Capacity Markets and Wholesale Market Outcomes

PRESENTED AT:

NBER
Economics of Electricity Markets and Regulation Workshop

PRESENTED BY

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THE Brattle GROUP

Agenda

I. **Why Capacity Markets?**

II. **Capacity Market Experience and Performance**

III. **Broader Context: Wholesale Power Market Trends and Challenges**

Why Capacity Markets?

Main Reason: "Resource Adequacy" requirements are more stringent than economically justified

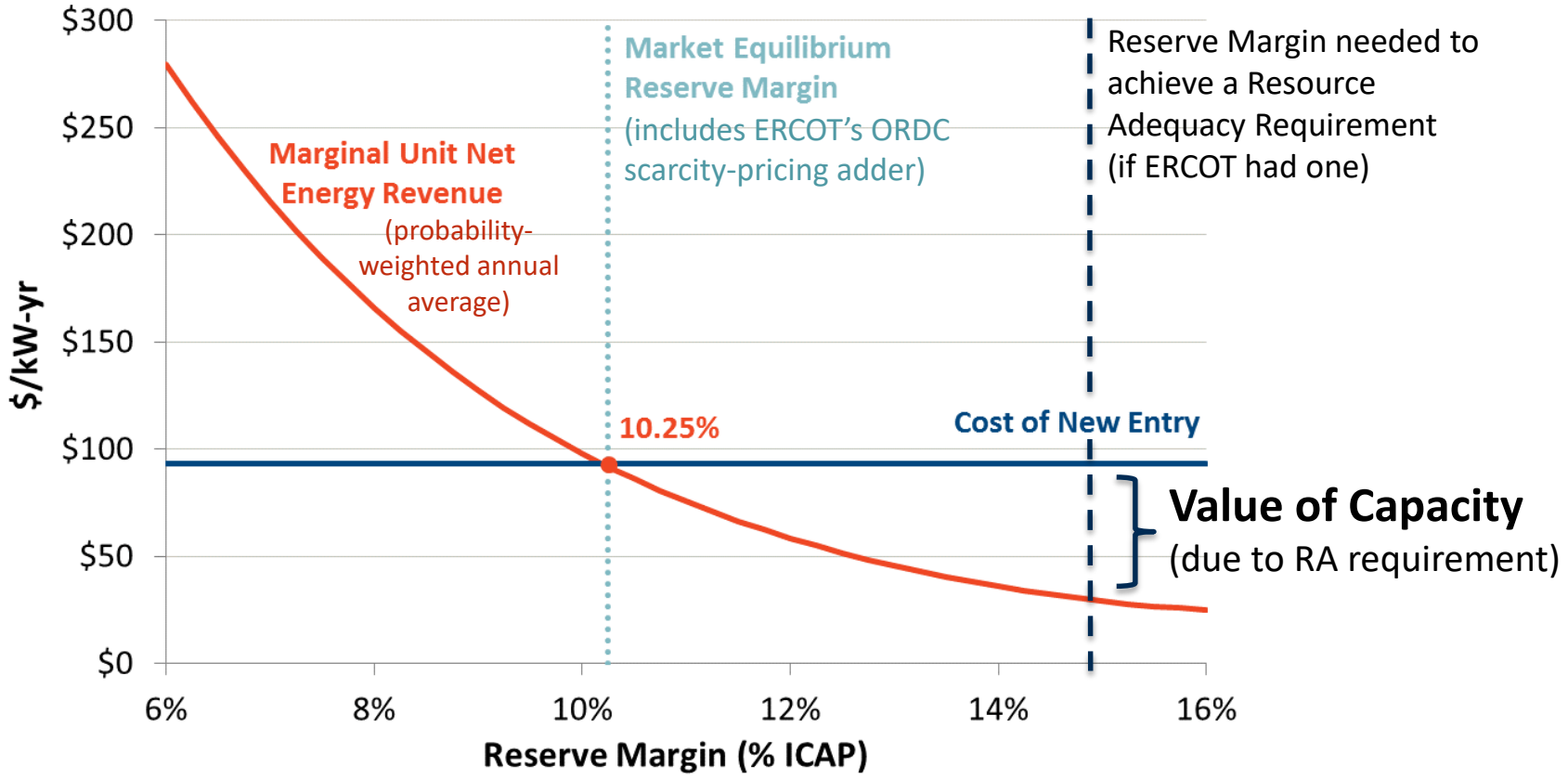
- Widely- and long-used RA standard: outages due to generation-shortages should occur only once in 10 years (the "1-in-10-year" standard)
  - Implies a Value of Lost Load (VOLL) that is approximately 10-times higher than the (risk-neutral) economic cost of outages
  - As a result, energy-only markets yields RA outcomes below what is acceptable from a public policy and operator preference perspective
- High RA requirement creates a capacity market, even if not centralized

RA outcome may even be below economically-optimal levels:

- Energy-market designs and system-operator actions that suppress prices
- Low price caps, inadequate scarcity pricing, poor integration of demand-response
- Challenging investment risks (e.g., in hydro-dominated markets)
- Incomplete or poorly-designed ancillary service markets

Capacity Value Created by a Resource Adequacy Requirement

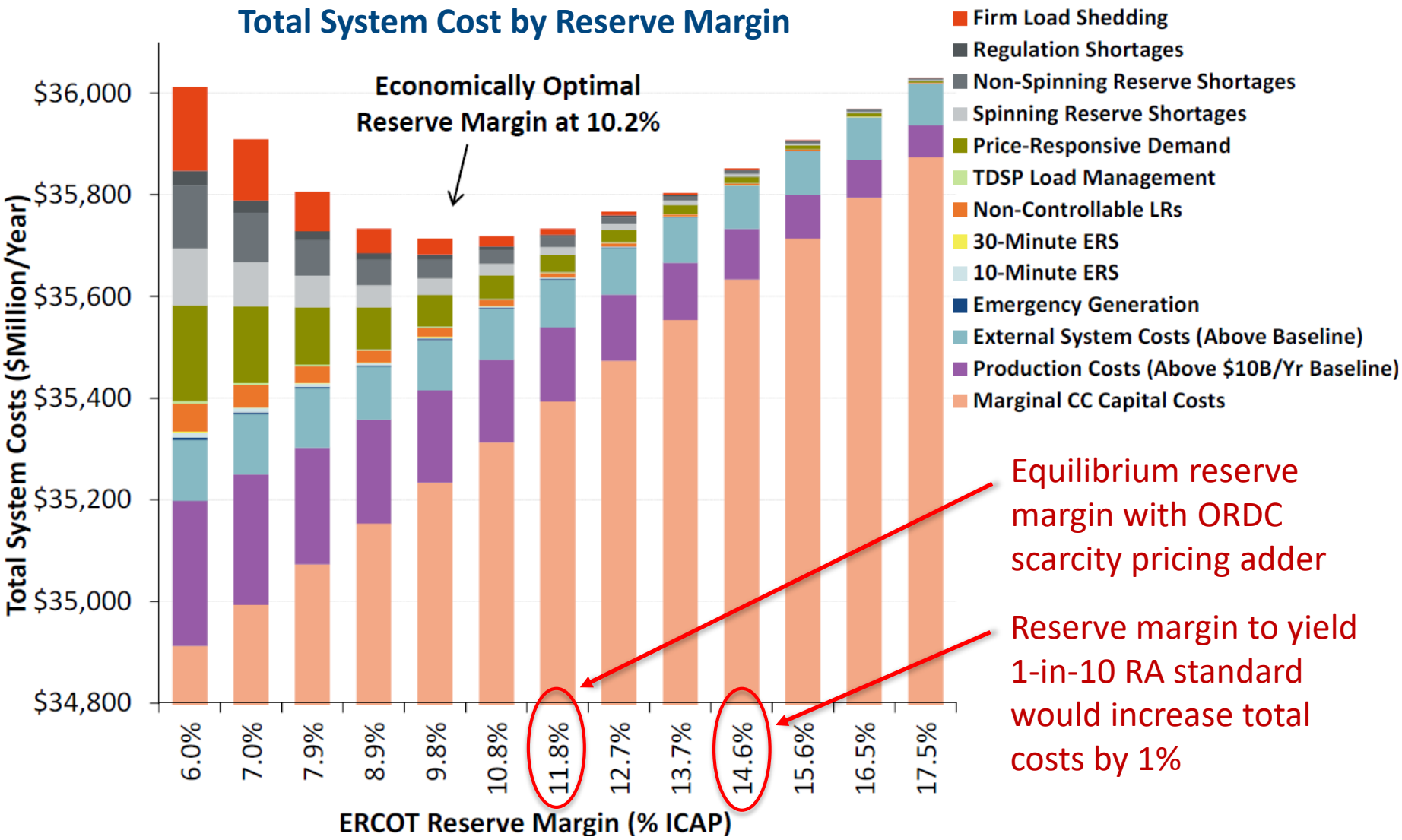
ERCOT Example: Projected 2022 Market Equilibrium Reserve Margin



Sources and Notes: Newell et. al., *Estimation of the Market Equilibrium and Economically Optimal Reserve Margins for the ERCOT Region—2018 Update* ("2018 MERM Report"), Figure 5.
http://files.brattle.com/files/15258_estimation_of_the_market_equilibrium_and_economically_optimal_reserve_margins_for_the_ercot_region.pdf.

Marginal Unit Net Energy Revenue represents the net revenue from a mix of added CCs and CTs (77:23 ratio); the CONE shown at $93.1/kW-year reflects this mix as well.

Comparison of ERCOT Market Design with and without 1-in-10 RA Requirement

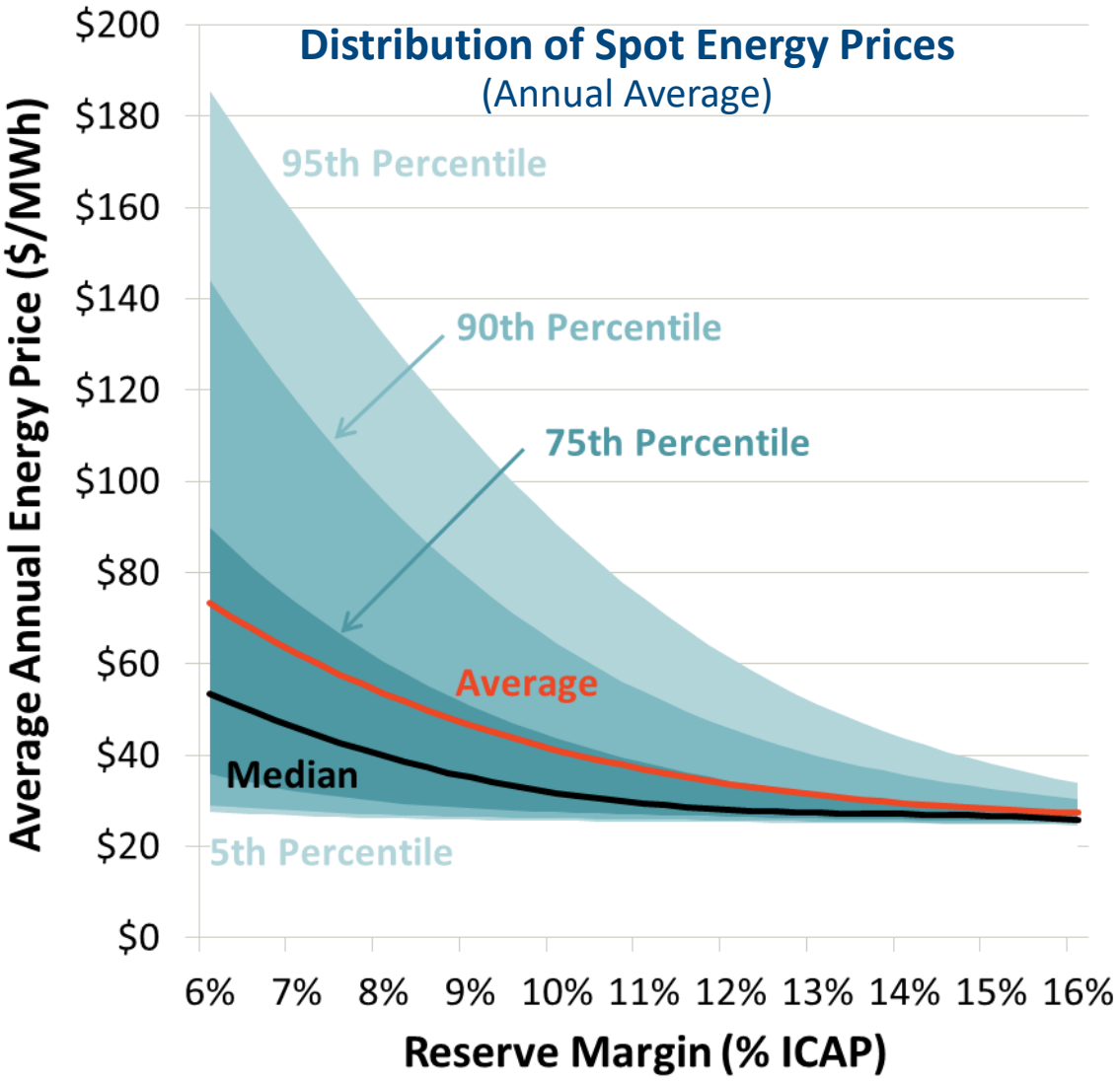


Equilibrium reserve margin with ORDC scarcity pricing adder

Reserve margin to yield 1-in-10 RA standard would increase total costs by 1%

Source: https://brattlefiles.blob.core.windows.net/files/6098_estimating_the_economically_optimal_reserve_margin_in_ercot_revised.pdf.

Additional Challenge of Energy-Only Market: Volatility in Annual Average Prices



Energy-only markets present unique investment-cost recovery and policy challenges:

- Annual averages tend to be below expected probability-weighted average most of the time
- **Cost recovery driven by 1-in-5 to 1-in-20 year scarcity events**
- High annual prices and load shed events driven by scarcity often not acceptable from public policy perspective

Source: Brattle 2018 MERM Report, Figure 6.

Comparison of ERCOT Market Design with and without 1-in-10 RA Requirement

		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

Source: https://brattlefiles.blob.core.windows.net/files/6098_estimating_the_economically_optimal_reserve_margin_in_ercot_revised.pdf.

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Capacity Market Experience to Date

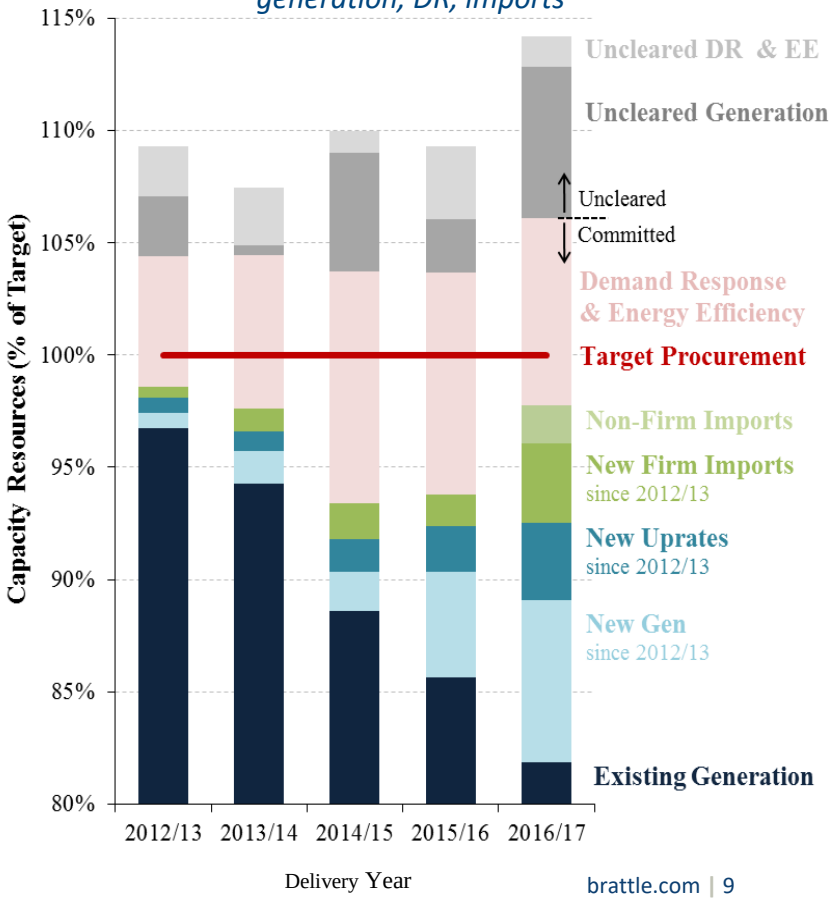
Centralized capacity markets are meeting objectives:

- *Meeting resource adequacy objectives*
  - All markets in surplus or balance
- *Fostering competition to lower costs*
  - Retention of existing capacity
  - Surprising amounts of new DR, uprates, and imports
  - Need for costly new generation was deferred
  - Clearing prices have generally been far below expected costs, even with new entry
- *Supporting merchant generation entry*
  - PJM attracted over 26 GW new generation in past 7 auctions, majority from merchants

Many ongoing refinements have been needed to ensure resources provide the reliability they advertise, to mitigate price volatility and address market power

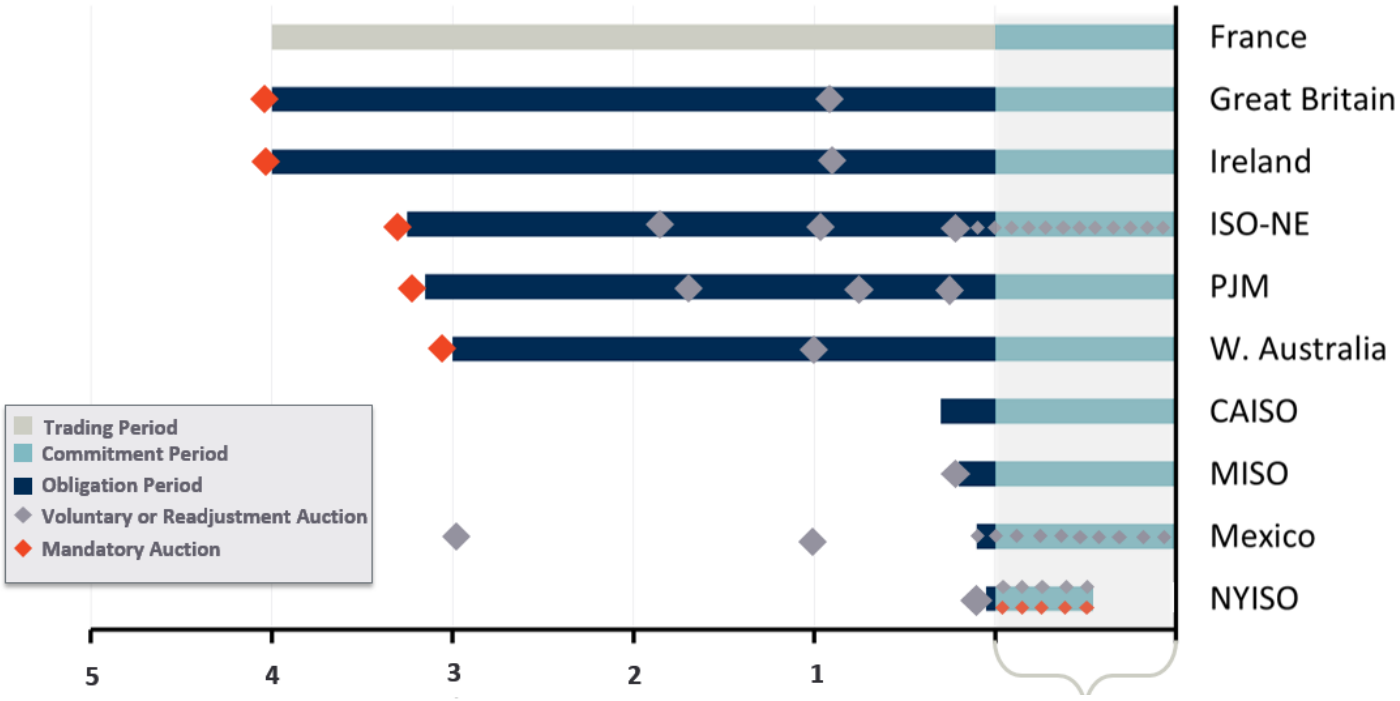
Case Study: PJM Attracting New Entry

25 GW of coal capacity retired in only a few years due to Mercury and Air Toxics Standards; the capacity market responded with replacement capacity, incl. merchant generation, DR, imports



Design Element:
Forward and Commitment Periods

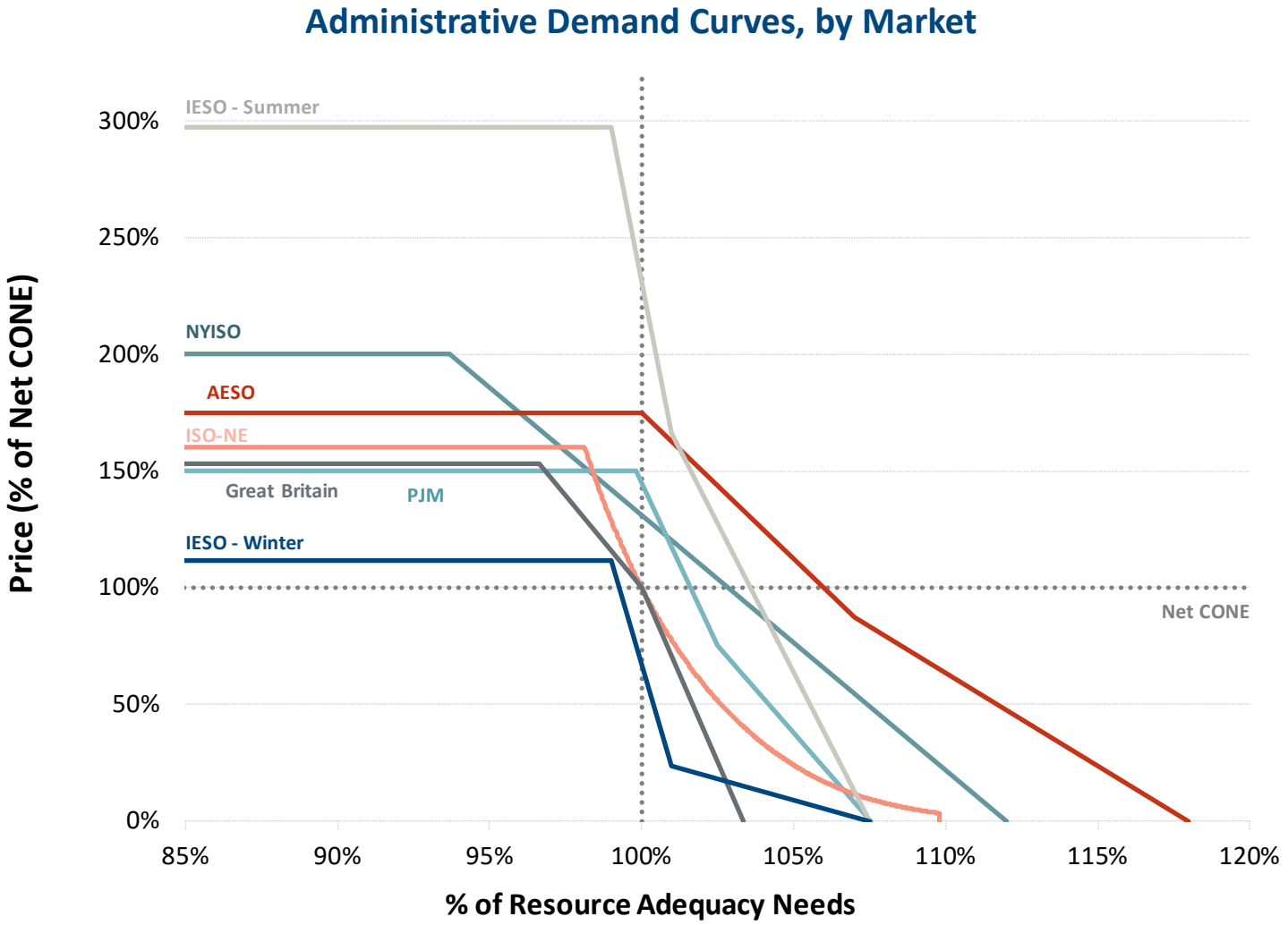
Forward Periods in Other Markets



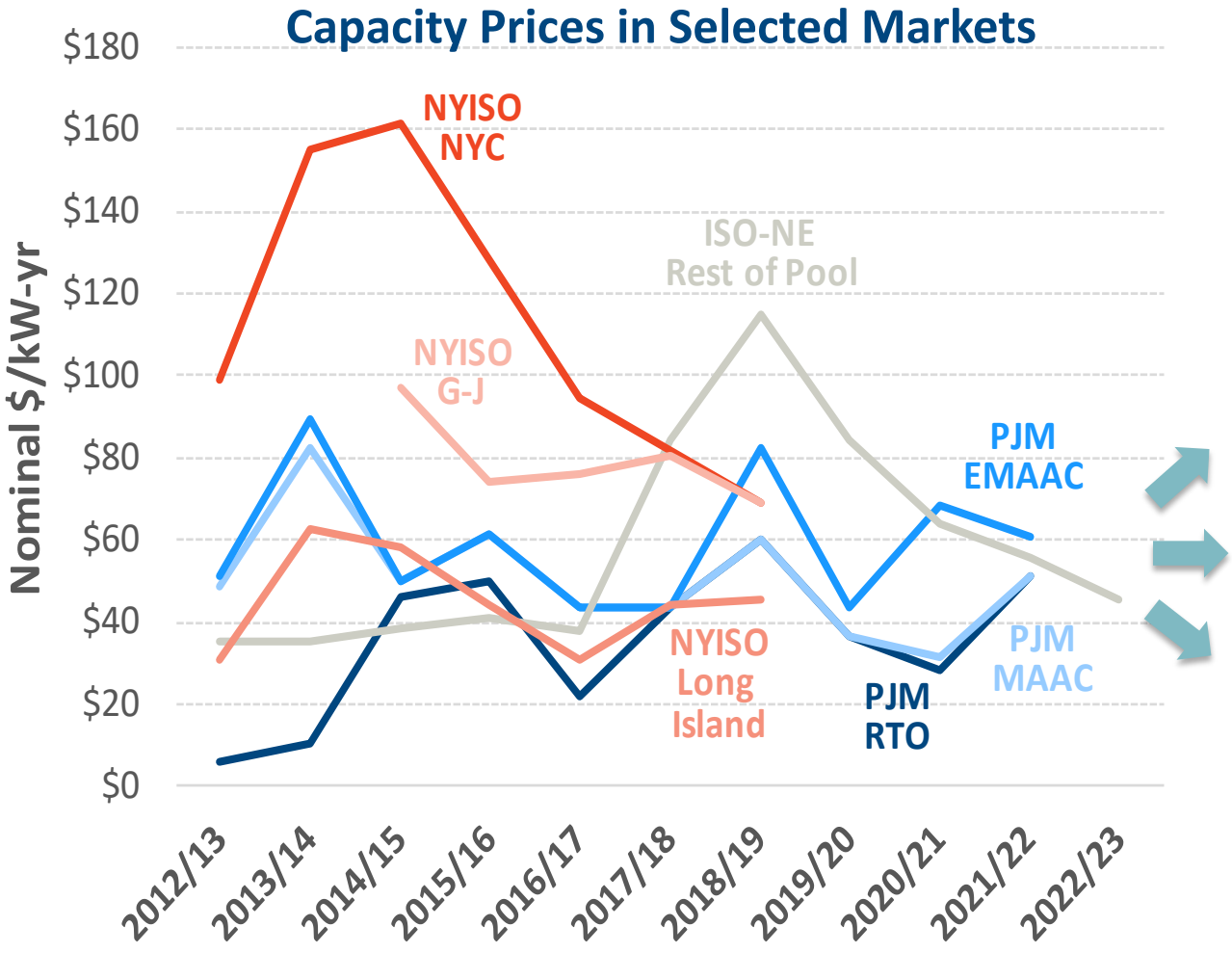
Commitment Period 1 year *except*

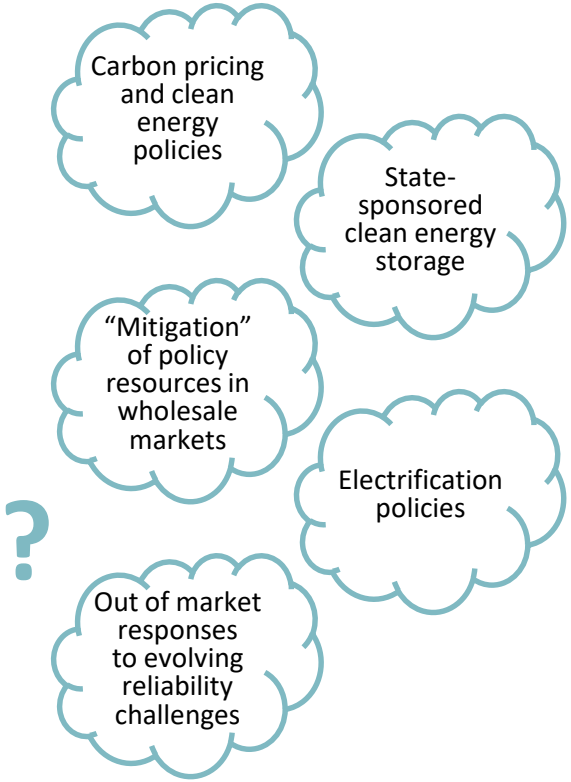
- 1 to 6 months in NYISO
- ISO-NE offers new 7-year price lock
- UK offers new 15-year term; 3 for refurbishments
- Ireland offers new up to 10-year term

Design Element:
Capacity Market Demand Curves



Capacity Price Levels and Trends





Many regulatory and policy uncertainties will impact capacity markets & prices going forward

Source: RTO websites and market reports.

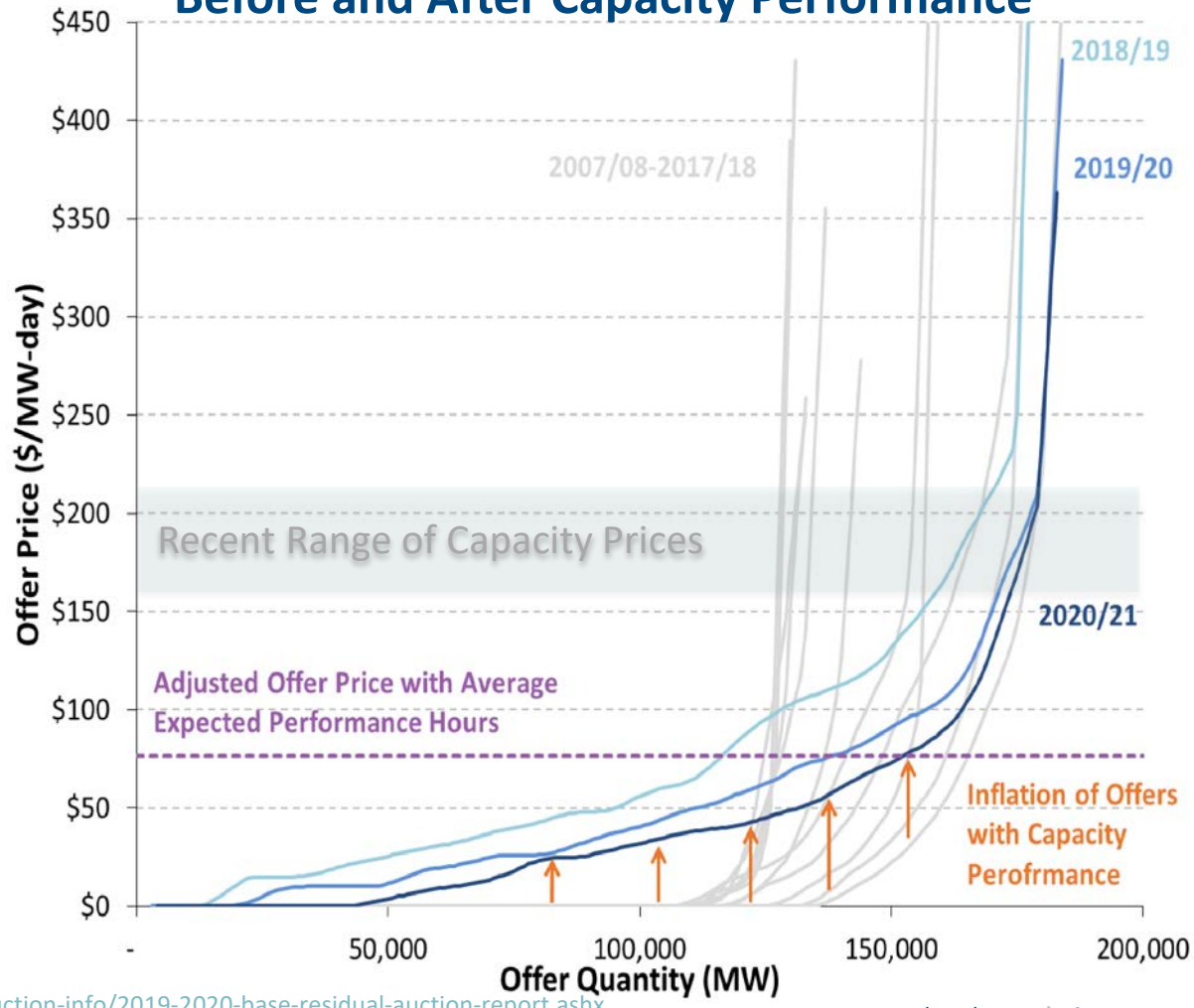
Design Element: "Capacity Performance" Penalties

PJM and ISO-NE introduced penalties for capacity resources that are not available during reliability events

- Penalties increase risks, particularly for older existing resources
- Increased price of capacity offers (but most pronounced in lower-end portion of supply curve)

Increased capacity prices by approx. $20/MW-day (10-20%) in PJM

PJM: Capacity Supply Curves Before and After Capacity Performance



Sources:
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https://www.pjm.com/-/media/library/reports-notices/special-reports/2018/20180420-pjm-2018-variable-resource-requirement-curve-study.ashx?la=en

Capacity Repricing Debate: How to Adjust for the Effects of State Policies?

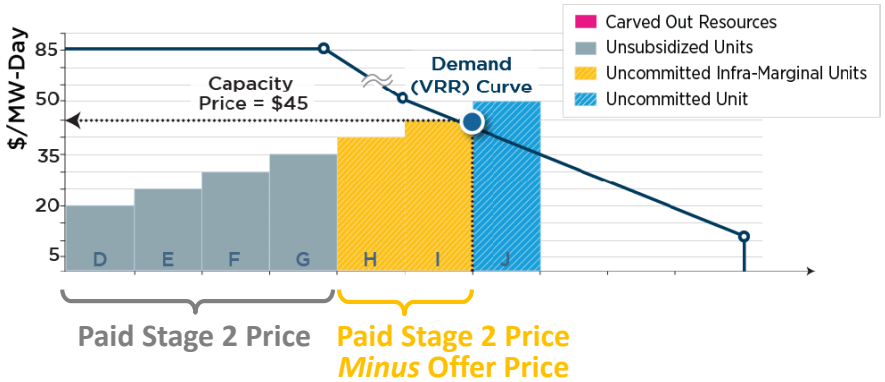
Some ISOs are concerned that increasing policy-supported resources undercut investment incentives. Their solution is:

- Restore capacity prices to the higher level that would exist without subsidies
- Introduce two-stage auctions with side payments to resources that don't clear even though they offered below the clearing price

But these solutions do not address the real problem: market forces working at cross-purposes with clean energy goals

PJM Stage 1: Set Capacity Obligations

PJM Stage 2: Set Higher Capacity Prices



Source: PJM Filing before the FERC (October 2, 2018)

Our Top-10 Characteristics of Successful Capacity Markets

Experience with resource adequacy designs from the last decade 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 will not achieve resource adequacy targets without a capacity construct
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

Source: Pfeifenberger and Spees, *Characteristics of Successful Capacity Markets*, APEX, Oct 31, 2013.
https://www.pjm.com/~/media/pjm-apex/presentations/20131031/20131031-panel-2-pfeifenberger-brattle.ashx

Capacity Markets are Not a Silver Bullet to Address all New Industry Challenges

Don't prematurely implement capacity markets…

- …without a clear understanding of the resource adequacy needs and the drivers of these needs
- …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 to some resources (including long-term contracts) that oversupply the market and distort both short- and long-term investment signals
- …without understanding and addressing deficiencies in energy and ancillary service markets, including the increasing need for more flexible (ramping) capacity

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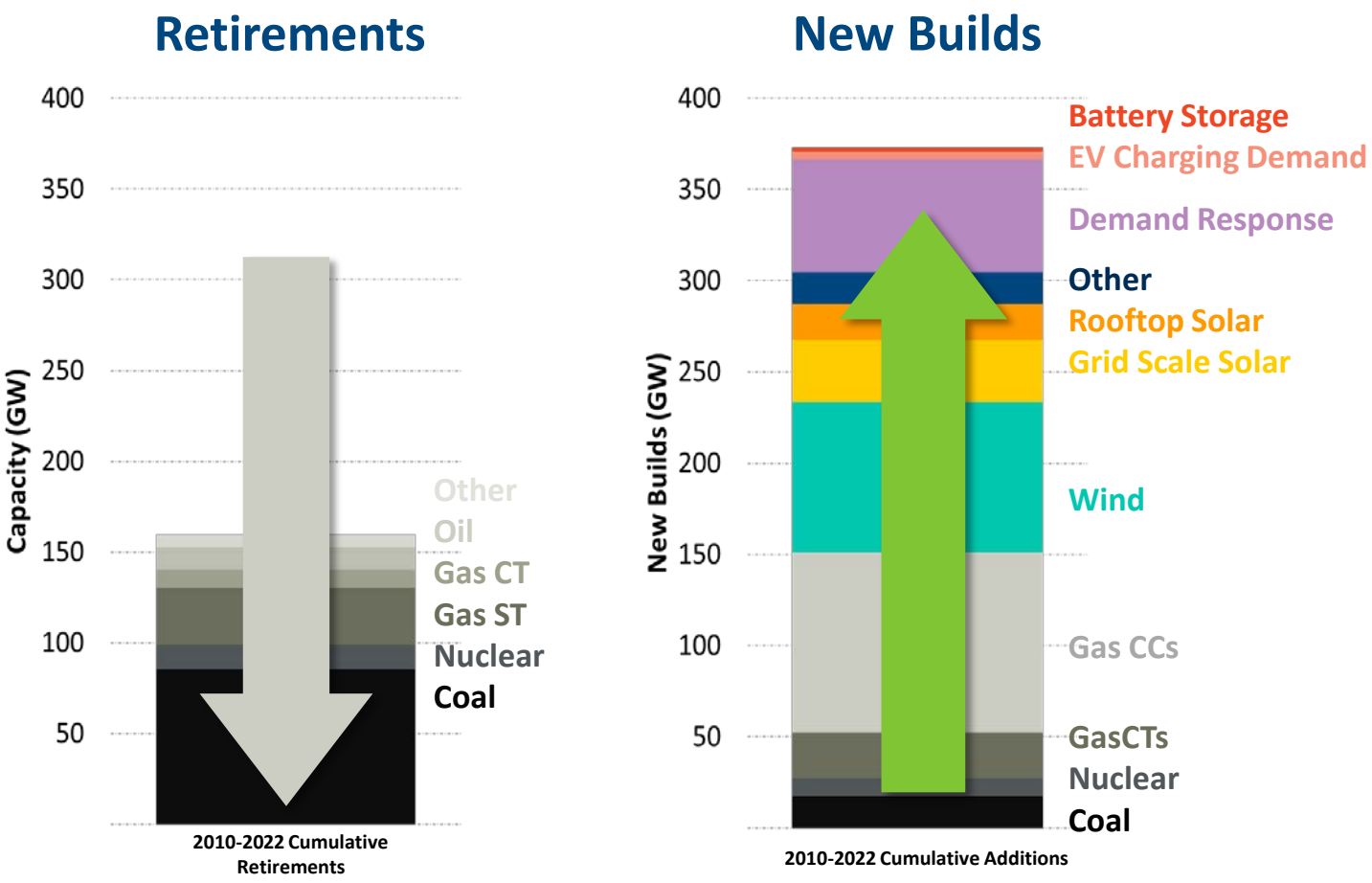
Electricity Industry Trends & Challenges

1. Substantial and continuing **cost reductions in solar and wind resources** will increasingly dominate the grid with low-marginal-cost generation
2. **Low natural gas prices** place significant downward pressure on coal and nuclear plants
3. **Reduced growth** in traditional electricity consumption
4. Strong customer and policy preferences for **clean energy** will shift resource mix beyond what is supported by current price signals
5. Increasing **electrification** of transportation, industrial processes, and home heating could double electricity demand by 2050
6. Declining cost of **battery storage** will fundamentally change the functioning of electricity markets

These are significant changes that utilities, grid operators, and regulators have to manage

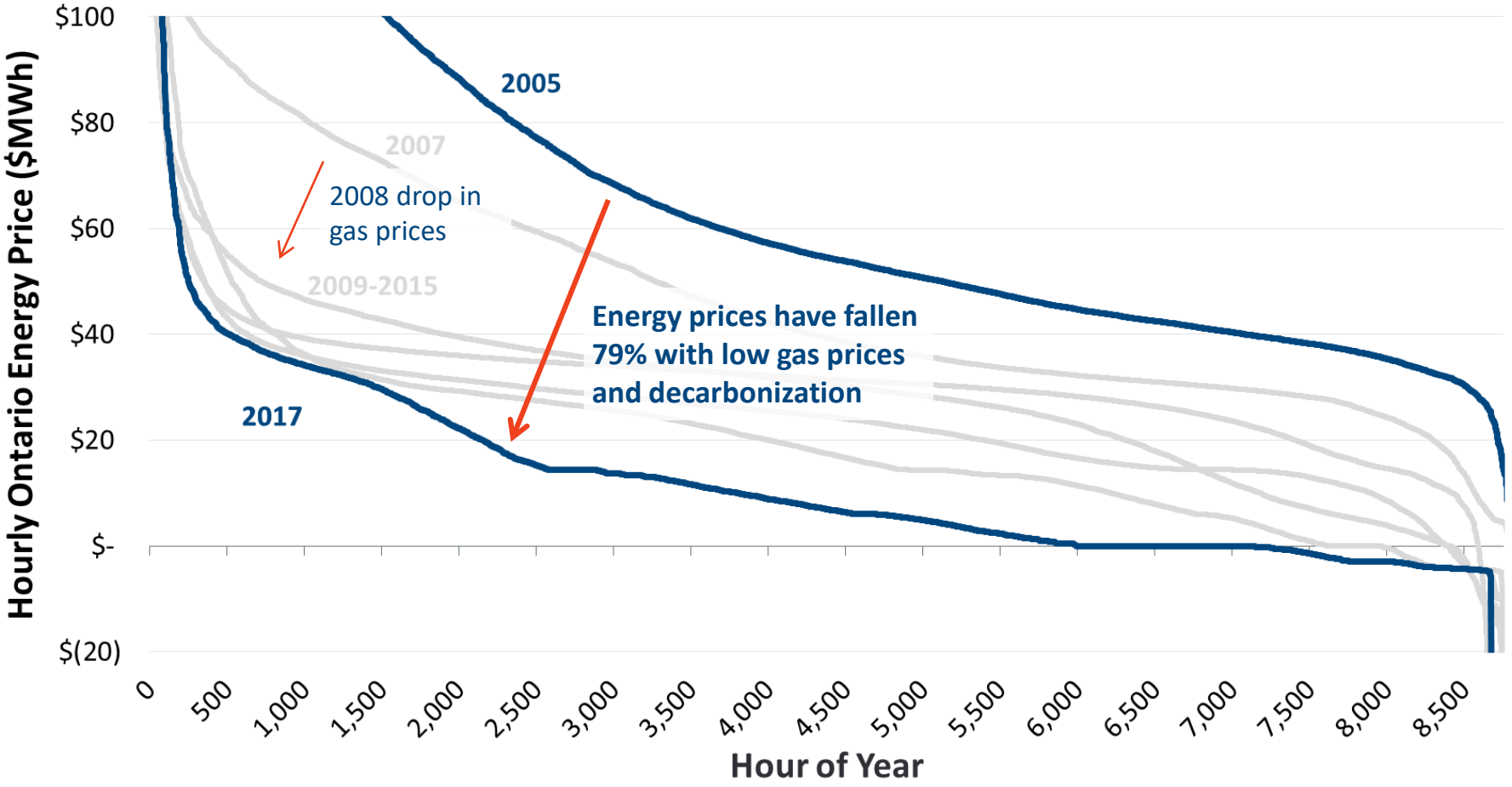
New Generation Technologies Are Rapidly Overtaking Traditional Supply



Sources: Energy Velocity Suite (US and Canadian generation) and Brattle research (US-only distributed resource and storage).

Energy Market Prices Decline with a Clean, Low-Marginal-Cost Generation Fleet…

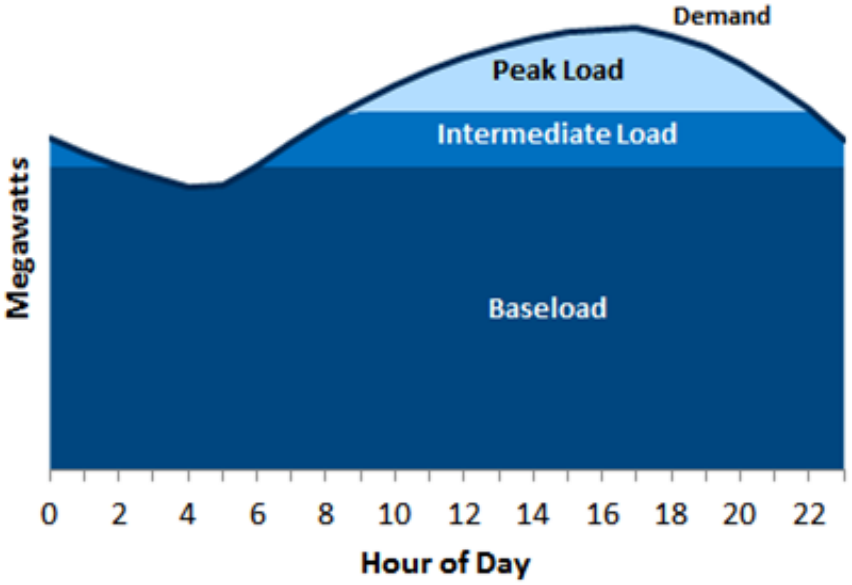
Ontario example: very low or negative prices (1) with a 90% clean and low-marginal-cost fleet and (2) low natural gas prices



Changing Supply Mix = Need for More Flexibility

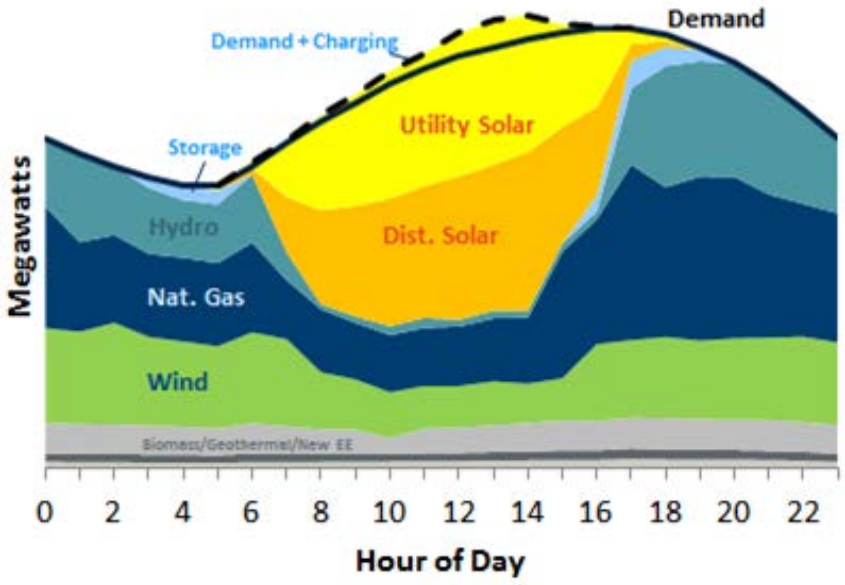
The more diverse supply mix creates new resource adequacy challenges and requires significantly more operational flexibility

Electricity Demand and Traditional Supply Mix



Source: The Brattle Group.

Electricity Demand and Supply Mix with High Renewable Generation



Source: The Brattle Group.

Revenue Sources will Shift from Energy to Other "Products"

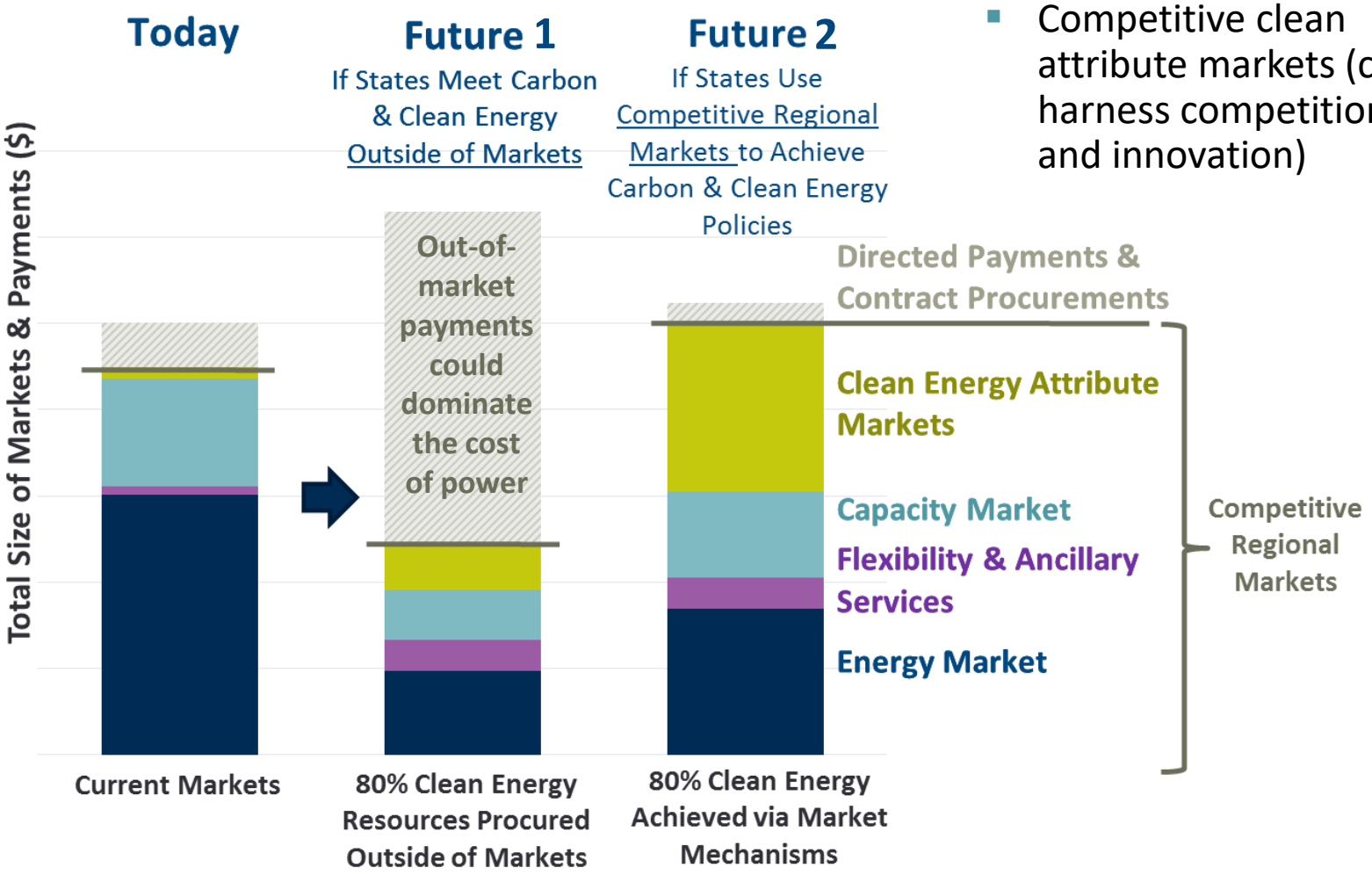
Markets designed for a clean, low-marginal-cost resource mix will need to focus more on flexibility and clean-energy products

Market	Value	Market Implications
Average Energy		▪ Lower energy prices during low-load and on average in most hours will most strongly affect baseload and dominant variable resources
Scarcity Pricing		▪ But higher peak prices, driven by volatility, scarcity pricing, and demand response/storage; rewards fast-response resources
Flexibility & Reserves		▪ Need for greater quantities and new types of flexibility products ▪ Higher ramping needs reward flexibility
Capacity		▪ Value may go up or down ▪ Down if additional clean energy contributes to excess supply for a period, or if new capacity sellers are attracted by other value streams ▪ Up if new fossil plants are needed for capacity, but only a small portion of their capital costs can be recovered from other markets
Clean Attributes		▪ Some form of CO_2 pricing and/or clean energy payments introduced to meet policy and/or customer demand ▪ Value must be large enough to attract new clean resources
Adjacent Customer & Distribution Markets		▪ Technology and consumer-driver demand for adjacent products and services (smart home, electric vehicles) ▪ Participation may overlap with wholesale, clean, and retail/distribution markets
Geographic Diversification		▪ Increasing value of larger markets and trade/diversification across market seams through inter-regional grids

How Will Clean Energy Products be Integrated into Regional Markets?

For wholesale markets to stay relevant, clean energy product markets are the "missing link" to align market design with customers & states' needs

- Competitive clean attribute markets (can harness competition and innovation)



Product Markets: Mobilize Competition from a Wide Range of Resources

Compared to asset-based planning and procurement, technology-neutral (capability-based) product markets are more competitive

Products	Resources/Technologies (Existing and New)												Number of Competing Technologies
	Nuclear	RoR Hydro	Hydro w/ Storage	Coal	CC	CT	Wind	Solar	Battery Storage	DR	EE	Imports	
DA Energy	✓	✓	✓	✓	✓	○	✓	✓	○	○	○	✓	10
RT Energy (5 min)	○	✓	✓	✓	✓	○	✓	✓	○	○	○	○	9
Regulation	X	✓	✓	✓	✓	○	○	○	✓	○	X	○	7.5
Spinning Reserves	X	○	✓	✓	✓	✓	X	X	✓	○	X	○	6.5
Non-Spinning Reserves	X	X	✓	X	✓	✓	X	X	✓	○	X	○	5
Load following / Flexibility	○	○	✓	○	✓	✓	○	○	✓	○	X	○	7.5
Capacity / Res. Adequacy	✓	○	✓	✓	✓	✓	○	○	○	✓	✓	✓	10
Clean Energy	✓	✓	✓	X	○	○	✓	✓	○	○	✓	✓	9
Reactive / Voltage Support	✓	✓	✓	✓	✓	✓	○	○	✓	X	X	○	8.5
Black Start	X	✓	✓	○	✓	✓	X	X	○	X	X	○	6

Legend	Technical Capability to Provide Service
✓	Well Suited (1.0)
○	Neutral (0.5)
X	Not / Poorly Suited (0)

Takeaways on Shifting Industry Trends

De-marginalization of wholesale power markets will fundamentally shift revenue streams and require changes in market design

- Wholesale power markets were built around 20th-century generation technology. They will need to evolve with entry of new technologies.
- Revenues will shift from "energy" to scarcity pricing, flexibility, and (hopefully dynamic) clean-energy products
- Customers and states want clean energy, with or without the help of centralized wholesale markets. If the wholesale markets do not evolve with the desires of customers and policy makers, they will become less relevant in the future.
- We need more comprehensive, technology-neutral "products" markets so that customers can benefit from increased products-based competition from the broadest possible set of resources
- Storage will be the intertemporal "glue" to enhance the market prices and value of both baseload and low-marginal-cost resources

Capacity markets provide a "safety net" — but only for resource adequacy. They can't do things they weren't designed for.

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Mr. 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 RTO capacity market and resource adequacy designs, the analysis of transmission benefits, testimony in contract disputes, 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.

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.

Additional Reading

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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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