

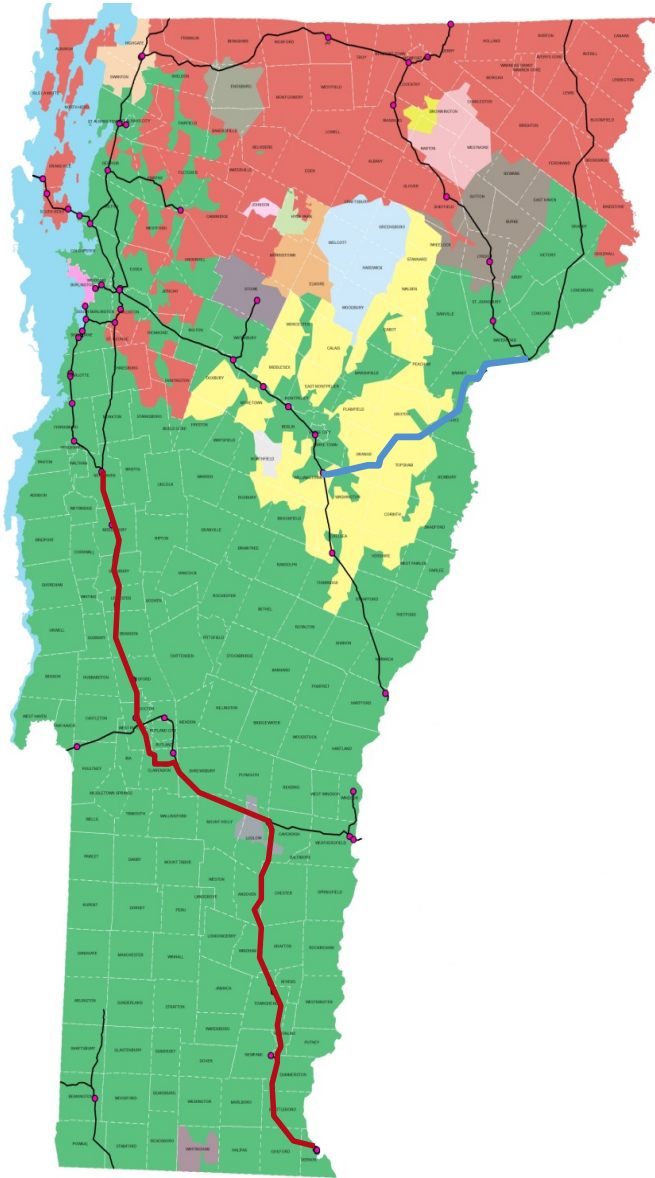
Integration of High Levels of Renewables on the Vermont Electric System



Lou Cecere
CIGRE Grid of the Future
Symposium

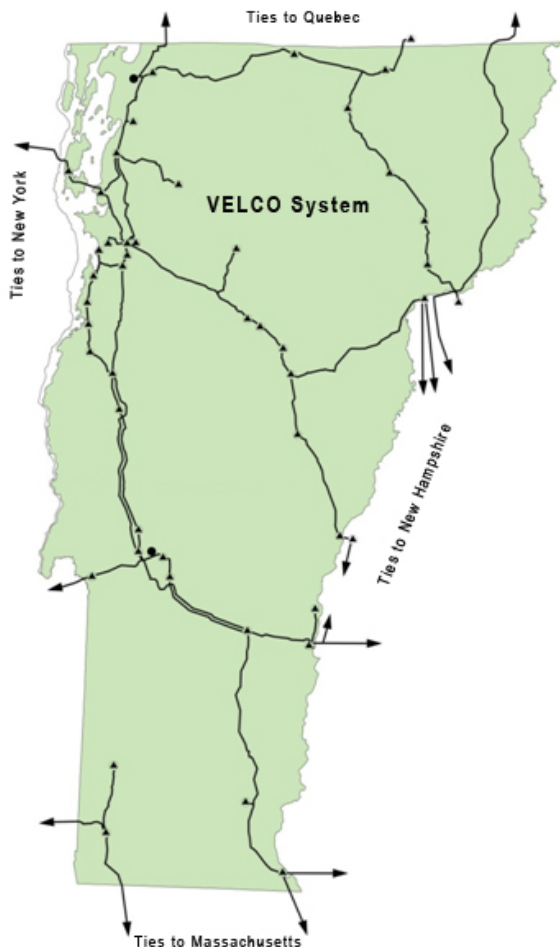
November 5, 2019

VELCO Overview



- Nation's first statewide, "transmission-only" company formed in 1956 by local utilities
- Owned by Vermont's 17 local utilities and VLITE (public benefits corporation)
- 738 miles of transmission, 115 kV, 230 kV, 345 kV, and 450 kV
- 55 substations, switching stations and terminal facilities
- 225 MW HVDC Converter connecting VELCO to Hydro-Québec
- 1 STATCOM, 1 SVC, 4 Phase Shifting Transformers, and 4 Synchronous Condensers
- 1400 miles of looped fiber optic networks
- VT's peak load is about 1,000 MW

Vermont Generation Mix

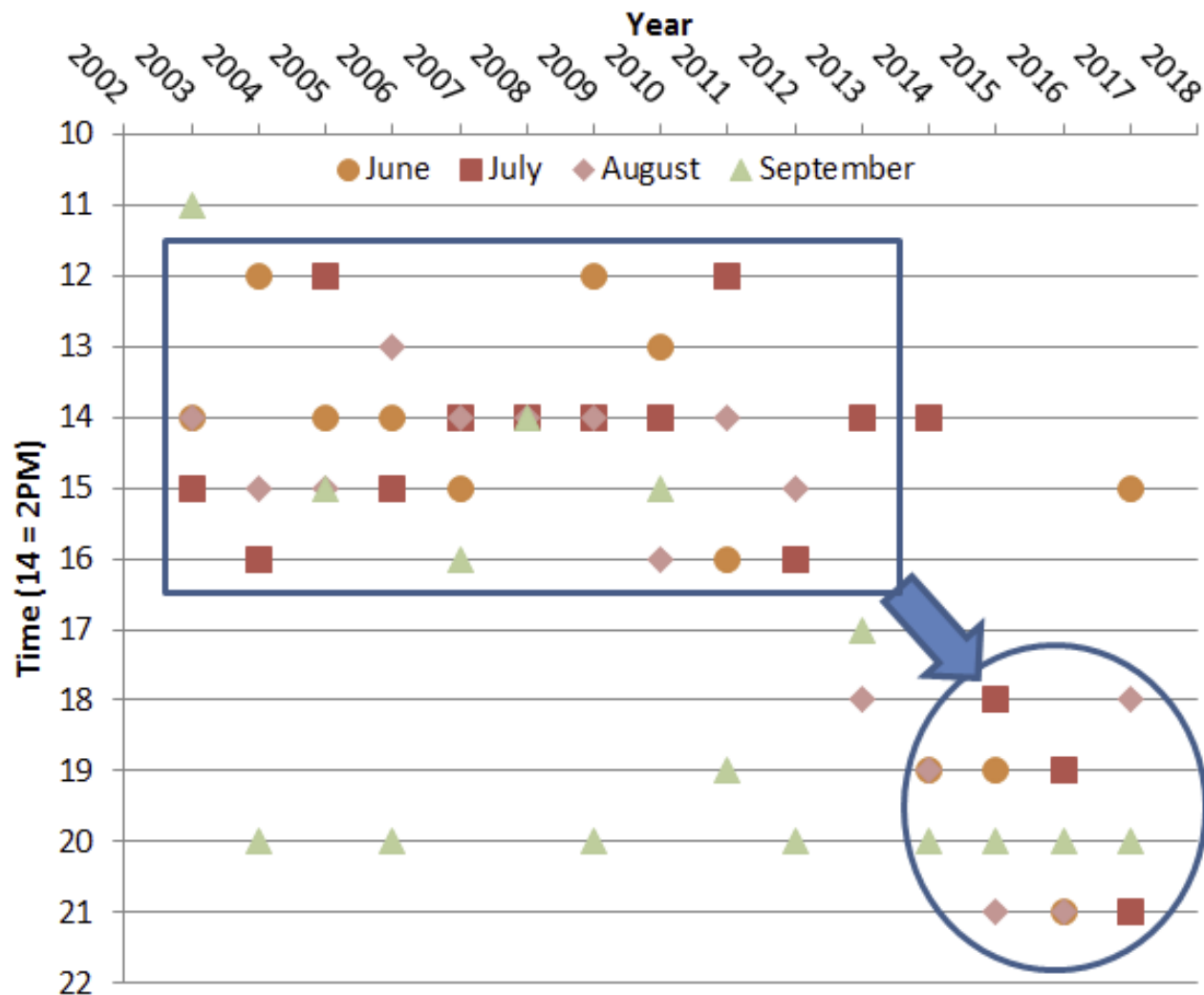


Type	MW 2014	MW 2019
Fossil (fast start units)	138	157
Hydro	152	129
Wind	123	150
Landfill gas	9	13
Biomass (wood)	72	72
Solar (grid-connected and BTM)	~100 and growing	~350 and growing
Other BTM	<10	62
Nuclear	625	0
TOTAL IN-STATE GENERATION	1219	933
Total Weather Dependent Generation	375	662
Hydro Québec Import	220	225

For 73% of hours in 2014, VT exported power
For all hours in 2019, VT imports power

Vermont Monthly Summer Peaks

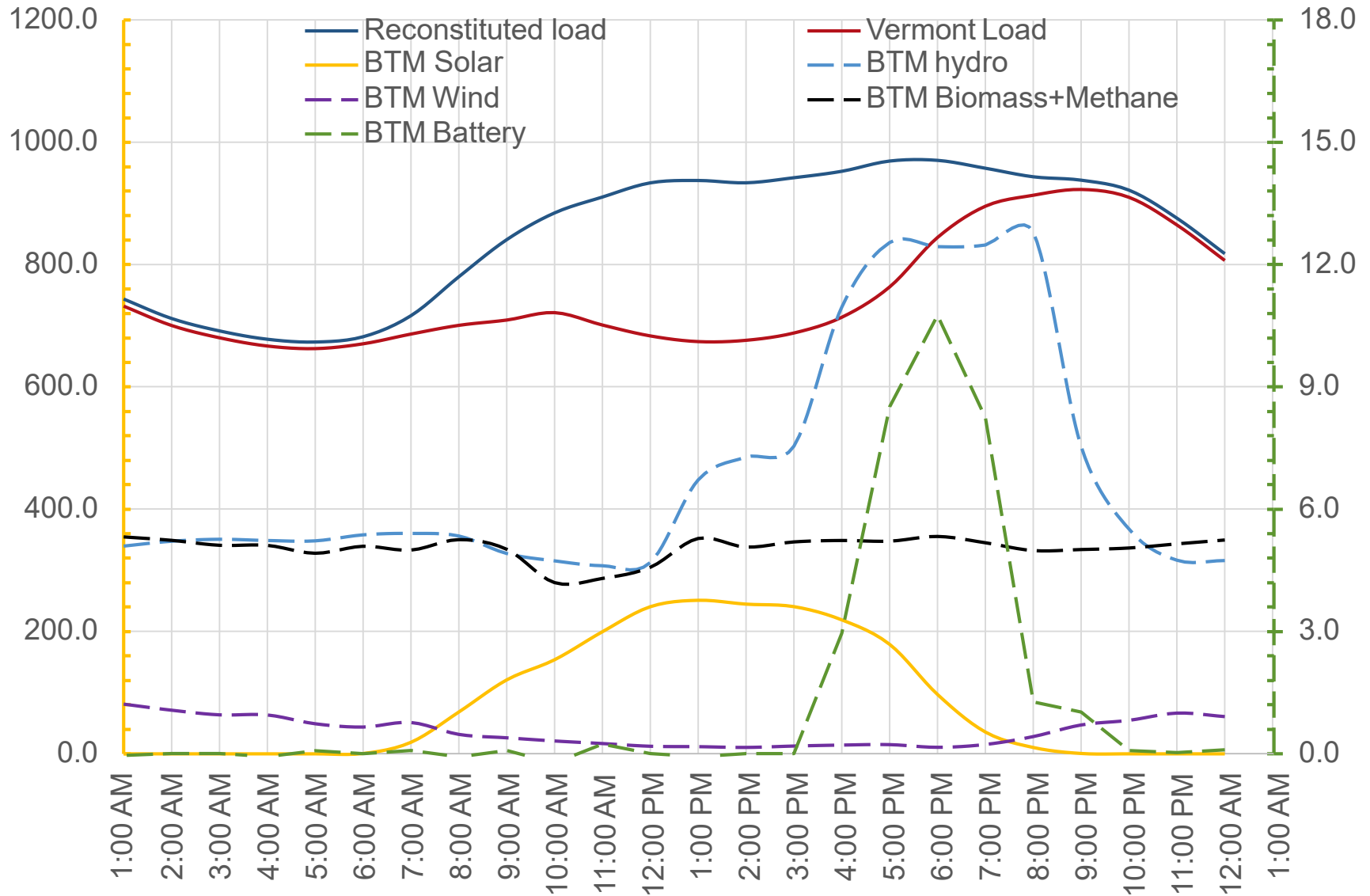
- Peaks occurring later in day
- Shift noticeable from 2013 onwards
- Corresponds with initial uptake of PV in Vermont
- Dependent on weather conditions



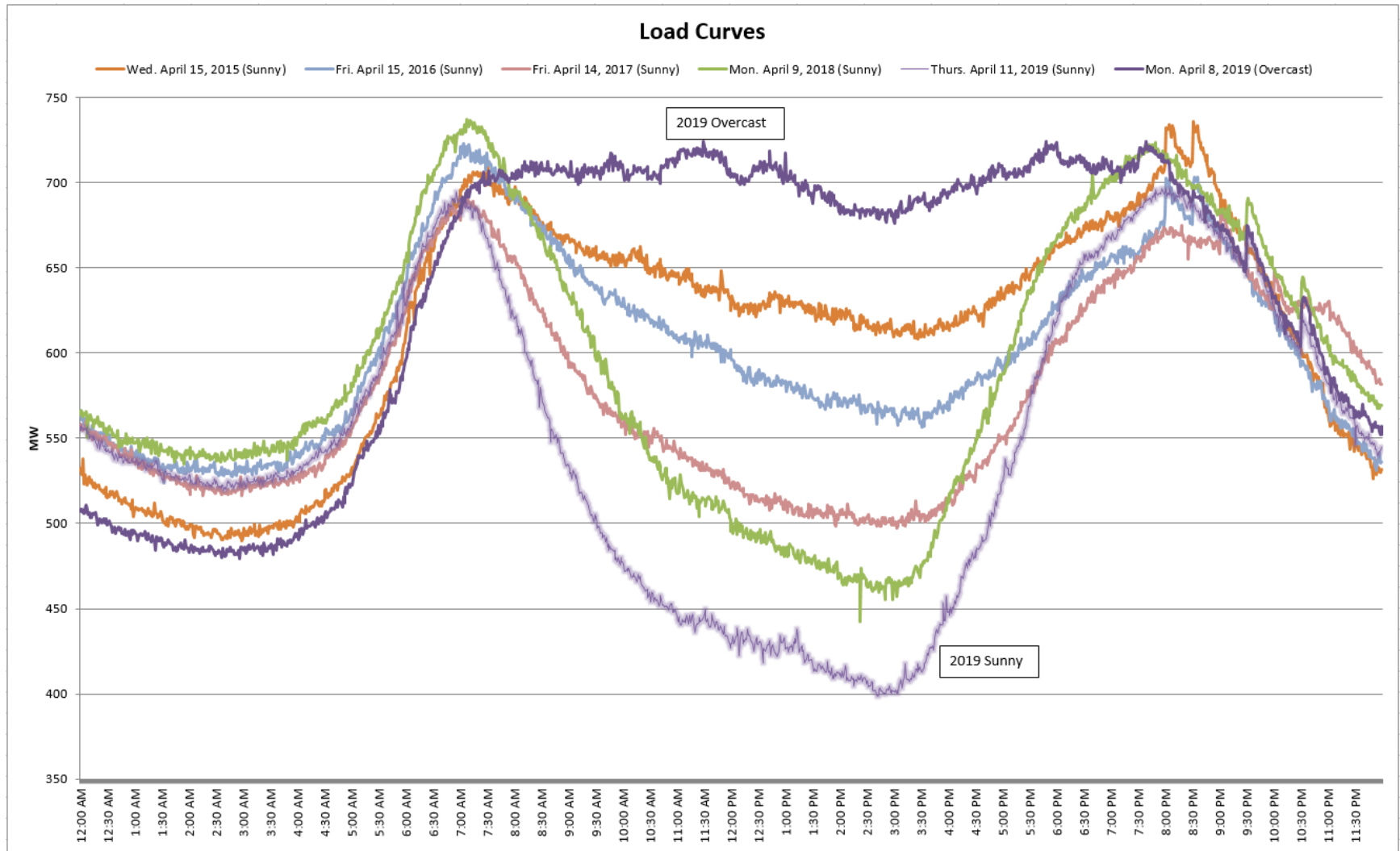
Battery Storage

- 2000 Tesla Powerwalls (5 kW/13.5 kWh)
 - Residential customers, behind the meter
 - Utility leased, backup and peak load
- Stafford Hill solar + storage (4 MW/3.4 MWh)
- Panton storage (1 MW/4 MWh)
- New units in development
- Act as load reducers

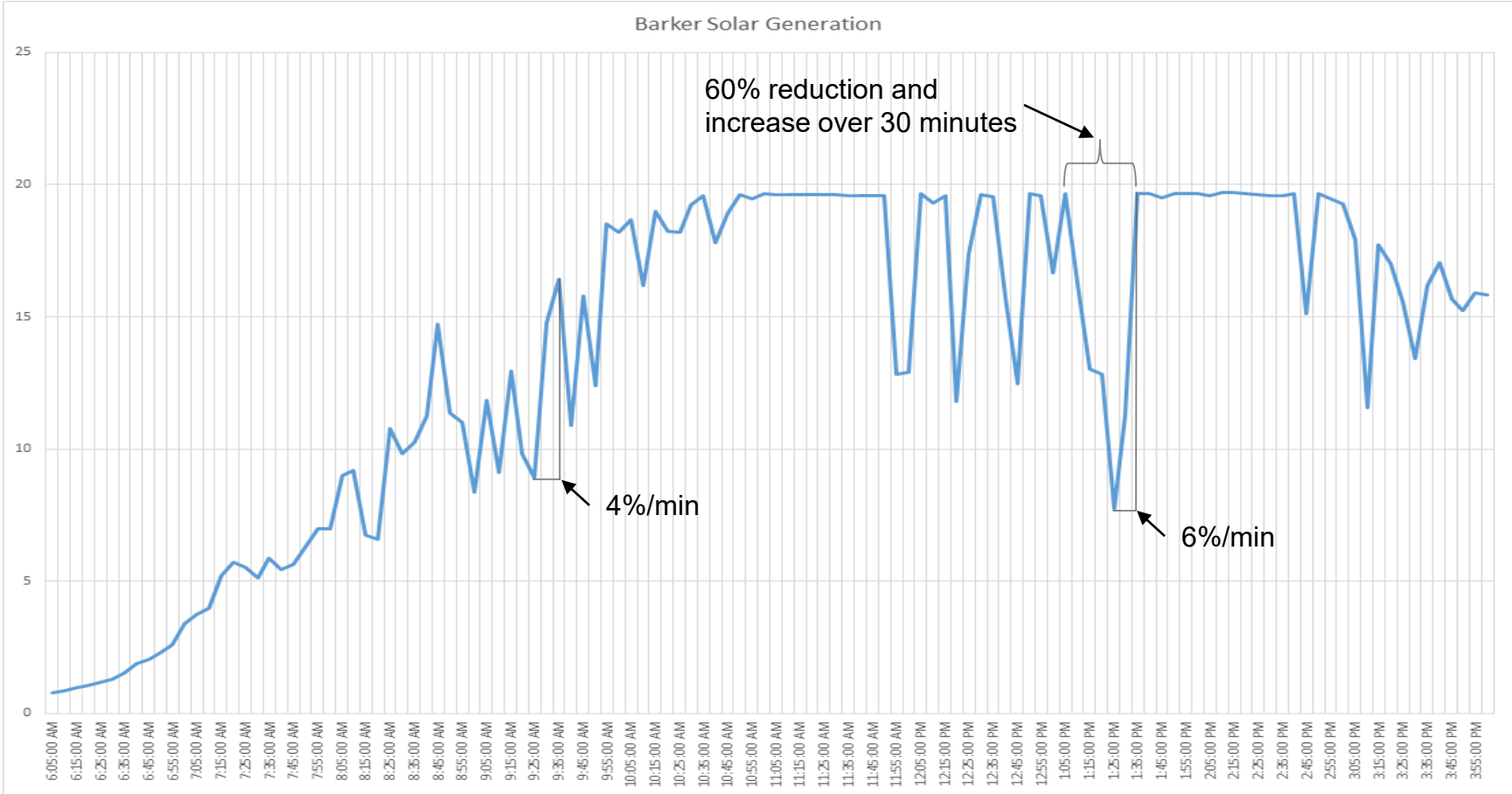
July 20, 2019 (Vermont Summer peak day)



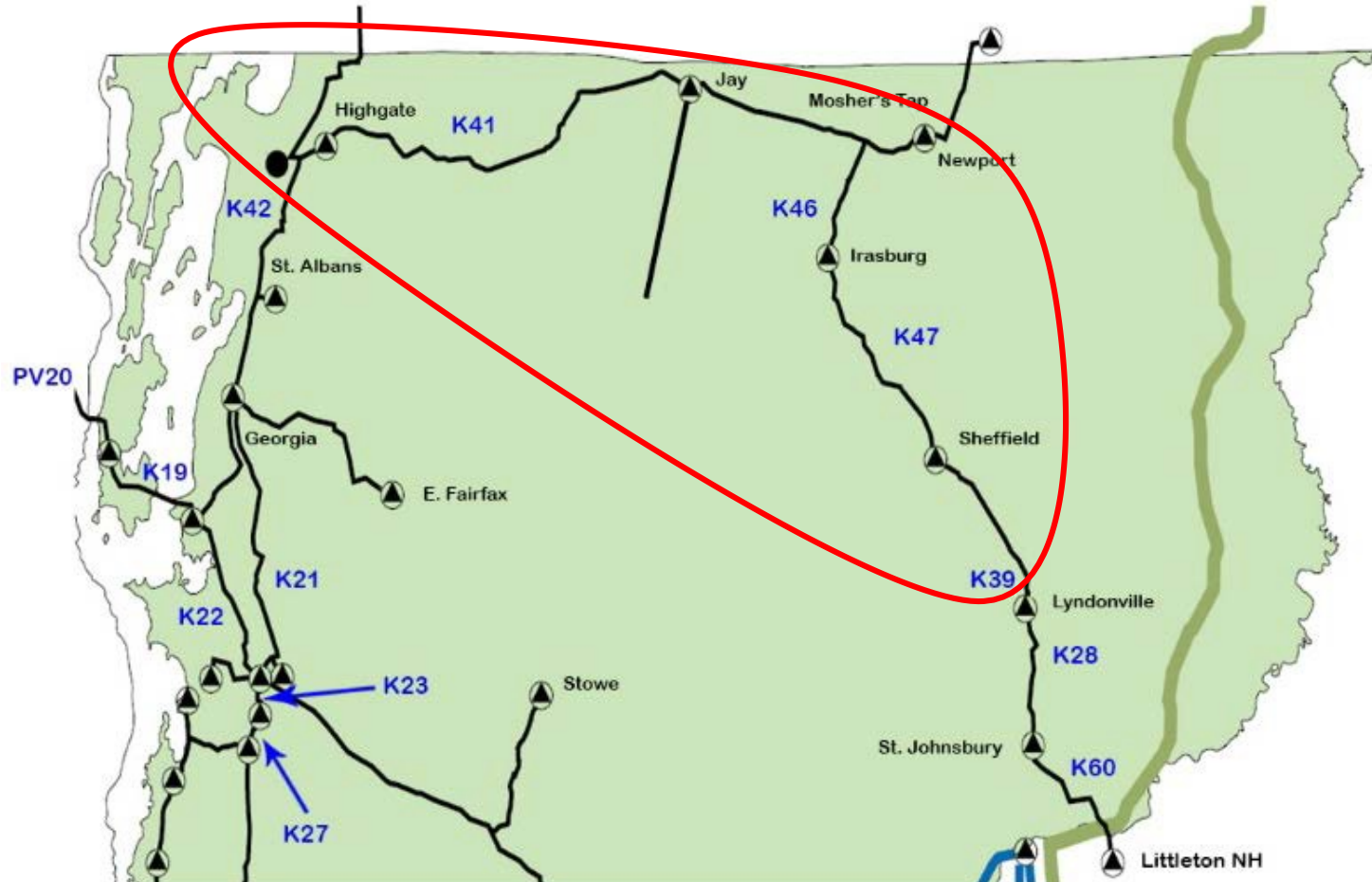
Vermont Net Load Curves



Barker Solar Generation Output (MW)



Sheffield-Highgate Export Interface



Challenges of Renewables

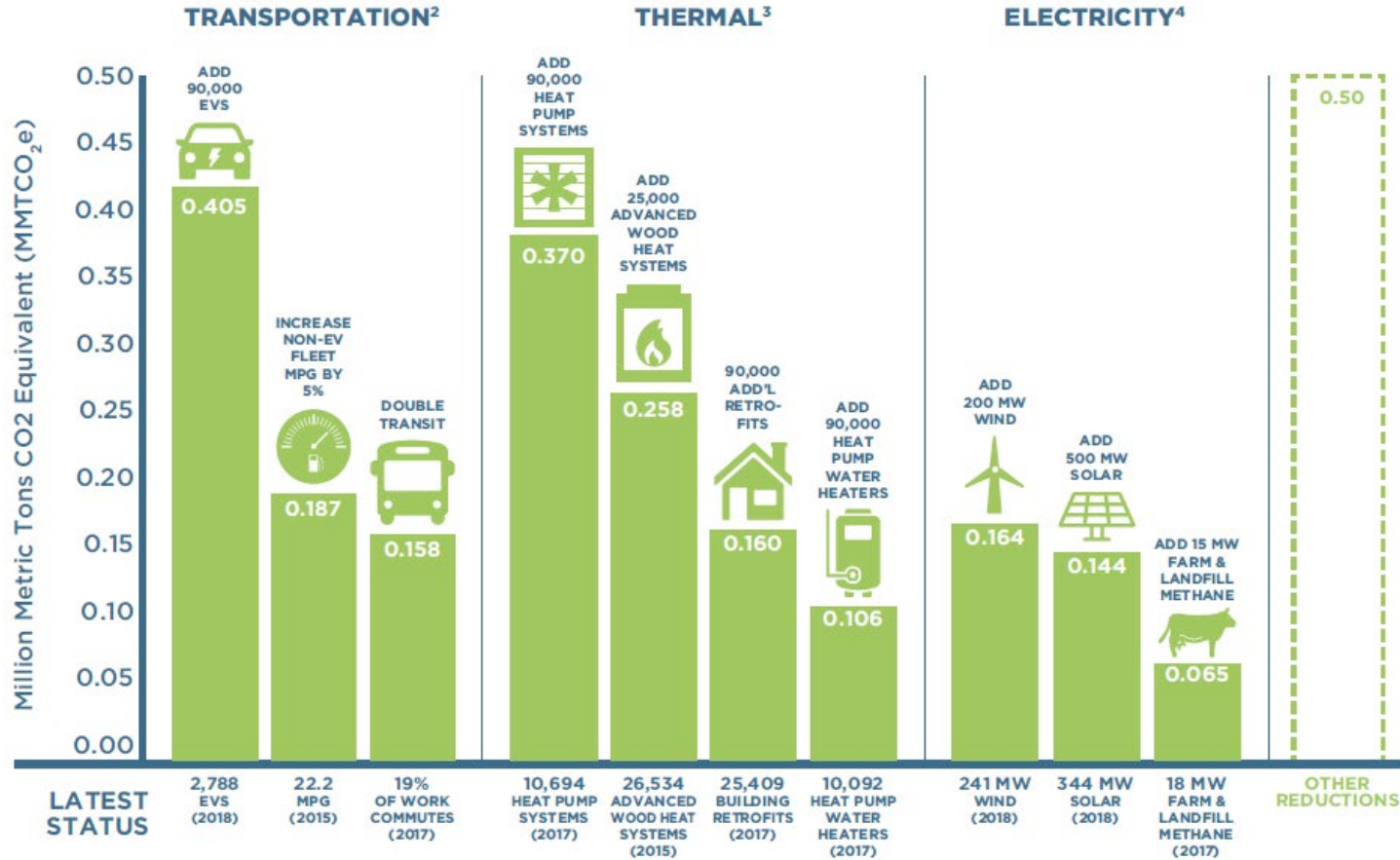
- Weather
 - Variability of wind and solar
 - Need for forecasting
 - Snow on solar panels
- Low capacity factor → reliance on imported power
- Need to track nameplate and real-time output of BTM resources
- Inverter voltage control
- Stay ahead of regulation

RES, Utility Portfolios, & CEP

- Renewable Energy Standard
 - Tier I: Total renewables (incl. large hydro)
55% renewable by 2017 → 75% renewable by 2032
 - Tier II: Distributed generation carve-out
1% of sales in 2017 → 10% of sales in 2032
 - Tier III: Energy transformation projects
2% of sales in 2017 → 12% of sales in 2032
- GMP planning for 100% renewable by 2030
- 2016 Comprehensive Energy Plan sets target
 - 90% of consumed energy renewable by 2050
 - Not a legal requirement

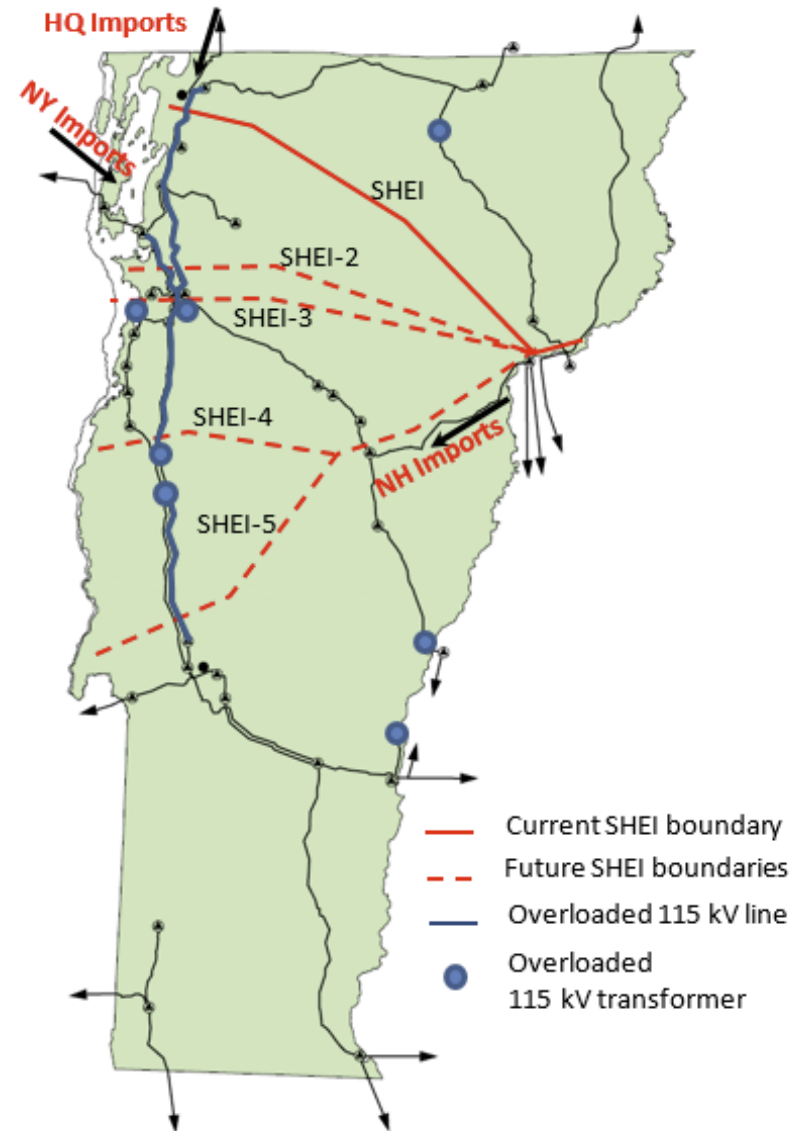
Energy Action Network

2.53 MMTCO₂e reduction by 2025 is required to meet the Paris Agreement¹



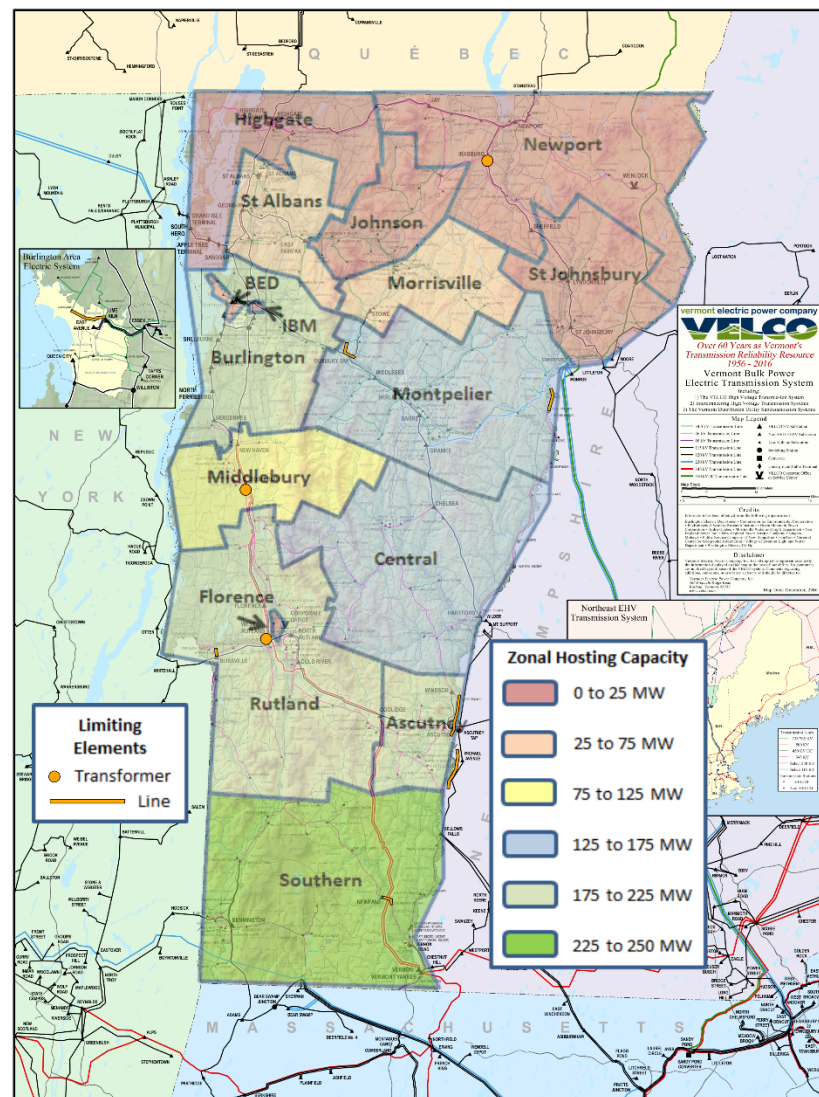
1000 MW Solar Analysis

- Vermont System Planning Committee, est. 2006
- Long-Range Transmission Plan to evaluate reliability
- Expanded scope to encompass renewables integration
- Vermont Solar Pathways – 1000 MW solar for 20% of electricity
- Assumed same distribution as present day
- High concentration of solar in Chittenden and Addison counties
- Overloads and potential for SHEI expansion



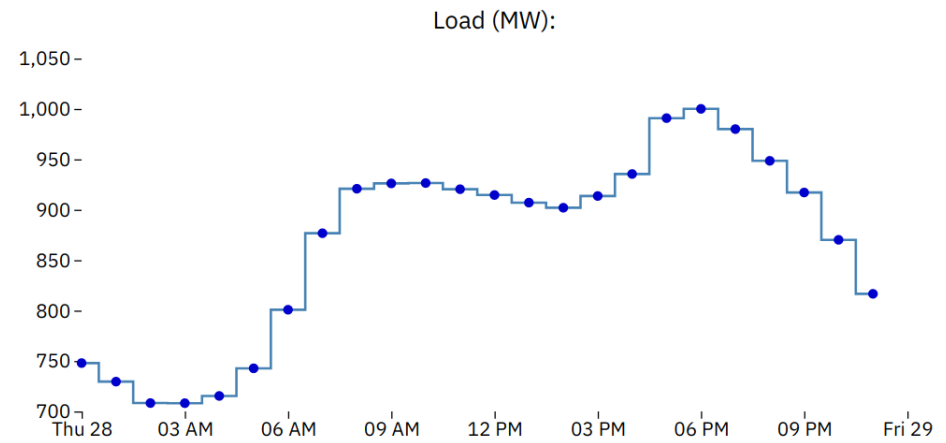
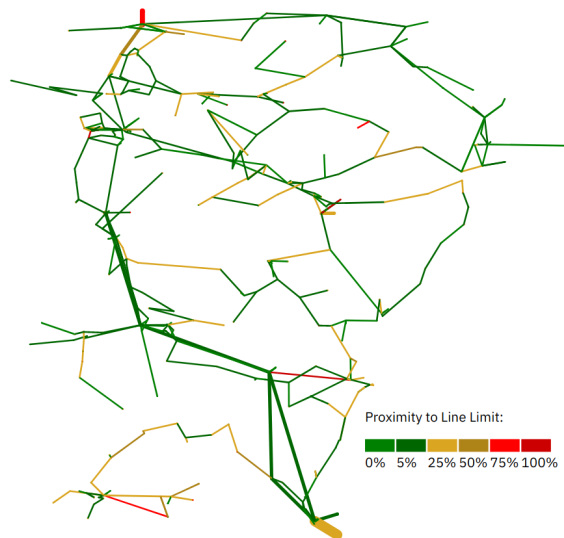
Optimized Distribution

- AC imports set to 0 MW
- Assumed new inverters are capable of voltage control
- Solar allocated zone by zone, south to north
- 1058 MW of solar with no violations
- Zonal limits dependent on adjacent zones
- 2021 Long-Range Transmission Plan to address distribution limits
- Regional Planning Commissions wish to install more than double available capacity



Other Vermont Energy Efforts

- Vermont Energy Dashboard
- Flexible Load Management
 - GMP/EVT/Dynamic Organics – C&I customers
 - Packetized Energy – residential customers
- University of VT – time series power flow



In conclusion

- 500 MW wind & solar on a 1000 MW system
- Aggressive GHG emissions reduction targets
- High growth in PV (BTM and utility scale)
- Existing and potential generation constraints
 - Requires stakeholder engagement
 - Not addressed by “cost causer pays” model
- Technical, regulatory, and policy issues

Thank you for your time!

Lou Cecere, VELCO

Transmission Planning Engineer

LCecere@VELCO.com