



Heat Pump Water Heaters: Fact or Fiction?

Presenters:

Kacie Bedney, BPA Engineering Team
Chuck Weseman, Hood River Electric Coop
Kevin Watier, Snohomish County PUD
Jeff Harris, NEEA's Emerging Technology Team



Kacie Bedney, Engineer Bonneville Power Administration

Heat Pump Water Heaters Tested



GE
50-gallon



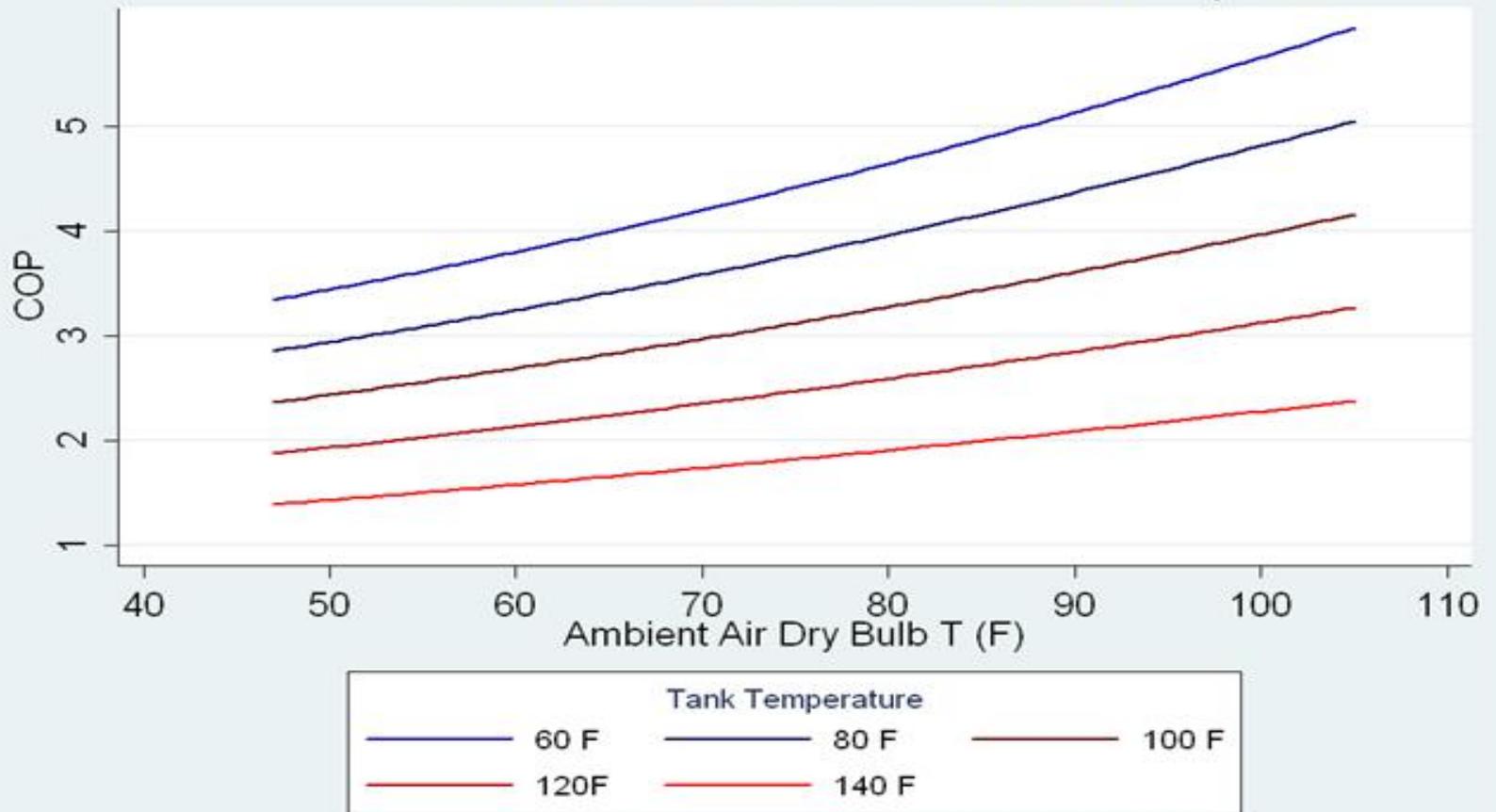
AO Smith
80-gallon



Rheem
50-gallon

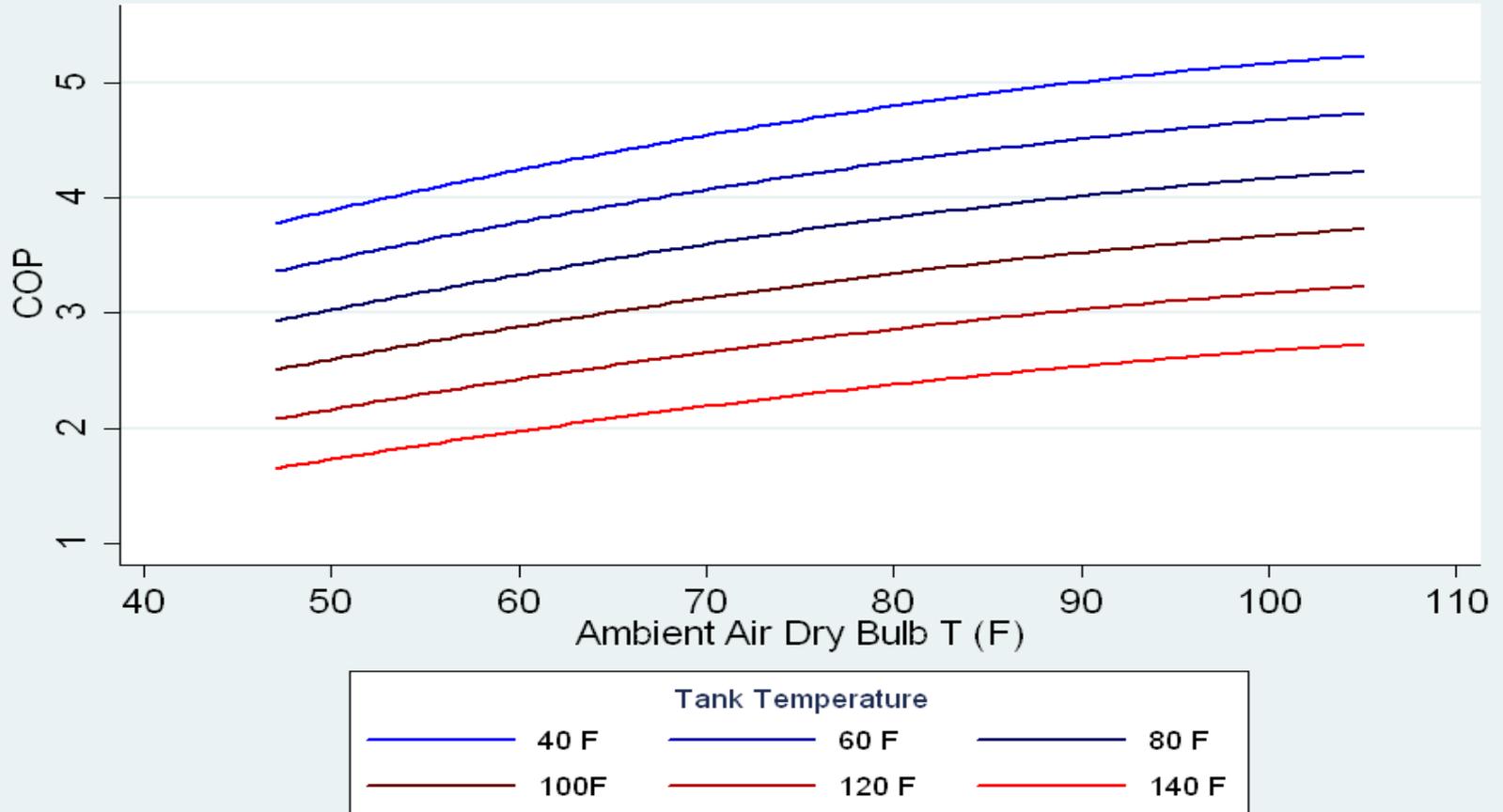
Our Lab Story:

Manufacturer A: HPWH COP vs Ambient Air Temperature



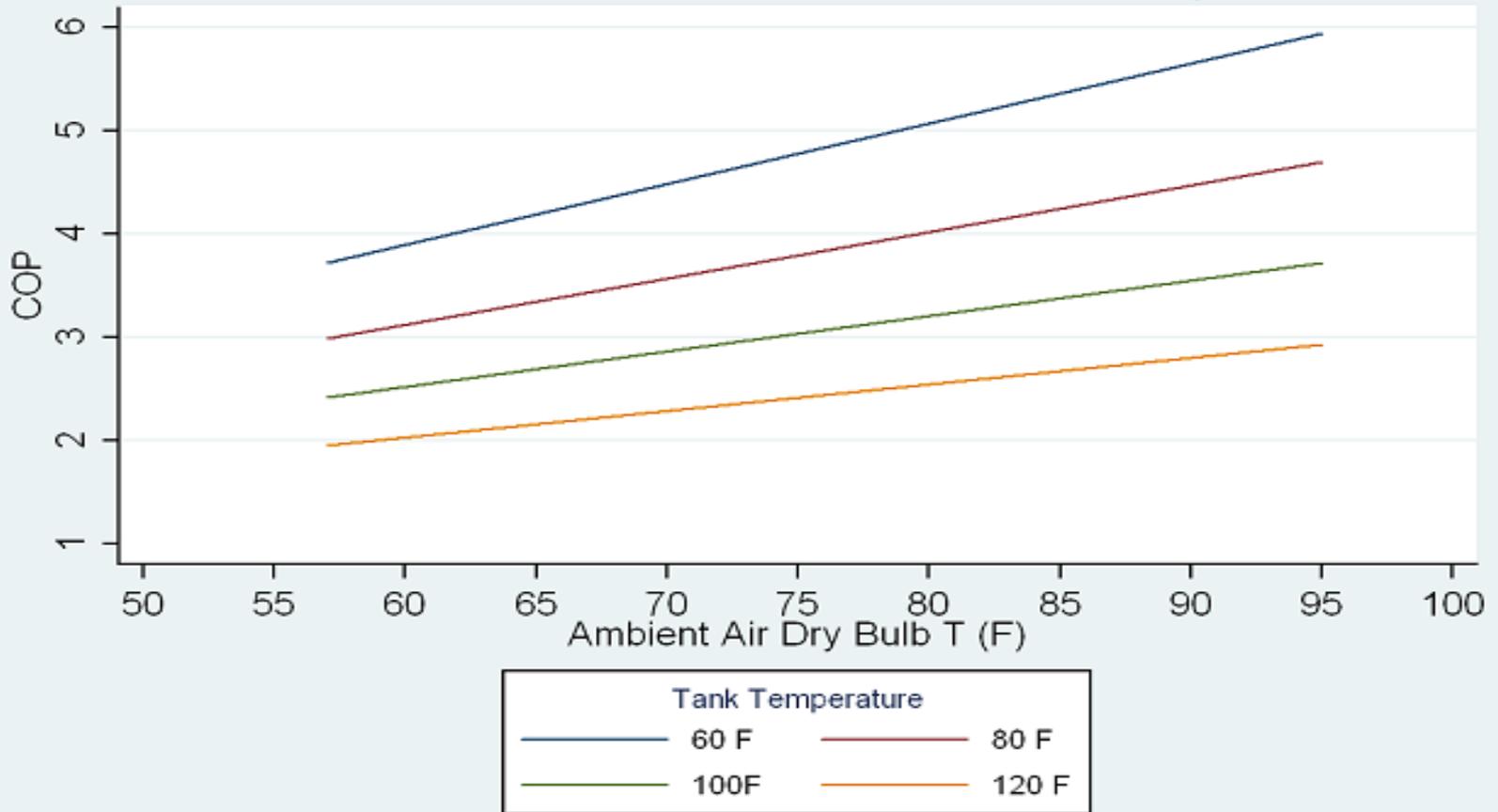
Our Lab Story:

Manufacturer B: HPWH COP vs Ambient Air Temperature



Our Lab Story:

Manufacturer C: HPWH COP vs Ambient Air Temperature

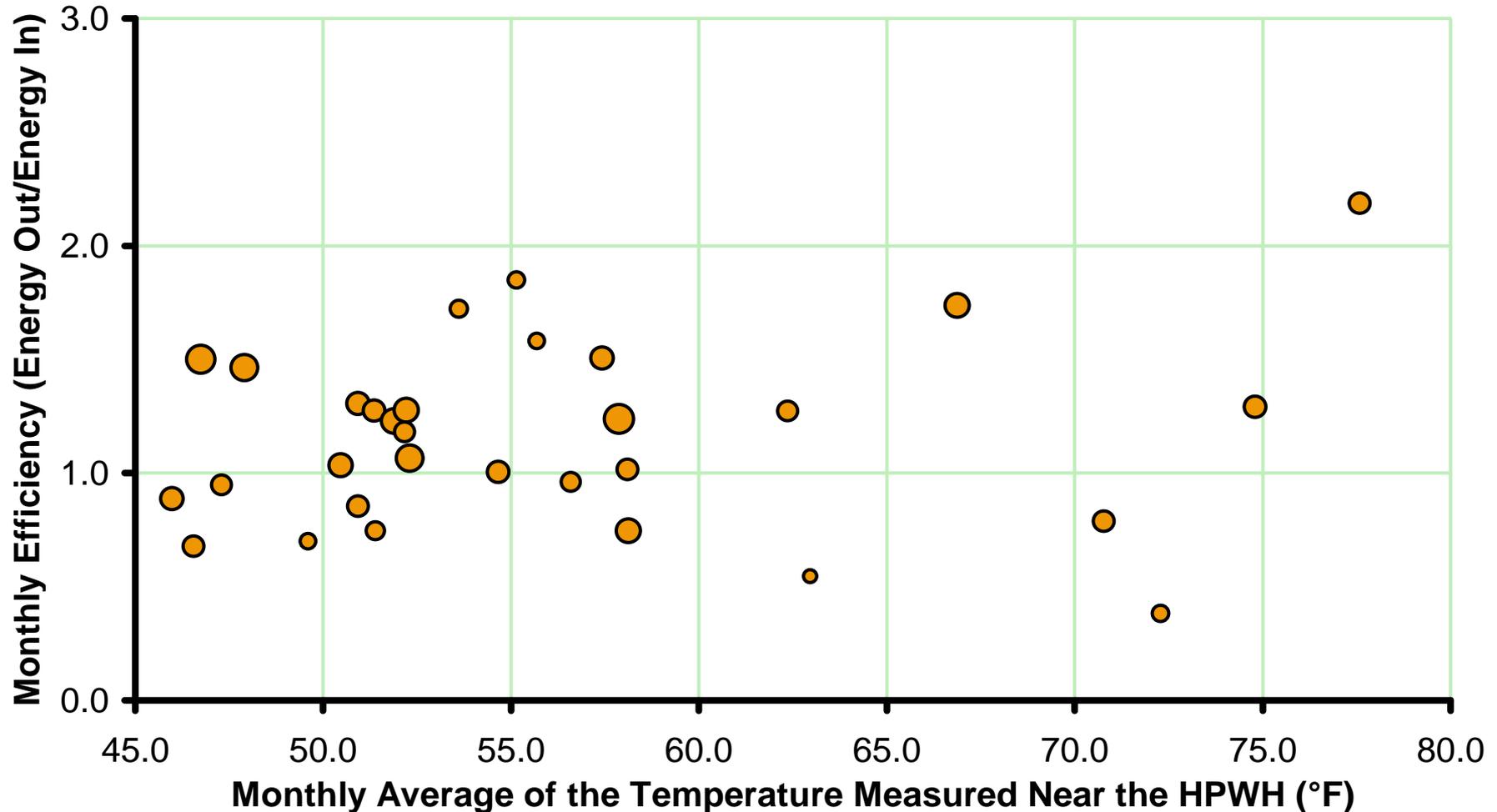


HPWH BPA / EPRI Demonstration

Research objectives:

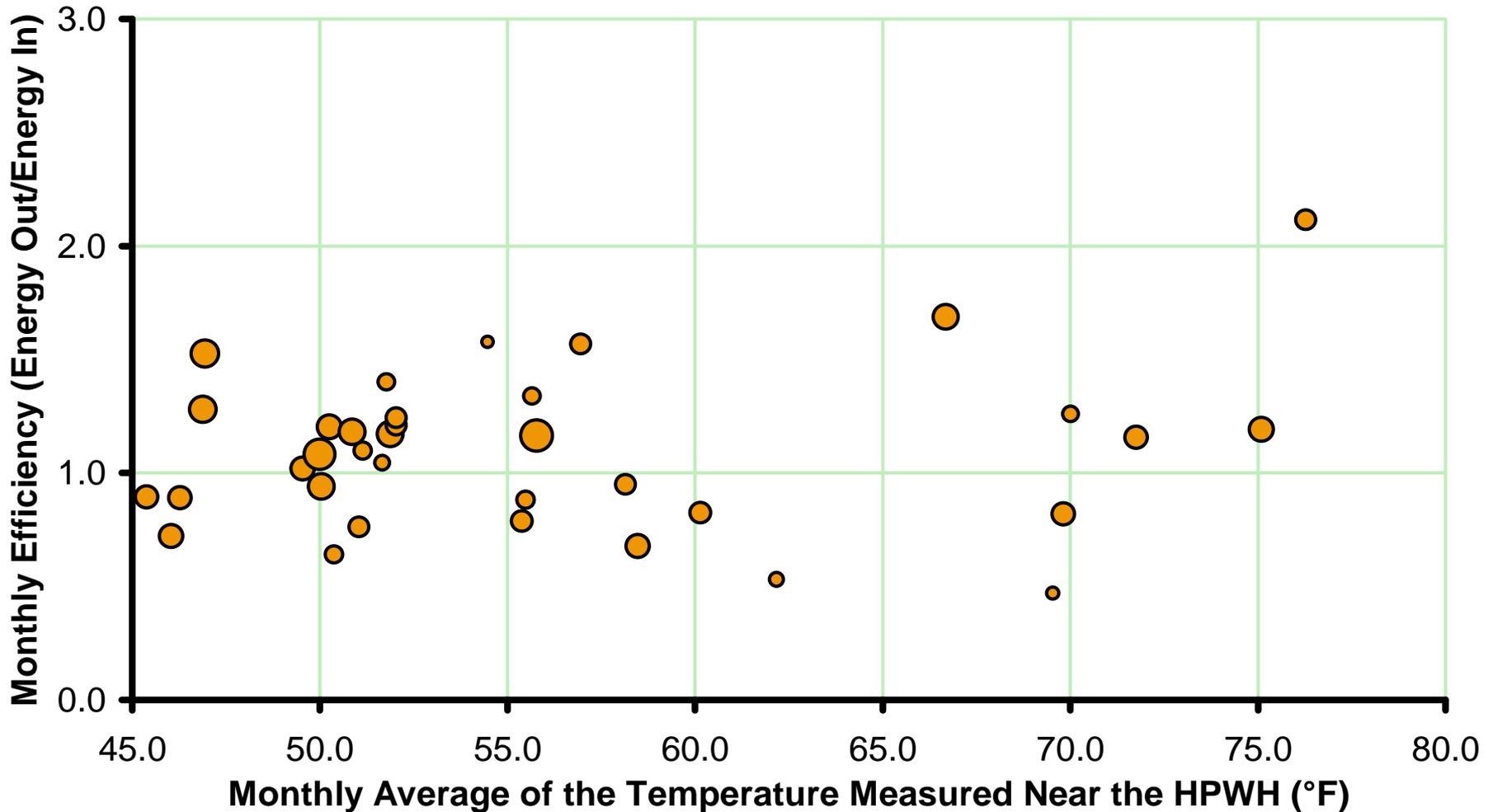
- Assess heat pump water heater technology by measuring efficiency
- Provide credible data on the performance and reliability of heat pump water heaters
- Assess user satisfaction in a residential setting

Monthly COP vs. Ambient Temp for BPA, January 2011



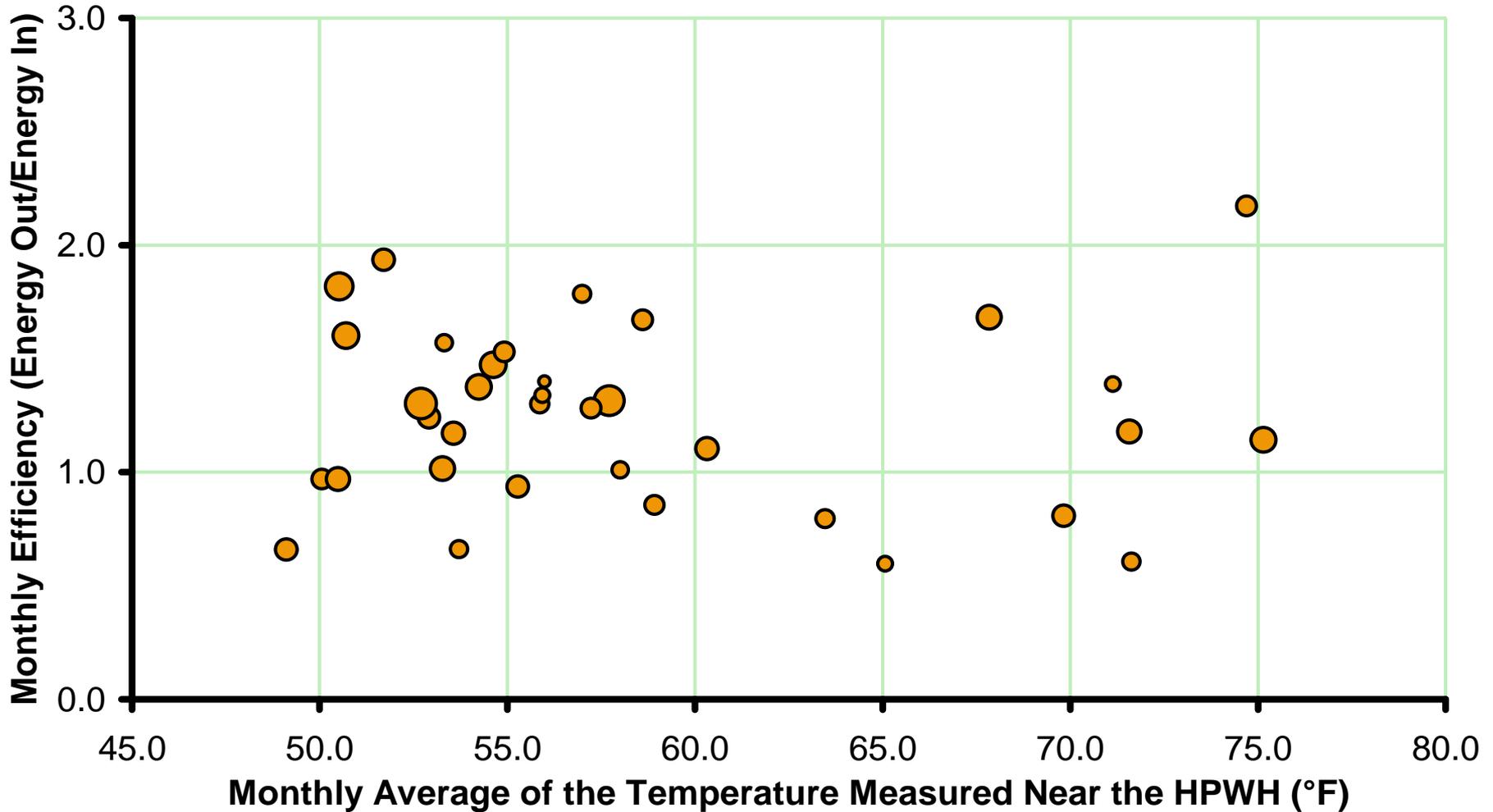
Caution! Raw Data – Not Fully Analyzed

Monthly COP vs. Ambient Temp for BPA, February 2011



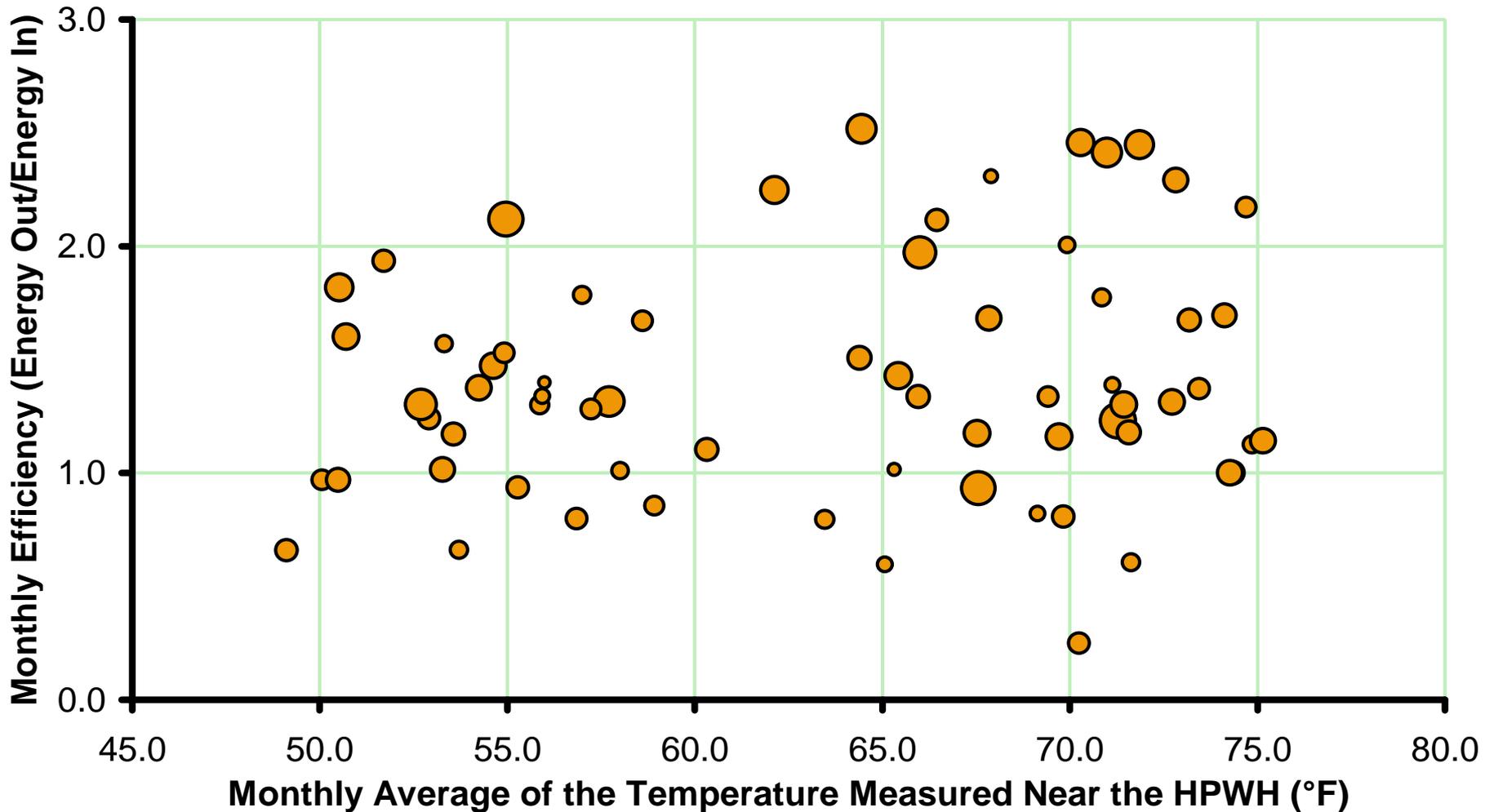
Caution! Raw Data – Not Fully Analyzed

Monthly COP vs. Ambient Temp for BPA, March 2011



Caution! Raw Data – Not Fully Analyzed

Monthly COP vs. Ambient Temp for All, March 2011



Caution! Raw Data – Not Fully Analyzed

Customer Feedback (~1 month)

Temperature Change around Water Heater

- 24 of 40 (60%) noticed it was colder around the unit
- The majority didn't find it bothersome – a minor annoyance at best

Noise

- 37 of 40 (93%) noticed the additional noise
- 7 answered it was "bothersome", but considered it a mild disturbance

Features and Controls

- Installers generally did little training & many didn't understand how HPWHs operate
- Homeowners found the features/controls easy to understand and use
- Most adjusted their water temperature (default is 120-deg F)

Noise Perspective

* Noise Pollution Clearinghouse

Refrigerator 40-43

Typical Living Room 40

Forced Air Heating System 42-52

Radio Playing in Background 45-50

Exhaust Fan 54-55

Microwave 55-59

Normal Conversation 55-65

Clothes Dryer 56-58

Window Fan on High 60-66

Dishwasher 63-66

Clothes Washer 65-70

Hair Dryer 80-95

30 Installed Sites

*HPWH Intake 55-64

*HPWH Exhaust 55-67

*(readings taken 3-ft
from unit, 5-ft from floor)

*<http://www.nonoise.org/library/household/index.htm>

Next Steps

- Provide manufacturer specific feedback on lab results
- Address NW specific issues with manufacturers on this technology
- Analyze the energy efficiency of the 40 installed units
- Review the RTF baseline, lab results and the data collected to date on the 40 units – is BPA ready to support this technology?

Chuck Weseman, Operations Manager Hood River Electric Co-op

Site 1 - *before*



Site 1- after



Site 2 - *before*



Site 2 - after



Site 3 - *before*



Site 3 - after



Kevin Watier, Energy Services Program Manager Snohomish County PUD

Scope

- Initiated conversation with EPRI
- Brought BPA in as EPRI heat pump water heater pilot host site
- Coordinated with BPA, EPRI, and Fluid to:
 - Select HPWH system types
 - Install and monitor 10 HPWHs and (2) control sites
- Monitor systems
- Produce findings

Roles

- BPA
 - Program Management (Fluid)
 - EPRI Coordination (installation & data monitoring)
- SnoPUD
 - Snohomish County site selection
 - Ten HPWH
 - Two control sties
 - Appropriate HPWH unit selection
 - Advocated for a split system (Daikin)

Successes

GE

- Collaboration with BPA Emerging Technology Sector
- Region-specific HPWH knowledge gain
- Progress toward:
 - New technology adoption
 - Cost-effective savings
 - Reality check with 6th PP projections



Challenges

Daikin

- Cross team coordination (BPA, EPRI, Fluid, Installer)
 - Process for addressing and tracking action items.
- Split unit installation & maintenance
 - Contractor training
 - Repair process
 - Cost of maintenance
- Data monitoring equipment



Recommendations

- **Status calls**
 - Weekly to support timely problem solving
 - Involve all parties from the outset
 - Share tools (tracking spreadsheet)
- **Issue resolution protocol**
 - Establish a formal, written protocol for tracking issues and timely resolution

Rheem



Recommendations

- **Installer training**
 - Require equipment-specific training
- **Customer education**
 - Provide on-site training
 - Reduce support needs
 - Improve equipment reliability
 - Increase customer satisfaction

AO Smith



Outcomes

- Installed 10 HPWHs
 - GE (5), AO Smith (1), Rheem (2), Daikin (2)
- Metered 12 sites
 - 10 HPWH & 2 Control sites
- Does this technology;
 - Align with 6th power plan assumptions
 - Technical potential
 - Market potential (currently <1%)
 - Economic potential (\$2,500 installed)

Jeff Harris, Director of Emerging Technology NW Energy Efficiency Alliance

Agenda

- About NEEA
- Summary of Test
- Test Unit
- Draw Profile
- COP – Compressor Only
- COP – Auto Mode (Resistance element & Compressor)
- Questions / Discussion

About NEEA

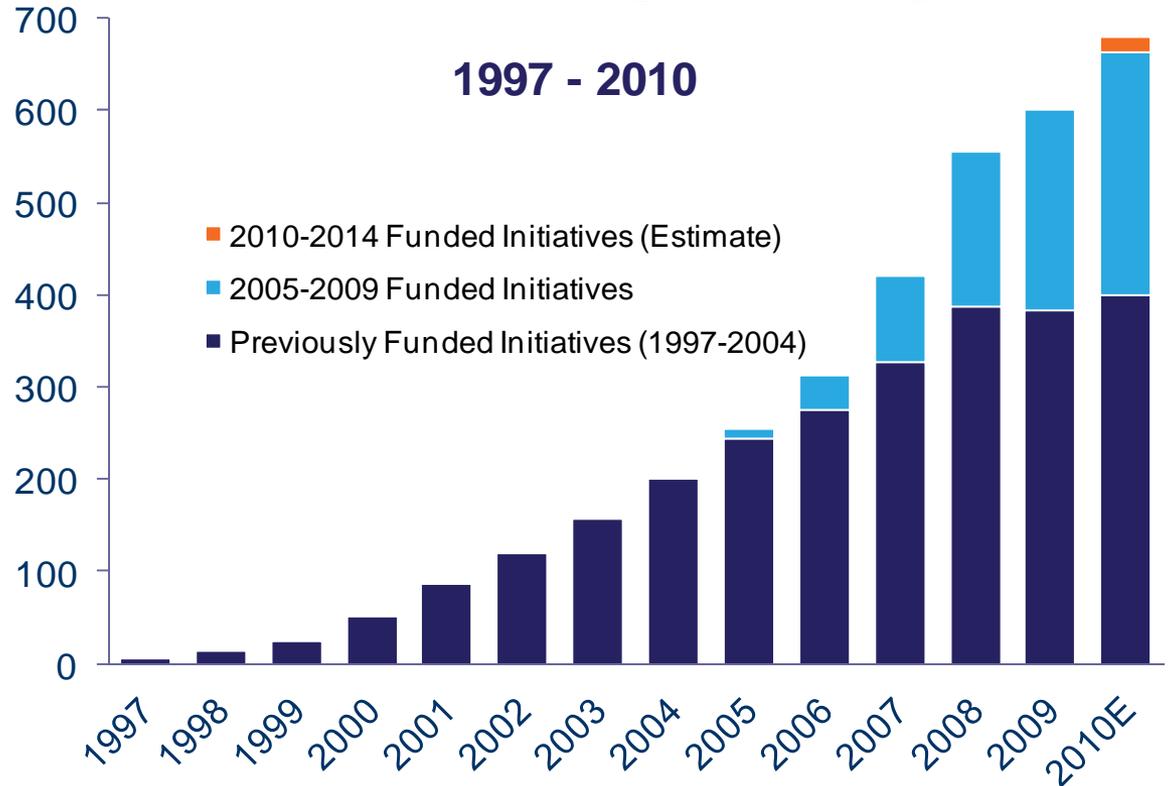
Our Purpose

To maximize energy efficiency

Our Mission

Mobilize the Northwest to become increasingly energy-efficient for a sustainable future

Cumulative Total Regional Savings



Source: NEEA 2009 Annual Report

Test Summary

Lab: Cascade Engineering Services, Redmond Washington

Test Date: Winter 2011

Test Protocol:

- Compressor Performance Mapping
- DOE Standard Rating Tests
- Operating Mode Characterizations
- Fan and Airflow Measurements
- Draw Patterns

	Test Name	Ambient Air Conditions			Airflow	Inlet Water	Outlet Water	Operating Mode	Test Description
		Dry-Bulb	Wet-Bulb	RH	inch. static	F	F		
		F	F	%					
COP Mapping	COP-30	30	28	80%	0.25"	55	130	Comp. Only	Fill tank with inlet water T. Turn tank on and heat to outlet set point.
	COP-50	50	44	58%	0.25"	55	130	Comp. Only	
	COP-50w	50	49	95%	0.25"	55	130	Comp. Only	
	COP-40-auto	40	39	95%	0.25"	55	130	Default	
Draw Files	DP-4	67.5	57	50%	0.25"	58	135	Default	Conduct draw

Test Unit

Manufacturer: AirGenerate

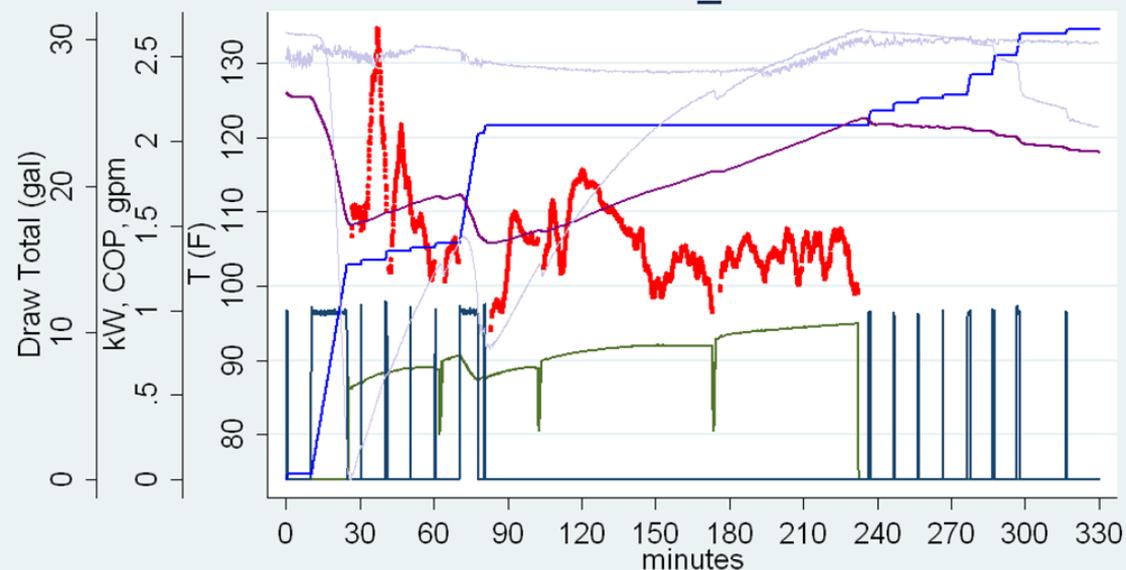
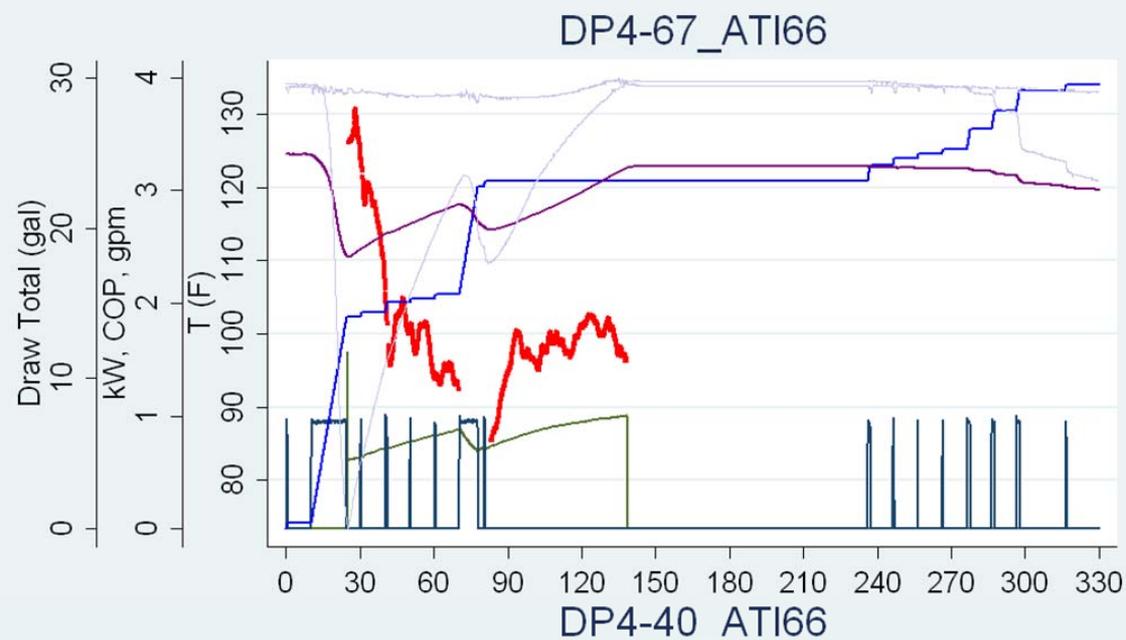
Model: ATI66

Features:

- 66 gallon nominal (64 measured)
- Tank Material: Stainless Steel
- Refrigerant – 410A
- Electric Element – 4kW
- Compressor Size – 7700 BTU/Hr
- Exhaust ducting
- Reverse cycle defrost
- Supports simultaneous resistance element and heat pump operation

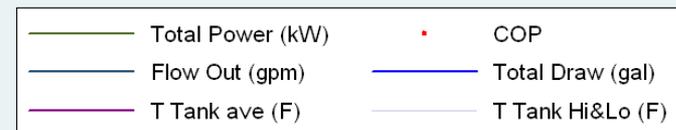


Draw Profile – Varied Ambient



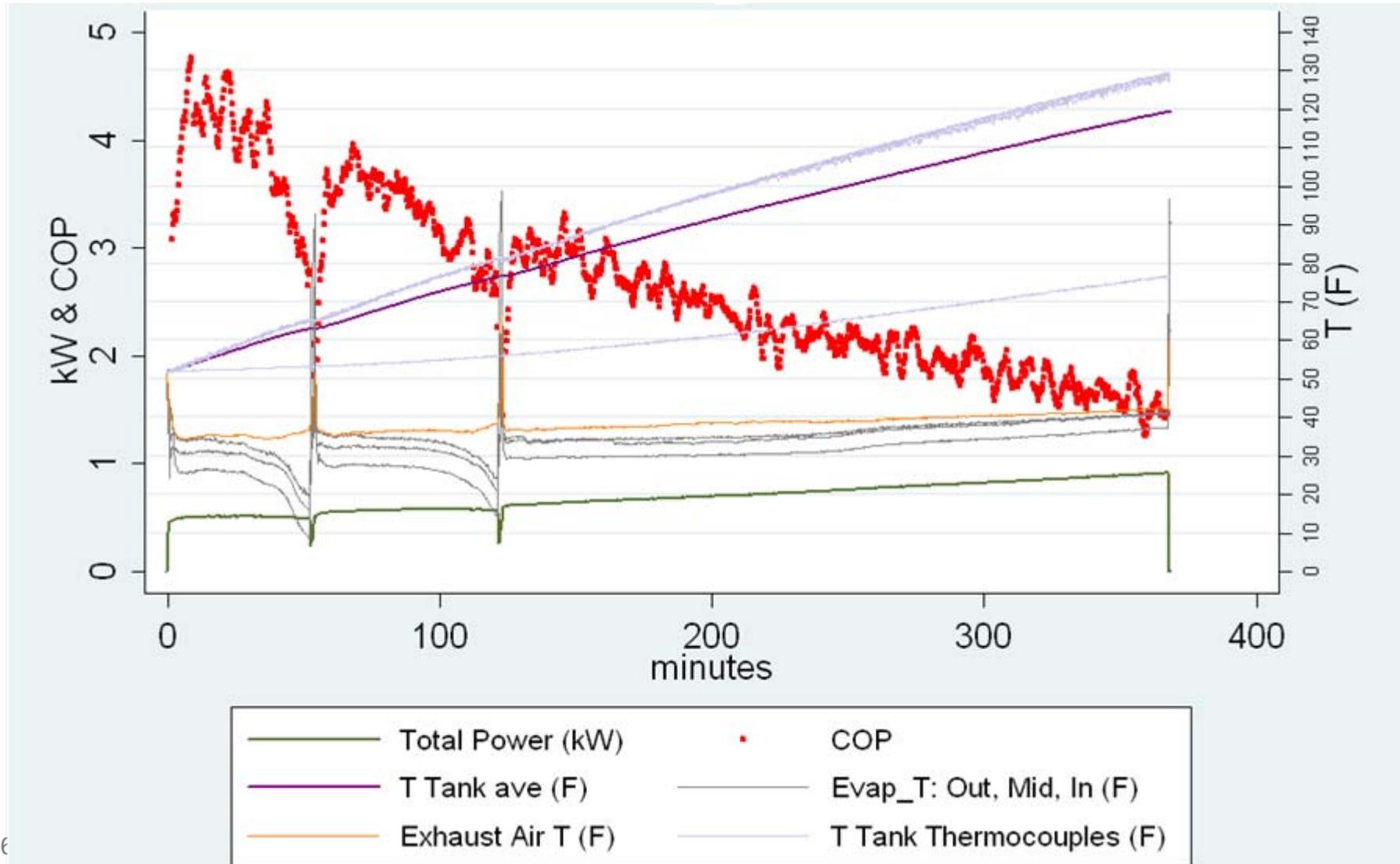
- Draw profile targets 30 gallons
- Based on small draw pattern from Gas Technology Institute (GTI) *
- Smaller draw profile can be performed quickly

	DP4-67	DP4-40
Ambient	67.5F, 50% RH	40F, 95% RH
T_{inlet}	58F	45F
$T_{setpoint}$	135F	135F
EF	2.2	1.5

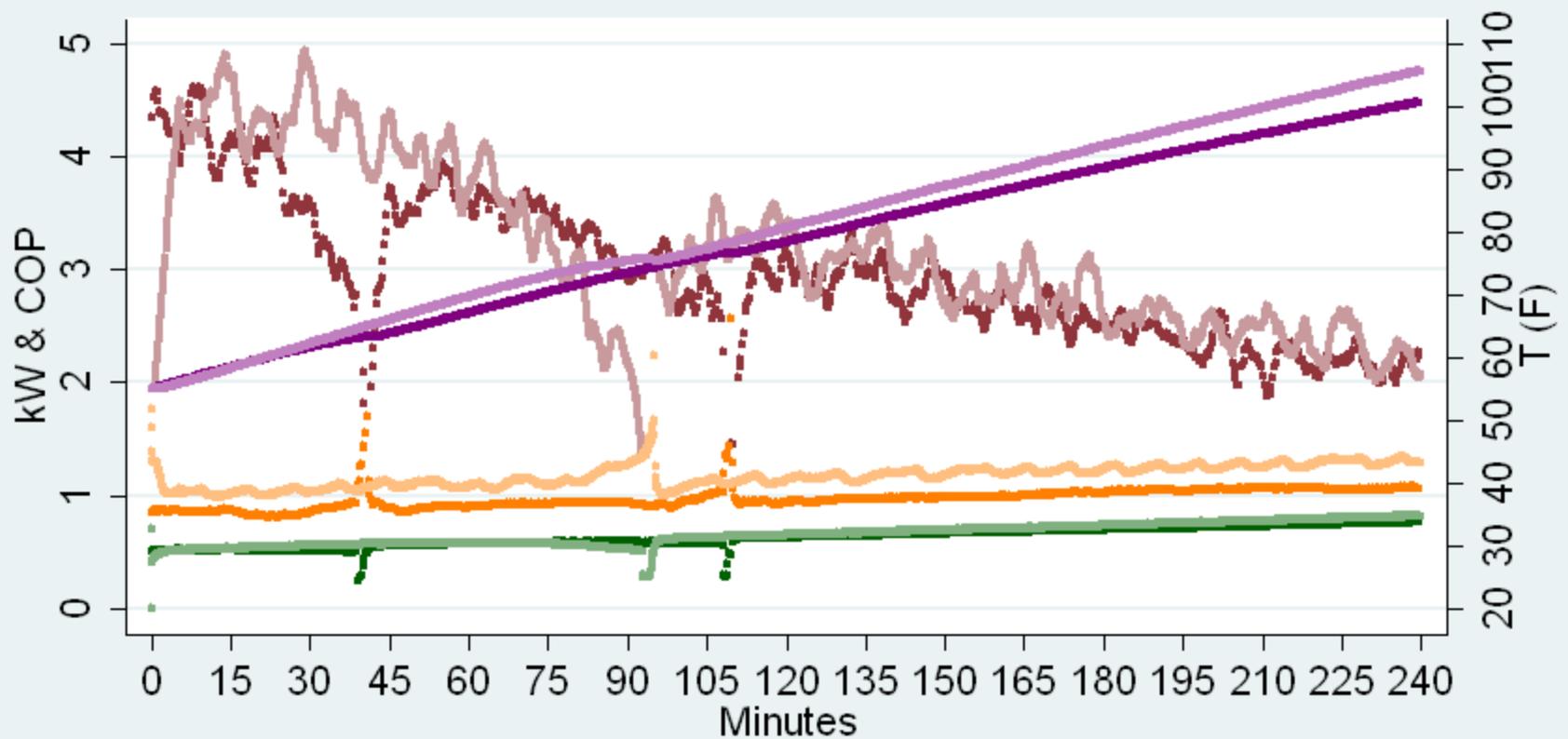


* Kalensky, D. and Scott, S. GRI-06/0014, GTI Combo System Field Test Final Report, Gas Research Institute, December 2006.

COP – Compressor Only – (50F / 58%RH)

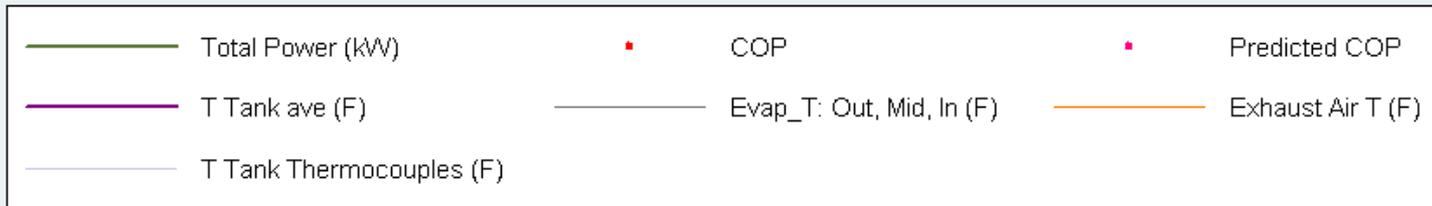
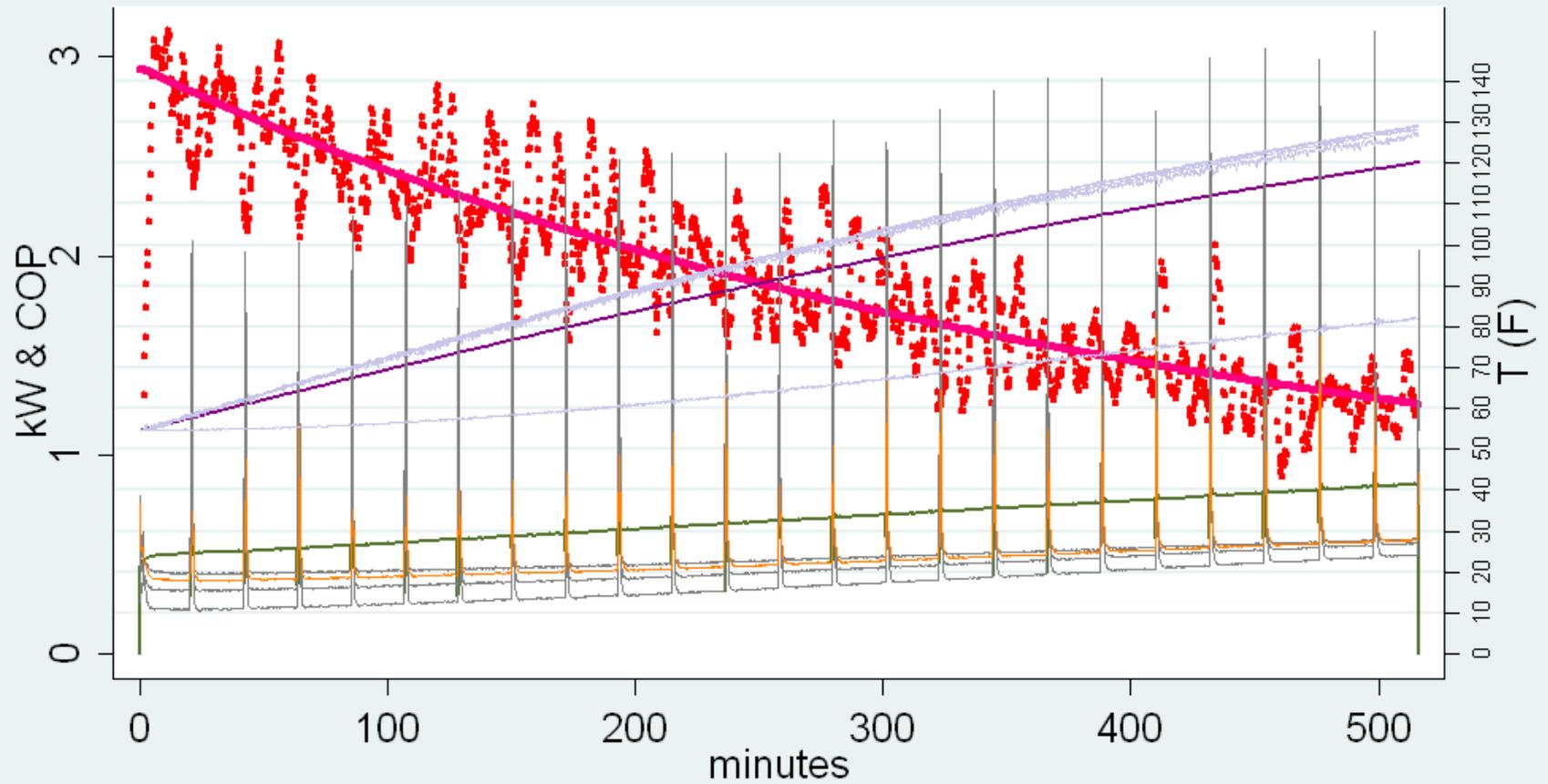


COP – (50F / 58%RH) / w(50F / 95%RH)



50F db, 44F wb	50F db, 49F wb
■ COP	■ COP
■ Power HPWH kW	■ Power HPWH kW
■ T Tank Ave (F)	■ T Tank Ave (F)
■ Exhaust Air (F)	■ Exhaust Air (F)

COP – (30F / 80%RH)



COP – Observations

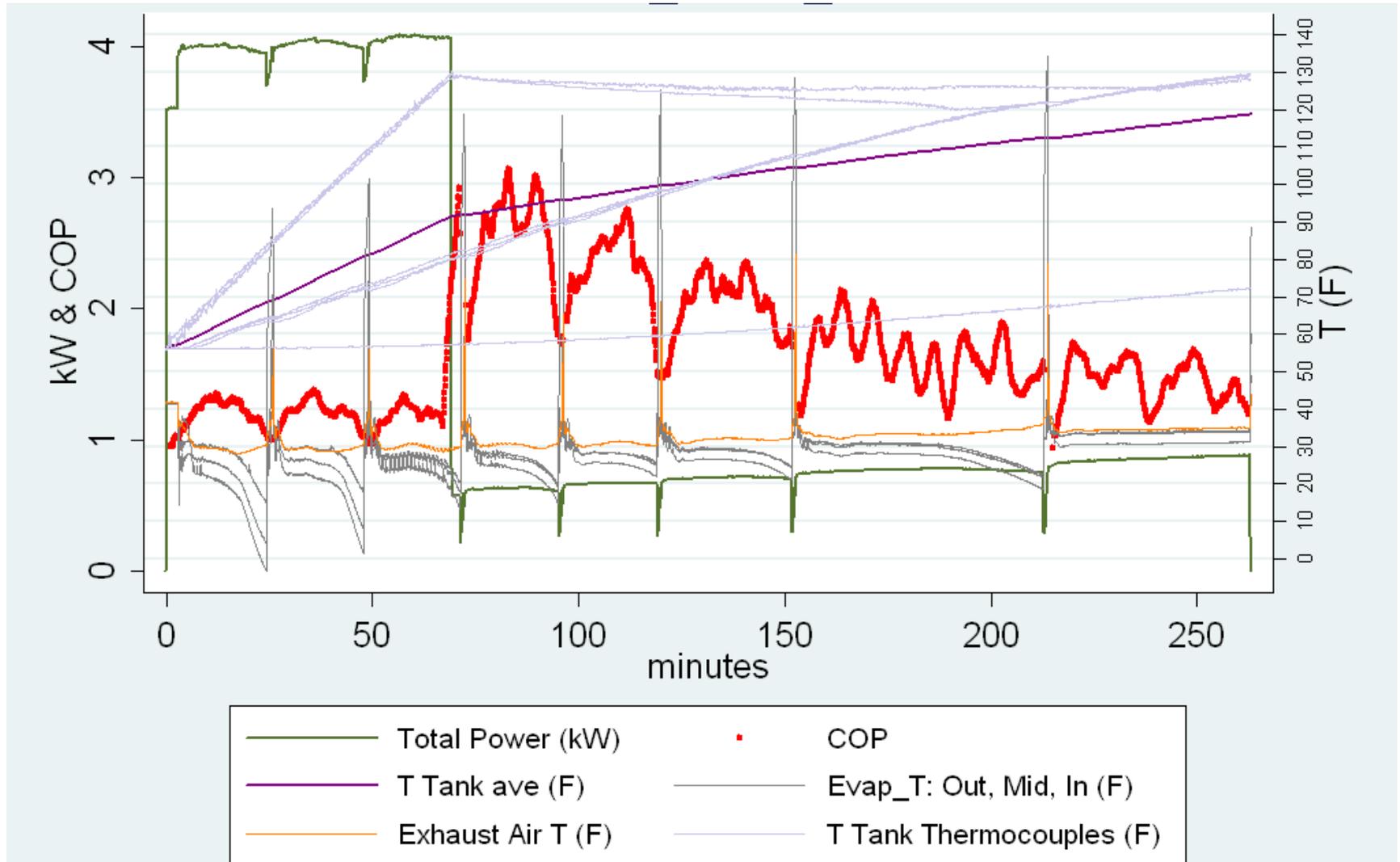
30 F Ambient

- Doesn't appear to buildup frost, but defrost cycle runs due to low evaporator temperature
- COP decreases with increasing tank temperature
 - With tank temperatures between 90F-120F, COP ~1.5

50 F (58% and 95% RH conditions)

- Demonstrates frosting. Shows active defrost is important to maintaining operation and efficiency for large tank draws.
- Greater enthalpy of 95% RH resulted in more heat transfer, less temperature drop across evaporator coil and, hence, fewer defrost cycles because coil stays warmer.

COP – Auto Mode (40F / 95%RH)



COP – Auto Mode - Observations

40 F / 95% RH

- Shows that defrost is necessary at nearly all operating tank temperatures (90F-120F) when unit is operated in 40-50F ambient conditions.
- Demonstrates efficiency of combined heating operation
 - Particularly applicable to recovery from large draw events
- Shows time between frosting increases as tank temperature increases

Contacts

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HPWH field pilot co-funding utility

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Questions / Discussion?

