Final Draft 2020 Heating Electrification Forecast

Load Forecast Committee

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Introduction

- ISO discussed methodology and assumptions used in the heating electrification forecast at the September 27, 2019 and November 18, 2019 LFC meetings, and the draft 2020 electrification forecast at the December 20, 2019 LFC meeting
- 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
  - ISO has compiled a summary of stakeholder comments on the current methodology at the end of this presentation to help guide areas of potential improvement in future forecast cycles
- 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

Stakeholder Comments on Draft Forecast

- The following comments were received:
  - MA Clean Energy Center
    - Adoption forecast for MA should begin in 2020 at 15k ASHPs (rather than 23k) and have an annual growth rate of 15% (rather than 20%)
  - NH Public Utilities Commission
    - Adoption forecast for NH should begin in 2020 with 2.9k ASHPs (instead of 3k)
  - VT Department of Public Service
    - The current forecast is a reasonable first iteration, but it likely overstates demand impacts when considering load control strategies that may be implemented
- Comments from MA and NH were incorporated into the final draft heating electrification forecast
  - As a result, the final draft regional forecast is approximately 25% lower than the initial draft
  - Comparison of the initial and final draft ASHP adoption forecasts are shown on the following slides

Initial Draft 2020 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%**

Note: Initial draft ASHP adoption forecast values that changed are highlighted in yellow

* 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

Final Draft 2020 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	15.0	13.0	2.9	0.4	5.7	42.0
2021	5.8	17.3	16.0	3.2	0.6	6.1	49.0
2022	6.6	19.8	19.5	3.6	0.9	6.7	57.2
2023	7.6	22.8	23.0	4.1	1.4	7.1	66.0
2024	8.7	26.2	27.5	4.6	2.0	7.8	76.9
2025	10.1	30.2	28.9	5.1	3.0	8.4	85.7
2026	11.6	34.7	30.3	5.7	4.6	9.0	95.9
2027	13.3	39.9	31.8	6.4	6.8	9.7	108.0
2028	15.3	45.9	33.4	7.2	10.3	10.4	122.4
2029	17.6	52.8	35.1	8.0	15.4	11.1	139.9
Cumulative Total	**101.5**	**304.6**	**258.6**	**50.9**	**45.3**	**82.1**	**842.9**
Approx. Share of Households with ASHP in 2029 (%) *	**6.9%**	**10.5%**	**42.8%**	**8.5%**	**10.0%**	**29.4%**	**13.3%**
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

Final Draft 2020 ASHP Adoption Forecast

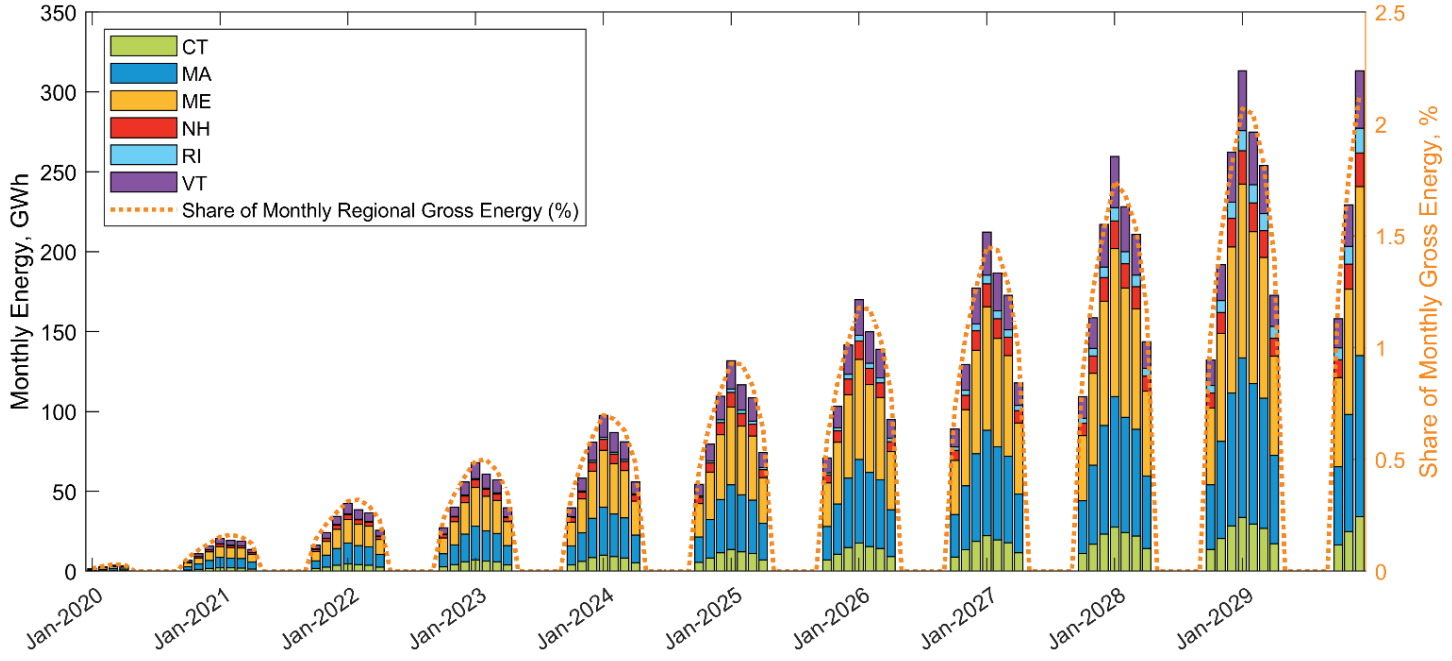
Excludes *Assumed Legacy Electric Heat Replacement*

- 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	12.8	12.2	2.6	0.4	5.4	35.3
2021	4.8	14.7	15.0	3.0	0.5	5.8	43.9
2022	5.6	16.9	18.3	3.3	0.8	6.4	51.2
2023	6.4	19.4	21.6	3.7	1.2	6.8	59.1
2024	7.3	22.3	25.9	4.2	1.8	7.4	68.9
2025	8.4	25.6	27.1	4.7	2.7	8.0	76.6
2026	9.7	29.5	28.5	5.2	4.1	8.6	85.6
2027	11.2	33.9	29.9	5.8	6.2	9.2	96.2
2028	12.8	39.0	31.4	6.5	9.2	9.8	108.9
2029	14.8	44.9	33.0	7.3	13.8	10.5	124.3
Cumulative Total	**85.3**	**258.9**	**243.0**	**46.3**	**40.8**	**77.9**	**749.9**

Final Draft 2020 Heating Electrification Forecast

Monthly Energy (GWh)



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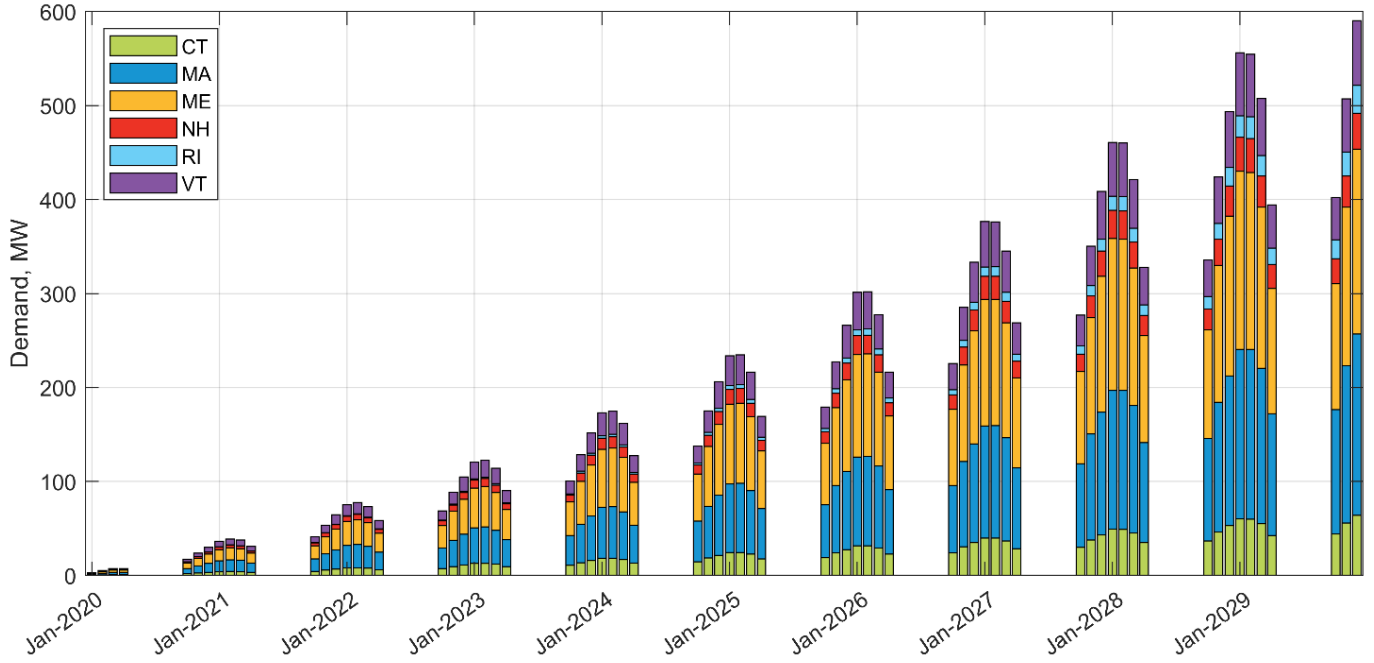
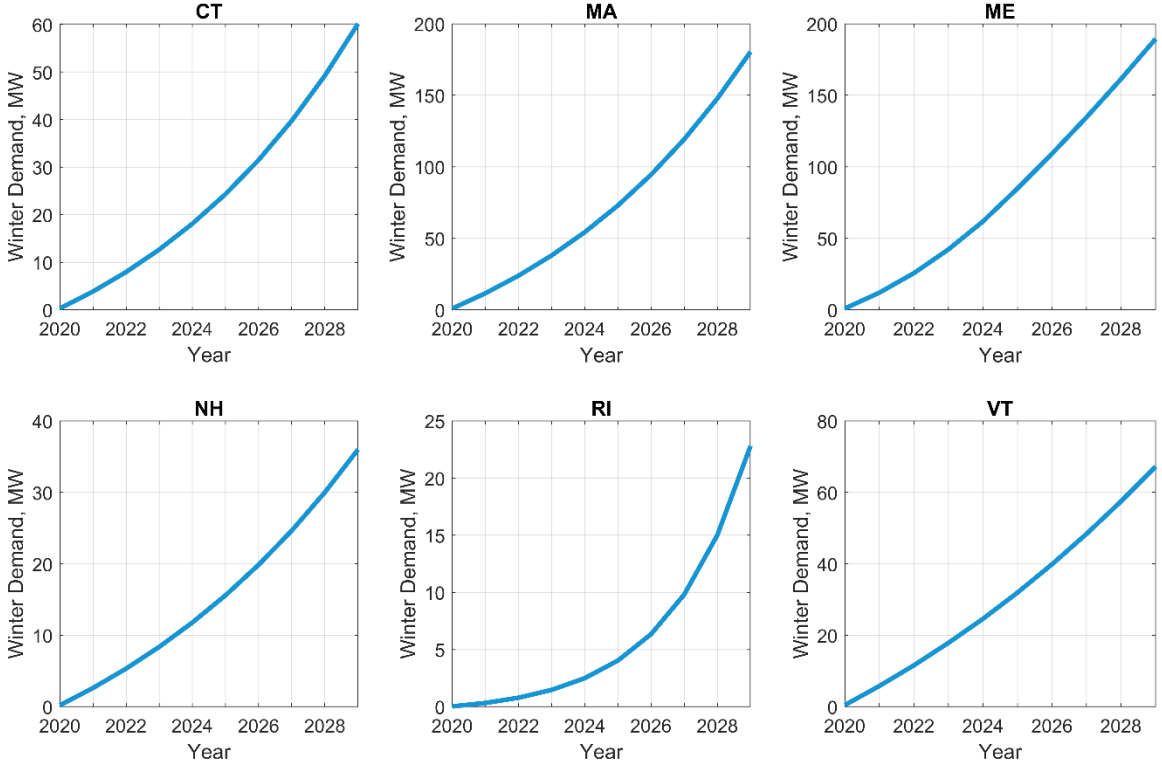
Monthly Demand (MW)



Final Draft 2020 Heating Electrification Forecast

State-by-State Winter Peak Demand (MW)



Stakeholder Feedback on 2020 Forecast

Potential Areas of Improvement

- Technologies other than ASHPs, such as ground source heat pumps (GSHP) and heat pump hot water heaters (HPHW), may also be included in state electrification initiatives and may need to be included in future forecasts
- ASHP adoption forecast accounting
  - Using a simple "number of ASHPs" as the metric to quantify adoption of heating electrification may not be sufficient to characterize the impacts
    - May need to more explicitly account for residential versus commercial applications, and total heating capacity (e.g., in tons or BTU)
- Assumptions used to estimate energy and demand impacts:
  - AMI data reflects a small sample of historical ASHP applications in northeastern MA
    - Data reflecting a larger sample size is desired
    - Data may not adequately reflect the anticipated utilization of future ASHP applications
      - E.g., applications with secondary heating source with integrated controls, or those where ASHP is only heat source
    - Data reflecting larger commercial applications are needed

Next Steps

- ISO will publish the heating electrification forecast as part of CELT 2020
  - Will be included in both the CELT report and the annual Forecast Data spreadsheet

APPENDIX

Information Supporting Assumptions Used in the 2020 Heating Electrification Forecast

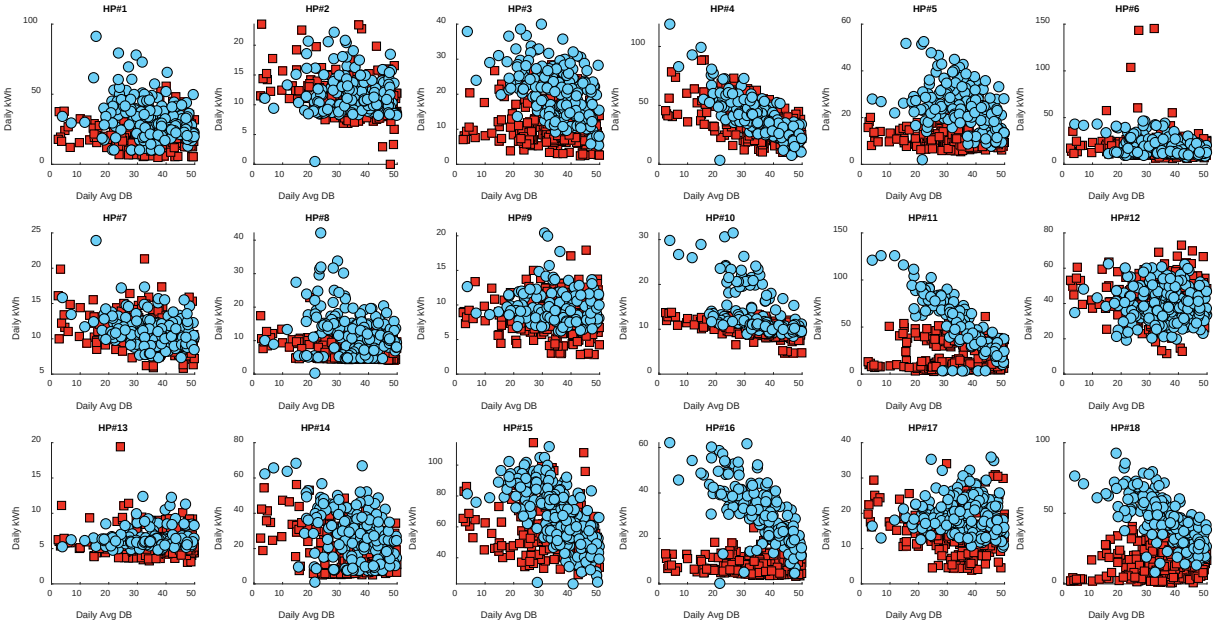
Residential AMI Data Analysis

- 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

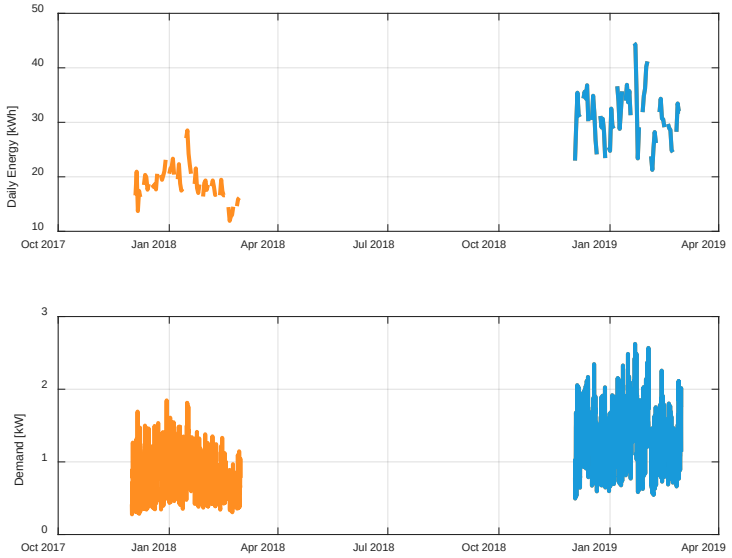
- To address stakeholder questions regarding the household-level AMI data, scatter plots to the right illustrate the relationship between daily energy and dry bulb temperature for each of the 18 sample AMI residences:
  - Period before ASHP installation is illustrated by red squares
  - Period after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



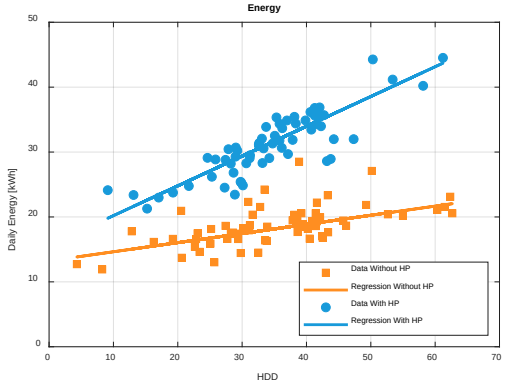
Data Source: Sagewell, Inc.

- 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



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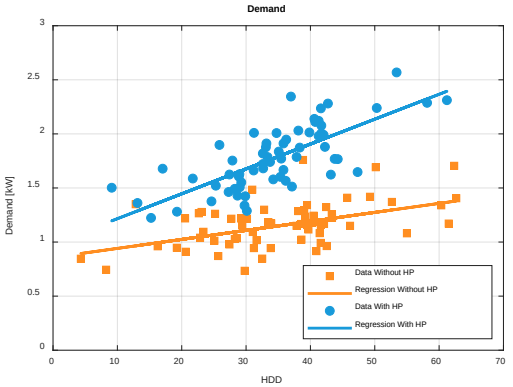

Estimating Energy Impacts of ASHP Adoption

Use of Response Functions in Load Forecast

- The process for estimating energy impacts is as follows:
  - The daily HDDs for each 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

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

Questions