Future Power Markets Forum

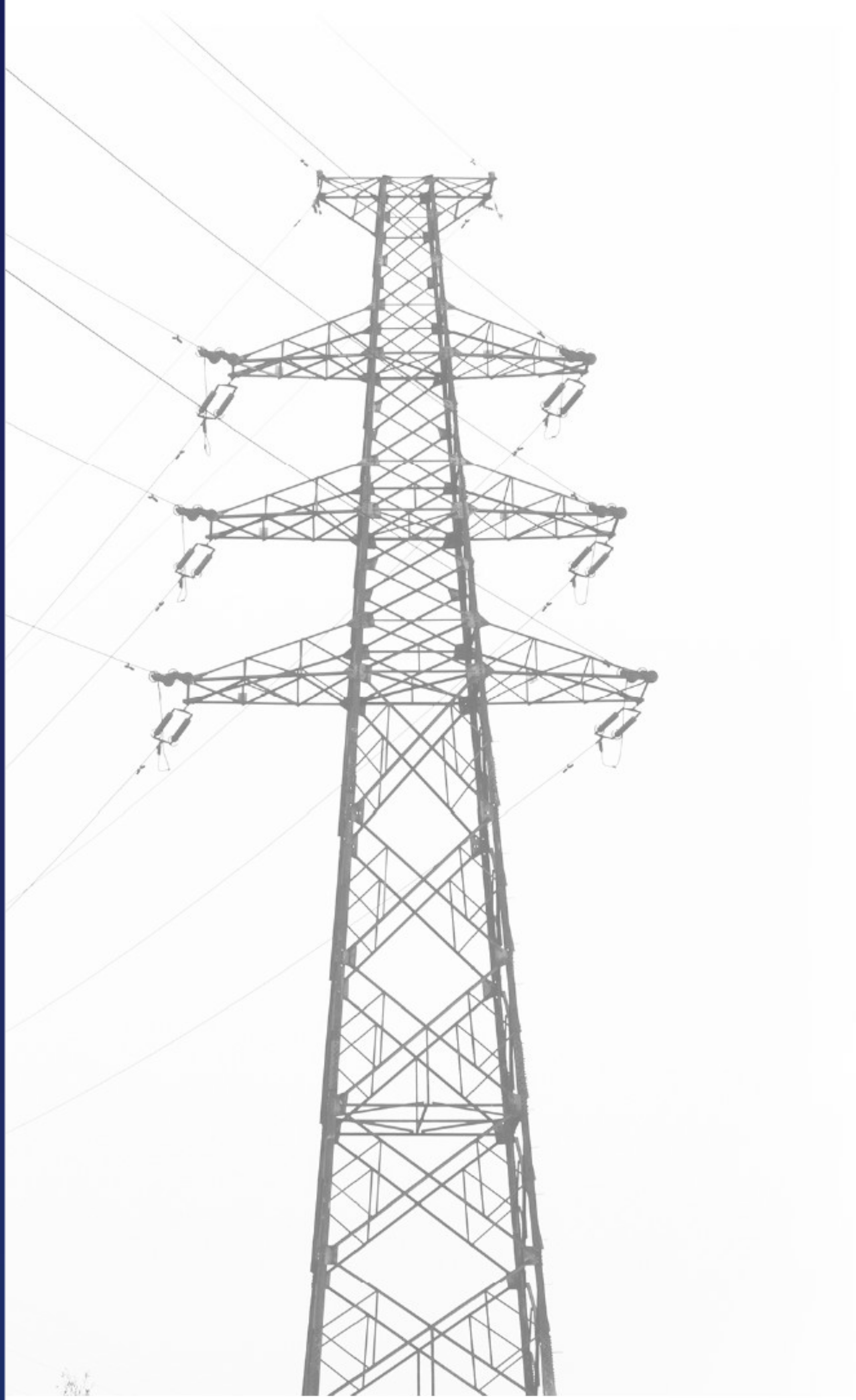
Central Procurement Structures for Energy, Capacity, and Environmental Products

A PROJECT OF

JOHNS HOPKINS
ENVIRONMENTAL HEALTH
& ENGINEERING

COLUMBIA | SIPA
Center on Global Energy Policy

About Future Power Markets Forum



Future Power Markets Forum investigates proposals for market designs that maintain system efficiency and reliability with a high penetration of variable generation.

Future Power Markets Forum began in May 2020 as a joint project of the Columbia University SIPA Center for Global Energy Policy and Johns Hopkins University Whiting School of Engineering.

The Future Power Markets Forum website hosts materials on proposals for electricity market structure and design and a research library of relevant papers.

Forum contributors, representing a balanced group of the sector's practitioners, researchers and regulators, offer commentary on the issues and proposals.

Topic 2: Central Procurement

Mr. Steve Corneli

Consultant

AN EFFICIENT CONFIGURATION MECHANISM FOR RAPID POWER SECTOR DECARBONIZATION

Steven Corneli

Three key lessons from the first session:

1. The cost of decarbonizing is really sensitive to the mix of clean energy resources.
2. The actual least-cost mix varies with technology costs and availability.
3. The "best least-cost" mix typically depends on new technologies working at scale
    - Continental-scale HVDC transmission network
    - Social acceptance of using very large areas for VRE
    - Clean firm (nuclear or similar) and clean flexible (CCGT or similar)
    - Widespread integration of price and dispatch signal responsive load and distributed storage into RTO markets
    - Zero carbon fuels such as biogas or ETFs

So what's the best way to get there?

It used to be so easy, part 1

- How can I always meet my peak load?

- Lots of feasible alternatives:

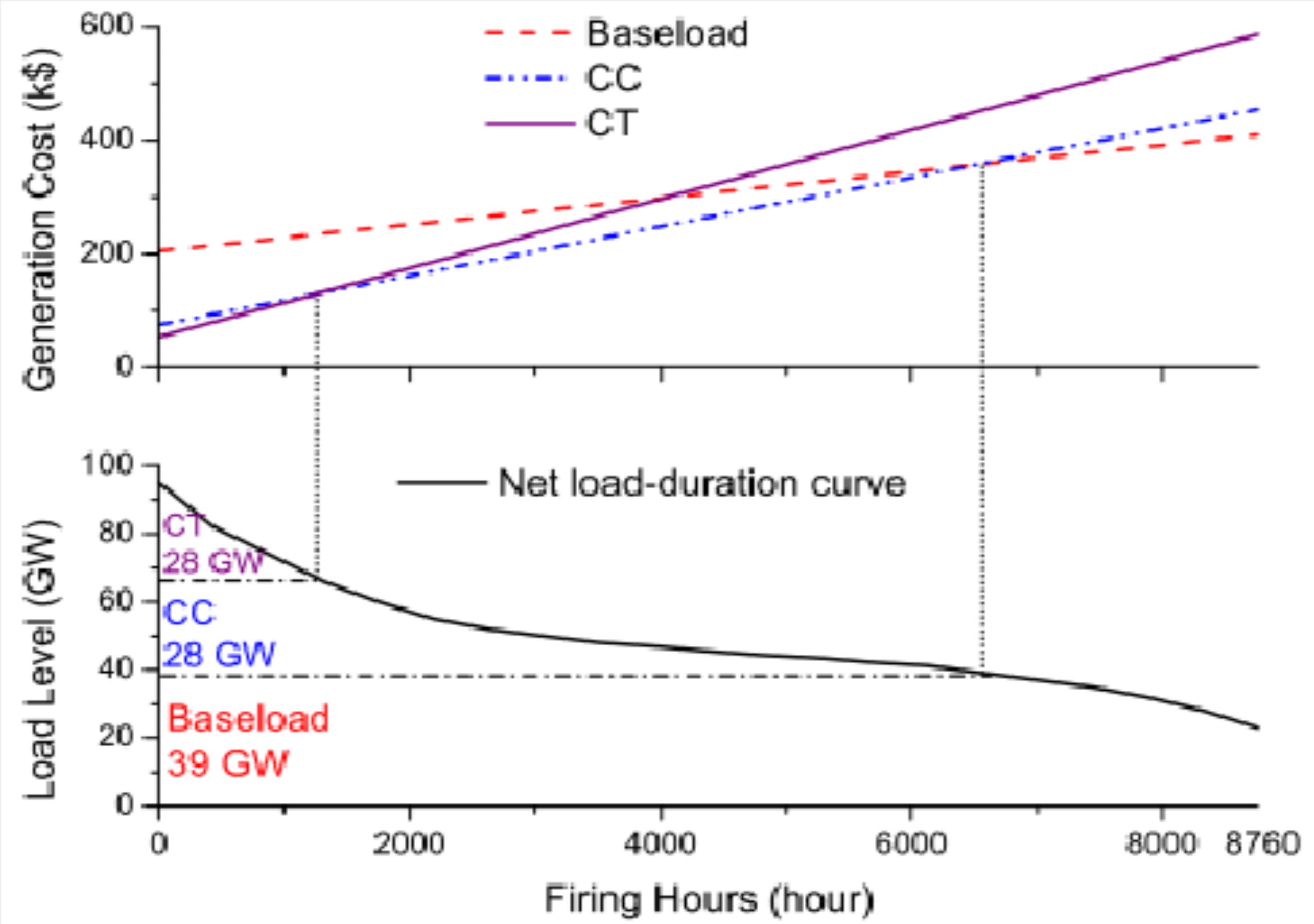
  (20) 200 MW GTs = (10) 400 MW CCGTs = (2) 2000 MW thermal plants ..

  The technologies are all dispatchable and flexible, so many mixes could work, depending on load shape and fuel costs

- But what's the most economical mix?

It used to be so easy, part 2

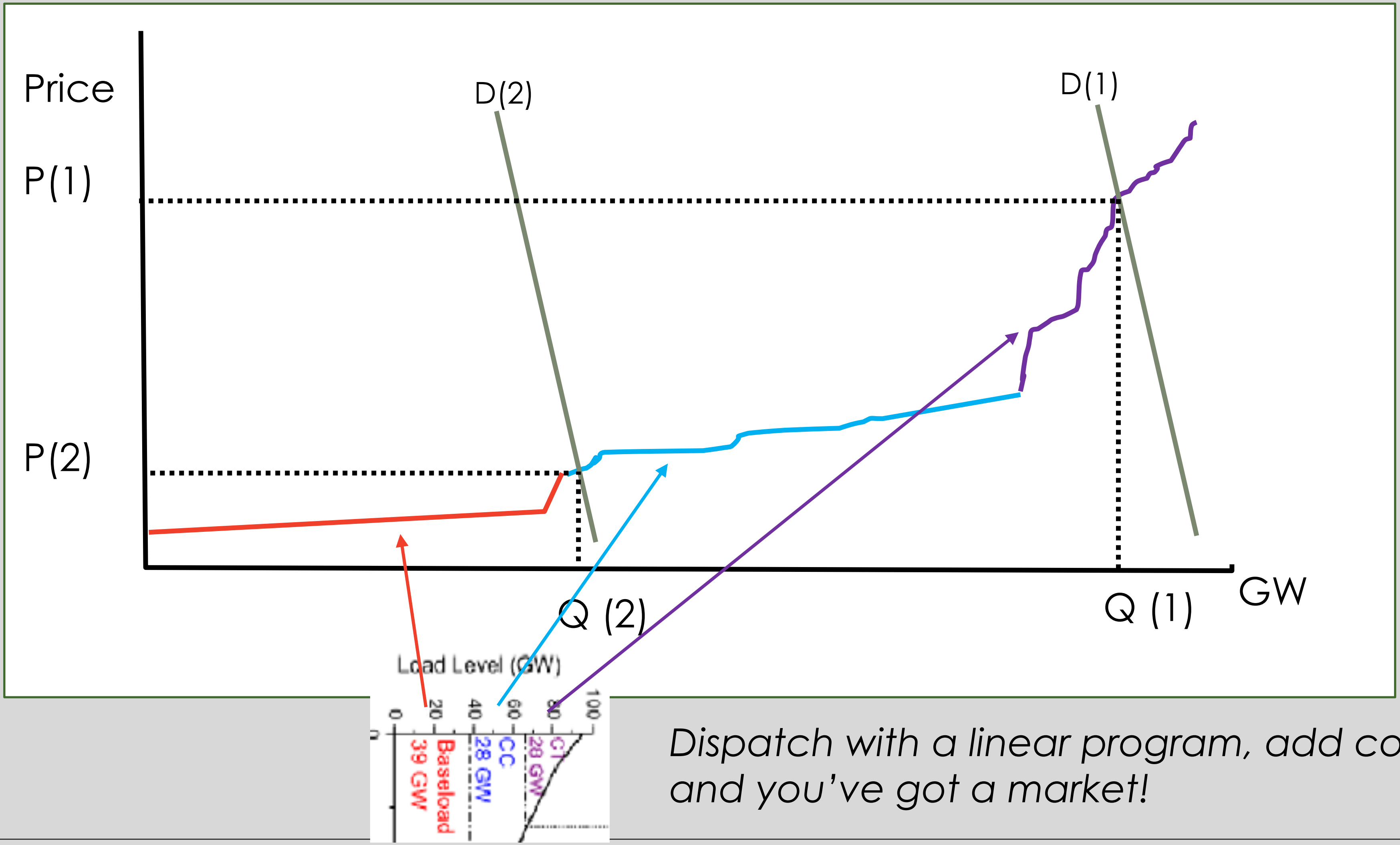
(big system!)



note the time stamp of the hours doesn't matter – *why is that?*

You can do this with a ruler and the sort function in your spreadsheet!

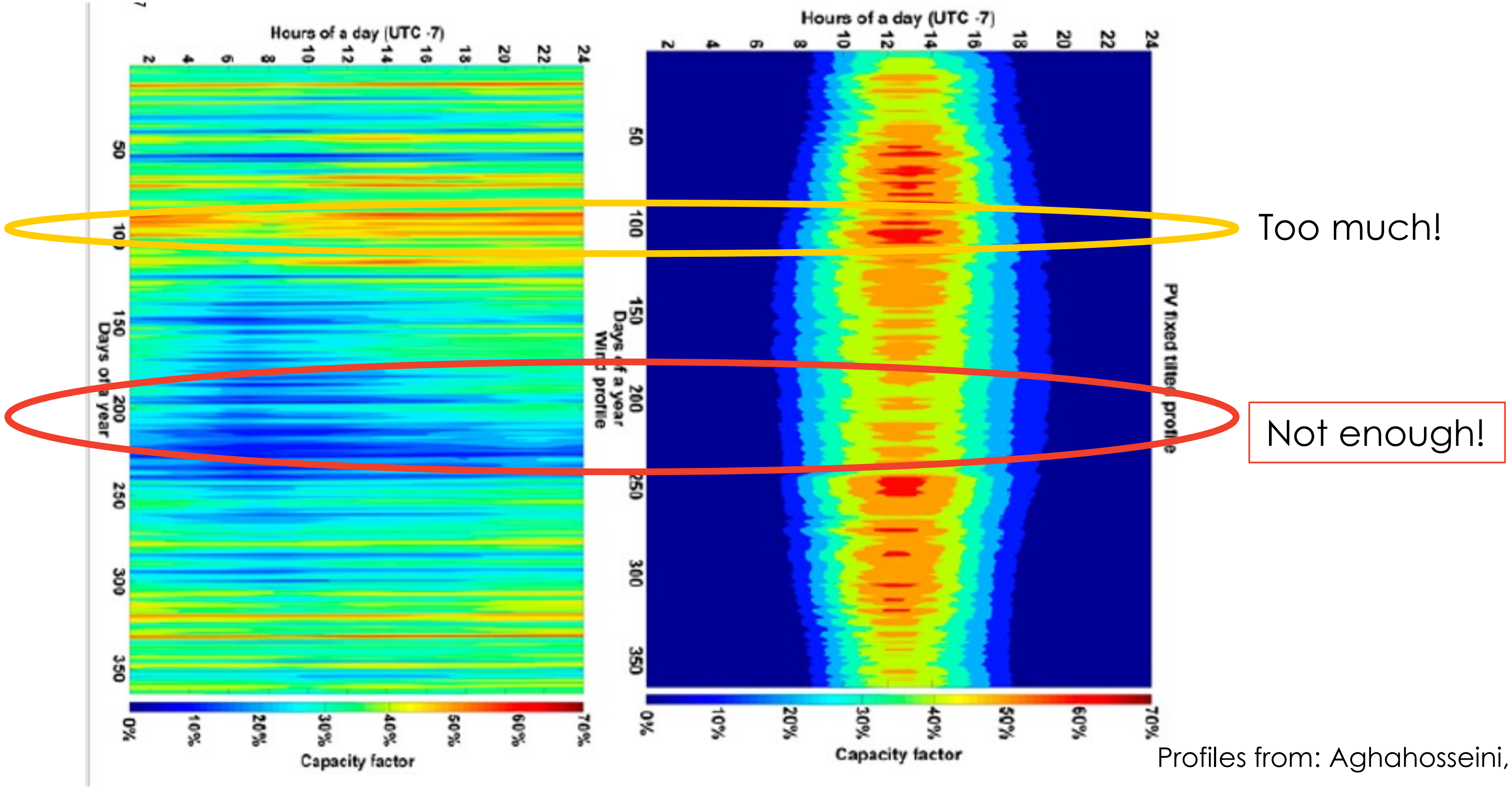
It used to be so easy, part 3



Dispatch with a linear program, add competitive bids and you've got a market!

It isn't so easy anymore

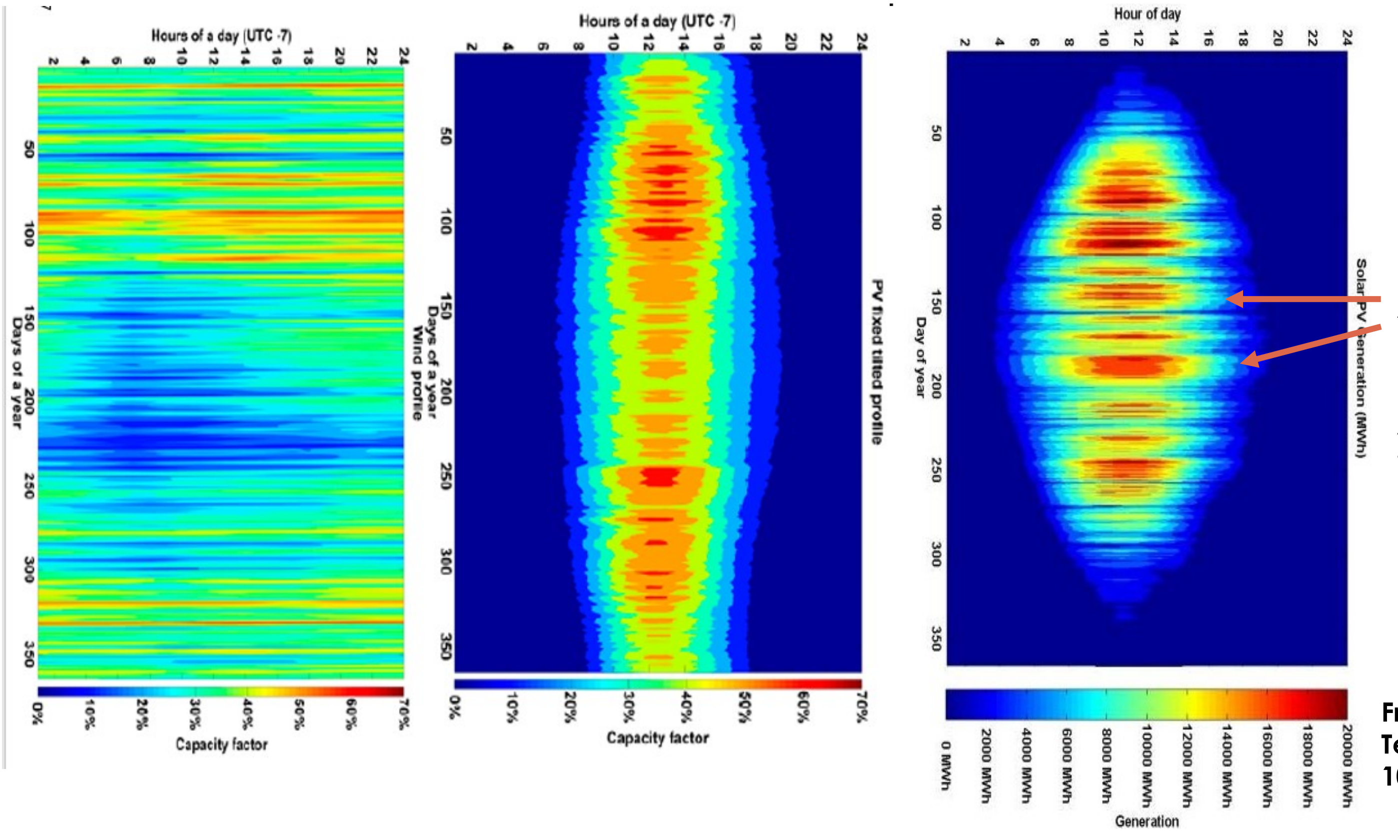
1. Finding mixes that work is not easy



Profiles from: Aghahosseini, et al., 2017

It's even harder

1. Finding mixes that work is not easy
2. It's much harder finding economic ones (information costs)



Maybe a bit better adding solar from another region – but still not good enough.

And who's going to build the transmission?

From: Child, Michael & Haukkala, Teresa. (2015). 10.4229/31stEUPVSEC2015-6DO.7.2.

But that’s not all ..

1. Finding mixes that work is not easy

2. It’s much harder finding economic ones (information costs)

3. Whether a particular mix works is beyond any one firm’s control

It *really* isn't easy anymore

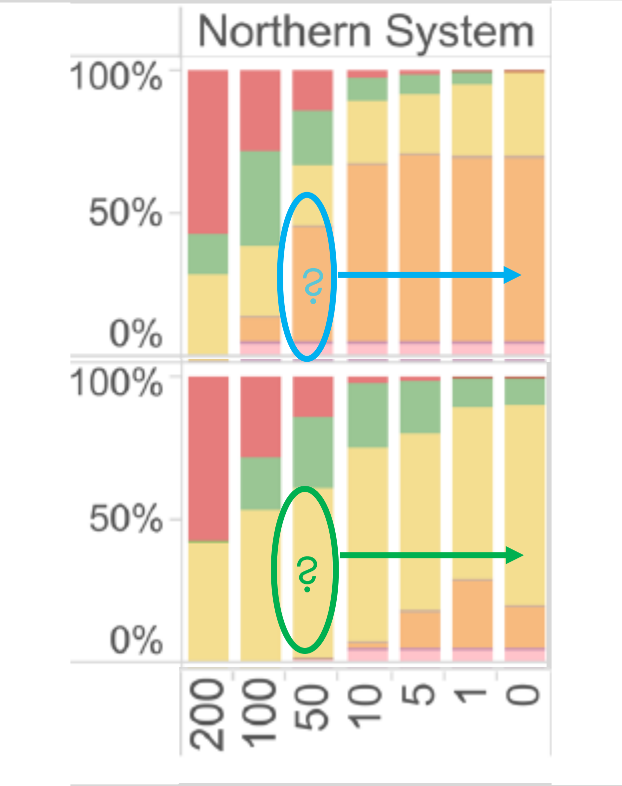
1. Finding mixes that work is not easy

2. It's much harder finding economic ones (information costs)

3. Whether a particular mix works is beyond any one firm's control

4. Pick the wrong mix and we're stuck with it

Conservative
Firm Low Carbon costs



Mid-range
VITL costs

Very low
VITL costs

CO2 g/kwh

How would LSEs know, on the basis of current price curves, whether to contract for forward supplies with a new nuclear or a new renewable portfolio that is going to last 30 years once it is built?

From Figure S8
Sepulveda et al. (2018)

It’s *wicked* hard ….

1. Finding mixes that work is not easy

2. It’s much harder finding economic ones (information costs)

3. Whether a particular mix works is beyond any one firm’s control

4. Pick the wrong mix and we’re stuck with it

5. All the best mixes require successful innovation

How can we possibly get a least-cost mix built .. in time?

Market design goal: find the best ***economic mechanism*** for solving the 5 problems above

"Economic mechanisms" ***elicit information*** from producers and consumers ("messages"), ***process the aggregate information*** ("equilibrium message"), and ***send optimizing signals*** back that allow them to make the best choices ("outcome function").

	Decentralized market	Vickrey Auction	RTO SCED market
Message	Individual willingness to consume or produce given environment (including current prices)	Attending auction with intention to bid	Submission of bid and offer curves into RTM
Equilibrium message	Aggregate demand and supply	A list of bids in ascending order to a final bid	All bids as presented to the SCED engine
Outcome function	New prices that lead to adjustment in consumption and production and a new environment	Highest bidder pays second price and gets the item	Dispatch signals to cleared generation, settlement of sales and purchases at efficient LMPs
Frequency	Continual iteration	One-time	At regular intervals

Note each mechanism is competitive, but only one is fully decentralized.

Real competitive economies use a mix of centralized and decentralized mechanisms

- Most firms in competitive economies optimize production *internally* using centralized managerial control rather decentralized prices. This must mean it's more efficient than decentralized prices in such uses. (Coase)
- Today, many firms use linear programs and related tools to solve complex production and logistic processes – both inside and collectively among firms.
- New mechanisms use these optimization tools so firms can use competition to solve problems that, until now, have been too complex to solve using decentralized prices:
  - ***Combinatorial auctions*** to buy optimized trucking service on complex routes.
  - FCC's ***incentive auction*** to repurpose TV spectra for mobile use
- The FCC *incentive auction* is highly relevant to the decarbonization problem.
  - **New technologies** taking over from old.
  - **Complex patterns of interaction and interference** make some configurations infeasible and inefficient.
  - **Complex information costs** prevent efficient decentralized transactions.

The Configuration Mechanism ("easy button" for decarbonization):

A "smart" ("algorithm-inside") auction like the FCC incentive auction. Key elements include:

1. Held every 3 – 5 years.
2. Procures incremental tranches of clean energy resources (transmission included!) in each auction to meet decarbonization goals of members (or law) at least cost and while retaining reliability.
3. Augments existing SCED or bilateral markets. Intended to ultimately replace existing capacity markets.
4. Invites **sealed bids** from clean energy resource developers structured around a pro-forma draft contract
   a) Contracts offer tenors long enough to support low-cost project finance for various technologies.
5. Bids and contract include cost, location, operating limits, and pay-for-performance features.
6. Bids are evaluated through a mixed integer linear programming model capable of selecting the cost-minimizing set of generation, storage and flexible load technologies, transmission expansion, and feasible operating instructions to meet forecast electricity demand subject to specific CO2 emission limits.
7. Projects included in the model's solution set are eligible for a contract at their **as-bid cost** and any accepted revisions to the pro-forma contract.
8. Net contract costs (e.g., net of SCED market revenues) are settled on participating LSEs.
9. Regulated utility projects may use their winning status and as-bid cost and performance requirements as prima-facie evidence of need and reasonable costs in jurisdictional regulatory proceedings.

The Configuration Mechanism, additional features

A. The model will have a detailed representation of existing resources and system elements, drawn either from public data or from bids to remain or retire from existing resources.

B. Similar to the FCC incentive auction, the mechanism will be able to support and co-optimize a retirement auction that will identify resources whose retirement is efficiency-enhancing. It may also be used to identify efficient incentives for such retirement, if warranted.

C. A "reconfiguration round" to elicit new or modified bids if certain combinations of complementary available resources did not bid or clear in the initial round, e.g., specific transmission or flexible load resources.

D. A small but commercially significant demonstration and deployment (D&D) carve-out for special bids from promising pre-commercial technologies.
   i. Winners will be chosen based on their ability to scale and their technology's potential benefits to system costs and performance.
   ii. Resources with out-of-market support will be encouraged, not penalized.

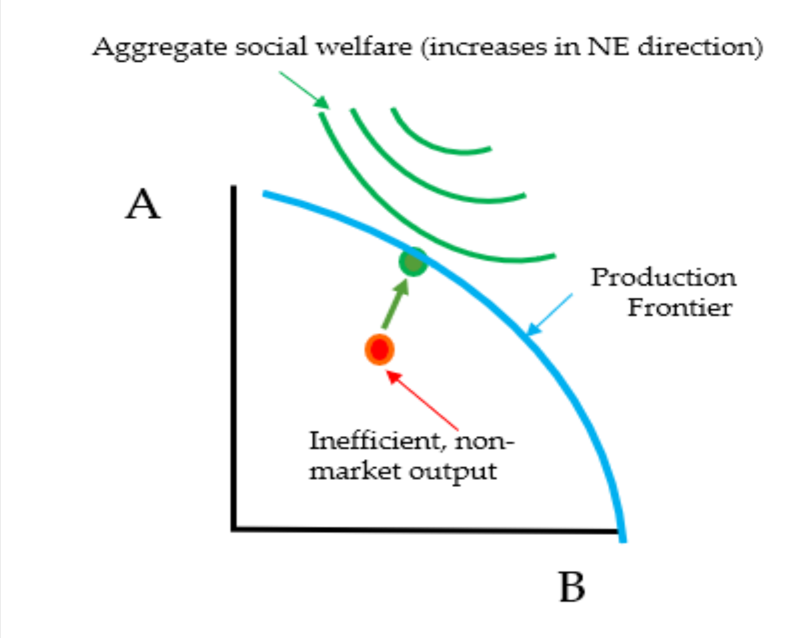
E. The mechanism will be designed to support a two-sided auction so that load and DERs can participate actively and passively. Will require conforming changes to SCED participation and settlement.

F. The configuration mechanism design will be based on game-theoretic principles to support and reward voluntary participation ["EIM business model"]. However, like many approaches to market failure problems, it may not perform adequately without some mandatory elements.

G. It will be designed to allow member self-supply options (bid into CM similar to "self-scheduling") if they do not cause higher costs or increased emissions for all participants.

Economic theory tells us decentralized prices only achieve efficient allocations with full, free information and convex technologies

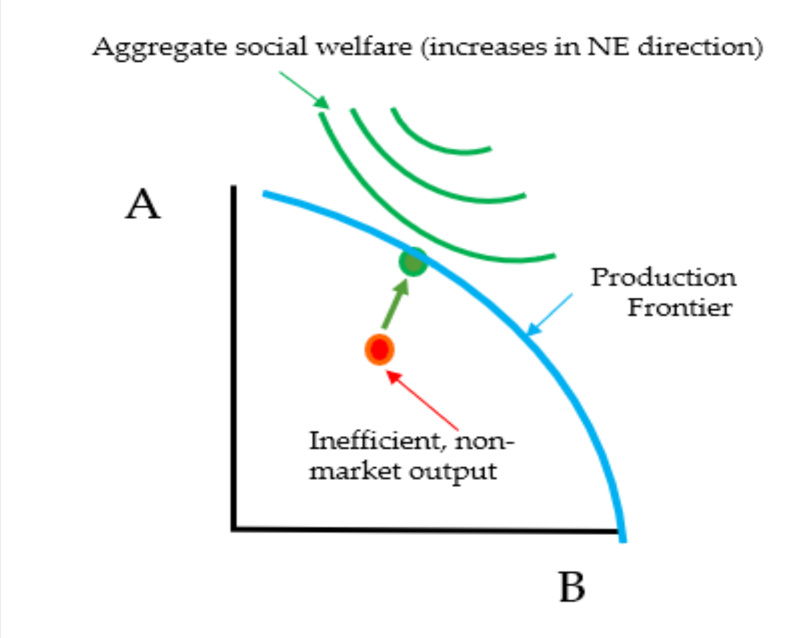
- "Convex" technologies can always substitute some or all output across different assets.



This is what allows marginal responses to price changes to be efficient

Economic theory tells us decentralized prices only achieve efficient allocations with full, free information and convex technologies

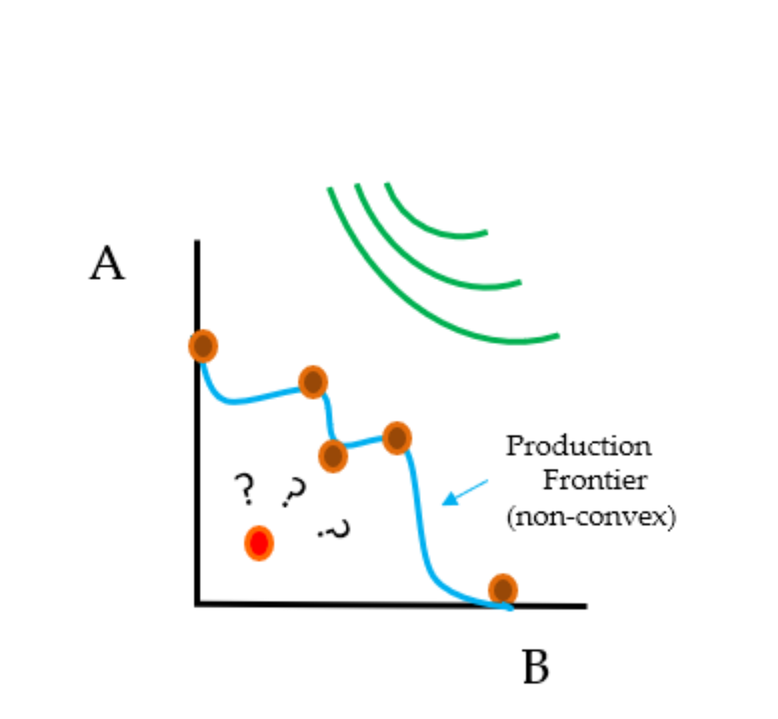
- “Convex” technologies can always substitute the output of one asset with that of others.



- ***The fossil generation resources we’re all used to have these characteristics.***
- ***This is what makes them flexible and dispatchable***
- ***<u>That’s</u> why screening and load duration curves can treat all hours as equivalent, regardless of sequence, in optimizing fossil portfolios.***

$\Rightarrow$ ***Decentralized responses to centrally optimized LMP prices should work relatively well to allocate existing and new fossil generation -- and any other highly dispatchable and flexible technologies that can compete on cost.***

Economic theory tells us decentralized prices don't achieve efficient allocations with non-convex production technologies



- *A fully decentralized process for such technologies is likely to end up stuck in any number of inefficient equilibria*
- *VITL technologies are not convex on their own,*
- *Costly and complex information makes it really hard to identify and aggregate them into convex configurations.*

⇒ *A fully decentralized allocation mechanism for such resources is probably the wrong way to achieve efficient, rapid decarbonization*

Topic 2: Central Procurement

Dr. Kathleen Spees

Brattle Group

Market Design for the Clean Energy Transition: Proposed Forward Clean Energy Markets

ACHIEVING CLEAN ELECTRICITY GOALS FASTER & CHEAPER BY HARNESSING COMPETITIVE MARKETS

PRESENTER
Kathleen Spees

STUDY CO-AUTHORS
Samuel Newell
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David Luke Oates
Judy Chang

July 2020

Full studies and study sponsors:

NEW ENGLAND FCEM PROPOSAL AND ECONOMIC IMPACT ANALYSIS (LINK)

NEXTera ENERGY
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DETAILED FCEM PROPOSAL (LINK)

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THE Brattle GROUP

EXECUTIVE SUMMARY

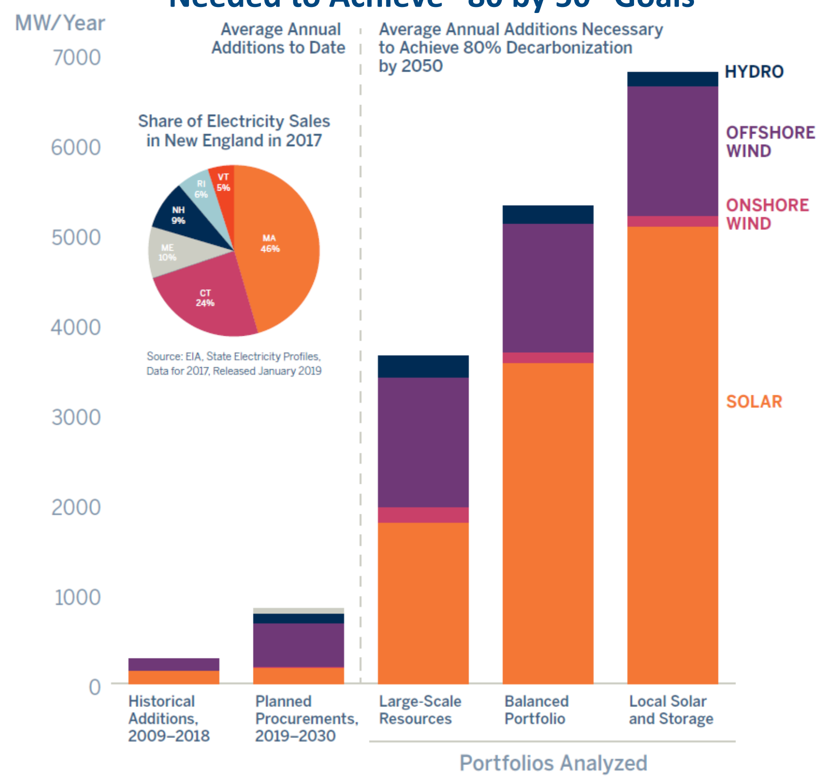
Why a Forward Clean Energy Market?

Thousands of MW of new clean resources will need to be built every year to meet policy goals and customer demand

We developed the Forward Clean Energy Market (FCEM) to **mobilize private investment and innovative players to meet these goals faster and cheaper** through a competitive market

Example: New England

Average Annual Clean Energy Additions Needed to Achieve "80 by 50" Goals



Source: Brattle Study by Jurgen Weiss and Michael Hagerty, "Achieving 80% GHG Reduction in New England by 2050"

What is the Forward Clean Energy Market?

The FCEM would be a centralized, forward auction in which buyers and sellers could voluntarily exchange clean energy attribute credits (CEACs)

- Auction conducted three years forward (payment on delivery)
- Unbundled CEAC product (energy and capacity can be sold separately into RTO markets)
- New resources can lock in CEAC price for 7-12 years

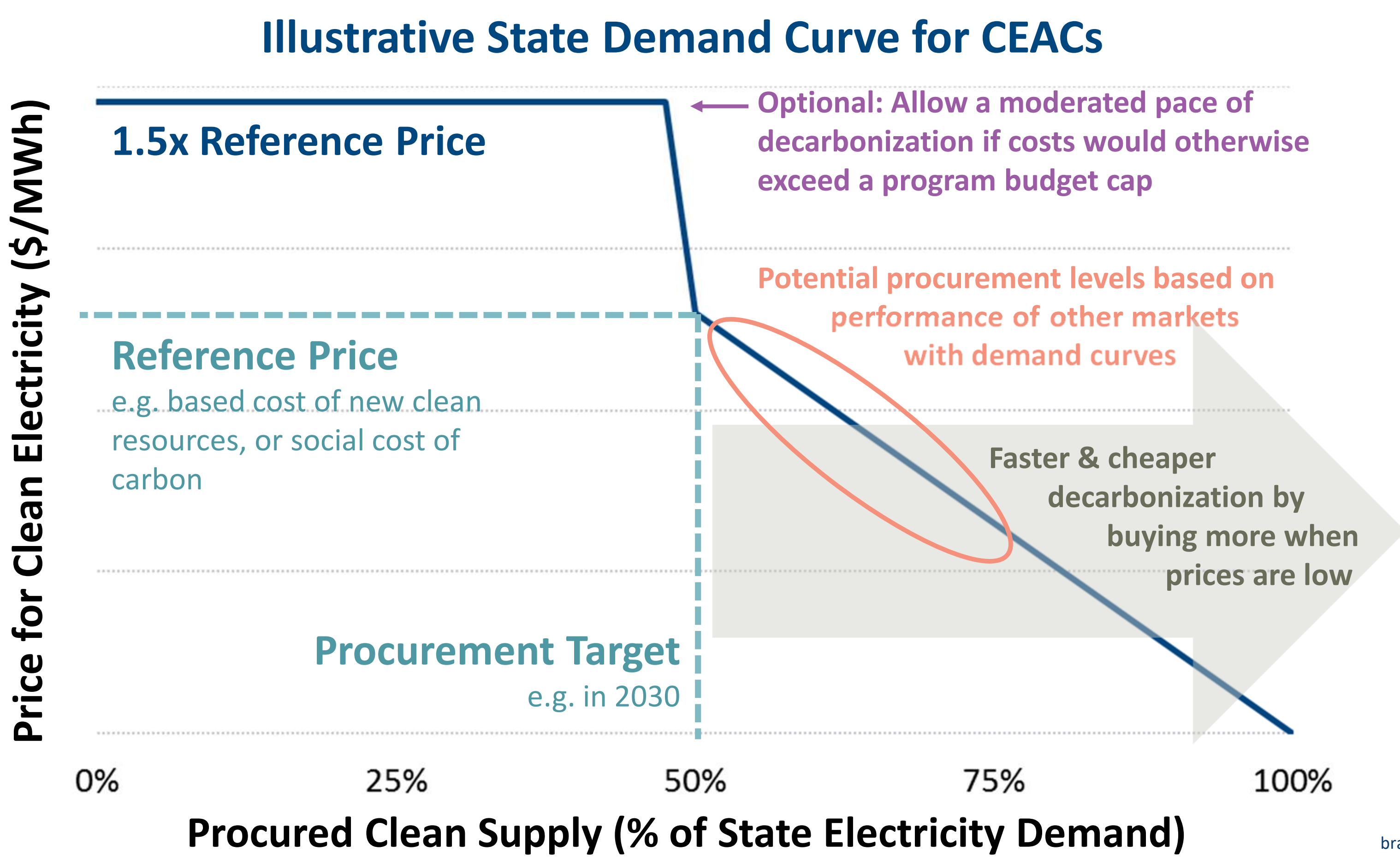
Design Overview

The FCEM would incorporate several best practices of existing wholesale electricity markets to improve on existing mechanisms

- **Product Definition** that matches the underlying objective (carbon abatement)
- **Unbundled Clean Energy Attributes** to maximize competition across markets and technologies
- **States 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
- **Alignment with energy, ancillary, and capacity markets**

Review the full study: Linked Here

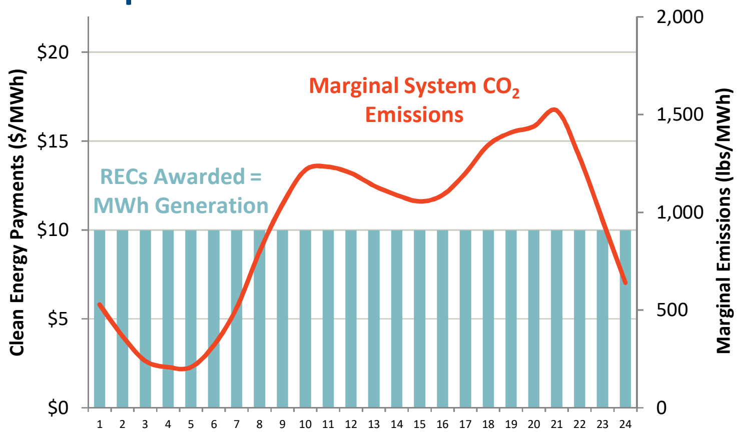
State Procurement Targets Translated into a Downward-Sloping Demand Curve



Dynamic CEAC Product: Achieves More Carbon Abatement at Lower Cost

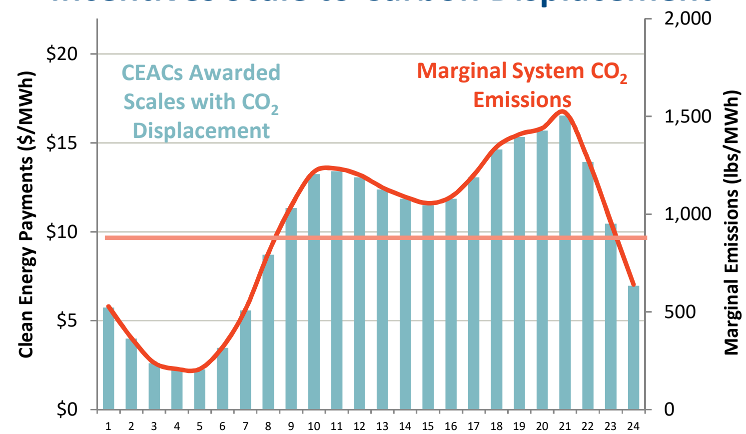
Design Option: Transition to a more advanced product design that focuses incentives on carbon abatement

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

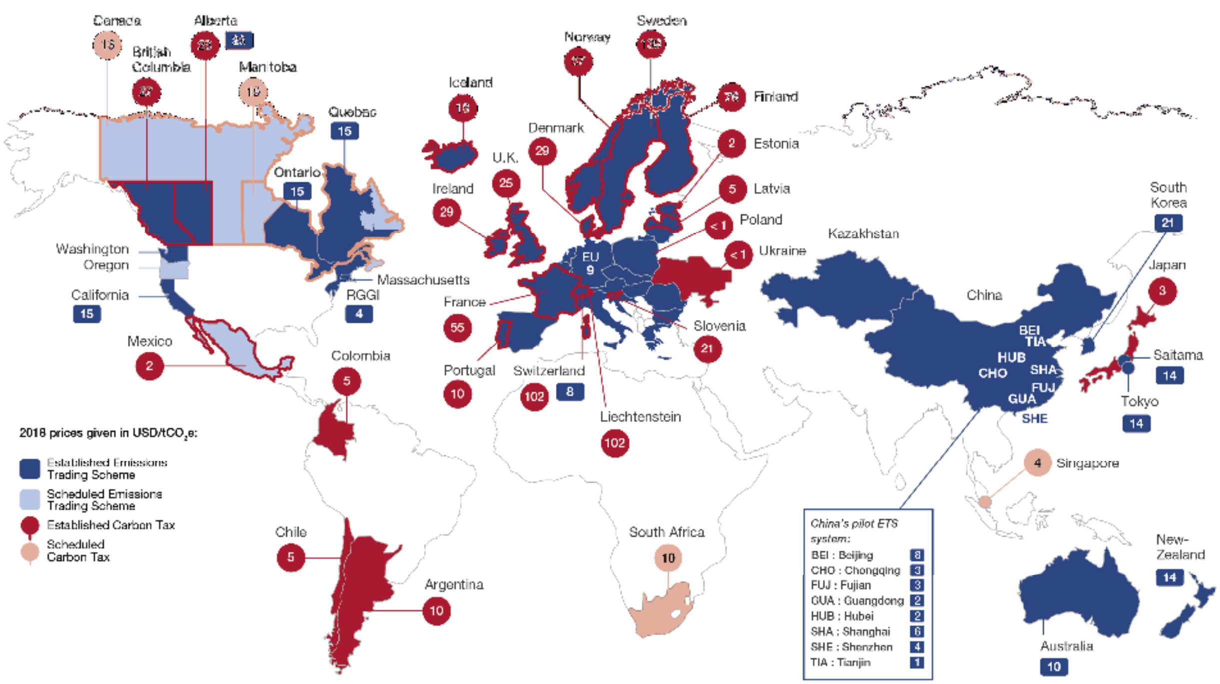
"Dynamic" CEACs: Incentives Scale to Carbon Displacement



- 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

Alignment with Carbon Pricing

FCEM is designed to work well in a common market crossing the boundaries of jurisdictions with a wide range of carbon prices (including no carbon price)



Source: I4CE "Global Carbon Account 2018"

FCEM Benefits Relative to Carbon Pricing Alone:

- Carbon prices often too low to achieve policy objectives
- FCEM does not require states, cities, companies to agree on a common price or policy goal
- States & customers pay to meet their own goals (no cost-shifting to non-participants)
- Lower developer risk with FCEM than carbon pricing

Customer Cost Savings

Our New England simulations estimate that

FCEM would save customers $3.60/MWh

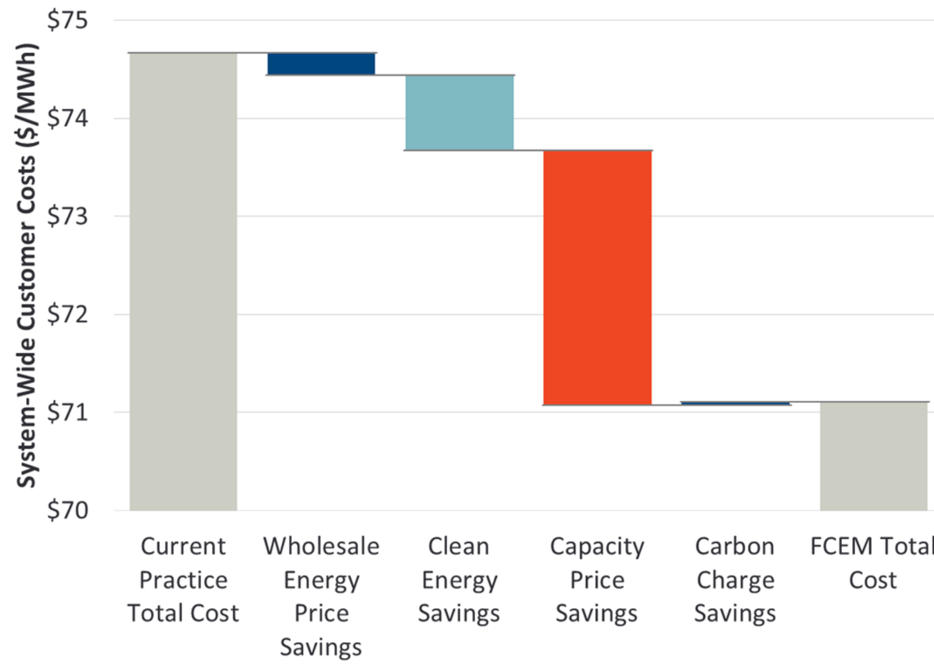
compared to current practice

On a 10-year NPV basis this would translate to about

$120 billion if scaled up nationwide

Example: New England Customer Cost Savings

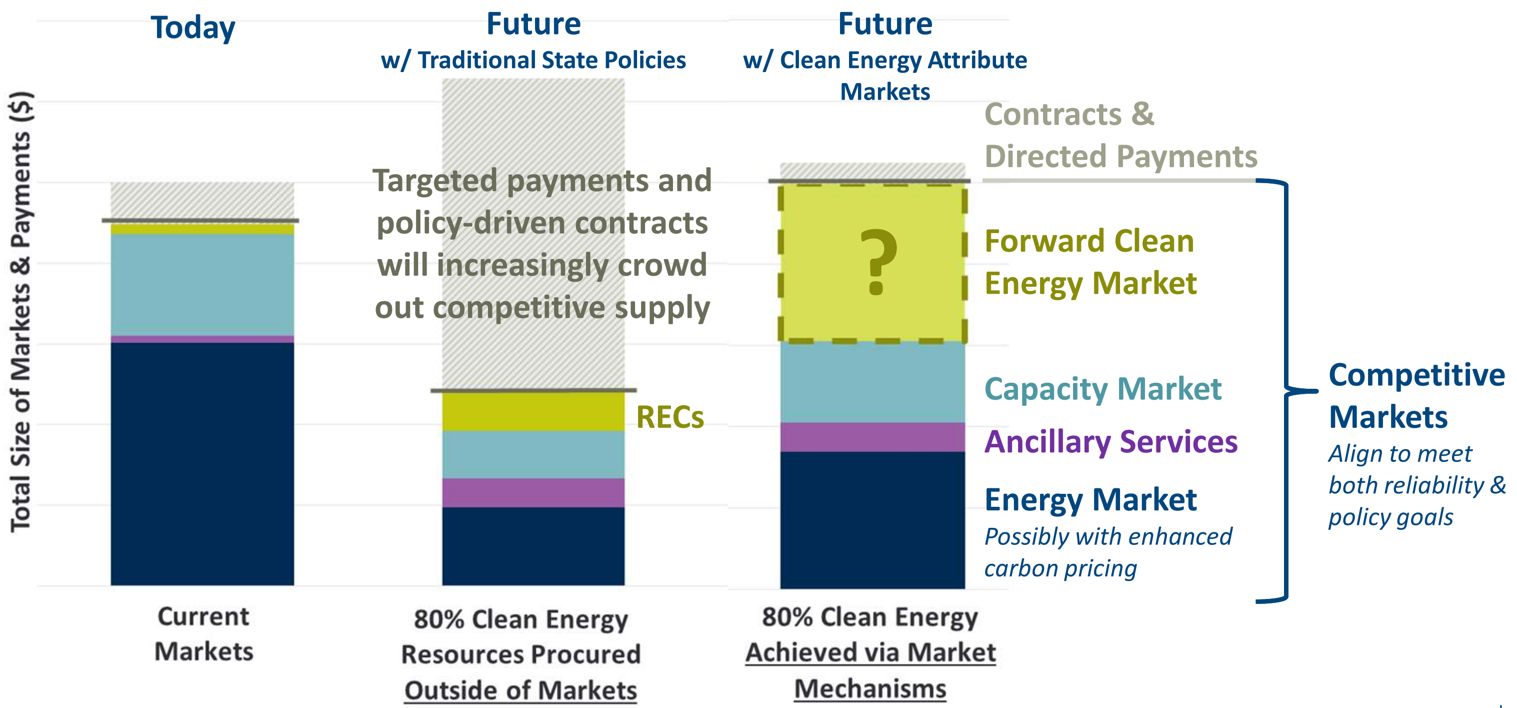
Forward Clean Energy Market vs. Current Practice



Source: Kathleen Spees, Judy Chang, DL Oates, and Tony Lee, "A Dynamic Clean Energy Market in New England," November 2017, The Brattle Group. Modeling results translated to nationwide based on US-total EIA forecasted load 2020-2029 assuming 5% discount rate.

Alignment with Wholesale Markets

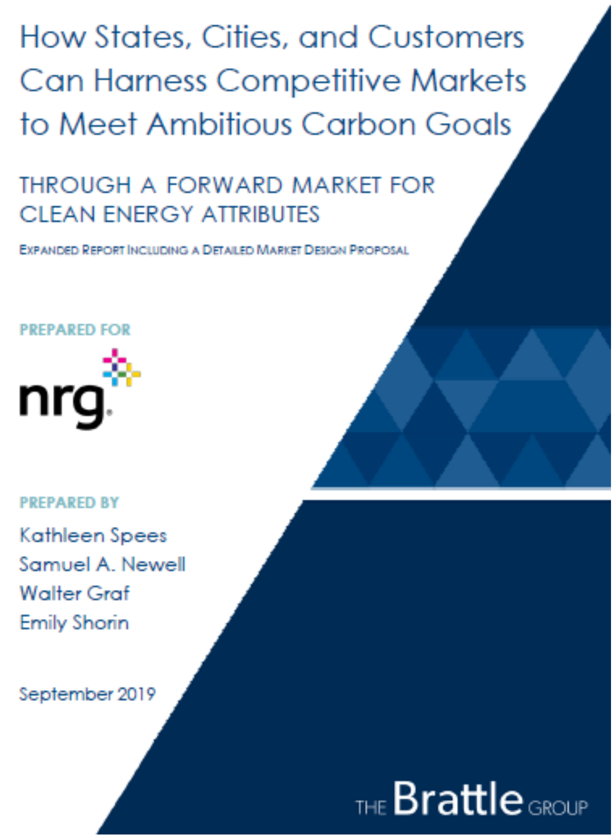
The FCEM would align with the merchant investment model, competitive retail markets & enable competitive co-optimization with energy and capacity markets



Why a Forward Clean Energy Market?

FCEM resolves several key challenges to meeting large-scale policy goals:

- Need to attract unprecedented high quantities of capital investment over short investment timeframes
- Achieve goals at lowest possible cost
- Incentivize innovative low-cost carbon-abating technologies and business models
- Maintain benefits of competitive wholesale & retail markets, including to express system reliability needs
- Enable aggressive and low/zero policy & customer preferences to co-exist


How States, Cities, and Customers Can Harness Competitive Markets to Meet Ambitious Carbon Goals

THROUGH A FORWARD MARKET FOR CLEAN ENERGY ATTRIBUTES

EXPANDED REPORT INCLUDING A DETAILED MARKET DESIGN PROPOSAL

PREPARED FOR

nrg

PREPARED BY

Kathleen Spees
Samuel A. Newell
Walter Graf
Emily Shorin

September 2019

THE Brattle GROUP

Review the full study: Linked Here

Appendix:
FCEM Design Details

Overview of FCEM

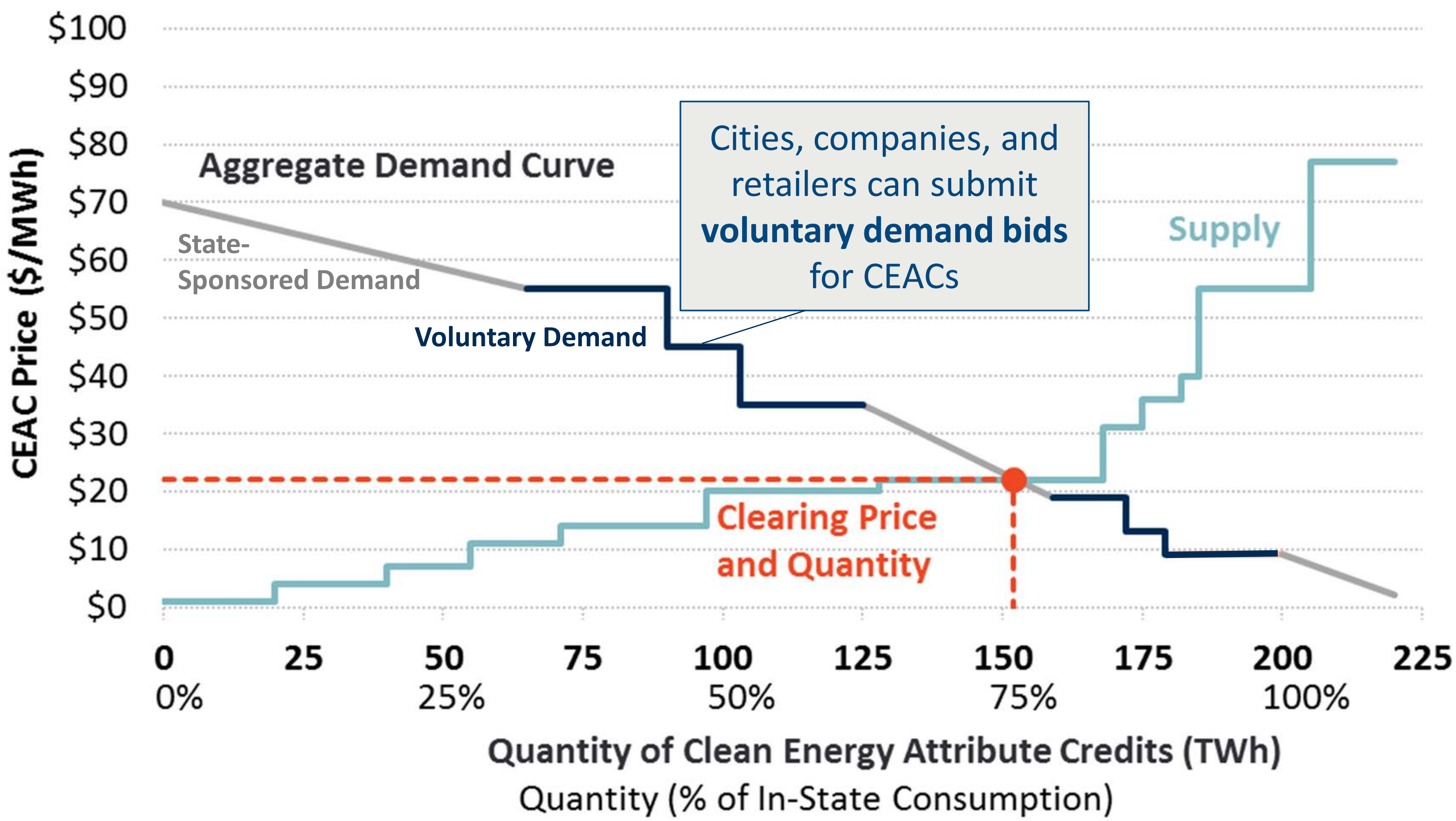
Design Element	Approach
Product Definition	• The product is an unbundled Clean Energy Attribute Credit (CEAC), similar to an unbundled Renewable Energy Credit (REC) • We prefer a "dynamic" CEAC accounting approach that awards more CEACs to resources that displace more carbon emissions. This approach can readily enable batteries and focus incentives toward achieving more carbon abatement faster
Demand Participation in the Forward Auction	• State demand will be expressed as a sloping demand curve that will buy higher quantities if supply is available at lower cost • Additional voluntary demand bids can be submitted by cities, public power entities, customers, companies, retail providers, or others. These bids are expressed as price-quantity pairs, representing the willingness to pay for CEACs • Optional Variation: Buyers will have an option to submit a preference for "targeted" resource types, for example to meet carve-outs for preferred technologies such as storage or offshore wind. The auction may procure these resource types even if they are higher cost than "base" resources, although the buyer can specify a limited willingness to pay such a premium
Technology-Neutral Supply Participation	• Resources are not restricted by type, location, or generation profile; any new or existing clean resources can participate, including hydro, wind, solar, nuclear, storage, or other • Storage resources can participate if their charging and discharging profiles displace system carbon emissions; they offer the value of carbon abatement when discharging, net of any additional carbon emissions they cause when charging
Forward Auction	• Forward auction three years before the one-year delivery period to align with development timeline of new clean resources • Up to seven-year commitment period is available to new resources, over which time the price is locked-in to guarantee revenue stability
Bilateral and Spot Markets	• Ongoing trading before and during the delivery year, with a final spot auction after the delivery year. Producers can adjust their positions until the spot auction when any net deficit must be remedied; retailers can continually adjust their positions until the compliance deadline at which point retailers must meet their clean energy obligation or face a compliance penalty
Monitoring and Mitigation	• Targeted mitigation measures to prevent large suppliers from exercising market power through physical or economic withholding
Wholesale Market Alignment	• Operates well with existing wholesale markets and maintains incentives to maximize energy, flexibility, and reliability value to the grid • CEAC-based revenues are counted as "in-market" in the capacity market, i.e. not subject to minimum offer price rule (MOPR) provisions that exist in some regions
Competitive Retail Market Alignment	• In states with retail choice, the CEAC is implemented as an obligation on retail providers to meet a certain fraction of their delivered load through clean energy, e.g. 50% by 2030 • Retailers can comply either by making their own CEAC supply arrangements (with self-supply volumes netted out of auction settlements), or by relying on the centralized auctions (passing the costs on to customers) • Retailers compete to offer innovative retail energy options to customers, including additional (up to 100%) clean energy. Retailers can participate in forward, bilateral, and spot markets and develop hedging strategies to minimize cost and risk

Procurement and Compliance Timeline

Three-year forward procurements are designed to align with developer needs, while fully enabling bilateral agreements retailer self-supply at all timeframes

<u>Pre-auction</u>: Voluntary long-term contracts and forward hedges
<u>Post-auction</u>: Producers and retailers use exchange trades and short-term contracts to manage position relative to obligations and banking value

Auction Clearing at a Competitive Price



Risk Sharing and Financeability

The FCEM intentionally places most **fundamentals-based and asset-specific risks on sellers** that are in the best position to manage the risks; we propose a few key **design features to mitigate regulatory risks and support financeability**:

- **Multi-Year Commitment Period** of around 7 years locks-in prices for clean energy payments for new resources (exact term is subject to adjustment)
- **Multi-Year Forward Period** supports development and financing new resources
- **Sloped Demand Curve** mitigates year-to-year price volatility, improving revenue certainty over time

Allocate Risks to Customers	Allocate Risks to Sellers	
Regulatory Risks	**Market Fundamentals**	**Asset-Specific Risks**
• Unanticipated changes to state policy • Unpredictable changes to state demand bids • Rule changes	• Resource mix • Load growth • Fuel prices • Transmission development • Energy, capacity, and ancillary service prices	• Construction delays • Unanticipated asset costs • Asset performance

Dynamic CEACs

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**

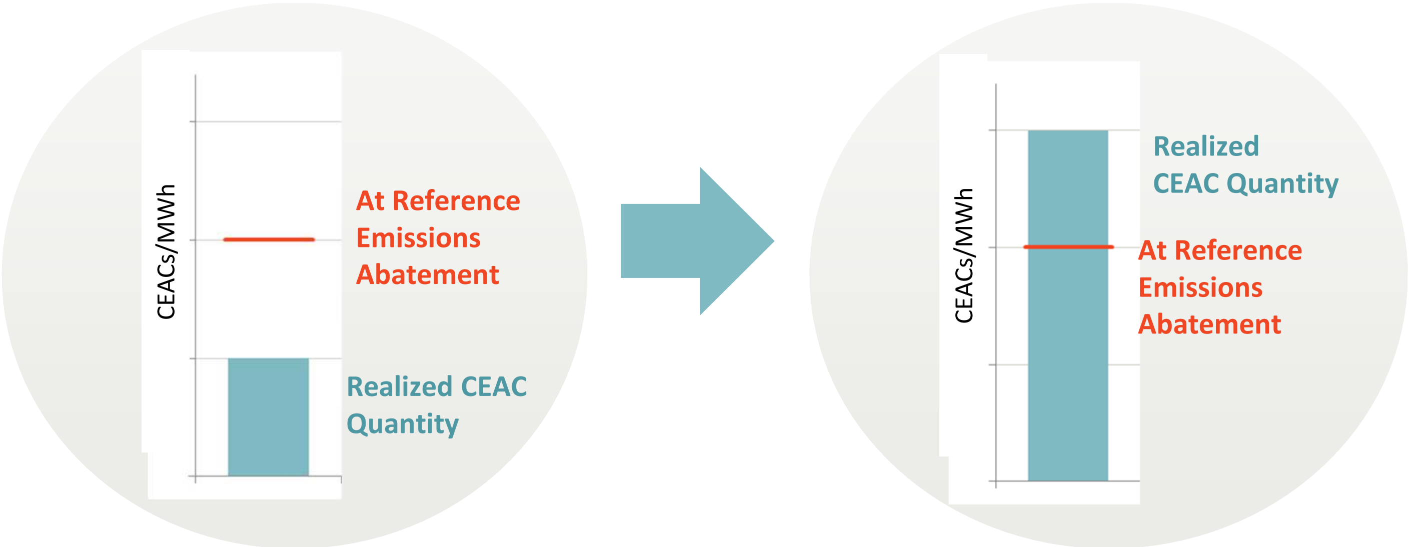
Varying the CEAC awards across locations in a way that reflects carbon emissions displaced will focus incentives to develop new clean energy where they are most valuable

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)

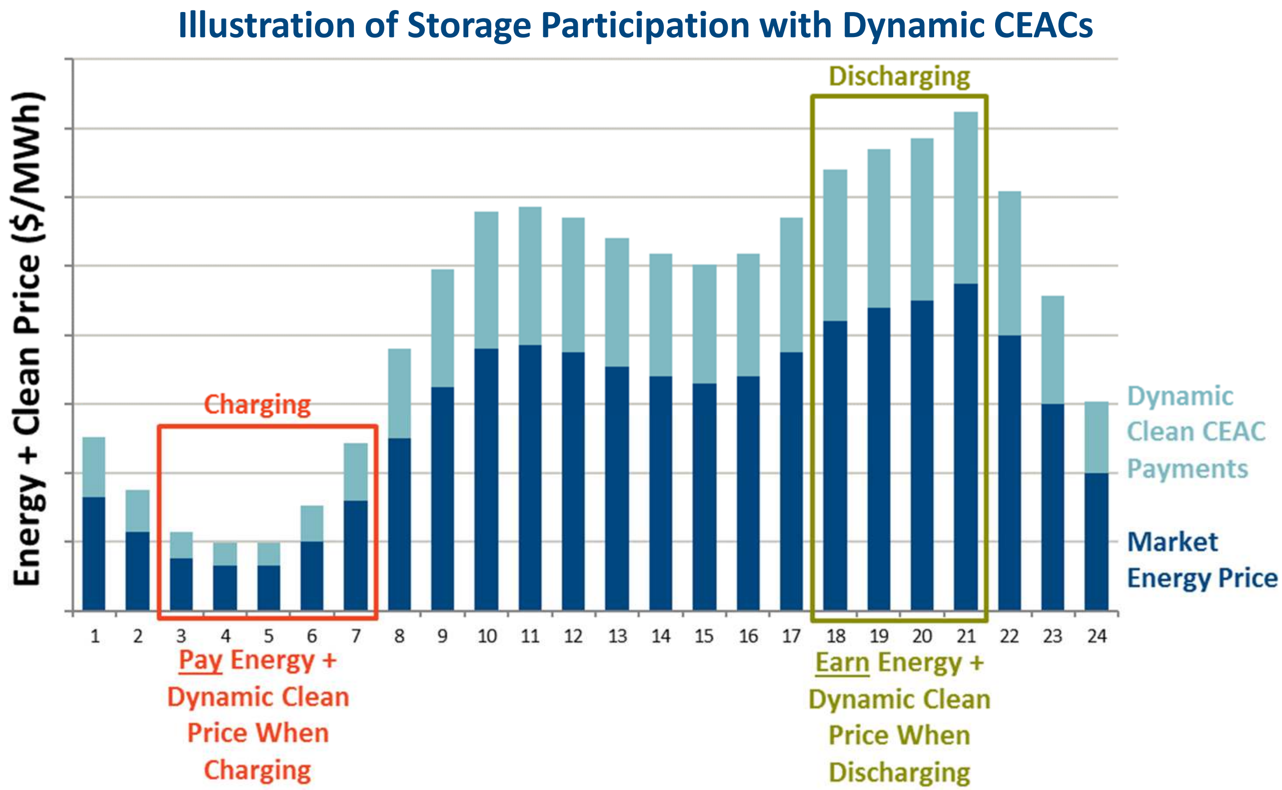
High-Emitting Location

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



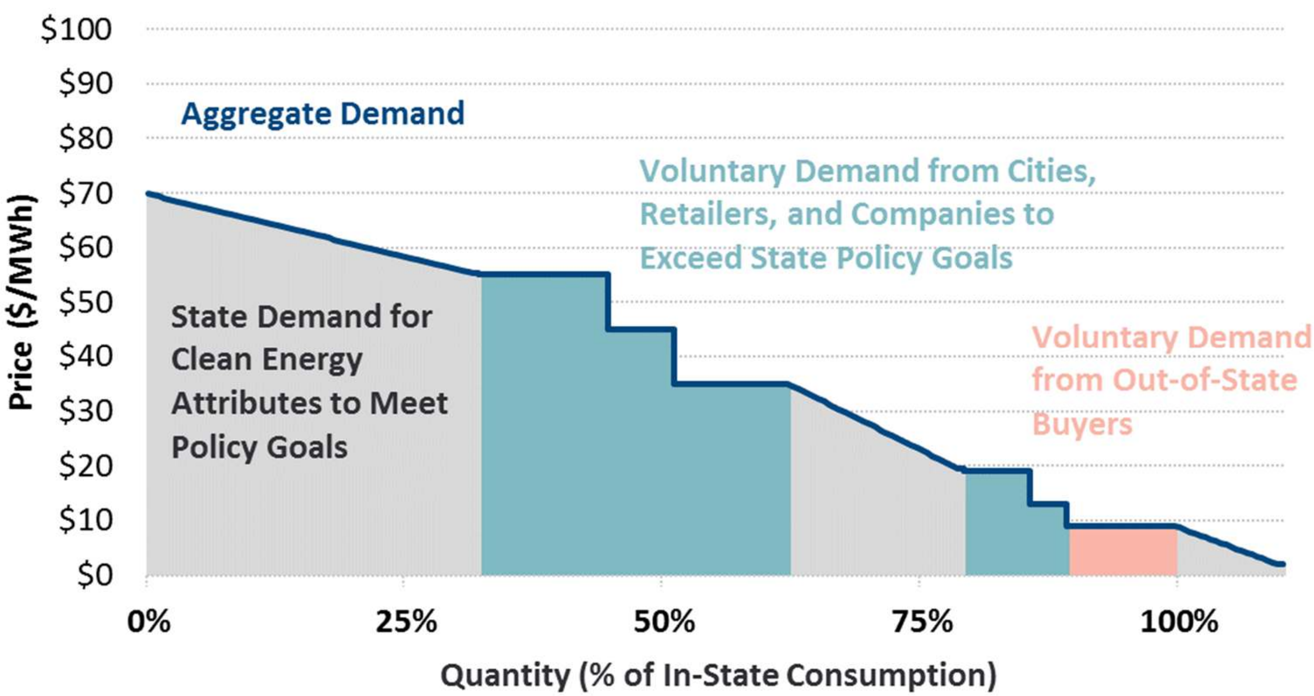
Incentives at the **Right Times** (Including for Storage)

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



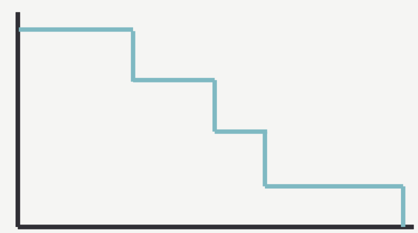
Demand Curve for State + Voluntary Demand

The market demand curve would be an aggregate sum of the willingness to pay from each state's sloping demand curve + voluntary demand from retailers, companies, cities, and other entities



How Would States and Customers Retain Control Over their Procurement Quantities and Costs?

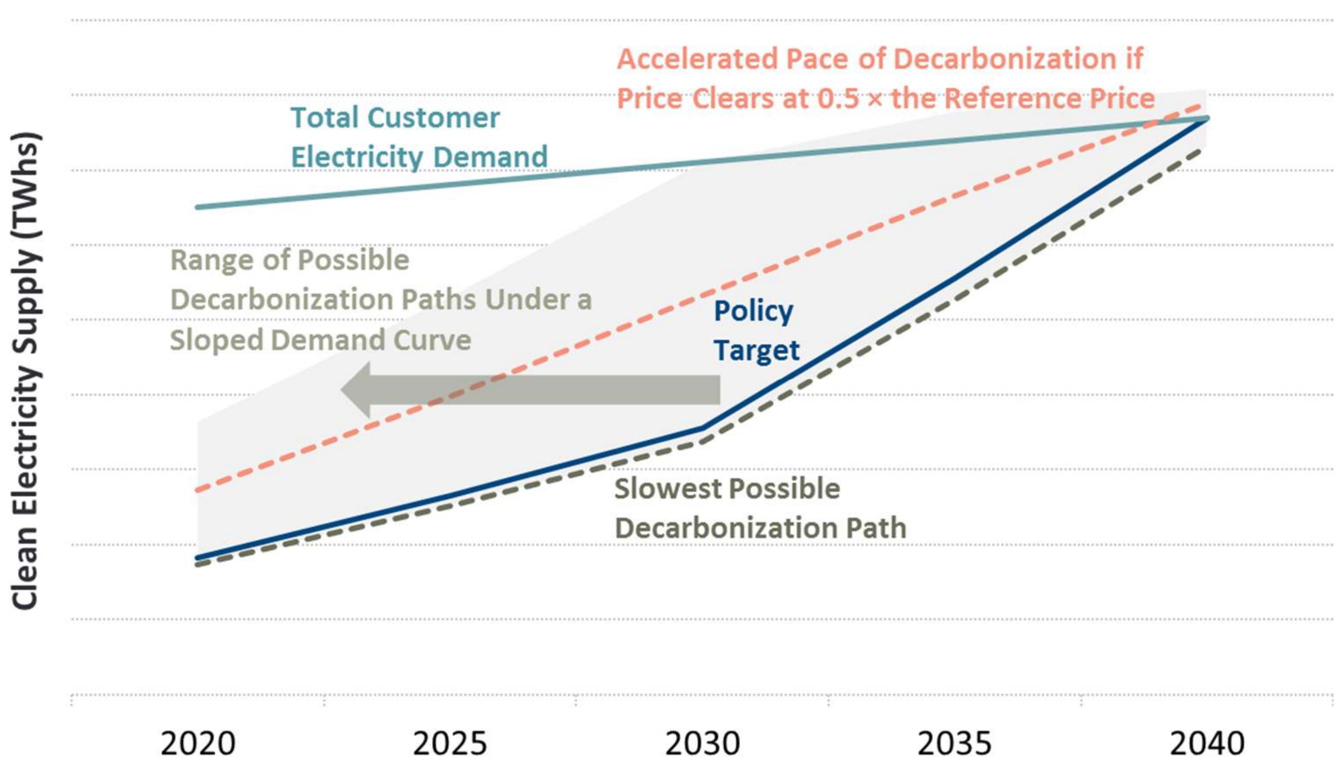
States and customers would maintain complete control over their own demand bids, with each potentially choosing a different responsible entity and approval process. Possible approaches include:

Example	Description	Curve
Clean Net CONE and Target Quantity	• State establishes tariff-like document approving curve shape, cap, and slope that reflect state priorities • State agency estimates "Clean Net CONE" and target quantity using approved method	
Price and Quantity Bids	• Customers specify P/Q pairs that reflect the amount of CEACs they are willing to buy at each price, reflecting demand from end customers (for retailers), corporate sustainability goals, and city goals	

By How Much Could a State Accelerate its Clean Electricity Goals?

Potential Pathways to Decarbonization with a Sloping Demand Curve

Example of a State with Clean Energy Targets of 25×2030, 50×2030, and 100×2040



Design Option: "Targeted" Resources to Comply with Technology-Specific Requirements

States submit the demand for clean energy and the maximum willingness to pay. States can choose to purchase:

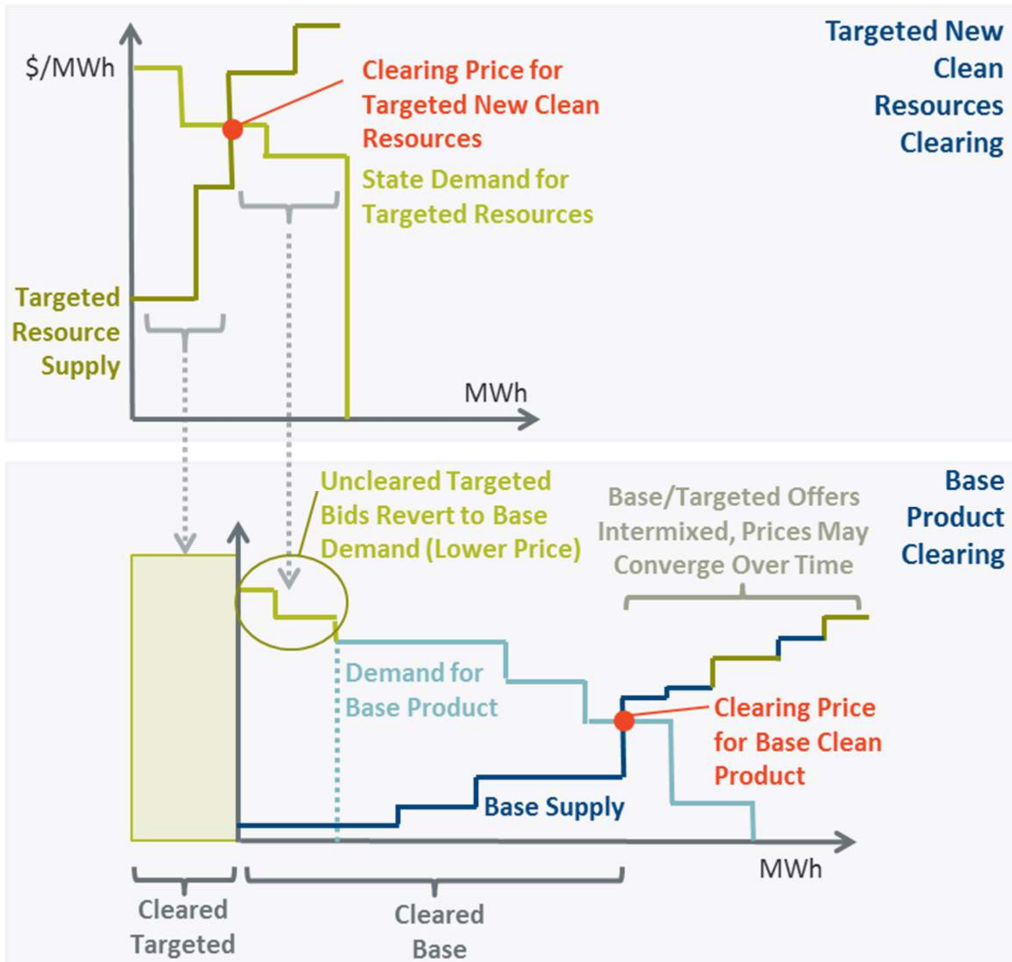
"Base" Resources

- Procures the least cost clean supply, whether new or existing
- All resources can participate (hydro, wind, solar, nuclear, storage), no restrictions by type or location
- 1-year commitments for existing resources; ~7 year price lock-in for new
- State commitment to submit demand bids in future years, e.g. for 10 years

"Targeted" Resources

- State carve-outs for new resources
- State has option to define a specific type (e.g. for emerging technologies)
- ~7 year anchor price lock-in (resources eligible as "base" supply in years 8+)
- No state commitment to submit demand in future years
- "Contingent bid" option: If targeted resource prices are too high, demand will revert to purchase lower-cost "base" resources

Illustration of Auction Clearing with Targeted Resources



Further Reading

How States, Cities, and Customers Can Harness Competitive Markets to Meet Ambitious Carbon Goals Through a Forward Market For Clean Energy Attributes

Sponsored by NRG (link)

A Dynamic Clean Energy Market in New England

Sponsored by Conservation Law foundation, Brookfield Renewable, NexEra Energy Resources & National Grid (link)

Harmonizing Environmental Policies with Competitive Markets: Using Wholesale Power markets to Meet State and Customer Demand for a Cleaner Electricity Grid More Cost Effectively (link)

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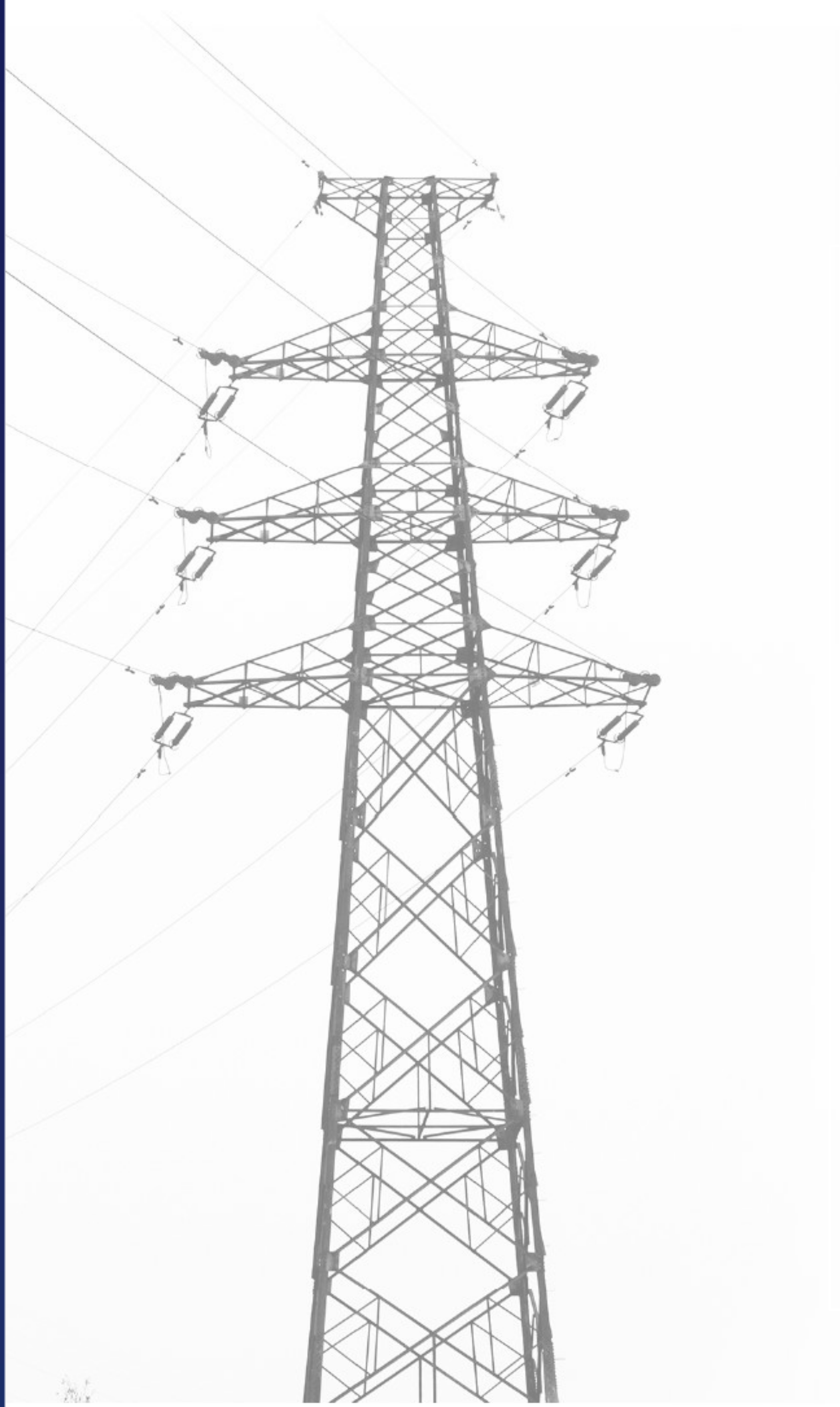

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Electricity Consumers Resource Council

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