Commercial HVAC Data Collection

Data Analysis Findings

February 23, 2022

Agenda

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1. TO32 Data Collection Background & Recap
2. Review Analysis Findings
   - Stage 1 Findings
   - Stage 2 Findings
3. Next Steps to Consider

TO32 Data Collection Background / Recap

Commercial HVAC Work: 3 Years In Review

2019	Cadeo Team conducted TO26 Pilot study into the plausibility of gathering commercial HVAC market data via building permits	
2020	Early 2020	Permit vs Installed Investigation
	Mid 2020	Team defines technology scope (principal HVAC systems)
	Late 2020	SBW defined the building sample frame for permit collection
2021	Early 2021	Permit data collection begins
	Late 2021	Team concludes data collection, delivers database to BPA
2022	Early 2022	Final data set, lessons learned memo, and analysis

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Permit vs Installed Comparison

1a. Permit vs Installed Investigation: Are permits a good source of data for representing NW commercial HVAC activity?

The results indicate permits are a good source of data for BPA to characterize the commercial new construction market.

ALL SIGNS POINT TO YES!

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What technologies are we considering?

Equipment	Regional Interest[1]	Magnitude of market change[2]	Seventh Plan Measure?	2021 Plan Measure?	Technology Categorization
1. VRF	High	High	Yes	Yes	Principal
2. DHP	High	High	Yes	Yes	Principal
3. Ducted Systems	High	Medium	No	Yes	Added to Principal after Stage 1
4. Heat Recovery	High	High	No	Yes	Collected for Principal systems only
5. WSHP	Medium	High	No	No	Ancillary
6. Chillers	Medium	Low	No	Yes	Ancillary
7. Packaged Systems	Medium	Low	No	Yes	Ancillary

[1]Qualitative Judgment, [2]Based on Pilot Study

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Determining Our Sample Frame

Final commercial HVAC data collection sample scope

Parameter	Requirement
Building Types	Commercial buildings (after data cleaning) Multifamily buildings with five or more units and four or more floors, **if central system**
Analysis Period	Operational between January 1, 2016 and December 31, 2021
Geography	Installed in Idaho, Oregon, Washington, or Montana counties served by BPA

Determining Our Sample Frame

	Exclusion Step	% of Projects (N)	% of Improved Value
Out of Scope Projects	Start dates outside of 2015 - 2019	22%	21%
	Excluded Building Types	14%	15%
	Eastern Montana Counties	1%	1%
	Multi-Family <4 units, <4 stories, or no central HVAC	7%	5%
Projects that lower out of scope risk	< $200,000 Improved Value	15%	0.4%
	< $1 Million Improved Value, Alterations/Renovations	16%	2%
	Alterations/Renovations without HVAC Permits	0.3%	0.3%
Sample Frame: 6,810 Projects $66 Billion of Improved Value		**26%**	**55%**

All Dodge Projects 26,473 Projects $120 Billion

Commercial HVAC Analysis Findings

Data Collection Goals

1. Use a representative sample of building permit drawings to **identify trends** in Commercial HVAC

2. Determine performance metrics necessary to inform a **future regional commercial HVAC momentum savings model**

CBSA Comparisons

	BPA Permit Data Collection	Commercial Building Stock Assessment
Sample Population	Regional commercial square footage **newly constructed or improved** during 2016-2021 period.	Regional **stock** commercial square footage

- Comparisons to CBSA data are valuable, but this data is not the same as CBSA evaluation of regional stock
- Goal is to look for **trends in new construction** to identify how the market is changing.

Stage 1 Findings

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Gather & Review Commercial Permits

- Confirm building data to validate representative sample

- Collect high-level HVAC system data to identify trends in Commercial HVAC

Construction work occurring in Office, Schools, and MF-Res

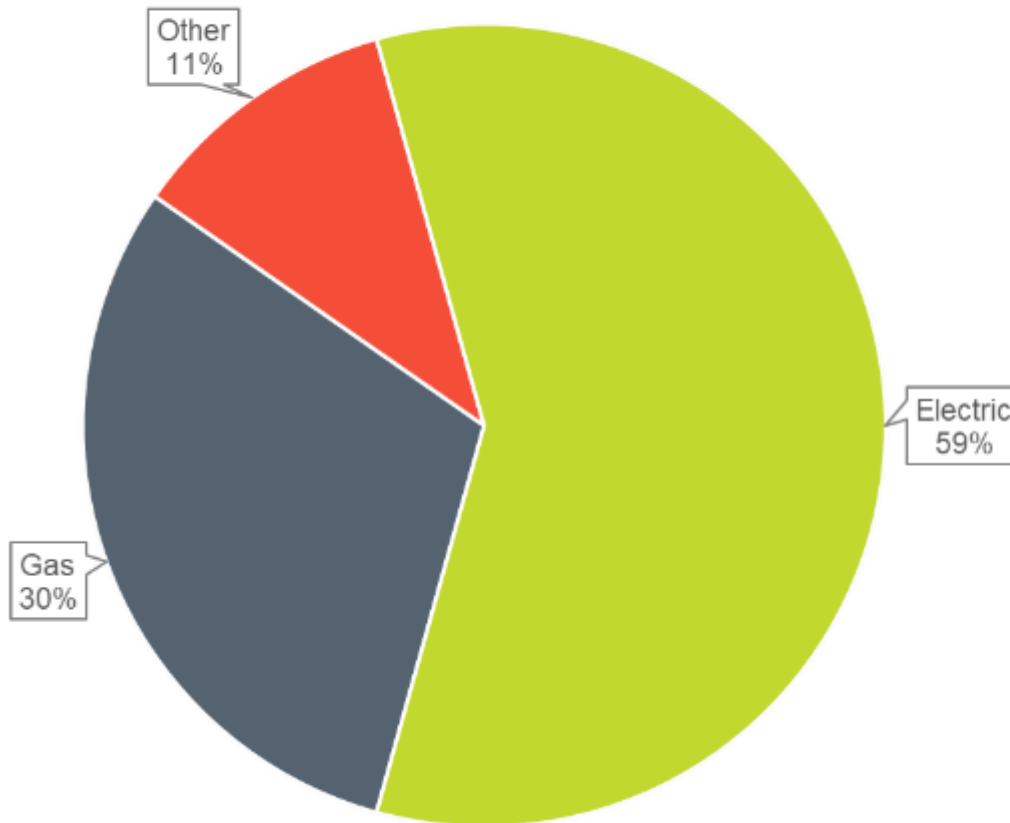Estimated Improved Regional Square Footage by Building Type (2016-2021)

School (University) 4%

School (K12) 23%

Retail 5%

Restaurant 1%

Residential Care 3%

Other 1%

Office 21%

Assembly 5%

Hospital 2%

Lodging 7%

Multi-Family Residential 28%
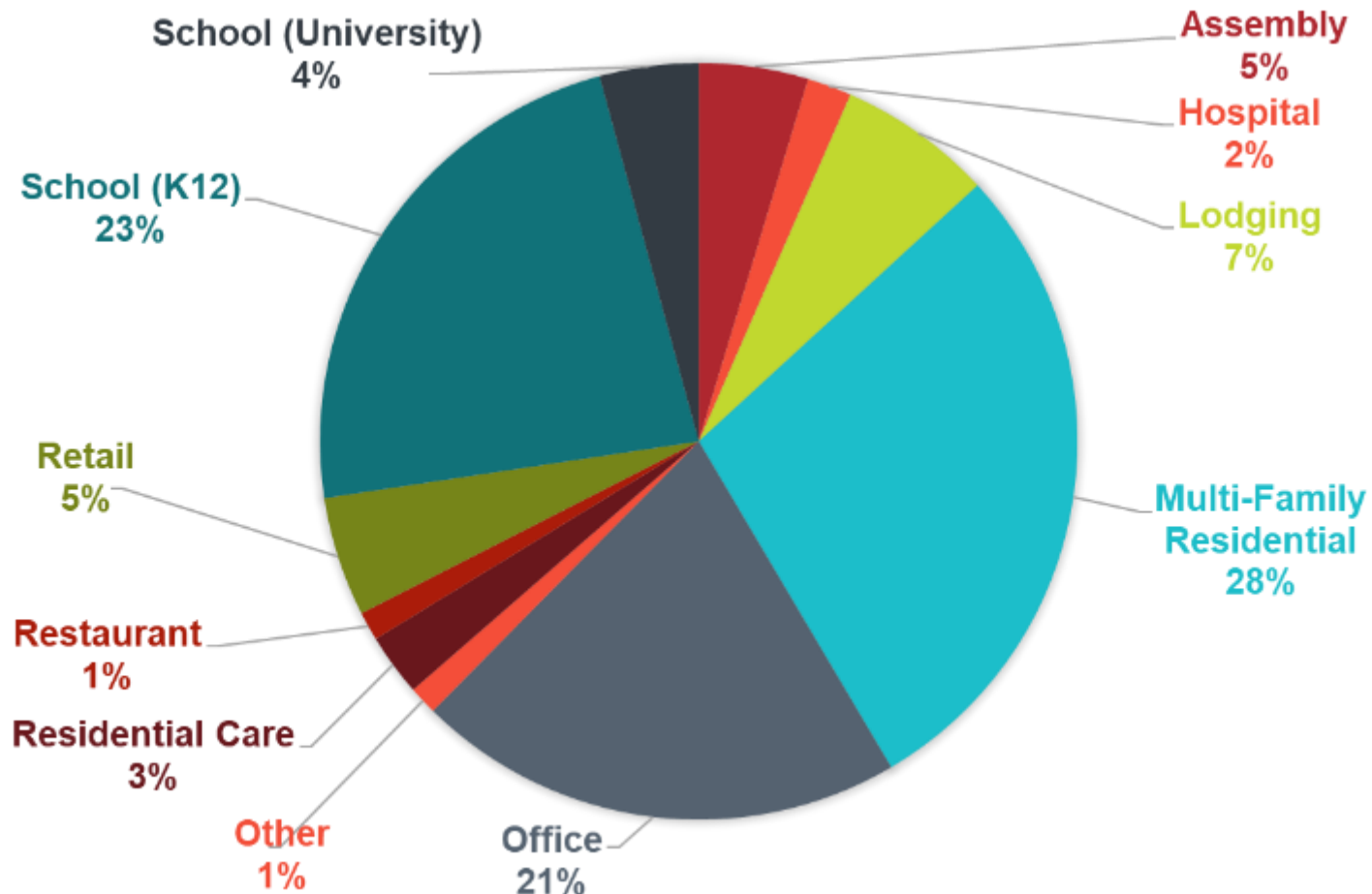
Multi-family new construction dominates, schools are getting renovated

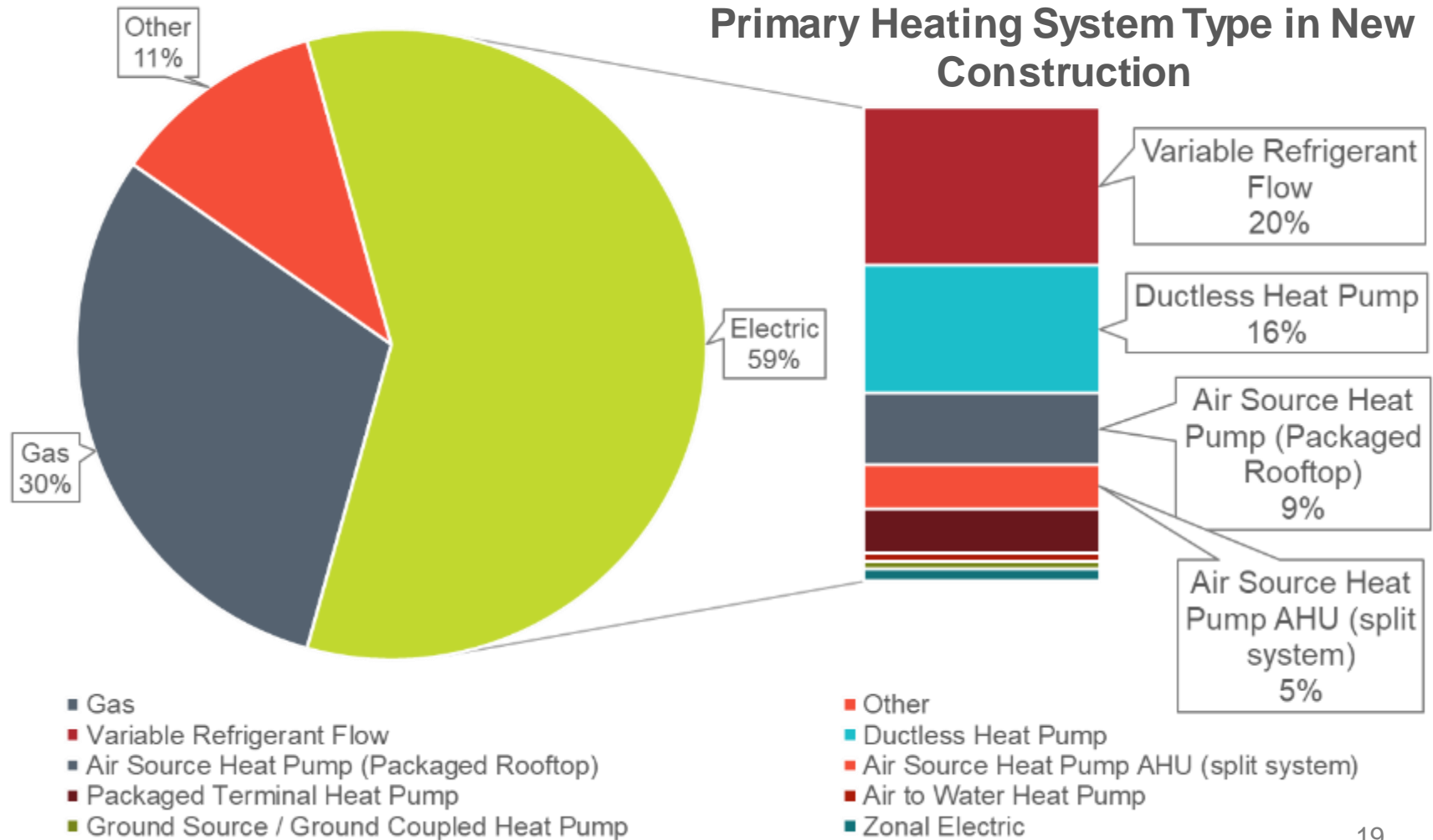Percent square footage by building type: All permitted activity vs New Construction only

■ % of Regional SF (All Permit Activity) ■ %e of Regional SF (NC Only)
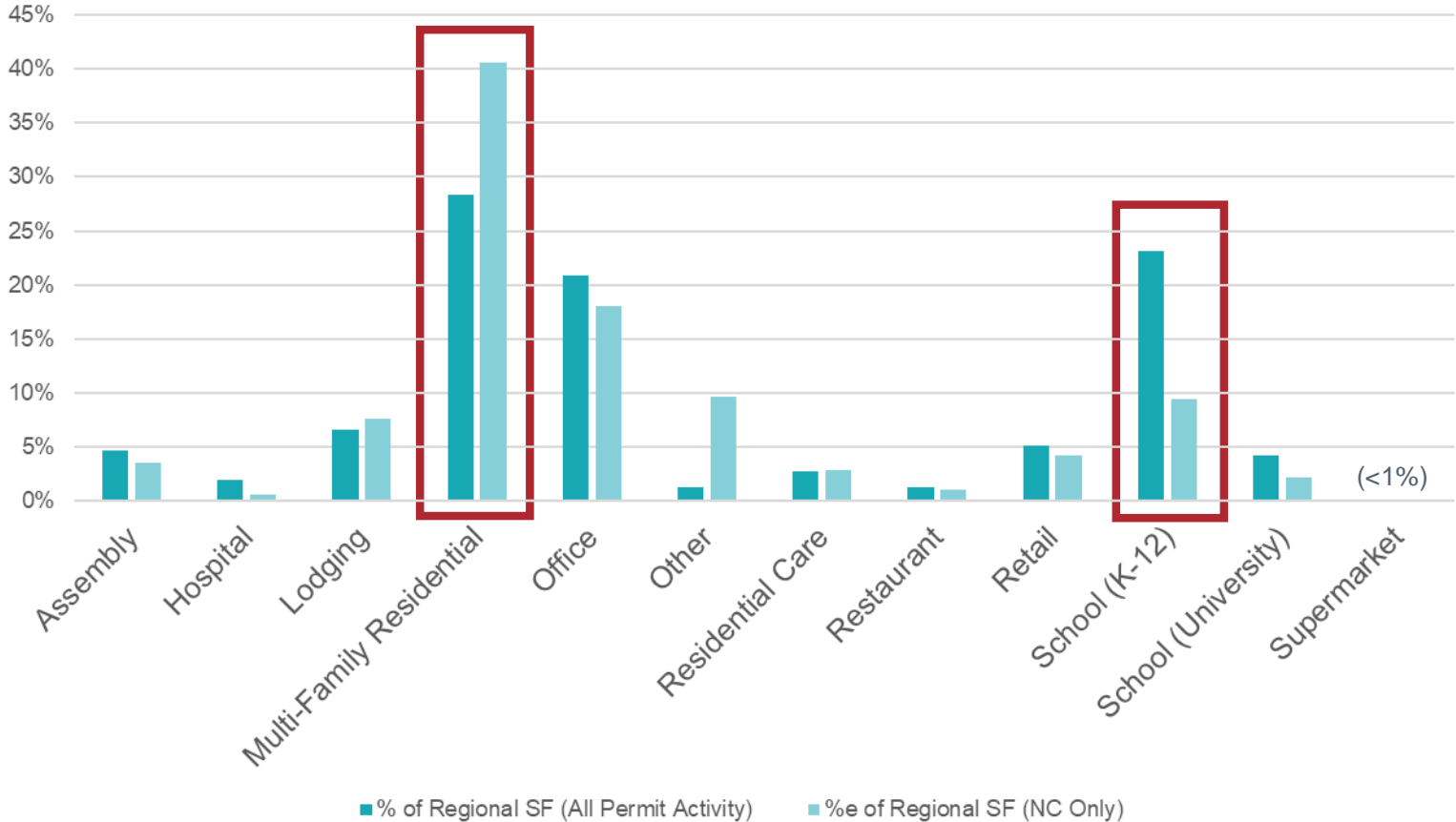
Majority of New Construction Uses Electric Heating Sources

Primary Heating Fuel Type in New Construction

Other 11%

Gas 30%

Electric 59%

Sample Data Indicates a Lot of Heat Pumps are Being Installed!

Primary Heating System Type in New Construction

Other 11%

Gas 30%

Electric 59%

Variable Refrigerant Flow 20%

Ductless Heat Pump 16%

Air Source Heat Pump (Packaged Rooftop) 9%

Air Source Heat Pump AHU (split system) 5%

- Gas
- Variable Refrigerant Flow
- Air Source Heat Pump (Packaged Rooftop)
- Packaged Terminal Heat Pump
- Ground Source / Ground Coupled Heat Pump

- Other
- Ductless Heat Pump
- Air Source Heat Pump AHU (split system)
- Air to Water Heat Pump
- Zonal Electric

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Regional Cooling Systems still primarily air-cooled DX

Primary Cooling System Types

- None/Other 11%
- Heat Pumps 33%
- Direct Expansion 33%
- Chilled Water 23%
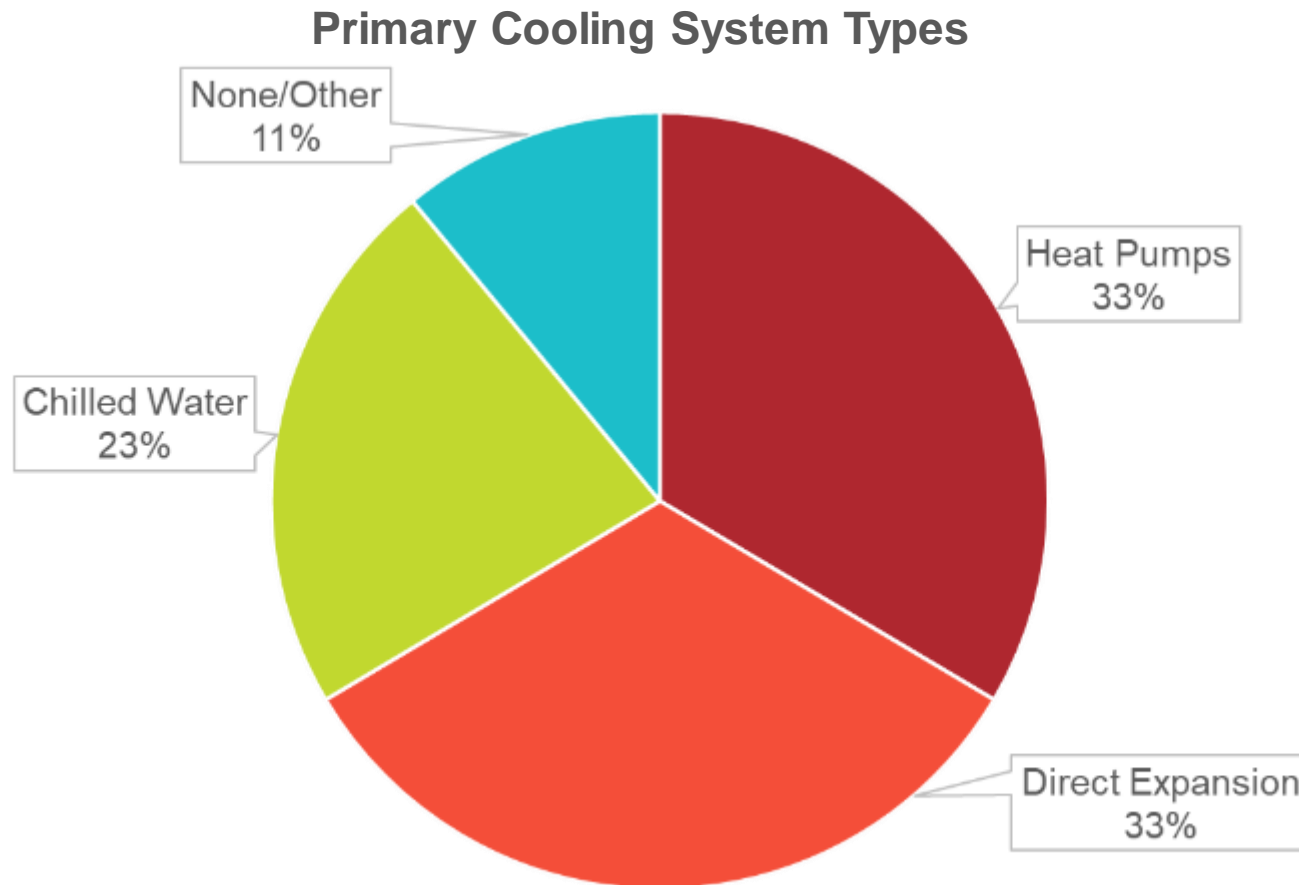
Not an obvious variation between CBSA (heavily DX) and our sample

ASHP, DHP & VRF increasing in NC. Gas RTUs more in renovation.

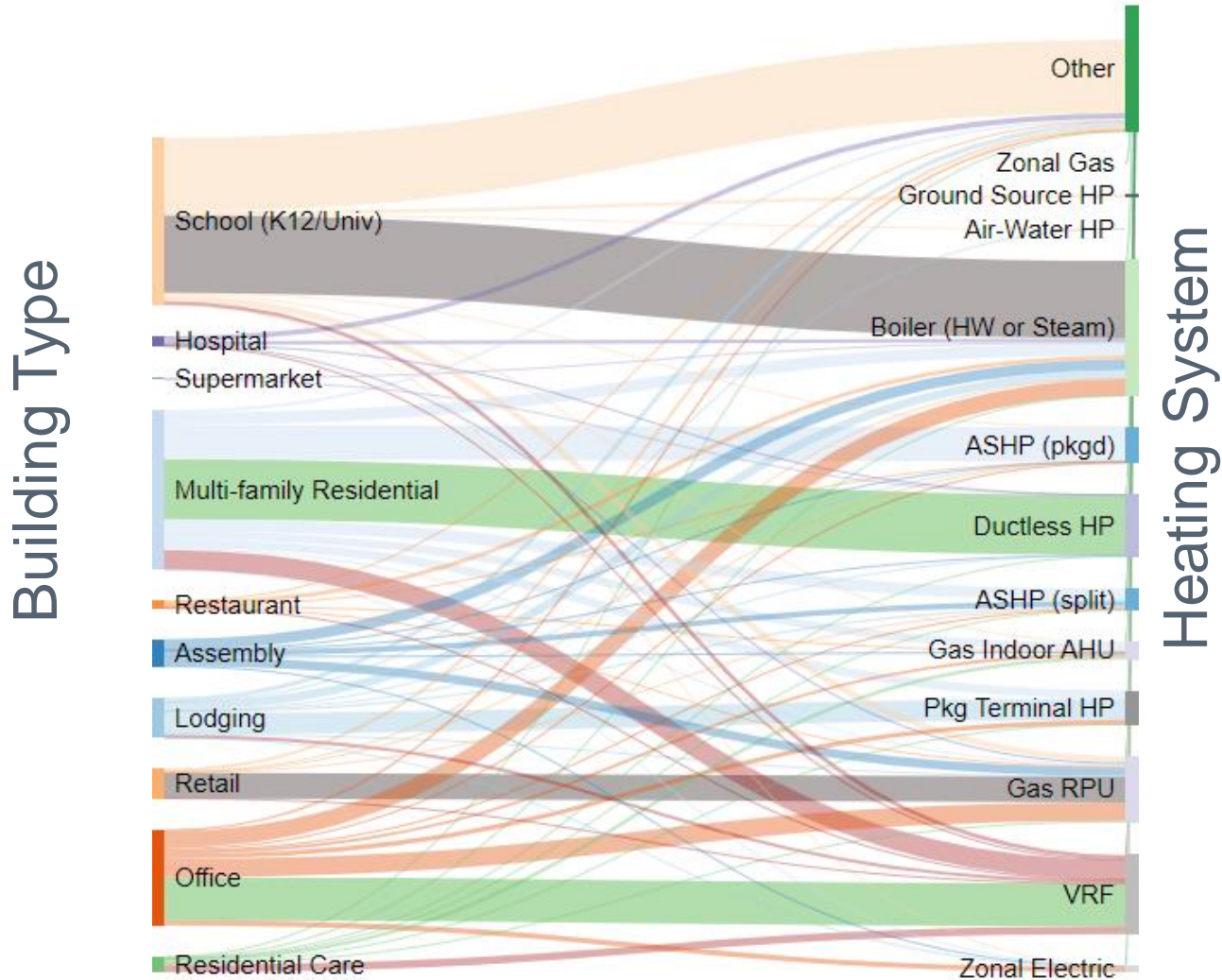Regional Square Footage by Heating System Type (NC vs Renovation)

Legend: ■ % of Regional SF by Heating Type (All Permits)   ■ % of Regional SF by heating type (NC)
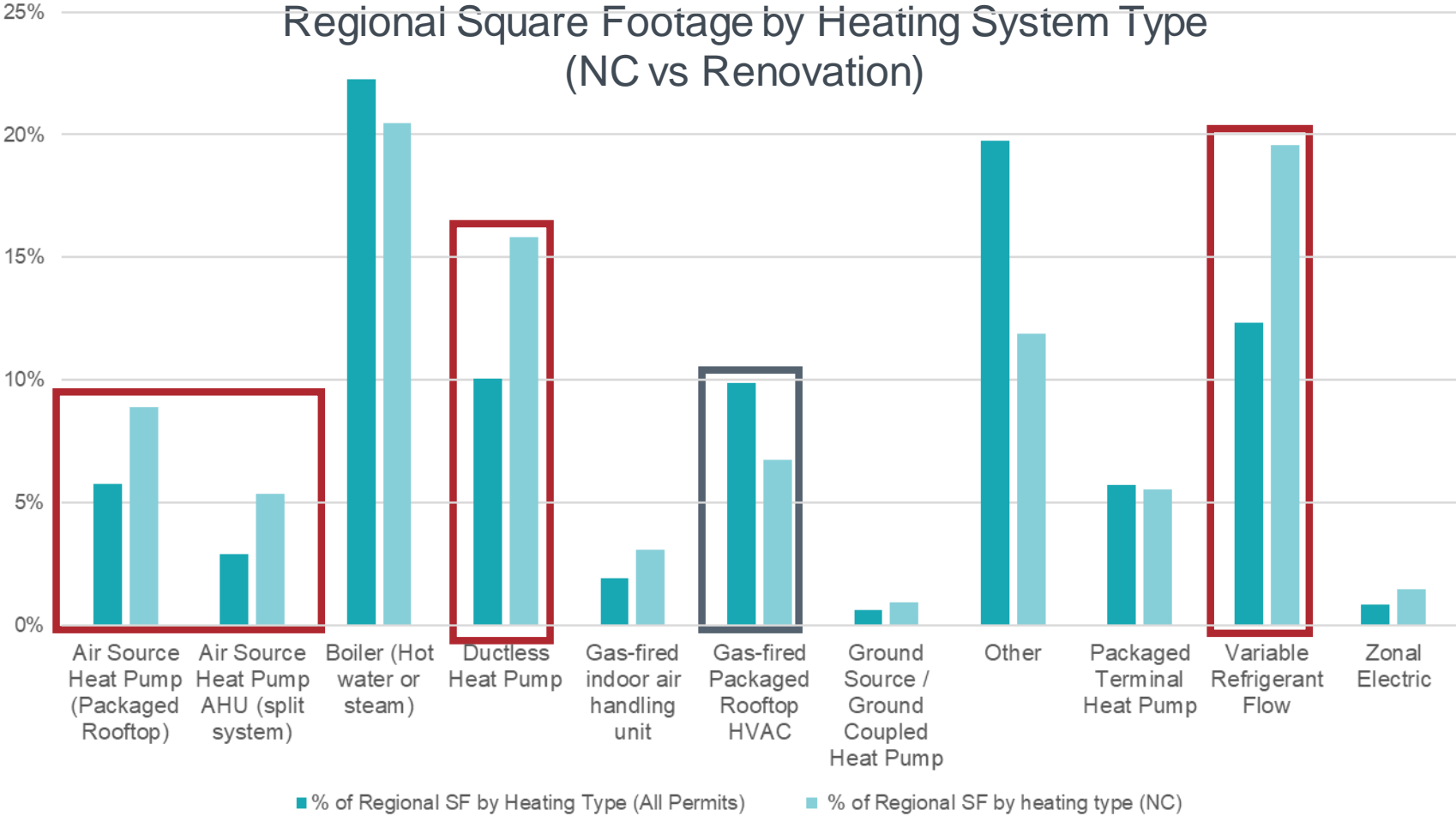
Regional Population Findings
HVAC System Types
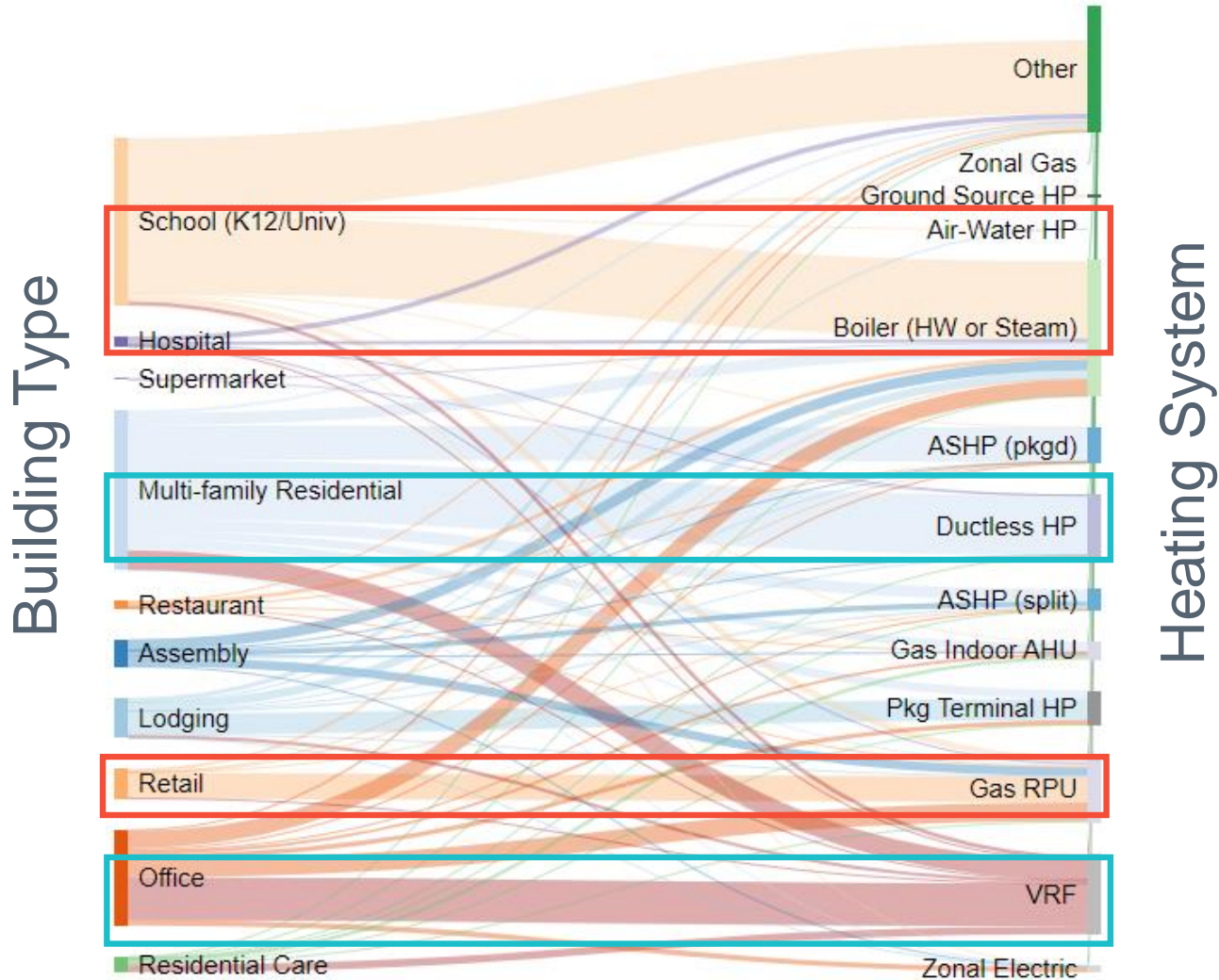
Regional Population Findings
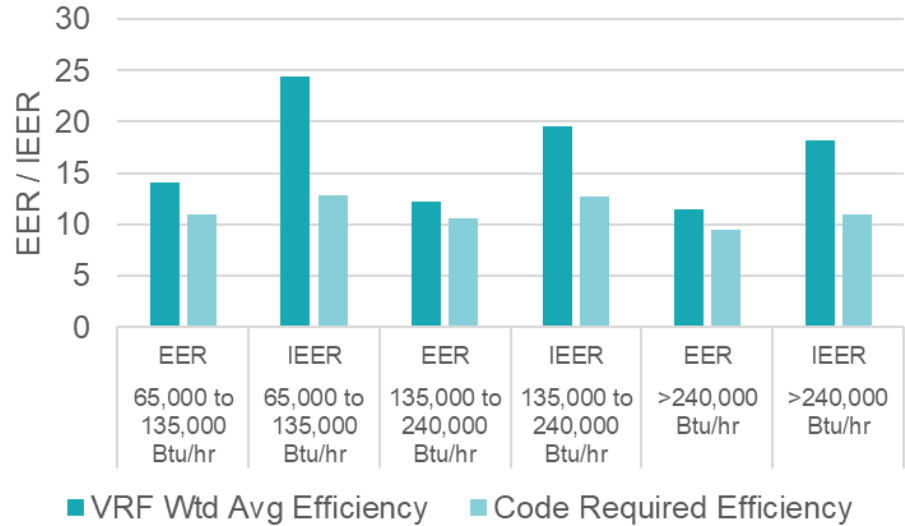## HVAC System Types

Stage 2 Findings

> **Stage 2 Review Recap**

- 169 of 300 projects (56%)
  - VRF
  - DHP
  - Ducted Cooling

- Collect detailed HVAC information

- Collect supplemental system information

VRF System Performance Exceeds Code Efficiency


VRF vs Code Required Heating Efficiency

Y-axis: COP (47), scale 0.0 to 4.0

Categories:
- COP(47) — 65,000 to 135,000 Btu/hr
- COP(47) — 135,000 to 240,000 Btu/hr
- COP(47) — >240,000 Btu/hr

Legend: ■ VRF Wtd Avg Efficiency ■ Code Required Efficiency
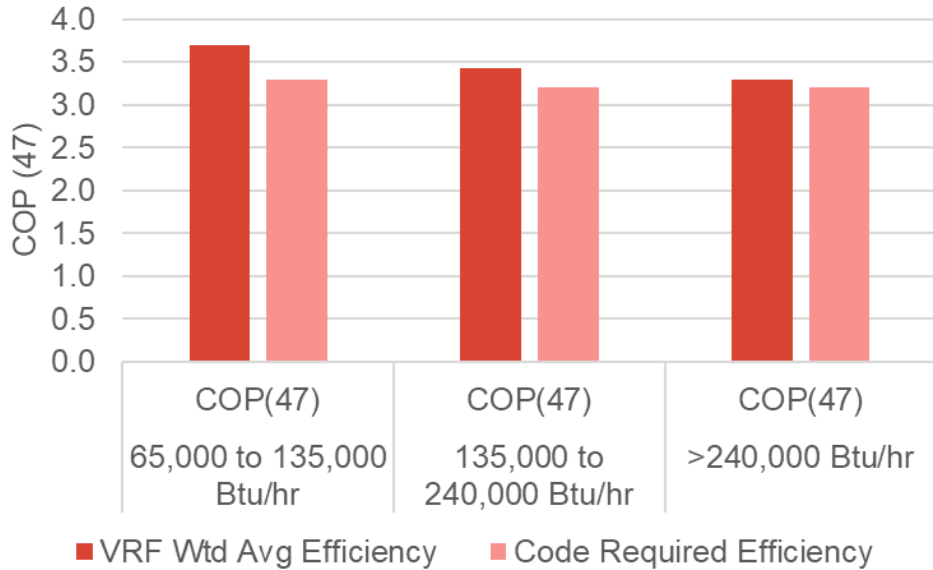
VRF vs Code Required Cooling Efficiency

Y-axis: EER / IEER, scale 0 to 30

Categories:
- EER — 65,000 to 135,000 Btu/hr
- IEER — 65,000 to 135,000 Btu/hr
- EER — 135,000 to 240,000 Btu/hr
- IEER — 135,000 to 240,000 Btu/hr
- EER — >240,000 Btu/hr
- IEER — >240,000 Btu/hr

Legend: ■ VRF Wtd Avg Efficiency ■ Code Required Efficiency

Code Referenced Efficiency represents Federal Standard minimum efficiency (increased in 2017)

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DHP System Performance Also Exceeds Code Efficiency

Code Referenced Efficiency represents Federal Standard minimum efficiency (increased in 2017)
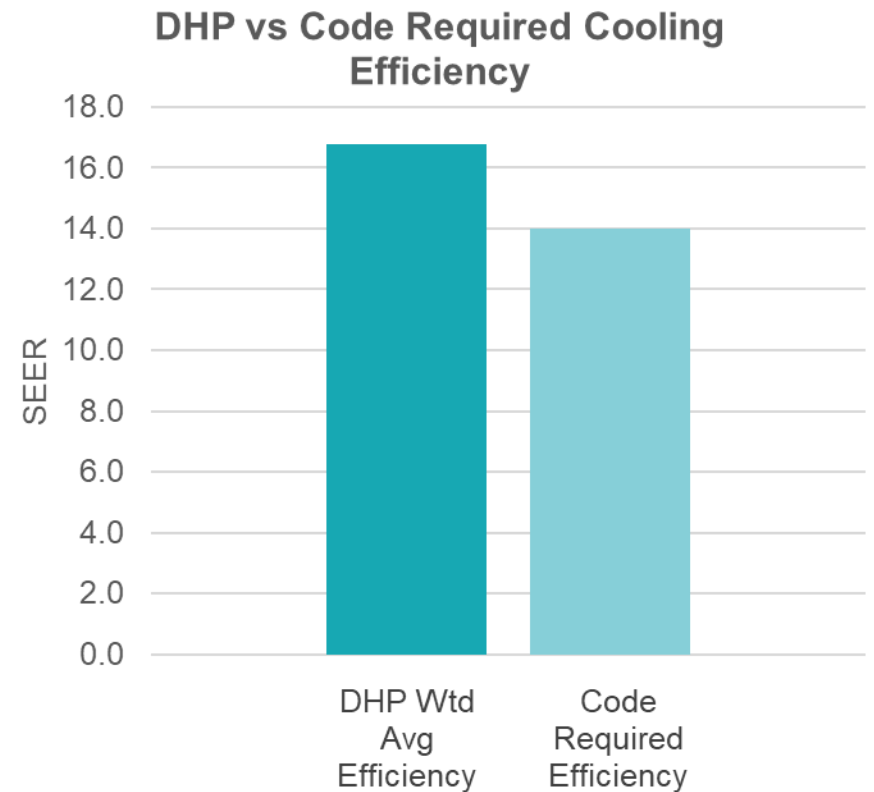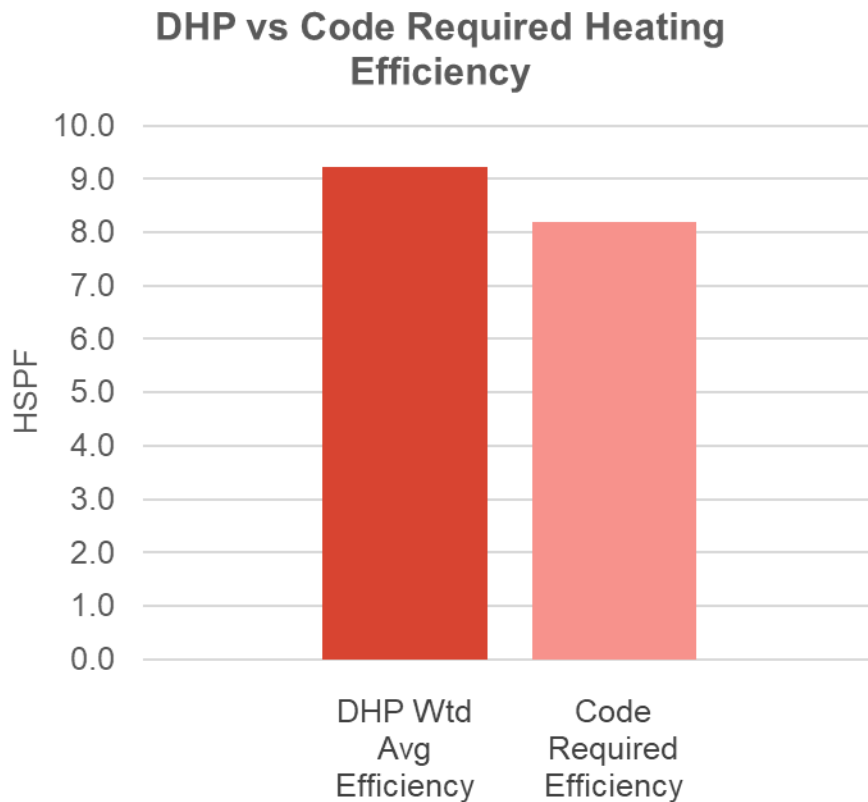
Ducted Cooling System Reminders

Elected to collect data on *ducted cooling* systems to learn more about the market

- Data collection for ducted cooling was uncertain at the project outset
- 2021 Plan includes high potential
- Wanted to get early trends for 2021 Plan
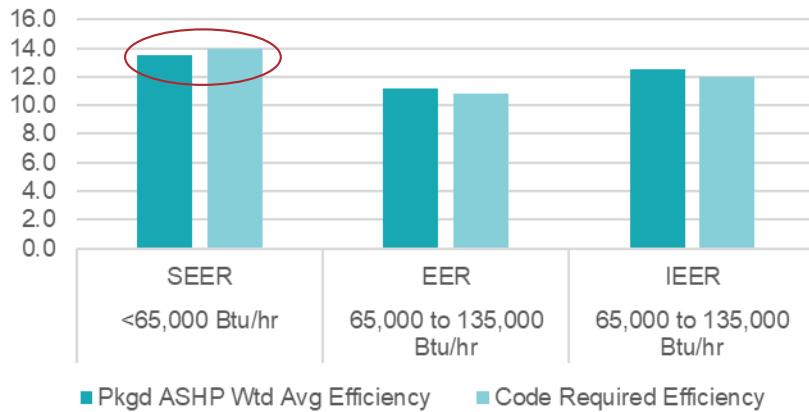
What do "ducted cooling systems" include?

Ducted heat pump systems (electric heating + cooling)

Electric (DX) Cooling units (gas or electric resistance heating)

Unitary AC (cooling only)

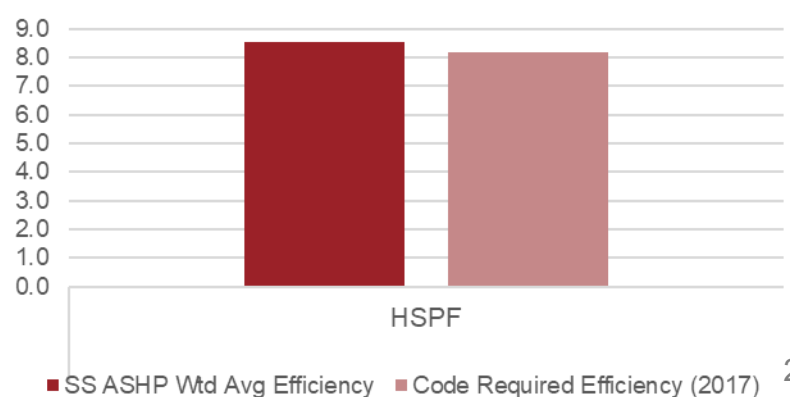# Ducted Heat Pump Performance Typically Follows Code

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DX Cooling System Performance Exceeds Code… with Caveats

Packaged DX Cooling Efficiency vs Code

Lots of above-code heat recovery happening!

Heat/Energy Recovery Systems (HRV/ERV)

Cataloged **110 HRV/ERV systems** (out of 334 total HVAC systems)

➔ HRV/ERV most prevalent in ductless system types
- VRF Projects (86%)
- DHP Projects (42%)

➔ Average effectiveness exceeds code by 15-20%
- Code required efficiency: 50% total effectiveness
- Regional average: **68% total effectiveness**

Recommendation: Include HRV/ERV savings with any modeled principal primary systems.

Questions & Discussion

Appendix

TO32 Regional Population Summary

Sample Frame Domain	Total Construction Value (000's)	Population (Number of Projects)	n (Final Sample)	Total Estimated Conditioned Square Footage	Relative Precision by Domain
East-Assembly	$ 1,166,645	242	17	2,943,604	2%
East-Hospital	$ 767,352	65	18	1,941,333	6%
East-Lodging	$ 1,180,046	127	14	4,187,149	1%
East-Multi-Family Residential	$ 1,114,280	161	12	6,582,584	14%
East-Office	$ 3,230,512	539	15	34,833,607	1%
East-Other	$ 381,714	102	13	2,424,052	10%
East-Residential Care	$ 243,677	41	8	1,796,719	3%
East-Restaurant	$ 121,068	132	15	702,041	25%
East-Retail	$ 537,032	242	17	5,274,569	24%
East-School (K-12)	$ 3,454,709	359	17	13,023,181	4%
East-School (University)	$ 1,182,379	122	13	3,986,772	2%
West-Assembly	$ 4,032,009	401	15	11,844,576	54%
West-Hospital	$ 1,855,652	91	21	4,057,781	3%
West-Lodging	$ 3,927,031	223	22	16,771,386	17%
West-Multi-Family Residential	$ 17,404,619	977	18	83,226,454	13%
West-Office	$ 9,388,982	1,113	29	31,281,466	1%
West-Other	$ 1,183,709	136	13	1,430,857	25%
West-Residential Care	$ 845,336	84	15	6,621,762	6%
West-Restaurant	$ 248,256	185	17	3,212,356	22%
West-Retail	$ 1,544,317	540	17	10,910,835	28%
West-School (K-12)	$ 9,566,691	690	17	60,429,386	3%
West-School (University)	$ 3,309,694	220	22	9,382,298	2%
Total	**$ 66,685,710**	**6,792**	**365**	**316,864,767**	

Regional Population Findings

Sampling was segmented geographically

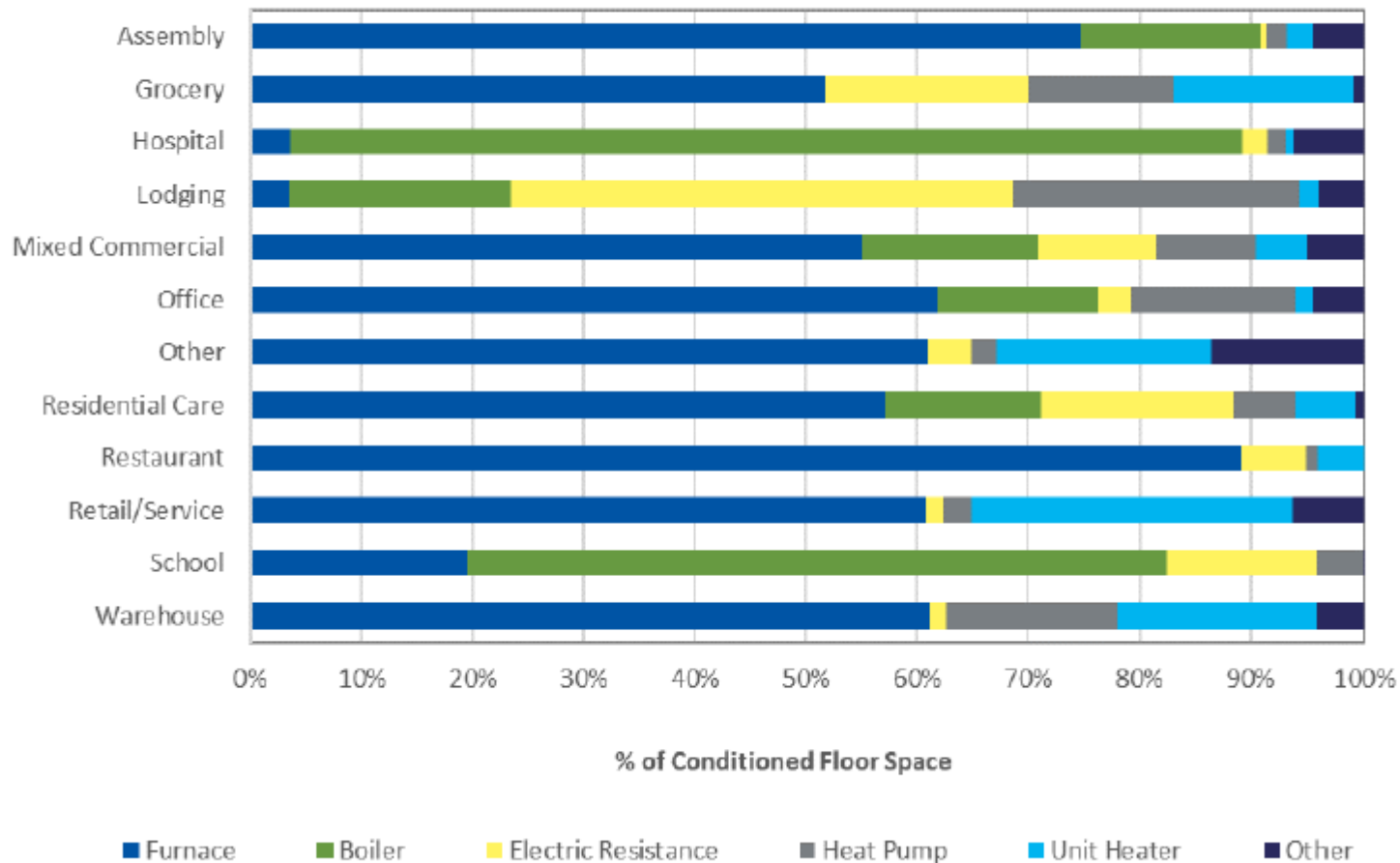% of Projects by State
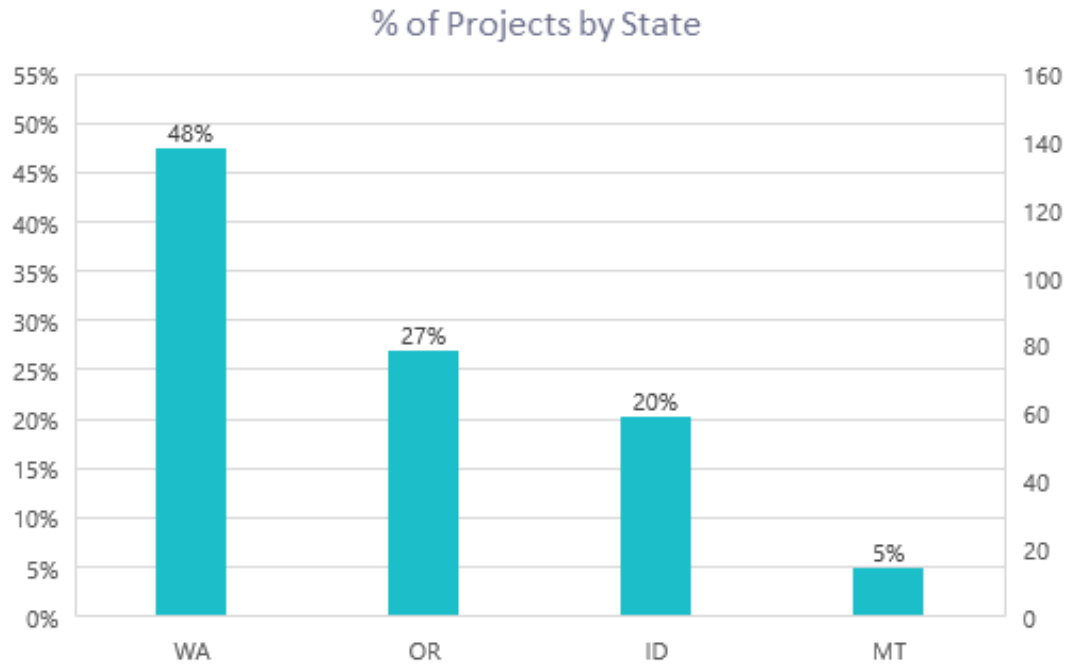
CBSA Heating Fuel Stock

Figure 15. Heated Floor Space by Predominant Heating Fuel
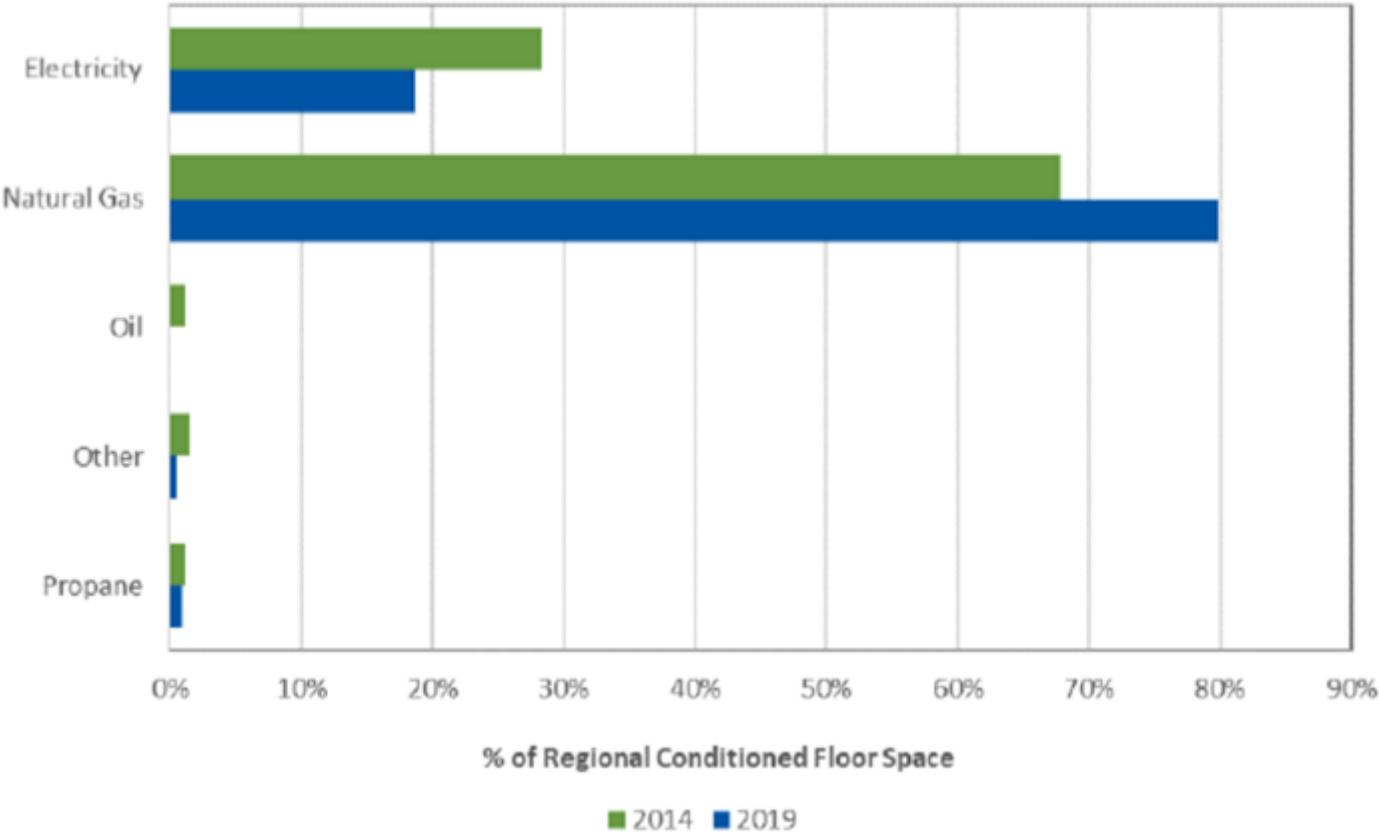
2019 CBSA Heating Systems

Figure 19. Primary Heating System by Building Type

% of Conditioned Floor Space

Legend: ■ Furnace ■ Boiler ■ Electric Resistance ■ Heat Pump ■ Unit Heater ■ Other

2019 CBSA Cooling Systems

Figure 21. Primary Cooling System by Building Type
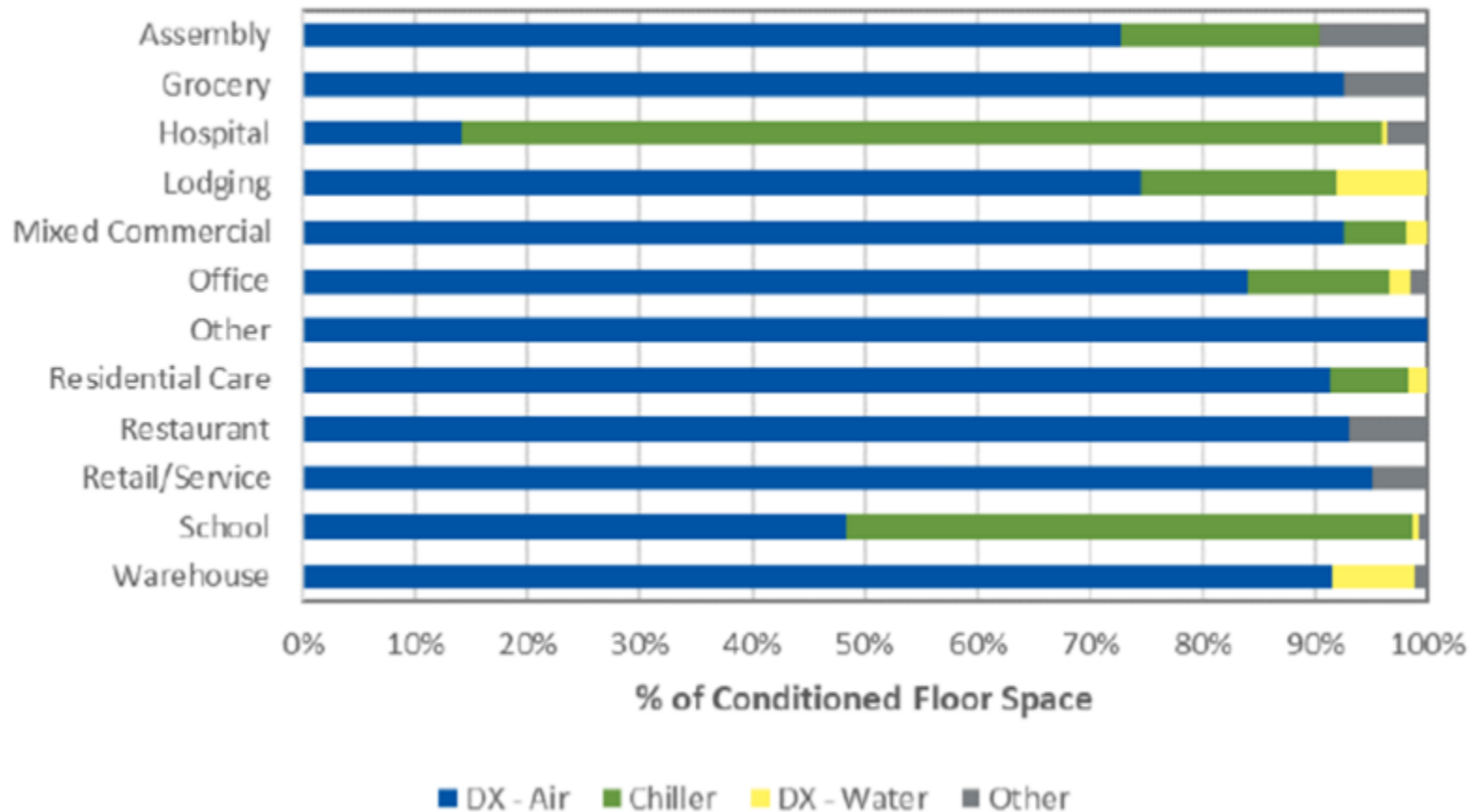
2019 CBSA Building Stock

Figure 6. Comparison of 2014 and 2019 Floor Area

Regional Floor Space
(Million Square Feet)

■ 2014 ■ 2019