Market Design for a Clean Grid

Unlocking the Potential of Non-Emitting and Emerging Technologies

PRESENTED TO

Non-Emitting Resource Subcommittee

PRESENTED BY

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January 22, 2018

THE Brattle GROUP

Agenda

- Overview
- Energy
- Flexibility
- Capacity
- Outlook in Ontario

Market Design for the Clean Grid of the Future

- The Non-Emitting Resource Subcommittee has begun to evaluate how clean resources can be accommodated, incorporated, and encouraged through Ontario's wholesale electricity markets
- Outcomes will be critical to the efficiency and sustainability of the market, given that clean resources supply 91%* of Ontario's energy, and may be increasingly relied upon to provide essential reliability services to the grid
- Our task in today's meeting is to:
  - Describe common challenges and emerging solutions for clean resources
  - Identify potential design enhancements and participation barriers to address
  - Focus on participation for energy, flexibility, and capacity needs (commercial mechanisms for environmental goals will be discussed in Phase III)
- Overall challenge for Ontario is to update market design to serve the evolving energy mix. The new reality is that "non-traditional" clean and emerging resources are the new normal

The question is not how to subsidise or favor any particular technology. Instead it is how to unlock latent potential and foster innovation from a broader resource base to sustain a clean, reliable grid and lower cost

*Source: IESO (2017), "Supply Overview".

Overview

What Services Can New Technologies Provide?

Starting point is to recognize the significant latent potential of clean and emerging technologies to provide a wide range of essential services to the grid. IESO's RFI will inform the capabilities and barriers

	Gas CC	Gas CT	Nuke	Hydro	Wind	Solar	DR	Storage	DER	EE	Interties
Energy	Yes	Yes	Yes	Yes	Yes	Yes	Some*	Some*	Some*	Yes	Yes
Flexibility	Yes	Yes	Some*	Yes	Some*	Some*	Yes	Yes	Some*	No	Some*
Capacity	Yes	Yes	Yes	Yes	Some*	Some*	Yes	Yes	Some*	Some*	Some*
Environment	No	No	Yes	Yes	Yes	Yes	Some*	Some*	Some*	Yes	Some*

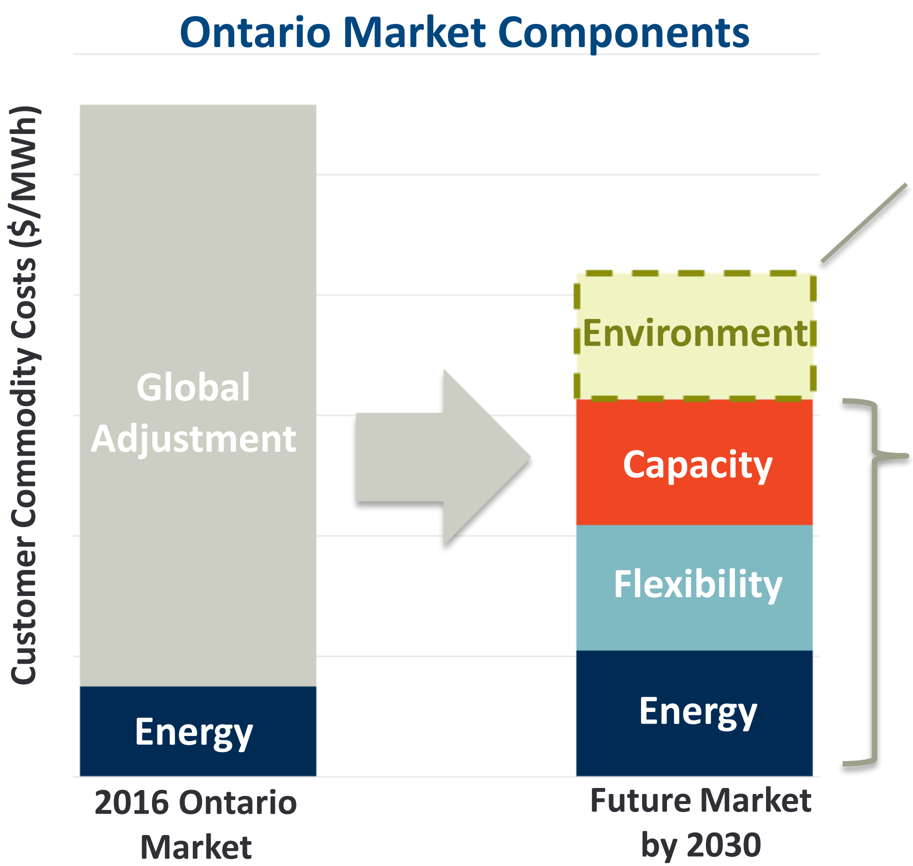
Yes | Some* | No

*A specific focus of the outstanding RFI is to understand whether and how these resources can provide various grid services, and what participation barriers exist in Ontario

Overview

A Path to the Future Ontario Market

Vision for Ontario's future market is to rely on a comprehensive suite of competitive markets. Will enable a wide range of technologies the opportunity to "value stack" a business case based on unique capabilities



Commercial Mechanisms

- Commercial mechanisms to achieve environmental policy objectives, including existing cap-and-trade
- Potential for additional commercial mechanisms will be addressed in Phase III by this subcommittee

Electricity Markets

- Market renewal begins the process of moving to resource-neutral markets for procuring unbundled grid services (replacing technology-specific, bundled contracts)
- Capabilities and characteristics of clean resources can be considered throughout design processes to unlock full potential

Sources and Notes: Left: 2016 realized Global Adjustment and HOEP. Right: Illustrative representation of future market design, magnitudes not based on value estimates.

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Energy Market for the Clean Grid

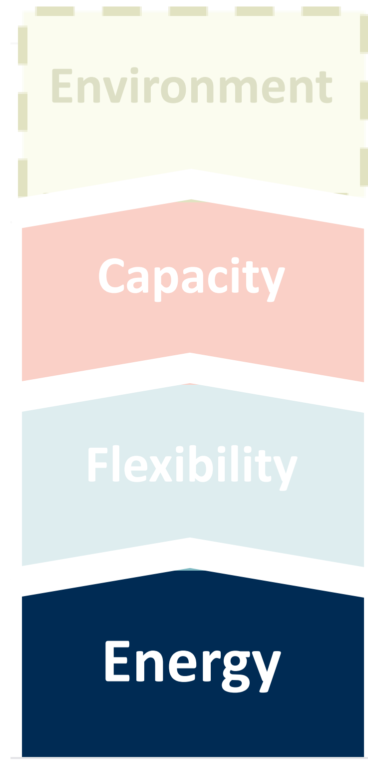
Market Renewal will help improve the foundations of Ontario's energy market, which can facilitate an efficient transition to a clean grid

- Energy prices that reflect system marginal costs by time and place are foundational to improving market signals for dispatch and allowing flexible resources to respond
- Higher penetration of variable clean resources leads to a need for more granularity in pricing, dispatch, and settlement
- Alignment of markets and customer arrangements can allow emerging resources to capture multiple value streams at the wholesale, distribution, and customer levels

Key Takeaways

- An improved energy market lays the foundation for efficient operation of an increasingly clean grid
- Fully integrating clean resources will require significant focus on participation, customer arrangements, and price formation

Ontario Market Components



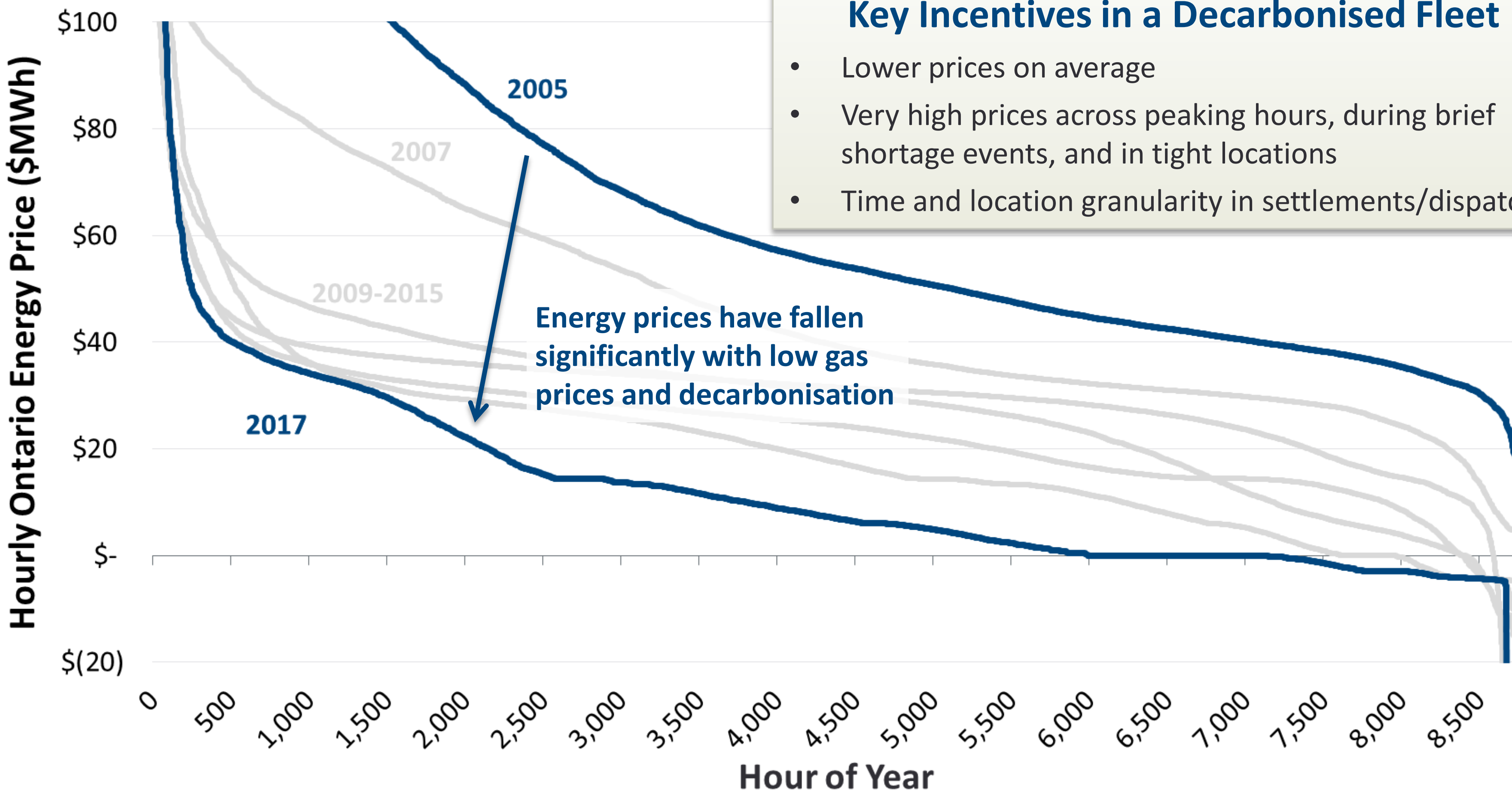
Energy

Energy Price Formation

Ontario average energy prices are lower with decarbonisation, consistent with lower marginal cost fleet. But the current market is missing <u>focused</u> incentives for delivery when and where needed

Key Incentives in a Decarbonised Fleet

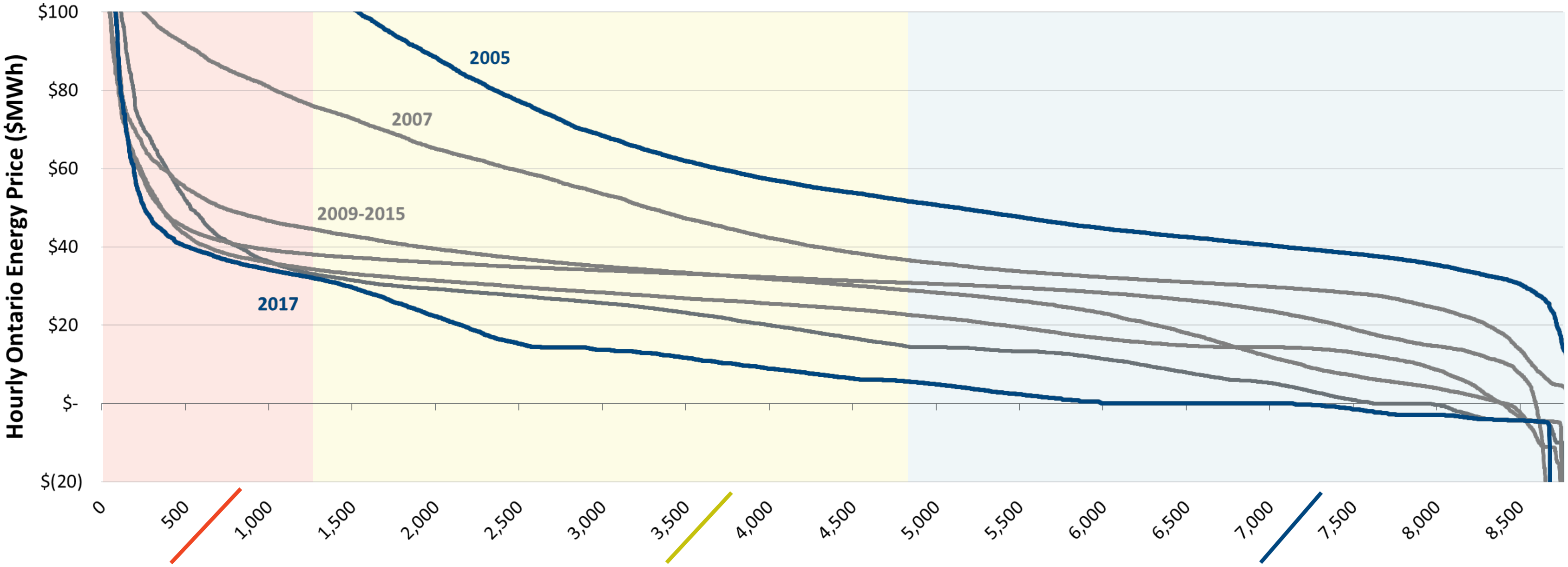
- Lower prices on average
- Very high prices across peaking hours, during brief shortage events, and in tight locations
- Time and location granularity in settlements/dispatch



Energy

Energy Price Formation

Basic concept of marginal cost based pricing is still the fundamental driver of good energy market design. So what does "marginal cost" mean in a market dominated by clean and emerging resources?



Scarcity and Peak Hours

- Administrative scarcity pricing sends strong incentives to deliver at peak and shortage
- DR and storage fully integrated into price formation

Intermediate Hours

- Hydro and interties fully integrated into price (including opportunity cost)
- Gas plant start costs recovered for over the day without uplift payments

Baseload and Surplus Hours

- Nuke, wind, and solar offer at true marginal cost (not at contract-driven levels)
- Gas plants at min generation offer negative (requiring higher on-peak price to commit)

Energy

Control Room Need for Visibility and Control

To maintain reliability with a growing large share of intermittent and distributed resources, system operators need increasingly granular visibility and control

Visibility & Control Challenges

Control Room Perspective

- Need to know exact time and place of power injection and withdrawal, including a reliable forecast
- Desire to control location-specific output/withdrawal levels and rate of change to maintain reliability
- Unable to predict how much non-dispatchable resources will react to price changes

Emerging Resources' Perspective

- Existing processes and standards are designed for traditional resources (not recognizing unique features)
- Lack of supporting infrastructure, or lack of cost-effectiveness relative to individual resource size
- Barriers to entry and lack of incentives leave some resource capabilities untapped

Potential Solutions

- Smaller time intervals and location granularity for dispatch, pricing, and settlements
- Modernized market and control systems designed for emerging resource types, including large numbers of small resources
- Ensure rate structures do not inadvertently incentivize inefficient grid defection, or unequitable shifting of legacy system costs
- Enabling supply-side participation for DR/DER
- Product definition and financial structures that provide enhanced incentives for more visible and controllable resources
- Balance qualification requirements with resource capabilities
- Pilot programs for gaining control room experience and confidence relying on new technologies to provide grid services

Enabling Distributed Resources

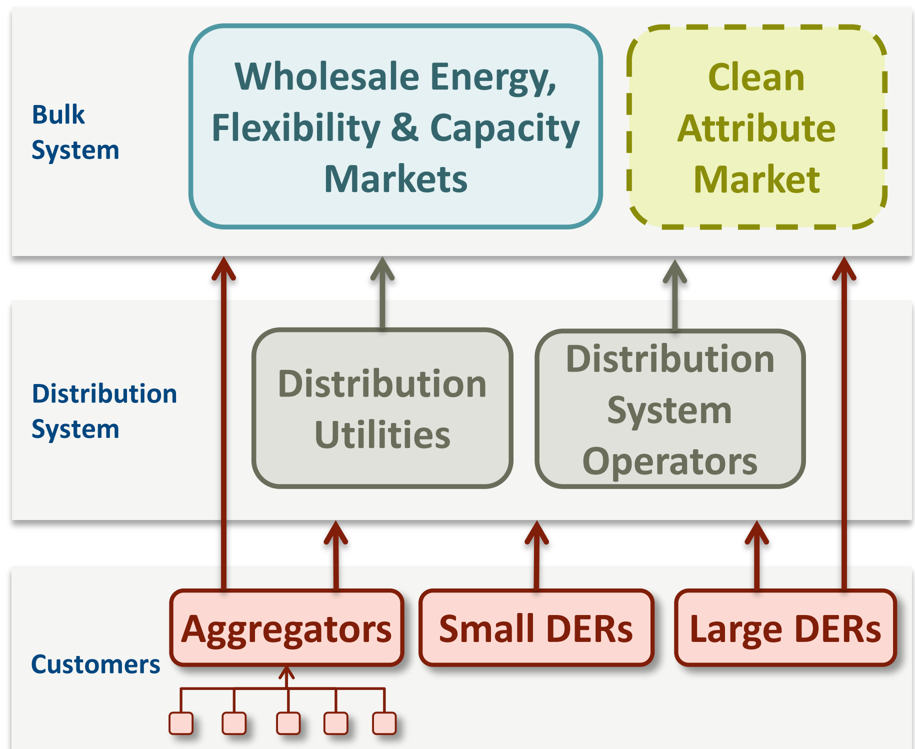
Enabling distributed resources requires an integrated systems view to unlock full value

- Consider many potential value streams to customer, distribution system, and wholesale market
- Identify and address barriers that may prevent DERs from capturing each type of value

Opportunities to Enable Distributed Resources

- Rates that incentivize efficient investment and operation, reflecting marginal cost
- Option for wholesale market supply-side participation
- Enable a range of business models including utility-owned, customer-owned, and third-party aggregated
- Provide third-party providers access to customer data
- Facilitate resources to capture multiple value streams to wholesale market, distribution system, and customers
- Proactively manage wholesale/DSO "seams"
- Enabling data and infrastructure

Potential Value Streams from Distributed Resources



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Flexibility Products for the Clean Grid

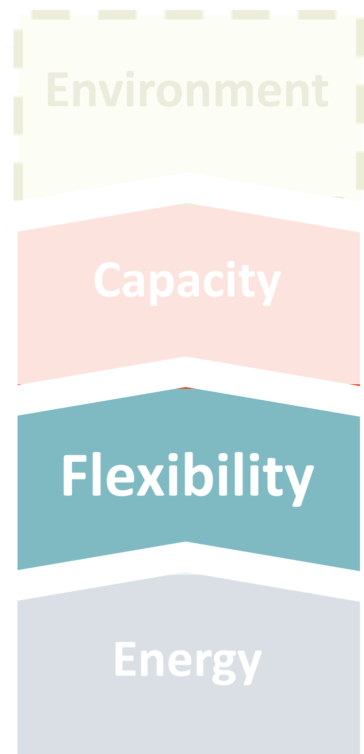
With the Market Renewal and other initiatives, Ontario has the opportunity to address flexibility needs in a holistic framework by:

- Starting with a clear definition of flexibility needs based on a robust analysis of historical and forward-looking flexibility requirements
- Translating that need into products/revenue streams that create efficient incentives in two timeframes:
  - **Operational Incentives:** best use of existing resources
  - **Investment Incentives:** efficient investments in flexibility

Key Takeaways

- Solutions for flexibility that enable all resources will unlock latent potential and innovative solutions
- Best solutions avoid subsidies and do not favor any particular resource types

Ontario Market Components



Examples: Emerging/Clean Technologies Providing New Flexibility Services

Many market designs and pilot programs highlight how clean/emerging technologies can provide a wide range of flexibility services today.

Load Shedding Service for Imports
- Frequency response for the trip of an intertie

485 MW Demand Response

Quebec Wind Synthetic Inertia
- Frequency response

~3,300 MW Wind Resources

Escondido Energy Storage
- Frequency regulation
- Energy time-shifting

30 MW/4hr Lithium Ion Batteries

First Solar PV Plant
- Regulation Up/Down
- Frequency Response

300 MW Utility-scale PV plant

Demand Side AS Program
- Regulation
- Operating reserves

106 MW Demand Response

Flex Services from Rooftop Solar
- Pilot testing and developing frameworks for integration

Pilot programs, not yet in AS market

Demand Response
- Response Reserve
- Frequency Regulation

~1,400 MW Demand Response

Dispatchable Intermittent Resources
- Ramp Management
- Reduce AS needs

Primarily Wind Resources

Beech Ridge Wind Storage
- Frequency Regulation
- Ramp Management

31.5 MW Storage with 100.5 MW wind

Other Resources: CAISO/NREL, Using Renewables to Operate a Low Carbon Grid

Flexibility

New and Unbundled Ancillary Service Products

Systems with high penetrations of intermittent and non-controllable resources typically need to define and remunerate a revised suite of ancillary service products

Higher Quantities

- More ancillary services are required to manage variability and uncertainty
- Enhanced efficiency if procured quantity changes with price

New Products

- Nature of operational reliability challenges depends on fleet makeup
- Some grid services previously provided "for free" may become scarce if not defined and procured

Unbundled Products

- Traditional product definitions often "bundle" multiple services together
- Unbundling enables more resources (e.g. wind may supply regulation down, but not regulation up)

- **Ontario, New England:** Additional quantities of 30-minute reserves
- **ERCOT:** Higher regulation requirements to balance intermittency

- **MISO, CAISO:** Ramping products
- **Australia:** Considering inertia, fast frequency response, and voltage control
- **Ireland:** Inertial response, longer ramping products, and voltage response

- **Many US Markets:** Regulation and ramp defined as distinct up/down products
- **ERCOT:** Proposed unbundling contingency reserves based on response timeframe

Flexibility

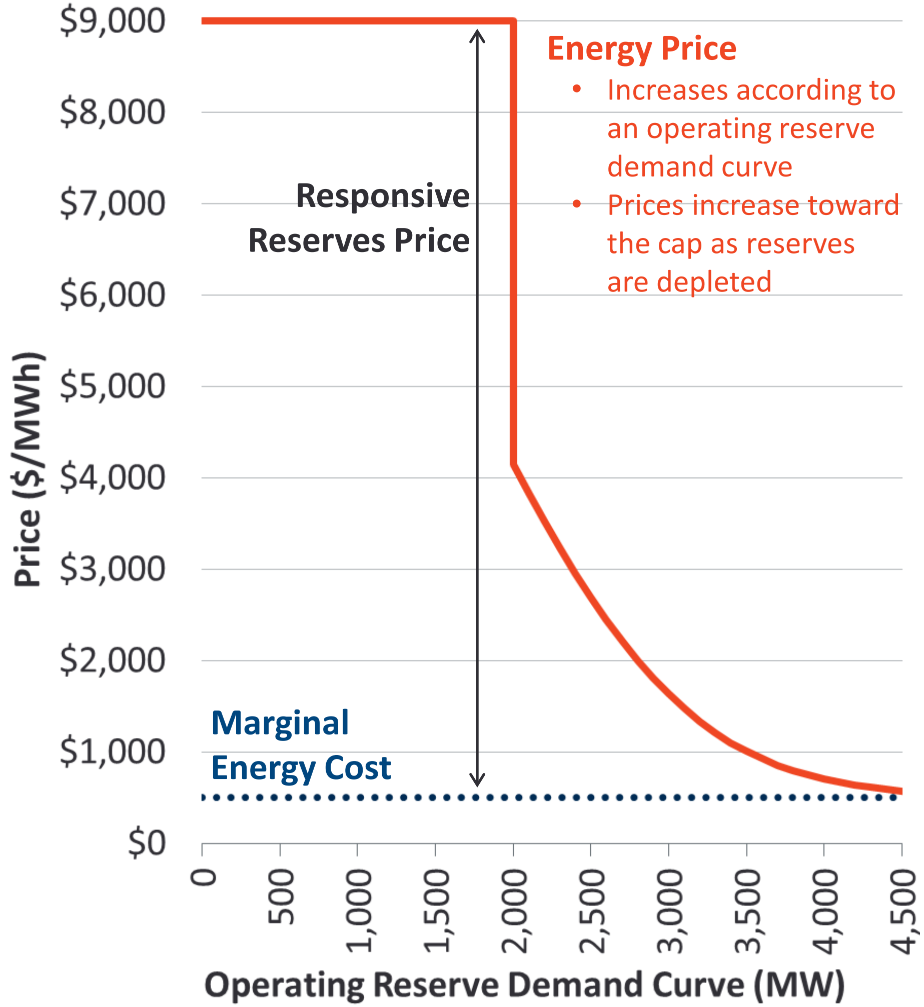
Efficient Pricing for Ancillary Services

Efficiently incentivizing flexibility may require sending very high prices for very short periods

- **Scarcity Pricing:** Sends acute signals for energy and ancillary services during shortage
- **Co-optimization:** Enhances efficient dispatch across products
- **Focused Time & Place:** Five-minute locational pricing, dispatch, and settlement create strongest performance incentives

Flexible resources can earn enhanced profits by quickly responding to system conditions

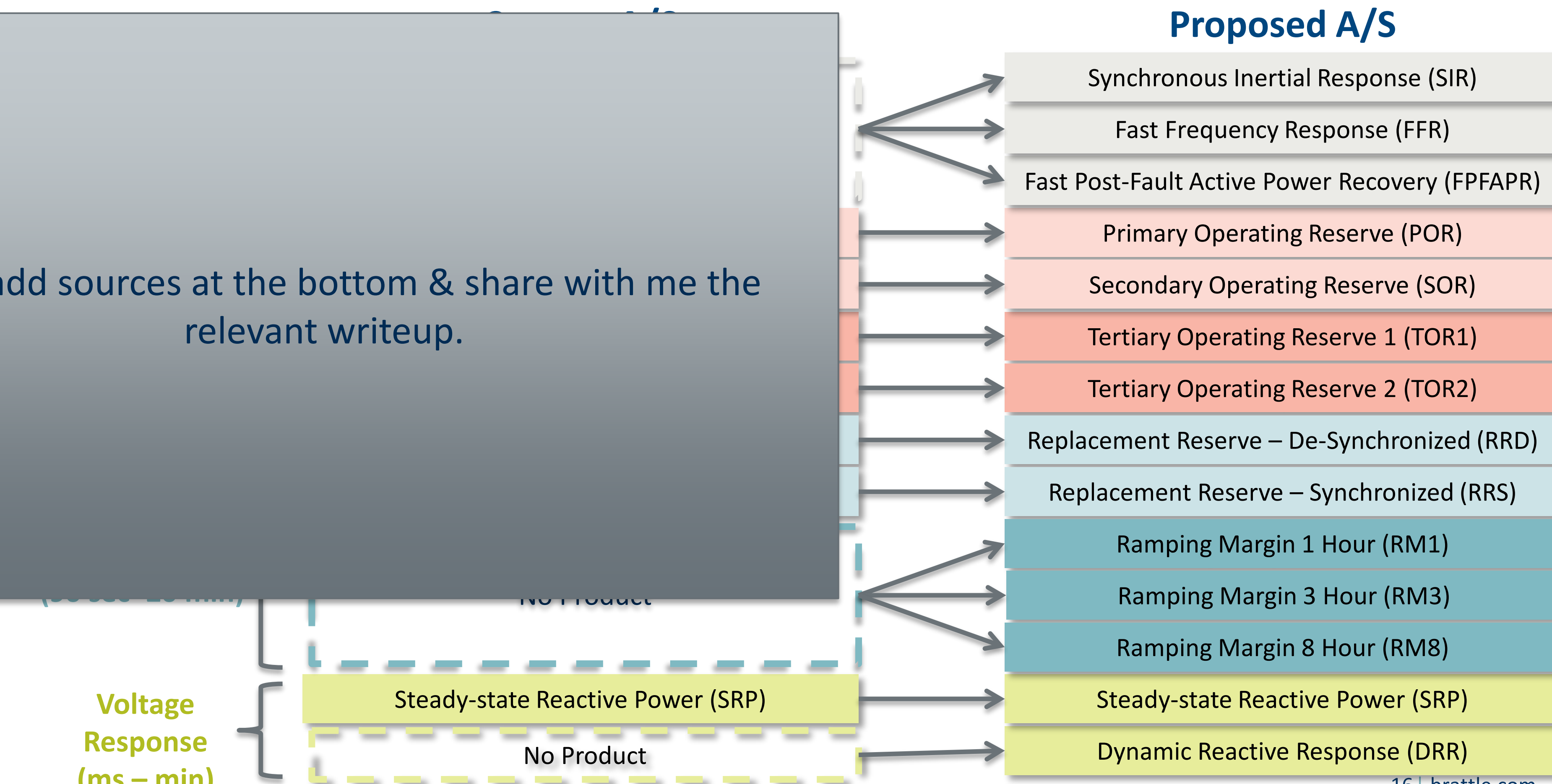
Texas: Operating Reserve Demand Curve



Source: The Brattle Group, *Estimating the Economically Optimal Reserve Margin in ERCOT*, January 31 2014

Ireland: Ancillary Service Reforms

Ireland introduced new products to meet the needs of a grid increasingly dependent on wind energy, providing opportunities to better enable new technologies (e.g. batteries, flywheels, wind, and short-duration load response)



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Capacity Auction for the Clean Grid

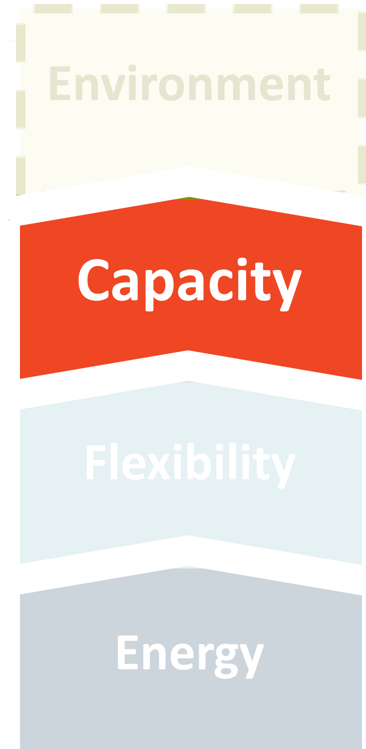
The Incremental Capacity Auction will help Ontario meet its resource adequacy needs at lower costs by integrating clean resources

- Enhanced reliability modeling can capture the changing nature of resource adequacy with growing intermittency
- Almost all resources can provide some capacity value, if enabled through technology-neutral capacity ratings and participation standards
- Growing recognition of benefits from aligning market and policy mechanisms to achieve both reliability and carbon objectives at least cost

Key Takeaways

- The ICA can recognize resource adequacy value of non-emitting resources
- Aligning policies with capacity auction design can reduce costs and mitigate regulatory risks

Ontario Market Components



Defining Capacity Needs

Timing and drivers of reliability events change with fleet makeup. May require adjustments to capacity product definition to unlock the full reliability contribution from all resources

Reliability Modeling

- New fleet leads to different reliability drivers
- May require enhanced ability to model wind, solar, DR, storage, intertie, hydro, and other changes

Defining Obligations

- Obligations such as availability hours need to consider both resource capabilities and system needs
- Unbundling products can enable resources with different capabilities (e.g. seasonality, flexibility)

Performance Incentives

- E&AS markets provide most performance incentives
- UCAP ratings
- Penalty and performance regime aligned with needs

- **Best Practices:** FERC-sponsored study documented enhanced reliability modeling approaches
- **California, Europe**: Enhanced modeling of flexibility-driven shortages

- **MISO**: Has considered a seasonal capacity market
- **PJM**: Series of reforms to address summer-only DR supply
- **California**: Flexible resource requirement

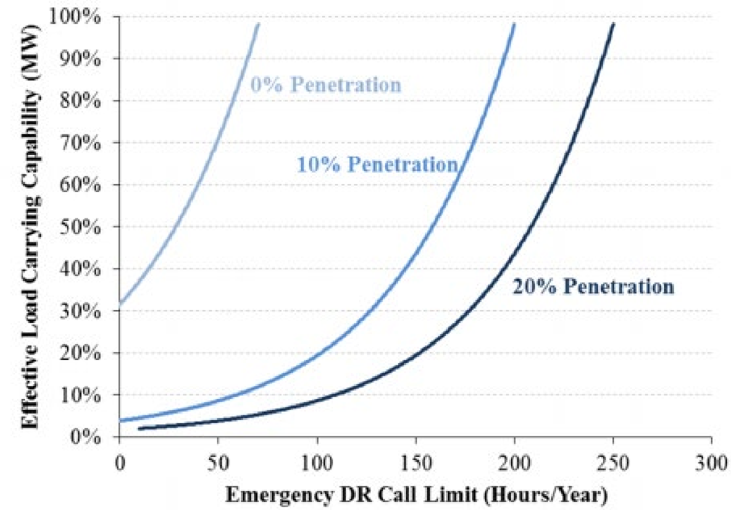
- **US Markets:** Energy and AS scarcity pricing to perform during shortages
- **ISO-NE**, **PJM**: Strong performance incentives add to delivery incentives during shortage events

Enabling Resource Participation for Capacity

Options for Enabling All Resources

- Acknowledge wide range of resource capabilities (variety growing over time)
- Effective Load Carrying Capability (ELCC) awards capacity value consistent with reliability contribution
- Active engagement between system operators and market participants may help to:
  - Establish a sufficient variety of defined resource types with capacity obligations consistent with resources' capability
  - Award accurate UCAP ratings consistent with the defined obligations
  - Engage in sufficient testing and pilot programs to ensure reliability is delivered

Example: Demand Response ELCC vs. Call-Hours Limit



Characteristics that May Affect Reliability Contribution and UCAP

- Outage rates, timing, and predictability
- Sustained output or energy limits
- Call-hour or call-event limits
- Response time
- Intermittency
- Defined availability hours or seasonality
- Visibility and controllability

Source: *Resource Adequacy Requirements: Reliability and Economic Implications*.

Aligning Policy and Market Design Objectives

Several markets face tensions driven by policy objectives that are not yet reflected in market designs

- Originally, wholesale electricity markets were designed to do one thing: maintain reliability at lowest system cost
- Many examples of how markets have enabled competition and innovation to achieve this objective…
- …But markets will only do what they were designed to do. Market outcomes will not necessarily satisfy policymakers if their objectives are not considered in the design
- Growing recognition of need to align market and policy mechanisms to achieve both reliability and carbon objectives at least cost

Possible Tensions from Non-Alignment of Market and Policy Objectives

- Market produces higher-carbon fleet than policymakers desire
- Policymakers pursue out-of-market mechanisms to support clean resources
- Excess supply results in suppressed market prices, greater regulatory risk, and higher customer costs

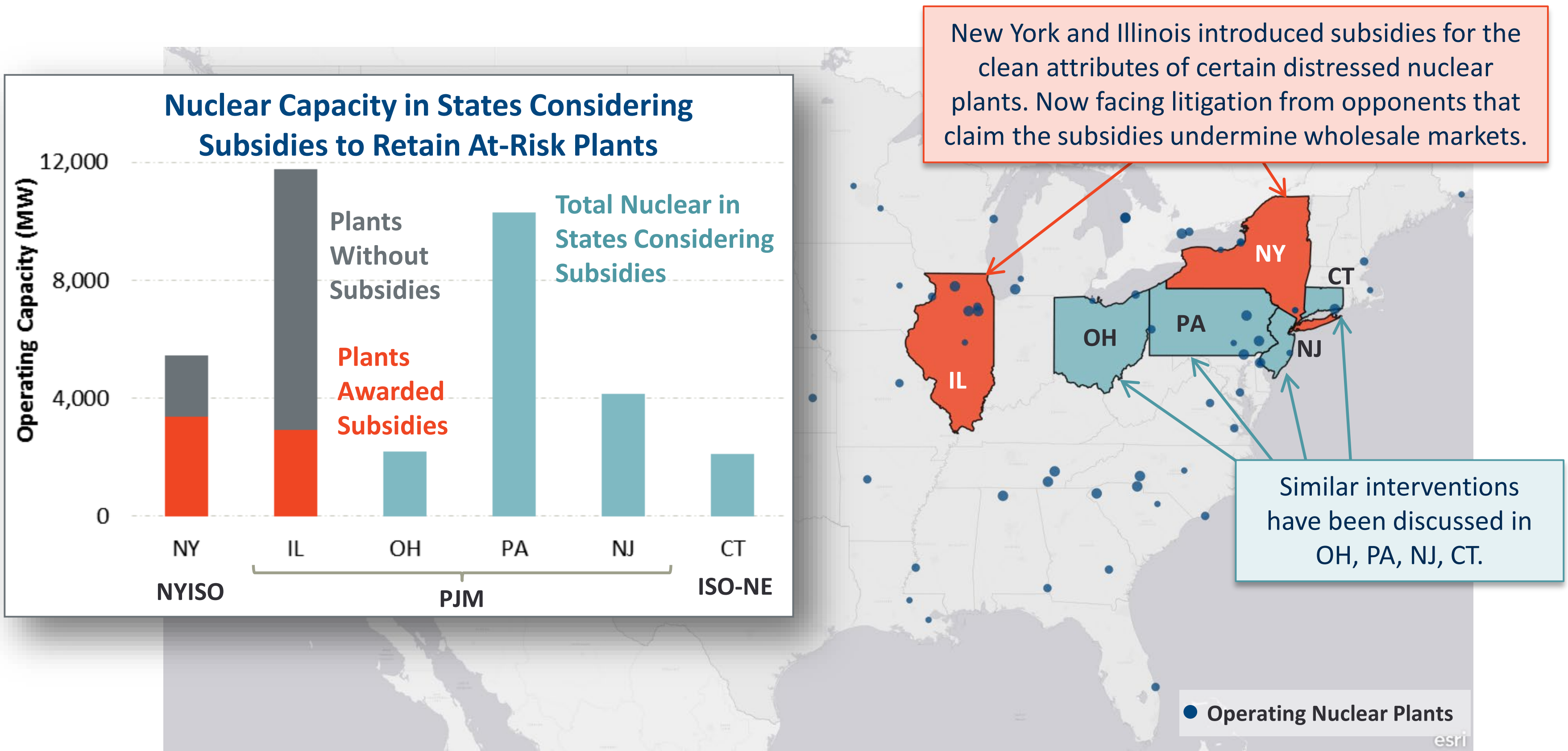
Market Design Solutions

- **Accommodate** policy objectives and mitigate regulatory risks within the capacity market design
- **Achieve** policy objectives through technology-neutral, market-based mechanisms

New York

Example: Interventions to Retain Nuclear Plants

New York and Illinois have adopted controversial subsidies to retain at-risk nuclear plants. Opponents argue that inefficiently low carbon and electricity prices are to blame for nuclear retirements and "in market" solutions are needed



Sources: Map based on Brattle analysis, created using SNL Maps. Data on nuclear capacity from SNL.
Legal challenges are proceeding before the FERC and within U.S. Federal Court, see also Power Magazine.

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Achieving Full Resource Participation

Enabling all resources to compete in a competitive market will unlock the innovative potential to meet reliability and policy needs at lower cost

- On the following slides, we suggest a series of potential design enhancements and participation barriers that this committee could evaluate in Ontario's context
- A subset of these enhancements will be partly or fully addressed through Market Renewal, while others may need a separate dedicated review
- Achieving full resource participation can deliver significant benefits to the province, but will likely require a dedicated, long-term commitment to continuously enhancing the markets to keep pace with innovation

Enhancing the Market Design for Clean Energy

Over time, Ontario can build on Market Renewal to achieve a resource-neutral market driven by design objectives and economic principles

Markets	Design Enhancements for the Clean Grid
Environment	• Clear definition of policy objectives based on system-wide outcomes • Translate policy objectives into resource-neutral, market-based products or services • Minimize and mitigate regulatory uncertainty • Align with other market structures
Capacity	• Clear definition of reliability requirement by time and place • Establish resource-neutral capacity ratings consistent with reliability contribution • Minimize and mitigate regulatory uncertainty • Minimize out-of-market procurement
Flexibility	• Product definitions and procurement quantities driven by technical system needs • Unbundled products • Technology-neutral qualification and performance standards • Co-optimization of all ancillary services with energy at all timeframes
Energy	• Pricing based on locational marginal price (both day-ahead and real-time) • Incorporate all resource types into price formation at all timeframes • Adjust clean payment and contract structures to mitigate negative offers • Settlements and pricing aligned with dispatch instructions • Minimize out-of-market instructions and uplift payments • Scarcity pricing aligned with reliability value; surplus prices consistent with marginal cost

Outlook

Participation Barriers to Evaluate and Address

For each <u>product</u>, <u>resource type</u>, and <u>timeframe</u>, the IESO and stakeholders can consider jointly evaluating barriers that may limit the ability to unlock resource potential

Barriers Checklist
• Are products defined based on technical system needs, and sufficiently unbundled to utilize the full capability of this resource type? • Are eligibility requirements resource-neutral and defined based on technical capabilities? • Is supply-side participation enabled? • Do customer rates/structures allow a range of business models to capture wholesale revenues (i.e., customer-owned, utility-owned, aggregated)? • Does the resource receive a price signal reflective of marginal value to the system at the time and place that the product is delivered? • Do contracted resources receive operating incentives consistent with market price? • Can distributed resources capture wholesale, distribution, and customer value streams? • Does the IESO have sufficient visibility and control to rely on this technology? • Do participation standards reasonably accommodate different technologies’ capability? • Can the resource participate in price formation?

Presenter Information

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Dr. Kathleen Spees is a Principal at The Brattle Group with expertise in designing and analysing wholesale electric markets and carbon policies. Dr. Spees has worked with market operators, transmission system operators, and regulators in more than a dozen jurisdictions globally to improve their market designs for capacity investments, scarcity and surplus event pricing, ancillary services, wind integration, and market seams. She has worked with U.S. and international regulators to design and evaluate policy alternatives for achieving resource adequacy, storage integration, carbon reduction, and other policy goals. For private clients, Dr. Spees provides strategic guidance, expert testimony, and analytical support in the context of regulatory proceedings, business decisions, investment due diligence, and litigation. Her work spans matters of carbon policy, environmental regulations, demand response, virtual trading, transmission rights, ancillary services, plant retirements, merchant transmission, renewables integration, hedging, and storage.

Kathleen earned a B.S. in Mechanical Engineering and Physics from Iowa State University. She earned an M.S. in Electrical and Computer Engineering and a Ph.D. in Engineering and Public Policy from Carnegie Mellon University.

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