Better Buildings Residential Network
Peer Exchange Call Series:
Comfort – The Biggest Driver of Residential Energy Efficiency?

February 13, 2020

Agenda and Ground Rules

- Agenda Review and Ground Rules
- Opening Poll
- Residential Network Overview and Upcoming Call Schedule
- Featured Speakers:
  - **Tom Turner,** Austin Energy
  - **Vance Payne**, National Institute of Standards and Technology (NIST)
  - **Kevin DeMaster**, Mitsubishi Electric Trane HVAC US
- Open Discussion
- Closing Poll and Announcements

Ground Rules:

1. **Sales of services and commercial messages are not appropriate** during Peer Exchange Calls.
2. Calls are a safe place for discussion; **please do not attribute information to individuals** on the call.

The views expressed by speakers are their own, and do not reflect those of the Dept. of Energy.

Better Buildings Residential Network

Join the Network

Member Benefits:

- Recognition in media and publications
- Speaking opportunities
- Updates on latest trends
- Voluntary member initiatives
- One-on-One brainstorming conversations

Commitment:

- Members only need to provide *one number*: their organization's number of residential energy upgrades per year, or equivalent.

Upcoming Calls (2nd & 4th Thursdays):

- Feb 27: Heat Pump Water Heaters – What You Need to Know Right Now
- Mar 12: The State of Gas Energy Efficiency Programs
- Mar 26: How Bad Installation Can Negate Good Equipment

Peer Exchange Call summaries are posted on the Better Buildings website a few weeks after the call

For more information or to join, for no cost, email bbresidentialnetwork@ee.doe.gov, or go to energy.gov/eere/bbrn & click Join

Tom Turner
Austin Energy

U.S. DEPARTMENT OF
ENERGY

AIRFLOW AND HUMIDITY CONTROL

KEYS TO COMFORT

AIRFLOW IS KEY TO:

- Refrigerant Charge
- Proper Distribution
- Acceptable Noise Levels
- Proper Filtration
- Efficient Operation

DUCTING AND ZONING

- Insure even air distribution by designing a space for air stratification off the evaporator and a rebound zone at the end of the plenum.
- Design to avoid airflow direction changes.
- Understand there will be a delta between takeoff on the side of a plenum and the top.
- Never zone single speed systems.

TRANSITIONS

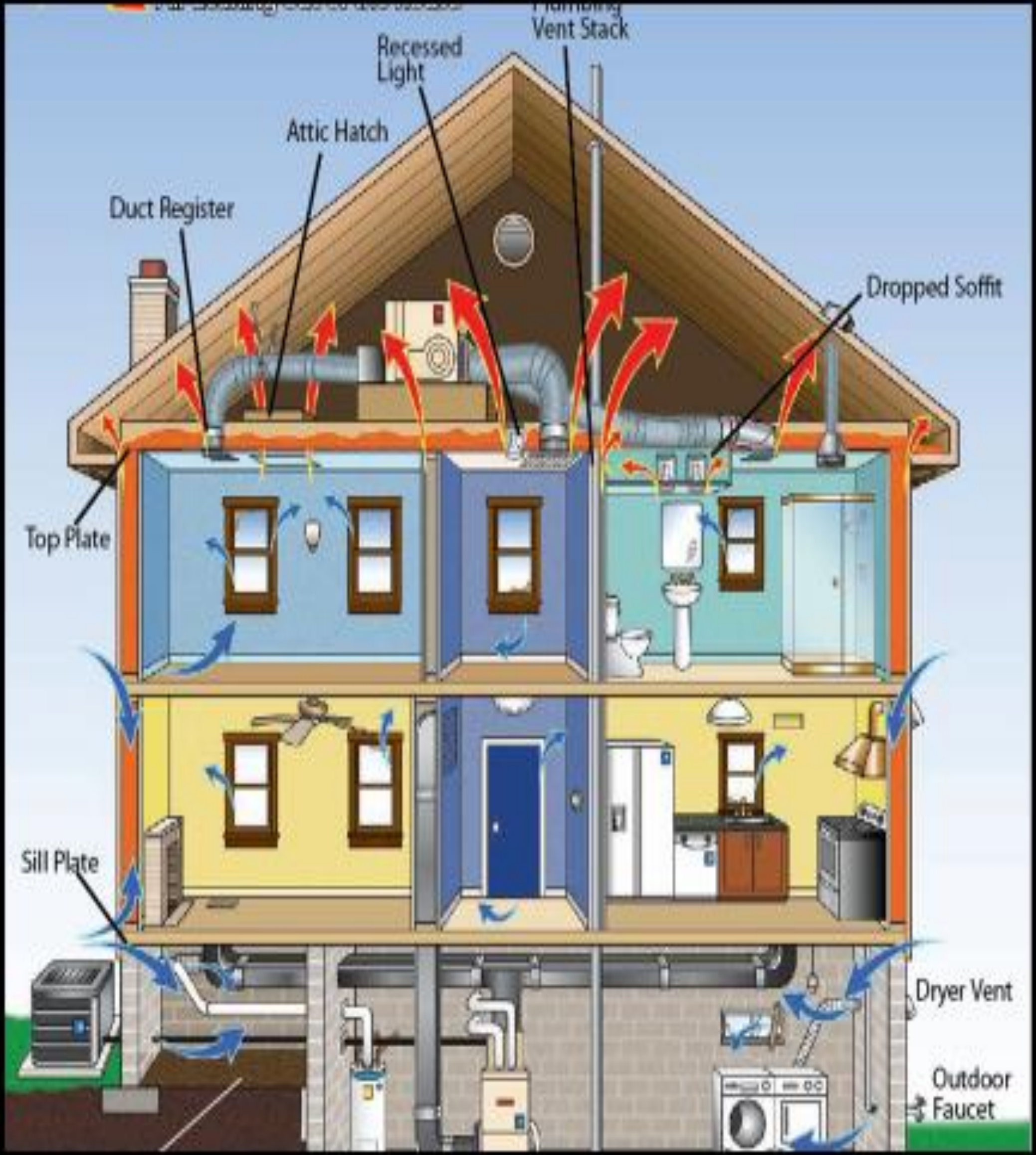
- Air is not forced in a confined space.
- Wherever transitions exceed 22 degrees airflow will fail.
- Evaporators will never meet capacity designs.
- Filter surfaces will not be utilized, and static pressures will be excessive.

HUMIDITY CONTROL

- Comfortable Conditions
- Efficient Operation
- Avoid Biological Growth
- Prolong the Life of the Structure and Furnishings

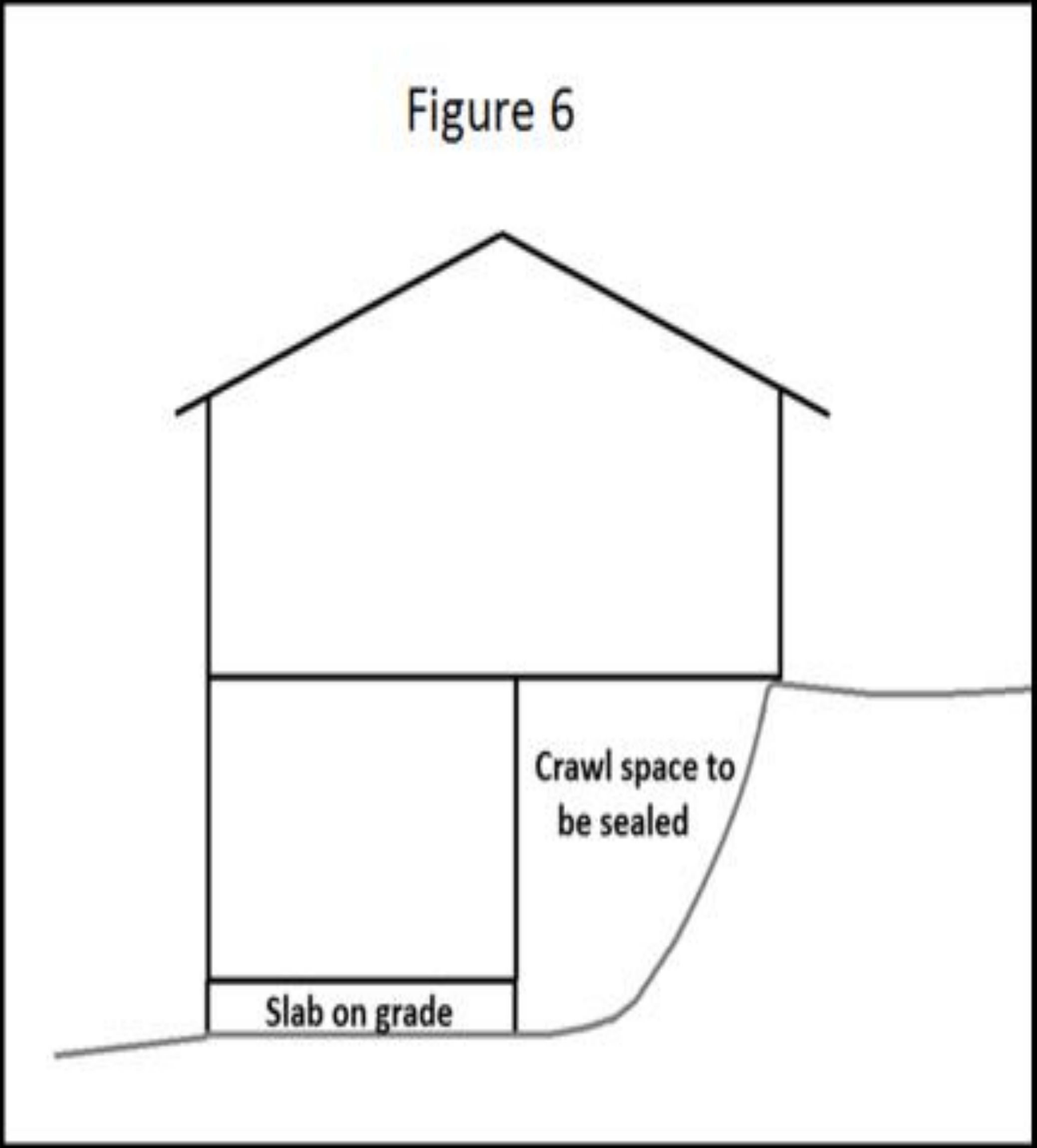
ENVELOPE CONTROL

- Slow down or eliminate air flow through structural components.
- Control internal moisture sources.
- Where crawl spaces or basements are included we must manage those spaces for moisture.
- Where high value insulation components are used think about alternative for managing latent loads without depending on environmental equipment.



HOMES WITH COMBINATION SLAB AND CRAWL SPACE

- If the ground is sealed, we avoid moisture migrating through the structure causing damage.
- Moisture can lift finished or warp flooring.
- Painted surfaces will loose integrity.
- Once inside the structure we will depend on equipment to remove and exaggerated latent load.

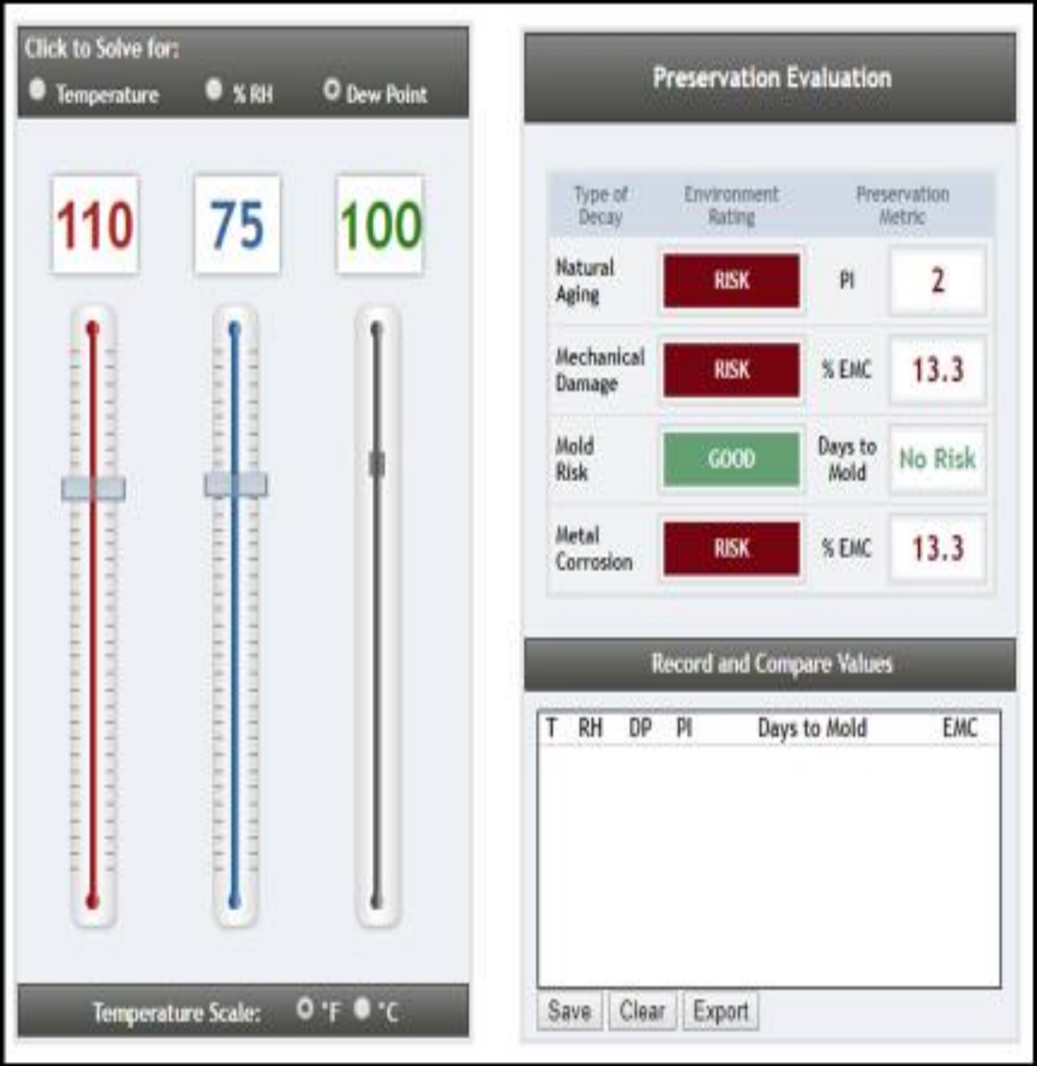


DEW POINTS IN HOT ATTICS

Equipment was never intended to be subjected to hot humid attics.

Another reason to bring equipment and duct inside the building envelope.

Slow moving air in ducts with long run times will overcome the insulation in the equipment and duct.



Graphic provided by: dpcalc.org

WATER BASED SEALANTS AND EQUIPMENT INSULATION

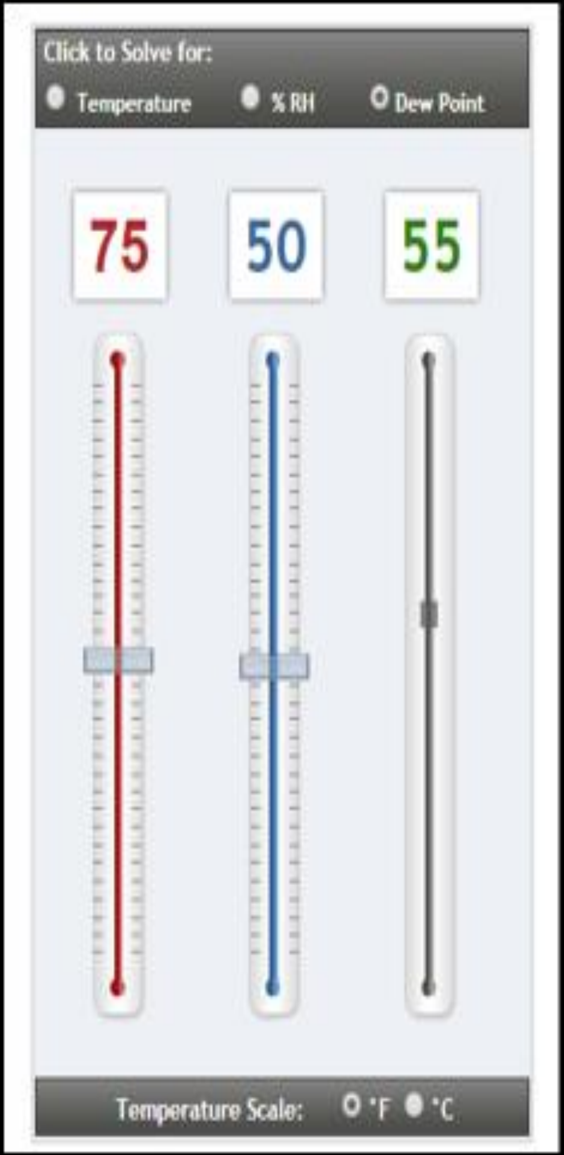
- Slow moving or turbulent air will cause insulation values to be overcome allowing dewpoint to be met on equipment and ducts.

- Water based sealants will liquefy and loose the adhesive qualities.

DEWPOINTS AT ACCA CONDITIONS

- Small margin for error if we meet ACCA conditions.
- Poor air flow design.
- Leaky duct to ceiling seal.
- Dirty filters.
- Out of balance duct systems.

Graphic provided by: dpcalc.org



CONTACT INFORMATION

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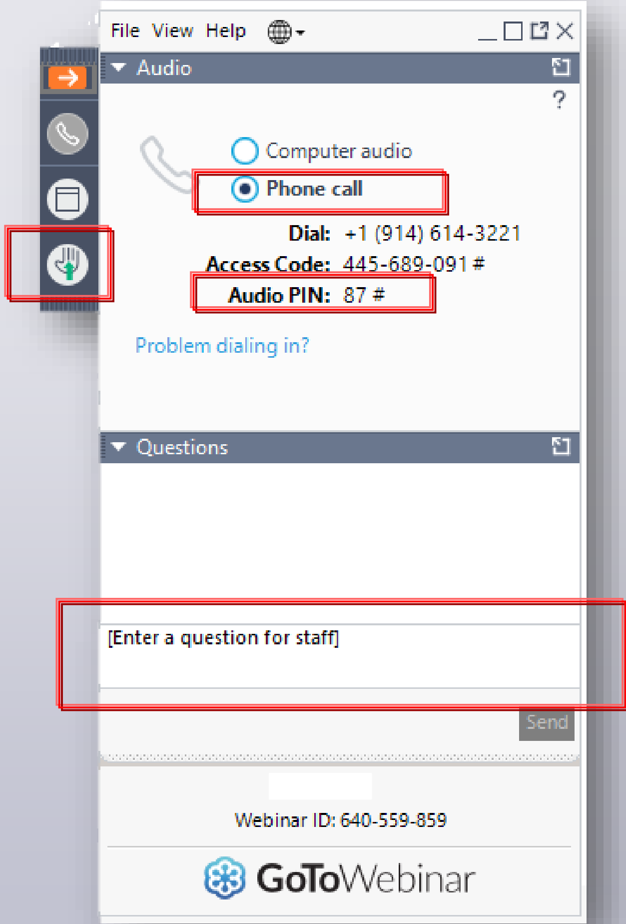
Discussion

Open and close your **control panel**

Raise your hand to enter the discussion



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If you have called in on a phone today, double check that you've selected telephone as your audio option.

Vance Payne
National Institute of Standards and Technology (NIST)

DOE Webinar: “Comfort --- The Biggest Driver of Energy Efficiency”

HOW TO CHARACTERIZE RESIDENTIAL AIR DISTRIBUTION SYSTEM PERFORMANCE FOR THERMAL COMFORT?

Hyojin Kim[1], Lisa Ng[2], Vance Payne[2], and Brian Dougherty[2]

[1] New Jersey Institute of Technology, Newark, NJ
[2] National Institute of Standards and Technology, Gaithersburg, MD

New Jersey Institute of Technology

National Institute of Standards and Technology
U.S. Department of Commerce

NIST MSE RESEARCH GRANT

FINAL REPORT

- Kim, H., K. Nguyen, A. McGuinness, and T.V. Dai. 2019. Characterization of Residential Air Distribution System Performance for Thermal Comfort. NIST GCR 19-021. 287 pages (December).

- Project PI: Hyojin Kim, Ph.D., currently at NJIT. (hyojin.kim@njit.edu)

NJIT
New Jersey Institute of Technology

NIST GCR 19-021

Characterization of Residential Air Distribution System Performance for Thermal Comfort

Hyojin Kim, Ph.D.
Khiem Nguyen
Anne McGuinness
Toan Vo Dai
The Catholic University of America

This publication is available free of charge from:
https://doi.org/10.6028/NIST.GCR.19-021

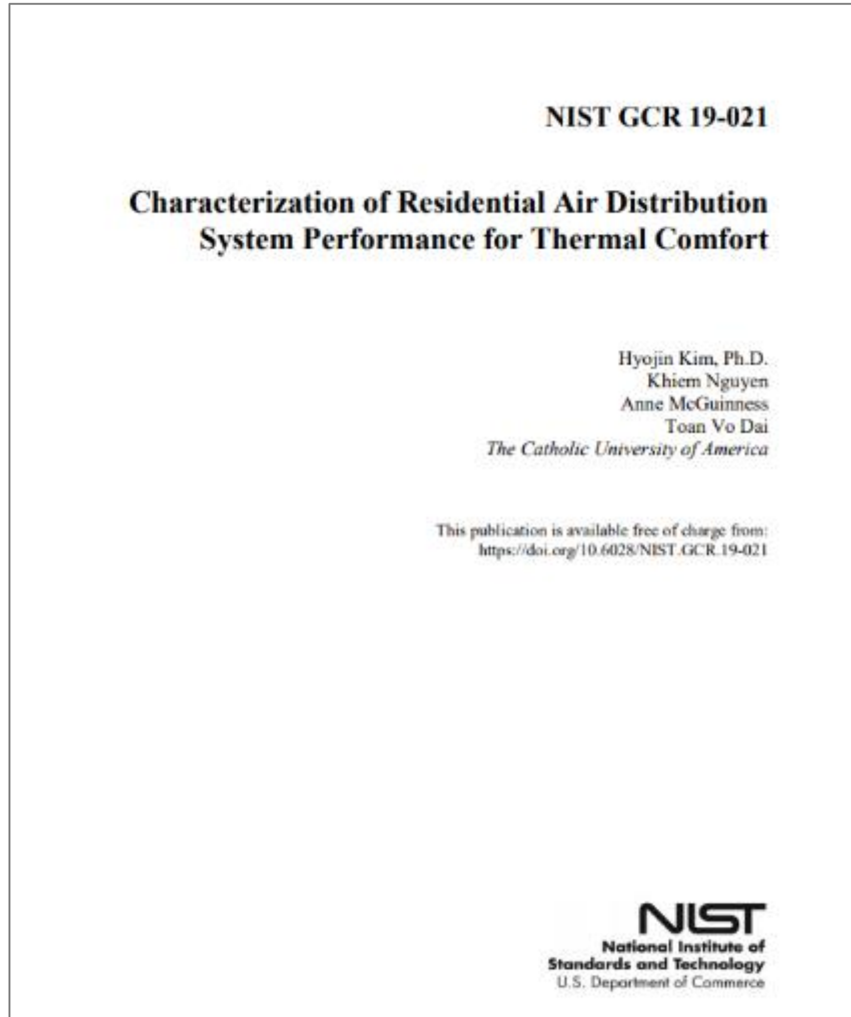
NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Full report is available at:
https://nvlpubs.nist.gov/nistpubs/gcr/2019/NIST.GCR.19-021.pdf

PROJECT OBJECTIVES

OBJECTIVES

- Develop an improved understanding of the impact of RESIDENTIAL AIR DISTRIBUTION systems on whole-house THERMAL COMFORT.
- Propose ANALYTICAL METHODS for evaluating this impact.
  - Whole-house thermal comfort performance
  - Spatial and temporal uniformity



NIST GCR 19-021

Characterization of Residential Air Distribution System Performance for Thermal Comfort

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NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Full report is available at:
https://nvlpubs.nist.gov/nistpubs/gcr/2019/NIST.GCR.19-021.pdf

NIST NZERTF

NIST NZERTF

- Laboratory with simulated occupancy/lighting/equipment

NIST NZERTF

- **Laboratory** for full-scale testing of low-energy technology

CDHP *"Big Duct"*

SDHV *"Small Duct"*

NIST NZERTF

- Year 3 NZERTF data (September 2016 to August 2017)
  - Big Duct = Conventionally-Ducted Heat Pump (CDHP)
  - Small Duct High Velocity (SDHV)

Table 3: Summary of the Characteristics of the Two HVAC Systems at NZERTF.

	CDHP *Two-stage compressor and variable-speed indoor blower*	**SDHV** *Variable-speed compressor and variable-speed indoor blower*
Cooling Capacity	7.6 kW	8.6 kW
Heating Capacity	7.8 kW at 8.3°C	10.3 kW at 8.3°C
Efficiency	SEER 4.63 W/W HSPF 2.65 W/W	SEER 4.10 W/W HSPF 2.45 W/W
Electric resistance heater	5 kW	None
External Static Pressure	0.5 inH_2O at 1,000 cfm 0.25 inH_2O at 600 cfm	1.8 inH_2O at 1,200 cfm 0.2 inH_2O at 200 cfm
Throttling range	±0.1°C	±0.14°C

DATA COLLECTION

THERMAL COMFORT DATA COLLECTION

- 1-min air temperature, humidity, and globe temperature data by room
- 10-sec thermal comfort data from a 3 x 3 x 3 grid system in BR3

One-Height (1.4 m)
Monitoring near Room Center

3 x 3 x 3 Grid of Measurement System with
3 Heights (0.6 m 1.1m, 1.7m) at 9 Locations

THE REPORT PRESENTS...

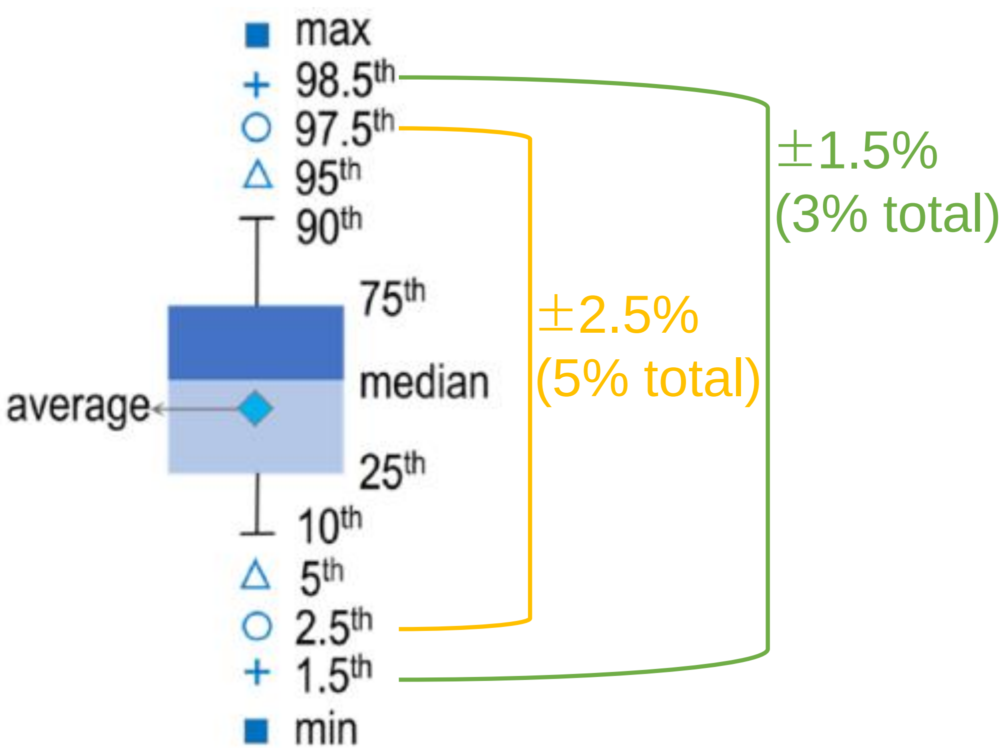
Today's Presentation

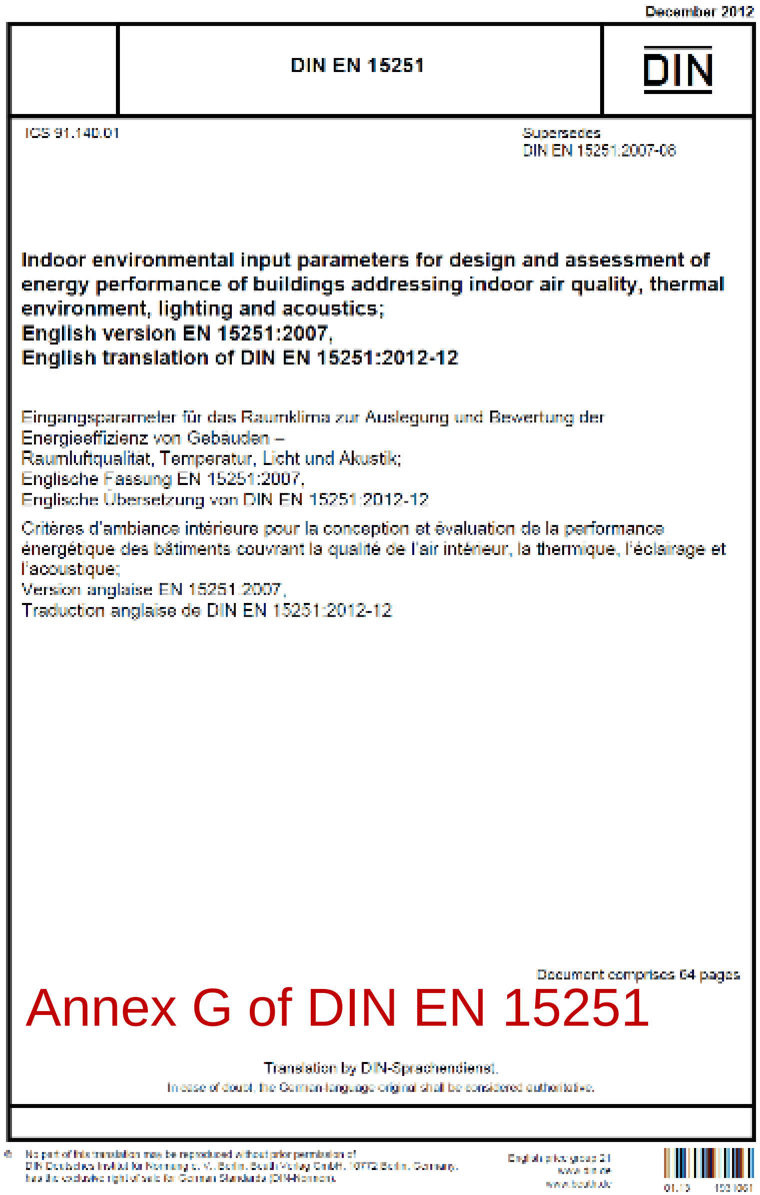
- **Whole-house** thermal comfort analysis & benchmarking
  - Room-to-thermostat temperature difference
  - Room-to-room temperature difference to evaluate spatial thermal uniformity
  - Cyclic discomfort to evaluate temporal thermal uniformity
  - Latent performance
- **BR3** grid analysis
  - Horizontal and vertical thermal stratification within a single room
  - Air velocity distribution
- **Advanced characterization** of long-term data
  - Statistical characterization of long-term thermal comfort data
  - Advanced characterization related to outdoor climate/time of the day
  - Graphical analysis using the psychrometric chart and trend animation

TEMPERATURE VARIATIONS

APPROACH

- Graphical indices for long-term thermal comfort data to characterize extreme variations based on ±1.5%, ±2.5%, ±5%, and ±10% deviation.





December 2012

DIN EN 15251

DIN

ICS 91.140.01

Supersedes
DIN EN 15251:2007-08

Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics;
English version EN 15251:2007,
English translation of DIN EN 15251:2012-12

Eingangsparameter für das Raumklima zur Auslegung und Bewertung der Energieeffizienz von Gebäuden –
Raumluftqualität, Temperatur, Licht und Akustik;
Englische Fassung EN 15251:2007,
Englische Übersetzung von DIN EN 15251:2012-12

Critères d'ambiance intérieure pour la conception et évaluation de la performance énergétique des bâtiments couvrant la qualité de l'air intérieur, la thermique, l'éclairage et l'acoustique;
Version anglaise EN 15251:2007,
Traduction anglaise de DIN EN 15251:2012-12

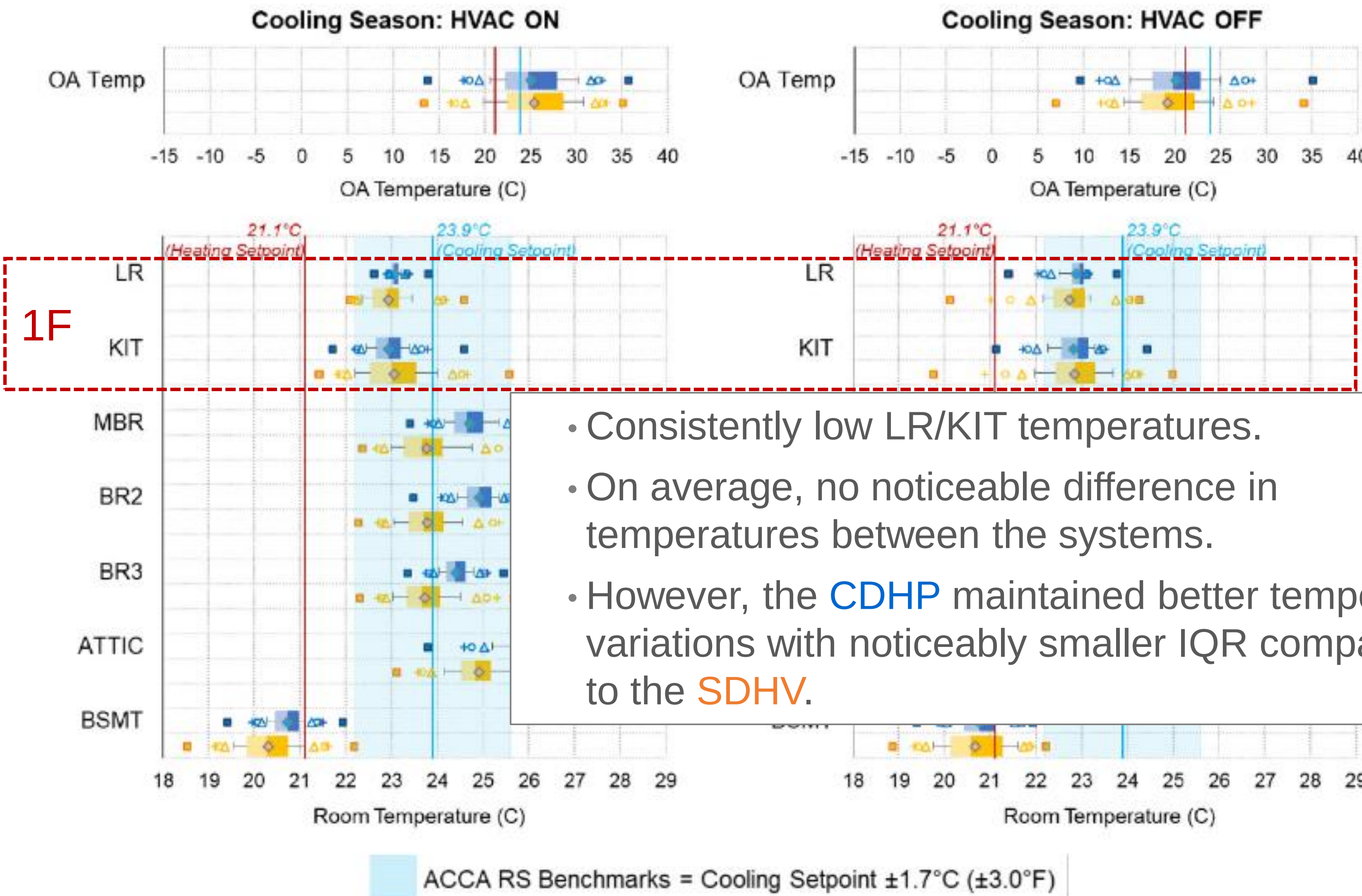
Document comprises 64 pages

Annex G of DIN EN 15251

Translation by DIN-Sprachendienst.
In case of doubt, the German-language original shall be considered authoritative.

TEMPERATURE VARIATIONS

KEY FINDINGS: COOLING SEASON

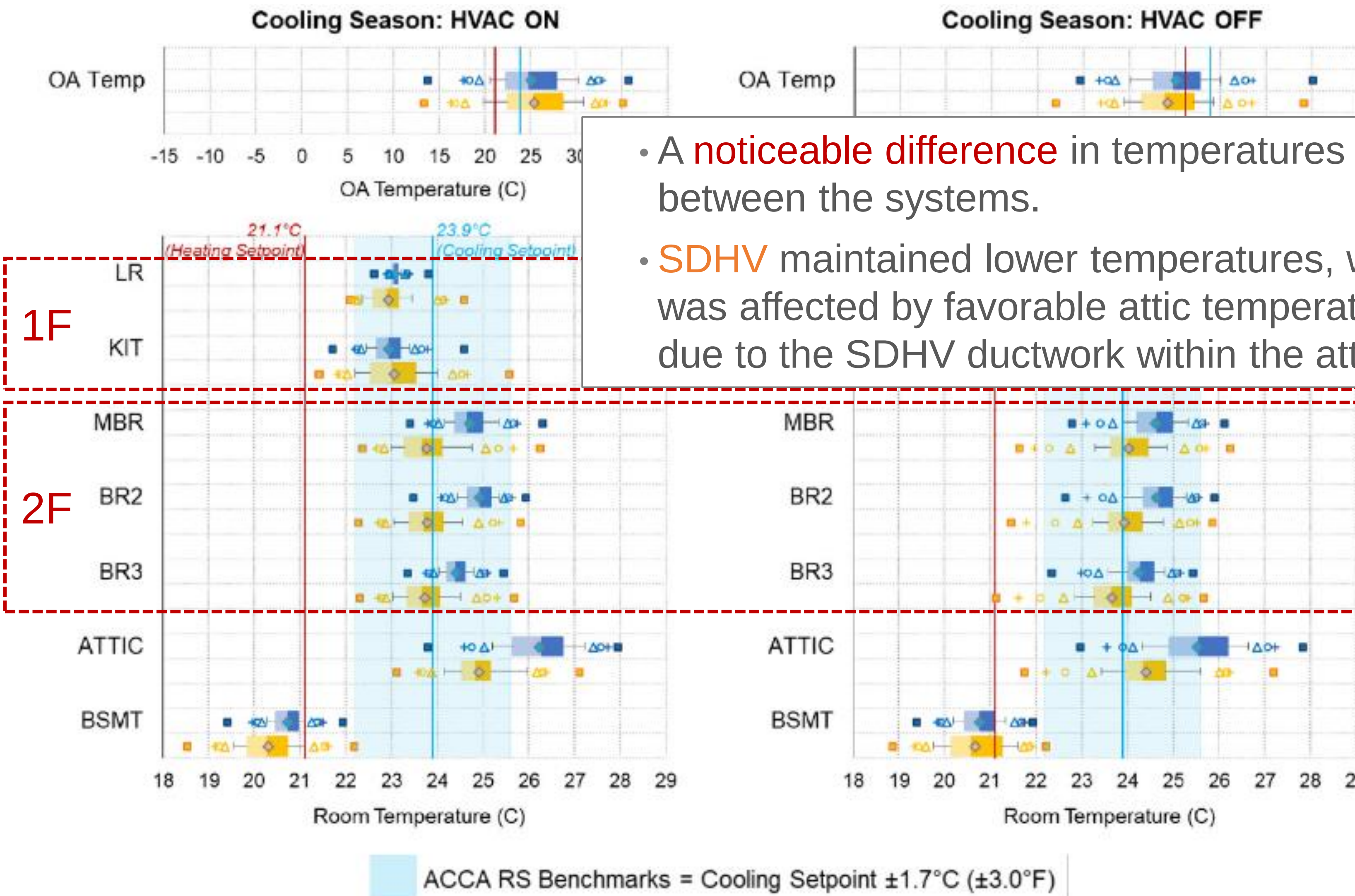


- Consistently low LR/KIT temperatures.
- On average, no noticeable difference in temperatures between the systems.
- However, the CDHP maintained better temporal variations with noticeably smaller IQR compared to the SDHV.

TEMPERATURE VARIATIONS

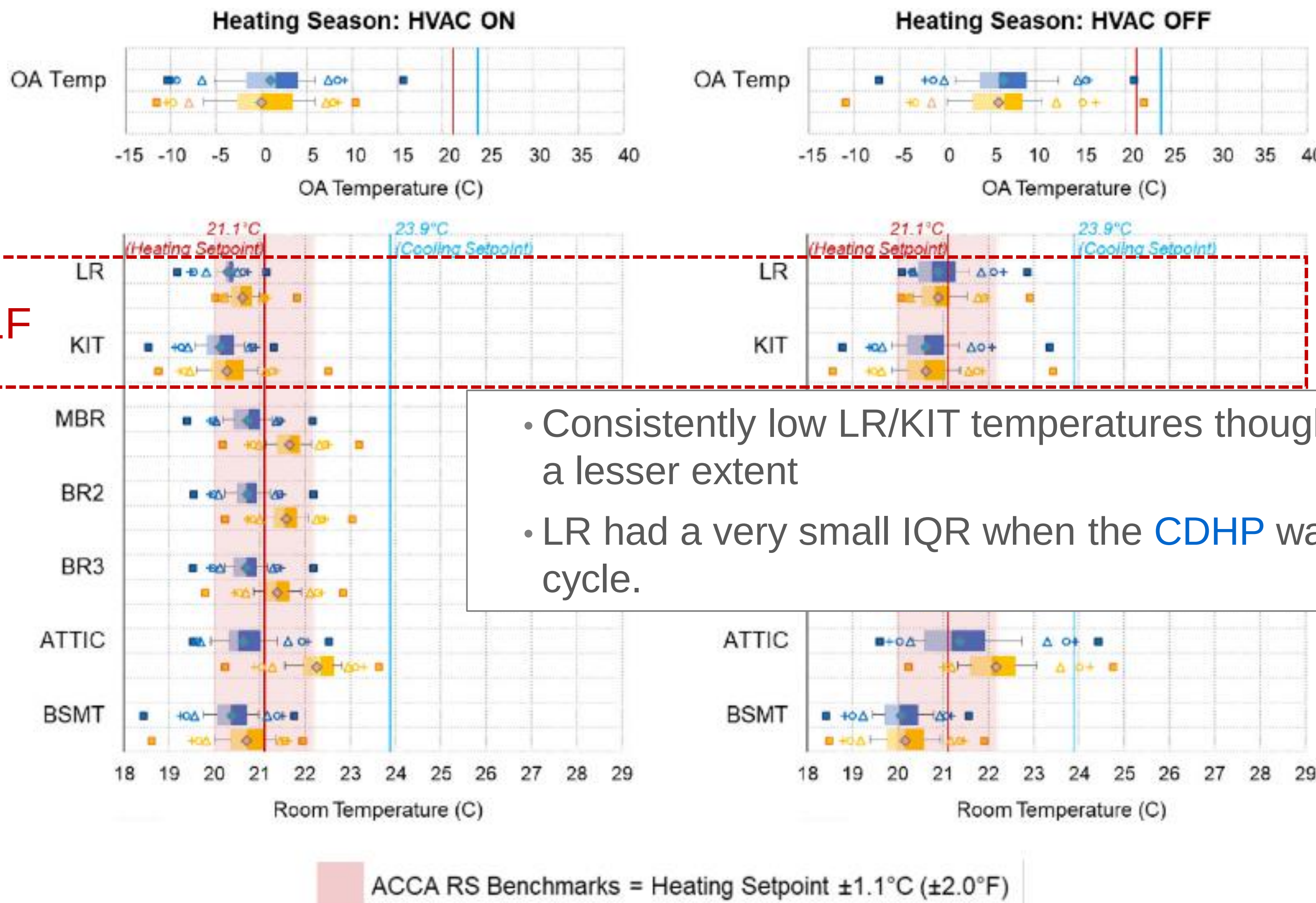
KEY FINDINGS: COOLING SEASON

- A noticeable difference in temperatures between the systems.
- SDHV maintained lower temperatures, which was affected by favorable attic temperature due to the SDHV ductwork within the attic.



TEMPERATURE VARIATIONS

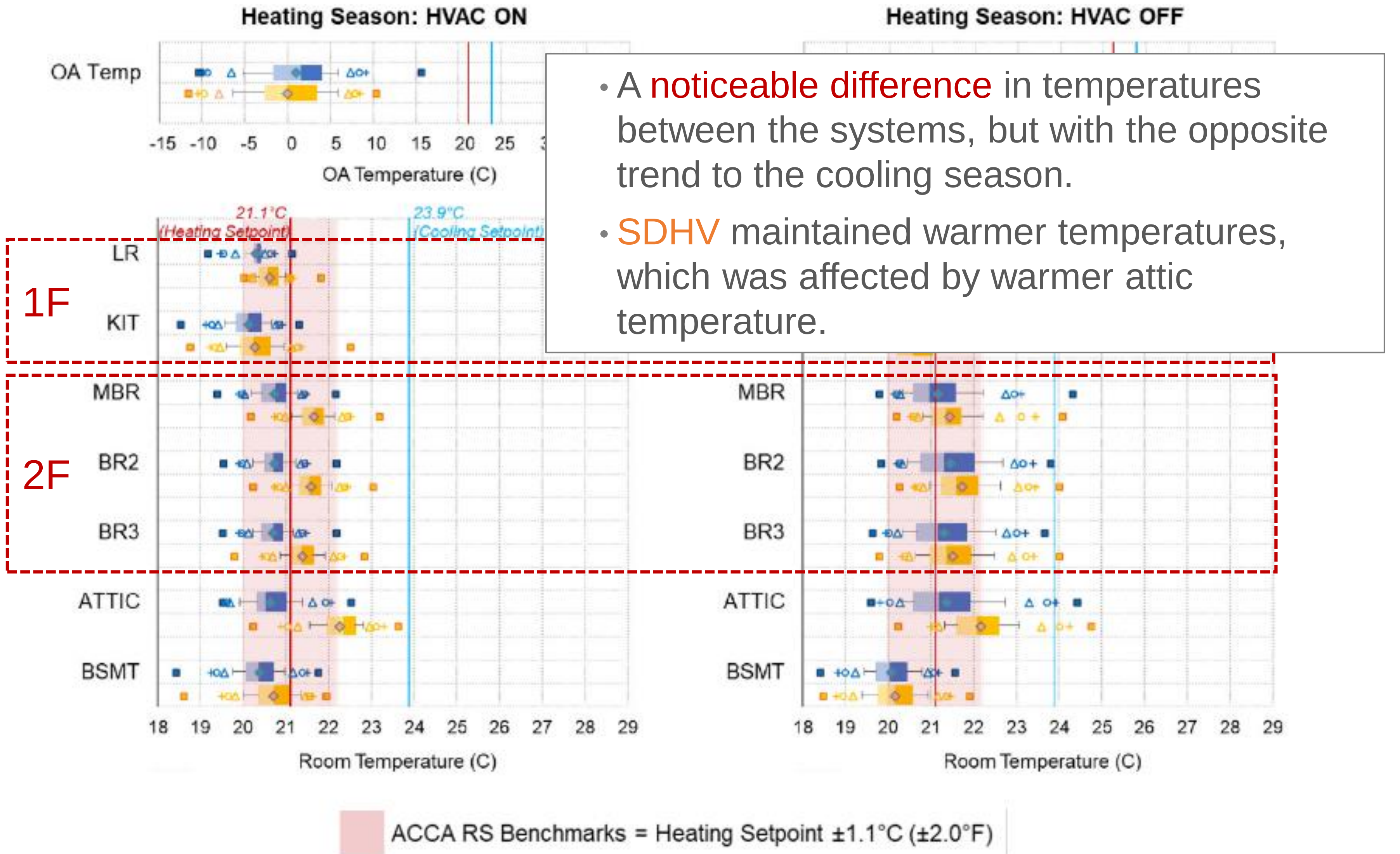
KEY FINDINGS: HEATING SEASON



- Consistently low LR/KIT temperatures though to a lesser extent
- LR had a very small IQR when the CDHP was on cycle.

TEMPERATURE VARIATIONS

KEY FINDINGS: HEATING SEASON



- A noticeable difference in temperatures between the systems, but with the opposite trend to the cooling season.
- SDHV maintained warmer temperatures, which was affected by warmer attic temperature.

ACCA MANUAL RS COMPLIANCE

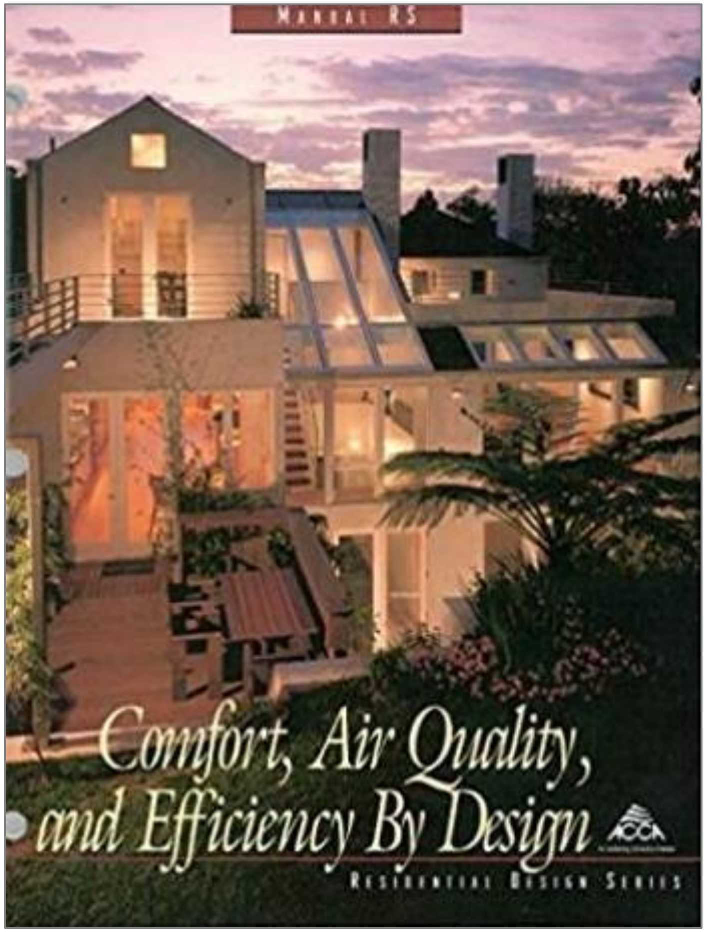
APPROACH

- Room-to-room temperature difference:
  - Delta T (°C)= MAX (T_{ROOM1}, T_{ROOM2}, …) – MIN (T_{ROOM1}, T_{ROOM2}, …)

  - ACCA Manual RS Benchmarks

  = *Average* ±1.7°C (±3.0°F) and *Maximum* ±3.3°C (±6.0°F) in Cooling Mode

  Average ±1.1°C (±2.0°F) and *Maximum* ±2.2°C (±4.0°F) in Heating Mode

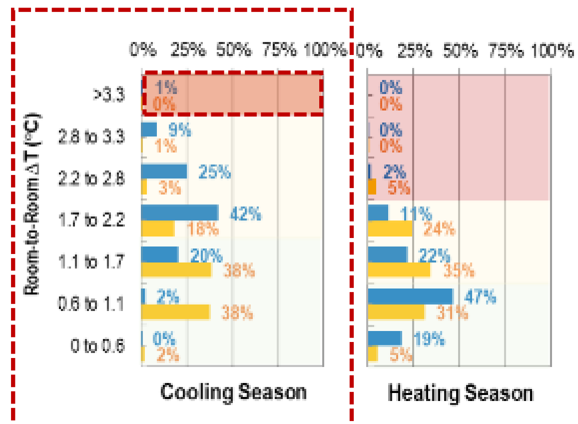


ACCA MANUAL RS COMPLIANCE

KEY FINDINGS

- Cooling Season
  - SDHV maintained smaller ΔT than the CDHP.
  - Average ΔT were 1.3°C (SDHV) lower than the ACCA average benchmarks; and 2.1°C (CDHP) exceeding the ACCA average benchmarks (1.7°C).
  - CDHP had occasions (1.0%) when ΔT exceeded the ACCA maximum benchmarks (3.3°C) due to the afternoon high-side deviation of MBR temperature.

		Cooling Season			Heating Season		
		n	% of period		n	% of period	
CDHP							
>3.33°C	(>6°F)	218		1.0%	0	0.0%	
2.78 to 3.33°C	(5 to 6°F)	1952	8.6%		5	0.0%	1.8%
2.22 to 2.78°C	(4 to 5°F)	5773	25.4%	**76.3%**	262	1.8%	
1.67 to 2.22°C	(3 to 4°F)	9634	42.3%		1654	11.3%	**32.9%**
1.11 to 1.67°C	(2 to 3°F)	4643	20.4%		3185	21.7%	
0.56 to 1.11°C	(1 to 2°F)	514	2.3%	**22.7%**	6864	46.7%	**65.2%**
0 to 0.56°C	(0 to 1°F)	18	0.1%		2718	18.5%	
AVG.			**2.1°C**			**1.0°C**	
SDHV							
>3.33°C	(>6°F)	1		0.0%	0	0.0%	
2.78 to 3.33°C	(5 to 6°F)	150	0.6%		9	0.1%	4.6%
2.22 to 2.78°C	(4 to 5°F)	761	3.1%	**22.1%**	672	4.6%	
1.67 to 2.22°C	(3 to 4°F)	4540	18.4%		3526	24.0%	**58.7%**
1.11 to 1.67°C	(2 to 3°F)	9479	38.4%		5089	34.6%	
0.56 to 1.11°C	(1 to 2°F)	9278	37.6%	**77.9%**	4613	31.4%	**36.7%**
0 to 0.56°C	(0 to 1°F)	489	2.0%		779	5.3%	
AVG.			**1.3°C**			**1.3°C**	



ACCA MANUAL RS COMPLIANCE

KEY FINDINGS

▶ Heating Season

- CDHP maintained smaller ΔT than the SDHV.
- Average ΔT were 1.0°C (CDHP) lower than the ACCA average benchmarks; and 1.3°C (SDHV) exceeding the ACCA average benchmarks (1.1°C).
- SDHV had more occasions when ΔT exceeded the ACCA maximum benchmarks (2.2°C) due to the nighttime low-side deviation of KIT temperature.

		Cooling Season			Heating Season		
		n	% of period		n	% of period	
CDHP							
>3.33°C	(>6°F)	218	1.0%		0	0.0%	
2.78 to 3.33°C	(5 to 6°F)	1952	8.6%		5	0.0%	1.8%
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AVG.		**2.1°C**			**1.0°C**		
SDHV							
>3.33°C	(>6°F)	1	0.0%		0	0.0%	
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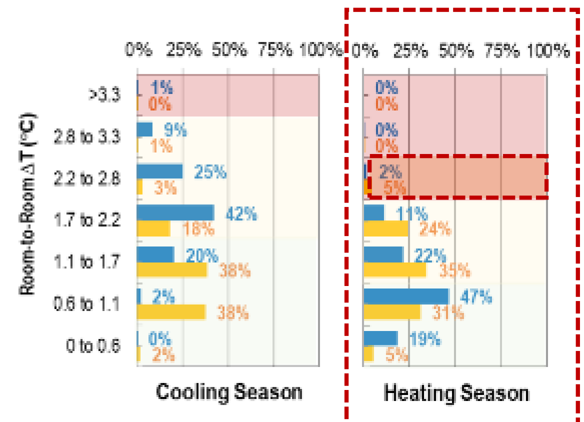
AVG.		**1.3°C**			**1.3°C**		



BENCHMARKING

KEY FINDINGS

- Comparison of the NZERTF cooling season results against the two field studies
  - Baskin and Vineyard (2003)
  - Poerschke et al. (2016)

Average ΔT

- NZERTF results were lower or similar to those of other test houses for the respective systems.
- In all three studies, the SDHV provided lower room-to-room ΔT.

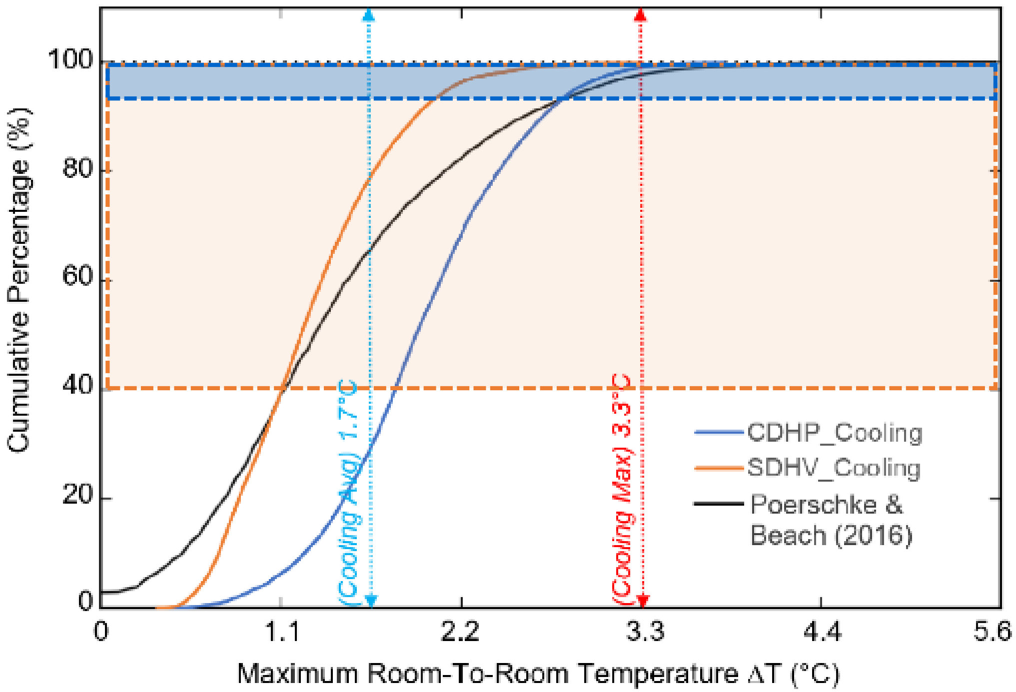
Table 17: A Comparison of the Average Room-to-Room Temperature Differences Between Studies for the Cooling Season.

	NZERTF	Baskin and Vineyard (2003)			Poerschke et al. (2016)		
	ΔT(°C) at 1.4m	ΔT(°C) at 1.1m	ΔT(°C) at1.7m	AVG.	ΔT(°C) in House Type 1	ΔT(°C) in House Type 2	AVG.
CDHP	**2.1**	2.3	2.4	**2.4**	1.4	2.7	**2.1**
SDHV	**1.3**	1.8	1.8	**1.8**	1.3	1.2	**1.3**

BENCHMARKING

KEY FINDINGS

- Graphical comparison of the NZERTF cooling season results with room-to-room ΔT reported by Poerschke and Beach (2016)
  - 36 high-performance occupied houses in hot and humid climate



- SDHV had better room-to-room temperature uniformity than the benchmarks based on the cumulative data above the 40th percentile.
- However, the CDHP had larger room-to-room temperature uniformity except for the upper 10% of data along.

RECOMMENDATIONS

- Room air temperature is recommended as primary index for a residential thermal uniformity analysis in terms of the house/HVAC system's fundamental ability to provide and deliver uniform space temperatures across the house as installed.
  - ACCA Manual RS benchmarks developed in 1997 may not be applicable for today's low-load houses.

  ➔ *Need to reexamine the ACCA Manual RS benchmarks based on low-load house data.*

- To fully understand the long-term thermal comfort data, it is recommended to perform a statistical characterization of data for both the primary rooms and the rooms that are thermally important due to possible heat transfer from/to the primary rooms (e.g., attic).

- Proper data decomposition is necessary and essential to extract meaningful information from large datasets.

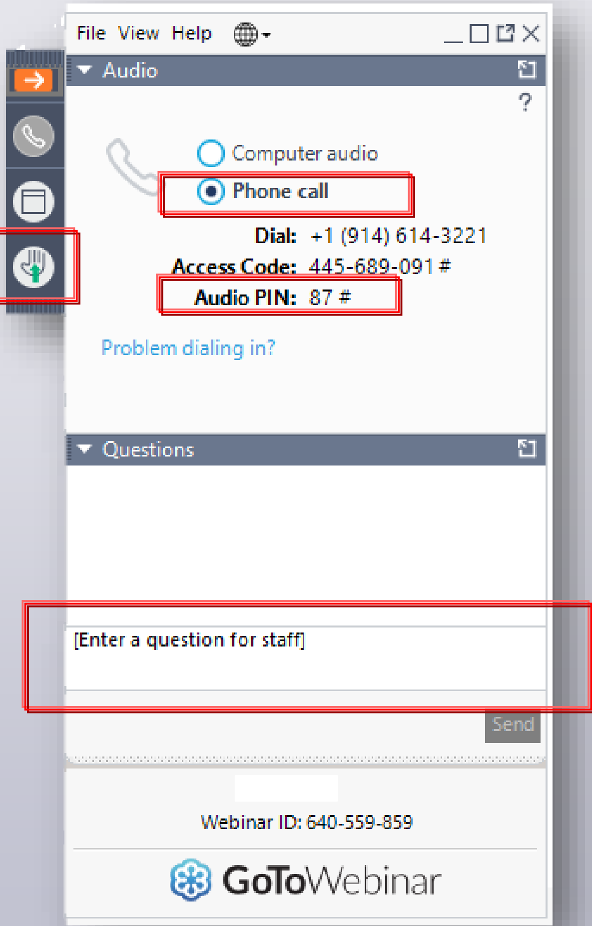
MORE IN THE REPORT…

- *Cyclic discomfort*
- *Latent performance*
- *Horizontal and vertical thermal stratification within a single room*
- *Air velocity distribution*
- *Advanced characterization related to outdoor climate/time of the day*
- *Graphical analysis using the psychrometric chart and trend animation*

Discussion

Open and close your **control panel**

Raise your hand to enter the discussion



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Kevin DeMaster

Mitsubishi Electric Trane HVAC

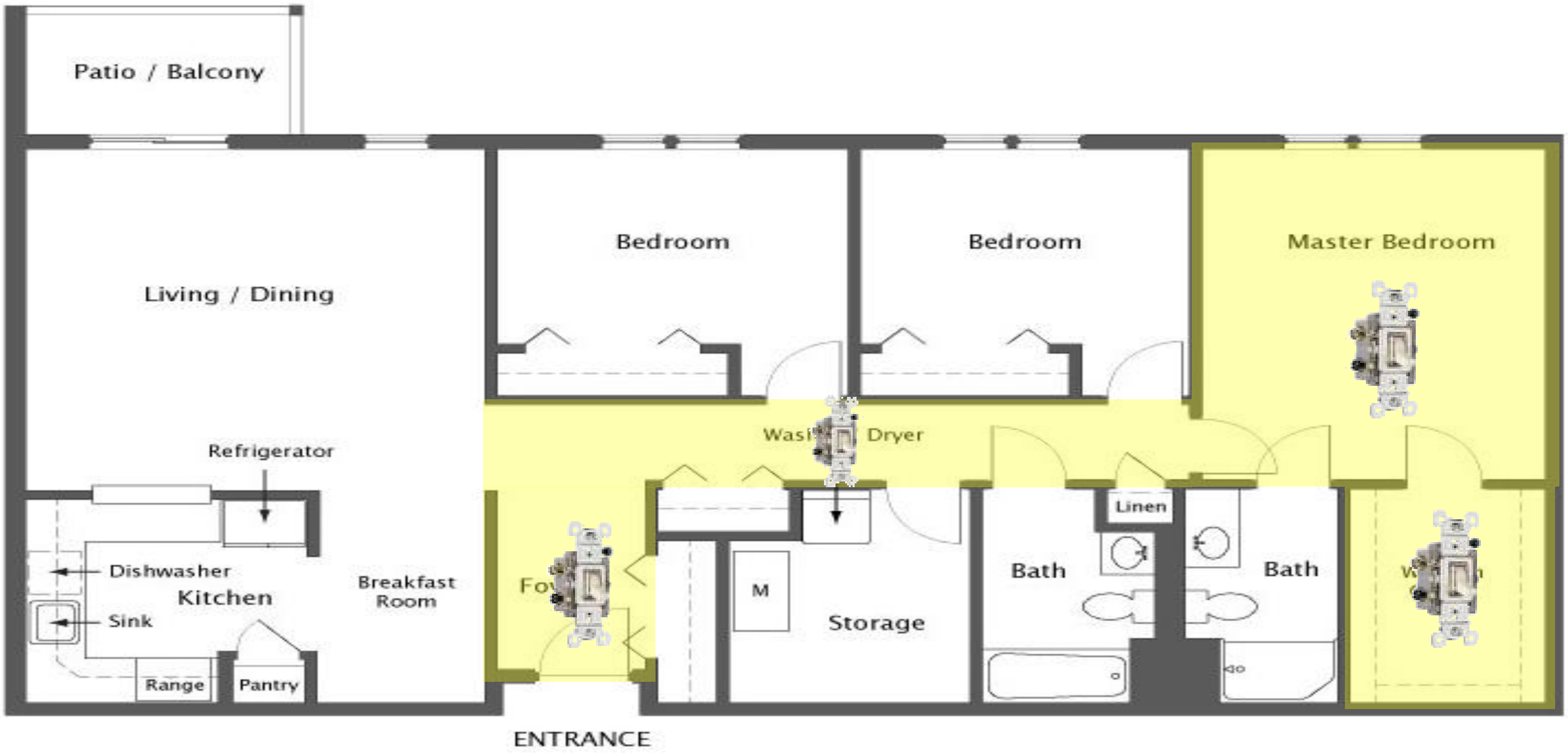
Better Buildings
U.S. DEPARTMENT OF ENERGY

Comfort - The Biggest Driver of Residential Energy Efficiency?

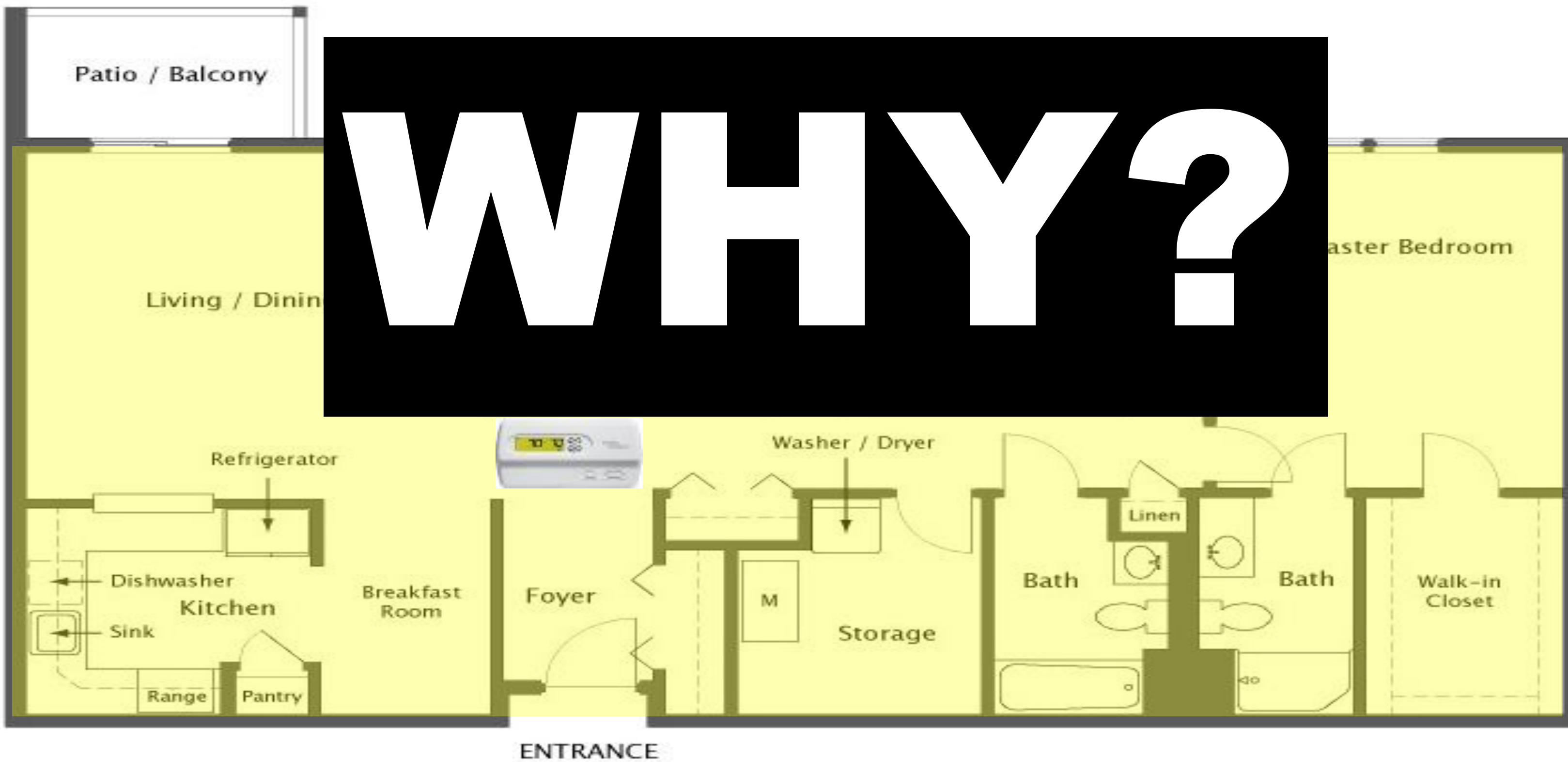
Inverter Compressor Heat Pumps – Turning up the Heat!

Challenge YOUR Thinking! - COMFORT

Challenge YOUR Thinking! – The NORM



Challenge YOUR Thinking! – The NORM

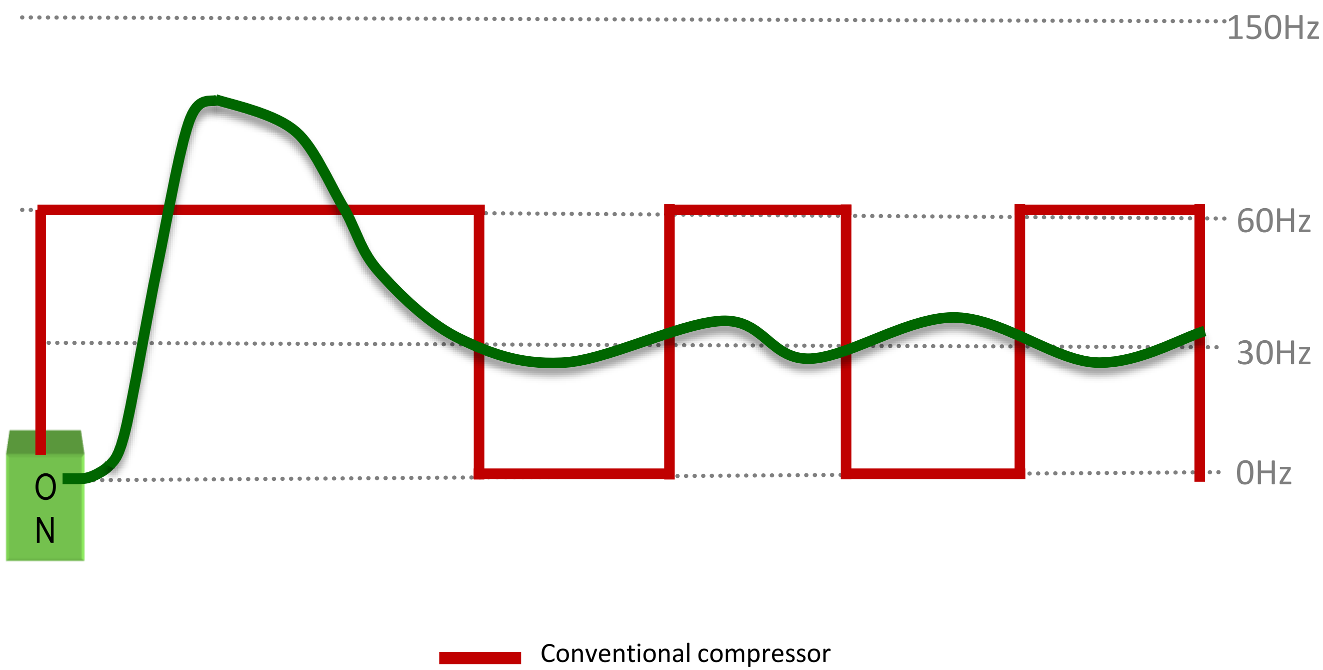


What do Consumers Want?

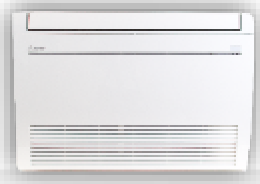
- More livable space
- Comfort
- Energy efficiency
- Healthier homes
- Peace of mind
- Quiet
- Environmentally Friendly

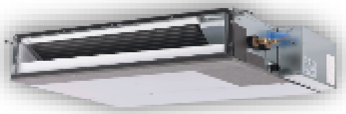
We All Have Heat Pump(s)

INVERTER Technology



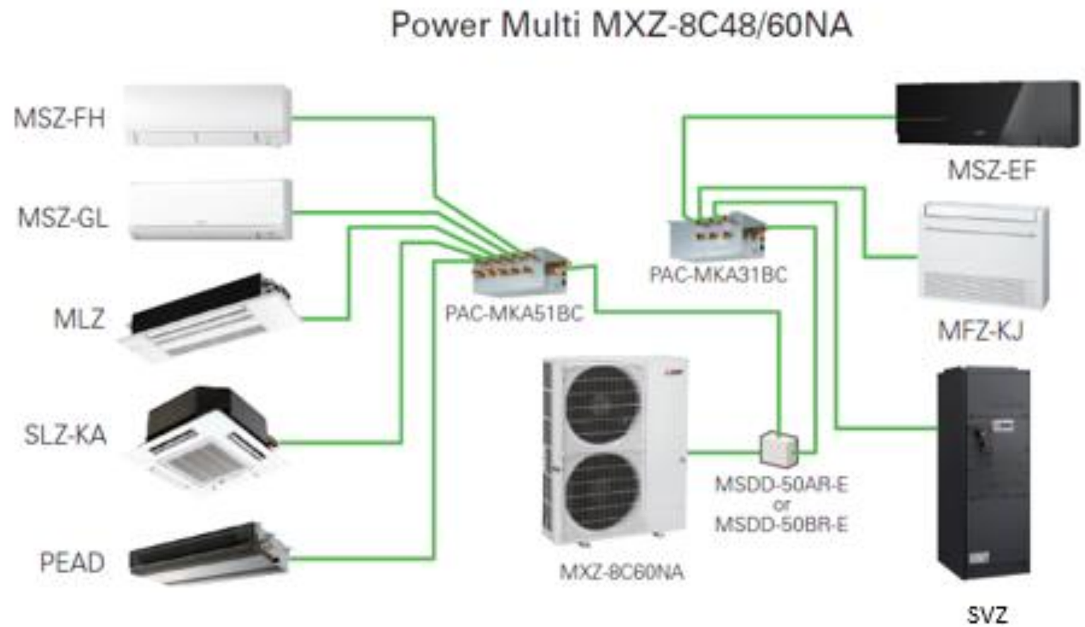
Technology Advancements - Zoned Comfort Solutions™





Mini Split Systems

Single Zone



Multi-Zone 2 – 8 Zones

Efficiency & Comfort

HEATING PERFORMANCE

100% @ 5F

80-90%@ -13F

COOLNG PERFORMANCE

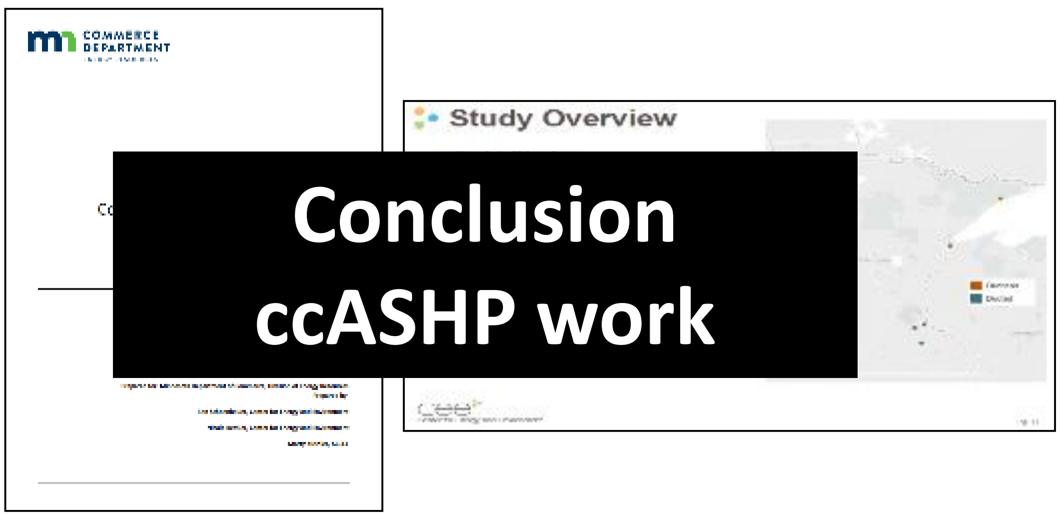
SEER 33.1 -

Dehumidification??

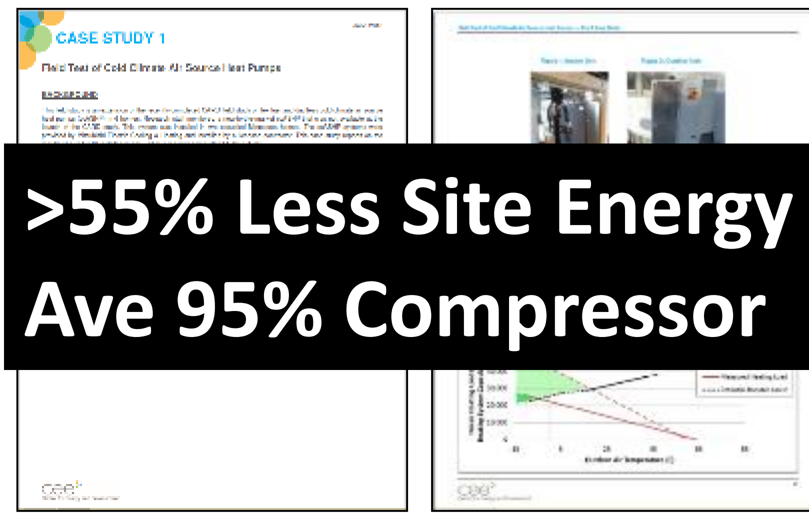
Cold Climate Heat Pump Research

Minnesota cee Center for Energy and Environment

- Statewide Assessment
- Fossil fuel displacement



Conclusion
ccASHP work



>55% Less Site Energy
Ave 95% Compressor

Pilot Collaboration – Improved Comfort & Efficiency Multifamily & Single Family

ComEd

80 MF units

AEP OHIO

30 SF homes

UPPCO
Upper Peninsula Power Company

16 Fourplexes

Energy Efficiency – Heat Pumps Not Created Equal

CASE EXAMPLE - MN Power Efficiency Requirements

- ASHP/MiniSplit (15 SEER/8.5 HSPF) - $300/$500
- Cold Climate (18 SEER/10 HSPF) - $1000

VS.

Heat Pumps AHRI 360,046 Listed.

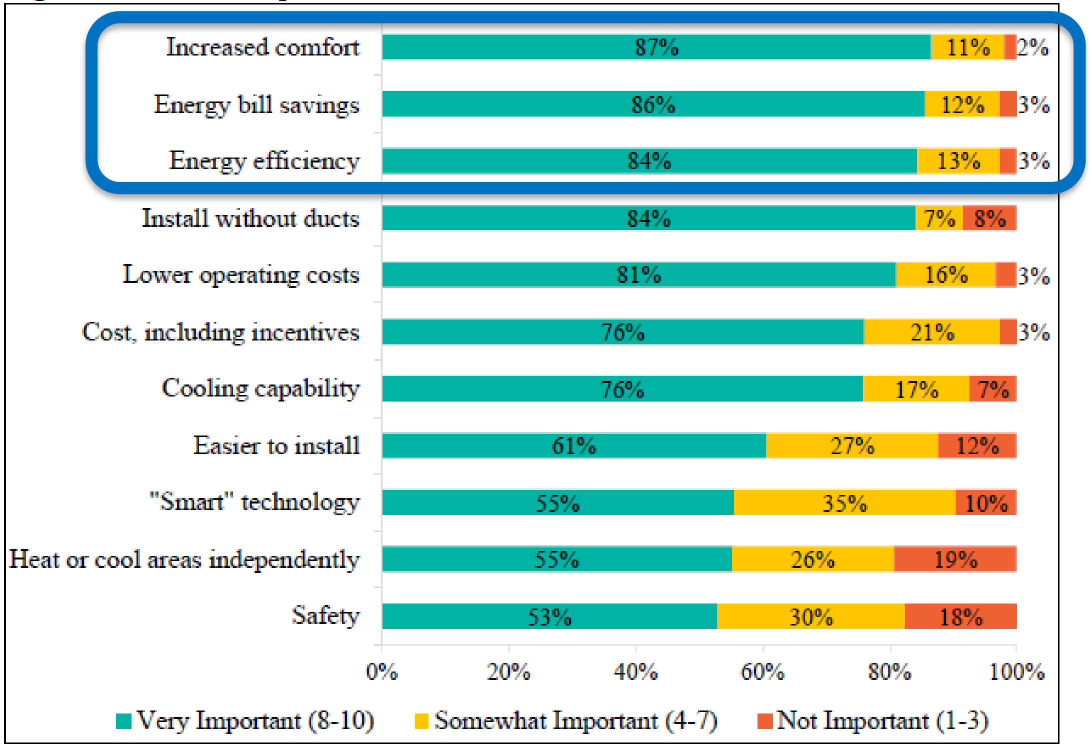
- 15 SEER/8.5 HSPF – 192,431 – (53%)
- 18 SEER/10 HSPF - 4,792 - (1%)

Variable Speed Heat Pumps AHRI 6,185

- 15 SEER/8.5 HSPF – (93%)
- 18 SEER/10 HSPF - 3,017 - (49%) – **MITSUBISHI 60%**

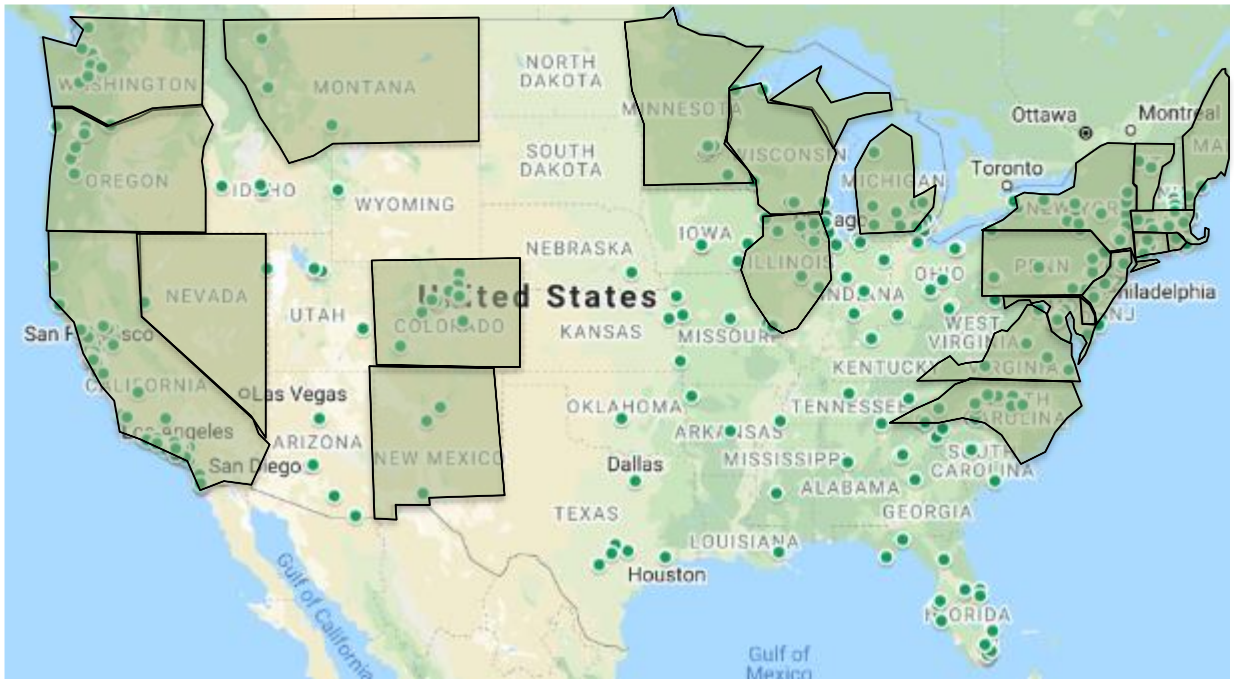
Comfort -- The Biggest Driver of Residential Energy Efficiency?

Figure 6. Overall Importance of DHP Benefits in Purchase of DHP



Source: Northwest Ductless Heat Pump Initiative: Market Progress Evaluation Report #5

Trend 80% by 2050 Carbon Neutrality



238 Cities

45 States

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MITSUBISHI ELECTRIC

COOLING & HEATING

TRANE®

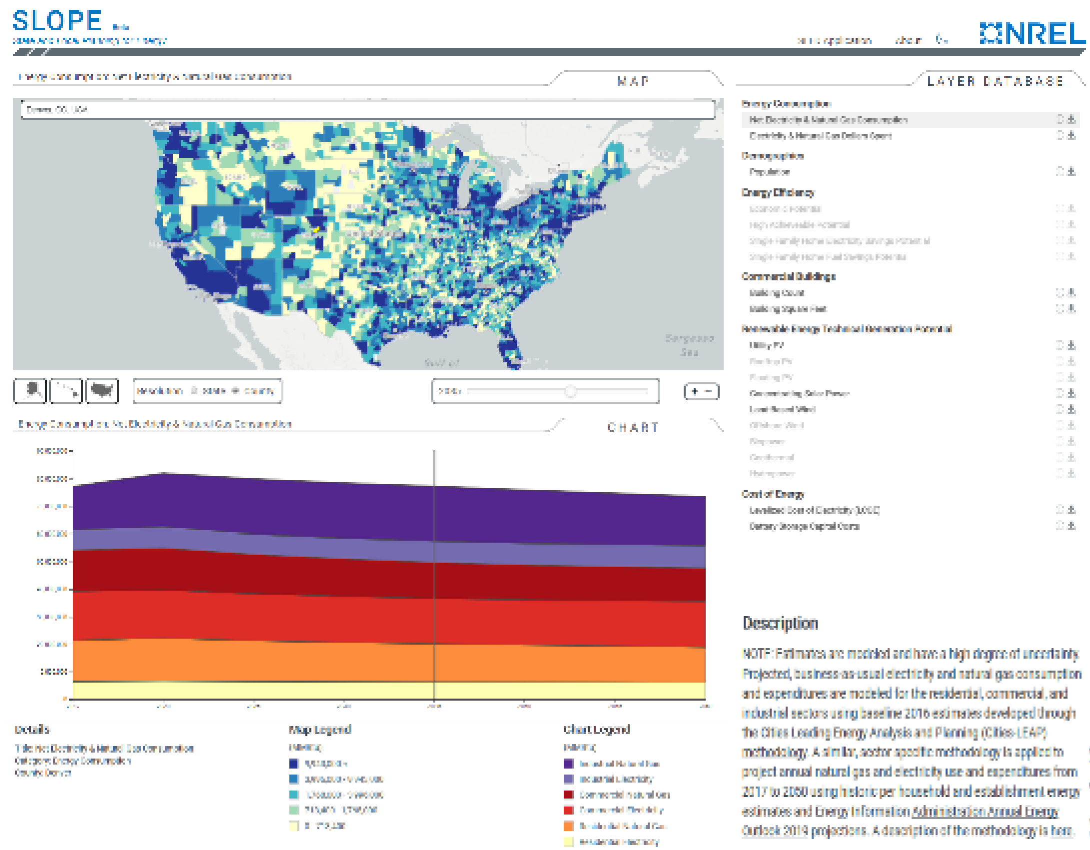
SLOPE Platform

A DOE-led collaboration between NREL and 8 EERE technology offices to create a ***dynamic, comprehensive energy planning platform*** of integrated, localized data for state and local decision makers

- **Phase I:** Beta version launched (Jan. 2020)
- **Phase II:** Adding transportation and generation mix data; enabling user-saved settings (under development in 2020)

Access the Platform:
https://gds.nrel.gov/slope

Comments or Questions?
slope@nrel.gov



Explore the Residential Program Solution Center

Resources to help improve your program and reach energy efficiency targets:

- Handbooks - explain *why* and *how* to implement specific stages of a program.
- Quick Answers - provide answers and resources for common questions.
- Proven Practices posts - include lessons learned, examples, and helpful tips from successful programs.
- Technology Solutions NEW! - present resources on advanced technologies, **HVAC** & **Heat Pump Water Heaters**, including installation guidance, marketing strategies, & potential savings.

https://rpsc.energy.gov

Thank You!

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Please send any follow-up questions or future call topic ideas to:
bbresidentialnetwork@ee.doe.gov