New Jersey Energy Master Plan Continued Research

Work Scope

November 2024

1 Energy Master Plan Continued Research

1.0 Motivation

The New Jersey BPU and Governor's Office seek to model additional electric supply side resource scenarios that explore a broader range of possible future outcomes for electric generation in the state. [redacted]. The new model scenarios will offer a range of options for New Jersey to explore while striving to reach 80% reduction in emissions by 2050.

The 2024 Energy Master Plan is expected to be released publicly in March 2025. This work scope describes continued research that E3 will perform between December 2024 and March 2025.

1.1 Task 1: Update New Jersey EMP Progress Report to Reflect Progress through End of 2024

E3 will complete a desk review of policy and programmatic progress made since the first round of research was completed in Summer 2024. This will ensure the EMP modeling includes any additional progress made through the end of 2024. Based upon the findings of the desk review, E3 will refresh the progress memo and the progress report chapter of the EMP report.

1.2 Task 2: Model Additional Supply Side Resource Scenarios

The additional modeling will involve making the following updates to assumptions and quantifying the impact relative to existing scenario results from Current Policy, High Electrification, Hybrid Electrification, and Demand Management:

1.3 Task 3: Determine Workforce Impacts of New Scenarios

The State team has expressed interest in better understanding the benefit-cost dynamics of in-state infrastructure investment, resulting in thousands of in-state jobs, versus out-of-state energy procurement, resulting in a smaller in-state green economy. To this end, E3 and the BW team will run two additional scenarios from Task 2 to develop a wider range of workforce impact results. The findings from these additional runs will be included in the EMP report.

1.4 Task 4: Update Customer Cost, Revenue Requirement Models and Cost Models with New Scenarios

E3 will update the customer cost, revenue requirement model, and societal cost models with the additional three scenarios discussed above.

[1]

[redacted]

[redacted]

E3 will also update the air quality analysis to align with the final chosen EMP scenarios, as electric generation will influence particulate emissions.

1.5 Task 5: Coordinate and Share Data with Ongoing New Jersey Research Efforts

E3 will continue to coordinate with the other critical studies that the State is working on, including OSWSP2 (Ramboll and Brattle), Equitable Rates (Brattle), the Whole Building Tool (McKinsey), Workforce Analysis (BW), and Future of Gas (London Economics). E3 will attend coordination meetings when required and will prepare data to the specifications requested by BPU contractors. E3's anticipated budget for this Task is 12 total staff hours per month, which aligns with our average project-to-date time commitment for requested coordination with external consultants.

[redacted]

1.6 Task 6: Update EMP Report and Hold Briefings

The additional modeling will require updating all reporting materials including:

- The written EMP report
- The slide deck that will be used to hold an additional public webinar
- Inputs and assumptions workbooks and documentation

Throughout the above documents, E3 anticipates making updates to quantitative findings in addition to narrative and framing changes based on the policy directives emerging from the new analysis.

E3 will hold three (3) commissioner briefing meetings before the public release of the EMP report. Clear narrative on rapid/substantial growth of in-state resources through the end of the study year, paired with short and long term need for more generation.

E3 will hold one public webinar before the release of the final report. E3 will answer questions during the webinar, document commentary in the final report, and adjust framing and messaging as necessary. The quantitative results of the analysis will not be altered based on the public webinar findings.

1.7 Project Management, Bi-weekly Meetings, and Progress Reports

E3 will continue to meet with BPU and GO on a weekly basis through mid-March 2025. E3 will continue to produce monthly progress reports through Q1 2025.

1.8 Timeline

To facilitate the EMP being released by mid-March, we have listed critical milestones dates and interim deliverables below. Steps that require BPU and GO input or lead are in **bold.**

Milestone	Due Date
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
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2 Clean Firm Resource Roadmap

2.0 Motivation

To meet system reliability needs in a fully decarbonized electricity sector, firm zero-carbon resources will be necessary to cost-effectively maintain reliability in extended periods when solar and wind generation is low and short duration Li-Ion battery storage is insufficient. New Jersey seeks to build off of the EMP research and produce a clearly-defined pathway to achieve capacity needs using clean resources. This research will include stakeholder engagement to both learn stakeholder interests and educate stakeholders on pathways to achieve clean, firm reliability. The research will also provide New Jersey with holistic roadmap to meet GHG reduction targets with clean firm resources.

2.1 Task 1: Stakeholder Engagement and Definition of System Needs

E3 proposes to commence the Roadmap by conducting meetings with key stakeholders, including but not limited to New Jersey's electric utilities, PJM, companies developing clean firm solutions, environmental justice stakeholders, and others.

E3 would use these stakeholder sessions for two purposes: (1) to present its existing research and analysis on resource adequacy needs in New Jersey, to provide context for these system needs and the motivation for studying clean firm resources; and (2) to gather information and feedback from a diverse set of stakeholders on key considerations – including but not limited to contributions to grid needs; technology feasibility and scalability; and community impacts – that may impact the viability of clean firm resources.

Table 1: Additional Considerations for Clean Firm Resources

Category	Key Questions
Grid Services	• In addition to inertia, what grid services from existing thermal resources cannot currently be met by inverter-based resources (e.g. black start capability)? • How would PJM think about dispatching resources of >24h duration during multi-day reliability events?

Siting, Deployment and Scalability	• What barriers exist to deploying technologies at scale in each region of New Jersey? For example:
	  ○ How much land does an iron-air battery require?
	  ○ What is the total resource potential of site-specific technologies (e.g. A-CAES) in New Jersey (if any)?

Safety and Environmental Risk	• What are the safety considerations for deploying each technology within or near urban areas? • What risks may be associated with deployment of each technology near protected lands or watersheds?
Feasibility	• What portion of the existing combustion-based fleet could feasibly be converted to utilizing hydrogen or another zero-carbon fuel?

Environmental Justice	• What are the air pollution impacts of the technology? • How might disadvantaged communities be impacted by deployment of this technology?

2.2 Task 2: Characterization of Technology Costs, Availability, and Operational Characteristics

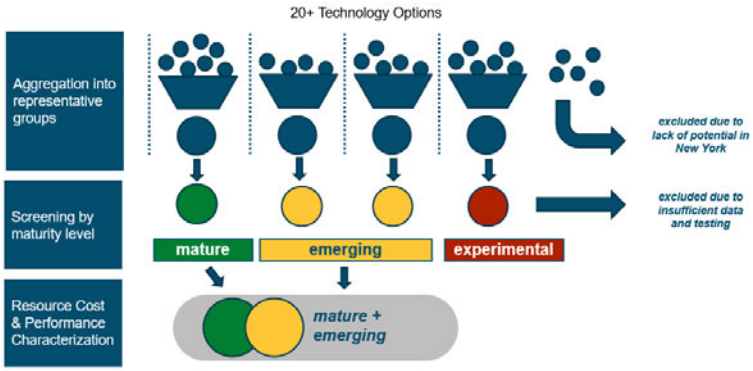
Building on IEA's "Technology Readiness" framework, E3 will focus this assessment on mature and emerging technologies that (1) can be deployed in New Jersey, and (2) have moved beyond the experimental stage (i.e., excluding technologies such as fusion). E3 can draw from its extensive experience and support for utilities, state agencies, and technology developers to support BPU in this task.

In its support for the **California Public Utilities Commission IRP**, E3 prepared a **Zero-Carbon Technology Assessment** in 2022 which explored zero-carbon firm capacity generation technologies that could support California's efforts to decarbonize its electricity grid but have not yet reached full commercialization. The report characterized emerging zero-carbon firm capacity technology options for the purpose of informing capacity expansion modeling to support long-term resource planning, and it includes a detailed review and synthesis of publicly available information regarding a number of technologies including long-duration ion air batteries, adiabatic compressed air energy storage, carbon capture and sequestration, enhanced geothermal, small modular light water nuclear reactors, and others.

Over the past 5+ years, private investors and energy technology companies have also engaged E3 to **assess numerous emerging longer-duration energy storage and firm generation technologies (early commercial stage) via technology assessments and due diligence**, including but not limited to: molten salt thermal storage; adiabatic compressed air energy storage (A-CAES); iron-air batteries; advanced pumped storage hydro (PSH); gravity energy storage; enhanced geothermal; green hydrogen production, storage, and power generation; and flexible loads including distributed loads such as virtual power plants (VPPs). For each engagement, E3 assessed the technology to evaluate its operational characteristics, siting considerations, and risks and identified competitive advantages and disadvantages relative to competing commercialized technologies. Though E3 cannot disclose the details of each specific project, we have developed unmatched breadth of experience working with investors and private companies that can be leveraged to support NYSERDA's investigation into the feasibility of these technologies to support the state's policy goals.

E3 plans to leverage both its technical and financial expertise, including but not limited to the examples above, to support BPU in this task. E3's in-house financial model has been extensively vetted and is relied upon by project developers and investors for diligence evaluations, and we have worked throughout the past year to incorporate the impacts of the Inflation Reduction Act into our financial modeling. The tax credits for emerging technologies including hydrogen production and storage, carbon capture, and new storage technologies are complex, and accurately characterizing the financial impacts of these credits will have a significant impact on the resulting resource costs and estimation of public funding available. E3 will provide BPU with a user-friendly version of its financial model that allows for selection of a range of input assumptions, including but not limited: relying on publicly available cost trajectories vs. any confidential data learned from stakeholders in Task 1; the lifetime of tax credits provided by the IRA; and the cost of capital available to project developers as technologies reach maturity.

Figure 1: Illustrative Screening Approach



2.3 Task 3: Comparative Assessment of the Technologies' Contributions to an Effective Resource Portfolio

E3 will develop a comparative evaluation framework that will assess technology contributions to key system reliability needs, including hourly and sub-hourly ramping, system inertia, black start capabilities, and resource adequacy. In this task, E3 proposes to both synthesize its findings from the previous tasks, including scalability by 2045, as well as to perform additional quantitative analysis on the resource adequacy contributions of each resource. Key questions for this assessment would include:

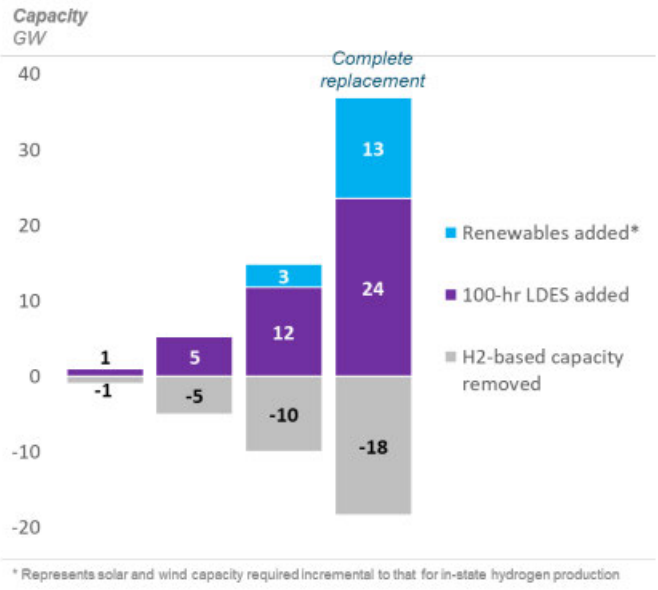
- What are the flexible ramping contributions of the portfolio and are there key capacity thresholds at which inflexible capacity would lead to costly levels of renewable curtailment?
- What key dependencies exist between resources to meet system needs such as inertia and black start capabilities, e.g. does a system with significant reliance on long-duration storage also need significant deployment of grid-forming inverters to provide inertia?
- How does the duration of a resource affect both its own resource adequacy contributions and the required portfolio of renewable resources?

To quantitatively evaluate the potential resource adequacy contributions of each technology, E3 proposes to use its reliability modeling tool, RECAP, which is designed to evaluate resource adequacy. E3 also proposes to study resource adequacy under multiple different load scenarios (e.g. High Electrification and Demand Management scenarios) to understand the impacts that varying levels of electrification-driven load growth and demand-side flexibility may have on both the magnitude, timing, and duration of system firm capacity needs. E3 will examine scenarios in which long-duration storage of multiple durations (e.g. 24-hour and 100-hour) is used to partially

replace the contributions of the existing gas fleet, building on similar work performed in New York State. The results of this analysis will provide New Jersey with a detailed picture of the resource adequacy contributions of different clean firm resources and how they can contribute to a reliable, fully decarbonized New Jersey electricity system.

In its work to support New York State's Energy Storage Roadmap in 2022[2], E3 performed a detailed examination of what it would look like to replace varying levels of the existing thermal generation fleet with energy storage of different durations. Starting from a 2050 portfolio in which New York retained its existing gas units by converting them to run on hydrogen (and built new hydrogen units as well), E3 performed a detailed reliability analysis of replacement of these combustion-based facilities with 24-hour and 100-hour storage. E3 examined a range of plausible outcomes, from replacing just 1 GW of existing facilities to full replacement of the combustion-based fleet, as shown in Figure 2 and Figure 3 below.

Figure 2: Replacement of Combustion-Based Capacity with 100-Hour Storage



These figures present how a 1:1 replacement of hydrogen or gas-based generation capacity with long duration storage with minimal to no incremental renewable capacity may be possible for a partial, targeted replacement of thermal capacity. The level of resource build increases exponentially as we inch towards complete replacement of the thermal capacity to meet multiple weeks of challenging conditions that may exist. E3 has already studied and presented resource portfolios for complete replacement of the thermal capacity in 2045 in the Demand Management scenario. Further analysis can be conducted as part of this roadmap for partial replacement.

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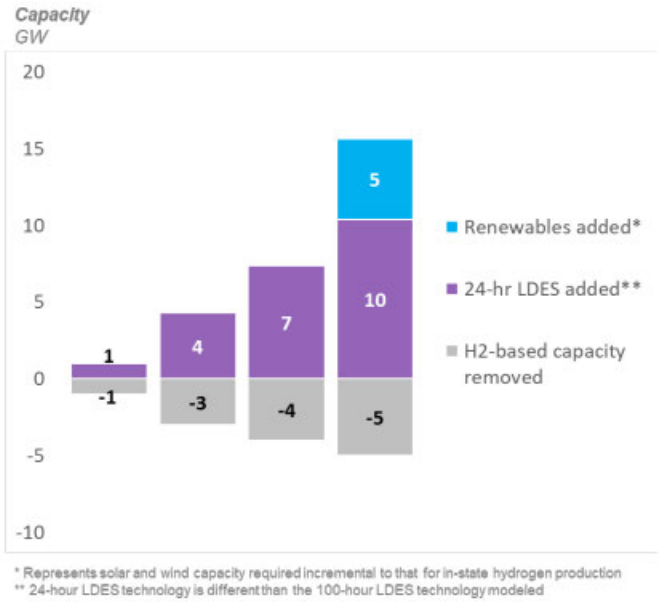
2 https://documents.dps.ny.gov/public/MatterManagement/MatterFilingItem.aspx?FilingSeq=297549&MatterSeq=55960

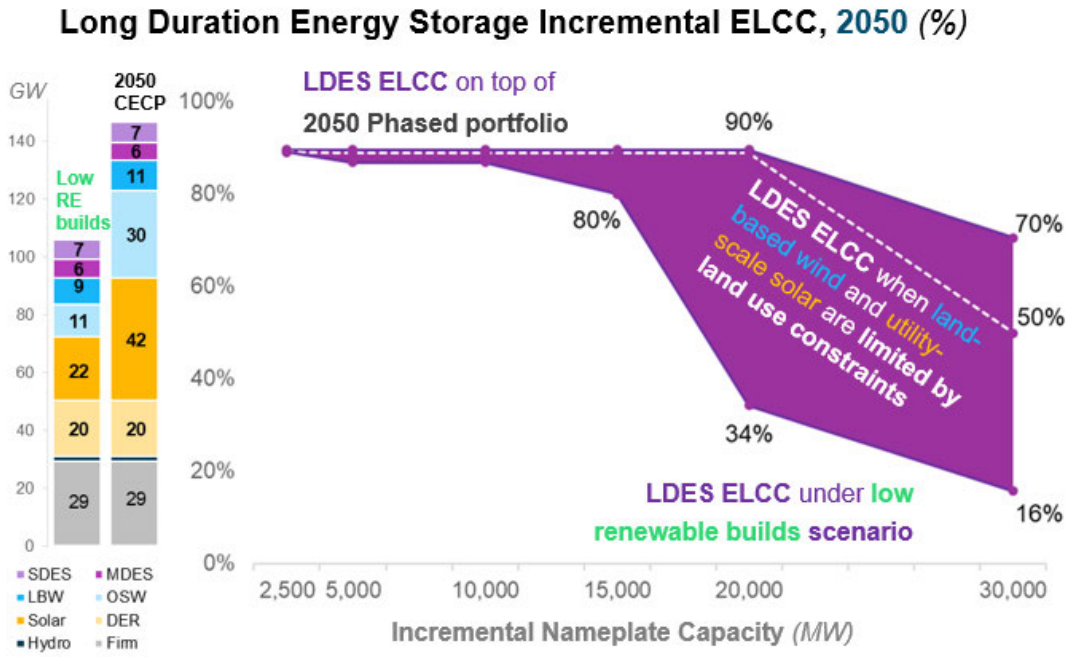
Figure 3: Replacement of Combustion-Based Capacity with 24-Hour Storage



More recently, E3 built on the foundational work of the New York Roadmap to directly evaluate the effective load carrying capability (ELCC) of long duration storage resources in New England[3]. Critically, E3 identified that the contributions of long-duration storage resources are highly dependent on the rest of the portfolio, as represented in Figure 4. In addition to diversity benefits between renewables and long-duration storage, there are also key interactions between different firm zero-carbon technologies. For example, if significant amounts of renewable capacity are being used to power electrolyzers during non-critical periods, those renewables may also be used during the winter to charge LDES, reducing the amount of overbuild required. By capturing diversity benefits between renewable resources and zero-carbon firm technologies such as long-duration storage, E3 will also be able to identify key tradeoffs between zero-carbon firm technologies and the rest of the portfolio.

[3] https://www.ethree.com/e3-massachusetts-energy-storage/

Figure 4: Range of ELCC Values for 100-Hour Energy Storage in New England



2.4 Roadmap Development

In this task, E3 will bring together its learnings from all previous tasks to provide New Jersey with an actionable Clean Firm Roadmap. **This Roadmap would complement the Energy Master Plan by developing strategies to advance the state's goals of achieving a zero-emissions electricity sector in New Jersey.** This document will be a polished report that both provides rigorous detail on E3's technical findings while also being accessible to external stakeholders with diverse expertise, including but not limited to those who participated in Task 1.

In this report, E3 will also qualitatively speak to the catalytic impact that NJ may have by being one of the leaders in deploying clean firm technologies. Being able to deploy clean firm technologies can help satisfy data center demand growth from data center owners targeting 24x7 clean energy and benefit deep decarbonization efforts nationwide.

In this task, E3 will lead the development of a draft and final report, scoped to be 30-50 pages in length, which includes a detailed and accessible summary of all findings completed in this work. We have budgeted to create a public-facing report, including graphic design.

2.5 Project Management, Weekly Meetings, and Progress Reports

E3 will meet with BPU and GO on a weekly basis for the project duration. E3 will produce monthly progress reports for the Clean Firm Resource Roadmap.

2.6 Timeline

This work will be completed and released publicly by the end of June, 2025. We have provided a detailed timeline by subtask in Table 2.

Table 2: Timeline for Clean Firm Resource Roadmap

Proposed Timeline	2025					
Tasks	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Task 1: Stakeholder Engagement and Definition of System Needs						
Hold meetings with experts and key stakeholders. Solicit data from clean firm technology developers						
Summarize takeaways from engagement						
Identification of major gaps, which can serve as a starting point for Task 2						
Task 2: Characterization of Technology Costs, Availability, and Operational Characteristics						
Ground truth data from tech developers. Lit review for remaining data needs						
Financial modeling representing costs and characteristics of all candidate technologies						
Research and summarize non-cost factors impacting resource availability and scalability						
Task 3: Comparative Assessment of Contributions to Effective Portfolio						
Development of evaluation framework						
RECAP inputs, model build, test runs						
Produce final ELCC Results by technology and by load scenario						
Summary of final comparative evaluation findings						
Task 4: Roadmap Development						
Aligning on report outline						
Draft report						
Final report						

3 Budget

The table below includes budgets for each of the tasks/steps for the studies and the grand total for the studies.

Continued EMP Research	Budget

Task 1: Update New Jersey EMP Progress Report to Reflect Progress through End of 2024	$19,569
Task 2: Model Additional Supply Side Resources	$99,116
Task 3: Determine Workforce Impacts of New Scenarios	$49,730
Task 4: Update Customer Cost, Revenue Requirement and Societal Cost Findings	$24,569
Task 5: Coordinate and Share Data with Ongoing New Jersey Research	$16,191
Task 6: Update EMP Report and Hold Briefings	$56,393
Study Subtotal	$284,229
Clean Firm Resource Roadmap	
Task 1: Stakeholder Engagement and Definition of System Needs	$50,000
Task 2: Characterization of Technology Costs, Availability, and Operational Characteristics	$79,000
Task 3: Comparative Assessment of Contributions to Effective Portfolio	$120,900
Task 4: Roadmap Development	$68,200
Task 5: Project Management, Weekly Meetings and Progress Reports	$22,800
Study Subtotal	$ 340,900
Grand Total	**$625,129**