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October 24-26, 2023
Northampton, MA

Capacity Zones Formation and Demand Curves

Lesson 4: Capacity Zones and Demand Curves

Forward Capacity Market (FCM 101)

This presentation is based on the current information available for the rules as they are today. The information in this presentation may change based on upcoming decisions made regarding the future of FCA 19 and will be covered in future training.

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Senior Engineer, System Planning

Some slides or portions of slides may be intentionally hidden in the printed and posted versions of this presentation.

Topics

Calculating System Requirements and System Demand Curves

- Concept and inputs used in calculating system requirements
- How system demand curves are derived

Modeling Capacity Zones, Zonal Requirements, and Zonal Demand Curves

- Concepts used to form capacity zones and determine zonal requirements
- How zonal demand curves are derived

Other Applications of Demand Curves

- How demand curves are (and are not) used in reconfiguration auctions

Objectives

- Recognize buy side of market
- Identify capacity zones and why they are important
- Explain how the demand curve for the system and constrained capacity zones are created

In *Lesson 4*, we are talking about the *buy* side of the market
- In *Lesson 3*, we covered qualification (*sell* side of market)
- In *Lesson 5*, we will cover auctions (where supply and demand meet)

Common Acronyms

In Order of Appearance

FCA	Forward Capacity Auction
ICR	Installed Capacity Requirement
LOLE	loss-of-load expectation
LOLP	loss-of-load probability
MARS	Multi-Area Reliability Simulation
CELT	Capacity, Energy Load, and Transmission
OP-4	Operating Procedure No. 4
FERC	Federal Energy Regulatory Commission

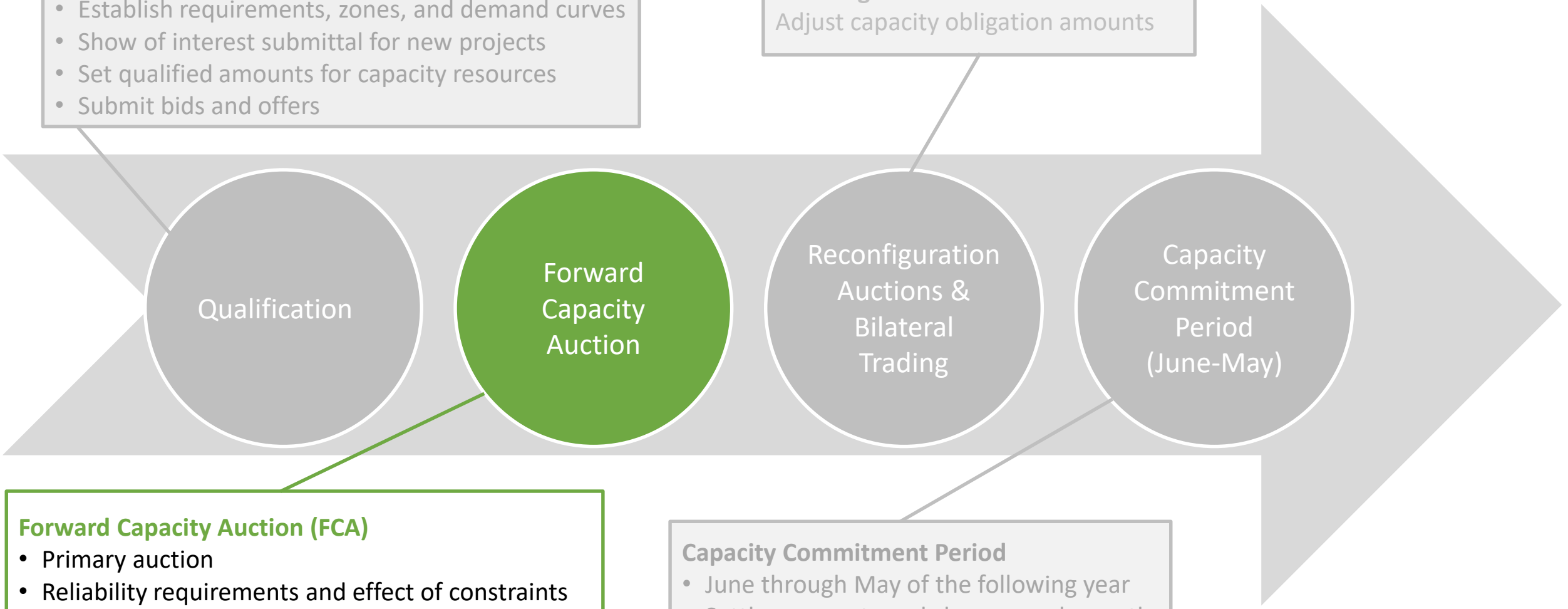
GADS	Generating Availability Data System
FERC	Federal Energy Regulatory Commission
HQICC	Hydro Québec Interconnection Capability Credit
AC	alternating current
DC	direct current
Net ICR	Net Installed Capacity Requirement
Net CONE	Net cost of new entry
MRI	marginal reliability impact

ECCZ	export-constrained capacity zone
ICCZ	import-constrained capacity zone
LSR	local-sourcing requirement
MCL	maximum capacity limit
TSA	transmission security analysis
ARA	annual reconfiguration auction

Forward Capacity Market Process – What Are We Talking About in This Lesson?

Qualification
- Establish requirements, zones, and demand curves
- Show of interest submittal for new projects
- Set qualified amounts for capacity resources
- Submit bids and offers

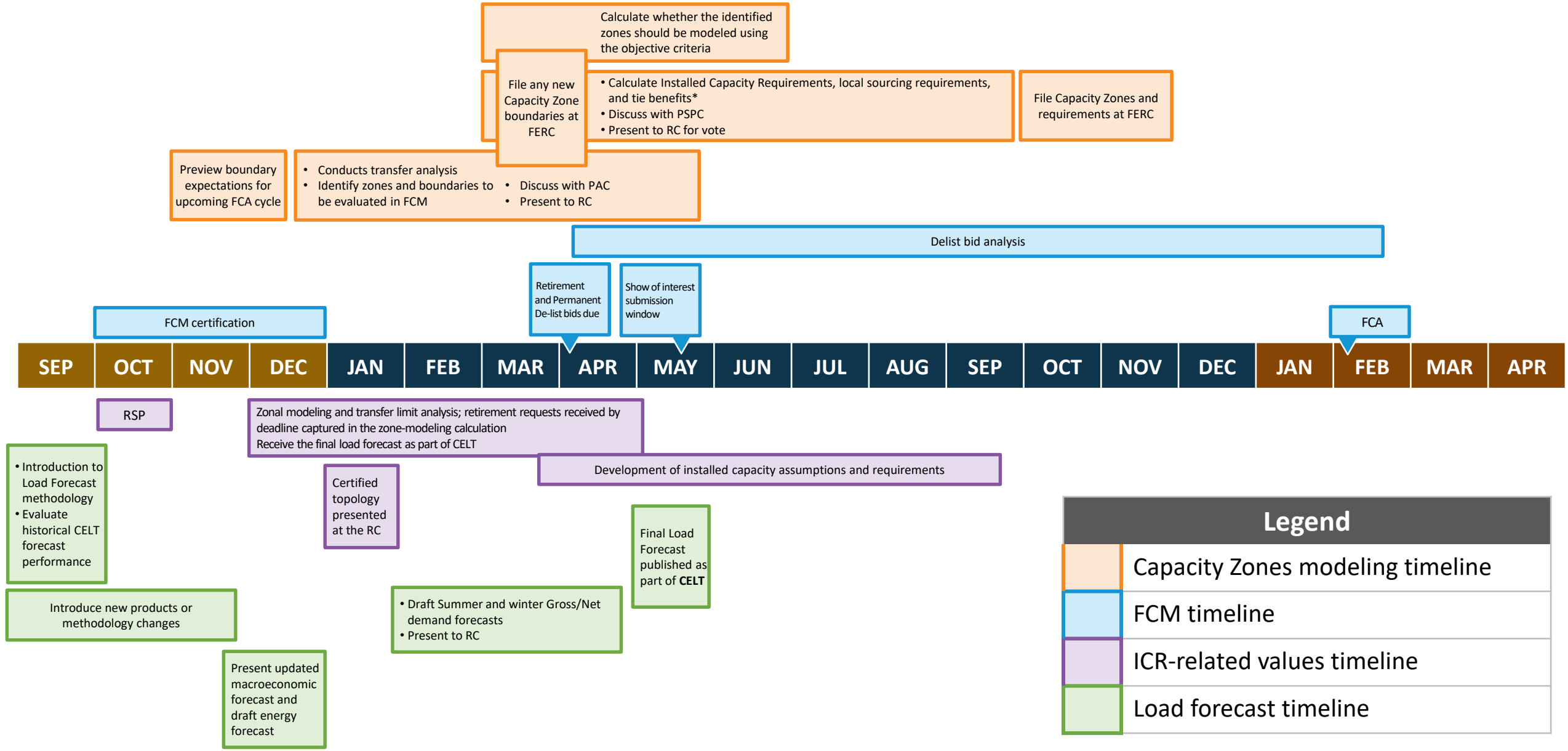
Reconfiguration Auctions
Adjust capacity obligation amounts



Forward Capacity Auction (FCA)
- Primary auction
- Reliability requirements and effect of constraints within the system (zones)

Capacity Commitment Period
- June through May of the following year
- Settle payments and charges each month

Timeline of Events



Disclaimer

- Keep in mind that descriptions in this lesson in particular are generalizations; it would be impractical to attempt to articulate every detail and nuance
- Our goal is to impart a working knowledge of the concept of demand curves; how they are developed and the role they play in the auction
- ‘How’ meaning what goes into the determination of the demand curve rather than how the procedure works and the stakeholder schedule
- Consequently, these materials should not be interpreted as any kind of technical manual or user guide

Calculating System Requirements and System Demand Curves

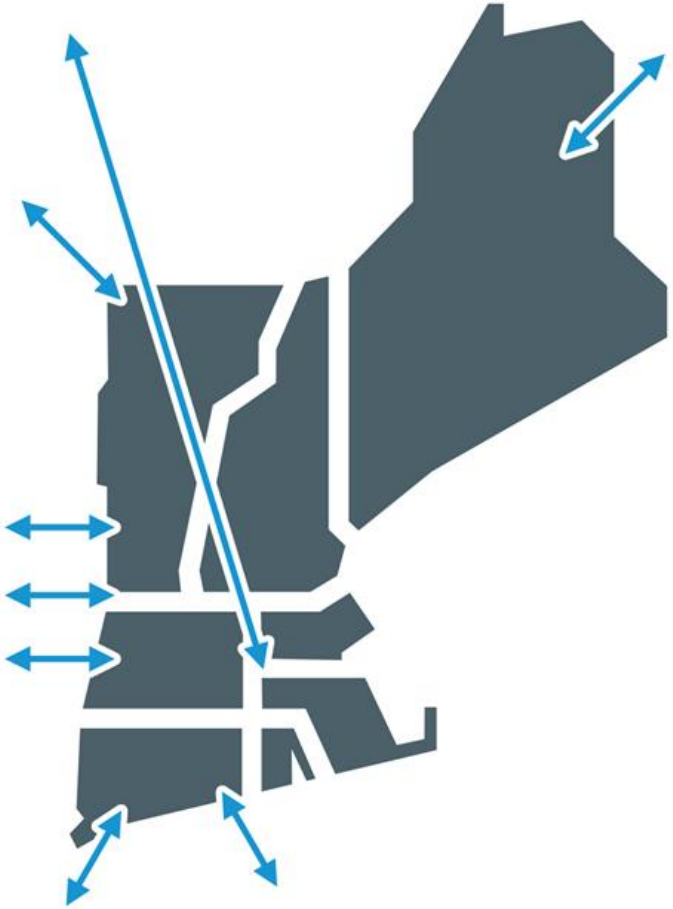
- *First, we will cover system requirements, how it is calculated, and the inputs to that calculation*
- *Then, we will cover how system demand curves are derived using the same model and inputs*

System Requirements

System and External Tie-Lines

All zones make up system

Several external tie-lines to adjacent control areas



ISO New England Planning Criterion

What is Installed Capacity Requirement (ICR)?
Amount of installed resources in New England needed to meet the resource planning reliability criterion

Reliability criterion: Such that the expected frequency of interrupting firm customer loads, due to insufficient resources, be **no more than one day in 10 years**

- Loss-of-load expectation (LOLE) criterion of 0.1 days with interruptions per year

Expectations In Reliability Studies

- For every hour of every day studied, probability of insufficient resources to serve load can be quantified
  - For most hours this probability is zero, but for some hours at peak load conditions the probability is non-zero
  - This metric is the loss-of-load probability (LOLP)
- The reliability criterion we are interested in is the loss-of-load expectation (LOLE)
  - LOLP is calculated for each hour and sum over study period is the LOLE

Computer Program Used

ISO uses General Electric Multi-Area Reliability Simulation (MARS) model

- Model is a computer program that uses a sequential Monte Carlo simulation to probabilistically compute the resource adequacy of the system by simulating the random nature of both loads and resources
- For Installed Capacity Requirement (ICR) calculation (a system metric), the model is based on a one-bus model and transmission system is assumed to have no internal constraints
- For zonal requirements, the same MARS model is used, but with specified internal constraints

Inputs to Multi-Area Reliability Simulation Model

Load Forecast Information

- Multi-Area Reliability (MARS) model uses a peak and hourly energy load forecast for each sub-area (using Capacity, Energy, Load and Transmission (CELT) Report and Load Forecast data)
- Load forecast uncertainty due to weather uncertainty is modeled

Capacity Resource (MW) Data

- Recent additions and/or retirements
- Resource characteristics and performance (e.g., forced outage rates and scheduled maintenance)

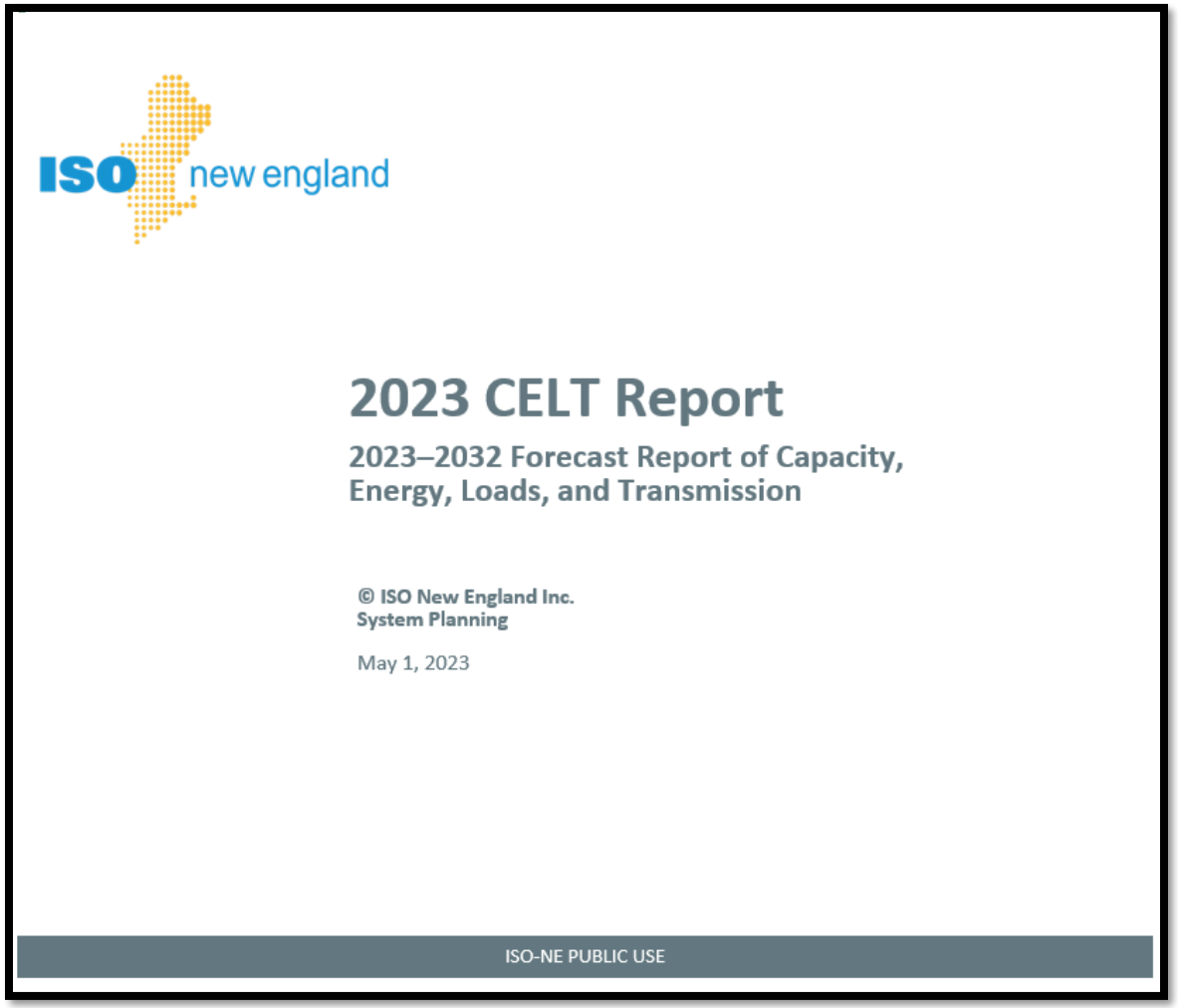
Load and Capacity Relief Available Through OP-4 Actions *(including tie benefits)*

- Operating Procedure No. 4 (OP-4) specifies criteria and guidelines ISO may use during capacity deficiencies
- For purposes here, this means ISO can use pre-specified emergency arrangements with neighboring control areas (e.g., purchase of emergency energy) and possibly lower system voltage

These inputs (assumptions) are reviewed with stakeholders each year and filed with FERC later in qualification cycle

2023 Capacity, Energy, Load and Transmission (CELT) Report

Load Forecast Information



System Planning > Plans and Studies > CELT Reports

Capacity Resource Data

In addition to MW total of all non-intermittent generating resources in New England, capacity resources are modeled with summer ratings, a forced outage rate, and scheduled outages (based on historical data)

Forced Outage Assumptions	Scheduled Outage Assumptions
Each generating unit's equivalent forced outage rate - demand is used and is based on a five-year average of submitted Generating Availability Data System (GADS) data	Each generating unit's annual weeks of maintenance are used and are based on a five-year average of each generator's actual historical average of planned and maintenance outages (i.e., outages scheduled at least 14 days in advance)

Tie Benefits

Load and Capacity Relief Available through OP-4 Actions *(including tie benefits)*

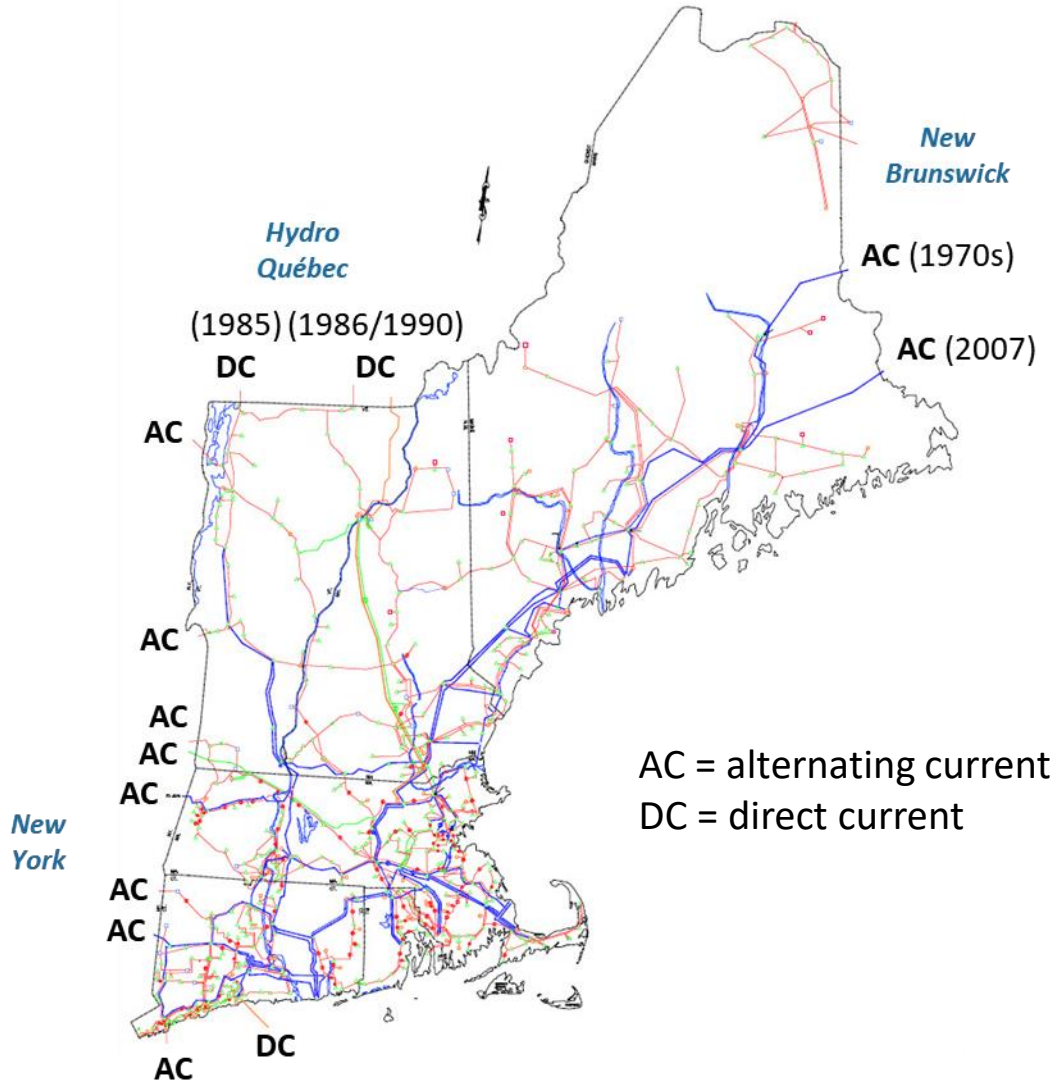
- In the event of a capacity shortage in New England, tie benefits reflect the amount of emergency assistance assumed to be available from neighboring control areas
- Tie benefits are an input in the determination of the Installed Capacity Requirement (ICR) and displace (i.e., lower) the capacity amount needed to meet reliability criterion by an almost one-to-one ratio
- Tie benefits are modelled using the General Electric MARS software

Tie benefits from Hydro Québec Phase II interconnection, called Interconnection Capability Credits (HQICCs) are allocated to specific entities holding contractual rights to this interconnection, and monetized as credits in the form of reduced capacity requirements

Neighboring Control Areas and Tie Lines

New England has 13 total interconnections to neighboring power systems:

- New York (9), which ties New England to Eastern Interconnection
- Hydro Quebec (2), which ties New England to the Quebec Interconnection through direct-current (DC) transmission
- New Brunswick (2), which is tied to the Eastern Interconnection through New England



Learn more in Industry Standards, Structure, and Relationships

Calculating Installed Capacity Requirement

MARS model determines system loss-of-load expectation (LOLE) for given set of inputs

- If model determines that system is *more reliable* than reliability criterion (LOLE < 0.1 days per year), load is increased so that LOLE equals 0.1 days per year
  - Additional load is termed Additional Load Carrying Capability
  - When model LOLE equals 0.1 days per year, the Installed Capacity Requirement (ICR) can then be calculated (notice the inputs are also used in this calculation)

$$Installed\ Capacity\ Requirement\ (ICR) = \frac{Capacity\ -Tie\ Benefits\ -OP4\ Load\ Relief}{1+\frac{\boldsymbol{Additional\ Load\ Carrying\ Capability}}{Annual\ Peak\ Load}} + HQICCs$$

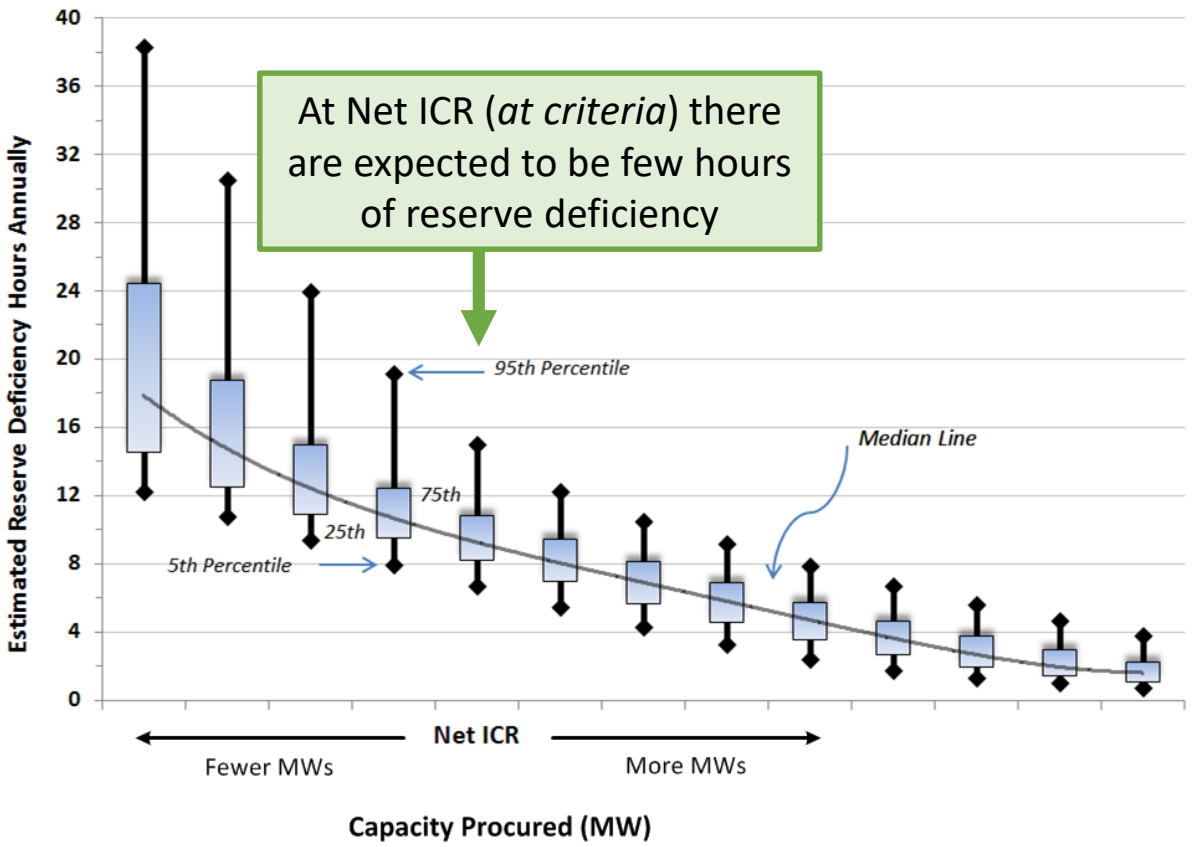
$$Net\ Installed\ Capacity\ Requirement\ (Net\ ICR) = Installed\ Capacity\ Requirement\ (ICR)\ - HQICCs$$

What to Remember About Installed Capacity Requirement

- On a probabilistic basis, we will not disconnect load more than once every ten years due to a lack of resources
- With precisely enough capacity to meet this target, the system is said to be '*at criteria*'
- Not the same as maintaining reserve requirement

The point: Even at criteria, there may be periods of reserve deficiency (which is not load shedding)

- While we will not be disconnecting load, we might be deficient reserves (performance during a scarcity condition)



Questions

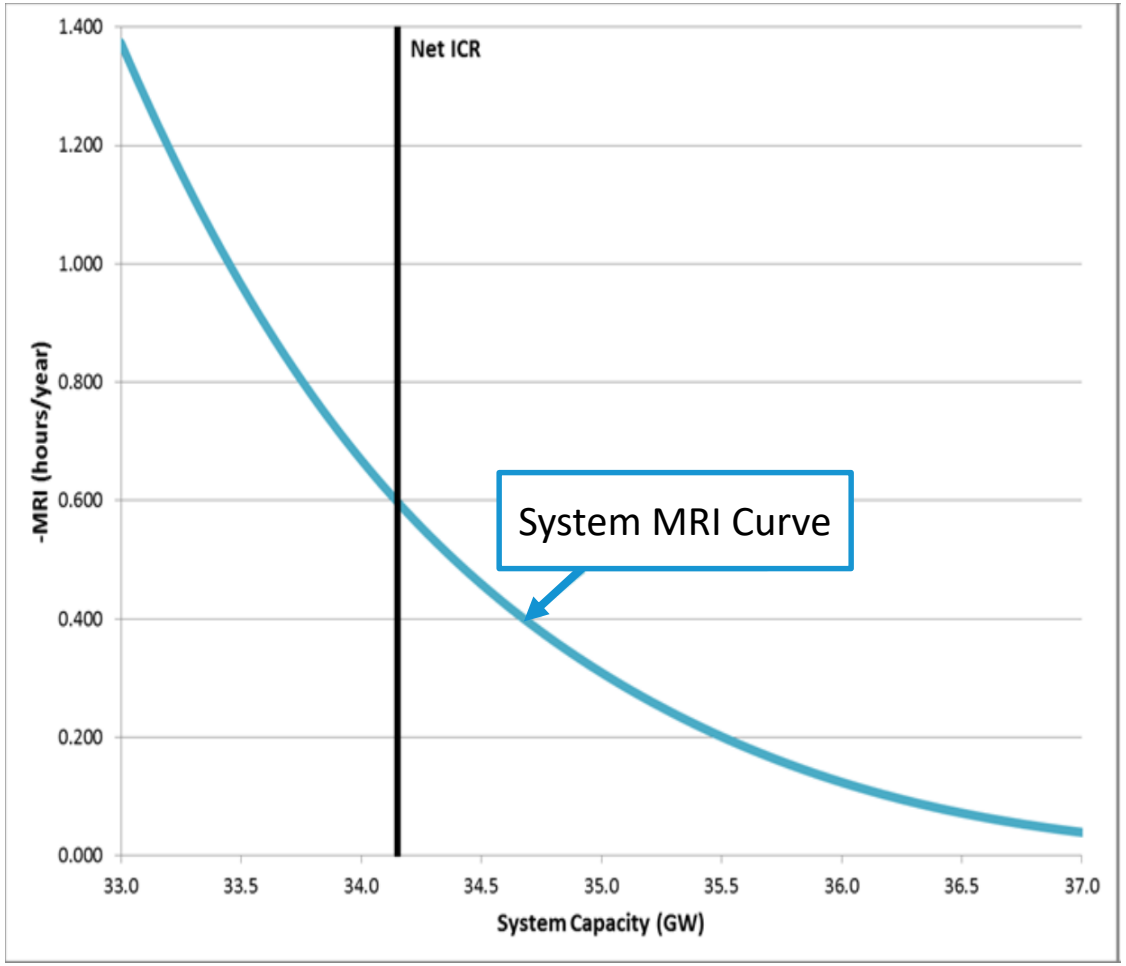
System Demand Curves

Demand Curves: Marginal Reliability Impact Approach

- This approach combines both engineering and economics to derive a demand curve that represents the incremental value of capacity across a range of total capacity amounts and locations
- **Engineering** method employs the same techniques used to determine the requirements we covered earlier, but rather than calculate only one value, we calculate several values to create a curve
- **Economics** means that the engineering curve is converted into a demand curve based on the net cost of new entry (Net CONE)

Engineering a Marginal Reliability Impact Curve

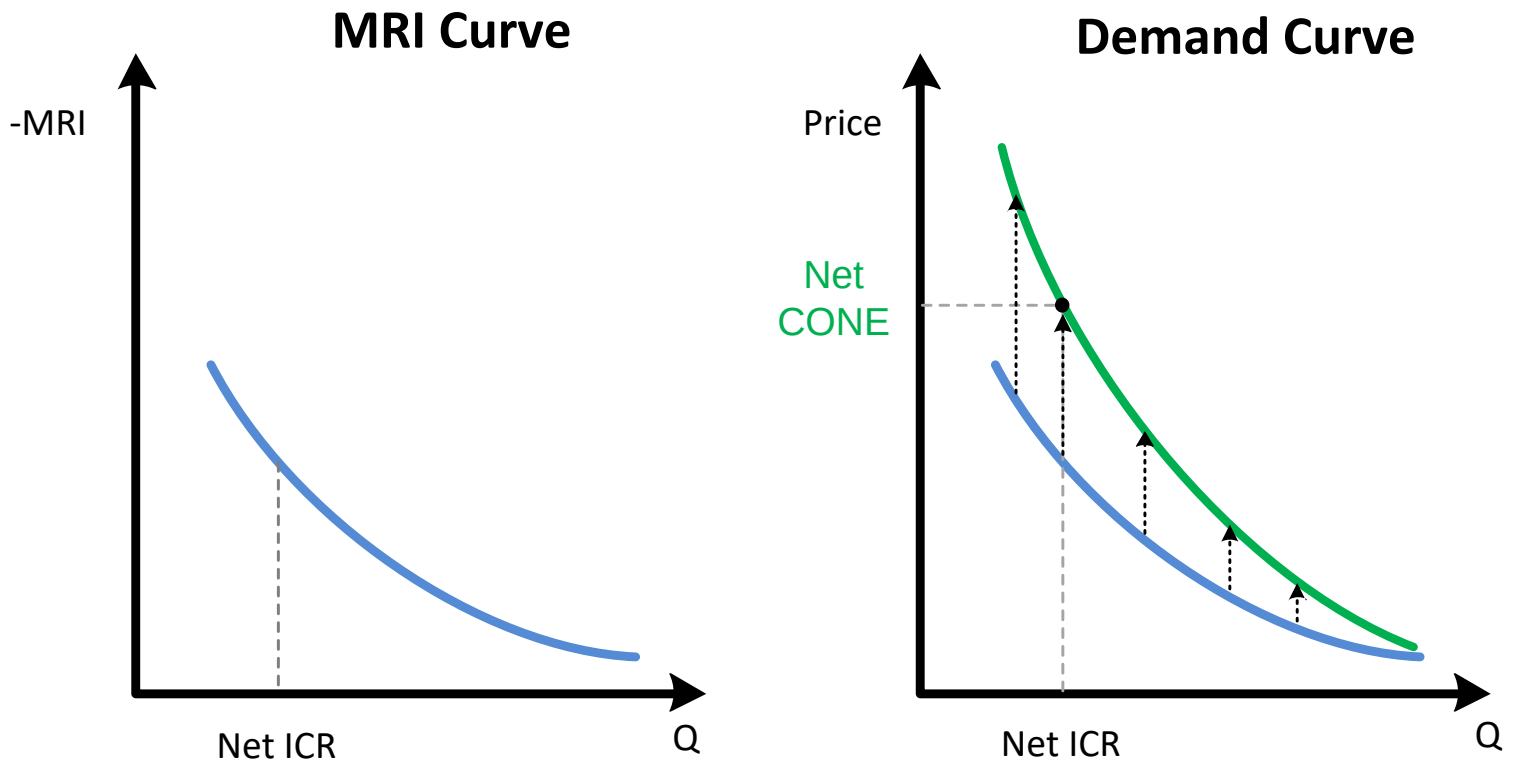
- Marginal reliability impact (MRI) curve is derived using the same MARS model and inputs used to derive requirements covered in first part of lesson
  - There, we used the model to determine conditions that would yield an LOLE of 0.1
  - Here, we are using the model to determine a different metric for different amounts of capacity (expected energy not served, in MWh/year)
- Data is then used to calculate a curve that reflects the incremental improvement in reliability associated with adding incremental capacity
- Curve is referred to as the marginal reliability impact of capacity (i.e., rate of change, in hour/year)



Economics of a Marginal Reliability Impact Based Demand Curve

With the shape of the curve, we now need to convert it into a price-quantity curve

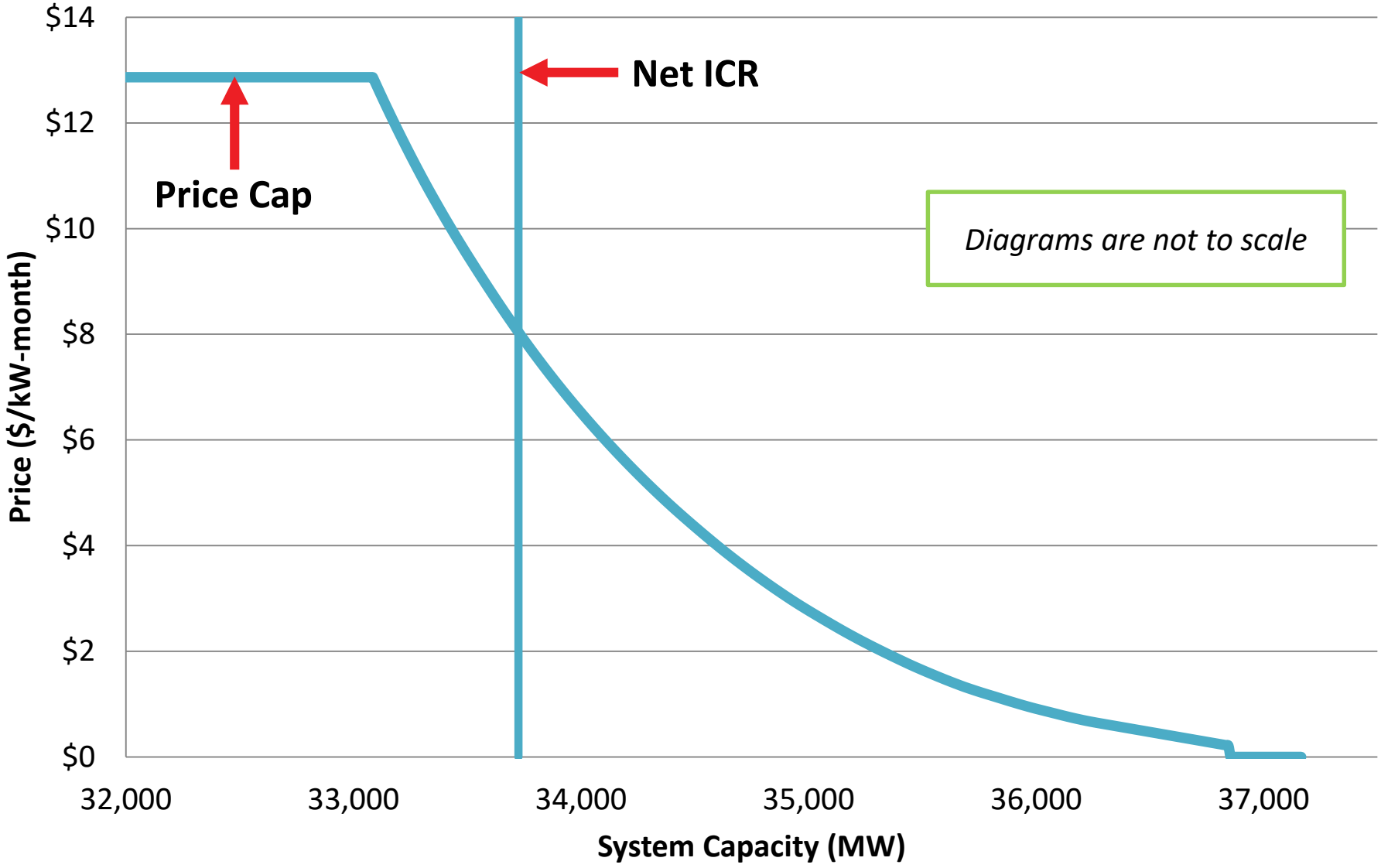
This is done by scaling the curve so that the price at the intersection with Net Installed Capacity Requirement (Net ICR) is equal to the net cost of new entry (Net CONE)



What is Net Cost of New Entry?

- Net cost of new entry (Net CONE) is a parameter that approximates net cost ($/kW-month) to build new supply in New England
  - Value of Net CONE is re-calculated approximately every three years via a stakeholder process
  - Performance payment rate is Net CONE divided by number of scarcity hours at-criteria
  - At the same time, and using some of the same data, other parameters are established
- Values are indexed for use in the in-between Forward Capacity Auctions (FCAs)
  - For example, an indexed Net CONE is used to scale the demand curves and set the auction price cap (1.6 x Net CONE)

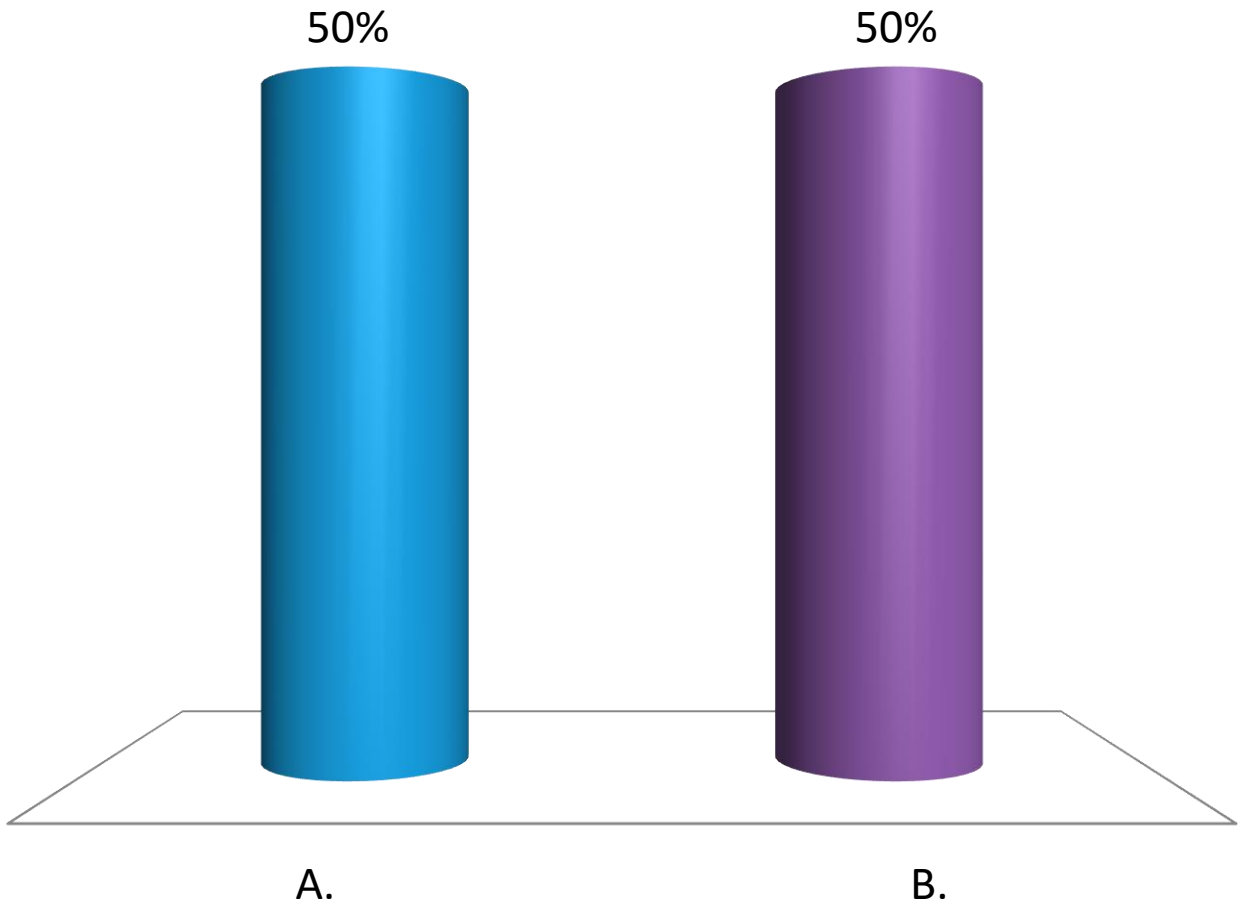
System Marginal Reliability Impact Based Demand Curve



Would an increase in tie benefits *increase* or *decrease* the Net Installed Capacity Requirement (NET ICR) value?

A. Increase

✓ B. Decrease

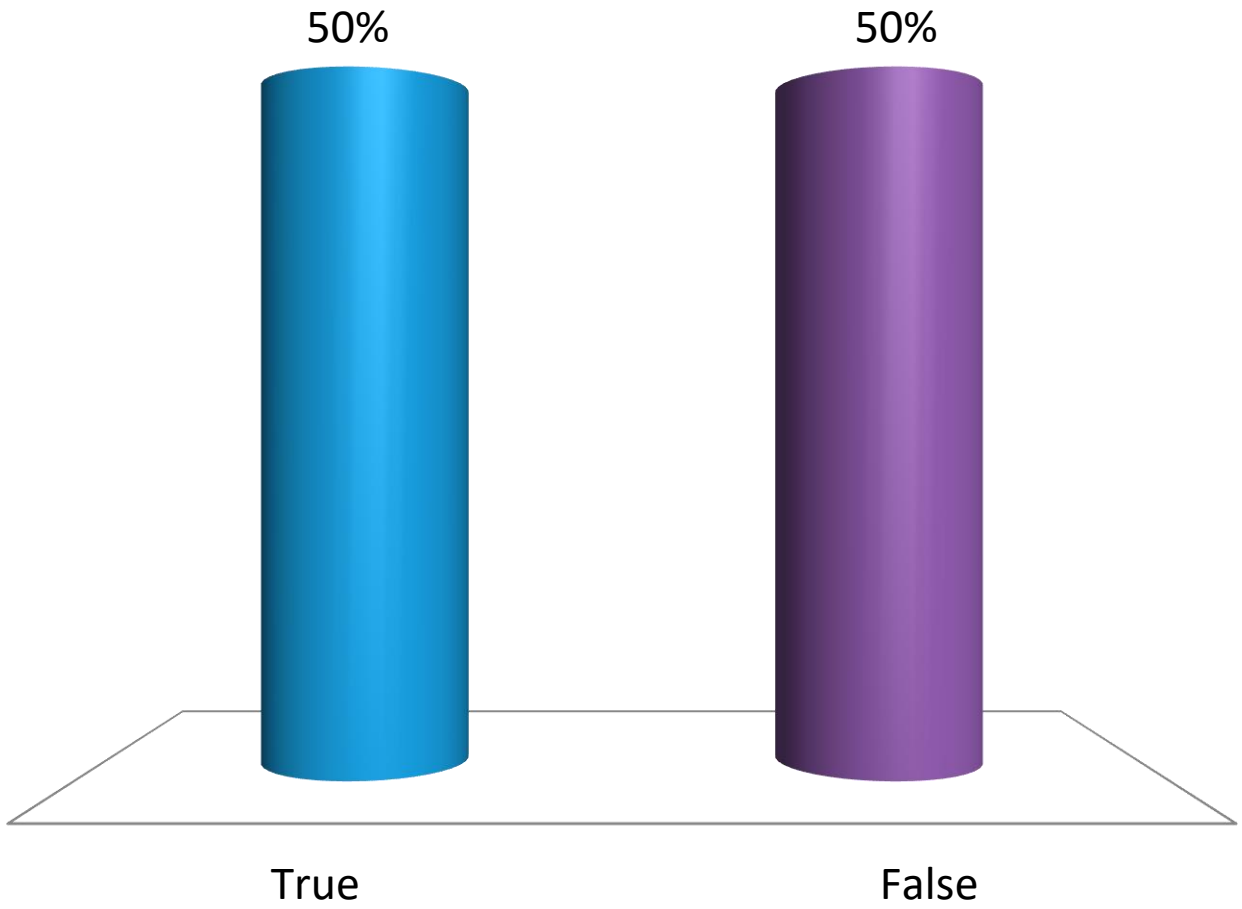


Q1 of 5

Tie benefits are a guarantee from ISO New England's neighboring control areas to provide emergency energy.

A. True

✓ B. False



Q2 of 5

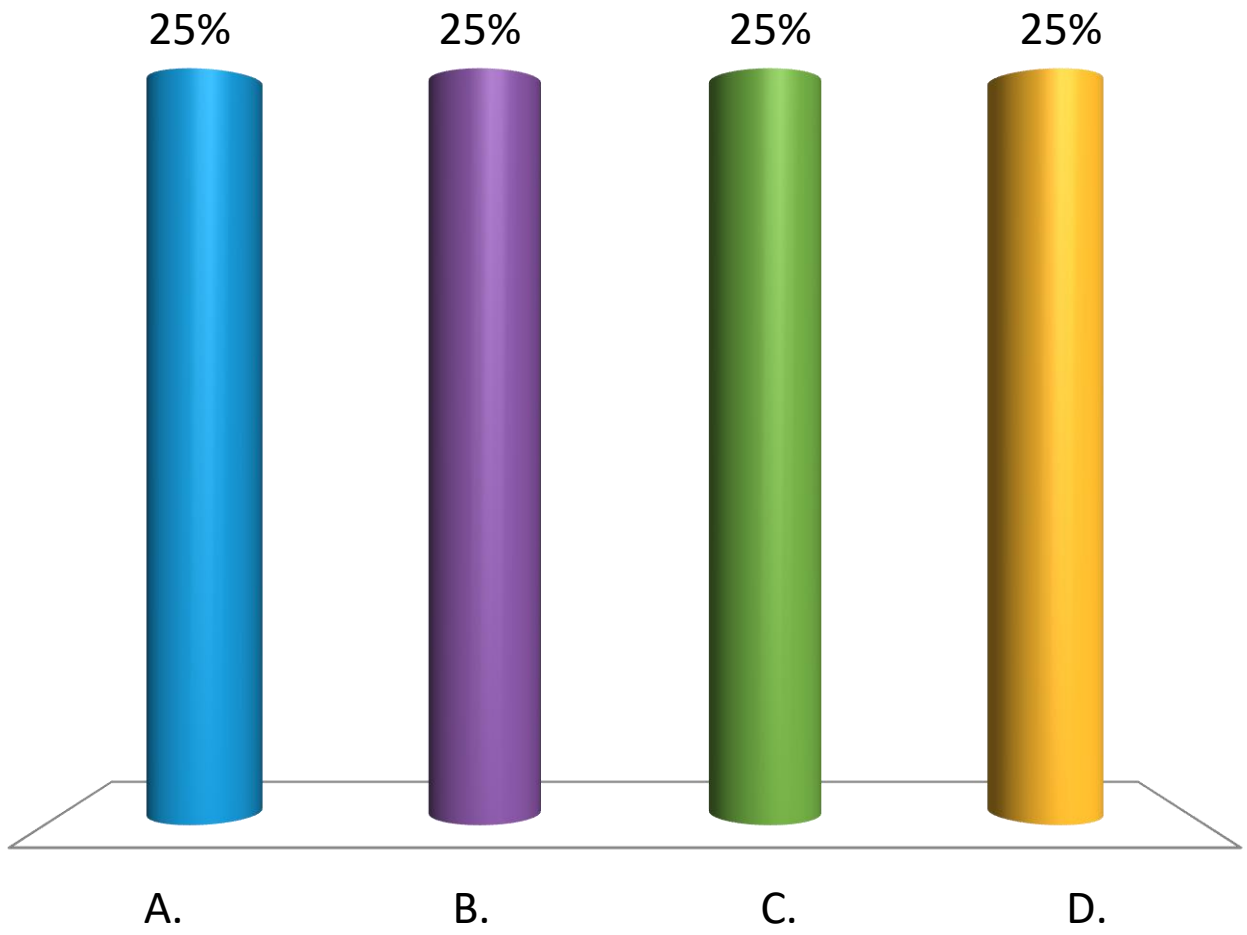
With just enough capacity to meet the Installed Capacity Requirement (ICR), the system is:

A. Safe from ever having to interrupt firm load customers

B. Safe from ever having a reserve deficiency

✓ C. Neither of the above

D. Both of the above



Q3 of 5

What to Know About Marginal Reliability Impact Based Demand Curves

- There is no fixed limit or requirement on how much the Forward Capacity Auction (FCA) will procure
- How much (or how little) is procured is based on price per demand curve
  - Amounts less than Net ICR are at relatively high prices (> Net CONE)
  - Amounts more than Net ICR are at relatively lower prices (< Net CONE)

Questions

Modeling Capacity Zones, Zonal Requirements, and Zonal Demand Curves

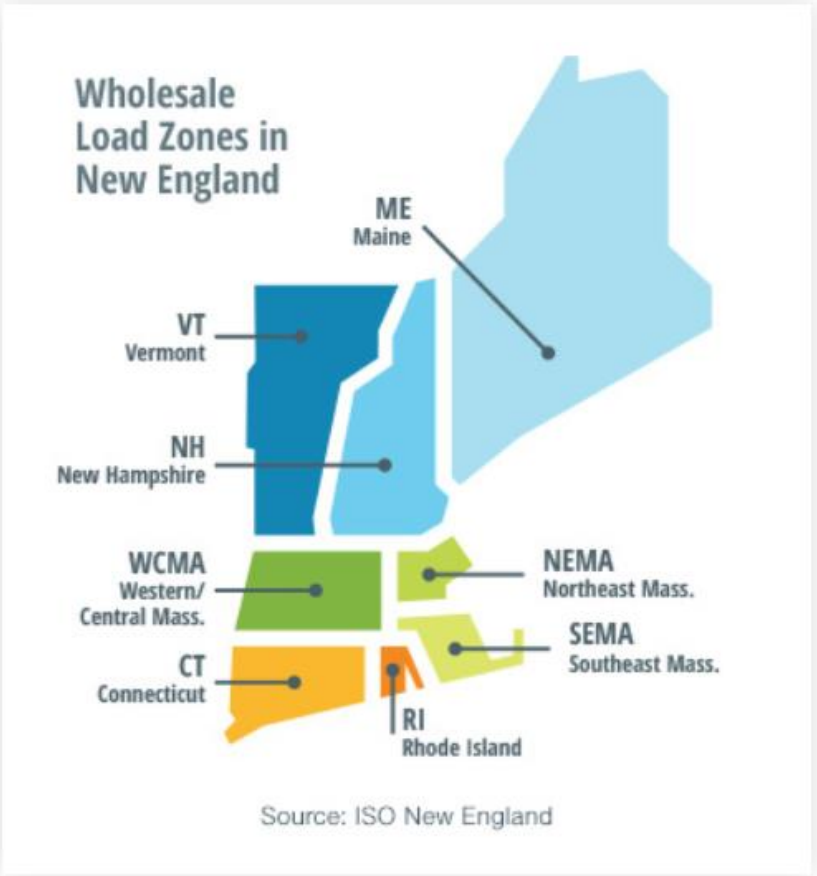
- *First, we will cover why a zone may be created and the demand requirement for a zone*
- *Then, we will cover how zonal demand curves are derived*

Zones

- There are many kinds of zones used in the various markets
- For the capacity market, capacity zones are made up of one or more load zones

Load Zones

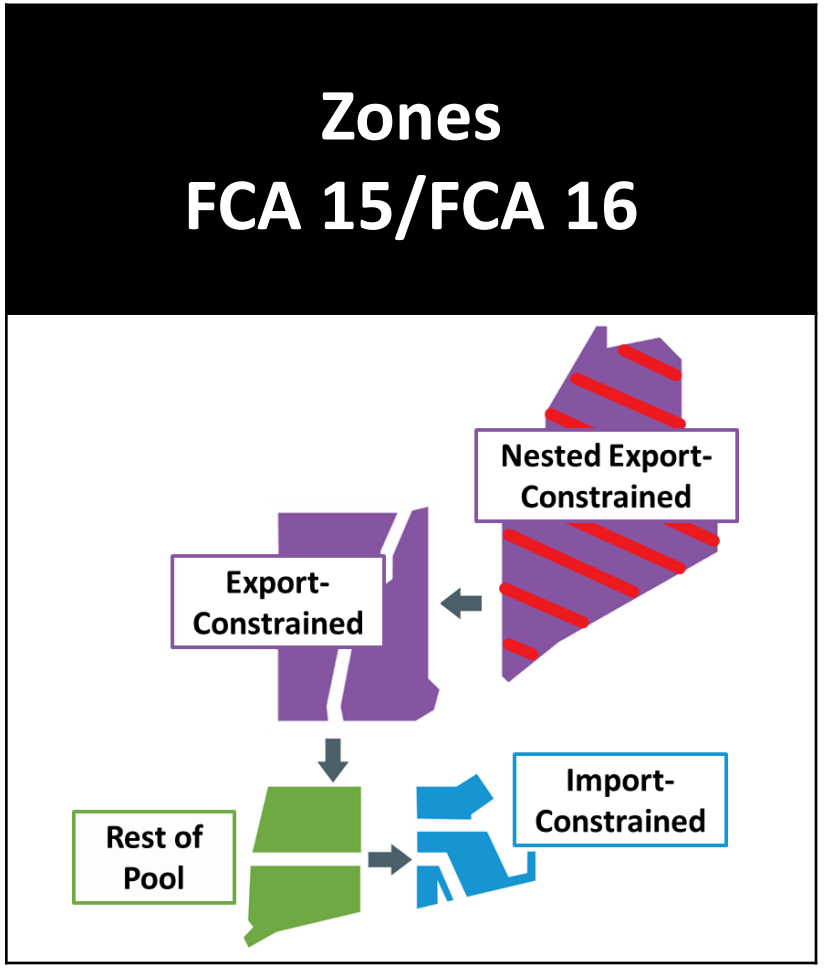
Pricing in wholesale electricity marketplace is calculated at individual generating units, about 900 load nodes (specific points on transmission system), eight load zones (aggregations of load nodes), and hub (a collection of locations in central New England where little congestion is evident



Capacity Zones Used in Forward Capacity Market

ISO continually analyzes and modifies zones as necessary

- Provides a market signal (location-specific prices)



Modeling Capacity Zones and Zonal Requirements

Capacity Zones – Why Location Matters

Capacity zones reflect the fact that there are constraints within the system

Export-Constrained Capacity Zones (ECCZ)

- In some areas behind a constraint there is *too much capacity* and *too little load*
- Internal constraints may limit the amount of energy that can be taken out of the zone
- Adding more capacity in these areas may do *less* to improve system reliability than adding capacity elsewhere in the system

Consequently, the value of capacity in these zones may be worth relatively **less** than capacity located somewhere else in the system

Import-Constrained Capacity Zones (ICCZ)

- In some areas behind a constraint there is *too much load* and *too little capacity*
- Internal constraints may limit the amount of energy that can be brought into the zone
- Adding more capacity in these areas may do *more* to improve system reliability than adding capacity elsewhere in the system

Consequently, the value of capacity in these zones may be worth relatively **more** than capacity located somewhere else in the system

Identify Potential Zonal Boundaries

ISO reviews the annual assessment of transmission transfer capabilities in the Regional System Plan to identify potential zonal boundaries and associated transfer limits to be tested for modeling in the Forward Capacity Auction (FCA)

- Regional System Plan is specified in Attachment K of Open Access Transmission Tariff
- This would also include updates to things such as transmission topology and any new information on capacity resources (e.g., Are any leaving the capacity market?; Are there any new resources that may enter the market?)

System Planning > Plans and Studies > Regional System Plan and Related Analyses

Zonal Requirements

- The same General Electric MARS model and techniques are used to determine the zonal demand requirements; but now internal constraints are modeled
- Instead of adding capacity to a specific zone, we move it around
  - We hold the amount of capacity in the system constant and measure the incremental change in reliability when we transfer an increment of capacity from the rest-of-pool capacity zone into the constrained capacity zone
- Similar to the system Installed Capacity Requirement analysis, the zone requirement is determined at a pre-defined point
  - These points are useful references, and used to determine whether or not a zone may be created
    - For an import-constrained zone this point is called the local-sourcing requirement (LSR)
    - For an export-constrained zone this point is called the maximum capacity limit (MCL)
  - These points are not used in the auction or used to scale the zonal demand curve

What Is the Trigger to Model an Import-Constrained Zone?

An import-constrained zone will be modeled when there is insufficient surplus of existing capacity above the line-line transmission security analysis (TSA) requirement in the zone to allow for removal of the largest station from the zone

- Line-line means loss of most critical transmission element followed by loss of next most critical transmission element (a.k.a., second-contingency N-1-1 transfer capability into zone)

Why?

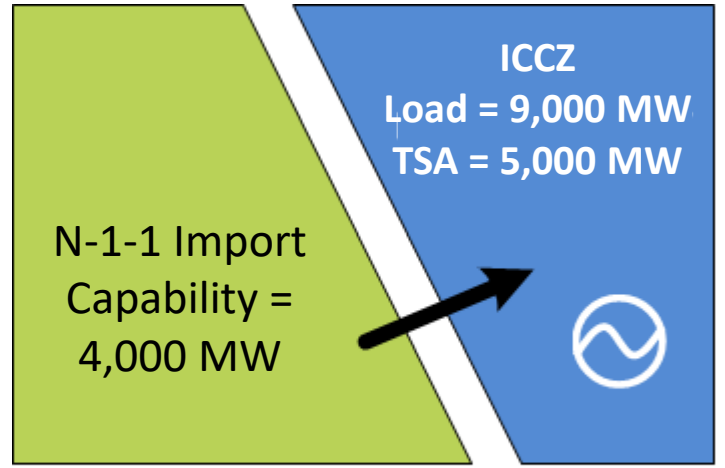
- A zone may start auction with more than enough resources
- Capacity resources that retire or otherwise leave capacity market *during the auction* would reduce the amount of capacity in the zone
- Modeling the zone allows the auction to send a market signal: that capacity in this zone may be worth relatively more, depending on how much or how little there is in the zone

Trigger to Model an Import-Constrained Zone – An Example

- Transmission Security Analysis (TSA) requirement is 5,000 MW
- Largest station in the zone is 1,000 MW

Why do we have a trigger model?

Because it's possible that an entire generating station is removed from the market



Largest station in zone is 1,000 MW

If there are less than 6,000 MW of existing resources in the zone, the zone would be modeled in the Forward Capacity Auction (FCA)

Import-Constrained Zone Requirement

For an import-constrained zone, the requirement is called the local sourcing requirement (LSR) and is the greater of (because one is the limiting factor):

- **Local resource adequacy** requirement, which is a probabilistic resource adequacy analysis (similar to the system Installed Capacity Requirement analysis)
  - Analysis uses first-contingency N-1 transfer capability into zone (meaning loss of most critical transmission or generator element)
- **Transmission security analysis (TSA)** requirement, which is a deterministic operational reliability analysis
  - Analysis uses second-contingency N-1-1 transfer capability into zone (meaning loss of most critical transmission element and loss of next most critical transmission element)

What Is the Trigger to Model an Export-Constrained Zone?

An export-constrained zone would be modeled when the maximum capacity limit is less than the total of existing and proposed new resources in the zone

- The maximum capacity limit (MCL) is a probabilistic resource adequacy analysis (similar to the system Installed Capacity Requirement analysis)

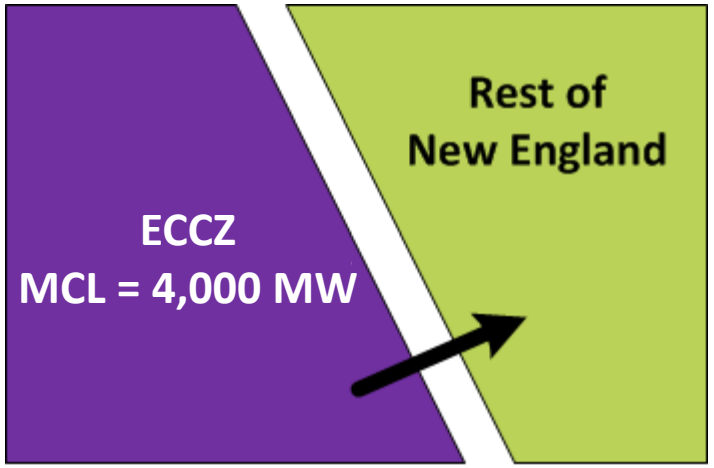
Why do we have a trigger model?

- A zone may start the auction with fewer resources (i.e., less than the MCL amount)
- New capacity resource additions coming into market during the auction would increase the amount of capacity in the zone
- Modeling the zone allows the auction to send a market signal: that capacity in this zone may be worth relatively less, depending on how much or how little there is in the zone

Export-Constrained Zone Requirement

For an export-constrained zone, the requirement is the maximum capacity limit (MCL)

- If the MCL is 4,000 MW, and there are 3,000 MW of existing resources, and 2,000 MW of proposed new resources, then the zone would be modeled as export constrained



Why? More than this amount quickly becomes less useful to system reliability

- General Electric MARS software is used to compute the MCL by shifting firm load into rest of New England until the system loss-of-load expectation (LOLE) reliability criterion is achieved

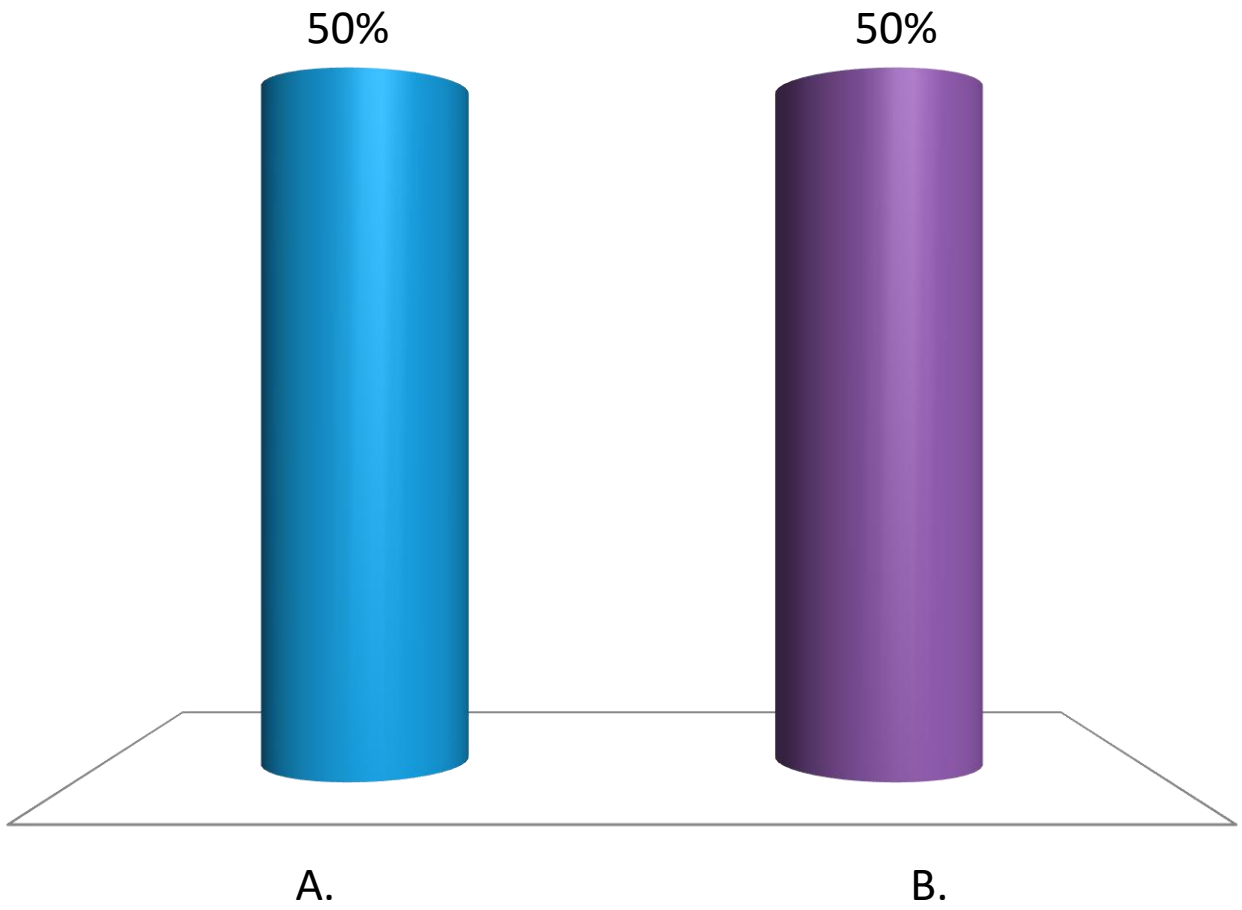
What type of zone provides a market signal for the Forward Capacity Auction (FCA)?

A. RSP zone

B. Load zone

✓ C. Capacity zones

D. Dispatch zones

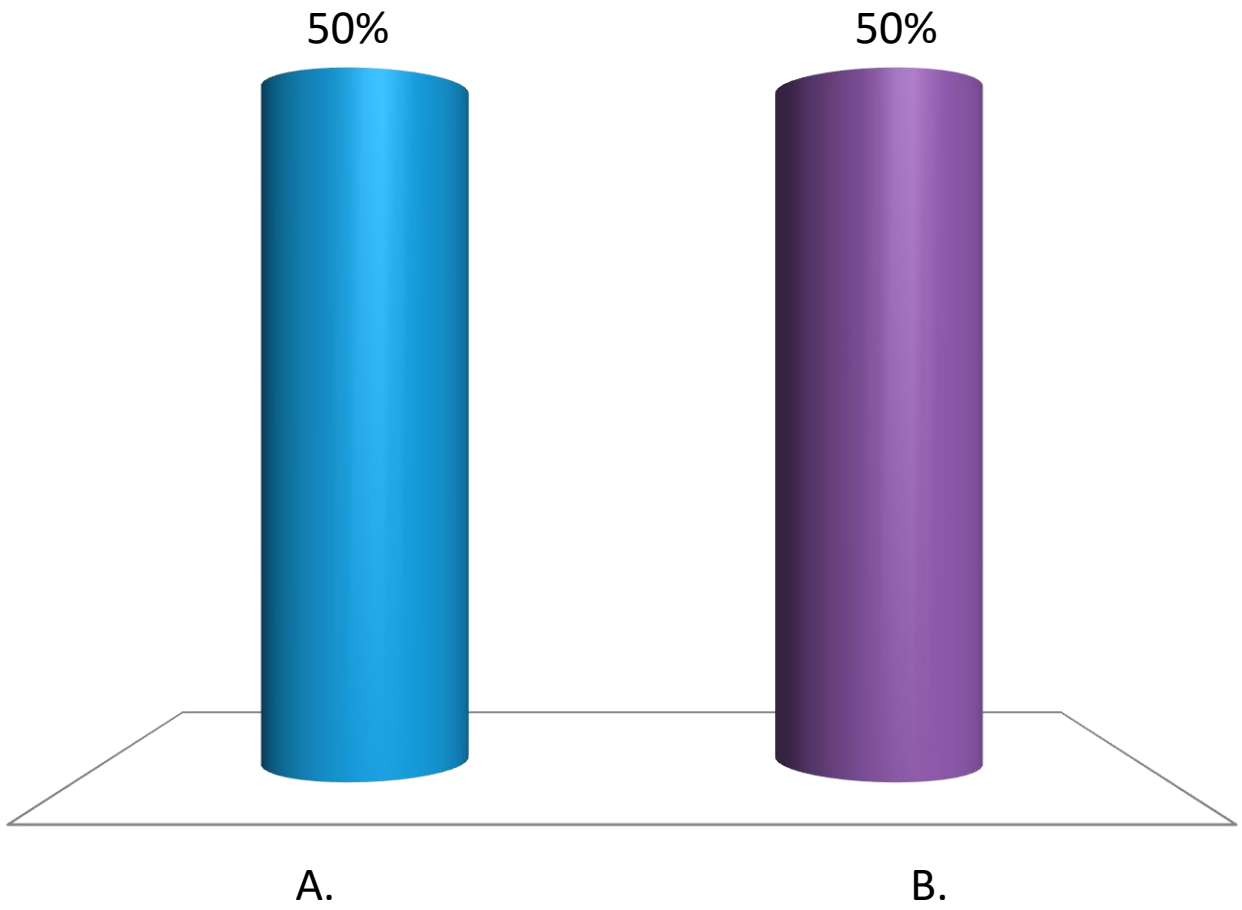


Q4 of 5

What type of zone would be modeled when the maximum capacity limit is less than the total of existing and proposed new resources in the zone?

A. Import constrained zone

✓ B. Export constrained zone



Q5 of 5

Questions

Zonal Demand Curves

Zonal Marginal Reliability Impact Based Demand Curves

- The same General Electric MARS model and techniques are used to determine the zonal demand curves
- Similarly, instead of adding capacity we move it around, but instead of searching for a pre-defined point, we plot the incremental value over a range (creating a curve)
  - We hold the amount of capacity in the system constant and instead measure the incremental change in reliability when we transfer an increment (1 MW) of capacity from the rest-of-pool capacity zone into the constrained capacity zone
- We also scale the zonal marginal reliability impact (MRI) curve but because the zonal MRI curve is incremental to the system, the zonal MRI-based demand curve reflects congestion prices
  - Congestion price meaning total price in zone is **sum** of system price and zone congestion price

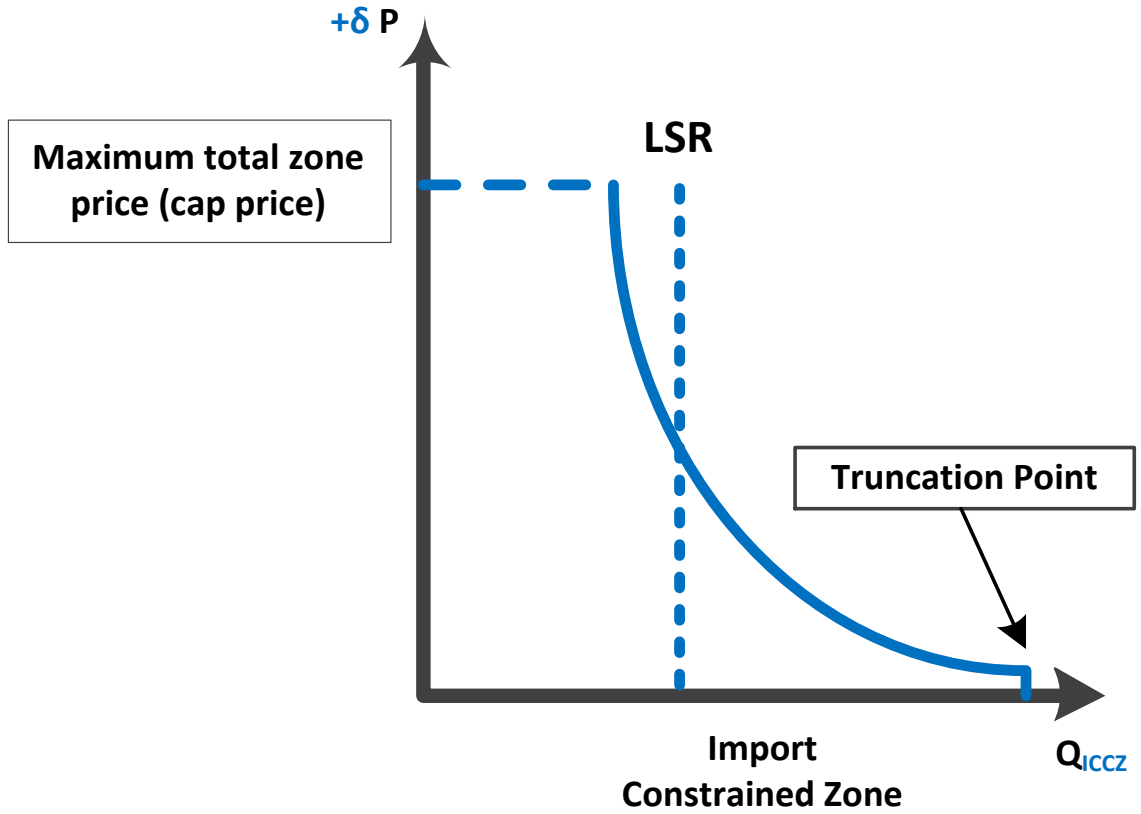
Some Specifics on Zonal Marginal Reliability Impact Based Demand Curves

Calculation of zonal marginal reliability impact (MRI) values depends on the transfer capability across the interface

Import-Constrained Capacity Zones

For **import-constrained zones**, curve is limited:

- On right by truncation point (where there is no discernable congestion price)
- On left by maximum total zonal price (i.e., price cap applies, but it applies to total zone price; sum of positive congestion price and system price)



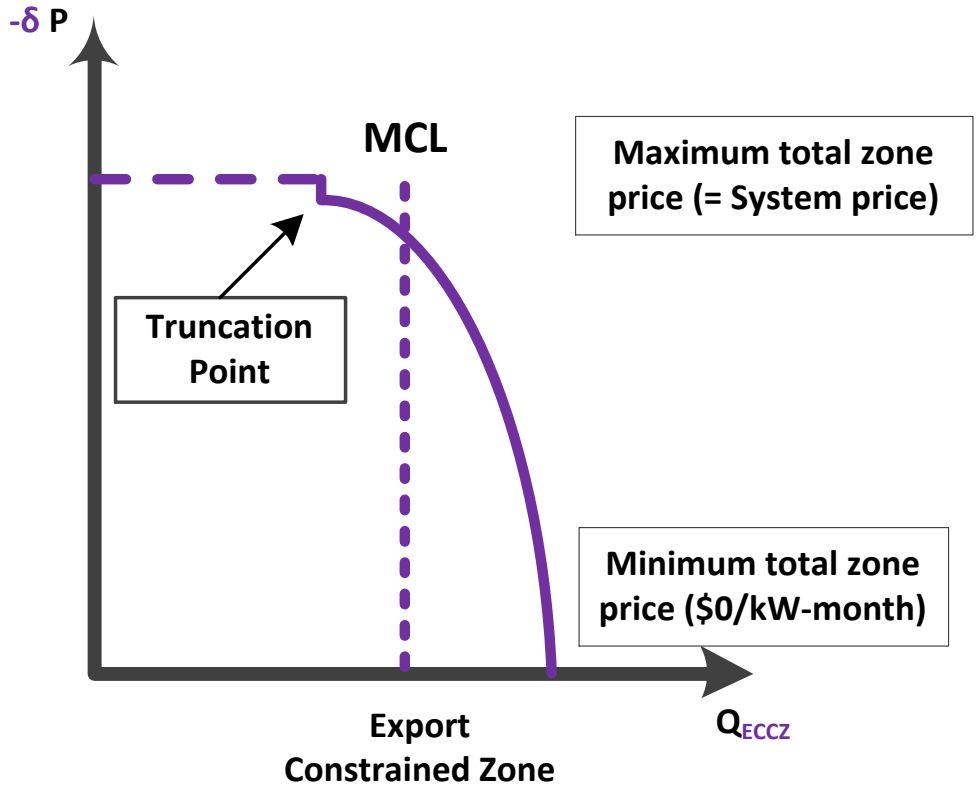
Some Specifics on Zonal Marginal Reliability Impact Based Demand Curves

Calculation of zonal marginal reliability impact (MRI) values depends on the transfer capability across the interface

Export-Constrained Capacity Zones

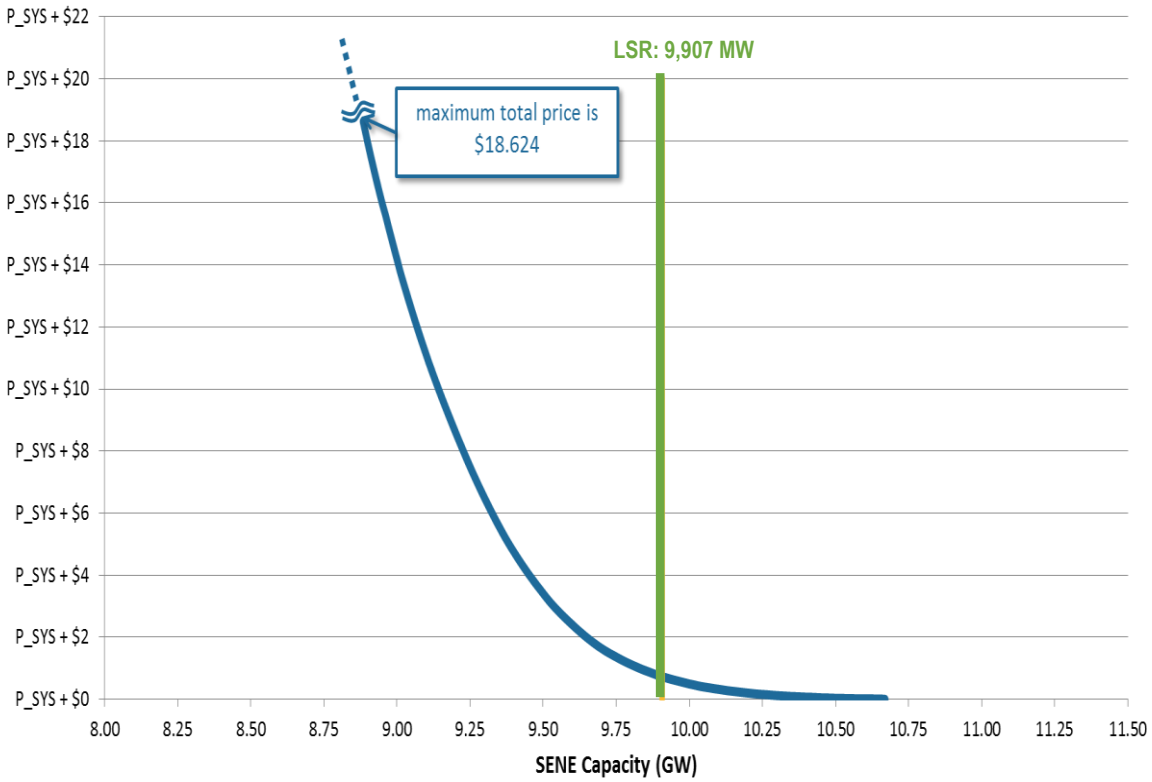
For **export-constrained zones**, curve is limited:

- On right by total zonal price (sum of negative congestion price and system price cannot be less than zero)
- On left by truncation point (where there is no discernable congestion price)

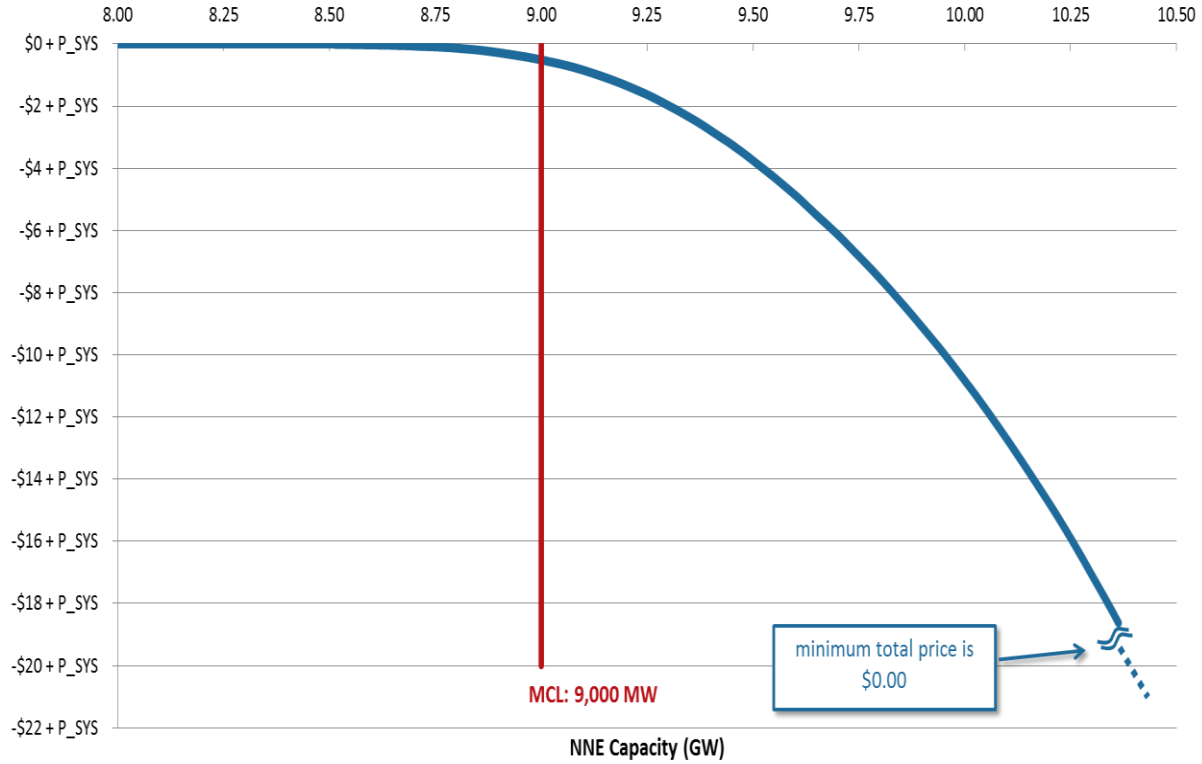


Congestion Pricing in Constrained Capacity Zones

Import-Constrained Capacity Zone

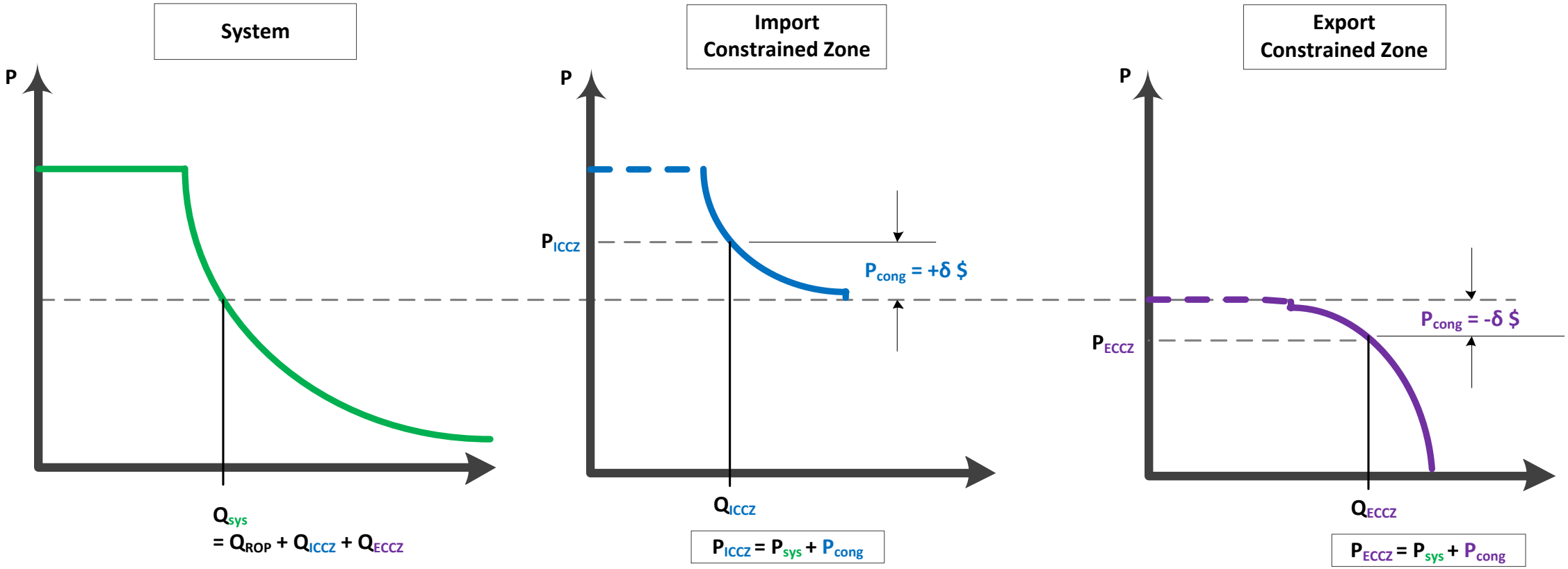


Export-Constrained Capacity Zone



How Demand Curves Work Together

It’s important to understand that zonal curves assign a locational value of capacity via the congestion price without imposing an actual limit on the amount of capacity in the zone



What to Know About Marginal Reliability Impact Based Demand Curves

At system level:

- There is no fixed limit or requirement on how much the FCA will procure
- How much (or how little) is procured is based on the price per demand curve
  - Amounts less than Net ICR are at relatively high prices (> Net CONE)
  - Amounts more than Net ICR are at relatively lower prices (< Net CONE)

At zonal level:

- There is no fixed limit or requirement on how much the FCA will procure inside a zone
  - How much (or how little) is procured is based on the price per demand curve(s)
- Auction does not clear zones in isolation
  - Supply offers inside and outside the zone are competing with one another; the reliability contribution from each is factored into the slope of the demand curves (i.e., congestion price)

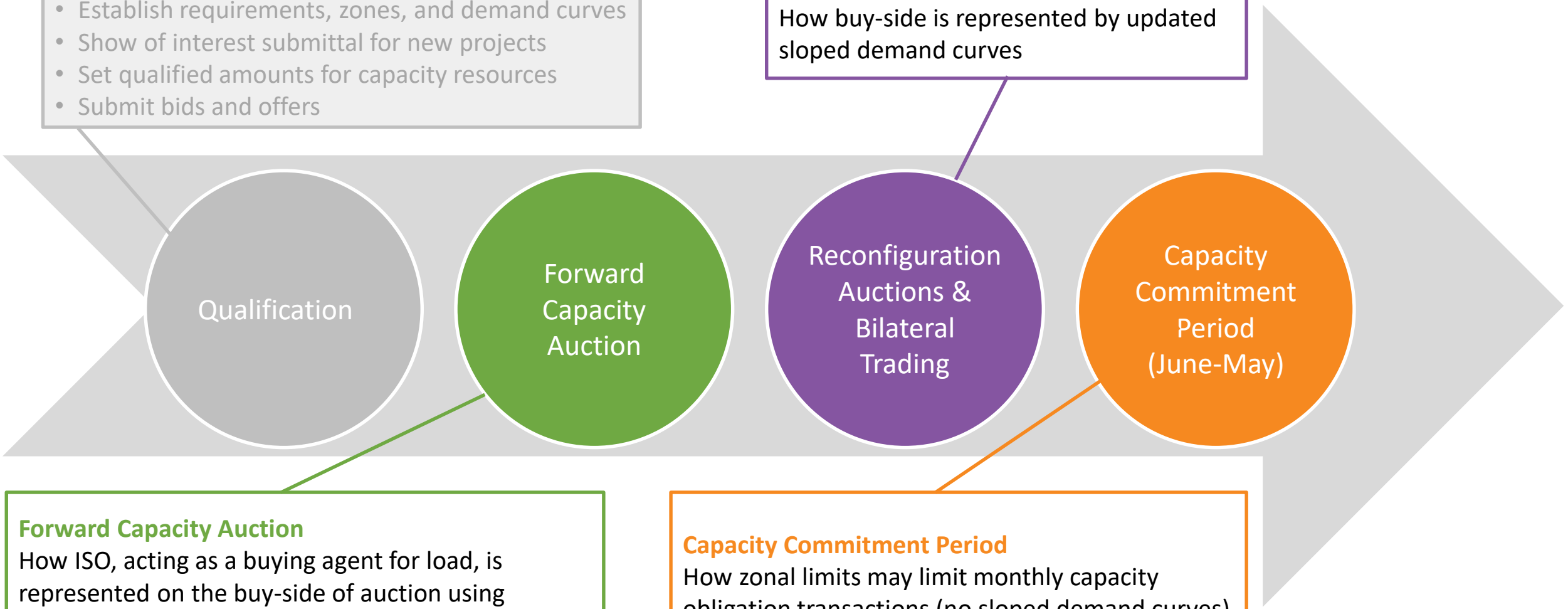
Other Applications of Demand Curves

Requirements and Demand Curves in Reconfiguration Auctions

Forward Capacity Market Process – What Are We Talking About in This Lesson?

Qualification
- Establish requirements, zones, and demand curves
- Show of interest submittal for new projects
- Set qualified amounts for capacity resources
- Submit bids and offers

Reconfiguration Auctions
How buy-side is represented by updated sloped demand curves



Forward Capacity Auction
How ISO, acting as a buying agent for load, is represented on the buy-side of auction using sloped demand curves

Capacity Commitment Period
How zonal limits may limit monthly capacity obligation transactions (no sloped demand curves)

What Is Used in the Auction? Who Is Buying Capacity?

It depends on the auction…

Forward Capacity Auction (FCA)	Annual Reconfiguration Auctions (ARAs)
• ISO acts on behalf of all (future) load (i.e., those who will be charged for capacity when we get to the commitment period) • ISO acts as an agent for load and is the **buyer** while participants with capacity resources are the **sellers** • Amount ISO buys is determined by demand curve	• Acting as agent for load, the amount ISO buys or now sells relative to amount procured in FCA is determined via updated demand curves • Suppliers wishing to shed (i.e., buy-back) their obligation can participate as buyers and suppliers with unobligated capacity can participate as sellers

Monthly Reconfiguration Auctions (Monthly RAs)
• No monthly demand curves are used; the total obligation amount is fixed; transfers between zones may be limited • Only suppliers participate (those looking to buy and those looking to sell)

Some Parameters are Specific to Commitment Period

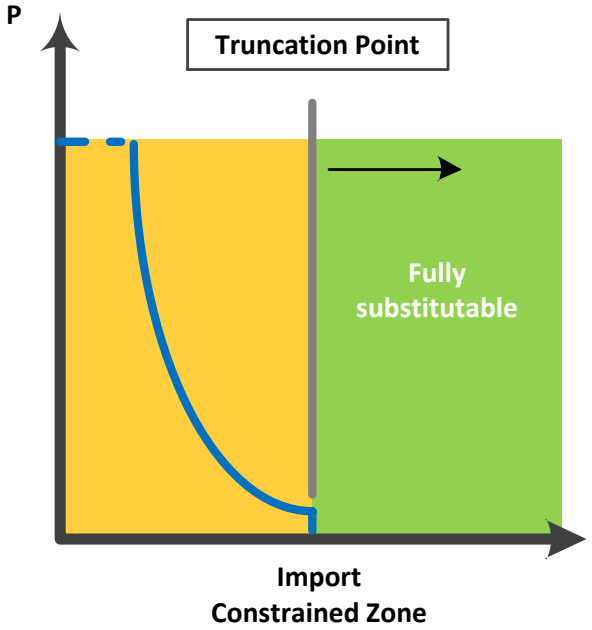
Today we are calculating the requirements and demand curves for FCA 18 *and* updates for the prior CCPs

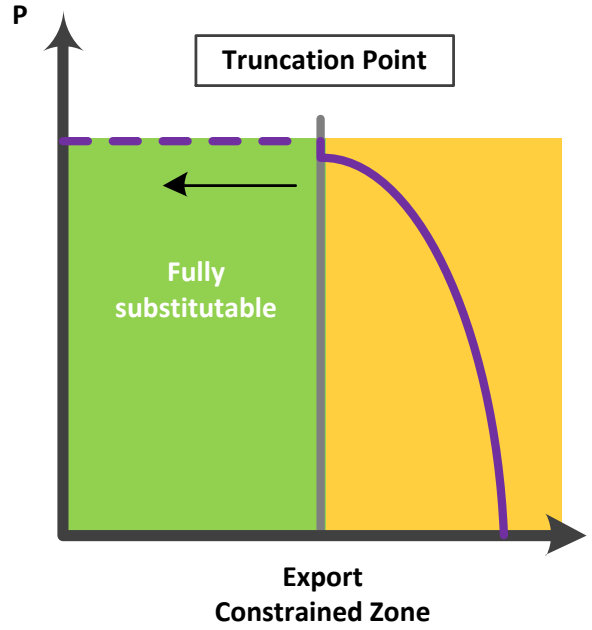
Capacity Commitment Period	June 2023 - May 2024	June 2024 - May 2025	June 2025 - May 2026	June 2026 - May 2027	June 2027 - May 2028	June 2028 - May 2029
	CCP 14	CCP 15	CCP 16	CCP 17	CCP 18	CCP 19
Upcoming Auctions						
Forward Capacity Auction	February '20	February '21	February '22	March '23	February '24	February '25
Annual Reconfiguration Auctions						
ARA 1	June '21	June '22	June '23	June '24	June '25	June '26
ARA 2	August '22	August '23	August '24	August '25	August '26	August '27
ARA 3	March '23	March '24	March '25	March '26	March '27	March '28
Notable Aspects & Differences						
Cost Allocation Method	Yes					
Net CONE ($/kW-month)	$8.187	$8.707	$7.468	$7.359	$9.078	TBD
Pay-for-Performance Rate			$5,455/MWh	$9,337/MWh		
Nested Capacity Zone	Yes					TBD

Note: This slide will be updated when the FCA 18 Schedule becomes final.

Monthly Obligation Transactions

- Demand curves are not used in monthly transactions (bilateral transactions or reconfiguration auctions)
  - Total capacity supply obligation amount at system level remains the same; exchanging obligations are essentially swaps between suppliers (must be MW-for-MW)
- There are limits because capacity may not be fully substitutable; exchanges are:
  - **Permitted** where exchange maintains reliability (where capacity is fully substitutable) or where exchange improves system reliability
  - **Not permitted** where exchange would worsen reliability





Summary

In this lesson, you learned:

- Auction has no fixed limits
  - How much is procured in an auction depends on where supply intersects with demand curves
- Zones are not cleared in isolation
  - Zonal demand curves determine congestion prices only
    - They do not limit or control how much is actually procured in the zone
    - Amount of capacity in zone is also included in system total
  - Capacity may be partially substitutable across constrained zone boundaries

Questions