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Update on 2020 Heating Electrification Forecast

Load Forecast Committee

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Objectives

- Provide an update on air-source heat pump (ASHP) adoption forecast activities based on recent discussions with the New England states
- Share additional details of the proposed methodology to forecast the impacts of heating electrification, including the analysis of residential advanced metering infrastructure (AMI) data that will inform assumptions regarding energy and demand impacts of ASHP adoption
- Obtain LFC feedback on proposed methodology and assumptions

Introduction

- Heating electrification is expected to play a pivotal role in the achievement of state greenhouse gas (GHG) reduction mandates and goals
- This presentation outlines the proposed methodology for initially forecasting heating electrification impacts on state and regional electric energy and demand as part of CELT 2020
  - ISO discussed initial methodology and assumptions to be used in the heating electrification at the September 27, 2019 LFC meeting
- ISO will focus forecast efforts on consumer adoption of air-source heat pumps (ASHPs) across the region
  - 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 will focus on winter months (January-April, and October-December)
- The ISO recognizes that heating electrification is a nascent trend, and expects that while this methodology serves as a starting point, improvements will likely be needed as policy drivers and state initiatives are further developed and additional data become available

Accounting for ASHPs in Load Forecast

Seasonal Differences

- The vast majority of ASHPs are installed as part of energy efficiency (EE) programs, and associated demand savings are submitted to ISO by EE program administrators (PAs)
- Summer accounting
  - Summer demand and energy savings are expected to mirror the typical savings associated with increased air conditioning efficiency
    - Cooling implications of ASHP adoption are reported as EE savings, and for which load is reconstituted
    - **This process already exists and no forecast changes are proposed for summer accounting**
  - However, increases in summer demand may result over the longer term if ASHP adoption significantly increases the total square footage of cooled building area in parts of the region
    - This would be a continuation of a long-standing trend of increasing AC saturation in many parts of the region, and therefore, may already be embedded in load forecast modeling
    - ISO will work with stakeholders to monitor this trend, particularly in northern states where AC saturation is lower
- Winter accounting
  - Despite an overall increase in winter electricity consumption resulting from most ASHP installations (due to the displacement of fossil fuel heating sources), PAs often report ASHP measures as winter savings based on a baseline of resistance heat or a lower efficiency ASHP
    - Reporting practices vary across the region
    - This accounting does not work in the current load reconstitution process, in which EE savings are added back to historical loads
  - For this reason, ISO is developing an exogenous heating electrification forecast, and will add the estimated energy and demand impacts to the gross load model forecasts to determine the final gross load forecast

Heating Electrification Forecast Framework

- There are two general components to the ASHP 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

ASHP Adoption Forecast Update

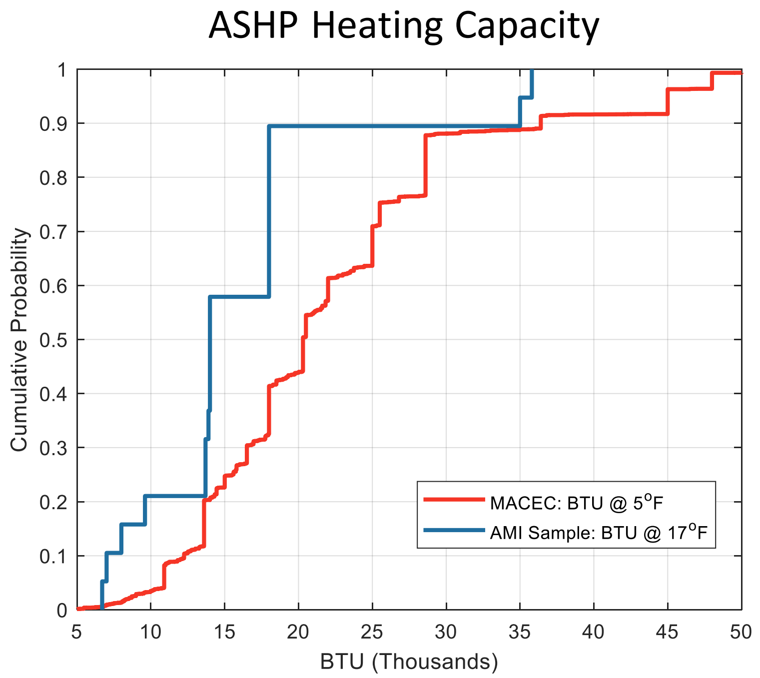
- Since the September 27th LFC meeting, ISO held discussions with each New England state to seek input regarding the appropriate state-level ASHP adoption forecasts
  - Specific guidance from some states is still forthcoming
- Preliminary values indicate that as many as 700,000 or more cumulative ASHP installations could occur in the region over the coming decade

Residential AMI Data Analysis

- To assist in developing assumptions about changes to electricity consumption due to the adoption of ASHPs, ISO licensed anonymized advanced metering infrastructure (AMI) and associated data from Sagewell, Inc., including:
  – 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 have been based on analysis and regression modeling performed on the average hourly electricity consumption from 19 residential AMI profiles:
  – Each of the 19 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 average of the 19 AMI profiles reflects an array of residential ASHP applications:
  – A mixture of natural gas and oil legacy heating fuels
  – Variety of ASHP heating capacities (see next slide)
- 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

ASHP Heating Capacity

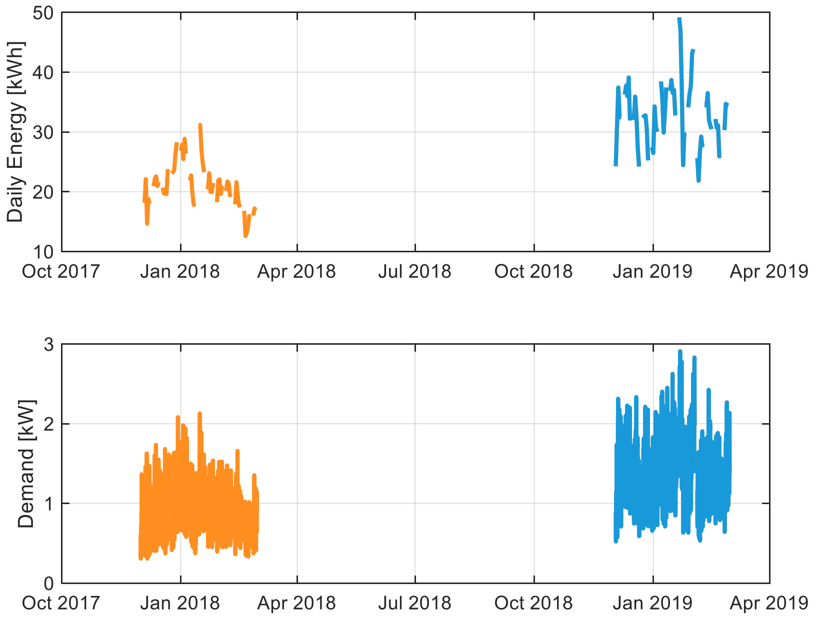
- Heating capacity is a measure of how many British thermal units (BTUs) of heating an ASHP can provide at a specific temperature, and indicates the magnitude of corresponding electricity demand
  - In general, units with a higher heating capacity will consume larger amounts of electricity
  - The coefficient of performance (COP) of the ASHP at the design temperature is also a factor
- The distribution of heating capacities of the 19 ASHPs in the AMI sample were compared with those of over 16,000 ASHP installations reported in MA Clean Energy Center data (see Appendix)
  - The plot to the right compares the cumulative probability of heating capacities of these two sets of ASHPs
- The plot suggests the AMI sample reflects a distribution of lower overall heating capacity than the larger MACEC sample of ASHP installations
  - May be indicative of a slight low bias in energy and demand impacts exhibited by the AMI sample relative to the total population of actual installations



AMI Data Analysis

Results Before and After ASHP Adoption

- Analysis was performed on the average hourly electric demand of 19 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



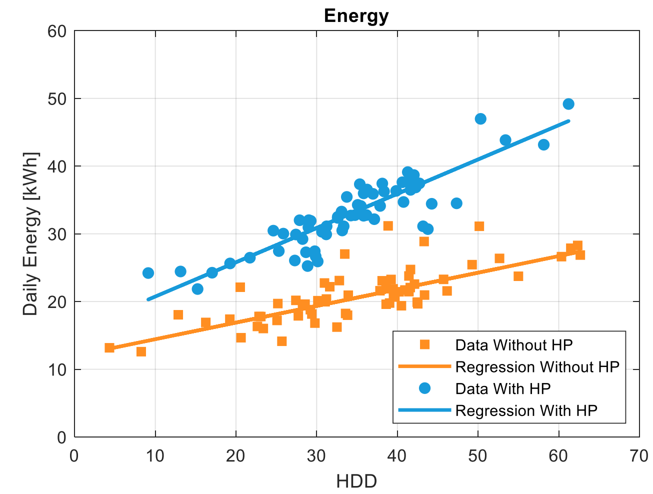
Data Source: Sagewell, Inc.

- The plots show the average of the 19 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 19 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



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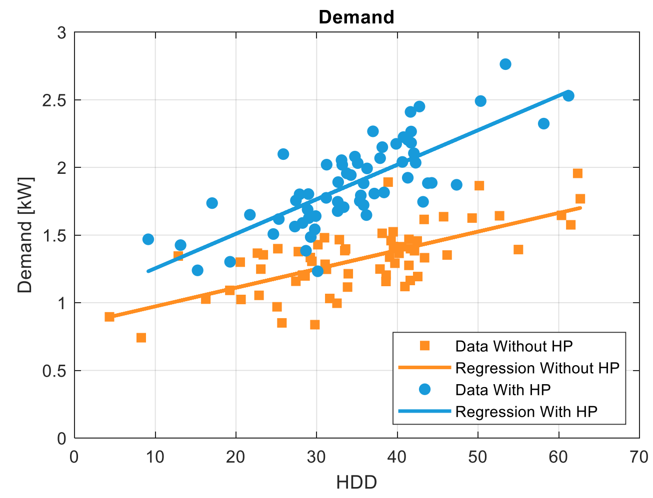

Estimating Energy Impacts of ASHP Adoption

Use of Response Functions in Load Forecast

- The process for estimating energy impacts is as follows:
  - The daily HDDs for each month over the period 1996 -2015 (i.e., the "normal weather" period) used for monthly energy modeling will also be used to estimate monthly energy impacts
    - Daily HDDs are input to each response function and the differences in resulting daily energy, which represent the estimated increase in energy due to ASHP adoption, are calculated and summed for each year
  - The average of the resulting 20 monthly energy differences is the estimated monthly energy impact of ASHP adoption
  - 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

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
    - Weekly distributions of HDDs are input to each response function for demand, and the demand differences are calculated, resulting in a distribution of demand impacts;
  - The resulting distribution of demand impacts will be added to the weekly load distributions generated by each monthly demand model
    - The gross load percentiles (i.e. the "50/50" and "90/10") will then be 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

ASHP Displacement of Electric Resistance Heat

- ASHP installations are likely to reduce winter demand and energy where they displace electric resistance heat that is utilized as a primary heating source
- To account for this, ISO will subtract a share of the ASHP adoption forecast equivalent to each state's estimated percentage of households that use electric heat as a primary heating source
  - Use the most recent 5-year estimates from the U.S. Census Bureau tabulated below

Residential House Heating Fuel (ACS 2013-2017)*							
Fuel Type	**CT**	**ME**	**MA**	**NH**	**RI**	**VT**	**New England**
Utility gas	35%	7%	51%	20%	53%	18%	39%
Bottled, tank, or LP gas	4%	10%	3%	15%	3%	16%	6%
Electricity	16%	6%	15%	9%	10%	5%	13%
Fuel oil, kerosene, etc.	42%	62%	27%	45%	31%	43%	37%
Coal or coke	0%	0%	0%	0%	0%	0%	0%
Wood	2%	13%	2%	8%	2%	17%	4%
Solar energy	0%	0%	0%	0%	0%	0%	0%
Other fuel	1%	2%	1%	2%	1%	2%	1%
No fuel used	0%	0%	0%	1%	0%	0%	0%

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

Next Steps

- ISO will continue to coordinate with the states to receive guidance on the appropriate state-level ASHP adoption forecasts
- ISO will present a draft heating electrification forecast for the region and states at the December 20, 2019 LFC meeting
- A finalized heating electrification forecast will be included in the 2020 CELT gross load forecast

APPENDIX

Massachusetts Clean Energy Center ASHP Installation Data

Massachusetts ASHP Data

- The data below comes from residential ASHP projects that received a rebate from Massachusetts Clean Energy Center (MA CEC) between November 2014 and March 2019

Legacy Heating Fuel	Number of Projects	Number of Installed ASHPs	Share of Total
Electric	1,566	2,246	14.0%
Natural gas	4,379	5,591	34.8%
Oil	4,437	6,321	39.4%
Propane	519	723	4.5%
Other/Unknown	827	1172	7.3%
Total	**11,728**	**16,053**	**100%**

Source: Massachusetts Clean Energy Center, Cost of Residential Air-Source Heat Pumps, available at: https://www.masscec.com/cost-residential-air-source-heat-pumps

Questions