



Field tests of variable speed heat pumps to compare load-based and fixed-speed test and rating methods (438)

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Track: Heat Pumps in Residential Buildings

*corresponding

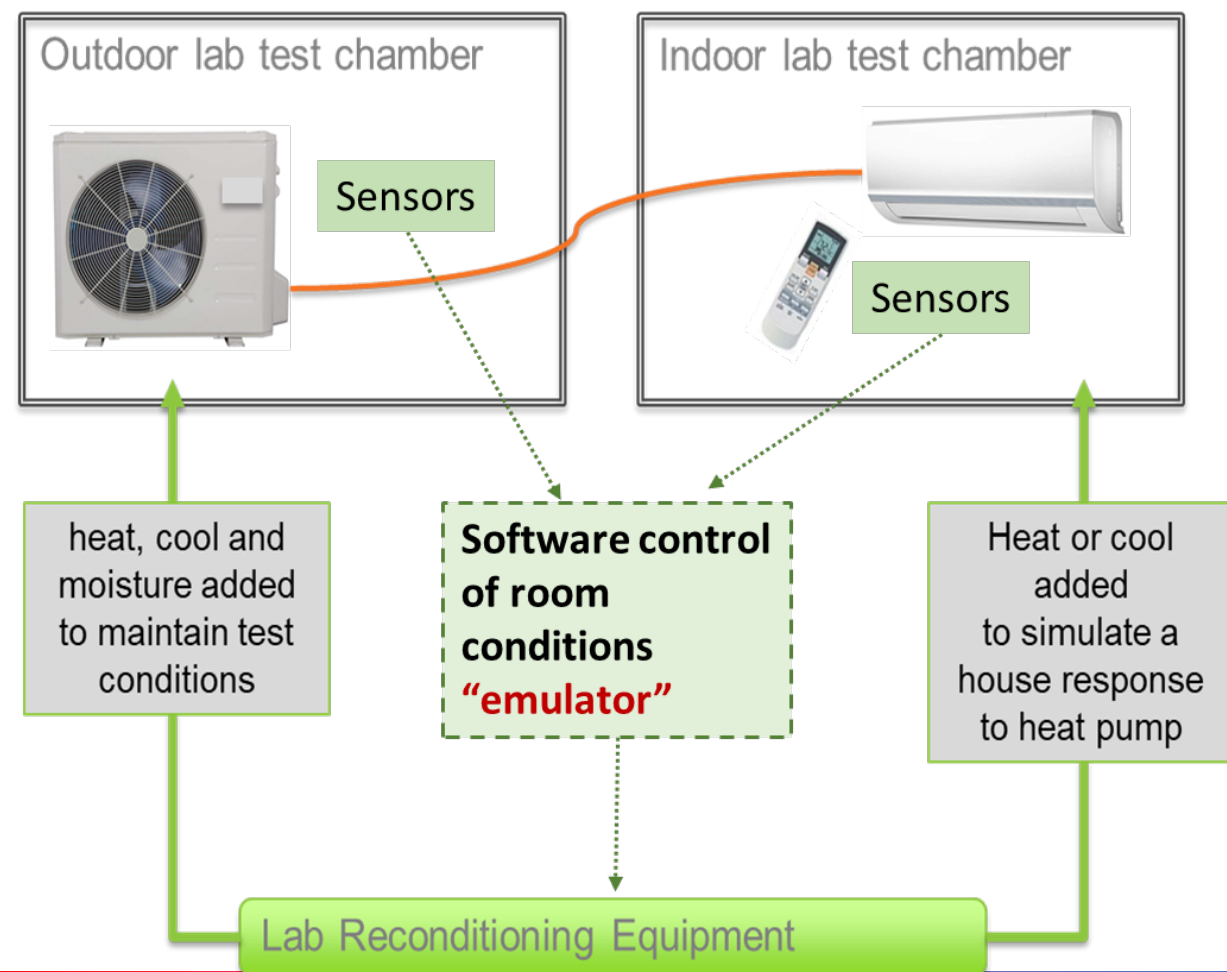


Background: SPE07 load based testing



- Load based testing and rating of heat pump efficiency
 - Emerging as alternate to traditional test methods
 - Traditional tests use fixed compressor speeds for variable-speed systems
 - These fixed-speed tests don't reflect performance
- Canadian Standards Association (CSA) developed SPE07 (was EXP07)
 - Goal: more realistic ratings for variable speed equipment
 - Seasonal heating & cooling efficiency ratings for multiple climate zones

- Approximating realistic performance in the lab
 - using a simulated, virtual building load
- Two psychrometric chambers
 - **Outdoor:** held constant for each test condition
 - **Indoor:** lab conditions controlled to simulate building response to load and heat pump capacity measured in real time





Previous lab results with EXP07



- Past research using EXP07-19:
 - Shows that load-based testing leads to very different seasonal efficiencies than fixed-speed tests
 - Even for units with the same rated efficiency
 - Controls are a significant factor





Field Validation Study



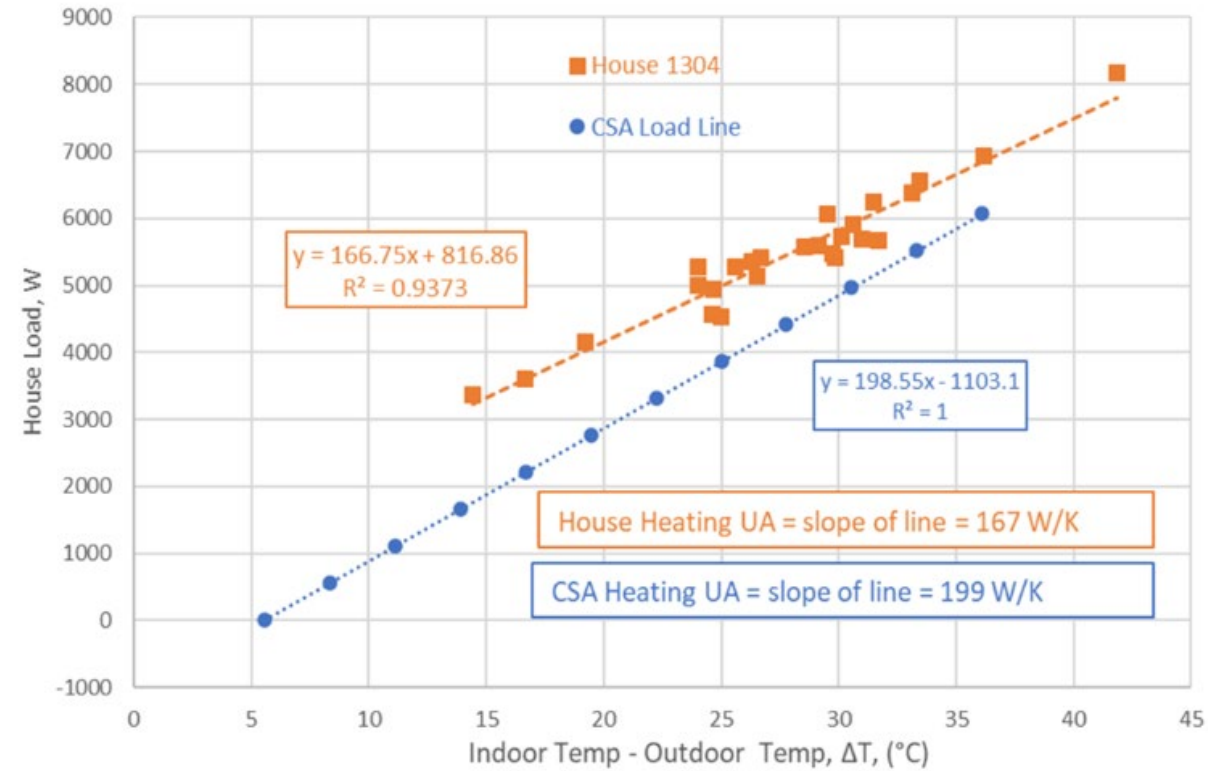
- This study is to establish how *representative* of field performance the rating methods are (both conventional and load-based)
- Study objective: compare the measured data from field operation with two test and rating methods:
 - Load-based test and rating method – **CSA SPE07-23**
 - Fixed-speed test and rating method – **AHRI 210/240-2023 (2020)**
- Broadly speaking, to test ***the test methods*** (not “test the products”)



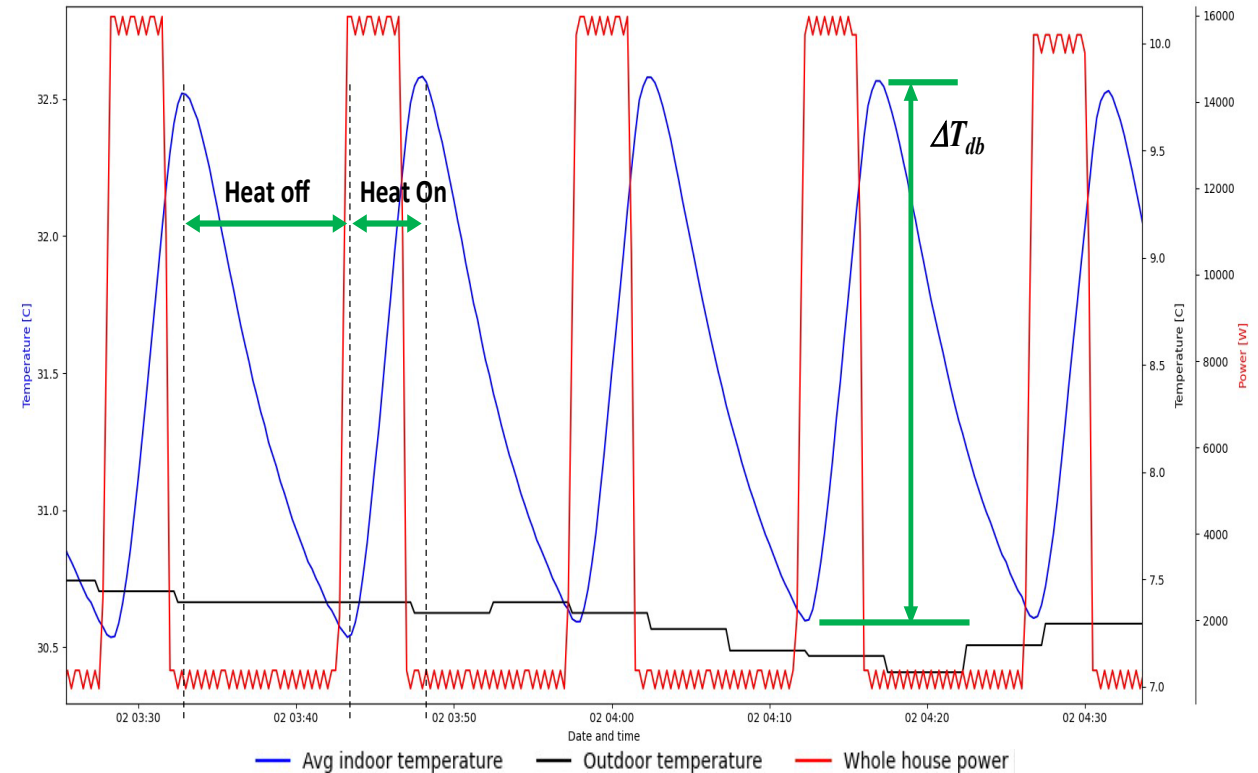
Field Study (Phase 1)



- Set up in Lincoln, Nebraska, US. August 2022
- 3 unoccupied mobile homes, 2 heat pumps in each
 - 1 ducted, 1 ductless (total of 4 manufacturers)
 - Alternating units used in each house, twice each week (3-4 days/week)
 - Scheduled internal gains (sensible and latent)
- Prior to unit installation, thermal load (UA) and shallow mass capacitance were estimated and adjusted
 - Heating load using electric heaters only
 - Capacitance by measuring cycling rates of homes' built-in furnaces



Load vs. outdoor temperature



Cycling time constant and deadband



Adjustments made to homes

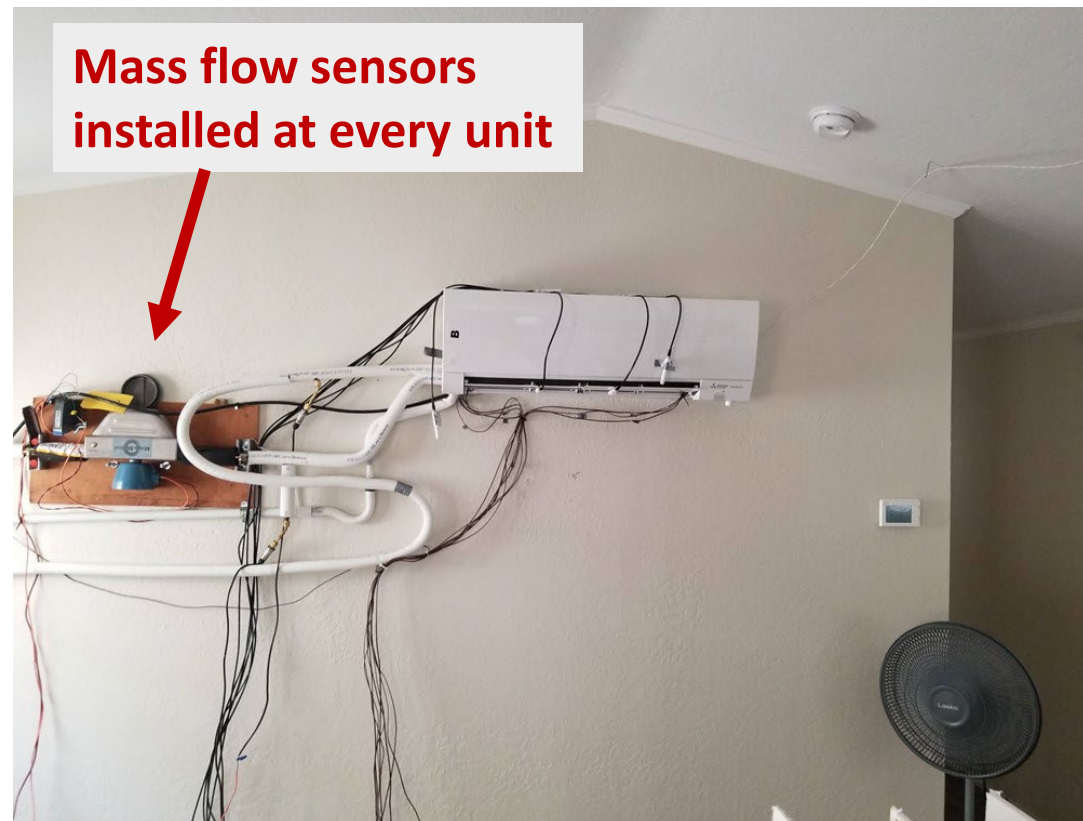


Steel window panels increased load



Added drywall to increase mass

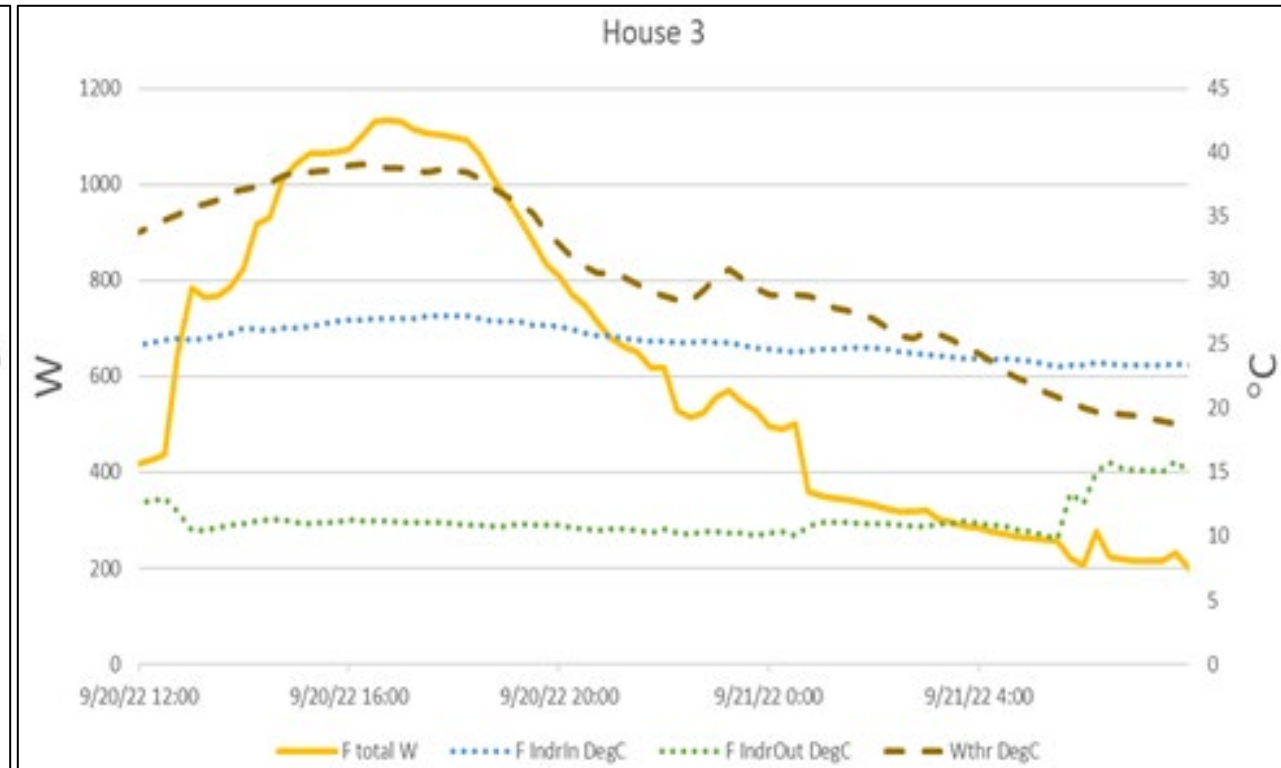
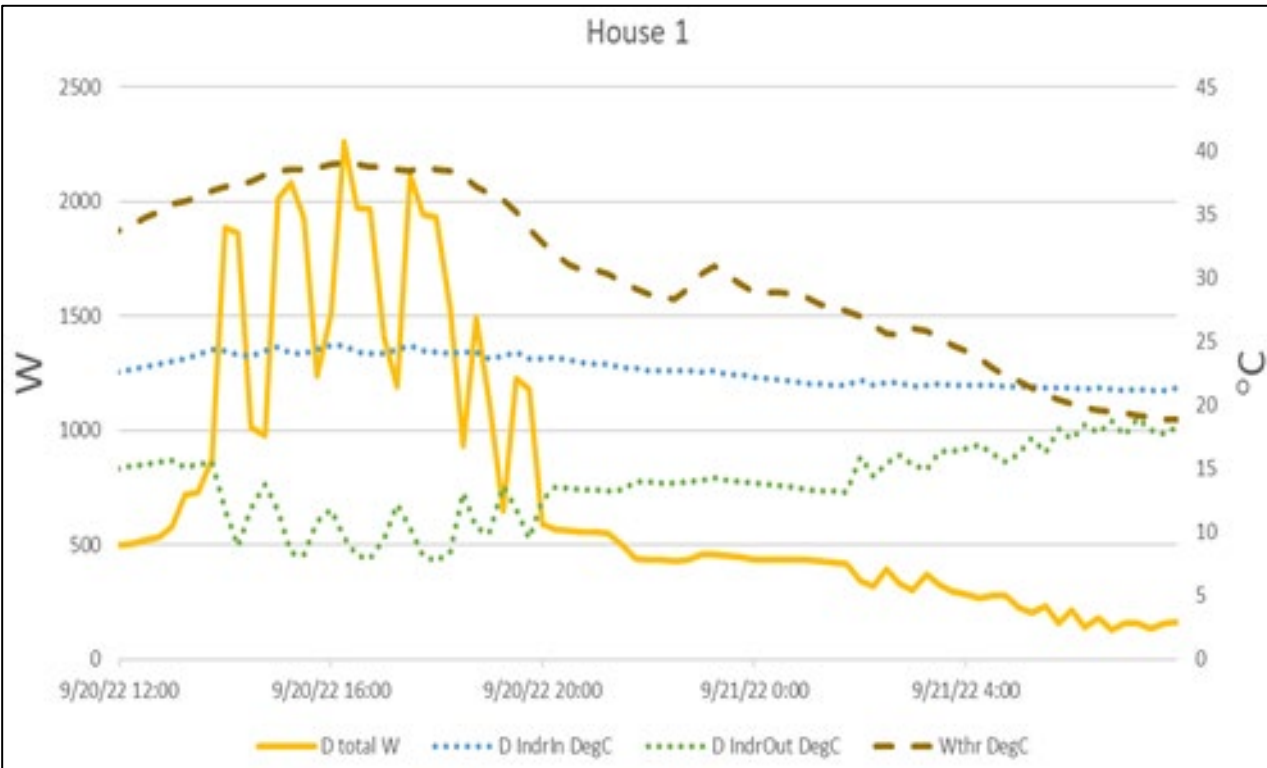
Instrumentation ~100 measurements/home



Ducted (L) and ductless (R) units installed



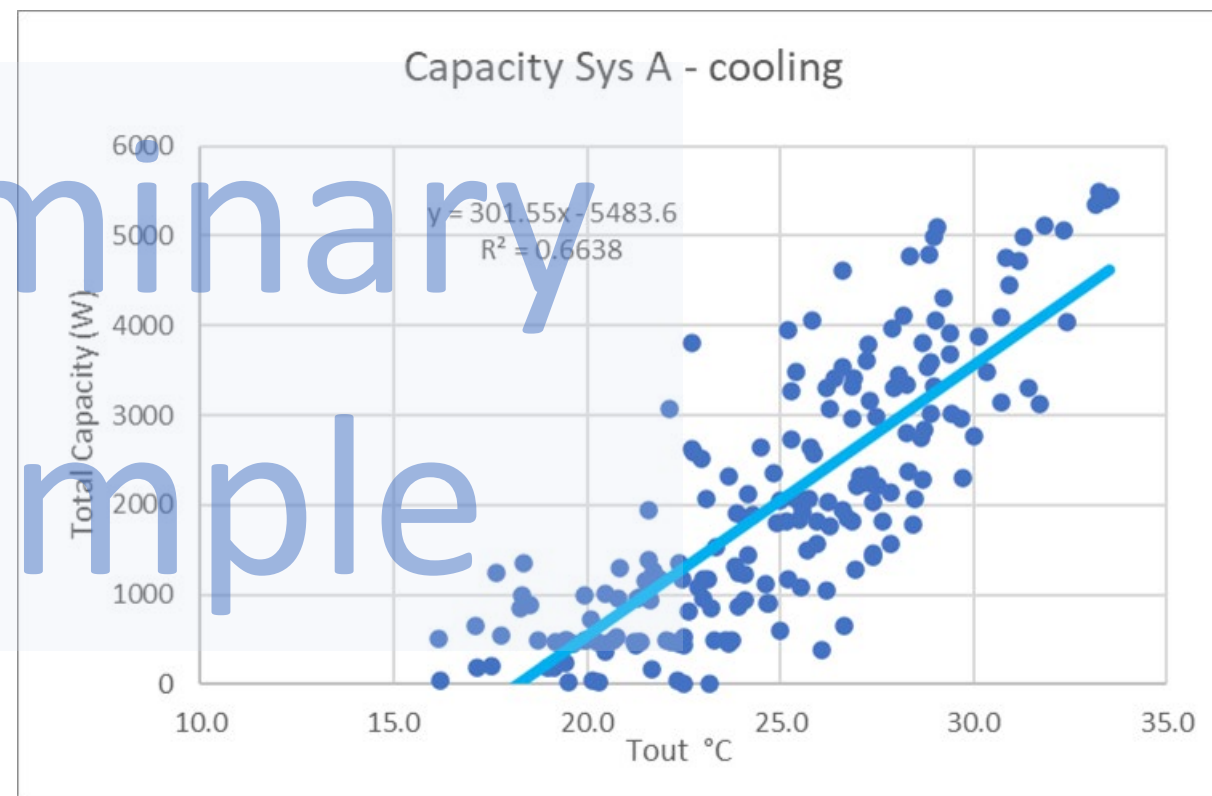
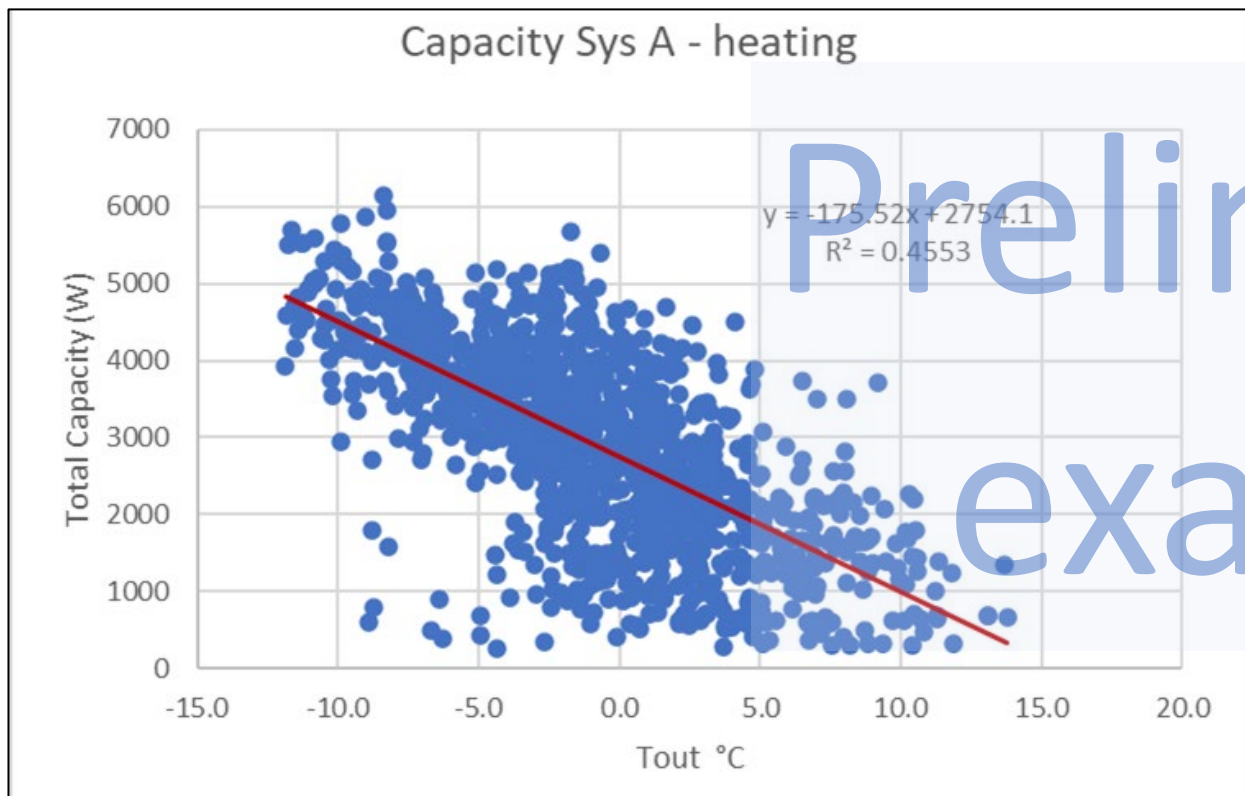
Two ductless, 39 °C peak afternoon/evening



1st unit swings widely - 2nd modulates smoothly. 2nd uses 30% less energy



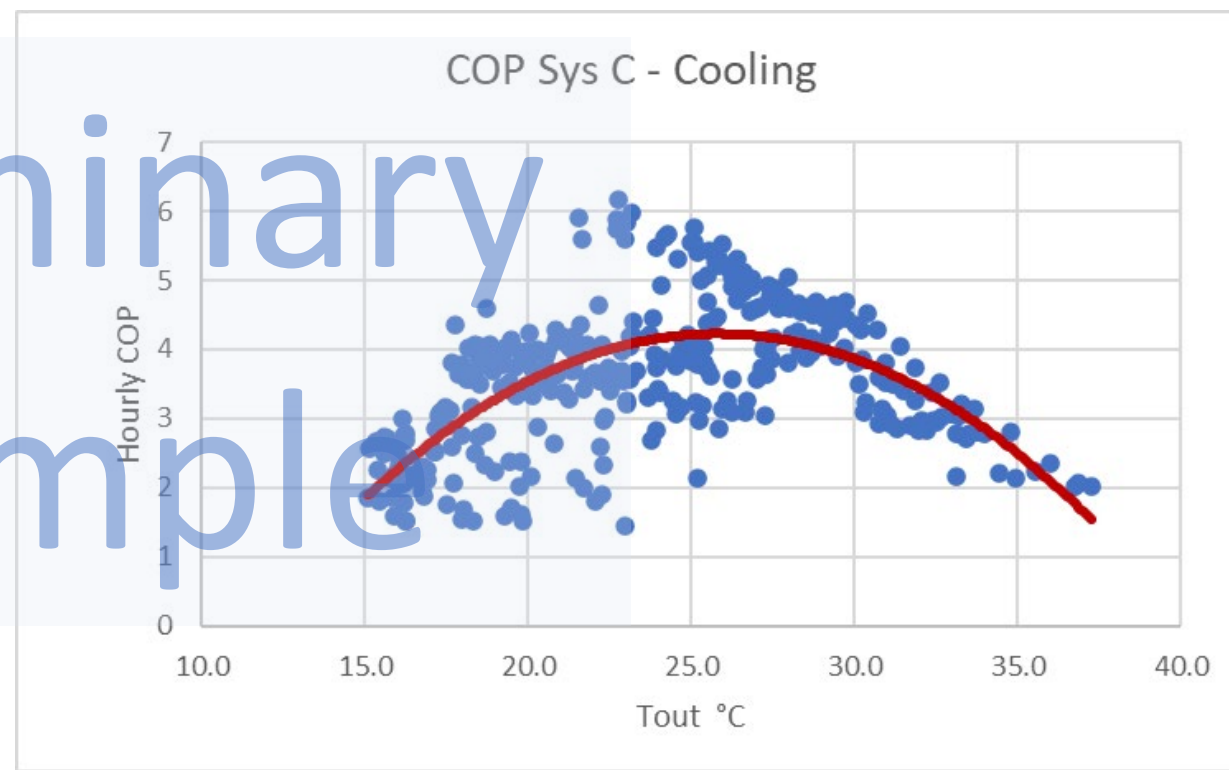
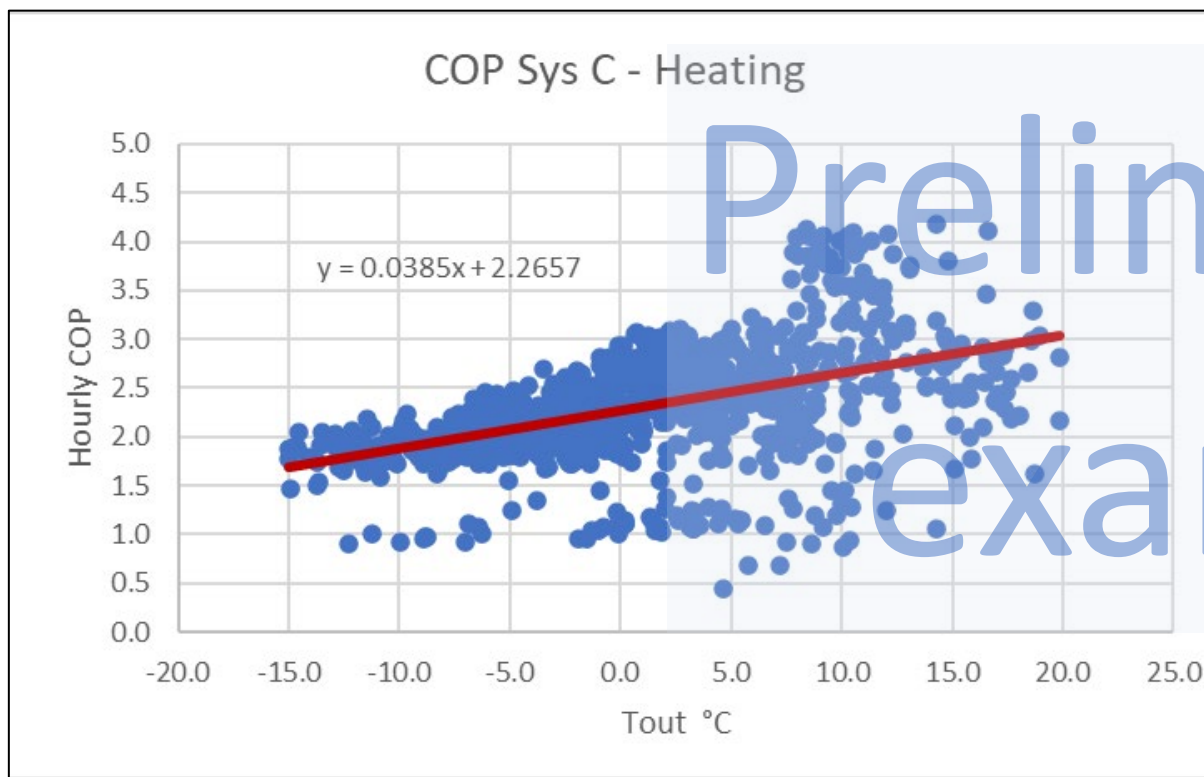
Hourly load profile of system A



Heating (L) and Cooling (R) – W/K will be basis of load-based lab test



Hourly COP profile of system C



Heating (L) and Cooling (R) – COP profiles vs. outdoor temperature



Current project status and Phase 2:



- Test period: Cooling 2022 Aug – Oct; Heating Oct – 2023 March
 - Still analyzing refrigerant-side measurements from field
- Units were shipped to load-based test lab in Plano, TX
- First unit is being tested, will continue until all are done
- Field results will be normalized and binned to weather conditions
 - Object: estimate normalized seasonal efficiency for each unit
 - Load-based and fixed-speed seasonal efficiency ratings can be compared
- Other operating parameters and some supplemental lab tests will be compared (controls verification “CVP” tests, others)
- Final report ~ end of 2024

Thank you!

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