NEPOOL
NEW ENGLAND POWER POOL

FINAL AGENDA

NEPOOL Participants Committee
Working Session: Pathways to the Future Grid
May 13, 2021, 9:30 a.m.

To participate in the special Participants Committee Teleconference,
please dial 1-866-803-2146; Passcode 7169224.
To join the WebEx, click this link and enter the event password **nepool**.

The final list of agenda items for the May 13 working session are as follows:

1. To approve the draft minutes of the April 15, 2021 Participants Committee “Pathways Study” meeting. The draft preliminary minutes of that meeting are included with this supplemental notice and posted with the meeting materials.

2. Presentation and continued discussion to help scope and define the ISO’s pathways analysis, including:

   - Continued discussions on modeling outstanding design elements, including:
     - Integration with existing state policies
     - Treatment of Imports in FCEM and Net Carbon Pricing
     - Treatment of storage in FCEM
     - ICCM/FCEM modeling equivalence
     - Other areas of stakeholder feedback

   - Continued discussions on key modeling inputs and assumptions for both frameworks.

**For your information, the May 13 meeting will be recorded, as are all Participants Committee meetings. All those in attendance or participating, either in person or by phone, are required to identify themselves and their affiliation at the meeting. Official records and minutes of meetings are posted publicly. No statements made in NEPOOL meetings are to be quoted or published publicly.*

PRELIMINARY

Pursuant to notice duly given, a meeting of the NEPOOL Participants Committee was held via teleconference beginning at 9:30 a.m. on Thursday, April 15, 2021. Attachment 1 identifies the members, alternates and temporary alternates who participated in the teleconference meeting.

Mr. David Cavanaugh, Chair, presided and Mr. Sebastian Lombardi, Acting Secretary, recorded. Mr. Cavanaugh welcomed everyone to the third meeting of Pathways to the Future Grid evaluation process. He thanked those who provided written comments following the March 18 meeting.

APPROVAL OF FEBRUARY 18, 2021 AND MARCH 18, 2021 MEETING MINUTES

Mr. Cavanaugh referred the Committee to the preliminary minutes of the February 18, 2021 and March 18, 2021 Pathways meetings, as circulated and posted in advance of the meeting. Following motion duly made and seconded, the Committee unanimously approved the preliminary minutes of the February 18, 2021 as circulated but with the addition of the identification of Mr. Peter Fuller's company, Autumn Lane Energy Consulting, and the preliminary minutes of the March 18, 2021 meetings as circulated.

ISO PRESENTATION

Interaction with Existing State Policy

On behalf of the ISO, Dr. Chris Geissler reviewed materials that had been circulated and posted in advance of the meeting that included material on existing state policies and the role of storage, along with a response to additional stakeholder comments. He noted that, following the ISO's presentation, the Analysis Group (AG) would join the call to kick off discussions on the modeling approach and the assumptions they intend to use to evaluate the straw Forward Clean Energy Market (FCEM) and net carbon pricing frameworks.

Dr. Geissler then turned the presentation over to Mr. Steven Otto, who provided an overview of the potential modeling approaches for consideration and reviewed the anticipated interactions between the alternative market frameworks being discussed and the existing state clean energy programs. He then presented six cases that demonstrated total payments to resources under the different approaches with different relationships between the demands for clean energy certificates (CECs) and renewable energy certificates (RECs). Referencing the ISO's presentation materials, Mr. Otto explained that the cases considered a stakeholder concern where, under Approach 1, resources that can sell both CECs and RECs may see increased payments relative to Approach 2.

In response to questions during his presentation, Mr. Otto confirmed that modeling efforts were expected to include some competitiveness assumptions with respect to the CEC and REC markets. He responded to comments noting that the new CEC and FCEM framework could provide a broader, more expansive regional market that could potentially benefit current state programs. Mr. Otto stated that the models anticipated that various stakeholders, including corporations or municipalities, would have the opportunity to purchase CECs. ~~He clarified the difference between RECs and CECS, noting that RECs are awarded based on production and represent actual generation; CECs would be awarded based on the type of energy produced and the level of carbon output.~~He clarified that RECs and CECs both represent MWhs of energy produced – RECs for MWh produced by a particular type of renewable resource; CECs for MWh produced in a way that doesn't produce carbon emissions. Throughout the presentation many questions and comments were provided by stakeholders about the relationship of RECs and

CECs and how they might be handled in the potential frameworks during the modeling process. Additionally, Mr. Otto took note of concerns with potential double counting of CECs and RECs. Concluding his presentation, Mr. Otto stated that the ISO planned to propose that the Analysis Group assume Approach 1 for modeling purposes, noting that Approach 1 appeared relatively simple to model, would avoid the “double payment” concern identified by stakeholders, and would allow for the continuation of existing state programs.

Role of Storage in FCEM and Net Carbon Pricing Frameworks

Dr. Geissler proceeded to review the portion of the presentation about the potential role of storage in the FCEM and net carbon pricing frameworks, noting the memos addressing these issues that had also been circulated and posted in advance of the meeting, and which used a series of numerical examples to examine the treatment of storage under both frameworks.

Under an FCEM framework, Dr. Geisler noted that clean energy resources could reduce their energy market offer price to reflect the value of CECs received. In this case, the FCEM would increase energy market revenues for storage resources that increase clean energy production by charging when the marginal supplier is clean, and discharging when the marginal supplier is not clean. In response to a question, Dr. Geissler reinforced the importance of appropriately identifying the overarching, expected end product for each framework. Regarding the value of storage, Dr. Geissler noted the importance of modeling in an effort to identify pricing structures that are in line with financing methods. After much stakeholder comment, Dr. Geisler reinforced the importance of keeping within the confines of the design stage of these pathways discussions, noting the other efforts underway that address many of the comments/issues being raised.

Under a net carbon pricing framework, Dr. Geissler explained that storage would be compensated for its marginal contributions to clean energy production via increased energy market revenues. By awarding CECs, storage would be compensated at a rate that exceeds its contributions, which would be inconsistent with sound market design. Lastly under the net carbon pricing framework, storage would be compensated for its marginal contributions to reducing carbon emissions when it is not charged ~~for~~by carbon~~-emissions-~~emitting resources.

At the conclusion of the ISO's presentation, Dr. Geissler responded to stakeholder feedback with preliminary observations, ~~suggesting~~explaining that the ~~FCEM framework should award CECs to low-emitting resources and should~~ISO does not propose to model CECs ~~that are awarded to~~for carbon -emitting resources. He indicated that the ISO would seek to align design elements with three criteria: (i) consistency with stakeholder preferences; (ii) sound market design principles; and (iii) simplicity in modeling. Additionally, he referenced stakeholder feedback in regard to understanding an Integrated Clean Capacity Market (ICCM) construct further, noting the memo provided by the ISO at the March 18, 2021 meeting, which offered initial thoughts on a conceptual ICCM approach that could be considered in the modeling efforts. Lastly, he expressed his appreciation for the stakeholder comments to date and welcomed additional stakeholder feedback.

Following the presentation, some members asked about the prioritization of the analysis of an ICCM construct. Dr. Geissler noted that this construct, should it be analyzed further, would be considered under one of the current models. When asked about the ISO's plans for ongoing stakeholder engagement throughout the modeling process, he stated that the ISO intended to provide updates throughout the process.

ANALYSIS GROUP: PATHWAYS STUDY

Mr. Cavanaugh introduced Mr. Todd Schatzki from the Analysis Group ~~(AG),~~, who from materials that had been circulated and posted in advance of the meeting summarized: (i) AG's assignment, approach and process schedule; (ii) its proposed model structure and mechanics; and (iii) the potential inputs, assumptions, and scenarios to be analyzed. Mr. Schatzki explained that AG's assignment is to evaluate proposed alternative market approaches (not designed to be immediately implementable) to support a more decarbonized future grid and compare them to continuation of the current markets/existing rules. AG will quantitatively and qualitatively differentiate three approaches – the status quo, FCEM/ICCM and net carbon pricing, including market incentives and implied environmental and economic outcomes. He emphasized the desire for, and importance of, timely and interactive stakeholder feedback throughout the process, with identified milestones through 2021 and a final report to be delivered in February 2022.

In response to questions during his presentation on model components and mechanics, Mr. Schatzki acknowledged reliability considerations, while not a focus of AG's efforts, could be picked up in AG's efforts, in part, in the targets and assumptions agreed upon, but were likely to come more directly into play in the Future Grid ~~economic~~reliability studies process. Nonetheless, he encouraged members to share with AG any relevant information or guidance from NERC. Mr. Schatzki explained further the roles, rationale and interplay among capacity expansion (different under each approach) and the energy and ancillary services and FCM modules in the market simulation process. With respect to project finance feasibility, structures and assumptions under the models, Mr. Schatzki acknowledged the importance of those issues, the need for more information in this area, and because the information may not be captured in the market simulations, the potential need to capture the information outside the models. Members stressed the importance of addressing those issues to inform any decision on which model to pursue.

Mr. Schatzki then reviewed the modeling inputs and assumptions that need to be agreed upon prior to the analysis with respect to study parameters, electricity markets and capacity markets. He also summarized and requested feedback on approach inputs and assumptions, including state policies (including whether and/or how to include renewable portfolio standards), the status quo, net carbon pricing, and FCEM/ICCM.

In discussions, members offered suggestions for incorporating state polices in the modeling and the need for adjustments should outputs not align with specific state policies. Mr. Schatzki further confirmed the importance of sharing relevant details by state in the output of the model. He then reviewed potential scenarios for the model, noting he does not intend to represent a 100% carbon reduction target. When asked about how storage is intended to be represented in the models, Mr. Schatzki acknowledged the importance of storage and described the role it will play in modeling. Lastly, he reviewed the project timeline, noting modeling efforts will begin after June, with feedback to be provided and solicited throughout the process.

Mr. Cavanaugh concluded the meeting by urging Participants to submit any written feedback or comments by e-mail to him and Dr. Geissler.

There being no further business, the meeting adjourned at 4:20 p.m.

Respectfully submitted,

Sebastian Lombardi, Acting Secretary

ATTACHMENT 1

PARTICIPANTS COMMITTEE MEMBERS AND ALTERNATES
PARTICIPATING IN APRIL 15, 2021 TELECONFERENCE MEETING

PARTICIPANT NAME	SECTOR/ GROUP	MEMBER NAME	ALTERNATE NAME	PROXY
Acadia Center	End User	Deborah Donovan		
Advanced Energy Economy	Fuels Industry Participant	Caitlin Marquis		
American Petroleum Institute	Fuels Industry Participant	Paul Powers		
AR Large Renewable Generation (RG) Group Member	AR-RG	Alex Worsley		
AR Small Load Response (LR) Group Member	AR-LR	Brad Swalwell		
AR Small RG Group Member	AR-RG	Erik Abend		
Ashburnham Municipal Light Plant	Publicly Owned Entity		Brian Thomson	
Associated Industries of Massachusetts (AIM)	End User			Roger Borghesani
AVANGRID: CMP/UI	Transmission		Alan Trotta	
Belmont Municipal Light Department	Publicly Owned Entity		Dave Cavanaugh	
Block Island Utility District	Publicly Owned Entity	Dave Cavanaugh		
Boston Energy Trading and Marketing	Supplier	Michael Kramek		
Boylston Municipal Light Department	Publicly Owned Entity		Brian Thomson	
BP Energy Company	Supplier			José Rotger
Braintree Electric Light Department	Publicly Owned Entity			Dave Cavanaugh
Brookfield Renewable Trading and Marketing	Supplier	Aleks Mitreski		
Brooks, Dick	End User	Dick Brooks		
Calpine Energy Services, LP	Supplier	Brett Kruse		Bill Fowler
Castleton Commodities Merchant Trading	Supplier			Bob Stein
Chester Municipal Light Department	Publicly Owned Entity		Dave Cavanaugh	
Chicopee Municipal Lighting Plant	Publicly Owned Entity		Brian Thomson	
Concord Municipal Light Plant	Publicly Owned Entity		Dave Cavanaugh	
Connecticut Municipal Electric Energy Coop.	Publicly Owned Entity	Brian Forshaw		
Conservation Law Foundation (CLF)	End User	Phelps Turner		
Cross-Sound Cable Company (CSC)	Supplier		José Rotger	
Danvers Electric Division	Publicly Owned Entity		Dave Cavanaugh	
DTE Energy Trading, Inc.	Supplier			José Rotger
Dynegy Marketing and Trade, LLC	Supplier	Andy Weinstein		Bill Fowler
Emera Energy Services	Supplier			Bill Fowler
Enel X North America, Inc.	AR-LR	Michael Macrae		
Environmental Defense Fund	End User	Jolette Westbrook		
Eversource Energy	Transmission	James Daly		Parker Littlehale; Jason Stark
Exelon Generation Company	Supplier	Steve Kirk	Bill Fowler	
FirstLight Power Management, LLC	Generation	Tom Kaslow		
Galt Power, Inc.	Supplier	José Rotger		
Generation Group Member	Generation	Dennis Duffy	Abby Krich	Alex Worsley
Georgetown Municipal Light Department	Publicly Owned Entity		Dave Cavanaugh	
Great River Hydro	AR-RG			Bill Fowler
Groton Electric Light Department	Publicly Owned Entity		Brian Thomson	
Groveland Electric Light Department	Publicly Owned Entity		Dave Cavanaugh	
H.Q. Energy Services (U.S.) Inc. (HQUS)	Supplier	Louis Guilbault	Bob Stein	
High Liner Foods (USA) Incorporated	End User		William P. Short III	
Hingham Municipal Lighting Plant	Publicly Owned Entity		Dave Cavanaugh	
Holden Municipal Light Department	Publicly Owned Entity		Brian Thomson	
Holyoke Gas & Electric Department	Publicly Owned Entity		Brian Thomson	
Hull Municipal Lighting Plant	Publicly Owned Entity		Brian Thomson	
Ipswich Municipal Light Department	Publicly Owned Entity		Brian Thomson	
Jericho Power LLC (Jericho)	AR-RG	Mark Spencer	Nancy Chafetz	

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PARTICIPANT NAME	SECTOR/ GROUP	MEMBER NAME	ALTERNATE NAME	PROXY
Littleton (MA) Electric Light and Water Department	Publicly Owned Entity		Dave Cavanaugh	
Long Island Power Authority (LIPA)	Supplier		Bill Killgoar	
Maine Public Advocate Office	End User	Drew Landry		
Mansfield Municipal Electric Department	Publicly Owned Entity		Brian Thomson	
Maple Energy LLC	AR-LR			Doug Hurley
Marble River, LLC	Supplier		John Brodbeck	
Marblehead Municipal Light Department	Publicly Owned Entity		Brian Thomson	
Mass. Attorney General’s Office (MA AG)	End User	Tina Belew	Ben Griffiths	
Mass. Bay Transportation Authority	Publicly Owned Entity		Dave Cavanaugh	
Mass. Municipal Wholesale Electric Company	Publicly Owned Entity	Brian Thomson		
Mercuria Energy America, LLC	Supplier			José Rotger
Merrimac Municipal Light Department	Publicly Owned Entity		Dave Cavanaugh	
Middleborough Gas & Electric Department	Publicly Owned Entity		Dave Cavanaugh	
Middleton Municipal Electric Department	Publicly Owned Entity		Dave Cavanaugh	
National Grid	Transmission	Tim Brennan	Tim Martin	
Natural Resources Defense Council	End User	Bruce Ho		
Nautilus Power, LLC	Generation		Bill Fowler	
New Brunswick Energy Marketing	Supplier			Andrew Robinson
New Hampshire Electric Cooperative	Publicly Owned Entity	Steve Kaminski		Brian. Forshaw; Dave Cavanaugh; Brian Thomson
New Hampshire Office of Consumer Advocate (NHOCA)	End User			Jason Frost
NextEra Energy Resources, LLC	Generation	Michelle Gardner		
North Attleborough Electric Department	Publicly Owned Entity		Dave Cavanaugh	
Norwood Municipal Light Department	Publicly Owned Entity		Dave Cavanaugh	
NRG Power Marketing LLC	Generation		Pete Fuller	
Pascoag Utility District	Publicly Owned Entity		Dave Cavanaugh	
Paxton Municipal Light Department	Publicly Owned Entity		Brian Thomson	
Peabody Municipal Light Department	Publicly Owned Entity		Brian Thomson	
Princeton Municipal Light Department	Publicly Owned Entity		Brian Thomson	
PSEG Energy Resources & Trade LLC	Supplier		Eric Stallings	
Reading Municipal Light Department	Publicly Owned Entity		Dave Cavanaugh	
Rodan Energy Solutions (USA) Inc.	Provisional	Aaron Breidenbaugh		
Rowley Municipal Lighting Plant	Publicly Owned Entity		Dave Cavanaugh	
Russell Municipal Light Dept.	Publicly Owned Entity		Brian Thomson	
Shrewsbury Electric & Cable Operations	Publicly Owned Entity		Brian Thomson	
South Hadley Electric Light Department	Publicly Owned Entity		Brian Thomson	
Sterling Municipal Electric Light Department	Publicly Owned Entity		Brian Thomson	
Stowe Electric Department	Publicly Owned Entity		Dave Cavanaugh	
Sunrun Inc.	AR-DG			Pete Fuller
Taunton Municipal Lighting Plant	Publicly Owned Entity		Dave Cavanaugh	
Templeton Municipal Lighting Plant	Publicly Owned Entity		Brian Thomson	
The Energy Consortium	End User	Roger Borghesani	Mary Smith	
Union of Concerned Scientists	End User		Francis Pullaro	
Vermont Electric Power Company (VELCO)	Transmission	Frank Ettori	Karin Stamy	
Vermont Energy Investment Corp (VEIC)	AR-LR		Doug Hurley	
Vermont Public Power Supply Authority	Publicly Owned Entity			Brian Forshaw
Versant Power	Transmission	Lisa Martin		
Village of Hyde Park (VT) Electric Department	Publicly Owned Entity		Dave Cavanaugh	
Wakefield Municipal Gas & Light Department	Publicly Owned Entity		Brian Thomson	

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PARTICIPANT NAME	SECTOR/ GROUP	MEMBER NAME	ALTERNATE NAME	PROXY
Wallingford DPU Electric Division	Publicly Owned Entity		Dave Cavanaugh	
Wellesley Municipal Light Plant	Publicly Owned Entity		Dave Cavanaugh	
West Boylston Municipal Lighting Plant	Publicly Owned Entity		Brian Thomson	
Westfield Gas & Electric Department	Publicly Owned Entity		Dave Cavanaugh	
Wheelabrator North Andover Inc.	AR-RG		Bill Fowler	

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ISO new england

Pathways to the Future Grid

Evaluating clean energy and carbon pricing frameworks as alternative market approaches to advance the region's clean energy transition

Steven Otto

SOTTO@ISO-NE.COM

Pathways work will evaluate two potential market approaches to decarbonization

- ISO is working with stakeholders and the Analysis Group to evaluate two market approaches that have been discussed as potential pathways to the future grid
  - Forward clean energy market (FCEM)
  - Net carbon pricing
- ISO plans to study both frameworks simultaneously and issue a final report in the first quarter of 2022 that discusses the market impacts of both approaches

Today's discussion focuses on several key design details

- Continued discussion of the straw FCEM and net carbon pricing frameworks
- These include consideration of key design elements that were discussed in April, including:
  - Integration of an FCEM with existing state policies (e.g., RECs)
  - Treatment of storage resources
- Offer thoughts on whether the modeling efforts should consider a FCEM or an ICCM
  - In addition to slides, refer to accompanying memo posted with materials
- Analysis Group will continue discussion of modeling approach and assumptions it will employ to evaluate the straw FCEM and net carbon pricing frameworks

Appreciate continued stakeholder engagement and feedback

- ISO welcomes feedback and questions associated with each straw framework put forth
  - Comments can be provided during committee discussions or in writing to Steven Otto (sotto@iso-ne.com) and the Chair of the Participants Committee (or designee) for posting
- Written comments received and posted for the NEPOOL meeting since the April meeting
  - Continued consideration of interaction with existing state programs, modeling specifics, model output, treatment of storage resources etc.
  - Today's discussion will consider some of these topics
  - AGI's presentation will also touch on some of these topics, with a greater focus on modeling specifics
  - Discussion of these topics will continue at future meetings

CONTINUED DISCUSSION OF INTERACTION BETWEEN CLEAN ENERGY CERTIFICATES (CECS) AND EXISTING STATE ENVIRONMENTAL PROGRAMS

Model is consistent with a range of approaches for how CECs and existing state programs interact

- In April, ISO discussed a range of potential approaches for how CECs and existing state environmental programs interact
- Consistent with stakeholder feedback, the ISO plans to consider existing programs in its modeling efforts
- The ISO has determined that AGI's modeling framework is consistent with multiple approaches to this interaction
- We do not believe it is necessary to pick between these approaches at this time, given that this stage of the Pathways process is not intended to determine a final, detailed proposal
- However, if the region were to pursue an FCEM/ICCM, further consideration of this interaction would be necessary

ISO's April memo proposed modeling both FCEM and existing environmental programs

- Detailed memo outlined three general approaches to how the FCEM could treat interaction between CECs and other environmental programs, particularly Renewable Portfolio Standards (RPS)
  - Separate certificates for clean energy and renewable energy; "bundled" certificates; discontinued state programs/CECs only
- Included numerical examples illustrating outcomes under various market conditions and approaches
- Memo noted that ISO was leaning towards modeling CECs and existing environmental programs as separate constraints in the pathways study, but explained that various approaches to modeling these constraints may produce similar outcomes

ISO appreciates stakeholder observations and concerns relating to this interaction

- During this discussion, stakeholders raised a number of observations and questions about the ISO's proposed approach, including:
  - Whether it is necessary to model existing state programs at all (even if they are assumed to continue)
  - Importance of accounting for existing statutory requirements in modeling assumptions
  - Whether RECs can or should be modeled as "premium" CECs, where all environmental attributes are bundled

ISO has assessed the modeling approach further in light of these comments

- ISO further considered the potential approaches, while being mindful of the fact that the pathways study seeks to model a straw framework to provide general simulations that may inform decisions on which path to take; not develop a final, detailed proposal for implementation purposes
  - Additional design work would follow if the region chooses to pursue and develop any new approach
  - This assessment has included discussions with AGI to understand the practicalities of their model, and how it relates to the various approaches that have been discussed

Propose to account for existing state programs as constraints in modeling

- There may be cases where accounting for these programs will not impact the results, especially when demand for clean energy is significantly greater than demand for energy satisfying these programs
  - E.g., Case C from the April memo
- However, incorporating existing state programs in the model will more robustly account for their impacts when they are binding, resulting in a price based on the marginal resource
  - E.g., Case B from the April memo
  - May also be important for certain cases and types of certificates, and in assessment of non-FCEM pathways
- Accounting for existing state programs in the model will provide better understanding of each of the potential pathways, including the status quo, under a broad range of market conditions

Model formulation is consistent with multiple approaches to integrating state policy

- This formulation is consistent with a "separate product approach" that treats RECs and CECs as separate products, where renewable resources are awarded separate certificates for each product
- However, this formulation is also consistent with another approach raised by stakeholders where the existing state policies are integrated into the forward procurement of CECs
  - Under this "premium CEC" approach the FCEM would include constraints to reflect additional value for specific environmental attributes (e.g., renewable)
- Because the model is consistent with both of these approaches, it is not necessary to choose between them at this stage of the pathways study

Both approaches compensate resources for their contributions to environmental objectives

- Consider a resource that produces both renewable and clean energy, where the system's cost to providing the next increment of **clean energy** is $10/MWh, and to providing **renewable energy** (while holding clean energy constant) is $15
  - Recall from the April memo that the introduction of a clean energy constraint may reduce the incremental cost to providing renewable energy, and does not introduce a double payment
- Under the "separate products approach," the renewable resource will be awarded a REC and a CEC for each MWh
  - The price is $10 for the CEC, and $15 for the REC, for total compensation of $25 per MWh
- Under a "premium CEC" approach, it will be awarded a premium CEC for each MWh of energy it produces
  - The price for this premium CEC will be $25 per MWh, equal to the sum of the incremental costs for each environmental attribute
- Thus, compensation is the same under each approach

Both approaches also allow states to meet their environmental objectives

- Under the “separate products” approach, states would separately procure CECs and RECs to ensure that their objectives associated with both clean energy and other environmental attributes are satisfied
  - E.g., if the states desire at least 100 MWh of clean energy, where at least 80 MWh of this clean energy is renewable, will require the procurement of 100 MWh of CECs and 80 MWh of RECs
- Under the “premium CEC” approach, states will specify demand for total CECs, as well as for premium CECs, to ensure that their total environmental attribute demand is satisfied
  - E.g., if the states desire at least 100 MWh of clean energy, where at least 80 MWh of this clean energy is renewable, will require the procurement of 20 MWh of CECs and another 80 MWh of premium CECs
- Model framework is sufficiently general to be consistent with both approaches

Modeling formulation is sensible for the pathways study, but would require further assessment if region pursues a FCEM

- This modeling formulation does not consider many of the accounting and legal questions that would need to be addressed to translate this conceptual framework into a complete design that could be implemented and administered, such as:
  - Will RECs be procured as a premium clean energy product in the forward auction?
  - Would legal definitions of existing environmental certificates need to be updated?
  - What product(s) would states need to procure to meet their environmental mandates?
- If the region opts to pursue a FCEM, stakeholders and the New England states would need to further consider precisely how these questions would be addressed

DESIGN CONSIDERATION OF IMPORTS AND SEAMS QUESTIONS

Model will consider energy imported from outside New England

- In addition to supply and demand conditions in New England, AGI's model will consider supply and demand in New York to inform how electricity may be transferred between regions
- The model will also consider electricity delivered from Quebec
- Accounting for these neighboring regions will help the model accurately simulate future outcomes under each of the potential pathways studied, including the status quo
- AGI can offer more detail on these modeling mechanics and assumptions
- Welcome stakeholder feedback on proposed approach discussed below

Sale of RECs across state lines

- Consistent with current market rules, propose the model will allow RECs generated outside the ISO-NE footprint to be used for compliance in New England, presuming that the certificate supplied is:
  - Consistent with the relevant environmental attributes associated with the state program, and
  - Not used for compliance in another state
- In doing so, model will allow RECs to be traded between New England and New York to the extent permitted by existing sate programs

Sale of CECs across state lines

- Propose that model allows allow sale of CECs into New England from resources outside the region if the resource provides both clean energy, as defined in the FCEM/ICCM, and RECs to the New England region
- Model will therefore not allow a resource to sell CECs into New England and RECs into New York for the same MWh
  - Limitation seeks to address a concern raised by stakeholders that a resource's environmental attributes are counted towards reducing carbon emissions in both New England and New York
  - Because New York does not have a CEC requirement, double-counting of clean energy could occur without this restriction
- If the region pursues a FCEM approach, further consideration of how to most sensibly account for clean energy originating outside New England is necessary

Application of a net carbon price to imports

- We expect that the model will “adjust” the cost of energy flowing into and out of New England based on the estimated emissions rate of the marginal resource importing energy across the intertie
- This approach seeks to put energy produced outside of New England on similar footing to that in New England
  - This will help produce efficient outcomes that account for both resource production costs and carbon emissions
- Still assessing precisely how this will be done in the model
- If the region pursues a net carbon pricing approach, further consideration of how the emissions rate of the marginal resource will be estimated or calculated would be necessary

PROPOSED TREATMENT OF STORAGE IN FCEM

ISO proposes not to award CECs to storage resources in straw FCEM framework

- ISO published a storage memo in April explaining why awarding CECs to storage resources does not align with sound market design
  - Storage is compensated for its contributions to clean energy production via increased energy market revenues
- Stakeholders noted that the market conditions under which storage is compensated for these contributions via increased energy market revenues may be limited
  - For example, may exclude conditions where storage reduces carbon emissions but does not increase clean energy production
  - This observation is correct, and highlights a key difference between the FCEM and net carbon pricing approaches

Treatment of storage in FCEM, cont.

- Co-located resources will qualify for CECs, based on the non-storage portion of the resource qualifying for clean energy
  - E.g., solar plus storage will receive CECs for any energy produced by its solar capability
- ISO and AGI will consider ways to explore the role of and compensation for storage further via qualitative analysis and/or sensitivities and welcome further stakeholder feedback

MODELING EQUIVALENCE OF FCEM AND ICCM

Background

- In March, the ISO presented a memo titled "Developing a Straw FCEM Framework" that detailed some of the outstanding design questions that need to be answered before Analysis Group can begin their modeling efforts
- Whether AGI would model a FCEM or an ICCM was one such design question
- After further consideration, the ISO now believes that it is not necessary for stakeholders to choose between a FCEM and an ICCM at this time, as AGI's modeling approach is consistent with both
- For additional detail, please see the posted "Modeling Equivalence of the FCEM and the ICCM" memo

Section overview

- Memo considers a pair of numerical examples
  - Each example includes the same set of resources and parameters
- Numerical examples are also available in Appendix slides
- First example considers awards, prices, and compensation when clean energy and capacity are procured simultaneously in an ICCM
- Second example considers awards, prices, and compensation when we procure clean energy first with a FCEM and subsequently procure capacity in a FCM
- Memo compares outcomes between the two examples
- Given assumptions consistent with AGI's modeling approach, the FCEM and the ICCM will yield identical awards and compensation to all resources

Assumptions

- Assumption 1: Resources submit offers for capacity and clean energy based on their missing money, where their missing money is defined as revenue they would need to receive, in addition to that from the energy and ancillary service markets, to recover their costs
- Assumption 2: The markets for RECs and CECs are competitive, so that the marginal resource recovers its missing money but no more
- Assumption 3: Resources offer to sell the entirety of their clean energy and capacity capability forward
- Assumption 4: Resources submit fully rationable (i.e., non-lumpy) offers for capacity

Assumptions, cont.

- Assumption 5: Resources have perfect foresight, so that they can exactly predict the capacity clearing price, their capacity award, their real-time energy profits, their clean energy production, etc.
- Assumption 5 is a particularly key assumption, but one that reflects AGI's broad, market-based modeling approach
- If Assumption 5 does not hold, we might observe divergent outcomes between the ICCM and the FCEM, particularly when the resources have different beliefs about capacity prices
- Consideration of how these beliefs may vary across resources, and how these might inform market design decisions, is outside the scope of this modeling exercise

Key takeaways

- Given Assumptions 1-5, the ICCM and the FCEM will have identical awards, prices, and compensation to resources
- Under a FCEM, resources incorporate their future capacity revenue when determining how much missing money they must recover by selling clean energy forward. When these capacity revenue predictions are accurate, as we assume in the above examples, we get equivalent results under a FCEM or an ICCM

Analysis Group's modeling efforts

- AGI's modeling approach will make assumptions that are generally consistent with those employed in the above examples
- Their model will assume that:
  - The markets for RECs and CECs are competitive
  - Resources submit offers to sell clean energy based on their clean energy production in the delivery year
  - Resources submit fully rationable offers for capacity and clean energy
  - Resources have perfect foresight about future prices and awards in all markets (including capacity) when making entry/exit decisions

Analysis Group's modeling efforts, cont.

- AGI's modeling approach does not distinguish between a sequential FCEM and a simultaneous ICCM
- More specifically, AGI's capacity expansion model will conduct a single, global optimization to determine the resource mix for each framework
- Their model will include constraints corresponding with capacity demand, renewable energy demand, and demand for clean energy or carbon emissions abatement
- **Key Takeaway:** This modeling approach is consistent with either a FCEM where resources correctly internalize the actual capacity price when formulating their clean energy offer price, or an ICCM where clean energy and capacity are procured jointly

The ISO does not believe it is necessary to decide between an FCEM and ICCM at this time

- AGI's modeling approach is broadly consistent with both, and the results can therefore be treated as reflecting potential market outcomes under either a FCEM or an ICCM
- In practice, there are likely to be differences between these approaches, but such differences are not accounted for in AGI's model
- If the region chooses to pursue such an approach, further consideration of the tradeoffs between an FCEM and ICCM will be necessary to determine which to pursue
- The ISO welcomes stakeholder feedback

ISO looks forward to working with stakeholders to evaluate pathways to the future grid

- With the help of stakeholders and the Analysis Group, ISO will evaluate market outcomes under the forward clean energy market and net carbon pricing frameworks
- Welcome stakeholder feedback today on these efforts, including the two frameworks to be studied and modeling assumptions discussed next by AGI
  - Seeking any written, follow up feedback by May 21 to best allow for consideration ahead of posting date for the June 11 meeting
- Share final report on modeled market outcomes with stakeholders in the first quarter of 2022

APPENDIX: FCEM/ICCM MODELING EQUIVALENCE NUMERICAL EXAMPLES

Parameter summary

- The table below includes the key parameter values for the following examples

		Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	Missing Money Per MW	$60,000/MW	$160,000/MW	$150,000/MW	$200,000/MW
[2]	Max Capacity Award	1,000 MW	300 MW	300 MW	300 MW
[3]	E[Clean Energy]	-	6,000 MWh/MW	3,000 MWh/MW	7,000 MWh/MW
[4]	CSO Demand	1,200 MW			
[5]	Clean Energy Demand	3,000,000 MWh			

Parameter summary, cont.

- Both examples consider the same four resources with the same parameter values
- Missing Money Per MW is the amount of revenue from capacity and clean energy these resources would require to be economical
- Max Capacity Award is each resource's capacity capability
- E[Clean Energy] provides each resource's expected clean energy production during the delivery year
  - E.g., if Clean 1 provides its entire 300 MW of capacity, it expects to produce 1,800,000 MWh of clean energy
- CSO Demand and Clean Energy Demand are both vertical demand curves, for simplicity

ICCM preview

- Next few slides consider awards and compensation in an ICCM
- Begin with a review of the proposed ICCM mechanics
- For more information on the ICCM, see the “Evaluation of an Integrated Forward Clean Energy Market” memo the ISO posted in March
- Awards, prices, and total revenue to resources in the ICCM will later be compared with comparable output from the FCEM

ICCM offer structure

Slide 29, March Working Session

- Participants would submit a capacity offer, as in the FCM today, that includes both a maximum quantity and a price reflecting the minimum payment rate they would accept to sell capacity
- The ICCM would introduce a new clean energy parameter to their offer that indicates how many MWh of forward clean energy it would sell per unit of CSO
  - E.g., a clean resource may specify that for each MW of capacity sold, it would also sell 100 MWh of clean energy forward
- A participant's offer price would then represent the minimum payment the participant would accept to take on a CSO *and* sell the associated bundled clean energy forward

Integrated auction clearing

Slide 30, March Working Session

- The ICCM would award capacity and clean energy positions to resources based on their offers and their contributions to meeting capacity and clean energy demand
- Much like with today's FCM, resources that offer these products at lower cost are more likely to be awarded positions than those that offer at higher prices
- However, the auction may award positions to a resource that submits a higher priced offer if this offer also includes clean energy
- Awards would be determined to maximize social surplus, where the social surplus considers the benefits of both products, as determined by the demand curves

ICCM numerical example

- The following tables provide key results form the ICCM numerical example

		Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	ICCM Offers	$60,000/MW	$160,000/MW	$150,000/MW	$200,000/MW
[2]	Clean Energy Parameter	-	6,000 MWh/MW	3,000 MWh/MW	7,000 MWh/MW

- Consistent with Assumption 1, the example assumes that resources submit ICCM offers at their missing money
  - Note that Row [1] contains the same values as the Missing Money row from the previous table

ICCM numerical example: CSO awards and prices

		Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	ICCM Offers	$60,000/MW	$160,000/MW	$150,000/MW	$200,000/MW
[2]	Clean Energy Parameter	-	6,000 MWh/MW	3,000 MWh/MW	7,000 MWh/MW
[3]	CSO Award	728.6 MW	300 MW	0 MW	171.4 MW
[4]	CSO Price	$60,000/MW	$60,000/MW	$60,000/MW	$60,000/MW

- In these examples, prices are set by the marginal resources
- Price for capacity is $60,000/MW, where Non-Clean 1 is the marginal resource with respect to capacity
  - $60,000 is the incremental cost associated with a 1 MW increase in capacity demand

ICCM numerical example: clean energy awards and prices

		Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	ICCM Offers	$60,000/MW	$160,000/MW	$150,000/MW	$200,000/MW
[2]	Clean Energy Parameter	-	6,000 MWh/MW	3,000 MWh/MW	7,000 MWh/MW
[3]	CSO Award	728.6 MW	300 MW	0 MW	171.4 MW
[4]	CSO Price	$60,000/MW	$60,000/MW	$60,000/MW	$60,000/MW
[5]	Clean Energy Award	-	1,800,000 MWh	0 MWh	1,200,000 MWh
[6]	Clean Energy Price	-	$20/MWh	$20/MWh	$20/MWh

- Price for clean energy is $20/MWh, where Clean 3 is the marginal resource with respect to clean energy
  - $20 is the incremental cost associated with a 1 MWh increase in clean energy demand
  - This cost results form a modest increase in Clean 3's capacity award, and a corresponding decrease in Non-Clean 1's capacity award, so that the total clean energy sold increases and capacity is unchanged

ICCM numerical example: clean energy awards and prices, cont.

		Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	ICCM Offers	$60,000/MW	$160,000/MW	$150,000/MW	$200,000/MW
[2]	Clean Energy Parameter	-	6,000 MWh/MW	3,000 MWh/MW	7,000 MWh/MW
[3]	CSO Award	728.6 MW	300 MW	0 MW	171.4 MW
[4]	CSO Price	$60,000/MW	$60,000/MW	$60,000/MW	$60,000/MW
[5]	Clean Energy Award	-	1,800,000 MWh	0 MWh	1,200,000 MWh
[6]	Clean Energy Price	-	$20/MWh	$20/MWh	$20/MWh

- Clean 2 does not clear for clean energy or capacity despite the fact that their ICCM offer is lower than Clean 3's offer
  - While Clean 2 submits a lower offer, their clean energy parameter is less than half of Clean 3's so Clean 3 contributes more to system demand; Clean 3 provides capacity *and* their bundled clean energy at less cost than Clean 2

ICCM numerical example: total revenue

		Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	ICCM Offers	$60,000/MW	$160,000/MW	$150,000/MW	$200,000/MW
[2]	Clean Energy Parameter	-	6,000 MWh/MW	3,000 MWh/MW	7,000 MWh/MW
[3]	CSO Award	728.6 MW	300 MW	0 MW	171.4 MW
[4]	CSO Price	$60,000/MW	$60,000/MW	$60,000/MW	$60,000/MW
[5]	Clean Energy Award	-	1,800,000 MWh	0 MWh	1,200,000 MWh
[6]	Clean Energy Price	-	$20/MWh	$20/MWh	$20/MWh
[7]	Total Revenue	$43,714,800	$54,000,000	$0	$34,285,200

- Total revenue to each resource is the combination of their capacity revenue and clean energy revenue: Row [3] times Row [4] plus Row [5] times Row [6]

FCEM preview

- Second example considers a FCEM framework, where clean energy is first procured in a FCEM and then capacity is procured in a subsequent FCM
- The example walks through this process in multiple steps:
  - First we consider FCEM offers, awards, and compensation
  - Then consider FCM offers, awards, and compensation

FCEM numerical example: offers in FCEM

- The table below describes how the clean resources would determine their FCEM offers

			Clean 1	Clean 2	Clean 3
[1]	Missing Money		$160,000/MW	$150,000/MW	$200,000/MW
[2]	E[Capacity Price]		$60,000/MW	$60,000/MW	$60,000/MW
[3]	E[Clean Energy]		6,000 MWh/MW	3,000 MWh/MW	7,000 MWh/MW
[4]	FCEM Offer	=([1]-[2])/[3]	$16.67/MWh	$30.00/MWh	$20.00/MWh

- Missing Money in Row [1] is the same as in previous tables
  - Non-Clean 1 does not appear; they are not eligible to sell CECs
- Forecasted FCM capacity price is $60,000/MW
- Each resource's forward clean energy offer is their per MWh missing money they need to recover, after accounting for their forecasted capacity revenue

FCEM numerical example: awards, prices, and revenue

- The table below describes awards, prices, and compensation in the FCEM

			Clean 1	Clean 2	Clean 3
[1]	FCEM Offer		$16.67/MWh	$30/MWh	$20/MWh
[2]	Clean Energy Award		1,800,000 MWh	0 MWh	1,200,000 MWh
[3]	Max Clean Energy Award		1,800,000 MWh	900,000 MWh	2,100,000 MWh
[4]	Clean Energy Price		$20/MWh	$20/MWh	$20/MWh
[5]	FCEM Revenue	=[2]*[4]	$36,000,000	$0	$24,000,000

- Clean 1 is inframarginal for forward clean energy
- Clean 3 is marginal and so sets the price at their offer: $20/MWh
- Note that the clean energy price and awards are the same here as in the ICCM example

FCEM numerical example: CSO offers after the FCEM

- The table below demonstrates how Clean 3 would formulate its CSO offer for the FCM
  - Note that we have omitted the other resources for brevity

			Clean 3
[1]	Missing Money		$200,000/MW
[2]	E[Capacity Award]		171.4 MW
[3]	Maximum Capacity Award		171.4 MW
[4]	FCEM Revenue		$24,000,000
[5]	FCEM Revenue Per E[MW of CSO]	=[4]/[2]	$140,000/MW
[6]	Missing Money Less FCEM Revenue	=[1]-[5]	$60,000/MW
[7]	CSO Offer	=[6]	$60,000/MW

FCEM numerical example: CSO offers cont.

- Consider how Clean 3 would develop its offer for the portion of tis capacity capability that sold clean energy in FCEM
- Clean 3 sold 57% of its clean energy capability in the FCEM, so we assume that it seeks to sell 57% of its capacity capability, 171.4 MW
- For this portion of its capability, Clean 3's per MW offer is their missing money minus FCEM revenue per forecast MW of CSO they will be awarded: $200,000/MW - $140,000/MW = $60,000/MW

FCEM numerical example: FCM after FCEM

- The following table provides awards, prices, and compensation to the resources from the FCM, as well as total compensation across the FCEM and the FCM

			Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	CSO Offer		$60,000/MW	$40,000/MW	$150,000/MW	$60,000/MW
[2]	CSO Award		728.6 MW	300 MW	0 MW	171.4 MW
[3]	CSO Price		$60,000/MW	$60,000/MW	$60,000/MW	$60,000/MW
[4]	FCM Revenue	=[2]*[3]	$43,714,800	$18,000,000	$0	$10,285,200
[5]	FCEM Revenue		-	$36,000,000	$0	$24,000,000
[6]	Total Revenue	=[4]+[5]	$43,714,800	$54,000,000	$0	$34,285,200

FCEM numerical example: FCM after FCEM cont.

- Non-Clean 1 is again marginal for capacity and sets the CSO price at $60,000/MW
- Clean 3 is willing to accept Non-Clean 1's offer as the clearing price, so we assume they submit an offer just below Non-Clean 1's offer of $60,000/MW
- Each resource's total revenue across the FCM and FCEM is the product of the capacity price, $60,000/MW, and their capacity award, plus their FCEM revenue

ICCM/FCEM comparison: identical awards, prices, and compensation

		Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	ICCM CSO Award	728.6 MW	300 MW	0 MW	171.4 MW
[2]	FCEM CSO Award	728.6 MW	300 MW	0 MW	171.4 MW
[3]	ICCM CSO Price	$60,000/MW	$60,000/MW	$60,000/MW	$60,000/MW
[4]	FCEM CSO Price	$60,000/MW	$60,000/MW	$60,000/MW	$60,000/MW
[5]	ICCM Clean Energy Award	-	1,800,000 MWh	0 MWh	1,200,000 MWh
[6]	FCEM Clean Energy Award	-	1,800,000 MWh	0 MWh	1,200,000 MWh
[7]	ICCM Clean Energy Price	$20/MWh	$20/MWh	$20/MWh	$20/MWh
[8]	FCEM Clean Energy Price	$20/MWh	$20/MWh	$20/MWh	$20/MWh
[9]	ICCM Total Revenue	$43,714,800	$54,000,000	$0	$34,285,200
[10]	FCEM Total Revenue	$43,714,800	$54,000,000	$0	$34,285,200

ISO new england

memo

To: NEPOOL Participants Committee Working Session

From: Market Development

Date: May 6, 2021

Subject: Modelling Equivalence of FCEM and ICCM

Introduction

The Pathways to the Future Grid study explores potential market frameworks that will help the region achieve clean energy goals. As part of this process, Analysis Group (AGI) will model a forward clean energy framework and a net carbon pricing framework to compare their expected market outcomes to a "status quo" framework where there are no substantial changes to the region's markets and states continue using bilateral contracts to achieve their policy objectives. In previous meetings and materials, stakeholders and the ISO have discussed whether AGI should model a forward clean energy market that is integrated with the capacity market or model a forward clean energy market that is conducted separately from the capacity market.[1]

Under an integrated clean capacity market (ICCM) construct, resources would submit a single offer for the forward sale of both capacity and clean energy, while in a separate forward clean energy market (FCEM) resources would first participate in a forward market for clean energy before submitting offers in a subsequent forward market for capacity. While both frameworks would require significant work to translate the high-level concepts into fully developed designs, the ISO views the ICCM as having particularly complex design and implementation challenges, given the added difficulties associated with jointly procuring two distinct products through a single auction.[2] Nonetheless, the ISO feels that AGI's modeling can simulate outcomes from a high-level ICCM framework, which will provide stakeholders with some insight about its theoretical application.

This memo considers potential differences between the FCEM and the ICCM concepts, with a focus on how these approaches may be similar or different in the context of the modeling efforts that are part of the Pathways to a Future Grid study. In particular, given AGI's proposed modelling structure and the

[1] See the "Scoping" document for the FCEM, located here: https://nepool.com/wp-content/uploads/2021/03/1a-FCEM-Scoping-Memo_vfinal.pdf

[2] While the ISO cannot fully evaluate the work or implementation challenges that may arise under an ICCM design that has not yet been established, we imagine that, at a minimum, the ICCM would likely add significant complexity to the FCM process. For more information on the ICCM, see the "Evaluation of an Integrated Forward Clean Energy Market," located here: https://nepool.com/wp-content/uploads/2021/03/NPC_FG_20210318_Supplemental-1.pdf

corresponding model inputs and assumptions, the memo concludes that the two approaches should produce identical awards and compensation. This result holds because the model makes two key assumptions: i) under an FCEM, resources account for their expected capacity revenue when formulating their competitive clean energy offers, and ii) that these expectations are accurate (i.e., the *expected* FCM prices are the same as the *actual* prices.) Based on this finding, it does not appear critical for the region to choose between an FCEM and an ICCM for the distinct purpose of finalizing the straw forward clean energy framework to be modeled.[3]

The memo begins by describing some of the key assumptions for the following examples. The memo next considers a numerical example that demonstrates awards, prices, and total compensation to resources in a hypothetical ICCM. The memo follows with a similar numerical example for a FCEM with the same assumptions and resource parameters as the ICCM example. The numerical examples show that the FCEM and ICCM will yield identical awards, prices, and total revenue for each resource, given the aforementioned assumptions. The memo concludes with a discussion of AGI's model mechanics and how their assumptions compare to those employed in these examples. It finds that because the assumptions listed in the memo's first section mirror AGI's model structure, the memo's numerical examples are consistent with the model output we would expect from AGI under equivalent conditions.

Given that AGI's expected modelling results can be viewed as consistent with either the FCEM or the ICCM, the ISO does not believe it is necessary for the region to pick one over the other for the purpose of studying a straw forward clean energy framework. The ISO welcomes stakeholder feedback on this issue and looks forward to further discussion.

Key Assumptions and Parameters for Numerical Examples

This section lists the key assumptions for the numerical examples in the subsequent section. Note that these assumptions reflect those AGI will make in their modelling efforts.

Assumption 1: Resources submit offers for capacity and clean energy based on their missing money, where their missing money is defined as the revenue they would need to receive, in addition to that from the energy and ancillary service markets, to recover their costs.[4]

Assumption 2: The markets for renewable energy certificates (RECs) and clean energy certificates (CECs) are competitive, so that the marginal resource recovers its missing money, but no more. In practice, if the REC or CEC markets were not competitive and the marginal resource recovered more than their missing money, we would expect additional resources to enter the markets to profit themselves. As more resources enter the markets, we would expect that competition would increase until the marginal

[3] While the modelling efforts are unlikely to detect differences between the FCEM and the ICCM, there will likely be important differences in practice. As a result, if the region decides to pursue a forward clean energy framework, further consideration of the pros and cons of an FCEM versus an ICCM, as well as additional design details, will be necessary. Moreover, we will seek to provide qualitative information on these differences to help inform the region before it proceeds further into developing potential proposals.

[4] This is a simplifying assumption and generalizes to cases where resources submit offers based on the maximum of their missing money and the "common value component", or the expected opportunity cost of taking on a forward position.

resources earn no profit. Note that this is a natural extension of Assumption 1: if resources submit offers to recover their missing money, the marginal resource will recover its missing money and earn no profits.

Assumption 3: Resources offer to sell the entirety of their clean energy and capacity capability forward. For example, if a clean energy resource expects to produce 3,000 MWh of clean energy for each MW of capacity during the delivery year, they will offer to sell this entire 3,000 MWh of clean energy in the forward markets. We make this assumption because, in equilibrium, we expect the forward clean energy price to equal the expected clean energy price in the delivery period, so that resources cannot profit from selling some of their clean energy in the spot market rather than the forward market.

Assumption 4: Resources submit fully rationable (i.e., non-lumpy) offers for capacity. This is a simplifying assumption to make the examples easier to follow.

Assumption 5: Resources have perfect foresight, so that they can exactly predict the capacity clearing price, their capacity award, their real-time energy profits, their clean energy production, etc.

Assumption 5 is an important modeling assumption that may not hold in practice, as it is likely that actual capacity prices will differ from those expected by resources when formulating the clean energy offer prices. However, it is consistent with the model framework that AGI will employ in the pathways efforts. Without this assumption, we might observe divergent outcomes between the ICCM and the FCEM, particularly when the resources have different beliefs about the expected capacity prices.[5]

Key Parameter Values for the Numerical Examples

The following numerical examples consider market outcomes for four resources. More specifically, the examples consider how the resources offer to sell their capacity and clean energy in a FCEM and an ICCM, and the resulting awards, prices, and compensation in each framework. The examples show that each framework results in the same awards and prices so that the resource's total compensation is identical in both the FCEM and the ICCM.

Table 1 below lists parameter values for the four resources included in this memo's numerical examples. Note that the parameter values are held constant across the two examples so that the results are comparable. Row [1] contains each resource's missing money per MW. This represents the revenue they would need to recover from capacity or clean energy to be economical. Row [2] contains their maximum capacity award, which is the maximum quantity of capacity the resource can sell in a FCM or an ICCM. Row [3] lists each resource's expected clean energy production during the delivery year. Row [4] sets the CSO demand at 1,200 MW and Row [5] sets the clean energy demand at 3,000,000 MWh. Note that we assume vertical demand curves, for simplicity, but the results generalize to sloped demand curves as well.

[5] While it may not be possible to fully eliminate this divergence, there may be mechanisms that would tend to reduce this divergence by decreasing the uncertainty of the price for the second product and ensuring that there are retrading opportunities for both products after the primary auction. If the region chooses to pursue a forward clean energy framework, further consideration of these mechanisms may be worthwhile when evaluating the relative merits of an FCEM versus an ICCM.

Table 1. Resource Parameters for Numerical Examples					
		Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	Missing Money Per MW	$60,000/MW	$160,000/MW	$150,000/MW	$200,000/MW
[2]	Max Capacity Award	1,000 MW	300 MW	300 MW	300 MW
[3]	E[Clean Energy]	-	6,000 MWh/MW	3,000 MWh/MW	7,000 MWh/MW
[4]	CSO Demand	1,200 MW			
[5]	Clean Energy Demand	3,000,000 MWh			

Numerical Example: Integrated Clean Capacity Market

With an ICCM, capacity and forward clean energy are procured simultaneously in one forward auction. Resources submit a single $/MW offer to provide both clean energy and capacity, where their offer includes a "clean energy parameter" that defines the quantity of forward clean energy they would need to sell per unit of capacity. In effect, the clean energy parameter "binds" a resource's capacity award with their clean energy award, so that a resource's capacity award cannot be increased without also increasing the resource's clean energy award by their clean energy parameter.[6]

For example, suppose that Clean 2 submits an offer of $150,000/MW into the ICCM with a clean energy parameter of 3,000 MWh/MW (equal to their expected clean energy production from Table 1). This offer suggests that they would need to be paid at least $150,000/MW to be awarded both 1 MW of CSO and 3,000 MWh of forward clean energy. If Clean 2 is awarded a MW of CSO, they must also be awarded 3,000 MWh of forward clean energy.

Table 2 below contains the resource offers, awards, prices, and total revenue in the ICCM, given the parameter values in Table 1.

Table 2. Resource Offers, Awards, Prices, and Revenue in ICCM						
			Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	ICCM Offers		$60,000/MW	$160,000/MW	$150,000/MW	$200,000/MW
[2]	Clean Energy Parameter		-	6,000 MWh/MW	3,000 MWh/MW	7,000 MWh/MW
[3]	CSO Award		728.6 MW	300 MW	0 MW	171.4 MW
[4]	CSO Price		$60,000/MW	$60,000/MW	$60,000/MW	$60,000/MW
[5]	Clean Energy Award		-	1,800,000 MWh	0 MWh	1,200,000 MWh
[6]	Clean Energy Price		-	$20/MWh	$20/MWh	$20/MWh
[7]	Total Revenue	=[3]*[4]+[5]*[6]	$43,714,800	$54,000,000	$0	$34,285,200

Rows [1] and [2] define the offer parameters for the resources. Row [1] provides the $/MW offer for each resource. These offers represent the amount of money the resources would need to be paid to sell 1 MW of CSO and the accompanying forward clean energy defined by their clean energy parameter, displayed in

[6] Stakeholders have questioned whether it would be possible for some resources to sell only clean energy in an ICCM. While submitting "clean energy only" offers in an ICCM is not considered in this memo, the ICCM (and AGI's model) can likely be modified to accommodate such offering behavior.

Row [2]. Note that the offers in Row [1] equal each resource's missing money in Table 1 Row [1]. Because Non-Clean 1 does not provide clean energy, they do not submit a clean energy parameter and their offer only represents the minimum amount they would need to be paid to sell capacity. In these examples, Non-Clean 1 would need to be paid $60,000/MW for capacity.

Row [3] lists CSO awards. Clean 1 clears for their entire capability because, as we will see, they are infra-marginal for clean energy and their capacity award is bound to their clean energy award by their clean energy parameter. Clean 3 is awarded 171.4 MW of capacity, but they are not marginal for capacity, as Non-Clean 1 can provide capacity more cheaply than Clean 3. Indeed, Clean 3 is awarded capacity because, when they sell capacity, they also sell clean energy that contributes to meeting the clean energy demand.

Row [4] lists the CSO clearing price. Non-Clean 1 is marginal for capacity and sets the CSO price at $60,000/MW. To see how this price is determined, consider an incremental increase in the installed capacity requirement of 1 MW, without a corresponding increase in clean energy demand. The least-cost way to meet this increment is to increase Non-Clean 1's CSO award by 1 MW, at a cost to the system of $60,000. Thus, Non-Clean 1 sets the CSO clearing price at $60,000/MW.

Note that Clean 2 does not clear for capacity despite the fact that their offer is less than Clean 3's offer (See Row [1]). While Clean 2 submits a lower-priced capacity offer, their clean energy parameter is also much smaller than Clean 3's and so they contribute less to clean energy demand. From the perspective of the optimization problem, Clean 3's additional contributions to clean energy demand per MW outweigh their increased cost, and so they are awarded capacity and clean energy positions ahead of Clean 2.

Row [5] lists the forward clean energy awards. Clean 1 is infra-marginal for clean energy and so clears for their entire capability, 1,800,000 MWh. Because they clear their entire clean energy capability, they also clear for their entire capacity capability. Clean 3 is awarded 1,200,000 MWh of forward clean energy to meet the remaining clean energy demand.

Row [6] lists the forward clean energy price. Clean 3 is the marginal resource for the forward clean energy positions and sets their price at $20/MWh. To see how this price is determined, consider an incremental increase in the forward clean energy demand of 1 MWh, without a corresponding increase in CSO demand. To meet this additional 1 MWh demanded, Clean 3 must be awarded an additional $\frac{1}{7000}$ MW of CSO, costing the system $\frac{1}{7000} * \$200,000 = \$28.57$. Because Clean 3 clears for an additional $\frac{1}{7000}$ MW of CSO, however, Non-Clean 1's CSO award can be decreased by $\frac{1}{7000}$ MW, saving the system $\frac{1}{7000} * \$60,000 = \$8.57$. The total change in system costs is thus $28.57-$8.57 = $20, and so the forward clean energy price is $20/MWh.

Finally, Row [7] lists the total revenue to each resource. Because Non-Clean 1 cannot sell clean energy, their total revenue is equal to their capacity revenue: $60,000/MW * 728.6 MW = $43,714,800. For the clean resources, their total revenue is the sum of their capacity revenue and their clean energy revenue. Clean 3's total revenue, for example, is their capacity revenue ($60,000/MW * 171.4 MW = $10,285,200) plus their clean energy revenue ($20/MWh * 1,200,000 MWh = $24,000,000), for a total of $34,285,200. Note that Clean 3's per MW revenue is their total revenue divided by their capacity award, $\frac{\$34,285,200}{171.4\ MW} =$

$\$200{,}000/MW$. That is, Clean 3 is paid their offer for their capacity and clean energy, and so they exactly recover their missing money. This is consistent with Assumption 2, the competitive markets assumption, as it indicates that the marginal resource for clean energy does not earn infra-marginal profits.

Numerical Example: Forward Clean Energy Market

In a market where forward clean energy is purchased in advance of the capacity market, clean resources submit offers to sell clean energy in the FCEM and then subsequently submit offers in the FCM. That is, unlike the ICCM which has one optimization that solves for both capacity and clean energy awards, the FCEM has two sequential optimizations, the first for clean energy and the second for capacity. As a result, resources know their forward clean energy awards and revenue before they submit offers for capacity in the FCM. This section considers 1) clean resource's offers into the FCEM, 2) the resulting forward clean energy awards and prices given those offers, 3) the resource's CSO offers in the capacity market, given the awards and prices in the FCEM, and, finally, 4) the capacity prices and awards in the FCM.

Resource Offers in the FCEM

Clean resources submit offers into the FCEM that reflect the missing money they would need to recover to enter the market or remain in operation. However, the calculus associated with this decision differs from that in the ICCM because clean energy and capacity are awarded in separate auctions. While resources seek to recover their missing money via payments for their clean energy and capacity (as they do in the ICCM), they now must determine their competitive FCEM offers before the capacity market price has been determined. Thus, when submitting their FCEM offers, the resources do not know how much of this missing money would be recovered via the sale of capacity. [7]

However, we assume that these resources have perfect foresight regarding the capacity clearing price when developing their clean energy offers (consistent with Assumption 5.) As such, resources set their clean energy offers as the remaining missing money that they must recover, net of their future capacity revenues. Table 3 below displays the clean resource's FCEM offers.

Table 3. Clean Resource Offers in FCEM

			Clean 1	Clean 2	Clean 3
[1]	Missing Money		\$160,000/MW	\$150,000/MW	\$200,000/MW
[2]	E[Capacity Price]		\$60,000/MW	\$60,000/MW	\$60,000/MW
[3]	E[Clean Energy Production]		6,000 MWh/MW	3,000 MWh/MW	7,000 MWh/MW
[4]	FCEM Offer	=([1]-[2])/[3]	\$16.67/MWh	\$30.00/MWh	\$20.00/MWh

Row [1] contains each resource's missing money, where this value does not account for their expected capacity revenue. In other words, the values in Row [1] are the quantity of money the resources need to recover through both capacity and clean energy revenue. For example, Clean 3 needs to be paid \$200,000 for each MW of capacity they sell *and* the clean energy they expect to produce with that capacity. Note that values in Row [1] above are the same as those in Row [1] of Tables 1 and 2.

[7] The results illustrated in this example would still hold if the order of the markets were reversed, so that the FCM occurs before the FCEM and where resources would develop their capacity offer prices using the expected clean energy price.

Row [2] contains the expected capacity price. By Assumption 5, each of the resources perfectly predicted the capacity price at $60,000/MW. (We will see in subsequent tables that the capacity clearing price in the FCM is indeed $60,000/MW, meaning each resource's expectations about this price is correct.)

Row [3] contains their expected clean energy production per MW, which is identical to the clean energy parameter the resources submitted as part of their offers in the ICCM example above. (See Assumption 3 in the first section.)

Finally, Row [4] contains each resource's per MWh offer. For each resource, they subtract their expected capacity revenue from their missing money (Row [1] – Row [2]), as they expect to recover this revenue via the capacity market and therefore do not include it in their clean energy market offers. They then divide the remaining missing money by their expected clean energy production per MW (Row [3]). This is the missing money they need to recover for each MWh of clean energy that they deliver, and therefore reflects their competitive clean energy market offer price.

FCEM Awards, Prices, and Revenue

Given the offers in Table 3 above, Table 4 contains the awards, prices, and revenue to each clean resource in the FCEM. As in the case of the ICCM, total demand for clean energy is equal to 3,000,000 MWh.

Table 4. Resource Awards, Prices, and Revenue in FCEM

			Clean 1	Clean 2	Clean 3
[1]	FCEM Offer		$16.67/MWh	$30/MWh	$20/MWh
[2]	Clean Energy Award		1,800,000 MWh	0 MWh	1,200,000 MWh
[3]	Max Clean Energy Award		1,800,000 MWh	900,000 MWh	2,100,000 MWh
[4]	Clean Energy Price		$20/MWh	$20/MWh	$20/MWh
[5]	FCEM Revenue	=[2]*[4]	$36,000,000	$0	$24,000,000

Each resource's FCEM offer is listed in Row [1], for convenience. Row [2] contains each resources clean energy award and Row [3] contains their maximum clean energy capability. Note that Clean 1 clears for their entire capability and so are infra-marginal.

The forward clean energy clearing price is listed in Row [4]. Clean 3 is the marginal resource and sets the price at $20/MWh. To see how we arrive at this price, consider an incremental increase in forward clean energy demand of 1 MWh. To meet this increase in clean energy demand, Clean 3's forward clean energy award is increased by 1 MWh at a cost to the system of $20. As a result, Clean 3 sets the forward clean energy price at $20/MWh. Note that the forward clean energy price is the same here as in the ICCM example, and in each case, it is set to Clean 3's incremental cost of supplying a MWh of clean energy (Row [5] of Table 2.) This will be important when we compare the two frameworks.

The total FCEM revenue for each resource is listed in Row [5]. Their total revenue is the product of the forward clean energy clearing price ($20/MWh) and their FCEM award, listed in Row [2].

Clean 3's CSO Offers after the FCEM

Now that the FCEM has been run and forward clean energy awards have been assigned, the FCM is conducted. Each resource will submit offers into the FCM that seek to recover any outstanding missing money while accounting for their revenue from the FCEM. Table 5 below lists only Clean 3's offer, for brevity.

Table 5. Clean 3's CSO Offer after FCEM

			Clean 3
[1]	Missing Money		$200,000/MW
[2]	E[Capacity Award]		171.4 MW
[3]	Maximum Capacity Award		171.4 MW
[4]	FCEM Revenue		$24,000,000
[5]	FCEM Revenue Per E[MW of CSO]	=[4]/[2]	$140,000/MW
[6]	Missing Money Less FCEM Revenue	=[1]-[5]	$60,000/MW
[7]	CSO Offer	=[6]	$60,000/MW

First, note that Clean 3 was awarded 1,200,000 MWh of forward clean energy in the FCEM. Because Clean 3 sold 57 percent of its forward clean energy capability (1,200,000 MWh out of a possible 2,100,000 MWh), we also assume that it seeks to sell 57 percent of its capacity capability, which as illustrated in Row [2] of Table 5 is 171.4 MW.[8] As a simplifying assumption, we assume that Clean 3 submits only one offer with a maximum award of 171.4 MW, as shown in Row [3].[9]

Clean 3 thus submits their CSO offer to recover the missing money associated with this 171.4 MW of capacity that was not recovered in the FCEM. To do so, Clean 3 incorporates the FCEM revenue it received, which totals $24,000,000. Given that its total missing money on this block of capacity is $34,284,000 (its missing money in Row [1], $200,000/MW, times its maximum offered capacity, 171.4 MW), it must recover the remaining $10,284,000 via the FCM. When this remaining missing money is translated into a $/MW value by dividing it by 171.4, it comes to $60,000 per MW. Thus, in order to recover the missing money on this 171.4 MW of capacity, Clean 3 offers its capacity at $60,000/MW.

Key Takeaway: For Clean 3's 171.4 MW of offered capacity, they only need to be paid $60,000/MW to recover their missing money because they also recovered some of their missing money in the FCEM.

Total Revenue to Resources Via the FCEM and FCM

Once the FCEM has been run and resources have received their forward clean energy awards, a separate FCM will be run to procure the region's capacity. Table 6 contains each resource's CSO offer and award, the CSO clearing price, and their total revenue across both the FCEM and the FCM.

[8] In any example, for the FCEM outcome to be an equilibrium, the clean resources have to recover missing money on the entirety of the capacity they would need to support their forward clean energy positions.

[9] In practice, Clean 3 may submit another offer block at a higher price for its remaining capacity that did not sell clean energy, where this second block may be priced at $200,000/MW to reflect the fact that all of their missing money per MW would need to be recovered by capacity revenue.

Table 6. Resource Awards, Prices, and Revenue in FCM after FCEM						
			Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	CSO Offer		$60,000/MW	$40,000/MW	$150,000/MW	$60,000/MW
[2]	CSO Award		728.6 MW	300 MW	0 MW	171.4 MW
[3]	CSO Price		$60,000/MW	$60,000/MW	$60,000/MW	$60,000/MW
[4]	FCM Revenue	=[2]*[3]	$43,714,800	$18,000,000	$0	$10,285,200
[5]	FCEM Revenue		-	$36,000,000	$0	$24,000,000
[6]	Total Revenue	=[4]+[5]	$43,714,800	$54,000,000	$0	$34,285,200

Each resource's CSO offer is listed in Row [1]. Note that Clean 3's offer has a maximum award of 171.4 MW. This quantity of capacity will result in enough clean energy to satisfy their forward obligation. Note also that Clean 1 submits an infra-marginal offer of $40,000/MW. Clean 1 has received sufficient revenue in the FCEM that they are price-takers in the FCM.

Row [2] lists each resource's CSO award. Clean 1 is infra-marginal for capacity and sells their entire capability. Clean 3 also sells their entire offered capability of 171.4 MW.[10] Non-Clean 1 satisfies the rest of the capacity demand, providing 728.6 MW of CSO.

Row [3] contains the CSO price. Non-Clean 1 is marginal for capacity and sets the capacity clearing price at $60,000/MW. To see how this price is determined, consider an incremental increase in the installed capacity requirement of 1 MW, without a corresponding increase in the clean energy bids. The least-cost way to meet this increment is to increase Non-Clean 1's CSO award by 1 MW, at a cost to the system of $60,000. Thus, Non-Clean 1 sets the CSO clearing price at $60,000/MW.

Row [4] provides each resources FCM revenue, defined as the CSO price (Row [2]) times their CSO award (Row [3]). Row [5] pulls each resources FCEM revenue from Table 4 Row [4]. Finally, Row [6] provides each resource's total revenue, defined as their FCM revenue (Row [4]) plus their FCEM revenue (Row [5]).

Comparison of Awards, Prices, and Total Revenue Between ICCM and FCEM

Table 7 below lists the CSO and clean energy awards and prices, as well as total revenue for each resource under both frameworks. As illustrated by comparing the ICCM and FCEM results, the awards, prices, and revenues are equivalent for each of the four resources between the two cases. Thus, in these examples and any examples with Assumptions 1-5, there is no difference between market outcomes under an ICCM and an FCEM.

[10] While the example assumes that Clean 3 submits the same offer as Non-Clean 1, Clean 3 is willing to accept Non-Clean 1's offer as the clearing price and so would likely submit an offer just below Non-Clean 1's offer. Thus, as a simplifying assumption, we assume that Clean 3 clears before Non-Clean 1.

Table 7: Awards, Prices, and Total Revenue Comparison

		Non-Clean 1	Clean 1	Clean 2	Clean 3
[1]	ICCM CSO Award	728.6 MW	300 MW	0 MW	171.4 MW
[2]	FCEM CSO Award	728.6 MW	300 MW	0 MW	171.4 MW
[3]	ICCM CSO Price	$60,000/MW	$60,000/MW	$60,000/MW	$60,000/MW
[4]	FCEM CSO Price	$60,000/MW	$60,000/MW	$60,000/MW	$60,000/MW
[5]	ICCM Clean Energy Award	-	1,800,000 MWh	0 MWh	1,200,000 MWh
[6]	FCEM Clean Energy Award	-	1,800,000 MWh	0 MWh	1,200,000 MWh
[7]	ICCM Clean Energy Price	$20/MWh	$20/MWh	$20/MWh	$20/MWh
[8]	FCEM Clean Energy Price	$20/MWh	$20/MWh	$20/MWh	$20/MWh
[9]	ICCM Total Revenue	$43,714,800	$54,000,000	$0	$34,285,200
[10]	FCEM Total Revenue	$43,714,800	$54,000,000	$0	$34,285,200

Key Takeaway: Table 7 shows that, given the assumptions listed in the first section, the ICCM and FCEM will yield identical outcomes for each resource. Under an FCEM, resources incorporate their future capacity revenue when determining how much missing money they must recover by selling clean energy forward. When these capacity revenue predictions are accurate, as we assume in the above examples, we get equivalent results under an FCEM or an ICCM.

Analysis Group's Model Framework

Analysis Group's modeling efforts determine the resource mixes under i) a forward clean energy framework, ii) a net-carbon pricing framework, and iii) a "status quo" framework. As part of this effort, AGI's model will make assumptions that are generally consistent with those employed in the above examples. Specifically, the model used to simulate market outcomes will assume the following: i) the markets for RECs and CECs are competitive, ii) resources submit offers to sell clean energy based on their clean energy production in the delivery period, iii) resources submit fully rationable offers for capacity and clean energy, and iv) resources have perfect foresight about future prices and awards in all markets when making entry/exit decisions.

Digging deeper into the modelling details, the capacity expansion model that will be used to determine the resource mix in each framework conducts a single, global optimization that considers each resource's costs and solves for the lowest cost set of resources that meet a series of constraints. In this case, the model will include constraints corresponding with i) capacity demand, ii) renewable energy demand, or renewable portfolio standards, and iii) clean energy or carbon emissions abatement demand. As such, this modelling approach does not clearly distinguish between a sequential FCEM and a simultaneous ICCM because it is equally consistent with either i) an ICCM where capacity and clean energy awards are determined simultaneously, as in the first example, or ii) a FCEM where resources correctly forecast capacity prices when formulating their clean energy offers, as in the second example. Thus, given these assumptions, this modeling approach is consistent with either an FCEM where resources correctly internalize the actual capacity price when formulating their clean energy offer price, or an ICCM where clean energy and capacity are procured jointly.

Conclusion

Using two numerical examples, this memo demonstrates that a FCEM and an ICCM will yield identical pricing, awards, and total revenue to resources under assumptions that mirror Analysis Group's modelling approach. Specifically, in an ICCM, capacity and clean energy are procured simultaneously in one optimization problem. In an FCEM, clean energy and capacity are procured separately in two sequential optimization problems. When determining their clean energy offers in an FCEM, resources will make predictions about the amount of revenue they will receive in the capacity market. If these predictions are accurate, then the same resources will sell the same quantity of capacity and clean energy at the same prices in a FCEM as in an ICCM, leading both approaches to produce equivalent results.

AGI's model output for the "forward clean energy framework" can thus be viewed as broadly consistent with either a FCEM or an ICCM. As a result, the ISO proposes that it is not necessary for stakeholders to choose one framework over the other at this time. Rather, the model results can be interpreted as representing both a FCEM and an ICCM. If the region chooses to pursue a clean energy framework, the region may wish to further consider the tradeoffs between a FCEM and an ICCM, including those that are not fully captured in the modeling during the pathways efforts.

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Pathways Study

Evaluation of Pathways to a Future Grid

Todd Schatzki and Chris Llop

May 13, 2021

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

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

Modeling Inputs and Assumptions: Study Parameters

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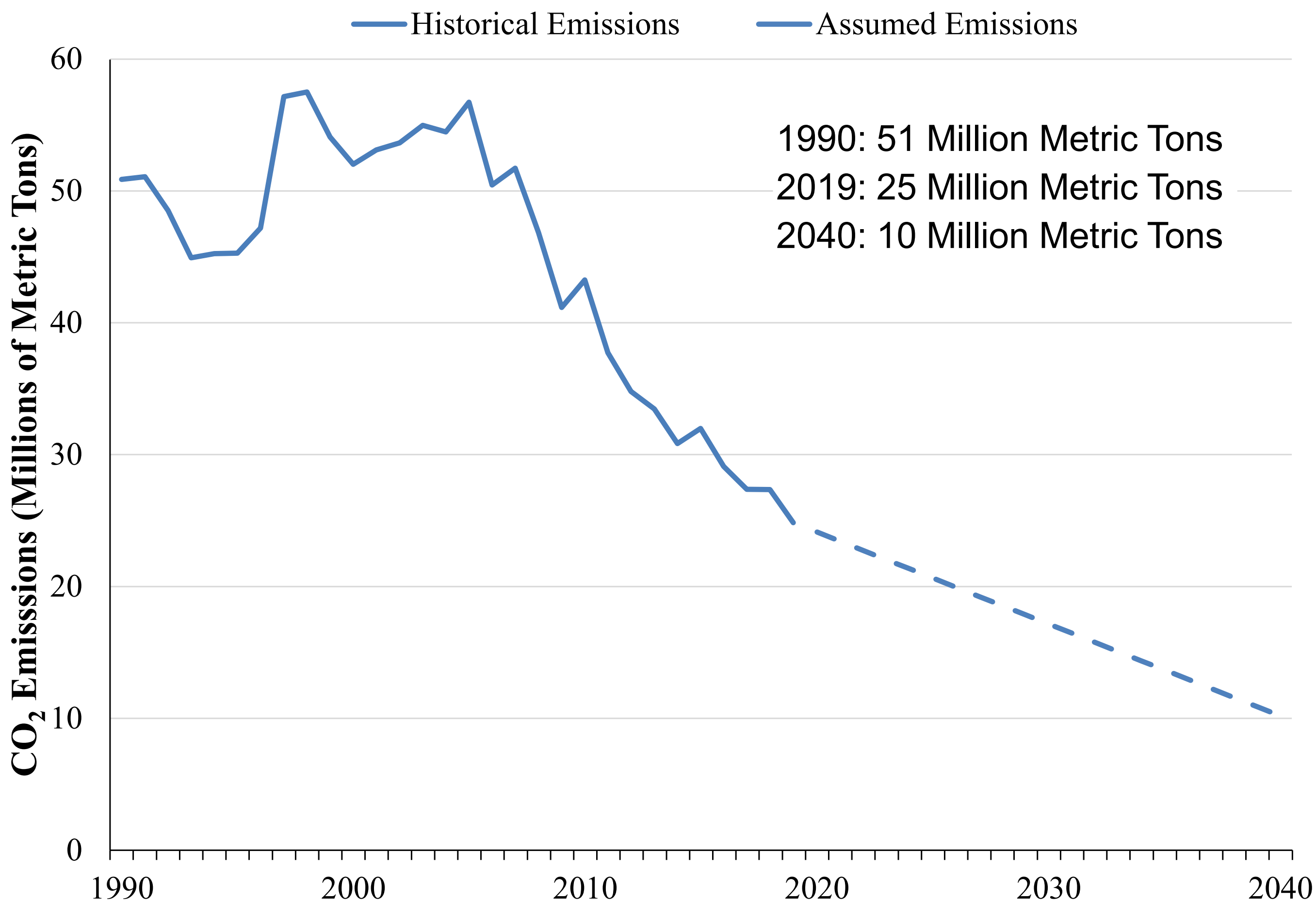
Study Parameters

- 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

Annual Historical and Assumed CO_2 Emissions



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

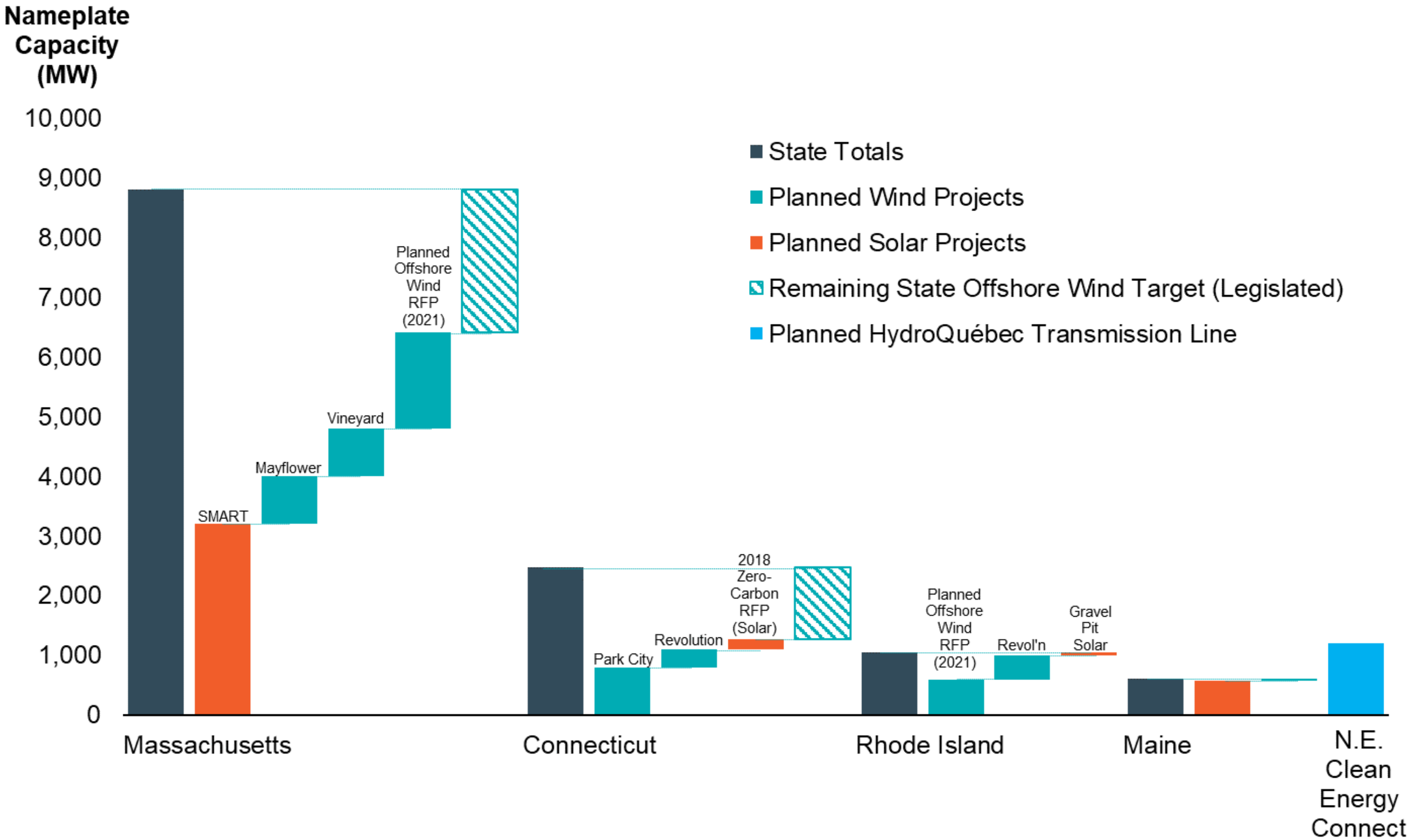
Modeling Inputs and Assumptions: Resource Characteristics, Operating Costs and Operating Specifications

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*

Assumed State Targets and Procurements

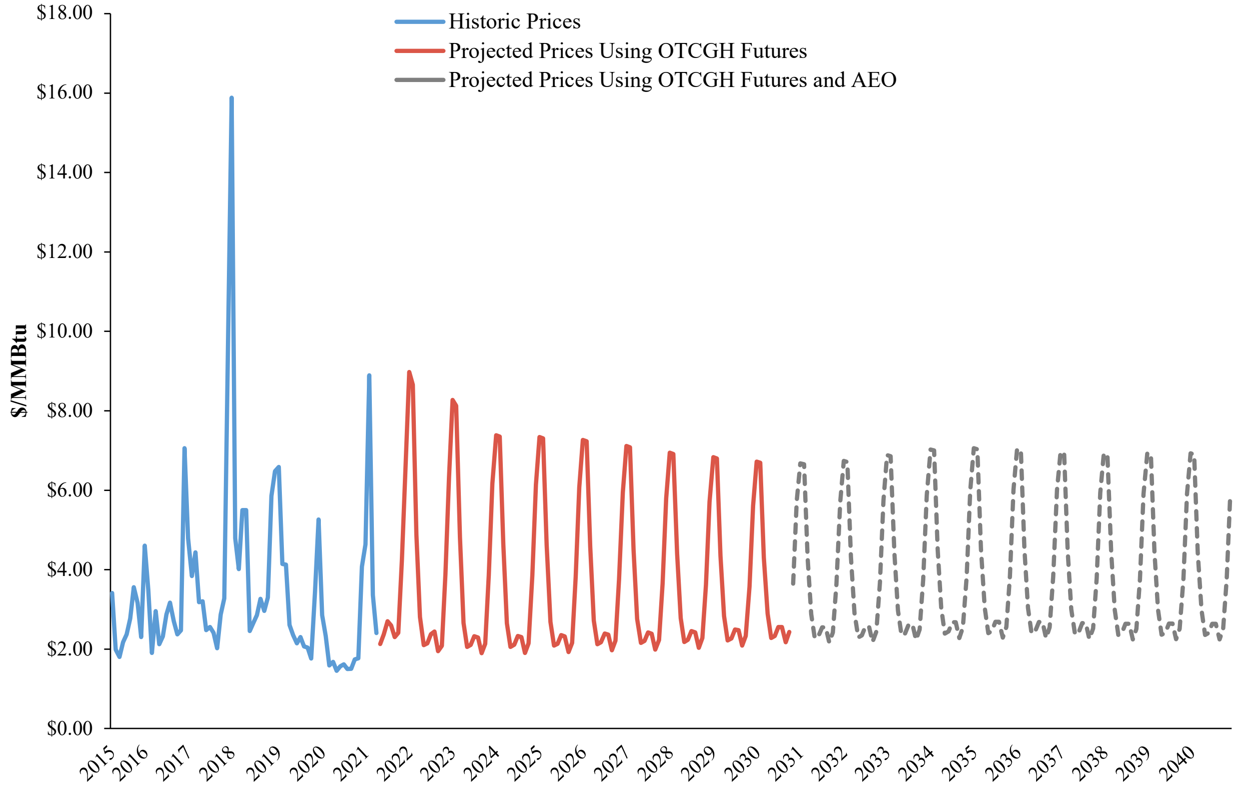
- The resources listed below will be included in addition to the resources in the CELT report and that were awarded capacity obligations in FCA 15



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

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.

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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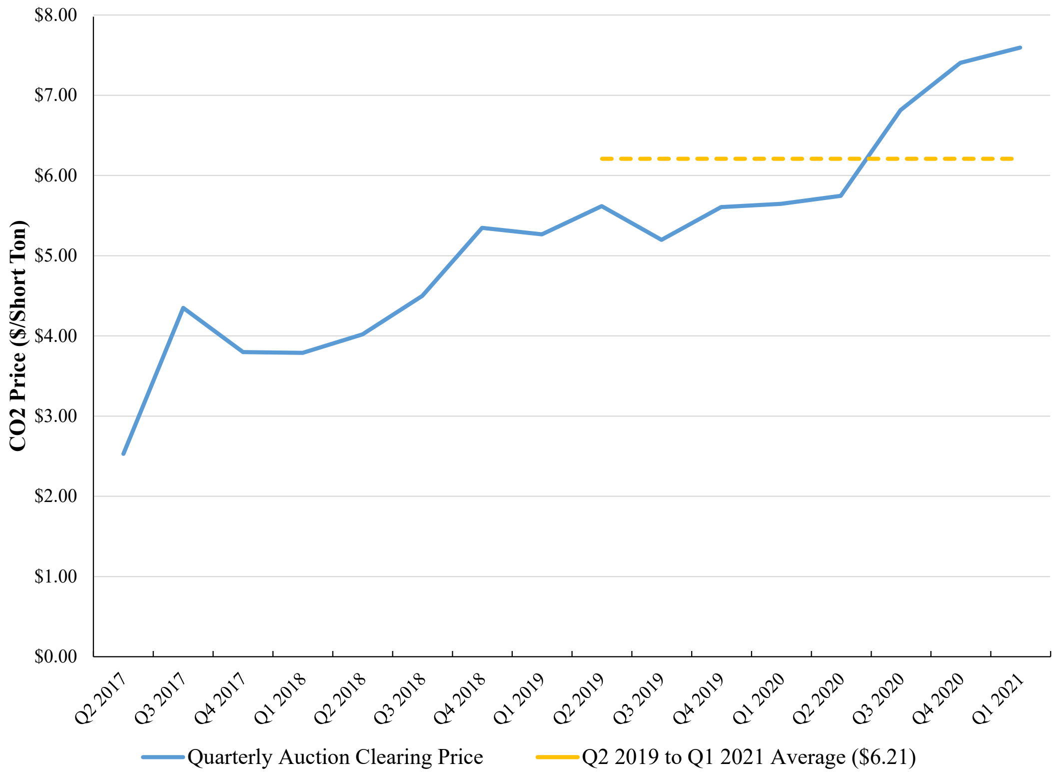
Emissions Prices

- 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)



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

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

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

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	✗

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*.)

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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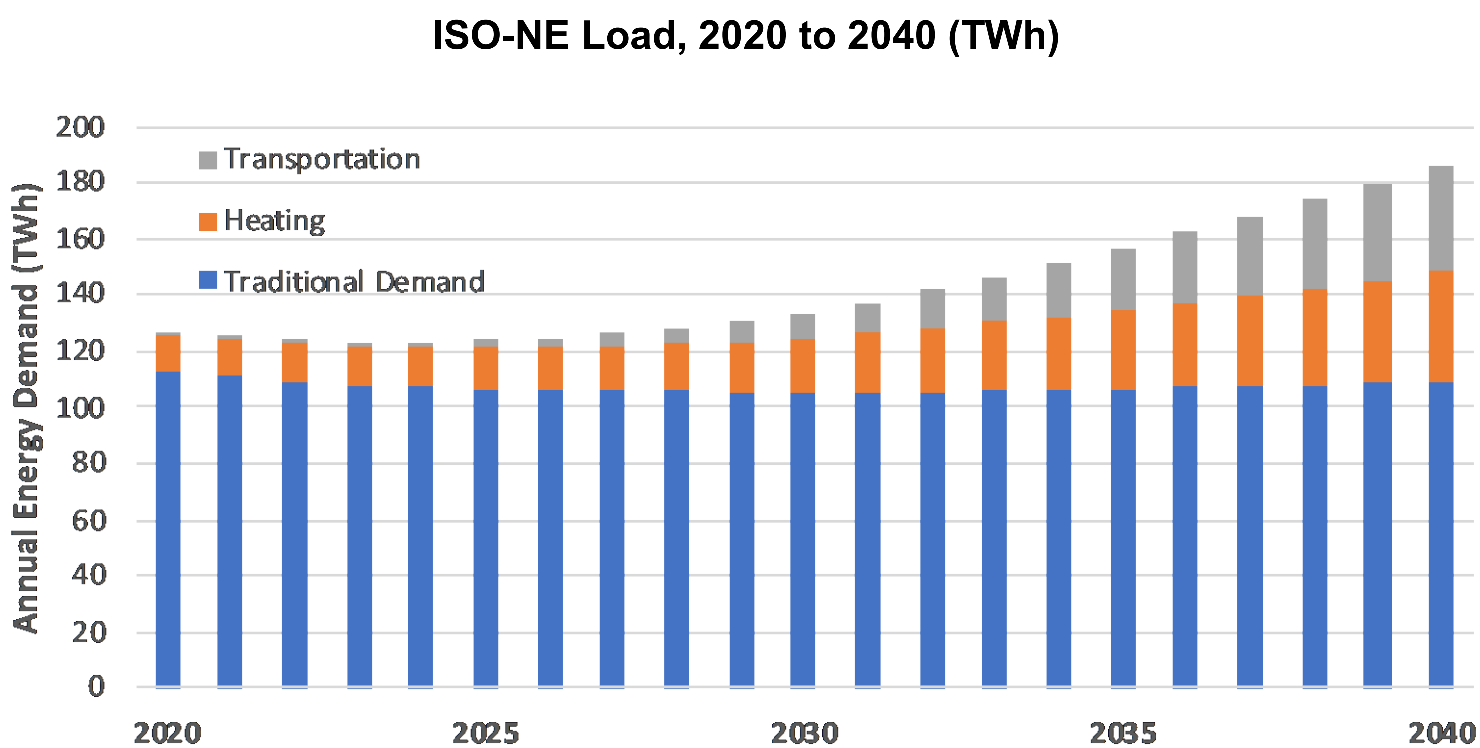
Modeling Inputs and Assumptions: Load Assumptions

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

FGRS Scenario 3 Load Growth



Source: Scenario 3 Load Assumptions, NESCOE

Case Assumptions:
State Policies

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

	2040 Requirement Quantity (% of Load)
State	**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.

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

Case Assumptions: Status Quo

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

Case Assumptions: FCEM/ICCM

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

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	✗

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

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

Case Assumptions:
Net Carbon Pricing

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.

Outcomes

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)

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

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

Contact

Todd Schatzki
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To: Chris Geissler, Todd Schatzki

Cc: Dave Cavanaugh

From: Bill Fowler

Date: April 22, 2021

Subject: Pathways Modeling - MSW

As you're formulating your models for FCEM and Carbon Pricing, I know you'll need to figure out how to characterize MSW in the various models. My suggestion is that you consider MSW as "clean" and thus in the mix that is eligible for CECs. Because MSW facilities offset large amounts of methane emissions from landfills, they can be considered net negative for overall GHG emissions, despite the actual CO_2 that they do release. As a result, MSW is currently exempted from RGGI in New England, and is also exempted from the need to buy MASS carbon offsets. If you were to create a rule, say, that just mirrors RGGI as far as what constituted "clean" then that could avoid having to go through a technology-by-technology assessment fraught with (political) judgment. While no one knows what the future holds for regulation, modeling based on the current regulatory framework seems most appropriate.

Please let me know what you think.

-Bill

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EVERSOURCE ENERGY

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April 28, 2021

Dear NEPOOL Participants and Stakeholders,

In response to the April 15, 2021 discussion during the NEPOOL Participants Committee Working Session: *Pathways to the Future Grid,* Eversource offers the following comments:

1. **Model structure and mechanics.** Developing clean energy projects absent long-term contracts with the Electric Distribution Companies (EDCs) as counterparties presents project developers with a higher level of risk due to volatility in market-based revenues. Eversource recommends that Analysis Group's (AG) modeling opine on the viability of project developers to finance new clean energy projects under a Forward Clean Energy Market (FCEM) and net carbon pricing. For example, including a weighted average cost of capital (WACC) input assumption that reflects a higher level of risk under FCEM if the developer doesn't have security of revenues equivalent to long term PPAs and net carbon pricing which could yield short term volatile pricing would produce capacity expansion results that informs stakeholders on the costs, benefits, and viability of incenting new clean energy resources under alternative market structures.

2. **FCEM interaction with existing state programs.** Allowing a clean energy resource to earn both renewable energy credit (REC) revenue and clean energy certificate (CEC) revenue as described in Approach 1 must conform with state greenhouse gas (GHG) emission inventory calculations. For example, the Massachusetts Department of Environmental Protection (MassDEP) is responsible for calculating the GHG emissions from electricity consumed in Massachusetts under the Global Warming Solutions Act (GWSA). Eversource is concerned that enabling a clean megawatt-hour (MWh) to earn *both* REC and CEC revenue will make the GWSA GHG emission inventory calculation significantly more complicated and opens the possibility of a single MWh of clean energy being accounted for multiple times and/or in the GHG emission inventories of multiple states.

   Eversource agrees with some stakeholders that state environmental programs are likely to continue and are unlikely to be discontinued (as proposed by Approach 3). However, existing state programs, such as renewable portfolio standards (RPS) and the Massachusetts Clean Energy Standard (CES), have not led to significant new clean energy project development. Therefore, modeling Approach 3 under an Integrated Clean Capacity Market (ICCM) construct is likely to provide a useful comparison to the net carbon pricing approach and should not be eliminated from consideration at this stage of the process.

Thank you for the opportunity to comment and we look forward to working with you on this initiative for New England market participants and stakeholders.

Sincerely,

James Daly
Vice President Energy Supply

NESCOE
New England States Committee on Electricity

To: ISO-NE and NEPOOL Stakeholders
From: NESCOE
Date: April 29, 2021
Subject: Pathways Analysis Scenario Request

As you know, NESCOE is evaluating many features of various proposed FCEM models and our responses to questions or analysis suggestions should be viewed in that context. They do not indicate and should not be interpreted to signal design preferences, or the point of view or position of NESCOE or any NESCOE Manager.

In general, NESCOE understands the theory that there would be market efficiency benefits from application of a broad product definition common across all states: a broad eligibility definition would increase competition and likely achieve lower overall costs. We agree that the base modeling should reflect such a broad product definition.

As noted, we continue to evaluate the many features of a proposed FCEM design, including the workability of, and any impediments to, the implementation of a broad product definition. To help inform our thinking, and possible approaches, we are interested in two proposed scenarios, FCEM with multiple constraints and a hybrid model. Again, we seek these scenarios to obtain information to further our understanding, not as design preference.

We explain these scenarios below and would be pleased to talk further about them if helpful.

FCEM with Multiple Constraints

Most state laws have objectives in terms of "renewable energy", or specific objectives, such as solar. The assumption for modeling purposes is that these state programs will remain. A CEAC demand bid for a broad common product definition could result in a purchase of attributes from resource types that may not meet one or more states legal requirements.

To mitigate this risk, a possible approach is to include a constraint in the FCEM for these existing state program requirements (similar to a zone in the Forward Capacity Market – or reserve product constraint in the energy market).

To better understand some of the effects of such a design change, we suggest a scenario where each requirement stands on its own and there is no relationship between them (incremental requirements). For example, under this scenario the FCEM would procure products with broad eligibility and also for renewable[1], off-shore wind, and solar photovoltaic (PV) minimum requirements.

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[1] This would be defined as On-shore Wind, Hydro, Anaerobic Digestion, Geothermal, Solar Thermal, Ocean Thermal, Wave, Tidal, Fuel Cell, Anaerobic Digestion. For efficiency reasons, we note the modeling may be limited to just a certain set of resources.

We are open to the specific volume targets; however, they should be large enough to illustrate the difference between this scenario and the base FCEM case.

Before moving forward with the analysis, we would like to discuss with ISO-NE to better understand how modeling these constraints in the FCEM would produce different results than just modeling the FCEM with the existing state programs, as our expectation is that expected revenues from state programs would impact how resources may offer into the FCEM.

Hybrid Model

In its March 5, 2021 memo to ISO-NE and NEPOOL stakeholders, NESCOE questioned if there should be a hybrid model.[2] As with the previous scenario request, we understand the possible reduction in economic efficiency resulting from a hybrid model; however, efficiency associated with a single product is a theoretical and long-run concept.

Under this possible scenario, holding all else equal, a hybrid model would have an FCEM supply eligibility that is limited to any resource that would qualify as "new" under the current FCM rules (or cleared in a prior FCEM where it met the prior eligibility) combined with net carbon pricing set at a level to ensure revenue adequacy for largest existing clean energy resource.[3]

[2] See page three question 9 of March 5, 2021 memo to ISO-NE and NEPOOL stakeholders.
[3] We believe this would be the Millstone facility.

MEMORANDUM

April 29, 2021

To: ISO New England, NEPOOL

From: Pete Fuller & David O'Connor, on behalf of NRG Energy and other stakeholders

Re: Future Grid Pathways Study – Additional Input for May Pathways Meeting

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We appreciate the thoughtful and deliberate approach that ISO-NE and Analysis Group are taking in formulating a meaningful analysis of the Forward Clean Energy Market (FCEM, or ICCM[1]) and Net Carbon Pricing options as sustainable mechanisms to incorporate State clean energy and emission reduction goals into the ISO markets. In preparation for the May 13 Pathways meeting, we offer this memo to provide additional input and feedback regarding the structure and assumptions for the Pathways study.

The content here was drafted by consultants for NRG Energy, Inc. based on discussions and collaboration with a number of other NEPOOL market participants. We appreciate the opportunity to continue to engage with the ISO, NESCOE and other stakeholders and provide our perspectives on the important design parameters for incorporating the New England States' clean energy and decarbonization objectives into the ISO competitive markets, and we look forward to continued collaboration on these issues.

Treatment of State Programs (RPS, RECs, etc)

We continue to believe that the modeling of any interactions between ICCM and the many State programs to encourage various energy resource technologies should strive for simplicity, focusing on the impact, within ICCM, of potential revenue streams that some resources participating in ICCM could receive from the sale of GIS certificates to RPS compliance entities. Modeling the full RPS environment appears beyond the scope of what is needed and seems likely to add unnecessary complexity to the effort.

As a baseline for comparison and based on the many complexities involved in envisioning a future with both RECs and ICCM, we believe it would be prudent to run a scenario based on ISO's proposed 'Approach 3,' in which States eliminate the RPS and similar programs in favor of the single clean energy product of the ICCM. This scenario would provide potentially useful information to

[1] As noted in our previous materials, we perceive a general preference among stakeholders for the Integrated Clean Capacity Market (ICCM) approach, so we generally refer to ICCM, recognizing that developing a design and model for ICCM will encompass all of the work needed to design and model the FCEM as a separate market from the Forward Capacity Market (FCM), and that the separate FCEM approach will have its own challenges with respect to designing its interactions with FCM.

policymakers regarding the relative cost of using ICCM as a replacement for RPS compared to using it as a complement to existing programs. Incorporating this assumption in the Capacity Expansion model would eliminate any technology or other constraints associated with State RPS programs and should lead to the most cost-effective resource mix for decarbonizing the New England grid.

However, since the status quo is that the State RPS programs exist, it is also important to model the various pathways options operating in tandem with the State programs. As we heard at the April 15 meeting, there are market participants that speak strongly in favor of a version of 'Approach 2,' in which a resource selling into ICCM would be deemed to transfer all of the environmental/REC attributes through that sale. As we understand this approach, ISO would effectively take possession of the associated GIS certificates and would allocate them proportionally to the LSEs having a payment obligation for the clean energy aspect of ICCM. Today's REC markets would become secondary markets for LSEs to trade and balance their positions to shed the certificates they don't need and to acquire the certificates they do need to meet their particular compliance obligations.

At the same time many, if not most, participants appear to be open to some version of ISO's 'Approach 1,' in which a resource selling into ICCM would be transferring the non-carbon-emitting attribute of its energy but would retain all other environmental/REC attributes in the form of GIS certificates. This is the approach ISO-NE tentatively endorsed at the April 15 Pathways meeting.

At that meeting, there was at least one observation that the difficulty many stakeholders are having with this topic might stem in part from the characterization of the ICCM clean energy product as a 'credit,' with all the implications of a product analogous to RECs, such as creating and transacting the 'Clean Energy Attribute Credit' (CEAC) in GIS and having LSE compliance obligations settled in the year following delivery.[2]

To expand on that idea, we suggest consideration of the following formulation of the ICCM clean energy 'product' as the basis for one scenario. This approach would de-emphasize the concept of clean energy 'credits' as the currency of ICCM/FCEM and would define the product simply in terms of an ISO market requirement, based on submitted State and voluntary demand bids. Clearing as a supplier in the clean energy aspect of the ICCM auction would create 'Clean Energy Supply Obligations' (CESO) analogous to 'Capacity Supply Obligations' (CSO) in the Forward Capacity Market, and an obligation on each affected LSE to pay for their proportional share of the total costs paid to CESO suppliers. Consistent with ISO's Approach 1, an eligible MWh of energy would satisfy a seller's CESO delivery obligation in the wholesale market and would also be eligible to generate whatever certificates the technology is eligible for in GIS. LSEs would continue to source RECs as they do today and would be responsible for their RPS compliance under the existing State statutes and regulations.[3]

[2] We have described FCEM/ICCM in these terms in our previous documents but we continue to explore other concepts as we learn more about the complexities of this topic.

[3] States could specify (through appropriate legal and regulatory actions) the extent to which an LSE's payment for ICCM supply that cleared in the ICCM Auction would satisfy some or all of the LSE's state clean energy compliance obligations.

For modeling purposes, the interaction between REC markets and ICCM would consist of ICCM suppliers accounting for anticipated REC revenues (if any) when formulating their ICCM offers, and in REC prices being reduced as a result of eligible resources also receiving ICCM clean energy revenues. This is consistent with our expectation that the two markets would operate with different formats and on different timeframes (ICCM as a one-time forward auction for an annual quantity vs. RECs traded through broker-based bilateral transactions that occur anywhere from years ahead to several months after delivery). At the time of the ICCM auction, suppliers would gauge their prospects for selling certificates and their anticipated revenues, as well as accounting for any certificates already sold for the future delivery period and their need for the multi-year price lock in ICCM to support financing new investment. These forecasts and expectations would inform their offers into ICCM. Likewise, after securing CESOs, suppliers would adjust their price requirements and expectations in the REC market based on the CESO payments. States may want to adjust the level of Alternative Compliance Payments (ACP) downward to account for the availability of revenues from ICCM.

Thus, for Pathways purposes, the model could simply assume a price for the various REC products and use these prices as a discount off of estimated resource costs for purposes of estimating offer prices into ICCM. For modeling purposes, this is a simple and straightforward approach, and could accommodate several REC pricing scenarios, as well as estimated risk adders that suppliers might build into their offer prices based on uncertainty in the price and ability to transact their certificates.

However, we also believe that modeling 'Approach 1' in this way would not preclude the States from adopting a different approach for flanging ICCM up to existing State programs. The approach suggested here would provide insights regarding how ICCM could co-exist with a continuation of these programs, and a comparison to a 'no RPS' scenario.

Treatment of Storage Resources

As noted in our previous feedback on Pathways modeling, we suggest modeling ICCM clean energy attributes as having a constant value in any hour, which we have previously referred to as a 'static' approach. We continue to believe that is the simpler approach for the quantitative modeling effort, but we also strongly support parallel efforts to better understand how dynamic, or time-varying value of the ICCM clean energy product could work. For example, understanding hourly dynamics, patterns and relationships of emission rates and correlations to demand, price or other observable factors. We would then expect to develop one or more frameworks for dynamic valuation of the ICCM clean energy attribute to be used in actual implementation of the new market.

Fundamentally, we agree with ISO-NE's observation in recent materials that energy storage will be a valuable part of the future mix and will need to be compensated for its contributions and services. We are not convinced that the assumed on-peak/off-peak energy price differentials that ISO hypothesizes in its most recent materials[4] will exist on a reliable basis or at the magnitudes suggested by ISO's examples. As such, we are still interested in exploring other vehicles to compensate energy

[4] ISO-NE, 'Storage Resource and Pathways to a Future Grid,' April 8, 2021

storage resources and other 'non-energy-intensive' resources that provide flexibility and responsiveness to the system, though these mechanisms may not necessarily be in the context of ICCM.

Additionally with respect to energy storage resources, NEPOOL and ISO-NE found in the context of the recent evaluations of FCM parameters that there are a number of ways in which traditional production cost and similar simulation models need to be specifically adapted and perhaps modified to properly reflect the operations and optimization of energy storage resources between functions and across the hours of a day. It would be very helpful to have some materials and discussion at the Pathways meetings regarding how the Analysis Group's model simulates the optimization and operation of energy storage.

Capacity Expansion Model

It also became clear at the April 15 Pathways meeting that the Capacity Expansion model would be a central component of the quantitative analysis. Analysis Group proposes, very reasonably, to set a near-term baseline of resources and system conditions and then run the Capacity Expansion model with each of the three assumption sets (ie, Status Quo contracting, ICCM, and Net Carbon Pricing) out to 2040 to estimate how the system would evolve under each of the frameworks. Since this model will be a major determinant of the study outcomes, Analysis Group should provide documentation and/or presentation on the inputs and logic of the model. Specifically, since financing of new projects is a key question to be explored in the Pathways analysis, how does the AG Capacity Expansion model simulate the investment decisions and the potentially different costs of capital under the different frameworks?

Modeling ICCM or FCEM

There continues to be a general preference for the ICCM approach and we look forward to further discussion of this issue at the May 13 meeting.

MOPR

In the materials for the April 18 Pathways meeting Analysis Group notes on slide 8 that 'Application of MOPR will be determined.' We note that the outcome of the pending Offer Review Trigger Price filing (anticipated in early June) and FERC's technical conference regarding ISO-NE's Resource Adequacy construct (May 25) will be instructive in terms of what the near-term MOPR will look like, and what changes might be expected, and on what time scale.

Regardless of what we learn in the near term, for setting up the modeling exercise we suggest evaluating the impact of a MOPR that draws a distinction between 'in-market' and 'out of market' revenues. For the Status Quo and Net Carbon cases, this would entail testing a scenario with MOPR and one without. For the ICCM case, there would be no explicit MOPR, but the model should assume all new resources offer at their full economic costs net of anticipated EAS revenues, ie, with no MOPR but with standard market-based incentives to not make an investment that is expected to lose money.

We appreciate the continued openness of ISO-NE, Analysis Group, NEPOOL and all the stakeholders to our input and we look forward to continuing to work toward a successful modeling exercise and ultimately to a successful reformation of the region's markets to support decarbonization and reliable operations of the power system.

Memorandum

TO: CHRIS GEISSLER AND DAVE CAVANAUGH

FROM: JASON FROST AND DOUG HURLEY, ON BEHALF OF POWEROPTIONS AND THE NEW HAMPSHIRE OFFICE OF THE CONSUMER ADVOCATE

DATE: APRIL 29, 2021

RE: PATHWAYS TO THE FUTURE GRID INPUTS AND ASSUMPTIONS

Thank you for presenting initial inputs and assumptions for the Pathways to the Future Grid analysis that will model and evaluate the Forward Clean Energy Market (FCEM) and Net Carbon Pricing (NCP) proposals. One difference between these two proposals that impacts end users is the potential for costs to load from an increase in payments to efficient, moderate emissions fossil fuel powered generation. Under FCEM, it is likely that only zero emissions resources would be compensated for their ability to reduce environmental externalities produced by fossil fuel powered generators. Under NCP, by comparison, compensation occurs indirectly through increased energy prices. Relatively less polluting fossil fuel powered generators, such as more efficient combined cycle generators, may incur a smaller carbon price fee (in $/MWh) in many hours than the carbon price incurred by the marginal generator. In this situation, the more efficient generator would see increased revenue despite not generating any carbon free energy that the region is seeking. It appears that the increase in revenue would be proportional to the amount of the carbon price. A higher carbon price would mean more revenue for more efficient fossil resources.

We would like the analysis to provide outputs that demonstrate the magnitude of this effect. We request that the analysis quantify the total net incremental payment to fossil fuel resources as a result of the net carbon pricing proposal. To understand the impact the carbon price has on LMPs and compensation to each class of resources, we specifically request that the following outputs be produced as part of the modeling process:

- The average impact of the carbon price on energy prices (in $/MWh) based on the emissions rate of the marginal unit, weighted by
    - Zero emissions generation
    - Fossil fuel fired generation
    - Total generation (excluding imports)
    - Total load
- Total quantities (in MWh) of zero emissions generation, fossil fuel fired generation, and load
- Total carbon price payments charged to all emitting generators that are impacted by the program (or equivalently, the total amount rebated back to load under the NCP construct)

These key outputs will allow stakeholders to evaluate not only the total cost of the NCP structure, but also how the total cost to end users is distributed among generation types.