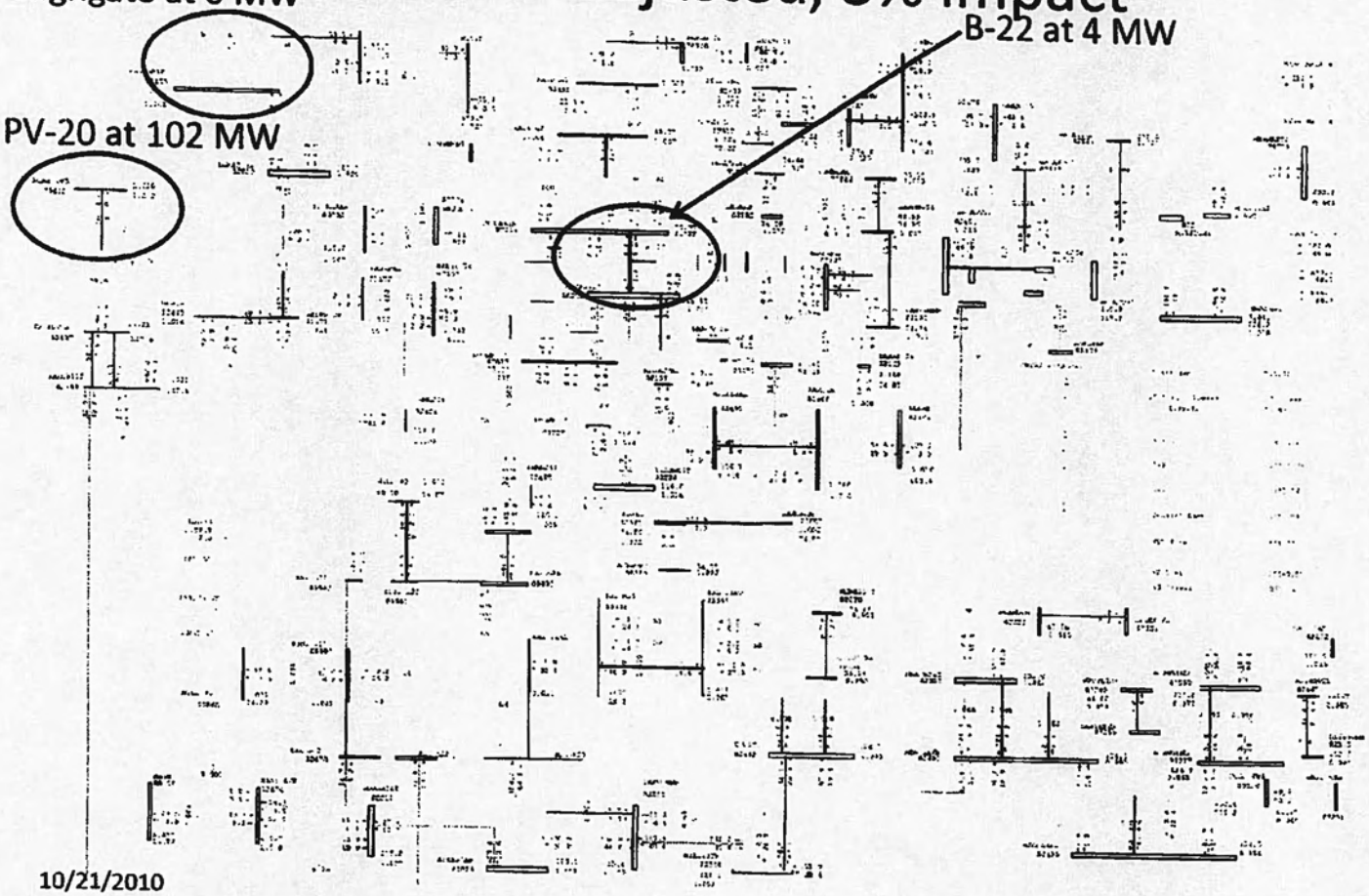
1150 MW, Low Hydro, Highgate Out, PV-20 Flows Re-adjusted, 3% impact



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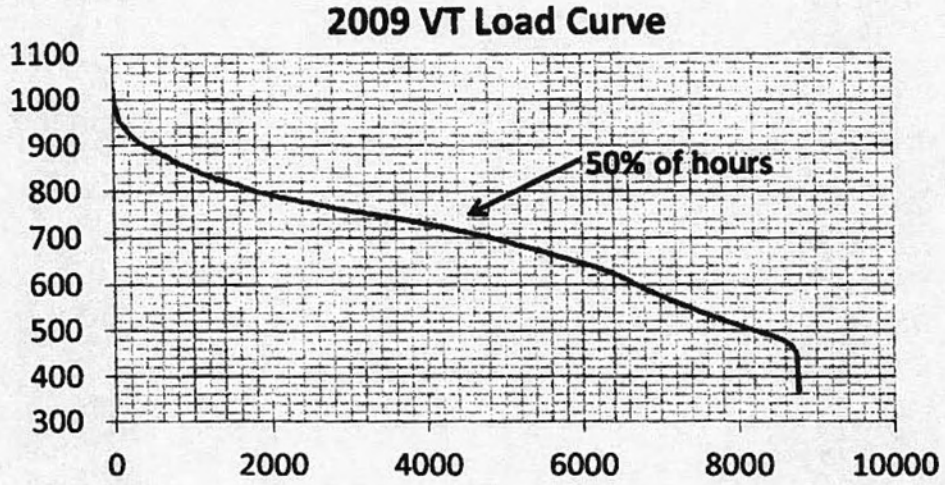
Load Levels Tested

- Tested 720 MW - 50% of hours above and below 720 MW
  - 37 days where the daily peak load was less than 720 MW
- Tested 820 MW – about 50% of days with daily peak loads above 800 MW
- Also tested 1150 MW as worst case



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Other Assumptions in Load Flow Analysis

- Highgate at 210 MW
- PV-20 (Plattsburgh to Sand Bar) at 100 MW
- F-206 (Comerford to Granite) at 100 MW
- Units that were always on: Ryegate (20 MW), Coventry (8 MW), Moretown methane (3 MW)
- Other small thermal units off, except for
  - McNeil (50 MW) in service in 1150 MW cases only
- Intermittent generation (hydro and wind)
  - Modeled VT units at 10%, 50% and 100% at three load levels (720 MW, 820 MW and 1150 MW)
  - Comerford and Moore out of service in all cases
- Modeled West to East transfers across New England

System Wide Loss Impacts of Opening B-22

- Opening the B-22 line reduced system losses by about 300 kW
  - Load levels: 1150 MW, 820 MW and 720 MW
  - 3 cases per load level Hydro: 10%, 50%, 100%
  - Loss reductions varied between 240 kW and 390 kW

	Loss Reduction Averages
All cases tested	0.308
1150 MW cases	0.357
820 MW cases	0.292
720 MW cases	0.276

VT load level	1150 MW	1150 MW	720 MW	720 MW
Generation	Low Hydro	Low Hydro	High Hydro	High Hydro
B22 status	B22 Closed	B22 Open	B22 Closed	B22 Open
Voltage in kV	MW Loss	MW Loss	MW Loss	MW Loss
11	0.000	0.000	0.001	0.001
13.2	0.060	0.060	0.021	0.021
13.8	0.910	0.910	0.456	0.456
34.5	**6.380**	**5.850**	**2.875**	**2.335**
46	7.390	7.400	2.929	2.928
69	0.320	0.320	0.170	0.170
115	**22.670**	**22.850**	**18.707**	**18.944**
230	0.680	0.720	0.750	0.777
345	5.960	5.960	2.090	2.090
other	9.620	9.560	7.683	7.659
System losses	53.990	53.630	35.682	35.381
Loss reduction		**0.360**		**0.301**
B-22 losses	0.101	0	0.78	0
Loss reduction		**0.101**		**0.78**

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Expected Reliability Impacts of Opening the B-22 line

- Weaker 34.5 kV system
  - High delta V for capacitor bank switching
    - Will probably be unable to use the 2nd Johnson capacitor bank
- The K-24/3313 double circuit tower contingency will cause voltage collapse at nearly all load levels
- Low voltage at nearly all load levels with the East Fairfax end of X29 open
- Low voltage at 820 MW and above with the Stowe end of 3329 open
- Low voltage above 820 MW for loss of K-24, Stowe transformer, 3329, K-19, Barre and East Fairfax transformers
- 4% overload of Milton to Wyeth 34.5 kV line for loss of the East Fairfax transformer at near peak load levels

Summary of Voltage Impacts

Load level	1150			820			720		
Level of hydro	100%	50%	10%	100%	50%	10%	100%	50%	10%
Contingencies	Voltages in percent of nominal								
K24+3313	Collapse	Collapse	Collapse	Collapse	Collapse	Collapse	Collapse	Collapse	Collapse
K24	<0.9	<0.8	Collapse						
Stowe transformer	<0.9	<0.85	<0.8						
3329 Stowe end open	Collapse	Collapse	Collapse	<0.9	<0.9	<0.9			
3329 Morrisville end open	<0.9	<0.8	Collapse						
3329	<0.9	<0.8	Collapse						
Barre transformer		<0.9	<0.9						
K19		<0.9	<0.9						
East Fairfax transformer			<0.9						
X29 E Fairfax end open	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.9	<0.9	<0.9

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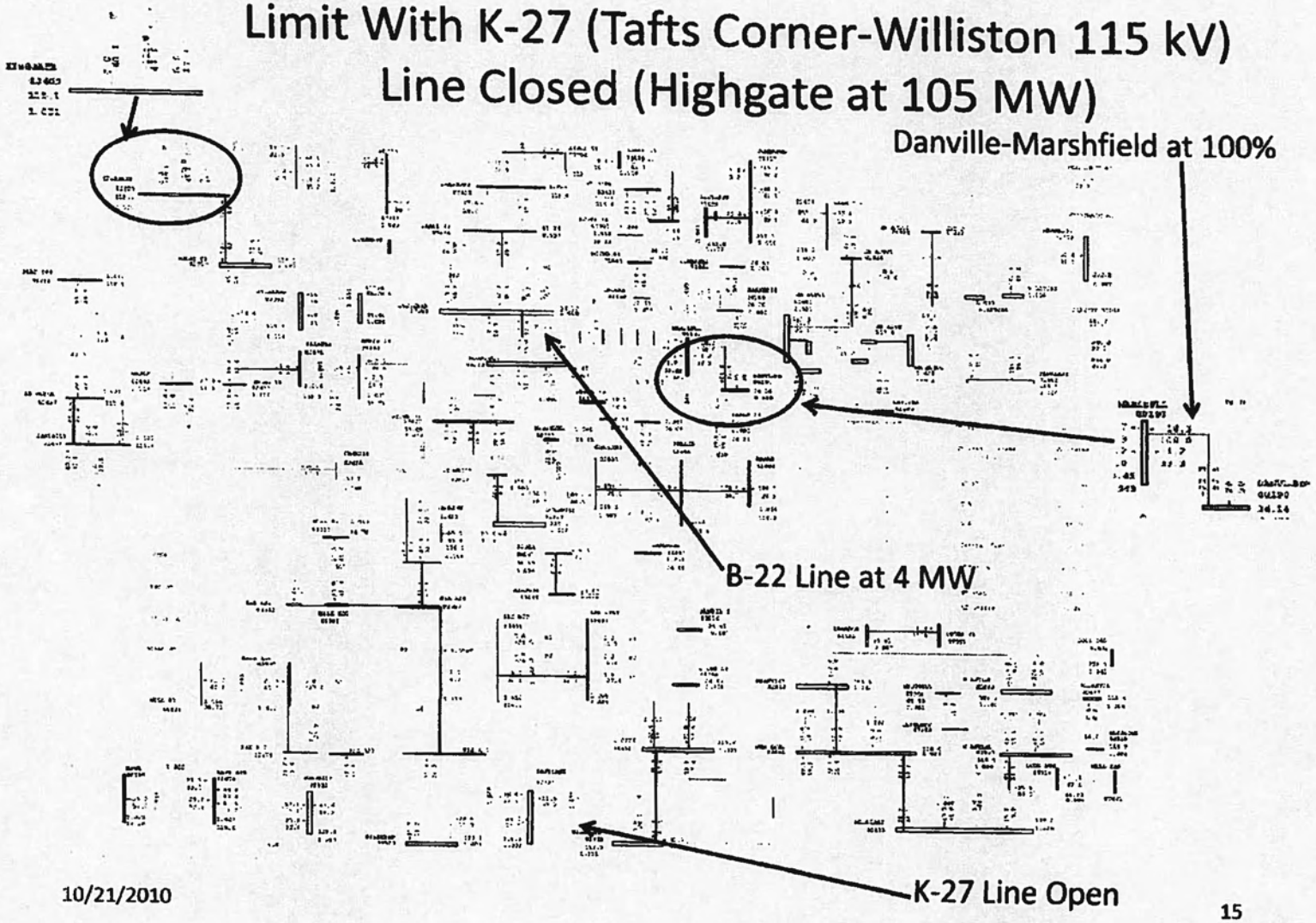
Other Impacts

- Potentially lower import limits into Northwest VT
  - Higher amount of must-run generation needed during hours of congestion
    - Limiting facility overloaded earlier
    - Generation required earlier
- Operational complexity
  - Determine when to close the line depending on
    - Load level
    - Generation dispatch
    - Transmission and sub-transmission facilities out of service
- Greater exposure to unanticipated reliability concerns

Limit With K-27 (Tafts Corner-Williston 115 kV) Line Closed (Highgate at 105 MW)



Limit With K-27 Line and B-22 Line Open (Highgate at 115 MW)