The Future of Electricity Markets

Case Studies from Regions with 80-100% Decarbonization Goals

January 27, 2021

PRESENTED TO

Carnegie Mellon Electricity Industry Center

PRESENTED BY

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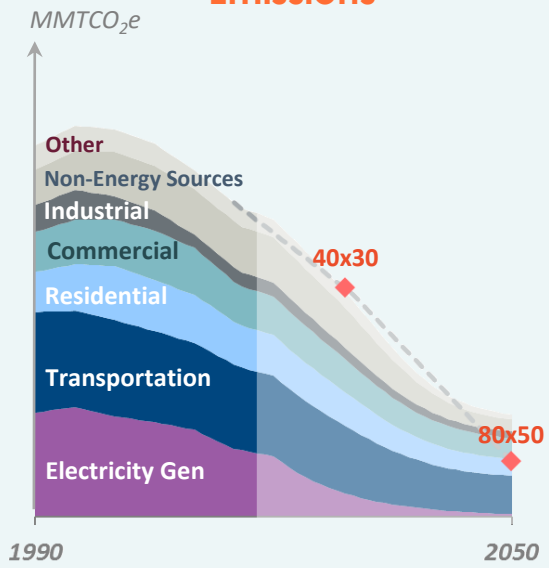
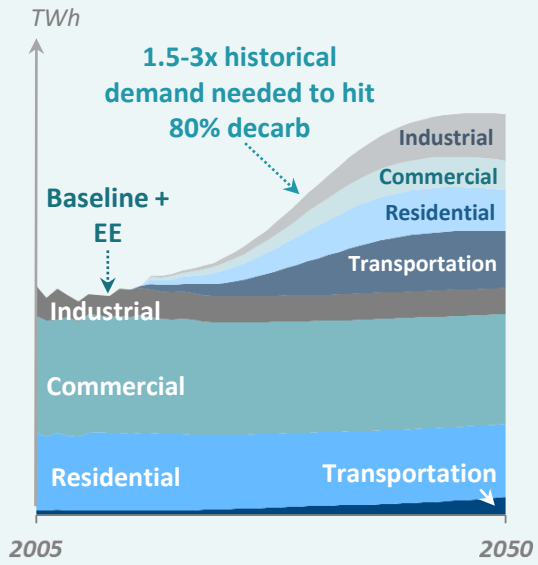
Brattle

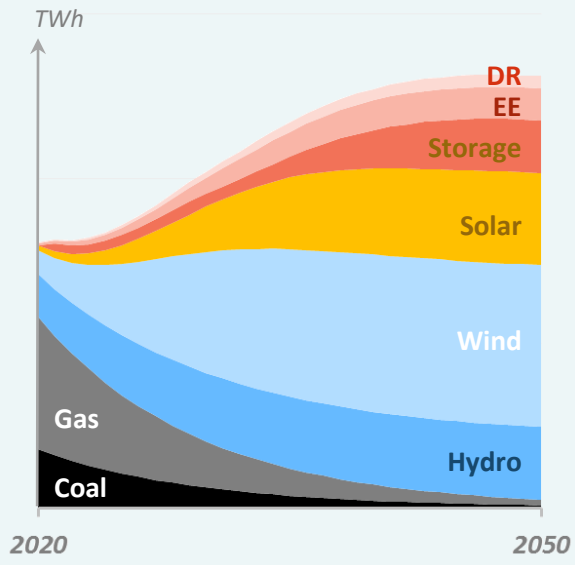
The clean energy transition is happening…



Policymakers and customers sets **GHG emissions targets** to address climate change



Demand growth from policy- and customer-driven electrification



"Non-traditional" supply resources will be the dominant source of energy economy-wide

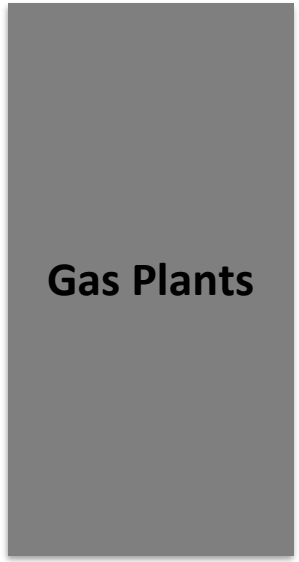
Examples: New England in an 80x50 decarbonization pathway and New York Grid in transition study.

…but I guess we didn't get the memo.

Current ISO Markets Are Designed to Achieve:

Reliable & Low-Cost Electricity

Markets designed for this purpose will attract and retain….



Market forces may drive carbon emissions up or down

But by 2050 We Need:

Reliable, Low-Cost & Carbon-Free Electricity

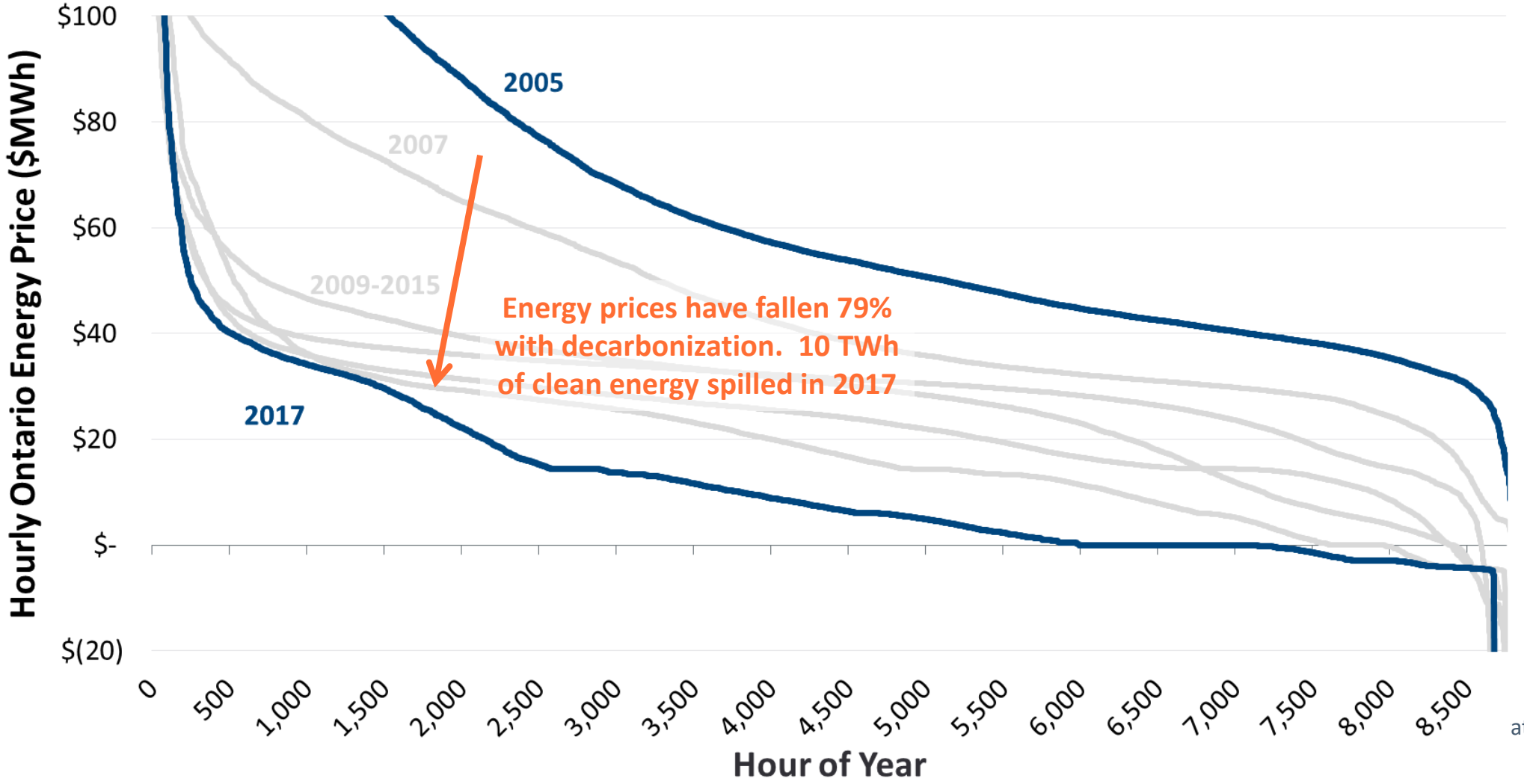
Market drives 80% carbon reductions at least cost

Ontario

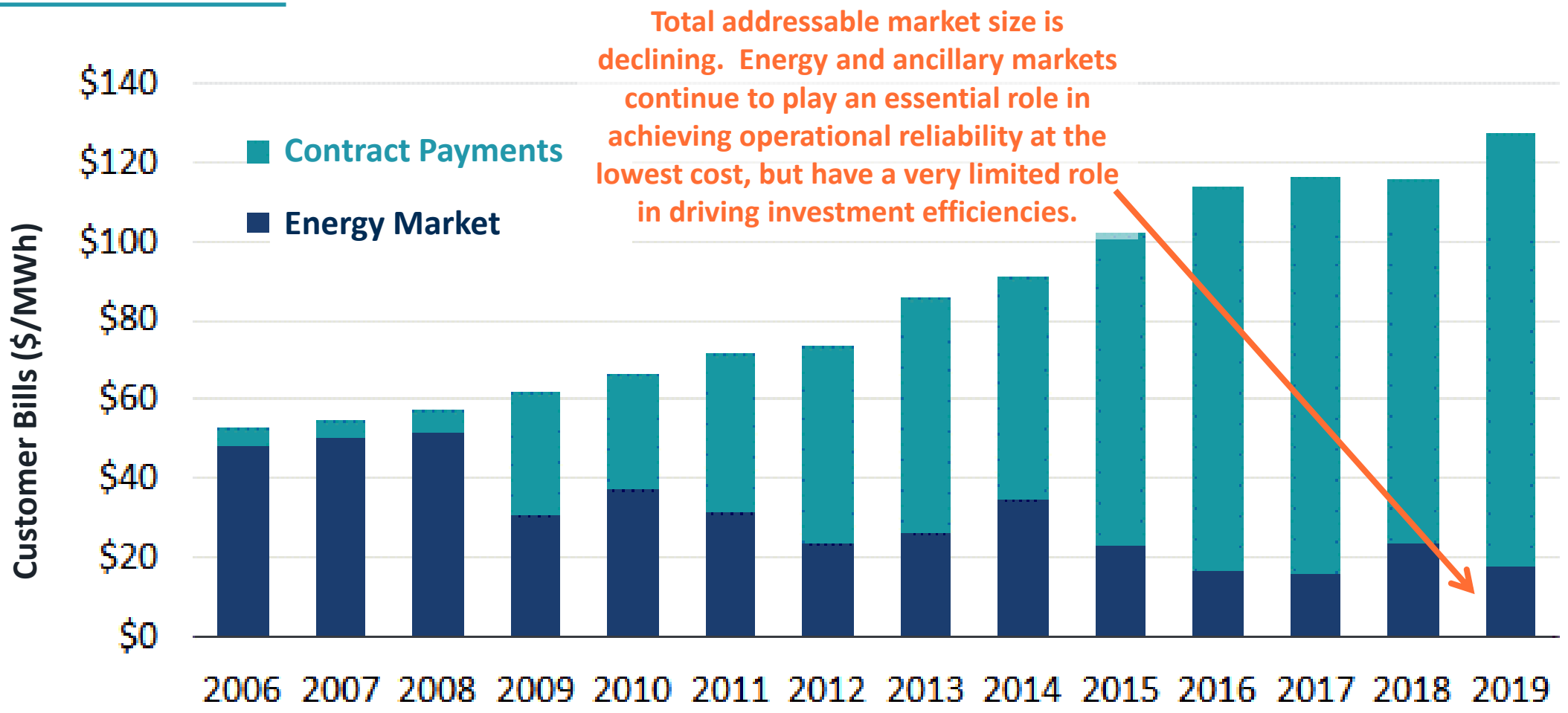
What Do Markets Look Like with Contract-Driven Decarbonization?

See Brattle's Ontario Future Market Evolution Study

Ontario: Energy Market "Bottoms Out", Enhancing the Importance of Proper DR, Storage, Hydro, and Scarcity Pricing

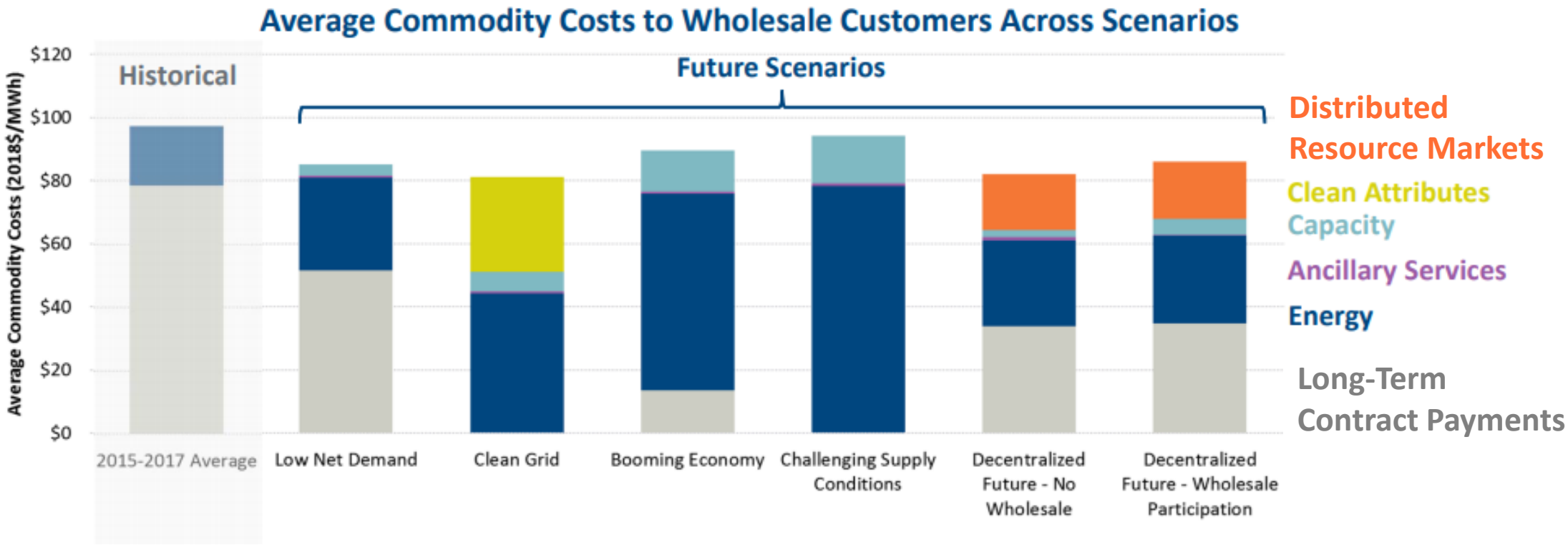


Ontario: Customer Bills Illustrate the Diminishing Role of Markets to Drive Electricity Sector Efficiencies



Ontario: Assessing Customer Costs Across Market, Clean Energy, and Economic Scenarios in 90% Clean Energy Market

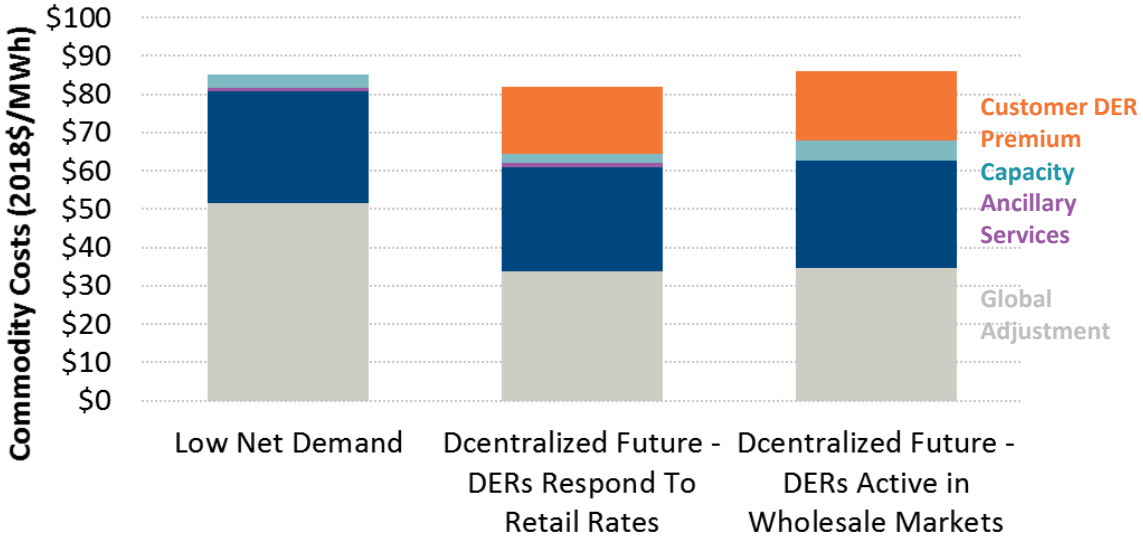
Stakeholder-driven futures explored a wide range of economic fundamentals and policy scenarios, including with an FCEM and DER markets



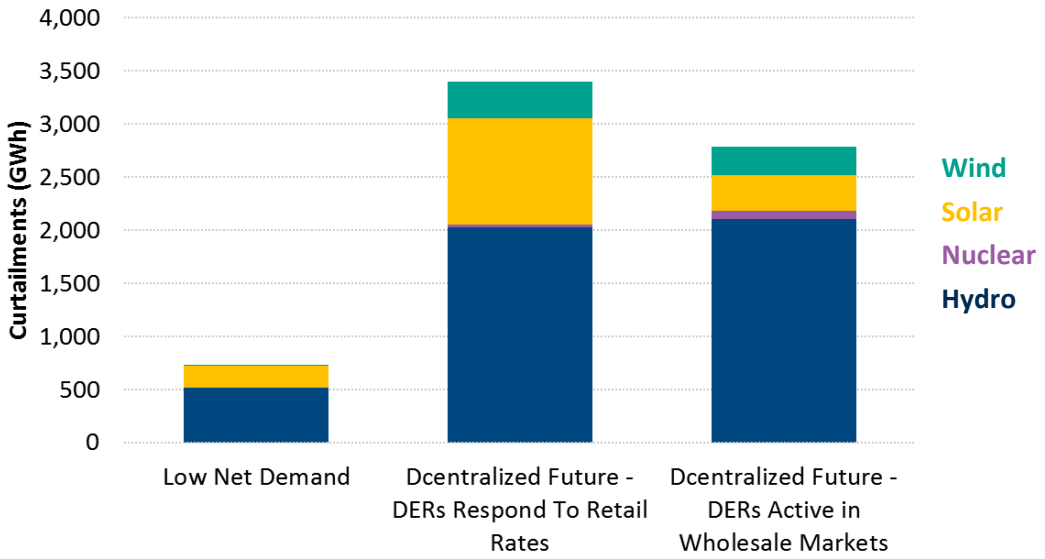
See Brattle's Study of Ontario's Future Market Evolution.

Ontario: A Look at Distributed Resource Markets

Scope of “markets” would shrink significantly if DERs are insulated from centralized market price incentives



Heavily DER-driven futures had many more clean energy curtailments (less if the DERs are bulk system dispatchable)



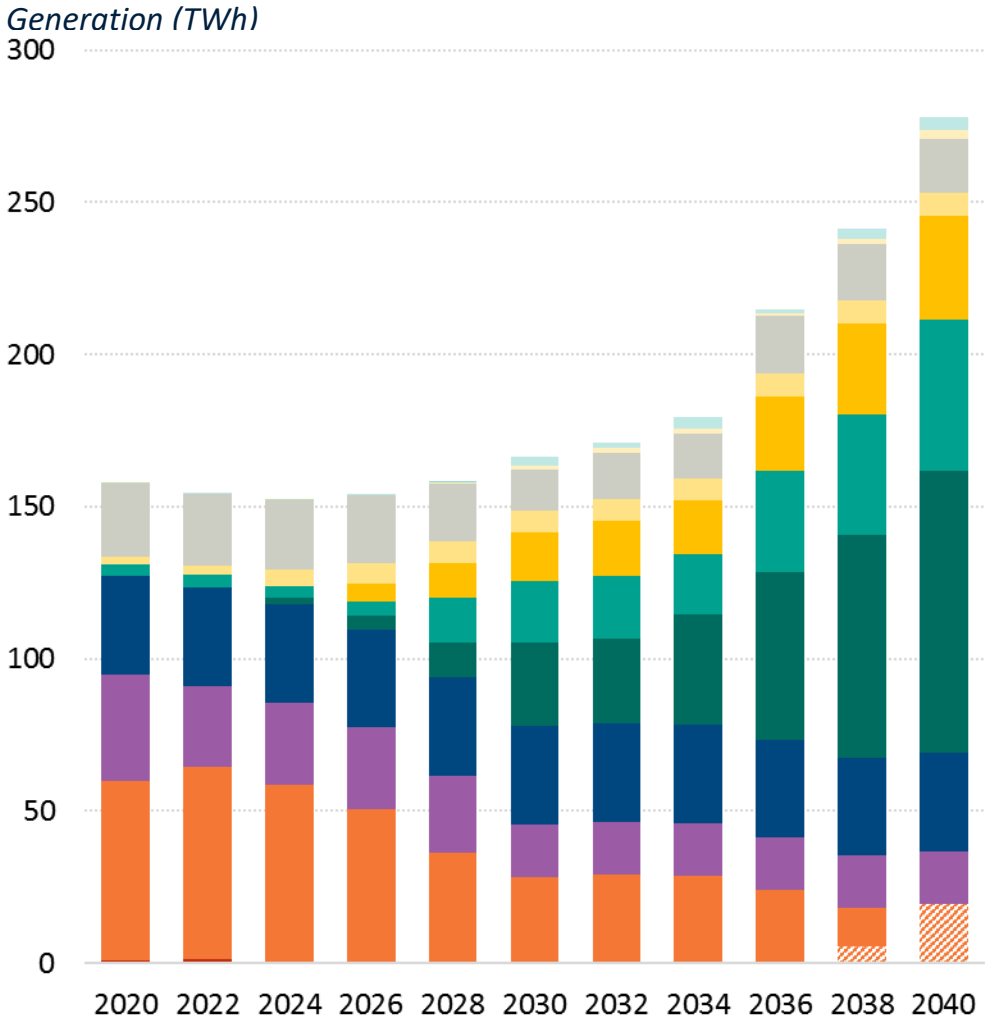
See Brattle’s Study of Ontario’s Future Market Evolution.

New York

Is a 100% clean electricity grid headed for blackouts when the sun goes down?

See Brattle's Evolution to a Zero Emission Power System Study

New York: Transition to Zero Emissions Generation



Wind Curtailment
Solar Curtailment
Net Imports
Distributed Solar
Solar
Onshore Wind
Offshore Wind
Hydro
Nuclear
Natural Gas
Zero-Emission Fuel (RNG) (Striped)
Biogen

Minimal curtailments due to short- and long-term balancing (including RNG production)

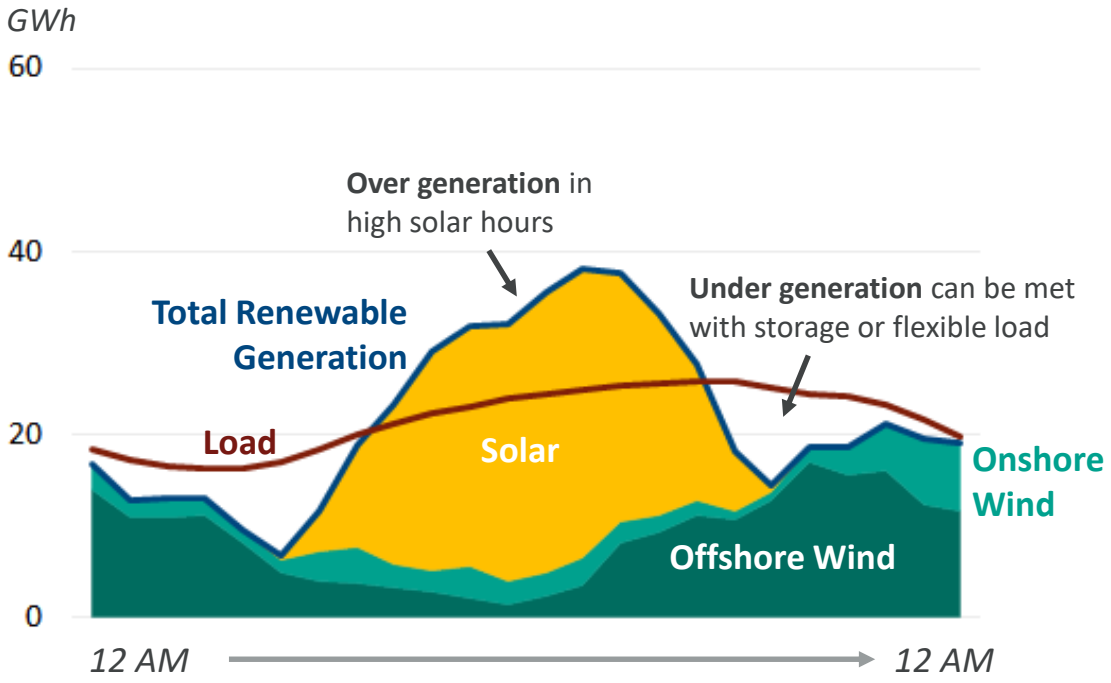
Wind and solar become primary source of energy

Gas-fired generation falls, eventually switches to zero-emission fuel sources (RNG)

See Brattle's Study of New York ISO's Grid in Transition.

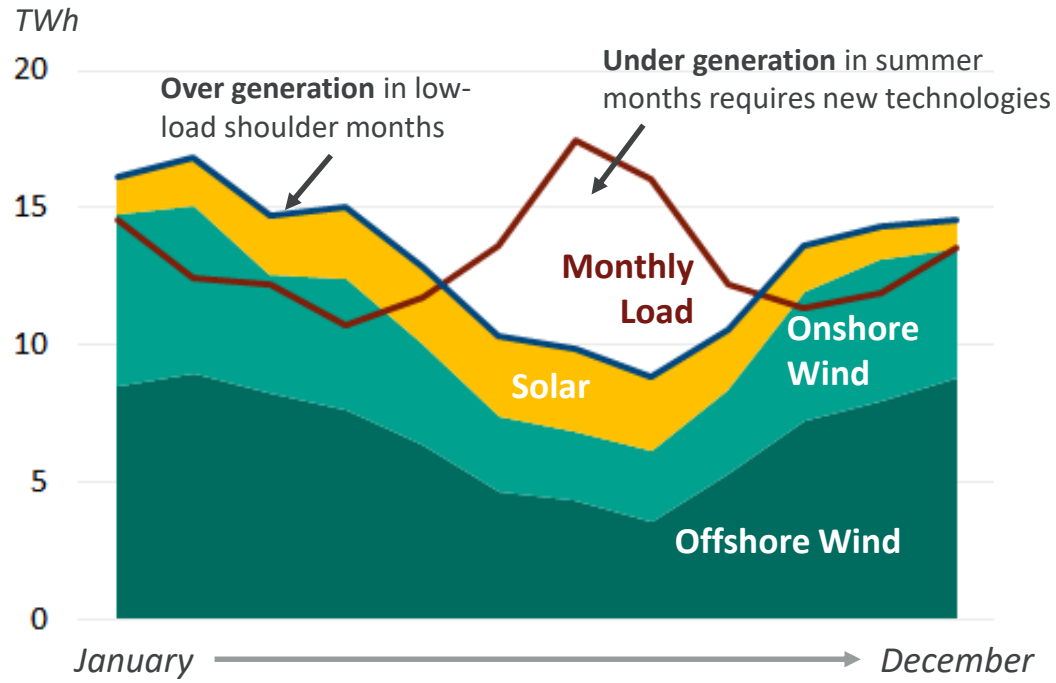
New York: Managing the System Balancing Challenge Across Multiple Timescales

Hourly Balancing Challenge



Batteries and load flexibility can provide short-term balancing.

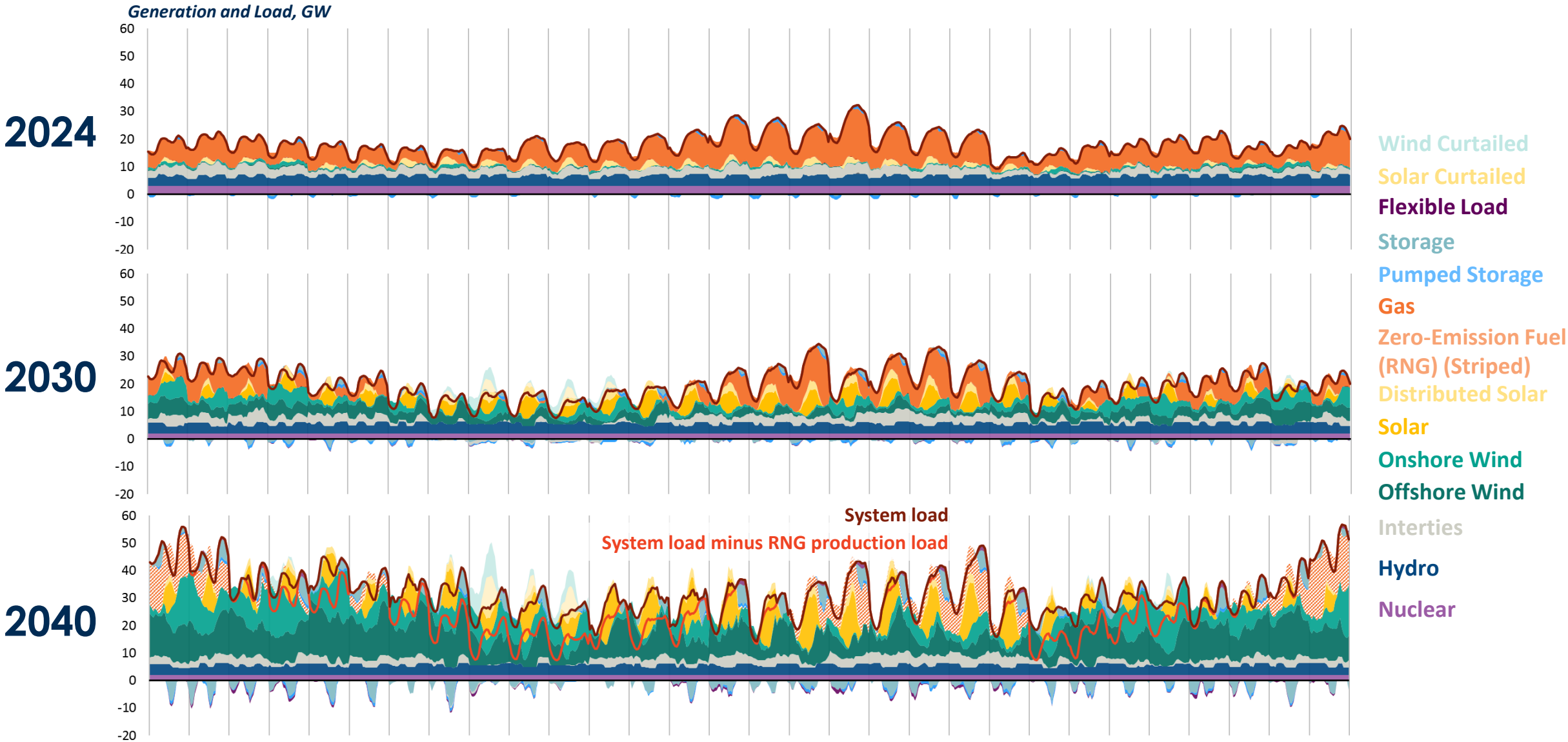
Seasonal Balancing Challenge



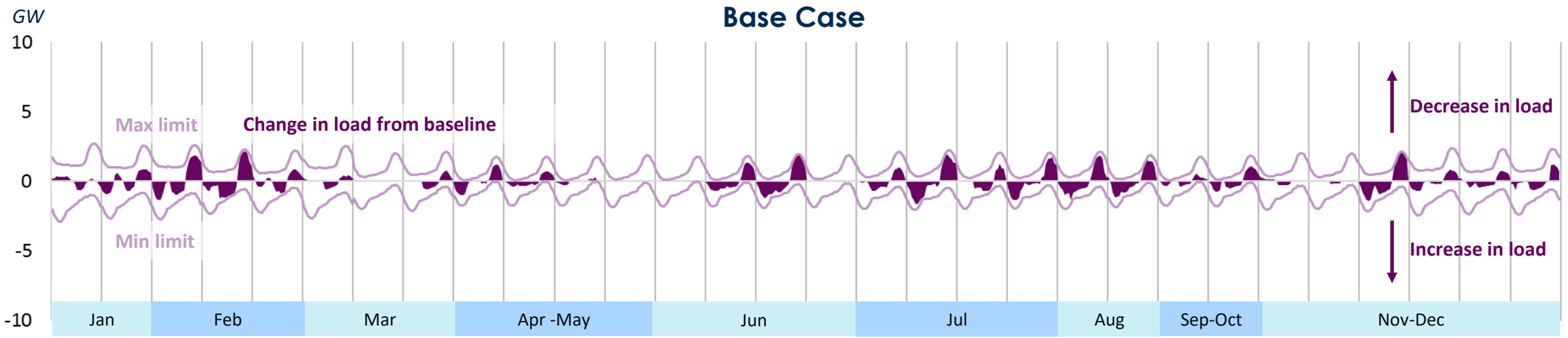
Seasonal balancing is the more difficult challenge, requiring new technologies such as seasonal storage or zero-emission dispatchable generation.

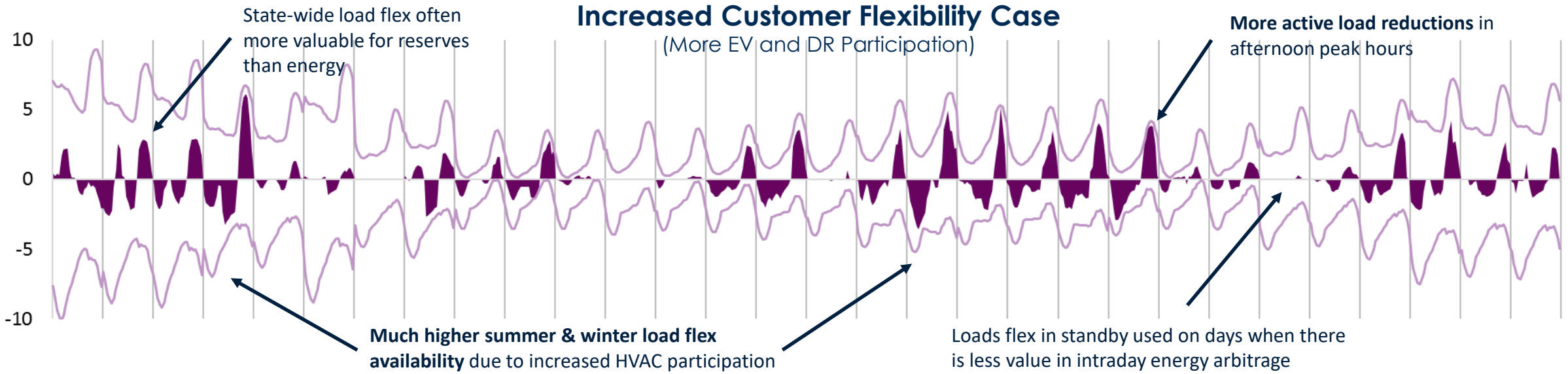
Sources and Notes: Illustrative examples. Load data is from NYISO's 2020 "High Electrification" CLCPA Load Case forecast. Generation capacities in both examples set such that total renewable generation over the period matches load. Left: Forecast for 8/19/2020; capacity of 63 GW assumed of each renewable type. Right: Capacity of 22 GW assumed for each type.

New York: Future 100% Carbon-Free Grid Will Badly Need Flexible Supply and Flexible Customers



New York: Increased Customer Flexibility (Activated by Proper Market Signals) Will Be Increasingly Essential for Reliability & Cost



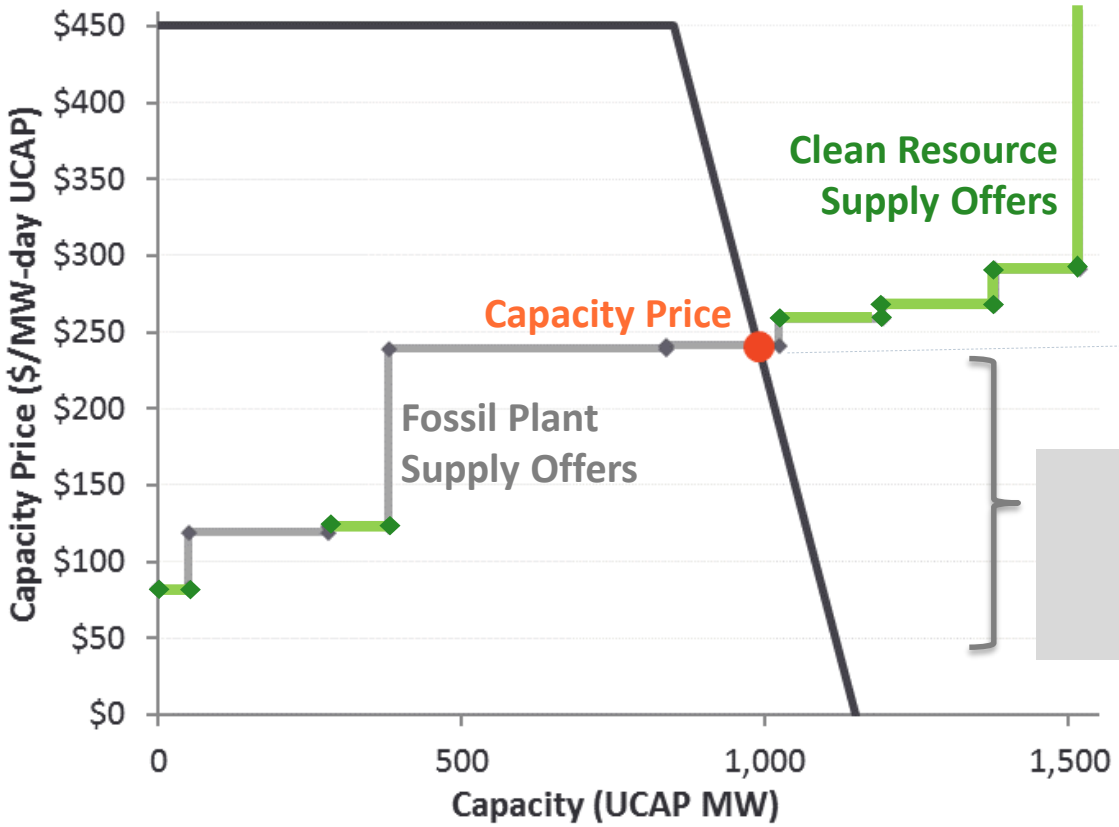


Markets vs. Policy Debate

What market design can cost effectively support the 100% clean energy grid?

Why are new gas plants getting built when policymakers aim for 50-100% clean grid?

Current Capacity Market Clearing



Capacity auction procures capacity at the lowest possible cost, setting prices at the intersection of supply and demand

Absent policy incentives for green power, most clean energy resources would fail to clear the capacity market. Minimum offer price rule (MOPR) exacerbates the problem by preventing policy resources from offering low enough to clear

Cleared supply is primarily fossil generation

Note: Simplified example. Not intended to reflect any specific market.

New England & New Jersey: Considering a new Integrated Clean Capacity Market (ICCM) to guide grid transition

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

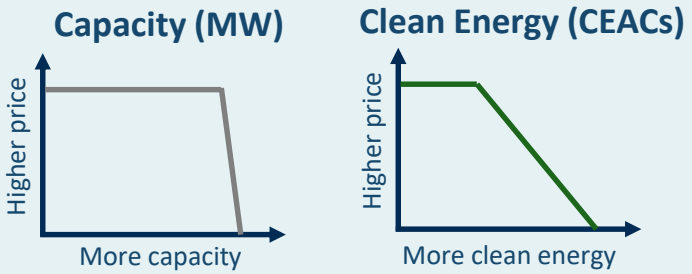
Auction Administrator

- 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 attribute credits (CEACs)
- 7-12 year price lock-in for new resources

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

BIDS

Demand



Supply

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

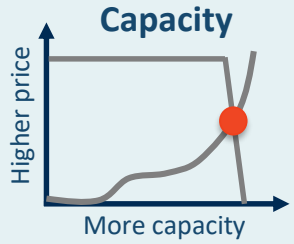
CO-OPTIMIZED AUCTION CLEARING

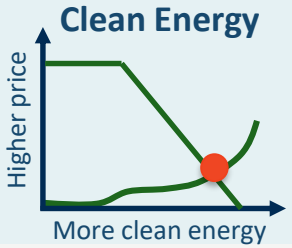
Similar to Current PJM Capacity Market Clearing

- **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

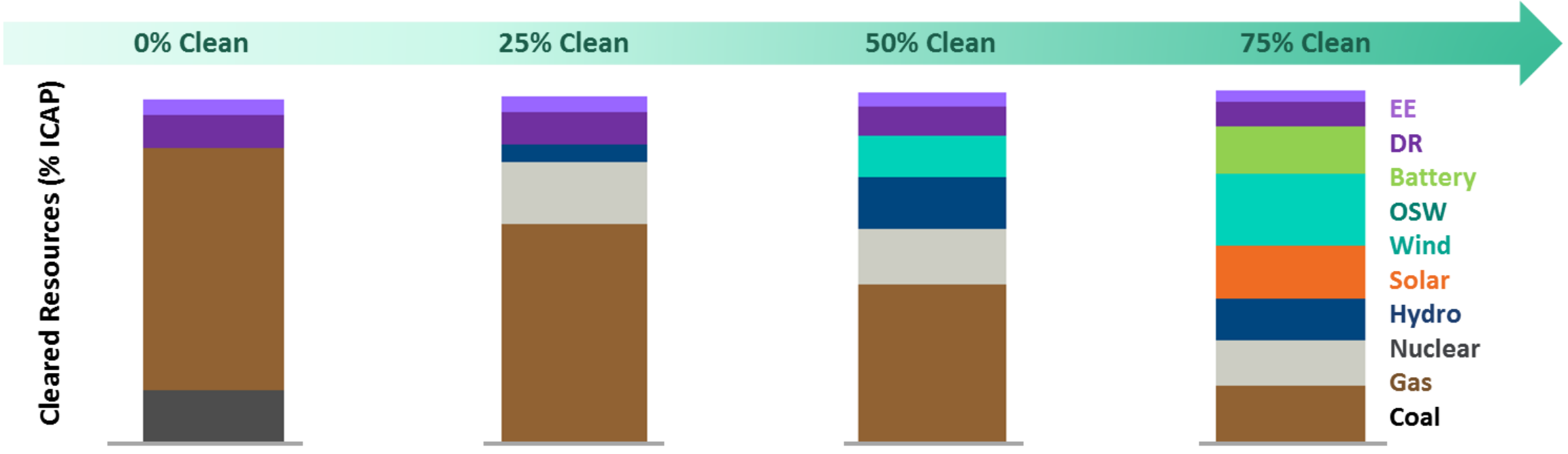




Cleared Resources

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 or New England.

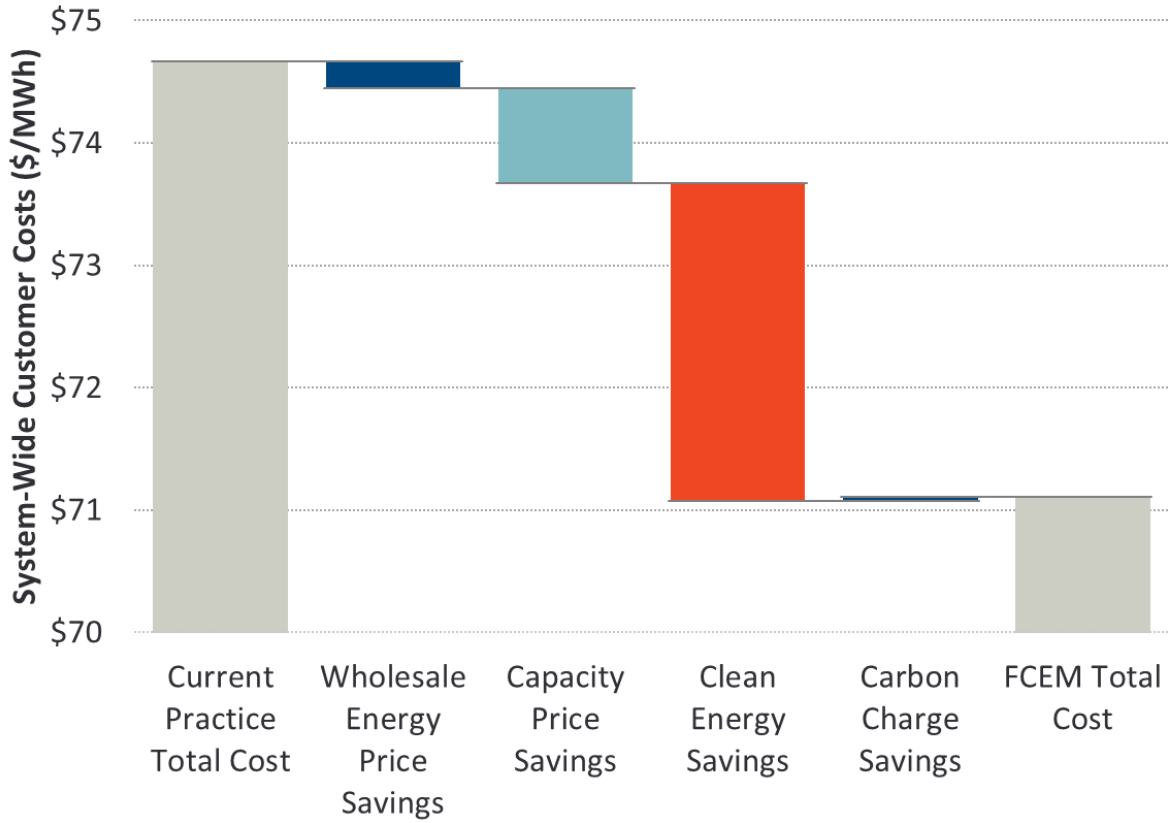
New England: Market-based procurement of clean energy could result in significant cost savings to customers

Our New England simulations in Brattle's GridSIM model estimated that **FCEM could save customers approximately $4.5 billion & abate 7.4 additional Megatonnes of CO_2** *over ten years compared to traditional state contracting*

gridSIM

New England Customer Cost Savings

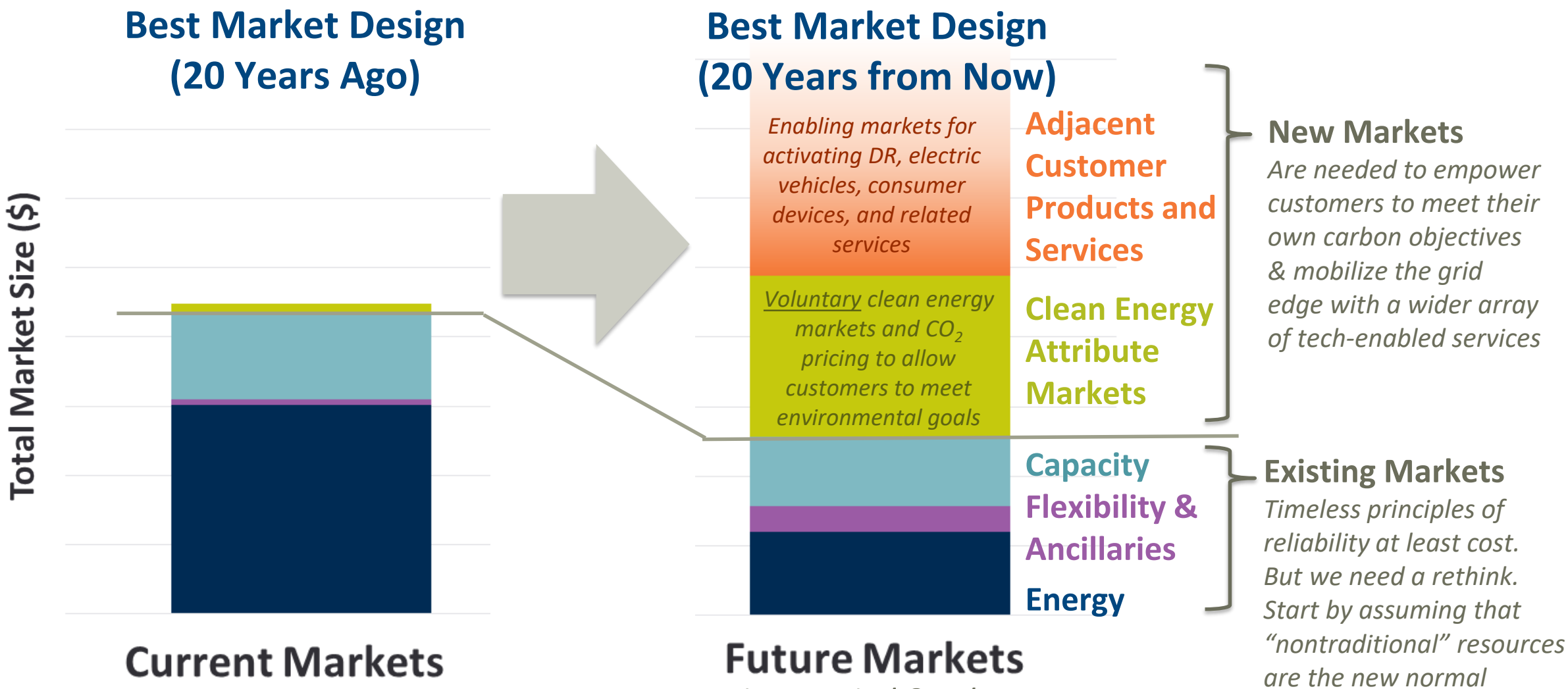
FCEM vs. Current Practice



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 reported over a ten year period 2020-2029.

So What Needs to Change?

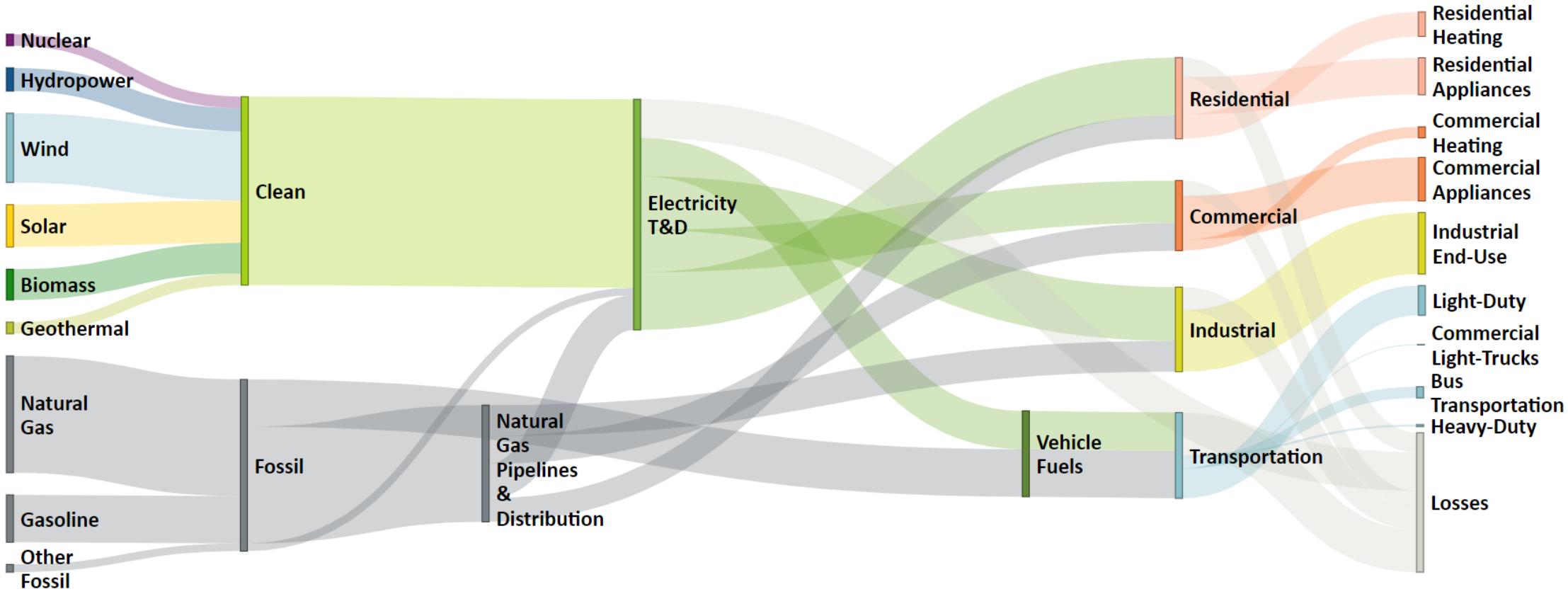
“Future markets” will be needed to unlock the promise of new technologies & competition



Appendix

DEEP Model: Near-term Energy Flows Prior to Economy-Wide Electrification and Decarbonization

We model flows of primary energy supply to customer energy demand across end uses and sectors, to examine cost and quantity of economy-wide carbon abatement opportunity, resulting electrification-driven demand growth, and (if relevant) multi-sector carbon market prices.



GridSIM: Brattle's Cutting-Edge Tool for Analyzing Resource Mix, Policy Levers & Market Design for Deep Decarbonization

INPUTS

Supply

- Existing resources and flexibility limitations
- Investment, fixed, and variable costs
- New technology (DR, DER, storage, EVs)
- Reliability contributions (ELCC, AS capability)

Demand

- Representative day hourly demand
- Capacity, ancillary & reliability needs

Transmission

- Zonal and intertie limits
- Neighboring regions (full or simplified)

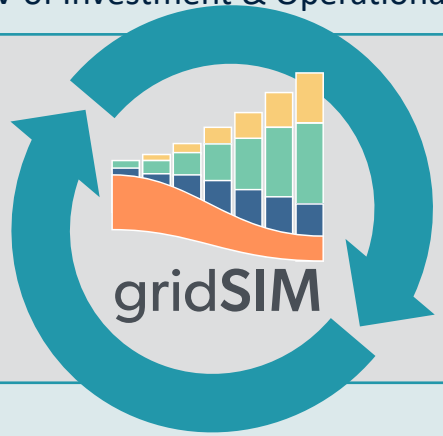
Regulations, Policies, Market Design

- Capacity market
- Carbon policy (cap, price, rate-based, other)
- Energy policies, RPS, technology carve outs, clean energy market designs

GridSIM OPTIMIZATION ENGINE

Objective Function

- Minimize NPV of Investment & Operational Costs



Constraints

- Market Design and Co-Optimized Operations
  - Capacity
  - Energy
  - Ancillary Services
- Regulatory & Policy Constraints
- Resource Operational Constraints
- Transmission Constraints

OUTPUTS

- Annual Investments and Retirements
- Hourly Operations
- Market Prices
- System and Customer Costs
- Supplier Revenues
- Emissions and Clean Energy Additions

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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 environmental 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, renewable integration, and enabling new technologies. She has worked with U.S. and international regulators to design and evaluate policy alternatives for achieving electricity sector and economy-wide decarbonization objectives reliably and affordably. She conducts advanced modeling analyses of wholesale power markets in the context of the future clean grid to support clients in making investment decisions, designing policies, and refining wholesale electricity market designs.

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.