

Challenges of an Evolving Electric Grid



i-PCGRID Workshop 2019
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Things are changing:

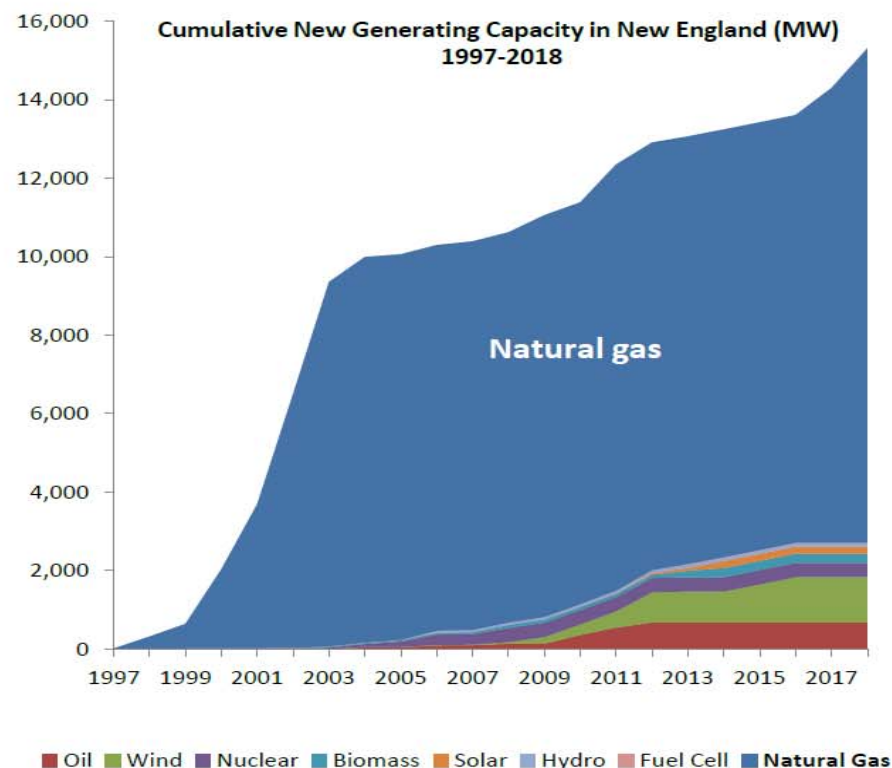
1. Generation mix is changing very fast
2. Operating issues which need to be addressed
3. Will there be another widespread blackout?

The Electric Power Grid is ongoing unprecedented changes

1. Rapid retirement of coal, oil and nuclear generating plants (>5,000MW in NE)
2. Rapid proliferation of renewable energy
3. Significant dependence on natural gas pipelines (Particularly in the Northeast)
4. Operating in modes which have never been experienced(net loads, inertia, fault current)
5. Storage is a wild card
6. Speed of electrification of heating and transportation is very uncertain

Transformation Region's Resource Mix Continues

- **Low natural gas prices**
 - Gas is the most economic fuel for new, conventional resources
 - 80% of new capacity since 1997 runs on natural gas
 - Nearly 65% of all proposed new generation would use natural gas
 - Demand for natural gas is rising
 - Gas pipelines are constrained during high demand periods, particularly winter
 - Creates grid reliability concerns and price volatility
- **Low prices are putting financial pressure on coal, oil and nuclear baseload generators; some are retiring**



Source: ISO New England "State of the Grid 2016"

Sources of Electricity Production

Major shift from oil and coal to natural gas over the past 17 years



Electric generation has changed sharply in less than a decade. Source: ISO New England

Shift to cleaner power continues

- **State policies drive renewable resource development**
 - Mostly large-scale wind and behind-the-meter solar
 - Other, fast & flexible resources will be needed to balance intermittent resources' variable output
 - New transmission needed to bring wind farms' energy from their remote locations to population centers
- **Distributed generation and the "hybrid" grid**
 - A significant portion of New England's future grid could be "behind-the-meter" (solar facilities on distribution system)
 - That will change how much and when power is used by consumers

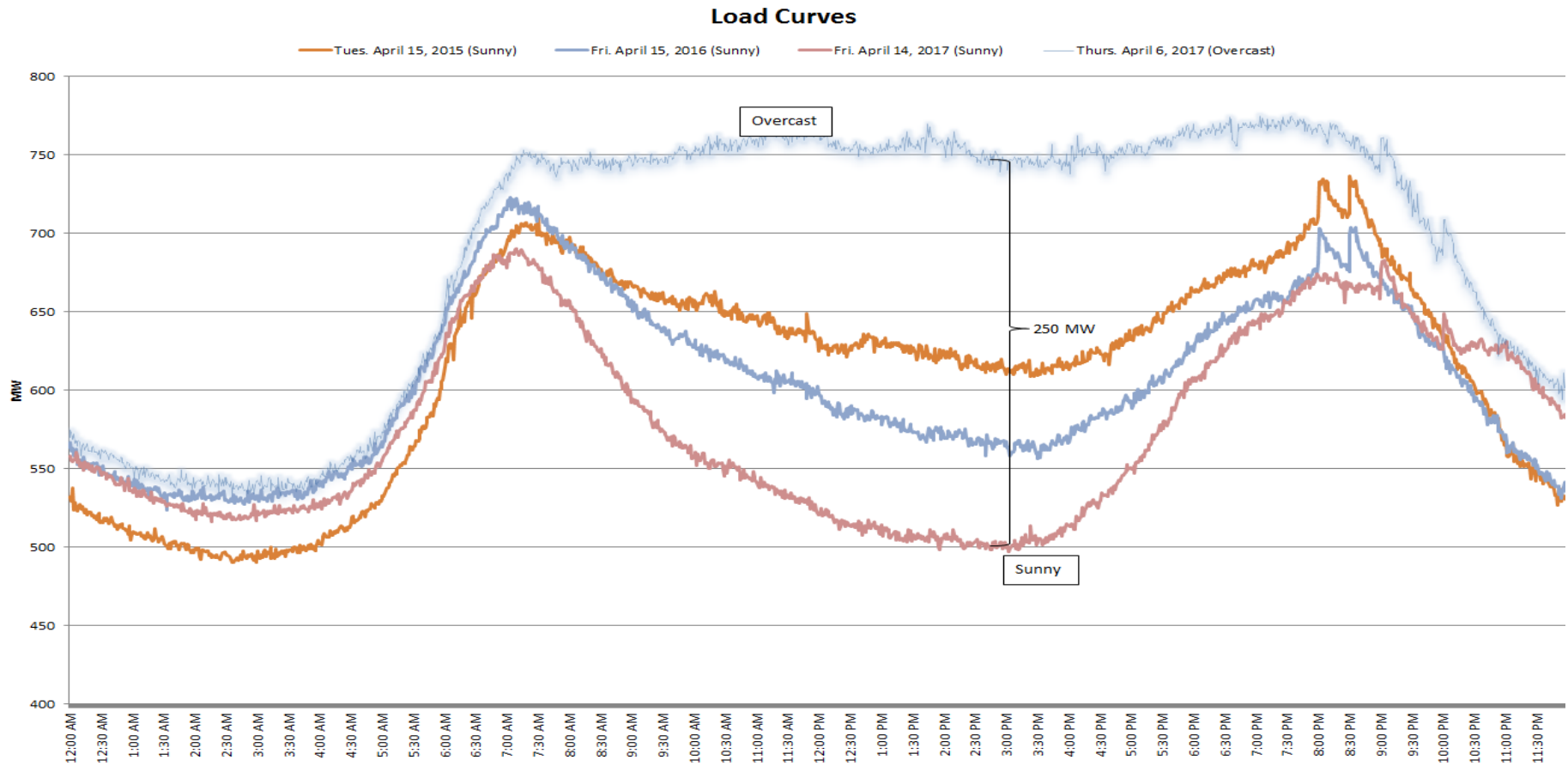


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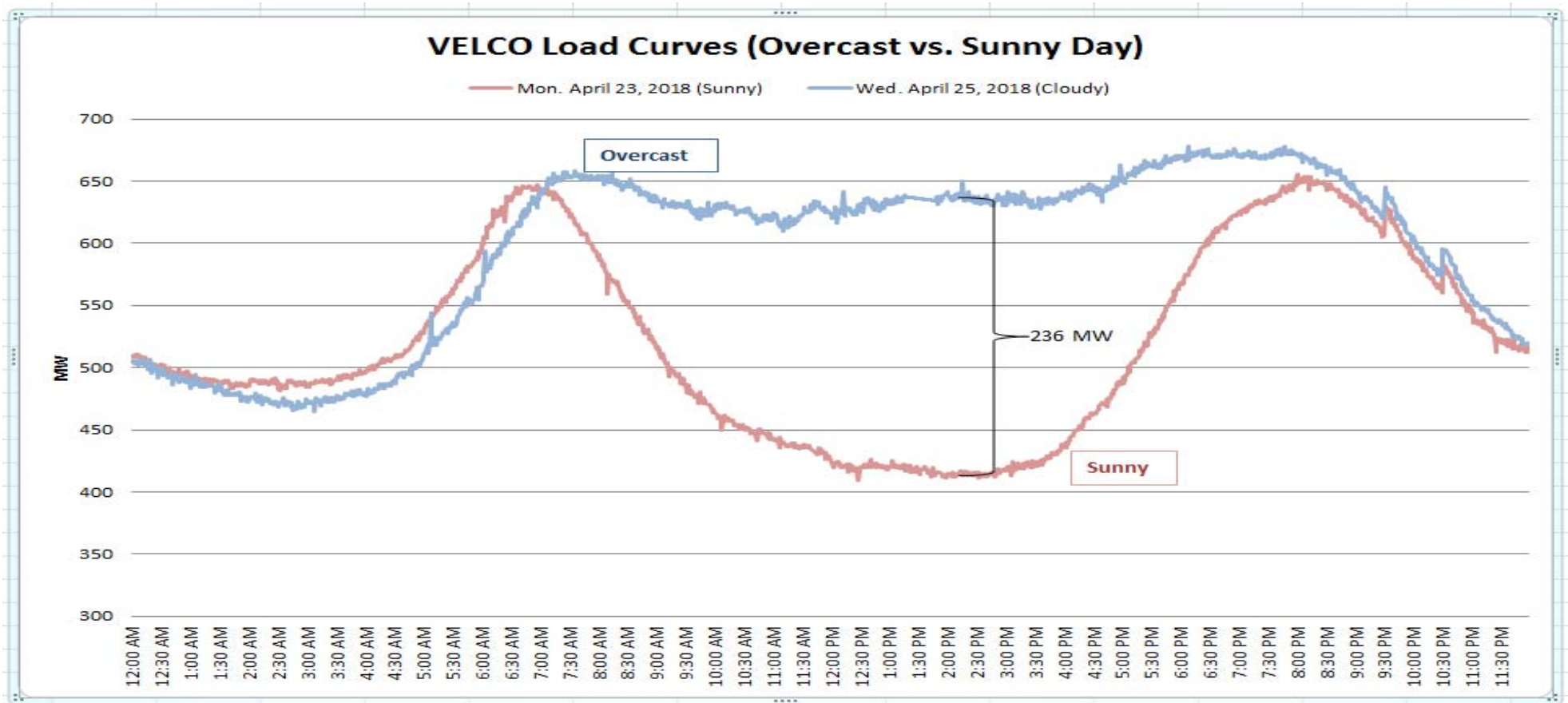
Vermont Situation

- 640 MW nuclear plant shut down in 2014
- Peak load of 1000 MW has been constant for over 10 years
- Peaks are after dark in winter (traditionally) AND summer
- Greater than 300 MW of PV
- 150 MW Wind Generation
- 120 MW Hydro
- 225 MW HQ Imports

April Load Comparison



April 2018 Load Comparison



Renewable Integration Issues

- Weather dependent in many areas (clouds, snow, calm winds)
- Renewables are inverter based
 - IEEE 1547 adoption
 - Reduction of fault current
 - Distributed renewables have NO malware or CIP regulations
- Distributed renewables are not visible to system operators

Voltage Regulation Challenges

- Inverter based generation is very fast
- Large swings between day and night
- Conventional utility methods are too slow
- Transmission voltages can be affected and will require more, faster regulation

Static VAR compensator (SVC)



Ascutney, Vermont

What about storage?

- What are the economic drivers?
- Perception vs. Reality
- Utility scale technologies?



GMP's Stafford Hill Solar Farm and 4 MWh battery installation



GMP is offering 2000 Tesla Powerwalls at \$15 per month to customers

Major Uncertainties

1. How will the storage market develop?
 - The answer is storage, what was the question?
 - What will be the technology?
 - MW vs. MWhR struggle
2. How much and how fast with electrification take place
 - Conversion of thermal heating to electric
 - Speed of electric vehicle adoption (200K vs. 17M) (1M sold worldwide in 2017, half in China)
3. Will there continue to be an electric wholesale market?
 - Many plants being pushed out of the market
 - Subsidization issues
 - Long term contracts for renewable energy

Risks to the reliability of the grid

NERC reliability issues steering committee

Risk has identified a number of emerging risks to the reliability of the Bulk Power System (BPS) to focus industry's efforts:

High Risk Profiles

- Cyber Security Vulnerabilities
- Changing Resource Mix (coal plant closures, increases in NG and renewables)
- BPS Planning
- Resource Adequacy

Moderate Risk Profiles

- Increasing Complexity in Protection and Control Systems and Asset Management
- Loss of Physical Awareness
- Physical Security Vulnerabilities
- Extreme Natural Events

Low Risk Profiles

- Human Performance and Skilled Workforce

Will there be another blackout?

YES!!!

The questions are:

1. How big?
2. When?
3. What are the causes?

Conclusions

- Great time to be a power engineer!
- This is a new world!
- External pressures for large amounts of renewables is out stripping the science of operating this new grid
- Storage is critical in the future
- Balancing load and generation is not easy or forgiving
- Social pressures are driving policies which are changing operating situations rapidly