DECEMBER 20, 2019

# Draft 2020 Heating Electrification Forecast

*Load Forecast Committee*

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# Introduction

- ISO discussed methodology and assumptions used in the heating electrification at the September 27, 2019 and November 18, 2019 LFC meetings
- The ISO recognizes that heating electrification is a nascent trend, and expects that while its 2020 forecast methodology serves as a starting point, improvements will be needed as policy drivers and state initiatives are further developed and additional data become available
- The 2020 heating electrification forecast focuses on adoption of air-source heat pumps (ASHPs)
  - Consideration of other heating electrification technologies, such as ground source heat pumps (GSHP) and heat pump hot water heaters (HPHW), may also be warranted in future forecasts
  - Forecast is relevant for winter months only (January-April, and October-December)
- There are two general components to the forecast:
  1. Forecast the adoption of ASHPs for each state and the region over the next ten years
  2. Use data-driven assumptions to convert the ASHP adoption forecast into estimated impacts on monthly energy and demand by state
     - Develop monthly demand and energy impacts per installed ASHP based on recent historical demand data associated with residences with ASHPs

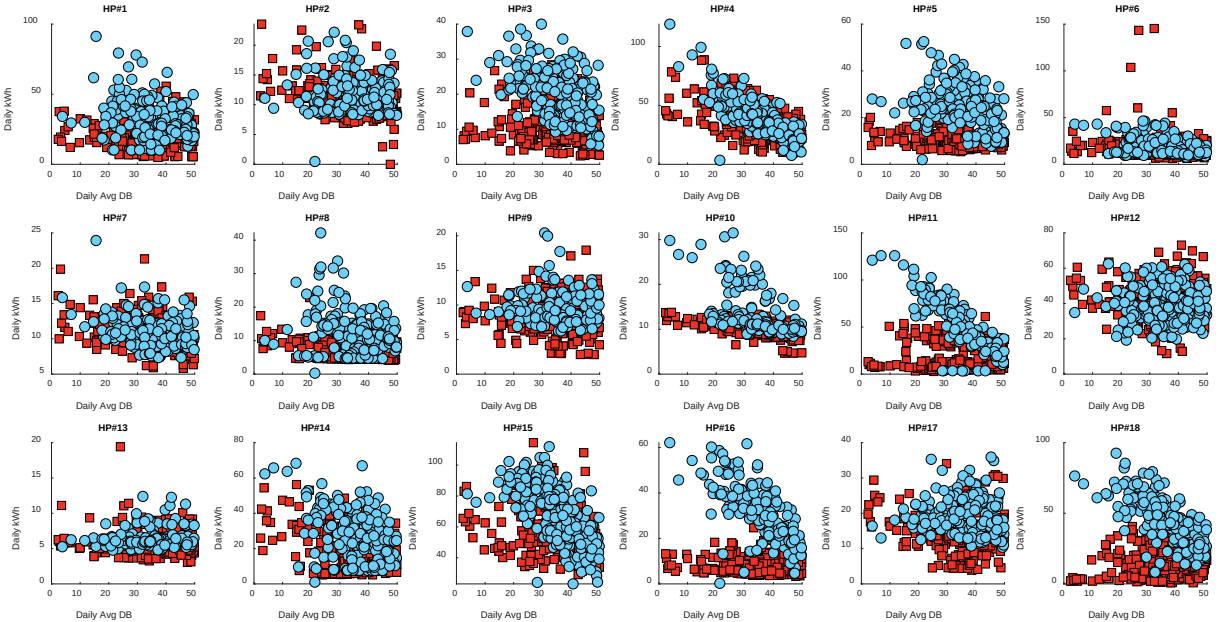
# Residential AMI Data Analysis

- To assist in developing assumptions about changes to electricity consumption due to the adoption of ASHPs, ISO licensed advanced metering infrastructure (AMI) data from Sagewell, Inc., including:
  - Anonymized building-level hourly interval energy consumption for residential sites in northeastern MA
  - Building characteristics and end-use details that match each AMI point
  - Interval energy consumption from more than 80 houses with ASHPs installed
- Assumptions are based on analysis and regression modeling performed on the *average* hourly electricity consumption from 18 residential AMI profiles:
  - ISO removed one profile from the analysis since the November LFC due to observed data issues
  - Each of the 18 profiles corresponds to a residence where an ASHP was installed between the winters of 2017/2018 and 2018/2019, which enables a direct comparison of winter electricity consumption before and after ASHP adoption
- The resulting average profile reflects a diversity of ASHP applications (see next slide):
  - A mixture of natural gas and oil legacy heating fuels
  - Variety of ASHP heating capacities
- ISO recognizes this is a relatively small AMI sample, and will continue working with stakeholders as part of future forecast cycles to seek out additional data sources as heating electrification efforts mature in the region

# Residential AMI Data

## *Household-Level Energy Scatter Plots*

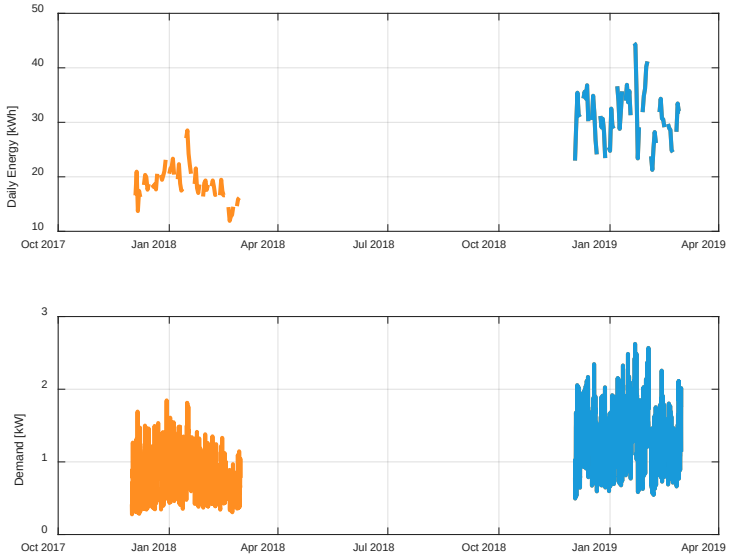
- To address stakeholder questions regarding the household-level AMI data, scatter plots to the right illustrate the relationship between daily energy and dry bulb temperature for each of the 18 sample AMI residences:
  - Period before ASHP installation is illustrated by red squares
  - Period after ASHP installation is illustrated by blue circles
- As illustrated, the data reflect a range of ASHP applications



# AMI Data Analysis

*Results Before and After ASHP Adoption*

- Analysis was performed on the average hourly electric demand of 18 residences with ASHP installations
- Since each of the ASHPs was installed between the winters of 2017/2018 and 2018/2019, a direct comparison of average winter electric energy and demand before and after ASHP adoption is possible



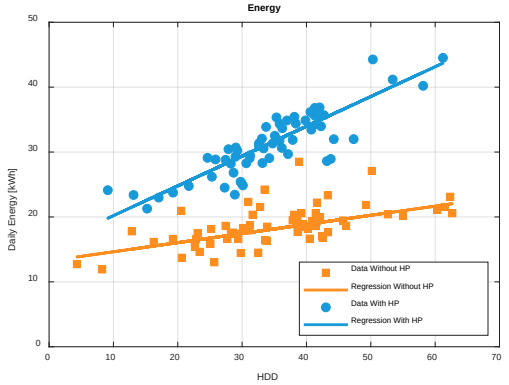

*Data Source: Sagewell, Inc.*

- The plots show the average of the 18 profiles during the two consecutive winters analyzed (weekdays only)
  - Top plot is average daily energy; bottom plot is average hourly demand
  - Orange plots are prior to ASHP adoption; blue plots are after ASHP adoption
  - The increase in both energy and demand after ASHP adoption is clearly illustrated by the higher blue plots

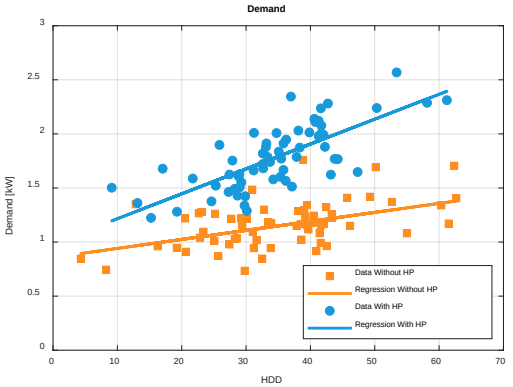
# Estimating Energy and Demand Impacts

*Development of Response Functions*

- ISO developed a regression-based approach to leverage AMI and weather data to derive response functions
  - Response functions are used to estimate ASHP impacts as a function of weather
- Separate regression models were developed for energy and demand using the average of the 18 AMI data series before and after ASHP installation
  - Heating degree days (HDD) was used as the weather variable since it is included in both energy and demand forecast models
  - Top plot is for energy and bottom is demand (HE 18), weekdays only
  - Orange points are for data prior to ASHP and blue points are for data after ASHP
  - Orange and blue lines show the regression line for each set of data
- *Model differences* reveal the incremental increase in electric energy and demand as a function of weather (i.e., HDDs) due to ASHP adoption




*Data Source: Sagewell, Inc.*



# AIR-SOURCE HEAT PUMP ADOPTION

# Draft ASHP Adoption Assumptions

| State | Draft Guidance/Assumptions |
|---|---|
| CT | Begin with ~5,000 installations in 2020; assume a 15% growth rate |
| MA | 2020-2021 values are estimated based on MA 3-yr EE plan; 20% annual growth to reach ~600,000 installations |
| ME | 2020-2024 values from Efficiency Maine Trust; 5% annual growth assumed thereafter |
| NH | Begin with 2020 planned installations; 12% annual growth |
| RI | Begin with 2020 planned installations; reasonable outlook would reflect a conversion of ~30% of existing homes that use delivered fuels as legacy heating source (results in ~50% annual growth) |
| VT | 2020-2029 values provided by Efficiency Vermont |

# ASHP Adoption Forecast

## ***Includes*** *Assumed Legacy Electric Heat Replacement*

| Year | Annual ASHP Installs (Thousands) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CT | MA | ME | NH | RI | VT | ISO-NE |
| 2020 | 5.0 | 23.0 | 13 | 3 | 0.4 | 5.7 | 50 |
| 2021 | 5.8 | 27.6 | 16 | 3.4 | 0.6 | 6.1 | 59 |
| 2022 | 6.6 | 33.1 | 19.5 | 3.8 | 0.9 | 6.7 | 71 |
| 2023 | 7.6 | 39.7 | 23 | 4.2 | 1.4 | 7.1 | 83 |
| 2024 | 8.7 | 47.7 | 27.5 | 4.7 | 2.0 | 7.8 | 99 |
| 2025 | 10.1 | 57.2 | 28.9 | 5.3 | 3.0 | 8.4 | 113 |
| 2026 | 11.6 | 68.7 | 30.3 | 5.9 | 4.6 | 9.0 | 130 |
| 2027 | 13.3 | 82.4 | 31.8 | 6.6 | 6.8 | 9.7 | 151 |
| 2028 | 15.3 | 98.9 | 33.4 | 7.4 | 10.3 | 10.4 | 176 |
| 2029 | 17.6 | 118.7 | 35.1 | 8.3 | 15.4 | 11.1 | 206 |
| **Cumulative Total** | **101.5** | **597.0** | **258.6** | **52.6** | **45.3** | **82.1** | **1,137** |
| **Approx. Share of Households with ASHP in 2029 (%) *** | **6.9%** | **20.5%** | **42.8%** | **8.8%** | **10.0%** | **29.4%** | **18.0%** |
| **Approx. Share of Legacy Electric Heat Replacement **** | **16%** | **15%** | **6%** | **9%** | **10%** | **5%** | **13%** |

* Assumes one ASHP/household; Based on Moody's Analytics October 2019 forecasts of number of households by state

** Source: U.S. Census Bureau, Selected Housing Characteristics, 2013-2017 American Community Survey 5-year Estimates

# ASHP Adoption Forecast

## ***Excludes*** *Assumed Legacy Electric Heat Replacement*

- The values below are net of ASHP installations assumed to replace legacy electric resistance heat and are used to estimate energy and demand impacts

| Year | Annual ASHP Installs (Thousands) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CT | MA | ME | NH | RI | VT | ISO-NE |
| 2020 | 4.2 | 19.6 | 12.22 | 2.73 | 0.4 | 5.4 | 42 |
| 2021 | 4.8 | 23.5 | 15.04 | 3.1 | 0.5 | 5.8 | 53 |
| 2022 | 5.6 | 28.2 | 18.33 | 3.4 | 0.8 | 6.4 | 63 |
| 2023 | 6.4 | 33.8 | 21.62 | 3.8 | 1.2 | 6.8 | 74 |
| 2024 | 7.3 | 40.5 | 25.85 | 4.3 | 1.8 | 7.4 | 87 |
| 2025 | 8.4 | 48.6 | 27.1 | 4.8 | 2.7 | 8.0 | 100 |
| 2026 | 9.7 | 58.4 | 28.5 | 5.4 | 4.1 | 8.6 | 115 |
| 2027 | 11.2 | 70.1 | 29.9 | 6.0 | 6.2 | 9.2 | 133 |
| 2028 | 12.8 | 84.1 | 31.4 | 6.8 | 9.2 | 9.8 | 154 |
| 2029 | 14.8 | 100.9 | 33.0 | 7.6 | 13.8 | 10.5 | 181 |
| **Cumulative Total** | **85.3** | **507.5** | **243.0** | **47.9** | **40.8** | **77.9** | **1,000** |

# DRAFT ENERGY AND DEMAND FORECASTS

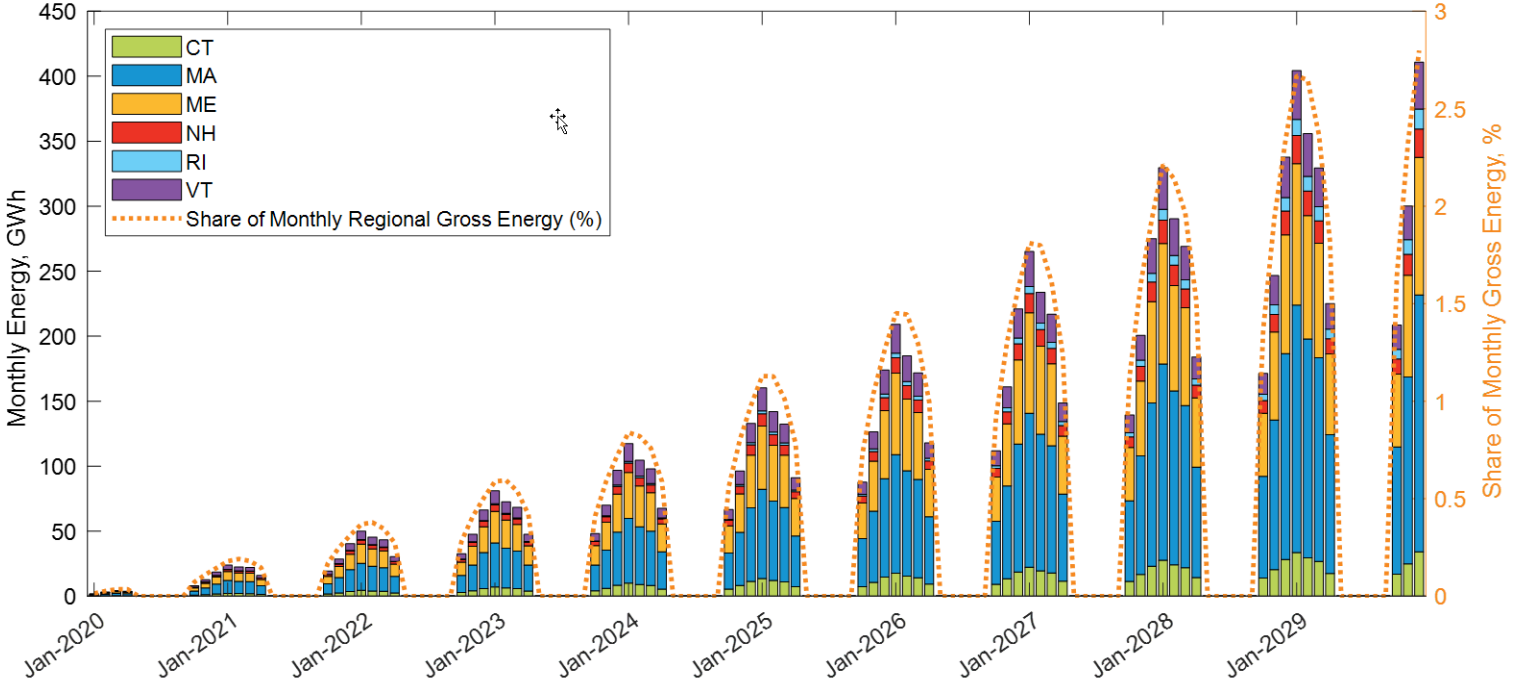
# Estimating Energy Impacts of ASHP Adoption

*Use of Response Functions in Load Forecast*

- The process for estimating energy impacts is as follows:
  - The daily HDDs for each winter month over the period 1996 -2015 (i.e., the "normal weather" period) used for monthly energy modeling is used to estimate monthly energy impacts
    - Input daily HDDs to each energy response function and multiply by the monthly ASHP penetration;
    - Differences in response function outputs reflect the resulting daily energy due to ASHP adoption, which are then summed for each year
    - The average of the resulting 20 monthly energy differences is the estimated monthly energy impact of ASHP adoption for that month
  - Energy will be grossed up by 6% to account for assumed transmission and distribution losses, consistent with other forecast processes
- Refer to slides 38-40 of the ISO's Long-Term Load Forecast Methodology Overview for background information on the methodology used for the energy forecast

# Draft 2020 Heating Electrification Forecast

*Monthly Energy (GWh)*



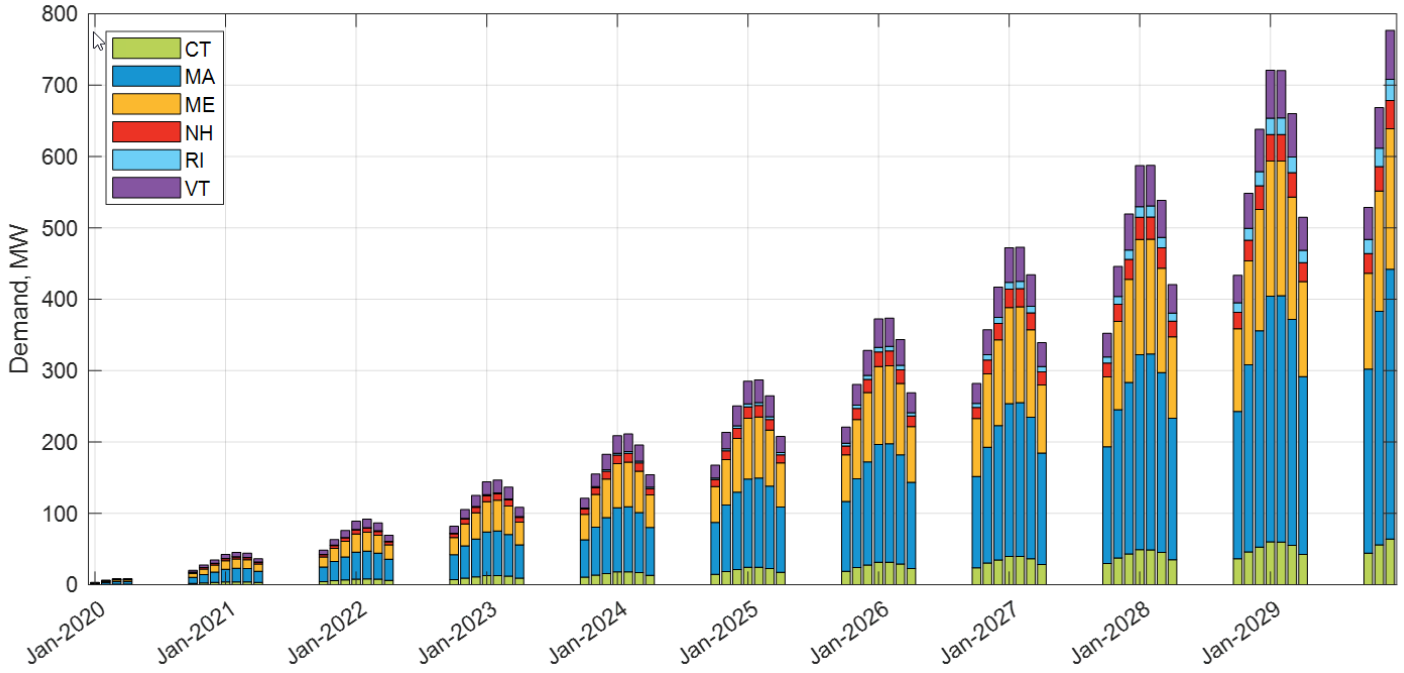
# Estimating Demand Impacts of ASHP Adoption

*Use of Response Functions in Load Forecast*

- The process for estimating demand impacts is as follows:
  - The weekly weather distributions used to generate weekly load forecast distributions, which include HDDs, will be used to estimate monthly demand impacts
    - Input weekly distributions of HDDs (for each week in a given month) to each response function for demand, and multiply by the monthly ASHP penetration;
    - Differences in response function outputs are calculated, resulting in a weekly distribution of demand impacts;
  - The resulting weekly distribution of demand impacts is added to the weekly load distributions generated by each monthly demand model
    - The gross load percentiles (i.e. the "50/50" and "90/10") are then calculated for each week of the load forecast
  - Demand will be grossed up by 8% to account for assumed transmission and distribution losses, consistent with other forecast processes
- Refer to slides 41-46 of the ISO's Long-Term Load Forecast Methodology Overview for background information on the methodology used for the demand forecast

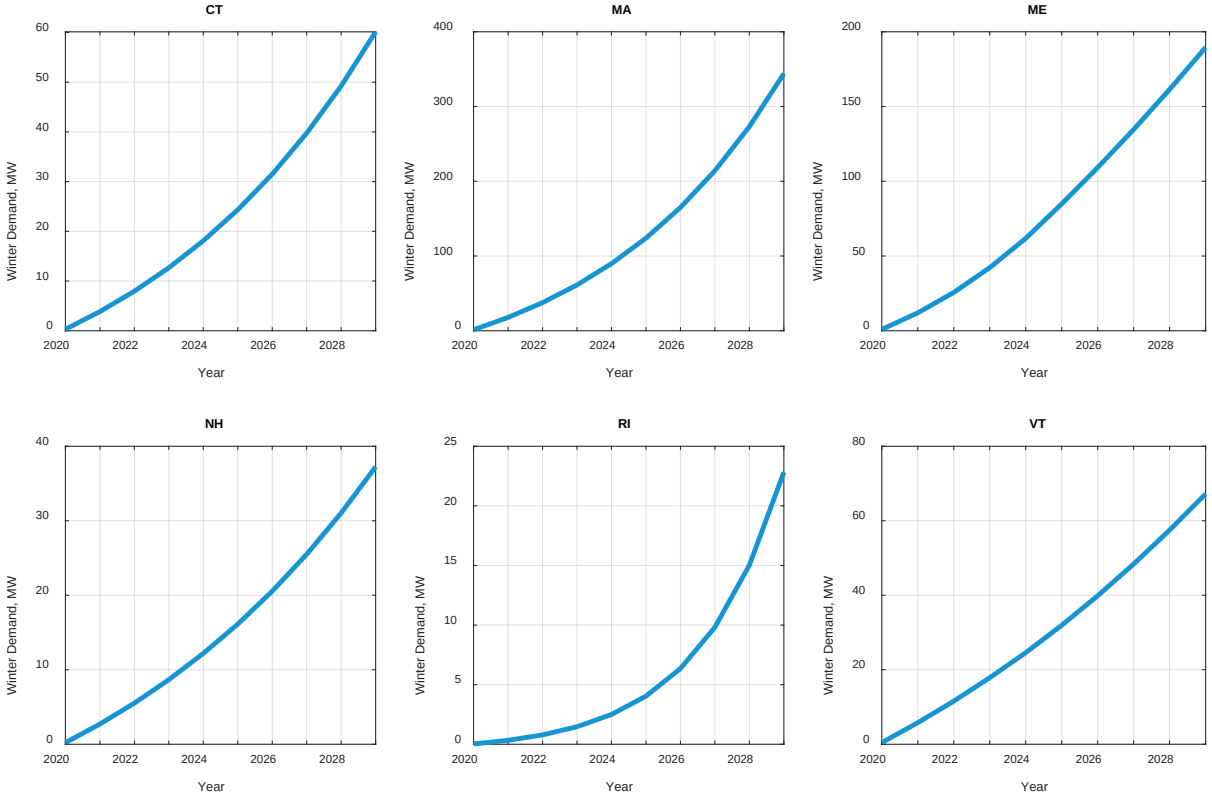
# Draft 2020 Heating Electrification Forecast

*Monthly Demand (MW)*



# Draft 2020 Heating Electrification Forecast

*State-by-State Winter Peak Demand (MW)*



# Next Steps

- Stakeholders are encouraged to provide any additional information or feedback regarding the forecast by January 17, 2019
  - Any resulting changes will be reflected in the final heating electrification forecast that will be shared with the LFC at the February 10, 2020 meeting
  - In the absence of additional guidance, ISO will use the existing draft ASHP adoption forecast
- Final forecast will be published as part of 2020 CELT

# Questions