2018 Vermont Long-Range Transmission Plan

vermont electric power company

VELCO

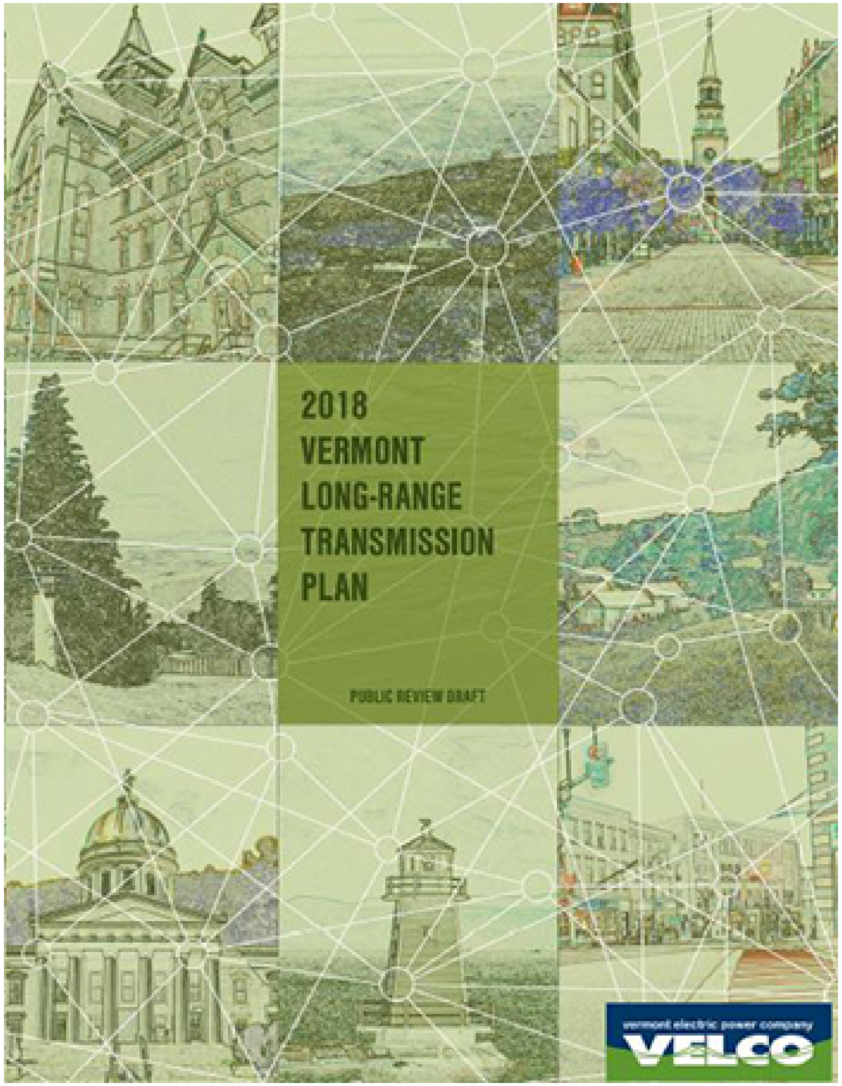
Public Review Draft

Why we prepare this plan

- Plan and associated public outreach required by Vermont law and Public Utility Commission order
- To support full, fair and timely consideration of all cost-effective non-wires solutions to growth-related issues
- To inform utilities', regulators' and other stakeholders' consideration of policy and projects

Questions for you

- What questions do you have about the process, the analysis and the conclusions?
- What feedback do you have about the plan?
- What is happening locally that is important to understanding the evolution of Vermont's electric grid?
- What else?



The short story

Vermont depends on transmission

2018-2028 no load growth expected

No upgrades to serve peak load

Some upgrades may be needed to meet renew-ables goals

Major growth in solar will require some combo of...

...storage, curtailment, load management, grid upgrades, operational changes etc.; voltage control from solar PV inverters; statewide coordi-nated planning.

Studies underlying the plan

2016 studies per NERC standards

Analyses use mandatory NERC, NPCC, ISO-NE reliability/planning standards enforceable by fines

V S P C
Vermont System Planning Committee

Provides input to forecast and overall plan

New this cycle

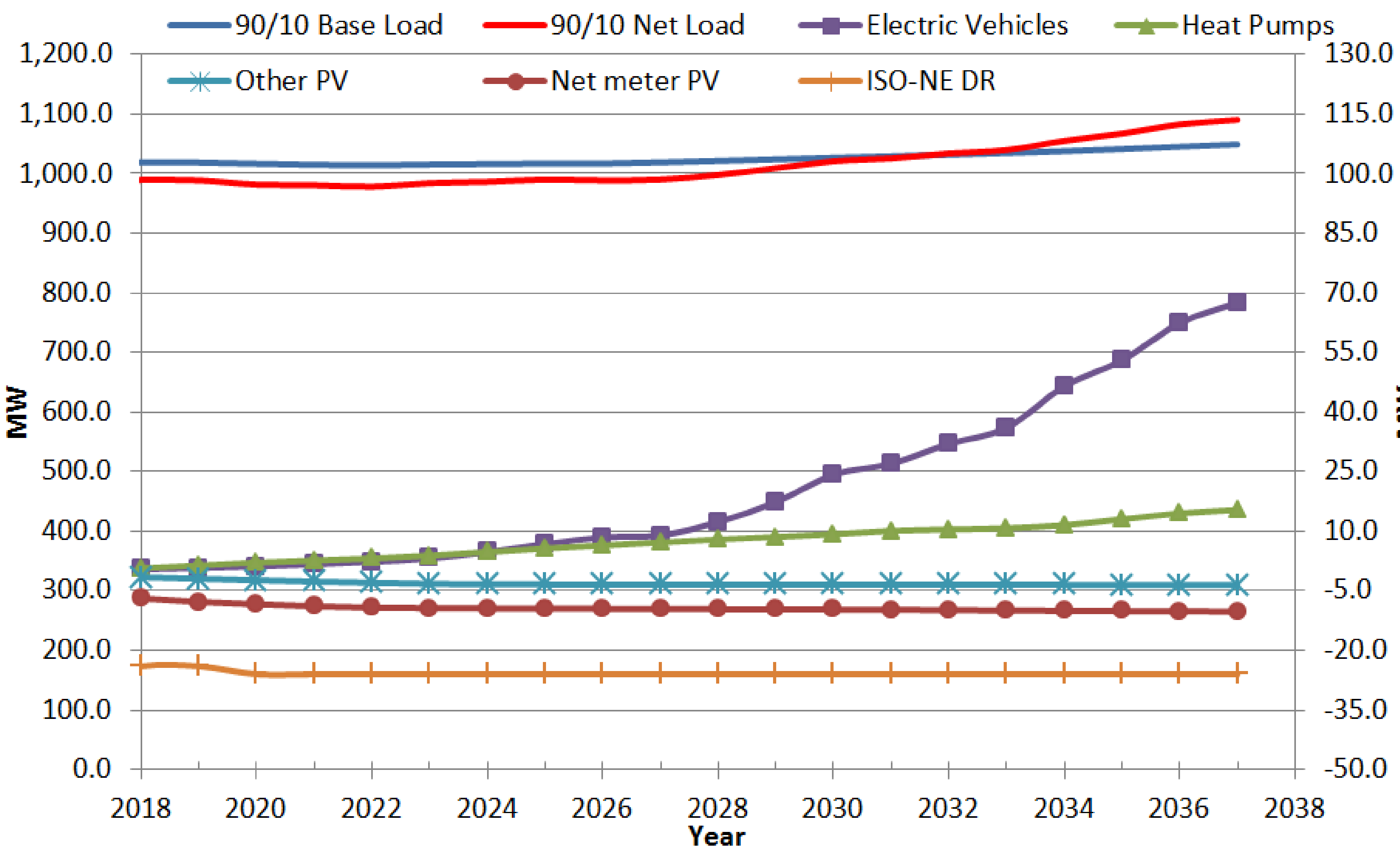
- Analyzed high load scenario calibrated to meet state 90% renewable energy by 2050 goal
- Analyzed high solar PV scenario—1000 MW by 2025 consistent with Solar Pathways study—assumes solar PV serves 20% of state's energy needs

NEW ANALYSIS…

…provides information to help VT regulators, utilities, other stakeholders develop long-term strategies

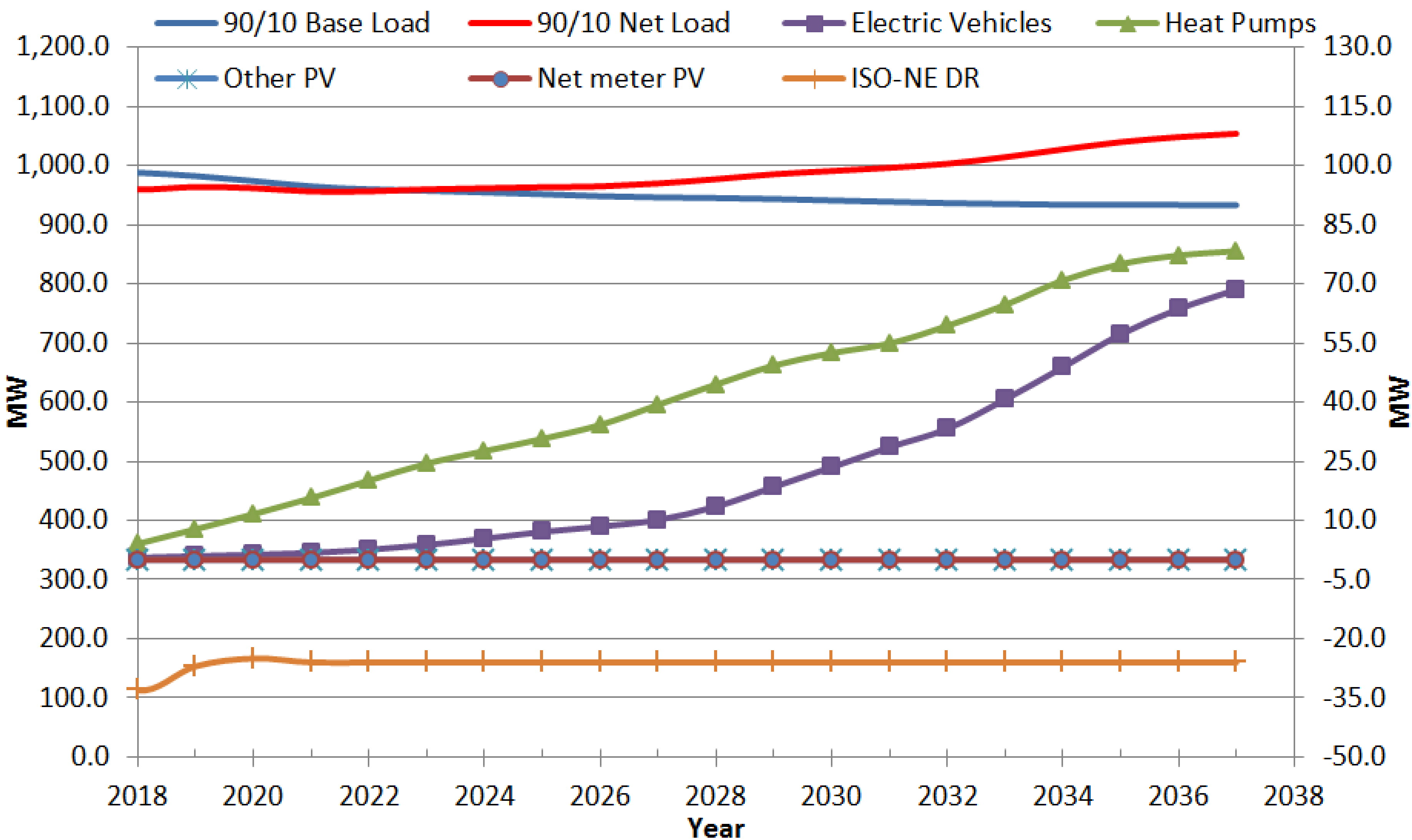
THE FORECASTS

Summer forecast



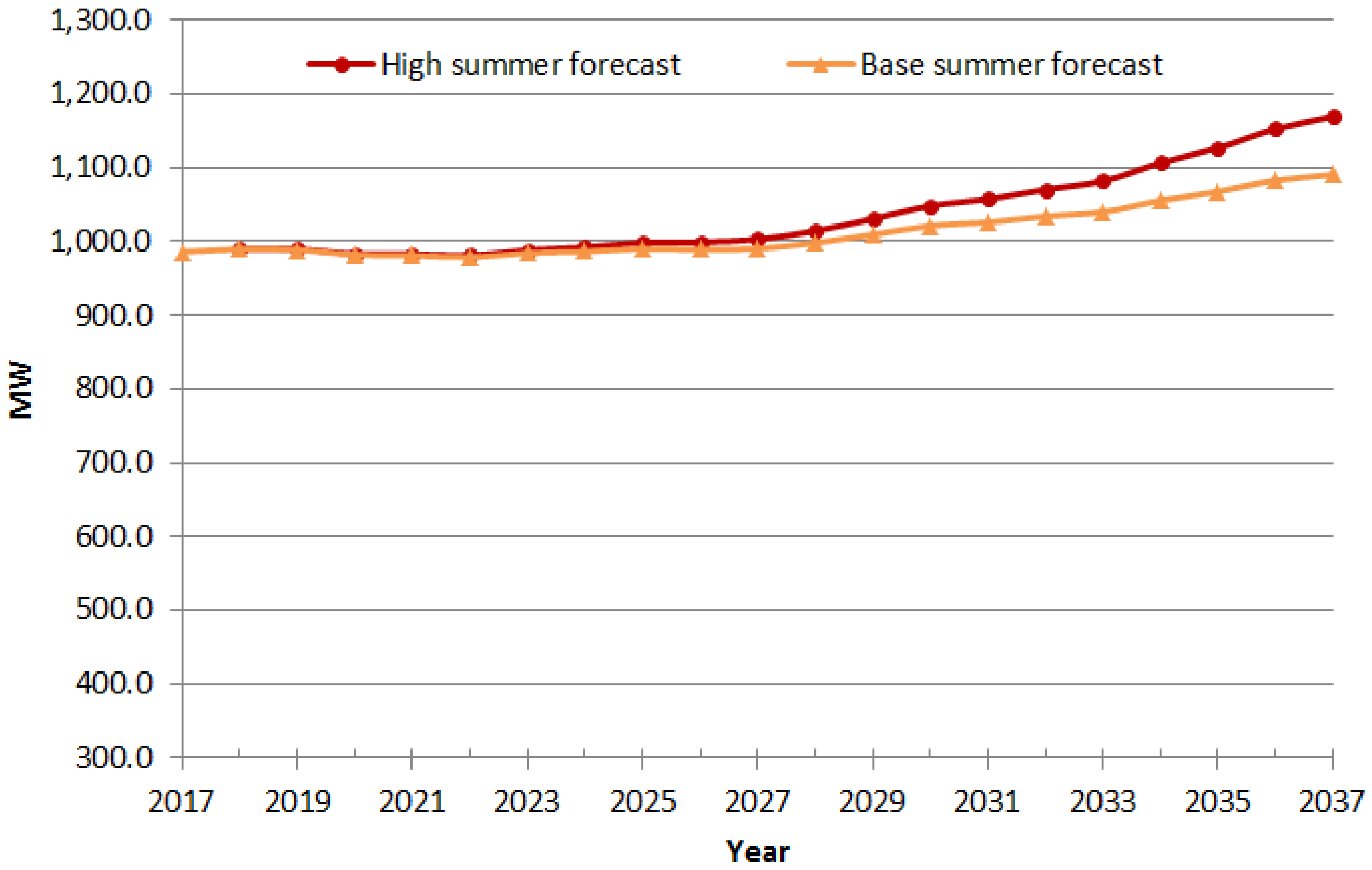
Peak load occurs in the evening → incremental solar PV has minimal effect

Winter forecast



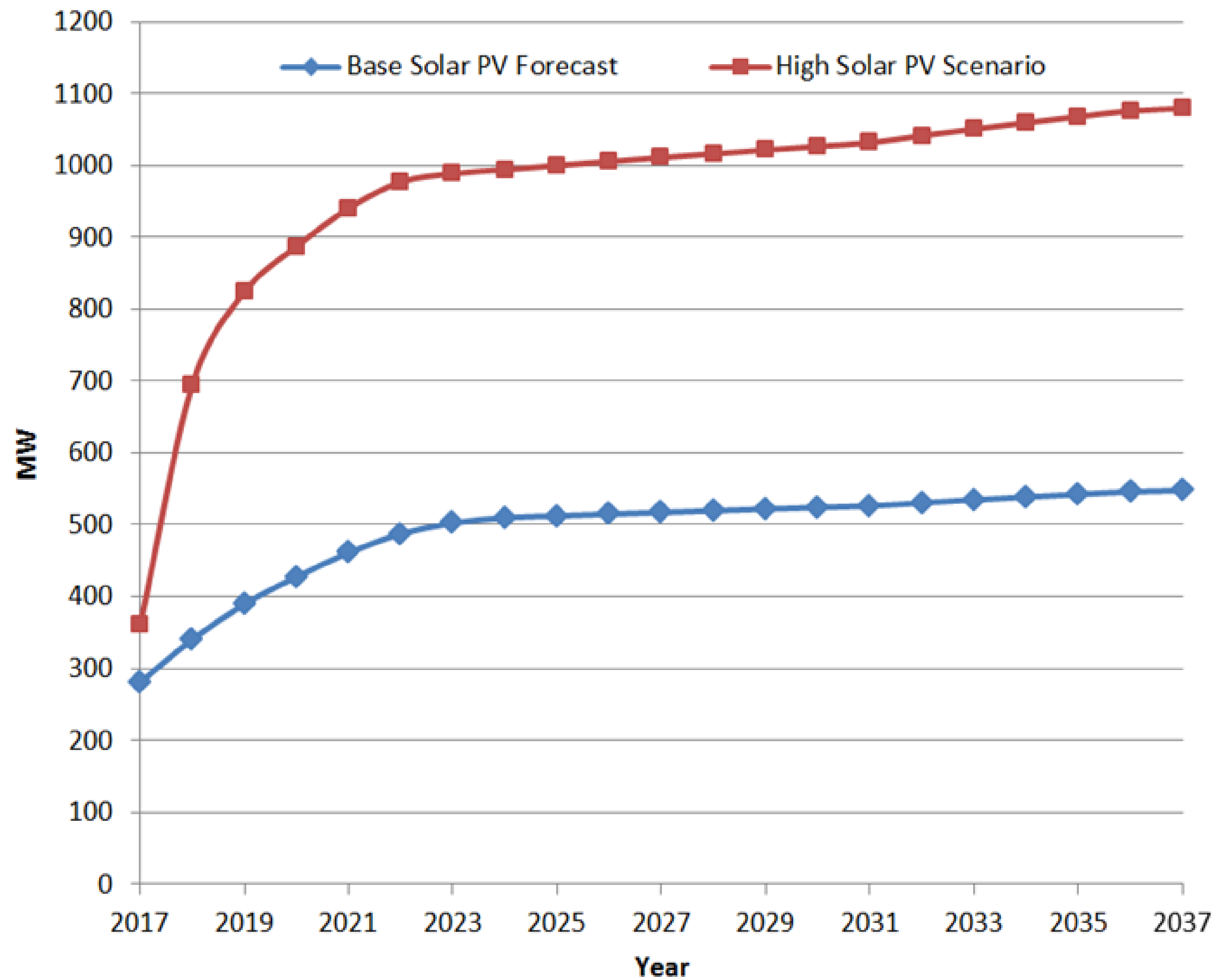
No solar PV during the winter peak

High load forecast scenario



More electric vehicle and heat pump load in the high load forecast

Solar PV forecast



RESULTS

No upgrades needed to serve load within 10-year horizon

Bulk system Predominantly bulk system	• No peak load concerns • Issues addressed by tie line adjustments • Issues addressed by lower loads, Rutland Area Reliability Plan • Acceptable loss of load (5-145 MW)
Subtransmission issues	• Will be evaluated by distribution utilities
High-load scenario	• Minimal effect • Raises no concerns

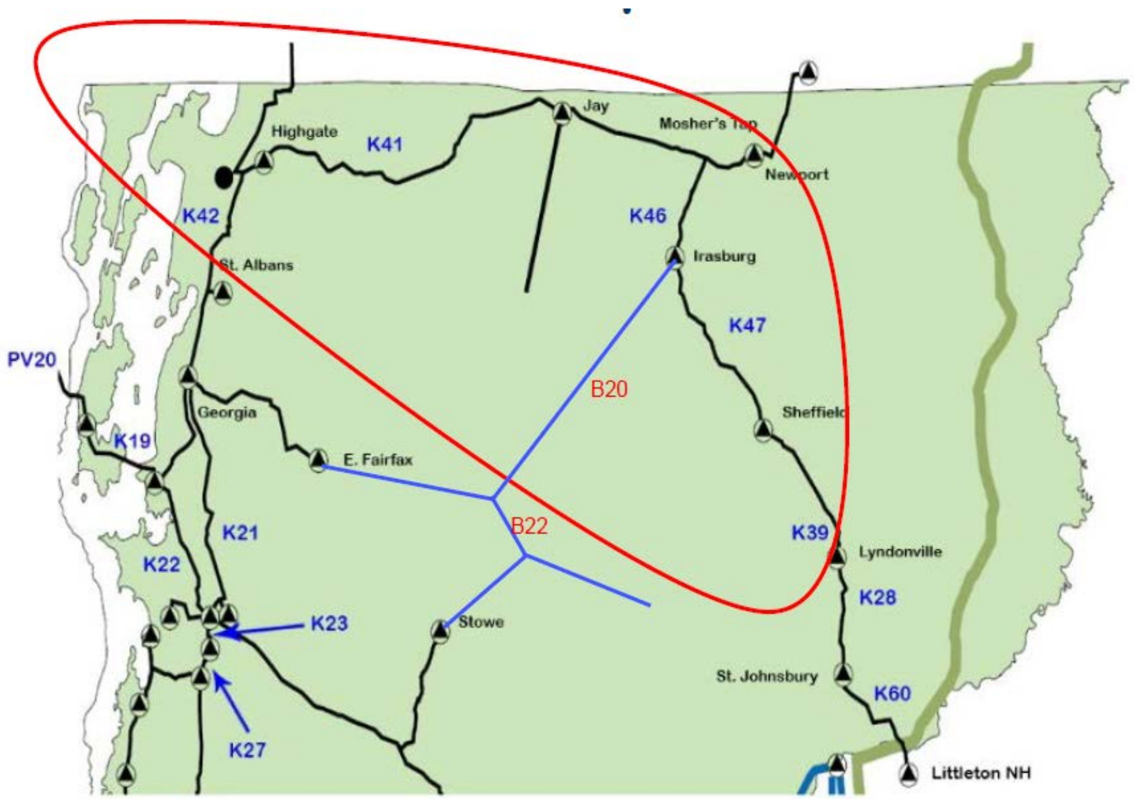
Results of base solar PV forecast (about 510 MW using 2018 solar PV distribution)

- Spring load and renewable generation modeled at maximum capacity
- System losses increased by about 13 MW
- Existing constraints aggravated
  - Voltage collapse in N. VT
  - Additional overloads along Highgate-St Albans-Georgia line
  - Overloads south of Georgia depending on Plattsburgh-Sand Bar tie flow

Zone names	Gross MW loads	MW AC solar PV capacity	Net MW loads
Newport	19.8	14.5	5.3
Highgate	23.8	20.3	3.5
St Albans	39.7	30.1	9.6
Johnson	6.6	8.3	-1.7
Morrisville	24.3	8.8	15.5
Montpelier	48.6	45.1	3.5
St Johnsbury	14.7	7.2	7.5
BED	39.8	9.2	30.6
IBM	60.6	0.0	60.6
Burlington	94.1	106.5	-12.4
Middlebury	19.7	45.4	-25.7
Central	37.6	74.3	-36.7
Florence	22.6	0.4	22.2
Rutland	61.7	58.4	3.3
Ascutney	39.5	22.4	17.1
Southern	65.6	61.3	4.3
Total	618.7	512.2	106.5
Losses	33.6	N/A	46.5

Sheffield-Highgate Export Interface (SHEI)

- Created to monitor power flows exiting highlighted area and maintain reliability
- Voltage concern more critical
- Thermal concern slightly less limiting
- Export limits change dynamically
- Flows maintained below limits by adjusting generation under operator control in anticipation of a system event



Additional SHEI info at https://www.vermontspc.com/grid-planning/shei-info

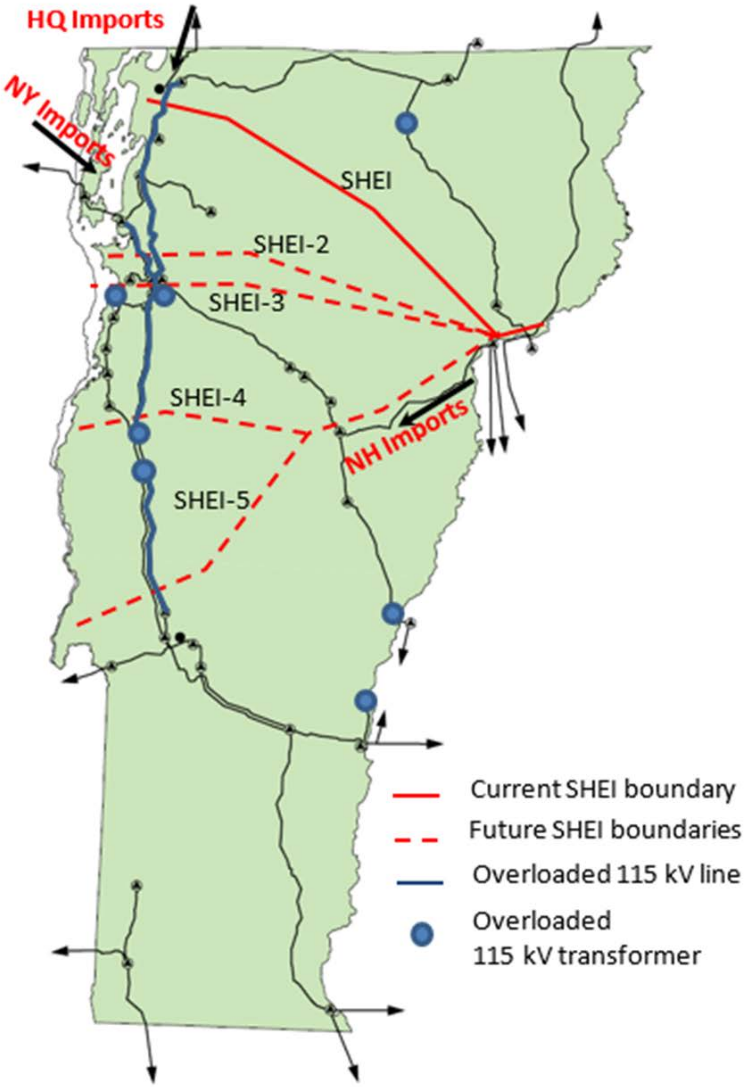
Tested three solar PV distributions for the 1000 MW solar PV scenario

		Same as 2018 solar PV distribution		MW load ratio share		MWh load ratio share	
Zone names	Gross loads	MW AC PV capacity	Net loads	MW AC PV capacity	Net loads	MW AC PV capacity	Net loads
Newport	19.8	27.1	-7.3	36.9	-17.1	40.0	-20.2
Highgate	23.8	34.9	-11.1	39.1	-15.3	38.0	-14.2
St Albans	39.7	58.0	-18.3	68.2	-28.5	63.6	-23.9
Johnson	6.6	17.0	-10.4	11.5	-4.9	12.0	-5.4
Morrisville	24.3	18.2	6.1	35.1	-10.8	36.7	-12.4
Montpelier	48.6	91.2	-42.6	86.0	-37.4	91.3	-42.7
St Johnsbury	14.7	13.3	1.4	26.2	-11.5	28.9	-14.2
BED	39.8	20.4	19.4	61.9	-22.1	61.8	-22.0
IBM	60.6	0.0	60.6	62.4	-1.8	70.5	-9.9
Burlington	94.1	203.8	-109.7	164.5	-70.4	142.4	-48.3
Middlebury	19.7	93.0	-73.3	36.1	-16.4	30.5	-10.8
Central	37.6	147.1	-109.5	67.5	-29.9	67.2	-29.6
Florence	22.6	0.9	21.7	25.6	-3.0	34.1	-11.5
Rutland	61.7	112.7	-51.0	93.0	-31.3	92.8	-31.1
Ascutney	39.5	45.7	-6.2	71.7	-32.2	69.7	-30.2
Southern	65.6	117.0	-51.4	114.4	-48.8	120.4	-54.8
Total	618.7	1000.3	-381.6	1000	-381.3	1000	-381.3
Losses	33.6	N/A	82.8	N/A	74.1	N/A	72.9

Results of high solar PV scenario (using 2018 solar PV distribution, MW or MWh ratio)

- 2018 PV distribution will introduce major operational challenges
  - System losses increased by about 50 MW
  - Very large flows pre-contingency
  - Transmission overloads extend south of SHEI towards Rutland
    - Even with no imports from NY along the Plattsburgh-Sand Bar tie
    - May run out of angle range on Sand Bar phase angle regulator to maintain flows low enough to prevent overloads under some conditions
    - Any reduction in Northern Vermont generation will be annulled by NY-VT tie flows
  - Voltage collapse in northern VT
  - Low voltage on bulk system and high voltage on subsystem
    - Managing pre- and post-contingency voltages will require dynamic voltage support
- MW or MWh ratio distribution results are the same as 2018 solar PV distribution, but with fewer transmission and distribution transformer overloads

Bulk and predominantly bulk concerns in high solar scenario (2018 solar PV distribution)



- SHEI is current constraint interface
- SHEI-1 to SHEI-5 are expansions of constraint
- Timing of expansion is unknown
  - Depends on how quickly solar PV is installed in individual zones
  - Not necessarily sequential—e.g., SHEI-3 could occur before SHEI-2
  - Optimal solar PV distribution analysis gives some insights

Summary of thermal* overloads for different load and generation levels

Solar PV distribution	2018 solar PV distribution	MW ratio solar PV distribution					
VT load w/o losses	620 MW	620 MW			745 MW		
Northern VT generation without solar PV	425 MW	425 MW	355 MW	280 MW	425 MW	355 MW	280 MW
Miles of Transmission Lines	49	49	49	49	49	49	11
Miles of Subtransmission Lines	87	75	60	29	46	31	29
Number of Transmission Transformers	5	1	1	1	1	1	1
Number of Subtransmission Transformers	9	1	1	1	1	1	1

* Voltage control will also be a concern

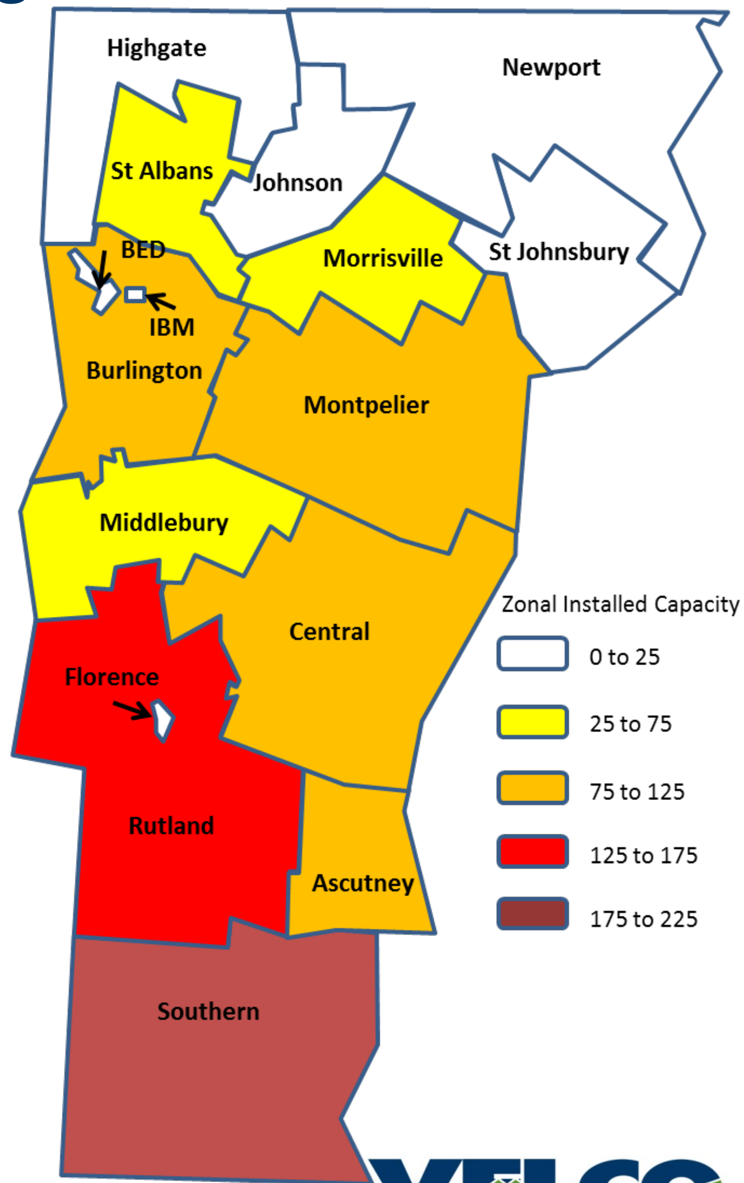
Assumptions affecting optimal PV distribution

- AC tie line imports reduced to 0 MW—may not always be possible
- Solar PV provides voltage control—essential to maximize solar PV
- Daytime load is not reduced below current levels—every reduced load MW = reduction in maximum zonal solar PV
- 5% over equipment thermal capacity allowed—accounts for occasional curtailments, future storage, load management, and other network management measures
- Existing system concerns, not related to solar PV additions, will be addressed by system upgrades—necessary to maximize solar PV.
- Distribution system concerns are addressed—if not, these concerns may limit solar PV below levels indicated in analysis
- Larger scale ISO-NE interconnected generation or elective transmission projects are not implemented—probably unrealistic due to economics and FERC open access requirements
- Solar PV will be installed exactly as laid out in this optimized distribution—unlikely because of several objectives or constraints including project economics, aesthetic impacts, regional acceptance of solar PV levels significantly higher than regional loads, etc.
  - Maximum zonal solar PV levels are interdependent—amount of solar PV in one zone will affect amount that can be installed in other zones

Maximum amount of solar PV that may be hosted with minimal system upgrades

Dependent on assumptions on previous slide

Zone names	Gross MW loads	MW AC solar PV capacity	Net MW loads
Newport	19.8	10.3	9.5
Highgate	23.8	15.5	8.3
St Albans	39.7	42.9	-3.2
Johnson	6.6	16.4	-9.8
Morrisville	24.3	50.7	-26.4
Montpelier	48.6	104.9	-56.3
St Johnsbury	14.7	12.1	2.6
BED	39.8	5.6	34.2
IBM	60.6	20.0	40.6
Burlington	94.1	107.4	-13.3
Middlebury	19.7	57.7	-38.0
Central	37.6	91.2	-53.6
Florence	22.6	21.2	1.4
Rutland	61.7	164.6	-102.9
Ascutney	39.5	112.8	-73.3
Southern	65.6	224.9	-159.3
Total	618.7	1058.2	-439.5
Losses	33.6	N/A	53.4



VELCO

The bottom line

- Vermont is highly dependent on transmission
- No load growth for the first ten years of the forecast—many uncertainties and emerging trends: economic, technological, climatic, societal, state and federal policies
- No transmission upgrades needed to serve peak load
- Some subtransmission issues to be evaluated by DUs
- Upgrades may be needed to support renewable energy resources depending on amount, location and whether they provide grid support
- System will be unable to host 1000 MW without a drastic change in solar PV distribution and other measures
  - Some combination of storage, curtailment, load management, grid upgrades, operational changes …
  - Voltage control from solar PV inverters is necessary
  - A statewide conversation regarding a coordinated plan for solar PV growth should be considered

Questions for you

- What questions do you have about the process, the analysis and the conclusions?
- What feedback do you have about the plan?
- What is happening locally that is important to understanding the evolution of Vermont’s electric grid?
- What else?

Deena wants your feedback (really)

- Using the comment form at www.velco.com/longrangeplan2018
- By mail: Deena Frankel, Facilitator
  VELCO
  366 Pinnacle Ridge Road
  Rutland, VT 05701
- By email: dfrankel@velco.com
- By phone: (802) 488-4489