Expanded Weather Analytics for 21-Day to Intra-Day Load Forecasting

Recent Updates to Load Forecast Process

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Summary of Initiative

- As signaled in the Annual Work Plan, this initiative improves the operational load forecasting process (i.e., between 21-days and intra-day) and is part of the Load, Solar, Wind Forecast Improvements noted in the ISO's 2022-2025 Roadmap to the Future Grid
- This project improves the operational load forecast inputs by adding precision to the weather forecast, adding components of BTM PV to the load forecast, and expands PV forecast inputs further

BACKGROUND

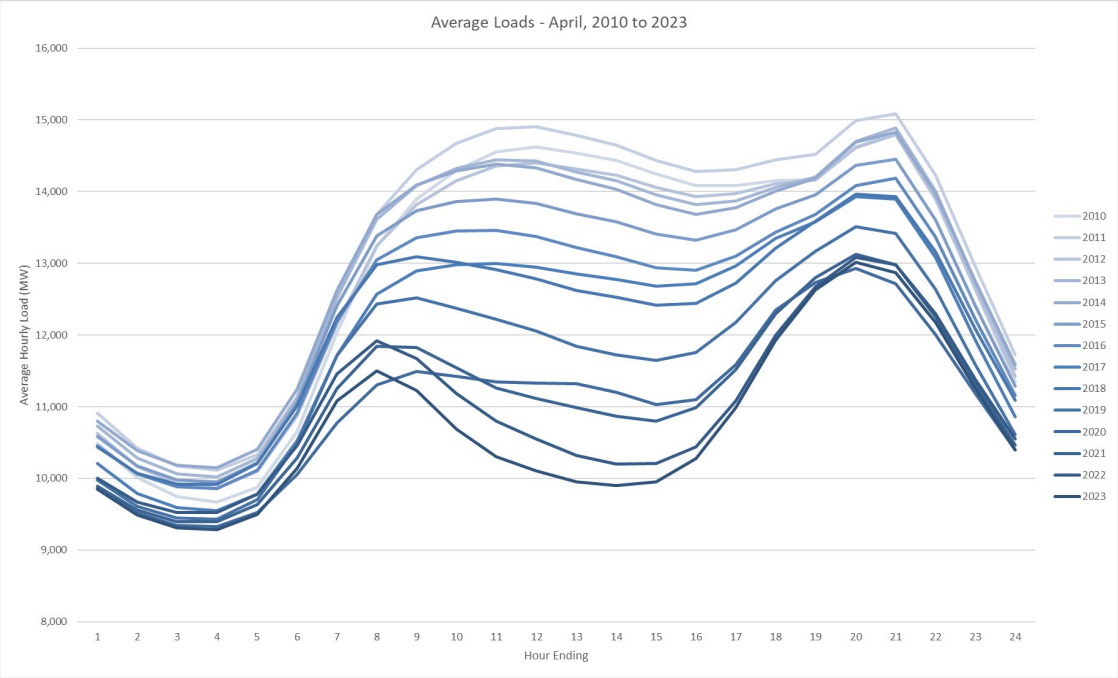
Increased quantities of BTM PV create new challenges in load forecasting

Background – PV Impact on Load

- Nameplate Behind the Meter (BTM) PV has grown from nearly 0 MW pre-2013 to nearly 6,000 MW in 2023
- Forecasts published by the ISO are showing an additional 5,000+ MW over the next 10 years
- BTM PV changes the shape of the hourly load profile and offsets the energy required from other sources

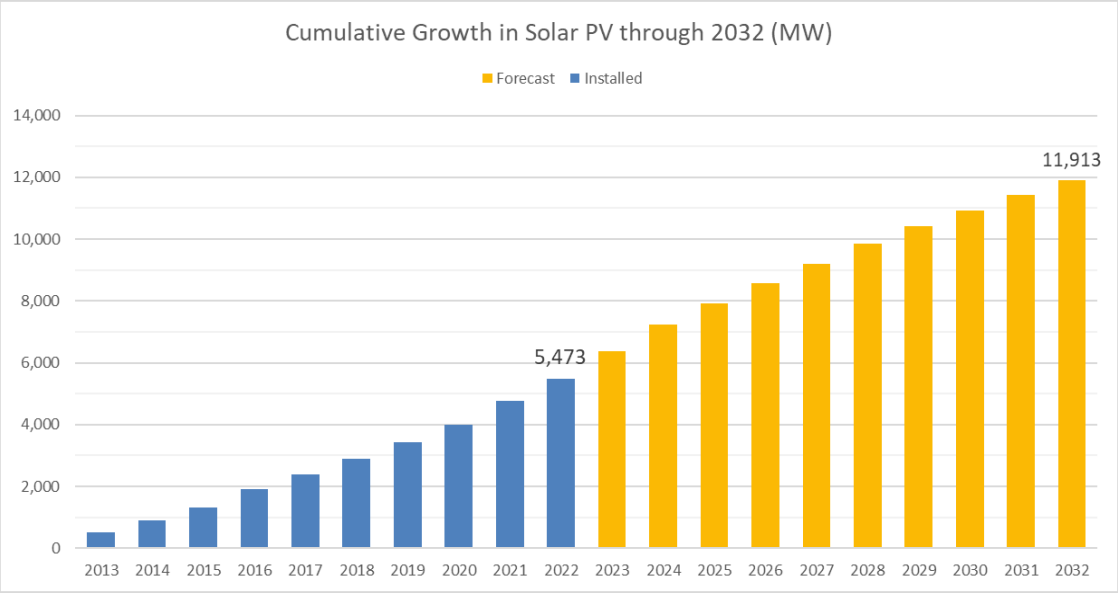
Average Hourly Loads

- Mid-day loads are significantly lower than prior years



BTM PV Forecast

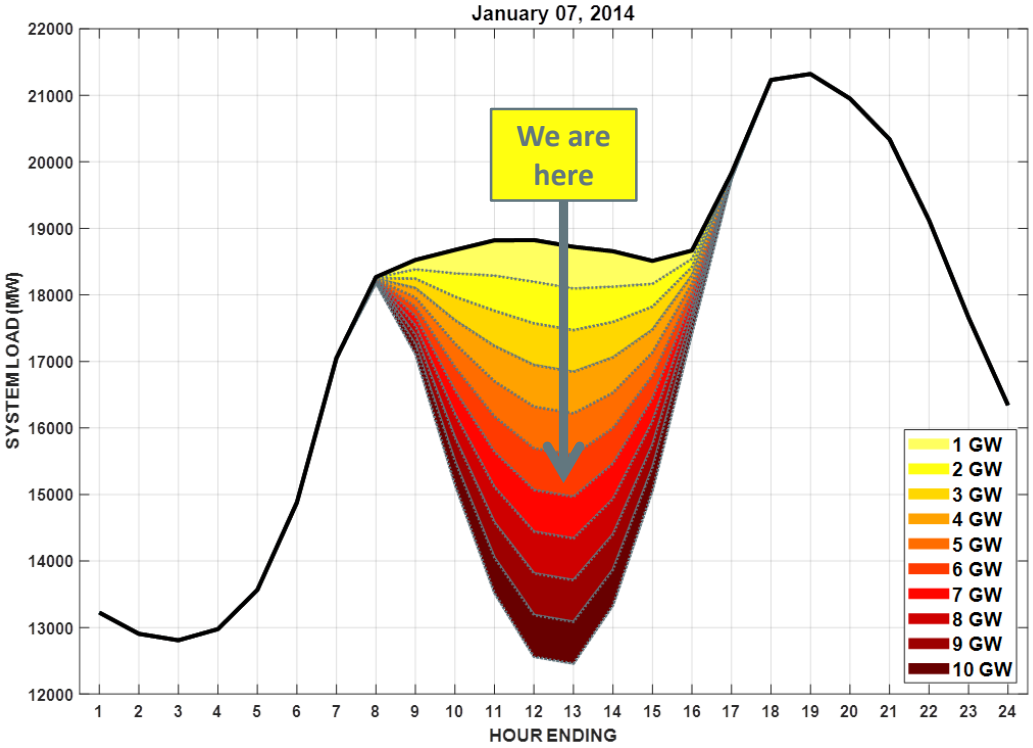
- ISO New England forecasts strong growth in solar photovoltaic (PV) resources



https://www.iso-ne.com/system-planning/system-forecasting/distributed-generation-forecast/

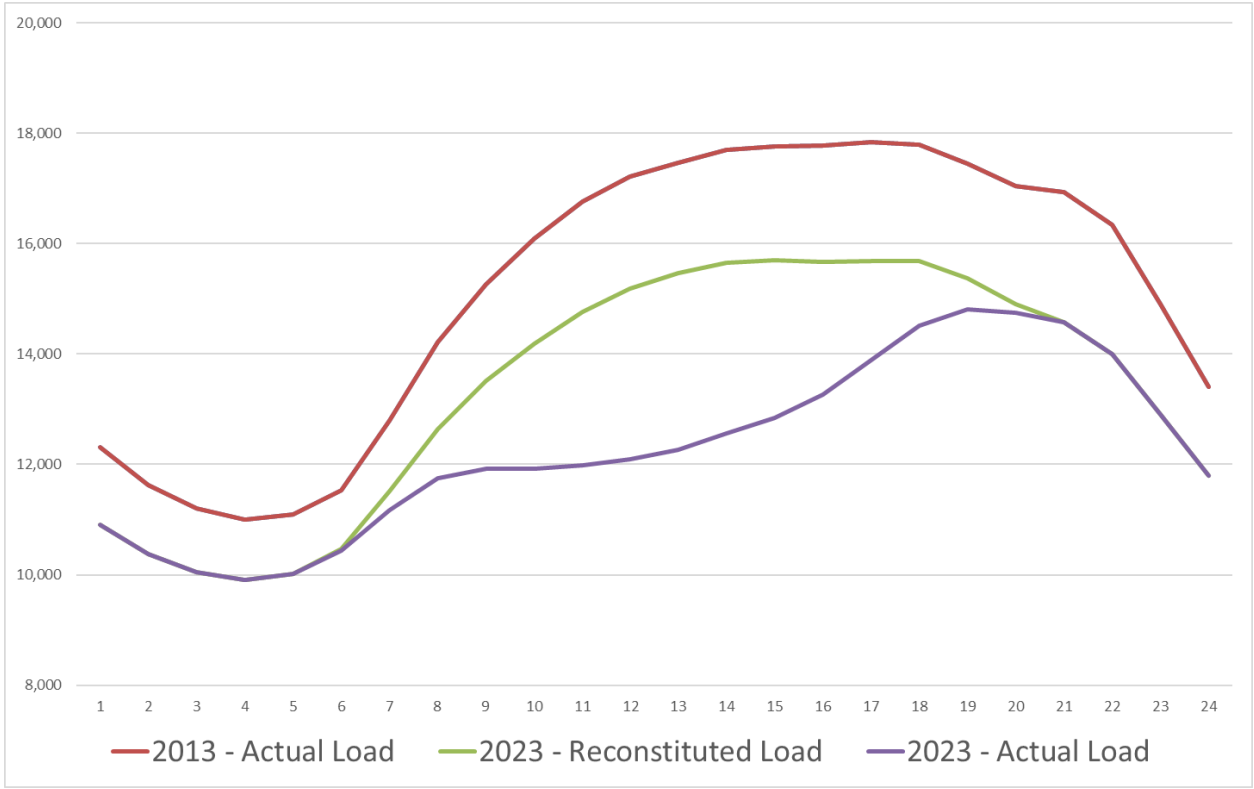
BTM PV Impact on Load Curve

- More than 6,500 MW forecasted by end of 2023
- Except for a few large facilities (~600 MW), PV is BTM and not visible to ISO in real time



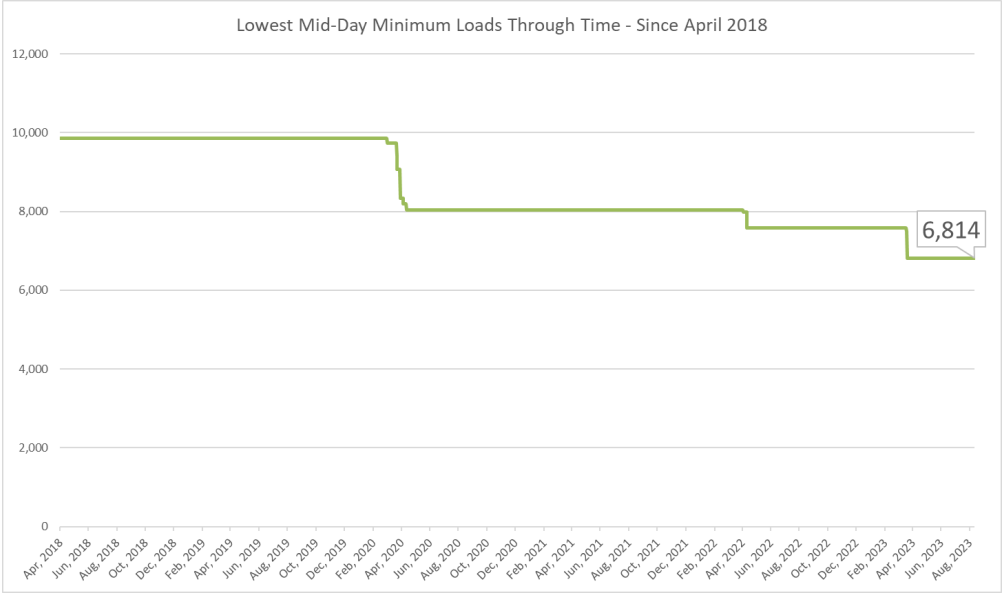
Average Hourly Load Shapes in 2023 and 2013 are Similar in Shape Once Reconstituted for BTM PV

- The 2023 load shapes demonstrate the significant impact from BTM PV



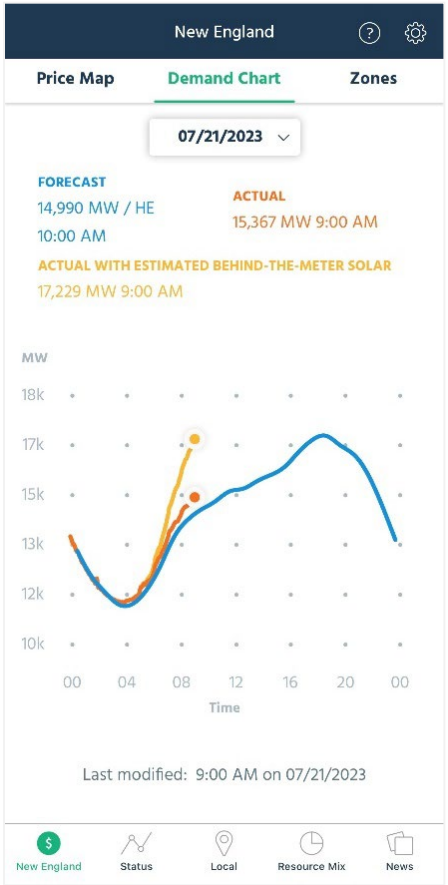
Lowest Mid-Day Minimum Loads

- Mid-day loads are lower as more BTM PV is installed, usually breaking minimum load records in the spring
- The demand is still there, but not seen in real-time by ISO-NE because it is served by BTM generation



ISO To Go and ISO Express

- Awareness of the impact of BTM PV is important
- *ISO to Go* and *ISO Express* are now showing an additional load curve that represents the Actual Load with Estimated BTM PV
  - This is the actual demand on the system, whether it is served by Generators or BTM PV



Challenges Introduced by BTM PV

- Forecast uncertainty
  - Forecasting clouds is exponentially more difficult than surface level temperature, humidity, and wind
    - Every inch of space between the panel and the sun is subject to potential cloud cover
- Load volatility
  - Partly cloudy days can result in intra-hour swings in load
- Lower mid-day loads are being observed
  - Four minimum generation warnings issued so far in 2023
    - 0 between 2018 and 2021; 1 in 2022
    - Back down margin less than 300 MW
  - 53 days of mid-day minimum loads in 2023, so far
    - 45 in 2022; 18 in 2021
- Compared to the stable night-time hours, the forecasting accuracy for mid-day has declined disproportionately due to the increase in BTM PV

FORECAST IMPROVEMENT PROJECTS

Weather Station Expansion, and Improved PV Processes & Information

Project Overview

- Two projects have already incorporated BTM PV explicitly into the Load Forecast process
  - Initial PV Project in March, 2019
  - PV Blending in October, 2022
- Latest project adds precision to the weather forecast
  - Zonal forecasts have more relevant weather information
  - Expanded the blended weather from 8 to 23 cities*
  - Added wet bulb temperature and irradiance as additional data points
- These improvements went into production on July 27, 2023

* See appendix at the end of this presentation for a list of the additional cities

PV Projects

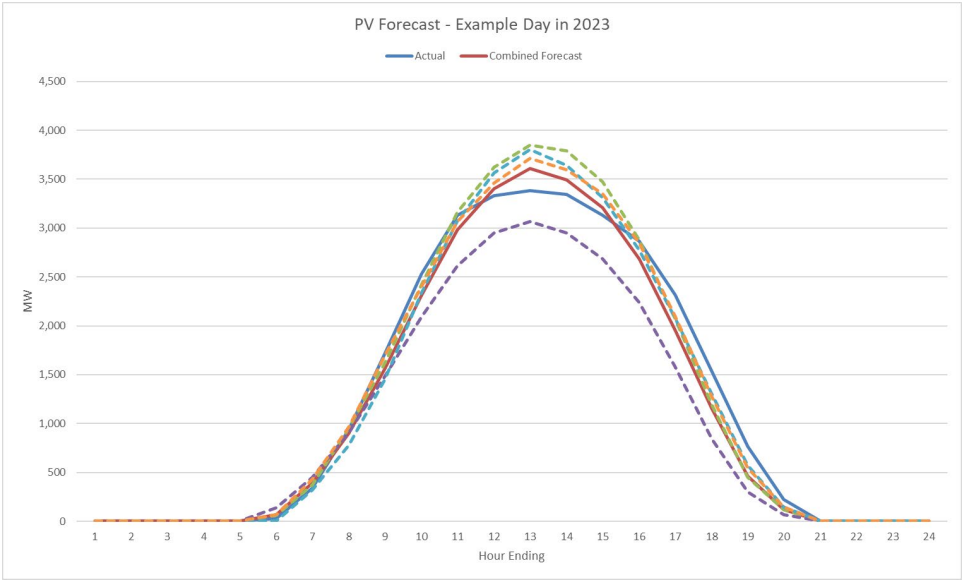
- In 2019, the ISO added BTM PV hourly MW data as a new component to the load forecast using:
  - Historic estimates of actual hourly production
  - Single forecast of next 7 days of hourly production
- In 2022, the ISO further expanded the PV forecast inputs
  - Multiple forecasts are blended by a Forecaster
    - This gives a sense of confidence on when forecasts converge and conveys appropriate risk when forecasts diverge

BTM PV Forecast Accounting Methods

Error Correction	Direct Input	Reconstitution
• In a blending process, forecaster uses cloud-cover forecasts to estimate PV effect on load • Forecaster adds or subtracts load if weather is expected to be cloudier or sunnier • Since load models learned the average effect, a partly cloudy day didn't need adjustment	• Load forecast models are trained using actual PV as an input, just like other weather variables • Model output is adjusted based on forecasted PV compared to actual PV from the past	• Load is "reconstituted"—actual past PV output data is added back into hourly loads • Models are retrained based on reconstituted load • PV forecast is subtracted from load in forecast models • Model output is NOT adjusted based on forecasted PV

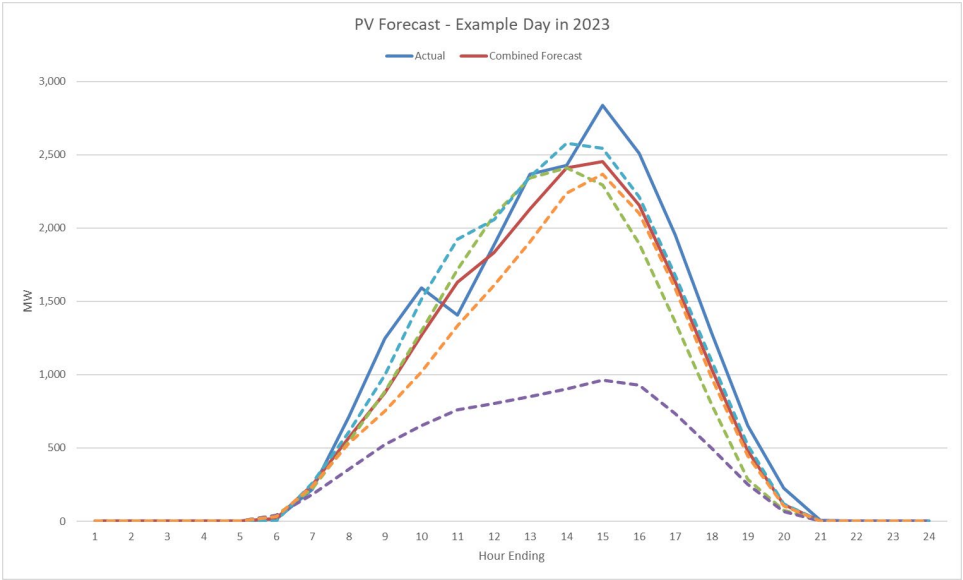
Blended PV Forecast

- Four BTM PV forecast models are blended to develop a single input to the load forecast models
- When BTM PV is below forecast, demand served by the wholesale market is higher



Blended PV Forecast

- It’s not easy – clouds are interpreted differently depending on the model
- The Forecaster and Meteorologist need to decide which models are likely to be most accurate, but multiple models give confidence in that decision



Weather Information and Station Expansion

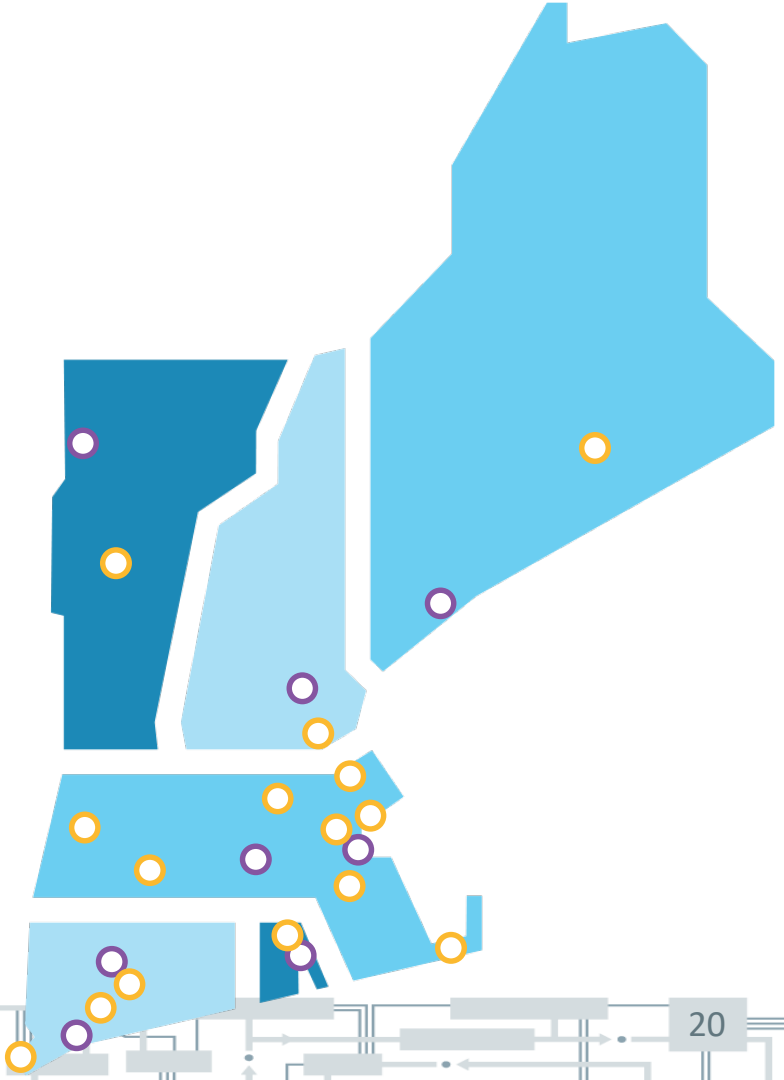
- Higher level of precision for the zonal load forecast
  - Expanding from 8 cities to 23 cities
  - More inclusive coverage of each zone
- More information available to ISO Forecasters
  - Adds irradiance and wet bulb temperature to the inputs to the load forecast (*e.g.* in addition to: temperature, dew point, wind speed, cloud cover)
    - This helps deliver better definition around what drives load
    - Including irradiance gives more precision than just using cloud cover which as a metric on its own does not account well for relatively translucent cloud cover

More Weather Information

- Wet bulb temperature helps improve summer forecasts with hot and humid weather
- Irradiance information provides another factor that not only drives BTM PV, but also the impact of sunshine heating buildings and the need for electric lighting
  - Distributing by the density of BTM PV installations
  - Distributing by population for heating and lighting

Additional Cities

- New cities represent the most populated regions of New England, in addition to the original 8 cities
- Every load zone now has representation
- Subtle differences can have a big impact on forecasted load
- See appendix for listing of cities



Key Takeaways

- Load forecasting is becoming significantly more complex and is not expected to change course
- Forecast enhancements are intended to keep up with the changes and maintain accuracy as much as possible, but will never return to the simple methods and measurements that have been sufficient in the past
- ISO New England is continuously working to improve load forecast products and processes
- Next steps require our vendors to improve their PV forecast models through study, research, and incremental adjustments

Questions

Appendix: 23 Forecast Cities

Burlington, VT	Concord, NH	Manchester, NH	Fitchburg, MA	Portland, ME
Rutland, VT	Springfield, MA	Worcester, MA	Lawrence, MA	Bangor, ME
Pittsfield, MA	Windsor Locks, CT	Bedford, MA		Beverly, MA
Waterbury, CT	Hartford, CT	NW Providence, RI	Boston, MA	
Stamford, CT	Bridgeport, CT	S Providence, RI	Taunton, MA	Barnstable, MA