GOVERNOR'S
Energy Office

New, updated considerations for Maine's Energy Plan

The GEO is the state's designated energy office charged with carrying out responsibilities of the state relating to energy resources, planning and development.

- Under Maine law, the GEO updates the State Energy Plan for delivery to the Governor and Legislature.
- The "Pathway to 2040" study will build off previous studies and bring together multiple components to supplement Maine's Energy Plan.

The process will build upon existing work to provide a comprehensive basis to inform Maine's best pathway to 100% clean electricity and enable greenhouse gas emissions reductions.

GOVERNOR'S
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"Pathway to 2040" Study Outcomes

- 3-5 modeling scenarios, informed by public input and ongoing aligned processes
- Concise, accessible digital summary of findings and comparison of different scenarios
- Policy considerations based on the scenario comparison and interpretation
- Incorporation into Maine Energy Plan

The "Pathway to 2040" study will be included as a technical volume within Maine's Energy Plan, delivered to the Governor and the Legislature in early 2024.

Maine Energy Plan

Maine is developing a comprehensive Energy Plan to meet the state's 2040 and 2050 requirements

The plan will be finalized in early 2024

Energy Plan Goals

- Identify policies to ensure Maine households and businesses have access to clean, affordable, and reliable energy in the coming decades.
- Support historically disadvantaged and low-income communities in this clean energy transition.

Informed by:

- *Detailed "Pathway to 2040" technical analysis and data*
- *Engagement with interested parties and communities*

Public Engagement Timeline

August 2023
- Public Kickoff; review demand-side results

September 2023
- Technical modeling update – pathway analysis

October December 2023
- Discuss policy implications of technical work

Early 2024
- Publish Maine Energy Plan

Multiple opportunities for public engagement and input over the coming months

For more information and to sign up for email notifications, see:
https://www.maine.gov/energy/studies-reports-working-groups/current-studies-working-groups/energyplan2040

Maine Energy Plan

PATHWAY TO 2040

THIRD STAKEHOLDER MEETING

THE BRATTLE GROUP
EVOLVED ENERGY RESEARCH

ON BEHALF OF THE
MAINE GOVERNOR'S ENERGY OFFICE

NOVEMBER 16, 2023

Brattle

EVOLVED ENERGY RESEARCH

GOVERNOR'S Energy Office

Viewing Maine in the Regional Context

Maine is part of regional fuel and electricity markets

- Electricity: Maine is ~10% of ISO-NE demand (Not counting NMISA – outside ISO-NE, ~155 MW peak, ~850 GWh load)

Other New England states also have ambitious decarb and renewable/clean electricity goals

- Modeling the regional context on an hourly basis captures important opportunities and challenges as multiple states pursue decarbonization objectives
- Modeling assumes all NE states pursue similar strategies, to yield realistic picture of system requirements
- Hourly results can be aggregated to annual and peak demand measures

≥80% by 2050	**Five states mandate greenhouse gas reductions economy wide: MA, CT, ME, RI, and VT (mostly below 1990 levels)**
100% by 2040	CT zero-carbon electricity requirement
80% by 2050 Net-Zero by 2050	MA clean energy standard MA statewide emissions requirement
100% by 2050 Carbon-Neutral by 2045	ME renewable energy goal ME emissions requirement
100% by 2030	RI renewable energy requirement
90% by 2050	VT renewable energy requirement

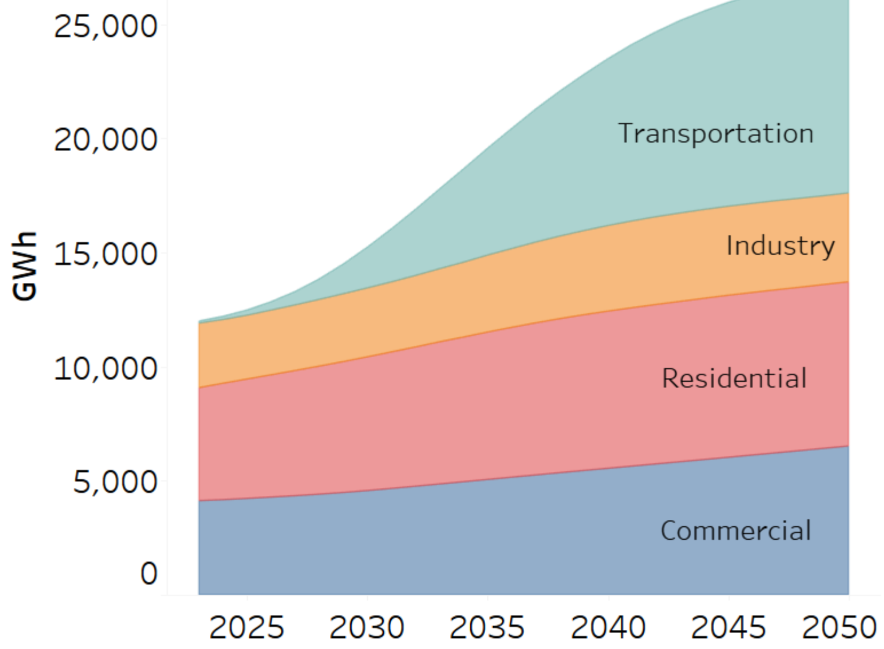
Figure Source: ISO-NE

Prior Results

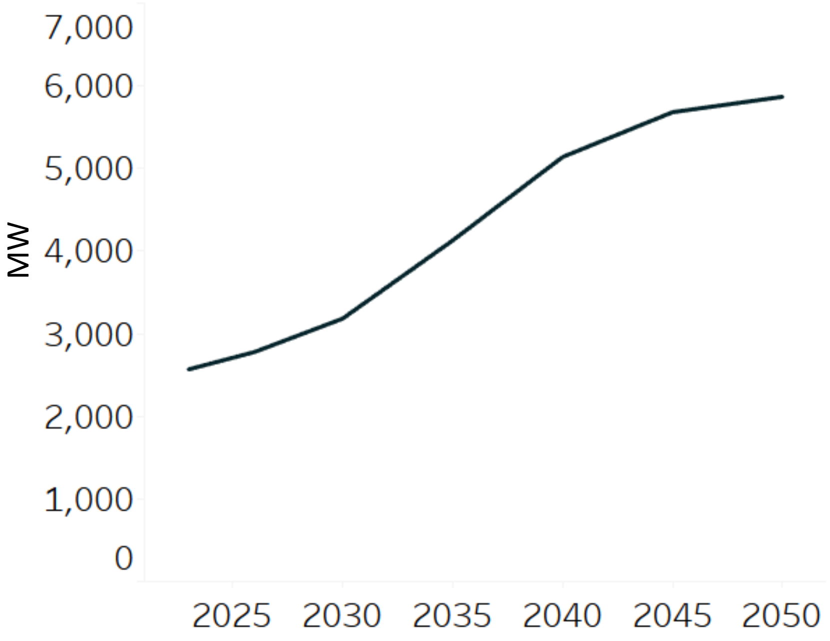
Electricity demand increases via electrification (mostly heating and transport)

- Nearly doubling electric demand by 2050, while reducing overall energy use (electricity is more efficient)
- Peak may increase by 2-3x, with implications for T&D expansion, as well as generation and storage capacity
  - Peak impact depends on Load Flexibility – and much of the new electrification load can be flexible

Electricity Demand, Maine (Core Pathway)



Distribution System Capacity, Maine (Core Pathway)



Precise impacts on electricity demand, peak, and fuel use differ by Pathway, but all show significantly increased reliance on electricity

DRAFT RESULTS

Prior Results

For each pathway:

- Initial hourly energy demand projection is based on types and degree of electrification over time
- Key Maine policies and targets are incorporated through 2050 for all pathways (similar for other states' policies)
  - Economy-wide GHG reductions: 45% by 2030; 80% by 2050 (vs 1990)
  - Electricity: 80% Renewable by 2030 (with supporting procurements); 100% Clean by 2040
    - 3,000 MW OSW by 2040; 400 MW Storage by 2030; planned resource and transmission projects
  - Heat pump targets: 100,000 by 2025; +175,000 by 2027
  - Other states' policies also reflected – GHG limits, RPS, renewable procurements, etc.

Analysis determines the most cost effective way to serve electricity and fuel needs

- Considers cost of energy (electricity and fuels), and distribution infrastructure (T&D expansion to meet peak)

Pathway Modeling

Pathways: scenario design

Pathways are designed to explore alternative ways for Maine to decarbonize its energy system while addressing policy questions and potential implementation challenges

We designed a **Core pathway** that uses our "core" assumptions and offers a point of comparison between alternative pathways

- **Additional pathways** were developed with stakeholder input in prior stakeholder meetings

Variations on the **Core pathway** explore key issues:

- Alternative supply resources to meet 100% clean electricity
- Alternative degrees of load flexibility
- Emerging technologies:
  - Alternative emerging technologies – e.g., heat decarbonization, distributed resources

Key Questions to be Addressed:

How to meet 100% clean electricity by 2040?

- Renewable energy is clearly able to cost-effectively decarbonize the bulk of the electricity system
- What supply resources may be best for the “last mile” to 100%?
  - Additional renewables with storage?
  - What is the role of clean thermal generation?
  - What other resources may be needed, based on operational considerations and economics?
    - E.g., Gas w Carbon Capture, Large Hydro, Nuclear?

Can Flexible Load help mitigate reliability concerns and/or reduce costs?

What are the impacts of emerging technologies, including:

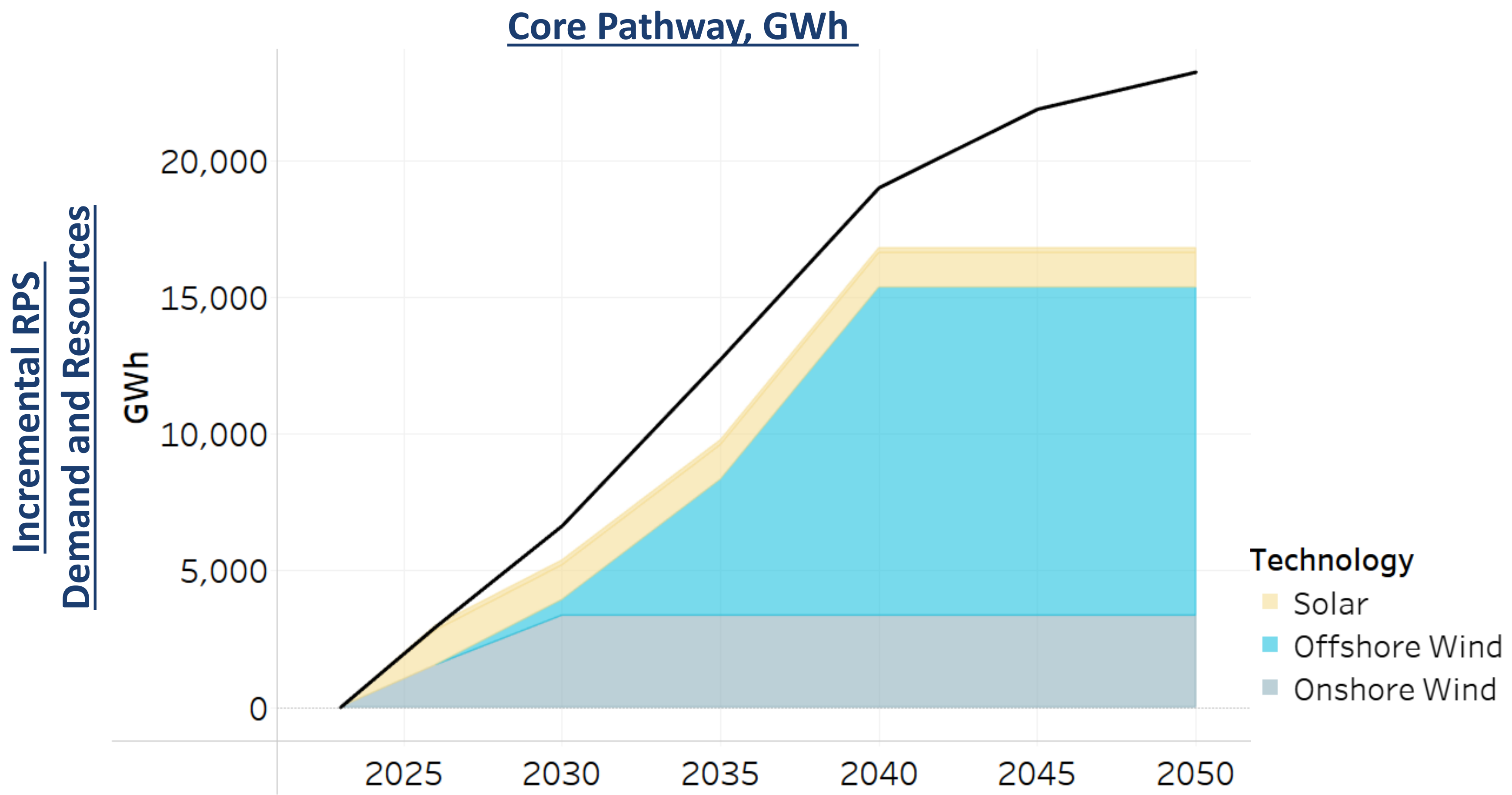
- Hybrid Heating (renewable fuel-fired heating systems used as backup in extreme cold conditions)
- Distributed energy resources

Pathways: Assumptions Matrix - REVISED

					Modeling not finalized	Modeling not finalized	Modeling not finalized
	Pathway	**Core**	**No Thermal Gen**	**No Flexible Load**	**High Flexible Load**	**Hybrid Heat**	**High Dist Resources**
	Question Addressed		What is role of Thermal Gen?	What is the role of Flexible Load?	What is the role of Flexible Load?	What is the role of Hybrid Heat?	What is Role of DER with Load Flex?
Policy	**Electricity**	**80% RPS by 2030 and 100% clean electricity by 2040**					
	Economy-wide GHG	**45% below 1990 levels by 2030 and 80% below by 2050**					
Demand side	**End-use electrification**	**High Electrification**	Same as Core	Same as Core	Same as Core	**Hybrid Heat**	Same as Core
	End-use load flexibility	**Medium**	Same as Core	**None**	**High**	Same as Core	**High**
Supply side	**Customer-sited resources**	**Medium**	Same as Core	Same as Core	Same as Core	Same as Core	**High**
	Existing thermal resources	**Retain if economic Burn zero carbon fuel by 2040**	**Retire**	Same as Core	Same as Core	Same as Core	Same as Core
	Planned infrastructure	**MPUC contracts, energy storage target, offshore wind target, NECEC, Aroostook Renewable Gateway and King Pine Wind**					

Maine's Incremental Clean Generation Needs

Currently contracted/committed resources meet most of Maine's incremental 2040 clean energy needs*



* In-service dates are estimated

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Pathway Results and Insights

100% Clean by 2040

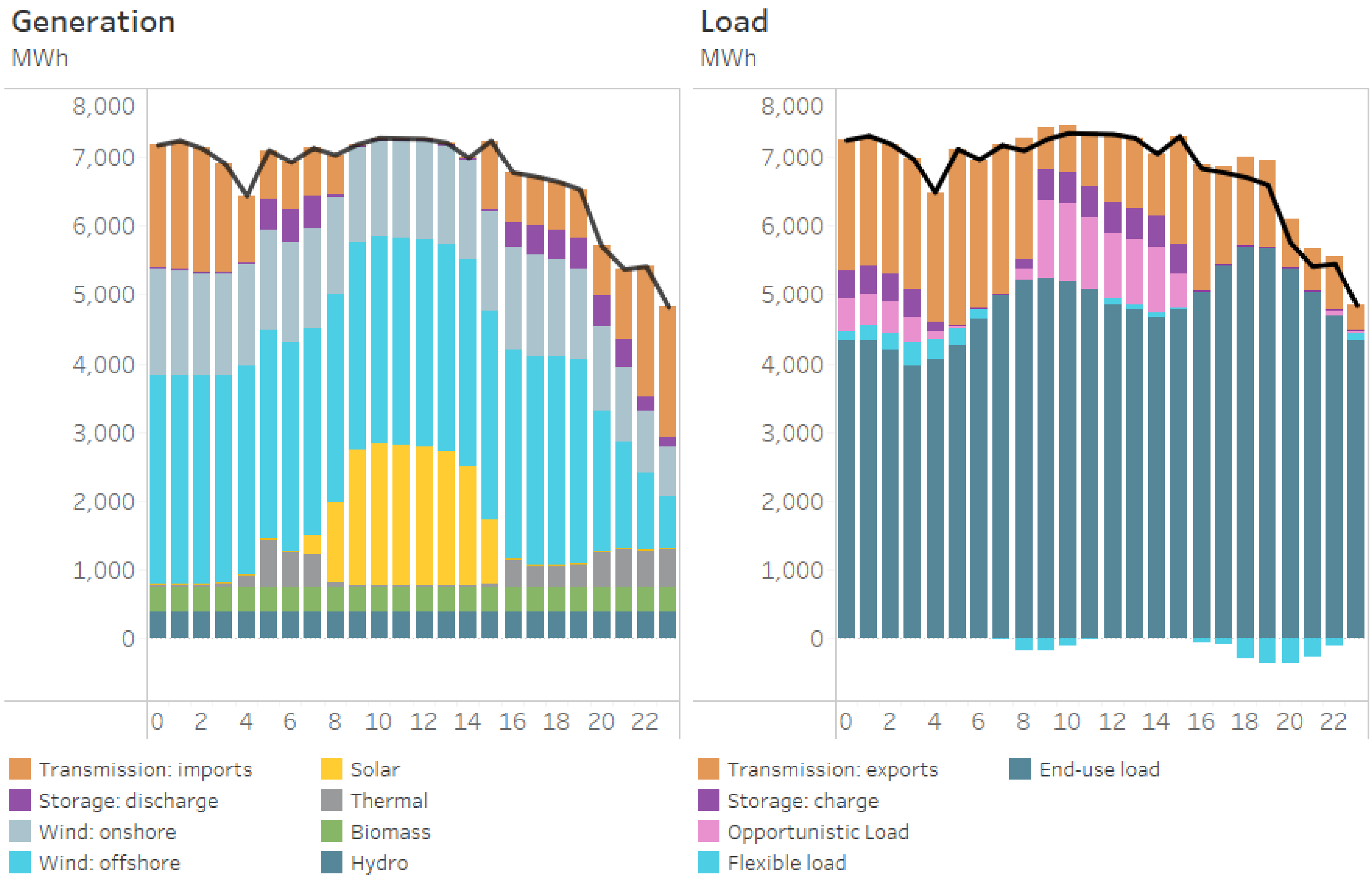
100% Clean Electricity System: Hourly Operations on a Typical Winter Day

Generation

- Renewable output, particularly from offshore wind, is high across most hours
- Storage and thermal generation dispatch during shoulder hours

Demand

- Load is high in the early morning and evening due to heating loads, but flexible load moderates peaks
- Electrolysis (H_2) and storage consume excess renewable output



*Opportunistic load refers to large industrial loads, such as electrolysis, that are not must-serve in each hour

DRAFT RESULTS

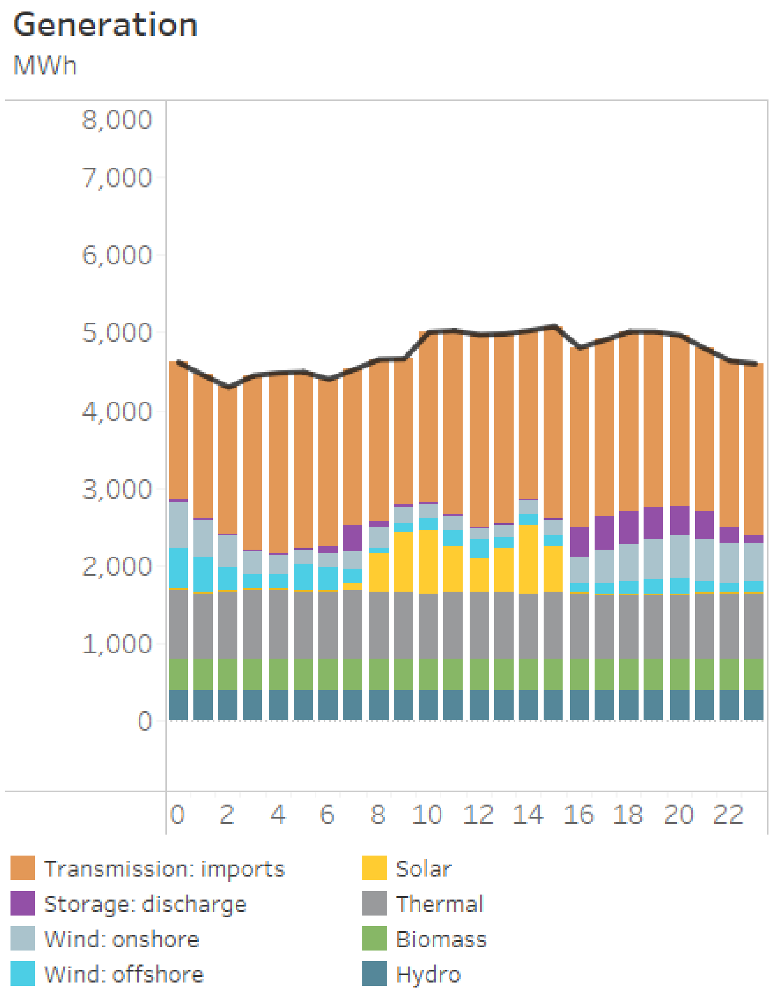
100% Clean Electricity System: Hourly Operations on a (Rare) Challenging Day

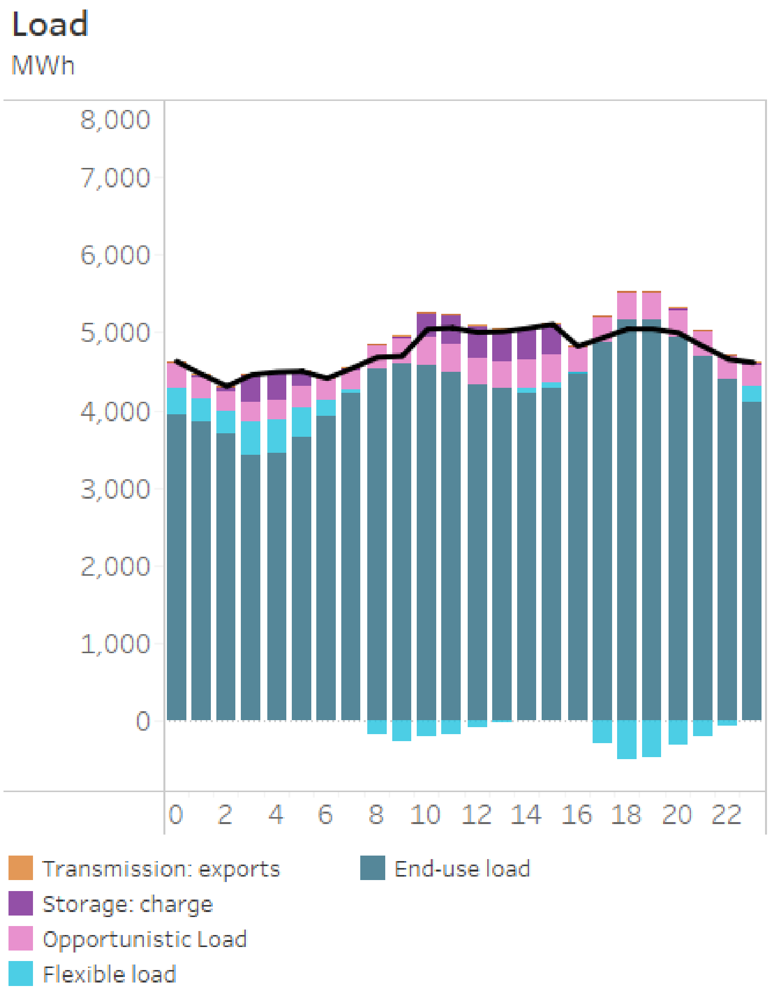
Generation

- Wind and solar generation is minimal
- Thermal resources burn zero-carbon fuel across the day
- Energy storage, flexible load and clean (mostly Canadian) imports contribute to maintain resource adequacy

Demand

- Storage, electrolysis and export demand all decline significantly
- Flexible load helps flatten total load but cannot address extended RE drought





DRAFT RESULTS

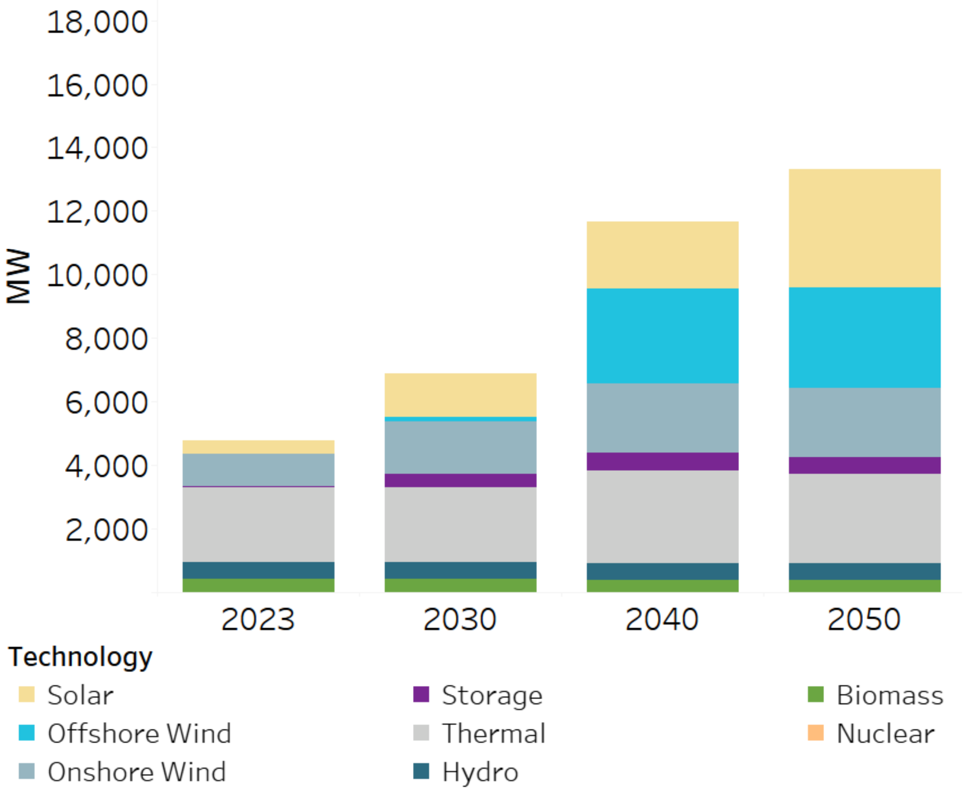
*Opportunistic load refers to large industrial loads, such as electrolysis, that are not "must-serve" in each hour

100% Clean Energy by 2040 – What Resources for "Last Mile" to 100%?

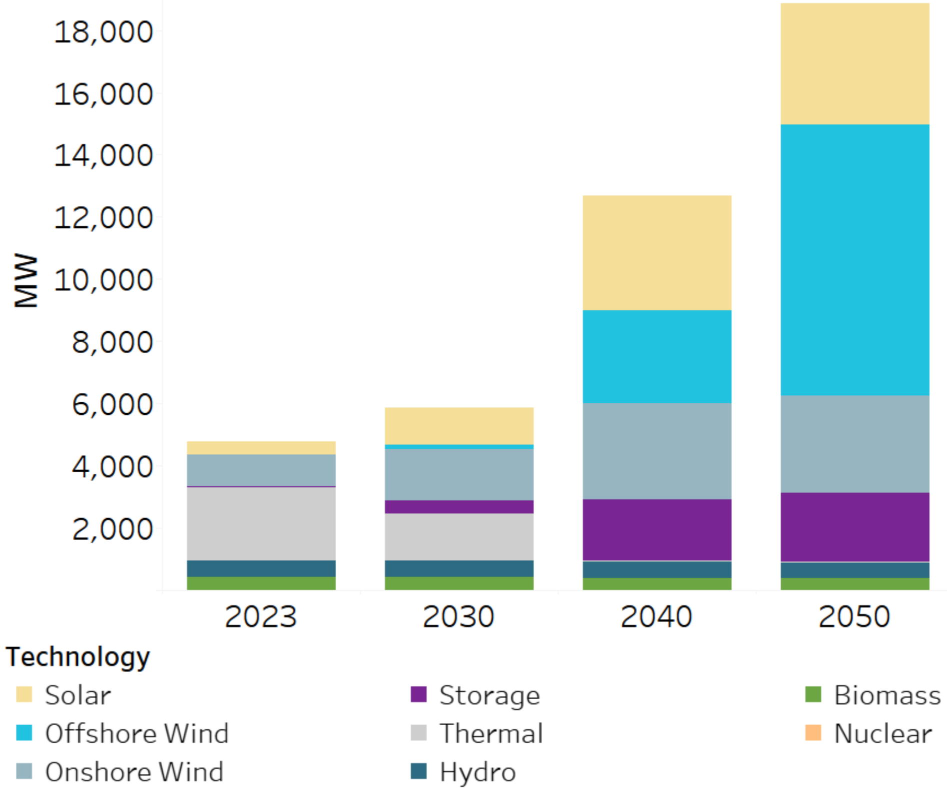
The **No Thermal Gen** pathway shows considerably higher resource needs (less thermal; much more storage, as well as wind and solar), and thus higher cost, than **Core** (which allows thermal/clean fuel).
- Greater renewable resource needs may have significant land use implications, as well.

Capacity, Maine

Maine Capacity (Core Pathway, MW)



Maine Capacity (No Thermal Gen, MW)



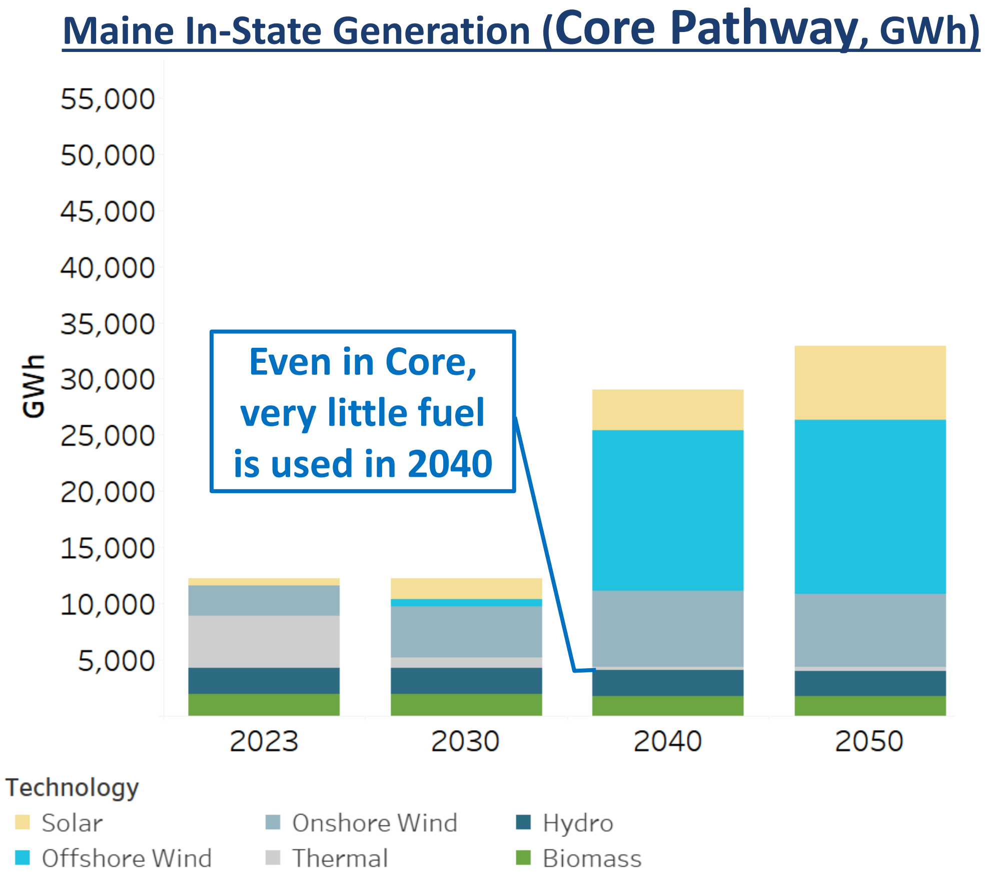
Note: Core pathway selects renewables, keeps thermal with clean fuel; other options (CCS, nuclear, new large hydro) were available but have higher cost

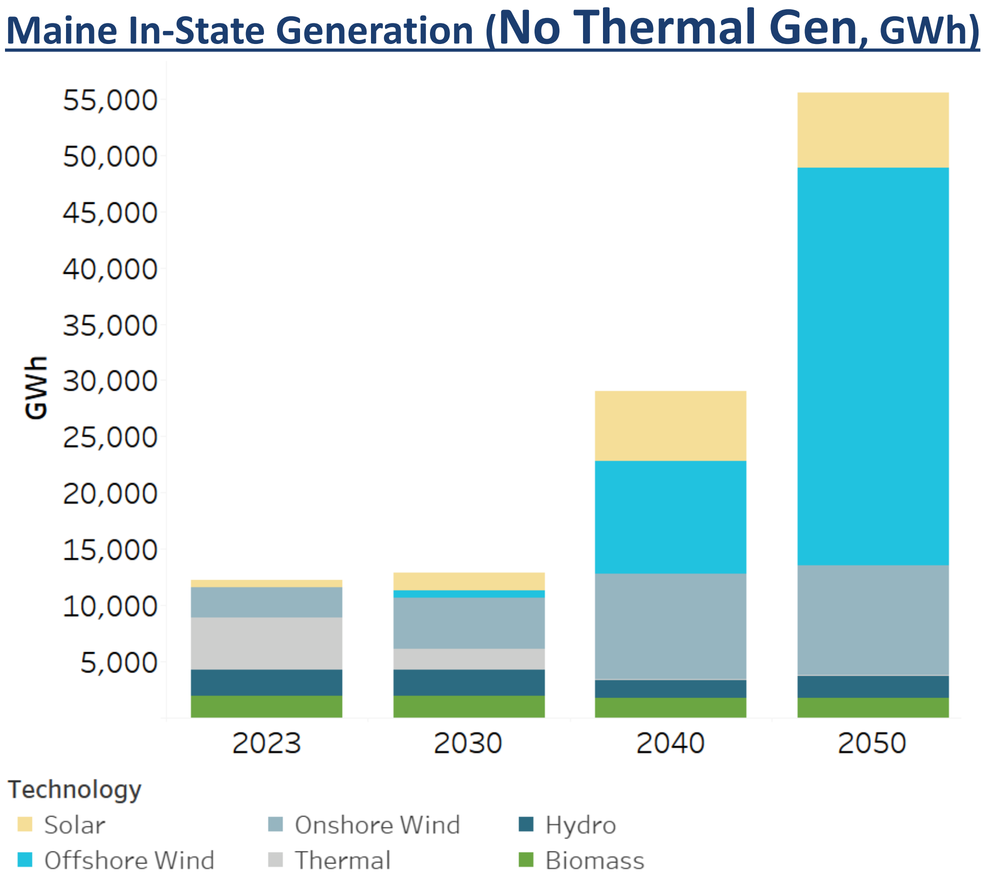
DRAFT RESULTS

100% Clean Energy by 2040 – What Resources for "Last Mile" to 100%?

Despite retaining significant thermal capacity in **Core**, it is used very infrequently, for little total fuel use (Additional renewables in **No Thermal Gen** provide energy at times it's not needed; utilized for e-fuels)

Energy, Maine





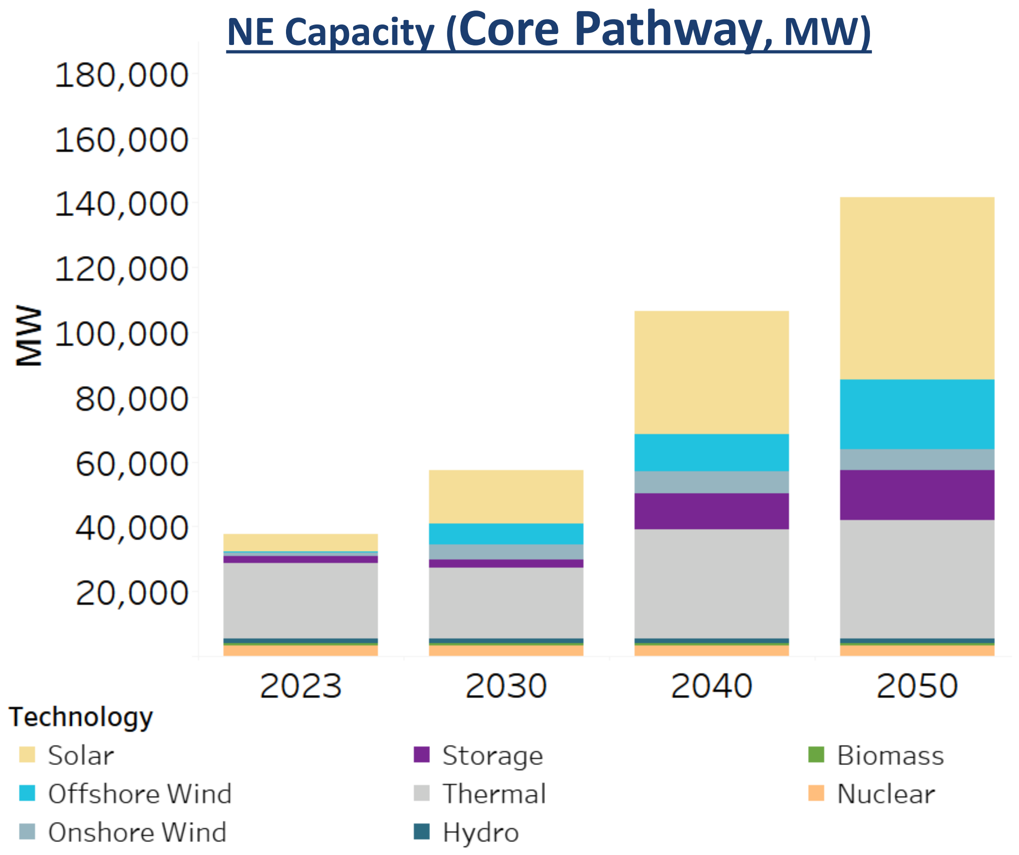
Note: Core pathway selects renewables, keeps thermal with clean fuel; other options (CCS, nuclear, new large hydro) were available but have higher cost

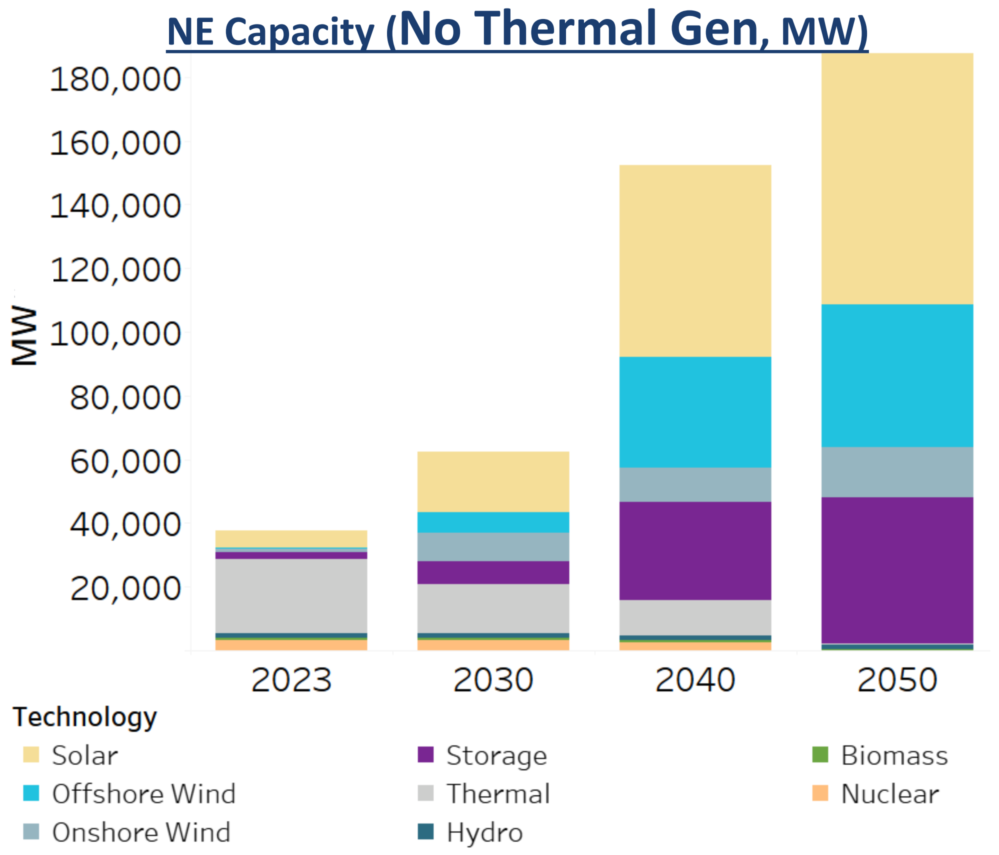
DRAFT RESULTS

100% Clean Energy by 2040 – New England View

Results are similar at New England level - **No Thermal Gen** pathway shows higher resource needs (though NE has a different mix than Maine – less OSW and more solar – and much more storage)

Capacity, New England





DRAFT RESULTS

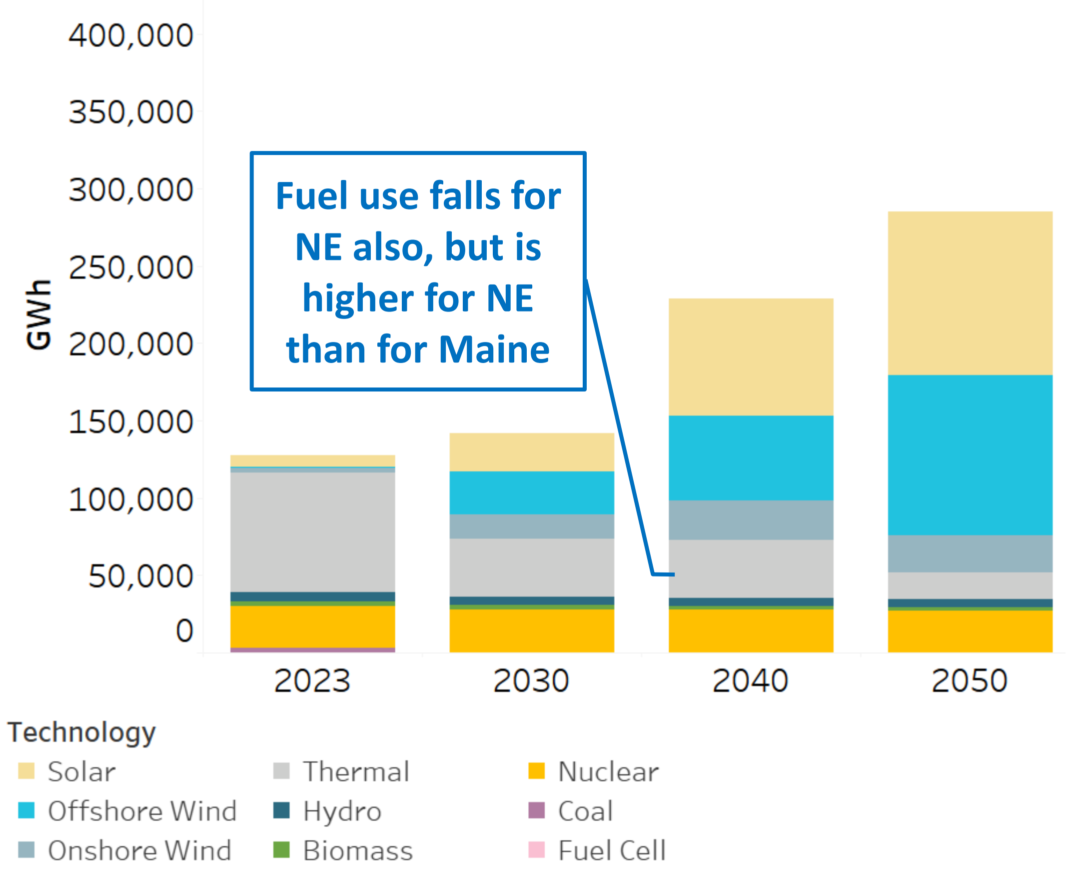
Updated

100% Clean Energy by 2040 – New England View

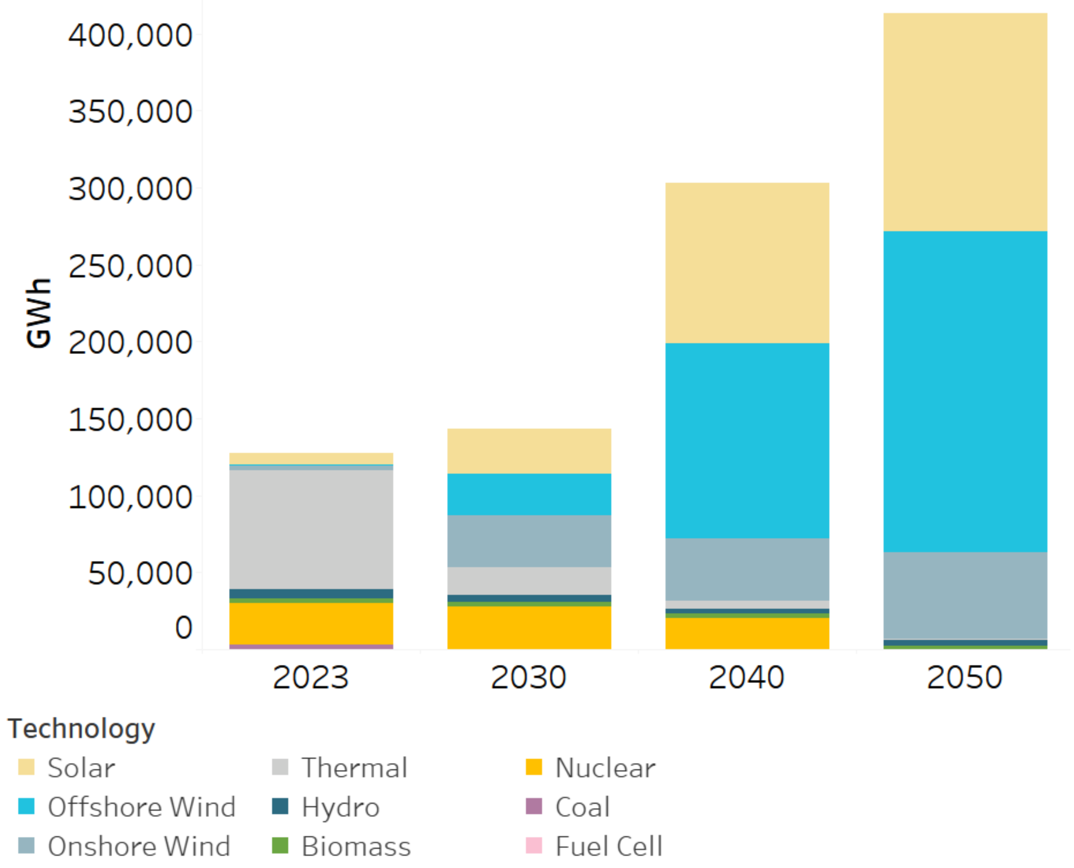
New England fuel use does fall, but by less; timing and level of clean requirements vary across NE states

Energy, New England

NE Generation (Core Pathway, GWh)



NE Generation (No Thermal Gen, GWh)



DRAFT RESULTS

100% Clean Energy by 2040 – What Resources for “Last Mile” to 100%?

The majority of hours can be cost-effectively served by renewables

Maintaining system reliability can be challenging in some hours as renewable penetration gets very high

- Need a cost-effective approach to meet the needs of the last few percent to achieve 100%

Wind and solar

- To meet load in hours with limited renewable resource (dark calm), intermittent renewables must be paired with significant storage for reliability
  - Including long-duration storage – emerging technology

Clean dispatchable resources (e.g., thermal generators with renewable/clean fuel)

- Could provide support for limited periods of system stress
- Fuel may be relatively costly, though relatively little would be needed
  - Must ensure advanced fuels are truly low emission and sustainable – emerging technologies

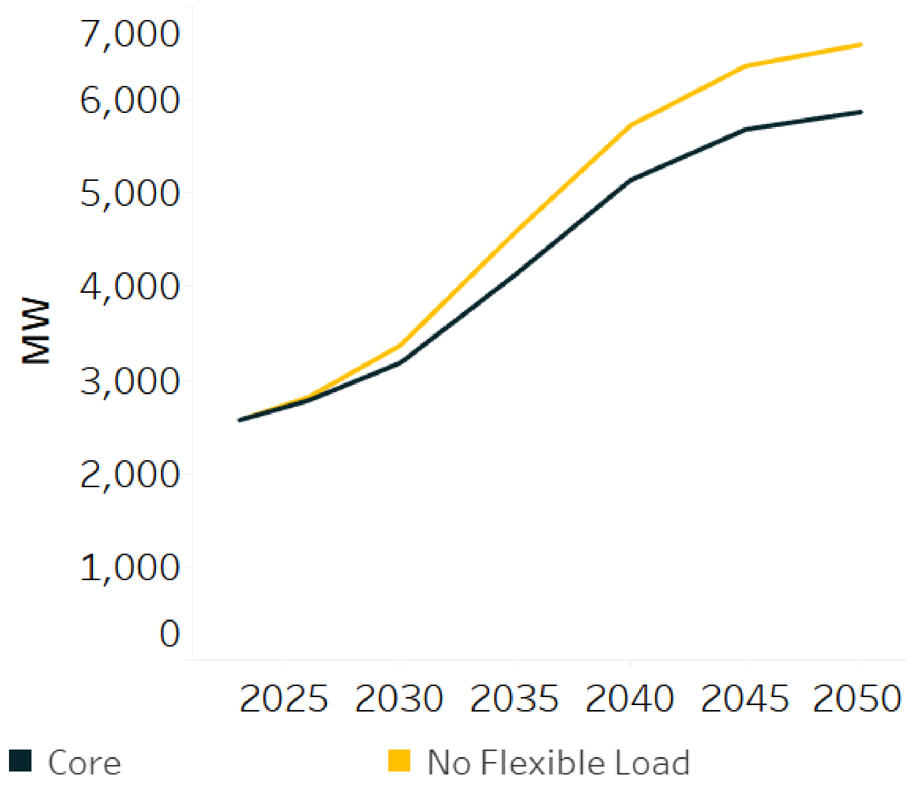
Discussion

Load Flexibility

Load Flexibility – Pathway Results

Load flexibility significantly mitigates electricity net peak, limiting distribution peak growth (thus T&D upgrade needs), generation and storage needs, and costs. The "Medium" level of flexibility in the Core pathway has a significant impact (High Flexibility case is still under evaluation)

Distribution System Capacity (MW)



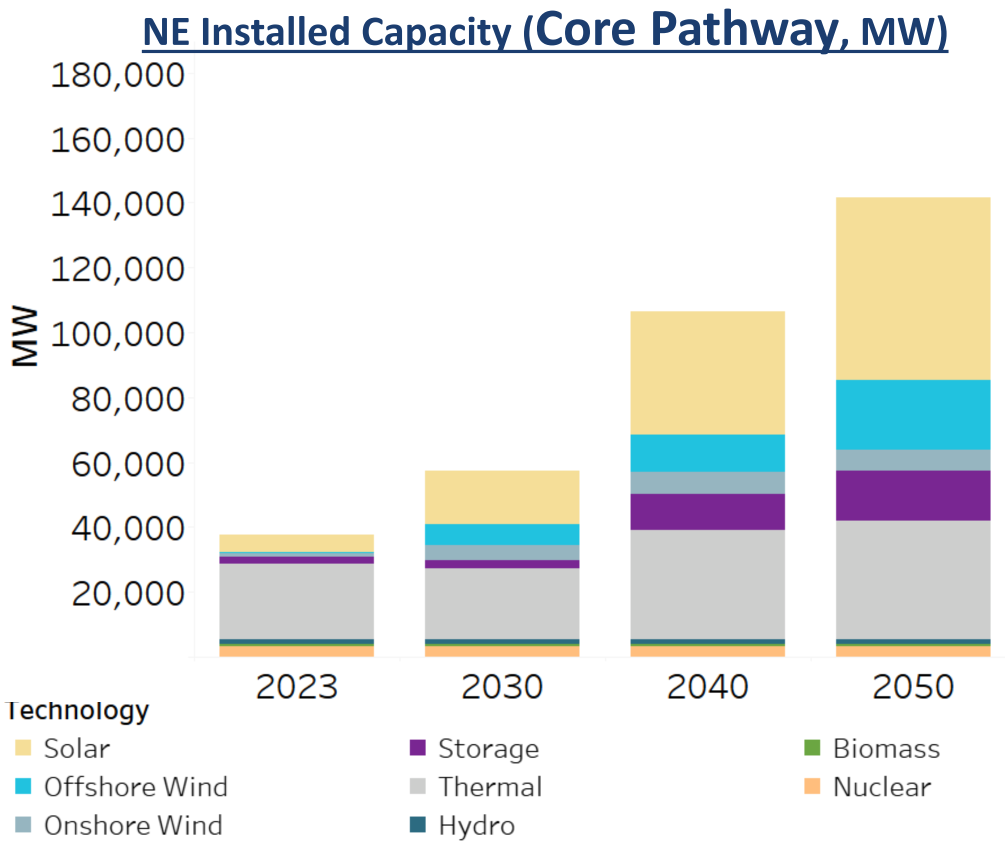
DRAFT RESULTS

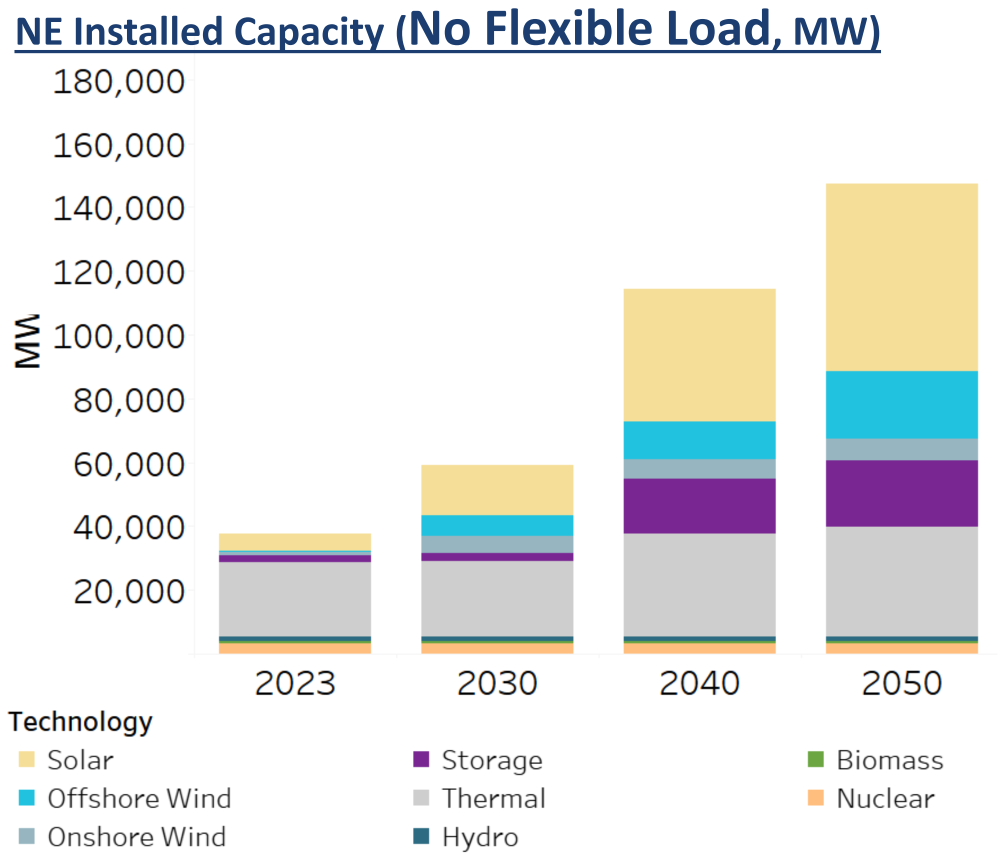
Load Flexibility – Pathway Results

Much more storage is needed with **No Flexible Load**, even with retained thermal capacity

High flexible load (more than **Core**; still under study) may go further to address longer-duration inter-day issues

Capacity, New England





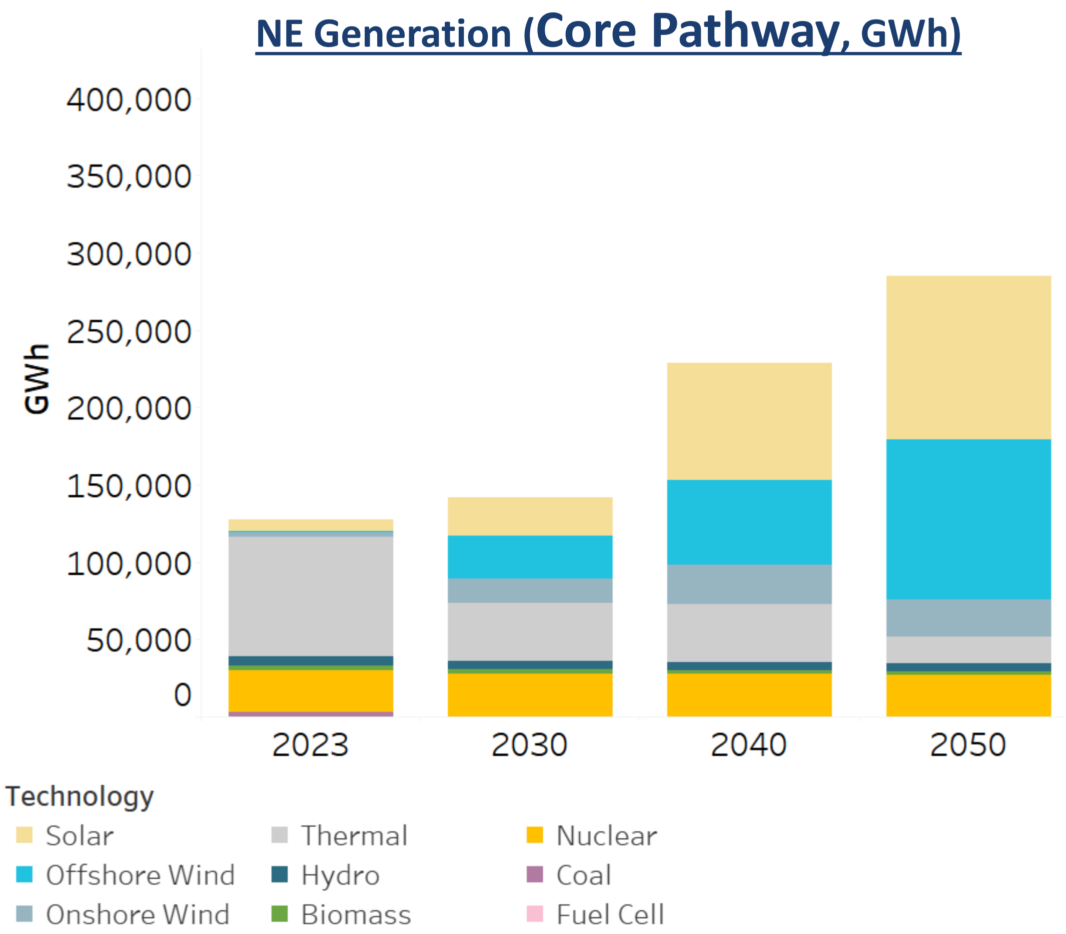
DRAFT RESULTS

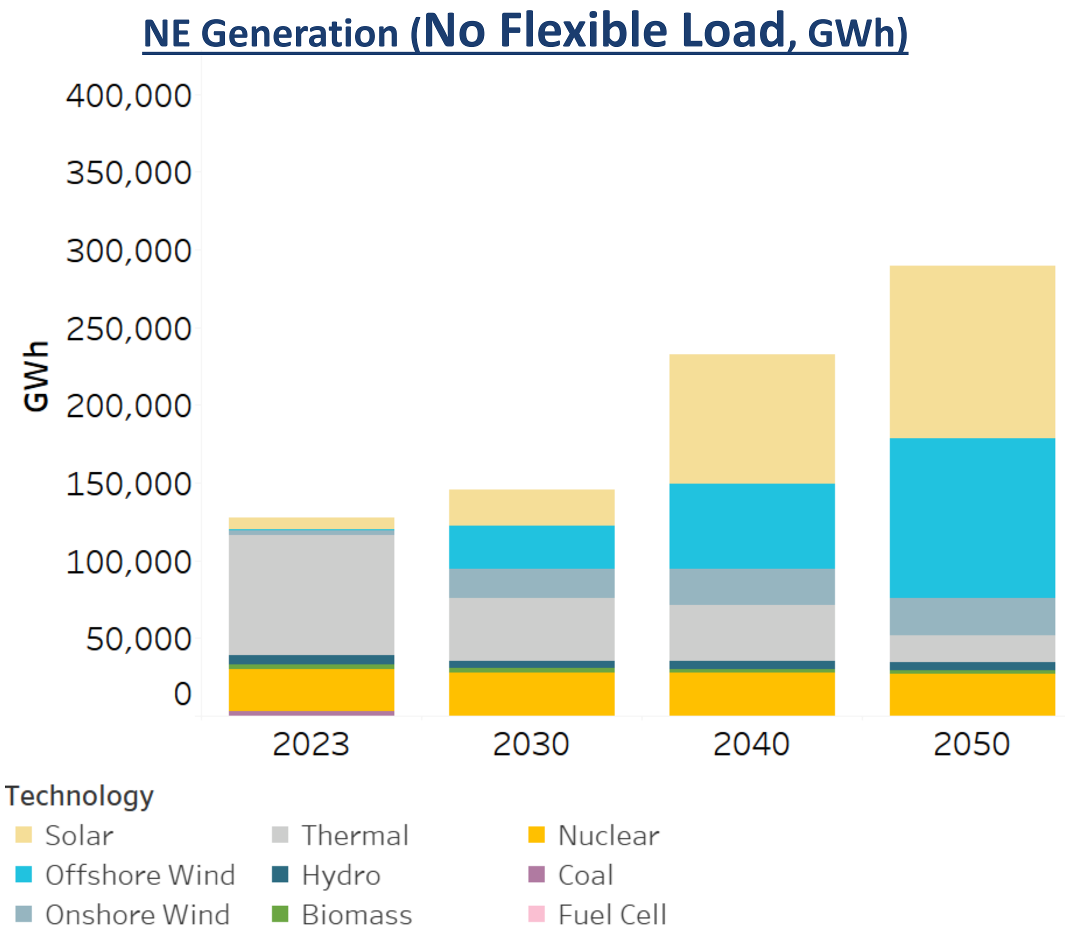
Updated

Load Flexibility – Pathway Results

Presence or absence of Load flexibility has little impact on energy production, since it mostly affects timing

Energy, New England





DRAFT RESULTS

Load Flexibility

A clean-energy future that relies heavily on intermittent renewable generation resources can put a premium on Load Flexibility – enables shaping demand to match intermittent supply

- Many new electrification loads lend themselves to at least some level of flexibility
  - Particularly EV charging – a very large load that is inherently flexible (must be done when the vehicle is not being used)

Three levels of load flexibility modeled – None, Medium (Core), High – specifying for each potentially flexible load type what share of that load is flexible, and how far that flexible load can be shifted in time

- No Load Flex – all load occurs at nominal time (not responsive to system – charge EV when it plugs in)
- Moderate Load Flex – e.g., 67% of EV load can be delayed up to 8 hours (other techs also have some flexibility)
- High Load Flex – Adds vehicle-to-grid (V2G) capability, in addition to flexible load timing

Model adjusts timing of flexible load (within the limits established), to respond to system conditions to minimize costs

- Primary effect is to shift load away from times of high net peak (Net Peak = Load – Intermittent Renewable Gen), to reduce net peak and the associated costs of expanding G, T & D

Discussion

Next Steps

Next Steps

Consultant Team:

- **Finalize modeling**
- **Consider policy implications of analyses**
- **Draft final report**

Governor's Energy Office:

- **Key stakeholder check-ins – now to end of year**
- **Meeting with Energy Working Group of Maine Climate Council – next Tuesday**
- **Stakeholder meeting with Draft Report – early 2024**