VELCO 2009 Long Range Plan Analysis

November, 2008

Outline

- Content of the plan
- Comparison between 2006 and 2009
- Analysis criteria and assumptions
- 2018 transmission results
  - Results with Vermont Yankee permanently shut down
  - Results with Highgate permanently shut down
- 2028 transmission results
- 2018 Sub-transmission results
- Recommendations
- Questions

Content of the plan

- 2006 requirements continued in 2009
  - Criteria and assumptions
  - Identification of transmission deficiencies
  - Estimated date and costs
  - Public comments and VELCO responses
- Additional 2009 requirements from Docket 7081
  - Identification (only) of sub-transmission deficiencies
  - Identification of Affected Utilities and Lead Distribution Utility (DU) to be addressed by VSPC if disputed
  - Vermont System Planning Committee (VSPC) comments (to be added by VPSC) and VELCO responses
  - Non-Transmission Alternative (NTA) screening results

Transmission = facilities connected at 115 kV and higher **Sub-transmission** = facilities between 34 kV and 70 kV

Affected Utilities = utility affected by a deficiency or whose load contribute to the deficiency

Lead DU = DU selected by affected utilities to facilitate decision making and lead the effort to conduct the NTA analysis

Comparison with 2006 Analysis
Changes due to Docket 7081 MOU

2006 Analysis	2009 Analysis
VSPC and public involvement: VSPC not yet created Public input requirements under 30 VSA 218c	***VSPC and public involvement:*** VSPC input requirements Public input requirements under 30 VSA 218c and Docket 7081 MOU
Planning horizon: 10-yr load at 1310 MW (year 2016) 20-yr load not tested	***Planning horizon:*** 10-yr load at 1275 MW (year 2018) 20-yr load at 1425 MW (year 2028)
Sub-transmission: Sub-transmission not analyzed	***Sub-transmission:*** Sub-transmission analyzed (7081 MOU)
Non-transmission alternatives: Not screened	***Non-transmission alternatives:*** Screening included in report

Comparison with 2006 Analysis
Changes due to Regional Planning Process

2006 Analysis	2009 Analysis
Regional input: No ISO-NE and TO involvement	***Regional input:*** Direct ISO-NE and TO involvement
Flow assumptions: NY-NE flow: 1000, 0 & -1000 MW East-West flow: -1000, 1200 & 2500 MW	***Flow assumptions:*** NY-NE flow: +/-1200 MW East-West flow: -1000 & 2400 MW
First contingency: Long-term outage	***First contingency:*** Long-term & short-term outages
Generation assumptions: 86 MW in all cases	***Generation assumptions:*** All-lines-in: 88 MW With long-term facility out: 119 MW With short-term facility out: 150 MW

NY-NE = New York-New England power transfer interface
ISO-NE = Independent System Operator in New England
TO = Transmission Owner
All-lines-in = no outages

Long-term outage = outage that is likely to exist for weeks at a time, such as outages of transformers, generators and cables
Short-term outage = outage that is likely to exist for a few hours, such as outages of overhead lines

Regional Interpretation of Design Criteria

- NERC planning standards
  - TPL-001 – No outages
  - TPL-002 – Outage of one element
  - TPL-003 – Outage of two or more elements
- ISO-NE planning standards
  - N-0, N-1, N-1-1
  - Stressed conditions
    - Extreme weather load (90/10)
    - Two largest generators unavailable and limited use of peaking units
    - Maximized regional power transfers

NERC = North American Electric reliability Council

ISO-NE = Independent System Operator of the New England electric system

90/10 = 90% chance that the actual load will be at or lower than the forecast, 10% chance that it will exceed the forecast

Load Assumptions

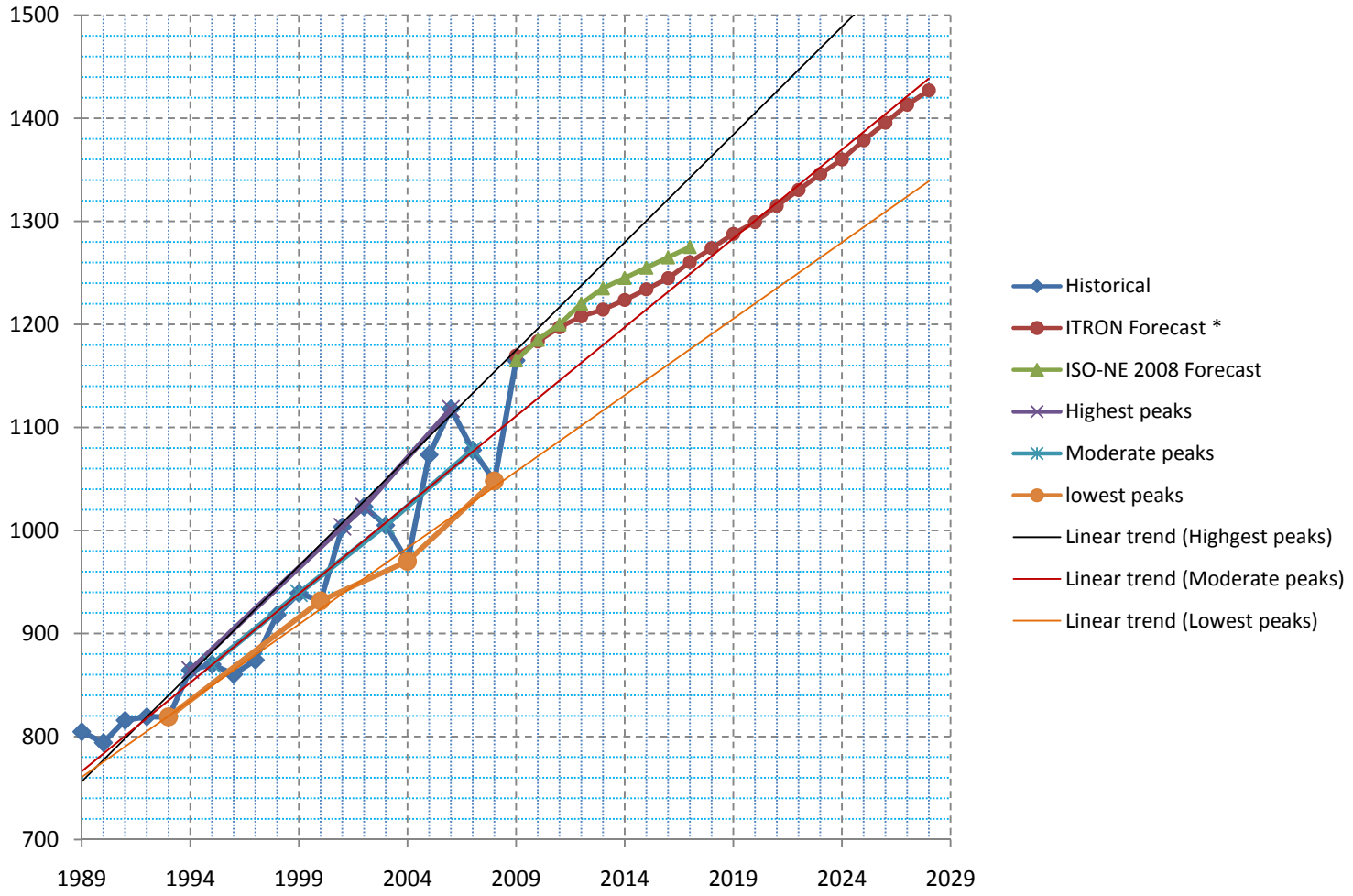
- 90/10 loads in all cases tested
  - 2018 projected load – 1275 MW (load and losses)
  - 2028 projected load – 1425 MW (load and losses)
- Newport block load supplied from Vermont
- Load power factor constant at 0.97 in all cases
  - Assumes ongoing power factor correction on the distribution and sub-transmission systems
- NY load remained constant in all cases
- Rest of New England load remained constant from 2016 to 2028

Power factor = Measure of real power in relation to reactive power, which are perpendicular to each other.

Real power = Part of the electrical power that does the work, i.e. heat, lighting

Reactive power = Part of the electrical power needed for the system to function properly. By-product of alternating current.

Load Forecasts



*** The ITRON forecast was used for the Vermont analysis**

Generation Assumptions

- Two largest units unavailable (reference ISO-NE & TO design standards)
  - McNeil (51 MW) and half of Berlin (25 MW)
- Base load units running at full
  - Ryegate (20 MW), Coventry (8 MW), Moretown planned (4.8 MW)
- Wind and water generation at 10% of capacity
  - 5 MW for wind and 15 MW for hydro
- Limited use of peaking units
  - ½ of Swanton planned (21 MW), 4/5 of Newport planned (8 MW), ¾ of Essex (6 MW)
- System adjustments between the first and second contingencies
  - Adjust angle of phase angle regulators (Sand Bar, Granite and Blissville)
  - Allow transformer tap changers to move, and redispatch capacitor banks
  - Add generation within 30 minutes
    - 31 MW for long-term outages
    - 62 MW for short-term outages
- Not running – 48 MW (33%) of peaking units

Base load unit = Generation that is expected to run 24 hours a day
Peaking unit = Generation that is expected to run during the peak load, e.g. two hours near the peak demand hour
Phase Angle Regulator (PAR) = A device used to adjust flow on a line. It is also called a phase shifter.

Transmission Performance Criteria

	Thermal criteria	**Voltage criteria**	
System event	For all facilities	For 115 kV facilities	For 230 kV and above
NERC Category A (All-lines-in)	At or below normal rating	At or above 0.95 pu and At or below 1.05 pu	At or above 0.98 pu and At or below 1.05 pu
Category B, C, & D (single or multi-element outages) N-1 and N-1-1	At or below LTE rating	At or above 0.95 pu and At or below 1.05 pu Delta V no greater than 10%	At or above 0.95 pu and At or below 1.05 pu Delta V no greater than 5%

Thermal = That which is related to current flow
Normal rating = Nearly continuous current capacity of a piece of equipment, such as a line, a transformer
LTE rating = Long-term (4 to 12 hours) emergency current capacity of a piece of equipment
Voltage = That which is needed to allow current to flow. The higher the voltage, the lower the current for the same power level
pu = per unit voltage, which is the ratio of the calculated voltage over the nominal/operating voltage level, such as 115 kV, 46 kV
Delta V = change in voltage before and after an outage

Sub-transmission Performance Criteria

System event	Thermal criteria	Voltage criteria
NERC Category A (All-lines-in)	At or below normal rating	At or above 0.95 pu and At or below 1.05 pu
NERC Category B (single-element outages) N-1	At or below LTE rating	At or above 0.90 pu and At or below 1.05 pu Delta V no greater than 10%

Typical Reasons for Upgrades and Associated Solutions

Criteria Violations/Deficiencies	**Typical Solutions**
Voltage below voltage limit	Capacitor banks
Voltage above voltage limit	Shunt reactors
Voltage collapse on network	Add another facility (line, transformer, substation)
Loss of load for loss of a transformer due to low voltage and very high overloads that cannot be resolved with sectionalization	Add another transformer
Flow above equipment capacity	Replace equipment or add another facility

Outages Examined

- Single element outages
  - Line, transformer, generator, Essex STATCOM, Highgate HVdc terminal
- Double-element outages for transmission only
  - DCT, breaker failure, Sandy Pond HVdc terminal
- First single element outage, then system adjustment, then another outage is tested for transmission only
  - Long-term outages as the first outage (studied in 2006)
    - Highgate HVdc, Vermont Yankee (VY) generator, PV-20 (Plattsburgh to Sand Bar 115 kV), 230/115 kV transformer at Littleton, and 345/115 kV transformers at West Rutland, Coolidge, Vernon and Vermont Yankee
  - Short-term outages, i.e. overhead lines, as the first outage (new in '09)
    - K-65 Queen City to Shelburne 115 kV
    - F-206 Comerford to Granite 230 kV line
    - 345 kV lines: 370 (New Haven to West Rutland), 350 (West Rutland to Coolidge), 340 (Coolidge to VY), 3321 (Coolidge to Newfane) and 3320 (Newfane to VY)

DCT = Double circuit tower outage that trips lines supported by the same poles
Breaker failures = outage that trips elements adjacent to a breaker

Development Stage of Upgrades

- Upgrades are at the conceptual stage except for the Lyndonville project
  - Cost estimates are based on 2008 dollars
  - Cost estimates are conceptual
    - Cost estimates are based on similar experience from recent system reinforcement projects
    - Substation costs do not account for physical conditions and soil conditions
      - Assumed no additional land
      - Assumed no soil replacement
    - Line costs are based on per mile figures and do not account for physical conditions
      - Assumed no additional right-of-way
      - Assumed no right-of-way clearing
      - Assumed wood pole construction
  - Priorities are based on the planning stage of the project, load exposure, and need dates

List of Deficiencies

Repeated from 2006	New in 2009
Loss of Middlebury transformer	Loss of Bennington station
Loss of Blissville transformer	VY-Vernon Rd line overload
Loss of Hartford transformer	Loss of Vernon autotransformer
Loss of North Rutland/Cold River transformers	Coolidge-Ascutney line overload
Loss of Ascutney Transformer & substation	Ascutney-Ascutney Tap line overload
Loss of St Johnsbury transformer	Williston-Tafts Corner line overload
Loss of St Albans transformers	Loss of Chelsea transformer
Loss of Barre transformer	High voltage at light load
Loss of Georgia station	System wide low transmission voltage
Coolidge autotransformer overload	System wide transmission voltage instability
Coolidge-Cold River line overload	
Cold River-North Rutland overload	
West Rutland-Florence overload	
New Haven-Williston overload	
Low voltage and voltage instability	

Upgrades in Southern VT

Location	Upgrade - NEW	Reasons for upgrade			
VY to Vernon Rd 115 kV K-186 line	Rebuild to higher rating	Line overloaded for loss of Fitzwilliam transformer and breaker failures at Fitzwilliam			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Bulk	2009	$5M to $10M	CVPS, GMP, (NU, NGRID)	CVPS	9
Location	**Upgrade - NEW**	**Reasons for upgrade**			
Vernon	Install 2nd 345/115 kV transformer	Loss of the Vermont Yankee transformer overloads the Keene-Monadnock 115 kV T-198 line, with the Vernon transformer out of service			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Bulk	2010	$15M to $30M	CVPS, GMP, (NU, NGRID)	CVPS	10
Location	**Upgrade -NEW**	**Reasons for upgrade**			
Bennington	Rebuild to ring station	Breaker failures cause voltage collapse			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Bulk	2009	$10M to $20M	CVPS,GMP,(NGRID)	CVPS	14

Loss of = Outage of **Out of service** = First contingency **Costs are rough 2008 dollars, conceptual projects**

Upgrades in Central VT – part 1

Location	Upgrade	Reasons for upgrade			
Middlebury	Install 2nd 115/46 kV transformer & Rebuild to ring station	Loss of transformer and breaker failures cause voltage collapse Timing depends on CVPS 46 kV line project			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Predominantly Bulk	2009	$10M to $20M	CVPS	CVPS	2
Location	**Upgrade**	**Reasons for upgrade**			
Blissville	Install 2nd 115/46 kV transformer & Rebuild to ring station. Install capacitor bank	Loss of transformer causes low voltages and overloads, which will result in loss of load Loss of 350 causes low voltage on 115 kV system			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Predominantly Bulk	2009	$15M to $30M	CVPS	CVPS	5

Upgrades in Central VT – part 2

Location	Upgrade	Reasons for upgrade			
Hartford	Install 2nd 115/46 kV transformer & Rebuild to ring station	Loss of transformer causes low voltages and overloads, which will result in loss of load. Breaker failures cause voltage collapse			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Predominantly Bulk	2009	$15M to $30M	CVPS, GMP, WEC	CVPS	6
Location	**Upgrade-NEW**	**Reasons for upgrade**			
Chelsea	Install 2nd 115/46 kV transformer & Rebuild to ring station	Loss of transformer causes low voltages Loss of Granite-Hartford line causes voltage collapse			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Predominantly Bulk	2018	$15M to $30M	CVPS, GMP, WEC	CVPS	19

Upgrades in Central VT – part 3

Location	Upgrade	Reasons for upgrade			
South Rutland	Construct new station with a 115/46 kV transformer	Loss of North Rutland or Cold River transformer causes sub-transmission and transformer overloads, which will result in loss of load			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Predominantly Bulk	2009	$15M to $30M	CVPS	CVPS	4
Location	**Upgrade**	**Reasons for upgrade**			
Ascutney	Install 2nd 115/46 kV transformer & Rebuild to breaker-and-a-half station Install capacitor banks	Loss of transformer causes low voltages and overloads, which will result in loss of load. Breaker failures cause voltage collapse Loss of K-31 or 350 causes low voltage			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Predominantly Bulk	2013 for transformer 2009 for capacitor banks	$22M to $44M	CVPS, Ludlow	CVPS	7 for cap 15 for transfm

Upgrades in Central VT – part 4

Location	Upgrade -NEW	Reasons for upgrade			
West Rutland	Install capacitor banks and shunt reactor	Loss of 350 or 370 causes low voltage. High voltages during low load levels.			
Category	Year of Need	Estimated cost	Affected DUs	Lead DU	Priority
Bulk	2009	$6M to $12M	All DUs except Readsboro and Jacksonville	CVPS	7

Upgrades in Central VT – part 5

Location	Upgrade	Reasons for upgrade			
Coolidge	Install 2nd 345/115 kV transformer Install shunt reactor	Loss of transformer causes low voltages and overloads High voltages during low load levels			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Bulk	2016 for transformer 2011 for reactor	$24M to $48M	NU, NGRID, NY, All DUs except R & J*	CVPS	7 for reactor 16 for transfm

Location	Upgrade	Reasons for upgrade			
Coolidge-Cold River 115 kV K-32 line	Rebuild to higher rating	Line overloaded with the 350 line out of service and for loss of K-31			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Bulk	2013	$35M to $70M	NY, All DUs except R & J*	CVPS	13

*** R & J =** Readsboro and Jacksonville

Upgrades in Central VT – part 6

Location	Upgrade- NEW	Reasons for upgrade			
Coolidge-Ascutney 115 kV K-31 line	Rebuild to higher rating	Line overloaded with the F-206 line out of service and for loss of I135N/J135N DCT			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Bulk	2009	$25M to $50M	CVPS, Ludlow, GMP, (NU, NGRID)	CVPS	8
Location	**Upgrade - NEW**	**Reasons for upgrade**			
Ascutney-Ascutney Tap 115 kV K149 line	Rebuild to higher rating	Line overloaded with the F-206 line out of service and for loss of I135N/J135N DCT			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Bulk	2013	$5M to $10M	CVPS, GMP, (NU, NGRID)	CVPS	11

Upgrades in Northeastern VT

Location	Upgrade	Reasons for upgrade			
St Johnsbury	Construct new station with 115/34.5 kV transformer. Install capacitor banks	Loss of transformer causes voltage collapse			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Predominantly Bulk	2009	$22M	CVPS, Lyndonville for station. CVPS, Lyndonville, & VEC for capctr banks	CVPS	1
	Upgrade - NEW	**Reasons for upgrade**			
Newport	Install capacitor bank	Loss of K-60 line causes voltage collapse			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Predominantly Bulk	2009	$1M to $2M	VEC	VEC	7

Upgrades in Northwestern VT – part 1

Location	Upgrade	Reasons for upgrade			
St Albans	Construct new ring station with two 115/34.5 kV transformers	Loss of St Albans tap causes voltage collapse Transformers overload for loss of either transformer or loss of East Fairfax transformer			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Primarily Bulk	2009	$25M to $50M	CVPS, VEC	CVPS	3
Location	**Upgrade**	**Reasons for upgrade**			
Georgia	Rebuild to ring station	Breaker failures cause voltage collapse			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Primarily Bulk	2009	$20M to $40M	CVPS, VEC, Swanton	VEC	3
Location	**Upgrade-New**	**Reasons for upgrade**			
Georgia-St Albans	Construct new Georgia-St Albans 115 kV line	Voltage instability with the Georgia-St Albans line section opened			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Primarily Bulk	2009	$15M to $30M	CVPS, VEC, Swanton	VEC	3

Voltage instability = phenomenon where the voltage does not behave as expected when real or reactive power changes

Upgrades in Northwestern VT – part 2

Location	Upgrade - NEW	Reasons for upgrade			
Queen City	Install capacitor bank	Loss of K-25 causes low voltages			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Bulk	2009	$2M to $4M	GMP, BED, VEC, CVPS	GMP	7
Location	**Upgrade**	**Reasons for upgrade**			
Barre	Install 2nd 115/34.5 kV transformer & Rebuild to ring station	Loss of transformer causes low voltages and overloads, which will result in loss of load.			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Predominantly bulk	2018 *	$10M to $20M	GMP, WEC	GMP	18

*** Barre timing assumes higher rating on line 3325 (Berlin-Mountain view Tap-Montpelier 34.5 kV). Otherwise, the timing is 2009. Sub-transmission deficiency on last slide.**

Upgrades in Northwestern VT – part 3

Location	Upgrade - NEW	Reasons for upgrade			
Plattsburgh to Essex	Construct 230 kV line from Plattsburgh to Essex in parallel with 115 kV lines	Severe voltage concerns and multiple overloads beyond 10-yr horizon Severe voltage concerns and multiple overloads with Highgate removed within 10-yr horizon			
Category	**Year of Need**	**Estimated cost**	**Affected DUs**	**Lead DU**	**Priority**
Bulk	2016 (2021)*	$200M to $300M	All DUs except Readsboro & Jacksonville	GMP	?Note

*** Note: 2021 Timing assumes Highgate remains available for dispatch even if the contracts are not renewed. Otherwise, the timing is 2016.**

The timing also depends on the review of the remaining life of existing facilities, recent operating events, ISO-NE interests, as well as regional coordinated planning between New England and New York.

Sub-transmission Contingency Performance

Location	Deficiencies	Year of Need	Affected DUs	Lead DU
St Albans	B-5 Fairfax Falls to Milton	2009	CVPS	CVPS
St Albans	Nason St to Nason V	2009	CVPS	CVPS
St Albans	North St Albans to Nat Carbide	2009	CVPS	CVPS
Rutland	North Rutland to East Rutland to South Rutland	2009	CVPS	CVPS
Montpelier	3325 Berlin to Mountain View Tap to Montpelier	2009	GMP, WEC	GMP

Affected DUs make final determination

Questions?