Introduction to Long-term Load Forecasting

Energy Systems Integration Group (ESIG)

2023 Long-Term Load Forecasting Workshop

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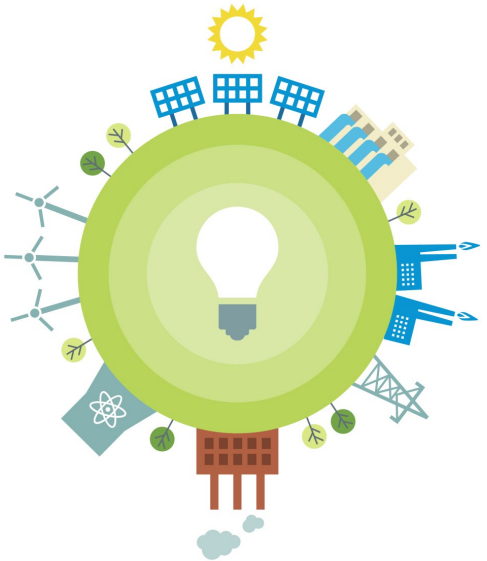
Overview of Presentation

- About ISO New England
- Introduction to Load Forecasting
- ISO New England's Forecast Methodology
- Forecasting for the Evolving Grid



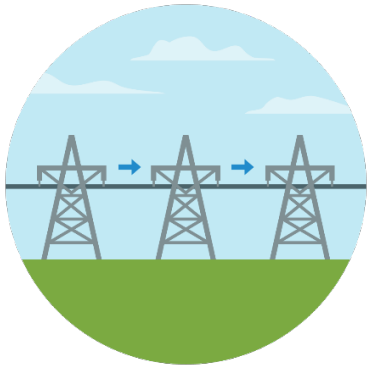
ISO New England (ISO) Has More Than Two Decades of Experience Overseeing the Region's Restructured Electric Power System

- **Regulated** by the Federal Energy Regulatory Commission
- **Reliability Coordinator** for New England under the North American Electric Reliability Corporation
- **Independent** of companies in the marketplace and **neutral** on technology

ISO New England Performs Three Critical Roles to Ensure Reliable Electricity at Competitive Prices

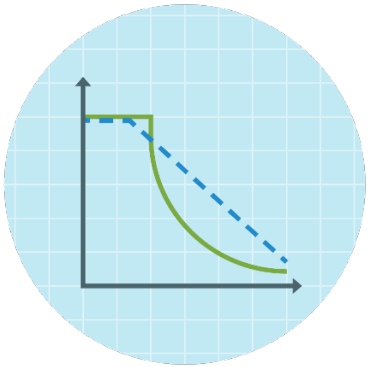
Grid Operation

Coordinate and direct the flow of electricity over the region's high-voltage transmission system



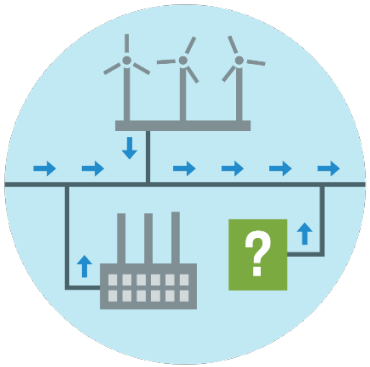
Market Administration

Design, run, and oversee the markets where wholesale electricity is bought and sold



Transmission System Planning

Study, analyze, and plan to ensure the transmission system will be reliable over the next 10 years



Things We Don’t Do

Handle retail electricity — the power you buy from your local utility or electric supplier

Own, maintain, or repair power grid infrastructure, such as power plants, power lines, and substations

Plan or control the resource mix, or have a financial interest in the companies that own energy infrastructure

Have jurisdiction over fuel infrastructure

ISO New England's Long-Term Load Forecast

What Is It and Why Does it Matter?

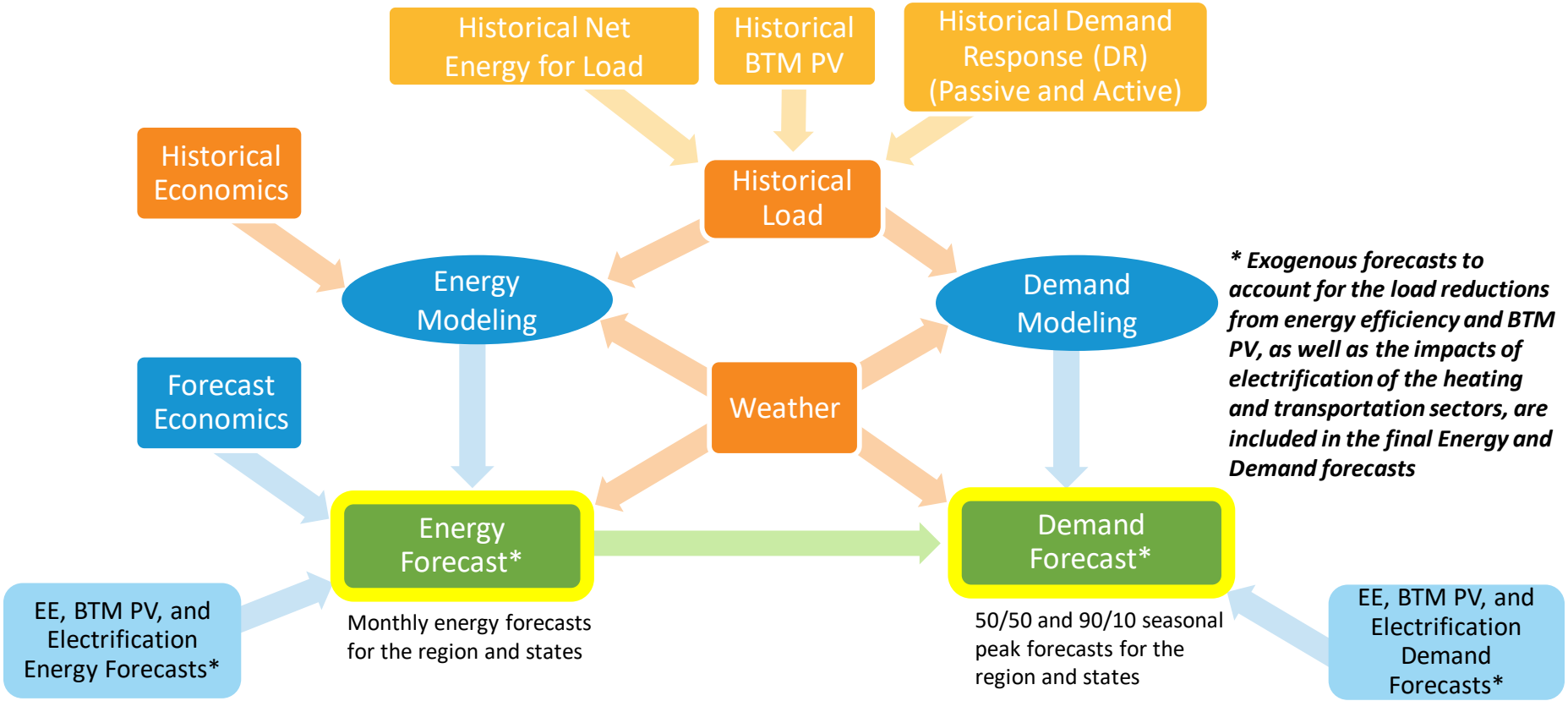
- The goal of long-term load forecasting is to provide foundational assumptions for markets and studies related to end use electricity consumption (a.k.a. load)
  - Which load characteristics are "important"?
- Long-term forecasts are vital to:
  - ISO's administration of the Forward Capacity Market
  - Transmission Planning Needs/Reliability Assessments
  - Economic studies and scenario analyses
  - Generator interconnection
  - Outage coordination
- Forecast is developed each year and covers the 10-year planning horizon
  - Published in ISO's annual Capacity, Energy, Loads, and Transmission (CELT) Report

ISO New England's Long-Term Load Forecast

High-Level Summary

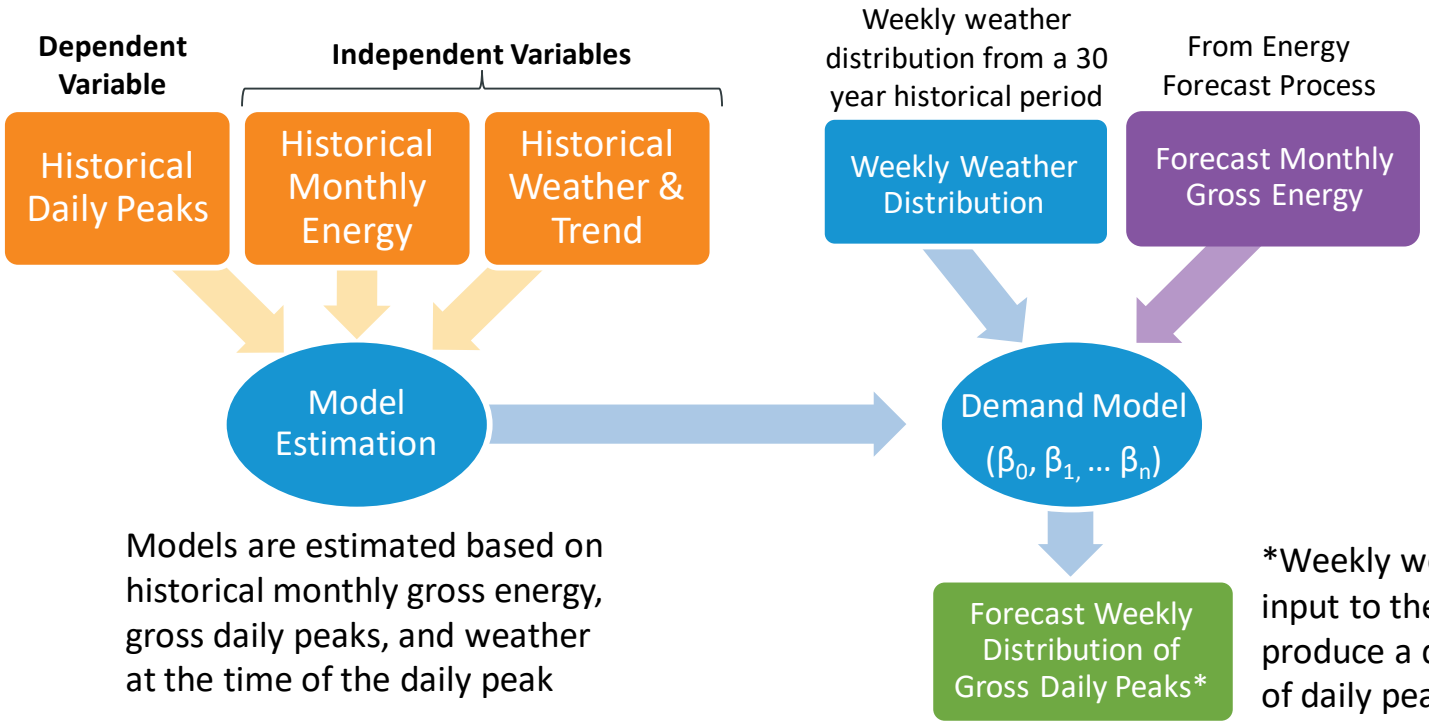
- ISO New England's long-term load forecast consists of econometric model-based forecasts of state and regional "gross" load that are adjusted by exogenous forecasts of:
  - Energy efficiency (EE) measures [2012]
  - Distributed energy resource (DER) photovoltaics, a.k.a. "behind-the-meter (BTM) PV" [2014]
  - Heating electrification [2020]
  - Transportation electrification [2020]
- The forecast has changed considerably over the past decade
  - Increased focus on quantifying the effects of state and federal policy
    - Greater uncertainty coming from more sources
    - No longer just forecasting electricity consumption (e.g., load masking of DER PV)
  - Greater need for modeling impacts of emerging technology and trends, rather than relying solely on econometric/statistical modeling
  - Growing number of "layers" and associated accounting
- Sources of forecasting challenges
  - Knowledge about emerging trends
  - Methodology development
  - Consideration of impacts to, and needs of, downstream users
  - Data availability constraints

Long-Term Load Forecast Process Flow Chart



**** Exogenous forecasts to account for the load reductions from energy efficiency and BTM PV, as well as the impacts of electrification of the heating and transportation sectors, are included in the final Energy and Demand forecasts***

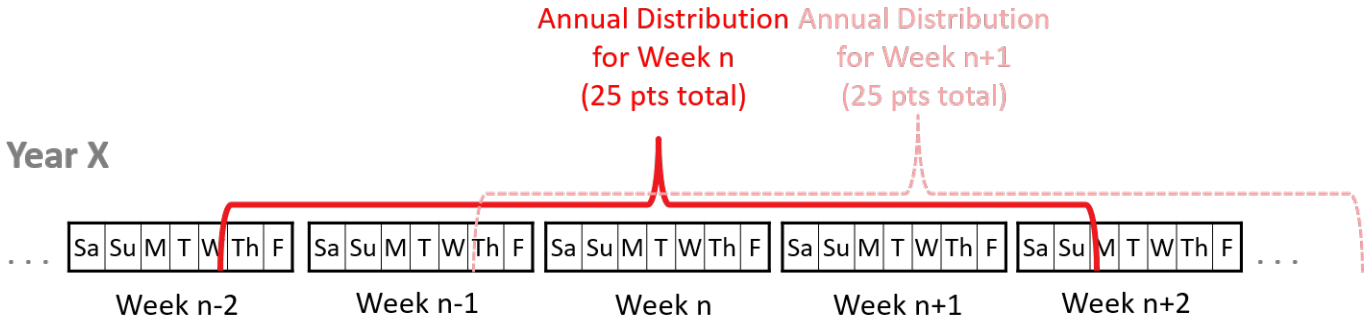
Demand Forecast Modeling



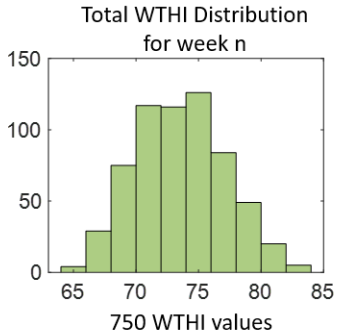
Models are estimated based on historical monthly gross energy, gross daily peaks, and weather at the time of the daily peak

*Weekly weather are input to the model to produce a distribution of daily peaks for each week of forecast

Weather Selection for Probabilistic Demand Forecast



Total distribution for week n:
25 pts x 30 years = 750 pts



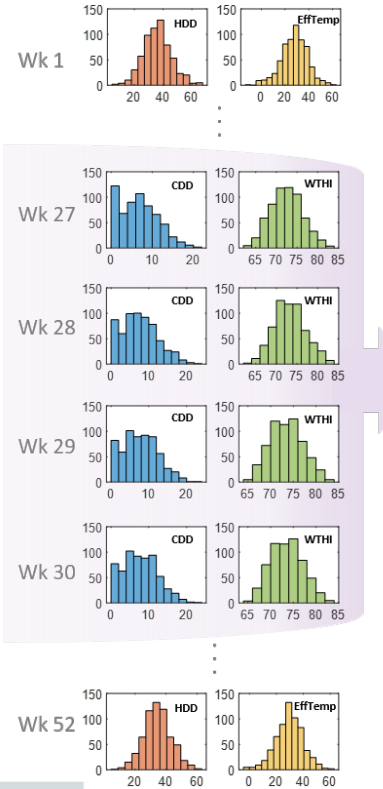
Repeat for each week and weather concept

Note: "WTHI" is a 3-day weighted temperature-humidity index

Developing Weekly Load Distributions

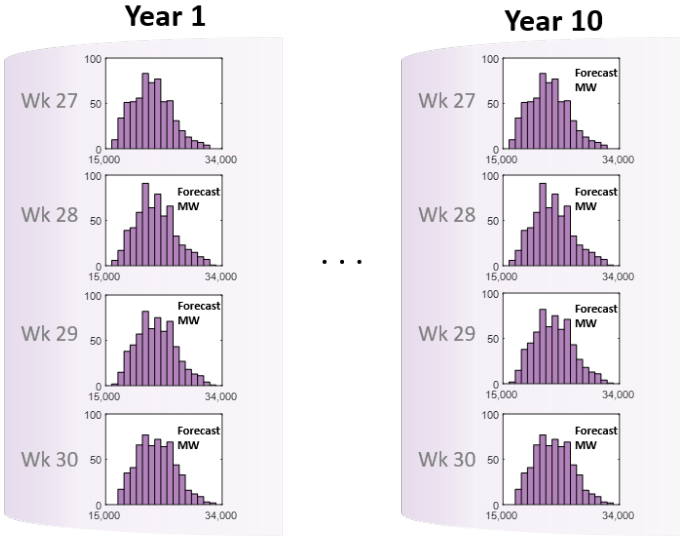
Weekly Weather Distributions

Note: Example shown is for July weeks



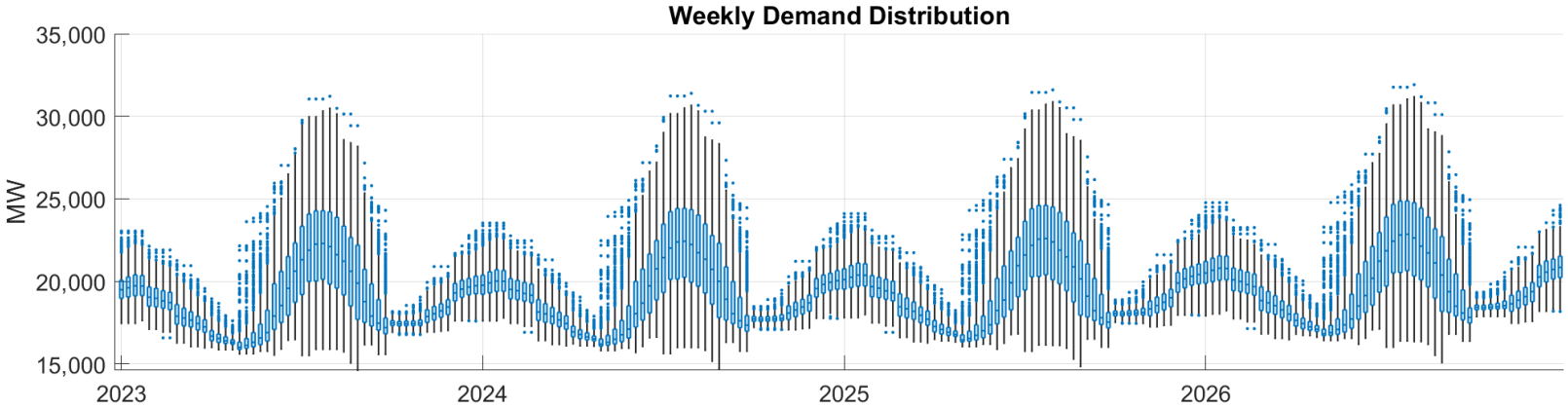
July Peak Model

Weekly Load Forecast Distributions



Weekly Peak Demand Forecast

- Some planning study assumptions (e.g., transmission planning) are based on discrete points in the distribution, which reflect the likelihood of varying extremities of weather
- Other planning studies (e.g., resource adequacy) use probabilistic inputs
  - Load forecast uncertainty (LFU), needed for reliability assessments, can be quantified directly from the load forecast distributions

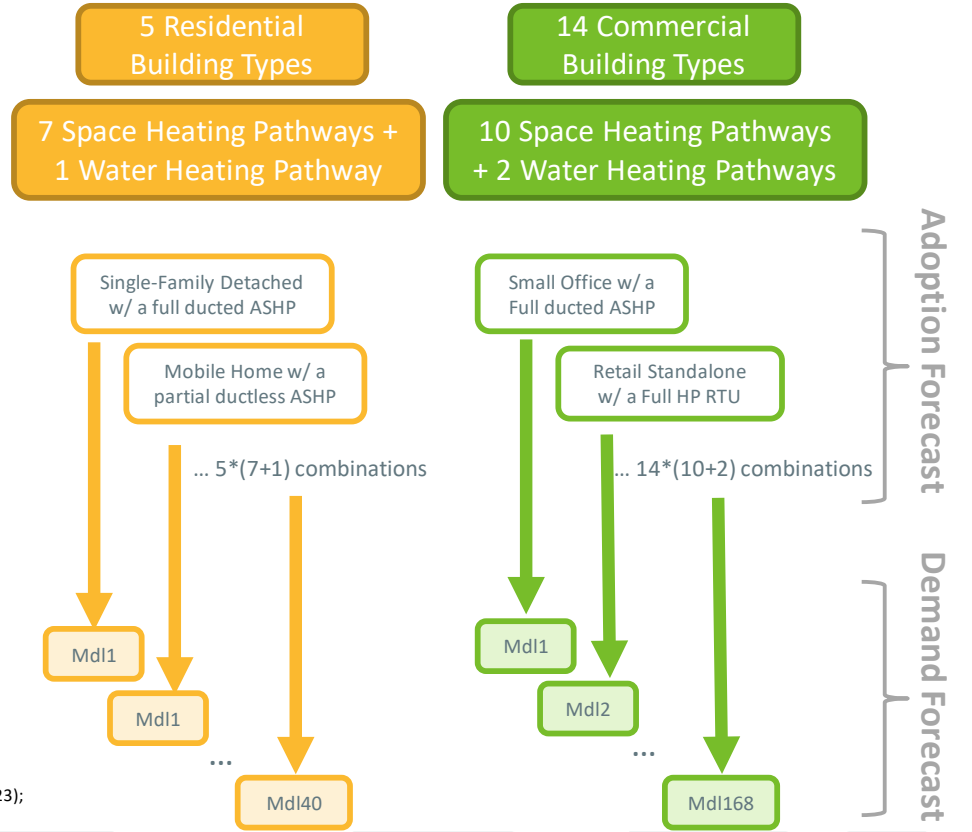


Heating Electrification Forecast

Methodology Overview

Methodology leverages the National Renewable Energy Laboratory's ResStock and ComStock datasets, and is based on four sequential tasks:

1) New England building stock characterization
2) Development of "heating pathways"
3) Forecasting adoption along each pathway
4) Hourly demand modeling



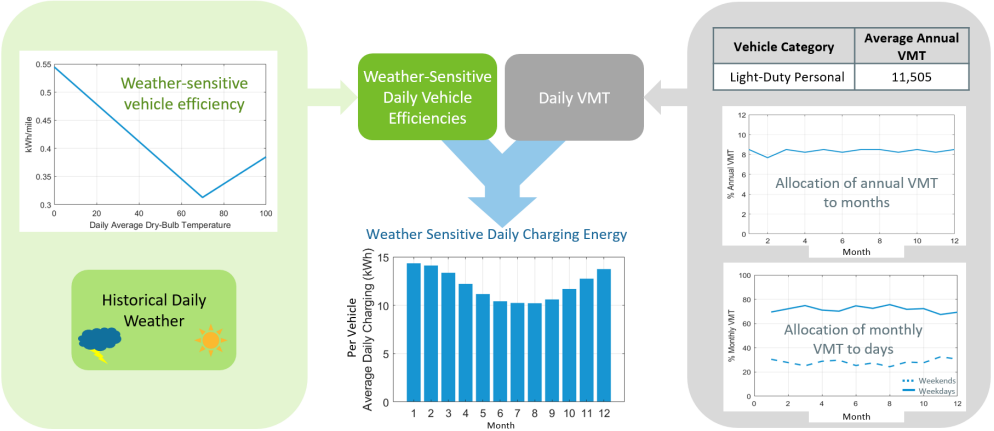
Source: ISO New England 2023-2032 Forecast Report of Capacity, Energy, Loads, and Transmission (2023 CELT Report) (May 2023); and ISO New England Final 2023 Heating Electrification Forecast

Transportation Electrification Forecast

Methodology Overview

Adoption Forecast Methodology

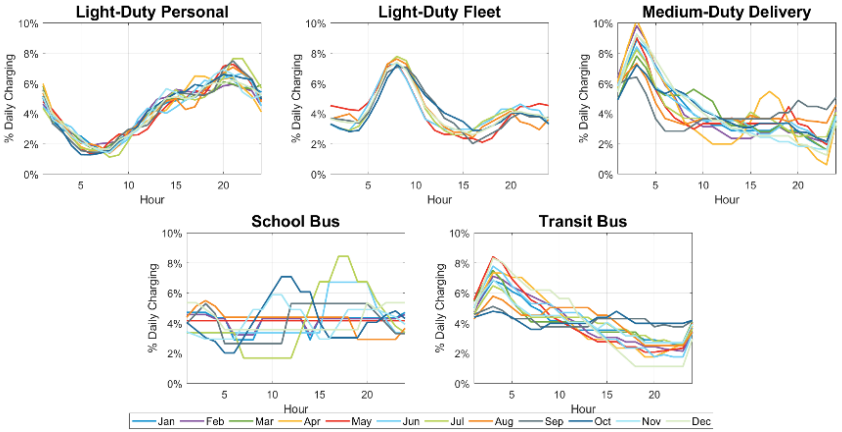
- Informed by federal, state, and local programs, goals, and mandates
- Intended to reflect the likely pace and level of EV adoption over the next 10 years
- Reflects uncertainty in the timing of goal achievement and extent of electrification



Energy and Demand Modeling

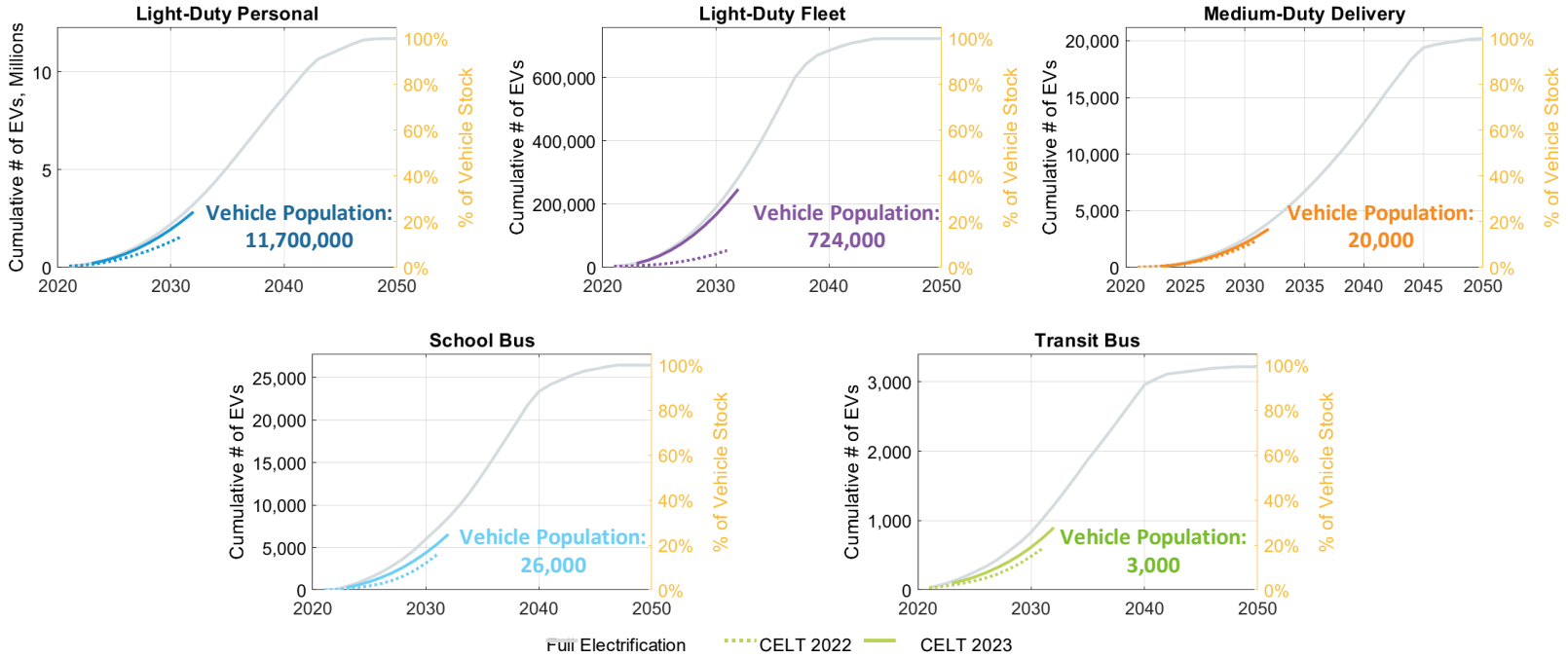
- Weather sensitive vehicle efficiency curves (based on average daily dry-bulb temperature)
- Vehicle miles traveled (VMT)
- Hourly charging shapes indicating relative allocation of daily charging energy

Allocation of Hourly Charging by Month



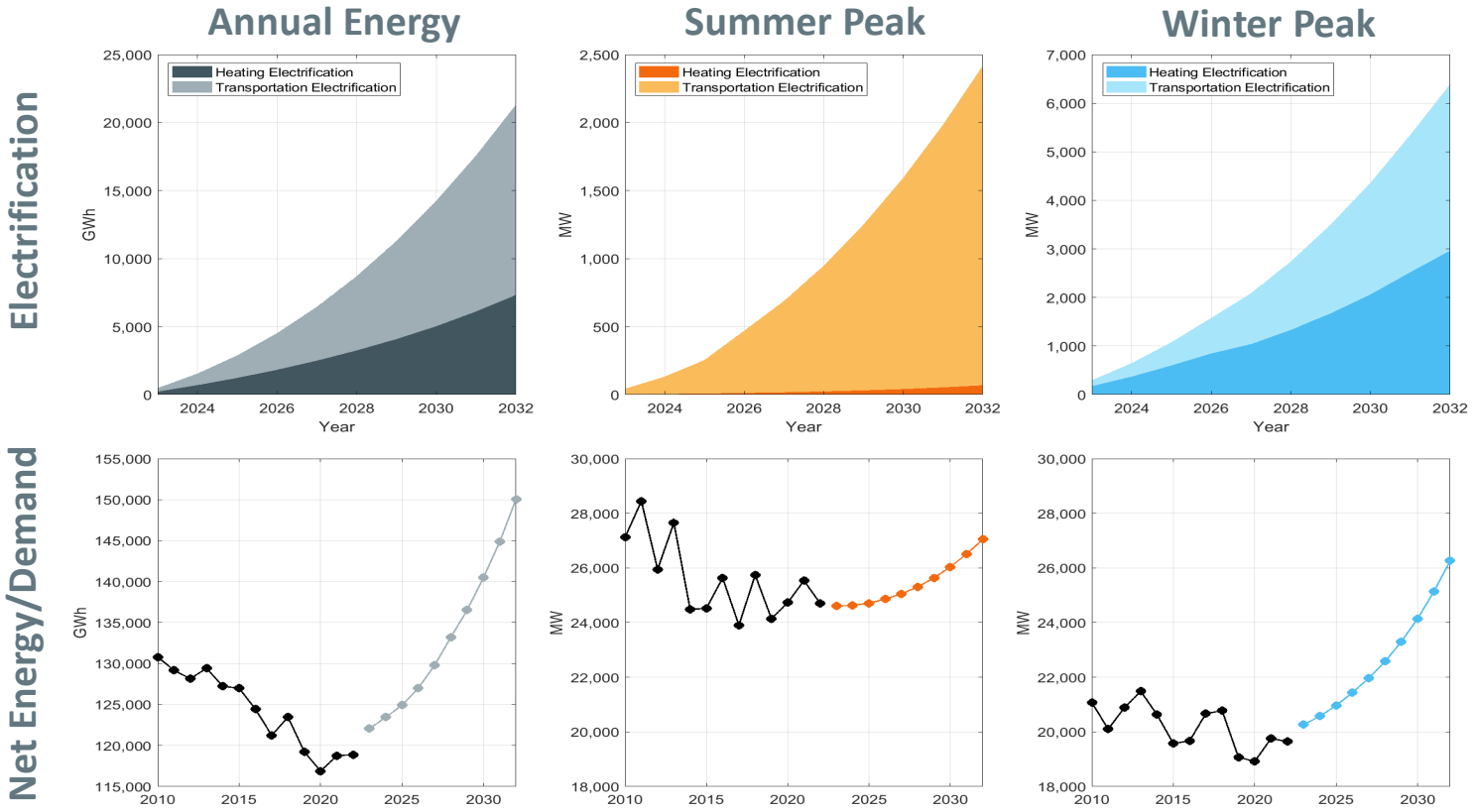
Transportation Electrification Forecast

Cumulative EV Stock for New England



The “Full Electrification” scenario is an upper bound on the pace of EV adoption that assumes all vehicles in each vehicle class are electrified by 2050

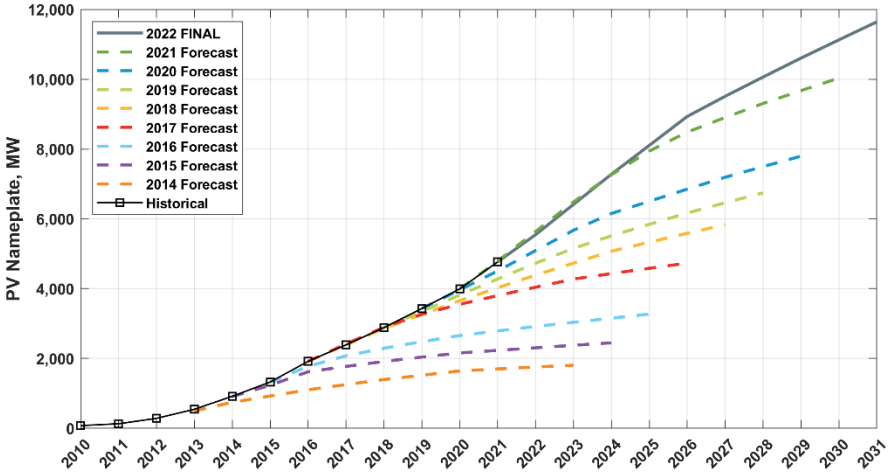
Annual Net Energy and Seasonal 50/50 Demand Forecasts



BTM PV Forecasting

- For the long-term forecast, BTM PV is DER PV that does not participate in wholesale markets, and is a load reducer
  - Historically, approximately 60% of all PV DER
- Historical BTM PV production estimates are reconstituted in the development of the long-term gross load forecast
  - Estimates cover the historical period starting January 1, 2012
- Develop historical hourly BTM PV profiles from:
  - Historical BTM PV performance data
  - Installed capacity data submitted by utilities
  - Historical energy production of market-facing PV
- Currently working with Distribution Owners to obtain substation locations of all DER and other DER metadata important to network modeling

Forecasts of Total DER PV



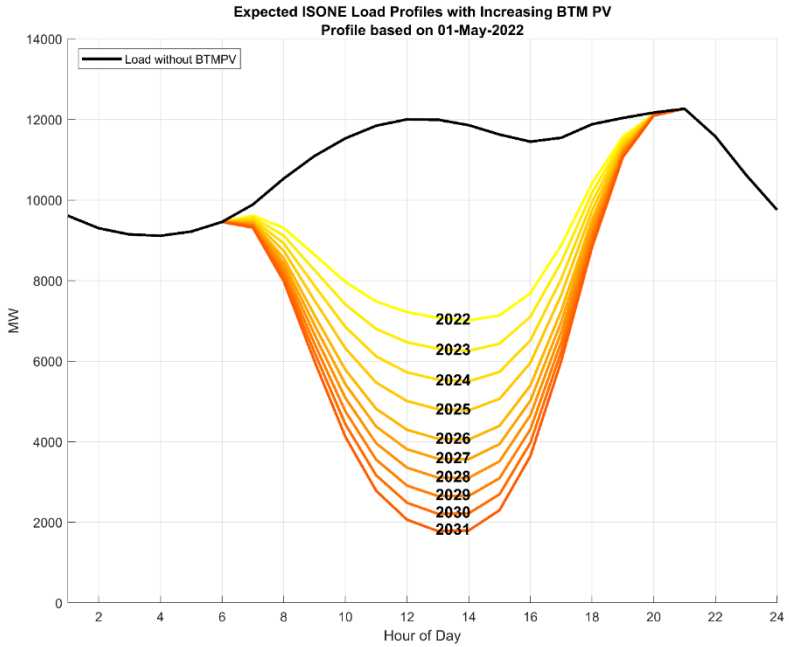
Forecast Allocations Based on Transmission Owner Load Distribution Data

- State forecasts of energy and demand are allocated to sub-regions using information obtained from ISO's annual Multiregional Modeling Working Group (MMWG) network model creation process
  - State forecasts are divided into operating companies, and then allocations to substations based on load distributions provided by Transmission Owners
  - Process is repeated for summer and winter load, and minimum load conditions

Source: Section 2.3 of the ISO New England's Transmission Planning Technical Guide Appendix J: Load Modeling Guide

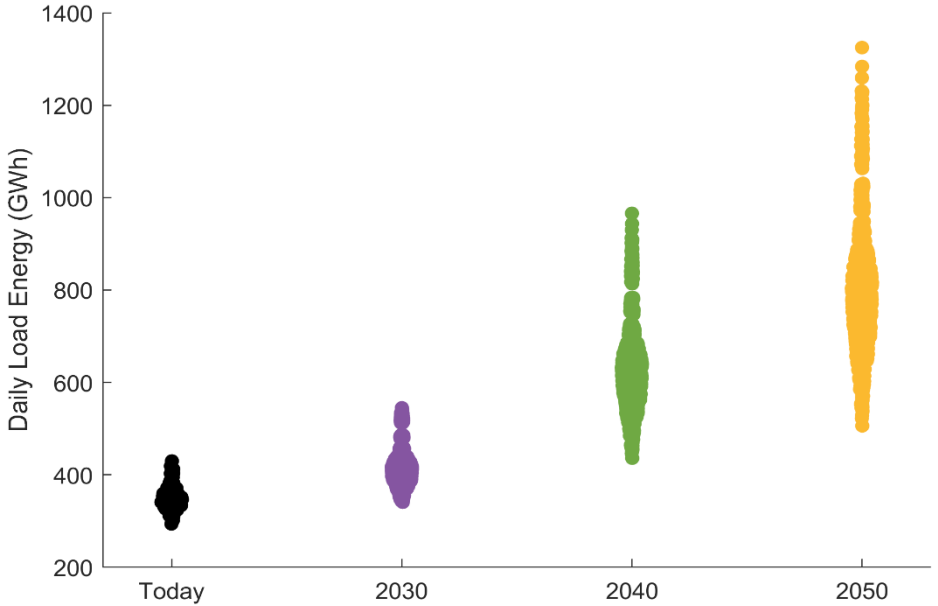
Evolution of Load is Poised to Accelerate

Load Shape Impacts of BTM PV



Electrification Impacts to Daily Load Energy

January Weekdays



Four Pillars of Supporting a Successful Energy Transition

New England is on a path to achieve a clean-energy future over the next several decades. Calling upon the results of several key studies, as well as 25 years' experience planning the region's power system, the ISO has identified four pillars critical to supporting the region's clean energy transition

1

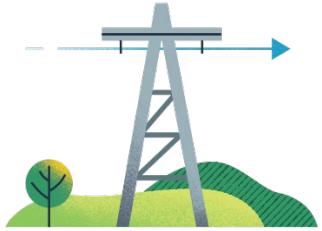
Significant amounts of clean energy to power the economy with a greener grid

2

Balancing resources that keep electricity supply and demand in equilibrium

3

Energy adequacy: a dependable energy supply chain and/or a robust energy reserve



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Robust transmission to integrate renewable resources and move clean electricity to consumers across New England

Long-term load forecasts provide critical assumptions and insights for studies of the future grid

Forecast Enhancements for the Evolving Grid

- Electrification and DER growth represent an unprecedented scale of change to the end use consumption of electricity
  - Continuous enhancements to forecasting processes and downstream uses of forecasts will be needed
- Potential methodological improvements, for consideration, to better position forecast processes to account for the evolving grid:
  - Integrate weather data that reflects future climate projections
  - Consider impacts of co-located and standalone DER storage
  - Transition from daily peak to hourly modeling to account for load shape impacts associated with each forecast "layer"
  - Extend forecast horizon to 20+ years
  - Develop additional probabilistic scenarios for exogenous forecasts to quantify additional sources of uncertainty

Questions