SEPTEMBER 6, 2017 | WESTBOROUGH, MA

Creation of Needs Assessment Dispatches Revision 1

Inclusion of Probabilistic Methodology

Revised 10/25/2017

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BACKGROUND AND PURPOSE

Background

- The ISO has developed a probabilistic dispatch methodology that is based on a “same probability” curve that describes the combined likelihood of load and generation unavailability in a study area
  - For a given group of generators, the “same probability curve” provides the maximum amount of generation that may be considered unavailable at a given load level
- The ISO has discussed the use of the “same probability” curve in developing generation unavailability for a study area
  - The representative base cases for a Needs Assessment will honor the maximum amount of generation based on the same probability curve as an “upward” boundary, while also considering all single generator unavailable dispatches to be acceptable

Background (Continued)

- The ISO has discussed the use of load levels in addition to 90/10 peak load levels
  - Based on the shape of the "same-probability" curve, there may be other combinations of load level(s) and unavailable generation to consider
- The ISO has discussed representative dispatches in Connecticut while considering different groups of generators within Connecticut
  - The concept of “nested” groups of generators was discussed and the use of the unavailable generation for each group of generators was described using examples

Purpose of Presentation

- Define the specific load levels that will be considered for Needs Assessment peak load base cases
- Review the methodology used to establish inter-area interface flows in the basecases
  - Minimum and maximum transfers on inter-area interfaces will be established
- Provide an overview of the methodology used to dispatch renewable generation
  - Modeled at de-rated output based on historical data
- Describe the creation of groups of generators to create “same-probability” curves
  - Consistent methodology used to identify groups of generators
- Discuss the procedure used to obtain transfer levels for the internal interfaces in New England
  - Use a combination of generation unavailability based on the probabilistic method and the requirement to establish reserves in the base cases

Dispatch Creation Methodology

- For a given load level and study area the following three-step procedure will be used to create dispatches

Step 1

- Dispatch Renewable generation based on historical availability at peak loads
- Set up key inter-area ties with respect to the study area at desired value

Step 2

- Calculate amount of unavailable generation for the Study Area, Study area + Adjacent Area, and Receiving End of System Stress by creating “same-probability” curves for each of the generator groups
- Assume generation unavailability for the groups of generators established above by honoring the maximum amount of generation based on the same probability curve as an “upward” boundary, while also considering all single generator unavailable dispatches to be acceptable

Step 3

- Establish reserves on the Receiving End of System Stress while respecting interface limits

Presentation Overview

- Overview of creating a study dispatch
  - Load levels studied
  - Inter-area transfers
  - New England generators
    - Dispatch of renewable generators
    - Dispatch of non-renewable generators
- Offline non-renewable generation
- Establishing generator groups for “same-probability” curves
- Three-step dispatch creation methodology
- Internal interface transfers
- Summary and next steps
- Appendix with additional examples

OVERVIEW OF CREATING A STUDY DISPATCH

Factors Involved in a 10-year out Peak Load Base Case

Load and Resource Balance in Base Cases

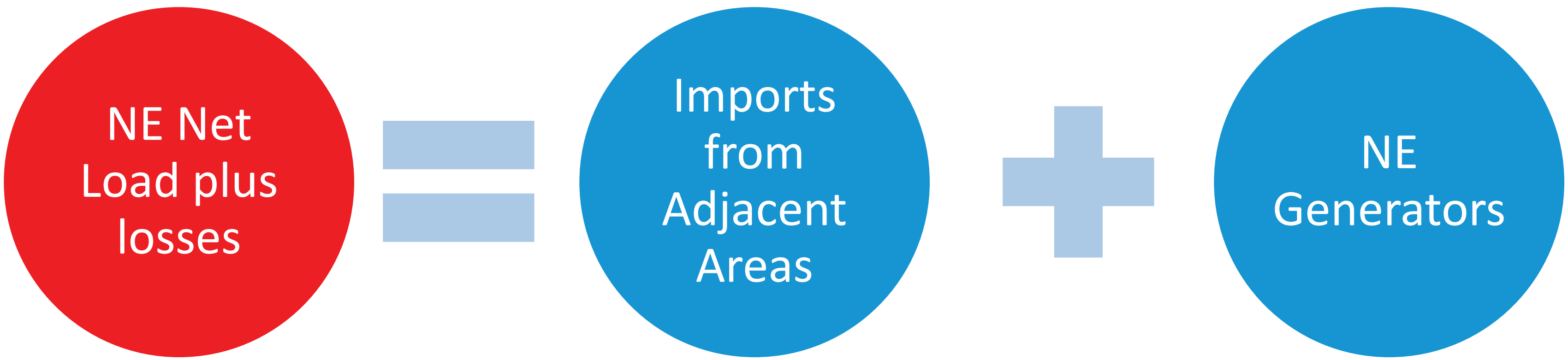
- In order to understand the impact of the probabilistic method on setting up base cases, a high-level summary of the different aspects of a base case is important
- In Needs Assessment base cases the following relation always holds true:

  NE Net Load[1] + Losses = NE Generation + Imports from Adjacent Areas
- The following slides provide a brief summary of how loads and imports from adjacent areas are handled before discussing in detail the modeling of generators

[1] NE Net Load includes the impact of demand resources and distributed generation that is modeled as negative load. It also includes station service loads that are online in the case.

LOAD LEVELS STUDIED

Load Levels Studied



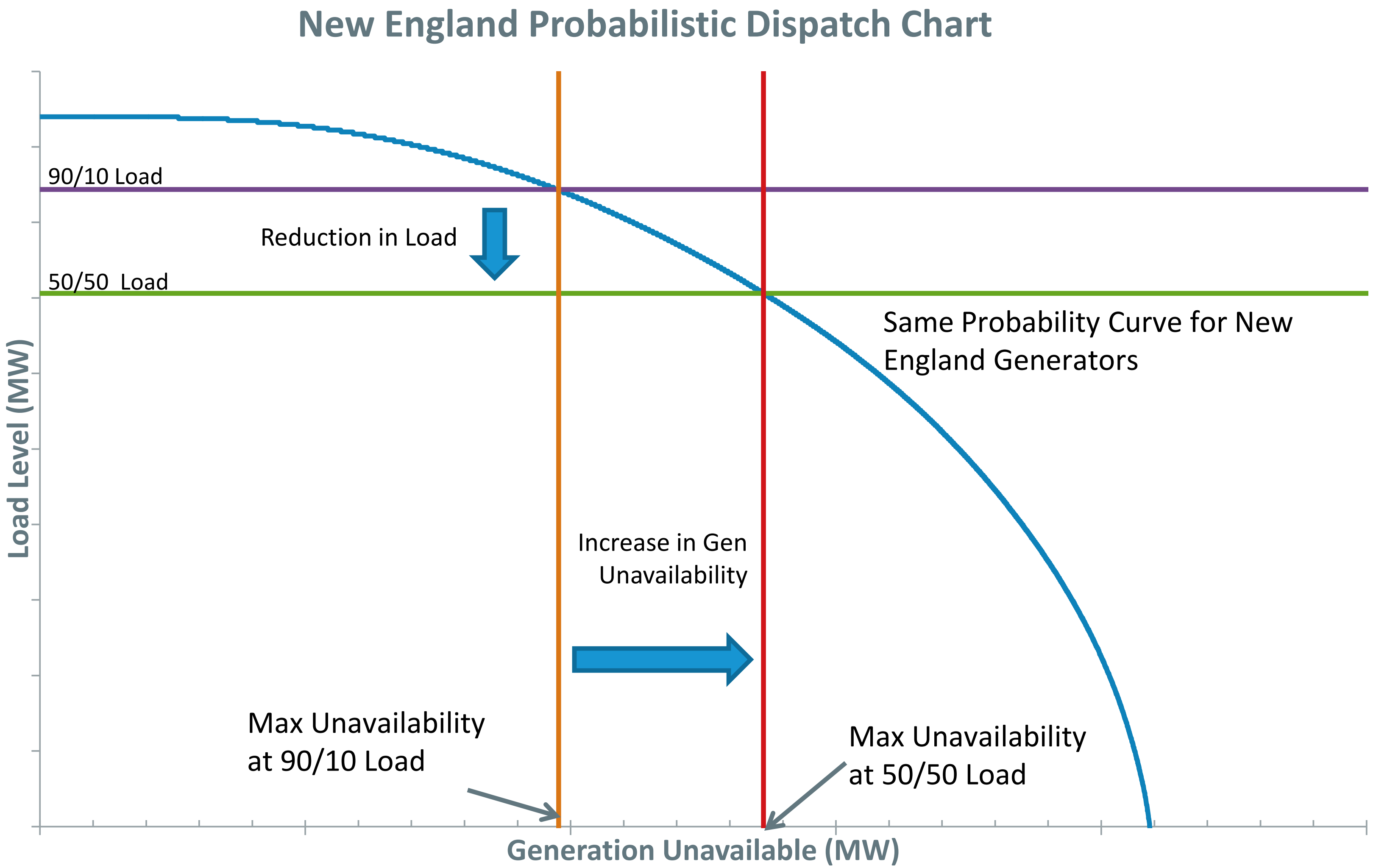
Load Levels Studied

- Past Needs Assessments only considered one peak load level – 90/10 Summer Peak
- The following relation describes the Same Probability Curve:

$$P_{Load\ Level} \times P_{Gen\ Unavail} \geq P_{Threshold}$$

- In the above function:
  - If load level tested increases, the amount of generation unavailable decreases
  - If load level tested decreases, the amount of generation unavailable increases
- To cover conditions with higher generation outages, the ISO may consider a 50/50 summer peak load case in addition to the 90/10 summer peak load case for Needs Assessments
  - A 10 year out 90/10 Summer Peak Load (90/10 Case)
  - A 10 year out 50/50 Summer Peak Load (50/50 Case)
- The generation unavailable in the 50/50 Case is higher than the generation unavailable in the 90/10 Case
  - The following slide demonstrates the change in generator unavailability for 50/50 summer peak loads when compared to 90/10 summer peak loads

Impact of Load Level Change on Generator Unavailability



Net Load plus Losses in New England

- The following table summarizes the net load in New England for the 90/10 and 50/50 summer peak load conditions in 2027
  - The load totals include station service loads in New England
  - 2.5% is used to estimate the transmission losses

Resources Required = New England load + 2.5% Transmission Losses

	90/10 Case	50/50 Case
(A) - Net Load in New England	29,000	26,200
(B) - Estimate for Transmission Losses (2.5% of Net Load in New England)	725	650
Resources Required (A) + (B)	29,725	26,850

INTER-AREA TRANSFERS

Imports from Adjacent Areas

Inter-area Ties

- New England (NE) has the following inter-area ties which can supply power to New England
  - New Brunswick to New England tie (NB-NE)
  - New York to New England AC ties (NY-NE)
  - Cross Sound Cable HVDC from Long Island to New England (CSC)
  - Phase II HVDC from Quebec to New England (Phase II)
  - Highgate HVDC From Quebec to New England (Highgate)
- New England does not model exports to other areas in Needs Assessments unless there is a long-term export realized through the Forward Capacity Market (FCM)
- At present there are no long term exports from NE to other areas through the FCM and thereby no exports to other areas will be modeled in the Needs Assessments conducted in 2017

Modeling of Imports on Inter-area Ties

Inter-area Interface	Minimum Transfer Tested (MW)	Maximum Transfer Tested (MW)
NB-NE	0[2]	700[3]
NY-NE	0[2]	1400[3]
Phase II Imports	950[4]	1400[3]
CSC Imports	0[2]	0[3]
Highgate Imports	200[5]	200[3]

[2] No long-term contracts for imports on this interface

[3] The maximum import tested on these interfaces is the capacity import capability on the interface. The details of the capacity import capability are in https://smd.iso-ne.com/operations-services/ceii/pac/2017/03/a8_fca_12_zonal_boundary_determination.pdf

[4] 950 MW value is based on a review of the Hydro-Quebec Interconnection Capability Credit (HQICC) in the past five FCA auctions

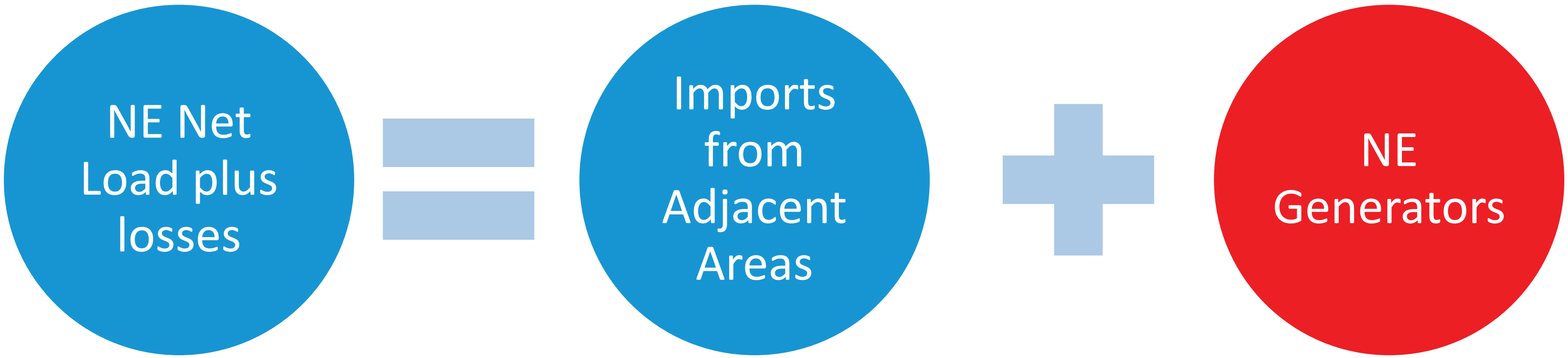
[5] Highgate is modeled at its capacity import capability based on a long-term contract to import power

Use of HQICCs for Minimum Phase II Imports

- Phase II has historically been treated differently than other import interfaces in New England
  - In the NEEWS Interstate Needs Assessment, Phase II was considered as one of the two largest resources out of service in eastern New England in addition to Seabrook
  - Turning off Phase II with two largest generators in eastern New England was considered to be too stressed for the NEEWS Interstate Needs Assessment
  - On this basis setting the minimum value on Phase II to 0 MW did not seem appropriate for use in future Needs Assessment studies
- HQICCs are compensated through the Forward Capacity Market and therefore the HQICC MW value was considered a reasonable minimum amount that can be relied upon in Needs Assessments, similar to other capacity resources

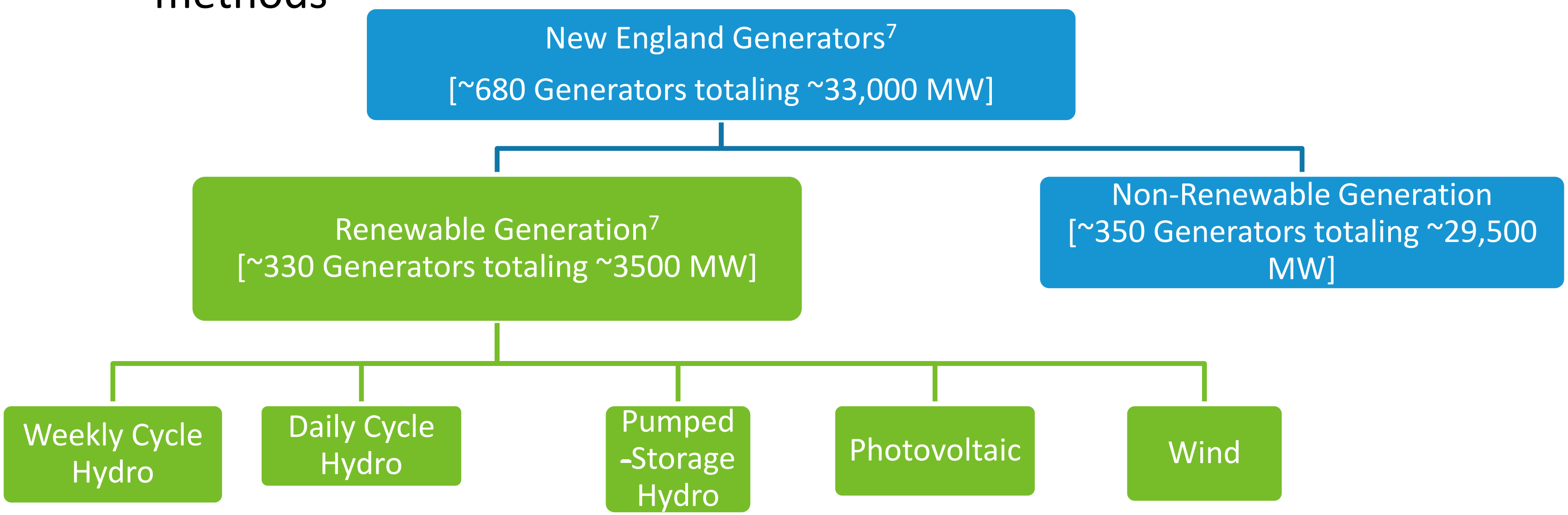
NEW ENGLAND GENERATORS

New England Generators



Generators in New England

- The New England generators that are modeled explicitly[6] in the 2027 peak load base case are broadly classified into renewable and non-renewable generation
  - Renewable generation is de-rated based on historical data and
  - Non-renewable generation is dispatched based on probabilistic methods

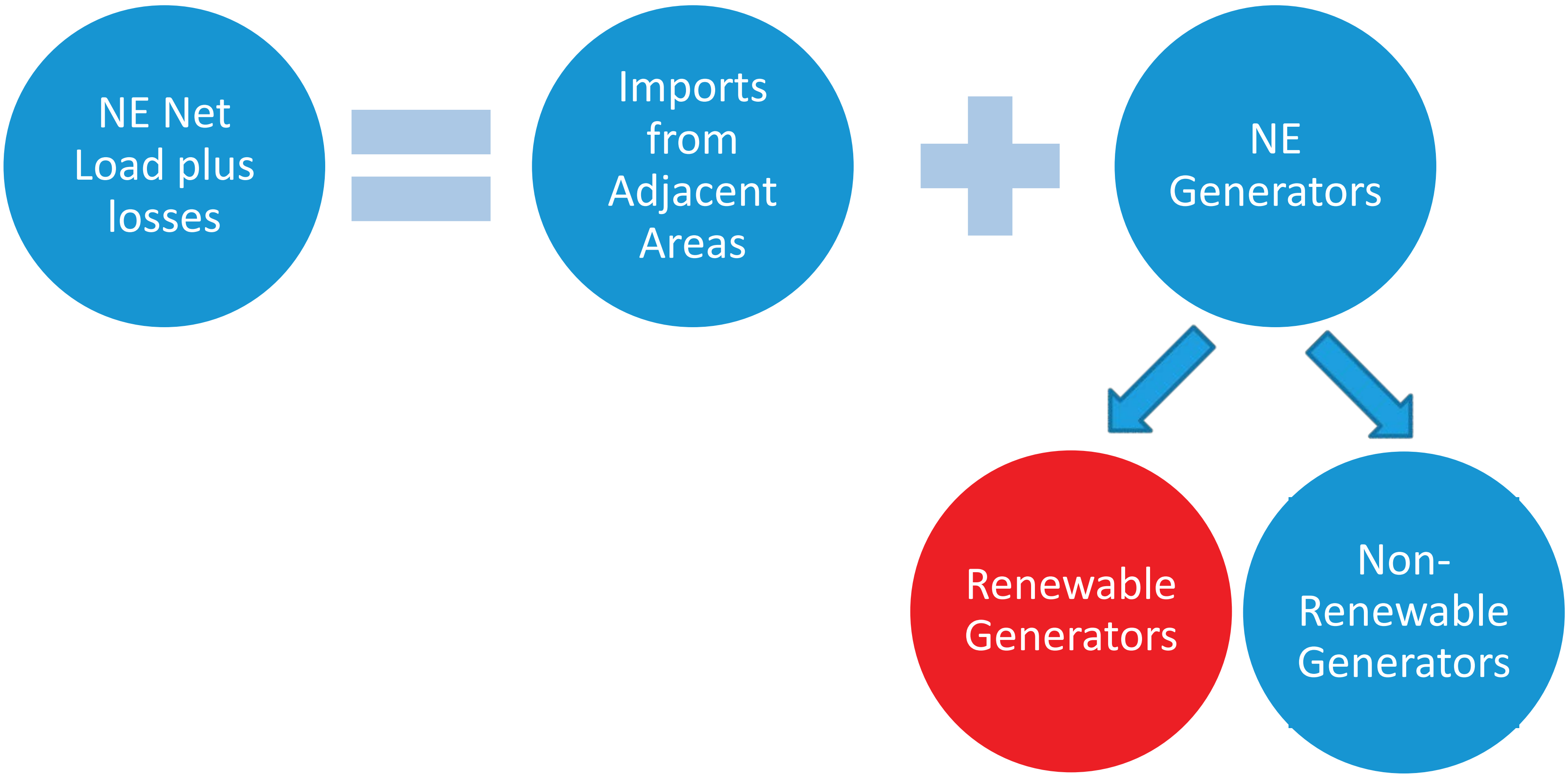


[6] Excludes behind-the-meter generation that is modeled as negative loads

[7] The maximum capability is based on the qualified capacities for all renewable generation in New England, and nameplate value for energy-only daily-cycle hydro units and energy-only photovoltaic units. The wind generators that do not have a qualified capacity have been excluded from the total MW

RENEWABLE GENERATORS

Dispatch of Renewable Generation



Dispatch of Renewable Generators with a CSO

- The rules for the dispatch of renewable generators are consistent with the planning technical guide
- The following table summarizes the rules applied to renewable generators that have a CSO through the FCM

Renewable Generator Type (with CSO)	Dispatch in Base Case
Daily Cycle Hydro	Minimum of Historical Output[8] and Summer Qualified Capacity (QC)
Weekly Cycle Hydro	Minimum of Historical Output[8] and Summer QC
On-shore Wind	Minimum of 5% of summer NRC and Summer QC
Off-shore Wind	Minimum of 20% of summer NRC and Summer QC
Photovoltaic	Minimum of 26% of summer NRC and Summer QC
Pumped-Storage Hydro[9]	Up to 50% of Summer QC[10,11]

[8] If historical data is not available 10% of Summer NRC is used
[9] The pumped-storage hydro at Rocky River is treated as a daily cycle unit
[10] The pumped-storage hydro at Northfield or Bear Swamp may be dispatched below 50% if they are being used as reserves
[11] For studies in western Massachusetts, generation dispatches with Northfield and Bear Swamp modeled at 100% of their Summer QC may also be simulated

Treatment of Future Renewable Generators >= 5 MW without a CSO

- A future renewable generator that is greater than or equal to 5 MW without a CSO will only be included in the basecase if it meets one of the two requirements below:
  - have been selected in, and are contractually bound by, a state-sponsored Request For Proposal
  - have a financially binding obligation pursuant to a contract
- For any generator >= 5MW that falls in the two categories above the dispatch in the basecase will be based on the methodology described on slide 25 with the “Contract Value” replacing the Summer QC
- No generators currently fall into this category

Treatment of In-service Renewable Resources >= 5MW without a CSO

- In-service wind resources >=5MW without a CSO consist of 432 MW of existing wind resources
  - A majority (417 MW) of in-service wind resources without a CSO are located in Northern ME
  - These generators are modeled offline in all the basecases
- In-service daily cycle hydro units >=5MW without a CSO consist of 48 MW of hydro generators associated with mills in ME
  - These resources are dispatched at 10% of their Summer NRC (4.8 MW)
- In-service photovoltaic resources >=5MW without a CSO that were accounted for in the PV forecast
  - Consist of 29 MW of existing PV generators
  - These resources are dispatched at 26% of Summer NRC (7.5 MW)
- In-service photovoltaic resources >=5MW without a CSO that were not accounted for in the PV forecast
  - No resources currently fall into this category
  - These resources are modeled offline in all the basecases

Dispatch of Renewable Generators

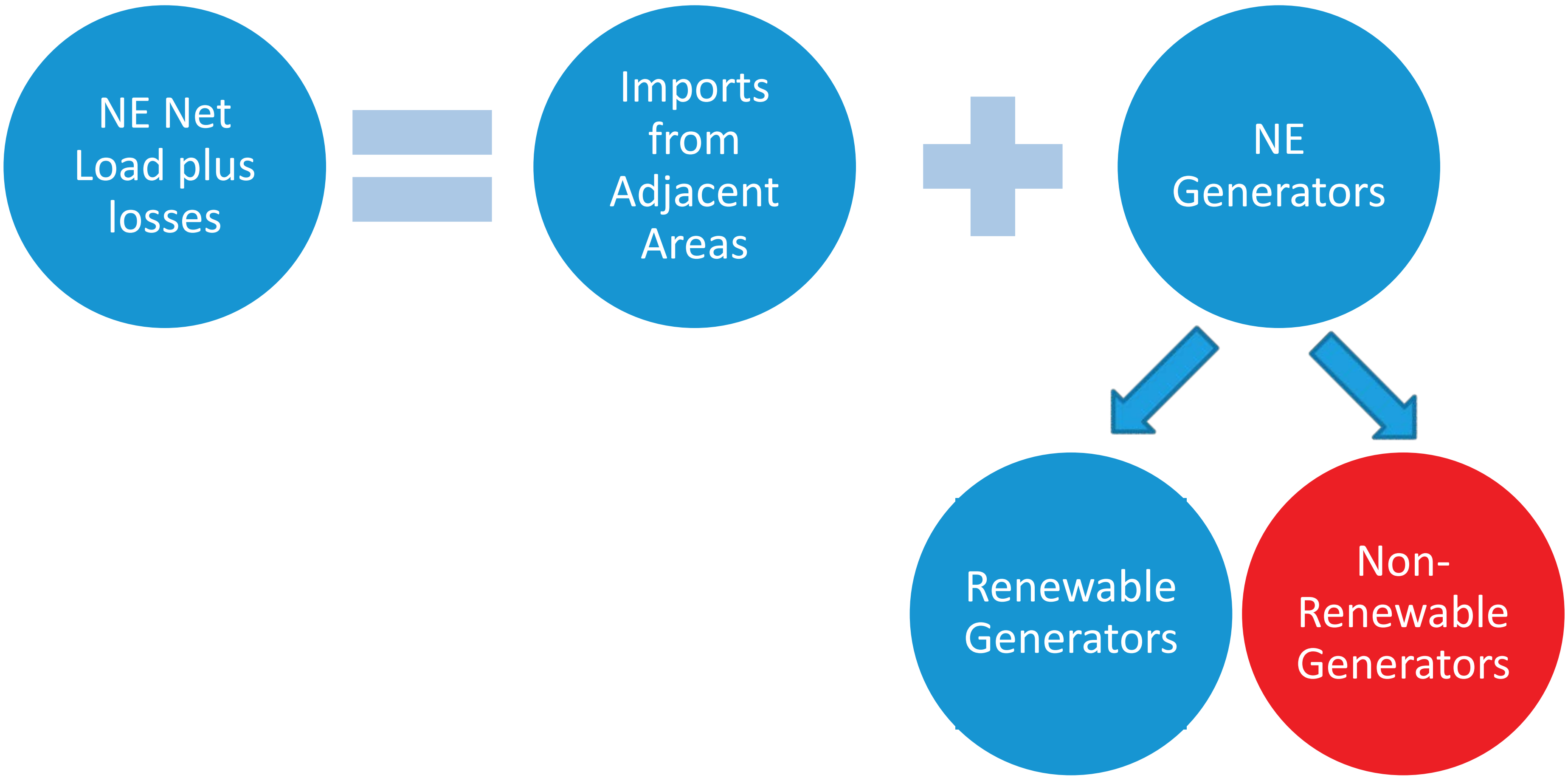
- If the dispatch methodology on the previous slides is applied to all renewable generation in New England the following is a summary of their dispatch

Resource Type	Max Capability[12] (MW)	Base Case Output (MW)
New England Renewable Generation	~3,500	~1,400

[12] The maximum capability is based on the qualified capacities for all renewable generation in New England, and nameplate value for energy-only daily-cycle hydro units and energy-only photovoltaic units. The wind generators that do not have a qualified capacity have been excluded from the total MW

NON-RENEWABLE GENERATORS

Dispatch of Non-Renewable Generation



Dispatch of Non-Renewable Generation

- The total amount of non-renewable generation dispatched in a base case is a function of the resources required to meet load and losses, available renewable generation and imports from adjacent areas

  Non-Renewable Generation Dispatched = Resources Required to Meet Load and Losses – Imports from Adjacent Area – Renewable Generation Dispatched

- To illustrate this concept the next few slides consider the following scenario (Scenario 1) for imports from adjacent areas:
  - 200 MW on Highgate
  - 1400 MW on Phase II
  - 700 MW on NB-NE
  - 0 MW on other external area interfaces

- Total Imports = 2300 MW

Calculating Total Non-Renewable Generation in 50/50 and 90/10 Scenario 1 Cases

	Max Capability (MW)	90/10 Case	50/50 Case
(A) Resources Required (Load + Losses)	N/A	29,725	26,850
(B) Phase II Imports	1,400	1,400	1,400
(C) NB-NE Imports	700	700	700
(D) Highgate Imports	200	200	200
(E) Imports from NY (NY-NE+CSC)	1,400	0	0
(F) Total Imports = (B)+(C)+(D)+(E)	3,700	2,300	2,300
(G) New England Renewable	3,500	1,400	1,400
New England Non-Renewable Generation (A)-(F)-(G)		26,025	23,150

OFFLINE NON-RENEWABLE GENERATION

Offline Non-Renewable Generation

- The non-renewable generation that is offline in Needs Assessment base cases falls in one of four categories
  - Unavailable
  - Reserves
  - Generation behind system constraints
  - Offline for load-resource balance
- The "Unavailable" generation is based on the same-probability curve and will be discussed in detail in later slides
- The "Offline for load-resource balance" are generators that are offline to ensure that that the supply is equal to demand. See slide 31
- The remaining two categories are discussed on the following slides

Reserves

- The term "reserves" described in this presentation refers to the *"resources available within ten minutes following notification"* as described in Planning Procedure 3
- Needs Assessment base cases will model 1200 MW of "reserves" to account for generation adjustments after the first contingency. These resources are available after the first contingency to:
  - Keep load-resource balance in the base cases if the first contingency involves the loss of a resource (generator/inter-area tie)
  - Make system adjustments in preparation for the next contingency while maintaining load-resource balance in the base cases
- The reserves in Needs Assessment base cases may include hydro generation and non-renewable generation

Impact of Reserves on Non-Renewable Generation Offline in Base Cases

- The reserves in the base case may be procured from the following sources
  - Weekly Cycle Hydro Units – These generators may be dispatched up to their qualified capacity from their historical de-rated output in the base case after the first contingency
  - Pumped-Storage Hydro Units – These generators may be dispatched anywhere between 0 and 50% of QC in the base case and may be dispatched up to 50%[13] of their QC after the first contingency
  - Offline Fast Start[14] Units – These generators may be dispatched up to their Summer QC after the first contingency
  - Online Non-Renewable Generators – If weekly cycle hydros, pumped-storage hydros and offline fast start units do not provide 1200 MW of reserves then generators capable of ramping up after the first contingency will be assigned reserves equal to their 10 minute ramp capability.

[13] An exception to this is if the study area for a Needs Assessment is in the Western Mass area, then a dispatch with the pumped-storage hydro units at 100% in the basecase may be studied. In this case the pumped-storage hydro units will not provide reserves.

[14] For the purpose of transmission planning studies, fast start units are those combustion turbines or diesel generators that can go from being off line to their full Seasonal Claimed Capability in 10 minutes.

Generation Behind System Constraints

- Generation that is located in an export constrained area may need to be kept offline to avoid violating system constraints
- These generators cannot count towards reserves because reserves that are behind a system constraint may not be useful for required system adjustments after the first contingency

ESTABLISHING GENERATOR GROUPS BASED ON “SAME PROBABILITY” CURVES

To Calculate Probability Based Unavailability

Setting up of Dispatches

- A Needs Assessment base case for a particular load level is established by:
  - Dispatching renewable generation based on historical availability
  - Setting inter-area ties to a desired value
  - Shutting off generation that is unavailable (Using the Probabilistic Method)
  - Establishing sufficient reserves for N-1-1 testing
  - Ensuring no key interface limits with respect to the study area are violated in establishing reserves and load-resource balance exists in the base case
- The following slides discuss how the generator groups are selected for the creation of same-probability curves

Need for Defining Groups of Generators

- It is unreasonable to apply the unavailable MW for New England to a small portion of the New England system
  - Using the probabilistic methodology, 2,346 MW of generation would be unavailable in New England at the 90/10 load level
  - Applying the 2,346 MW of maximum MW unavailable at 90/10 peak load to the NEMA/Boston area would result in almost all major generators in the NEMA/Boston area being unavailable in the base case
- It is also recognized that the probability threshold for a portion of New England is smaller than the system-wide threshold
  - As the group of generators approaches the size of the New England Control Area, the threshold will converge to the system-wide value of 1.2 E-03

Study Area as a Group of Generators

- For each Needs Assessment, at a minimum, all the study area generators will be considered as a group of generators
  - For the study area generators, the maximum unavailable generation will be calculated for 90/10 and 50/50 peak loads
- The total unavailable generation in the study area will honor the maximum amount of generation based on the same probability curve as an “upward” boundary, while also considering all single generator unavailable dispatches to be acceptable
- Non-renewable generators in the study area will not be dispatched below Pmax to meet the maximum generation unavailable in the study area

Example of Study Area - SWCT

- To illustrate the study area as a group of generators, consider the SWCT study area

Generator Group Characteristic	Value
No. of non-Renewable Generators	38
Total Capacity of Non-Renewable Generators	3410 MW
Variable Probability Threshold[13]	2.46×10^{-4}
Maximum Gen Unavailable at 90/10 Peak Load	671 MW
Maximum Gen Unavailable at 50/50 Peak Load	969 MW
Capacity of Largest Generator in SWCT (Towantic)	770 MW

- The following slide contains two representative dispatches for the SWCT study area at 90/10
  - In Dispatch A the total Unavailable generation is less than the probability based maximum unavailable generation value of 671 MW
  - In Dispatch B the largest resource (770 MW) is considered unavailable and no additional generators are assumed unavailable since a single resource exceeds the probability based subarea threshold

[13] The variable probability threshold calculation can be described and found at the following link – https://www.iso-ne.com/static-assets/documents/2017/09/a5_transmission_assumptions_probabilistic_methodology_implementation_for_base_cases.pdf

SWCT Example Dispatches at 90/10 Peak Load

Generator	Pmax	Dispatch A	Dispatch B
Milford Power 1	273	OFF	
Towantic	770		OFF
Bridgeport Harbor 4	17	OFF	
Devon 11	30	OFF	
Devon 15	48	OFF	
Devon 16	48	OFF	
Bridgeport Resco	65	OFF	
Cos Cob 14	18	OFF	
Waterside Power 1	23	OFF	
Waterbury	98	OFF	
Yale DG 1	8.7	OFF	
Yale DG2	8.7	OFF	
Sikorsky	9.2	OFF	
Branford 10	16	OFF	
Total Gen Unavailable in SWCT (Max of 671MW)		663	770

Additional Groups of Generators – Subgroups within the Study area

- It is possible that within a study area, there are subsets of generation that are either electrically close to each other, (e.g. share the same point of interconnection), or are a part of the same plant
- These subsets of generators can be formed into sub-groups for which a probability based maximum unavailable generation is determined for the load levels being tested
- An example of a subgroup is the Devon generating station in SWCT
  - A max unavailable generation for the Devon generation station will be determined in addition to the calculated unavailable generation for the entire SWCT area
  - The total generation unavailable at the Devon station will not exceed the Devon generating station maximum unavailable generation

Additional Groups of Generators – Receiving End for System Stress

- For Needs Assessment base cases, four stress conditions are considered
  - For each stress condition the generators on the receiving end are considered a group of generators and the maximum generation unavailable on the receiving end is calculated

System Stress	Group of Generators on Receiving End
North-South	Southern New England (Generators south of North-South interface)
South-North	Northern New England (Generators north of North-South interface)
East-West	Western New England (Generators west of East-West interface)
West-East	Eastern New England (Generators east of East-West interface)

Additional Groups of Generators – Study Area and Adjacent Area

- If the generators in a portion of the New England system that is adjacent to the study area are considered to have a material impact on the study area, then a group comprised of the study area generation and the adjacent area generation is created and a maximum generation unavailable is calculated
- In establishing the study area dispatches, the total generation unavailable in the study area and adjacent area combined will honor the maximum amount of generation based on the same probability curve for the combined group of generators as an "upward" boundary, while also considering all single generator unavailable dispatches to be acceptable
- The adjacent area considered must be no larger than a load zone

Example of Adjacent Area for SWCT Study Area

- The generators in the rest of Connecticut (outside SWCT) are considered to have a material impact on the SWCT study area
- On this basis, all the generators in Connecticut are included in a group of generators that covers the study area (SWCT) and the adjacent area (rest of CT outside SWCT) and the maximum unavailable generation for Connecticut is calculated for 90/10 and 50/50 peak loads
- Details of Connecticut group of generators

Generator Group Characteristic	Value
No. of non-Renewable Generators	82
Total Capacity of Non-Renewable Generators	9730 MW
Variable Probability Threshold	4.78×10^{-4}
Maximum Gen Unavailable at 90/10 Peak Load	1369 MW
Maximum Gen Unavailable at 50/50 Peak Load	1901 MW
Capacity of Largest Generator in CT (Millstone 3)	1283 MW

Additional CT Gen Unavailable in SWCT Example Dispatches at 90/10 Peak Load

- The details of the SWCT dispatch are provided on slide 43
- The maximum generation unavailable for SWCT is 671 MW
- When additional generators are considered unavailable in rest of CT the total generation unavailable in CT (including generators unavailable in SWCT) does not exceed the 1369 MW threshold for CT

Generator	Pmax	Dispatch A	Dispatch B
SWCT Generators OOS (Max of 671 MW)		663	770
Middletown 4	414		OFF
New Haven Harbor 1	465	OFF	
New Haven Harbor 2	45	OFF	
Total MW OOS in CT (Max of 1369 MW)		1173	1184

Study Area and Adjacent Area at 90/10 Peak Load

- Maximum Gen Unavailable at 90/10 Peak Load in SWCT = 671 MW
- Maximum Gen Unavailable at 90/10 Peak Load in CT = 1369 MW
- Gen Unavailable in SWCT + Gen Unavailable in Rest of CT <= 1369 MW

Adjacent Area = Rest of CT

Maximum Gen Unavailable in Rest of CT = 1369 – Gen Unavailable in SWCT

Study Area = SWCT

Maximum Gen Unavailable in SWCT = 671 MW

DISPATCH CREATION METHODOLOGY

Steps to Setup Needs Assessment Dispatches

Step 1:
Set Renewable Generation and Imports

Step 2:
Model Probability Based Generation Unavailability

Step 3:
Establish Reserves while Respecting Interface Limits

Step 1: Set Renewable Generation and Imports

Step 1:
Set Renewable Generation and Imports

Step 2:
Model Probability Based Generation Unavailability

Step 3:
Establish Reserves while Respecting Interface Limits

Step 1: Set Renewable Generation and Imports

- Setup the renewable generation in New England based on historical availability at peak loads

Renewable Generator Type	Dispatch in base case
Daily Cycle Hydro (with CSO)	Minimum of Historical Output[14] and Summer Qualified Capacity (QC)
In-service Daily Cycle Hydro (w/o CSO)	10% of Summer NRC
Weekly Cycle Hydro	Minimum of Historical Output[14] and Summer QC
On-shore Wind (with CSO)	Minimum of 5% of summer NRC and Summer QC
In-service On-shore Wind (w/o CSO)	0
Off-shore Wind	Minimum of 20% of summer NRC and Summer QC
Photovoltaic (with CSO)	Minimum of 26% of summer NRC and Summer QC
In-service Photovoltaic included in PV forecast (w/o CSO)	26% of Summer NRC
In-service Photovoltaic not included in the PV forecast (w/o) CS))	0
Pumped-Storage Hydro[15]	Up to 50% of Summer QC[16,17]

[14] If historical data is not available 10% of Summer NRC is used

[15] The pumped-storage hydro at Rocky River is treated as a daily cycle unit

[16] The pumped-storage hydro at Northfield or Bear Swamp may be dispatched below 50% if they are being used as reserves

[17] For studies in western Massachusetts, generation dispatches with Northfield and Bear Swamp modeled at 100% of their Summer QC may also be simulated

Step 1: Renewable Generation and Imports (Continued)

- Setup inter-area ties using the table below
- If an interface is critical to the study area, different levels of transfer on the interface may be considered

Inter-area Interface	Dispatch Range
New Brunswick to New England tie (NB-NE)	0-700 MW
New York to New England AC ties (NY-NE)	0-1400 MW
Cross Sound Cable HVDC From Long Island to New England (CSC)	0 MW
Phase II HVDC from Quebec to New England (Phase II)	950-1400 MW
Highgate HVDC From Quebec to New England (Highgate)	200 MW

Step 1: Example for SWCT Study Area – Setting up Renewable Generation and Imports

- Renewable generation in New England, including the SWCT study area renewable generation, is dispatched
- Two interarea dispatch conditions are considered
  - NY-NE = 0 MW
  - NY-NE = 1400 MW
  - Other interfaces are fixed in both inter-area dispatch conditions

Inter-area Interface	Dispatch Range
New Brunswick to New England tie (NB-NE)	700 MW
New York to New England AC ties (NY-NE)	0 MW/1400MW
Cross Sound Cable HVDC from LI to New England (CSC)	0 MW
Phase II HVDC from Quebec to New England (Phase II)	1400 MW
Highgate HVDC From Quebec to New England (Highgate)	200 MW

Step 2: Model Probability Based Generation Unavailability

Step 1: Set Renewable Generation and Imports

Step 2:

Model Probability Based Generation Unavailability

Step 3:

Establish Reserves while Respecting Interface Limits

Step 2: Model Probability Based Generation Unavailability

- For each study area and load level determine the maximum generation unavailable for the following groups of generators
  - Max Gen Unavailable for Study Area
  - Max Gen Unavailable for (Study Area + Adjacent Area) [May not be needed in all instances]
  - Max Gen Unavailable for Receiving End of System Stress
- Each study area needs to determine the system stress being modeled
  - East-West, West-East, North-South or South-North
- Identify non-renewable generators that will be considered unavailable in the study area, study area + adjacent area and receiving end of the system stress while honoring the maximum amount of generation unavailable for each of the groups, while also considering all single generator unavailable dispatches to be acceptable

Step 2: Example for SWCT – Creating Generator Groups for Max MW Unavailable

- For the SWCT study area, the max unavailable MWs are shown for the three groups of generators in the table below

Type of Group	Group of Generators	Max MW Unavailable at 90/10 Peak Load	Max MW Unavailable at 50/50 Peak Load
Study Area	SWCT Generators	671	969
Study Area + Adjacent Area	Connecticut Generators	1,369	1,901
Receiving End of System Stress	Western New England	1,424	1,969

Step 2: Example for SWCT – Overview of Generator Groups

- Maximum Gen Unavailable at 90/10 Peak Load in SWCT = 671 MW
- Maximum Gen Unavailable at 90/10 Peak Load in CT = 1369 MW
- Maximum Gen Unavailable at 90/10 Peak Load in Western NE = 1424 MW

Receiving End of System Stress = Western New England

Maximum Gen Unavailable in Rest of Western NE = 1424 – Gen Unavailable in CT

Adjacent Area = Rest of CT

Maximum Gen Unavailable in Rest of CT = 1369 – Gen Unavailable in SWCT

Study Area = SWCT

Maximum Gen Unavailable in SWCT = 671 MW

Step 2: Example for SWCT Representative 90/10 Dispatches

- The following table shows the MW considered Unavailable for two representative 90/10 peak load dispatches
  - The details of the SWCT dispatch and Rest of CT dispatch are provided on slides 42 to 49
  - The 234 MW Berkshire Power unit is the only unit made unavailable outside CT to honor the Western New England MW unavailability limit

Type of Group	Group of Generator	Max Unavailable MW at 90/10 Peak Load	Unavailable MWs in Group for Dispatch A	Unavailable MW in Group for Dispatch B
Study Area	SWCT Generators	671	663	770[18]
Study Area + Adjacent Area	Connecticut Generators	1,369	1,173	1,184
Receiving End of System Stress	Western New England	1,424	1,407	1,418

[18] Represents the largest single resource in SWCT (Towantic)

Step 3: Establishment of Reserves

Step 1:
Set Renewable Generation and Imports

Step 2:
Model Probability Based Generation Unavailability

Step 3:
Establish Reserves while Respecting Interface Limits

Step 3: Establishment of Reserves

- For a particular system stress selected, an attempt is made to establish reserves on the receiving end of the system stress
- However, interface limits must not be violated when establishing reserves on the receiving end
  - If interface limits are violated by establishing all reserves at the receiving end, stop establishing reserves on the receiving end when the interface limit is reached and establish the remaining reserves on the sending end

Step 3: Establishment of Reserves (Continued)

- If the study area is on the receiving end of the system stress, additional generation may not be turned off in the study area to establish reserves
  - If the study area is a part of a load zone, additional generation in the load zone containing the study area may not be turned offline to establish reserves
  - An exception to this rule is the available weekly cycle hydro units in the study area which may be used to establish reserves on the receiving end
- The reserves may be established by relying on the following types of generators and using the priority in parenthesis
  - Receiving end weekly cycle hydro units (Priority 1)
  - Study area weekly cycle hydro units (Priority 1)
  - Receiving end pumped-storage hydro units (Priority 2)
  - Receiving end offline Fast Start units (Priority 2)
  - Receiving end online Non-Renewable units (Priority 3)
  - Sending end units outside the study area (Priority 4)

Step 3: Example for SWCT – Establishing Reserves

- For the SWCT Study area the receiving end of the system stress is Western New England and the SWCT weekly cycle hydro units are a part of the Western New England weekly cycle hydro units
- The non-renewable generation in SWCT (Study area) and rest of CT (in the load zone containing the study area) may not be turned off to establish reserves on the receiving end
- This leaves the pumped-storage hydro units in western Massachusetts and the fast starts in western New England outside CT that may be used to establish reserves

Step 3: Example for SWCT – Reserves for Sample Dispatches at 90/10 Peak Load

Group of Generators	Max MW Unavailable at 90/10 Peak Load	Dispatch A	Dispatch B
Unavailable SWCT Gen	671	663	770[19]
Unavailable Western New England Gen	1,424	1,407	1,418
Unavailable Connecticut Gen	1,369	1,173	1,184
(A) Weekly Cycle Hydro Units Available After the 1st Contingency in Western NE		179	179
(B) Bear Swamp and Northfield Offline for Reserves		870	870
(C) Western Massachusetts and VT Fast Starts Offline for Reserves		151	151
Total Reserves (A+B+C)		1,200	1,200

[19] Represents the largest single resource in SWCT (Towantic)

Step 3: Example for SWCT – Ensure Transfer Limits are not Violated

- Check if the establishment of reserves on the receiving end results in the violation of any interface limits
- If all interfaces are within their limits and the reserves are considered acceptable

Interface Name	Limit	Dispatch A	Dispatch B
East-West	3500	294	309
CT Import	3400	-1008	-997
SWCT Import	2500	991	1081
North-South	2725	2103	2103

INTERNAL INTERFACE TRANSFERS

Interfaces as a Product of Dispatch Assumptions

- In the process described for the creation of the dispatches, generators are assumed out of service and the interface transfers are a result of generation dispatch assumptions
  - An exception to this is interfaces with external areas where a set amount of imports is assumed in the base cases
- For export constrained interfaces, if interface limits are violated at the end of the three-step generation dispatch methodology discussed in the previous slides, additional generation may be turned off to respect interface capabilities
  - Any additional generation turned off to respect interface limits is not included in the probability based MW unavailability

Comparison with Past Practices on Interfaces

- This method replaces the prior practice of trying to stress interfaces in the vicinity of the study area to the maximum extent possible
  - In general interface transfers with this methodology will be lower than past Needs Assessments
- This is considered acceptable because the object of the Needs Assessment is to evaluate load serving capability under a set of generation dispatch conditions that can be justified based on probability based generation unavailability
  - The additional consideration of reserves is done to reflect the need to always have sufficient reserves to allow system adjustments between the first and the second contingencies

SUMMARY AND NEXT STEPS

Summary

- The following summarizes the 3-step process used to setup Needs Assessment peak load dispatches:

Step 1

- Dispatch Renewable Generation based on historical availability at peak loads
- Set up key inter-area ties with respect to the study area at desired value

Step 2

- Calculate amount of unavailable generation for the Study Area, Study area + Adjacent Area, and Receiving End of System Stress by creating "same-probability" curves for each of the generator groups
- Assume generation unavailability for the groups of generators created above by honoring the maximum amount of generation based on the same probability curve as an "upward" boundary, while also considering all single generator unavailable dispatches to be acceptable

Step 3

- Establish reserves on the Receiving End of System Stress while respecting interface limits

Next Steps

- Each study area will utilize the dispatch creation methodology to establish a set of Needs Assessment base cases
- A scope of work for the Needs Assessment for each study area will be developed and presented to PAC at future PAC meetings

Questions

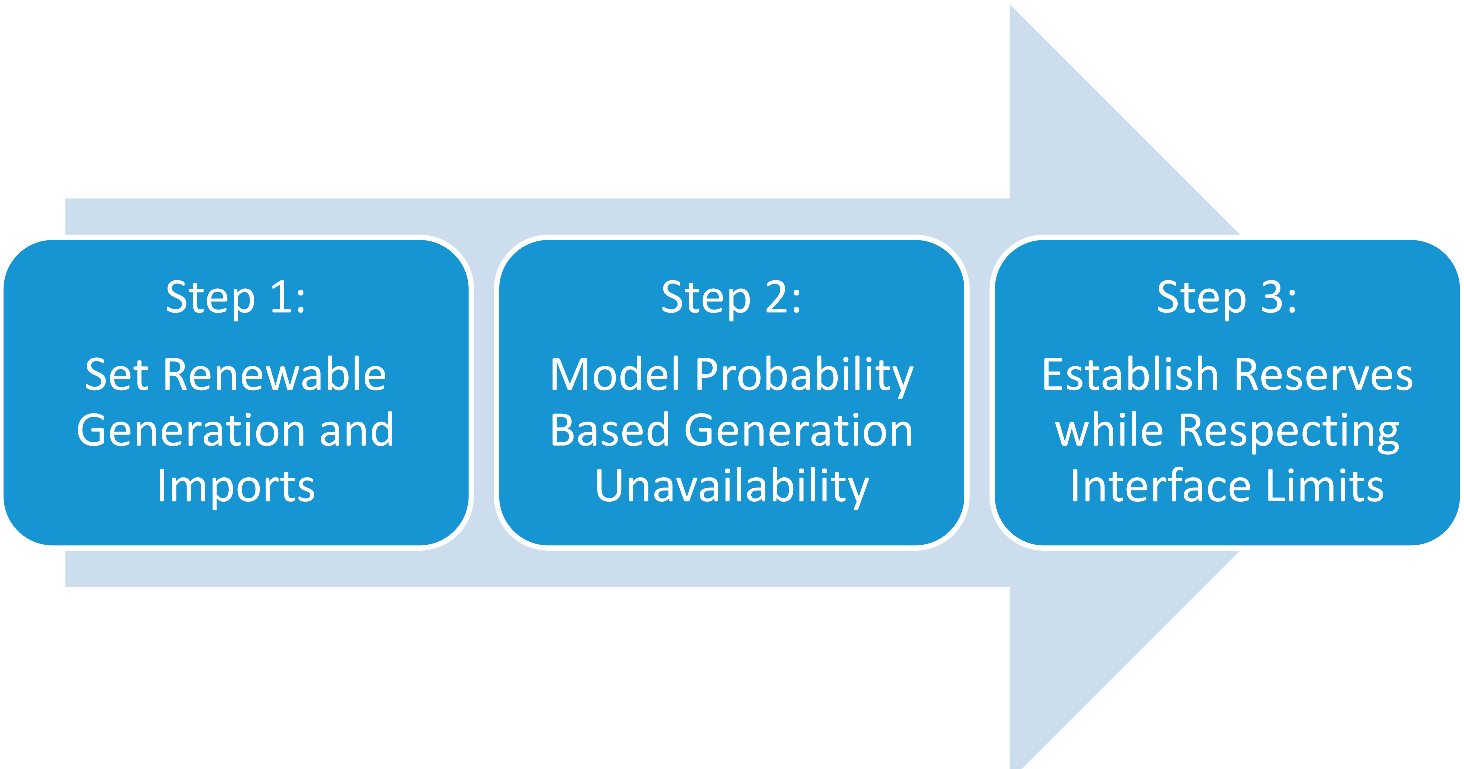
APPENDIX – ADDITIONAL EXAMPLES

ECT Dispatch with West-East Bias at 90/10 Peak Load

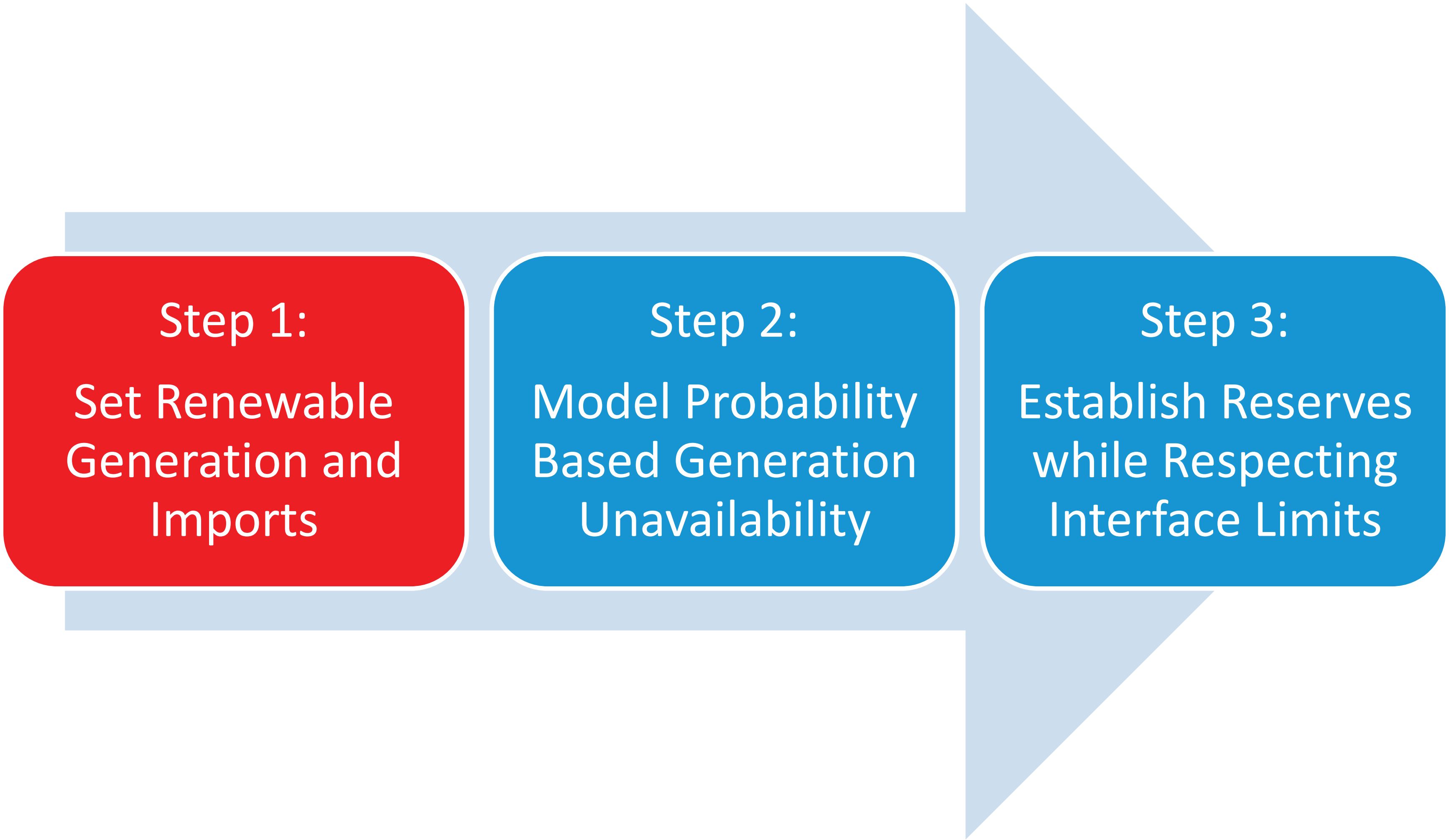
NOTE: This is not an actual study dispatch for the ECT study. This is an example for demonstrating the dispatch creation methodology

Steps to Setup Needs Assessment Dispatches

- The following process will be used to demonstrate the creation of an Eastern CT study area dispatch with West-East system stress



Step 1: Set Renewable Generation and Imports

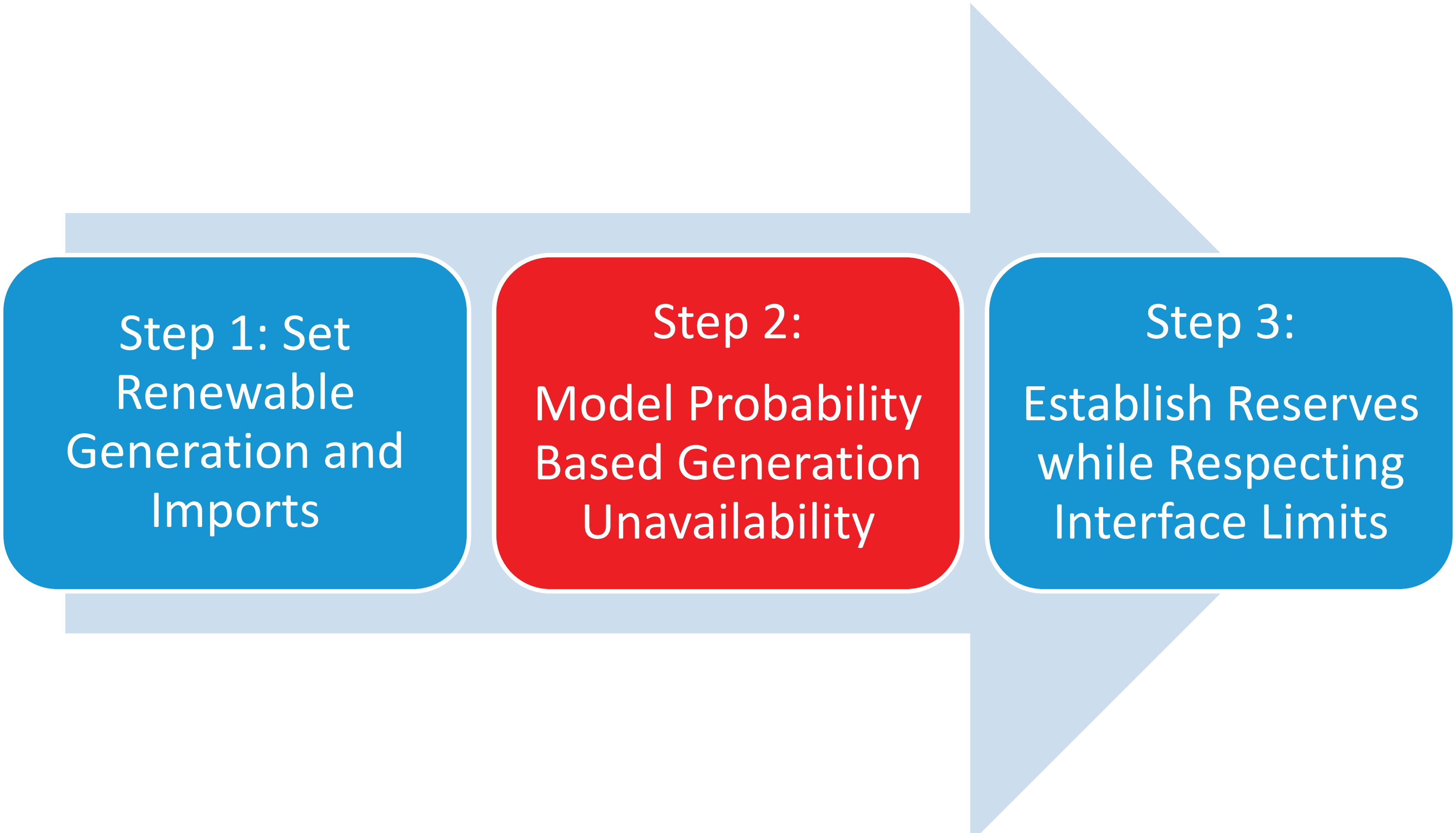


Step 1: ECT Study Area (Renewable + Imports)

- Renewable generation in New England including the ECT study area renewable generation are dispatched based on historical availability
- To stress West-East
  - The eastern NE import interfaces were set to their minimum values
  - New York to New England was set to a maximum flow of 1400 MW
  - All inter-area interface details are found in the table below

Inter-area Interface	Dispatch Range
New Brunswick to New England tie (NB-NE)	0 MW
New York to New England AC ties (NY-NE)	1400MW
Cross Sound Cable HVDC From Long Island to New England (CSC)	0 MW
Phase II HVDC from Quebec to New England (Phase II)	950 MW
Highgate HVDC From Quebec to New England (Highgate)	200 MW

Step 2: Model Probability Based Generation Unavailability



Step 2: ECT Study Area (Study Area Generators)

- The following table summarizes the ECT generation as the study group generators

Generator Group Characteristic	Value
No. of non-Renewable Generators	13
Total Capacity of Non-Renewable Generators	668 MW
Variable Probability Threshold	1.45×10^{-4}
Maximum Gen Unavailable at 90/10 Peak Load	488 MW
Maximum Gen Unavailable at 50/50 Peak Load	537 MW
Capacity of Largest Generator in ECT (Montville 6)	413 MW

Step 2: ECT Study Area (Study Area + Adjacent Area Generators)

- The generators in the Rhode Island are considered to have a material impact on the ECT study area when stressing from West to East
- On this basis, the generators in Eastern CT and RI are included in a group of generators that covers the study area (ECT) and the adjacent area (RI) and the maximum unavailable generation for “ECT+RI” is calculated for 90/10 and 50/50 peak loads
- Details of ECT+RI group of generators

Generator Group Characteristic	Value
No. of non-Renewable Generators	24
Total Capacity of Non-Renewable Generators	2996 MW
Variable Probability Threshold	2.30×10^{-4}
Maximum Gen Unavailable at 90/10 Peak Load	636 MW
Maximum Gen Unavailable at 50/50 Peak Load	954 MW
Capacity of Largest Generator in ECT+RI (RISE)	564 MW

Step 2: ECT Study Area (Generators on Receiving End of System Stress)

- For the two example dispatches discussed here, the system stress considered is West-East and a group of generators that consists of all non-renewable generators east of the East-West interface are considered
- Details of eastern New England generators

Generator Group Characteristic	Value
No. of non-Renewable Generators	143
Total Capacity of Non-Renewable Generators	17723 MW
Variable Probability Threshold	7.72×10^{-4}
Maximum Gen Unavailable at 90/10 Peak Load	1554 MW
Maximum Gen Unavailable at 50/50 Peak Load	2263 MW
Capacity of Largest Generator in Eastern NE (Seabrook)	1299 MW

Step 2: ECT Study Area (Groups of Generators)

- For the ECT study area with a West-East bias the following are the three groups of generators

Type of Group	Group of Generators	Max MW Unavailable at 90/10 Peak Load
Study Area	ECT Generators	488
Study Area + Adjacent Area	ECT + RI Generators	636
Receiving End of System Stress	Eastern New England	1,554

Step 2: ECT Study Area–
Overview of Generator Groups

- Maximum Gen Unavailable at 90/10 Peak Load in ECT = 488 MW
- Maximum Gen Unavailable at 90/10 Peak Load in ECT+RI = 636 MW
- Maximum Gen Unavailable at 90/10 Peak Load in Eastern NE = 1554 MW

Receiving End of System Stress = Eastern New England
Maximum Gen Unavailable in Rest of Eastern NE =
1554 – Gen Unavailable in RI

Study Area = ECT

Maximum Gen
Unavailable in ECT =
488 MW

Adjacent Area = RI

Maximum Gen Unavailable in RI =
636 – Gen Unavailable in ECT

Step 2: ECT Study Area (Total MW OOS in Each Group of Generator)

- The following table shows the MW considered Unavailable for two representative 90/10 peak load dispatches

Type of Group	Group of Generators	Max MW Unavailable at 90/10 Peak Load	Unavailable MW in Group for Dispatch A	Unavailable MW in Group for Dispatch B
Study Area	ECT Generators	488	456	63
Study Area + Adjacent Area	ECT+ RI Generators	636	612	627
Receiving End of System Stress	Eastern New England	1,554	1,519	1,515

Step 2: ECT Study Area (Generators OOS in Study Area and Adjacent Area)

Generator	Subarea	Pmax	Dispatch ECT-A	Dispatch ECT-B
Montville 6	ECT	413	OFF	
Plainfield	ECT	43	OFF	OFF
Tunnel	ECT	17		OFF
Montville 11	ECT	2.7		OFF
Manchester/ Franklin 9	RI	156	OFF	
RISE	RI	564		OFF
ECT Total Unavailable Generation (Max of 488 MW)			456	63[19]
ECT+RI Total Unavailable Generation (Max of 636 MW)			612	627

[19] When the largest resource in the adjacent area (RISE in RI) is taken OOS, the amount of generation considered unavailable in ECT has to be significantly lower than the ECT maximum Unavailable generation to respect the ECT+RI total maximum MW unavailable

Step 3: Establishment of Reserves

Step 1:

Set Renewable Generation and Imports

Step 2:

Model Probability Based Generation Unavailability

Step 3:

Establish Reserves while Respecting Interface Limits

Step 3: Example for ECT

- For the ECT Study area the receiving end of the system stress is Eastern New England and there are no weekly cycle hydro units in the ECT Study area
  - The weekly cycle hydro units in Eastern New England are used to establish reserves
- The non-renewable generation in ECT (Study area) and rest of CT (in the load zone containing the study area) are both on the sending end of the system stress
  - No concern of reserves on receiving end being established in the study area
- The remainder of the reserves on the receiving end of the West-East interface is established using fast starts in eastern New England

Step 3: Unavailable Generation and Reserves for ECT Example Dispatches at 90/10 Peak Load

Group of Generators	Max MW Unavailable at 90/10 Peak Load	Dispatch A	Dispatch B
Unavailable ECT Generators	488	456	63
Unavailable ECT+RI Generators	636	612	627
Unavailable Eastern New England	1,554	1,519	1,515
(A) Weekly Cycle Hydro Units Available After the 1st Contingency in Eastern NE		489	489
(B) Eastern Massachusetts Fast Starts Offline for Reserves		711	711
Total Reserves (A+B)		1,200	1,200

Step 3: Reserves for ECT Example Dispatches at 90/10 Peak Load

- The final step is to check if the establishment of reserves on the receiving end results in the violation of any key interfaces in the vicinity of the study area or the receiving end of the stress
- All interfaces are within their limits and the reserves are considered acceptable

Interface Name	Limit	Dispatch A	Dispatch B
West-East	2200	1877	1881
SEMA/RI Import	1280	-436	-41
North-South	2725	823	924
CT Import	3400	-804	-1009