Transmission Planning for the Future Grid

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Presentation Overview

- New Challenges in Transmission Planning
- Proposed Study Conditions
- Distribution Coordination Needs
- Use of New Assumptions
- Feedback & Next Steps

NEW CHALLENGES IN TRANSMISSION PLANNING

What new concerns and phenomena do we need to analyze?

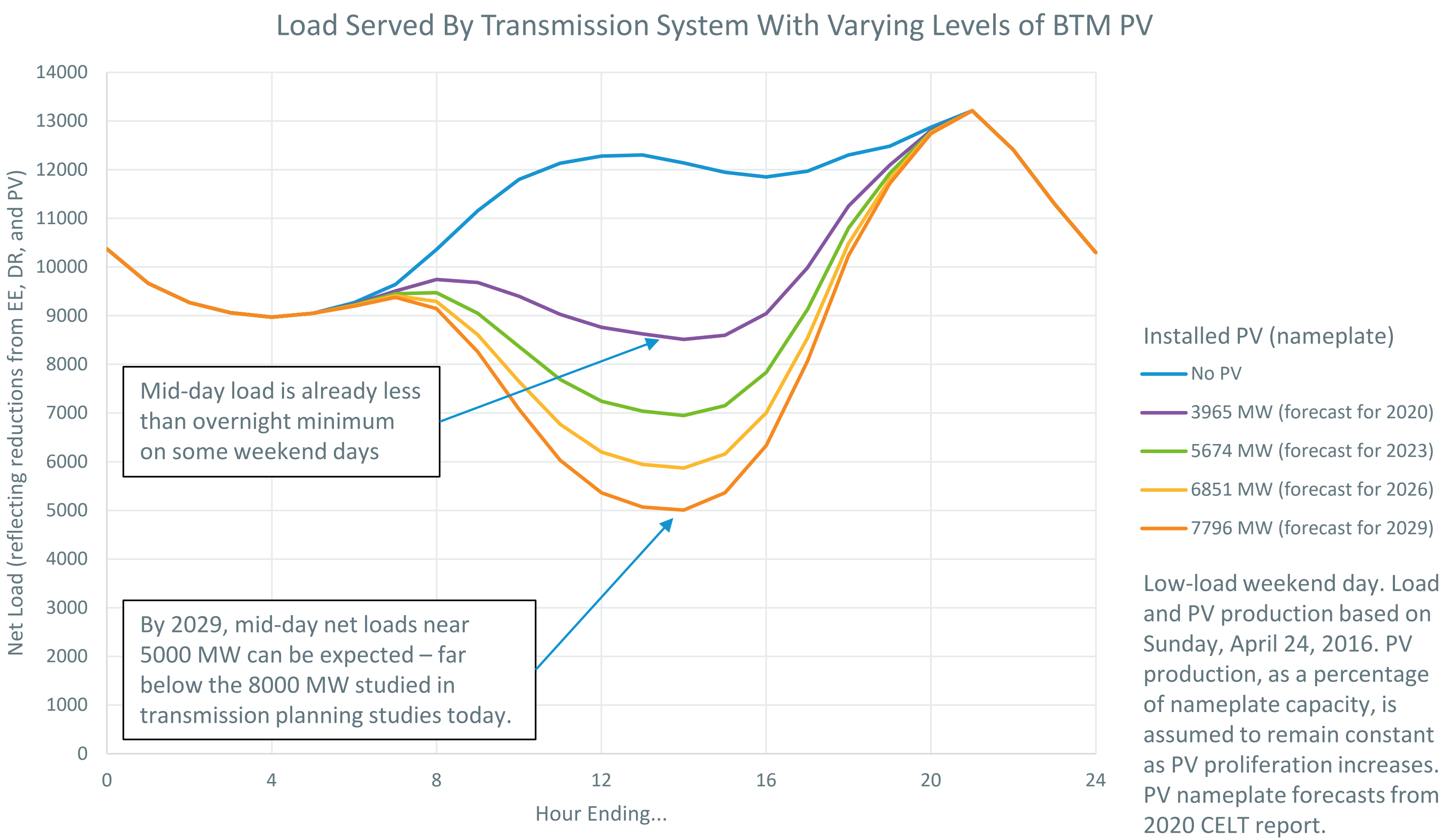
Why Are New Approaches Needed?

- New England continues to lead many industry trends
  - Development of Distributed Energy Resources (DER)
  - Integration of renewable resources, including offshore wind
  - Increasing imports via HVDC interconnections
  - Integration of battery energy storage resources
- Our current methods of handling these trends were developed, and work well, when these resources make up a small portion of New England's power system as they do today
- As these trends continue to accelerate, our planning studies need to proactively examine new challenges that will arise
  - Different system conditions will drive transmission planning needs
  - New approaches to data collection will be required for accurate modeling
- Today's presentation will be the first of many discussions on rethinking transmission planning to address these emerging challenges

What Does the Future Power System Look Like?

- High penetration of DER, primarily solar photovoltaic (PV)
  - Resources generally under 5 MW connected to the distribution system
  - 2020 CELT forecasts 7,796 MW of PV resources by Dec. 2029
- Increased development of offshore wind generation
  - 30 MW of offshore wind generation in service today
  - 1,504 MW of offshore wind generation has secured state contracts, with 156 MW committed through the Forward Capacity Market
  - 1,600 MW of further state contracts already under negotiation
- Increased development of battery energy storage
  - Transmission-connected: visible & controllable, participates in markets
  - Co-located with renewable generation: ISO-NE may not have independent visibility or controllability of storage assets, especially for distribution-connected installations

Decreasing Load in Mid-Day Periods



Low-load weekend day. Load and PV production based on Sunday, April 24, 2016. PV production, as a percentage of nameplate capacity, is assumed to remain constant as PV proliferation increases. PV nameplate forecasts from 2020 CELT report.

Other Impacts of DER on Transmission Planning

- Areas with lower load density and high DER proliferation will export power under daytime light load conditions
- Many DER installations connected prior to the development of ride-through requirements will likely trip offline for transmission faults

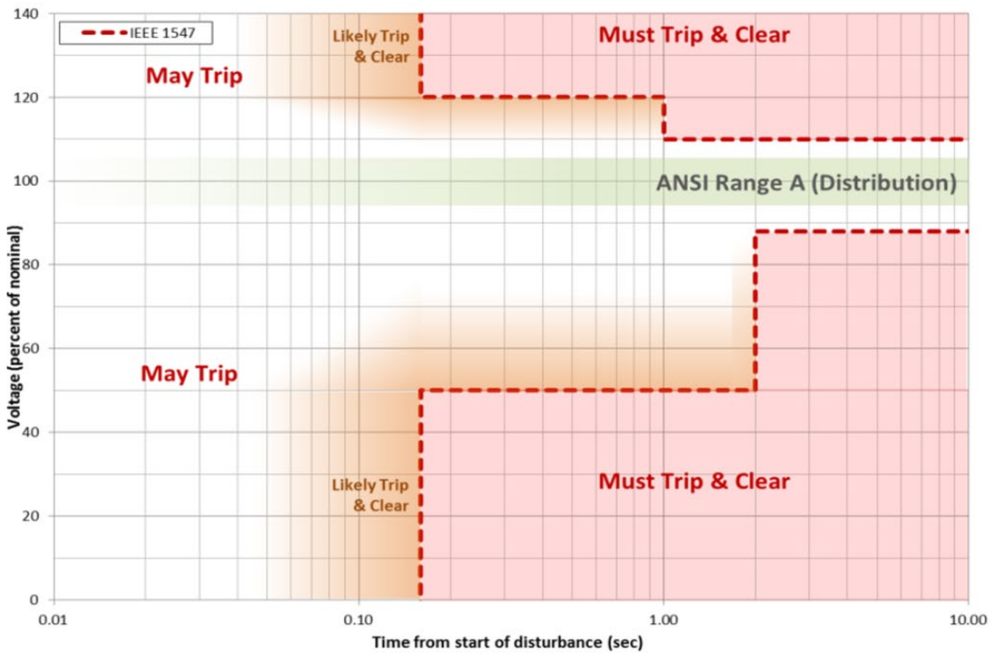


Figure shows IEEE Std. 1547-2003, under which much of ISO-NE's existing DER fleet was interconnected.

Source: NERC IVGTF, "Performance of Distributed Energy Resources During and After System Disturbance," December 2013

Increasing Development of Offshore Wind

- New England’s planned offshore wind interconnections, to date, are primarily located in Southeastern Massachusetts and Rhode Island
- As presented previously at PAC*, output of offshore wind is highly variable and uncorrelated with load
  - Low wind production at peak load could lead to high SEMA/RI imports
  - High wind production coincident with high solar production at lower load levels could lead to high SEMA/RI exports
  - High wind production could lead to voltage control challenges, due to a smaller number of synchronous generators online

* https://www.iso-ne.com/static-assets/documents/2020/02/a7a_wind_power_time_series_isone.pdf

Low-Inertia Conditions

- With increases in PV and wind generation, and additional HVDC imports into New England, the amount of synchronous generation online will decrease
- Reduced inertia can adversely affect transient stability performance and major inter- and intra-area transfer limits
  - Low-inertia conditions will need to be studied
  - Stability analysis will need to be performed as part of Needs Assessments and when developing transmission solutions
- Reduced inertia can also adversely impact frequency response
  - Frequency response needs to be addressed on an interconnection-wide basis; EIPC has already begun studies on this topic*, and further model development for low-inertia conditions will be required

* https://eipconline.com/s/EIPC_FRTF_2018_Final_Report_Public_Version_EC_Approved_2019-02-27.pdf

PROPOSED STUDY CONDITIONS

What times of day/times of year need to be studied?

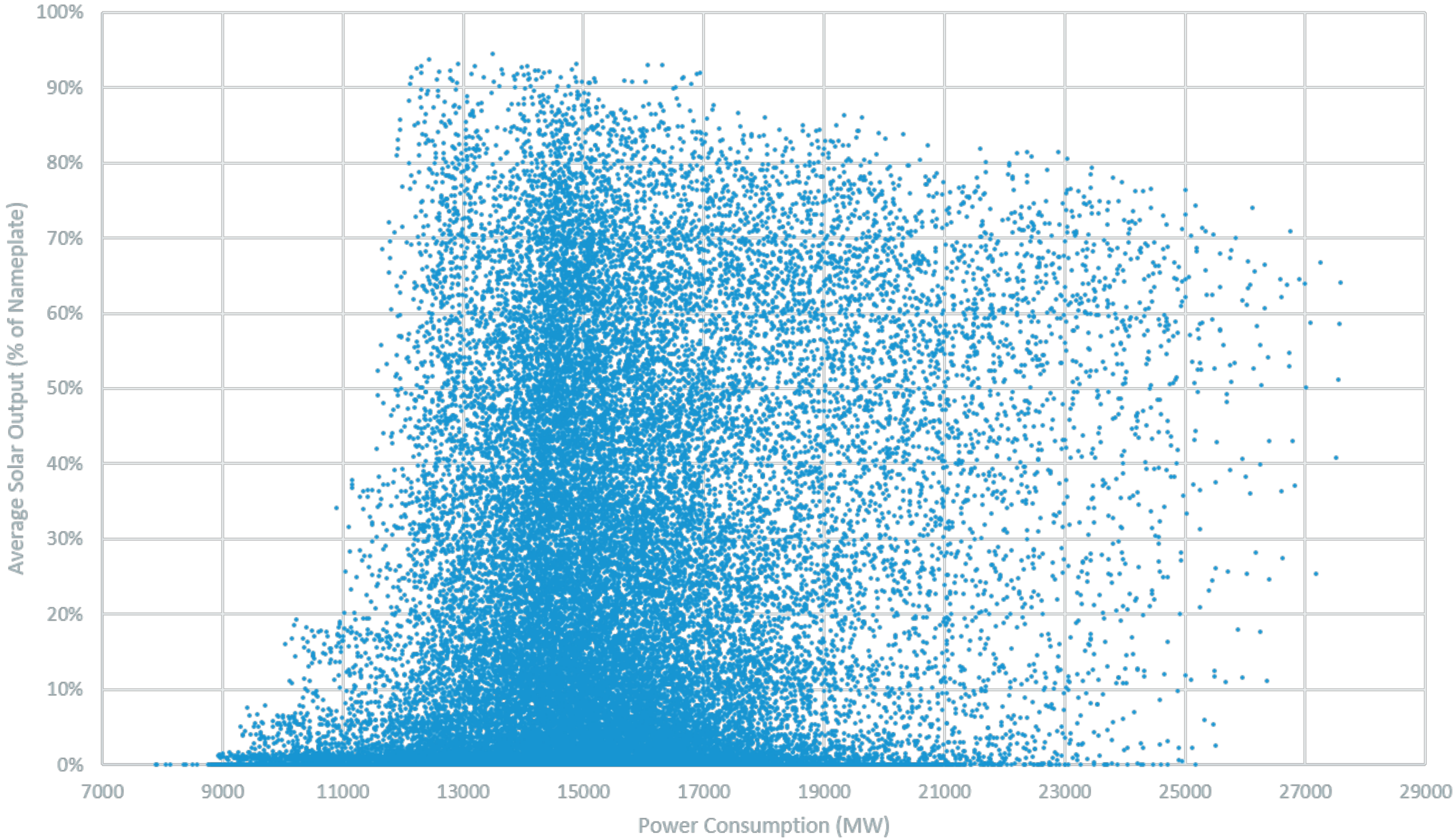
Net Load Level Is Only Part of the Picture

- Current practice is to study net load levels (load served by the transmission system)
  - Peak load: 90/10 forecast – energy efficiency/demand resources – DER
  - Minimum load: 7,680 MW
- With increased DER penetration, net load levels aren't enough to fully define a system condition
  - 3 AM on a mild spring night:
    8,000 MW consumed – 0 MW DER = 8,000 MW net load
  - 1 PM on a mild, sunny spring day:
    14,000 MW consumed – 6,000 MW DER = 8,000 MW net load
  - While underlying conditions can result in identical net loads, system behavior will be very different!

Analysis of Historical Load and Solar Conditions

- On the following slides, a scatterplot is used to show historical conditions from the calendar years 2012-2018
- Each blue dot represents a single hour of data
  - Horizontal position represents power consumption – the load consumed by customers, *before* any reductions due to behind-the-meter generation
  - Vertical position represents the average production of photovoltaic resources during that hour, as a percentage of nameplate rating
  - Data represents average of load and PV throughout the hour
- The “corners” of this plot show the conditions that must be considered in transmission planning studies
  - Studying these boundary points will ensure that any reasonably likely condition will be “bookended” by conditions that have been adequately studied and planned for

Analysis of Historical Load and Solar Conditions



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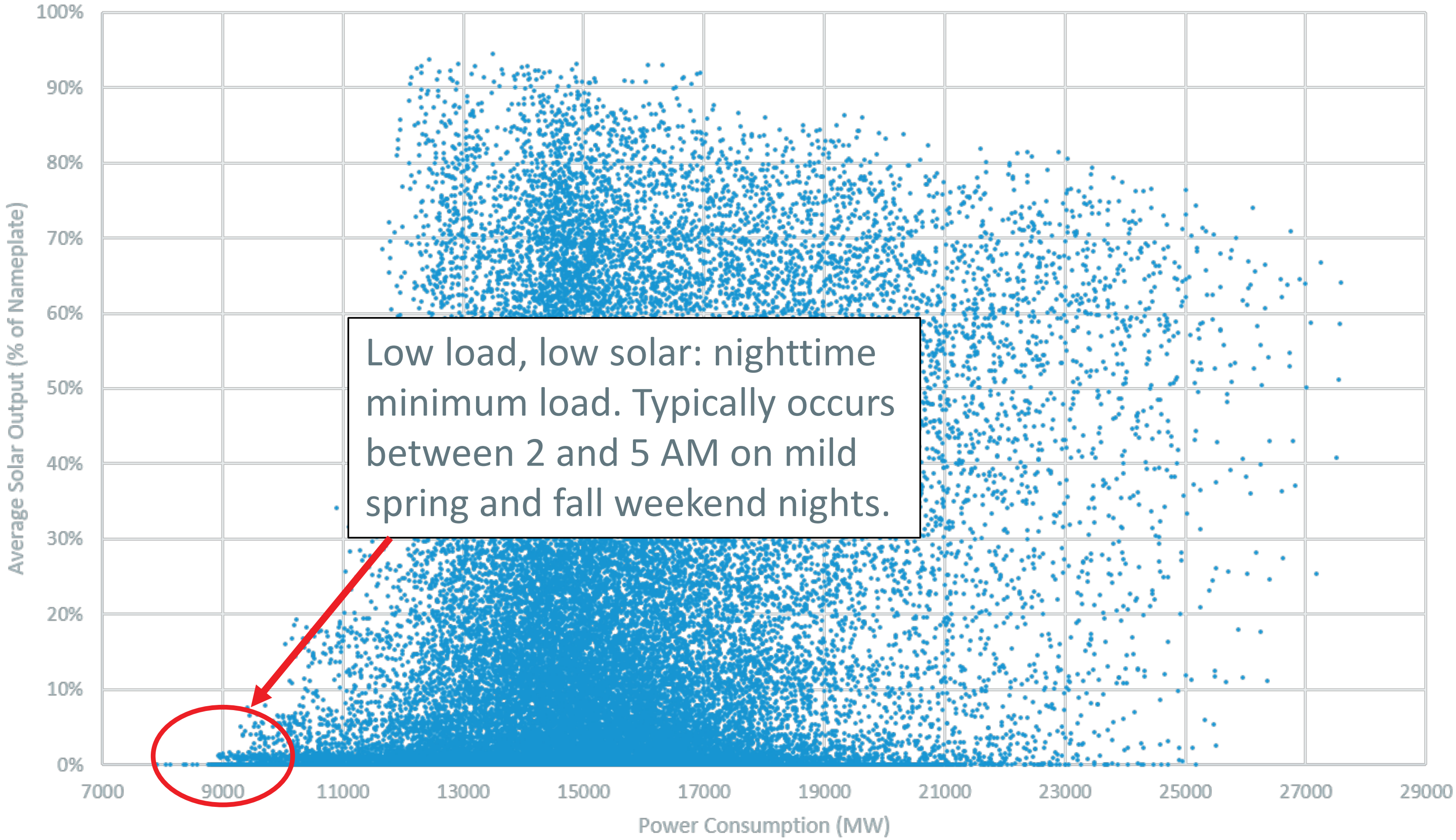

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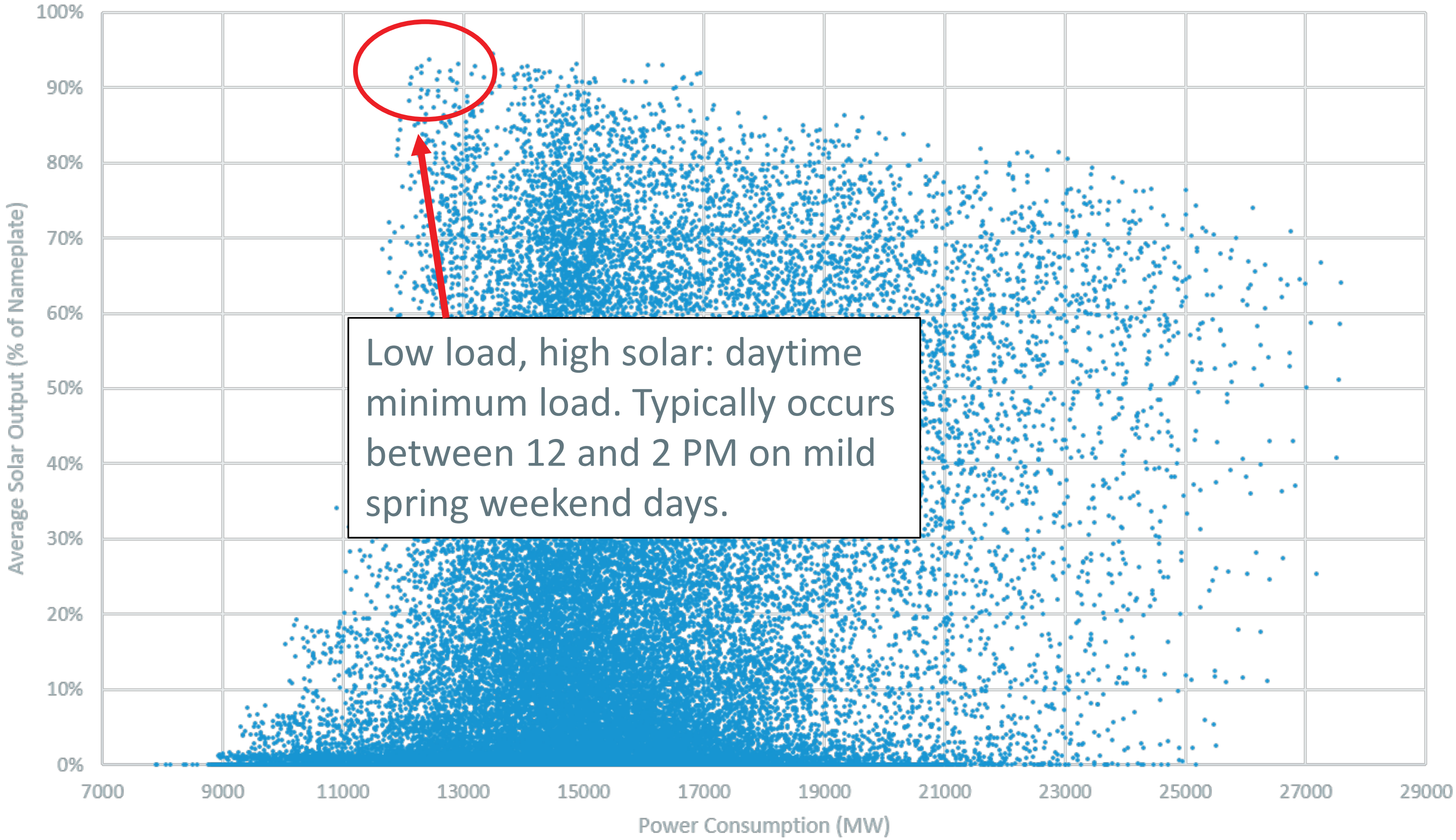

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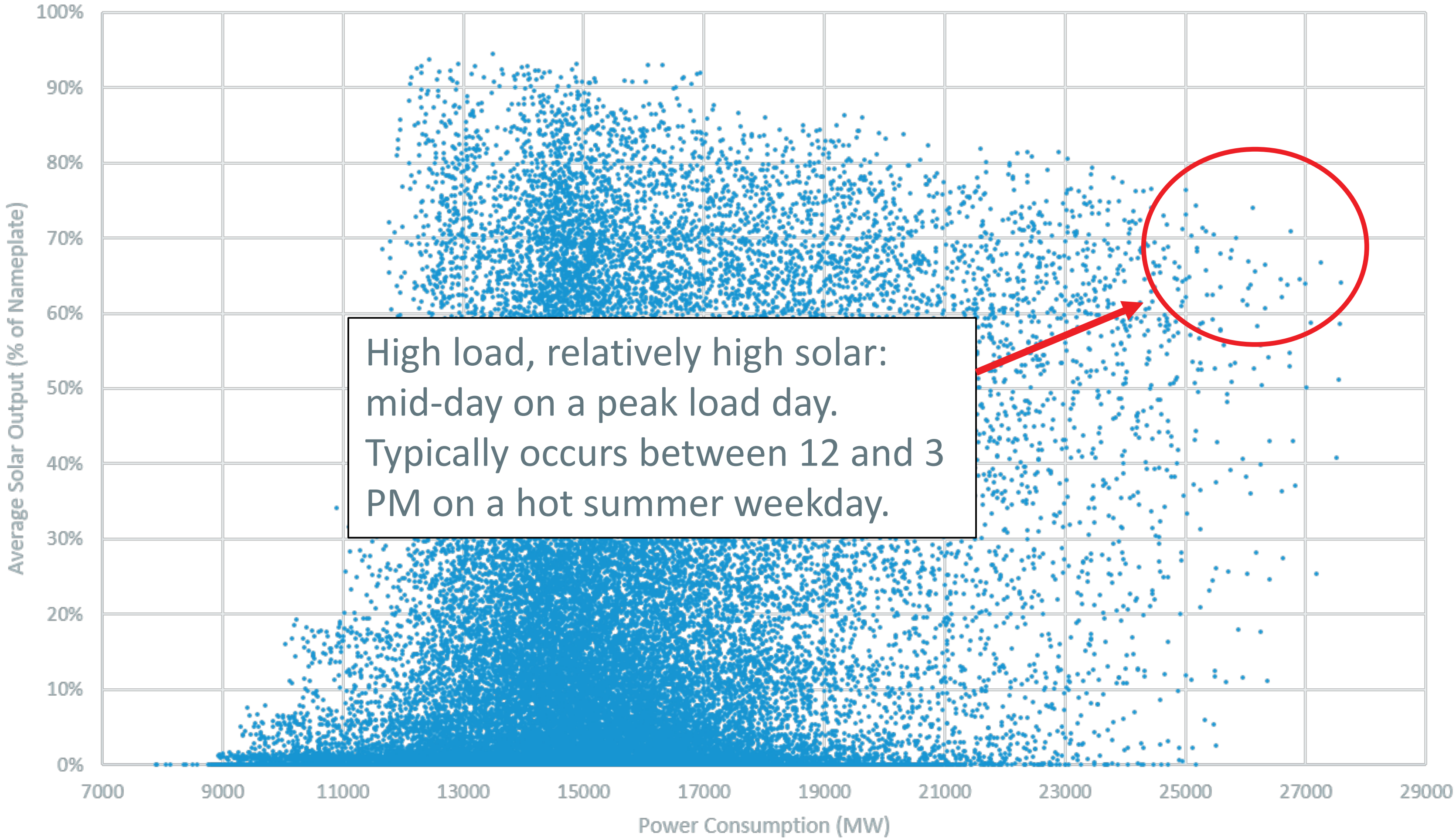

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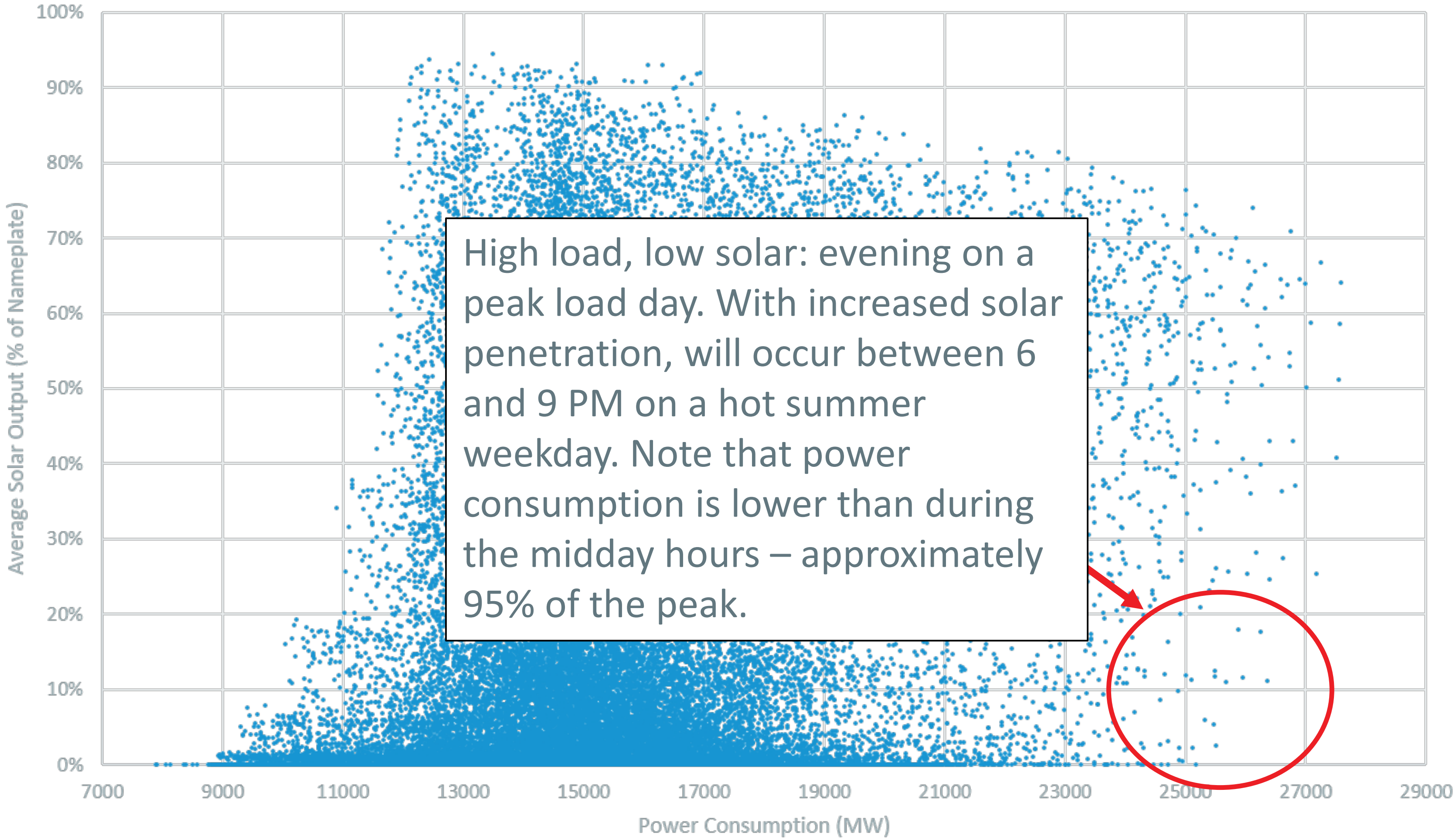


Study Conditions Proposed: Load & Solar

Condition to Study	Power Consumption Assumption	Solar Output Assumption	Forecasted Net Load in 2029[1]
Spring Weekend Nighttime (minimum consumption)	8,000 MW[2]	0%	8,000 MW
Spring Weekend Mid-Day (minimum net load)	12,000 MW[2]	90%	4,984 MW
Summer Weekday Mid-Day (maximum consumption)	100% of 90/10 forecast	40% (steady-state) 65% (stability)[3]	24,424 MW
Summer Weekday Evening (maximum net load)	95% of 90/10 forecast[4]	10%[4]	25,329 MW

[1] Based on 2020 CELT forecast of summer peak loads and installed solar capacity; reflects reductions due to EE and DR.

[2] Historical data shows that consumption under these conditions has not significantly changed from one year to the next.

[3] Solar output is typically in the 40-65% range for these conditions. 40% will be used for steady-state studies, as lower solar output is more conservative. 65% has been proposed for stability studies, as higher solar output and lower synchronous generation output is expected to be more conservative in stability analysis.

[4] The conditions proposed here result in the maximum net load based on the load and solar forecast for 2029. As solar penetration increases, the maximum net load may be pushed later into the evening or night; study conditions will be updated as necessary.

Analysis of Historical Wind Availability

- Actual performance data on offshore wind generation output in the BOEM lease area is unavailable
  - Data used is based on historic wind speeds, translated into estimated MW output by DNV GL (details in February 2020 PAC presentation*)
- Existing onshore wind installations also used the same DNV GL weather model as offshore wind to estimate availability
  - Congestion could lead to real output less than the available wind
- Sets of hours were chosen with load and PV conditions most similar to the assumptions on the previous slide

* https://www.iso-ne.com/static-assets/documents/2020/02/a7a_wind_power_time_series_isone.pdf

Analysis of Historical Wind Availability

Condition to Study	Onshore Wind		Offshore Wind	
	Min	Max	Min	Max
Spring Weekend Nighttime (minimum consumption)	4.5%	65.7%	12.4%	91.2%
Spring Weekend Mid-Day (minimum net load)	2.2%	53.0%	2.6%	61.5%
Summer Weekday Mid-Day (maximum consumption)	1.5%	58.3%	1.3%	92.6%
Summer Weekday Evening (maximum net load)	4.7%	54.8%	1.3%	93.0%

For each wind farm, a minimum and maximum value was determined for a set of hours similar to the desired study condition. The values for each wind farm were averaged together to give the values in this table.

Study Conditions Proposed: Wind Generation

- Studies will examine the end of the output range that is conservative for the condition studied
  - High wind generation when low inertia may be a concern
  - Low wind generation where load serving may be a concern

Condition to Study	Onshore Wind Generation	Offshore Wind Generation
Spring Weekend Nighttime (minimum consumption)	5% (steady-state) 65% (stability)	15% (steady-state) 90% (stability)
Spring Weekend Mid-Day (minimum net load)	55%	60%
Summer Weekday Mid-Day (maximum consumption)	5% (steady-state) 30% (stability)	5% (steady-state) 90% (stability)
Summer Weekday Evening (maximum net load)	5%	5%

Further Work on Study Conditions: Storage

- Two categories of energy storage assets will be treated differently in planning study assumptions
- Transmission-connected storage assets
  - Likely bidding and operating based on price signals in the day-ahead or real-time markets
- Distribution-connected storage assets
  - Often co-located with intermittent generation; co-located storage resources will likely charge based on generation output
  - Discharging behavior may be driven by distribution feeder loading or generator unavailability rather than market signals
- Assumptions on energy storage behavior are still under development, and will be presented at a future PAC meeting

DISTRIBUTION COORDINATION NEEDS

How will we collect the necessary data on DER installations?

DER Location: Today's Approach

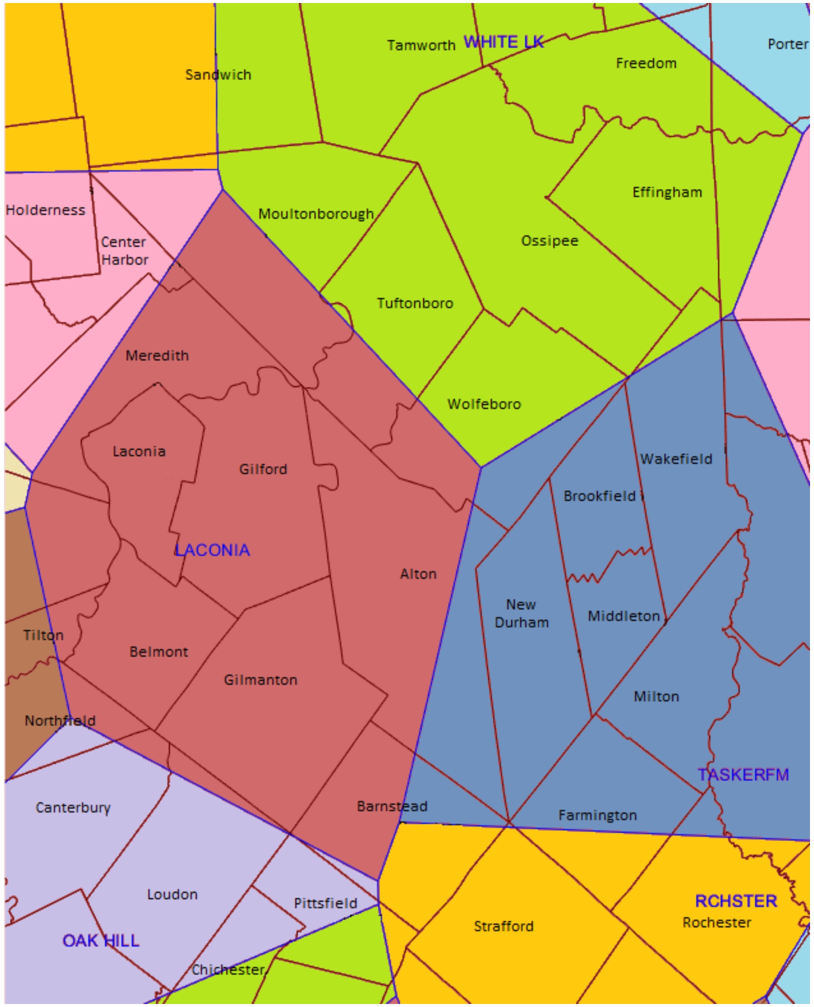
- The electrical location of DER 1 MW or larger in size is known
  - PP5-1 Generator Notification Form includes the nearest transmission substation and PSS/E bus number
- DER smaller than 1 MW do not have known electrical locations
  - Load-zone totals for DER installations are available in the CELT Report
  - Exact substation location is not known
- DER smaller than 1 MW is assumed to be distributed with the "peanut butter" method
  - Assumes that DER distribution is identical to load distribution
  - If a substation has 2% of a load zone's load, then it has 2% of the DER
  - Assumption is workable for low levels of DER penetration, but breaks down at higher levels: for example, consider urban vs. suburban environments

DER Location: Geographic Approach

- With the data that ISO-NE already collects, can we get better accuracy than today’s approach?
- Load Forecasting’s DER survey collects data on all individual DER installations, regardless of size
  - Data includes location by town/city, and in-service date, but not the substation to which an installation is connected
  - Participation rates are fairly good, but not all distribution providers participate in the survey
  - Some data also collected from sources related to policy programs
- The DER survey data is currently an input to load forecasting; can we use this for modeling DER in transmission studies?

DER Location: Geographic Approach

- We can use town-by-town DER totals, boundaries of each town, and substation locations to estimate the amount of DER at each substation
- Relies on two assumptions:
  - Any given point is served by the closest substation, geographically
  - DER <1 MW in size is evenly distributed throughout each town's area



Comparison of Estimates and Real Data

- Eversource has provided the totals of DER <1 MW connected at each of their substations
- Comparison of estimates vs. real data at a sampling of substations in Eastern Massachusetts:

Substation*	Distributed in same proportion as load	Geographic estimate	Actual DER interconnected
Acushnet	8.400 MW	4.833 MW	8.491 MW
Alewife	3.594 MW	4.768 MW	4.655 MW
Arsene Street	4.077 MW	3.200 MW	3.155 MW
Bell Rock	11.728 MW	9.755 MW	9.749 MW
Chatham Street	3.531 MW	1.056 MW	0.001 MW
Hawkins Street	3.334 MW	0.332 MW	1.682 MW
Scotia Street	4.360 MW	0.942 MW	0.128 MW

Need For Actual DER Data

- Although the geographic estimate is closer than today's method, it still does not give the desired degree of accuracy
- ISO-NE will be working with distribution providers to set up a more detailed process to collect data about DER installations
- In addition to substation location, more information to be provided could include:
  - Voltage protection/ride-through settings
  - Voltage/frequency control mode and capability, if any
  - MWh capacity of co-located energy storage, if any
- Revisions to NERC MOD-032 may eventually require this data, but we will need it for studies before MOD-032 is revised

USE OF NEW ASSUMPTIONS

Scope of Proposed Changes

- Proposed changes will be used in studies performed by the Transmission Planning group in accordance with Attachment K
  - Needs Assessments/Competitive Solution Process/Solutions Studies
  - Studies associated with Market Efficiency Transmission Upgrade and Public Policy Transmission Upgrades, as needed
- Changes may also be adopted in studies performed by the Transmission Strategy and Services department in accordance with Schedules 22, 23, and 25
  - Feasibility Studies, System Impact Studies
  - Cluster Regional Planning Studies

Treatment of Past and Ongoing Studies

- Studies already underway will continue under existing transmission planning assumptions, and will not be restarted
  - Upgrades identified under existing transmission planning assumptions will likely continue to be required under the new proposal
- Solutions already planned or under construction based on previous studies will not be re-examined

FEEDBACK & NEXT STEPS

Feedback and Next Steps

- Feedback on the proposals and open issues in this presentation may be submitted to pacmatters@iso-ne.com by October 9, 2020
- Next Steps:
  - Further development of study assumptions
    - Treatment of energy storage resources
    - Treatment of areas with non-coincident peak loads
    - Treatment of conventional generator outages
    - Interface transfer assumptions
    - Load levels to be used for light and shoulder load conditions in Proposed Plan Application (PPA) studies
  - Outreach to distribution providers regarding data collection
  - Further discussion on open questions at future PAC meetings
  - Studies using new assumptions may begin in 2021