Review of Transmission Planning Assumptions

Conceptual Methodology for Base Case Assumption Quantification

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Background

- ISO has been reviewing the key assumptions used in transmission planning studies and how they should be applied to Needs Assessment studies
- At the December 2015 and January 2016 PAC meetings, the ISO presented a conceptual methodology for base case assumption quantification
  http://www.iso-ne.com/static-assets/documents/2015/12/a2_review_of_transmission_planning_assumptions.pdf
- At the February 2016 PAC meeting, the ISO shared with the PAC a summary of current industry efforts related to probabilistic transmission assessments
  http://www.iso-ne.com/static-assets/documents/2016/02/a6_review_of_transmission_planning_assumptions_probabilistic_transmission_assessment_and_tools.pdf
- At the May 2016 PAC and August 2016 PAC meetings, the ISO presented the PAC with detailed updates on the ISO's developing conceptual methodology for base case assumption quantification
  http://www.iso-ne.com/static-assets/documents/2016/05/a3_methodology_for_base_case_assumptions_follow_up.pptx
  http://www.iso-ne.com/static-assets/documents/2016/08/a2_review_of_transmission_planning_assumptions.pdf

Purpose of Today's Presentation

- Continue discussion related to the implementation of a conceptual methodology for base case assumption quantification
  - Review elements of the conceptual methodology presented in past PAC meetings
  - Provide additional analysis related to the choice of a probabilistic threshold
  - Apply the conceptual methodology for base case assumption quantification to a "real" base case creation example
  - Next steps

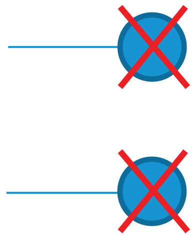
BASE CASE ASSUMPTION QUANTIFICATION

Conceptual Methodology - Background

Proposed Approach to Transmission Planning Assessments

Separate the different types of resource unavailability:

Generic model of two generators out in the base case



Sudden events:

- Modeled as contingencies

Longer duration, cumulative or concurrent events:

- Reasonable range of stressed system conditions
- Modeled as base case conditions

Broad trends:

- Events resulting in extended plant outages
- Modeled as scenarios

Maintenance conditions:

- Model to be determined

Base Case Assumption Quantification, Focus on Study Area

- Designed to determine the reasonable range of stressed system conditions that should be modeled as base case conditions
- Given an identified study area, consider the combined uncertainty of
  - Generation unavailability
  - Load
- Results in modeled base case conditions, which reflect
  - The generation population in the identified study area
    - Both, size and performance
  - The concurrent impact of load

Sudden events:

- Modeled as contingencies

Longer duration, cumulative or concurrent events:

- Reasonable range of stressed system conditions
- Modeled as base case conditions

Broad trends:

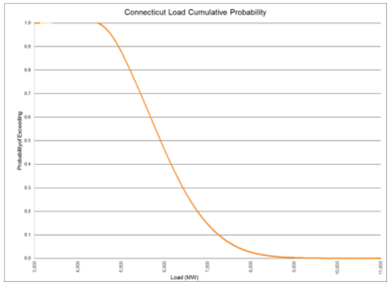
- Events resulting in extended plant outages
- Modeled as scenarios

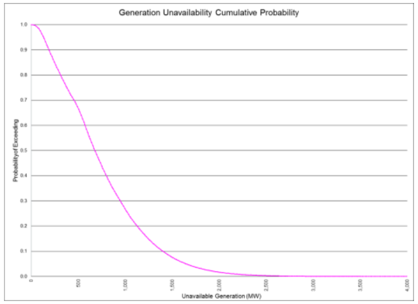
Future - Maintenance conditions:

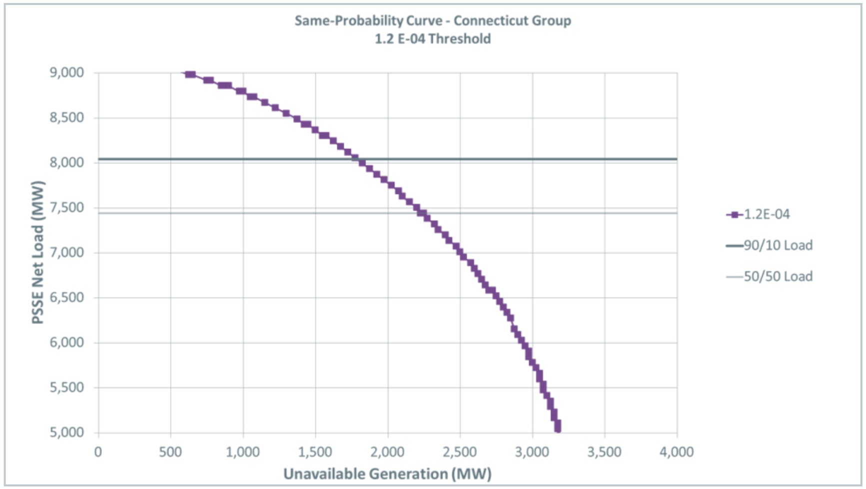
- Model to be determined

Base Case Assumption Quantification, Focus on Study Area, cont.

- Step 1: determine the cumulative **probability of load** for the study area
- Step 2: determine the cumulative **probability of generation unavailability** for the study area
- Step 3:
  - Combine both sets of cumulative probabilities to develop combined cumulative probabilities
  - Select **“same-probability” curve**: curve shows combinations of load and unavailable generation with nearly identical cumulative probability
    - Probability is equal to selected **probabilistic threshold**
  - The curve represents the boundary of reasonable test conditions
- Step 4: Derive **representative dispatches** from the “same-probability” curve for the study area





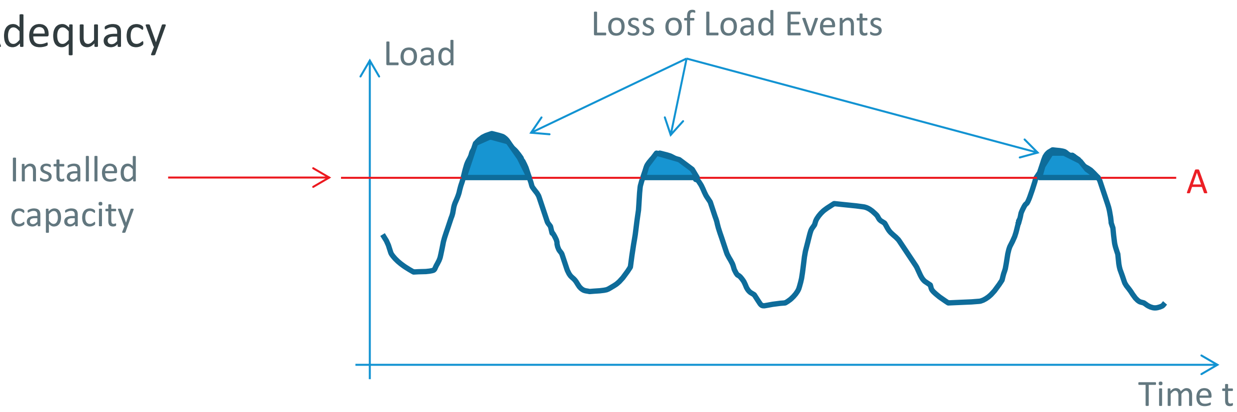


BASE CASE ASSUMPTION QUANTIFICATION

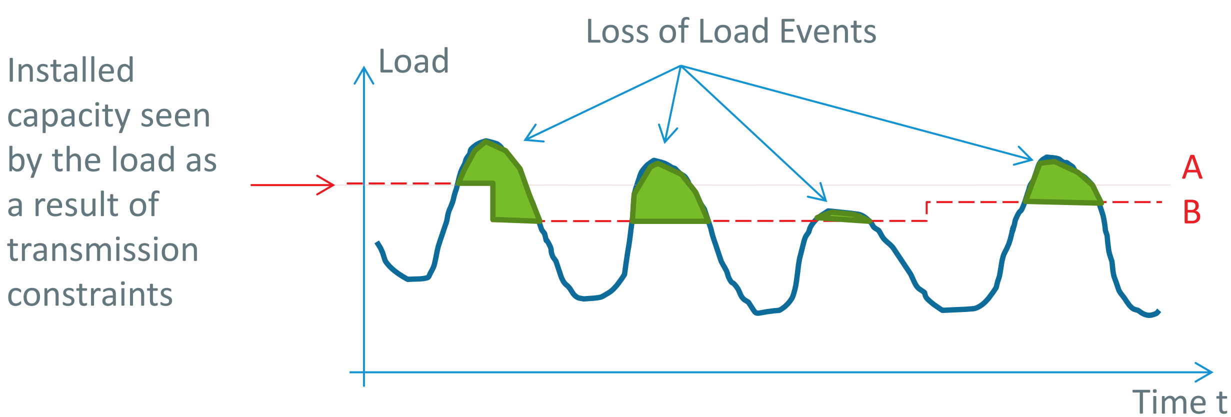
Choice of a probabilistic threshold

Link between Resource Adequacy and Transmission Security

Resource Adequacy

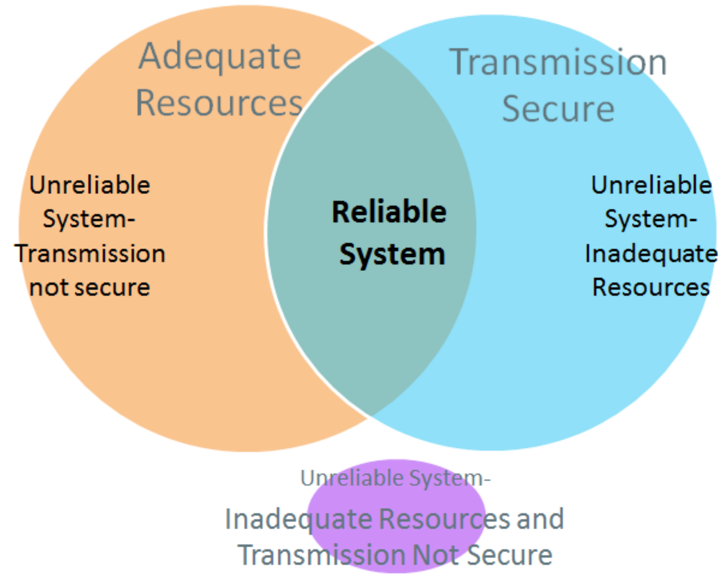


Resource Adequacy and Transmission Security



Similar Risk Tolerance Should Apply to Resource Adequacy and Transmission Security

- We must plan a reliable system
  - Adequate: limited loss of source event (blue areas)
  - Secure: limited excursions from line A to line B
- In terms of risk tolerance, it seems reasonable to assume a similar risk for both resource adequacy and system security
- This is the reason for deriving the probabilistic threshold from the metrics used in resource adequacy assessments (LOLE and LOLP)



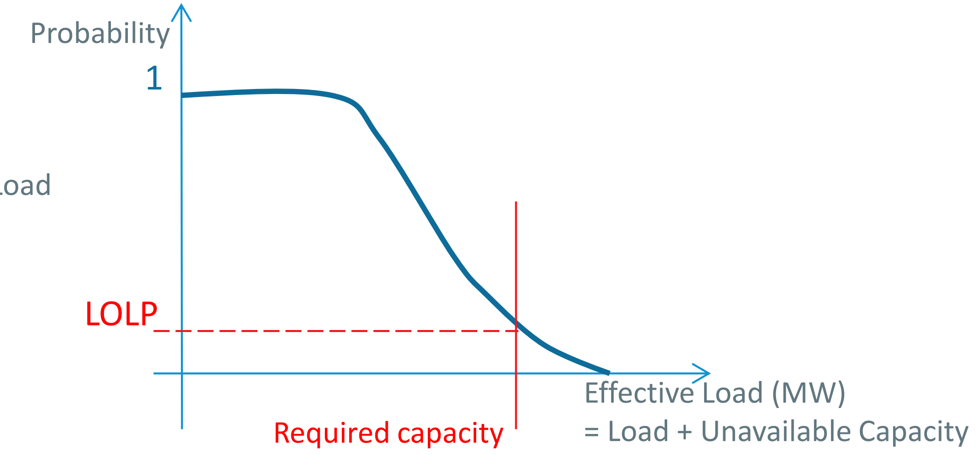
Derive Probabilistic Threshold from Average Loss of Load Probability

- Average daily LOLP:
  - Assuming a small, constant risk every day, the criteria Loss of Load Expectation (LOLE) is equivalent to a Loss of Load Probability (LOLP) of 0.1/365 = 2.7 E-04
- Average summer daily LOLP:
  - The New England LOLE is currently driven by summer business days
    - 85 days (17 weeks, 5 days/week) from June through September
  - The load distribution used in the conceptual methodology is also based on summer business days
    - Combination of daily peak distributions for 85 days (17 weeks) from June through September
  - Assuming a small, constant risk every summer business day, at criterion, the New England LOLE is equivalent to an LOLP of 0.1/85 = 1.2 E-03

Alternative: Derive Probabilistic Threshold From New England Effective Load Curve

- Relies on the simple approach to resource adequacy described by Dr. R.R. Booth in the article titled: "The A-B-C of Probabilistic Simulation"
  - "Effective Load" is "Load + Unavailable Capacity"
  - When system is adequate (at criterion):
    - Required capacity – Unavailable Capacity = Load
    - Required capacity = Load + Unavailable Capacity
    - Required capacity = Effective Load
  - An LOLP can be derived from the New England effective load curve and the New England Installed Capacity Requirement (and associated values)

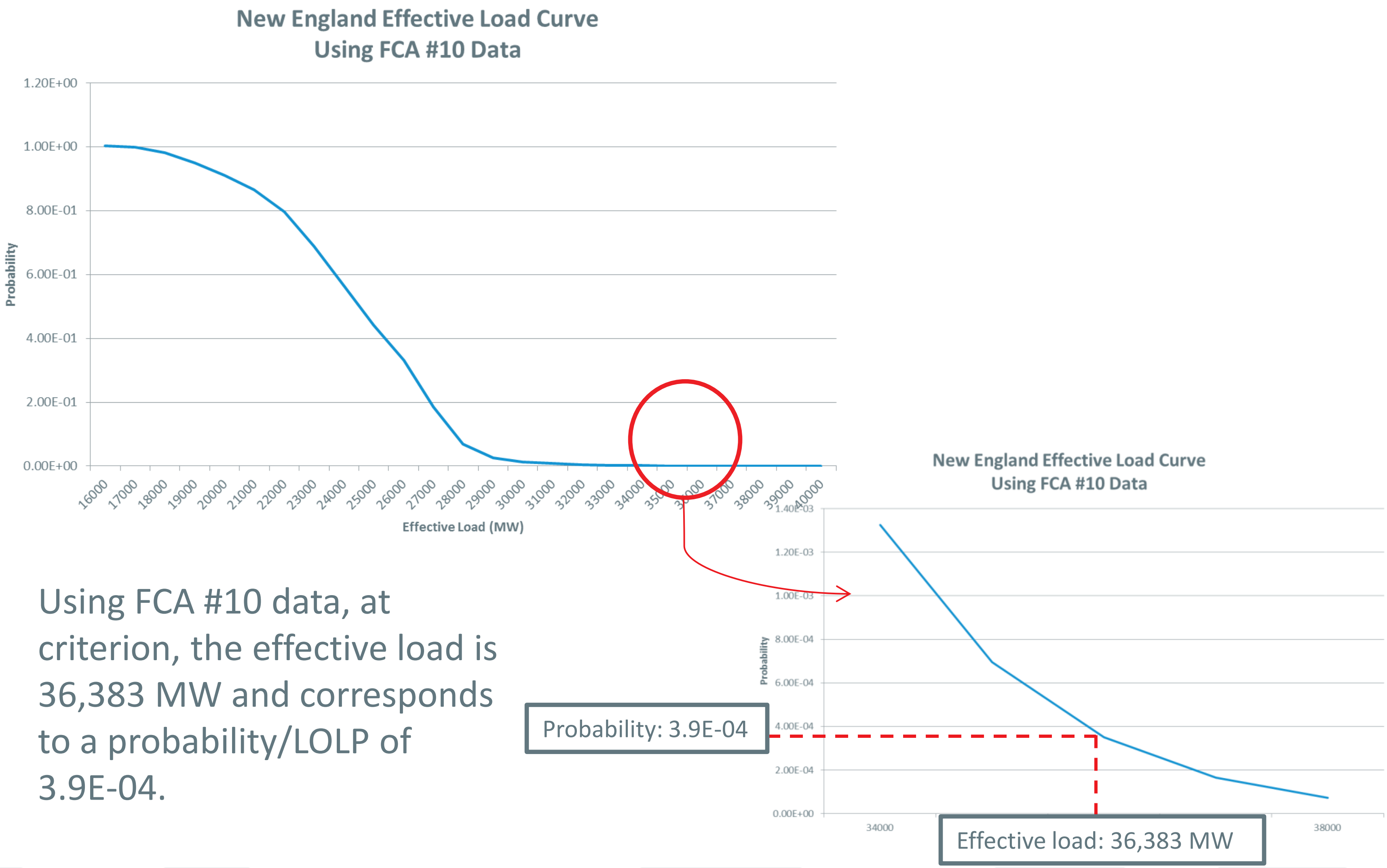
Effective Load Curve:
Cumulative probability of having an Effective Load greater than a given MW amount



New England Effective Load Curve Was Drawn Using Past Installed Capacity Requirement Data

- The New England Effective Load Curve was drawn using past data
  - Data used to determine the Installed Capacity Requirement for the 2019_2020 Capacity Commitment Period (FCA #10 data)
    - https://www.iso-ne.com/static-assets/documents/2015/09/a9_icr_results.pdf
- Per the Booth equation, when system is adequate (at criterion):
  - Effective Load = required capacity
- Applying this principle to New England, using FCA #10 data, leads to, at criterion:
  - Effective Load = Net Installed Capacity Requirement (“iron in the ground”) + Tie Benefits + OP4 Load Relief
  - Effective Load = 34,151 + 1,990 + 242 = 36,383 MW

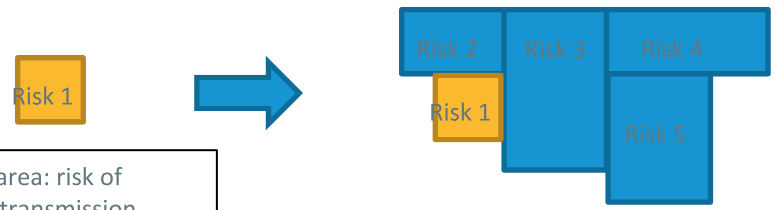
New England Effective Load Curve Was Drawn Using Past Installed Capacity Requirement Data, cont.



Using FCA #10 data, at criterion, the effective load is 36,383 MW and corresponds to a probability/LOLP of 3.9E-04.

Considerations for Sub-sections of the Aggregate System

- As presented on slide #21 of the May 2016 PAC presentation:
  - Transmission planning study areas are sub-sections of the aggregate system



In study area: risk of having a transmission security issue is "risk 1"

Aggregate system: risk of having a transmission security issue
= "risk 1"+"risk 2"+"risk 3"+"risk 4"+"risk5"

  - Each sub-section carries its own risk and the aggregate system additively carries the risk of all its sub-sections
    - Assumes that the transmission security risk of a study area is not improved by it being part of the aggregate system
    - Assumes that the transmission security risk of each study area is independent

- Regardless of the method selected to derive an equivalent New England risk, we recommend sub-dividing the New England-wide figure by 5 or 10 to be used as a probabilistic threshold

Possible Probabilistic Thresholds

- Deriving the probabilistic threshold from the metrics used in resource adequacy assessments results in thresholds that are relatively close from one another
  - From 2.7 E-05 to 2.4 E-04
- The ISO wants to continue its stakeholders' discussion before committing to a final threshold
- The example on the following slides was assembled using a threshold of 1.2 E-04
  - Threshold developed assuming a small constant risk every summer business day (0.1/85 and further divided by 10 to account for the additive transmission security risk)

BASE CASE ASSUMPTION QUANTIFICATION

Example of base case creation

Create Base Cases for Needs Assessments Studies: Before and After Use of Conceptual Methodology

Before Conceptual Methodology

- Model 90/10 peak load, by default
- Determine series of representative load-flow conditions (base cases) by taking two generators out in different parts of the study area
- Engineers determine which two generators should be modeled out of service in each base case
- For each base case, engineers determine how to dispatch generators in the parts of the study area where the two generators are not taken out

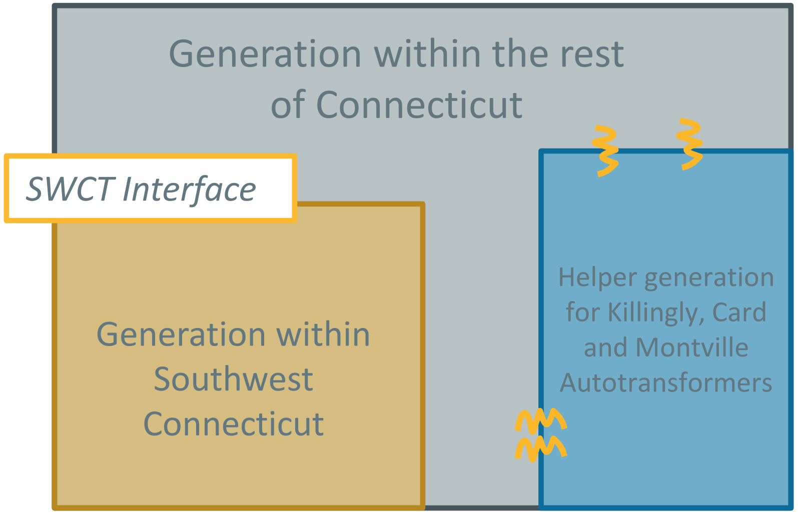
After Conceptual Methodology

- Identify key generators that stress different parts of the study area
- Draw "same-probability" curve for each group of key generators
- Model 90/10 peak load and/or other load levels as deemed relevant based on the shape of the "same-probability" curve
- Determine amounts of generation to simultaneously take out of service, based on the "same-probability" curve
- Engineers select representative base cases by taking into account results from the prior step

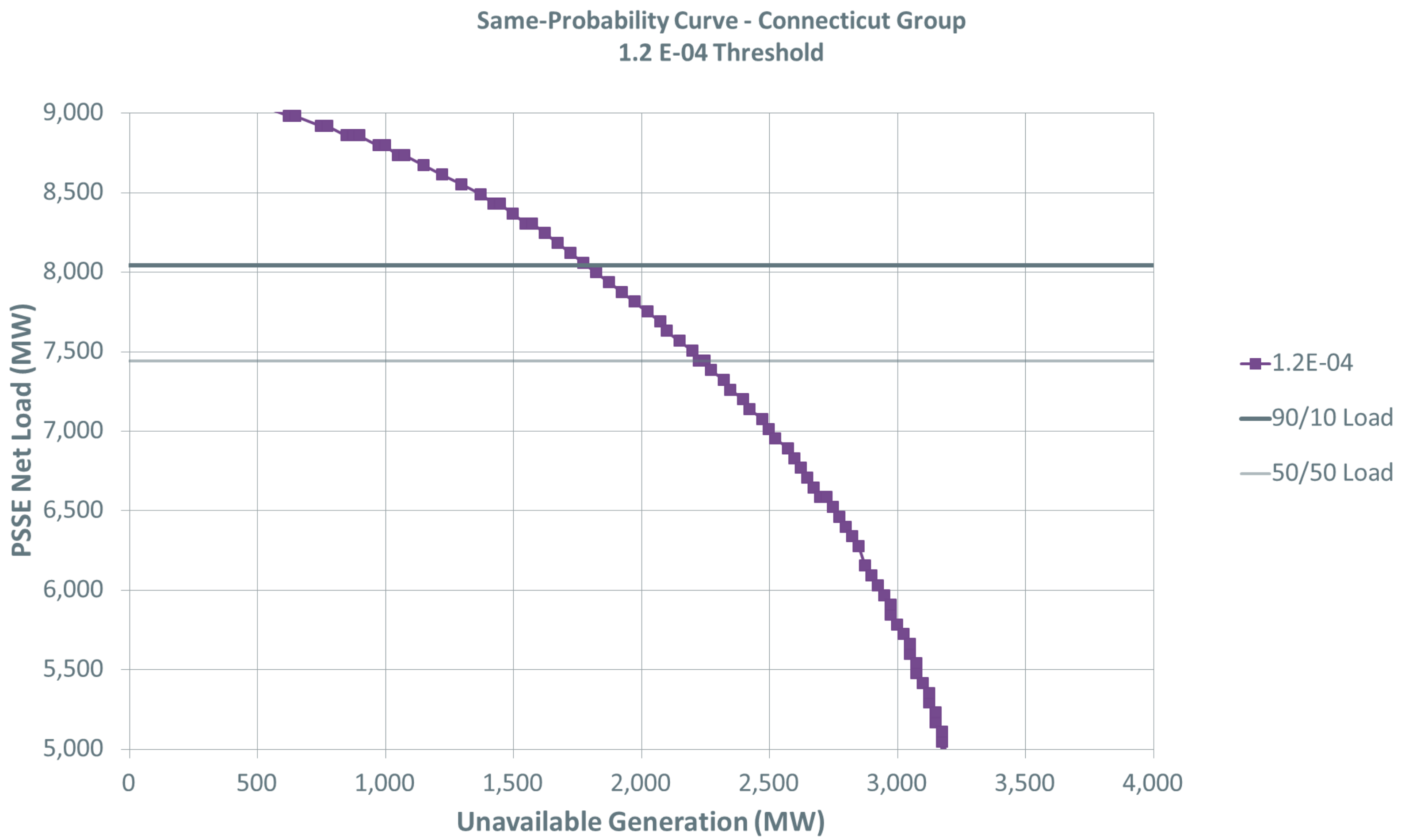
Identify Key Generators that Stress the System

- Example of a Needs Assessment study that would focus on the Connecticut area; two (or more) groups of key generators can be identified beyond the Connecticut generation
  - Southwest Connecticut generation
  - Eastern Connecticut generation

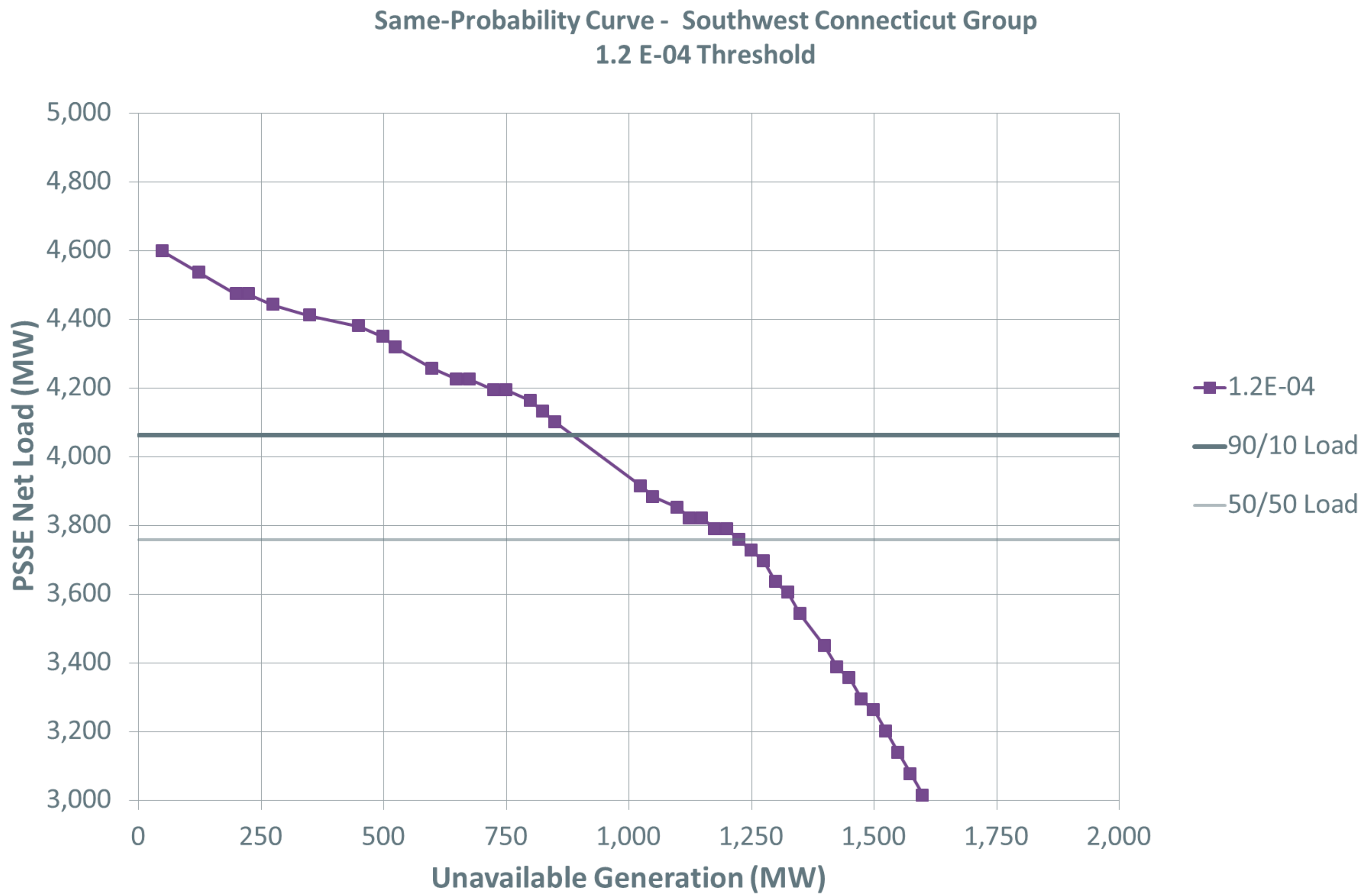
Known Issue	Representative Constraint	Associated Group of Generators
Delivery to Southwest Connecticut Load	Southwest Connecticut Interface	Generation within Southwest Connecticut
Delivery to Eastern Connecticut Load	Killingly, Card and Montville 345/115 kV Autotransformers	Helper generation with regard to the Killingly, Card and Montville 345/115 kV Autotransformers



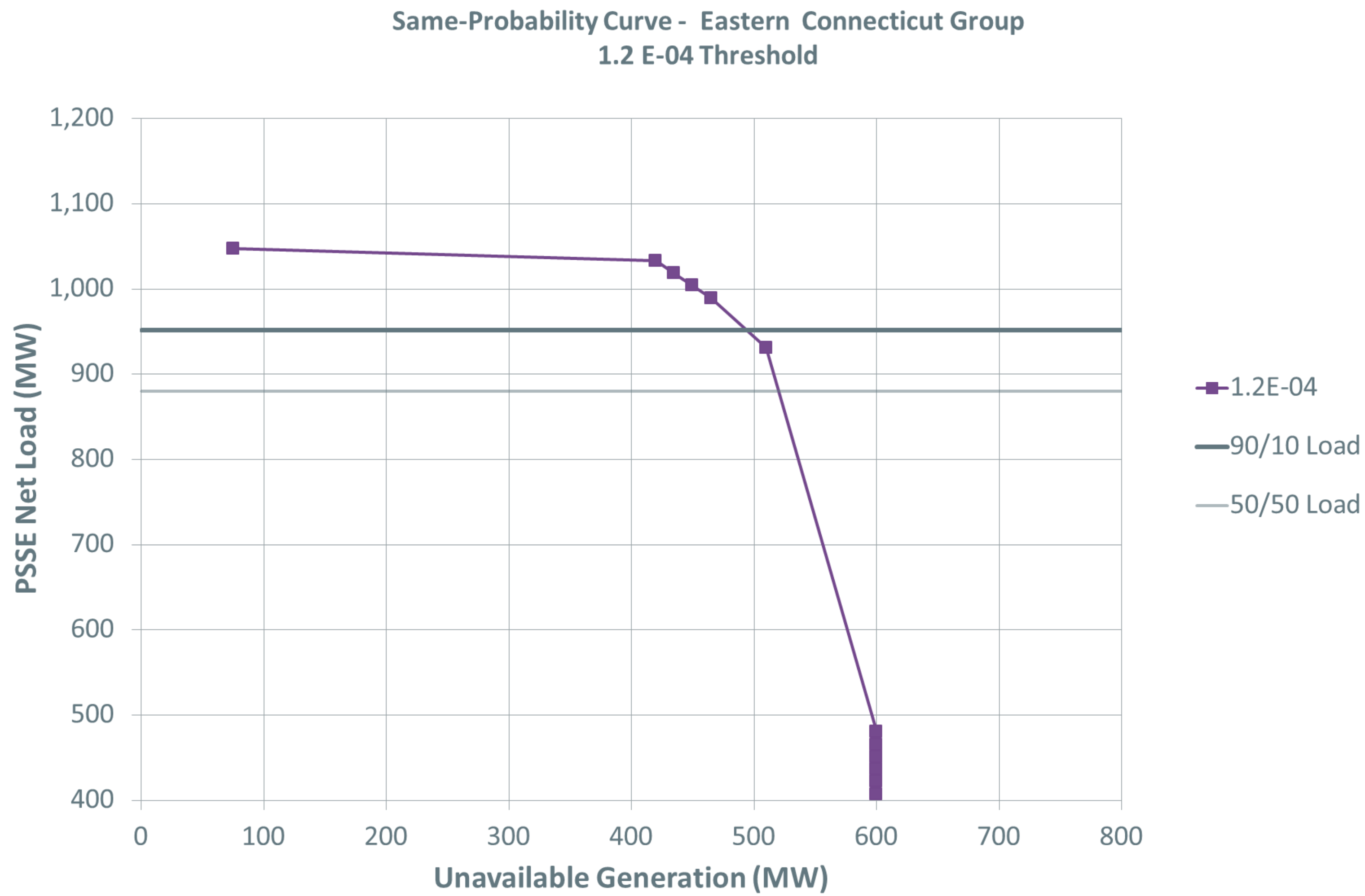
Draw "Same-Probability" Curves for Each Group of Key Generators – Connecticut



Draw "Same-Probability" Curves for Each Group of Key Generators – Southwest Connecticut



Draw "Same-Probability" Curves for Each Group of Key Generators – Eastern Connecticut



Determine Which Load Level to Model in Base Case

- In the past, Needs Assessments have been performed using a 90/10 or 50/50 peak load
- In current practice, the 90/10 peak load is a point of reference
- Depending on the shape of the "same-probability" curve, one or two other data points may become relevant
  – Parts of the curve where the combined amount of load and unavailable generation is the highest
- In our example, studying the 90/10 peak load level appears sufficient for the Connecticut and Eastern Connecticut groups
- For the Southwest Connecticut group however, data point at the 50/50 peak load shows a slightly higher level of combined generation unavailability and load
    - 5,000 MW instead of 4,900 MW

Determine Amount of Generation to Take Out in Base Case

90/10 Load

Rest of Connecticut

Maximum Total Connecticut Generation Out* = 1,775 MW

SWCT

Maximum Southwest Connecticut Generation Out = 875 MW

ECT

Maximum Eastern Connecticut Generation Out = 500 MW

50/50 Load

Rest of Connecticut

Maximum Total Connecticut Generation Out* = 2,250 MW

SWCT

Maximum Southwest Connecticut Generation Out = 1,225 MW

ECT

Maximum Eastern Connecticut Generation Out = 520 MW

* Total Connecticut generation includes generation in Southwest Connecticut, Eastern Connecticut and in the rest of Connecticut.

Select Representative Base Cases – Examples*

		90/10 Load	90/10 Load	90/10 Load	50/50 Load	50/50 Load	50/50 Load
		90/10_Dispatch1	90/10_Dispatch2	90/10_Dispatch3	50/50_Dispatch1	50/50_Dispatch2	50/50_Dispatch3
KEY SOUTHWEST CONNECTICUT GENERATION UNITS							
Generating Unit	**Gross Pmax (MW)**						
CPV-Towantic	765	OFF	ON	ON	OFF	ON	ON
Bridgeport Energy	460	ON	OFF	ON	ON	OFF	ON
Bridgeport Harbor 3	405	ON	OFF	ON	ON	ON	ON
Milford Power 1	259	ON	ON	ON	ON	OFF	ON
Milford Power 2	258	ON	ON	ON	ON	OFF	ON
Total MW OFF - SOUTHWEST		***765***	***865***	***0***	***765***	***977***	***0***
KEY EASTERN CONNECTICUT GENERATION UNITS							
Generating Unit	**Gross Pmax (MW)**						
Montville 6	414	OFF	ON	ON	OFF	ON	ON
Montville 5	85	OFF	ON	ON	OFF	ON	ON
Plainfield	40	ON	OFF	OFF	ON	OFF	OFF
Exeter	23	ON	ON	ON	OFF	ON	ON
Total MW OFF - EASTERN CONNECTICUT		***499***	***40***	***40***	***522***	***40***	***40***
KEY REST-OF-CONNECTICUT GENERATION UNITS							
Generating Unit	**Gross Pmax (MW)**						
Millstone 3	1283	ON	ON	OFF	ON	ON	OFF
Millstone 2	912	ON	ON	ON	OFF	ON	OFF
Kleen Energy	635	ON	OFF	ON	ON	OFF	ON
New Haven Harbor 1	465	ON	ON	ON	ON	OFF	ON
Middletown 4	416	OFF	ON	OFF	ON	ON	ON
Middletown 3	248	ON	ON	ON	ON	ON	ON
Lake Road 1	254	ON	ON	ON	ON	ON	ON
Lake Road 2	259	ON	ON	ON	ON	ON	ON
Lake Road 3	263	ON	ON	ON	ON	ON	ON
Total MW OFF - CONNECTICUT		***1680***	***1540***	***1739***	***2199***	***2117***	***2235***

* These dispatches can be further optimized by turning off some smaller units that are not displayed on this slide.

NEXT STEPS

Next Steps

- Provide final recommendations with regard to transfer modeling and the selection of a probabilistic threshold
- Implementation of the base case assumption quantification methodology
  - Exclusively to derive base cases in Needs Assessments studies
  - Starting in 2nd half of 2017
- Development of criteria and guidelines for assessing scenario-related concerns
- Data refinement
  - Data review: EFORd for lower capacity factor units
  - Examine how best to represent intermittent resources
  - Examine sensitivity of load distribution to distributed resources
- Analysis of maintenance periods
  - Is the system capable of supporting generation and transmission maintenance?
  - How to assess this?

Questions