

Resource Adequacy Requirements, Scarcity Pricing, and Electricity Market Design Implications

Presented to

IEA Electricity Security Advisory Panel (ESAP)
Paris, France

Prepared by

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July 2, 2014



Acknowledgements

This presentation is based in part on the following reports and presentations:

- Pfeifenberger, Newell, Spees, *Energy and Capacity Markets: Tradeoffs in Reliability, Costs, and Risks*, Harvard Electricity Policy Group, February 27, 2014.
- Newell, Spees, Pfeifenberger, Karkatsouli, Wintermantel, and Carden, *Estimating the Economically Optimal Reserve Margin in ERCOT*, Report prepared for The Public Utility Commission of Texas, The Brattle Group, January 31, 2014.
- Pfeifenberger, Spees, *Characteristics of Successful Capacity Markets*, APEx Conference, October 31, 2013.
- Pfeifenberger, Spees, Carden, Wintermantel, *Resource Adequacy Requirements: Reliability and Economic Implications*, Prepared for the Federal Energy Regulatory Commission (FERC), The Brattle Group, September 2013.
- Spees, Newell, Pfeifenberger, *Capacity Markets: Lessons Learned from the First Decade*, Economics of Energy & Environmental Policy, Vol. 2, No. 2, September 2013.

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I. What is Resource Adequacy?

Resource adequacy is the ability to supply load with adequate generation resources

- Traditionally defined as ability to provide adequate supply during peak load and generation outage conditions
 - Measured as “Loss of Load Probability” or LOLP (likelihood of involuntary “Loss of Load Events” or LOLE)
 - Resources include controllable (curtailable or non-firm) loads
- Increasing trend to include the ability to supply load during challenging ramping conditions (system flexibility)
- Resource adequacy often expressed in terms of “target” or “planning” reserve margins
 - Based on forecasts of normalized load and generation outages
- Does not include impact of T&D disturbances
 - Transmission and distribution-related outages greatly exceed impact of resource adequacy (typically 10 to 50 times)

I. Market Designs for Resource Adequacy

	Regulated Planning (Customers Bear Most Risk)			Market Mechanisms (Suppliers Bear Most Risk)		
	Regulated Utilities	Administrative Contracting	Capacity Payments	LSE RA Requirement	Capacity Markets	Energy-Only Markets
Examples	SPP, BC Hydro, most of WECC and SERC	Ontario	Spain, South America	California, MISO (both also have regulated IRP)	PJM, NYISO, ISO-NE, Brazil, Italy, Russia	ERCOT, Alberta, Australia's NEM, Scandinavia
Resource Adequacy Requirement?	Yes (Utility IRP)	Yes (Administrative IRP)	Yes (Rules for Payment Size and Eligibility)	Yes (Creates Bilateral Capacity Market)	Yes (Mandatory Capacity Auction)	No (RA not Assured)
How are Capital Costs Recovered?	Rate Recovery	Energy Market plus Administrative Contracts	Energy Market plus Capacity Payments	Bilateral Capacity Payments plus Energy Market	Capacity plus Energy Markets	Energy Market

See Also:

Pfeifenberger & Spees (2009). *Review of Alternative Market Designs for Resource Adequacy*.

Spees, Newell, & Pfeifenberger (2013). "Capacity Markets: Lessons Learned from the First Decade," *Economics of Energy & Environmental Policy*, Vol. 2, No. 2, September 2013.

I. Market Designs for Resource Adequacy

The most appropriate market-based design for resource adequacy depends on a region's policy objectives and risk tolerance:

- **Energy-Only Market** likely most appropriate if:
 - Economic efficiency is the primary policy objective
 - Lower reserve margins, higher outage levels, and potential for periodic scarcity events is sustainable from a public policy perspective
- **Resource Adequacy Requirement (e.g., implemented with a centralized capacity market)** likely most appropriate if:
 - Maintaining physical resource adequacy standards is the primary policy concern
 - Policy makers wish to prevent potential low-reliability, high-cost events (thereby creating potential long-run benefits through risk-mitigation)

I. Resource Adequacy Requirements

Administrative resource-adequacy requirements are generally needed when energy-only markets do not attract adequate investments. Main reasons include:

1. Energy market designs that lead to price suppression
2. Incomplete or poorly-designed ancillary service markets
3. Distortions created by out-of-market payments for some resources that lead to over-supply
4. Challenging investment risks (e.g., in hydro-dominated markets)
5. Resource adequacy preferences (e.g., only 1 loss of load event in 10 years) that are higher than what even fully-efficient energy and ancillary service markets would provide

I. Energy-Market Design Gaps

Energy market design gaps often undermine adequate generation investments:

- Low price caps and inadequate scarcity pricing
- Poor integration of demand-response (DR) resources
- Substantial locational differences not reflected in market prices
- Absence of liquid and transparent balancing energy markets (e.g., 5-minute real-time energy markets)
- Operational actions (e.g., out-of-market dispatch of emergency resources) that depress clearing prices

Market design gaps often include incomplete or poorly-designed ancillary service markets

- Absence of liquid and transparent markets for ancillary services
- Missing ancillary service products (e.g., ramping capability)
- Not co-optimized with imbalance energy market
- Operational (out-of-market) actions that depress clearing prices

I. Scarcity Pricing and DR Integration

	Res. Ad. Construct	Price Cap	Offer Cap	DR	Reserves Shortage Pricing	Other
Alberta	Energy-Only	\$1,000/MWh	\$999.99/MWh	DR bids	n/a	Permissive generator offer guidelines
Australia	Energy-Only	\$12,900/MWh (AUD) Adjusted Annually	Price cap (considering peak period restrictions on dominant generators)	DR bids	n/a	- Administrative ex-post pricing corrects for interventions - Cumulative Price Threshold limits persistent high prices
ERCOT	Energy-Only	None (but exceeding offer cap unlikely)	\$7,000/MWh (increasing to \$9,000/MWh in 2015)	DR bids in day-ahead	Dispatched at prices from \$120 up to offer cap	Peaker Net Margin cap limits persistent high scarcity pricing
CAISO	Reliability Requirement and Regulated Planning	None (But exceeding \$2,000 unlikely)	\$1,000/MWh or lower w/ mitigation	DR bids in day-ahead and real-time	Additive \$100-\$700 penalty factors	n/a
MISO	Reliability Requirement and Regulated Planning	\$3,500/MWh (Based on Residential VOLL)	\$1,000/MWh or lower w/ mitigation	DR bids in day-ahead and real-time	Additive penalty factors and function of VOLL·LOLP	n/a
ISO-NE	Forward Capacity Market	\$2,000 to \$2,250/MWh by location	\$1,000/MWh or lower w/ mitigation	DR bids in day-ahead and real-time	Additive \$50-\$850 penalty factors by location and type	n/a
PJM	Forward Capacity Market	\$1,000/MWh in 2012, increasing to \$2,700/MWh by 2015	\$1,000/MWh or lower w/ mitigation	- DR bids in DA and RT - Emergency DR can set price	Additive \$850 penalty factors for spin and non-spin	Emergency imports can set price
NYISO	Prompt Capacity Market	\$1,850 to \$2,750/MWh by location	\$1,000/MWh or lower w/ mitigation	- DR bids in DA - Emergency DR at \$500	Additive \$25-\$500 demand curves	n/a

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II. Resource Adequacy Study Results

- Simulating Reliability, Scarcity Pricing, and Risks of Energy-only and Capacity Markets

III. Successful Capacity Market Designs

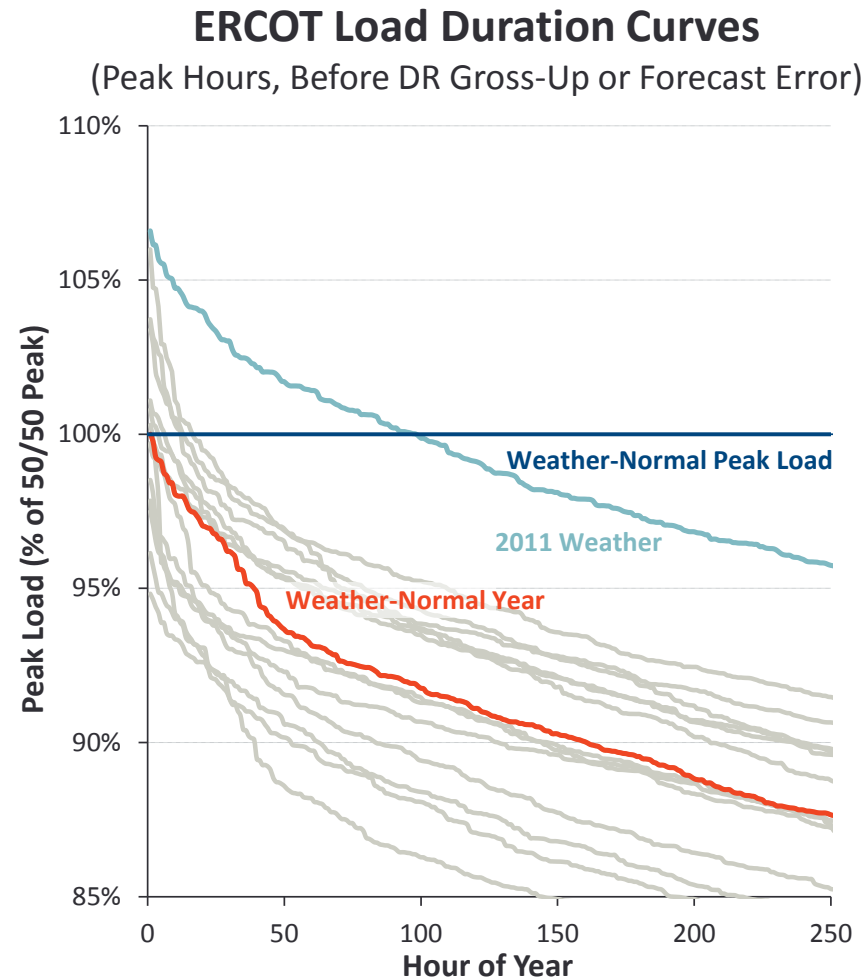
Appendix A: FERC and ERCOT Resource Adequacy Study Results

Appendix B: Characteristics of Successful Capacity Markets

Appendix C: Additional Reading, About the Author, About Brattle

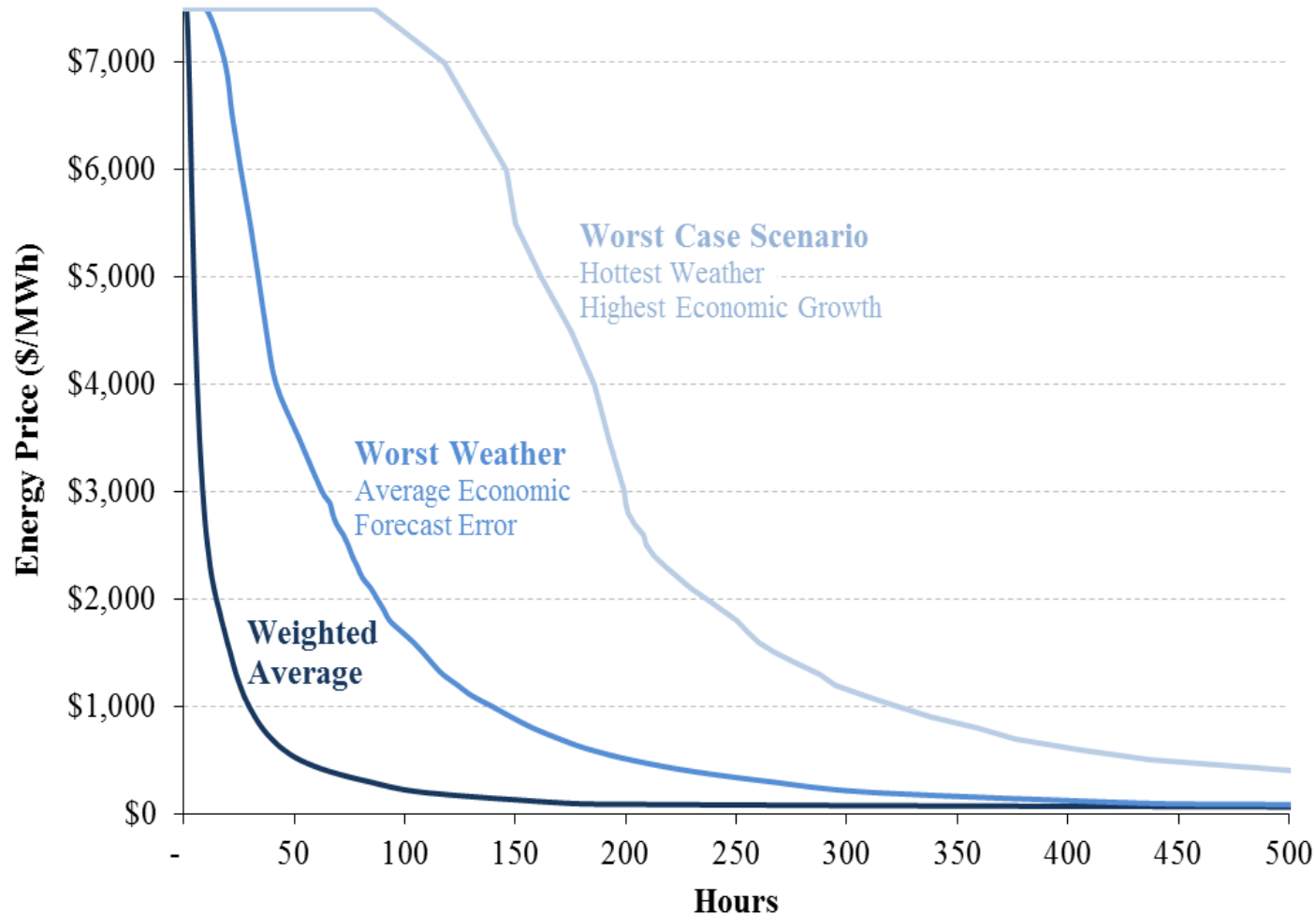
II. Resource Adequacy Simulations

- Probabilistic multi-area reliability and economic modeling studies, representing:
 - **Demand** in study/external regions
 - **Generation** with randomized outages
 - **Demand response** of several types with differing availability and emergency or economic triggers
 - **Emergency procedures** that system operator triggers in shortage conditions
- Monte Carlo simulation of 7,500 full annual (hourly-sequential) simulations at each reserve margin using SERV
- Primary outputs reported at different levels of target reserve margins:
 - **Reliability metrics** (LOLE, LOLH, EUE)
 - **Economic costs** (production costs, DR curtailment costs, emergency intervention costs)
 - **Market results** (prices, energy margins)

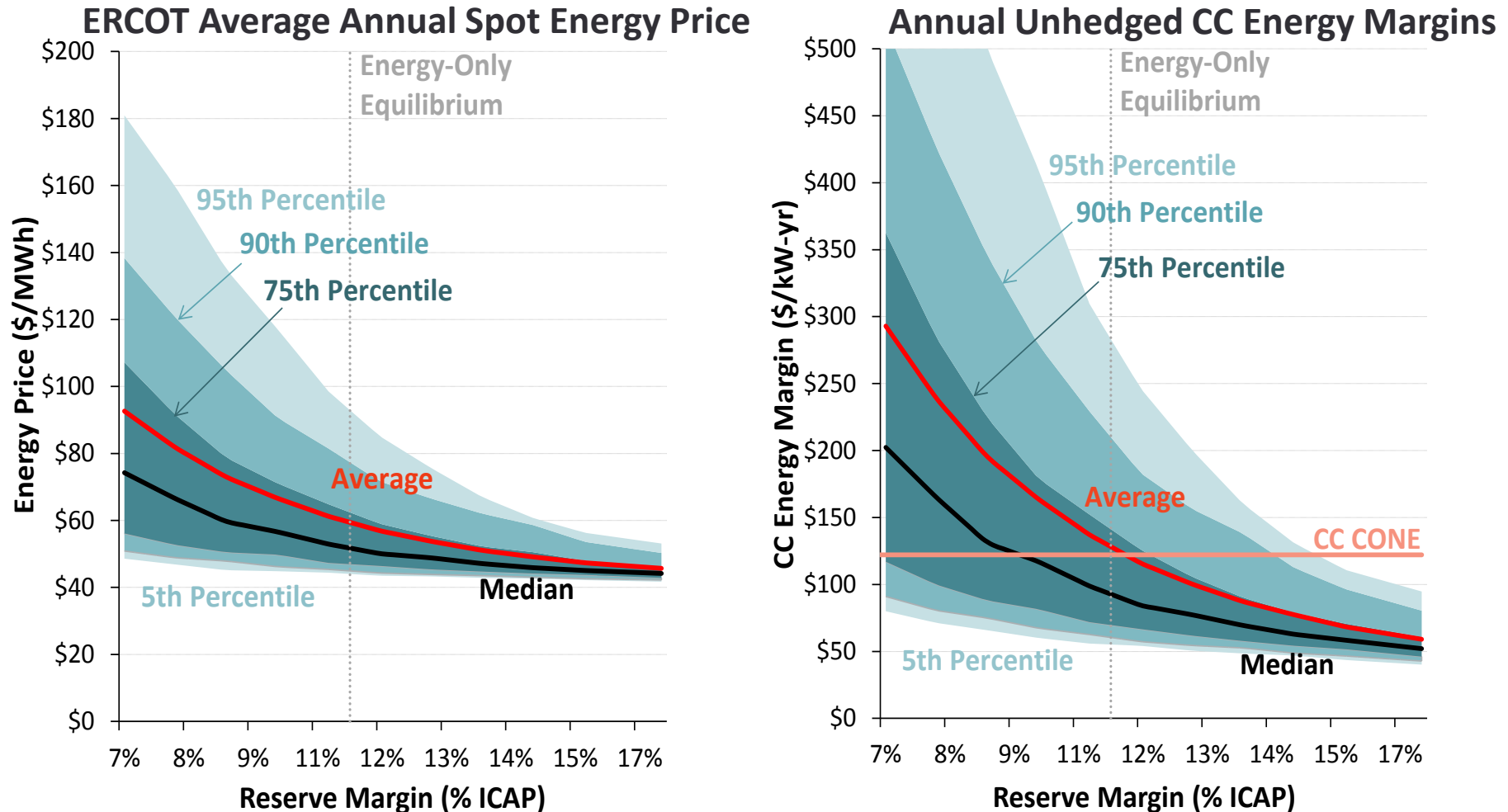


II. Scarcity Prices in Hourly Energy Market

Price Duration Curve at the Economically-Optimal Planning Reserve Margin



II. Energy Spot Prices and Generator Margins

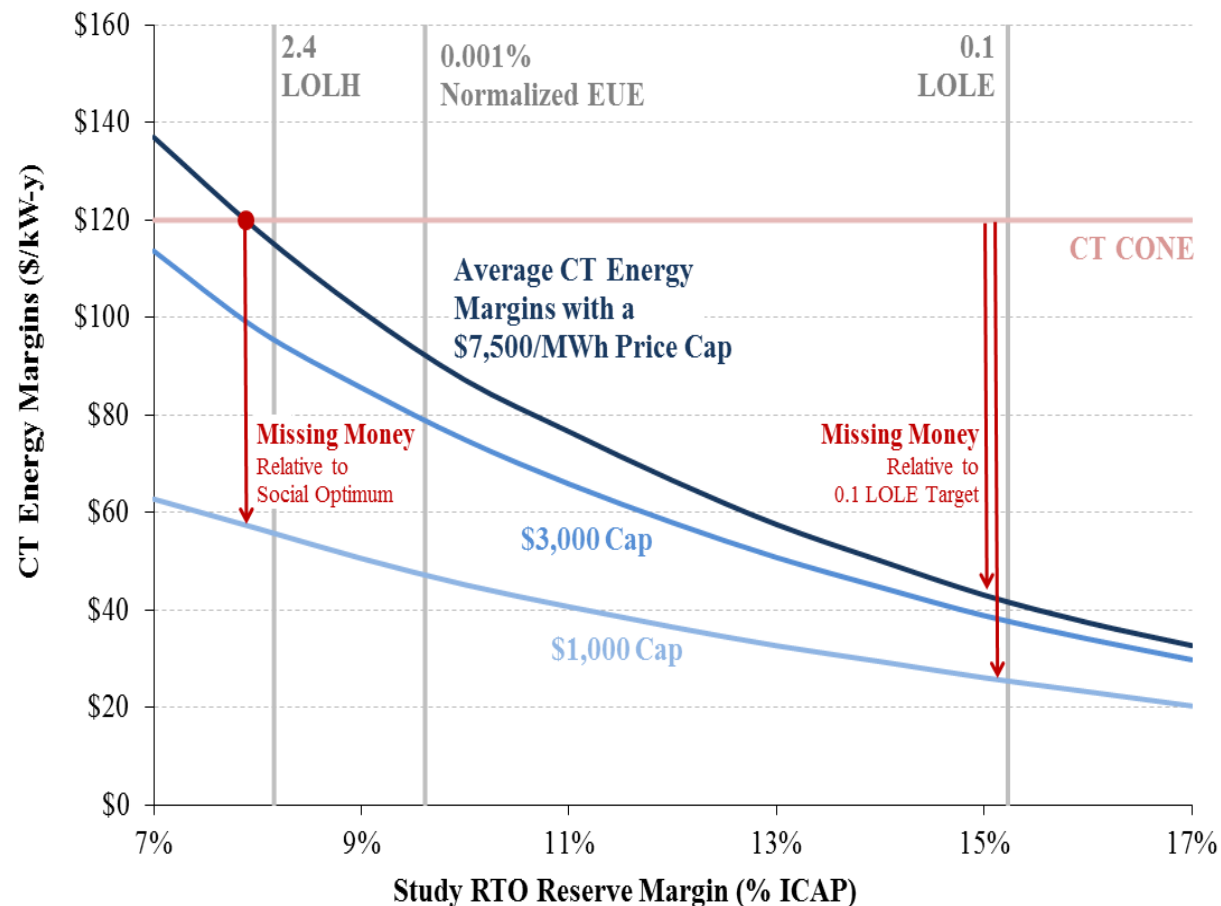


- At 11.5% the average annual energy price is 20% higher than at 14%; average of top 10% of annual prices (unhedged) is 50% higher. Median prices significantly below average.

II. Impact of Price Caps

- Price caps substantially reduce the reserve margins achieved by energy-only market
- Caps below \$3,000/MWh significantly increase the “missing money” at any particular planning reserve margin
- Generator revenues shift from energy market to capacity market
- Reduced dispatch efficiencies and demand response during scarcity pricing periods

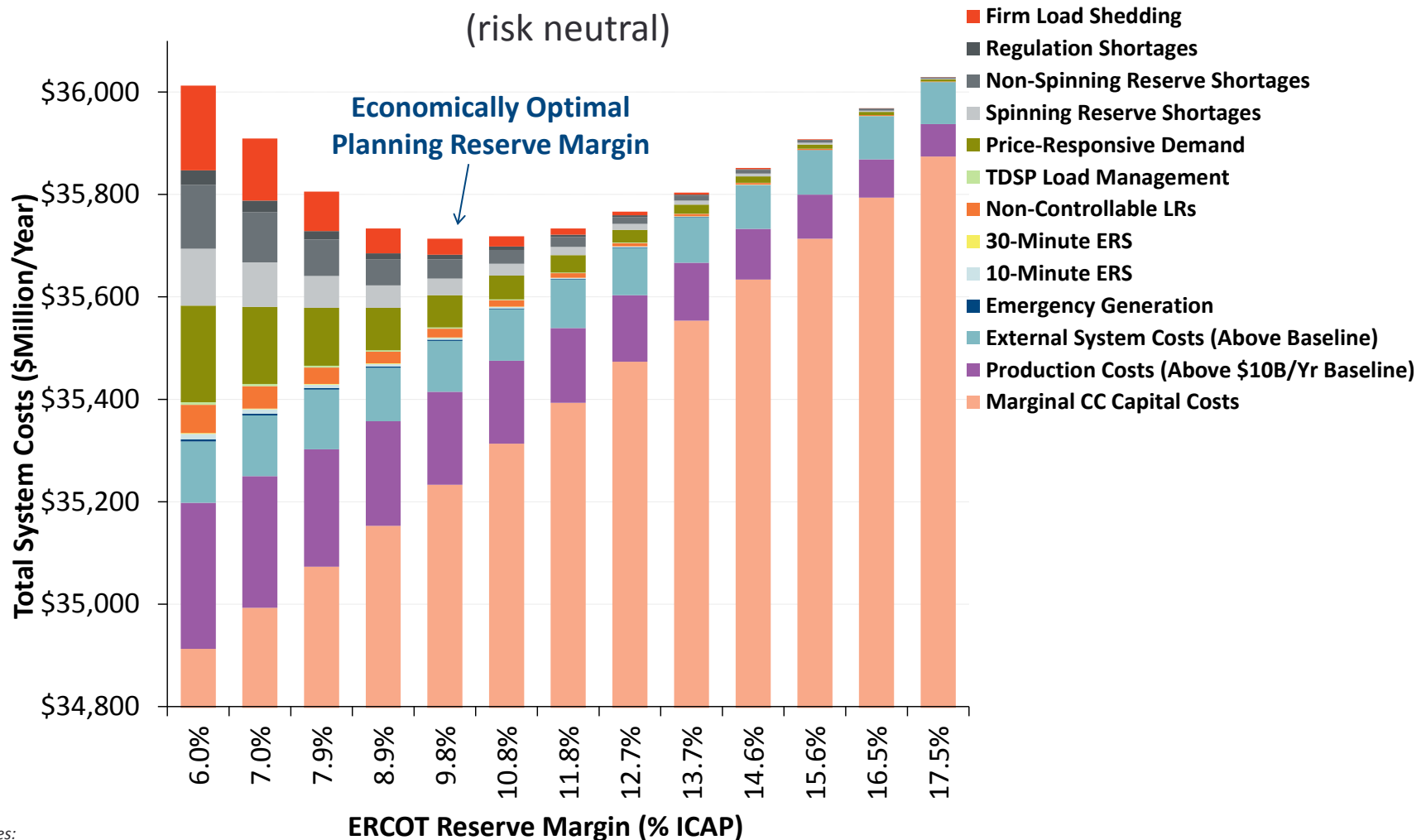
Generator Energy Margins and Capacity Prices (“Missing Money”) at Different Price Caps and Planning Reserve Margins



II. Economically Optimal Reserve Margin

ERCOT Total System Costs across Planning Reserve Margins

(risk neutral)

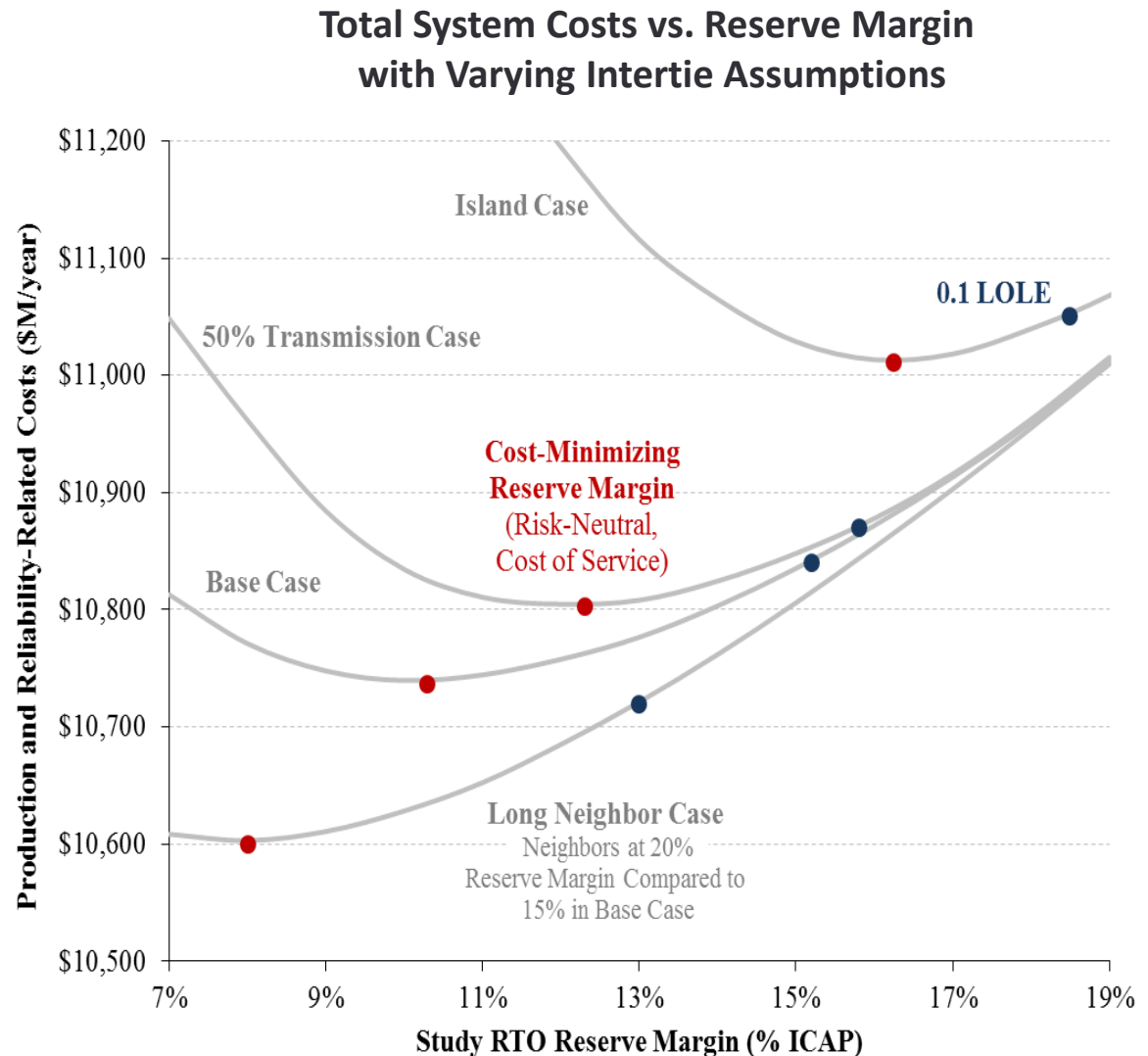


Notes:

Total system costs include a large baseline of total system costs that do not change across reserve margins, including \$15.2 B/year in transmission and distribution, \$9.6 B/year in fixed costs for generators other than the marginal unit, and \$10B/year in production costs.

II. Sensitivity to Intertie Capacity

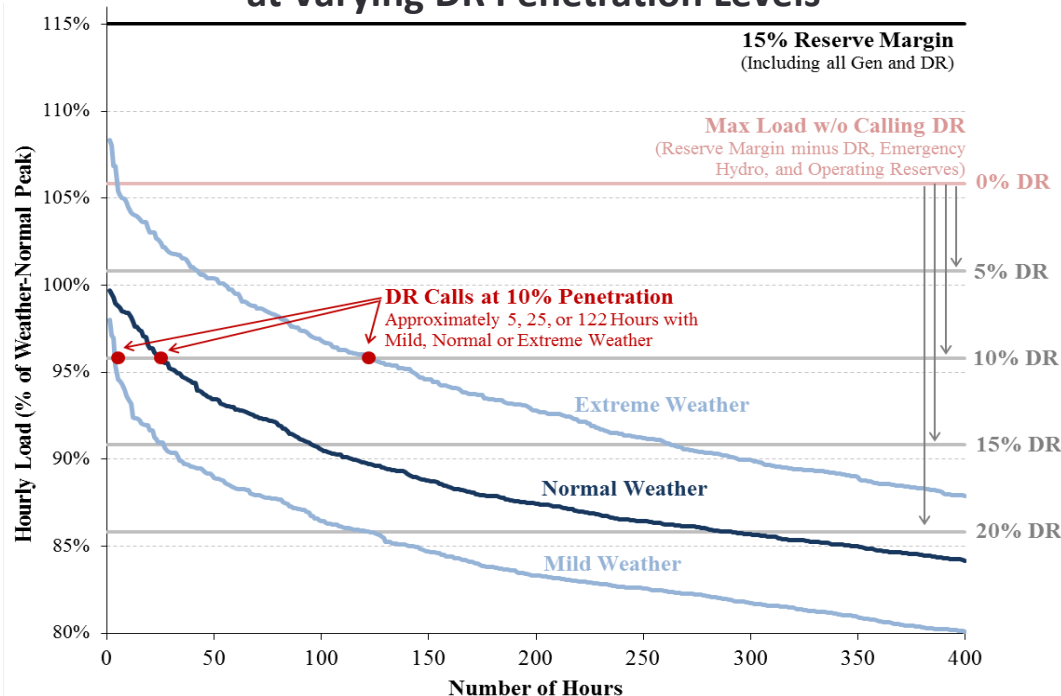
- Intertie capacity with neighboring systems has large impact on planning reserve margin
 - **Blue dots:** reserve margins to achieve 1-in-10-year LOLE
 - **Red dots:** economically-optimal reserve margins
- Strongly dependent on reserve margins in neighboring systems



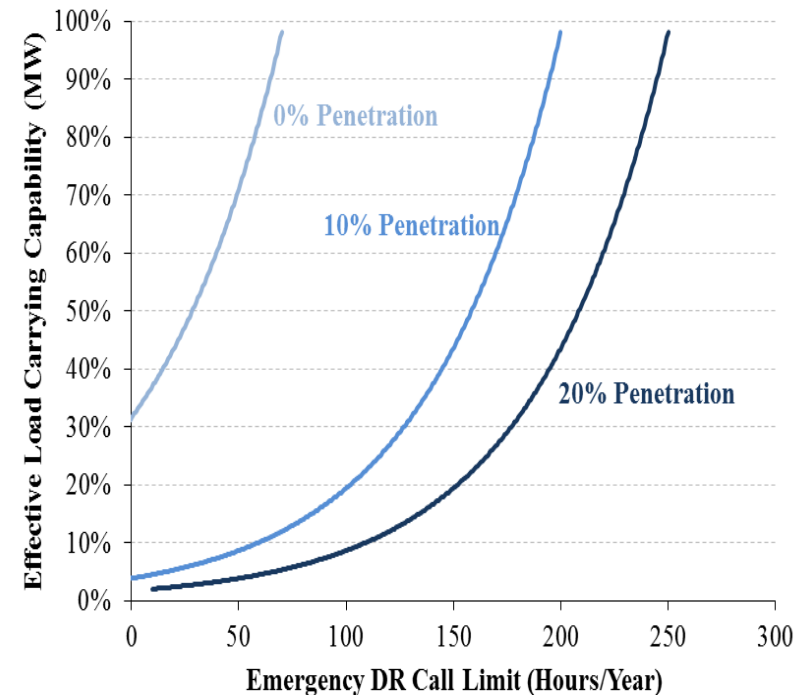
II. Value of Demand Resources

- Simulations of different levels of economic and (call-hour-limited) emergency DR show significant benefits with economically-optimal DR levels in 8%-14% range
 - Lower total costs, improved scarcity pricing, lower capacity prices
- Capacity value decreases with higher DR penetration for: (a) emergency DR with call-hour limits and (b) economic DR with bid caps

Approximate Emergency DR Dispatch Hours at Varying DR Penetration Levels

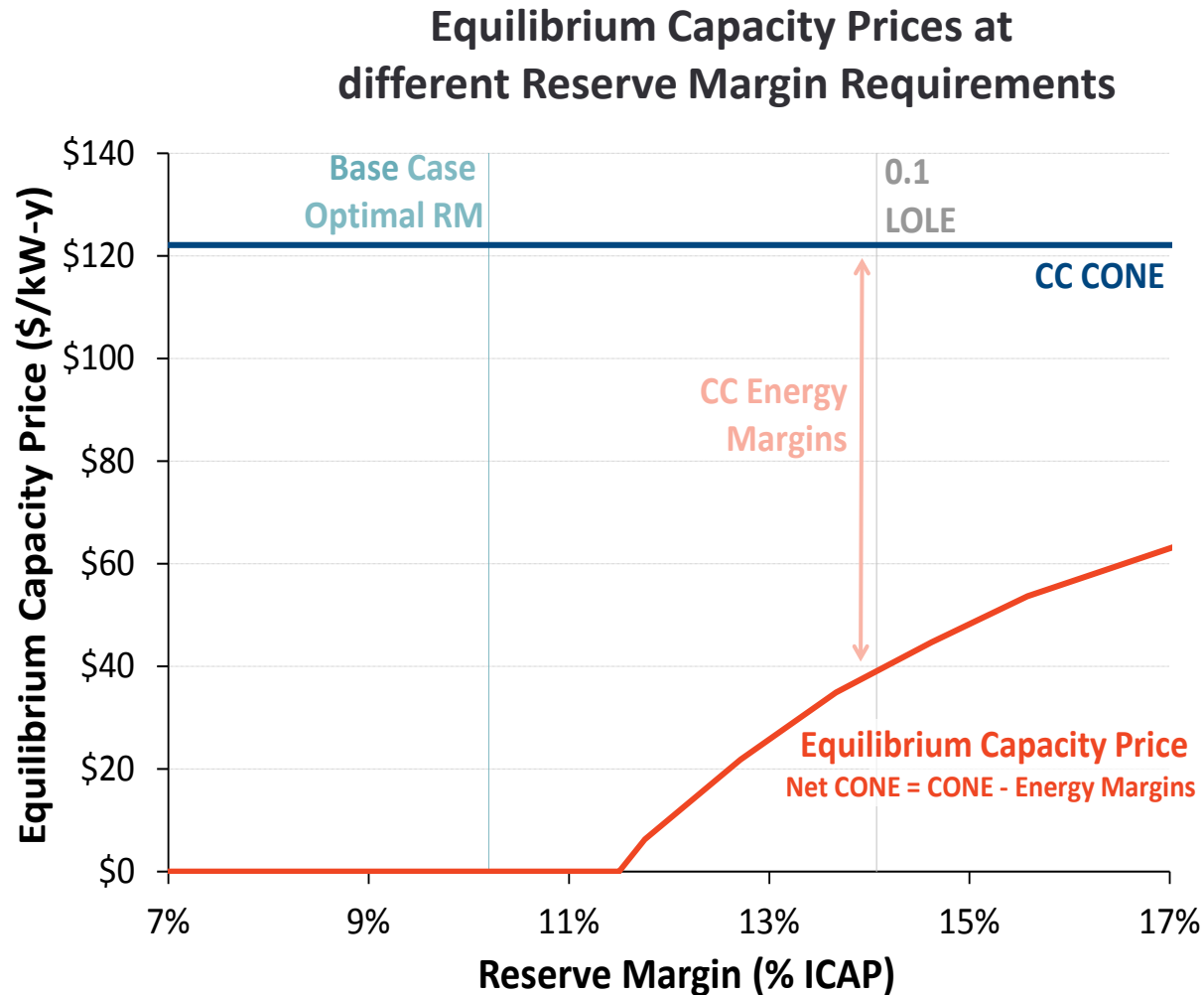


Emergency DR's Effective Load Carrying Capability (Varying DR Penetration and Call Hours)



II. Equilibrium Capacity Market Prices

- ERCOT Example: Capacity is valuable for reserve margin requirements above the 11.5% energy-only equilibrium
 - Equilibrium capacity prices set by the market at Net CONE (gross “Cost of New Entry” minus energy margins)
 - 1-in-10 reliability at 14.1% requires average capacity price of \$40/kW-yr (\$30-\$60/kW-yr in sensitivity cases)
- Even below 11.5%, a reserve margin mandate will prevent very low reserve margin outcomes, mitigate some boom-bust cycles, and make capacity more valuable than in equilibrium



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III. Experience with U.S. Capacity Markets

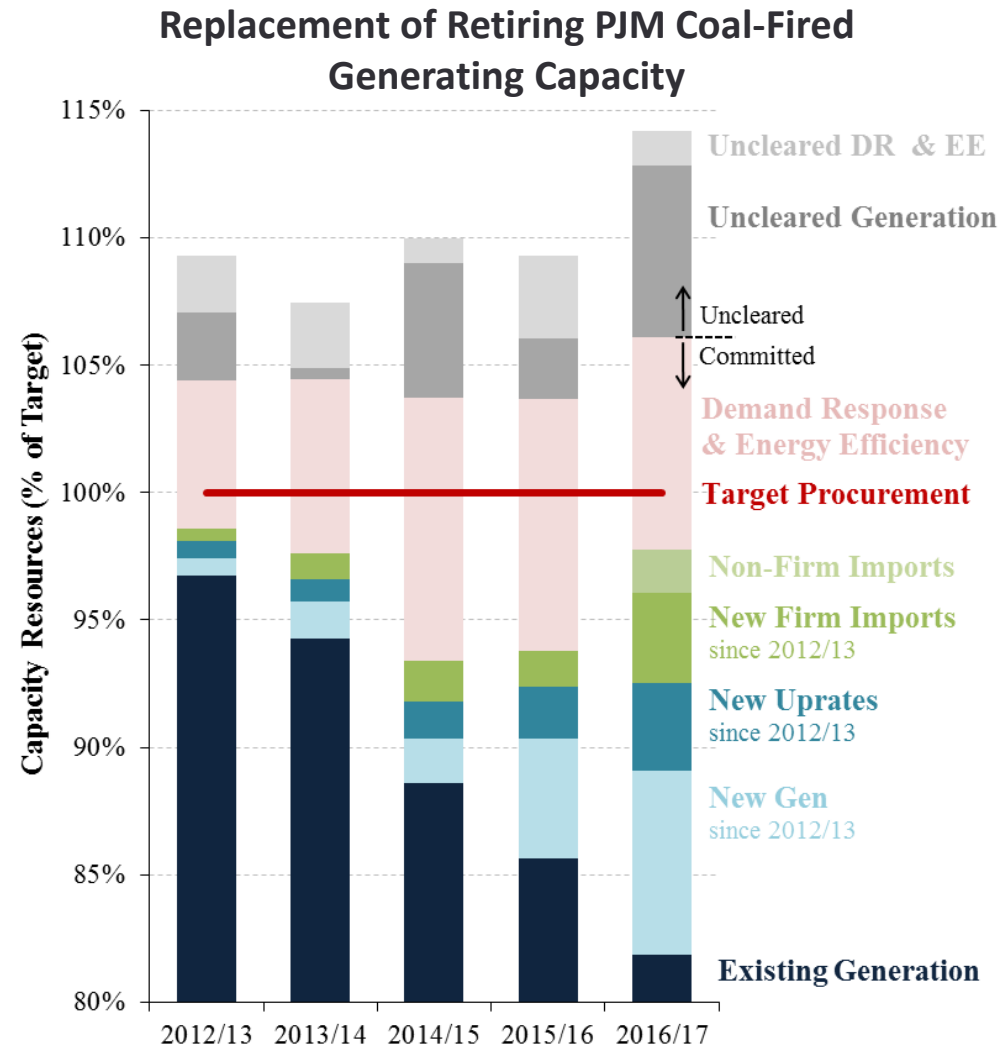
The last decade documented the efficiency and effectiveness of well-designed capacity markets:

- Attracted resources of significantly lower costs than new plants
 - Demand response, retained generation, imports, retrofits, repowering
- Quickly and efficiently adjusted to economic and regulatory “shocks”
 - Sharply lower prices (and consumer costs) after economic downturn
 - Replaced 25,000 MW of coal plant retirements in PJM at low market prices
 - Quickly restored resource adequacy in import-constrained zones
- Identified lowest-cost options for new generating plants
 - Recent merchant entry at costs substantially below common estimates for cost of new plants
 - Merchant entry at market prices well below NJ cost of long-term PPAs
- Entry despite significant merchant generation risks
 - Avoided shifting investment risks to consumers through long-term contracts
 - Stimulated innovative approaches to financing and hedging

III. Example: Market Response to Retirements

Stress Test: 25,000 MW of Coal Plant Retirements in PJM

- PJM's capacity market efficiently addressed large environmentally-driven retirements at low capacity prices (\$22-43/kW-year)
- Other markets face similar concerns, but may have less efficient response w/o forward capacity markets
- Coal retirements replaced through new generation, uprates, increased DR, and imports
- Many higher-cost new generation options offered but not needed



Sources: BRA results and parameters. Brattle 2011 RPM Review.

III. Designing Successful Capacity Markets

Market-based mechanisms for resource adequacy offer unique efficiency and innovation advantages, reducing out-of market costs imposed on consumers

But don't prematurely add capacity markets...

- ...that explicitly or inadvertently:
 - discriminate between existing and new resources
 - exclude participation by demand-side and renewable resources
 - ignore locational constraints and transmission interties
- ...just to add revenues for certain resources or to address a perceived lack of long-term contracting
- ...while also providing out-of-market payments (including long-term contracts) to some resources that oversupply the market and distort both short- and long-term investment signals
- ...without understanding and addressing deficiencies in energy and ancillary service markets

III. Designing Successful Capacity Markets

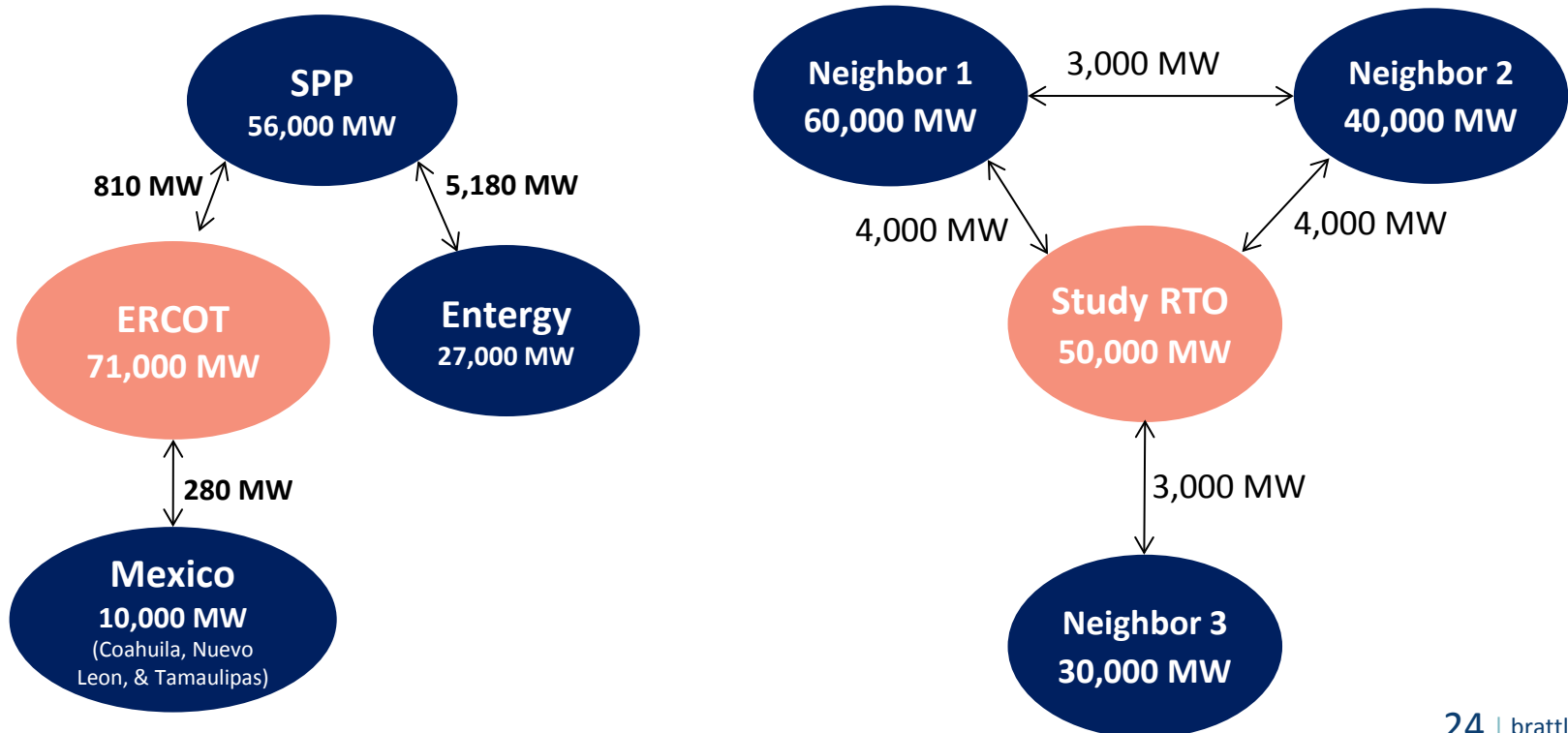
Experience from the last decade strongly suggests that successful capacity markets require:

1. Well-defined resource adequacy objectives and drivers
2. Clear understanding why market design is deficient without capacity market (inefficient or not able to achieve resource adequacy targets)
3. Clearly-defined capacity products, consistent with needs
4. Well-defined obligations, auctions, verifications, and monitoring
5. Efficient spot markets for energy and ancillary services
6. Addressing locational reliability challenges
7. Participation from all resource types (incl. DR, renewables, imports)
8. Carefully-designed forward obligations
9. Staying power to reduce regulatory risk while improving designs and addressing deficiencies
10. Capitalizing and building on experience from other markets

Appendix A: FERC and ERCOT Resource Adequacy Study Results

III. ERCOT and FERC Study Design

- ERCOT study based on actual market design and conditions. FERC study based on a hypothetical but realistic, medium-sized power market (“Study RTO”)
- Unlike ERCOT, the FERC study market has significant transmission interconnections to three similarly-sized neighboring regions
 - Realistic resource mix based on scaled NYISO, MISO, PJM, and Southern Company data
 - Weather (hourly load and renewable generation) based on actual TVA, MISO, PJM, and SoCo data

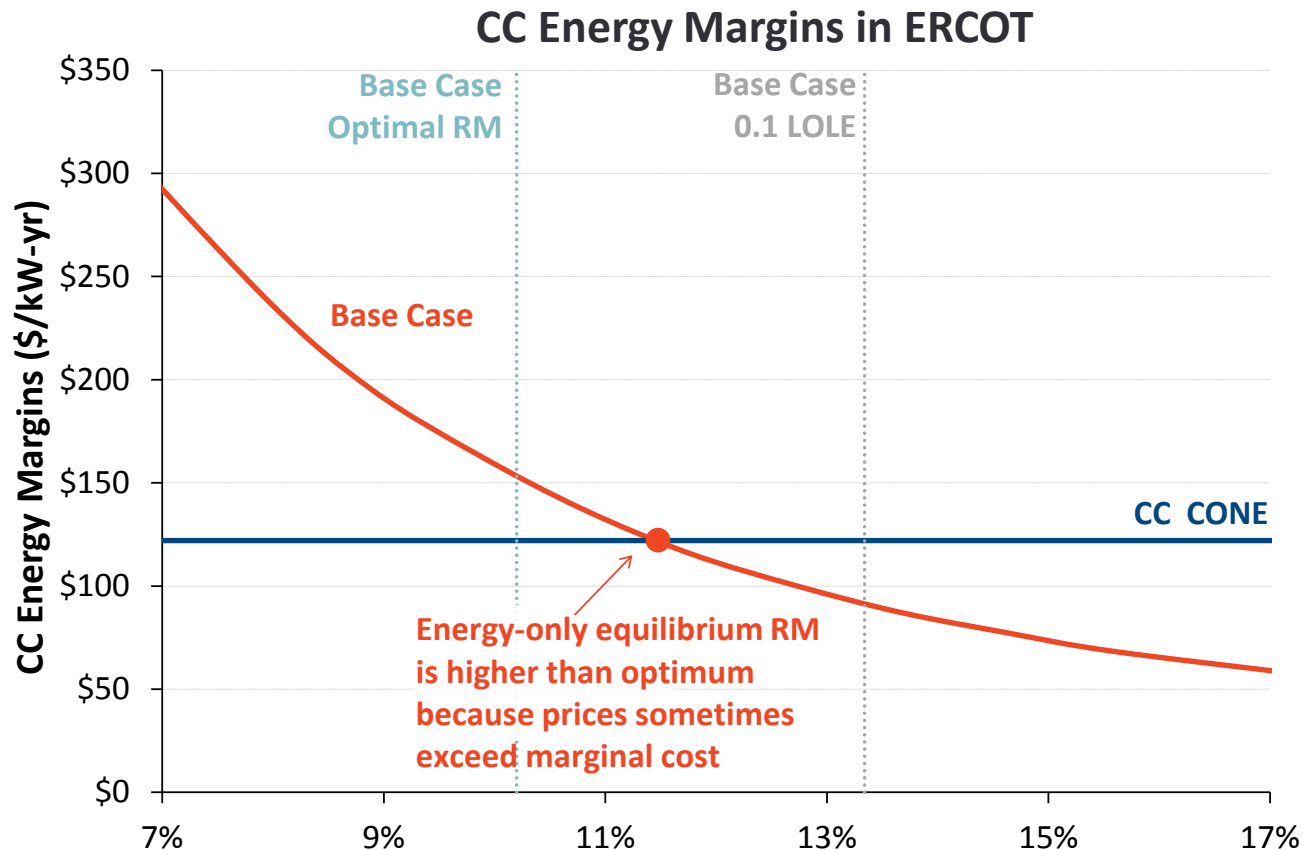


Summary of ERCOT Study

- The PUCT asked us to estimate the economically-optimal reserve margin in ERCOT to inform their ongoing review of market design for resource adequacy.
- Under base case assumptions, we estimate reserve margins of:
 - 10.2% economic optimum
 - 11.5% in equilibrium of current energy market design (minimizes customer cost)
 - 14.1% required to meet 1-in-10 reliability standard
- Enforcing a 1-in-10 reserve margin requirement at 14.1% (with or without a centralized capacity market) would increase long-run average customer costs by approximately 1% of retail rates relative to the 11.5% energy-only market in equilibrium :
 - Considered only energy and capacity price impacts
 - Potential additional benefits: risk mitigation, DR integration
 - Potential additional costs: implementation, added complexity, disputes

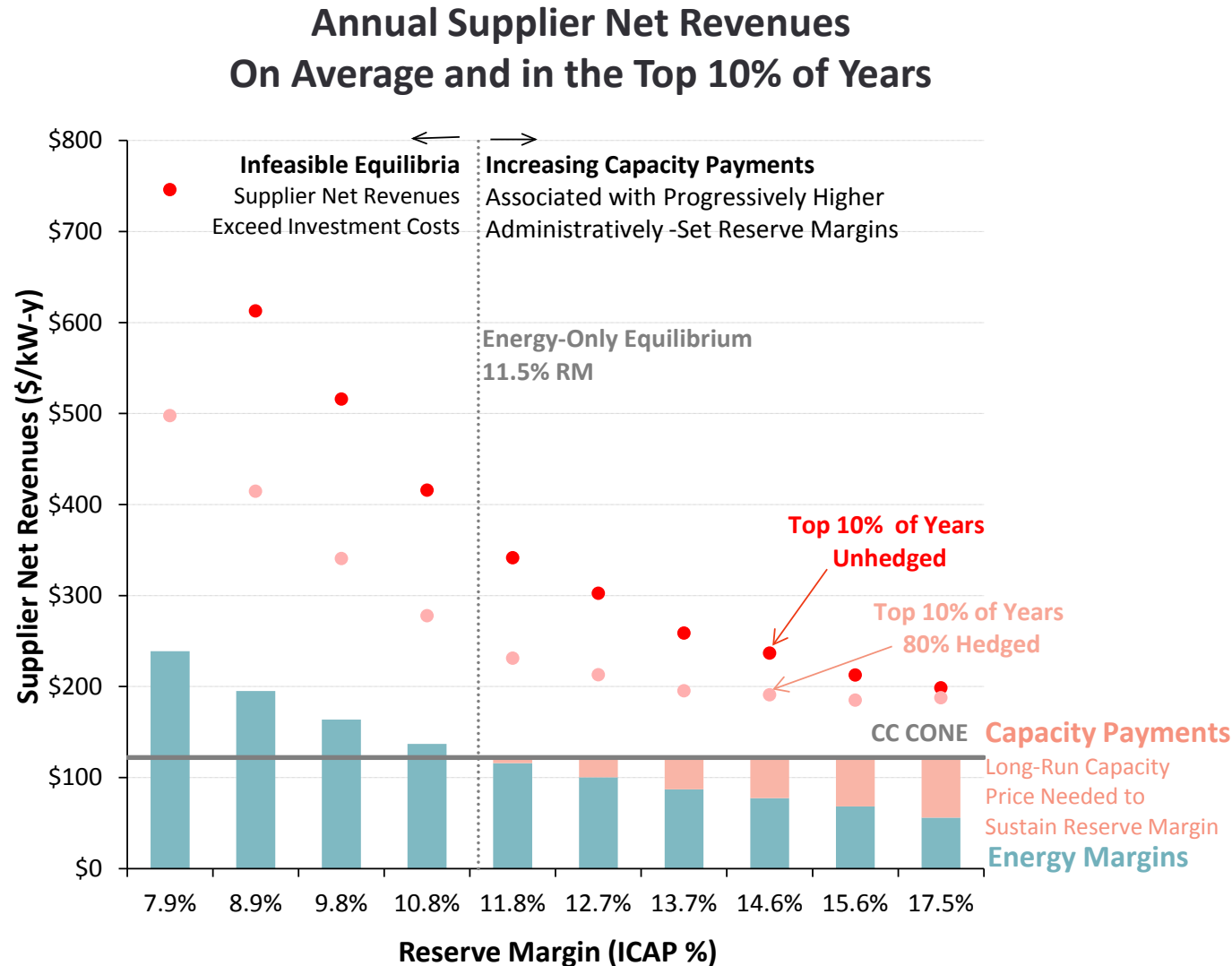
ERCOT Energy-Only Market Equilibrium

- Risk neutral, equilibrium reserve margin determined by market forces, where supplier energy margins equal the gross Cost of New Entry (CONE)
- Current ERCOT market design results in 11.5% equilibrium reserve margin for base case (9-13% for sensitivity cases)
 - Equilibrium exceeds economic optimum because administrative scarcity prices exceed marginal costs in some cases
- Significantly greater uncertainty of actual outcomes



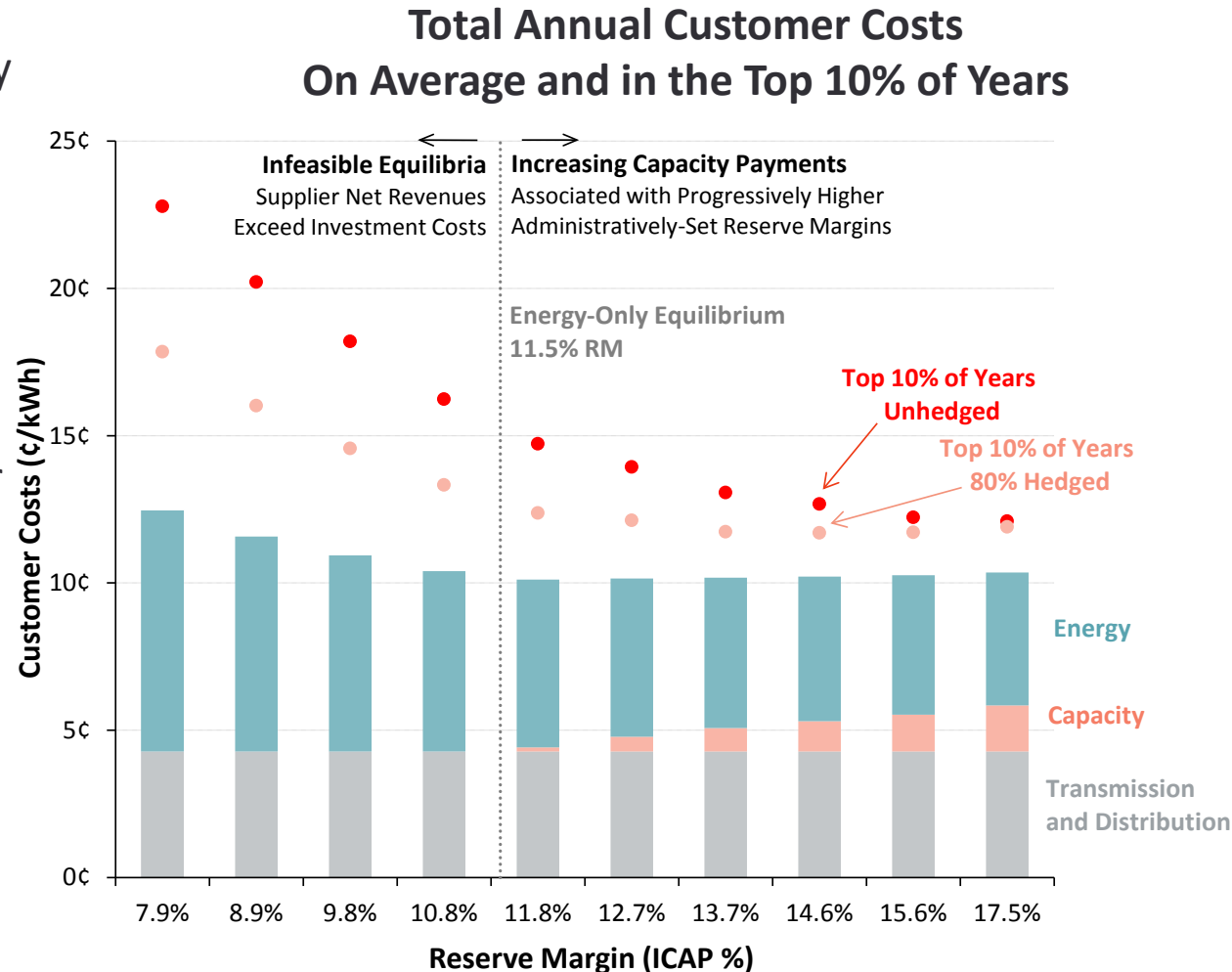
ERCOT Study: Supplier Net Revenues

- Total supplier net revenues must reach CONE (on a long-run average basis) to attract new entry
- At higher reserve margin mandates, the source of revenues shifts from energy to capacity market (capacity makes up 32% of net revenues at 1-in-10)
- Volatility in supplier net revenues is reduced at higher reserve margins (but much of it can also be achieved through hedging)



ERCOT Study: Total Customer Costs

- ERCOT customer costs are minimized at the energy-only equilibrium and increase if higher reserve margin mandates are imposed
- A 14.1% reserve margin mandate (at 1-in-10) would increase customer costs by approximately \$400 mil/year or 1% in long-run equilibrium
- The near-term difference between energy-only and capacity markets is more substantial because energy prices are currently below equilibrium levels (excess capacity relative to energy-only equilibrium)



ERCOT Study: Summary of Results

		Energy-Only Market		Capacity Market at 1-in-10	
		Base Case	Sensitivity Cases	Base Case	Sensitivity Cases
Equilibrium Reserve Margin	(%)	11.5%	9.3%-12.9%	14.1%	12.6% - 16.1%
Realized Reliability					
Loss of Load Events	(events/yr)	0.33	0.27 - 0.85	0.10	0.10 - 0.10
Loss of Load Hours	(hours/yr)	0.86	0.68 - 2.37	0.23	0.22 - 0.23
Normalized EUE	(% of MWh)	0.0004%	0.0003% - 0.0013%	0.0001%	0.00008% - 0.0001%
Economics in Average Year					
Energy Price	(\$/MWh)	\$58	\$58 - \$60	\$48	\$46 - \$53
Capacity Price	(\$/kW-yr)	\$0	\$0 - \$0	\$39	\$30 - \$60
Supplier Net Revenue	(\$/kW-yr)	\$122	\$97 - \$122	\$122	\$97 - \$122
Average Customer Cost	(¢/kWh)	10.1¢	10.1¢ - 10.7¢	10.2¢	10.2¢ - 10.8¢
Total Customer Costs	(\$B/Yr)	\$35.7	\$35.7 - \$37.8	\$36.1	\$36.0 - \$38.3
Economics in Top 10% of Years					
Energy Price	(\$/MWh)	\$99	\$95 - \$102	\$65	\$58 - \$77
Capacity Price	(\$/kW-yr)	\$0	\$0 - \$0	\$76	\$30 - \$116
Supplier Net Revenue (Unhedged)	(\$/kW-yr)	\$362	\$173 - \$444	\$249	\$152 - \$302
Supplier Net Revenue (80% Hedged)	(\$/kW-yr)	\$244	\$119 - \$259	\$193	\$128 - \$289
Average Customer Cost (Unhedged)	(¢/kWh)	15.1¢	13.4¢ - 23.0¢	12.9¢	12.4¢ - 17.9¢
Average Customer Cost (80% Hedged)	(¢/kWh)	12.6¢	9.8¢ - 21.8¢	11.7¢	10.2¢ - 17.7¢
Total Customer Costs (Unhedged)	(\$B/Yr)	\$53.6	\$37.4 - \$81.5	\$45.7	\$43.9 - \$63.3
Total Customer Costs (80% Hedged)	(\$B/Yr)	\$44.7	\$34.6 - \$77.2	\$41.5	\$36.2 - \$62.9

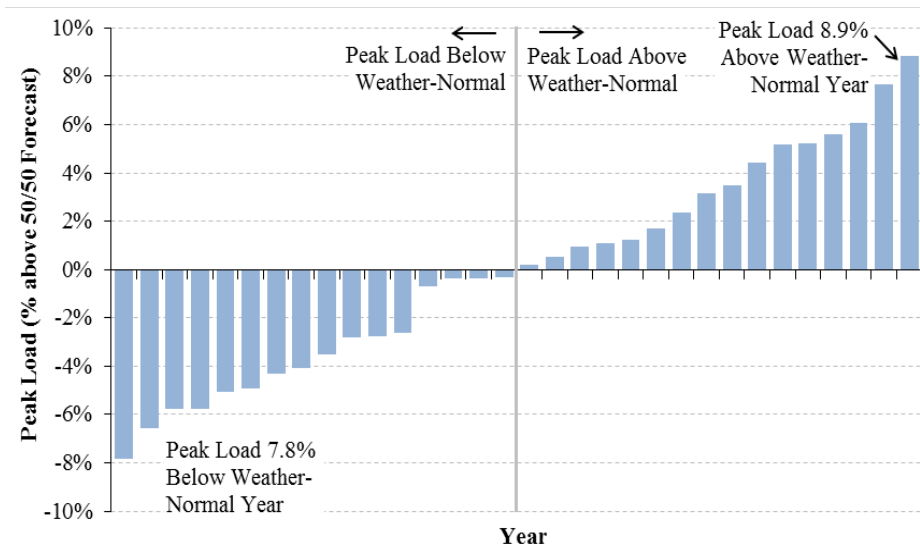
Summary of FERC Study

- Scope of September 2013 Study (released by FERC in Feb 2014):
 - Assessed economic/reliability implications of different resource adequacy standards.
 - Examine the widely-used one-day-in-ten-years (1-in-10) loss of load standard and compare it to alternative approaches to defining resource adequacy
 - Evaluate the implications of different resource adequacy standards from a customer cost, societal cost, risk mitigation, market structure, and market design perspective.
- Documented wide differences in application of 1-in-10 standard
 - 0.1 loss of load events (LOLE) per year interpretation is most widely used
 - 2.4 loss of load hours (LOLH) per year, economic reserve margins, and normalized expected unserved energy (EUE) also applied
- Even different applications of 0.1 LOLE standard and calculation of reserve margin have up to 5 percentage point impact on planning reserve margin
 - Different definition of “event” (e.g., load shed vs. operating reserve depletion)
 - Reserve margin based on name plate or de-rated capacity (e.g. for renewables)
 - Different treatment of inertia benefits, load growth uncertainty, etc.
- More explicit recognition of these wide difference would provide much-needed flexibility in market design for resource adequacy and flexibility needs

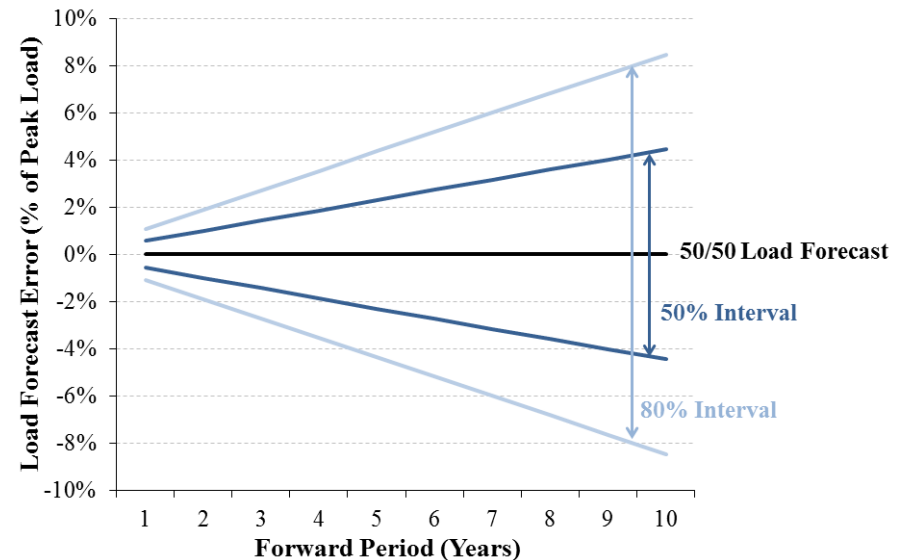
Uncertainties Considered

- Key uncertainties considered:
 - Forced/planned generation outages and intertie-transmission derates
 - Weather-related impacts on load and renewable generation (32 weather years)
 - Economic load-growth uncertainty over range of forward periods (1 to 10 years, 4-yr base)
- Administrative scarcity pricing, reserve depletion, DR- and emergency-generation

**FERC Study RTO Summer Peak Load
under Different Weather Profiles**

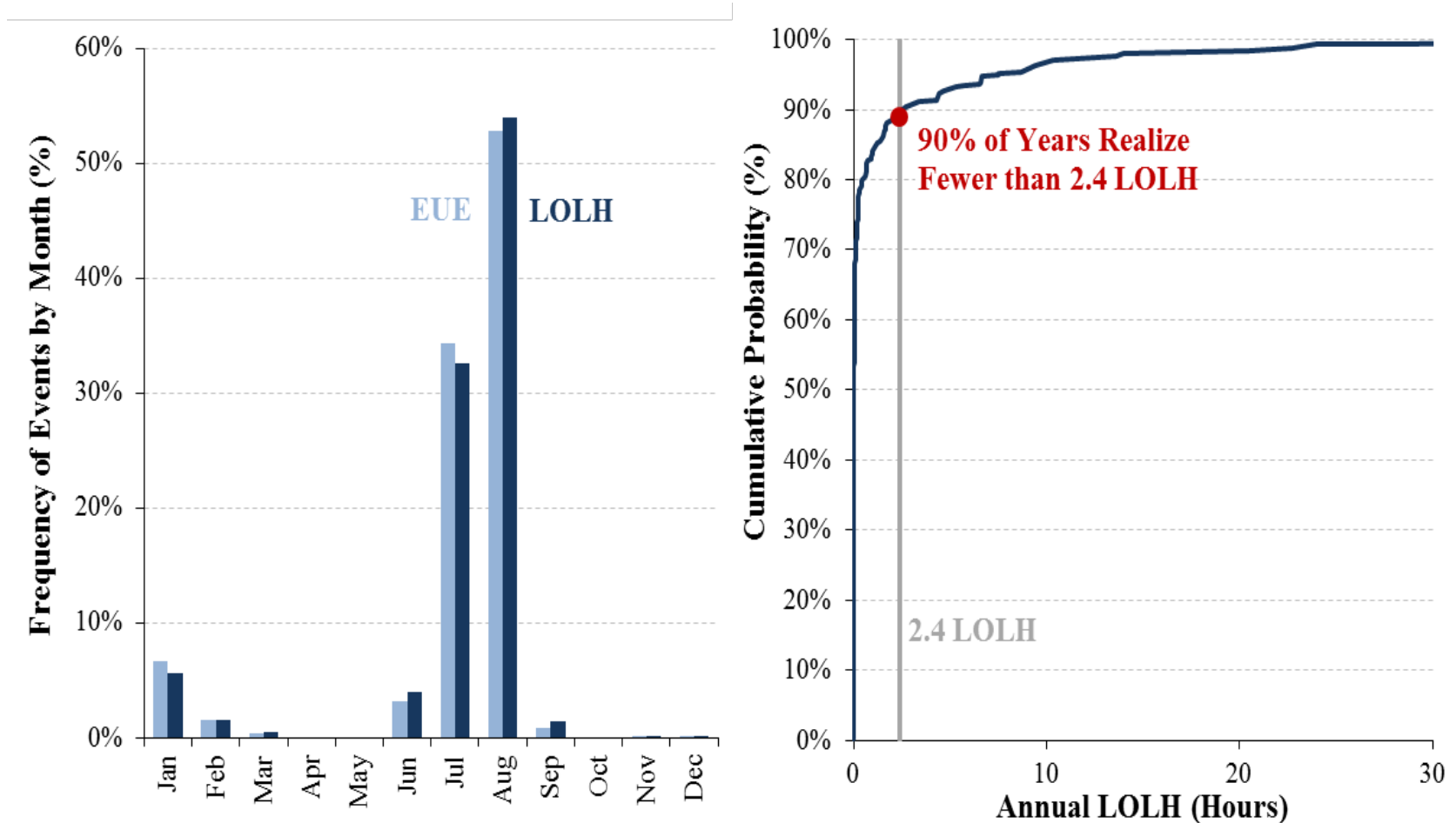


**FERC Study Economic Load Forecast Error
vs. Forward Planning Period**



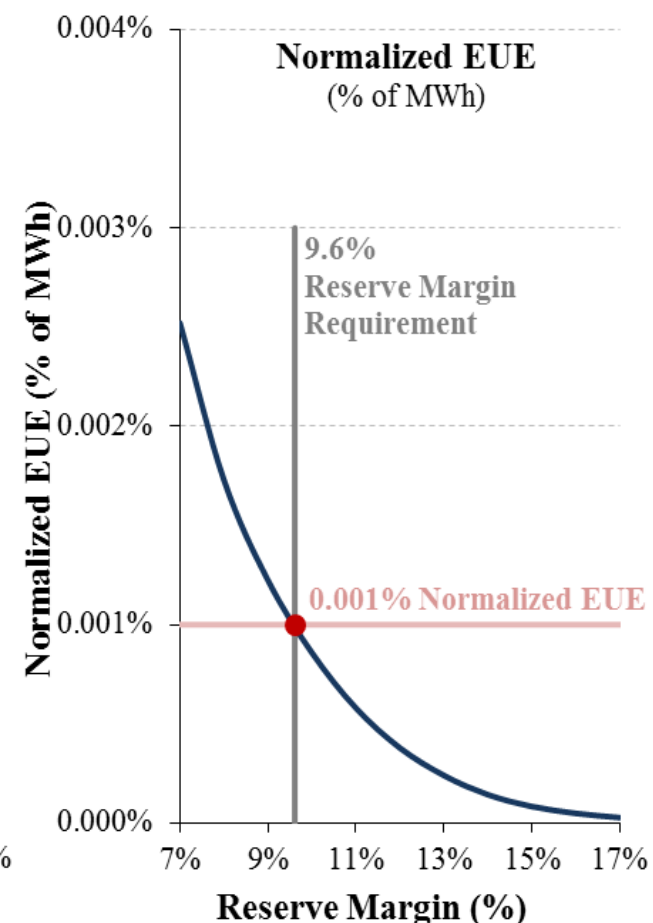
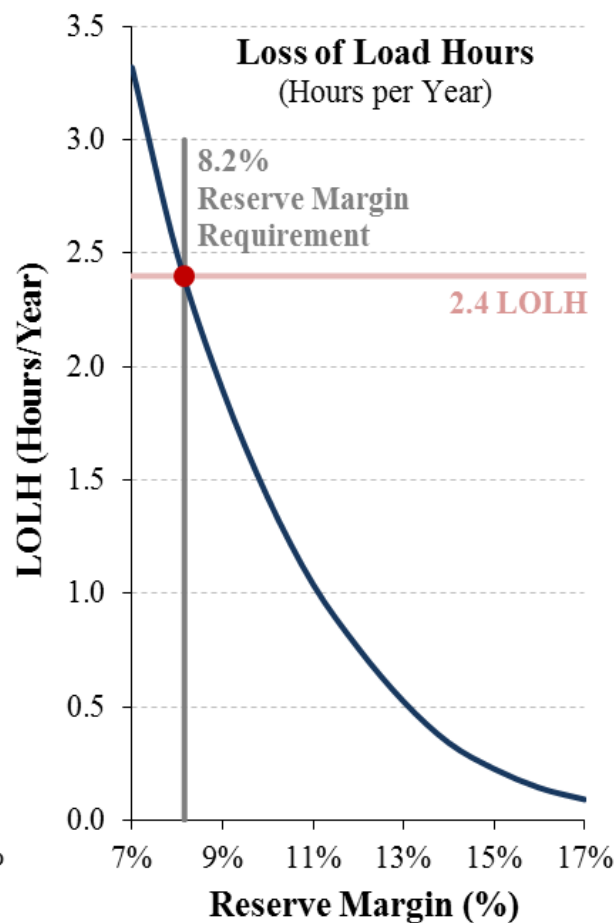
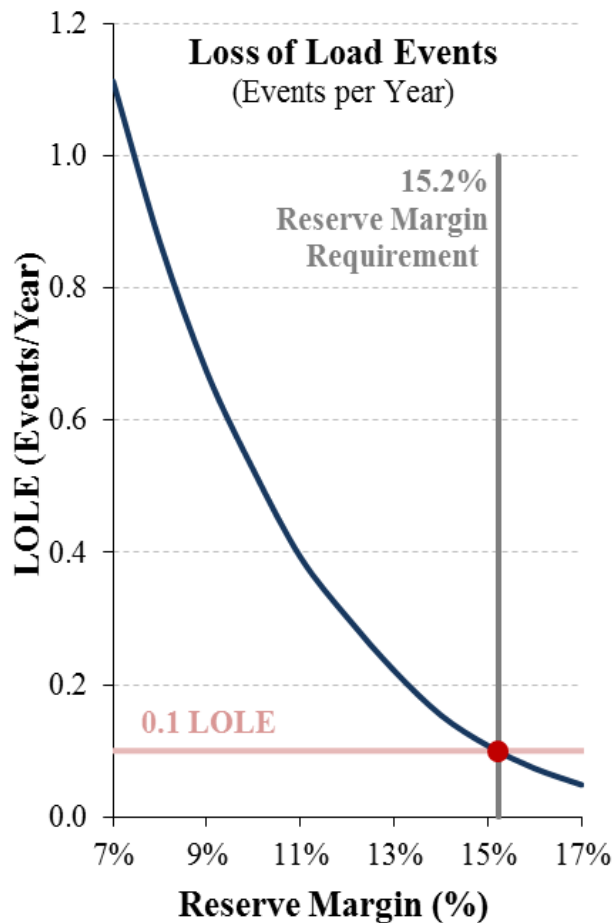
Distribution of Outage Events

Distribution of Loss of Load Hours at 12% Planning Reserve Margin in FERC Study
Across Months (Left) and Across Simulation Years (Right)



Outage Events vs. Planning Reserve Margin

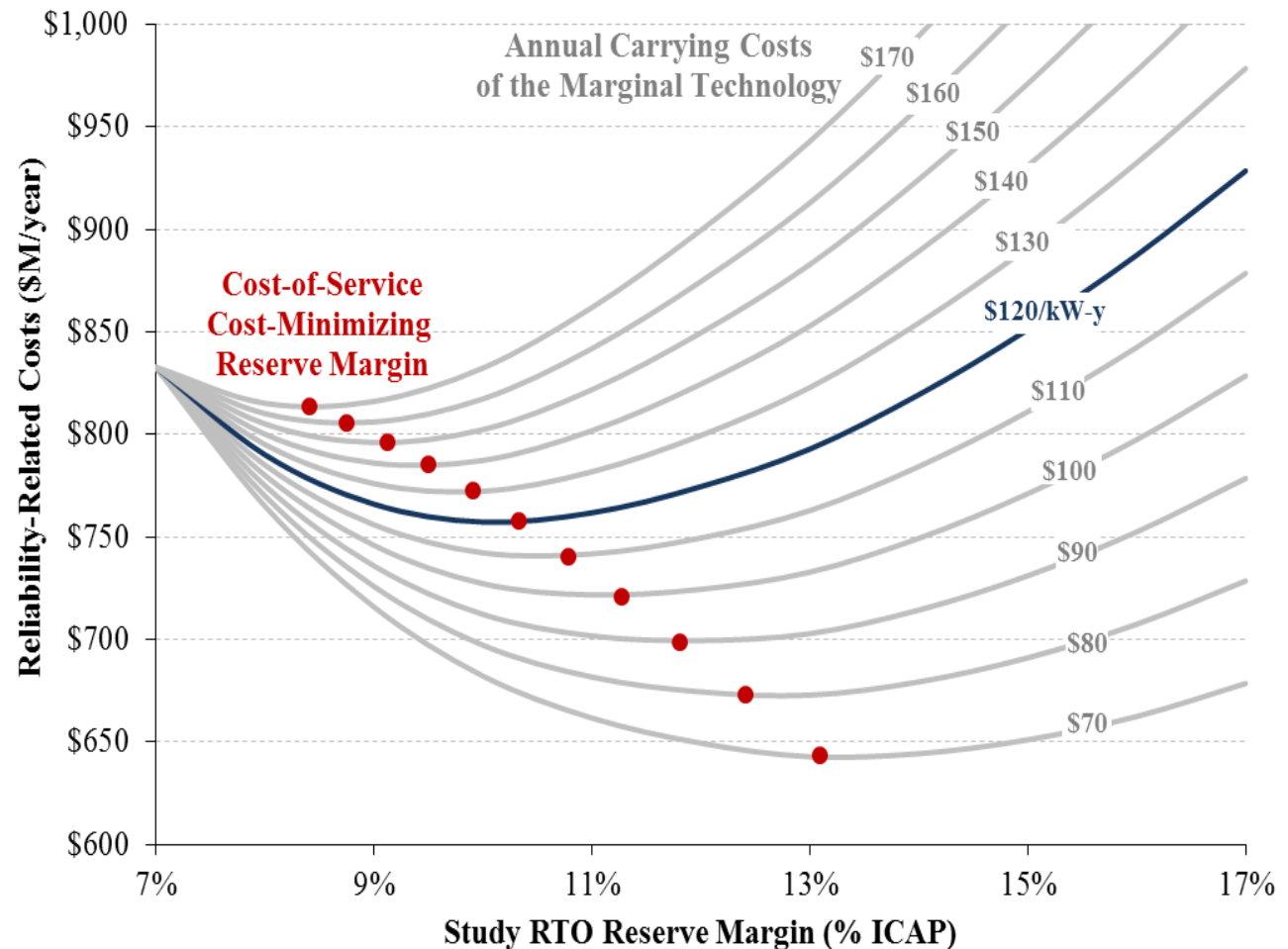
Planning Reserve Margins Required to Meet Different Physical Reliability Standards in FERC Study



Economic Reserve Margins vs. Cost of New Entry

- Economically-optimal reserve margins decrease as the marginal cost of adding new resources increases
- Allows estimation of a capacity market “demand curve” that is not dependent on estimates for Net CONE

Cost-Minimizing Reserve Margin with Varying CT CONE
(FERC Study, Risk-Neutral, Cost of Service Perspective)



FERC Study: Physical & Economic Reserve Margins

Reliability-Based and Economically-Based Reserve Margin Targets (FERC Study: Base and Sensitivity Case Simulations)

Simulation	Reliability-Based			Risk-Neutral, Cost-Minimizing	
	0.1 LOLE	2.4 LOLH	0.001% Normalized EUE	Cost-of-Service Perspective	Societal Perspective
Base Case	15.2%	8.2%	9.6%	10.3%	7.9%
Lower Price Caps					
\$1,000 Price Cap Case	15.2%	8.2%	9.6%	8.7%	7.9%
\$3,000 Price Cap Case	15.2%	8.2%	9.6%	9.5%	7.9%
Smaller System Size					
40% Size Case	14.8%	<6%	7.5%	<6%	<6%
40% Size and Transmission	15.1%	6.9%	8.1%	<6%	<6%
Neighbor Assistance					
Long Neighbors Case	13.0%	<6%	7.0%	8.0%	<6%
50% Transmission Case	15.8%	9.8%	10.0%	12.3%	10.5%
Island Case	18.5%	16.5%	15.8%	16.5%	16.5%
Marginal CC Case	15.3%	8.3%	9.8%	10.1%	7.7%

FERC Study: Economic Reserve Margin

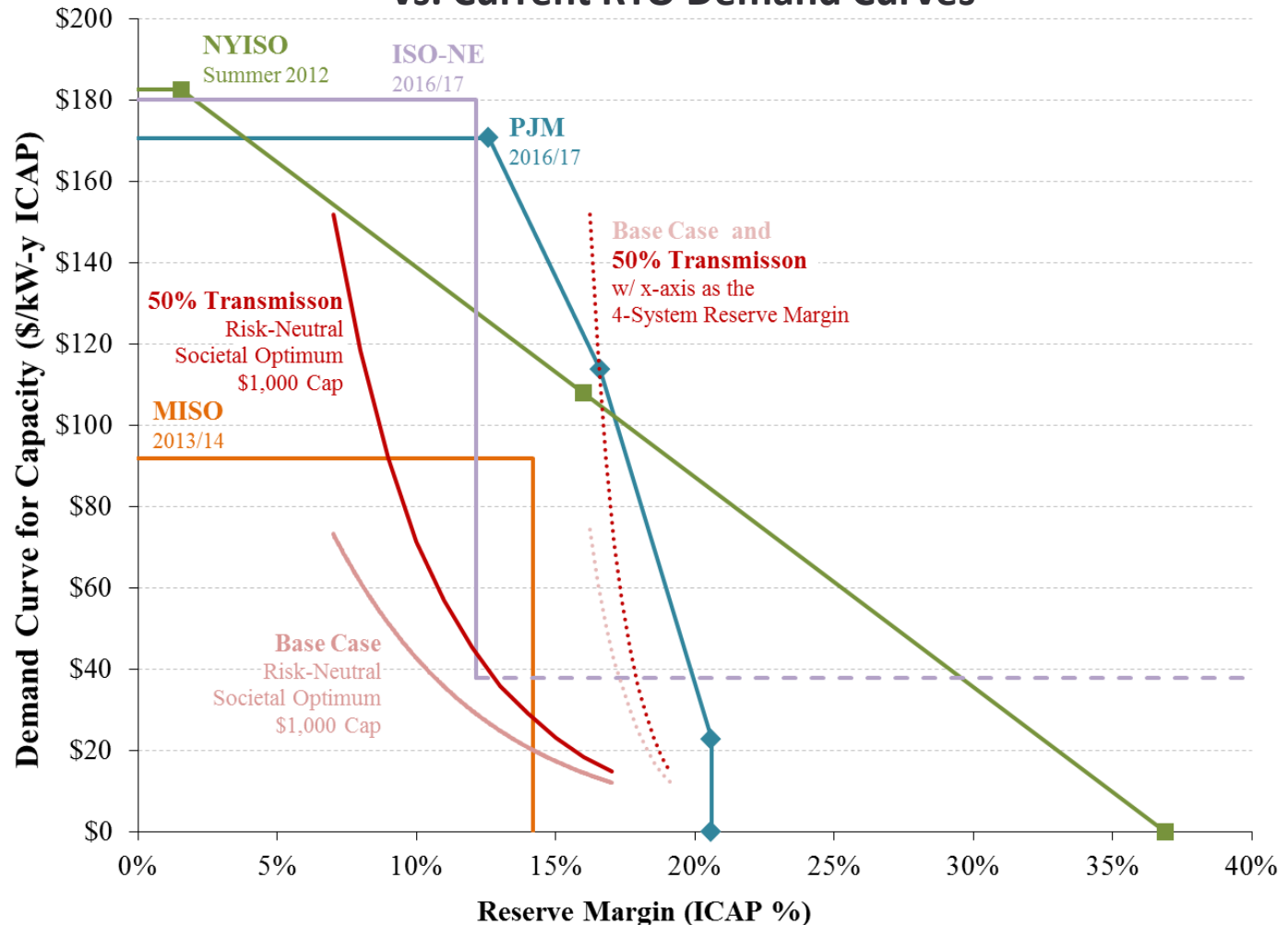
Sensitivity of Economically Optimal Reserve Margin to Economic Study Assumptions (Risk Neutral, Cost-of-Service Perspective)

	Reserve Margin Range (% ICAP)	Base Case	Low/High Sensitivity
Base Case	10.30%	n/a	n/a
Emergency Event Costs			
Emergency Generation	10.2% - 10.5%	\$500/MWh	\$250 - \$1000/MWh
Emergency DR	9.9% - 10.9%	\$2000/MWh	\$1000 - \$3000/MWh
Emergency Hydro	10.2% - 10.5%	\$3,000/MWh	\$1,500 - \$6,000/MWh
Voltage Reduction	10.2% - 10.4%	\$7,000/MWh	\$3,500 - \$14,000/MWh
VOLL	10.0% - 11.6%	\$7,500/MWh	\$3,750 - \$15,000/MWh
<i>All Emergency Event Costs</i>	<i>9.2% - 12.1%</i>	<i>Base</i>	<i>50% or 200% Base</i>
Other Assumptions			
Load Forecast Error	9.4% - 11.0%	4 Years Forward	2 Years - 6 Years
CONE	9.5% - 11.3%	\$120/kW-y	\$100 - \$140/kW-y
Transmission Ownership	8.3% - 12.3%	50/50 Ownership	Importer/Exporter Owns

Demand-Curves for Capacity Markets

- FERC Study showed economically-determined demand curves for capacity are in the general range of markets' actual demand curve
- Very sensitive to market structure (such as interties with neighboring systems) and market design features (such as price caps)

Cost-Minimizing Capacity Demand Curve from FERC Study vs. Current RTO Demand Curves



Appendix B:

Characteristics of Successful Capacity Markets

Characteristics of Successful Capacity Markets

Experience from the last decade also strongly suggests that successful capacity markets require:

1. Well-defined resource adequacy needs and drivers of that need
2. Clear understanding why the current market design is deficient (inefficient or not able to achieve resource adequacy targets)
3. Clearly-defined capacity products, consistent with needs
4. Well-defined obligations, auctions, verifications, and monitoring
5. Efficient spot markets for energy and ancillary service
6. Addressing locational reliability challenges
7. Participation from all resource types
8. Carefully-designed forward obligations
9. Staying power to reduce regulatory risk while improving designs and addressing deficiencies
10. Capitalizing and building on experience from other markets

Characteristics of Successful Capacity Markets

1. Well-defined resource adequacy needs

- Meet seasonal/annual peak loads or ramping/flexibility constraints?
- Drivers of the identified needs?
- System-wide or location-specific due to transmission constraints?
- Near-term vs. multi-year forward deficiencies? Uncertainty of projected multi-year forward needs?
- Ability of all demand- and supply-side resources , including interties, to meet the identified need?

Characteristics of Successful Capacity Markets

2. Clear understanding why the current market design is inefficient or will not achieve resource adequacy targets

- Energy market designs that lead to price suppression?
 - Low price caps and inadequate scarcity pricing?
 - Poor integration of demand-response resources?
 - Substantial locational differences not reflected in market prices?
 - Operational actions that depress clearing prices?
- Challenging investment risks (e.g., in hydro-dominated markets)?
- Distortions created by out-of-market payments for some resources that lead to over-supply or high costs?
- Incomplete or poorly-designed ancillary service markets?
 - Missing ramping products?
 - Not co-optimized with energy market?
 - Operational actions that depress clearing prices?
- **Most Likely**: Resource adequacy preferences higher than what even fully-efficient energy and ancillary service markets would provide

Characteristics of Successful Capacity Markets

3. Clearly-defined capacity products, consistent with needs

- Annual and seasonal capability
- Near-term or multi-year forward obligations
- Peak load carrying vs. ramping capability
- Effective load carrying capability and outage rates of different resource types (including renewables, demand-response, and interties)
- Integration with energy and ancillary service markets

4. Well-defined obligations, auctions, verifications, monitoring, and penalties

- Ensure quality of resources and compliance without creating inadvertent bias against certain resources (e.g., demand-response, intermittent resources, imports)

Characteristics of Successful Capacity Markets

5. Efficient spot markets for energy and ancillary service

- Capacity markets can “patch-up” deficiencies in energy and ancillary service markets from a resource adequacy perspective
- Less efficient investment signals (e.g., resource types, supply- vs. demand-side resources, locations) if deficiencies in energy and ancillary service are not addressed

6. Addressing locational reliability challenges

- Resource adequacy won't be addressed efficiently if reliability concerns are locational but capacity markets aren't
- Requires locational resource adequacy targets and market design
- Requires understanding of how transmission (including interties between power markets) affect resource adequacy

Characteristics of Successful Capacity Markets

7. Participation from all resource types

- Existing and new generating plants
- Conventional, renewable/intermittent, and distributed generation
- Load (demand response)
- Interties (actively committed imports vs. resource adequacy value of uncommitted interties)

8. Carefully-designed forward obligations

- Efficiency of near-term obligations (avoid forecasting uncertainty, adjust to changes in market conditions, reduced commitment risk)
- Benefits of multi-year forward obligations (competition between new and existing resources; forward visibility; financial certainty)
- Questionable need for forward commitments greater than 3-4 years
- Avoid capacity markets as substitute for long-term contracts

Characteristics of Successful Capacity Markets

9. Staying power to reduce regulatory risk while improving designs

- Staying power of market design reduces regulatory risk and improves investment climate
- Requires careful balancing of staying power and the need to improve design elements and address deficiencies
- Challenge due to strong financial interests of different stakeholders

10. Capitalizing and building on experience from other markets

- Regional difference are important but often overstated
- Avoid the “not invented here” syndrome
- Avoid “urban myths” (e.g., no new generation built in regions with capacity markets; insufficient to support merchant investments unless 5-10 year payments can be locked in)

Appendix C: Additional Reading, About the Author and Brattle

Additional Reading

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Pfeifenberger, Newell, Earle, Hajos, Geronimo. "Review of PJM's Reliability Pricing Model (RPM)." June 30, 2008.

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Note:

The views expressed in this presentation are strictly those of the presenter and do not necessarily state or reflect the views of *The Brattle Group, Inc.*

Johannes (Hannes) Pfeifenberger is an economist with a background in power engineering and over 20 years of experience in the areas of public utility economics and finance. He has published widely, assisted clients and stakeholder groups in the formulation of business and regulatory strategy, and submitted expert testimony to the U.S. Congress, courts, state and federal regulatory agencies, and in arbitration proceedings.

Hannes has extensive experience in the economic analyses of wholesale power markets and transmission systems. His recent experience includes reviews of capacity market and resource adequacy designs, testimony in contract disputes, and the analysis of transmission benefits, cost allocation, and rate design. He has performed market assessments, market design reviews, asset valuations, and cost-benefit studies for investor-owned utilities, independent system operators, transmission companies, regulatory agencies, public power companies, and generators across North America and internationally.

Hannes received an M.A. in Economics and Finance from Brandeis University and an M.S. in Power Engineering and Energy Economics from the University of Technology in Vienna, Austria.

About The Brattle Group

The Brattle Group provides consulting and expert testimony in economics, finance, and regulation to corporations, law firms, and governmental agencies worldwide.

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Our services to the electric power industry include:

- Climate Change Policy and Planning
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- Demand Response and Energy Efficiency
- Electricity Market Modeling
- Energy Asset Valuation
- Energy Contract Litigation
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- Fuel and Power Procurement
- Incentive Regulation
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- Regulatory Strategy and Litigation Support
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- Retail Access and Restructuring
- Risk Management
- Market-Based Rates
- Market Design and Competitive Analysis
- Mergers and Acquisitions
- Transmission

About The Brattle Group

Client or Market	Resource Adequacy and Capacity Market Experience
PJM	Helped review performance and improve PJM capacity market since 2007
ISO-NE	Designed ISO-NE's new demand-curve approach
MISO	Helped implement develop MISO resource adequacy framework; short-term capacity market design; and long-term strategic planning of market design
NYISO	Evaluated benefits of switching to multi-year forward design
ERCOT	Analyzed ability of Texas energy-only market to assure resource adequacy; proposed and fully evaluated five market design alternatives; simulated cost/risk/reliability tradeoffs between energy-only and capacity market
CAISO	Reviewed for Calpine California resource adequacy construct, documented inefficiencies created by of state-sponsored long-term planning and procurement process, proposed options to improve market
Alberta	Analyzed ability of energy-only market to assure resource adequacy
Italy, Russia	Helped Terna (Italian system operator) design its forward capacity market proposal; reviewed Russian capacity market for two clients
FERC	Analyzed resource adequacy designs and tradeoffs between costs, risks, and reliability of in energy-only and capacity markets; analyzed impacts of key market features
Various	Analyzed resource adequacy alternatives internationally and implications of transmission interconnectors (Italy, PJM, AB, ISO-NE), renewables (AB), and demand-side (PJM, MISO)

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