# Tie Benefits – Developments

*Wayne Coste*
*ISO New England, Resource Adequacy*
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# Presentation Overview

- Progress to date
  - Review of previous analyses presented to PSPC
  - Development of results
    - Preliminary tie benefits
    - Numerical precision issues
  - Identification of load diversity problem with the NPCC CP8 data
    - Load model calendars
    - Exaggeration of load diversity between New England and New York
  - Effect of resolving identified load model issues
  - Process of bringing control areas to a reliability criterion
    - Various approaches used for this process
    - Incorporation of Rau/Zeng reliability optimization methodology
    - Extending Rau/Zeng methodology to internal constrained areas
  - Linkages to joint ISONE and NYSRC interconnection studies

# Development of Preliminary Results

- Presented preliminary tie benefits
- Identified numerical precision issues with MARS
- Develop method to quantify tie benefits given limited numerical precision
  - Margin State 1
  - Margin State 2
- Range of results presented graphically
  - Graphs highlighted the uncertainty in the tie benefits
  - Highlighted uncertainty due to numerical precision problems

# Overview of ISONE "As-Is" Cases

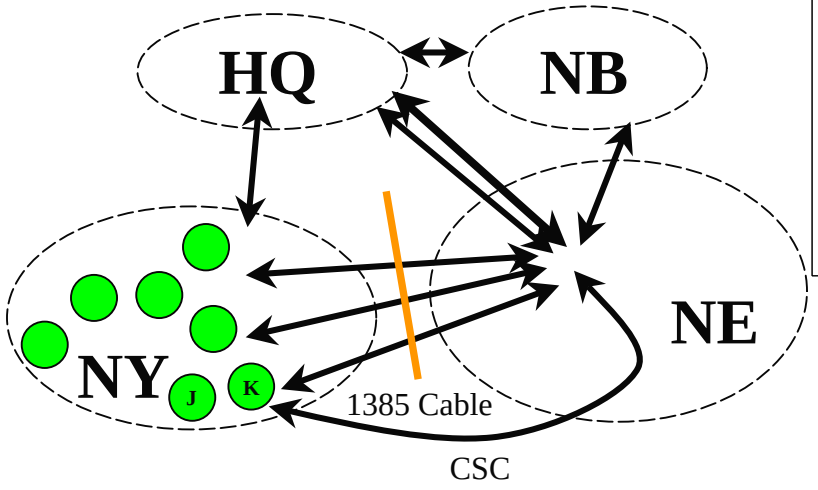
- External areas modeled "As-Is"
  - New England modeled "As-Is"
    - These scenarios indicated tie benefits of ~1400 to ~2300 MW
    - As modeled, NYISO is much less reliable than ISONE
      - NYISO LOLE ~0.028 days/year
      - ISONE LOLE ~0.001 days/year
    - Based on "As-Is" conditions
      - New England tends to act like an infinite bus to New York
      - NYISO tends to degrade reliability of New England
      - This results in lower tie benefits to New England

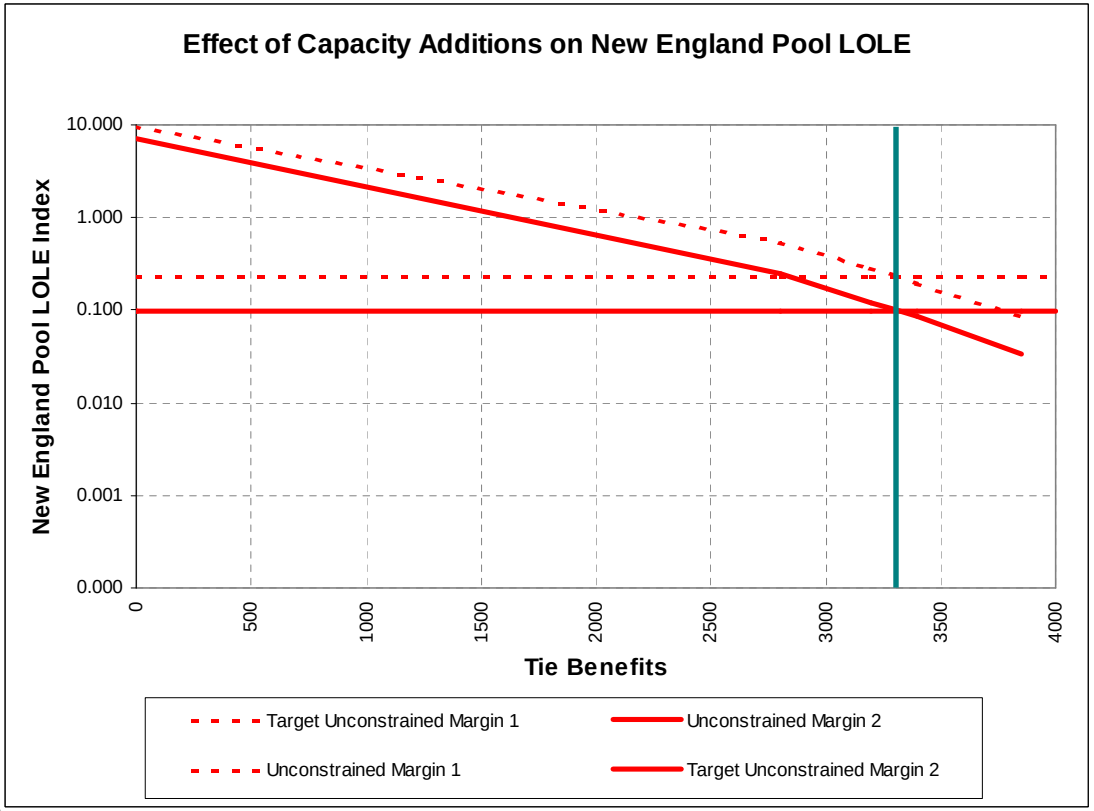
# Overview of ISONE "At-Criterion" Cases

- External areas still modeled "As-Is"
  - New England modeled "At-Criterion"
    - These scenarios indicated tie benefits of ~2500 to ~3400 MW
    - As modeled, NYISO more reliable than ISONE
      - NYISO LOLE ~0.028 days/year
      - ISONE LOLE ~0.100 days/year
    - Based on NYISO "As-Is" conditions
      - NYISO tends to enhance reliability of New England
      - This results in higher tie benefits to New England
    - If NYISO were to be bought "to criterion"
      - This would decrease NYISO's ability to provide capacity assistance
      - Tie benefits to New England would tend to decrease
    - This framework seems to suggest an answer to the question about
      - Minimum iron in ground in New England
      - Not necessarily appropriate to call all capacity support "tie benefits"

# At Criterion - NE Internal Constraints Not Modeled

Other external NPCC areas not brought to criterion (As-Is) and have surplus.



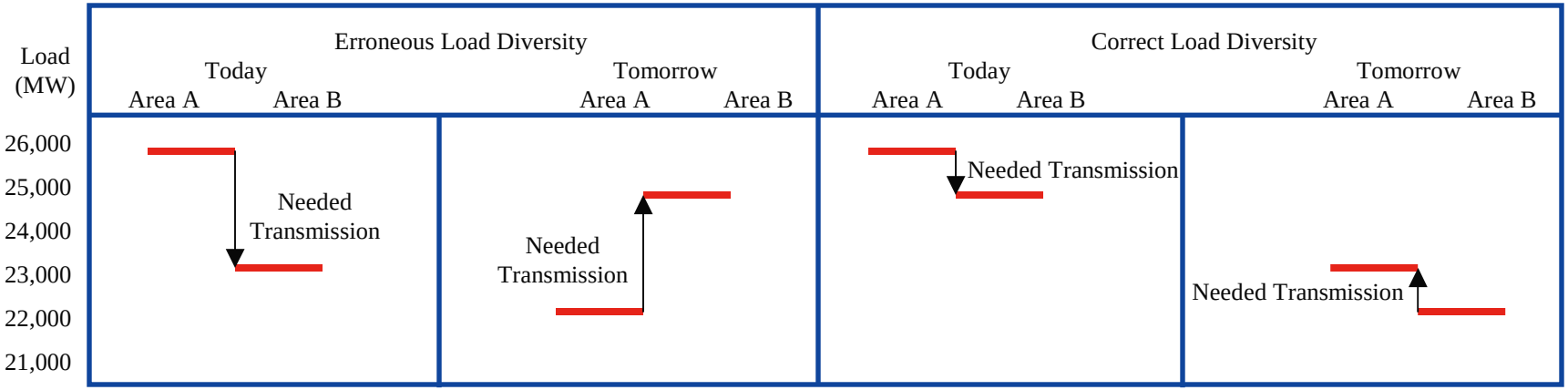



# Data Problems within NPCC CP8 database

- A significant problem was identified in the NPCC CP8 database
  - Load model calendar problem
  - Exaggerates load diversity: New England vs. New York
    - Year 2002 load shape off by one day
      - One day means somewhat similar weather patterns
      - Additional several hundred MW of load diversity
    - Year 1995 load shape off by six days
      - Six says means entirely different weather
      - About 1300 MW of load diversity
    - Load correlation with Canadian control areas
      - Presence of load correlation problem and associated magnitude is unknown
      - Probably not significant because transmission constraints overshadow load diversity
- Additional hundreds / thousand MW of load diversity should make New York look more like an infinite bus to New England

# Data Problems within NPCC CP8 database

- Magnitude of load diversity effect
  - Reduces reserves necessary in combined NY and NE area
  - Significantly exaggerated flows across interfaces
  - May leads to overstating benefits of interconnections




- To bring a control area to “At-Criterion”
  - By raising load proportionally in sub-areas
  - Creates transmission isolated sub-areas that set pool level LOLE

# Correction of Load Correlation "At-Criterion"

- New England and New York load models were revised
- Tie benefits recalculated for New England "At Criteria"
  - Elimination of hundreds of MW of load diversity
    - Between New England and New York
    - Nearly zero impact
  - Further investigation identified a key issue
    - New England pool-wide "At Criteria" LOLE is driven by NOR/STAM
      - Raising load proportionally in sub-areas made NOR/STAM dominant
      - Resulting sub-areas outside NOR/STAM were nearly an infinite bus
    - In first step when interconnected to rest of NPCC
      - Areas outside NOR/STAM appear to be nearly an infinite bus
    - In second step when isolated from NPCC
      - Again, areas outside NOR/STAM appear to be nearly an infinite bus
    - Effect of load diversity was to make infinite bus even "more infinite"

# Load Correlation Under "At Criterion"

- Tie benefits to New England "At-Criteria"
  - Not driven by capacity benefits to New England
  - Driven by conditions in NOR/STAM
- Review of other control areas indicated that
  - NB LOLE index was
    - Driven by NMISA
    - Most of New Brunswick was effectively an "infinite bus"
  - NYISO LOLE index was
    - Driven by Zones J and K
    - Most of New York upstate zones were effectively "infinite busses"
- These issues suggest that a review of methods for bringing a system to criterion is needed

# Development of Control-Area Wide Tie Benefits

# Tie Benefits – Three Possible Frameworks

- With a single area, tie benefits are easy to understand
- With multiple areas, complications exist that require a method of bringing the area (or areas) to criterion
- Different methods exist for control areas
  - Load increases
  - Firm capacity adjustments
- Additional issues for multi area models
  - Control area reliability index calculation
  - Minimum capacity to meet reliability criterion in control area
    - This is the same definition as classic single bus model
    - Goal of capacity minimization is generally accepted
  - Sub areas can have minimum capacity requirements defined so that the pool-wide minimum capacity requirement is not violated

# Framework: End with Internal Constraints

- All areas are brought to 0.1 days per year reliability criterion without internal constraints
  - Amount of capacity so control area has minimum capacity
  - Reflects inter-control area support, constraints and limitations
    - Areas with significant load diversity may be transmission constrained
      - ISONE and Quebec
      - NYISO and Quebec
    - Area with high load correlation will not be transmission constrained
      - ISONE and NYISO
    - Load model diversity error between ISONE and NYISO would make
      - Transmission constraint more likely
      - Exaggerate benefits of additional interconnections
  - Minimum capacity framework probably most appropriate method of quantifying tie benefits

# Framework: Start with Internal Constraints

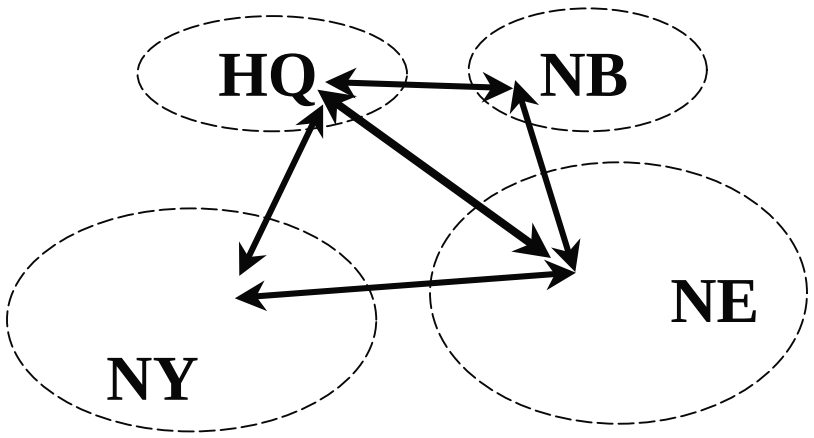
- All control areas are brought to 0.1 days per year reliability criterion with internal transmission constraints
  - Brought to criterion by adjusting sub areas according to a “formula”
    - Increase peak loads proportionally everywhere according to some metric
      - Typically presented as an approximation of normal load growth
      - Alternatively, as a “year-of-need” indication
    - Reducing capacity proportionally according to some capacity metric
      - Based on amount of capacity actually located in each area
      - Other basis for proportional capacity adjustment are possible (i.e. reserves)
  - With a framework that makes adjustments proportionally
    - Minimum capacity in control area not assured
    - Minimum capacity only occurs when internal transmission constraints are not binding
    - Some sub-areas may be “infinite bus” and others “quite unreliable”

# Framework: Alleviate Internal Constraints

- Framework adjusts capacity/load based on sub-area LOLE
- No proportional adjustments needed
  - LOLE based adjustments
    - Load added to areas with zero / low LOLE indices
    - Load can be removed from areas with high LOLE indices
  - Capacity based adjustments
    - Capacity removed from areas with zero / low LOLE indices
    - Capacity can be added to sub-areas with high LOLE indices
  - Goal of this methodology:
    - Approach a minimum pool wide capacity requirement while explicitly recognizing transmission constraints
    - Effectively creates an unconstrained transmission system
- Similar to “End with Internal Constraints” Framework

# Process to Bring NPCC to Criterion

- Use the first framework that neglects internal constraints
- To bring NPCC to criterion, each area must have an LOLE index of 0.1 days per year
  - Each control area has the LOLE index of 0.1
  - Total NPCC has LOLE of about 0.26 [Check]




  - Considering inter-area constraints
  - Neglecting internal constraints
  - Focus on minimum capacity requirements throughout NPCC
  - Minimum capacity requirements is the level below which NPCC areas cannot go below
  - Inter-area purchases not precluded

# Methodology for Bringing to Criterion

- Calculate base case LOLE for each NPCC control area
  - Add an increment of capacity in each area … one at a time
  - Calculate the partial derivative ∂ (LOLE)/∂ (MW) for each area
  - Develop a Jacobean matrix of these partial derivatives
  - Solve for control area where increments have the greatest impact
    - Subject to minimizing total capacity
    - Estimate changes for each area
  - Input estimates of capacity changes into each area
- Reiterate previous step until solution is reached
- Characteristics of solution (except for Quebec due to significant seasonal diversity)
  - Each area's ∂ (LOLE)/∂ (MW) is the same
  - Transmission is not constraining

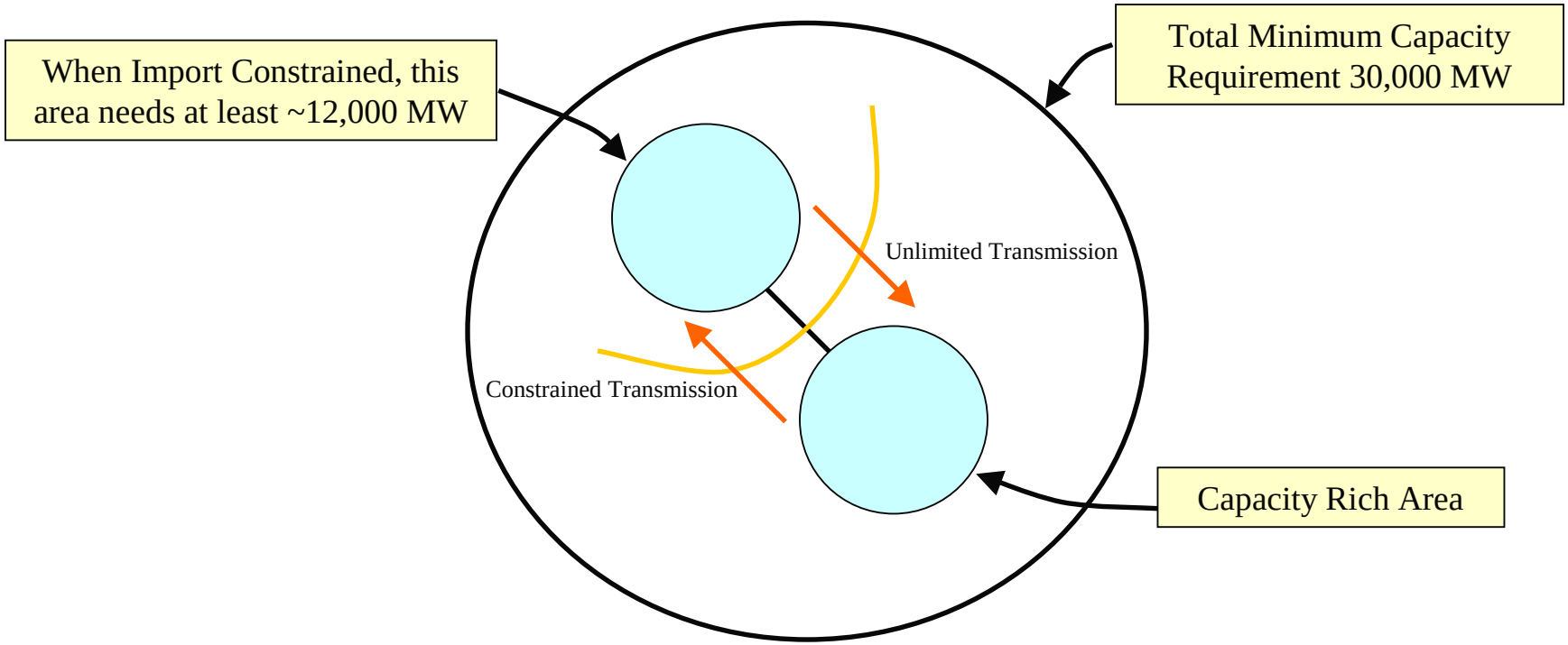
# Development of Tie Benefits Reflecting Sub-areas

# Tie Benefits and Internal Constraints

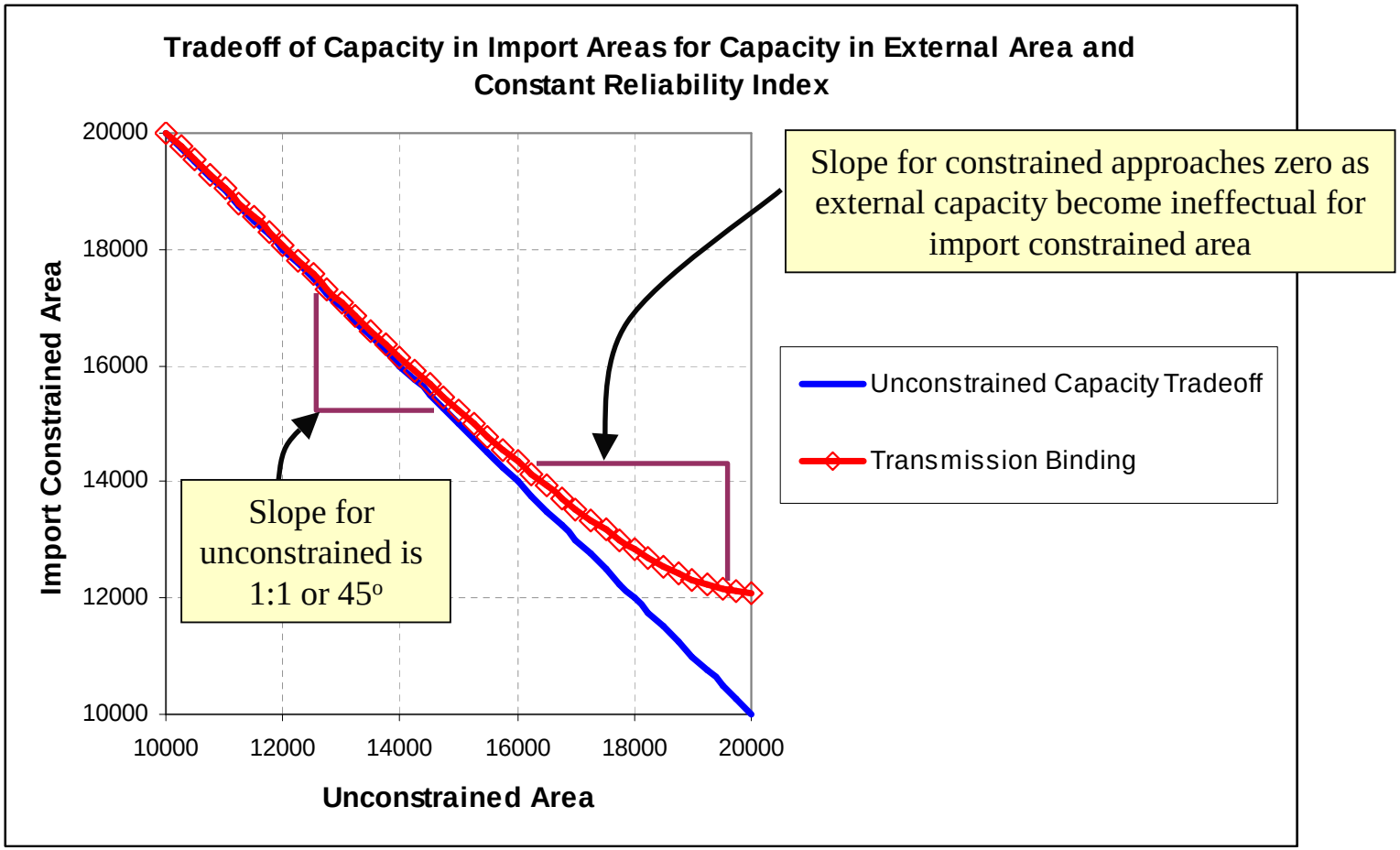
- In the "Start with Internal Constraints" framework, resulting capacity is not necessarily at the minimum
  - Transmission constraints may require locationally inefficient capacity
    - Due to non-optimal location of capacity resources
    - Non-optimal location of resources means that to some extent:
      - "Two MW over there is the same as one MW here" (Jacobean coefficient)
      - Control area reliability index may be satisfied in this manner
      - Does not provide the information needed to get capacity installed where it would be most effective
    - If the reliability criterion is attained, but not at the minimum capacity:
      - Stakeholder process / administrative rule / market reaction could eliminate capacity until minimum is attained
      - Ultimately, cannot have less capacity than this minimum
  - Following example system illustrates non-optimal location concept

# Example 30,000 MW System

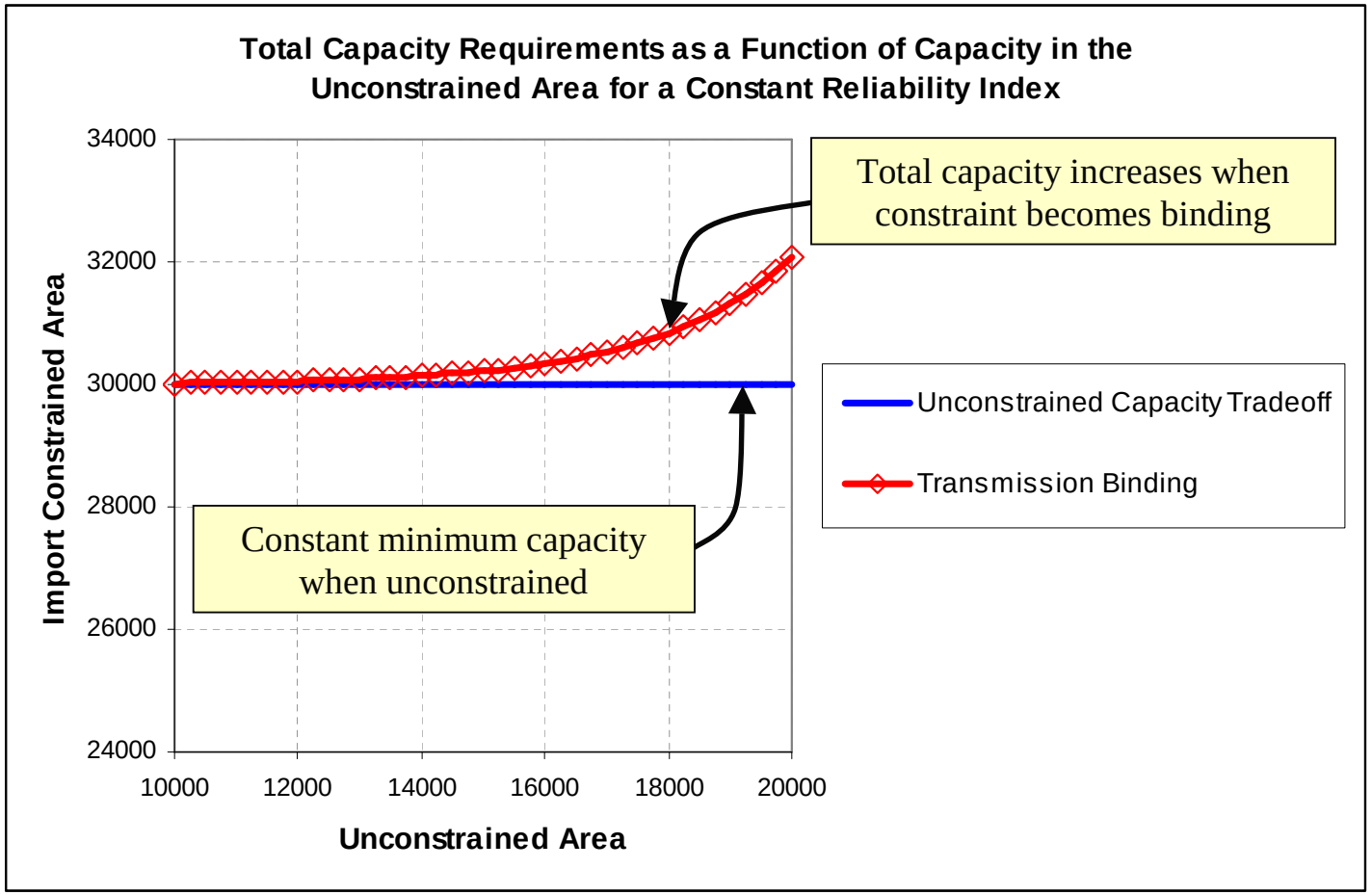
- To attain a constant reliability index in the total area
  - Need at least 30,000 MW
  - May need more than 30,000 if transmission constrained



# Effect of Location on Minimum Capacity



# Total Capacity Increase When Constrained



# Viewing Tie Benefits Consistently with Installed Capability Requirement Adjustment Methodology

# ICR Adjustments to “At-Criterion”

- View from a perspective that is consistent with other aspects of ISONE reliability modeling
- How to adjust New England system “to criterion”
  - Westinghouse single area model used for ICR
  - New England typically has a surplus of capacity
    - Uses concept of “Additional Load Carrying Capability” (ALCC)
    - ALCC represents the increase in load necessary to reduce the reliability of the New England area to 0.1 day / year LOLE criterion
    - ALCC increases the load distribution moments (mean, sigma etc)
  - Resource distributions are unaltered i.e. left “As-Is”
  - At criterion, margins [capacity - (load + ALCC)] describe conditions when New England has minimum capacity to meet criterion

# How Much Capacity to be Supported

- LSE must support, in aggregate, the total amount of ICR
  - LSEs do not need to support all existing resources
  - Only a share of total ICR … not total existing resources
- No requirement that each LSE meet 0.1 days per year LOLE individually with their own resources
  - Because if an LSE's "stable" of resources are unavailable, then probabilistically other LSEs will have surpluses in their "stables"
  - Each LSE only needs to support its "stable" of resources
    - Support their share of ICR
    - When all LSEs support their "share" of capacity there will be enough to satisfy the control area reliability criterion
    - Each LSE effectively receives internal "tie benefits" from other New England LSE's available capacity
  - There are parallels to inter-control area sharing of capacity
    - Each NPCC area receives "tie benefits" from other NPCC areas
    - Each NPCC area must support only its capacity requirements

# ICR Evaluation: "As-Is" or "At-Criterion"

- The tie benefit question has a parallel in ISO New England's long history with Installed Capability Requirements (ICR)
  - Each load participant supports its peak-load share of the ICR
  - Long history of consensus on this point
  - In aggregate, sufficient capacity is supported
- In the event of a surplus in available capacity, LSE requirement is not reduced
  - Argument could be: "I know that my peak load share of ICR should be 100 MW, but because of a 1000 MW surplus, I do not need to support any (zero) capacity … there is plenty to support reliability."
  - If zero is not appropriate, how should the surplus be allocated to LSEs and to which LSEs?
  - Reduction in supported capacity begets more surplus … and further reduction in supported capacity … further increasing the surplus
- In a market, surplus supply reduces price not "quantity demanded"

# Short Term vs. Long Term Tie Benefits

- Interest in current tie benefit study is for short term
  - The short term is what we are comfortable with in the ICR calculations
- Tie benefits seem logically tied to minimum capacity
  - Tie benefits from minimum natural capacity / reliability support from neighboring areas
  - Neighboring areas frequently have surplus above these needs
  - Neighboring control areas can support sales of capacity
    - Sales to New England or others
    - Unless sales violate minimum installed capability requirements
- Short term and long term “natural” tie benefits
  - Approximately constant over time
  - Minor adjustments for changes in system configurations

# Minimum Tie Benefits / Natural Tie Benefits

- What are the maximum amounts of tie benefits?
  - Maximum amounts possible to attain is when surplus exists in neighboring areas
  - Include “natural amount” of tie benefits from neighboring areas
  - Plus maximum amount the neighboring control area could sell
    - Without violating their reliability criterion
    - Subject to available transmission constraints
- Minimum amount of tie benefits
  - Include only “natural amount” of tie benefits from neighboring area
    - Includes capacity needed to support the NPCC reliability criterion
  - Exclude any amount of capacity that
    - Is surplus in the neighboring area
    - Could be sold under contract without violating NPCC reliability criterion

# Linkages to Other Studies

# Installed Capability Working Group

- The Installed Capability Working Group will include discussions of tie benefits
  - Several outcomes are likely to emerge
    - Increase tie benefits
    - Decrease tie benefits
    - Keep tie benefits unchanged
- This tie benefits study will provide background information
  - Additional information requires a review of basic premises
  - Original scope of work did not envision this level of review
  - Problem with data and modeling added impetus to basic framework

# Linkages to ISONE and NYSRC Tie Study

- ISONE meeting with NYISO staff on behalf of NYSRC set for February 23, 2006 in Holyoke
- The approved scope of work for the ISONE/NYSRC study
  - Sets the evaluation at minimum capacity in each control area
  - Reflects the inter-area transmission limitations
- Current effort helps set the stage for that analysis
  - Need to develop understanding of MARS “Mod MW table”
  - Quantification of tie benefits for specific interconnections
- Need to reflect key internal transmission constraints

# Include Key Transmission Constraints

- Location is important relative to transmission constraints
  - RSP05 “winter gas” analysis framework establishes series of capacity requirements based on each constraint
  - Values of specific ties can / may then be determined