Using Carbon Pricing in Dispatch to Meet the IMAPP Process Goals

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Carbon Price Solution – Summary

- ISO and states work together to translate state carbon reduction goals into a schedule of year-by-year carbon emission goals for the ISO-NE footprint
- ISO determines carbon price necessary to meet carbon emission goals
  - Year 1 carbon price set at EPA social cost of carbon (~$47/ton in 2017)
  - Following year 1, ISO compares committed emissions to year 1 goals. If goals are met, carbon price for year 2 left unchanged. If goals are not met, carbon price is increased by an agreed-upon fixed increment (e.g. $5/ton)
  - This iterative process continues indefinitely
  - While carbon price may initially increase, feedback loops will dampen impact
    - ✓ Pass-through rate of carbon prices to wholesale energy prices will fall as low/zero carbon resources are increasingly on the margin, reducing consumer impact and mitigating “windfall profits” concern
    - ✓ Existing capacity and reserve markets will provide price signals necessary to maintain reliability and ensure a sufficient amount of fast-ramping and load-following resources
- ISO incorporates carbon price into energy market dispatch via an ISO-administered resource-specific, energy bid adder for carbon emitting resources
  - Reflecting the cost of carbon into energy dispatch = carbon price ($/ton) x emission rate for resource (tons/MWh)
  - Emitting resources pay the bid adder to the ISO, and the ISO remits the proceeds to LSEs, using an agreed-upon allocation approach that could accommodate differences in state goals
  - States may direct LSEs to use proceeds to offset customer costs or for other purposes (i.e., LIHEAP)

A carbon price is compatible with a forward clean energy market

- A carbon price raises energy prices in proportion to the marginal system carbon emissions
- If the carbon price is set at a level sufficient to fully compensate new entrant zero-carbon resources, a carbon price is all that is needed to achieve both state renewable goals and state carbon reduction goal
- A clean energy attribute procurement (FCEM) could, however, serve as a transitional overlay to a carbon price solution to ensure that the desired resources are procured, particularly if the carbon price is set at a level below that needed to fully compensate renewable entry:
  - Renewable attribute price would be set by "missing money" of marginal new entrant clean energy resource after bidders consider expected energy and capacity revenues
  - A carbon price will be incorporated into the expected energy price and by extension will reduce the amount of "missing money" on which clean energy resources set their bids
  - If the carbon price is set high enough, the clean energy procurement will clear at a price near zero. If the carbon price is set below this level, it will still reduce the clearing price for the clean energy procurement while producing additional benefits outside of the clean energy procurement process
- Over time, the FCEM could phase out as an adequate carbon price phases in or as renewable costs come down (or both).

A carbon price enhances forward clean energy procurement and provides additional benefits

A carbon price combined with a forward clean energy procurement provides benefits that cannot be achieved with a clean energy procurement alone:

1. By embedding some or all of the compensation for clean energy in the energy price, a carbon price reduces the size of the clean energy attribute payment necessary to attract new clean energy, while creating a revenue stream that can offset customer costs

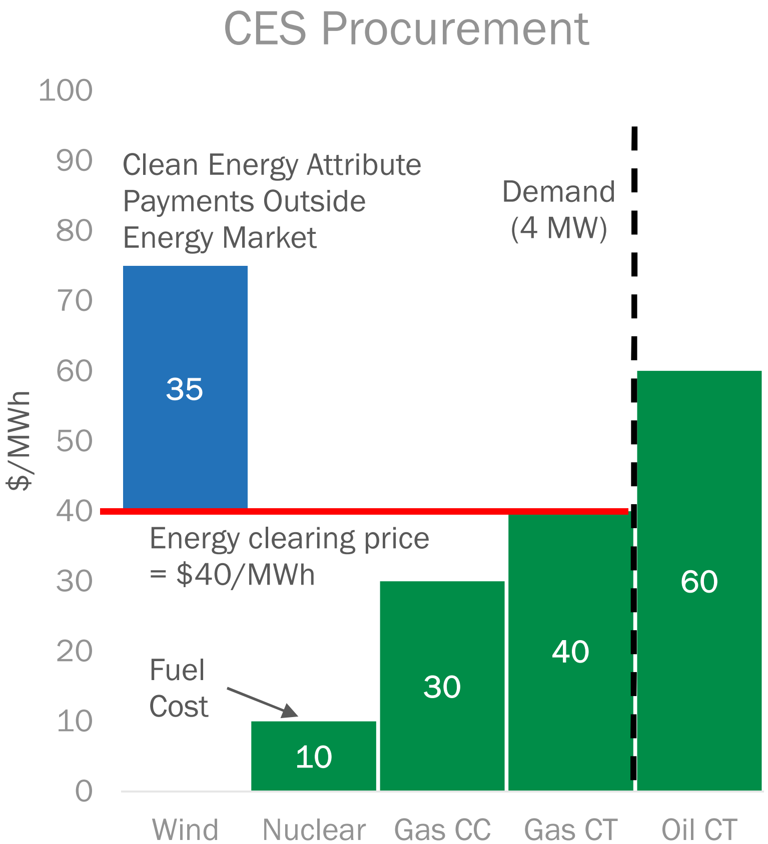
2. By reducing the attribute payment to clean energy resources, a carbon price reduces or even eliminates distortions in the energy market

3. A carbon price correctly prices the actual differential carbon abatement attributes of different zero-carbon resources and will thus better align the results of a clean energy procurement with actual carbon reduction

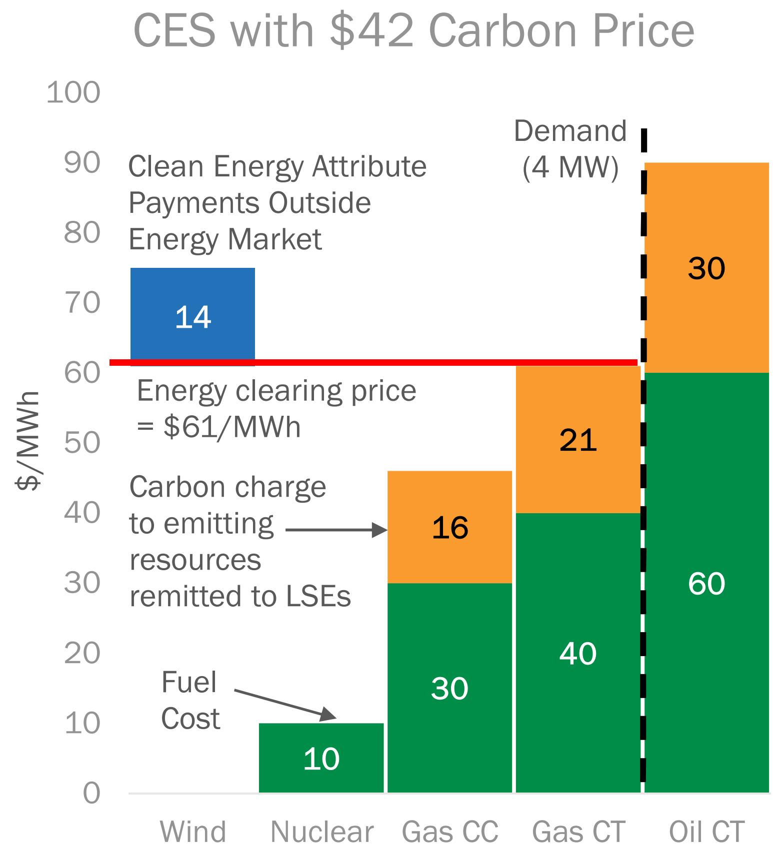
4. A carbon price recognizes the contribution of low-carbon resources, not just zero-carbon technologies (such as energy efficiency and highly efficient gas generation). The carbon price creates incentives for additional carbon abatement actions that are not addressed by a clean energy procurement

5. Depending on level, a carbon price can avoid the need to include nuclear and low-tier renewables within the clean energy procurement

By moving a portion of compensation to the energy market, a carbon price reduces the cost of clean energy attributes



	Gross Margin (Excluding Capacity):				
	Energy	Attribute	Carbon	Fuel	Total
Wind	40	35	0	0	75
Nuclear	40	0	0	(10)	30
Gas CC	40	0	0	(30)	10
Gas CT	40	0	0	(40)	0



	Gross Margin (Excluding Capacity):				
	Energy	Attribute	Carbon	Fuel	Total
Wind	61	14	0	0	75
Nuclear	61	0	0	(10)	51
Gas CC	61	0	(16)	(30)	15
Gas CT	61	0	(21)	(40)	0

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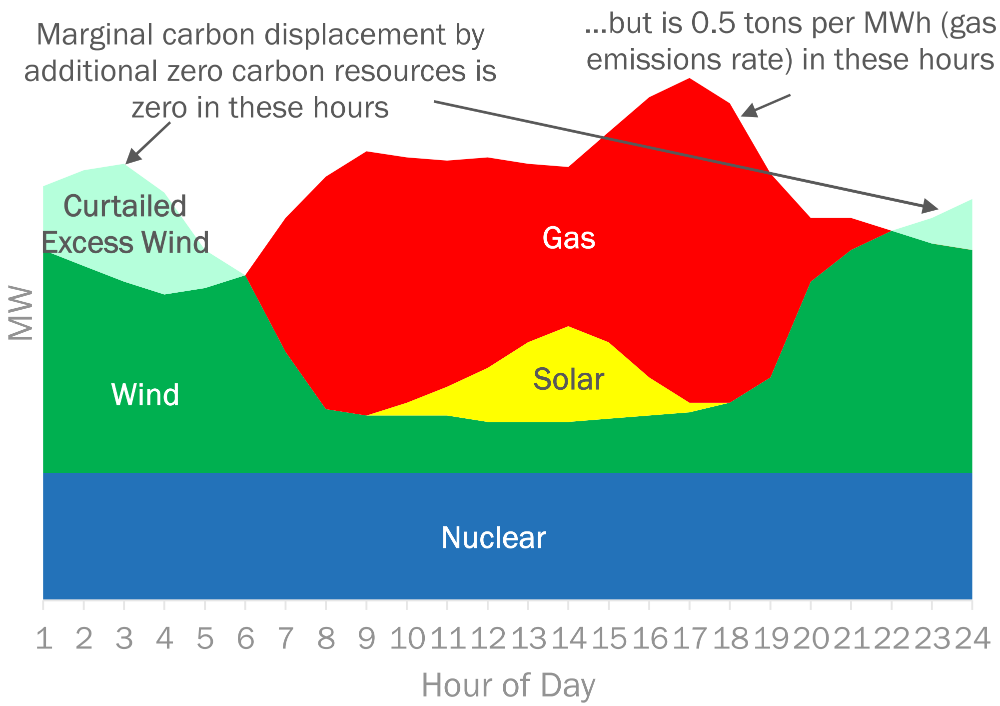
A carbon price reduces or eliminates energy market distortions

- Payments for energy production which do not flow through the energy market create an incentive for distorted energy market bids
  - For example, with a $35/MWh REC price, a wind generator is paid the energy price plus $35, and additionally generates a production tax credit worth another $35 in pre-tax terms for each MWh it produces
  - This generator will make money even with an energy price of negative $69/MWh, and will thus have an incentive to bid negative $70/MWh in the energy market to ensure it runs and receives its non-energy production-based payments
  - This effect is further compounded if instead of a REC-style attribute payment the resource receives a fixed contract price – the incentive in this instance will be to bid the negative of the contract price (plus the production tax credit) into the energy market
  - If state-supported resources are built in large enough quantities these distorted bidding incentives can create significant problems for the efficient commitment and dispatch of generating resources
- A carbon price reduces or eliminates the need for non-energy production-based payments, and thus diminishes or eliminates these potential problems

Zero-carbon resources are not necessarily equivalent and a carbon price correctly values the differences

Example: Too Much Wind, Too Little Solar



	Marginal Carbon Passthrough Rate	Energy Uplift from $42/ton Carbon Price
Solar	0.50 tons/MWh	$21/MWh
Nuclear	0.35 tons/MWh	$15/MWh
Wind	0.20 tons/MWh	$8/MWh

The resource with the most marginal carbon abatement (solar) correctly receives the biggest benefit from the carbon price.

- Not all zero-carbon resources are equal in terms of their carbon abatement. Depending on production profile and existing supply stack there may be significant differences
- A carbon price correctly values these differences while a clean energy procurement on its own does not
- When a carbon price and FCEM are combined, resources with superior carbon abatement will be better compensated in the energy market, and thus will be able to offer more competitive bids in the FCEM

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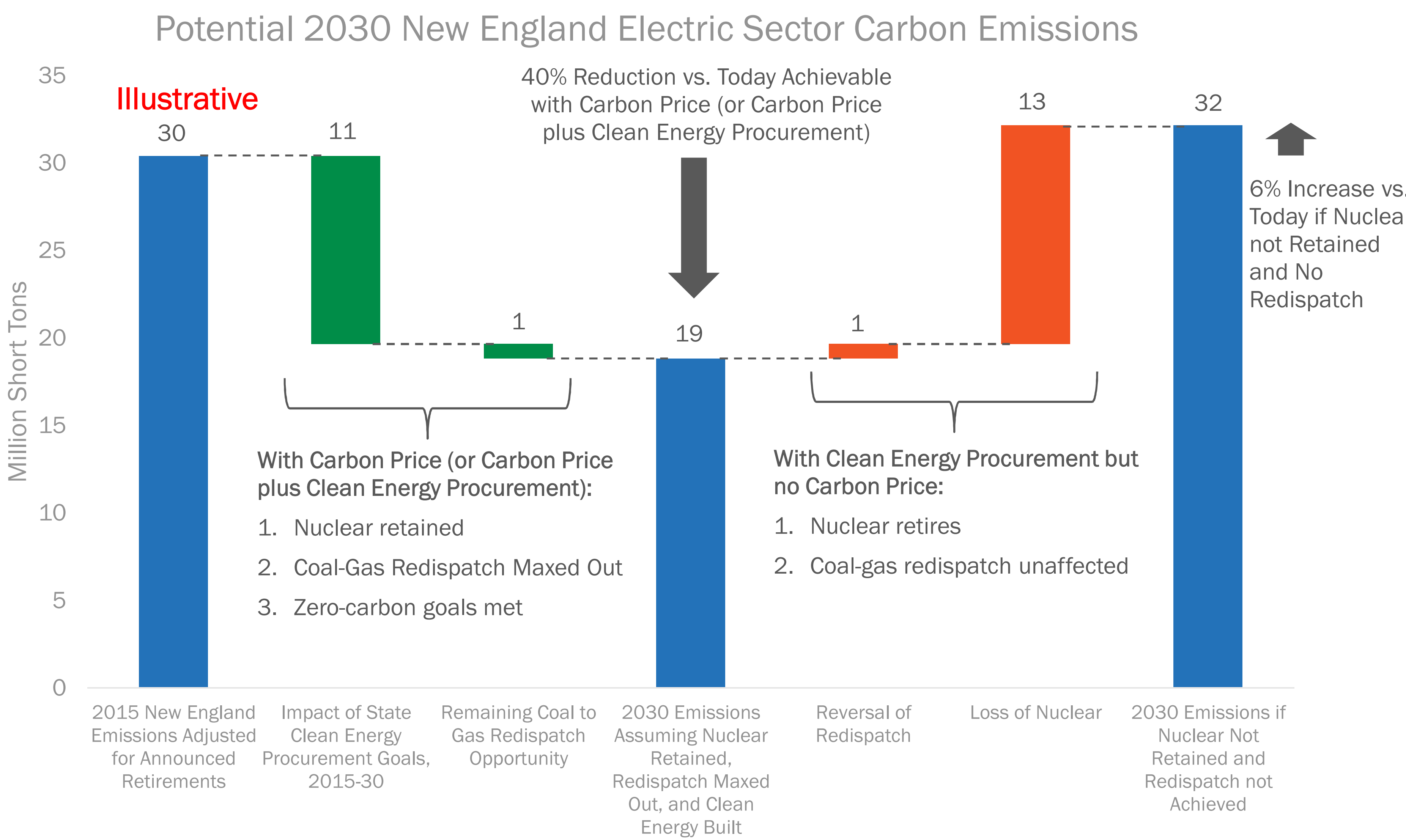
A price on carbon creates incentives for additional carbon-reducing actions

While a price on carbon provides incentives for zero-carbon resources, it is a broad-reaching solution that provides incentives for other carbon-abatement sources not addressed by a clean energy procurement:

- Incentivizes re-dispatch in favor of lower emitting generators (such as gas CCGTs) over higher carbon generators (such as coal and oil)
- Provides appropriate price signals for nuclear to remain in the market
- Correctly prices the emission attributes of power imports
- Creates incentives that favor high efficiency, low-emissions technologies for new builds, uprates and retrofits versus resources with higher emissions rates.
- Provides correct emissions-related price signals sent to consumers in favor of energy efficiency and other consumer-side emissions abatement measures, particularly in conjunction with smart meter technology
- Provides immediate incentives for emerging zero/low carbon technologies which may not be covered by the procurement
- Provides correct emission-related price signals for investment in, and dispatch of, storage resources, particularly if carbon price is incorporated into ISO unit commitment decisions
- Provides correct emission-related price signals for behind-the-meter zero-carbon generators, with appropriate rate design

A carbon price enables nuclear retention and environmental re-dispatch, both of which are critical to reducing emissions



Assumptions: Utilizes 2015 RGGI emissions data adjusted for retirement of Brayton Point and Pilgrim. Does not include emissions from sources not covered by RGGI. Nuclear loss estimate includes impact of Seabrook, and Millstone shutdown. All carbon impacts estimated using 0.47 tons/MWh marginal emission rate.

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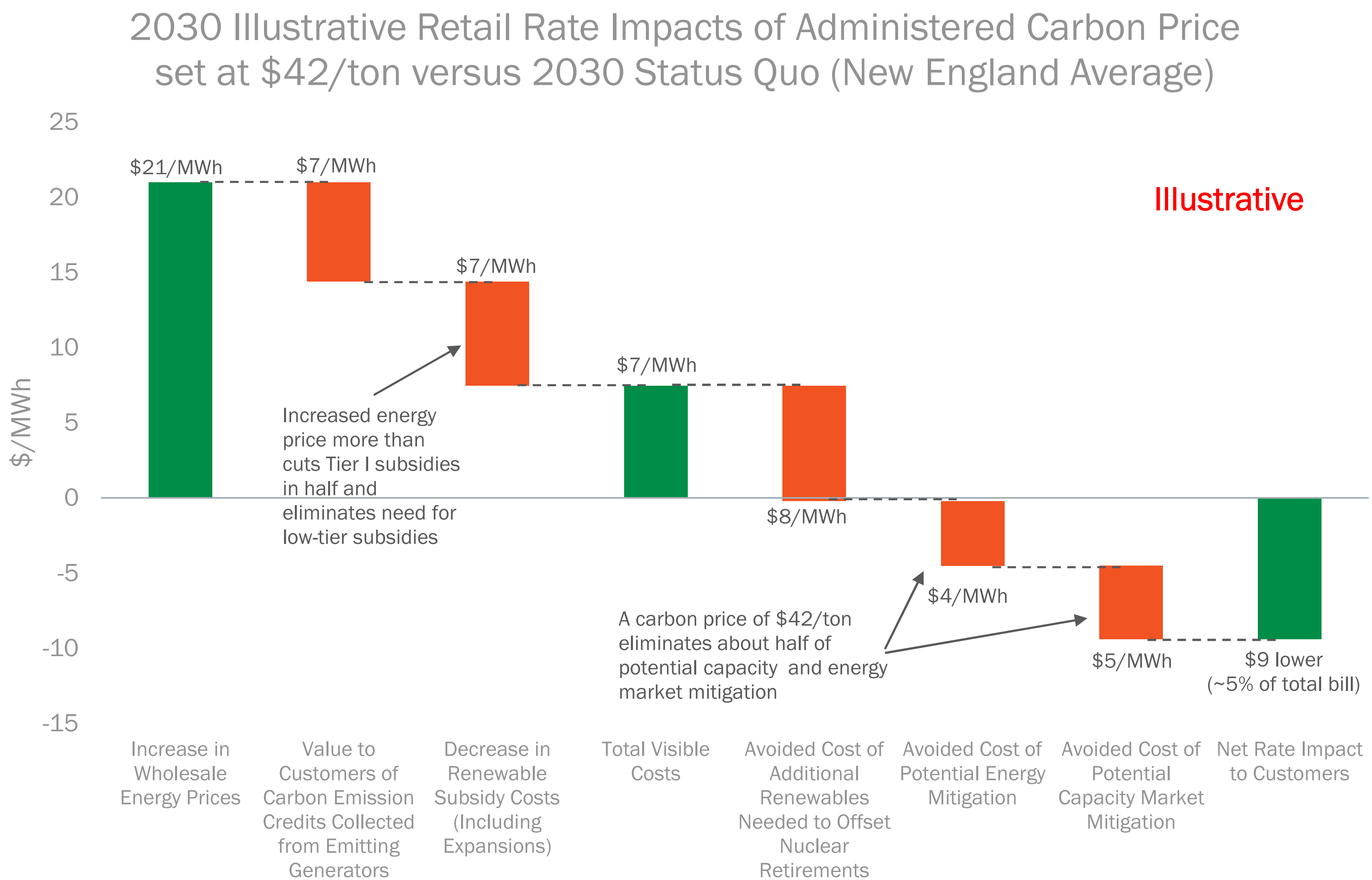
With the overall result that a carbon pricing solution is actually much cheaper for customers over the long run than a current state bilateral contract model



Assumptions: 0.47 short ton per MWh marginal emission rate; 0.17 short ton per MWh average emission rate; baseline REC price of $35/REC; capacity market mitigation requires that additional non-subsidized capacity resources be equal to UCAP value of subsidized resources be purchased.

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Appendix

Methodology for Customer Cost Calculation (1)

Cost (Benefit) Category	Value ($/MWh)	Calculation Methodology
Increase in Wholesale Energy Prices	$21.0	= Carbon Price x Marginal Emission Rate x Wholesale-to-Retail Multiplier Where: • Carbon Price = $42/ton (Illustrative) • Marginal Emission Rate = 0.4705 tons/MWh. Based on ISO-NE 2014 Reported Marginal Emission Rate of 941 lbs / MWh for all locational marginal units from 2014 ISO-NE Air Emissions Report. • Wholesale-to-Retail Multiplier = 1.0611. Based on 2014 6-state retail load of 120 TWh as reported in EIA Electric Power Monthly and 2014 ISO Wholesale Load of 127.3 TWh as reported in 2014 CELT report. Retail-to-Wholesale multiplier = 127.3/120.0 = 1.0611.
Value to Customers of Carbon Emission Credits Collected from Emitting Generators	$6.6	= Carbon Price x Projected 2030 Emissions / Retail Load Where: • Carbon Price = $42/ton (Illustrative) • Projected 2030 Emissions = 18.8 million short tons. Based on 2015 New England Emissions of adjusted downward for new renewables and redispatch. See slide 8 for illustration. • Retail Load = 120 TWh (see above)

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Methodology for Customer Cost Calculation (2)

Cost (Benefit) Category	Value ($/MWh)	Calculation Methodology
Decrease in Renewable Subsidy Costs	$6.9	= (2030 Tier 1 Renewable Target x Carbon Price x Marginal Emission Rate + 2030 Low-Tier Renewable Target x Low-Tier REC Price) / Retail Load Where: • Carbon Price = $42/ton (Illustrative) • Marginal Emission Rate = 0.4705 tons/MWh. See Previous Slide. • 2030 Tier 1 Renewable Target = 37.1 TWh. Based on scheduled 2030 Tier 1 RPS Targets of 27.5% for MA, 20% for CT, 31% for RI, 8.8% for VT, 24.8% for NH, 10% for ME multiplied by relevant state-level retail load, plus 9.45 TWh of incremental renewables associated with MA H. 4568 • 2030 Low-Tier Renewable Target = 9.8 TWh. Based on Scheduled Low-Tier RPS Targets of 3.5% for MA, 7% for CT, 62.2% for VT, 20% for ME. Low-Tier renewables include tiers that cover resources generally not eligible for Tier 1 such as large-scale hydro and certain types of biomass. • Low-Tier REC Price = $10/MWh. Assumed value based on low-tier REC alternative compliance payments. • Retail Load = 120 TWh. See Previous Slide.
Avoided Cost of Additional Renewables Needed to Offset Nuclear Retirements	$7.8	= Nuclear Output at Risk x Tier 1 REC Price / Retail Load Where: • Nuclear Output at Risk = 26.6 TWh. Projected annual output of Millstone 2 and 3 and Seabrook (3,380 MW total) at 90% capacity factor. • Tier 1 REC Price = $35/MWh. Based on recent Tier 1 REC price for MA and CT as published in Megawatt Daily. • Retail Load = 120 TWh. See Previous Slide.

Methodology for Customer Cost Calculation (3)

Cost (Benefit) Category	Value ($/MWh)	Calculation Methodology
Avoided Cost of Potential Energy Mitigation	$4.3	= (Price Impact of All Potential Subsidized Resources x Fraction of Energy Market Not Subsidized + Price Impact of All Potential Subsidized Resources x Fraction of Energy Market Subsidized x 0.5) x (Fraction of Mitigation Avoided) Where • Price Impact of All Potential Subsidized Resources = $12/MWh. Based on internal modeling of replacement of 73 TWh of subsidized infra-marginal resources with non-subsidized gas resources • Fraction of Energy Market Not Subsidized = 42% • Fraction of Energy Market Subsidized = 58% • Fraction of Mitigation Avoided = 51% This assumes that energy price impact of subsidized will be restored to on-subsidized resources that still clear the market, and that non-subsidized resources that would otherwise have cleared the market are paid their lost energy margin.
Avoided Cost of Potential Capacity Mitigation	$4.9	= (Low-Tier Renewable Capacity + Nuclear Capacity) x Net CONE x (12/1000) / Retail Load Where • Low-Tier Renewable Capacity = 1,122 MW. Based on 9.8 TWh of Low-Tier renewables receiving UCAP credit at 100% of average hourly output • Nuclear Capacity = 3,380 MW • Net CONE = $10.81/kw-mo • Retail Load = 120 TWh. See previous slides. This assumes that mitigation requires that capacity effectively be purchased twice for the mitigated capacity: once by removing this capacity from the market, and once by making up for the loss of capacity revenues via further subsidy payments

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