NW Ductless Heat Pump PROJECT

Ductless Heat Pump Performance Results

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Northwest Ductless Heat Pump Pilot Project

Impact and Process Evaluation: Status Update and Lab Test Findings

NORTHWEST ENERGY EFFICIENCY ALLIANCE

Agenda

Introduction

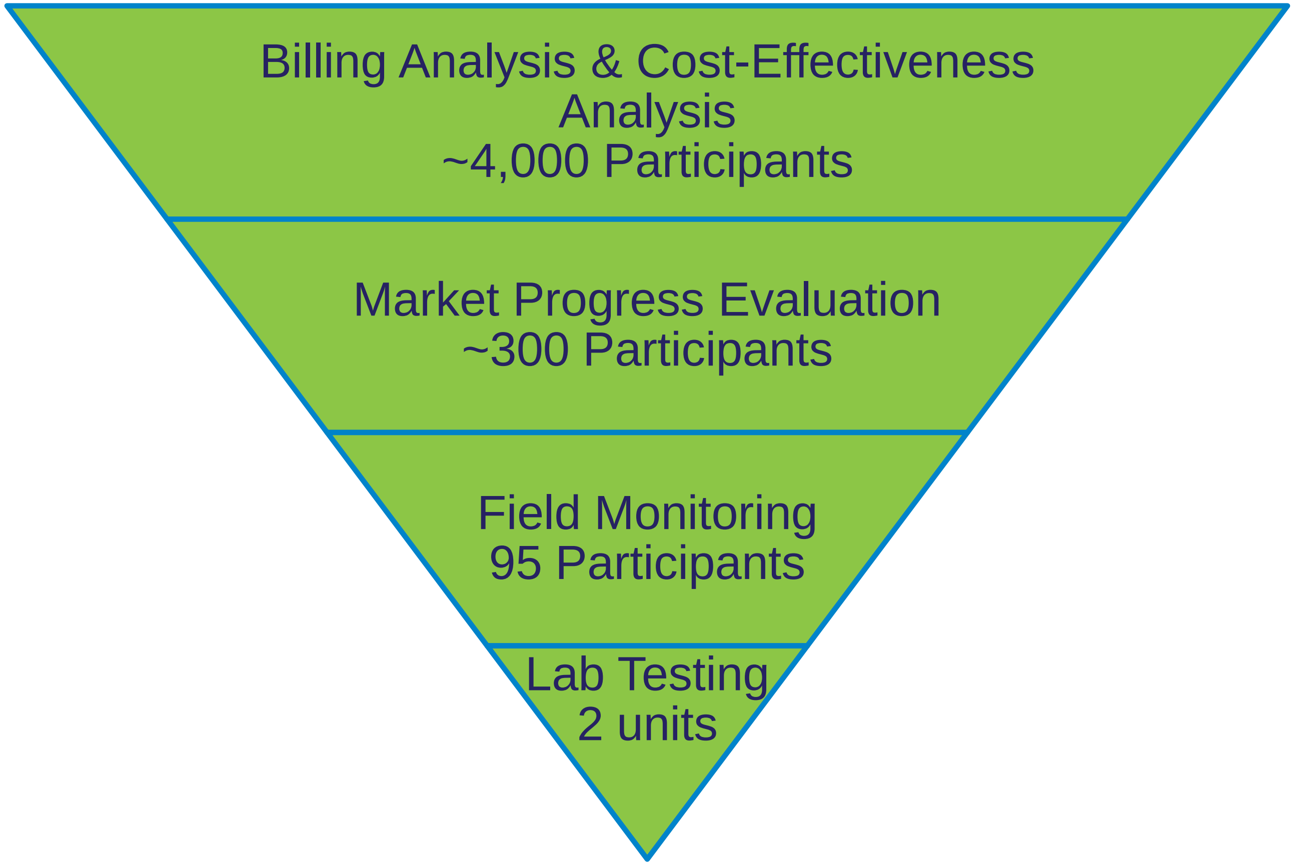
Overview & Timeline

Performance Evaluation Goals

Lab Findings

Q & A

DHP Impact & Process Evaluation Overview



DHP Evaluation Timeline

2009
- Q2 – Q4 = install field meters
- Q3 = launch lab tests
- Q2 – Q3 = collect data for Wave 1 market progress evaluation

2010
- Q1 = Wave 1 market progress report
- Q2 – Q3 = collect data for Wave 2 market progress report

2011
- Q1 = lab analysis report and Wave 2 market progress report
- Q2 = decommission field sites
- Q4 = field monitoring analysis report

2012
- Q1 = billing analysis report
- Q2 = cost-effectiveness analysis
- Q3 = final summary report

DHP Performance Evaluation Goals

- Use a tiered analysis approach to get a comprehensive understanding of DHP performance
- Assess the viability of DHP as a electricity conservation resource
  - Focus on electric resistance zonal heating
  - Assess the interaction with occupants
  - Quantify the cooling interaction in various climate zones
- Assess the impact of the displacement model of system design
- Develop energy savings assessments
  - What determines savings?
  - What is the improvement in heating efficiency ?
  - What are the impacts of climate?
  - What are the impacts of wood heat?
- Assess cost effectiveness of DHPs as a conservation resource
  - Costs of installation
  - Benefits for the utility
  - Benefits for the consumer

Lab Testing: Purpose and Goals

- Develop a performance map of the equipment at all temperature bins and operating modes
  - AHRI ratings exist for DHPs but provide only limited information on performance
  - Assess low temperature performance
- Assess performance variation with various control strategies and operating modes
- Conduct measurements to verify and inform the data collected in the field metering
- Establish empirical performance curves to predict the efficiency and output of the equipment in simulations (SEEM) or other engineering calculations.

→ Directly support:

  - Conservation program design
  - Regional planning efforts

Broad Methodology Summary

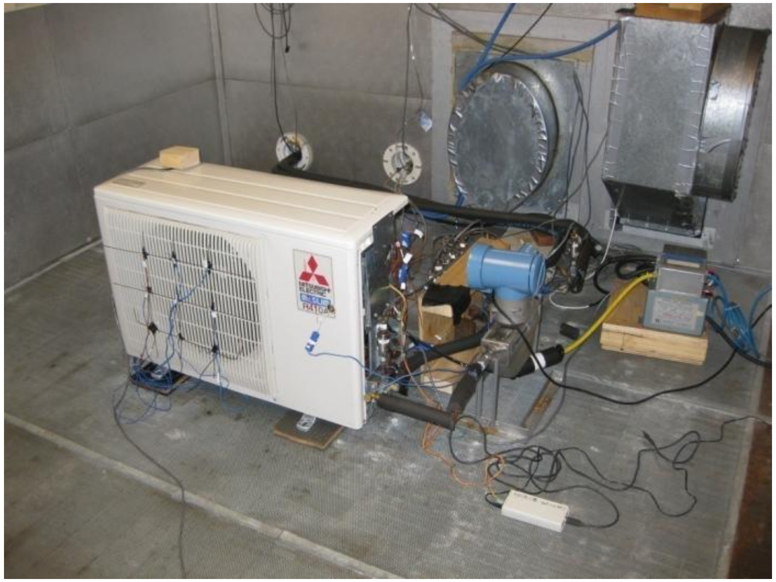
- Install indoor and outdoor units in separate, controllable environments
  - Vary environmental conditions over range of interest: Tout -5F to 105F
  - Vary equipment operating modes and observe performance:
    - Compressor power: high/med/low
    - Fan speed: high/med/low
- Use procedures adhering to industry standards:
  - ASHRAE Standard 116 and AHRI Standard 210/240

Test Suite

- Steady-state measurements of efficiency and output with variations in outdoor temperature (and RH), indoor temperature (and RH), indoor fan speed, and compressor power
- Additional tests with wet and dry indoor coils, outdoor defrost conditions, and equipment on/off cycling
- Heating and cooling modes
- Full set of AHRI rating point tests

Facility: Herrick Labs

Measurements conducted by Herrick Labs at Purdue University using two side-by-side psychrometric chambers. Each chamber provides an independently controlled temperature and humidity environment.



- Outdoor unit installed in chamber with instrumentation

- Indoor unit installed in chamber connected to an outlet plenum (green insulated box) for airflow & temperature measurement

Equipment Specifications

Data from manufacturers catalogs:

Model:		UNIT A		UNIT B	
	Units	Rated*	Range	Rated*	Range
Cooling Capacity	Btu/hr	12,000	3,800-14,500	12,000	2,800-12,000
Heating Capacity	Btu/hr	16,000	3,100-24,000	13,600	3,000-21,000
Cooling Input Power	kW	0.83	0.20-1.53	0.93	0.16-0.96
Heating Input Power	kW	1.2	0.20-2.23	0.95	0.15-2.25
EER Cooling	Btu/hrW	14.46	--	12.9	--
COP Heating	kW/kW	3.9	--	4.2	--
SEER	Btu/hrW	25	--	23	--
HSPF (IV)	Btu/hrW	12	--	10.6	--
Defrost		Reverse Cycle		Reverse Cycle	
* Rating conditions: 47F outside temperature for heating. 95F for cooling. Compressor operation at manufacturer determined intermediate speed. Indoor fan on high flow rate.					

Prevalence of Equipment in Field Study

- Percent of installed models in field study:
  - Unit A: 7%
  - Unit B: 6%
- Field data has shown that certain models from the same manufacturer behave in very similar ways. Lab data provides insight into all of these units. Percent of similar units in field study:
  - Unit A: 32%
  - Unit B: 25%

Performance Mapping Results: Heating

Summary Findings:

- Both models demonstrate high performance
  - Provide a solid foundation on which to build electricity savings
- Both models perform well at low outdoor temperatures
  - Operation at all temperature ranges should be encouraged

Summary of Conclusions

- The lab data demonstrates the high performance of both models.
  - Both equipment models have the potential to deliver generous energy savings.
  - House will depend on a number of factors including the installation occupant behavior
- Lab and field COP measurements show good agreement.
  - Field data compares well to the lab measurements.
  - The field metering of COP shows which equipment operating modes are most common and therefore the most important parameters to measure in the lab.
- Both equipment models perform well at low outdoor temperatures.
  - Installers and home-owners should be made aware of equipment performance at low temperatures
- The current HSPF and SEER ratings are not well suited to DHPs.
  - The testing standard do not always produce ratings that characterize the range of performance
  - More data is needed to assess both the relative performance between models
  - An updated testing procedure should include changes to the testing conditions, compressor speeds in particular
- The equipment can be modeled in SEEM.

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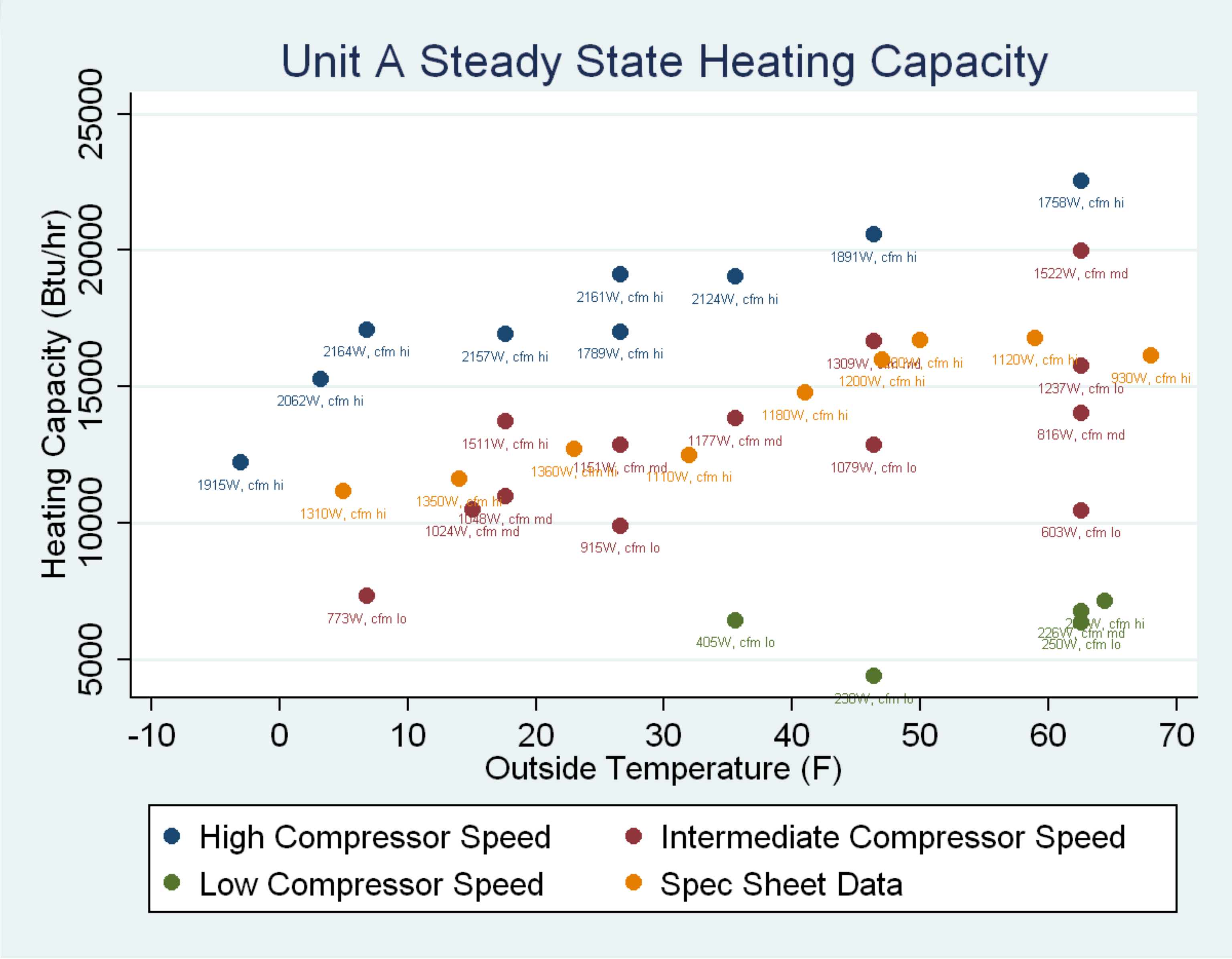
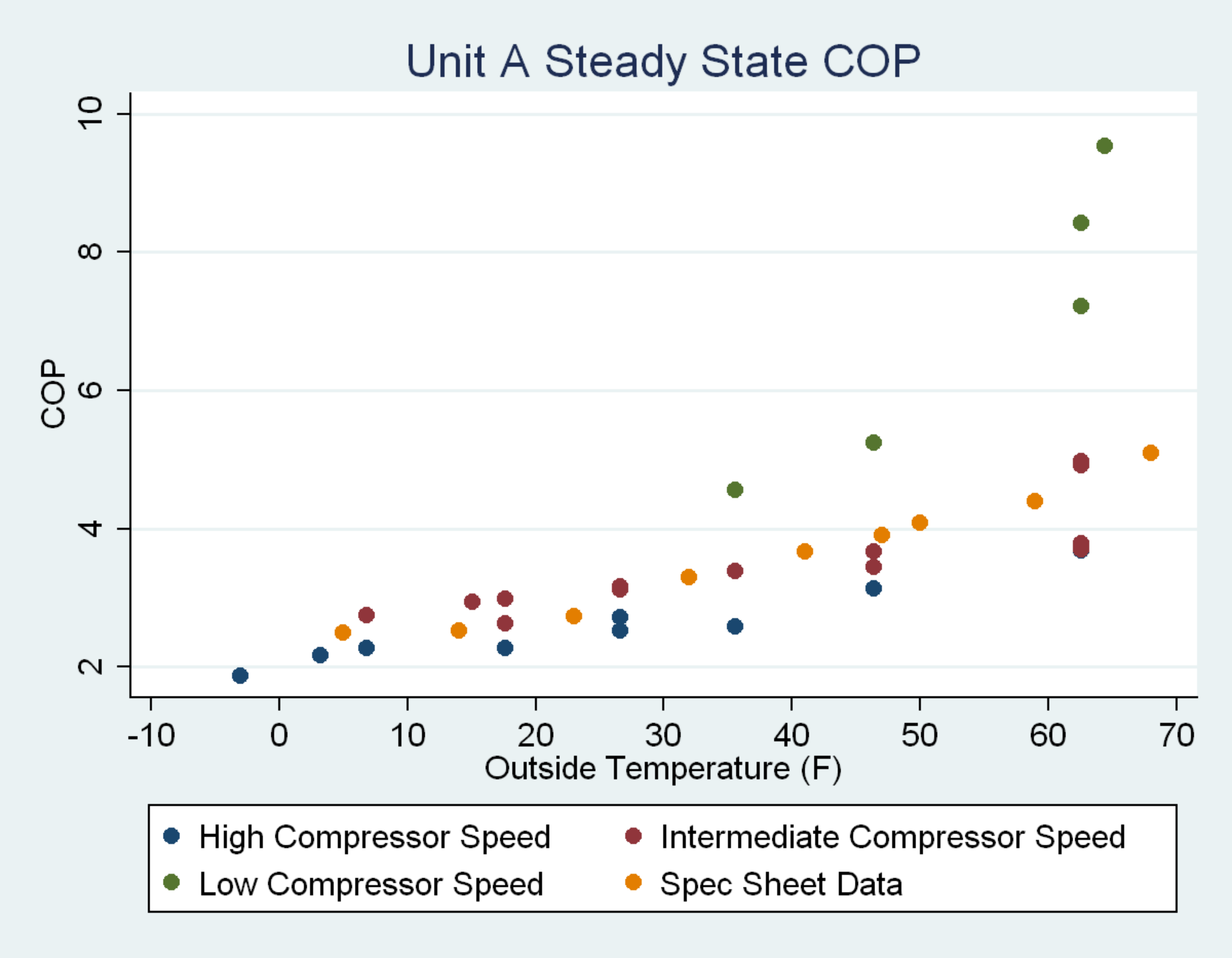
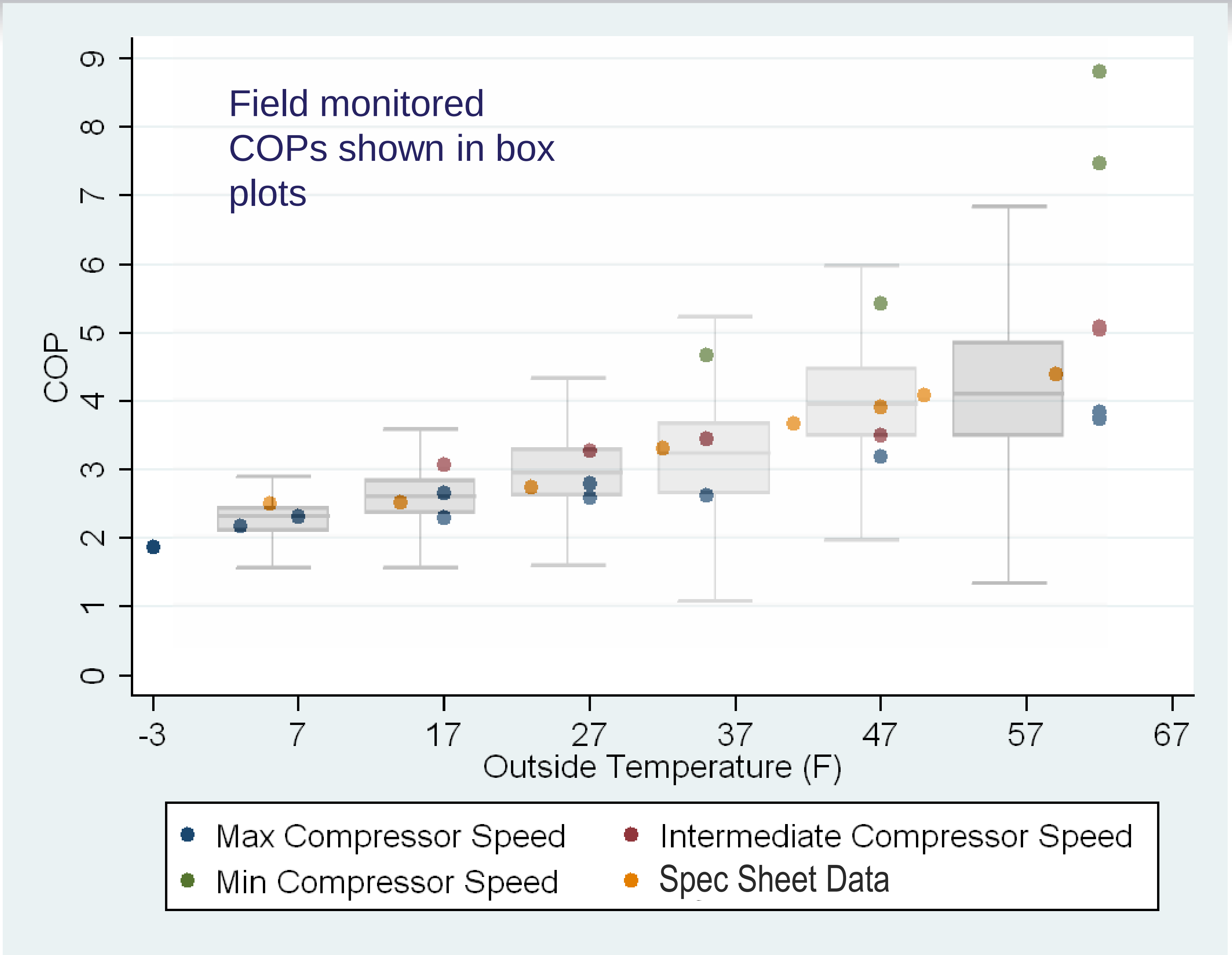
Unit A Steady State Heating Capacity



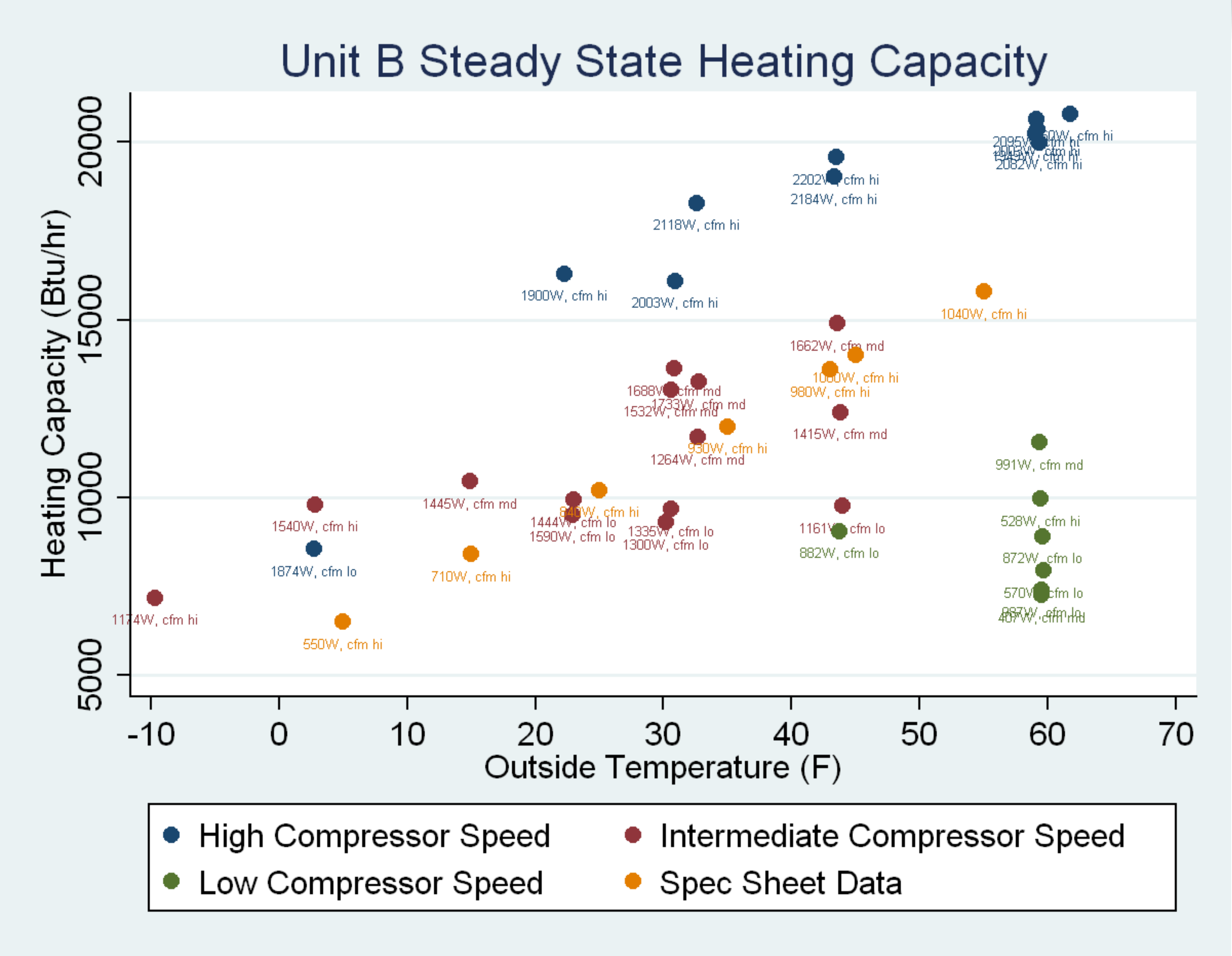
Unit A Steady State Heating COP



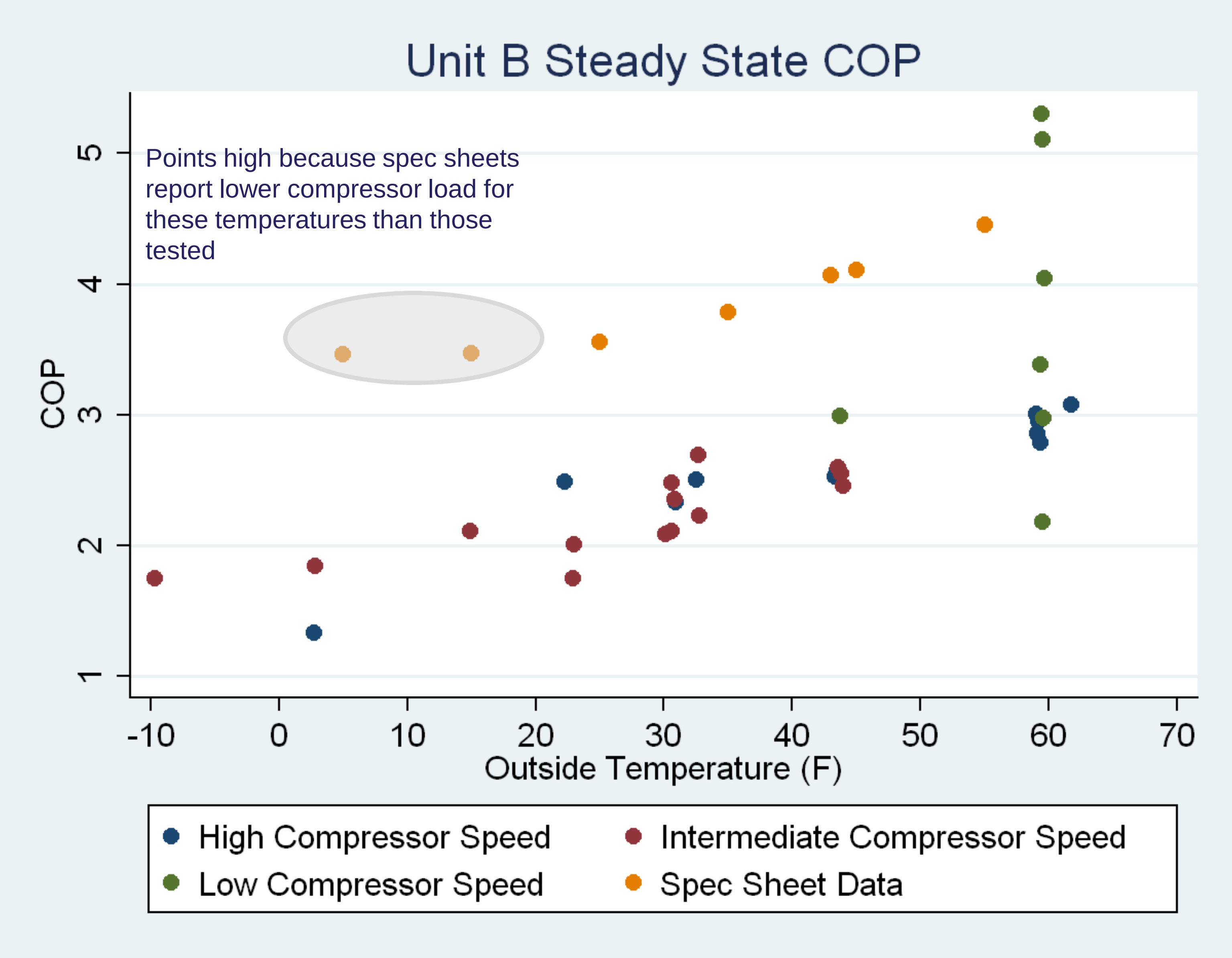
Unit A COP Lab & Field Data Comparison



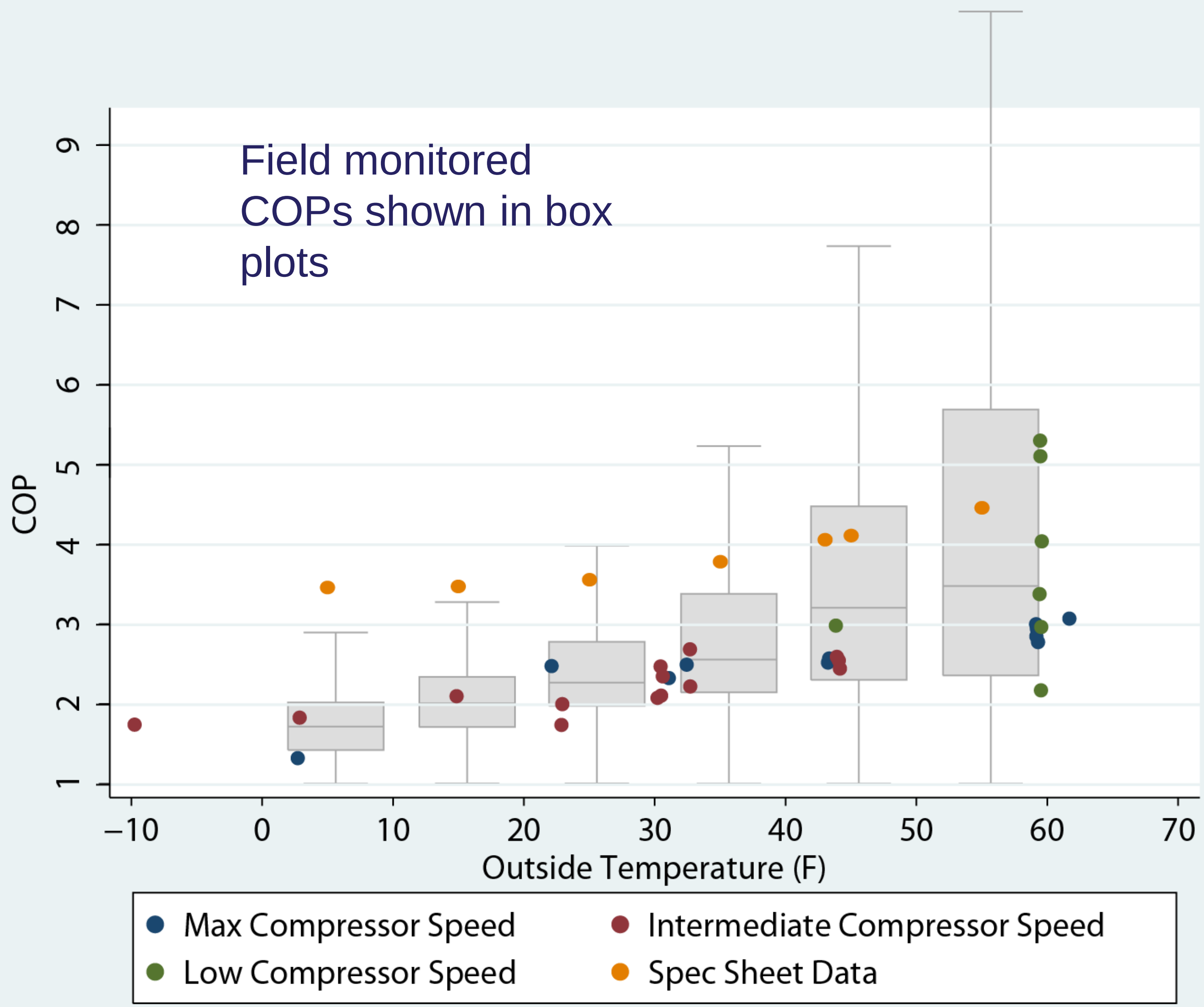
Unit B Steady State Heating Capacity



Unit B Steady State Heating COP



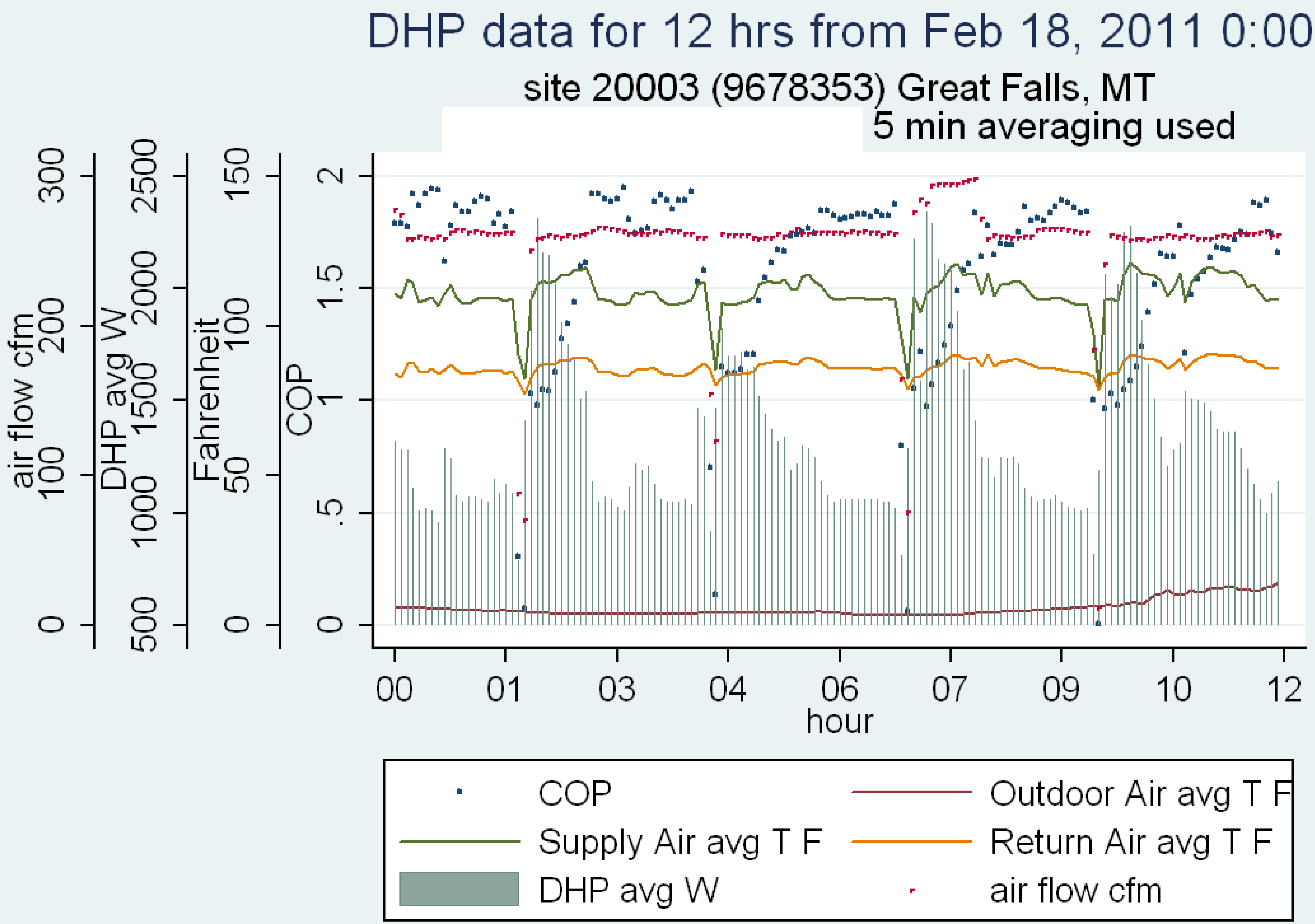
Unit B COP Lab and Field Data Comparison



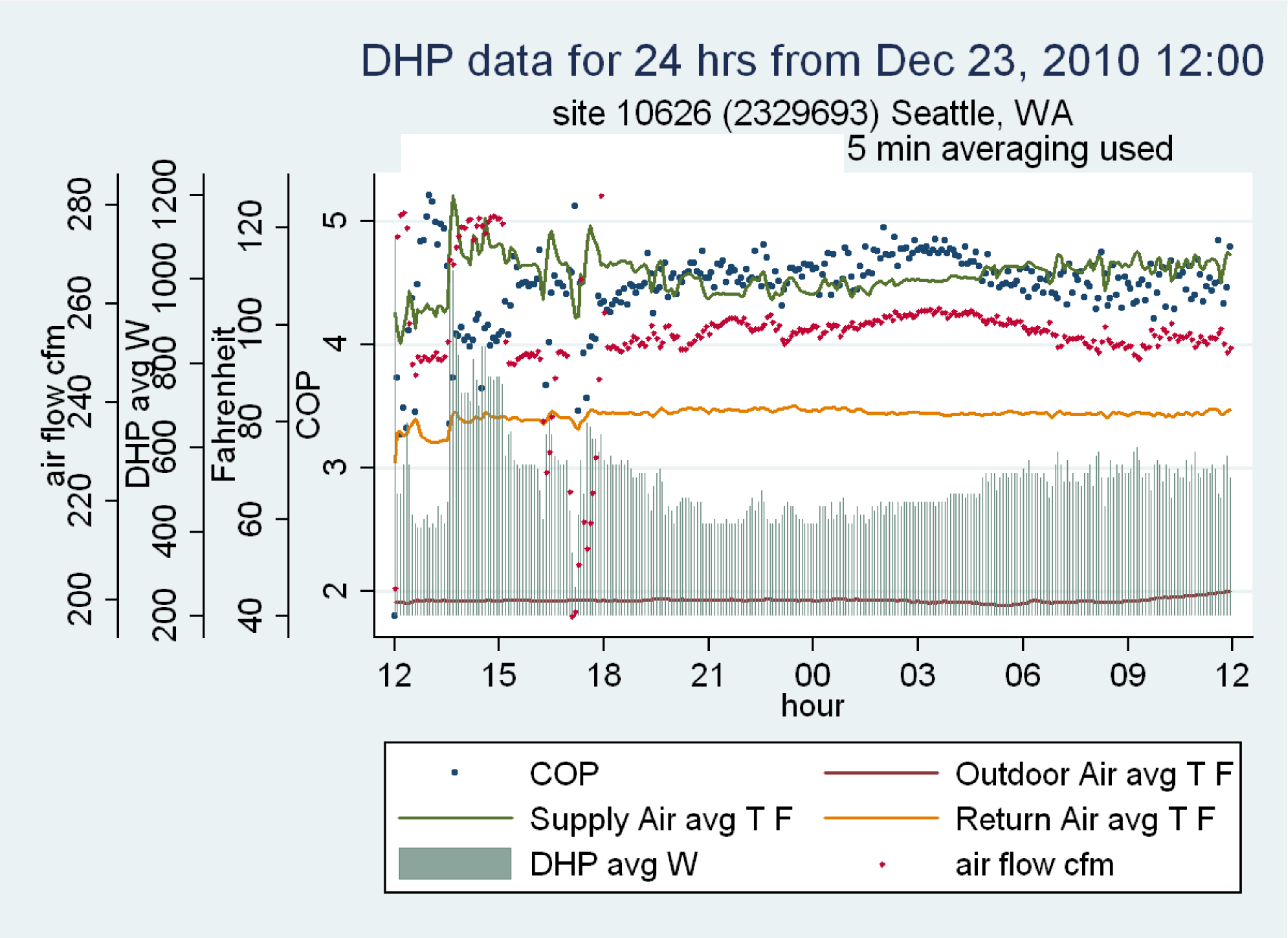
Field COP Metering

- Field metering shows the compressor performance
  - Strong tendency at fractional capacity
  - Very stable at fractional capacity
- Reasonable agreement with laboratory test results
- Good performance at low temperatures
- Both pieces of equipment show good field performance

Unit B Sample Field Data Plot, 5-15°F



Unit B Sample Field Data, 40F Outside



Heating Performance Model

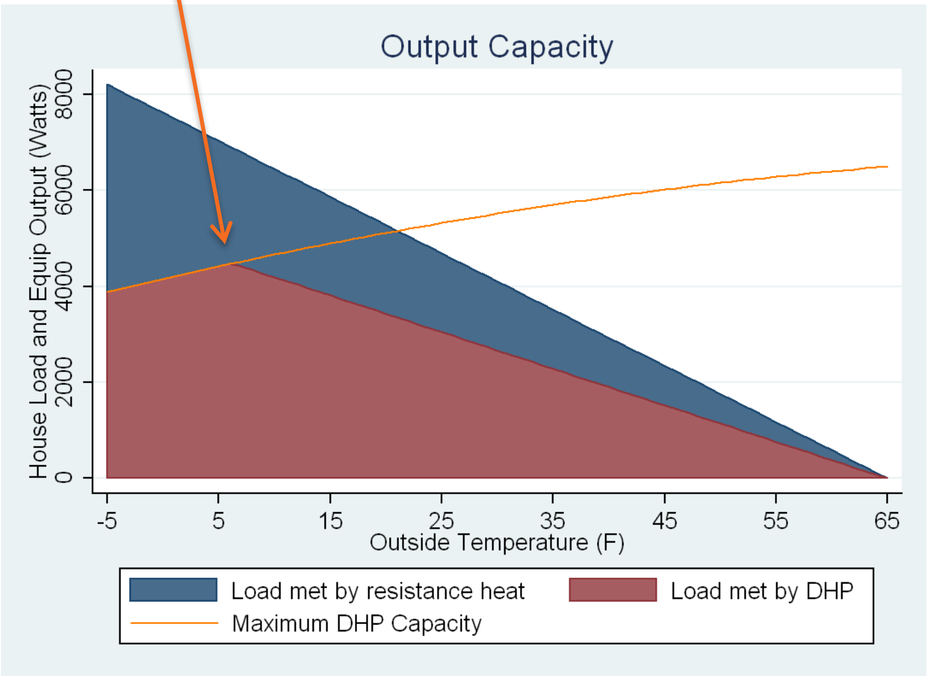
Example:

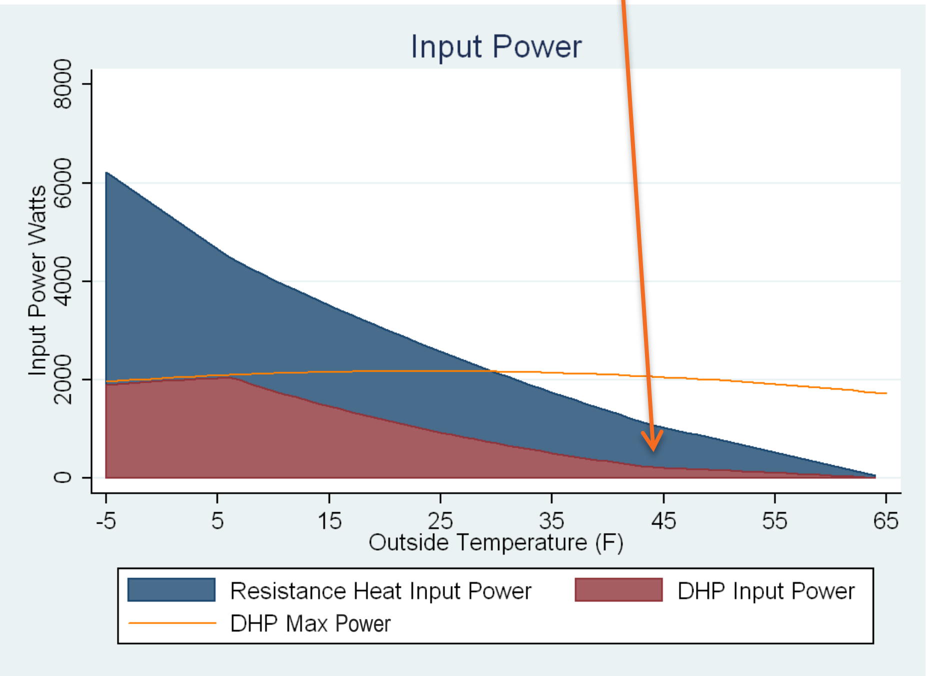
- House UA=400Btu/hrF. 65F balance point.
- DHP assumed to heat 65% of house. Remaining 35% heated with resistance baseboards.
- Using "Unit A" DHP. Defrost not yet in model

- DHP capacity increases to match load until maximum output reached (near 5°F).
- Simultaneously, DHP input power is also increasing (not linearly – this follows the empirical performance curve) until maximum is reached.
- After maximum DHP output is reached, the house is heated with as much resistance heat (>35%) as needed in the colder temperature bins

Maximum DHP output reached

Load so low that DHP begins cycling; reducing efficiency

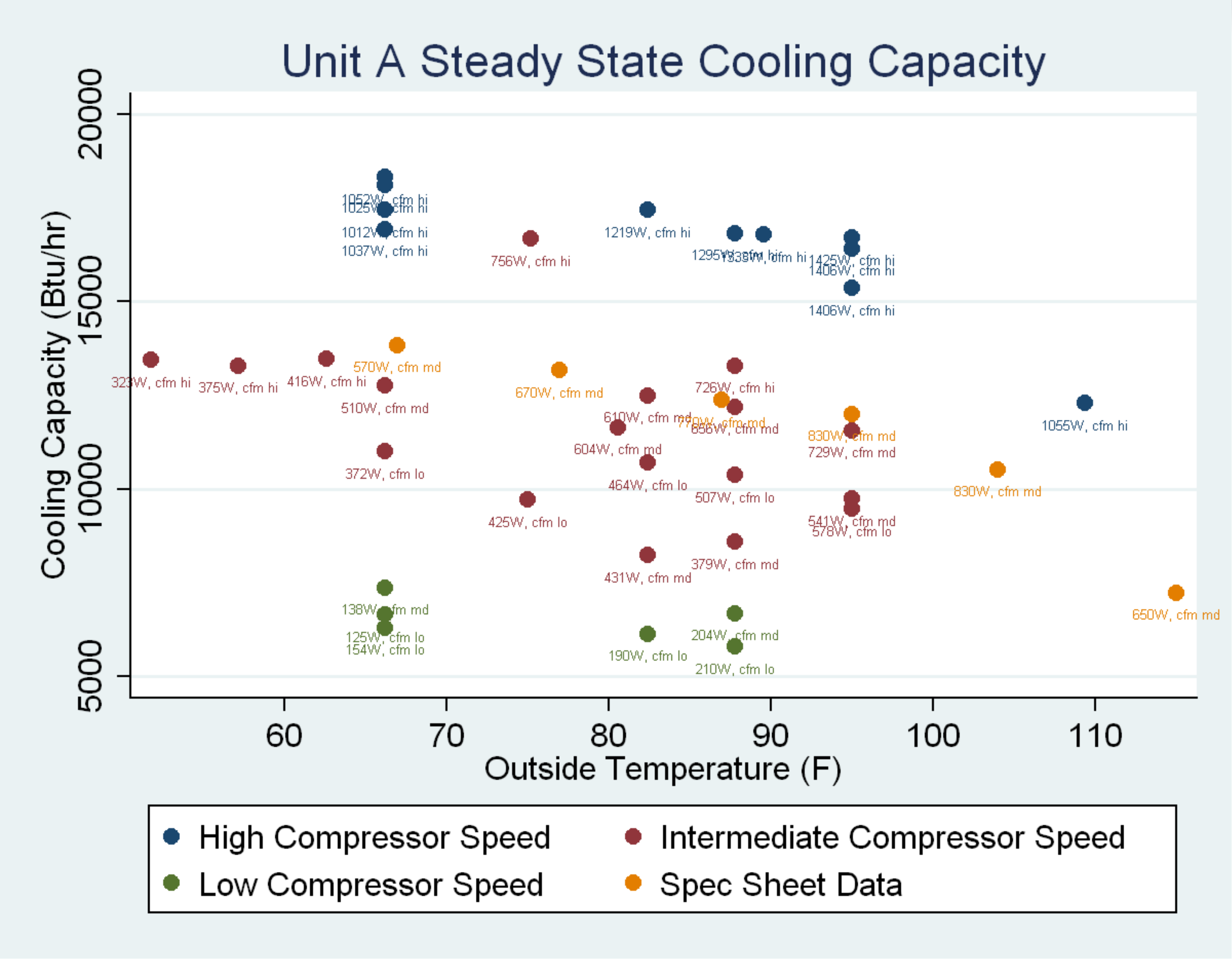




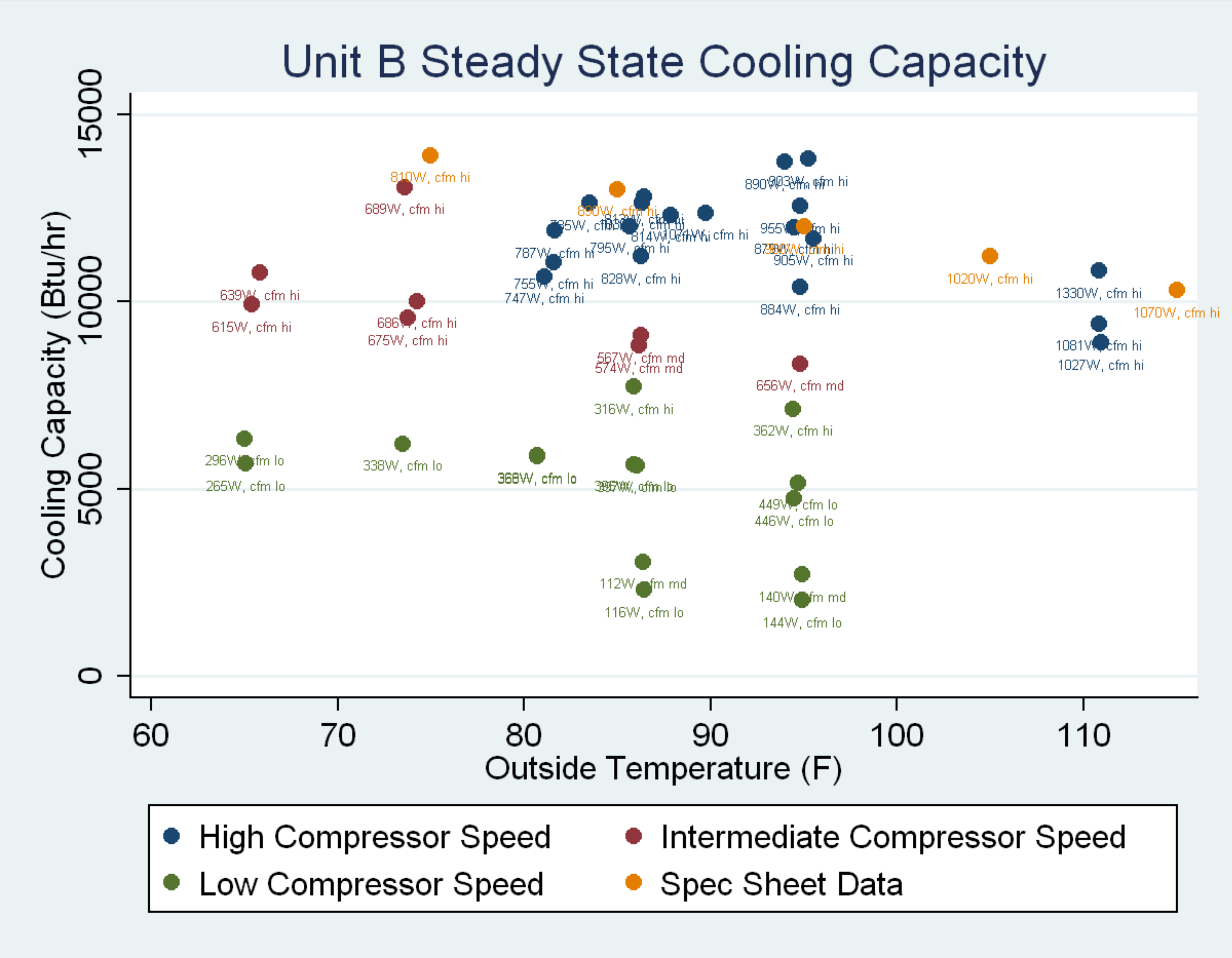
Cooling

- Similar to heating, both models show high performance levels
  - SEER= 16 to 17
  - Rated points somewhat higher SEER=23 to 25
- Very good cooling performance for real conditions

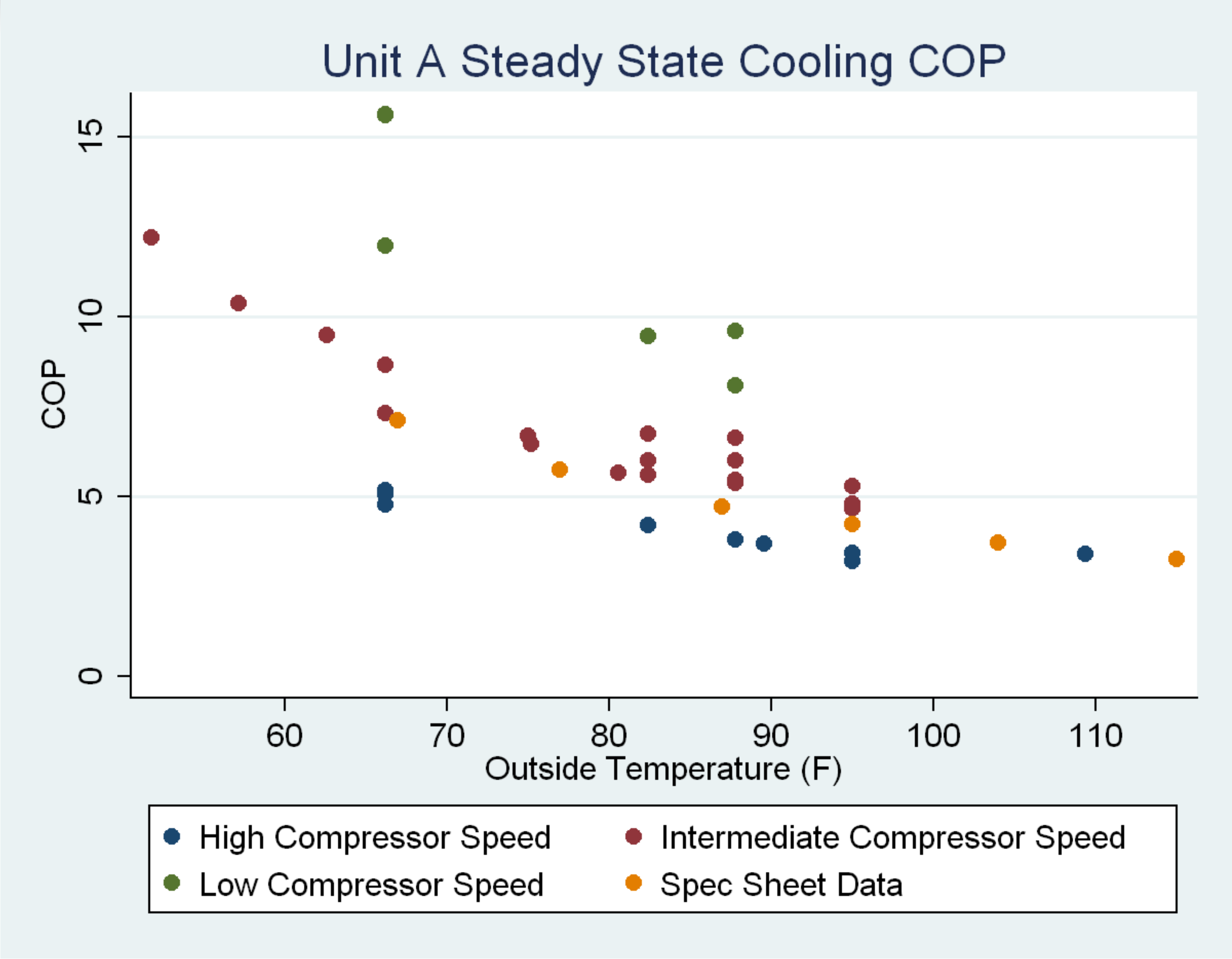
Unit A Steady State Cooling Capacity



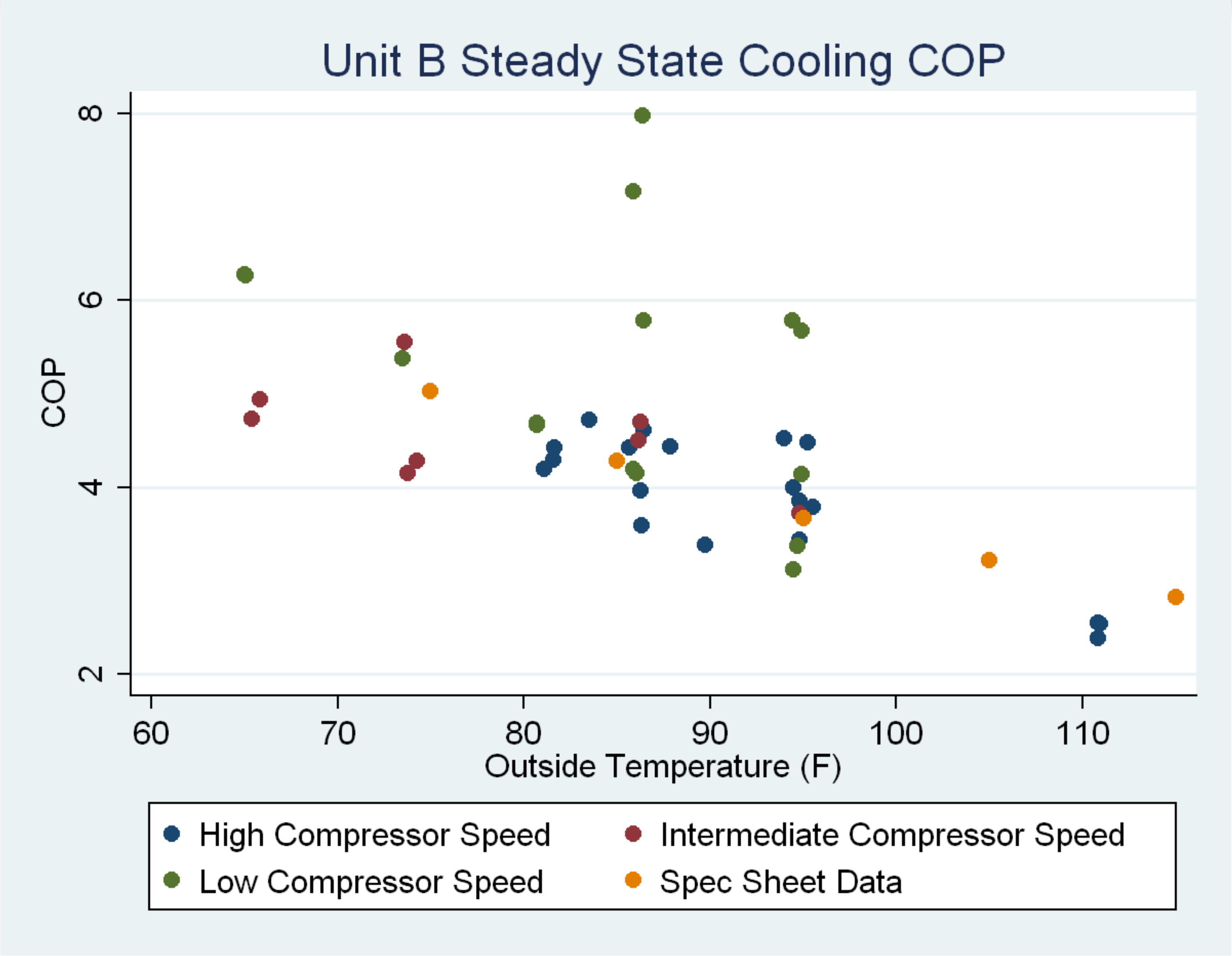
Unit B Steady State Cooling Capacity



Unit A Steady State Cooling COP



Unit B Steady State Cooling COP



Questions and Answers