Integrated Clean Capacity Market

A DESIGN OPTION FOR ALIGNING INVESTMENT INCENTIVES TO ACHIEVE REGIONAL RELIABILITY AND CLEAN ENERGY MANDATES

PREPARED BY

Kathleen Spees

Walter Graf

Samuel Newell

PRESENTED TO

PJM Capacity Market Workshop

Session 3: Market Design Proposals

Derived from this ICCM design basis document developed on behalf of New Jersey Board of Public Utilities

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What is the “Integrated Clean Capacity Market”?

The ICCM would be a scalable, technology-inclusive forward clean energy procurement mechanism to meet regional clean energy goals affordably

The ICCM would:

- Be a **three-year forward auction** to procure two unbundled products: (1) capacity, and (2) clean energy attributes
- Build on the successful elements of today’s capacity market (and address current limitations) to achieve **reliability at least cost**
- Integrate state and customer **clean energy objectives** into the forward capacity market to attract a reliable and carbon-free supply mix

For a more comprehensive description see:
ICCM design basis document developed on behalf of New Jersey Board of Public Utilities

How would the ICCM work?

States

- Set clean energy goals and clean energy resource qualification standards
- Determine quantity of clean energy to buy through the ICCM

RTO

- Determines quantity of capacity needed for reliability (regionally and by location)

Buyers & Sellers

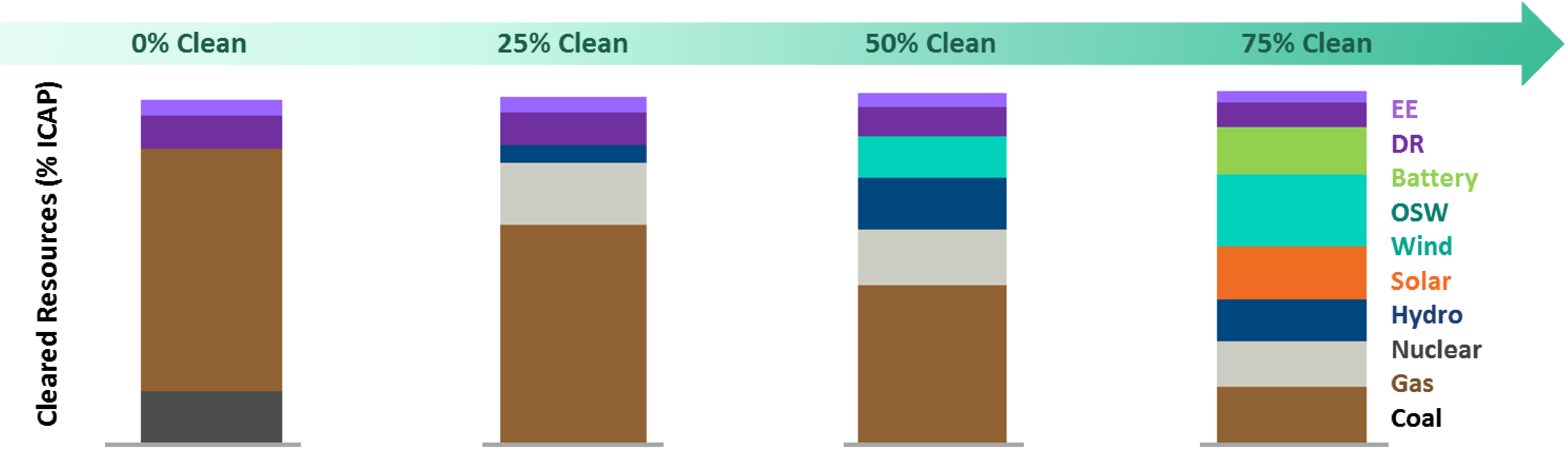
- Fossil generation: can sell capacity
- Clean resources: can sell both capacity and clean energy
- Voluntary buyers (cities, companies): can procure additional clean energy

Auction Administrator

- Three-year forward auction
- Least-cost procurement to meet both capacity and clean energy needs
- Separate prices for: (1) MW of capacity, and (2) MWh of clean energy attributes (RECs, ZECs, and CEACs)
- 7-12 year price lock-in for new resources

How could the ICCM guide the clean energy transition?

State mandates for clean energy would increase over time, driving a least-cost pathway to a cleaner grid



Note: Illustrative auction clearing and pricing model used to develop this example is available upon request. Simplified example is not intended to reflect PJM.

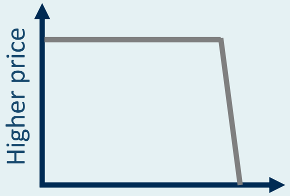
Three-Year Forward ICCM Auction Clearing

How would the ICCM meet capacity and clean energy needs at the lowest combined cost?

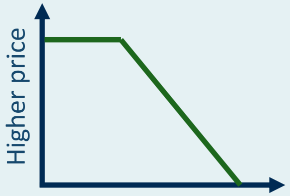
BIDS

Demand

Capacity (MW)



Clean Energy (CEACs)



Supply

- Total annual resource cost ($)
- Capacity quantity (UCAP MW)
- Clean attribute quantity (CEAC)

CO-OPTIMIZED AUCTION CLEARING

Similar to Current PJM Capacity Market Clearing

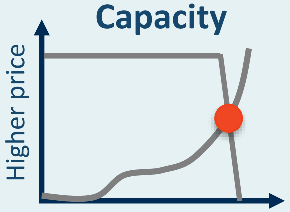
- **Objective function:** Maximize social surplus (area under demand curves minus cleared resource cost)
- **Cleared resources:** Least cost resources for meeting capacity & clean energy demand
- **Price setting:** Marginal cost of meeting incremental demand

CLEARING RESULTS

Clearing Prices

Cleared Resources

Capacity



Cleared Capacity Resources

Clean Energy

Cleared Clean Energy Resources

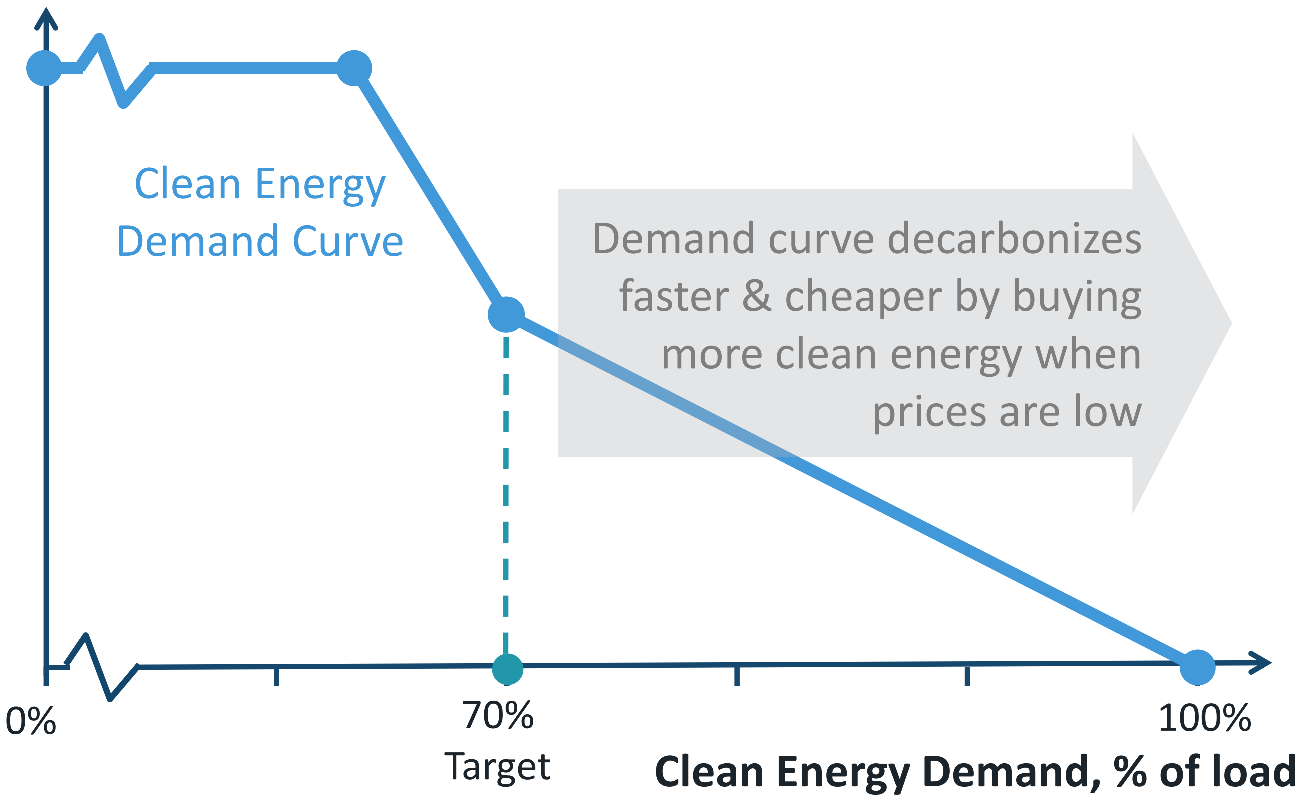
How would states and customers express demand for clean energy attributes?

For the first time, the wholesale market would empower states and customers to demand clean energy within their own budget constraints

Buyers would have flexibility to:

- Set their own demand quantities (including zero)
- Express demand in state-defined REC/ZECs, or in a new regionally-defined CEAC product (including the option for a new "dynamic" CEAC that is awarded in proportion to marginal carbon abatement)
- Determine their own willingness to pay through price-quantity pairs or sloping demand curves
- Set technology-specific carve-outs
- Develop clean energy outside the ICCM (e.g. through resource planning, contracting, or state programs)

Example: State Demand Curve for 70% Clean Energy



How do sellers offer?

Sellers can offer up to three types of offers: capacity-only, attribute-only, or capacity+attribute. Examples of typical fossil and clean resource offers:

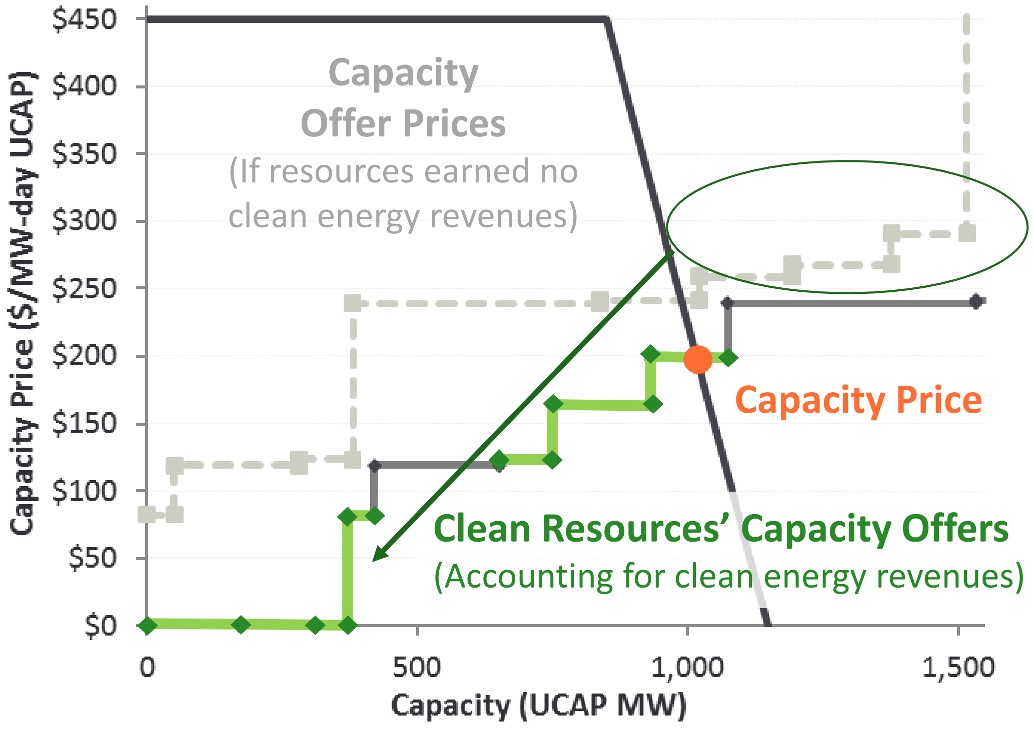
	Gas Plant	Solar Resource
Installed Capacity	100 MW ICAP	100 MW ICAP
Qualified Offer Quantity	**Capacity:** 95 MW UCAP **Attributes:** n/a (not eligible)	**Capacity:** 42 MW UCAP **Attributes:** 131 GWh RECs
Offer Price	$200/MW-day UCAP Same as current capacity market offer structure.	$80/kW-year ICAP One total revenue requirement to sell two products; resource will clear if total revenues from selling both products exceeds the offer price.

ICAP = Installed capacity, or maximum/nameplate rating
UCAP = Unforced capacity, or de-rated value contributing to capacity market reliability needs
Attributes = any REC, ZEC, or CEAC product that the resource is eligible to sell

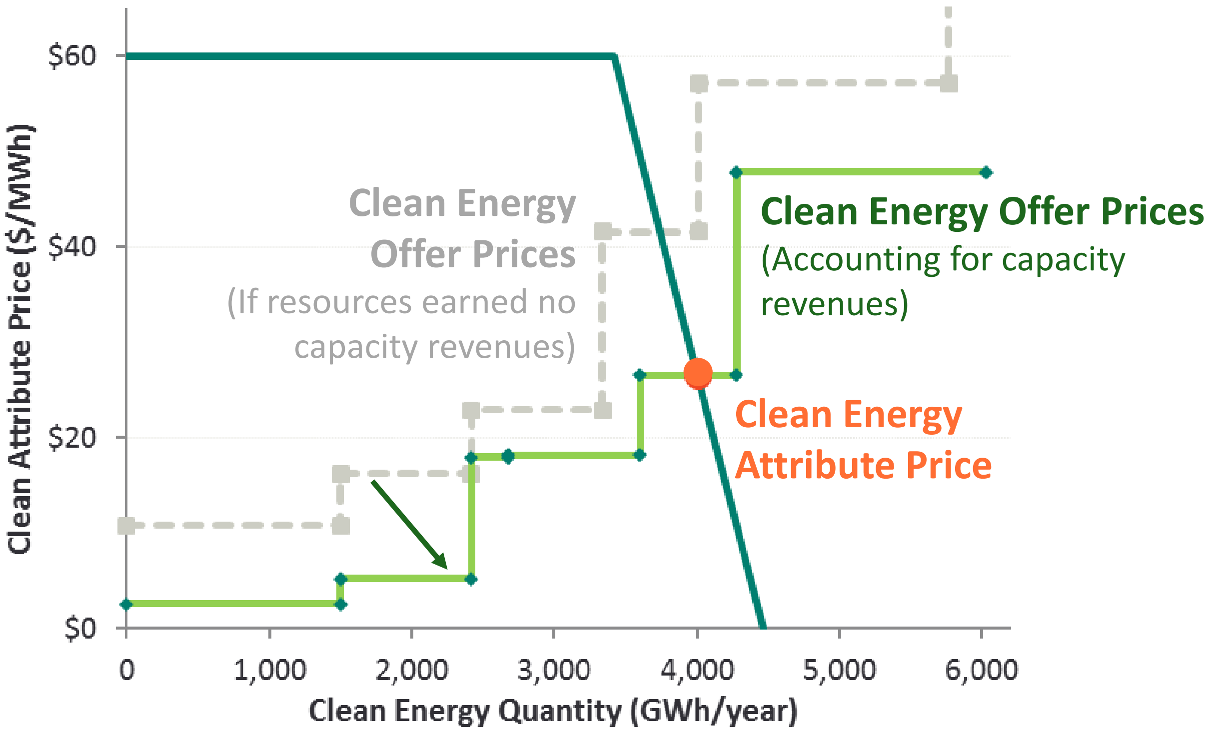
How are prices set?

Co-optimized price formation reflects marginal cost of each product.

Capacity Clearing



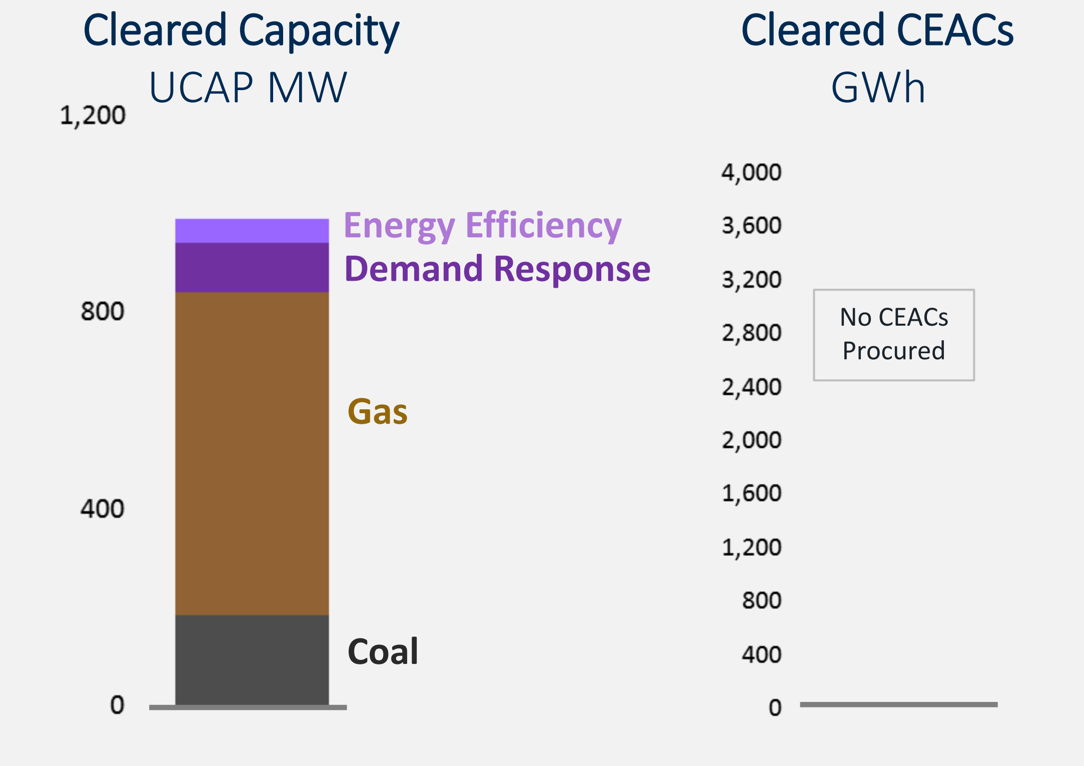
Clean Energy Clearing



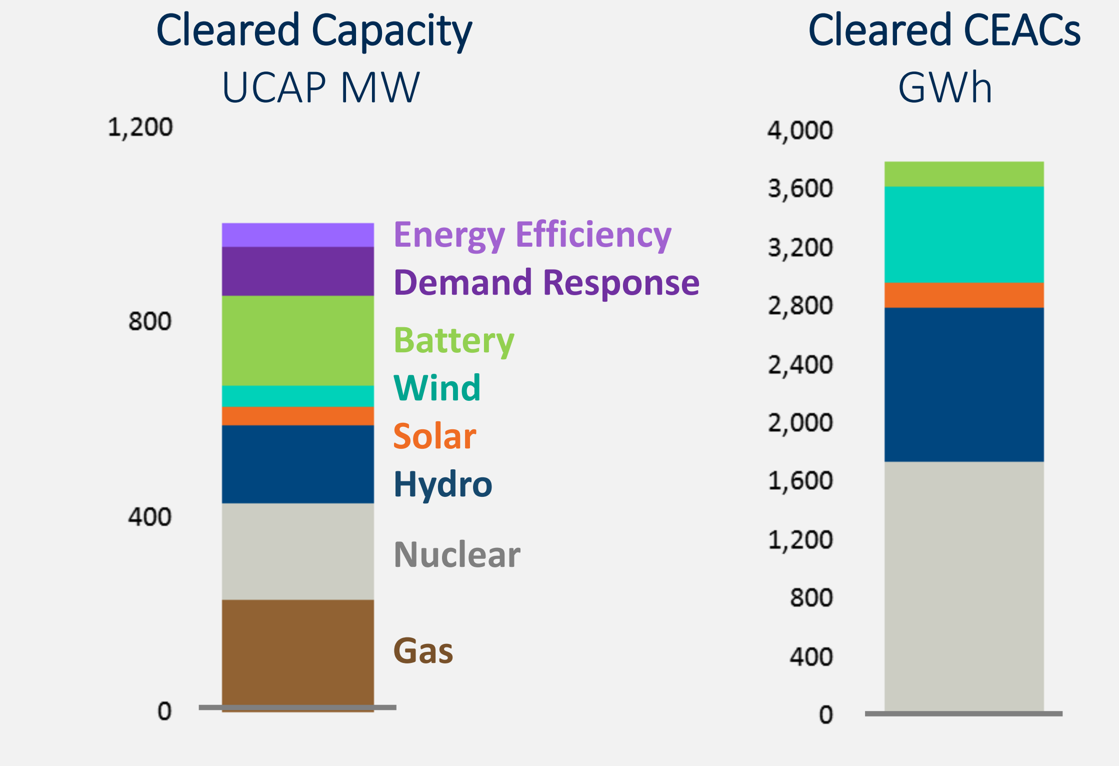
Note: Simplified example is not intended to reflect PJM. Clearing model available upon request.

What resources clear?

Traditional Capacity Market



Integrated Clean Capacity Market



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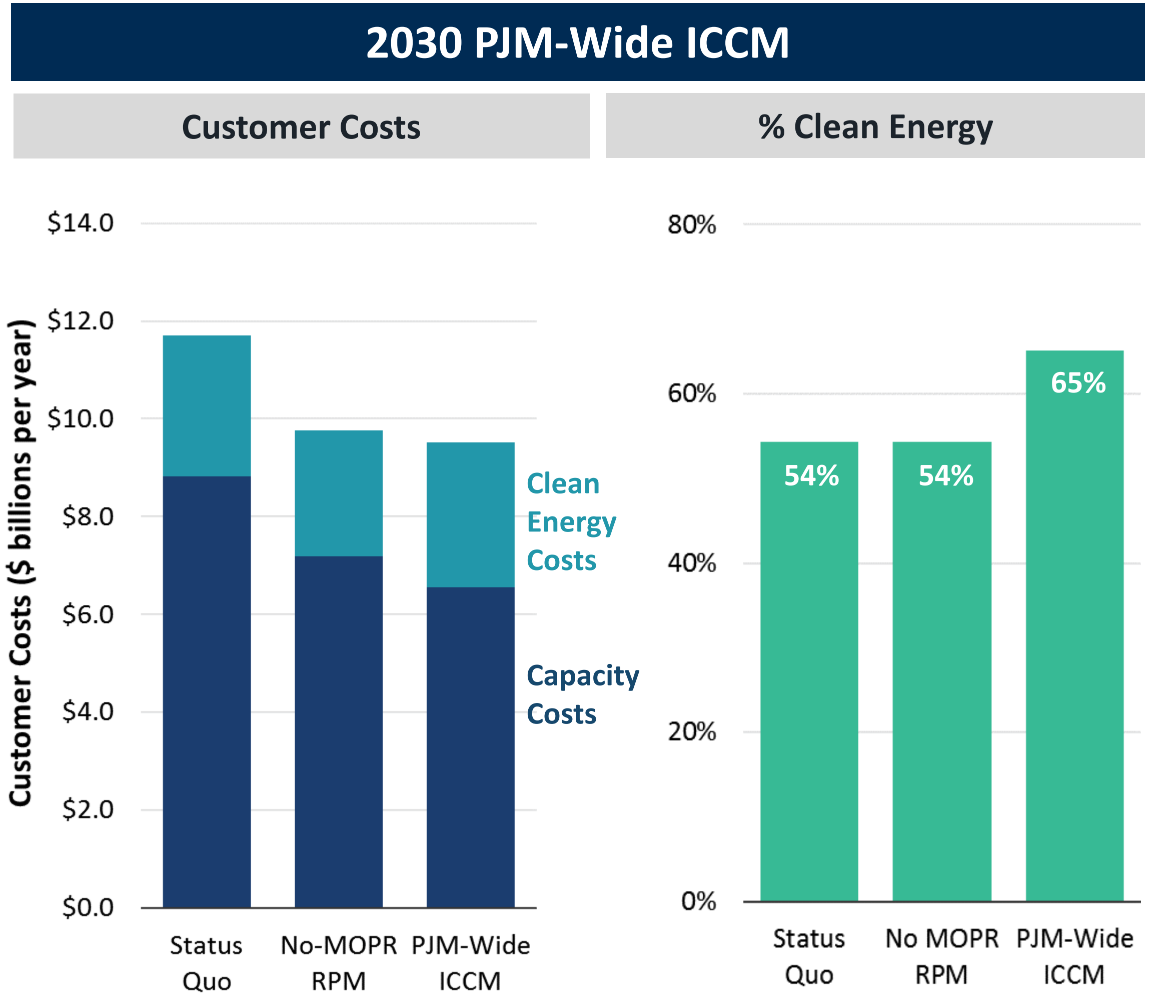
Why Consider ICCM?

ICCM offers a number of potential benefits to the region

- **Lower Costs:** A PJM-wide ICCM would achieve enormous cost savings to all states, including those that have *no clean goals* or *100% clean goals*
- **Accelerated Decarbonization:** Downward-sloping demand curve can accelerate clean energy achievement for states/customers
- **Customer-First Approach:** Offers flexibility for states and customers to define clean targets, participation level, eligibility requirements, and willingness to pay
- **Expand the Role of Competitive Markets:** ICCM can be the foundation of a long-term sustainable market design that meets reliability and policy goals; attracting the private capital that will be needed to achieve the clean energy transition



Note: Preliminary results subject to change with finalized study assumptions; comprehensive analysis will be posted within the NJ BPU Resource Adequacy Docket.

Beneficial ICCM design elements can be implemented in stages or incorporated to other proposals

Core RPM reforms

Worth considering regardless of ICCM

- Address over-procurement via load forecast, Net CONE, and demand curve shape
- ELCC accounting for all resources including fossil plants
- True two-season capacity market design and winter accounting
- Assess need for “flexible capacity” requirements

ICCM Design Elements

Potentially useful in other related designs

- Regionally-defined CEAC product(s)
- Forward market for CEAC and REC procurement (with or without RPM co-optimization)
- Flexibility for states and customers to set their own demand for clean energy
- “Dynamic” CEAC product that assigns value in proportion to marginal carbon abatement

Contact Information

Kathleen Spees

Principal, Washington DC

+1.202.419.3390
Kathleen.Spees@brattle.com

Dr. Kathleen Spees is a principal at The Brattle Group with expertise in wholesale electricity markets design and environmental policy analysis.

Dr. Kathleen Spees is a Principal at The Brattle Group with expertise in designing and analyzing 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.

Dr. Spees earned her PhD in Engineering and Public Policy within the Carnegie Mellon Electricity Industry Center and her MS in Electrical and Computer Engineering from Carnegie Mellon University. She earned her BS in Physics and Mechanical Engineering from Iowa State University.

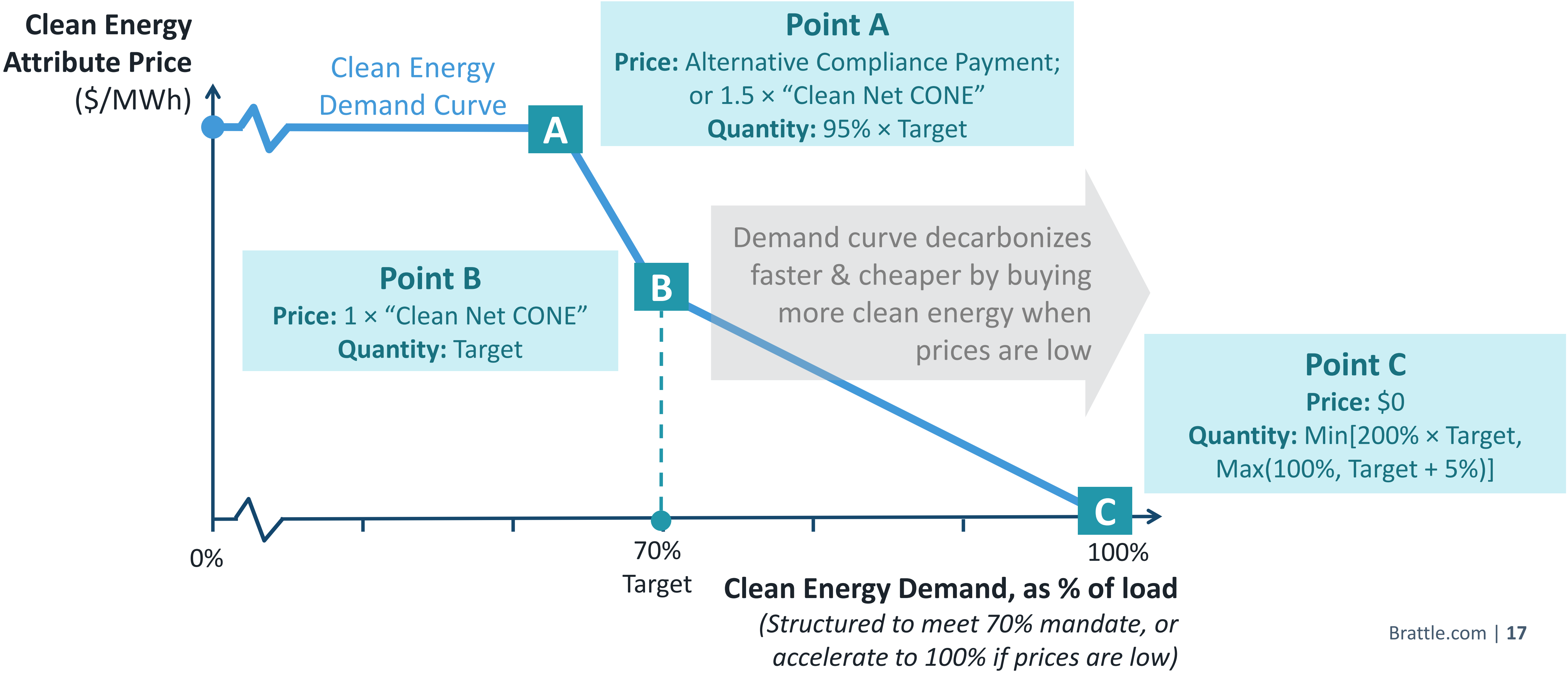
Appendix

ICCM Market Design Details

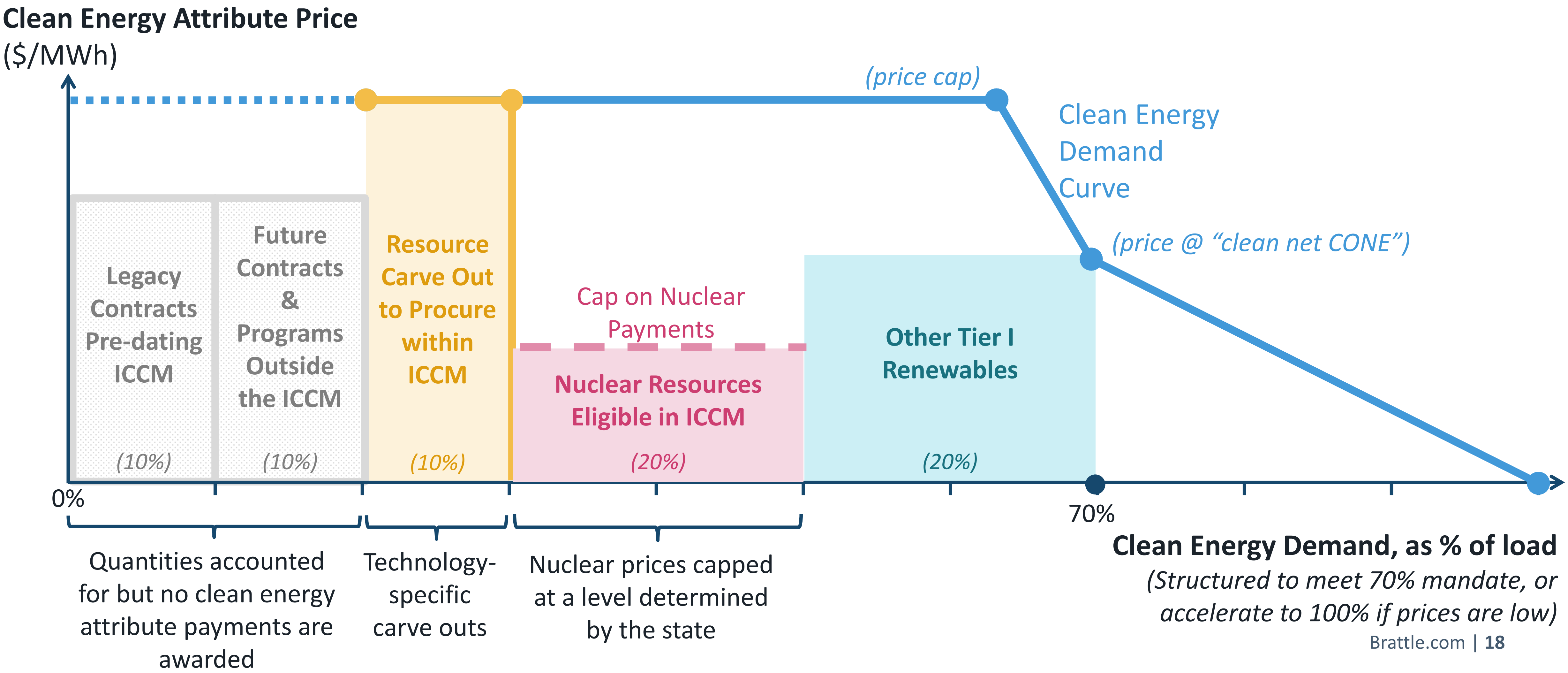
ICCM key design elements

Design Element	Resource Adequacy Objectives	Clean Electricity Objectives
Who Sets Demand?	• **RTO**	• **State policymakers** • **Voluntary buyers** (retailers, companies)
Product Definition	• Unforced capacity (UCAP MW) • Keep locational specificity (as today) • Accurate accounting of capacity needs and values of resource types	• Buyer selects which product to buy: state-defined RECs, state-defined ZECs, or regionally-defined clean energy attribute credits (CEACs) • *Consider*: CEAC accreditation tied to carbon abatement value
Supply Eligibility	• All clean and fossil resources are eligible • ELCC-based accounting for resource-neutral capacity values (by location, season, and flexibility)	• State REC/ZEC: utilize current eligibility rules from each state • Regional CEAC: PJM-wide product with uniform eligibility (likely renewable, nuclear, and storage charged from clean energy)
Quantity to Procure	• Quantity needed to support 1-in-10 • Based on advanced reliability modeling that considers emerging flexibility needs in the clean grid • *Consider*: State option to impose a maximum on the share of capacity procured from fossil plants	• States and customers decide the quantity needed • Pre-existing contracts enabled as self-supply • In vertically integrated or other Fixed Resource Requirement states, the resource mix is approved by the state and not subject to ICCM
Willingness to Pay for Each Product	• Sloping demand curves for each system-wide and locational capacity requirement • *Consider:* Separate demand curves for summer/winter needs and “flexible” capacity needs	• States submit sloping demand curves for state-mandated clean energy demand • Voluntary buyers can submit price-quantity pairs to exceed state mandates

Indicative demand curve parameters



ICCM structure can be adapted to multiple policy structures that may exist in any one state



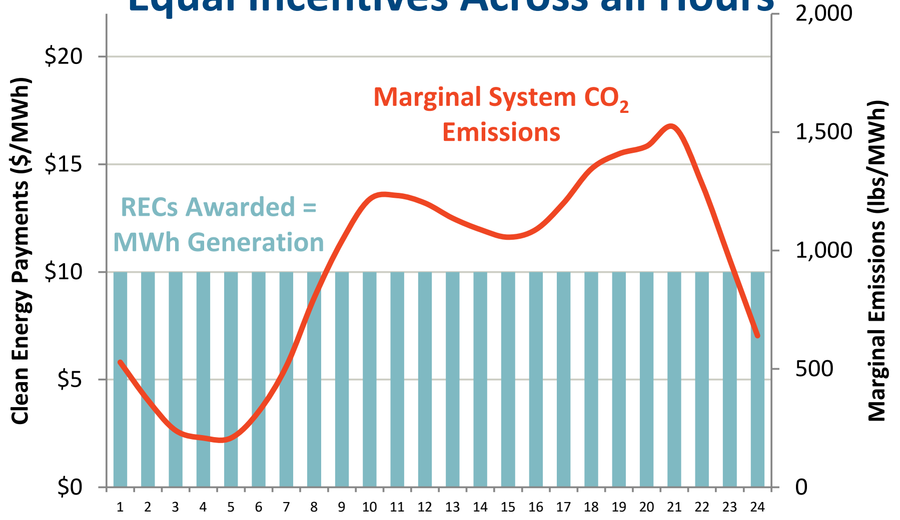
Appendix

Dynamic Clean Energy Attribute Product Definition

Achieves more carbon abatement at lower cost

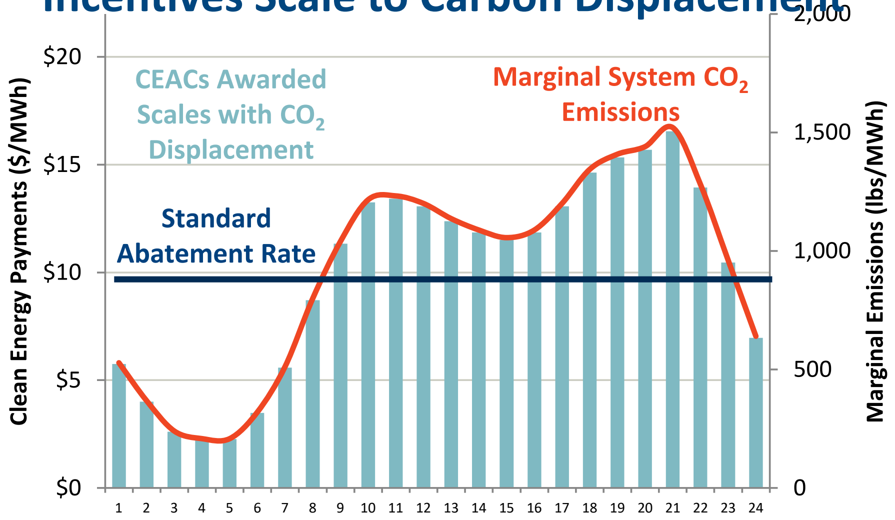
Design Option: Transition to a more advanced product design that focuses incentives on carbon abatement

Traditional RECs: Equal Incentives Across all Hours



- Flat incentives over every hour
- Incentive to offer at negative energy prices during excess energy hours when displacing other clean supply

"Dynamic" CEACs: Incentives Scale to Carbon Displacement



- 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

Achieves More Carbon Abatement at Lower Cost

Clean energy suppliers earn CEAC awards (and thus payments) that scale in proportion to carbon abatement value:

$$\text{CEACs} = \text{Physical Generation} \times \frac{\text{Realized Abatement Rate}}{\text{Standard Abatement Rate}}$$

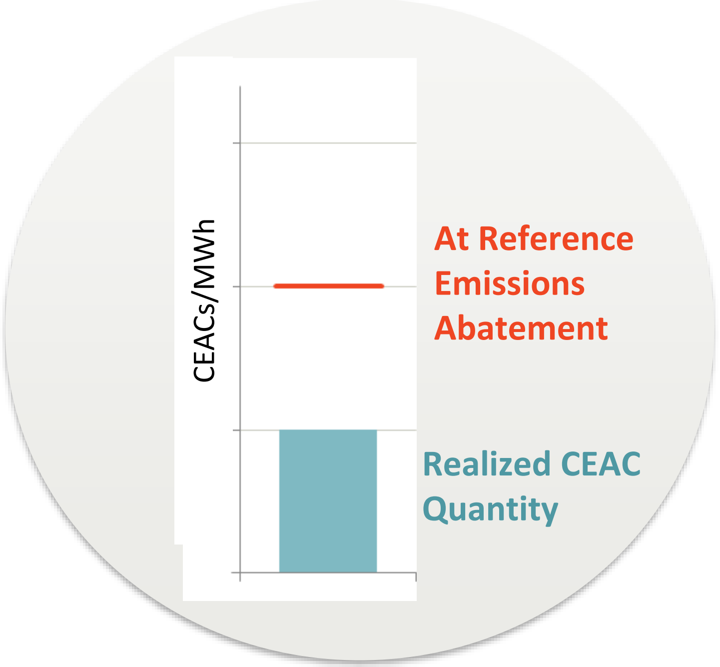
- **CEACs:** annual quantity of CEACs awarded to the clean resource. The rate of CEACs awarded per physical MWh produced may be greater than the average across all clean suppliers (if displacing primarily coal) or less than the average across all clean suppliers (if displacing primarily other clean supply)
- **Physical Generation:** the as-metered MWh produced by the clean resource
- **Standard Abatement Rate:** the standard quantity of marginal carbon displacement required to produce one CEAC (e.g. 1,100 lbs/MWh). This value adjusts over time with the average abatement value across the clean fleet
- **Realized Abatement Rate:** the measured marginal carbon abatement value of the resource in question, based on the time and place of clean energy production

Incentives for Clean Energy in the Right Locations

Locational variation in CEAC awards will focus incentives to develop new clean energy where they are most valuable for displacing carbon

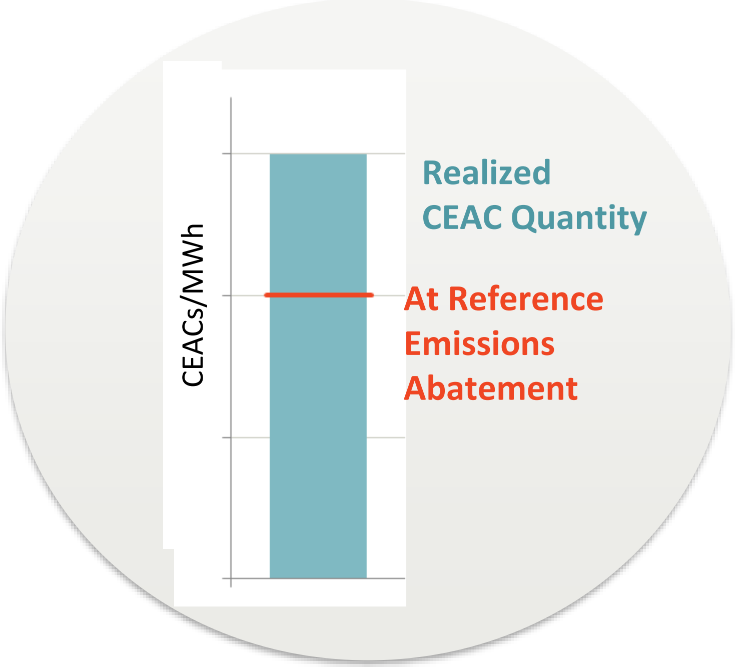
Low-Emitting Location

Generation pocket that is already saturated with wind. New clean energy will mostly displace the generation of existing wind resources (and will earn fewer CEACs)



High-Emitting Location

Load pocket where high-emitting steam oil units are often called on. Clean energy will displace more emissions (and earn more CEACs)



DYNAMIC CEAC

Incentives at the Right Times (Including for Storage)

Dynamic CEACs incentivize clean energy at the right times to displace the most CO_2 emissions, enabling storage to compete with other technologies

Illustration of Storage Participation with Dynamic CEACs