Heating Performance of Variable Capacity Heat Pumps

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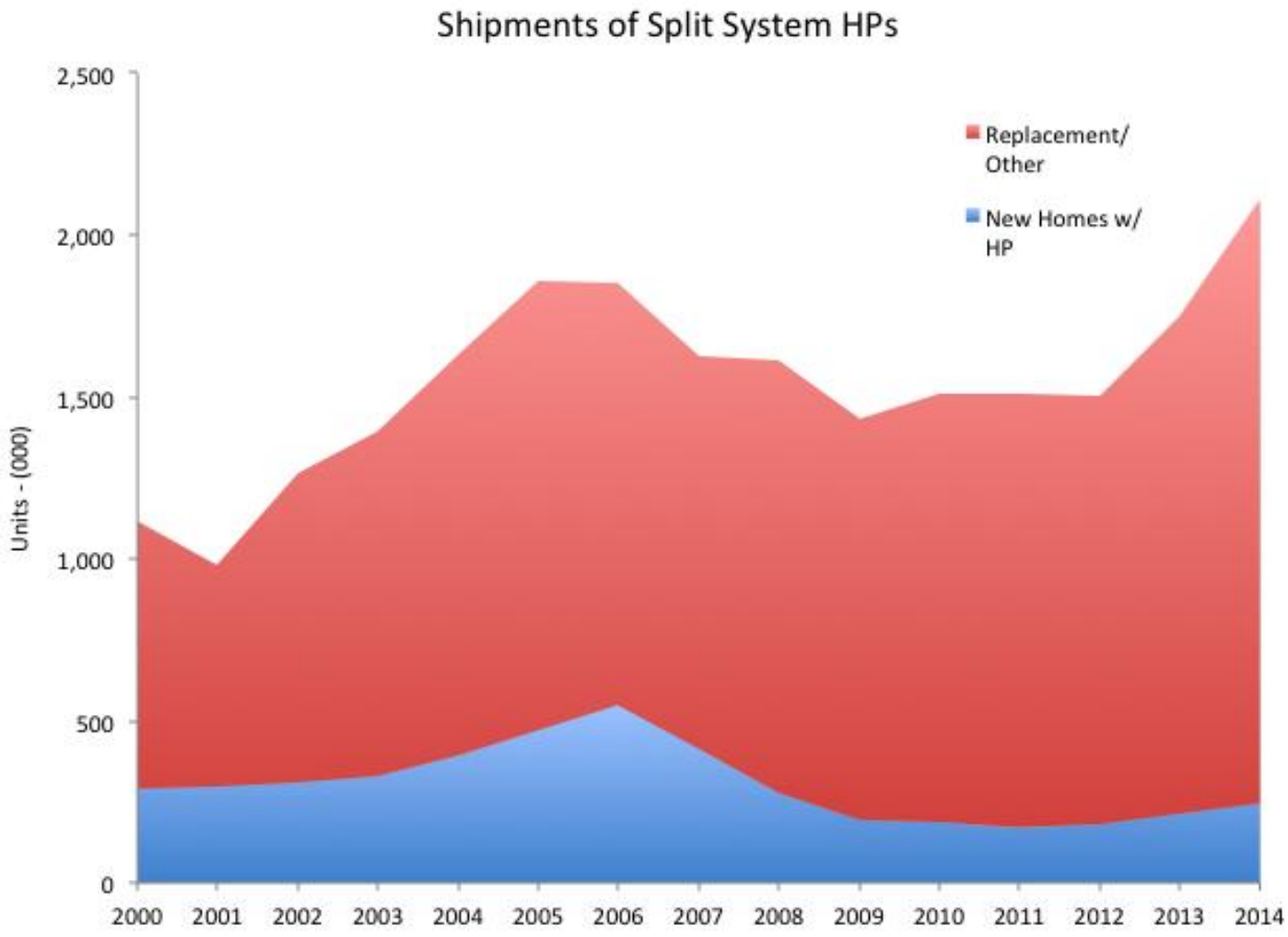
Overview

- Historical market for VCHP Equipment
- How is performance represented now relative to VCHP equipment & how is it achieved?
- What information about performance is available in the market now (such as from manufacturers) that goes beyond the performance information reported according to the applicable DOE test procedure, and what means are currently available to leverage that information?

Current status of market for VCHP Equipment

- In 2015, nearly 20% of the split system HP's sold were over 17 SEER
- In 2009, 17 SEER units accounted for less than 4% of split system HPs sold
- In 2005, 0% of the market was over 17 SEER

Shipments Mostly for Replacement - HPs



Source: AHRI, US Census Characteristics of New Homes Completed

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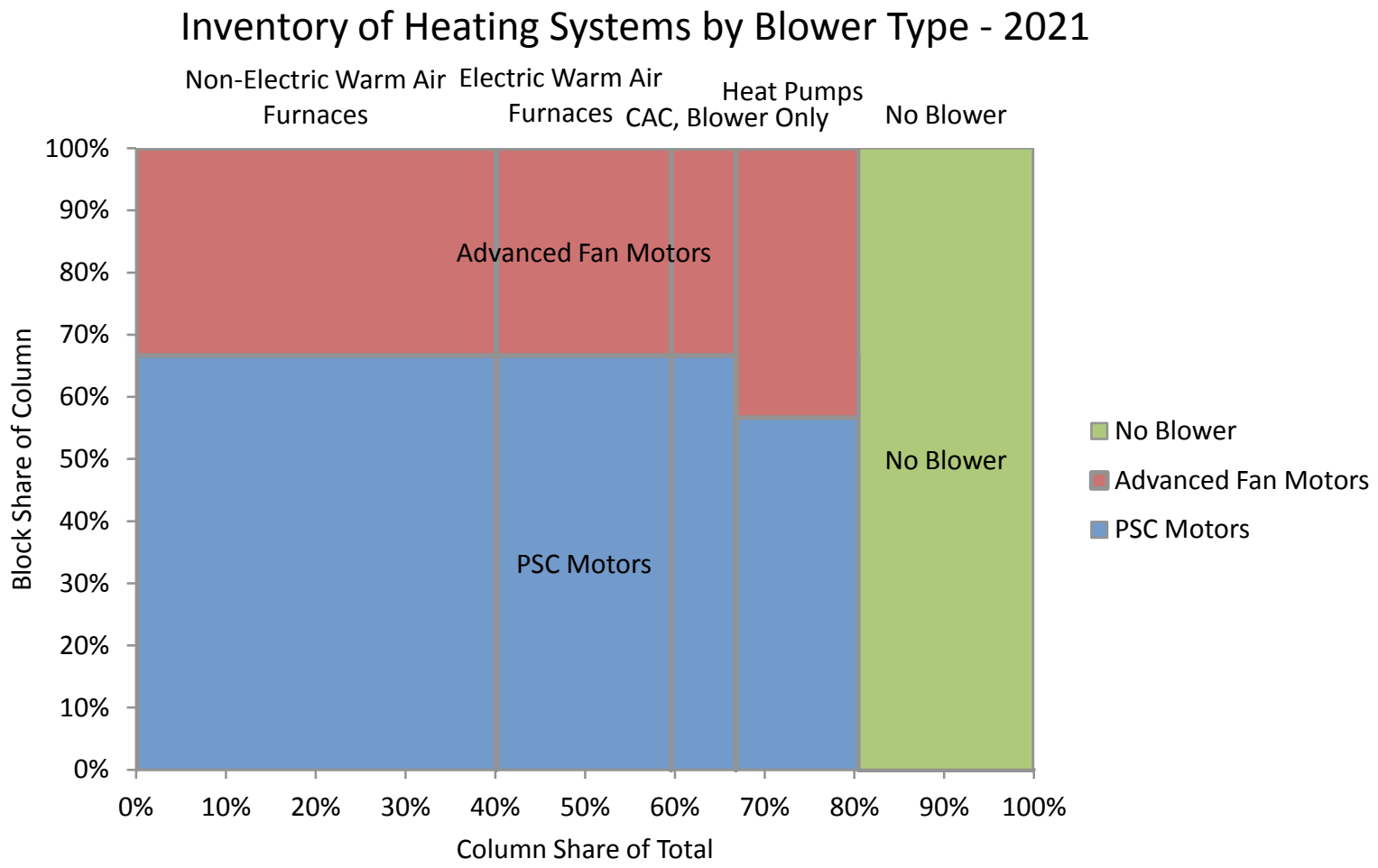
Housing Inventory Mostly PSC Blower Motors



Source: RECS 2009 Inventory Data and Shorey Shipment Projection. Total is 110 million houses in 2009

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How is performance represented now relative to VCHP equipment?

- **Heating Seasonal Performance Factor (HSPF): Rating procedure for residential heat pumps is defined in ANSI/AHRI 210/240-2008**
  - Total space heating required during the space heating season, in Btu's, divided by the total electrical energy consumed by the heat pump system during the same season, in watt-hours.
  - Procedure defines minimum and maximum **heating load lines** and temperature bin data for DOE climate regions I through VI
  - Provides a means for predicting heating performance for a range of climates and house envelope performance levels
  - Publication of data for DOE Region IV using the minimum design heating requirement (DHR_{min}) load line
- **Additional calculations for two-capacity and variable speed compressors**
  - Accounts for operation at multiple speeds to accommodate changes in building load

Heating Load Line

- **Given that the HSPF rating for residential heat pumps is based on the minimum load line, does the rated HSPF overestimate actual heating season performance?**
  - Current HLL: 65°F intercept & 0.77 heating load correction factor, C
- **The equation for the minimum load line in Region IV can be written as**

$$\text{Minimum Heating Load } (T_j) = Q_h(47) * 0.77 * (65\text{-}T_j)/60 \text{ ,}$$

where $Q_h(47) = DHR_{min}$ in DOE Region IV and T_j is the bin ambient temperature.

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Proposed Heating Load Line

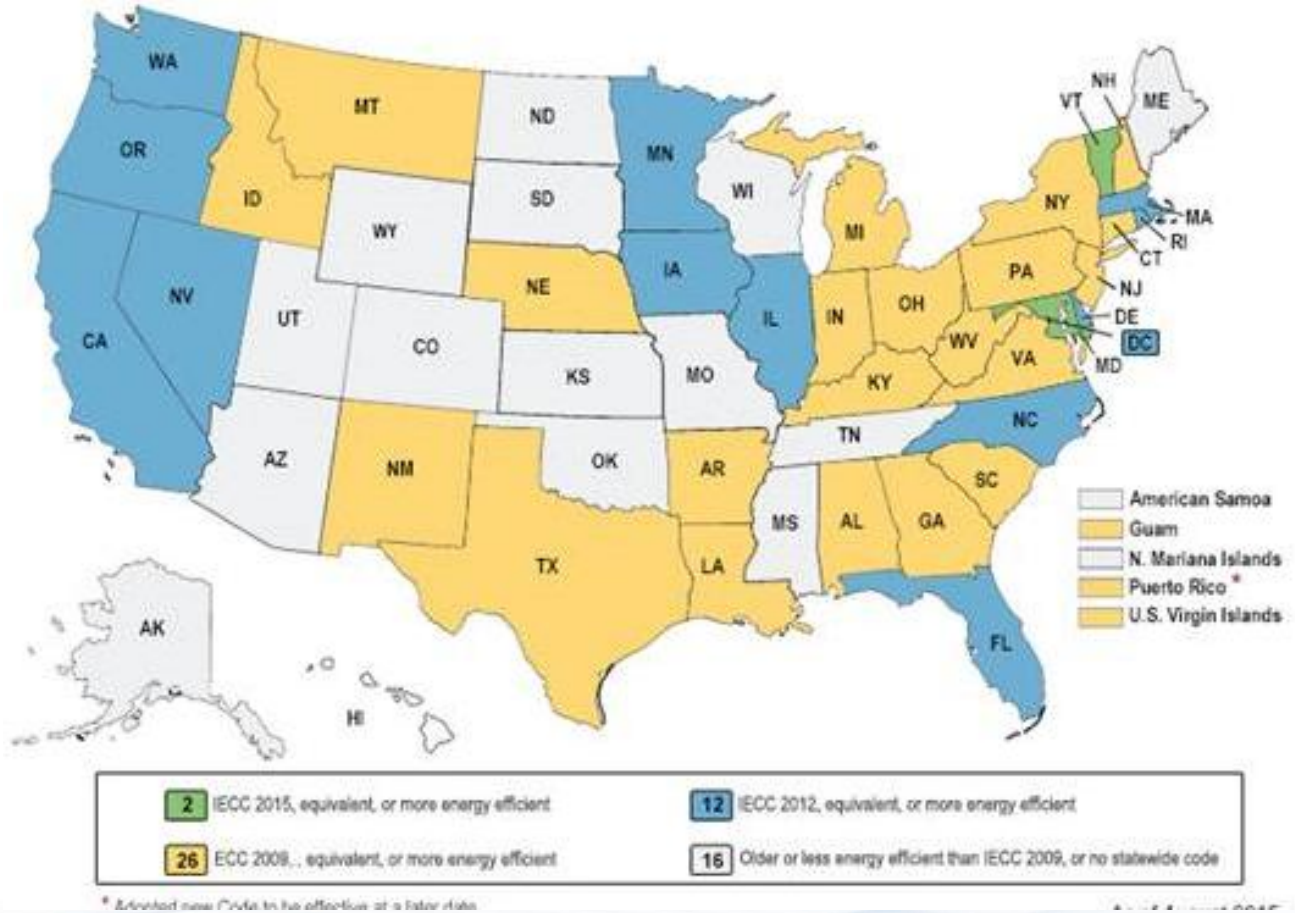
- **Energy Plus building energy simulation, conducted analysis of Region IV HSPF**
  - Baltimore,
  - Salt Lake City, and
  - Indianapolis
- **Noted drops of 10% (cooling load) and 30% (heating load) going from the IECC 2006 code to IECC 2012**
  - Due to the improved insulation, lower leakage, and better ducts, etc

$$\text{Heating Load } (T_j) = Q_c(95) * 1.3 * (55 - T_j)/50 ,$$

  - where T_j is the bin midpoint temperature rounded down to an integer, starting at 52°F and decreasing in 5°F increments, and $Q_c(95)$ is the rated cooling capacity of the heat pump at 95°F ambient.

Proposed Heating Load Line

- **IECC Code adoption map as of August 2015**



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Data Comparison for Current Heating Load Line Requirements Vs. Proposed Heating Load Line

- **New heating load line significantly decreases HSPF ratings**
- **Recommendation for impact percentage to be used in analysis**
  - Single and two-stage product, HSPF reduced by 17.1%
  - **Variable speed products, HSPF reduced by 25.0%**

	AHRI Type	Motor Type	Number of Data Points	% HSPF Change	
				Range (%)	Average % HSPF Change
HP	Single Stage	PSC	1	17.8 - 17.8	17.8
		Constant Torque or X13	16	10.3 - 21.7	17.3
		Constant CFM or ECM	4	14.8 - 19.1	16.9
	Two Stage	Constant CFM or ECM	7	11.1 - 21.1	16.6
	Variable Stage	Constant Torque or X13	1	21.6 - 21.6	21.6
		Constant CFM or ECM	9	20.8 - 27.6	25.4

Proposed Heating Load Line

- **AHRI recommends 1.02 as the heating load line**
  - Maintains differentiation between single stage, two stage and variable speed products
  - Do not expect HLL to change for significant time period, 1.02 will continue to be appropriate

Performance Questions

- **Are there shortcomings, and if so, how does the market currently try to overcome those?**
- **What risks does this create in the market?**
  - Customer satisfaction risk
  - Energy Savings risk
  - Others?
- **What would be ideal to represent through AHRI (from the trade association's standpoint) and what would it take to do that?**
  - Standards
  - Test labs
  - Costs

Performance Questions

- **What information about performance is available in the market now (such as from manufacturers) that goes beyond the performance information reported according to the applicable DOE test procedure, and what means are currently available to leverage that information?**
  - Are there standardization challenges presented by this information?
  - Can consumers and others easily compare Apples with Apples?

Data Comparison for Current vs. Proposed Default Watts

- **The new default watts decreases SEER, EER & HSPF ratings**
- **Impact for cooling based on calculations**
  - SEER decreases by 4.2% based on 400 CFM/ton and 0.1 C_D (for 13 SEER base product)
  - SEER decreases by 4.4% based on 400 CFM/ton and 0.1 C_D (for 14 SEER base product)
  - EER decreases by 4%
- **Impact for heating based on member data**
  - HSPF decreases by 2.3% using 17 data points
- **Impact of default watts will increase with increasing efficiency**

Data Comparison for Current Static Requirements vs. Proposed Increase in Static

- **Increasing Static pressure decreases SEER, EER & HSPF ratings**
- **Recommendation for impact percentage to be used in analysis**
  - Reduce SEER by 7%, based on analysis of 98 data points
  - Reduce EER by 6%, based on analysis of 89 data points

	AHRI Type	Motor Type	Number of Data Points	% SEER Change		% EER Change	
				Range (%)	Average % SEER Change	Range (%)	Average % EER Change
AC	Single Stage	PSC	4	1.8 - 5.7	4.5	1.3 - 4.8	2.9
		Constant Torque or X13	30 [1]	1.7 - 11.5	5.5	1.2 - 9.8	4.1
		Constant CFM or ECM	28	1.8 - 12.3	6	1.8 - 9.0	4.7
	Two Stage	Constant Torque or X13	4	2.9 - 7.6	5.4	2.1 - 8.4	5.1
		Constant CFM or ECM	2	5.0 - 5.1	5.1	5.1 - 5.6	5.3
	Variable Stage	Constant CFM	2	4.5 - 12.9	8.7	7.7 - 8.8	8.2

Notes:

1. For % EER Change, Number of Data Points = 26

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Data Comparison for Current Static Requirements vs. Proposed Increase in Static *(continued)*

- **Recommendation for impact percentage to be used in analysis**
  - Reduce HSPF by 4.5%, based on analysis of 27 data points

	AHRI Type	Motor Type	Number of Data Points	% SEER Change		% EER Change		% HSPF Change	
				Range (%)	Average % SEER Change	Range (%)	Average % EER Change	Range (%)	Average % HSPF Change
HP	Single Stage	PSC	1	5.4 - 5.4	5.4	5.0 - 5.0	5	1.5 - 1.5	1.5
		Constant Torque or X13	17 [2]	2.3 - 9.5	5.6	1.6 - 7.6	4.1	1.5 - 19.7	4.6
		Constant CFM or ECM	4	4.1 - 7.6	5.7	3.7 - 6.9	5.3	2.5 - 4.2	3.2
	Two Stage	Constant Torque or X13	1	7.8 - 7.8	7.8	6.4 - 6.4	6.4	6.1 - 6.1	6.1
		Constant CFM or ECM	5 [3]	2.6 - 6.5	4.2	2.9 - 5.8	4.6	1.7 - 3.5	2.4

Notes:

2. For % EER Change, Number of Data Points = 12
3. For % HSPF Change, Number of Data Points = 4

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Questions?

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