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Pathways Study

Evaluation of Pathways to a Future Grid

Todd Schatzki and Chris Llop

June 11, 2021

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Overview

- Purpose of today's presentation is to give an update on several of the proposed modeling inputs and assumptions for the central case, and to provide more information on several questions from the May meeting
- As with our May presentation, inputs and assumptions discussed today are preliminary; we have endeavored to provide information on current thinking, and will refine based on our continued analysis and additional feedback
- We appreciate the stakeholder feedback to date and encourage further stakeholder feedback to help ensure our assumptions are reasonable and reflect a range of viewpoints regarding future policies

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Agenda

- Overview of Capacity Expansion Model
- Continued Discussion of Modeling Inputs and Assumptions
  - Capital Costs of New Entry
  - Status Quo Procurements
  - Central Case Retirement Assumptions
- Proposed Set of Scenarios
- Questions and Answers from Prior Meetings
- Appendix: May 2021 AG Pathways Presentation

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Overview of Capacity Expansion Model

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Overview of Modeling Approach: Model Components

- Analysis will use a multi-module model to simulate the New England electricity markets:
  - Energy and ancillary service (reserve) (EAS) markets
  - Forward capacity market
  - Proposed forward clean energy market (FCEM) frameworks
  - Proposed net carbon pricing framework
- Except for the proposed FCEM and net carbon pricing frameworks, models will reflect current market structures and rules, and not include potential modifications that may occur in the future
- Model follows two steps:
  1. Determine the future resource mix using a “capacity expansion” model
  2. Analyze outcomes in EAS market, and capacity market, reflecting approach taken to meeting decarbonization target (status quo, FCEM or net carbon pricing)

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Overview of Capacity Expansion Module

- The Capacity Expansion Model (CEM) simulates outcomes in energy and capacity markets over an extended time horizon (i.e., 2021-2040)
  - Mix of resources selected to minimize the costs of meeting energy demand and capacity requirements given:
    - Decarbonization targets and approaches (mechanisms) take to achieve those targets (e.g., FCEM requirements or carbon pricing)
    - Inputs regarding full cost of operation, including annualized (amortized) capital costs for new builds, fixed O&M costs, and generation costs (variable O&M, emissions, fuel costs, heat rates)
  - Timing of new resource entry and resource exit reflects multiple factors, including evolving loads (levels and profiles), evolving costs (e.g., new technology improvements) and evolving environmental requirements
  - CEM simplifies certain aspects of market operations, particularly the net EAS market simulation
  - CEM allows for the specification of annual carbon limits or technology requirements (e.g., RPS or CEC)

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Overview of Energy and Capacity Modules

- Energy and reserve market modules
  - Provides more granular representation of energy market outcomes, reflecting full 8760 hour analysis with resource commitment
  - Model simulates provision of both energy and ancillary services in each hour
  - Refined estimates of net EAS revenues to reflect more granular representation
- Capacity market module
  - Capacity market prices reflect “missing money” required for the marginal non-CO_2 emitting resource
  - Market price for environmental certificates (e.g., CECs and RECs) reflecting “missing money” for clean resources relative to other resource types
  - Estimates market outcomes for capacity and environmental reflects more granular net EAS revenue estimates

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Overview of Modeling Approach: Model Components

Inputs and Assumptions

- Existing resource going-forward costs
- Costs of new entry
- Variable O&M
- Fuel prices
- Heat rates
- Load
- Etc.

Market Simulation

Capacity Expansion

Resource entry/exit

- Embedded EAS market
- Resource adequacy requirements
- Policy targets

Energy & Ancillary Service (EAS) Market

- Energy
- Operating reserves
- Carbon pricing

Net EAS Revenues

Forward Capacity Market (FCM) and Forward Clean Energy Market (FCEM)

- Based on going-forward costs, given net EAS revenues
- Resource adequacy requirements
- FCEM requirements

Results

EAS Market

- Payments
- Production costs
- LMPs
- Carbon prices
- Emissions
- Generation mix

Forward Market

- Capacity prices
- CEC prices
- CEC payments

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Continued Discussion of Modeling Inputs and Assumptions

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Preliminary New Entry Capital Costs

- Criteria for costs of new entry (capital costs)
  - Independent and publicly available
  - Region-specific cost factors (*e.g.*, labor costs, project requirements, etc.)
  - Full scope of installed costs (*e.g.*, interconnection, transmission)
  - Forward-looking time period (*i.e.,* present to 2040)
- Preliminary proposal for current capital costs – EIA AEO 2021 overnight capital costs
  - Independent, region-specific cost factors
  - Bottom-up cost engineering analysis
  - Only region specific for current year
  - Includes certain transmission costs
- Other cost factors still under consideration (e.g., transmission infrastructure necessary for a significant capacity build-out in certain regions, e.g., Maine)

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Preliminary 2021 Capital Costs

- EIA costs include:
  - Project contingency
  - One-mile of transmission
  - Regional adjustment for New England
- Offshore wind (EIA) additionally includes:
  - Offshore transmission line
  - Interconnection costs
  - 5 miles of onshore transmission
  - Regional adjustment that accounts for further distance from coast
  - 25% increased cost due to current "technology optimism"
- Costs do not reflect investment tax credits

Technology	Overnight Costs ($/kw)
Onshore wind	$1,680
Offshore wind	$6,360
Utility-scale solar	$1,276
Battery storage (four hour)	$1,201
Biomass	$4,842
Combined cycle H-class (1x1)	$1,298
Combined cycle H-class (2x1)	$1,134
Combustion turbine F-class	$801

- We propose to use the EIA capital costs as a starting point for 2021, and then project out the change in capital costs, based changes in costs over time
  - Potential sources for capital cost projections include EIA and NREL

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Status Quo Resource Mix

- Under all central cases, region-wide emissions from the electricity sector will be **80% below 1990 levels** in 2040
- Under the Status Quo, we assume states meet environmental goals via procurement of multi-year contracts with wind, solar, and hydro resources
  - State statutes do not specify many aspects of how targets will be met – i.e., how resource development will be achieved, resource preferences, etc.
  - State policy analysis suggest certain resource preferences, in some cases developed through certain analyses or plans – for example:
    - Massachusetts has indicated a preference for offshore wind and solar resources, premised on these being the lowest cost resources (MA 2050 Decarbonization Roadmap)
    - Connecticut has developed an Integrated Resource Plan, and Rhode Island has developed a "Road to 100% Renewable Electricity by 2030 in Rhode Island"

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Status Quo Resource Mix

- The Status Quo modeling analysis will assume:
  - Incenting of resource finance through long-term contracts
  - Resource mix consistent with New England State's policy assessments
- Analysis Group is reviewing prior PPA agreements as one source of information regarding technology types procured and agreement term and conditions
- Scenario analysis can explore the impact of changes to both technology mix and assumed contract costs
- We welcome feedback from stakeholders regarding these items

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Status Quo and FCEM Policy Contribution Allocation

- States have expressed varying preference for the quantity and the technology of future renewables through statute, executive orders and other policy pronouncements
- The Status Quo and FCEM analyses will allocate policy contributions (long-term contracts and CEC demand) across states based on assumed state preferences
  - Scenario analysis can consider alternative allocations of contributions with corresponding changes in allocation of costs
- Below is a preliminary Status Quo/FCEM allocation, informed by current RPS demand and other state-level policies – assumes that 90% of total energy must be non-CO_2 emitting to meet the 80% decarbonization target (reflects an outside-the-model approximation):

	2040 Quantities	
State	**Load (MWh)**	**% Renewable**
Connecticut	46,096,394	95%
Maine	22,010,571	85%
Massachusetts	89,745,057	95%
New Hampshire	18,724,458	60%
Rhode Island	11,815,643	95%
Vermont	10,102,929	80%
Total (load weighted)	198,495,052	90%

[1] Load based on FGRS Load Scenario 3.

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Resource Retirement

- The model will assume that any currently announced retirements have taken effect in all three future cases
  - Roughly 2,400 MW Turbines, 1,800 MW Combined Cycles, and 950 MW Coal
- Additional retirements will be determined via the capacity expansion module, which may find new entry to be less expensive than the continued operation of more costly plants
- For the purposes of the pathways study, we propose to assume that both Seabrook (1,309 MW) and Millstone (2,163 MW) remain in operation for all three central cases:
  - Seabrook's operating license is approved until 2050
  - Millstone Unit 2 is licensed until 2035, and Unit 3 is licensed until 2045, and the current contracts extend through 2029; however, going forward costs are uncertain
  - If desired, scenarios assuming retirement of Millstone (and/or Seabrook) can be evaluated

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Proposed Set of Scenarios

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Scenarios

- Assumptions different from those in the central case will be evaluated through alternative scenarios, to the extent feasible
- Scenario analysis will be completed after the central cases are built; however, early discussion of the potential scenarios are important to ensure the model is built in a way that makes specific scenarios possible to run
- In addition to quantitative scenarios, key features of the proposed policy approaches will be studied qualitatively
- We look forward to input from stakeholders on a mix of scenarios
  - Timely input will increase likelihood that model is capable of evaluating or can reasonably evaluate the desired scenario

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Potential Scenarios

- Across approaches:
  - Alternative regional carbon target
  - Alternative levelized costs of new entry for renewable resources (given uncertainty in cost trajectory)
  - Alternative load forecasts (e.g., different levels of electrification of heating, transportation)
  - Alternative natural gas price projection
  - Remove existing (central case) state policies (e.g., remove RPS, of interest only if it binds)
  - Inclusion of basic transmission congestion
- Status Quo
  - Alternative costs of long-term renewable contract procurement
- FCEM / ICCM
  - "Dynamic" CEC pricing (may be studied in an abridged fashion)
  - CEC penalty rate (binding, with corresponding increase in emissions)
- Net Carbon Pricing
  - Leakage rules

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Questions and Answers from Prior Meetings

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CEC Resource Eligibility

Question: Should municipal solid waste (MSW) and other biomass be eligible for CECs?

- Based on feedback provided, we are proposing that MSW and other biomass be eligible for CECs
- These resources are exempt from RGGI compliance and eligible to supply RECs under some state RPS
- We are still reviewing the implications of modeling BTM PV as eligible to receive CECs

Technology	Eligible for CECs?
Onshore wind	✓
Offshore wind	✓
Utility-scale solar	✓
Canadian hydro	✓
Run-of-river hydro	✓
Pondage hydro	✓
Pumped storage	×
Nuclear	✓
Battery storage	×
Municipal solid waste	✓
Other biomass	✓
Natural gas combined cycle	×
Fuel cells	×

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CEC eligibility of “clean” imports from outside ISO-NE

Question: Will we assume clean resources outside New England (e.g., New York and Quebec) be eligible for CECs?

- At present, compliance with RPS requirements can be achieved through REC from eligible resources in other states or provinces, so long as double-counting of benefits does not occur
- We are proposing to allow clean resources in neighboring states and provinces to import CECs if they also import the associated certificates for all clean/renewable attributes (e.g., RECs)
- As a result, we will assume that nuclear generation in New York will be used to meet NY’s clean energy goals, and that nuclear resources in NYISO will not supply CECs to New England
- Note that our analysis will assume that New York is decarbonizing in parallel to ISO-NE (*e.g.*, the New York Climate Leadership and Community Protection Act calls for 100% zero-emission electricity by 2040), and thus zero-carbon generation will be required to meet these environmental targets

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Transmission

Question: How will the analysis account for transmission, including export constrained regions (e.g., Maine)?

- Stakeholders have reached out to ask for more information regarding AG's proposed decision not to model transmission in the central cases
- The Pathways study aims to understand the differences in economic outcomes under the three potential policy approaches; it is not intended to be a reliability study or a systems transmission planning study
- Transmission considerations are important when evaluating the future renewables pathways for the ISO-NE region. Given this, we propose to address transmission through several approaches:
  - In the central cases, assume no transmission congestion
  - Consider adjustments to costs for new renewable generation from export-constrained areas to account for incremental transmission costs
  - Evaluate a scenario with the existing transmission system and power flows to analyze how outcomes differ under each policy approach

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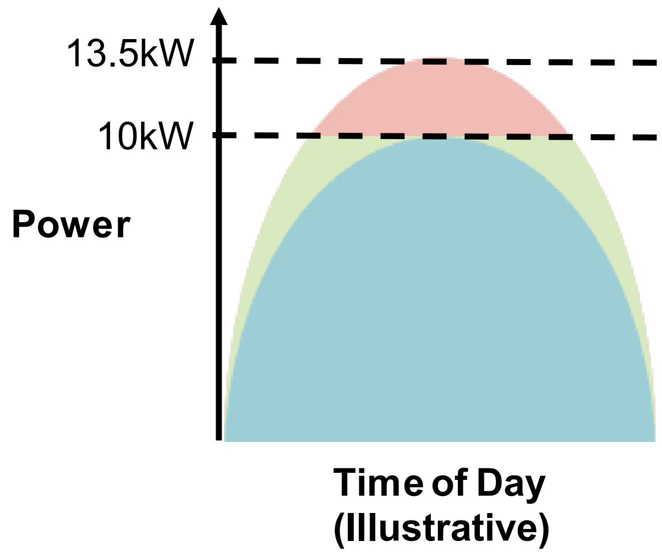
Integrated solar + storage

Question: Will the analysis consider integrated solar+storage resources?

- Some stakeholders asked whether we would model integrated solar+storage resources to address system engineering constraints. For example, developers may pair solar and storage resources to save on inverter costs and/or in response to injection constraints. This leads to inverter clipping:
  - In the diagram below, the 13.5 kW solar array is limited by a 10kW inverter. As a result, the red portion of the figure is 'clipped' and cannot be immediately injected; however, if paired with storage, this 'clipped' energy can be stored and discharged at a later period
- Accurately modeling such behavior is complex
- AG is still considering whether these complexities can reasonably be modeled, but currently believes that accounting for these engineering limitations and complications is not warranted given the purposes of the Pathways study



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Model Year(s)

Question: Will the model results include runs in intermediate years, between now and the 2040 central cases?

- Analysis Group is still evaluating the tradeoffs to producing results for intermediate model years, given the scale of the analysis already underway, the value (information) provided by results in intermediate years (given the study's focus on the comparison of approaches), and the existing stakeholder feedback regarding other desired scenarios
- We may be able to provide targeted information on particular items of interest
  - For example, as discussed in May, cost allocation outcome may differ across approaches at different levels of stringency/cost; analysis could focus on this (and other issues sensitive to timing), rather than providing full analysis for interemediate years

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Model Outputs

Question: Will the model outputs allow for drawing insights into the changes in payments to different types of generators, including efficient fossil-fuel resources, under net carbon pricing?

- Specifically, PowerOptions/ NH Customer Advocate requested information on the extent to which a "more efficient [gas-fired] generator would see increased revenue despite not generating any carbon free energy that the region is seeking" because its emissions rate is lower than that of the marginal (marketing-clearing) unit
  - The request suggested certain outputs to facilitate this analysis, including the marginal impact of carbon pricing on LMPs, output (MWh) by resource type, and carbon price payments
- We plan to analyze these issues and provide results informative to them, but are still assessing how best to measure and quantify output relevant to developing a better understanding these effects

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Next Steps

- July
  - Begin market simulations and analysis
  - As needed – meet with stakeholders to discuss responses to any additional feedback from stakeholders and/or present any updates to inputs, assumptions, and potential scenarios
- August
  - Continue simulations
  - As needed, additional meetings to discuss further detail on inputs, assumptions and methodologies
- October 2021
  - Presentation of preliminary analysis results

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Appendix – May 2021 AG Pathways Presentation

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Pathways Study

Evaluation of Pathways to a Future Grid

Todd Schatzki and Chris Llop

May 13, 2021

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Overview

- Purpose of today's presentation is to review our **proposed** modeling inputs and assumptions for the central analysis cases
  - The proposal reflects multiple considerations, including appropriate data and analysis regarding future market conditions (*e.g.*, input costs, loads, *etc.*) and technology (*e.g.*, costs, performance), and input received to date from stakeholders
- We encourage further stakeholder feedback to help ensure our assumptions are reasonable and reflect a range of viewpoints regarding future policies
- Future iterations on modeling inputs and assumptions will be shaped by this feedback
- Assumptions different from those in the central case will be evaluated through alternative scenarios, to the extent feasible

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Agenda

- Modeling Inputs and Assumptions
  - Study parameters
  - Resource characteristics, operating costs, and operating specifications
  - Entry, exit and going-forward costs
  - Load and electrification
- Case Assumptions
  - State policies
  - Status Quo
  - FCEM/ICCM
  - Net Carbon Pricing
- Proposed Outcomes

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Modeling Inputs and Assumptions: Study Parameters

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Study Parameters

- Study year
  - Analysis will evaluate detailed outcomes in year **2040**
    - Consistent with Future Grid Reliability Study (FGRS)
  - Resource mix will be reported for (certain) intermediate years
  - Potential to include full results for other years or certain policies/scenarios, particularly if we determine that intermediate years provide meaningful information to assess differences between approaches
- Regional carbon target
  - Under all cases, region-wide emissions from the electricity sector will be **80% below 1990 levels** in 2040
    - *For example*, consistent with achieving target of 80% below 1990 levels by 2050 (e.g., MA Global Warming Solutions Act's economy-wide target) assuming faster decarbonization in the electricity sector compared to other sectors
  - Annual emissions target will be linear interpolation between 2021 and 2040 using a straight line annual target
  - This assumption will be met in all central cases, but may be modified in scenario analysis

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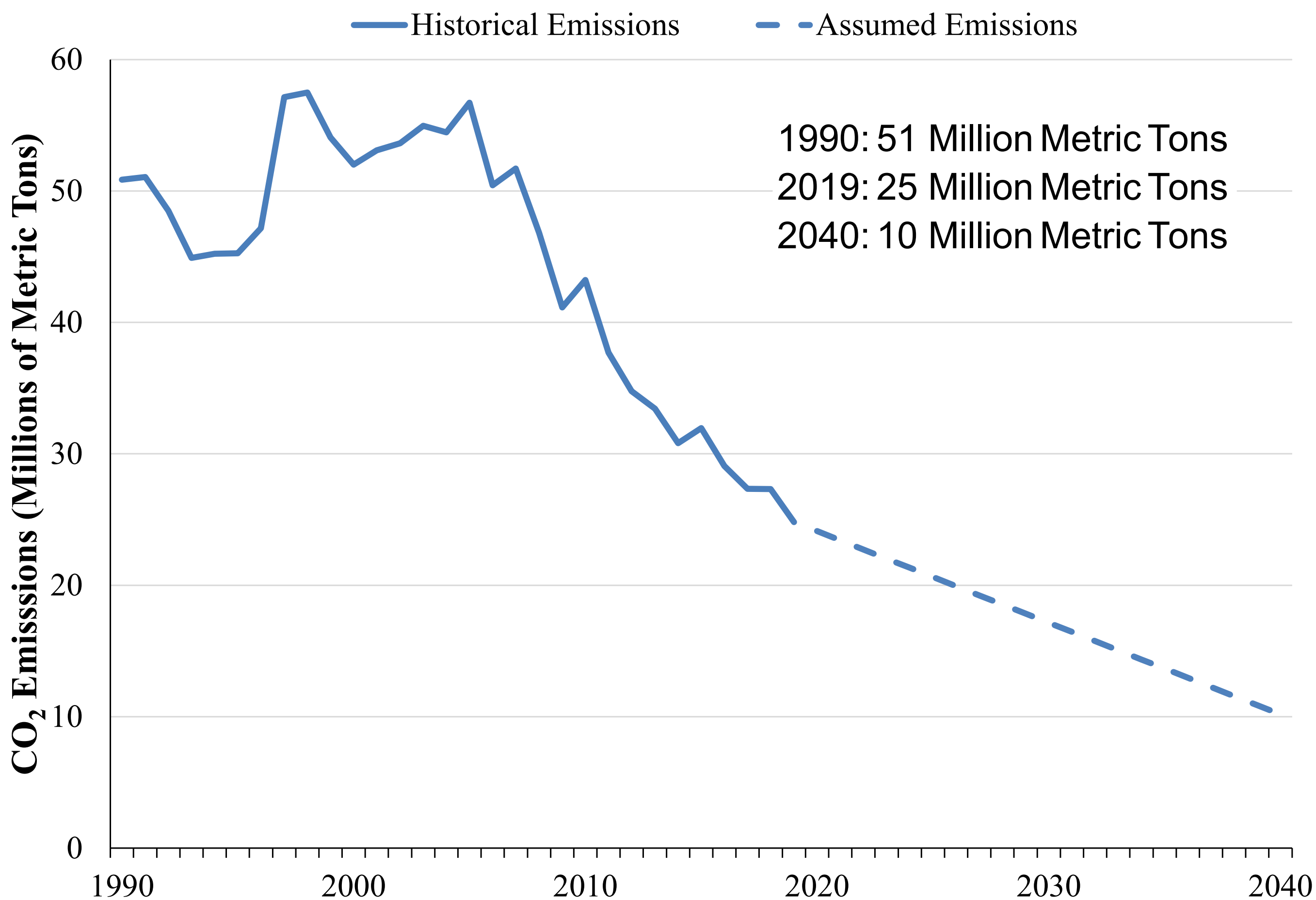
Annual Historical and Assumed CO_2 Emissions



Source: EIA, Electricity, Detailed State Data, available at https://www.eia.gov/electricity/data/state/

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Modeling Inputs and Assumptions: Resource Characteristics, Operating Costs and Operating Specifications

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Resource Mix

- Existing resources will include:
  - Resources (from most-recent CELT report) and resources that were awarded capacity obligations in FCA 15, adjusted for announced additions/retirements
  - Resources procured through legislated renewable procurements and announced contracts entered into by New England states (see next slide)
- Future changes in resource mix
  - New entry
    - Depending on the case, will reflect both resources prescribed through assumed state policies (e.g., Status Quo) and resources that are most economical/least-cost given incentives from FCEM and net carbon pricing
  - Retirements
    - Reflect resources that are not economical given assumed and/or economic entry
- *More detail on new entry and retirements provided in next section*

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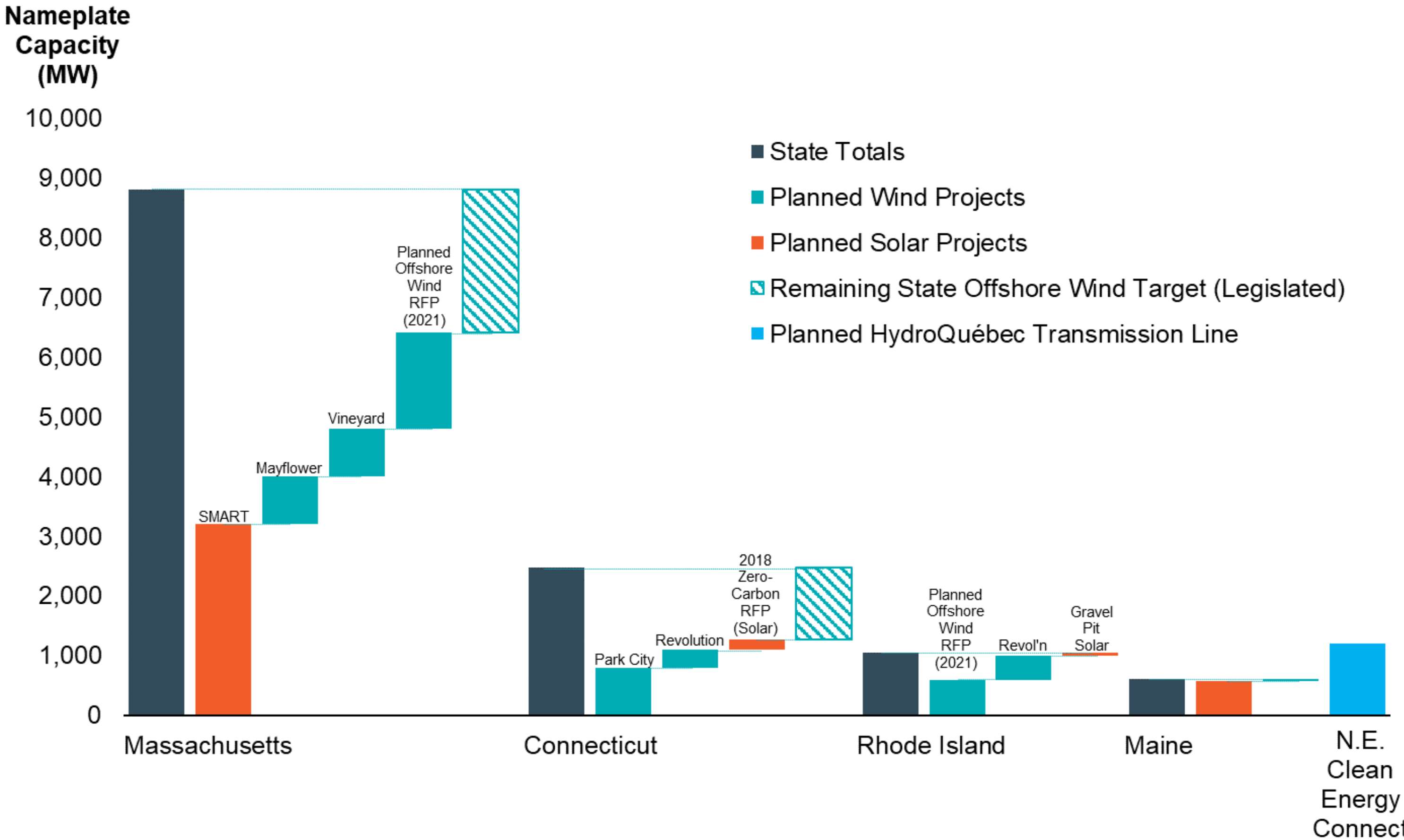
Assumed State Targets and Procurements

- The resources listed below will be included in addition to the resources in the CELT report and that were awarded capacity obligations in FCA 15



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Fuel Prices

- Fuel price assumptions based on reasonable estimates of likely market clearing prices, recognizing that such assumptions are subject to uncertainty
- Natural gas
  - One natural gas price, based on Algonquin City Gates pricing
  - Source: OTC Global Holdings (OTCGH) future prices plus U.S. Energy Information Administration Annual Energy Outlook (EIA AEO) growth rates
  - As electrification in the heating sector increases, consider potential impact of medium/long-run changes in total winter and summer gas demand on winter and summer basis
- Oil prices
  - Source: OTCGH future prices plus EIA AEO growth rates
- Coal prices
  - Source: EIA AEO

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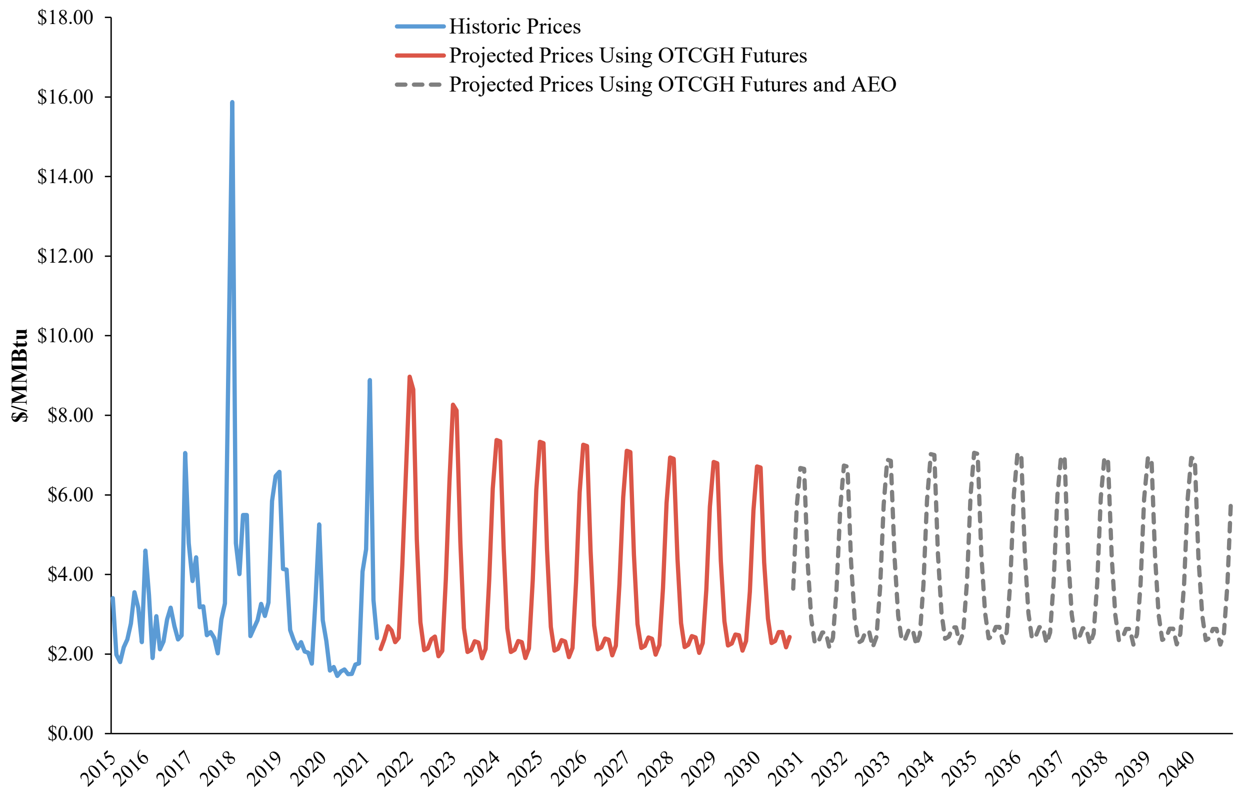
Natural Gas Algonquin City Gates Monthly Price Series (April 2015-December 2040)



Sources:
[A] "SNL Day-Ahead Natural Gas Prices" (Algon Gates), S&P Global Market Intelligence.
[B] "Natural Gas Forwards & Futures" (As of 4/30/2021), S&P Global Market Intelligence.
[C] "Table 3: Energy Prices by Sector and Source," EIA Annual Energy Outlook 2021.

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Variable Operating Costs

- Variable operations and maintenance costs ("Variable O&M") for existing generation will be based on recent historical Variable O&M
  - FERC Form 1 or RUS 12 annual filings as reported by SNL
  - For new generation, we will rely on historical Variable O&M costs from comparable existing resources, by technology type
  - We will assume that Variable O&M costs are constant over time

- Emission costs
  - Only CO_2 emissions under RGGI will be quantified and costed
  - NO_X and SO_2 emissions do not impose incremental costs in New England under current federal regulations

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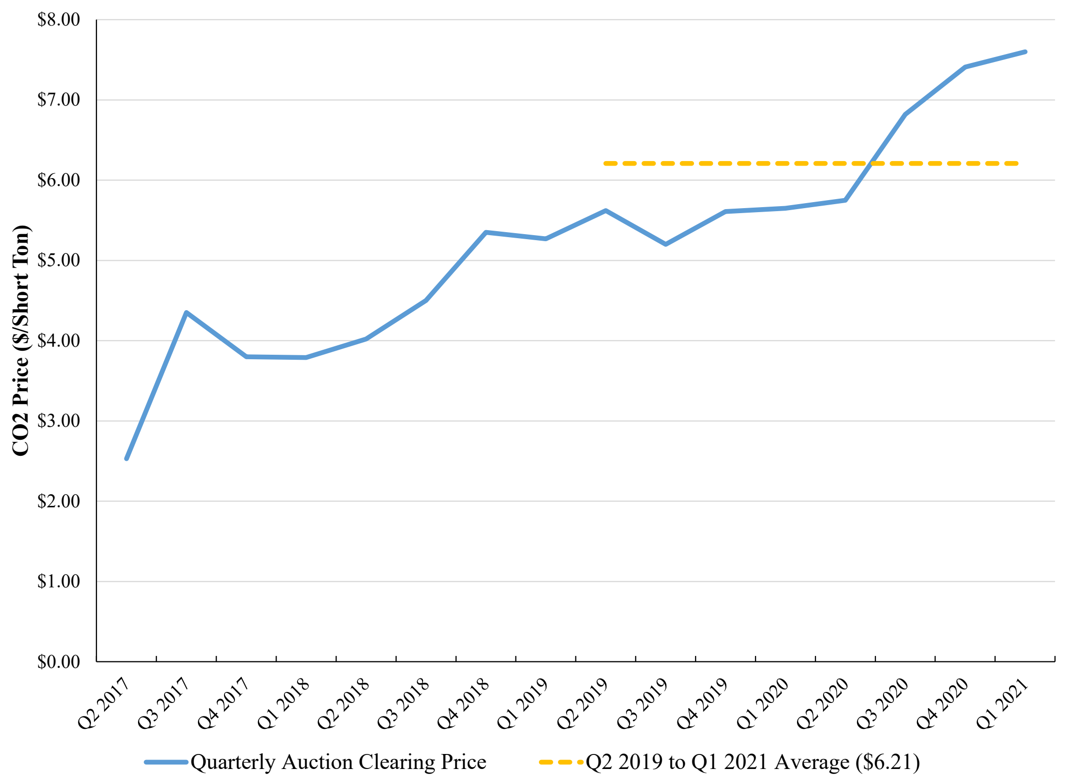
Emissions Prices

- We will assume that RGGI still exists. The RGGI price will be set at the average of the price from recent auctions (e.g., the last two years)

RGGI CO_2 Auction Clearing Price (Q2 2017 – Q1 2021)



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Non-Fossil Fuel Resource Assumptions

- Renewable Hourly Resource Profiles
  - For existing and new generation, rely on DNV profiles
- Battery Storage
  - Will earn net energy market revenues by charging when prices are low and discharging when prices are high (*i.e.*, price arbitrage)
  - Gains to charging and discharging must exceed hurdle rate reflecting roundtrip efficiency of 85% and other opportunity costs
  - Can also supply ancillary services, subject to ISO-NE rules
  - Co-located solar + battery resources modeled as separate solar and battery resources
- Imports/Exports
  - Imports from Canada will be modeled using an hourly profile
  - NYISO will be modeled concurrently

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Modeling Inputs and Assumptions: Entry, Exit and Going-Forward Costs

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Going-Forward Costs for Existing Resources

- Consistent with market rules, Going-Forward Costs (GFC) for existing resources will reflect the expected avoidable costs from suspension of operations
  - The GFC will take into account fixed operations and maintenance costs ("Fixed O&M") as well as expected energy and ancillary service ("EAS") market net revenues, consistent with current market rules
  - Fixed O&M for existing resources will be based on data from SNL
  - Expected EAS net revenues will be estimated within the simulation model

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Potential Resource Additions

- Consider resource additions for commercially available technologies with costs that potentially support economic entry and meaningful new resource potential
- Certain technologies not evaluated due to cost considerations (e.g., fuel cells) or limited resource opportunities (e.g., non-Canadian hydro)

Technology	Modeled for Potential New Entry?
Onshore wind	✓
Offshore wind	✓
Utility-scale solar	✓
Canadian hydro	✓
Run-of-river hydro	✗
Pondage hydro	✗
Pumped storage	✗
Nuclear	✗
Battery storage	✓
Solar + storage	✓
Municipal solid waste	✗
Biomass	✓
Natural gas combined cycle	✓
Fuel cells	✗

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New Entry Capital Costs

- Costs of new entry (capital costs) will be based on independent, reliable and representative estimates of current costs – such estimates need to reflect, among other things:
  - Region-specific cost factors (*e.g.*, labor costs, project requirements, etc.)
  - Full scope of installed costs (*e.g.*, transmission)
  - Forward looking time period (*i.e.,* present to 2040)
- Costs are assumed only for the purpose of evaluating alternative approaches to achieving decarbonization targets
  - Rely on publicly available sources
  - Rely on sources with information for multiple resource types of technologies to best characterize the relative costs across resource types given common assumptions regarding underlying cost factors
  - May combine information from different sources regarding different components of costs (*e.g.*, cost trajectories, region-specific cost factors, transmission costs, *etc.*)

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Other Market Rule-Related Issues

- MOPR
  - A process to remove the MOPR has been proposed (*Updated 2021 Annual Work Plan*), although specific rules to replace the MOPR are yet known
  - In light of this proposal and other factors (e.g., FERC identification of this as a priority), assume no MOPR in the central case for modeling simplicity
  - Assumption made only for modeling purposes of the Pathways project
- Capacity credits for variable renewable
  - Analysis will need to account for capacity credits for renewable resources
  - The analysis will assume current rules regarding capacity credits to variable renewables
    - ISO-NE is currently working to assess if the existing methodology to determine resource capacity contributions should be modified to account for the increase in variable renewables such as wind and solar
    - However, this work is just beginning, and we do not expect any changes would be determined in time to be considered as part of this modeling effort

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Modeling Inputs and Assumptions: Load Assumptions

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Load Shape

- Assume FGRS Load Scenario 3 in our central case
  - Reflects (MA) goal to achieve 80% economy-wide carbon reduction by 2050
  - Assumes:
    - Investment in energy efficiency
    - Heating and transportation electrification that reduces emissions from these sources by two-thirds relative to 2020 levels
      - Heating: 38.9 TWh
      - Transportation: 40.0 TWh
  - Total energy: 198.5 TWh (excluding Behind-the-Meter (BTM) solar)
  - Based on 2019 load shape, modified for the future changes described above
  - We will test modifications to the load shape in scenario analysis
- BTM solar will be based either on the most recent CELT report or FGRS assumptions
  - If CELT, growth from 2031-2040 will be based on 3-year compound annual growth rate

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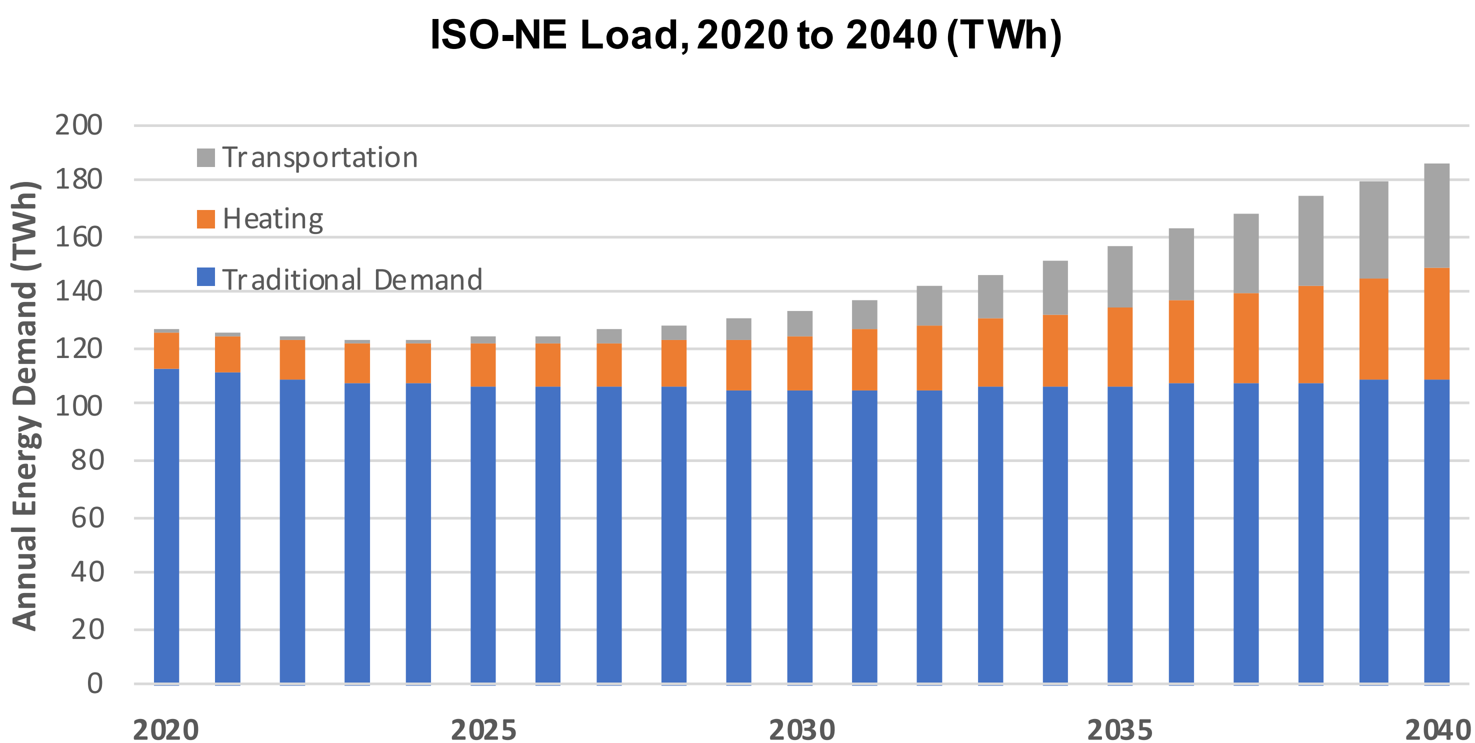
FGRS Scenario 3 Load Growth



Source: Scenario 3 Load Assumptions, NESCOE

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Case Assumptions: State Policies

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Existing State Policies

- For all central cases, assume existing RPS remain in place
- Analysis will assume RPS targets, but measures/instruments used to achieve those targets will vary across cases

State	2040 Requirement Quantity (% of Load) RPS Only
Connecticut	48%
Maine	80%
Massachusetts	57%
New Hampshire	25%
Rhode Island	39%
Vermont	75%
Total (load weighted)	54%

Note: Estimates by AG based on review of state legislative mandates. Load weighting based on ISO-NE's 2029 load forecast, net of behind the meter solar and energy efficiency.

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Meeting Decarbonization (and RPS) Target

- Resources used to meet 80% decarbonization target (and RPS) will differ across cases
- Status Quo:
  - New clean energy resource entry assumed reflecting recent procurements, state policy plans, and other policy indications
  - Resources will be financed through long-term contracts
- FCEM/ICCM and Net Carbon Pricing
  - Entry (and exit) will occur to minimize costs of meeting decarbonization target (and RPS) given the different ways in which the policy mechanisms incent decarbonization:
    - FCEM/ICCM – provides additional revenues to "clean" resources that do not emit carbon
    - Net Carbon Pricing – imposes a direct cost on all carbon emissions (which makes clean resources more competitive)
  - No long-term contracts beyond what are currently in place or legislated to be procured

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Case Assumptions: Status Quo

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Approach and Resource Mix

- States have indicated that they plan to meet their environmental goals primarily via procurement of multi-year contracts with wind, solar, and hydro resources
  - States have not specified binding procurement plan
  - State policy analysis suggest different preferences for mix of technical approaches and resources to achieve decarbonization
- Analysis will assume:
  - Resource mix consistent with New England State's policy assessments (we will provide a proposed mix at a future meeting)
  - Incenting of resource finance through long-term contracts
- Additional information on approach to resource procurement under the Status Quo will be presented at the next PC meeting

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Case Assumptions: FCEM/ICCM

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FCEM Assumptions

- Model will determine capacity and CEC awards simultaneously
  - This approach is consistent with an ICCM
  - ICCM outcomes are similar those of an FCEM in which resources have perfect foresight about FCM outcomes (assuming the FCEM goes first)
  - Thus, from a modeling standpoint, these approaches result in identical outcomes (absent introduction of assumptions regarding differences between expected and actual outcomes of the FCM)
- Proposed resource types eligible for CECs include wind, solar, nuclear, and all hydro
  - Only criteria for eligibility is technology type
- Storage will not be eligible, but we expect it to benefit
  - More detail is provided in ISO-NE's materials
- CECs imports
  - Imports will be eligible for CECs, including Hydro Quebec imports
  - Other out of state resources will need to bundle CECs and RECs to avoid double payment

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CEC Resource Eligibility

- Proposed CEC eligibility reflects stakeholder input and certain market design considerations
- Combined solar + storage resource eligibility to reflect solar capacity only
- Look forward to further stakeholder feedback before determining study assumptions

Technology	Eligible for CECs?
Onshore wind	✓
Offshore wind	✓
Utility-scale solar	✓
Canadian hydro	✓
Run-of-river hydro	✓
Pondage hydro	✓
Pumped storage	✗
Nuclear	✓
Battery storage	✗
Solar + storage	✓
Municipal solid waste	?
Other biomass	?
Natural gas combined cycle	✗
Fuel cells	✗

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Clean Energy Credit Assumptions

FCEM / ICCM will assume:

- No partial CECs for efficient gas-fired resources
- CEC banking
- Static CEC value based on the results of the FCEM / ICCM
  - The process for studying dynamic credits is still under development and will be studied separately
- New England states demand the necessary quantity of CECs to meet the regional decarbonization target
  - We will assume that individual States' demand is proportional to their current RPS/clean energy policy requirements, not exceeding their load

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CEC Offers and Settlement

- Resource CEC offer quantity
  - Existing dispatchable resources will offer an amount of clean energy consistent with recent performance
  - Existing wind, solar, and hydro will offer based on 2019 performance
  - Wind and solar added through the capacity expansion model will offer based on 2019 performance of a similar existing resource or DNV profiles
- Compliance penalty
  - Resources can fulfill CEC obligations through generation or purchase of CECs
  - Compliance penalty, in effect, reflects a price at which resources can purchase CEC's in lieu of generating or purchasing CEC's
    - Like an Alternative Compliance Payment in state RPS programs
  - Thus, in effect, the compliance penalty acts as a price cap on CECs
  - In the central cases, we will not assume any compliance penalty

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Case Assumptions: Net Carbon Pricing

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Net Carbon Pricing

- Carbon price will be set to achieve the 80% electricity sector decarbonization target
  - In practice, carbon price could be set through a fixed carbon price or through a quantity-based approach
    - Under a fixed carbon price, the price would be fixed and the resulting emissions would be uncertain
    - Under a quantity-based approach (e.g., a cap-and-trade system), the quantity would be fixed (at the policy target), and the price would be uncertain
  - Analysis will encompass both price-based and quantity-based carbon pricing, as it will not evaluate the distribution of outcomes given price/quantity uncertainty
  - Analysis will equalize emissions across approaches to facilitate comparison of carbon pricing, FCEM and status quo
- Carbon revenues will be credited against EAS costs
  - The specific method for allocating costs by load is under consideration
- To offset leakage, we will include a cost adder for imports when the marginal generator in the exporting region is an emitting resource.

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Outcomes

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Proposed Study Outcomes

- This study will focus on differences in outcomes across approaches to give insight into how outcomes may differ under each approach.
  - This will be assessed by holding relevant central case assumptions constant across approaches: total emissions, existing state policies and procurements, load, fuel prices, etc.
- Potential quantitative outcomes include:
  - Customer payments
  - Total production costs, by technology type
  - Changes in net revenues, by technology type, relative to status quo case
  - Wholesale energy and reserve prices (LMPs)
  - Capacity prices
  - Environmental prices (carbon, CEC)
  - Total CEC payments by states
  - Total carbon price payments by resources
  - Emissions, by technology type
  - Resource mix, by technology type (MW, MWh)

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Proposed Study Outcomes

- Qualitative analysis
  - Quantitative analysis will capture some but not all differences in approaches, while qualitative analysis will aim to identify and evaluate other consequential differences in outcomes across approaches
- As with feedback on input and modeling assumptions, we encourage stakeholder feedback on additional outcomes of interest

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Next Steps

- June
  - Review any additional feedback from stakeholders
  - Present finalized assumptions and inputs
  - Present initial set of proposed scenarios

- Summer
  - As needed, additional meetings to discuss further detail on inputs, assumptions and methodologies

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