GOVERNOR'S
Energy Office

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

www.maine.gov/energy

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.

“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

GOVERNOR'S Energy Office

Feedback from August

Key themes on modeling and planning

Demand management*: Will be essential to minimize new generation and infrastructure*

Other studies*: Link with other studies, in particular ISO New England*

Distributed energy*: Consider implications of distributed energy resources*

Sensitivity tests*: Use modeling to test sensitivity to technology and other changes*

Grid upgrades*: Will be essential. How to incentivize investment?*

Key themes on engagement

Clear ask*: What are the 5-6 questions you want input on?*

Reach out*: Many suggestions on groups to reach out to*

Attend related events*: Incorporate updates into other ongoing proceedings / meetings*

Our Conversation Today

1. **Demand management – reflections from the technical team**
2. **Update on modeling – Part 1 – Pathway Approach**
3. **Update on modeling – Part 2 - Initial Reference Pathway**

Participant Comments & Q&A after each section

Demand Management

Reflections from the technical team

Maine Energy Plan

PATHWAY TO 2040

SECOND STAKEHOLDER MEETING

THE BRATTLE GROUP
EVOLVED ENERGY RESEARCH

ON BEHALF OF THE
MAINE GOVERNOR'S ENERGY OFFICE

SEPTEMBER 28, 2023

Brattle

EVOLVED ENERGY RESEARCH

GOVERNOR'S Energy Office

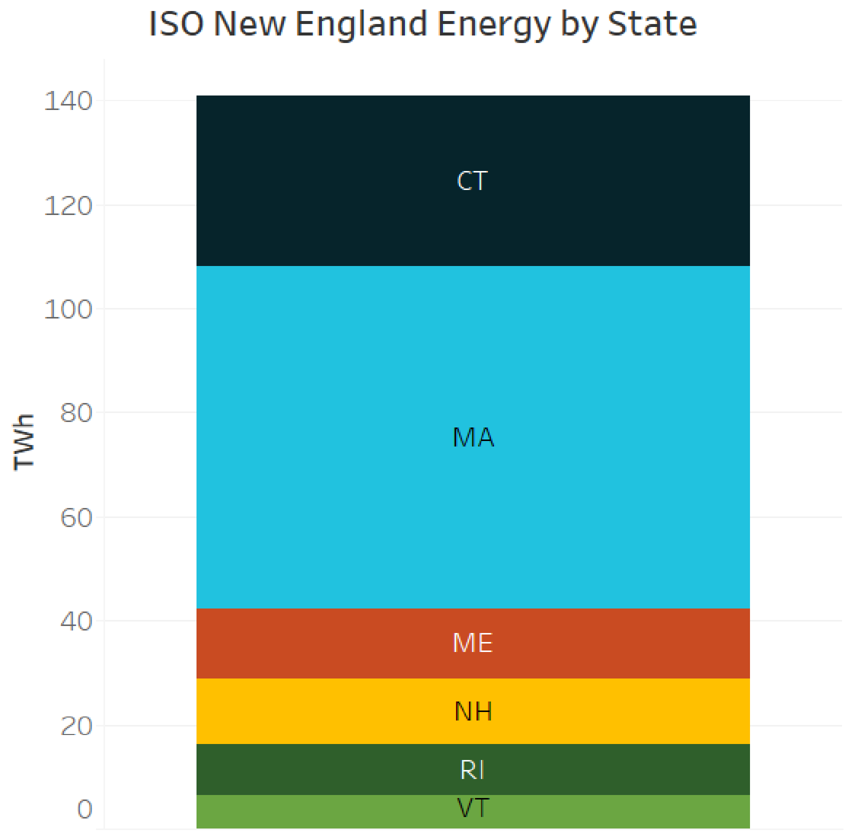
Regional Context

States across New England have targets to increase renewable and clean energy, and deeply reduce GHG emissions

≥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: figure from ISO-NE

Maine uses about 10% of all electricity across New England



Data source: ISO-NE

Regional Modeling Representation

Modeling represents multiple geographies across U.S. and Canada

Maine is represented with four zones

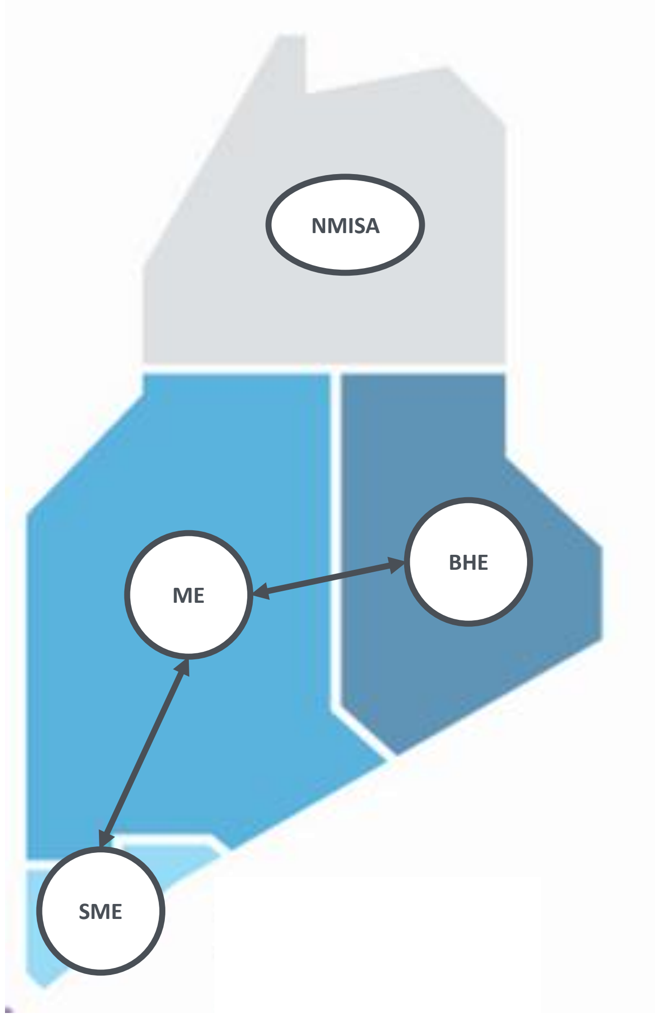
- Three zones consistent with ISO-NE system planning: Southeastern Maine(SME), Western and central Maine/Saco Valley (ME), Northeastern Maine (BHE)
- Northern Maine (NMISA) is outside of ISO-NE

Additional modeled zones

- Other ISO-NE states: NH, VT, MA, RI, CT
- New York, New Brunswick , Hydro Quebec, Rest of U.S.

Modeling the regional context on an hourly basis captures important opportunities and challenges as multiple states pursue decarbonization objectives

Four Maine Zones



Modeling Approach

We project the energy needs of Maine's economy and the most cost-effective way to provide that energy while meeting emission and electricity targets

Focus of August stakeholder meeting

Focus of today's stakeholder meeting

Maine's Energy Infrastructure

Residential
Commercial
Industrial
Transportation

→

Maine's Energy Needs

Electricity
Pipeline Gas
Liquid Fuels
Hydrogen

→

Maine's Energy Supply

Generation
Delivery (T&D)
Energy Storage
Fuel Supply

Modeling Approach

Assumptions on how consumers adopt end-use technologies

Supply-side technology cost, performance and potential

Maine's Energy Infrastructure

Residential
Commercial
Industrial
Transportation

Maine's Energy Needs

Electricity
Pipeline Gas
Liquid Fuels
Hydrogen

Maine's Energy Supply

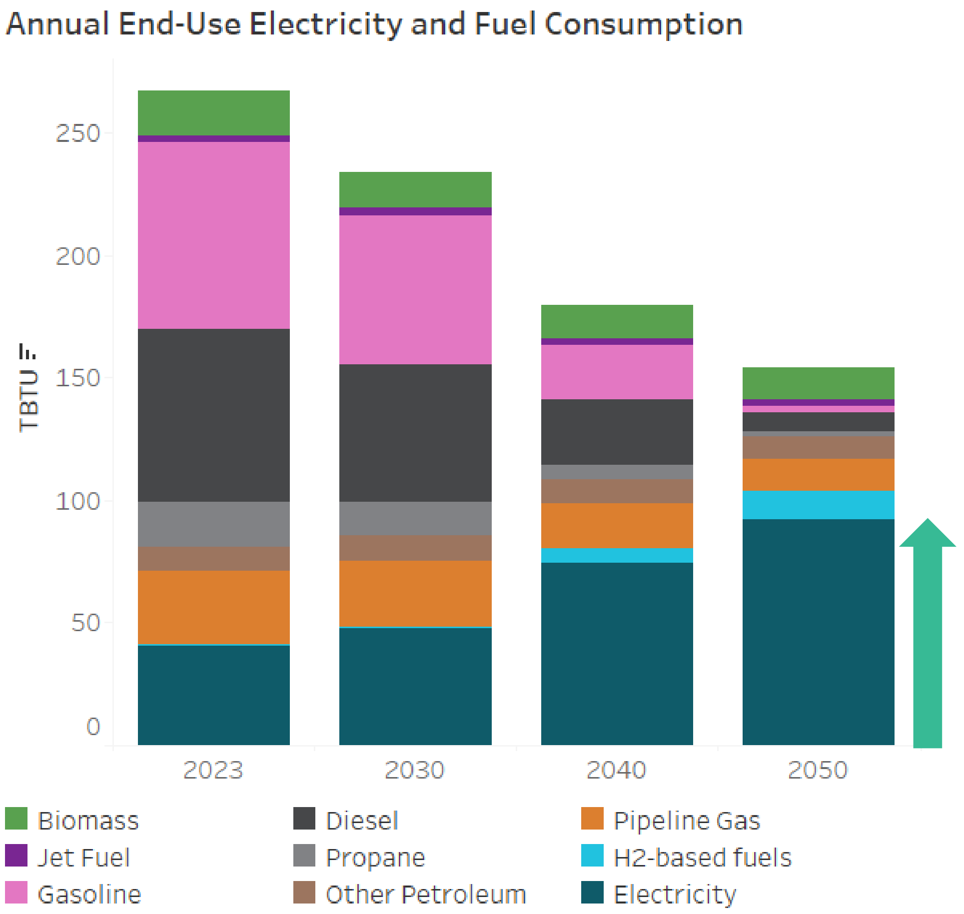
Generation
Delivery (T&D)
Energy Storage
Fuel Supply

Policy targets

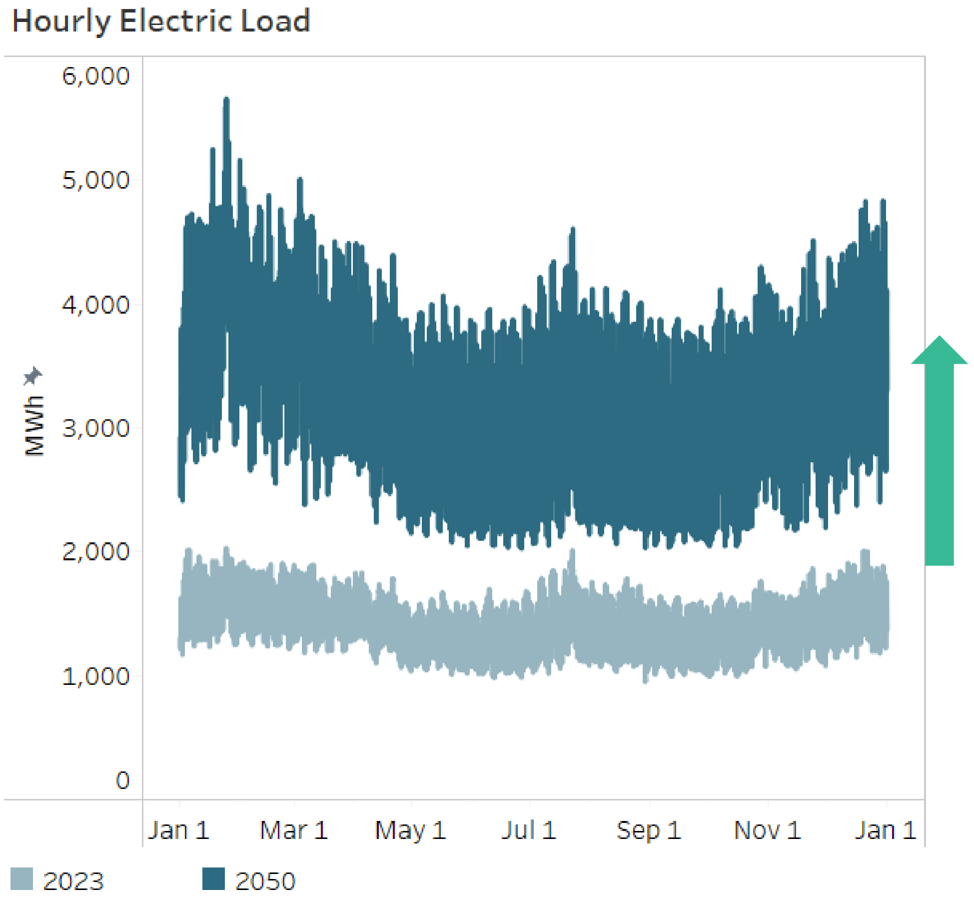
- 80x50 GHG target
- 100% clean electricity by 2040

August recap: ME's changing energy demand with high electrification

Rapid adoption of electric and efficient appliances and vehicles reduces fuel consumption and more than doubles electricity use…



…which affects the overall level and timing of when electricity is consumed

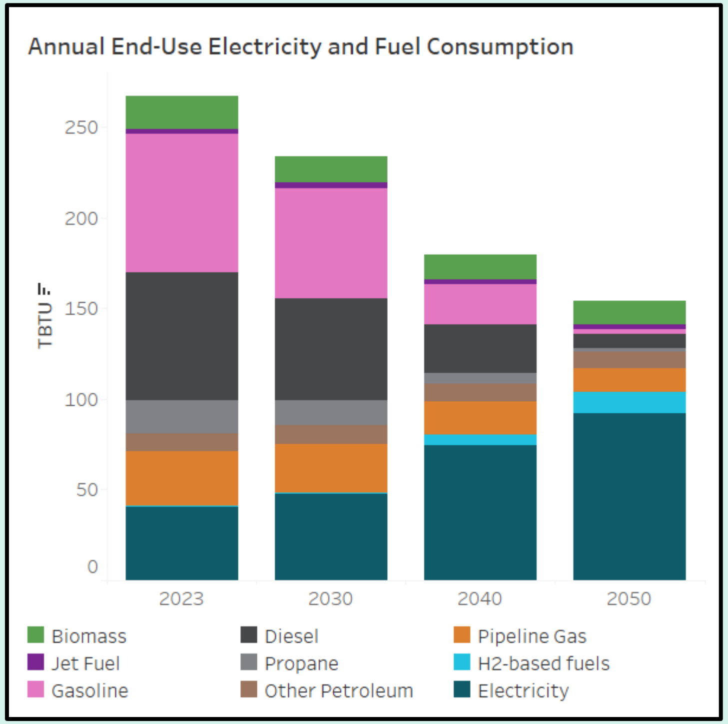


Note: load profile is prior to flexible end-use load shifting.

Pathway Modeling Approach

Supply-side modeling optimizes investments to meet policy targets

Energy Demand



Key Inputs

End-Use Energy Demand (Hourly)

Detailed Technology Representation (Hourly)

- Wind
- Solar PV
- Thermal & hydro resources
- Electric storage
- Transmission
- Load flexibility
- Hydrogen
- Other zero carbon fuels

Policy Constraints

- Renewable portfolio standard
- Clean electricity requirements
- Greenhouse gas reductions

Key Outputs

Capacity Expansion
Optimizes investments in energy infrastructure to meet demand, reliability and policy targets

Hourly Electricity Operations
Hourly dispatch of supply-side resources, customer-sited resources and transmission to meet load in each modeled hour

Pathways: scenario design

The goal of designing multiple pathways is to explore alternative ways to cost-effectively meet Maine’s energy needs and decarbonize Maine’s energy system

The analysis starts by defining a Initial Reference pathway that incorporates base assumptions consistent with deep energy system emission reductions in prior analyses

- This pathway is not “preferred,” but rather an initial reference point against which alternatives can be compared

For this meeting, we are presenting draft results for this Initial Reference pathway and will incorporate feedback to inform future pathways development

Pathways incorporates key Maine policies and targets through 2050

Economy-wide greenhouse gas reduction: 45% reduction by 2030; 80% by 2050 (vs 1990 levels)

80% renewable portfolio standard by 2030 and supporting procurements

100% clean electricity by 2040

3,000 MW of offshore wind by 2040

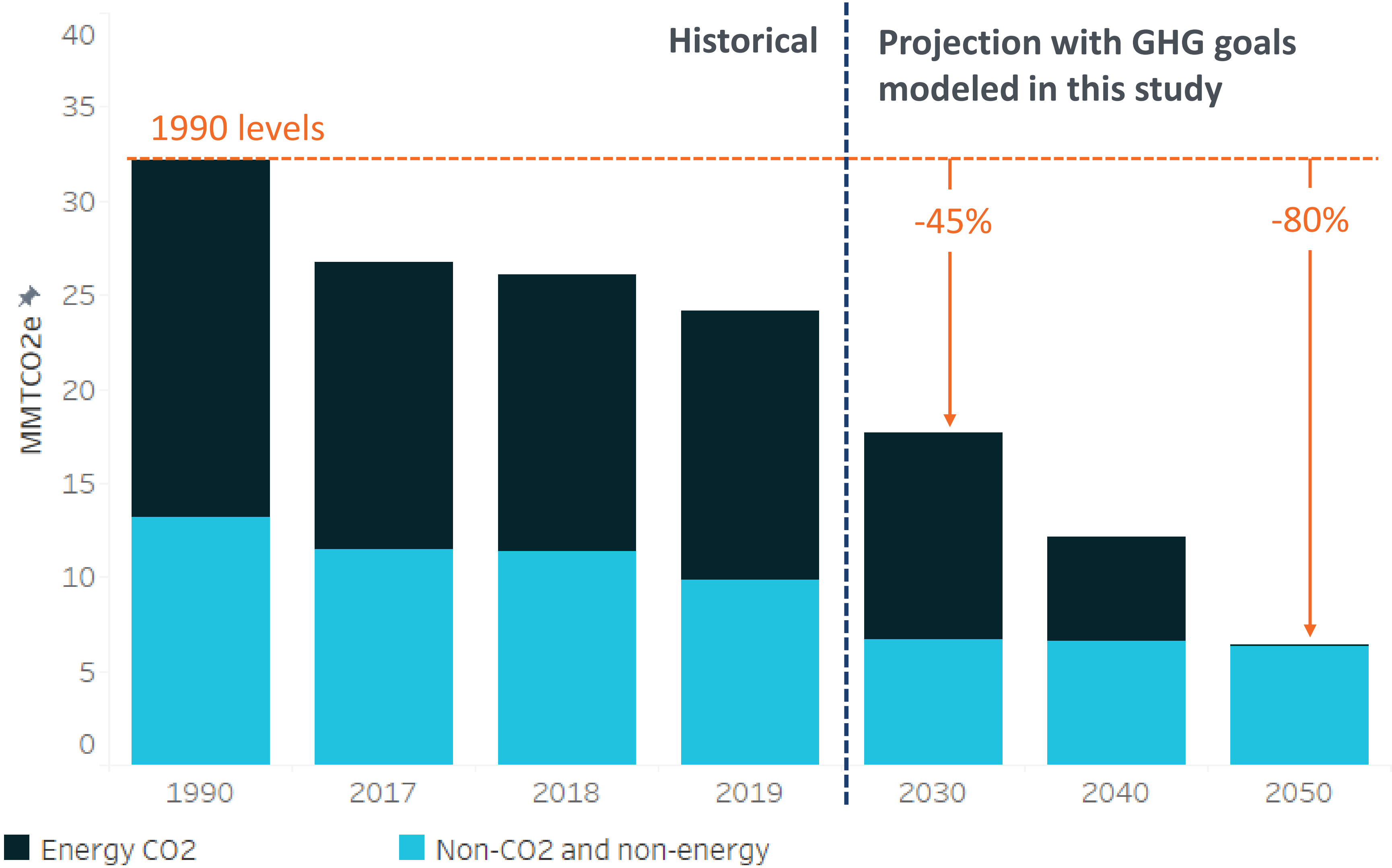
400 MW of energy storage by 2030

100,000 new heat pumps by 2025 and an additional 175,000 by 2027

Planned resource and transmission projects

Our modeling implementation for these are described in the following slides

Maine Statutory Greenhouse Gas Emissions Targets



Energy-related CO_2
-Fossil fuel combustion in electric power, buildings, transportation & industry

-Constrained in energy system modeling

Initial Model Assumptions for 100% Clean Electricity Resources

	2030	Transition →	2040
Policy	**80% renewable portfolio standard (RPS)**		**100% clean electricity generation**

Technologies

- Biomass
- Hydro
- Solar
- Wind

Examples of clean energy resources in other states to be considered in modeling

- Zero carbon thermal
- Nuclear
- Carbon capture and storage
- Imports from non-emitting sources

Q&A

Initial Reference Pathway: Preliminary Results

Key Takeaways from the Initial Reference Pathway

If achieved, Maine's existing procurement and resource targets will address most clean energy requirements for 2040

- This is accounting for significant load growth from electrification and end-use load flexibility

One of the key areas of continued focus for meeting 100% clean electricity by 2040 is how Maine will address capacity and balancing needs

- Extended periods of low renewable output is the primary driver
- This is a departure from today's planning where peak demand is the primary consideration

The electric distribution system will require further investment to accommodate electrification, but customer participation, such as smart electric vehicle charging, can moderate impacts

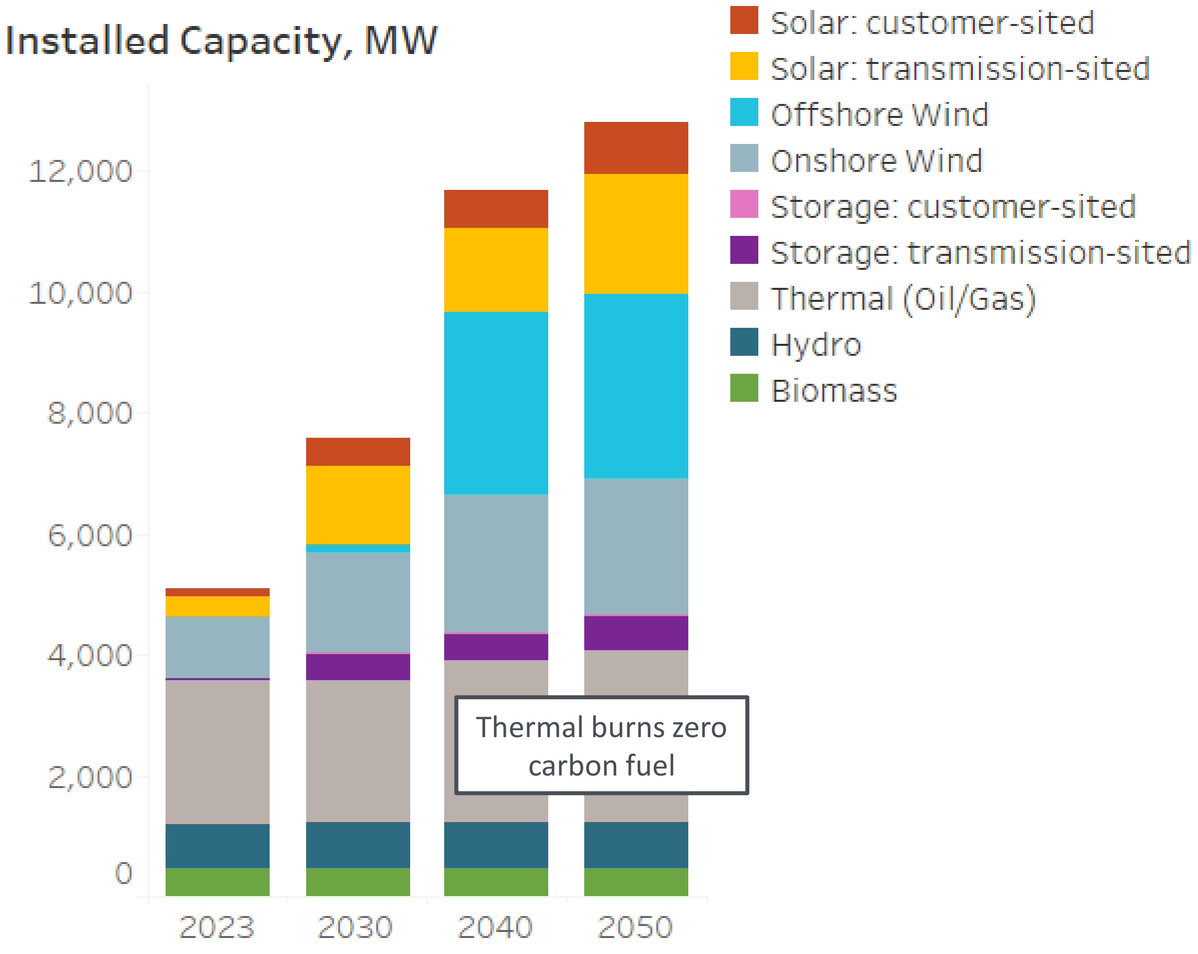
Electrification, clean electricity, and energy efficiency ("three pillars") drive the bulk of emission reductions across the transportation, buildings and industrial sectors

- Remaining gap is met with zero carbon fuels (hydrogen, biofuels and synthetic liquid fuels), particularly for industry and electric reliability

DRAFT RESULTS

Maine's generating capacity more than doubles by 2040

- Wind and solar resources expand rapidly to supply most energy needs
- Energy storage grows to 600 MW for daily balancing needs (duration ~10 hours)
- Level of thermal resources is similar to today, but switches to zero carbon fuel by 2040 and operates less frequently
- Hydro and biomass resources maintain their capacity



DRAFT RESULTS

Maine's generating capacity to meet 100% clean by 2040

Existing and planned procurement address most energy needs to 2040

Technology	Existing Resources (MW)	Planned Resources (MW)	Modeled Additions (MW)	Total (MW)
Biomass	450	0	0	**450**
Hydro	750	0	0	**750**
Onshore Wind	1,010	620	630	**2,260**
Offshore Wind	0	3,000	0	**3,000**
Solar PV: grid-connected	310	470	600	**1,380**
Solar PV: distributed	140	510	0	**650**
Energy storage	50	350	70	**470**
Thermal	2,320	0	330	**2,650**
Total	**5,030**	**4,950**	**1,630**	**11,610**

DRAFT RESULTS

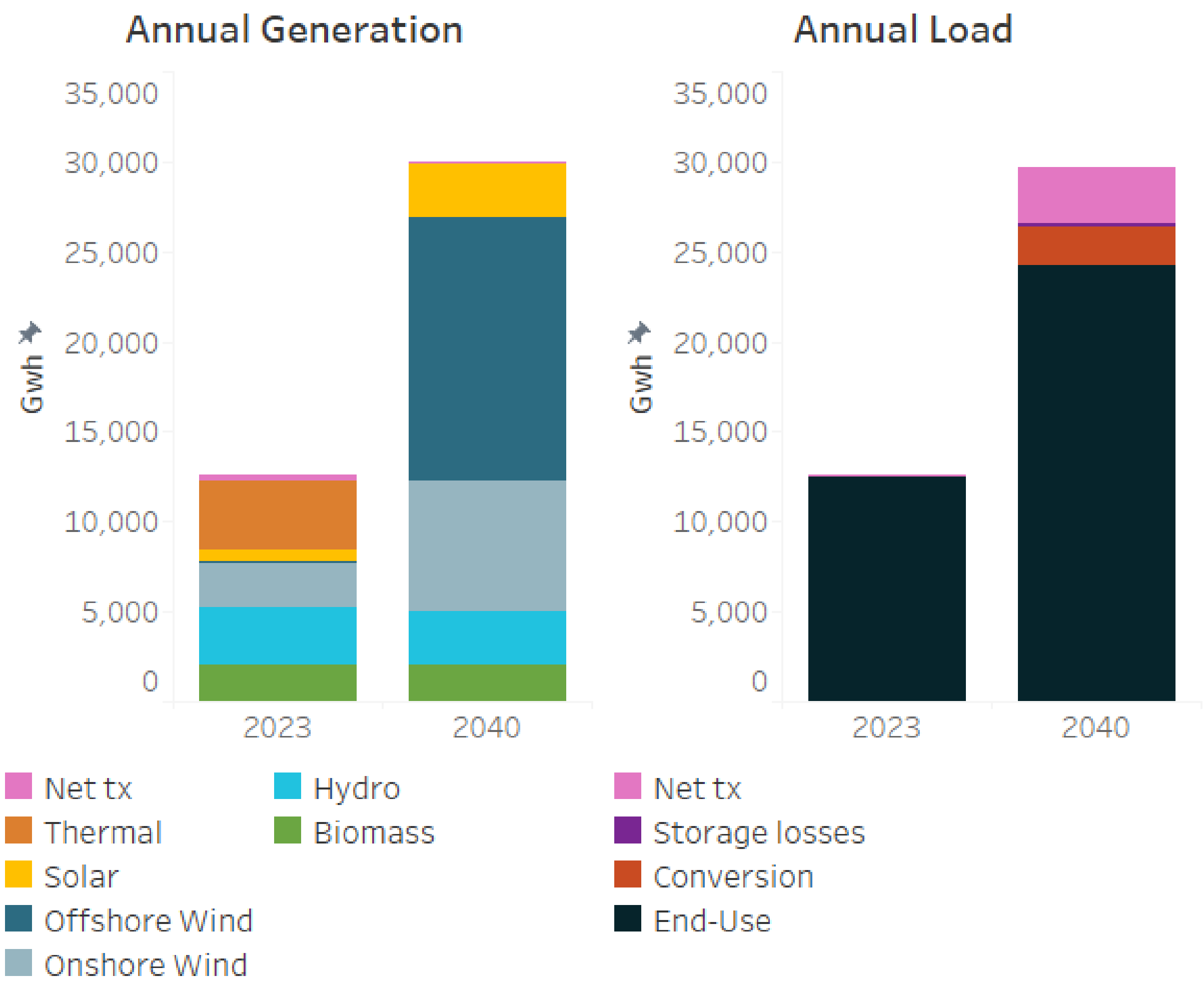
Changes to Annual Electricity Generation and Load – Now to 2040

Generation

- Land-based and offshore wind expand rapidly to account for more than 2/3 of generation
- Biomass and hydro generation stay at current levels, but their share decreases with large load/generation growth
- Thermal resources switch to zero-carbon fuel sources but operate very infrequently

Load

- End-use consumption grows with transport and building electrification
- H_2 production from electrolysis and industrial heat (steam) production ("conversion loads") help balance electricity system while decarbonizing other sectors



DRAFT RESULTS

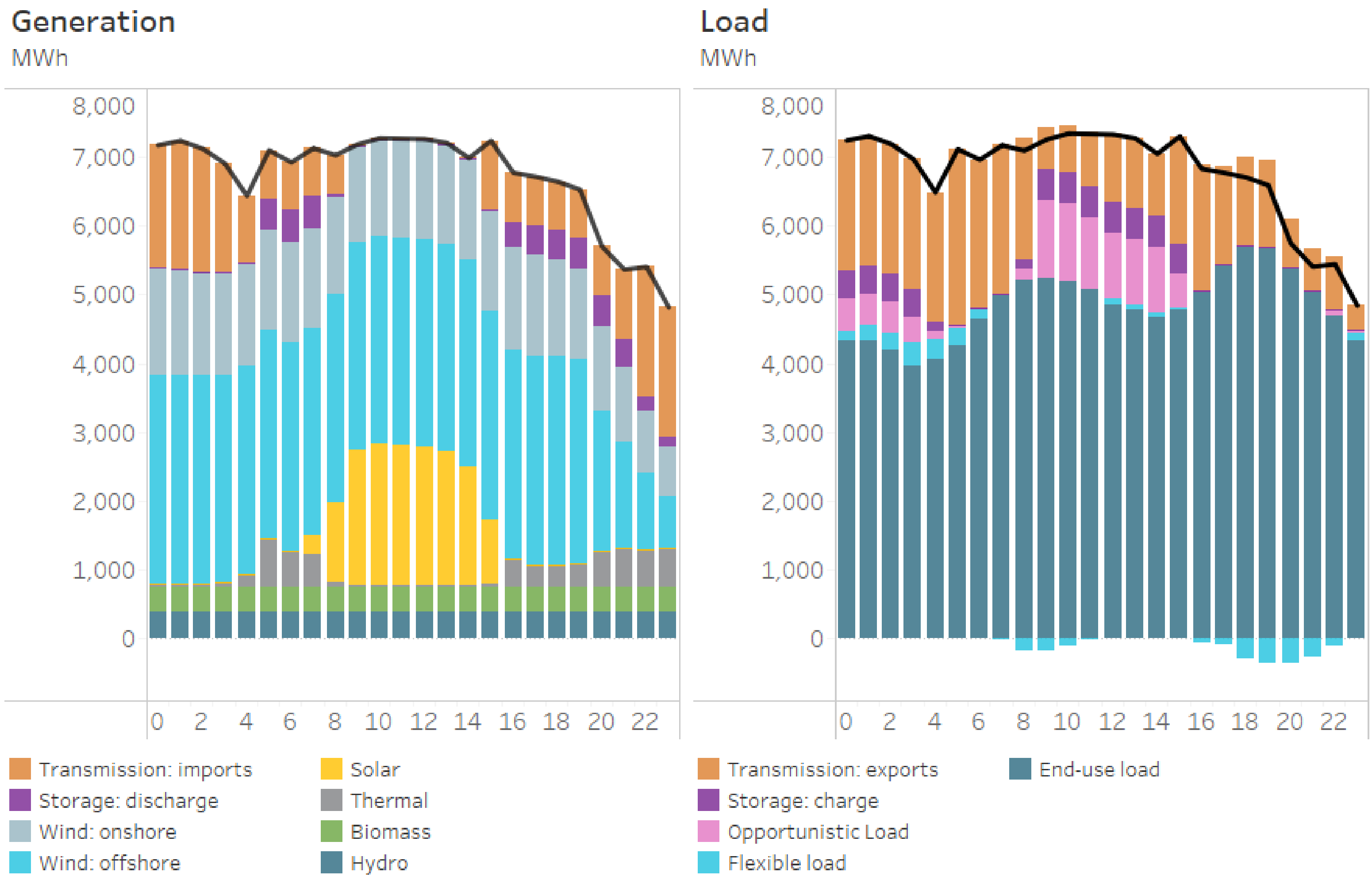
100% Clean Electricity System: Hourly Operations on a Typical Winter Day

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

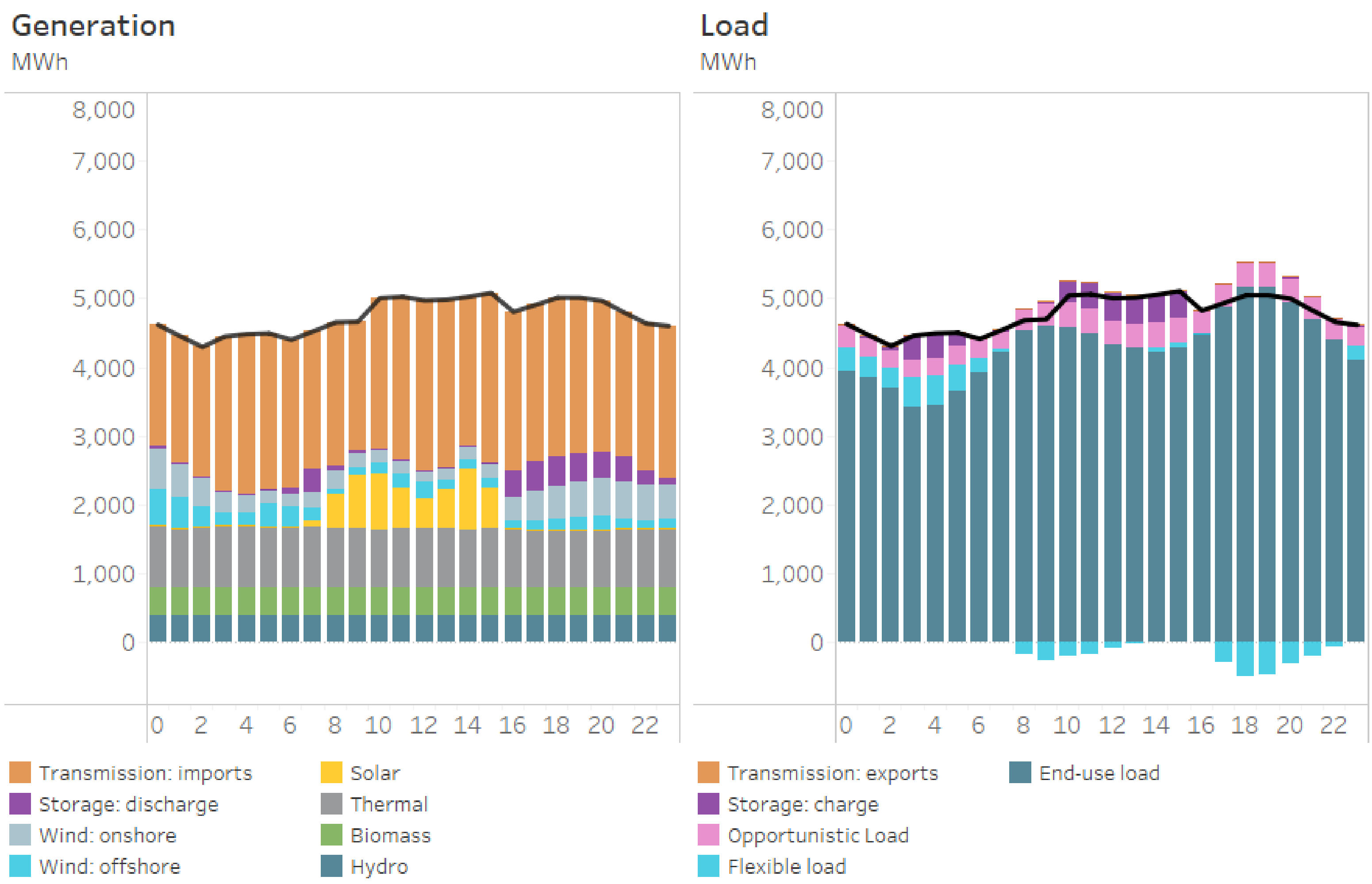
100% Clean Electricity System: Hourly Operations on a Challenging Winter Day

Generation

- Wind and solar generation is minimal
- Thermal resources burn zero carbon fuel across the day
- Energy storage, flexible load and clean 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

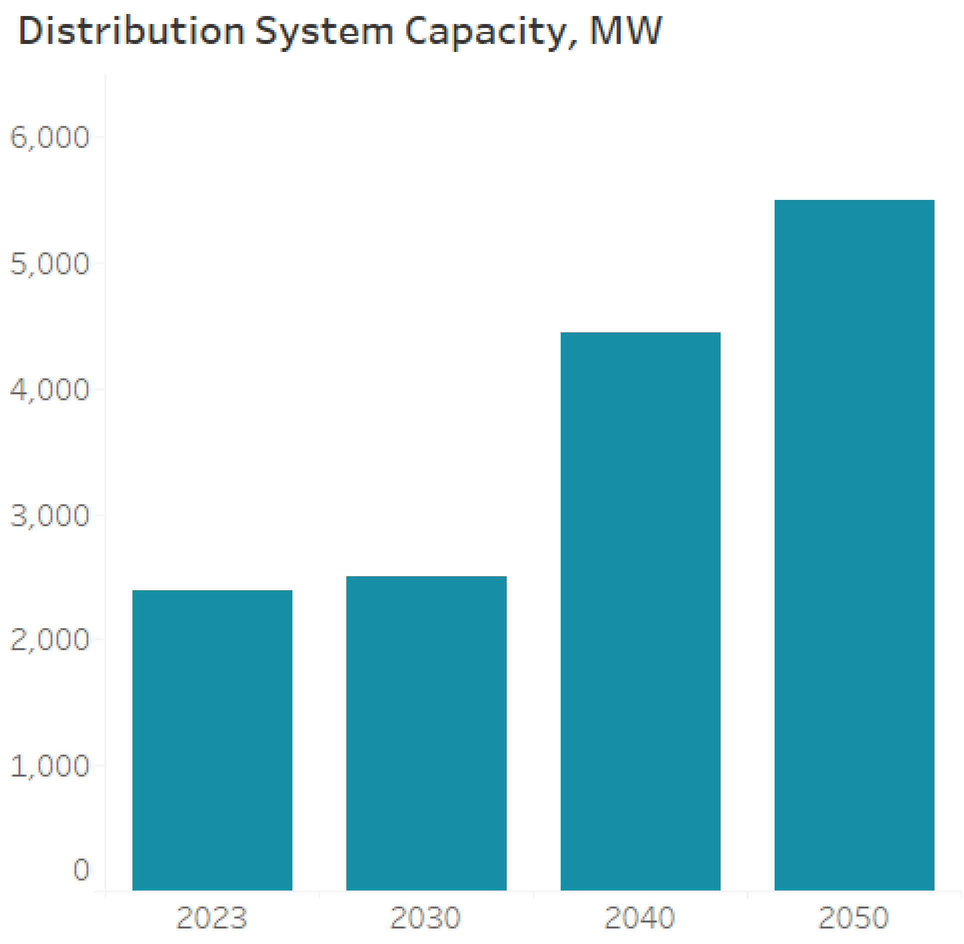
Electric distribution system impacts

Maine's electric distribution infrastructure grows to accommodate additional electric heat pumps and vehicles

Distribution system growth trajectory is consistent with retail sales growth, so the load factor is similar to today

Flexible load, particularly from EV charging, is an important strategy to moderates growt

Impacts on the electric distribution would vary with different assumptions about flexible load and distributed resources

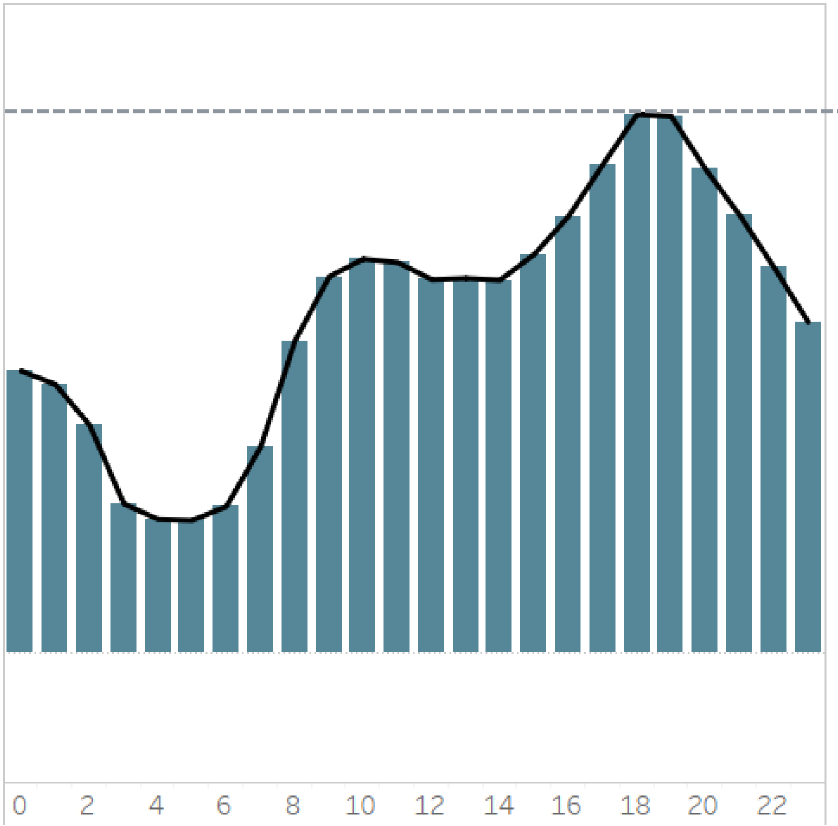


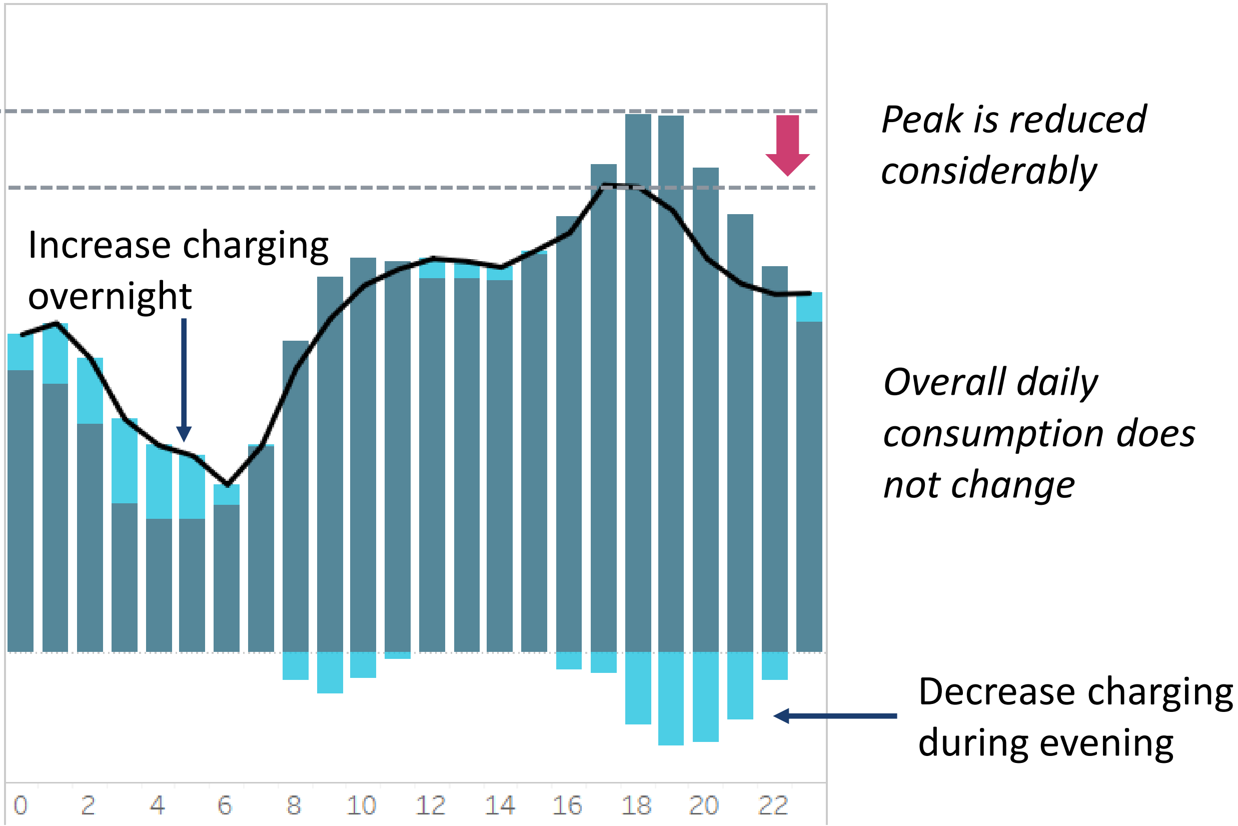
DRAFT RESULTS

Example of load flexibility: battery electric vehicle charging

Load <u>without</u> flexibility

Load <u>with</u> flexibility





What happens after this work shop?

Continued public input and outreach

Develop additional pathways

- Model additional pathways exploring key variables that could affect results
- Candidate topics
  - Alternative flexible load and distributed resource assumptions
  - Alternative heat decarbonization strategies
  - Alternative resource qualifications for meeting 100% clean

Estimate relative cost impacts for each pathway

- Scope of costs includes energy system (electricity and fuels) costs: annualized capital costs of energy supply- and demand-side equipment; fixed and variable O&M costs; and variable fuel costs
  - In other words, we are looking beyond just changes to electricity generation, transmission & distribution costs, and including components such as EVs, heat pump and fuel oil costs

Consideration of policy and implementation considerations

Q&A