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Weather Applications in ISO New England's Long-Term Load Forecast

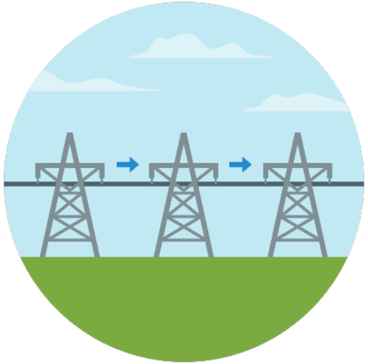
IEA Task 51 Workshop, Rutgers University

Victoria Rojo
LEAD DATA SCIENTIST
ISO NEW ENGLAND

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

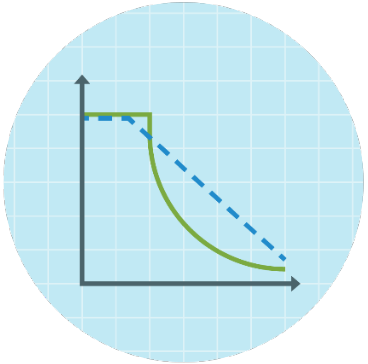
Grid Operation

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



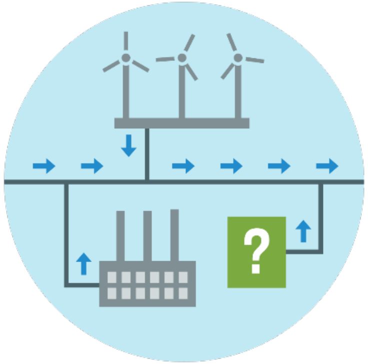
Market Administration

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



Uses of Weather at ISO New England

- Load forecasting
  - Short term (intraday, day-ahead, 21-day)
  - Long term (decades)
- Resource planning
  - Capacity market
  - Economic studies
- Transmission planning
- Outage coordination
- Operational assessments and studies
  - Risks of extreme weather

Relevant Features Vary by Application	Sources
• Spatial resolution (surface and vertical) • Temporal resolution • Time horizon (historical and forecast) • Expanse and fidelity of weather concepts	• ERA 5 (public) • Climate-adjusted ERA5 (consultant) • ASOS observations (vendor) • Station-level forecasts, intraday - 7 day (multiple vendors)

Weather Use Case: Long-Term Load Forecasting

Weather

Base Load Forecast

- Input to model training
- Out of sample model testing
- Forecast simulations
- Load research and analysis of historical weather events

HP Forecast

- Develop temperature dependent building heating needs
- Temperature-dependent COPs inform HP electric consumption

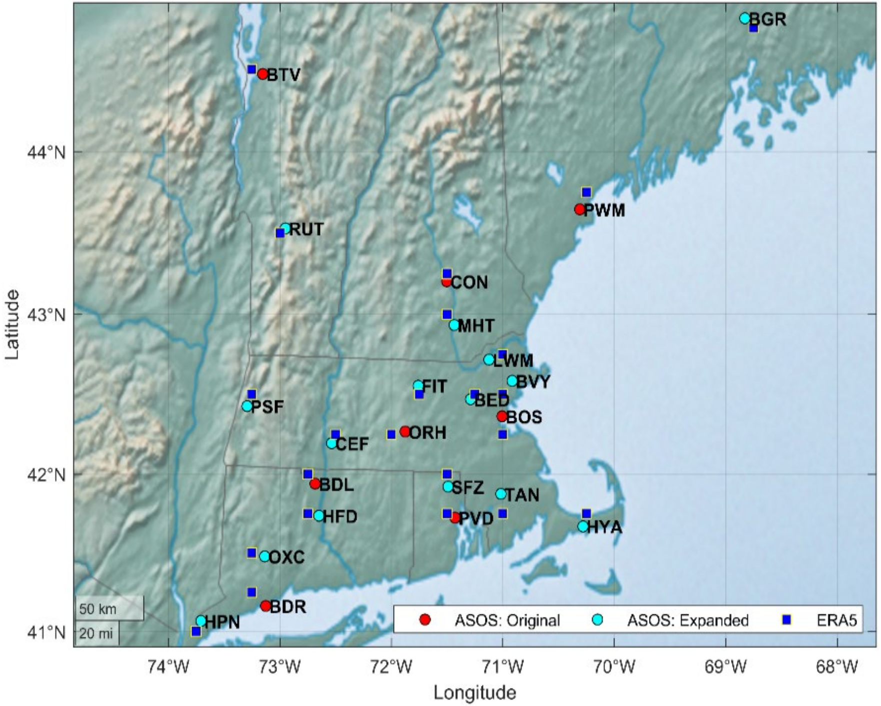
EV Forecast

- Weather-sensitive daily charging energy relies on temperature-dependent vehicle efficiency curves

Weather Locations and Concepts

- Day-ahead forecasts use daily 7-day forecasts for 23 ASOS weather stations
- Long-range forecasting maps nearest ERA5 grid points to each of the 23 weather stations
  - ERA5 data are associated with grid points (blue squares) most proximal to the 23 weather stations illustrated to the right (red and light blue circles)
  - Climate-adjusted weather is derived from the same grid points
  - Previous forecasts used only 8 weather stations (red circles)
- Weather concepts
  - Dry bulb temperature
  - Dew point temperature
  - Wet bulb temperature
  - Global horizontal irradiance
  - Precipitation rate
  - Snow fall
  - Wind speed
  - Cloud cover

Weather Source	Use
Historical ERA5	• Model training • Out of sample model validation
Climate-Adjusted	• Forecast simulations across base load and electrification forecasts

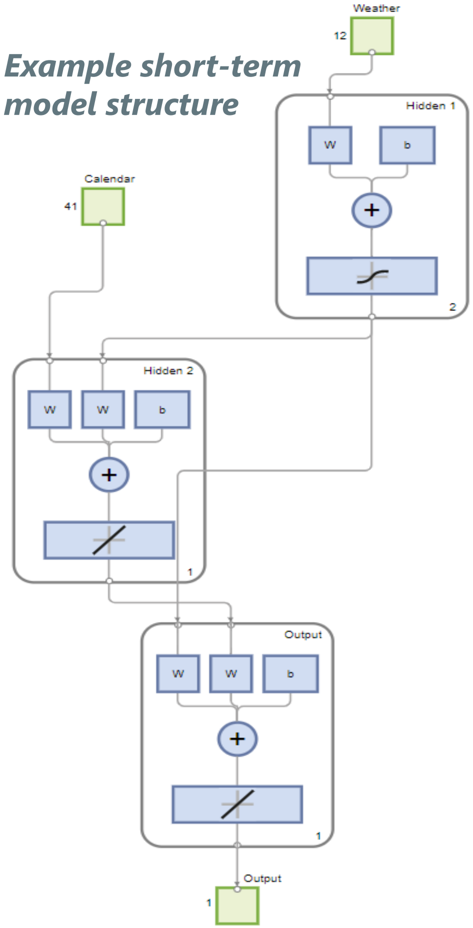


Base Load Model Architecture

A Work In Progress!

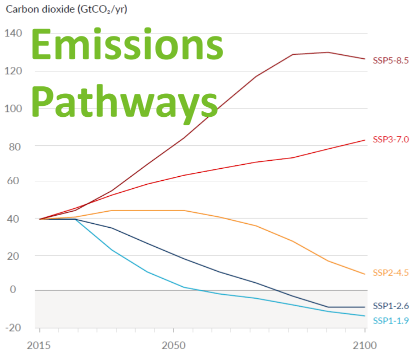
- 25 “adapted” short-term forecasting models:
  - A daily energy model that feeds 24 hourly models
  - ~15 weather features (i.e., transformations of dry bulb, dew point, wet bulb, wind speed and cloud cover);
  - ~40 calendar features (i.e., day of week, monthly binaries, various holiday binaries)
  - Statistically-adjusted end use (SAE) variables reflecting trends in efficiency, technology saturations, and economics
  - 9-10 years of training history

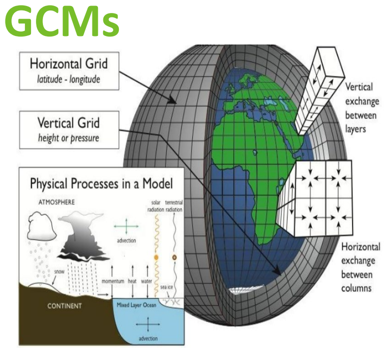
Example short-term model structure

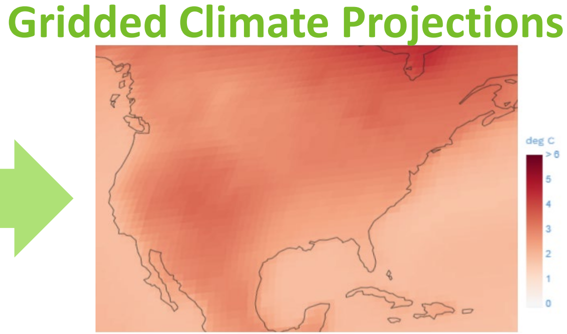


Forecast Simulation Relies on Climate Scenarios

- A total of 10 climate projections developed by EPRI are based on two emissions pathways and five global climate models (GCM)
  - EPRI's methodology for developing climate projections is described here: An Approach to Synthetic Future Climate Hourly Profiles for Power System Modeling







Emission pathways explore a range of possible future outcomes

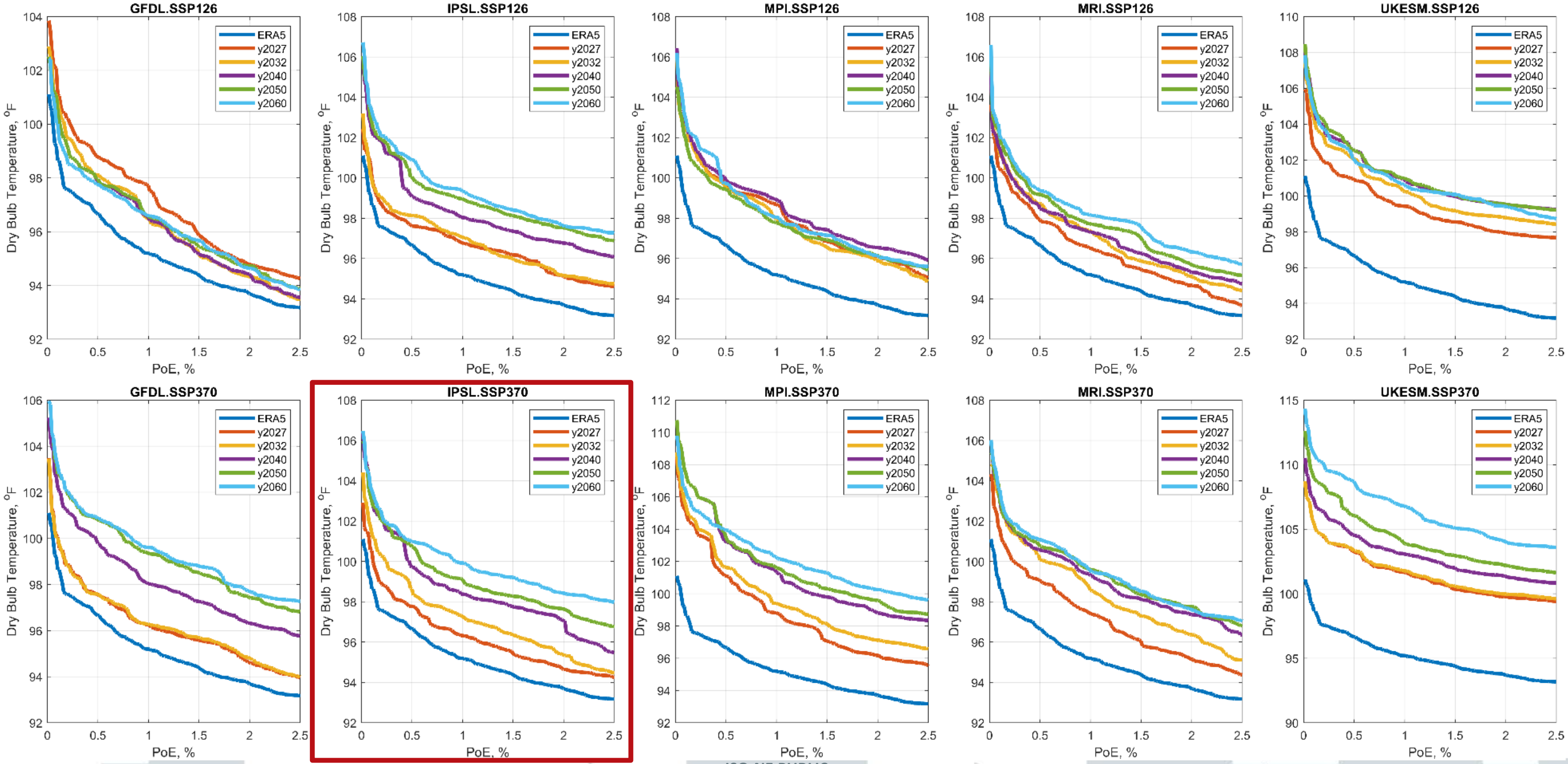
- **SSP1-2.6:** ambitious policy, "lower warming scenario"
- **SSP3-7.0:** no-policy baseline, "higher warming scenario"

Five selected Global Climate Models (GCMs) span a range of climate sensitivities

- NOAA Geophysical Fluid Dynamics Laboratory: GFDL-ESM4 2.7°C
- Max Planck Institute (Germany): MPI-ESM1 3.0°C
- Meteorological Research Institute (Japan): MRI-ESM2 3.1°C
- Institut Pierre-Simon Laplace (France): IPSL-CM6A 4.6°C
- UK Met Office: UKESM1 5.4°C

Figure sources: IPCC WGI AR6 Report (2021) SPM.4 (left), GCM schematic by Jablonowski & Limon (2020), North America CMIP6 ensemble for 2C average warming (IPCC 2021)

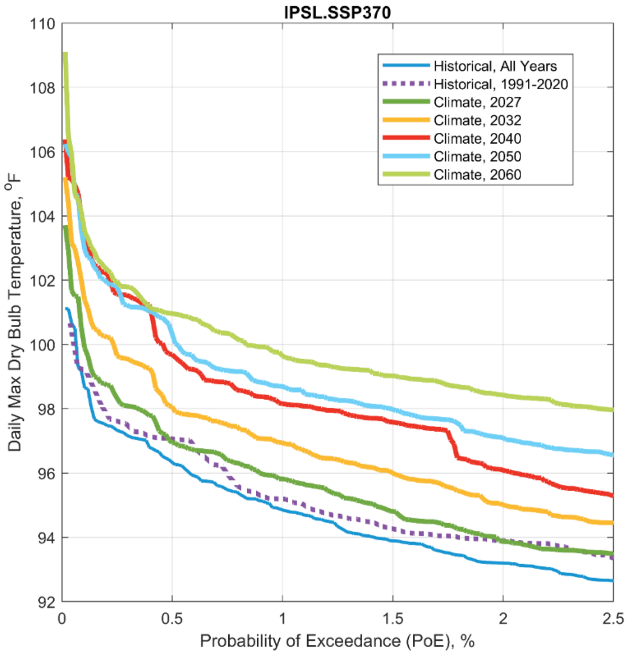
Maximum Summer Daily Temperature, 10 Climate Realizations



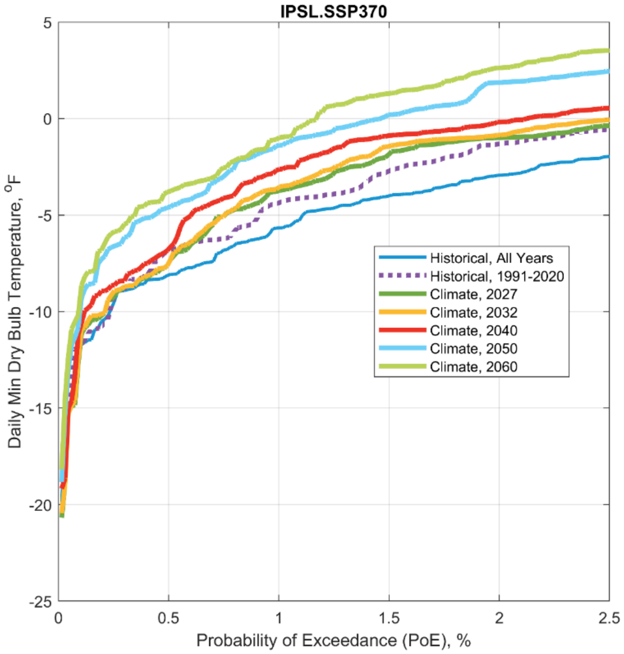
Selection of Climate Projection for Forecasting

- Plots compare the probability of exceedance of summer daily maximum (left) and winter daily minimum (right) temperatures for BDL weather station in CT
  - Extreme tails of distribution shown
- Selected scenario: IPSL-SSP3-7.0
  - **GCM**: IPSL
  - **Emissions pathway**: SSP3-7.0
- Selection based on:
  1. Moderate warming, especially in near-term
  2. Relatively uniform pace of warming

Summer



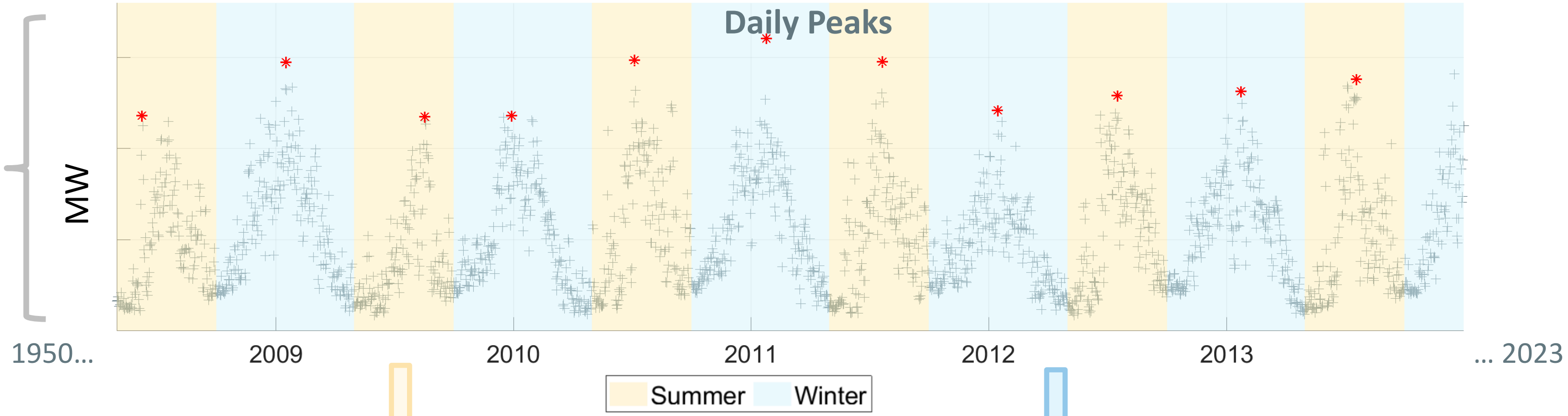
Winter



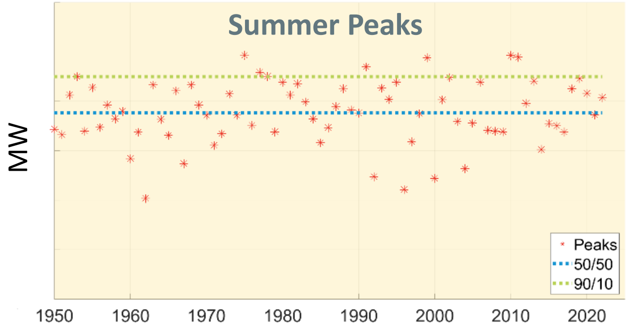
Calculation of Seasonal Peaks

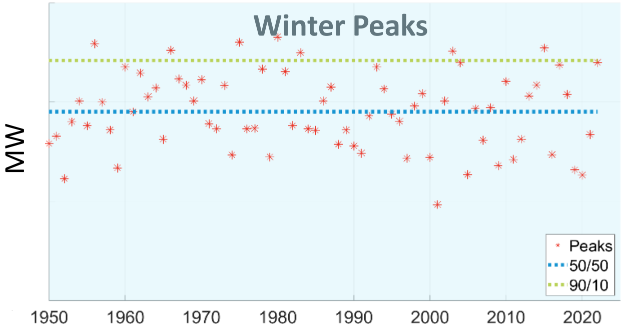
Example for a Single Forecast Year

73 years of daily peaks for forecast year 20XX



73 seasonal peaks for forecast year 20XX



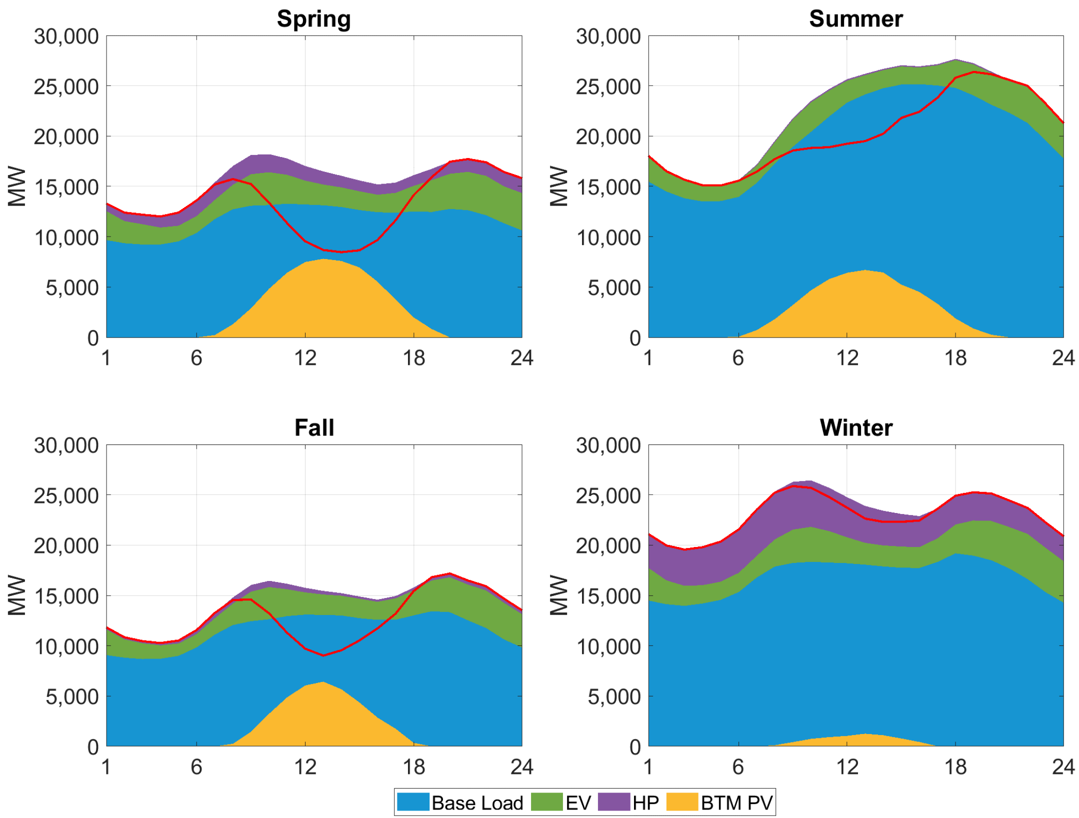


"50/50" forecast is expected to exceeded 50% of the time

"90/10" forecast is expected to be exceeded 10% of the time

Typical Seasonal Load Shapes

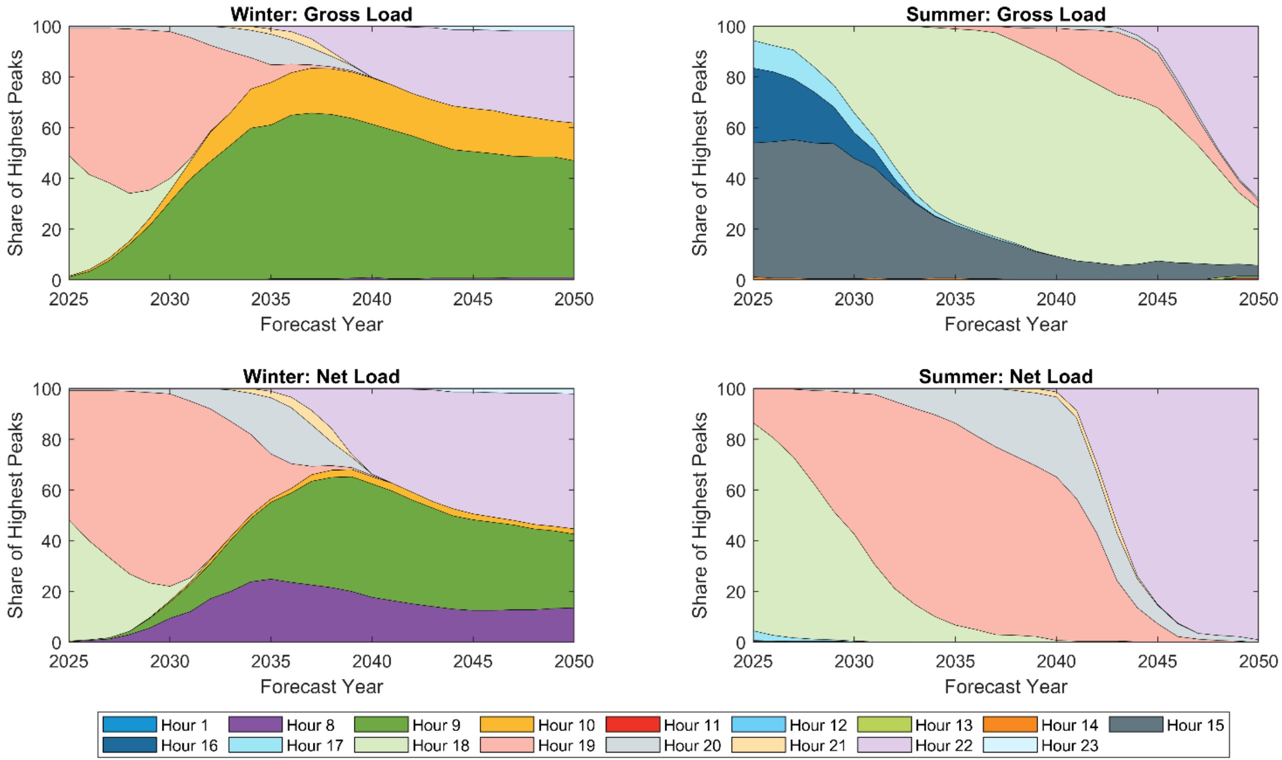
- Example profiles can be extracted for any "weather day", for any given forecast year
- Captures the coincident effect of weather on all load components
- Results provide insights into important load characteristics:
  - Midday minimum loads in spring caused by BTM PV
  - A morning winter peak as HP adoption increases



Evolution of Peak Load Timing, 2024-2050

Example: Timing of Highest 5% of Daily Peaks in Each Season

- Example of changes in peak timing that emerge from hourly methodology
- The forecast for each year of the forecast horizon is based on 73 years of hourly simulations
- BTMPV helps serve the winter peak once it shifts to morning hours



Thank You