Negative Pricing in Wholesale Energy Markets

PRESENTED TO

Non-Emitting Resources Subcommittee

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THE Brattle GROUP

Agenda

Overview

What Are the Drivers of Negative Pricing?

Are Negative Prices Efficient?

Jurisdictional Scan

Takeaways

NERSC is Studying the Causes, Impacts, and Options for Mitigating Negative Prices

We have been asked to review the questions that stakeholders have posed on the role of negative pricing in Ontario's highly decarbonised electricity system:

Questions from the NERSC Terms Of Reference

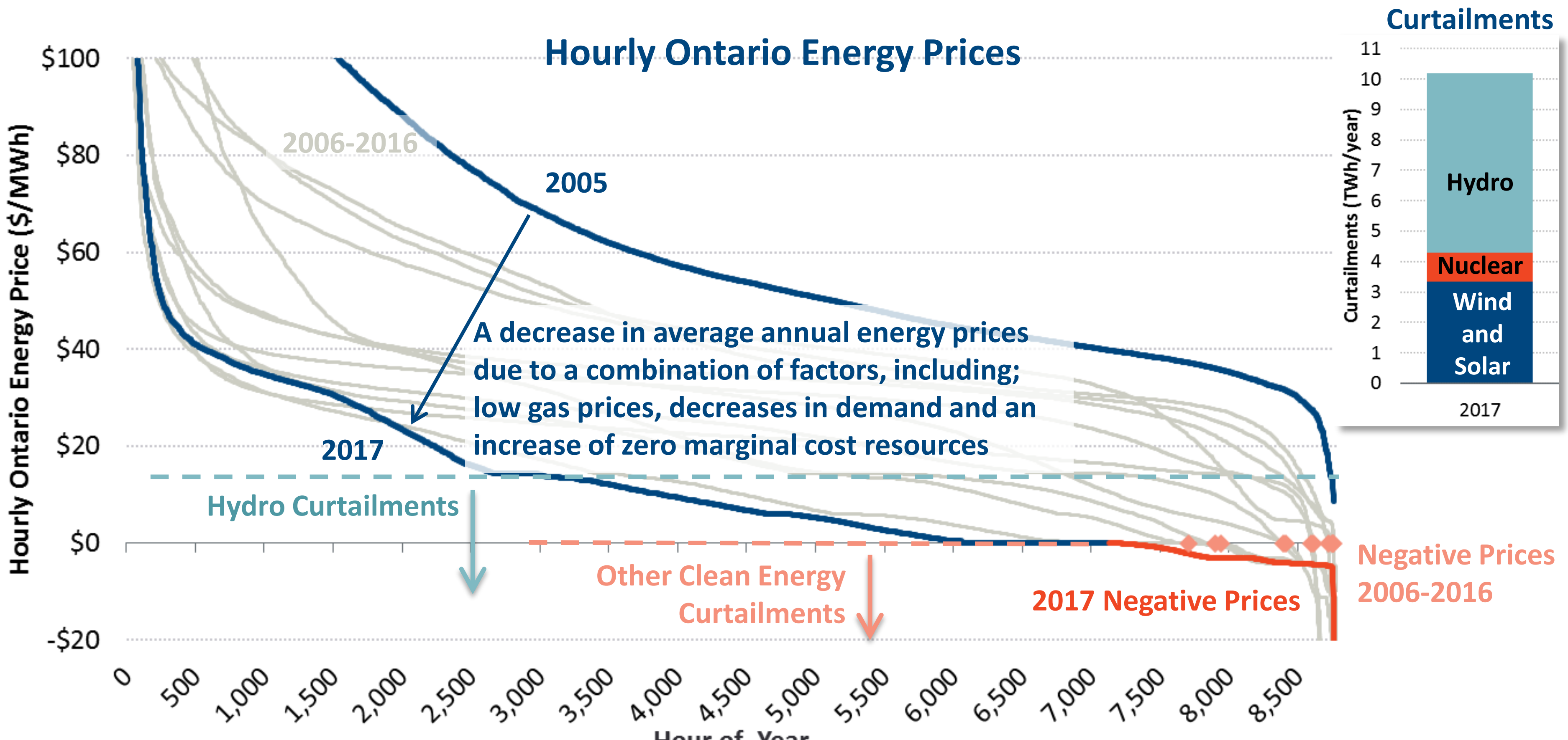
4.3.3. What are the market efficiency impacts of sustained negative pricing?

4.3.4. What options are available to mitigate or address market inefficiencies from sustained negative pricing?

4.3.5. What approaches are being considered in other jurisdictions to manage these challenges and what lessons can Ontario learn from other jurisdictions?

Ontario Prices Were Negative 19% of the Time in 2017

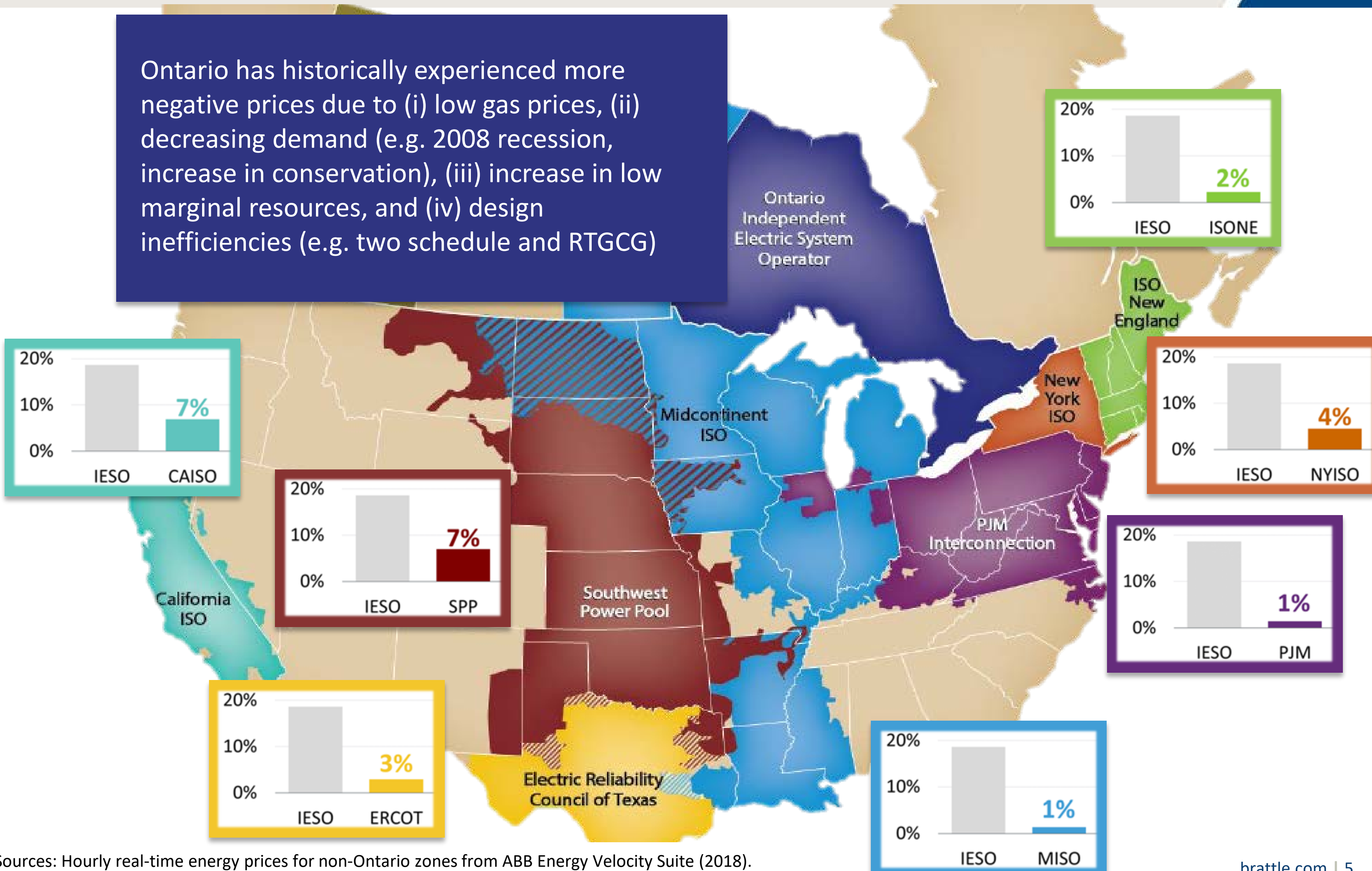
Ontario has had an increasing frequency of low or negative prices, with corresponding high curtailments of clean energy resources



Sources: Hourly Ontario Energy Prices taken from IESO Data Directory. Curtailments taken from IESO year-end data and OPG's annual & financial reports. Water rental charge and property tax calculated from Ontario Ministry of Finance, assuming $43/MWh contract price and over 700 GWh/year generation.

Negative Pricing Occurs in Other Jurisdictions

Ontario has historically experienced more negative prices due to (i) low gas prices, (ii) decreasing demand (e.g. 2008 recession, increase in conservation), (iii) increase in low marginal resources, and (iv) design inefficiencies (e.g. two schedule and RTGCG)



Sources: Hourly real-time energy prices for non-Ontario zones from ABB Energy Velocity Suite (2018). Hourly Ontario Energy Prices taken from IESO Data Directory. Map from ISO/RTO Council, isorto.org.

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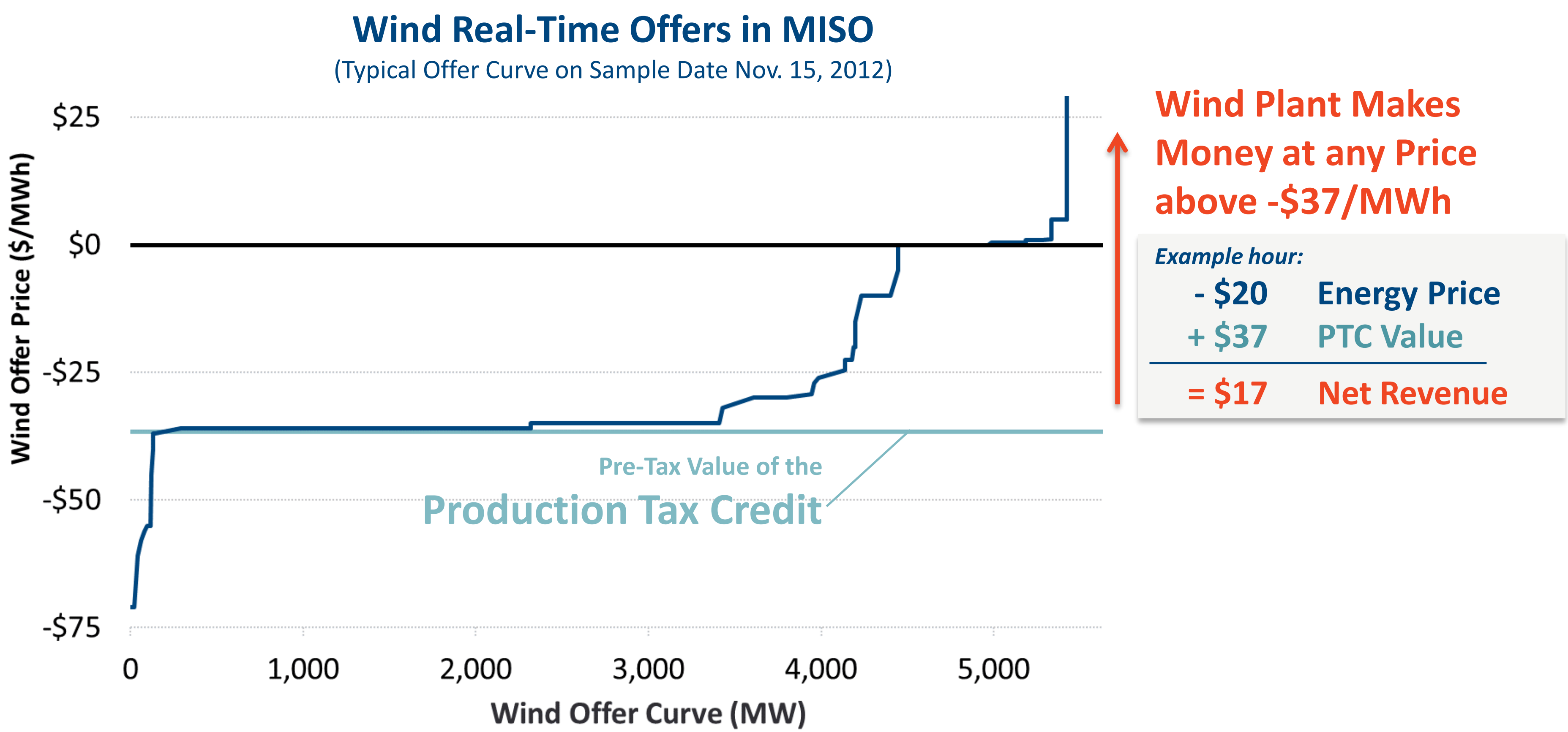
What Are the Drivers of Negative Pricing?

Several drivers combine to produce more frequent, severe, and sustained negative pricing:

Drivers of Negative Pricing
Operational Surprises
Surplus Supply
Inflexible Baseload
Transmission Constraints
Contract & Policy Incentives

Contractual and Policy Incentives to Offer at Negative Prices

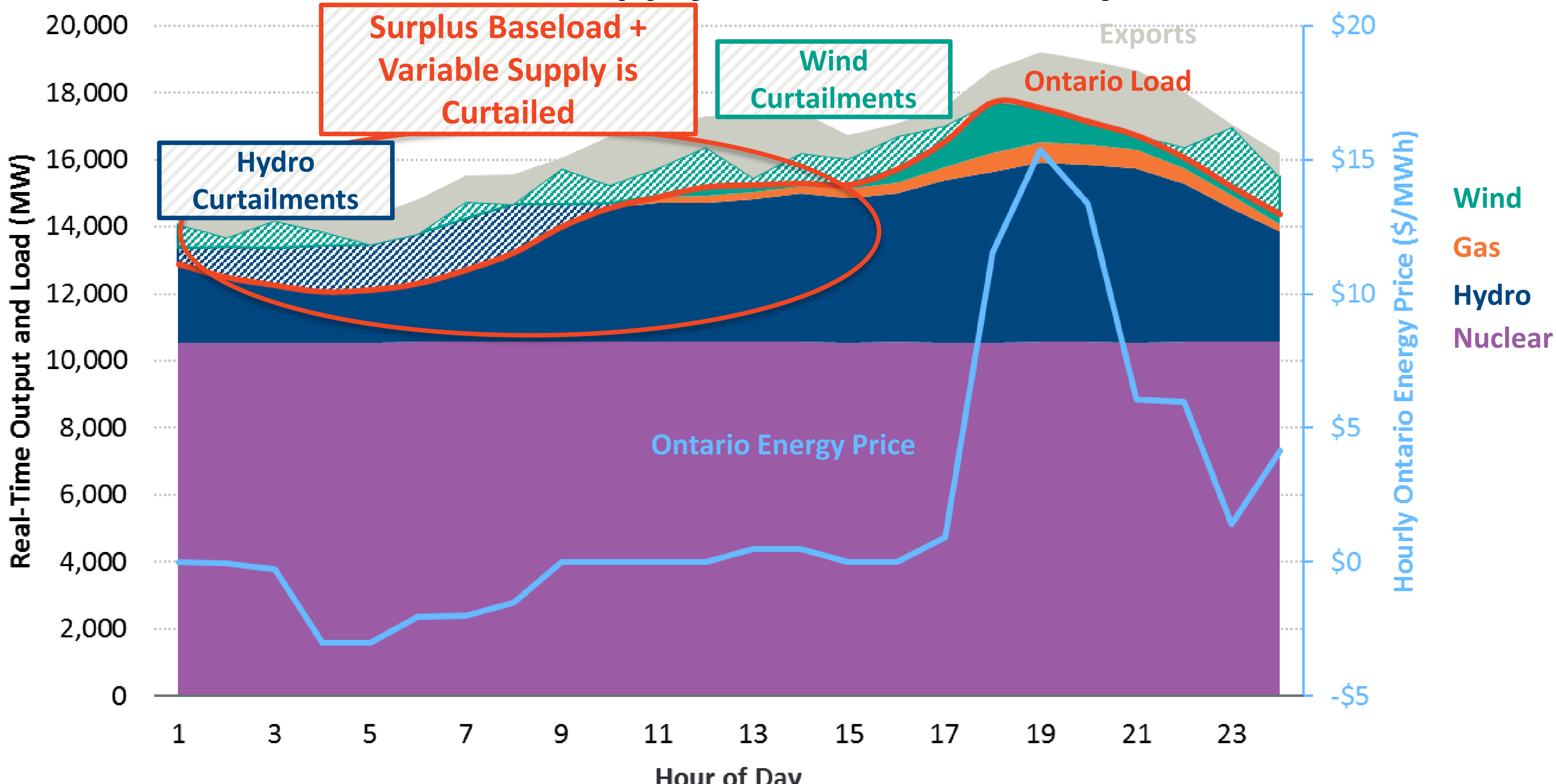
Policies like the U.S. production tax credit (PTC) and contracts like Ontario's Feed-in-Tariff (FIT) pay even during negative price hours



Note: PTC value and tax rate shown here were relevant at time of offer curve. PTC Credit = PTC ÷ (1 - 40% tax rate) = $22/MWh ÷ (1-40%) = $36.67/MWh.

Surplus Baseload and Intermittent Supply

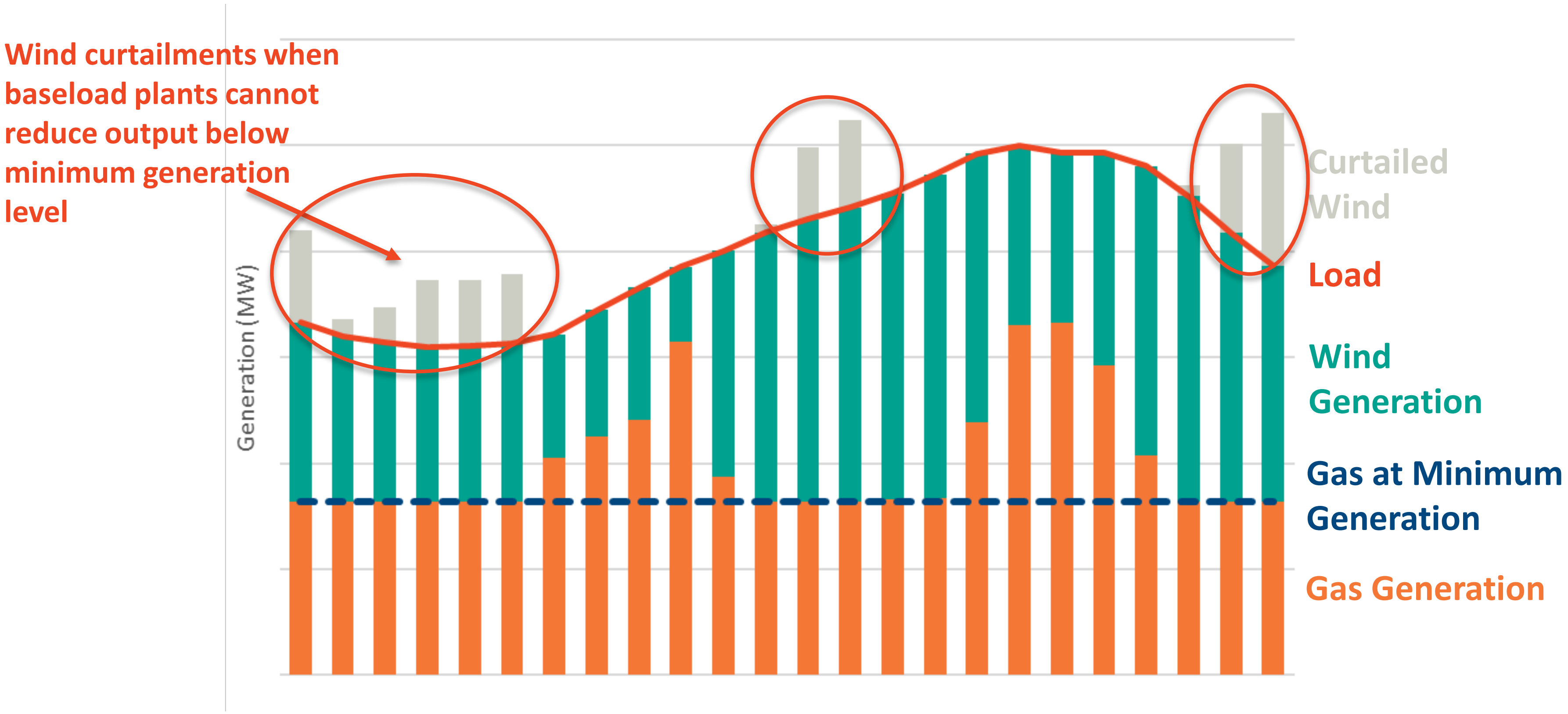
The biggest driver of negative pricing in Ontario is an abundance of baseload & intermittent supply that cannot always be absorbed



Sources: Illustrative figure based on data for November 19th, 2017. Found on IESO data directory. Hourly curtailments taken from SIM calibration case from NERSC Phase 2 Modelling Exercise .

Thermal Plant Minimum Generation & Other Constraints

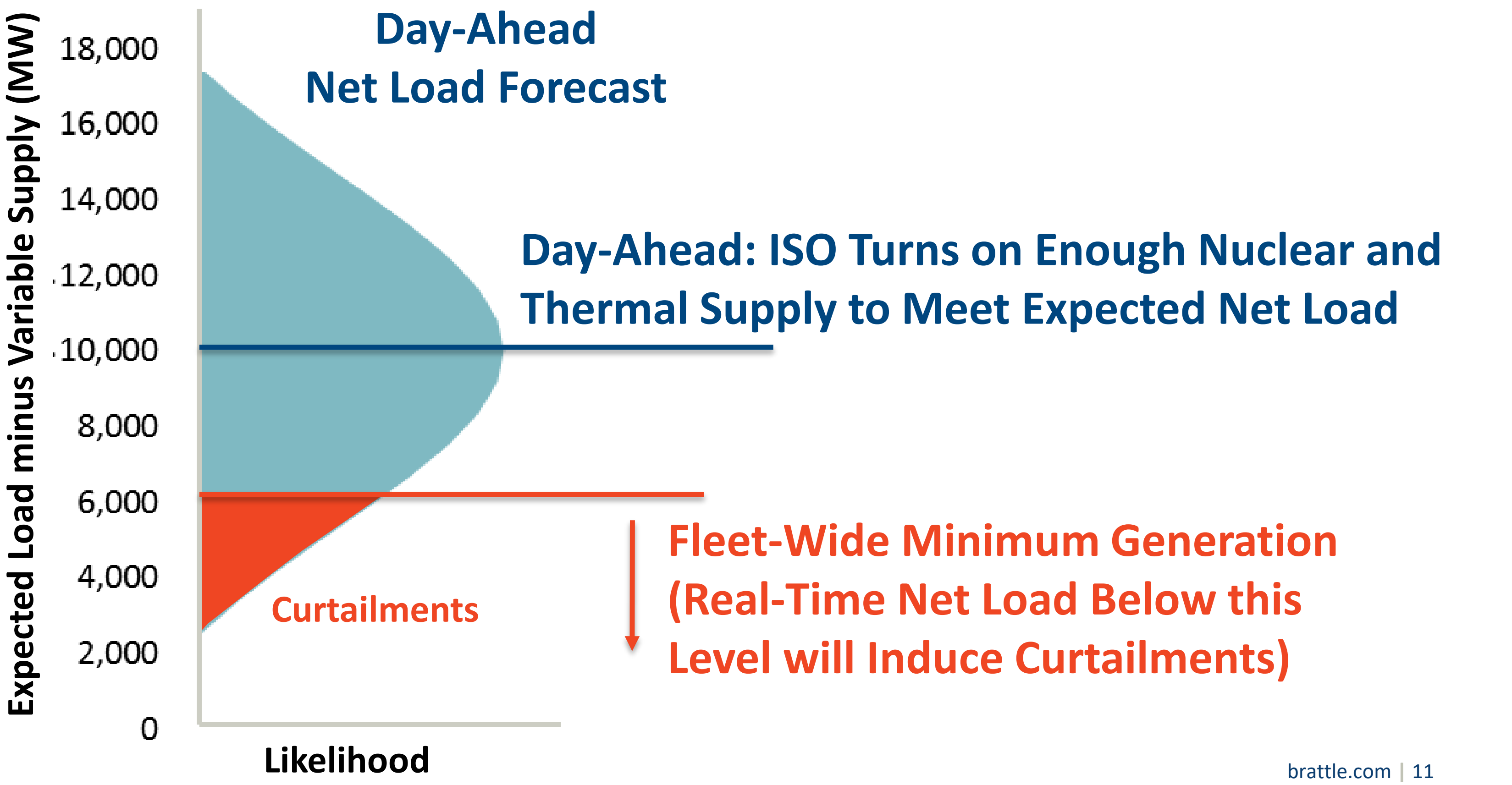
Nuclear and thermal plants contribute to negative pricing & curtailments via minimum generation, run time, and down time constraints



Notes: Figure represents illustrative scenario of one wind plant and one gas CC plant meeting demand.

Operational Uncertainties at the Time of Unit Commitment Decisions

Real time "surprises" including higher output from variable resources or lower demand can produce excess supply conditions (ramping & other intra-day constraints create a similar effect)

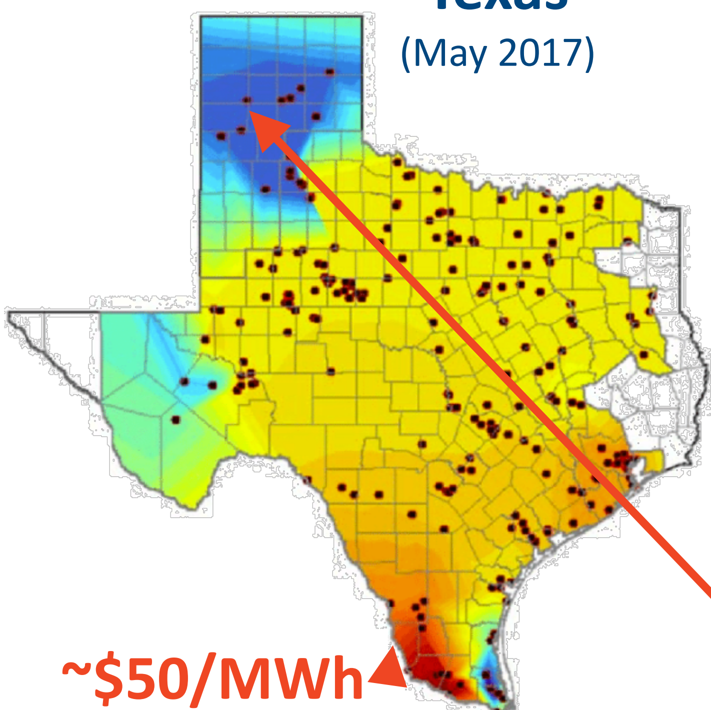


Transmission Constraints that Bottle Generation in Export-Constrained Zones

Locational markets reveal where transmission bottlenecks induce negative prices & curtailment, even if other sub-regions have high prices. Inefficient system export barriers have a similar effect

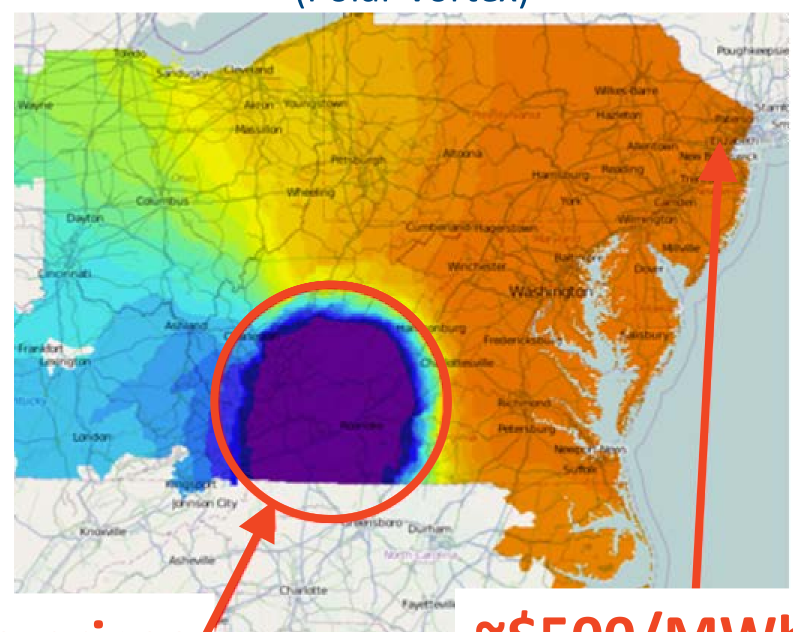
Texas

(May 2017)



PJM

(Polar Vortex)



~$50/MWh

Negative prices

~$500/MWh

Sources: Seel, Joachim & Wiser, Ryan & Mills, Andrew & Levin, Todd & Botterud, Audun. (2017). Impacts of Variable Renewable Energy on Bulk Power System Assets, Pricing, and Costs, p. 35. http://eta-publications.lbl.gov/sites/default/files/lbnl_anl_impacts_of_variable_renewable_energy_final_0.pdf. https://avalonenergy.us/category/negative-electricity-prices/.

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Are Negative Prices Efficient?

YES

Negative prices use market-based signals to prioritize curtailments and incentivize system flexibility during surplus generation events

BUT

Large, sustained negative prices or resource curtailments often indicate an underlying inefficiency in fleet mix, operations, market incentives, transmission planning, or policy

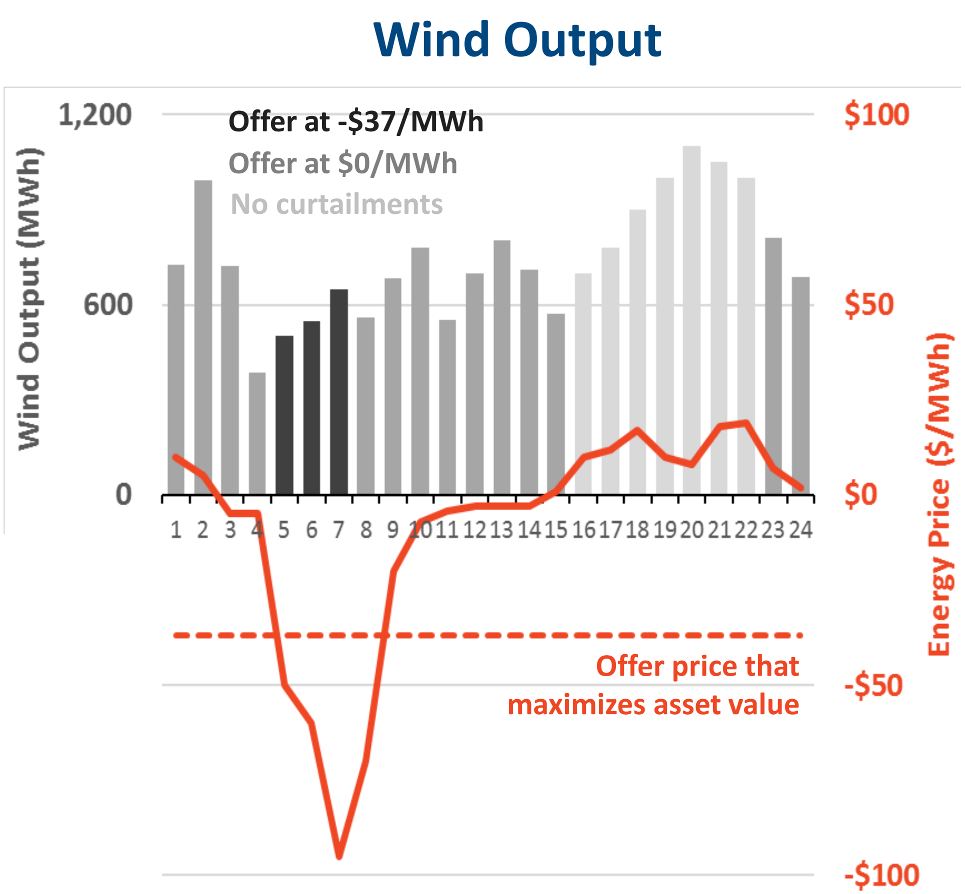
The Efficiency Implications of Negative Pricing Has Several Layers/Perspectives:

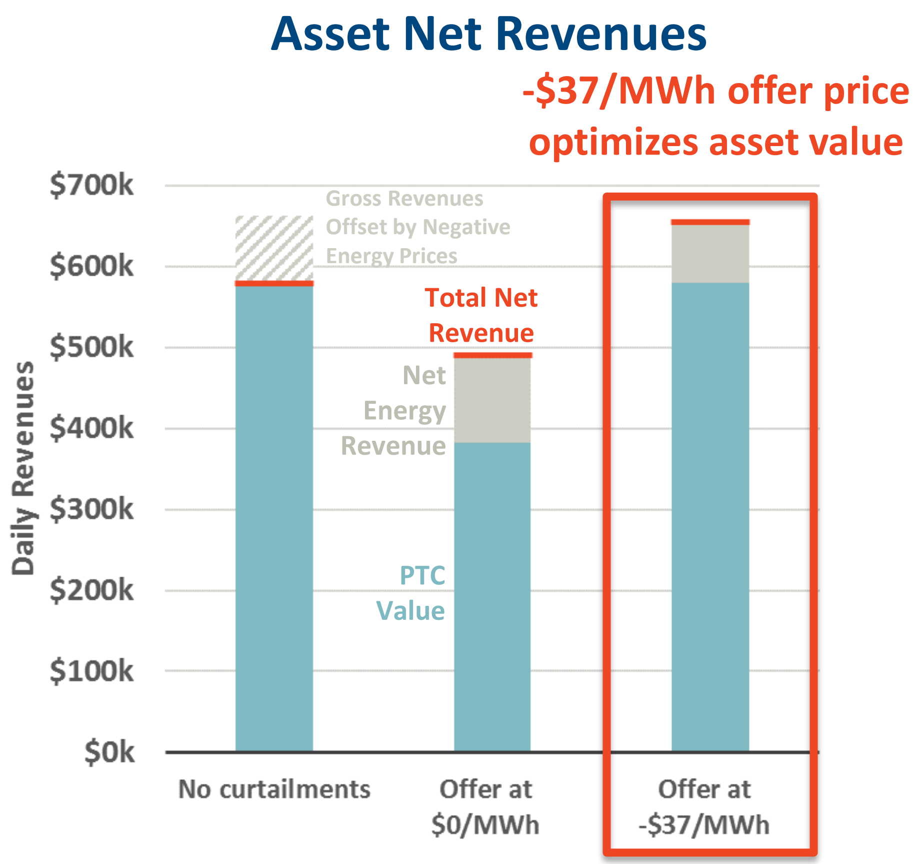
- Individual Assets' Value
- Fleet-Wide Operating Costs
- Fleet-Wide Investment + Transmission Costs
- Environmental Policy Goals

Source: Images from www.flaticon.com.

Offering at Negative Prices Can Maximize Private Returns for an Individual Asset

Enabling negative offers is efficient at the resource-specific level, because it aligns private incentives with prices and dispatch signals





Negative Pricing Does Not Always Help Minimize Fleet-Wide Operating Costs

Negative pricing may reveal underlying inefficiencies in private incentives that may ultimately drive higher fleet-wide operating costs

Do negative prices help minimize system production cost?

Yes if...	&	No if...
– They incentivize flexibility and storage		– Offers deviate from true marginal cost due to contract, tax, FIT, or REC incentives – Inflexible baseload resources are protected from negative prices via uplift payments

Excess Locational Negative Pricing Can Indicate Underlying Inefficiencies

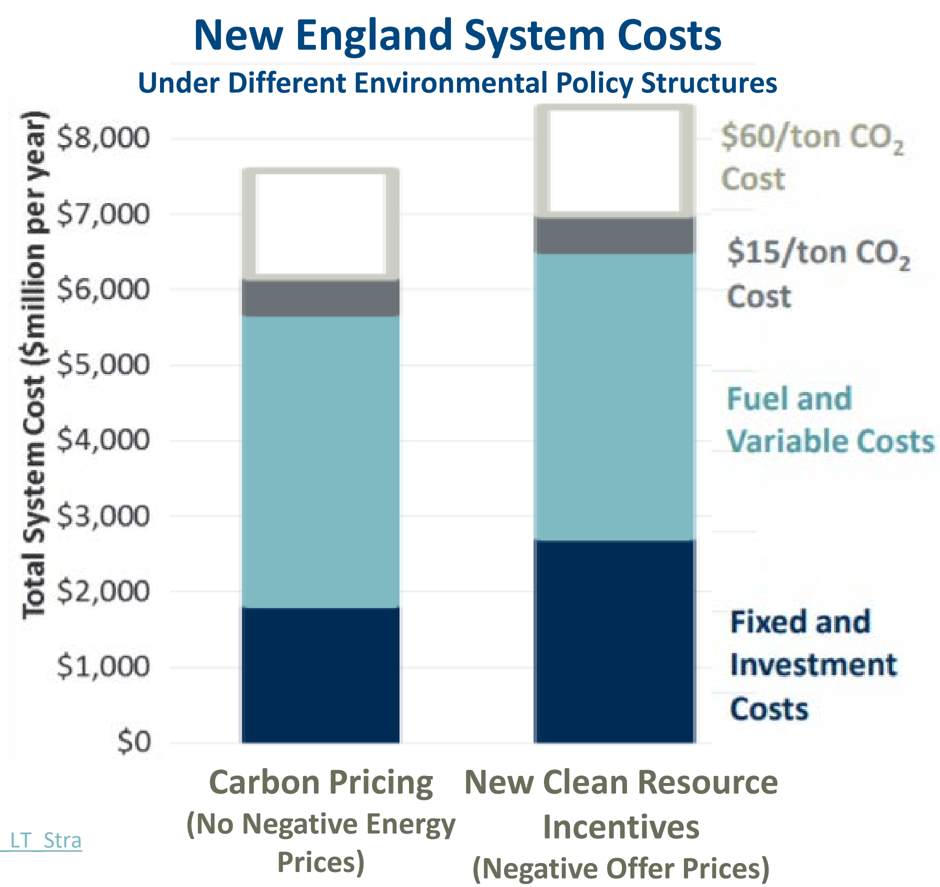
Negative pricing efficiently reflects over-supply in a bottlenecked sub-region. But extensive negative pricing can sometimes reveal other underlying inefficiencies

Potential Underlying Inefficiencies Driving Excess Locational Negative Prices

	Operating Timeframe	Investment Timeframe
Resources	• Operating incentives exceed locational value (e.g. CMSC-down payments)	• Excess incentives (or lack of disincentives) for supply to locate in generation pockets
Transmission	• Barriers to efficient 5-min real-time intertie scheduling, preventing efficient export	• Insufficient development of cost-effective transmission projects

Negative Pricing May Indicate Policy Incentives Partly Misaligned with Objectives

Environmental payments awarded in negative price times may not fully align incentives with carbon goals. Aligning private incentives with goals can reduce the cost of the policy



Source: See the full study: http://www.nepool.com/uploads/IMAPP_20170517_LT_Straw_Dynam_Clean_Energy_Market.pdf

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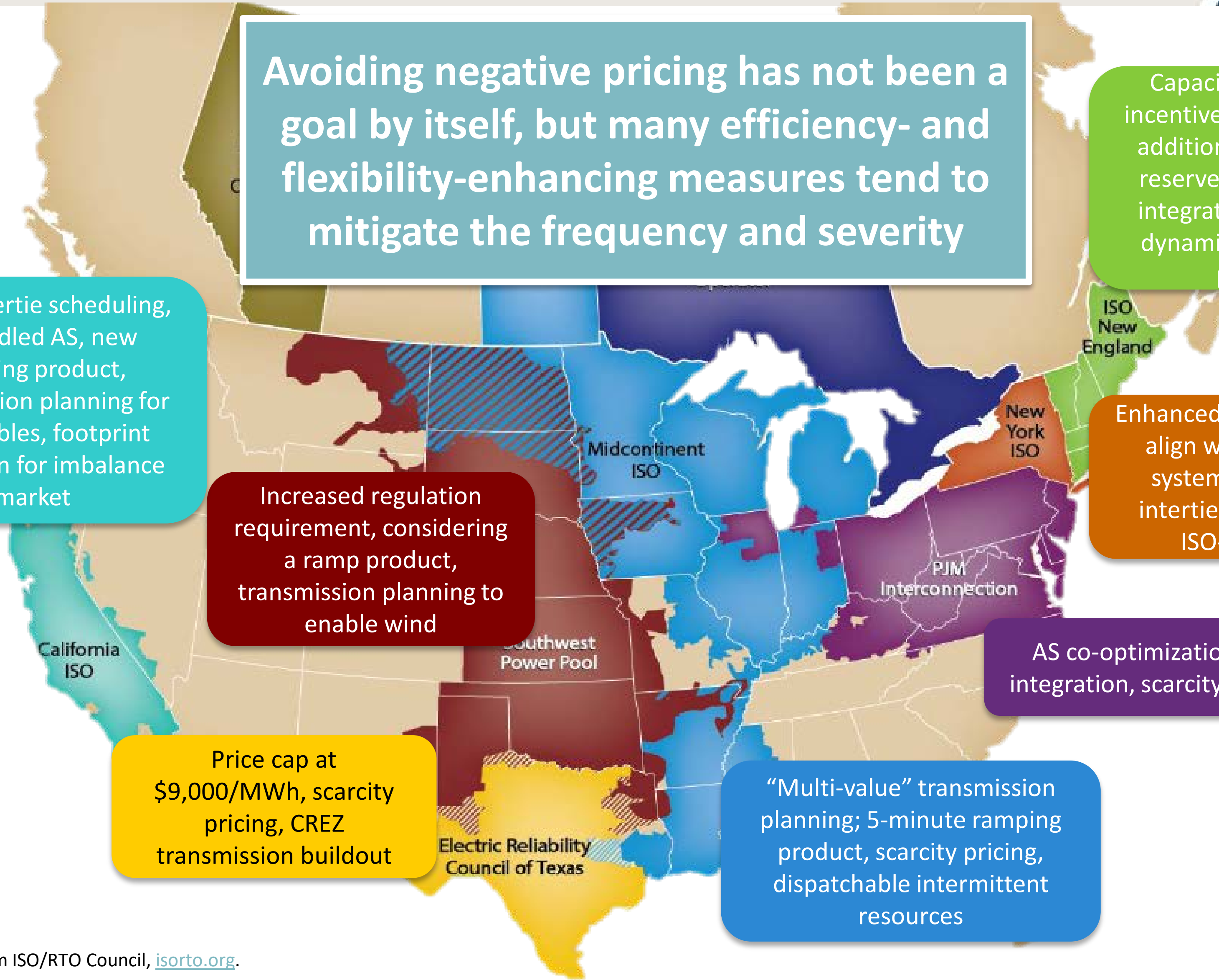
Examples of Reforms that Mitigate Curtailments and Sustained Negative Pricing

Avoiding negative pricing has not been a goal by itself, but many efficiency- and flexibility-enhancing measures tend to mitigate the frequency and severity



Capacity performance incentives, scarcity pricing, additional "replacement reserve" AS product, DR integration, proposal for dynamic clean attribute payments

5-min intertie scheduling, unbundled AS, new ramping product, transmission planning for renewables, footprint expansion for imbalance market

Increased regulation requirement, considering a ramp product, transmission planning to enable wind

Enhanced scarcity pricing to align with neighboring systems, coordinated intertie scheduling with ISO-NE and PJM

AS co-optimization, DR integration, scarcity pricing

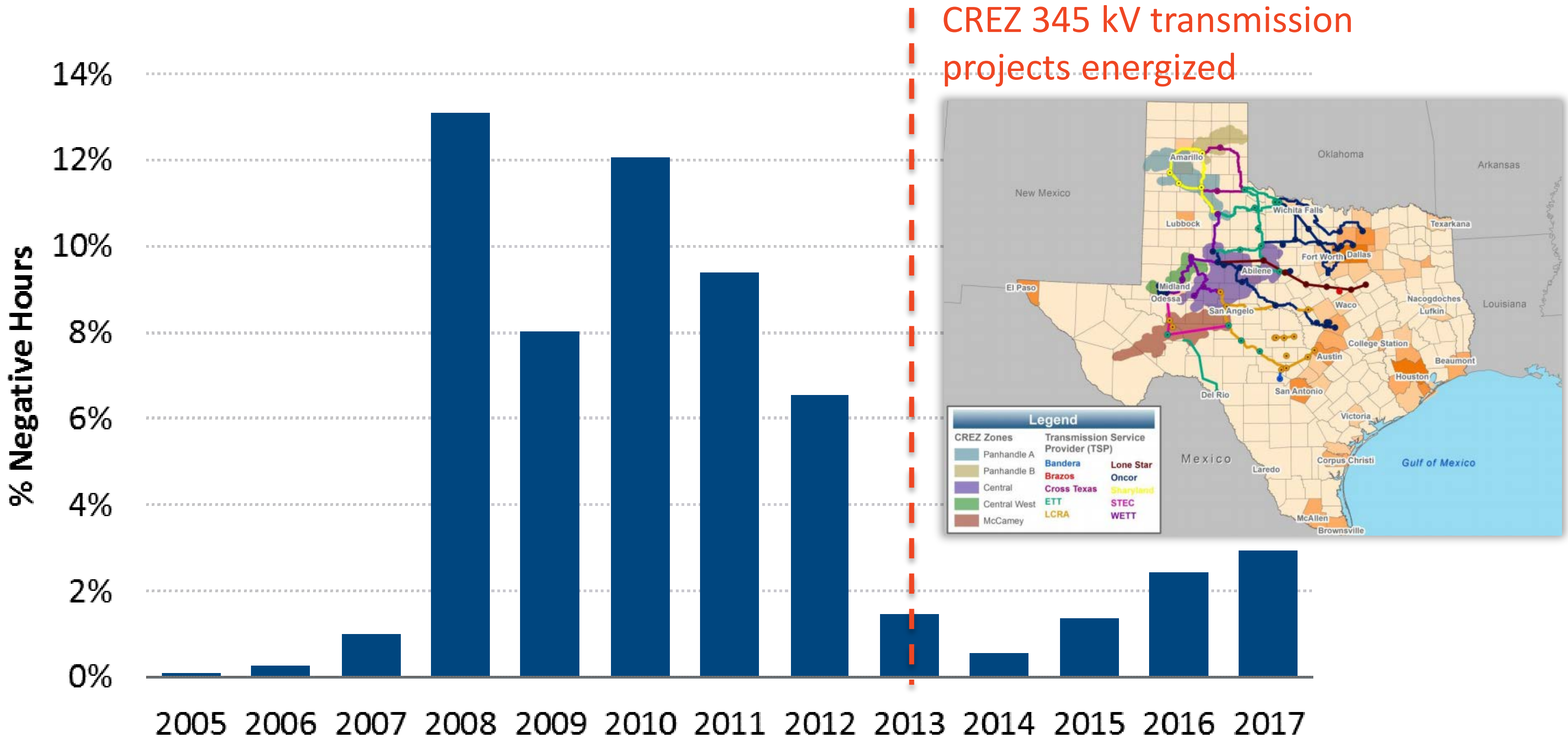
Price cap at $9,000/MWh, scarcity pricing, CREZ transmission buildout

"Multi-value" transmission planning; 5-minute ramping product, scarcity pricing, dispatchable intermittent resources

Source: Map from ISO/RTO Council, isorto.org.

Texas: CREZ Transmission Developments Reduced Frequency of Negative Prices

Incidence of negative prices decreased with introduction of Competitive Renewable Energy Zones to help relieve congestion



Sources: ERCOT, *The Competitive Renewable Energy Zones Process,* August 11, 2014, p. 6.
https://www.energy.gov/sites/prod/files/2014/08/f18/c_lasher_qer_santafe_presentation.pdf.
Hourly real-time energy prices for ERCOT West from Ventyx (2018).

California: Taking an Integrated Approach to Mitigating Curtailments

Growing intermittency and curtailment are a large reason for expanding the regional market and optimizing interties

Storage – increase the effective participation by energy storage resources.

Western EIM expansion – expand the western Energy Imbalance Market.

Demand response – enhance DR initiatives to enable adjustments in consumer demand, both up and down, when warranted by grid conditions.

Regional coordination – offers more diversified set of clean energy resources through a cost effective and reliable regional market.

Time-of-use rates – implement time-of-use rates that match consumption with efficient use of clean energy supplies.

Electric vehicles – incorporate electric vehicle charging systems that are responsive to changing grid conditions.

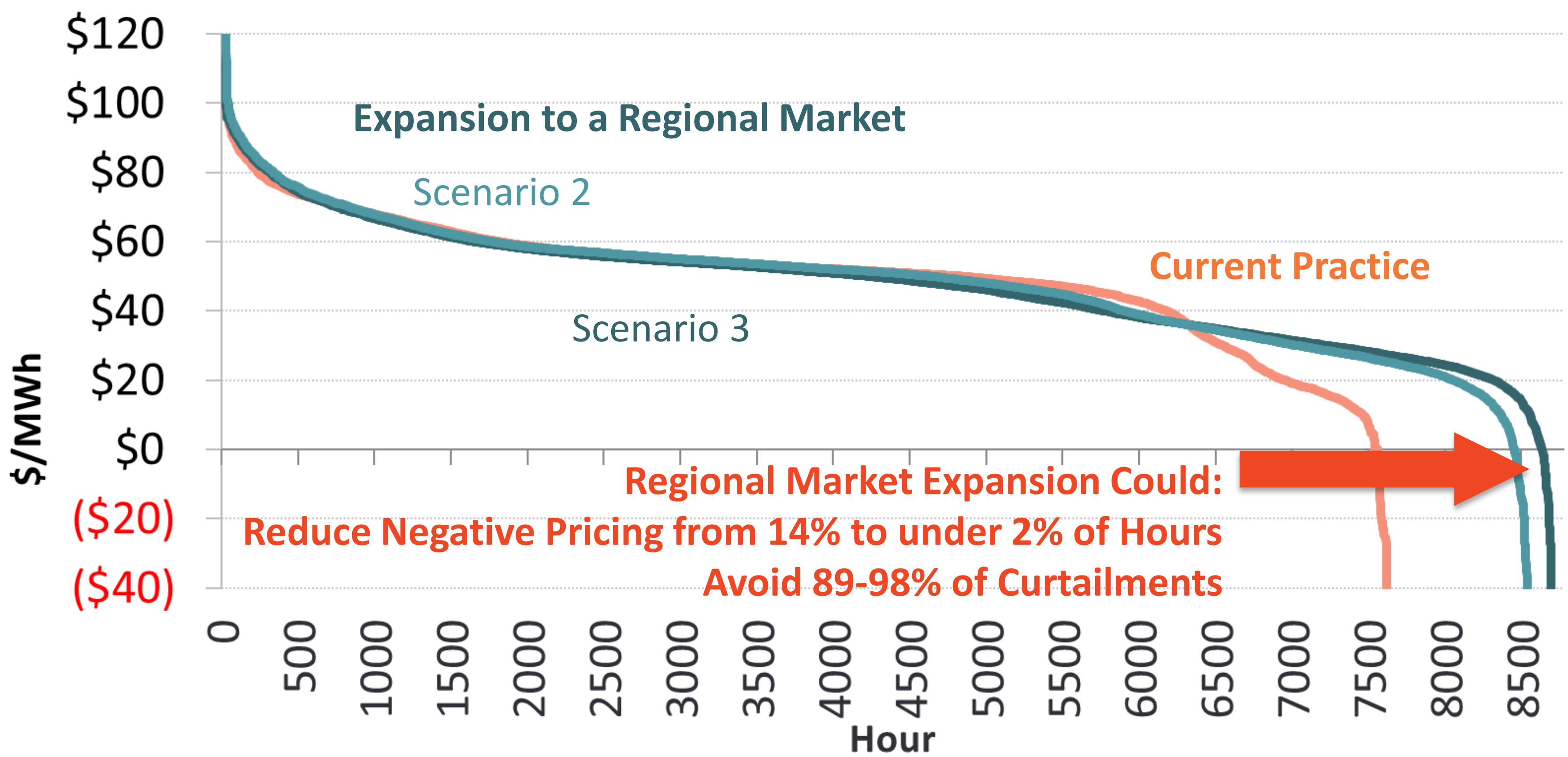
Minimum generation – explore policies to reduce minimum operating levels for existing generators, thus making room for more renewable production.

Flexible resources – invest in modern, fast-responding resources that can follow sudden increases and decreases in demand.

Source: https://www.caiso.com/documents/curtailmentfastfacts.pdf

California: Potential Impact of a Broader Regional Market on Curtailments

Expanding CAISO into a WECC-wide regional market could eliminate most negative pricing and renewable curtailments by 2030



Source: CAISO. Senate Bill 350 Study: The Impacts of a Regional ISO-Operated Power Market on California: Volume 5

Emerging Best Practices for Environmental Policies Would Mitigate Negative Prices

Best practices for designing policy incentives for clean energy resources…

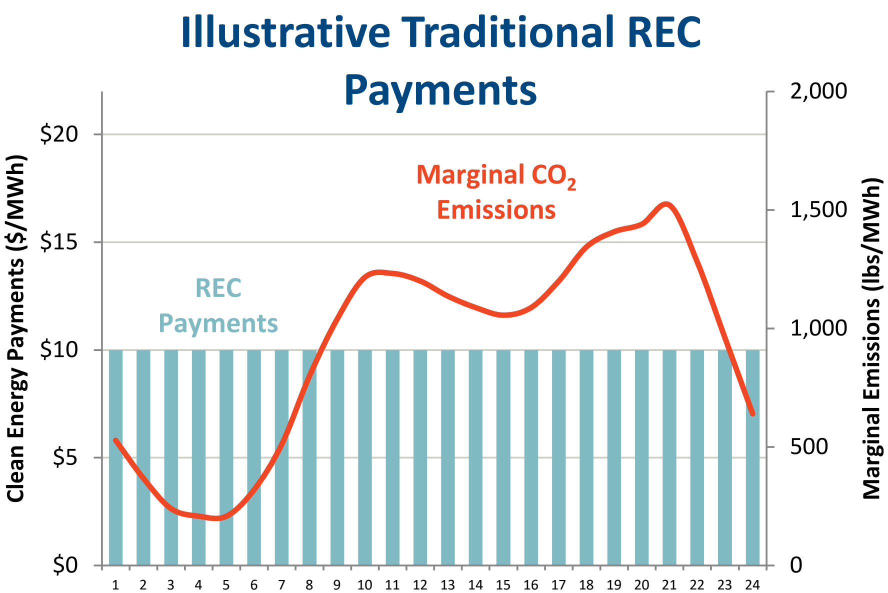
- ★ **Product Definition** that matches the underlying objective (carbon abatement)
- ★ **Unbundled Attributes** that maximize competition across markets and technologies
- **Policymakers and Customers Choose** their own demand quantities and willingness to pay (no costs shifted to non-participants)
- **Technology-neutral** qualification and payments
- ★ Broad **regional competition**
- Mechanisms to **mitigate regulatory risk** and ensure financeability at competitive costs
- ★ Care to ensure **alignment with energy, ancillary, and capacity markets**

★ = will help mitigate negative prices

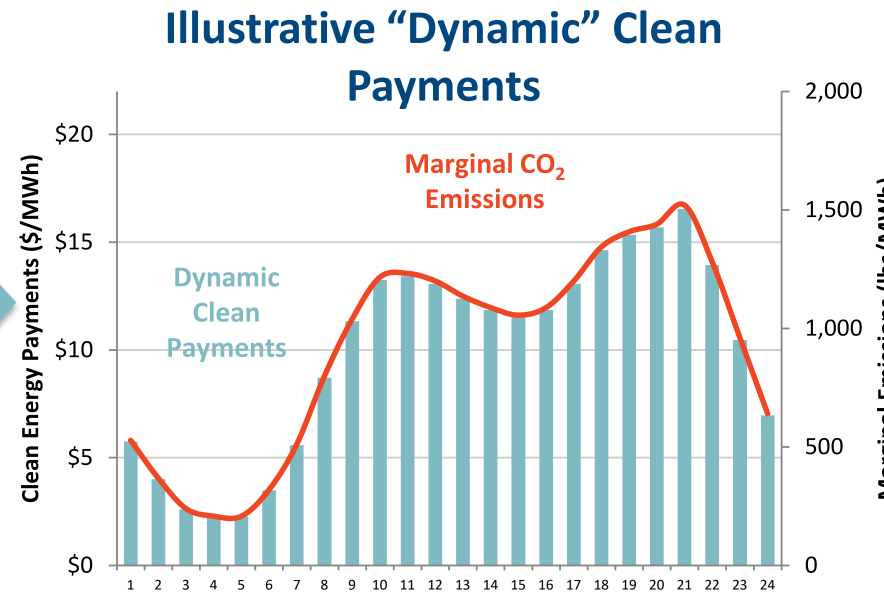
Sources: Spees, Kathleen, *Clean Energy Markets: the "Missing Link" to Market Design 3.0*, presented to Harvard Electricity Policy Group, October 4, 2018, p. 7. European Commission, *European Commission Guidance for Renewables Support Schemes*.

New England: Proposal for Clean Energy Payments Aligned with Carbon Value

"Dynamic" attribute payments would not induce negative offer prices



- Flat payments over every hour
- Incentive to offer at negative energy prices during excess energy hours

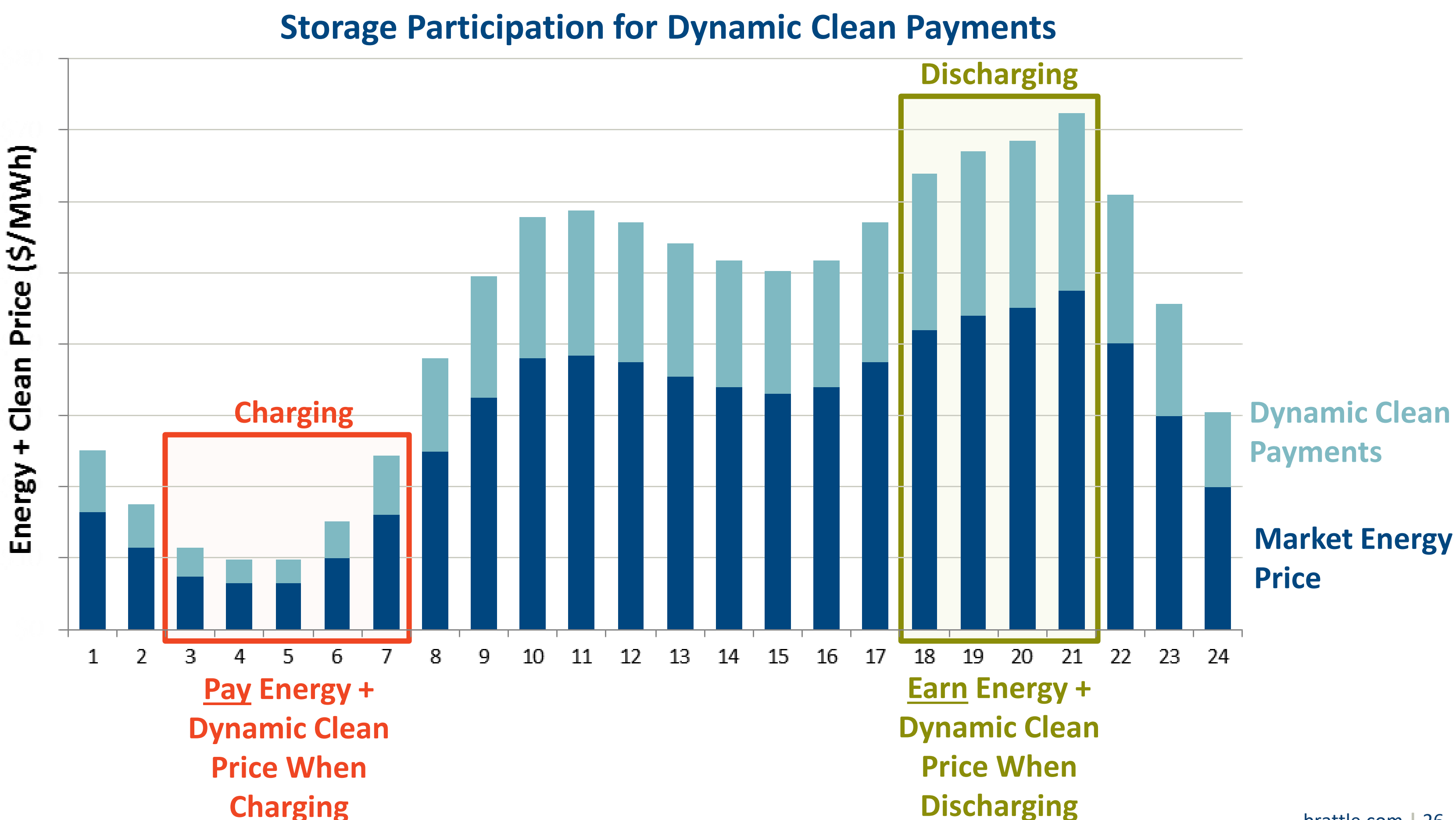


- Payments scale in proportion to marginal CO_2 emissions (by time and location)
- Incentive to produce clean energy when and where it avoids the most CO_2 emissions
- **No incentive to offer at negative prices**

Source: See the full design proposal : http://www.nepool.com/uploads/IMAPP_20170517_LT_Straw_Dynam_Clean_Energy_Market.pdf

New England: Dynamic Attribute Payments Would Enable Storage to Compete

Dynamic payments for clean energy at the right times to displace emissions would help mitigate negative prices and enable storage



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Takeaways for Ontario

- Negative pricing is not a problem in itself, but it often signifies an underlying inefficiency
- In recent years, Ontario has faced a perfect storm of these issues (e.g. oversupply of baseload, negative offer prices, hydro rental charges), causing extensive negative pricing and curtailments
- Going forward, we expect curtailments to be significantly alleviated by reduction in nuclear supply and over time by the improved incentives under Market Renewal
- Several other issues are not directly addressed by Market Renewal (hydro rental charges, intertie efficiency, flexibility products)
- Even if frequency of negative prices is largely reduced, continued effort toward addressing underlying inefficiencies will improve system performance, reduce costs, and avoid curtailments

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