AGENDA
JOINT MEETING
NEPOOL MARKETS & RELIABILITY COMMITTEES
WEDNESDAY, MAY 27, 2020

LOCATION: Teleconference
Call-in Number: 1-866-803-2146 / Access Code: 7169224
WebEx: WebEx Link
WebEx Password: nepool

Item	Description	Time Allotted
WEDNESDAY, MAY 27		
1	CHAIRS' OPENING REMARKS ***(A) Approval of Minutes [66.67% MC vote] [66.67% RC vote]*** Joint MC/RC Meeting Date: April 7, 2020	12:30 – 12:35
2*	TRANSITION TO THE FUTURE GRID STUDY	
	(A) INTRODUCTION (NEPOOL Chair: Nancy Chafetz) (1st MC/RC Mtg) Introduction and background on where NEPOOL is in the process and the goals for the Transition to the Future Grid Study.	12:35 – 12:50
	(B) REFINED CONCEPTUAL APPROACH (NESCOE: Ben D'Antonio) (2nd MC/RC Mtg) Discussion of other studies, implications for Future Grid Study, approach for developing assumptions and proposed study areas.	12:50 – 2:40
	(C) CURRENT MODELING CAPABILITIES OF POWER SYSTEM AND MARKET STUDIES AT ISO NEW ENGLAND (ISO-NE: Xiaochuan Luo) (1st MC/RC Mtg) Presentation of ISO's key modeling capabilities in reliability, economic, and market assessments and the types of information these models can provide.	2:40 – 4:30
	(D) FUTURE GRID – THOUGHTS ON A PATH FORWARD (NRG and SunRun: Peter Fuller) (1st MC/RC Mtg) Presentation of what questions need to be addressed with the analysis and initial considerations on how to structure the study.	4:30 – 5:00
	(E) REVIEW FUTURE JOINT MC/RC MEETING DATES (MC Chair and RC Chair) Discussion of next steps and review tentative dates for future joint MC/RC meetings.	5:00 – 5:15
3	OTHER BUSINESS	5:15 – 5:20

* Material distributed for this agenda item
AGENDA ITEMS with BOLD & ITALICIZED FONT: MC ACTION Requested
WMPP: Wholesale Markets Project Plan

Transition to the Future Grid

Concepts for Stakeholder Discussion

NEPOOL Joint MC and RC Meeting

May 27, 2020

Overview

- NESCOE's Point and NEPOOL's Objective
- Thoughts on Feedback from Last Meeting
- Some On-Going Relevant Studies
- Frontloaded Work on Study Areas

Context

- All materials are preliminary and offered for the purpose of facilitating reactions, questions and discussion.
  - This presentation is being made to prompt discussion and feedback to move the process ahead.
- None of the materials reflect the views of NESCOE or any NESCOE Manager.
  - NEPOOL’s feedback may help inform those views.
- Nothing in this material is intended to imply a view about NEPOOL processes and none should be inferred.

NESCOE's point, in asking for work on Markets & State Laws

Ultimately, to support states and stakeholders in analyzing and discussing potential future market frameworks that contemplate and are compatible with the implementation of state energy and environmental laws, consistent with reliable power system operations.

Reference *NESCOE July 2019 Work Plan Request*
http://nescoe.com/wpcontent/uploads/2019/07/WorkPlan2020Request_16July2019.pdf

NESCOE
New England States Committee on Electricity

NEPOOL identified interest in analysis, which ISO-NE and NESCOE support

February 2020

NEPOOL Feedback to NESCOE April MC/RC Preliminary Discussion on Analysis

1. What is the most efficient way to move necessary analysis along?

2. What about other relevant studies in process? Is additional study needed? If so, of what level of analysis?

3. How would a new study interact with ongoing discussions on market mechanisms ?

Our Thoughts on NEPOOL Feedback

- We share interest in finding efficiency
- We're talking with other study sponsors to understand:
    1. Can preliminary assessment of the "Gap Analysis" bubble on Slide 5 be determined from these past/current studies – are we already 80% of the way there?
    2. If a reasonable preliminary assessment can be accomplished from past/current studies, can the discussion on the last bubble begin without a new study?
    3. If additional study elements are required, then:
        1. Can carbon compliant resource mixes (and other assumptions) be determined from these past/current studies?
        2. Can these studies' scenarios be imported into any economic and/or engineering analyses for efficiency?
        3. Could they be limited in scope to answer specific unanswered questions from past/current studies?

- Answering these questions will help "Transition to the Future Grid" process (slide 5) and achieve NESCOE's point (slide 4)
- Any "Transition to the Future Grid" study will overlap with discussions about market mechanisms happening now in various forums. The "Future Grid" analysis could help inform those discussions, and vice versa, as well as when NEPOOL begins to discuss market mechanisms.
    - What might sound reasonable in the short-term may not be the place we want to be in the long-term.
    - Knowing where we want to be in the future could guide short-term actions.

One Possible Approach

- First assess current studies and identify what analysis remains necessary.
- Conduct any additional analysis ("gap analysis") to determine whether, given the requirements of state laws (power, heating, transportation), the wholesale markets and transmission network enable reliable system operation, and if not, what deficits need to be addressed to achieve reliable power system operations.
- To that end -
  - leverage existing analyses (to narrow what needs to be analyzed as appropriate and to capture efficiencies in remaining analysis),
  - ensure sufficient economic, operational, and engineering analyses as necessary to inform discussions,
  - examine operational issues, reliability concepts, and resource economics in a hypothetical future with an electricity grid that is carbon compliant pursuant to the requirements of state laws (power, heating, transportation, etc.),
  - per NEPOOL direction, plan on an MC/RC forum for participation and transparency, and
  - deliver actionable information as quickly as possible in clear, concise, and plain language and graphics.
- Discuss potential market approaches to address any such gaps, and their pros and cons, ("market framework discussions").
- Provide useful and actionable information by the end of 2020, which timing may also inform other near-term market framework discussions.

What we plan to do next

- Continue talking to stakeholders and provide our thoughts on the previous questions
- Seek out stakeholder views on the same
- Request to hear from as many other study sponsors as possible at the next RC/MC
- Continue to work with NEPOOL and ISO-NE on the overall process

Review of Current Studies

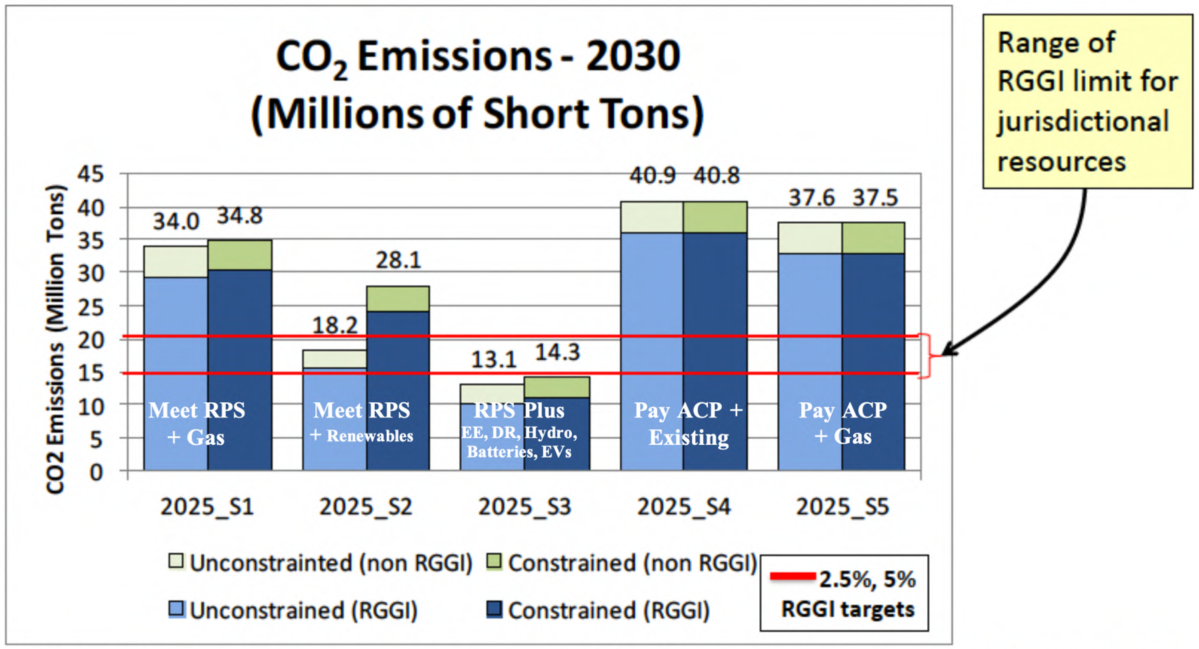
The list of studies here is non-exhaustive and is provided for information. Discussion of studies does not indicate a preference for any particular study, scenario, consultant, project, or mechanism.

Also see NEPOOL's Transition to the Future Grid Reference Library

Review of Current Studies

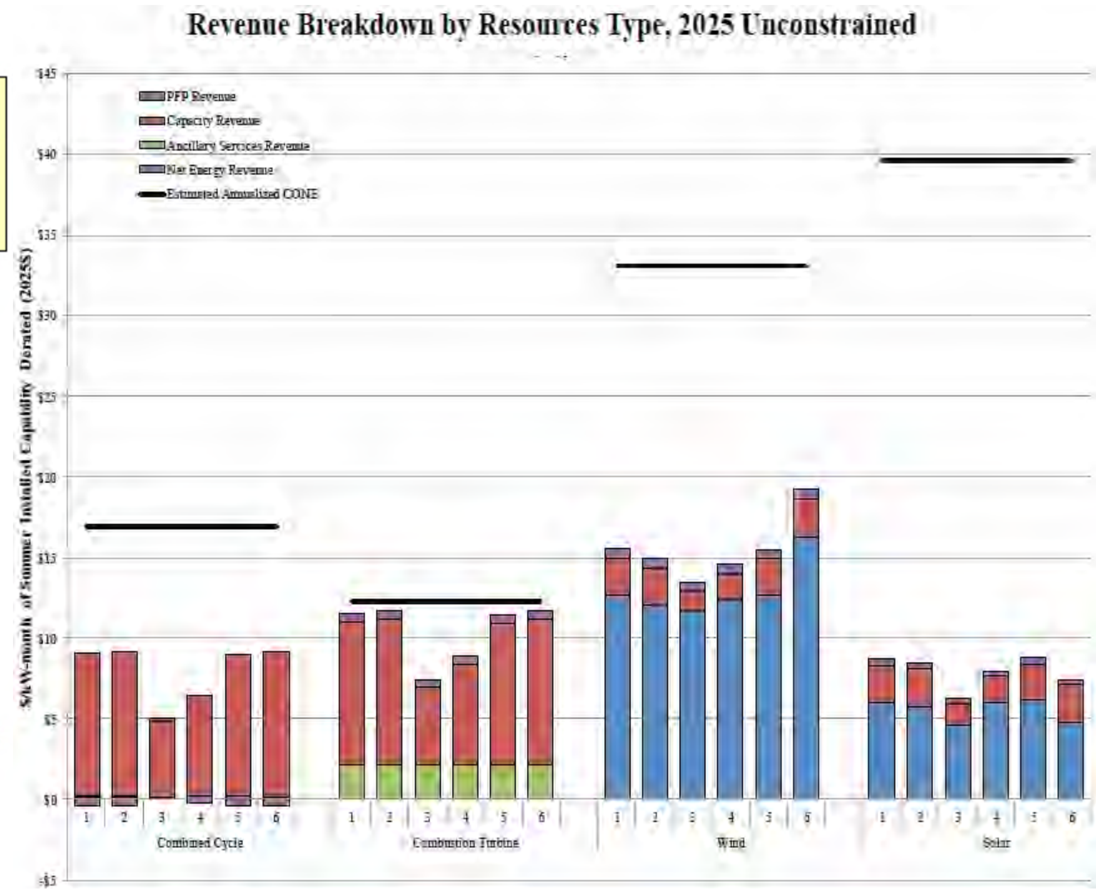
	Study	Study Objective	Finding(s)
1	NEPOOL 2016 Economic Study	Scenario analysis in 2030 – Energy, Capacity, Ancillary Services, High Level Tx Cost Estimates	"As the quantity of new clean resources added to the system increases, the cost (per MWh or MW) of supporting clean resources increases. The gap in revenue requirement (for new entry) needs to be filled by other sources because of decreases in revenues from both the FCM and energy markets." ~ Analysis Group "Higher carbon prices reduce emissions only when carbon prices effect the economic dispatch order of generating units and lower carbon emitting replacement energy is available" – ISO-NE Carbon Sensitivity Results
2	Conservation Law Foundation 2017 Economic Study	Low-carbon-emitting resource-expansion scenarios and potential effects on resource adequacy, operating and capital costs, and options for meeting environmental policy goals	The EE + Offshore scenario has the lowest CO2 emissions and, along with the Renew Plus scenario, meets both the 2.5% and 5% RGGI targets for both the constrained and unconstrained cases. The relative annual resource cost (RARC) for the EE + Offshore scenario is similar to the reference RARC (the Renew Plus scenario, 2016 NEPOOL Scenario Analysis 3)
3	NESCOE 2019 Economic Study	Offshore Wind Integration in 2030 – Energy, Ancillary Services, High Level Tx Cost Estimates	High Level Transmission Findings (to date) • Based on the currently expected transmission system for 2030, the ISO anticipates that the depicted levels of offshore wind additions (approx. 7,000 MW) have the potential to be accomplished without major additional 345 kV reinforcements* • This assumes FCA 13 retirements have occurred, including the retirement of Mystic 8 & 9 Ancillary Services (TBD)

Review of Current Studies – NEPOOL 2016 Economic Study



Source: 2016 Economic Studies: Draft Results Part II, slides 107-108, available at https://www.iso-ne.com/static-assets/documents/2016/09/a6_2016_economic_study_draft_results_part_2.pdf.

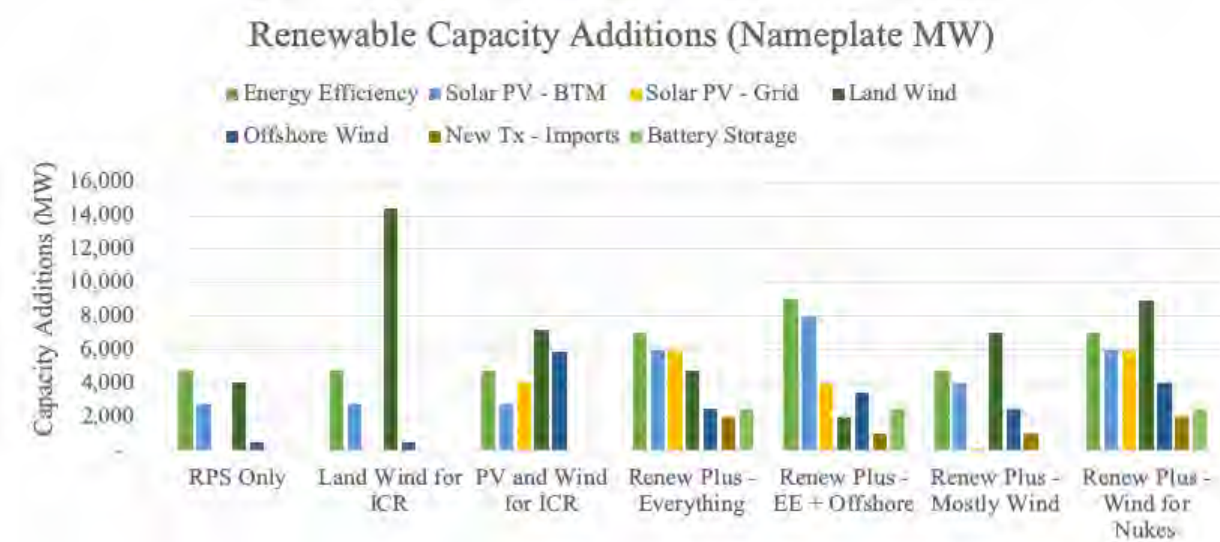
(Source: NEPOOL 2016 Economic Study)



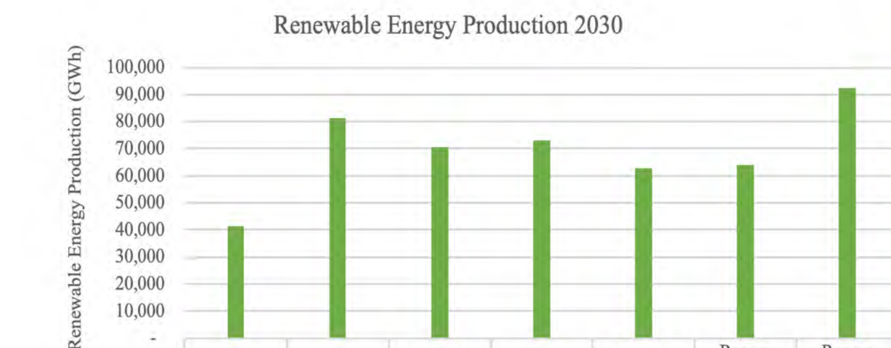
(Source: Analysis Group for NEPOOL 2016 Economic Study)

Review of Current Studies - NEPOOL 2016 and CLF 2017 Economic Studies

How much renewable and clean energy did those studies analyze?



'Status quo' → Increasing Penetration → 'All-of-the-Above' and variations



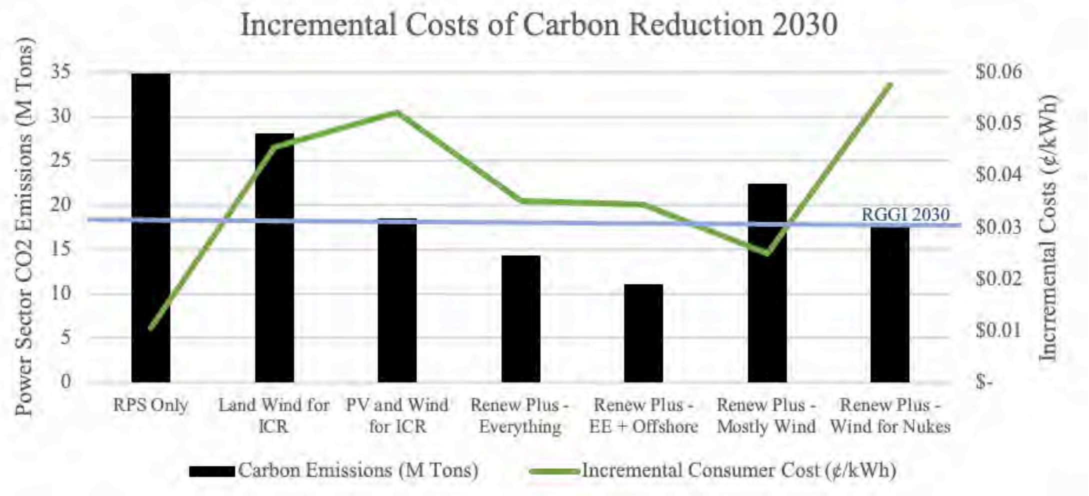
	RPS Only	Land Wind for ICR	PV and Wind for ICR	Renew Plus - Everything	Renew Plus - EE + Offshore	Renew Plus - Mostly Wind	Renew Plus - Wind for Nukes
Renewable Production	41,319	81,243	70,638	73,237	62,686	63,983	92,517

'Status quo' → Increasing Penetration → 'All-of-the-Above' and variations

Data Sources: ISO-NE 2016 and 2017 Economic Study Results
Charts: NESCOE Staff Analysis

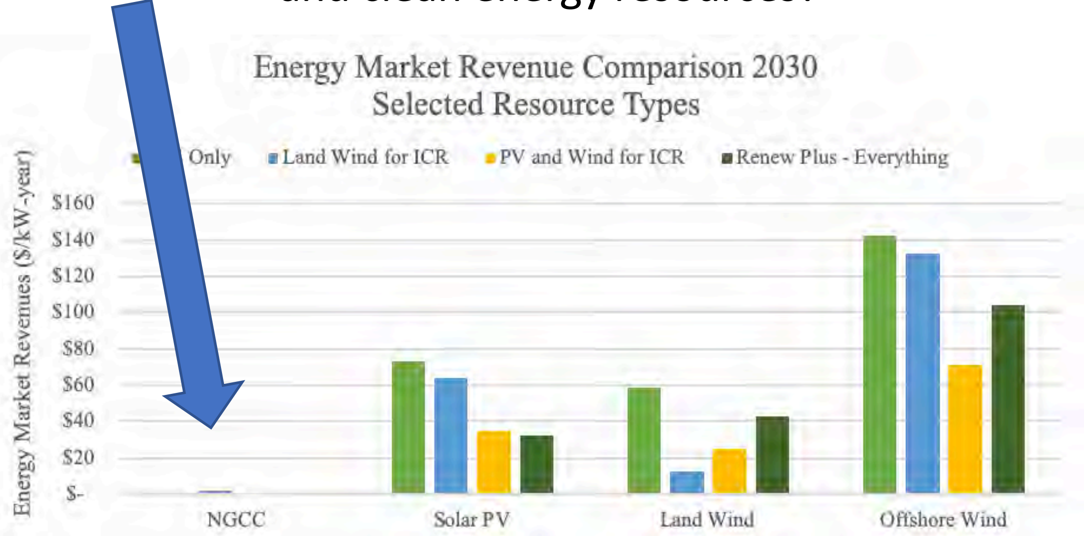
Review of Current Studies – NEPOOL 2016 and CLF 2017 Economic Studies

How much power sector carbon emissions resulted from resource mixes with the assumed new renewable and clean energy resources?



'Status quo' → Increasing Penetration → 'All-of-the-Above' and variations

What are the energy market revenues resulting from resource mixes with the assumed new renewable and clean energy resources?



Data Sources: ISO-NE 2016 and 2017 Economic Study Results
Charts: NESCOE Staff Analysis

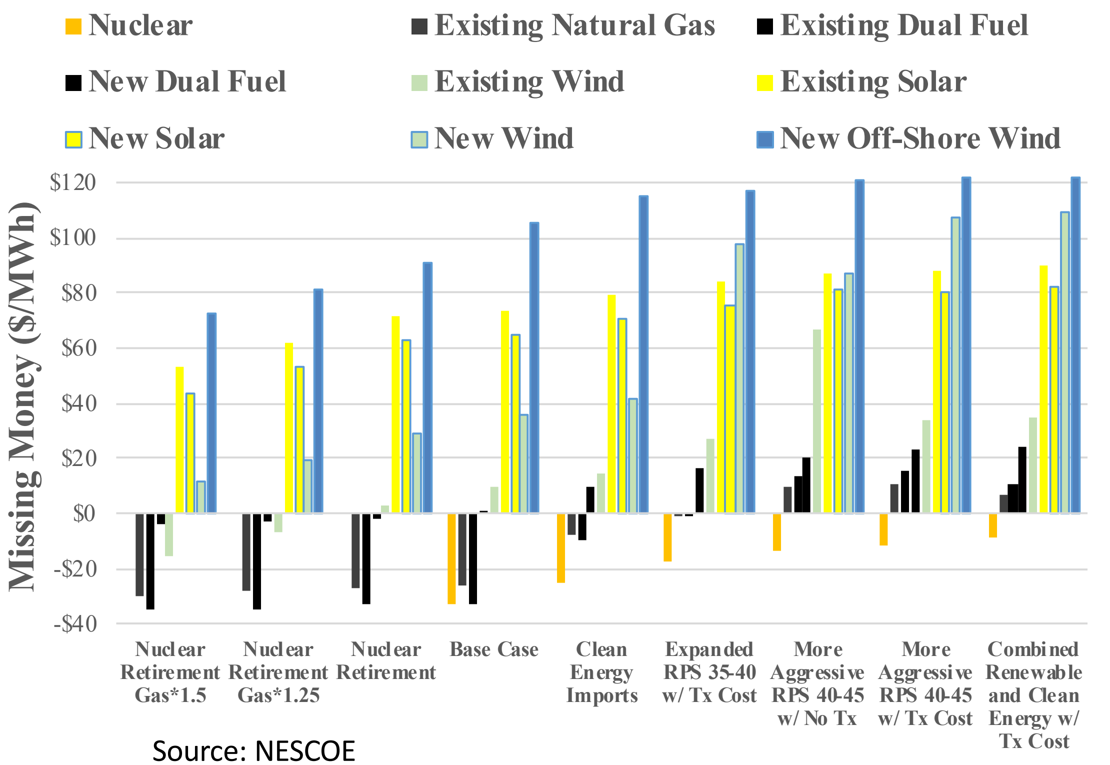
Review of Current Studies

	Study	Study Objective	Finding(s)

4	NESCOE Renewable and Clean Energy Scenario Analysis and Mechanisms 2.0 Study (Spring 2018)	Economic analysis of some of the possible incentive mechanisms states may wish to use to support meeting their renewable and clean energy requirements	• Wholesale energy and capacity costs move in the opposite direction from mechanism costs, and both directly affect consumer bills
			  ◦ As energy and capacity costs decline, mechanism costs increase
			  ◦ Temporary capacity cost declines have a significant impact on total costs to consumers
			• "Missing Money" increases outweigh the difference in estimated cost among mechanisms.
			• Whether one or more mechanisms may better serve consumers than another depends on a state's objectives and the trade-offs a state is interested in making

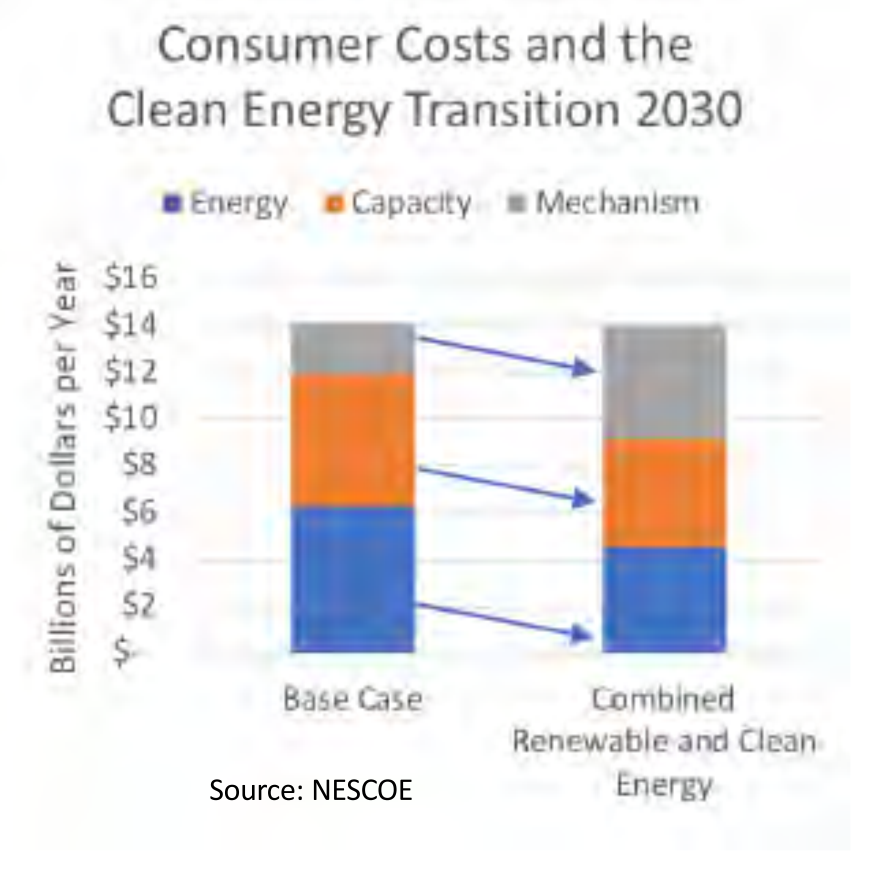
Review of Current Studies – NESCOE Mechanisms 2.0 Study

Estimated Missing Money: Selected Resource Types - 2025



Source: NESCOE

Illustration of the Shift in Costs from Markets to Mechanisms



Source: NESCOE

Review of Current Studies

	Study	Study Objective	Finding(s)
5	Clean Energy Accelerator by Brattle (Sept 2019)	Scenario analysis in 2030 – Energy, Capacity, Ancillary Services, High Level Tx Cost Estimates	Annual clean energy resource additions need to increase by a factor of four to eight times the current level (4x to 8x) to achieve 2050 carbon emissions reduction goals
6	Deep Decarbonization with HQ (April 2018)	Economic scenario analysis of the Northeast (New York and New England) and Hydro Quebec energy supply mix in 2050	More interconnections between the Northeast and HQ may be a less expensive approach to decarbonization than an alternative with an even greater reliance on offshore wind and solar
7	Deep Decarbonization in California by E3 (June 2019)	Examine resource adequacy under future scenarios in which California's economy is deeply decarbonized and heavily dependent on renewable energy	The least-coast electricity portfolio to meet the 2050 economy-wide greenhouse gas goals for California includes 17-35 GW of natural gas generation capacity for reliability

Review of Current Studies

	Study	Study Objective	Finding(s)
8	**FCEM Detailed Design by Brattle** (Sept 2019)	Propose a detailed market design for a competitive, regional forward clean energy market (FCEM) for clean energy attributes	Broad competition will minimize the costs of achieving carbon goals
9	**NESCAUM White Paper** (Sept 2018)	Provide high-level insights about the magnitude of actions needed to achieve New England's ambitious climate goals	• Immediate action is required • Electrify end-use energy consumption • Decarbonize the electric grid

Gap in Current Studies

Figure 11 - Business-as-Usual and Mitigation Scenarios through 2050 for New England

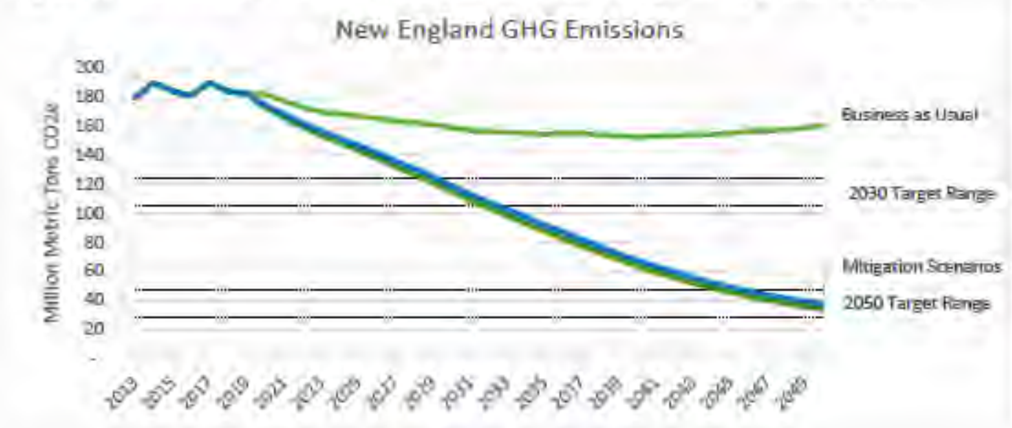
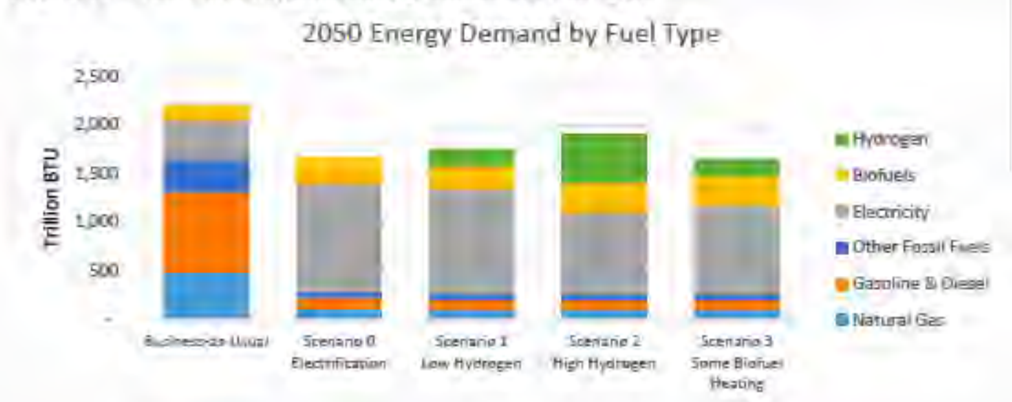


Figure 12 – Total New England Energy Demand by Fuel Type



Source: NESCAUM

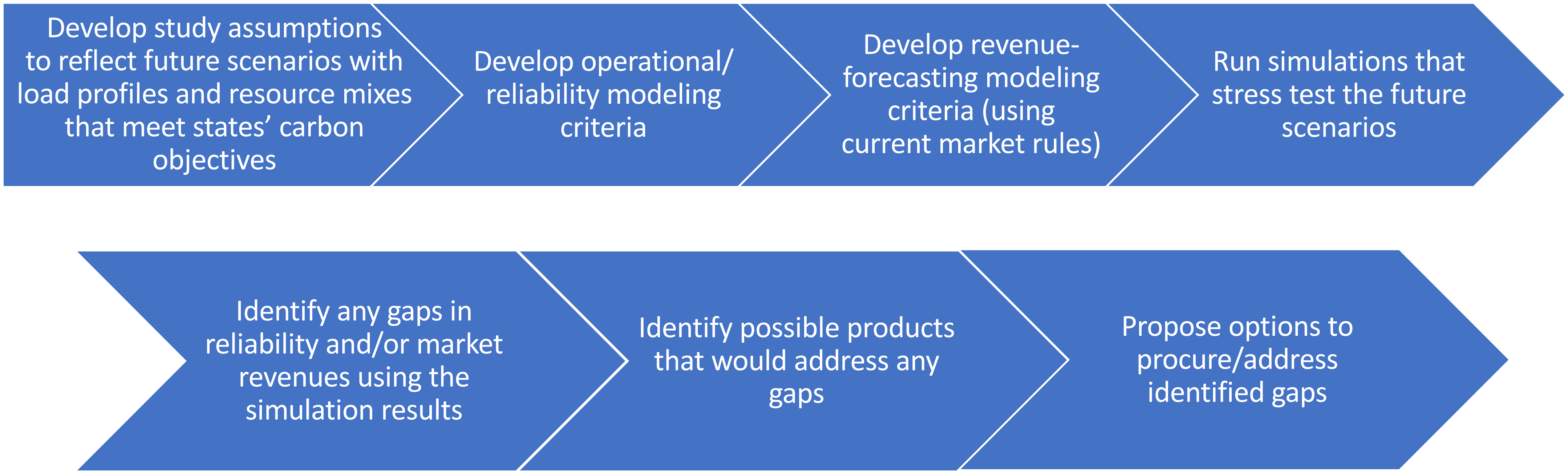
- Decarbonize Power System & Electrify Heating and Transportation
  - How much new load and when?
  - Managed heating and transportation loads or coincident? – Daily load shapes?
  - Retirements to decarbonize
  - New renewable and clean energy resources to serve loads with lower power sector air emissions

General Study Approach

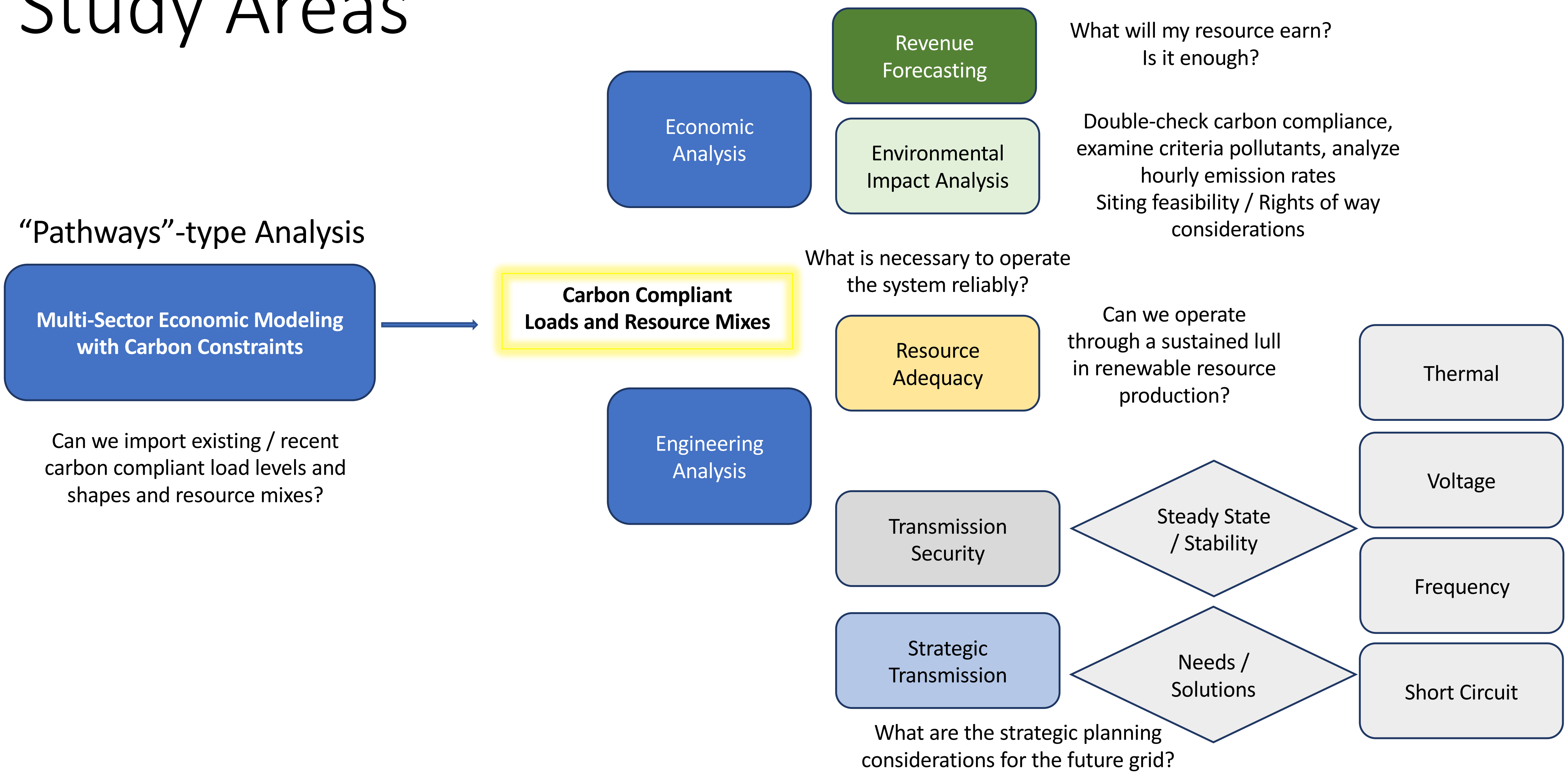
We believe we need to assess the prior studies and answer the questions just identified before deciding what analysis remains.

In the interest of time, we frontloaded some work on study analysis to make use of time and to facilitate everyone’s thinking. We review that next and note it would need to be revisited after assessing current studies.

General Study Approach



Study Areas


“Pathways”-type Analysis
Multi-Sector Economic Modeling with Carbon Constraints
Can we import existing / recent carbon compliant load levels and shapes and resource mixes?
Carbon Compliant Loads and Resource Mixes
Economic Analysis
Revenue Forecasting
What will my resource earn? Is it enough?
Environmental Impact Analysis
Double-check carbon compliance, examine criteria pollutants, analyze hourly emission rates
Siting feasibility / Rights of way considerations
Engineering Analysis
What is necessary to operate the system reliably?
Resource Adequacy
Can we operate through a sustained lull in renewable resource production?
Transmission Security
Steady State / Stability
Strategic Transmission
Needs / Solutions
What are the strategic planning considerations for the future grid?
Thermal
Voltage
Frequency
Short Circuit

Develop study assumptions to reflect future scenarios with load profiles and resource mixes that meet states' carbon objectives → Develop operational/reliability modeling criteria → Develop revenue-forecasting modeling criteria (using current market rules) → Run simulations that stress test the future scenarios → Identify any gaps in reliability and/or market revenues using the simulation results → Identify possible products that would address any gaps → Propose options to procure/address identified gaps

The list of studies here is non-exhaustive and is provided for information. Discussion of studies does not indicate a preference for any particular study, scenario, consultant, project, or mechanism.

Relevant "Pathways"-type Studies on the Future New England Power Grid

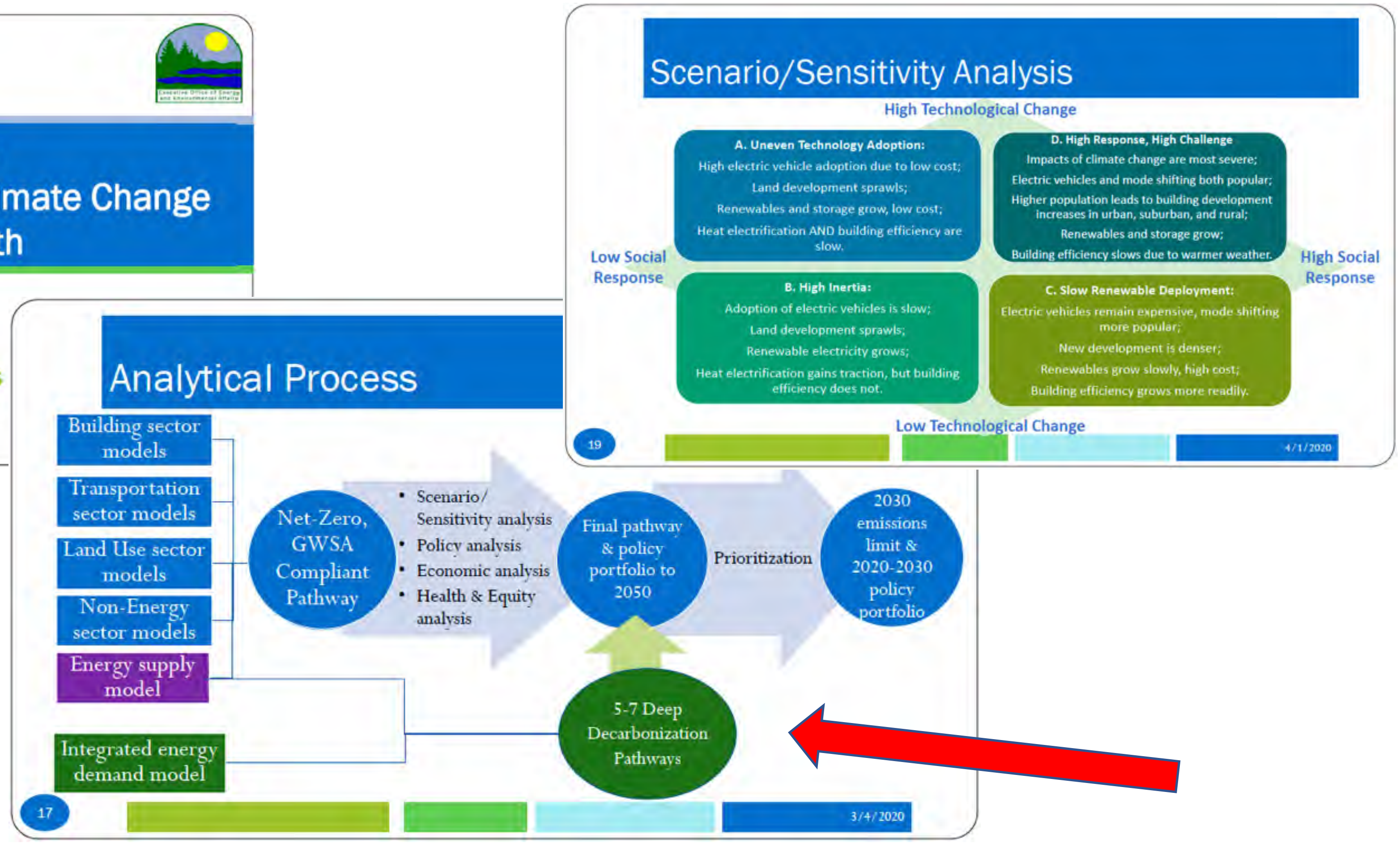
Key Issues:

- Whether carbon compliant resource mixes (and related details) can be determined from ongoing or recently completed analyses?
- To what extent do these studies inform the questions the Future Grid Study asks?
- Can scenarios from existing studies be successfully imported into the economic and engineering analyses to save time in the overall process?

Relevant "Pathways"-type On-Going Studies

	Study	Study Objective	Progress to Date	Expected Finish Date
10	Massachusetts 80 by 50 with Cadmus and Evolved Energy Research	Scenario Analysis 2030-2050	Pathways modeling underway	Winter 2020
11	Connecticut Clean Energy Pathways Analysis with Levitan	Scenario Analysis in 2035-2040 with more heating and transport loads and 100% renewable by 2040 – Energy, Capacity, Resource Adequacy, Gas Infrastructure Hydraulics	Pathways modeling underway	Fall 2020
12	Calpine (and others?) "?" with Energy Futures Initiative		?	Fall 2020
13	Eversource with London Economics	Grid of the Future Study: Scenarios cover a range of potential technology and policy pathway scenarios that achieve economy-wide carbon reduction	Pathways modeling almost complete	Summer 2020
14	National Grid 2020 Economic Study	Scenario Analysis in 2035 with more heating and transport loads – Energy, Ancillary Services, and High-Level Tx Cost Estimates • Examine mitigating renewable curtailment with batteries and incremental bi-directional interconnections with neighboring systems	Beginning scoping and assumptions	1st and 2nd quarter 2021

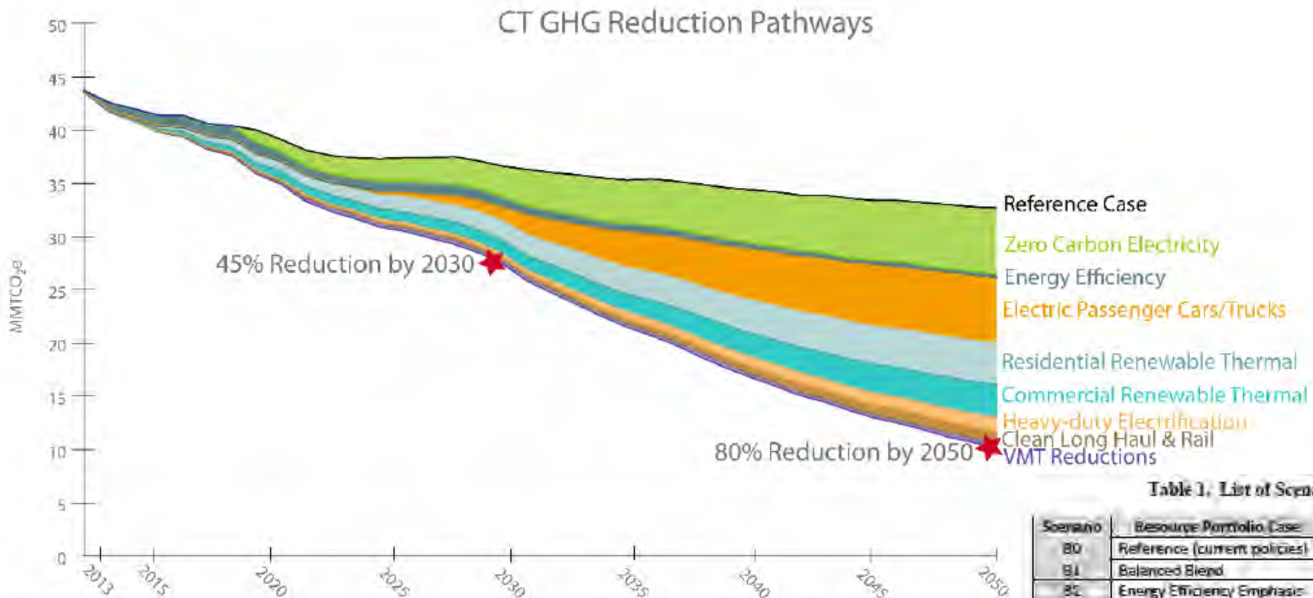
Relevant "Pathways"-type Studies - Massachusetts



[Massachusetts Decarbonization Roadmap]()

Relevant "Pathways"-type Studies – Connecticut

GOVERNOR'S COUNCIL ON CLIMATE CHANGE



Appendix C: Connecticut Business-As-Usual Case

The first step in developing a climate strategy is building a Connecticut-specific business-as-usual reference case to provide a basis for examination of potential GHG mitigation technologies and measures. Utilizing projection data from the Energy Information Administration and factors expected to shape Connecticut's future energy consumption, Northeast States for Coordinated Air Use Management (NESCAUM), GC3's technical consulting group, developed a reference case projection of future emissions through 2050.

Table 1. List of Scenarios

Scenario	Resource Portfolio Case	Gross Load Case
B0	Reference (current policies)	Base
B1	Balanced Blend	
B2	Energy Efficiency Emphasis	
B3	Offshore Wind Emphasis	
B4	Solar (grid & BTM) Emphasis	
B5	HQ Hydro Emphasis	
B6	Millstone PPA Extension	
E0	Reference (current policies)	Electrification
E1	Balanced Blend	
E2	Energy Efficiency Emphasis	
E3	Offshore Wind Emphasis	
E4	Solar (grid & BTM) Emphasis	
E5	HQ Hydro Emphasis	
E6	Millstone PPA Extension	

Connecticut Department of ENERGY & ENVIRONMENTAL PROTECTION

Energy and Technology Policy

10 Franklin Square • New Britain, CT 06051 www.ct.gov/deep Affirmative Action/Equal Opportunity Employer

February 24, 2020

INTEGRATED RESOURCES PLAN

ATTACHMENT A: CLEAN ENERGY PATHWAYS ANALYSIS MODELING ASSUMPTIONS AND INPUTS

Purpose

The purpose of this Factor Inputs memorandum is to identify key input assumptions and data that Levitan and Associates, Inc. (LAI) is using in the electric system simulation modeling for the Clean Energy Pathways study for each of the 14 scenarios.

Regional Electric System Simulation Modeling Approach and Software Tools

LAI utilizes the zonal version of Aurora, a production cost and capacity expansion optimization model licensed from Energy Exemplar, for long-term capacity planning and hourly commitment and economic dispatch of resources. LAI uses the default database provided by Energy Exemplar as a foundation. LAI augments the database with extensive customization based on public data sources, proprietary calculations, and professional judgment informed by ongoing consultation with the Department of Energy and Environmental Protection (DEEP).

Study Period, Base Weather Year, and Time Steps

LAI will run Aurora for a 20-year period, from 2021 to 2040. The planning horizon corresponds to the endpoint of Connecticut's statutory goal to meet 100% of power generation needs with clean energy.

Given the importance of weather-based coincident relationships among load, solar energy, and wind energy under increased penetration of variable energy resources (VER), consistent hourly load, solar PV output and wind output profiles must be used. The best way to ensure the correct correspondence between load and VER generation is to use a common historic weather year to set the load and VER generation profiles. LAI analyzed load data for 2007 through 2012, the years for which NREL data is available for hourly wind and solar PV output profiles. 2011 was selected as the most representative year based on being most typical as measured by deviations from average monthly energy demand and summer and winter hourly peak loads over the six years.

Capacity expansion and retirement decisions are made in Aurora on an annual time-step. Production cost simulation is conducted using chronological 8760 hourly dispatch.

[Connecticut Integrated Resources Planning]

Relevant "Pathways"-type Studies – Market Participants

CALPINE®

ENERGY FUTURES INITIATIVE

EVERSOURCE

LE
LONDON ECONOMICS

nationalgrid

Relevant "Pathways"-type Studies - Eversource's Grid of the Future Study

Background

- Meeting regional carbon emission reduction targets will result in major changes to the electric system over the next three decades
- As New England's largest energy delivery company, it's our responsibility to help implement the changes needed to meet these goals, while reliably and affordably delivering energy
- With a primary objective of understanding the impact of decarbonization policies on the electric grid, we have been working with London Economics International (LEI) to model a variety of scenarios that achieve economy-wide carbon reduction

Overview of Study

- Scenarios cover a range of potential technology and policy pathways
  - All scenarios are driven by either current policy (80% economy-wide carbon reduction by 2050) or more aggressive policy (95% economy-wide carbon reduction by 2040)
  - Scenarios make different technology assumptions for supply capacity expansion: balanced assumptions across all renewable resources, expansion focused on distributed solar, or expansion focused on offshore wind
  - Electrification of heating and transportation are driven directly by carbon reduction policy targets in those sectors, not by forecasted market-based adoption rates
- Modeling methodology uses hourly simulations to develop supply mix that meets emission and reliability objectives
  - Renewable energy production profiles and electrification demand profiles based on public data sources (e.g. NREL, EIA)
  - Battery storage used as the unit of choice for resource adequacy and to balance intermittent supply with demand
  - Allows for intra-regional transfer limit increases for reasonably uncongested flows
- Detailed zonal outputs include hourly supply and demand, energy market prices, storage operation, etc.

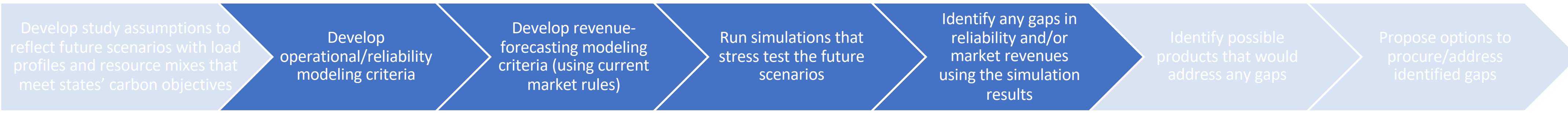
EVERSOURCE

More Detailed Approach

Develop study assumptions to reflect future scenarios with load profiles and resource mixes that meet states' carbon objectives → Develop operational/reliability modeling criteria → Develop revenue-forecasting modeling criteria (using current market rules) → Run simulations that stress test the future scenarios → Identify any gaps in reliability and/or market revenues using the simulation results → Identify possible products that would address any gaps → Propose options to procure/address identified gaps

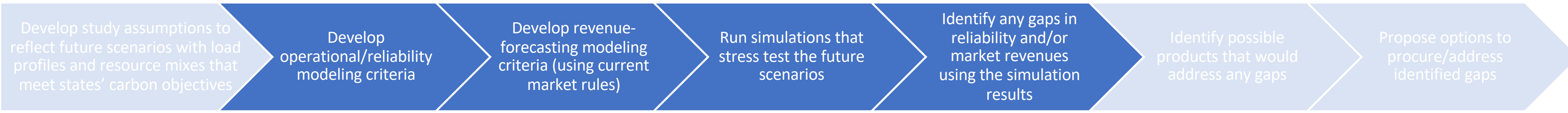
- **Study Components 1-3:** Agreement on Future Grid Analysis
  - **Key Issue:** Developing carbon compliant resource mixes that meet the requirements of state laws (power, heating, transportation, etc.) is a significant analytical challenge on its own. Time matters in this process if the region is to work through this matter on a calendar of its making, rather than in a reactive posture. For that reason, and for overall efficiency, as noted earlier, there is interest in exploring whether carbon compliant resource mixes (and related details) can be determined from ongoing or recently completed analyses.
  - Can scenarios from existing studies be successfully imported into the economic and engineering analyses to save time in the overall process?
  - Some level of data translation / mapping / supplementation may be necessary
  - Details to be determined in consultation with market participants

More Detailed Approach - Continued



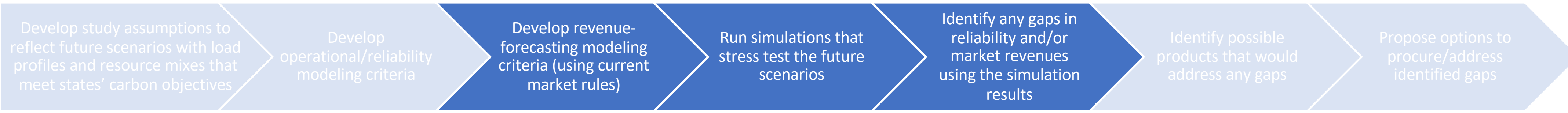
- **Study Components 2-5**: Economic and Engineering Analyses
  - Ancillary Services Requirements Analysis
    - Depending on available information and the scope of other aspects of the analysis, this would identify system operational needs like ramping, regulation, load following, etc.
  - Time-Series Approach to Probabilistic Reliability Analysis
    - Seasonal Energy Sufficiency – Analysis and/or internal constraint
      - Several week time frame
      - production lull and load pattern coincidence - extent and duration
    - Multi-Area Reliability Simulation – Estimate available dispatchable capacity needed to maintain LOLE statistics over a time series by examining the magnitude, frequency and duration of reliability events
      - Resolution and many details TBD –

More Detailed Approach - Continued



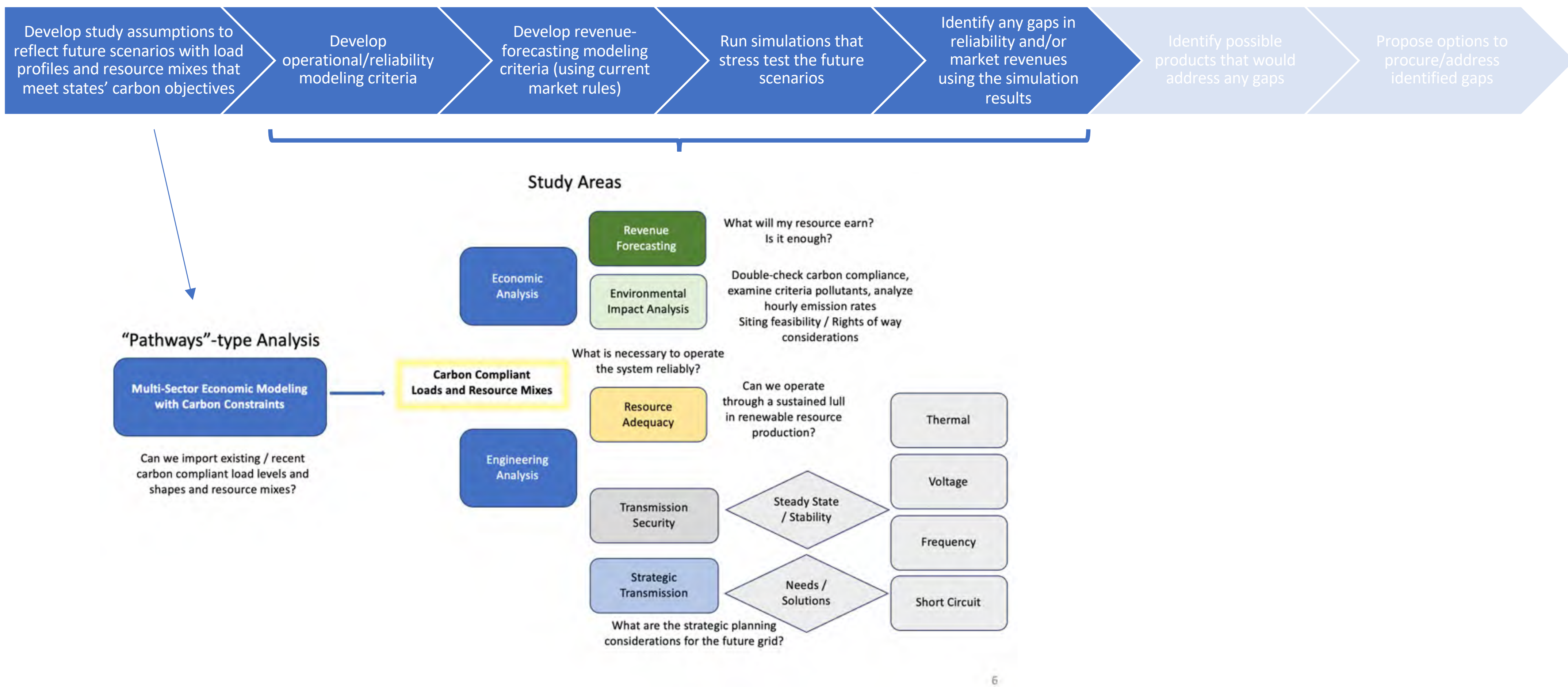
- **Study Components 2-5**: Economic and Engineering Analyses
  - Transmission Security
    - Dynamic stability issues from weak grid and operational characteristics of resource mix
      - Operating through a contingency (i.e., managing frequency and volt-var regulation) in a system with diminished spinning mass and increased inverter-based resources; Analyze dynamic capabilities of power electronics and storage devices
  - Strategic Transmission
    - High-level feasibility of upgrades necessary for future resources mixes that serve power, heating, and transport loads

More Detailed Approach - Continued



- **Study Components 2-5**: Economic and Engineering Analyses (cont.)
  - Revenue Forecasting
    - Energy and Ancillary Services
      - Production Cost and/or Capacity Expansion
      - Resolution and many details TBD – for example:
        - Hourly, sub-hourly, shorter time frames (more detail on ancillary services)
        - Copper sheet, zonal, nodal (that's where the distributed generation is)
        - Load shape availability and resolution also important
    - Capacity Market Simulation
      - Energy and Ancillary Services Revenues inform Resource Adequacy Offers
      - Resource Adequacy Simulation Results Inform Resource Mix
        - Two approaches: Jump forward in time vs. evolve market year-over-year
        - Economic retirement logic TBD

Suggested Study Approach - Summary



Study Approach – Summary continued

- Develop study assumptions to reflect future scenarios with load profiles and resource mixes that meet states' carbon objectives
- Develop operational/reliability modeling criteria
- Develop revenue-forecasting modeling criteria (using current market rules)
- Run simulations that stress test the future scenarios
- Identify any gaps in reliability and/or market revenues using the simulation results
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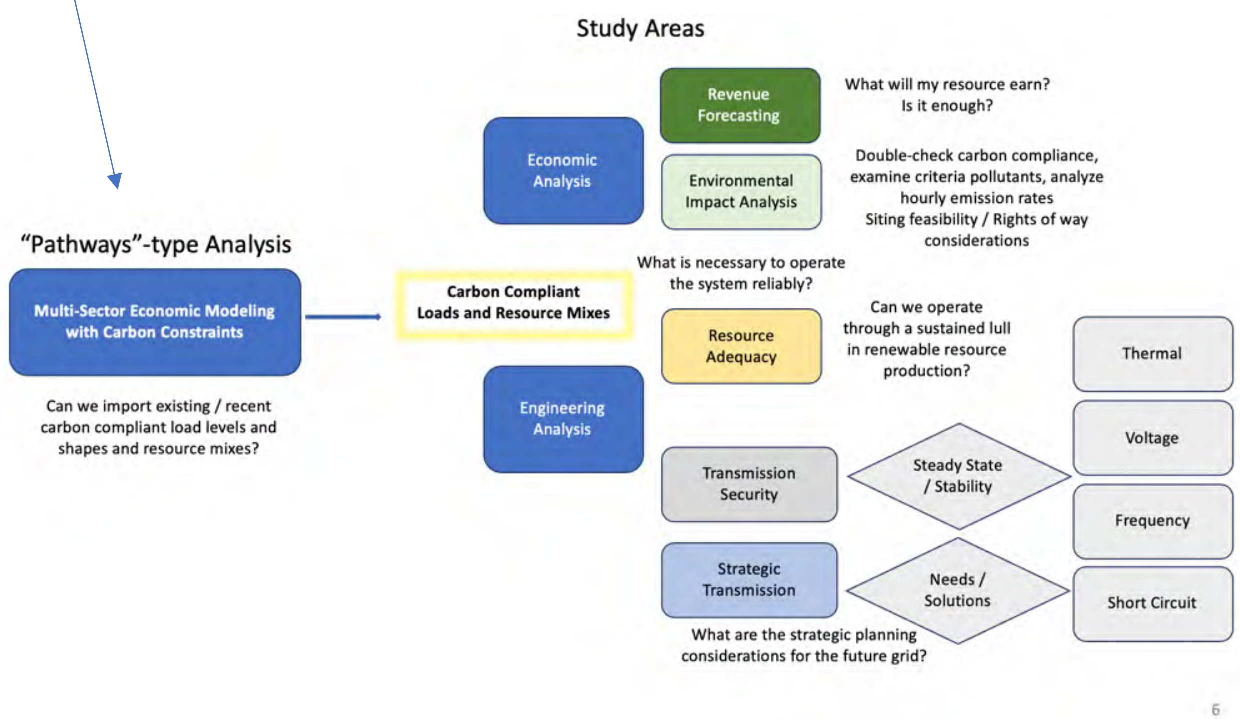
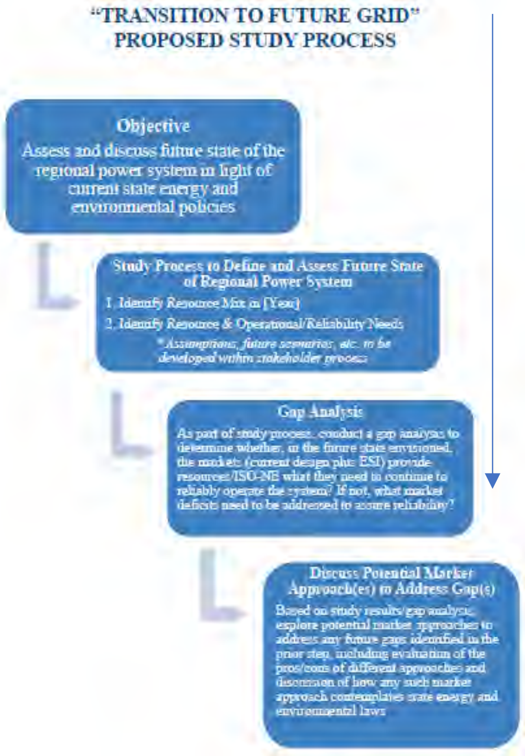
- Propose options to procure/address identified gaps





Study Preparation- Next Steps

- Come back in June with more information about the relevant ”Pathways”-type studies
  - Other study sponsors are encouraged to present their studies
- Work towards selecting scenarios from the “Pathways”-type studies
  - Loads
  - Resource Mixes
  - Dispatches
- Continue to develop analytical approaches for the economic and engineering analyses that could help inform questions about the Transition to Future Grid

Questions?

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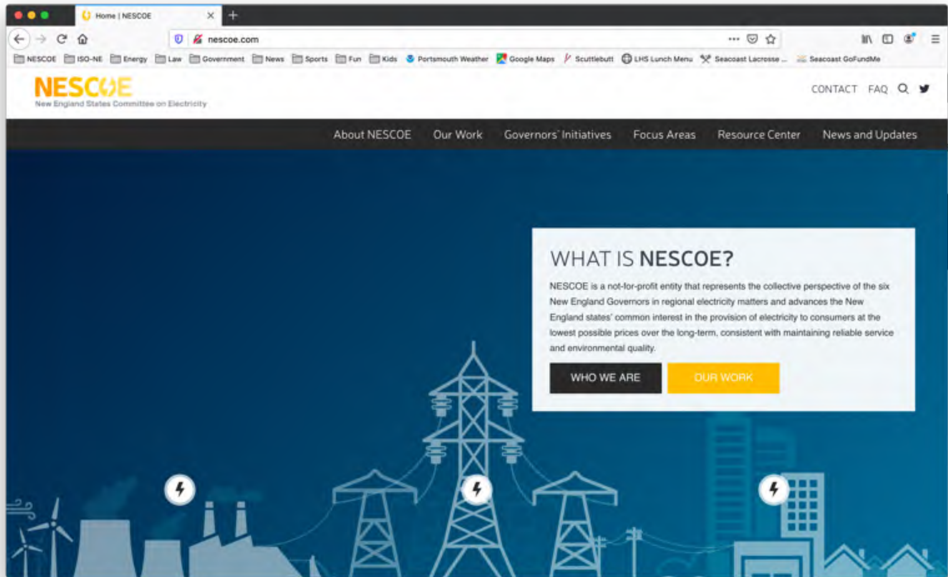
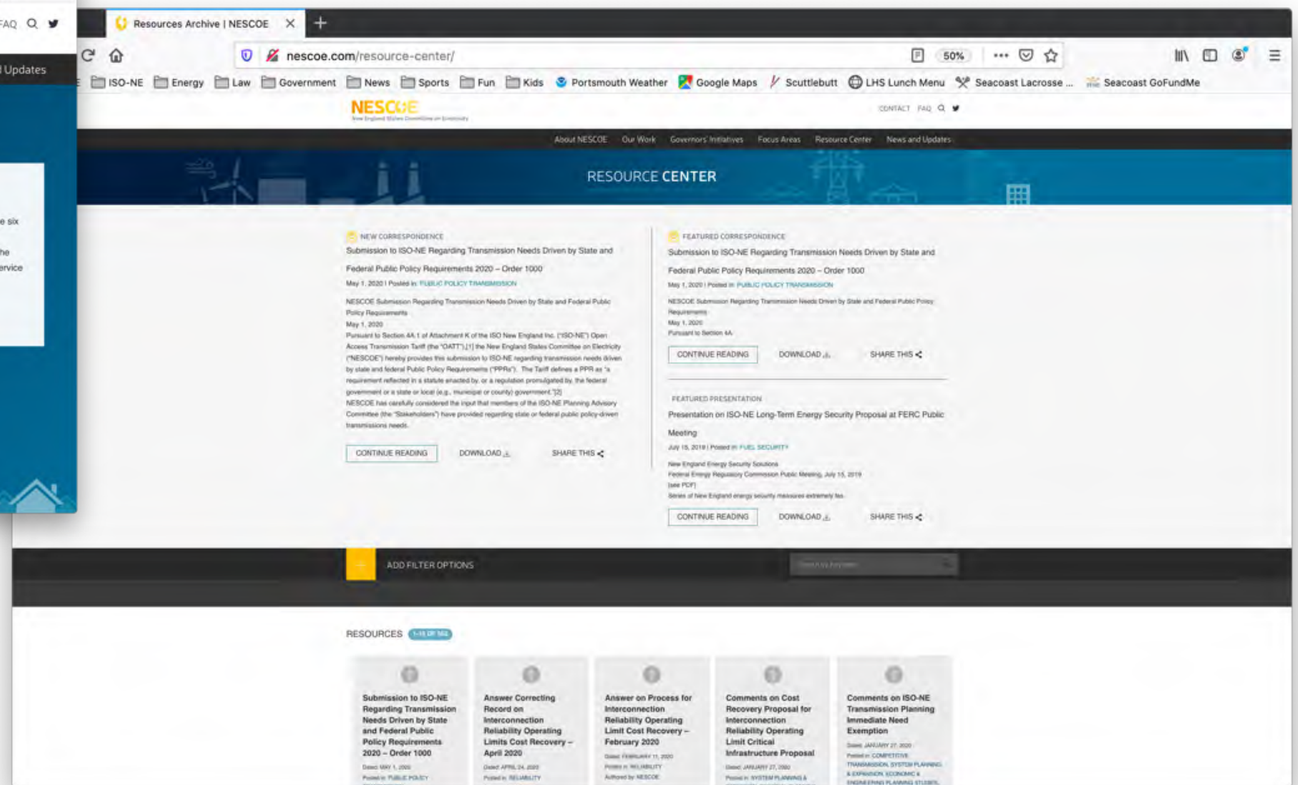
New England States Committee on Electricity





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MAY 27, 2020 | JOINT MC/RC TELECONFERNCE

REVISION 1

Power System and Market Studies at ISO New England

Current Capabilities

Xiaochuan Luo

BUSINESS ARCHITECTURE AND TECHNOLOGY

Overview of ISO-NE's Modeling Capabilities

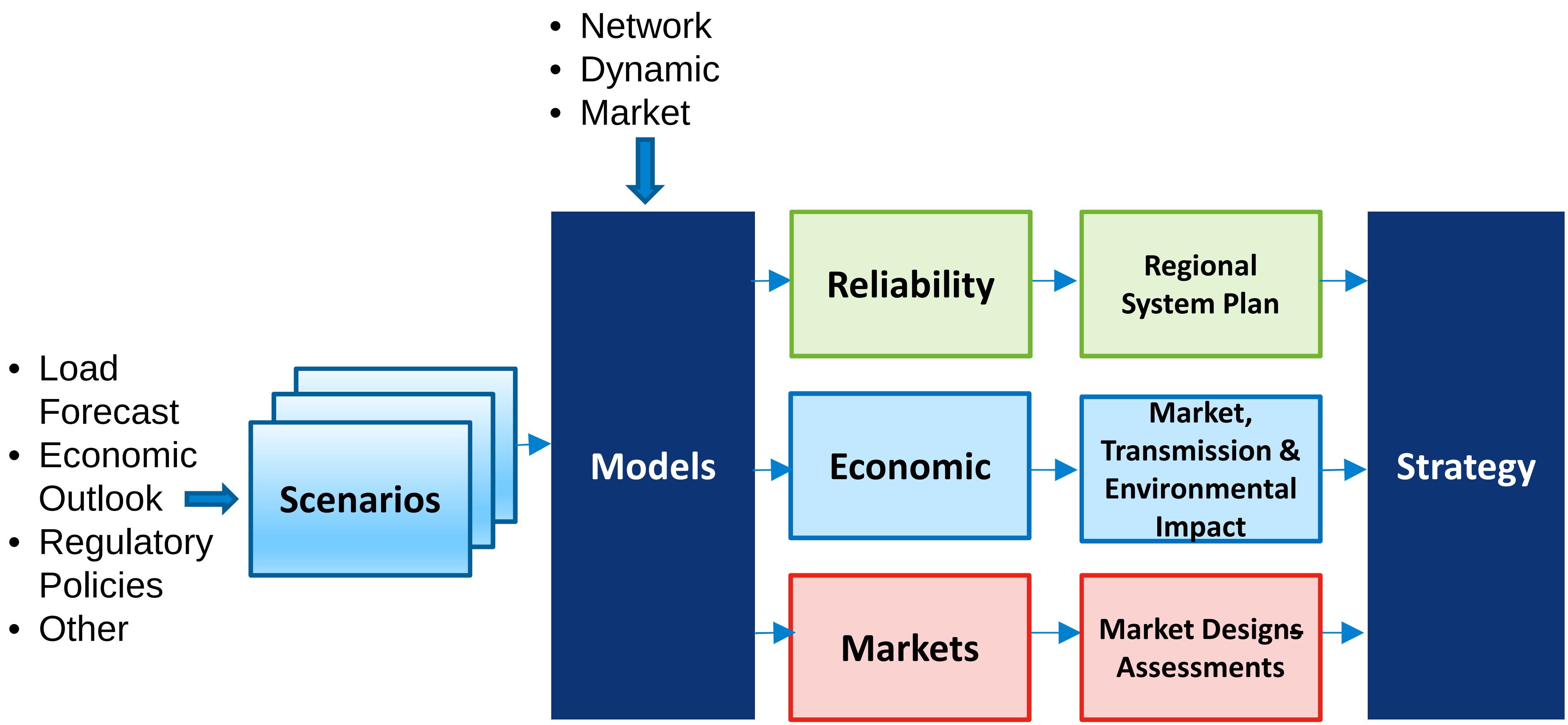
- To aid stakeholders in the decision on what models and tools to employ in their future grid study, the ISO has compiled information on its key modeling capabilities for reliability, economic, and market assessments
- The ISO's existing studies can be categorized by four time horizons:
  - Long-term (3 - 10 years)
  - Mid-term (21 days - 3 years)
  - Short-term (1 day – 21 days)
  - Real-time (5 min – 24 hours)
- The ISO offers information on its processes and tools for reference and discussion, with emphasis on its long-term modeling

LONG-TERM STRATEGIC ANALYSES AND MODELING PROCESSES

Long-term Modeling Capabilities

- ISO carries out a variety of studies focusing on assessing changes in the bulk transmission system, the generation resource mix, and market conditions in 3-10 years
  - Reliability studies, economic studies, and market simulations
- Modeling capabilities include:
  - Forecasting regional demand of electricity
  - Evaluating transmission system adequacy and resource interconnections
  - Evaluating long-term resource adequacy
  - Analyzing energy policies and their impact on planning, operations, and markets
  - Evaluating new market designs

Long-Term Strategic Analysis Process



Key Processes for Reliability Studies

Building Network Models

- Load Forecast
- Generation forced outage rate
- Steady-state power flow
- Dynamic
- Short-Circuit
- Electromagnetic Transients (EMT)

Performing Reliability Assessments

Resource Adequacy

Transmission Adequacy

Proposed Plan Applications (PPA)

Analyzing Reliability Outcomes

Capacity requirements and margin

Transmission needs and solutions

Impact on reliability or operating characteristics of the system

Regional System Plan

Key Processes for Economic Studies

Constructing Test System

- Resource Mix
- Fuel Price Forecast
- Allowance for Environmental Emissions
- Load Forecast
- Transmission Network

→

Performing Production Cost Simulations

Simulate economic operation of power system chronologically, in hourly intervals (ranging from one day to many years)

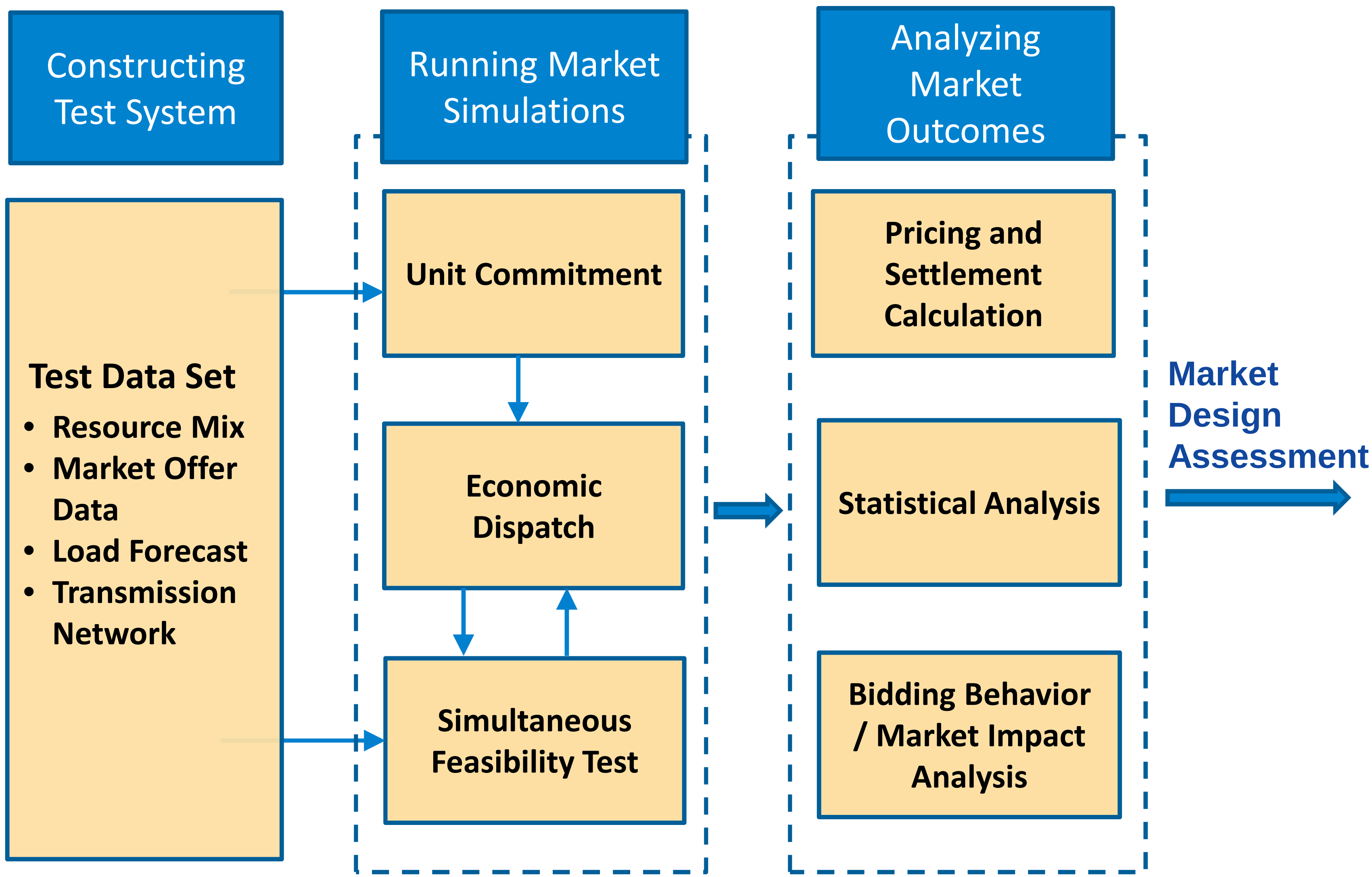
→

Analyzing Economic Study Outcomes

- Energy production by fuel type
- Production cost, LMP, transmission congestion
- Carbon emission, Renewable spillage, etc.

Market, Transmission, Environment Impact →

Key Processes for Market Simulation



Forecasting Regional Electricity Demand

- Demand forecasting is a fundamental task in providing one of the key inputs to reliability studies, economic studies and market simulations
- ISO develops up to 10-year projections of electric energy usage and seasonal peak demand, based on
  - Economic outlook
  - Weather and load patterns
  - Pending or proposed legislation, regulation, and standards
- It also includes forecasting of
  - Energy Efficiency (EE)
  - Behind the Meter (BTM) PV
  - Electrification

Evaluating Transmission System Adequacy and Resource Interconnections

- An essential capability for evaluating system reliability
  - Identify transmission overloads, voltage violations and system dynamic behavior under different system conditions
- Widely used in planning studies:
  - Regional planning needs assessment and solution development
  - Annual NERC TPL Standards compliance assessment
  - Annual assessment of transmission transfer capability
  - Proposed Plan Application (I.3.9) study
    - ➢New generators
    - ➢Changes to existing generators
    - ➢Transmission upgrades
    - ➢Elective transmission upgrades

Evaluating Long-term Resource Adequacy

- Estimate representative net Installed Capacity Requirements (ICR) beyond Capacity Commitment Period (up to 10 yrs), based on
  - Latest Capacity, Energy, Loads, and Transmission (CELT) load forecast
  - Latest Forward Capacity Auction (FCA) resource assumptions
- System-wide Operable Capacity Analysis (up to 10 yrs) to estimate operable capacity margin
  - 50/50 and 90/10 peak load, plus operating reserve requirements
  - Representative net ICR, plus assumed unavailable capacity
  - Load or capacity relief actions of Operating Procedure 4 (OP-4)

Long-Term Reliability Studies

Studies	Purposes of the Study	Type of analysis (models)
Long-term load forecasting	• 10-year projections of electric energy usage and seasonal peak demand, based on economic outlook, weather and load patterns, etc. • Includes forecasting of EE, BTM PV and electrification	• Descriptive statistics • Probabilistic and AI-based predictive forecast modeling, etc.
Regional planning needs assessment and solution development	• Evaluate transmission system adequacy over a 10-year planning horizon and identify reliability-based transmission needs • Development of transmission solutions to address identified needs using either the Solution Study process or the Competitive Solution process	• Steady-state power flow • Transient stability • Short circuit

Long-Term Reliability Studies, cont.

Studies	Purposes of the Study	Type of analysis (models)
Proposed Plan Application (I.3.9) study	• Determine whether the proposed changes have any significant adverse effect on the stability, reliability or operating characteristics of the bulk power system • Include new generators, changes to existing generators, transmission upgrades, and elective transmission upgrades	• Steady-state power flow • Transient stability • Short circuit • Electromagnetic transient
NERC TPL compliance study	• Annual compliance assessment of New England Bulk Electric System (BES) with NERC TPL planning criteria	• Steady-state power flow • Transient stability • Short circuit • Geomagnetic disturbance (GMD)

Analyzing Energy Policies and Their Impact on Planning, Operations, and Market

- New England Wind Integration Study (NEWIS)
  - Determined the operational, planning and market impact of integrating substantial wind resources
  - ISO-NE, GE, EnerNex, AWS Truepower
- Economic Studies
  - Analyze impacts on energy market, transmission system, or environment, based on different scenarios of future resource mix and transmission expansion options
- System operational analysis and renewable energy integration study (SOARES)
  - Focused on system imbalance and operating reserves needs under different scenarios

Evaluating New Market Designs

- ISO evaluates new market designs through a variety of production cost simulation and market simulation tools
  - Impact analysis studies of new market design alternatives using market simulation tools developed in-house with Unit Commitment, Economic Dispatch, and Pricing capabilities
  - Analysis of various alternative pricing schemes for different market products using production and in-house developed market clearing software
  - Retrospective market studies using Day-Ahead study system

Limitations of in-use Economic and Market Simulation Tools

- Current production (GE) or in-house developed market simulation tool lack long-term simulation capability
- Production cost simulation tools don't capture real-time operational impact; require significant efforts of benchmarking upon change of market structure
- Electric Power Enterprise Control System (EPECS) simulation tool
  - Performance
    - Input/output data, simulation process control and speed
  - Modeling capability
    - Storage modeling, transmission constraints, etc.
  - Modeling accuracy
    - Reflection of ISO-NE market clearing, LMP, settlement, etc.

Long-Term Economic Studies and Market Simulations

Studies	Purposes of the Study	Type of analysis (models)
Economic Study	• Analyze impacts on energy market, or transmission system, or environment, based on different scenarios of future resource mix and transmission expansion options	• Production cost simulation
Wind Integration Study	• Determine the operational, planning and market impact of integrating substantial wind resources in NE	• Mesoscale wind • Statistical analysis • Production cost simulation
System operational analysis and renewable energy integration study	• Investigate the effect of varying generation mix on system imbalance and operating reserves	• Market Simulation

Long-Term Economic Studies and Market Simulations, cont.

Studies	Purposes of the Study	Type of analysis (models)
Fast-start pricing assessment	• Assess the market impact of fast-start pricing on both DAM and real-time market; The study implemented fast-start pricing prototype in the real-time market, and performed settlement calculations.	• LMP calculation
ESI market mitigation rule design	• Design the market mitigation rules for ESI based on simulating different offering strategies for energy options and assessing the corresponding impact on the market	• GAMS-based market simulator

Modeling Challenges for Long-Term Studies

- Increasing number of inverter-based resources
  - Accuracy of dynamic models, esp. off-shore wind
  - Weak grid interconnection (control interaction resonance, protection, etc.)
  - Impact of reduced system inertia
- Strong and rapid growth of distributed energy resources
  - Tripping of DERs for a transmission fault adds to source loss
  - Accurate dynamic models and parameters
  - Mix of legacy and smart inverters
  - Under frequency and under voltage load shedding

Modeling Challenges for Long-Term Studies, cont.

- Transmission and distribution coordination
  - Unbalanced transmission faults
  - 1-ph and 3-ph inverters in distribution system
  - May need T&D co-simulation
- Multi-timescale market simulation
  - Simulation of the market operation process
  - Coupling of different markets
  - Consistent data set
  - Consideration of uncertain parameters
  - Computational performance

New Requirements for Network Models

- Bus-branch model
  - Eastern Interconnection representation
  - All transmission planning studies and operations planning technical studies
  - DERs are explicitly modeled at the specific substation, either as negative loads (1-5 MW) or generators (>5MW)
- Node-breaker model
  - EMS representation (NE, NY, and NB)
  - DA and RT network analysis and market clearing, outage coordination, FTR
  - Gradually expand the EMS model with sub-transmission network, potentially to model future DER integration

SHORTER-TERM ANALYSES AND MODELING PROCESSES

Mid-term Modeling Capabilities

- ISO operates mid-term markets and conducts planning studies to address both transmission and resource adequacy in a 3-year time frame
- Modeling capabilities include:
  - Assessing resource adequacy and reliability impacts of FCM resources
  - Evaluating reliability and economic impacts of transmission and generation outages
  - Establishing transmission operating limits and guides

*See Appendix for additional detail**

Short-term Modeling Capabilities

- ISO prepares for the real-time system and market operation through a variety of planning processes up to 21 days before the operating day
- Modeling capabilities include:
  - Short-term load forecasting
  - Evaluating short-term transmission and generation outages
  - Establishing current operating plan (COP)

*See Appendix for additional detail**

Real-time Modeling Capabilities

- ISO maintains system balance using various power system monitoring and controls, as well as decision-making tools during real-time system operation
- Modeling capabilities include
  - Assessing real-time security
  - Economically dispatching systems while maintaining system security

*See Appendix for additional detail**

LINKING ANALYSIS WITH TOOLS

List of Analysis Types and Tools

Analysis Types	Tools
Long- term load forecasting	ISO developed tools based on statistics, ANN, etc.
Short-term load forecasting	Simday, ANN, MetrixND
Market Clearing	• FCA MCE • FTR (FTRO/SFT) • DAM (RSC/SPD/SFT) • RTM (SPD/SFT) • LMPC (LMP Calculator)
Market simulation	• Day-ahead Study System (DASS) • EPECS Simulator (Dartmouth) • GAMS-based market simulator

List of Analysis Types and Tools, cont.

Analysis Types	Tools
Steady-state power flow analysis	• PSS/E, TARA, PowerWorld, PSAT/VSAT • EMS PWRFLOW, RTCA, ILC, etc.
Voltage and transient stability	PSS/E, VSAT/TSAT
Small signal analysis	SSAT
Short circuit	ASPEN
On-line cascading failure analysis	POM, TSAT
Electromagnetic transient (EMT)	PSCAD
Production cost simulation	GridView, PROBE
Resource adequacy assessment	GE MARS
AGC simulation	KERMIT

CONCLUSION

Current and Future Modeling Needs

- Discussion covers the ISO's current capabilities for modeling and tools addressing various time horizons
- If the Future Grid studies would benefit from these capabilities, the ISO offers them to assist in that effort
- If there is a gap between the ISO's modeling processes and tools and those deemed necessary for the Future Grid studies, the ISO will work with stakeholders on the best way to address such gaps

Questions

APPENDIX

MID-TERM MODELING AND STUDIES

Assessing Resource Adequacy and Reliability Impacts of FCM Resources

- Determining Tie Benefits and ICR
- Determining FCA and ARA parameters
- Interconnection analysis during FCM new resource qualification
- Reliability reviews of
  - permanent or retirement delist bids
  - dynamic de-list bids between FCA rounds
  - monthly CSO bi-laterals and reconfiguration auction

Evaluating Reliability and Economic Impacts of Transmission and Generation Outages

- Evaluating the reliability impact of long-term (21 days – 2 years) transmission and generation outage request
- Evaluating the economic impact of long-term (>90 days) transmission outage request

Establishing Transmission Operating Limits and Guides

- Transmission operations technical studies to identify thermal, voltage and stability limits
  - Transmission Operating Guides (TOGs)
- System restoration studies to develop and validate restoration plan
- Operational studies to determine Load Power Factor (LPF) limits, voltage schedules and limits for generators and key transmission substations, etc.

Mid-term Reliability Studies

Studies	Purposes of the Study	Type of analysis (models)
Resource Adequacy	• Determine Tie Benefits • Determine FCA and ARA parameters	• Sequential Monte-Carlo simulation
Interconnection analysis during FCM new resource qualification	• Ensure that the new generating resource does not cause overloads that cannot be fixed in time for the CCP • Assess capacity deliverability within the load zone	• Steady-state power flow
FCA dynamic de-list bids reliability review	• Reliability study to determine acceptance or rejection of dynamic delist bids between rounds of the FCA	• Steady-state power flow
Monthly FCM reliability analysis	• Reliability reviews of bi-lateral and Reconfiguration Auction in support of the Monthly FCM process	• Steady-state power flow

Mid-term Reliability Studies, cont.

Studies	Purposes of the Study	Type of analysis (models)
Long-term transmission and generation outage reliability analysis	• Evaluates the reliability impact of long-term outage request (> 21 days) per OP-19.	• Steady-state power flow • Transient stability
Transmission operations technical studies	• Identify thermal, voltage and stability limits • Transmission Operating Guides (TOGs)	• Steady-state power flow • Transient stability • Short circuit • Electromagnetic transient

Mid-term Reliability Studies, cont.

Studies	Purposes of the Study	Type of analysis (models)
System restoration study	• Develop and verify restoration plans after a partial or total shutdown of the New England BES	• Steady-state power flow • Dynamic stability • Electromagnetic transient
System voltage and reactive study	• Establish load power factor limits for study areas as defined in OP-17 • Develop voltage schedules and limits for generators and key transmission substations	• Steady-state power flow • Dynamic stability

Mid-term Economic Studies and Market

Studies	Purposes of the Study	Type of analysis (models)
Forward Capacity Auction	• Determine capacity market clearing; • Annual/monthly/CASPR	• Market clearing
Long-term transmission outage economic analysis	• Evaluate economic impact of long-term transmission outages (> 90 days) • Reposition transmission outages that exceed an incremental production cost of at least $200,000 per week	• Production cost simulation
FTR Auction	• Determine FTRs awards and market clearing prices; Annual/ Monthly and BOPP	• FTR Market clearing

SHORT-TERM MODELING AND STUDIES

Short-term Load Forecasting

- Forecast hourly system-wide demand for today and the next two days
- Forecast capacity deficiency seven days in advance, based on forecasted weather, generating capacity, and peak demand

Evaluating Short-Term Transmission and Generation Outage

- Evaluate the reliability impact of short-term transmission and generation outage request (< 21 days)
- Estimate economic impact of short-term transmission outages (1 to 5 days in advance)
- 21-day energy security assessment forecast per OP-21

Establishing Current Operating Plan (COP)

- Calculate day-ahead 2nd contingency interface limits, which are enforced in Day-Ahead Market
- Day-Ahead Market clearing and analysis
- Reserve Adequacy Analysis (RAA) to assess system reliability for the operating day

Short-term Reliability Studies

Studies	Purposes of the Study	Type of analysis (models)
Short-term transmission and generation outage reliability analysis	• Evaluates the reliability impact of short-term transmission and generation outage request (< 21 days) per OP-19.	• Steady-state power flow • Transient stability
Day-Ahead 2nd contingency interface limits	• Calculate limits and load shed values for 2nd contingency interfaces. • Calculate proxy limits which are enforced in the DAM	• Steady-state power flow (TTC Calculator)

Short-term Reliability Studies, cont.

Studies	Purposes of the Study	Type of analysis (models)
21-day energy security assessment forecast	• Forecast 21-day energy security based on current system conditions, forecasted weather, load, generators' reports of stored-fuel inventories and emissions limitations, and status of fuel delivery systems.	• Production cost simulation
Short term load forecasting	• Forecast hourly system wide demand for today and the next two days • Forecast capacity deficiency seven days in advance	• ANN • Similar day • METRIX

Short-term Economic Studies and Market

Studies	Purposes of the Study	Type of analysis (models)
Short-term outage economic analysis	• Evaluate economic impact of short-term transmission outages (1 to 5 days in advance)	• Production cost simulation
Price Analysis	• Satisfy FERC's data inquiry • Compute the constraint sensitivities used in LMP calculation	• DA Study System
Day-ahead Market clearing	• Clear DAM	• SCUC • SCED • CA
Reserve Adequacy Analysis	• Assess system reliability for the operating day	• SCUC

REAL-TIME MODELING AND STUDIES

Assessing Real-time Security

- Evaluating system conditions using real-time data to assess existing (pre-Contingency) and potential (post-Contingency) operating conditions
  – State Estimation, real-time contingency analysis, interface limits, etc.
- On-line voltage stability assessment
- On-line transient stability assessment
- On-line cascading analysis
- Resilience – look ahead power grid risk monitoring for extreme events (prototype)

Economically Dispatching Systems While Maintaining System Security

- Intra-day SCRA study to assess system security and needs for intraday unit commitment
- Real time unit commitment and economic dispatch
- Automatic generation control
- Compute real-time LMP and fast-start lost opportunity cost
- Analyzing real-time pricing

Real Time Reliability

Studies	Purposes of the Study	Type of analysis (models)
Real time analysis and assessment	• Evaluate system conditions using real-time data to assess existing (pre-Contingency) and potential (post-Contingency) operating conditions	• State Estimation • RTCA • ILC
On-line voltage stability assessment	• Compute interface limits based on voltage violation and voltage instability	• Steady state power flow P-V analysis
On-line transient stability assessment	• Compute interface limits based on angle stability, transient voltage dip, and oscillation damping	• Transient stability

Real Time Reliability, cont.

Studies	Purposes of the Study	Type of analysis (models)
On-line Cascading Analysis	• Evaluate system exposure to instability, cascading failure, and uncontrolled separation for more severe than (n-1) conditions	• Steady-state power flow • Transient stability
Resilience – look ahead power grid risk monitoring for extreme events (Prototype)	• Estimate equipment outage probabilities taking into account real-time weather forecast, network equipment loading conditions, network equipment fragility characteristics, and available historical data	• Weather model • Statistics • Facility fragility models

Real-Time Market

Studies	Purposes of the Study	Type of analysis (models)
Intra-day SCRA	• Assess system security and needs for intraday unit commitment	• SCED
Real-time unit commitment and dispatch	• Determine the commitment of fast-start units; runs every 15 minutes • Dispatch resources to satisfy system demand • Determine the dispatch points for variable resources (DNE)	• SCUC • SCED
CTS process	• Determine schedules for transactions with NYISO; every 15 min	• SCED

Real-Time Market, cont.

Studies	Purposes of the Study	Type of analysis (models)
RT pricing	• Compute real-time LMP and fast-start lost opportunity cost	• LMP calculation
LMPC Monitoring and Analysis	• Analyze real-time prices	• Dispatch and LMP analysis

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Future Grid – Thoughts on a Path Forward

NEPOOL MC/RC – May 27, 2020

Peter D. Fuller

Presented with the endorsement of NEPOOL Members NRG Energy and Sunrun

Overview

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- **While the precise dimensions of the future grid's mix of resources is unclear, we can be fairly certain of the broad outlines**
- **The 'gap study' proposed by NESCOE, NEPOOL and ISO-NE will undoubtedly be helpful in developing some quantitative estimates, but the focus of our efforts should be the broad outlines, not the precise details**
  - **Forecasts are always wrong**
  - **We're not trying to intercept an asteroid at a specific point in time and space – we're trying to establish a foundation and a framework for clean energy and reliability resources to thrive in a competitive market structure**
- **Don't let a desire for precision obscure the bigger picture objective**

The Four-Product Future*

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Renewable Energy	Storage	Grid Edge Resources/ Responsive Demand	Flexible Dispatchable Generation
• Primary source of electric energy for consumer needs • Growth in grid-connected projects follows from improving economics and state RPS and related clean energy goals • Rate designs, consumer demand and technological advances drive distributed resource growth	• Two-way operation balances variability of both renewable energy generation and consumer demand • Meets peak demand and ramping needs – capacity and ancillary services • Distributed storage also supports resilience	• Advances in data and telecomm support distributed resources and programmable responses to price and reliability needs • Real-time pricing/variable rate designs provide consumer incentives and business opportunities to link retail loads and edge resources with wholesale markets	• Fast-start dispatchable capacity to ramp as needed to fill short-term imbalances • Hydrogen and RNG may provide lower net emissions and longer-term/seasonal storage

* With thanks to my former colleagues at NRG Energy

The Big Questions

- **The key question we should be trying to answer:**
  - **Given a future resource mix scenario*, do the markets we have today (plus ESI) provide sufficient revenues to support:**
    - **i) renewable/non-emitting resources that achieve the region's emission reduction targets, <u>and</u>**
    - **ii) dispatchable resources and operating capabilities that achieve required levels of security and reliability?**

- **Conceptually, markets developed around fossil fuels and central-station rotating machines are probably not a good match for a system focused on low emissions, inverter-based resources and a dynamic 'grid edge' of DER and responsive load**

* More thoughts on constructing resource mix scenarios in later slides

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Preview of Coming Attractions

- The 2016 NEPOOL Economic Study was pretty definitive
  - "New resources will likely require sources of revenue in addition to the wholesale energy market to remain economically viable. Natural gas units show the greatest energy market revenue shortfall as a result of their production costs being higher than the $0/MWh fuel costs of renewables, but renewable resources also show significant revenue shortfalls relative to their assumed annual fixed costs."
    - The report likewise suggested existing resources may be revenue-inadequate in the energy market
- Recognizing that the 2016 study probably didn't look far enough into the future or deeply enough into emission reductions, a new study is warranted. Nonetheless, the clarity and extent of the result in 2016 suggests that we'll find a similar answer this time around

Future Resource Mix Scenarios (aka, things we need to include in any study)

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- **Aggregate emission reduction goals – what level of emission reductions should we assume – 80%, 90%, 100%? And in what year – 2040, 2050?**
- **Broad brush resource mix assumptions/scenarios – what are the rough proportions of wind, solar, hydro and nuclear in the energy mix?**
- **Electrification of demand – How much replacement of internal combustion engines and combustion heat sources should we assume – 50%, 75%, 100%?**
- **Responsive demand and distributed resources – How much of the demand will be actively adjusting to market conditions – 10%, 20%, 30%, more? How much load modification and load/supply balancing will come from active and non-dispatchable edge resources?**
- **System security and reliability – given all those assumptions, how much dispatchable capacity will be needed to ensure reliability on daily and seasonal time-scales? How much energy storage, and with what duration(s)?**

Then, use appropriate modeling tools to estimate costs and market revenues for each resource type.

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Other Considerations (aka, some things we don't)

- There are real technical and policy challenges in reaching a reliable, low-emission future, but many are not central to designing a market structure
  - Transmission topology – assume a single bus, or a simplified system with a few zones
  - Inertia, fault current, etc – assume the technical challenges of an inverter-based system can be solved with power electronics, synchronous condensers or other technological applications and innovations, provided the needs are made clear and the markets provide compensation for these services
  - Feasibility of specific new technologies – assume resource characteristics – eg, long-duration storage, emission-free thermal generation – rather than trying to prove out any specific technology
  - Fuel infrastructure, ie, gas pipelines, LNG – overall gas usage is likely to decline with electrification and more reliance on renewable sources
- All these challenges will best be addressed in the context of a robust market for grid services that transparently values what the system needs

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Stay focused on the task at hand

- While it could be interesting to give policymakers a comprehensive economic comparison of, for example, 80% vs. 90% vs. 100% decarbonization, that's not our task here
- While it could be interesting to determine whether we need a higher voltage bulk network - potentially including offshore cables - to integrate the future resource mix, that's not our task here
- While it would be interesting to evaluate the technical potential and viability of hydrogen electrolysis and storage, CCS, modular nuclear, and any number of other cool technologies, that's not our task here
- **Our task: Will our current market designs support a reliable low-carbon resource mix? And if not, what should we do about it?**

Practical Suggestions

- Since the detail matters far less than the broad themes, use the scenario(s) from an existing study, such as the Brattle study (2019) or similar, to save some study time
  - These studies are highly consistent: a system with lots of electrification, served with lots of renewable resources, needs lots of storage and dispatchable generation and may be 2x to 3x larger than our current peak and energy demand
- Given the results of the 2016 NEPOOL Study, begin a parallel effort to identify options that could provide "sources of revenue in addition to the [current] wholesale energy market" that will be needed to support emission goals and reliability

DRAFT

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Advanced Energy Economy's Initial Recommendations for ISO-NE / NEPOOL / NESCOE *Future Grid Study*

AEE continues to strongly support efforts to prepare New England to meet the ambitious policy goals of the six states cost-effectively and reliably. We believe that a rigorous analysis can serve as a useful tool as the region seeks to ask and answer fundamental questions about the grid of the future, but we also recognize that without careful attention to scope and process such an effort could fail to provide actionable insights and could even delay the start of urgent discussions of the potential market reforms needed to get us to the grid of the future.

We are optimistic that stakeholders are aligned in wanting to make the most of the *Future Grid Study* process itself as well as any parallel discussions about market reforms, and appreciate the thought and effort that NESCOE has put into the effort to date. To that end, AEE has compiled some initial feedback as NESCOE, NEPOOL, and ISO-NE launch the Future Grid Study. We look forward to participating in the kick-off meeting and subsequent discussions.

- **Timeline** -
    - AEE agrees with those stakeholders at the April 7 meeting who encouraged finding any opportunities to shorten the proposed 15-month study period (recognizing that the 15-month study timeline was illustrative). Given the inherent lags in identifying, designing, and implementing any needed market reforms, it is vitally important that the study proceed without further delays.
    - Given that detailed analysis is inherently a lengthy process, AEE strongly supports NESCOE's proposal to include interim milestones, and encourages those milestones to be used as opportunities to inform ongoing exploration of potential market reforms and/or to incorporate market reform discussions into the study process. The need for market reforms is a key reason why NESCOE requested (and AEE supported) this study process, and discussion of those reforms should not be delayed.
- **Process recommendations** -
    - AEE supports NESCOE's suggestion that ISO-NE retain an outside consultant to conduct the work. Tasking a neutral party with the analysis will increase trust in the process, and relieving ISO-NE of the primary workload will avoid bandwidth constraints or conflicts with other priorities that might slow the study process.
    - While AEE encourages a transparent, stakeholder-driven process that works toward consensus wherever possible, we also support a process that gives New England states significant input whenever consensus is not reached. Given the origin and objective of the Future Grid Study, it is appropriate that states should have a *greater* say in its scope and inputs than they are currently afforded in the normal NEPOOL process. We therefore support NESCOE's proposed voting structure and the option for NESCOE to unilaterally request an additional study scenario, and would support other reasonable efforts to ensure that states' requests and suggestions are adequately incorporated throughout the study process. The time, resources, and thought that will go into the Future Grid Study

will be worthwhile only if the New England states find the process and outcomes relevant and useful.

- **Scope** -
  - The description of the Future Grid Study discussed at the March NEPOOL Participants Committee meeting indicated that the focus would be on how markets will operate when the resource mix reflects the successful achievement of state goals. AEE also urges consideration of what role the markets can or should play in delivering the transition to that future resource mix. For example, NYISO's *Grid In Transition* paper (described in more detail below) identified as its central question: "how the wholesale markets in New York can continue to provide the pricing *and investment* signals necessary to reflect system needs *and to incent resources* capable of resolving those needs" (emphasis added). The Future Grid Study should similarly address the transition to the future grid, not just the end state.
  - At the April 7 meeting, several stakeholders encouraged consideration of a robust and diverse set of scenarios that acknowledge the potential for increased ambition in state policy, advances in technology, the rise of electrification, and other key unknowns. We agree that consideration of a variety of potential future scenarios is useful, but would encourage a focus on identifying the common types of resource and system attributes that will be needed in those future scenarios rather than designing the study around specific future resource mixes.
- **Consideration of reforms** -
  - AEE strongly encourages either integrated or parallel discussion by states, ISO-NE, and NEPOOL to identify and discuss potential market reforms. NESCOE's draft process timeline suggests that states would "consider alternative mechanisms to achieve the requirements of state law" on an ongoing basis, outside the study process. AEE is concerned that the Future Grid Study may fail to produce actionable results on a useful timeframe if it does not include some analysis or consideration of potential market reforms as part of the core study process; or, in the alternative, allow for a feedback loop through which these parallel efforts could be folded in.
  - NYISO's *Grid In Transition* effort is a model that ISO-NE and NEPOOL should consider borrowing from. A report released by NYISO last December (available here) identified a series of near- and medium-term opportunities for market improvements to better enable the realization of the state's goals, and work is starting through stakeholder working groups on topics that range from carbon pricing to enhancing energy and shortage pricing to enhancements to resource adequacy models (see p. 7 of NYISO's Jan. 8, 2020 presentation). Importantly, discussion of these potential market reforms is not being held up while The Brattle Group completes a longer-term quantitative analysis as part of a related but separate process that kicked off earlier this year.

Transition to the Future Grid Study

Tentative Stakeholder Schedule

Stakeholder Committee and Date	Agenda Topics & Submission Deadlines
Markets & Reliability Committees April 7, 2020	• Preliminary suggestions on process-oriented ideas and related analysis tasks from NESCOE
Markets & Reliability Committees May 27, 2020	• NESCOE presentation on other studies, implications for Future Grid Study, approach for developing assumptions and proposed study areas. • ISO presentation of key modeling capabilities in reliability, economic, and market assessments • NRG discussion of questions to be addressed by the analysis and considerations for structuring the study
Markets & Reliability Committees July 1, 2020	• **Focus of Agenda Topics –** Proposals for what kinds of analysis should be performed in the study and associated analysis assumptions • **June 12** – Inform MC Secretary of agenda topic and timing • **June 25** – Materials posted for meeting
Markets & Reliability Committees August 4, 2020	• **July 17** – Inform MC Secretary of agenda topic and timing • **July 29** – Materials posted for meeting
Markets & Reliability Committees September 1, 2020	• **August 10** – Inform MC Secretary of agenda topic and timing • **August 26** – Materials posted for meeting

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Tentative Stakeholder Schedule (cont.)

Stakeholder Committee and Date	Agenda Topics & Submission Deadlines
Markets & Reliability Committees September 29, 2020	• **September 11** – Inform MC Secretary of agenda topic and timing • **September 24** – Materials posted for meeting
Markets & Reliability Committees November 12, 2020	• **October 23** – Inform MC Secretary of agenda topic and timing • **November 5** – Materials posted for meeting
Markets & Reliability Committees December 17, 2020	• **November 30** – Inform MC Secretary of agenda topic and timing • **December 11** – Materials posted for meeting