FLORIDA SOLAR ENERGY CENTER®

Creating Energy Independence

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FLORIDA SOLAR ENERGY CENTER®

Creating Energy Independence

Heat Pump Water Heater Performance in Laboratory House

Building America Technical Update 2013

ACI National Home Performance Conference

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Building America U.S. Department of Energy — Partnership for Improved Residential Construction — BA-PIRC

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Alliance for Residential Building Innovation

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PARR
The Partnership for Advanced Residential Retrofit

FSEC

Hot Water Systems (HWS) Laboratory
FSEC Grounds, Florida (east coast)

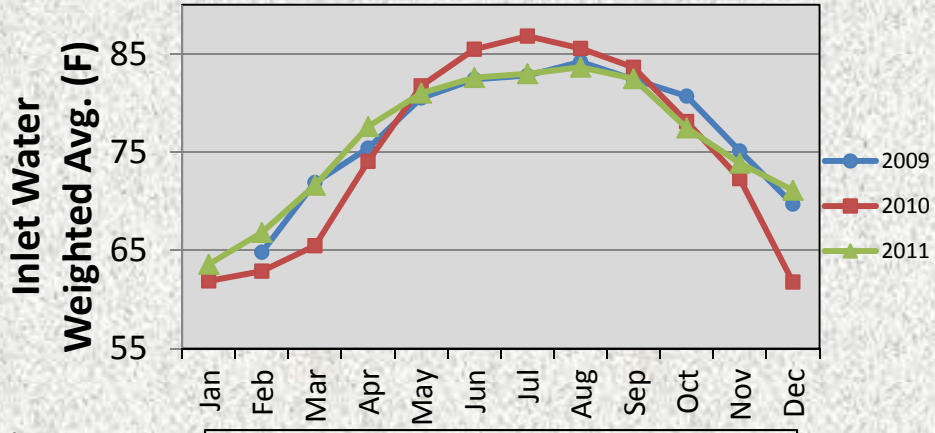
2009 –Present (Currently fourth testing rotation)

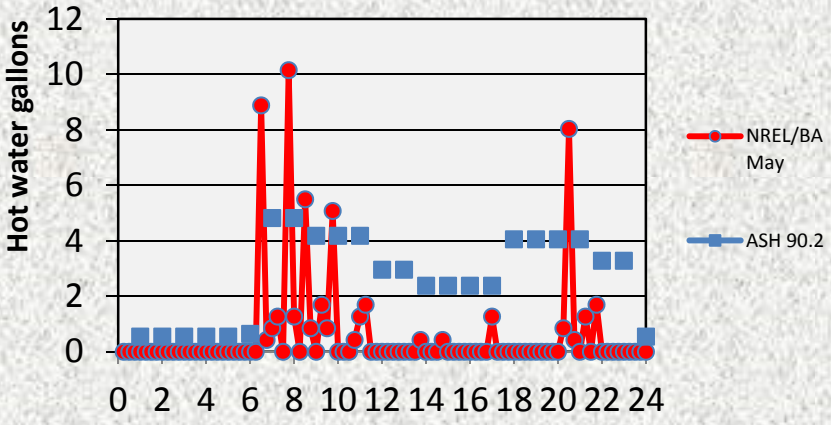
Hot Water Systems (HWS) Laboratory
One-Year Testing Rotation

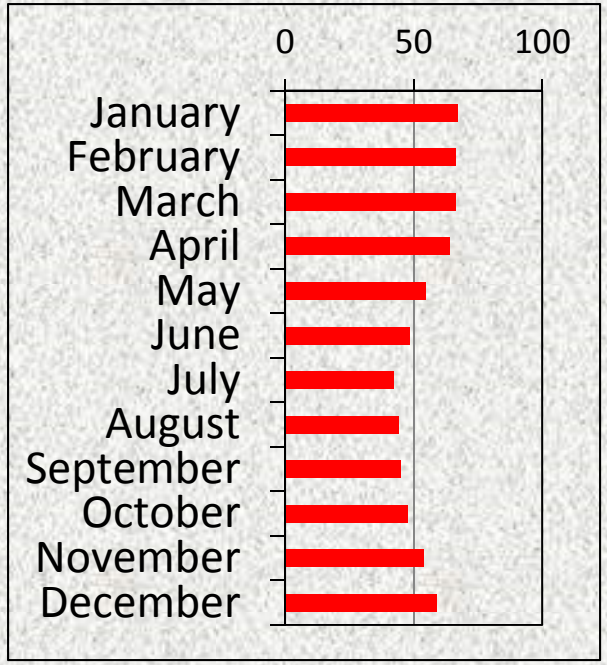
2010 – 2011 Testing Rotation (Phase II)

HWS Lab Testing Conditions, Cocoa, FL

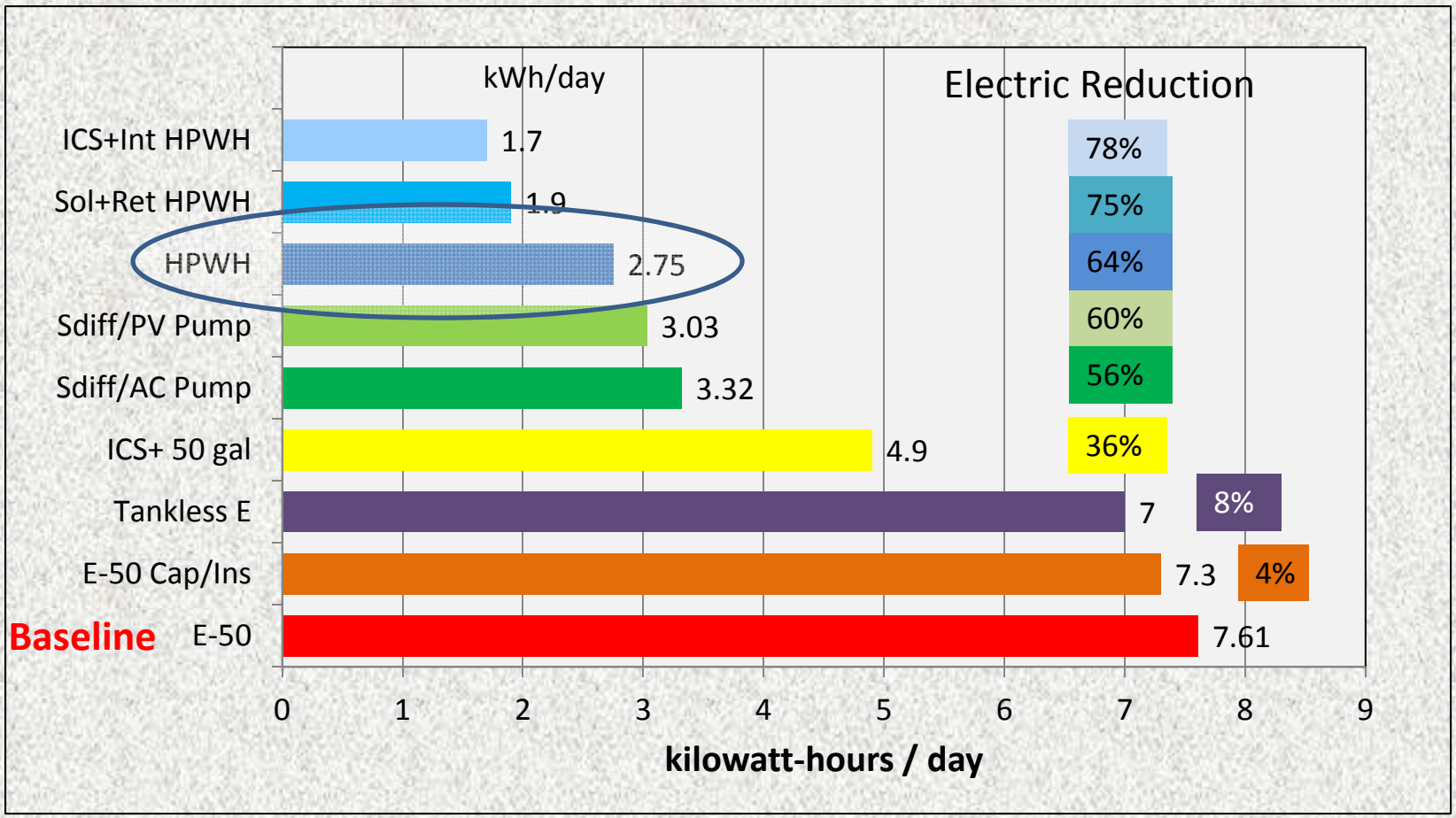
- 120 F Thermostat Setting
- Draws @1.5 gpm flowrate
- Real mains inlet water and ambient temperature
- Hot water draw schedules
  - ASHRAE (64.3 gpd)
  - NREL/BA (varies magnitude monthly)





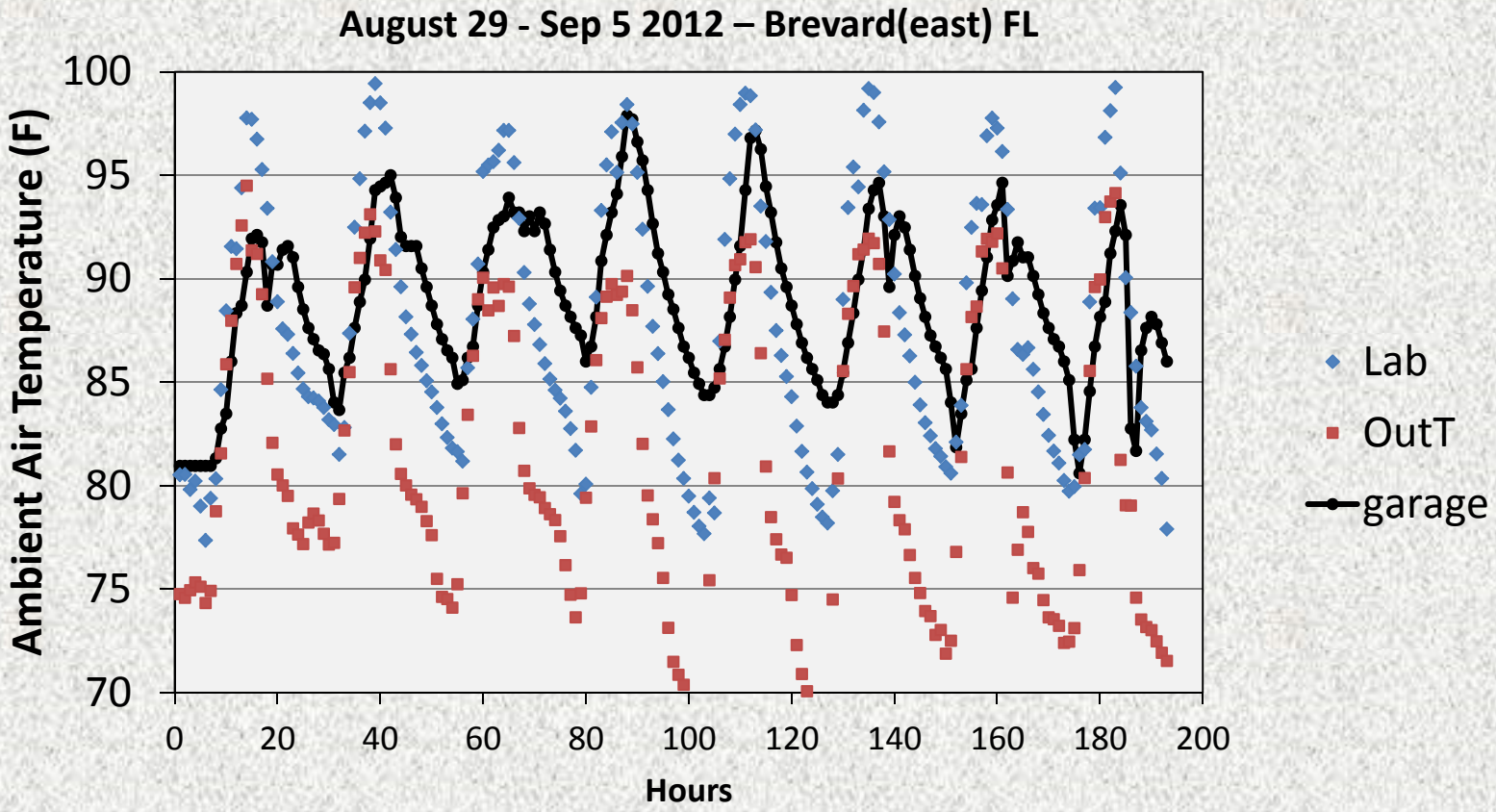


Performance History of Electric-based Water Heaters at Laboratory (Cocoa, FL)

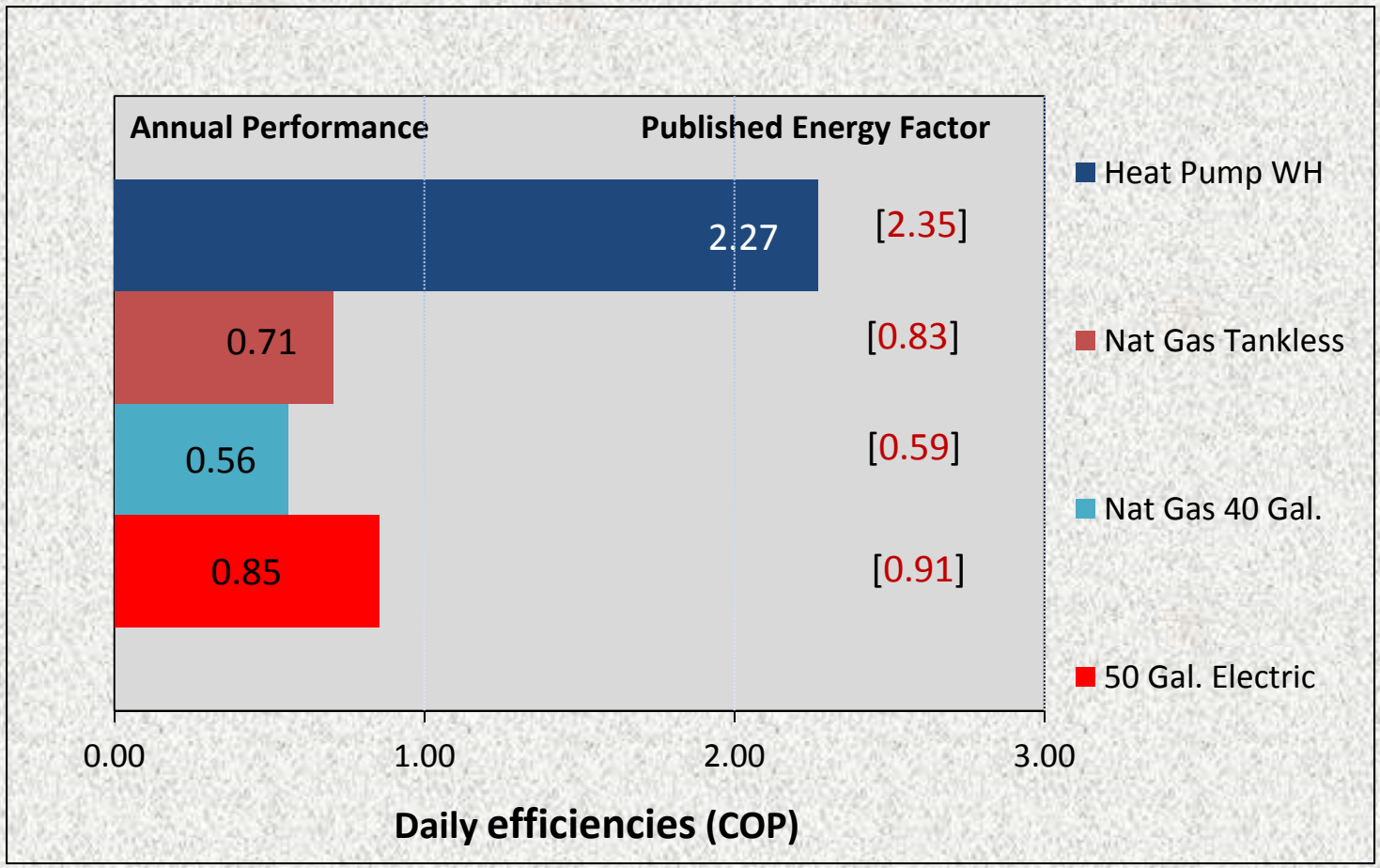


How's your Garage Temperatures?

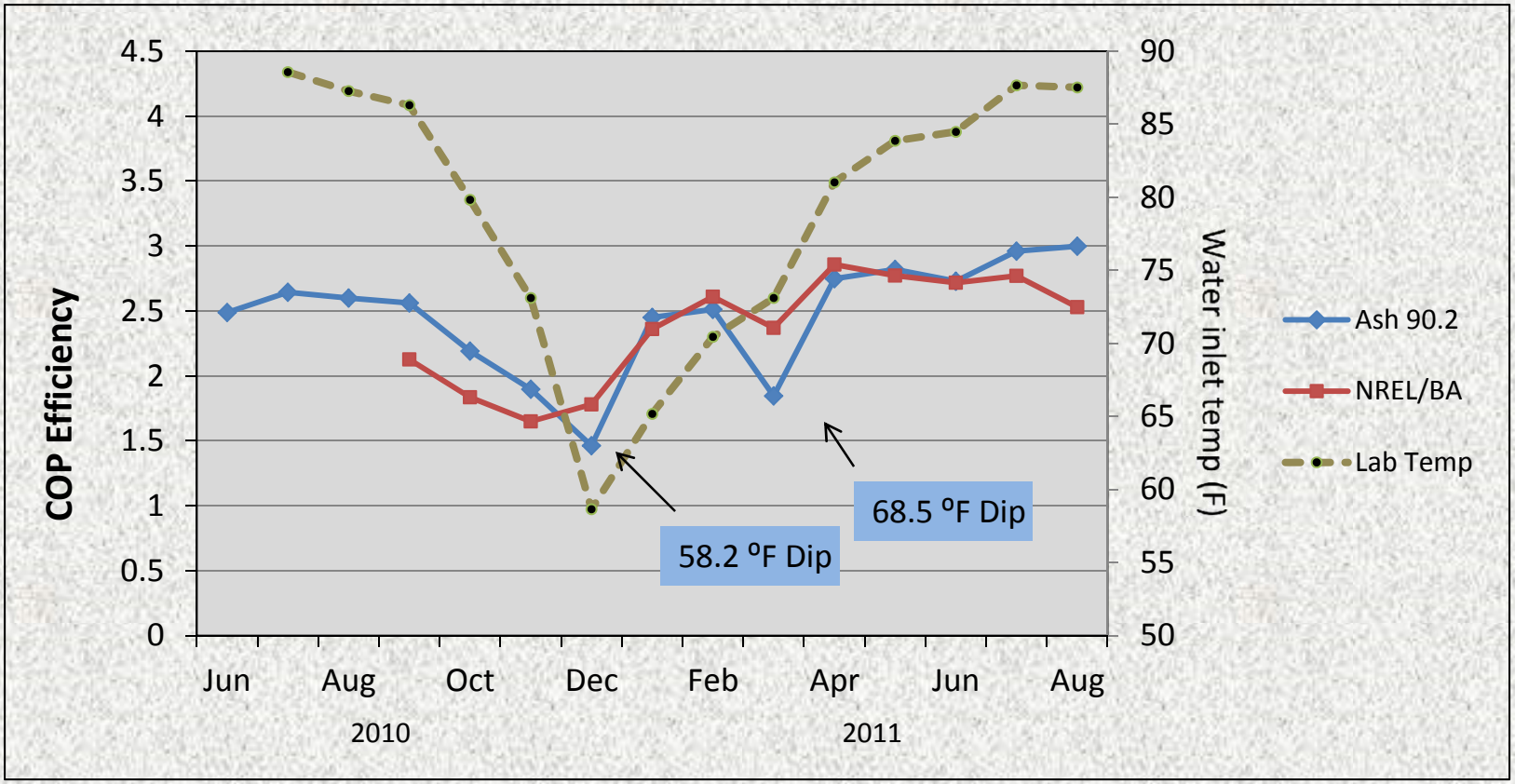
…Probably not quite as Hot as Florida



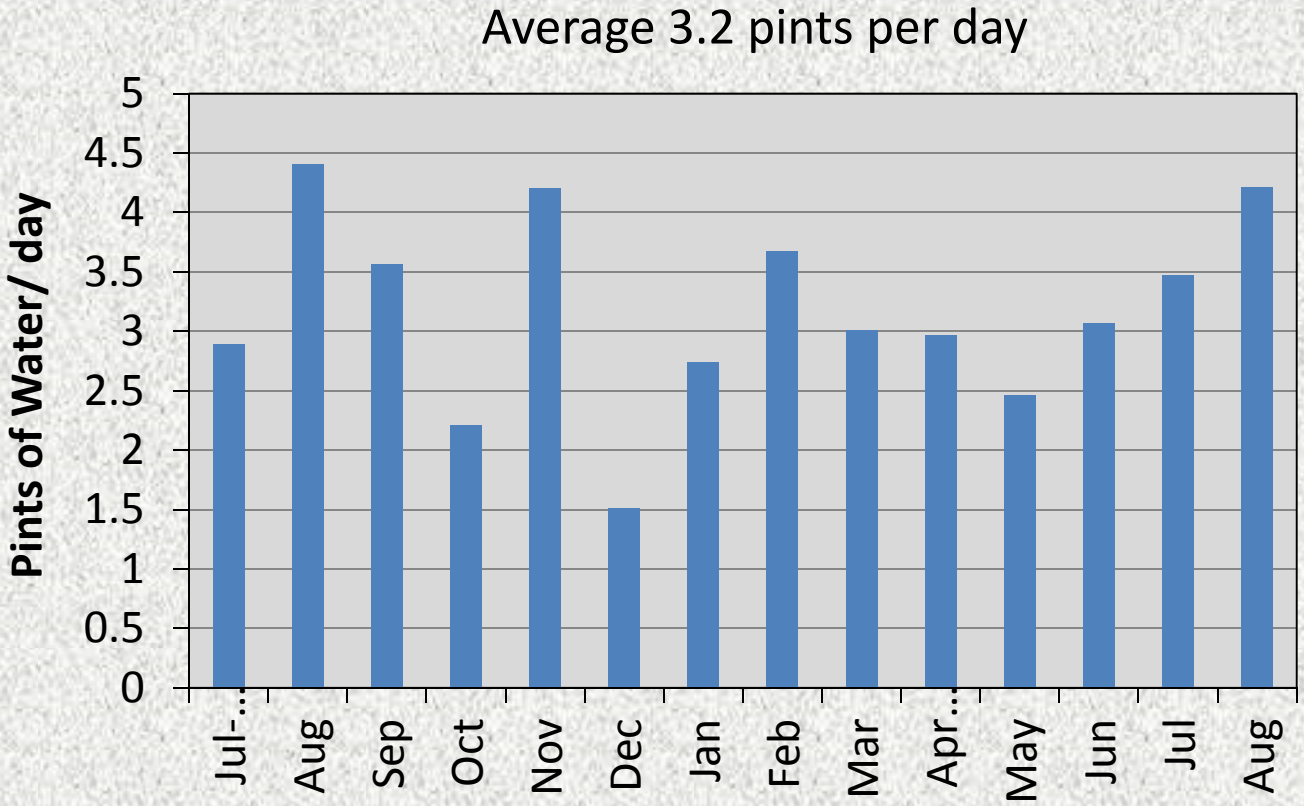
Averaged 1-Year Performance of Water Heaters and HPWH in Laboratory (Cocoa, FL)



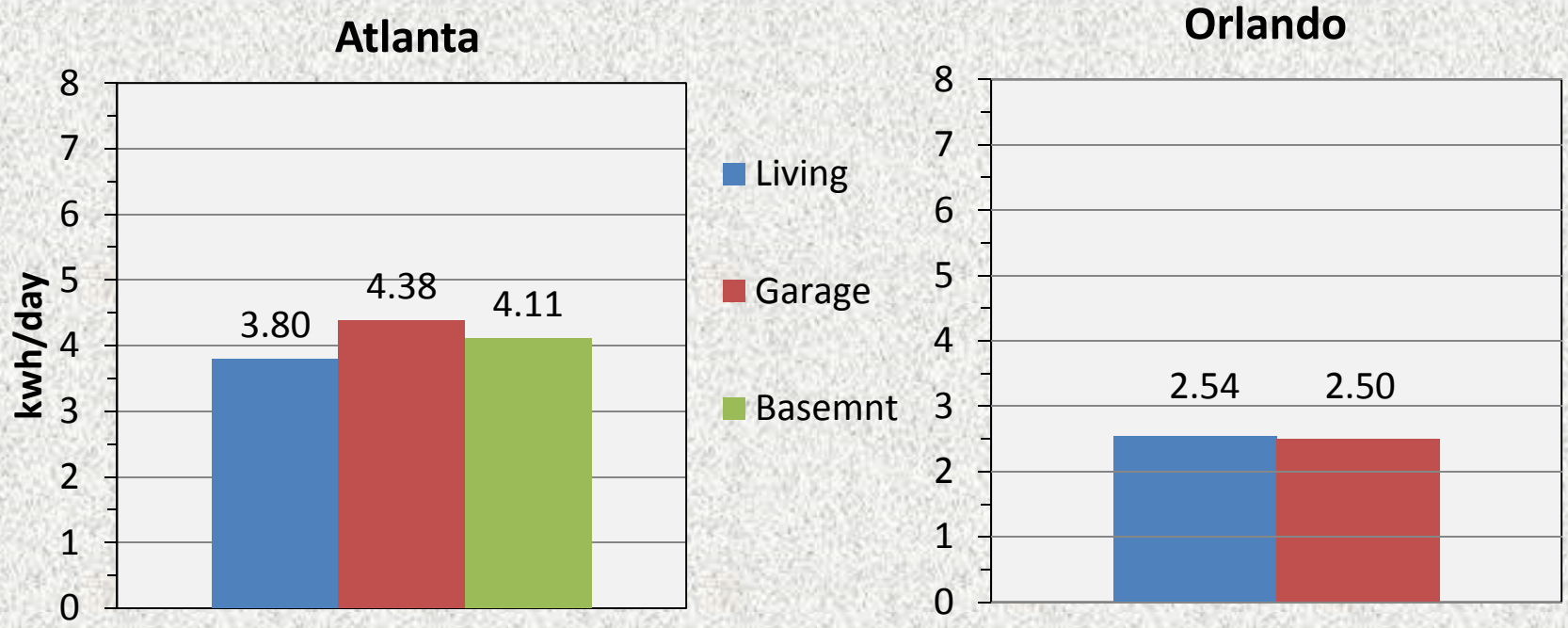
50 gal. HPWH Efficiency by Draw Pattern



Heat Pump Water Heater Condensate Moisture Removal (Florida)

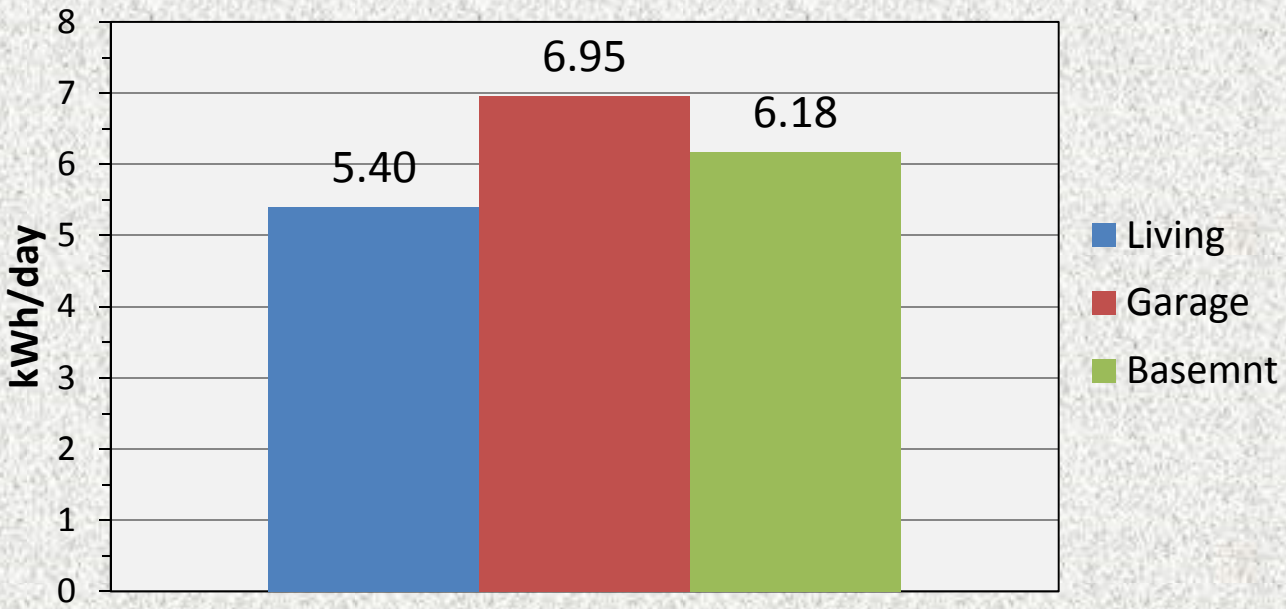


HPWH Average Daily Electricity
Southern U.S. Region Examples



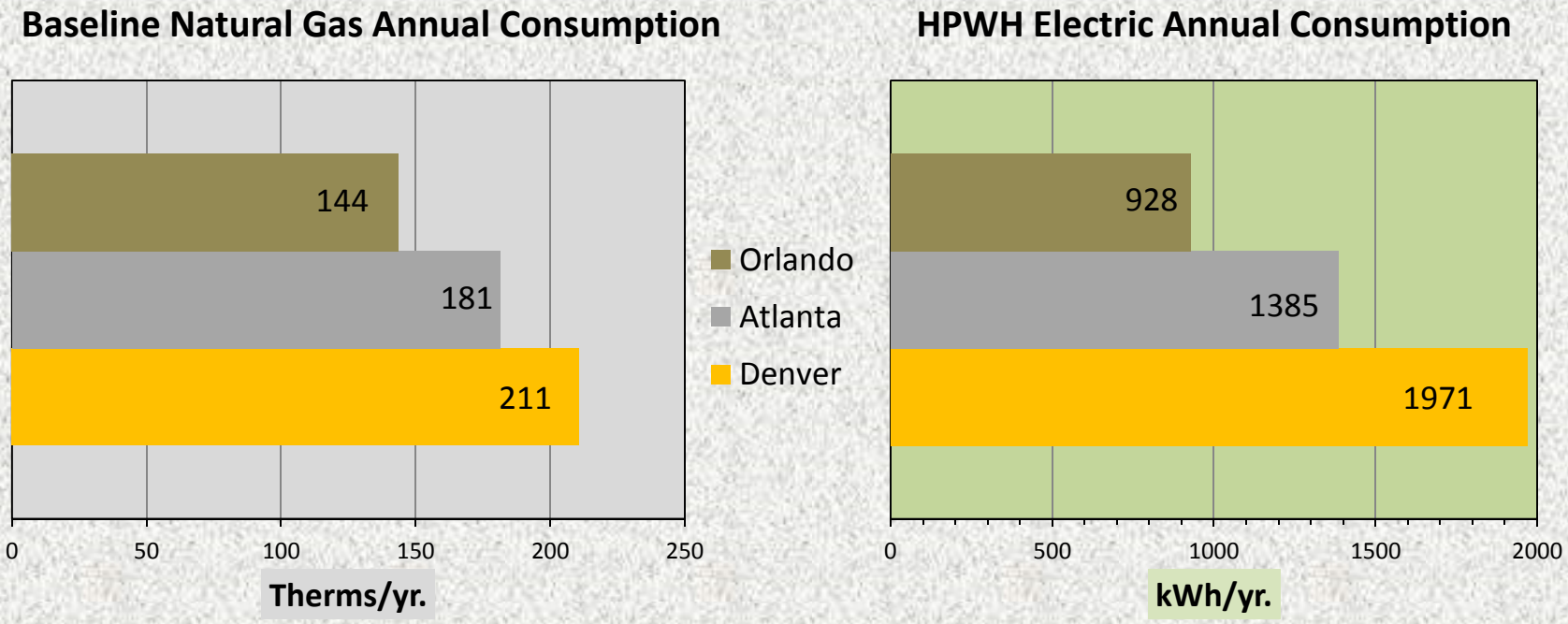
* Simulations Performed using BEopt 2.0 Two-story home 1500 ft^2, 130 F setting

HPWH Average Daily Electricity
Denver – Colder Climate



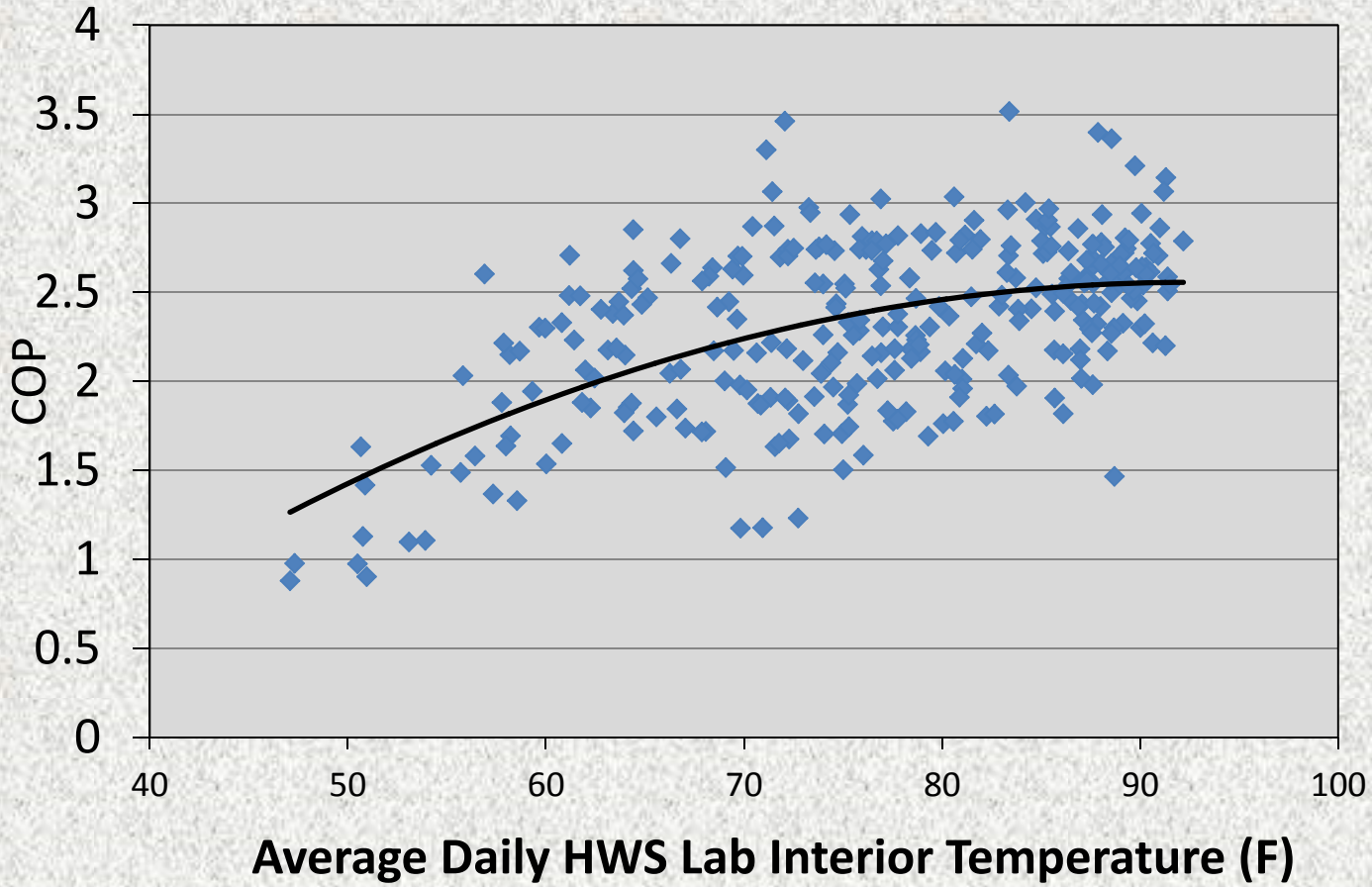
* Simulations Performed using Beopt 2.0 : Two-story home 1500 ft^2 / Basement

Baseline Gas and Electric HPWH

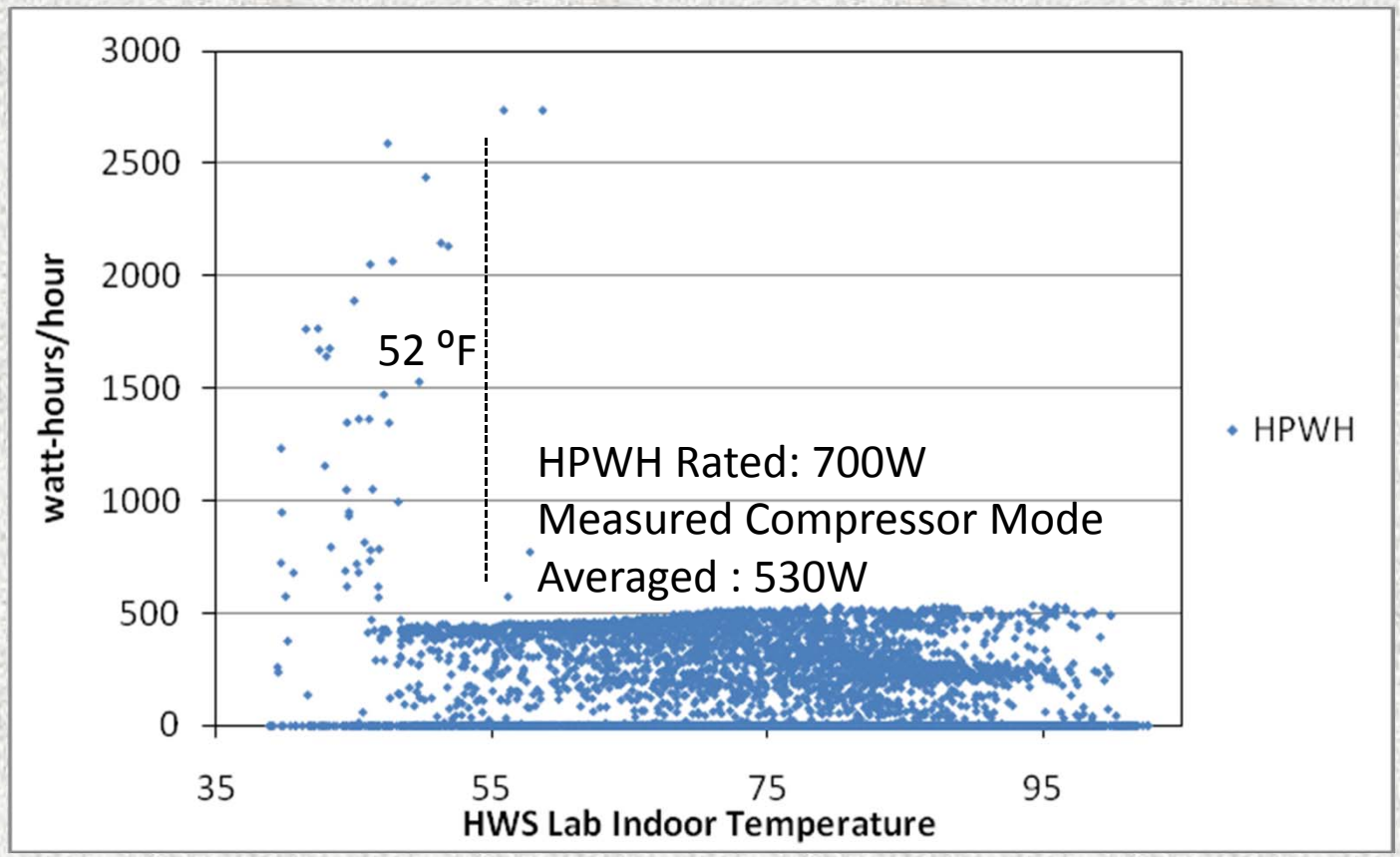


*As reported in Beopt 2.0 simulations for 1500 ft^2 3-BedRm two-story home
Water heating systems simulated in Living Conditioned space.

50 Gal. Heat Pump Water Heater Efficiency

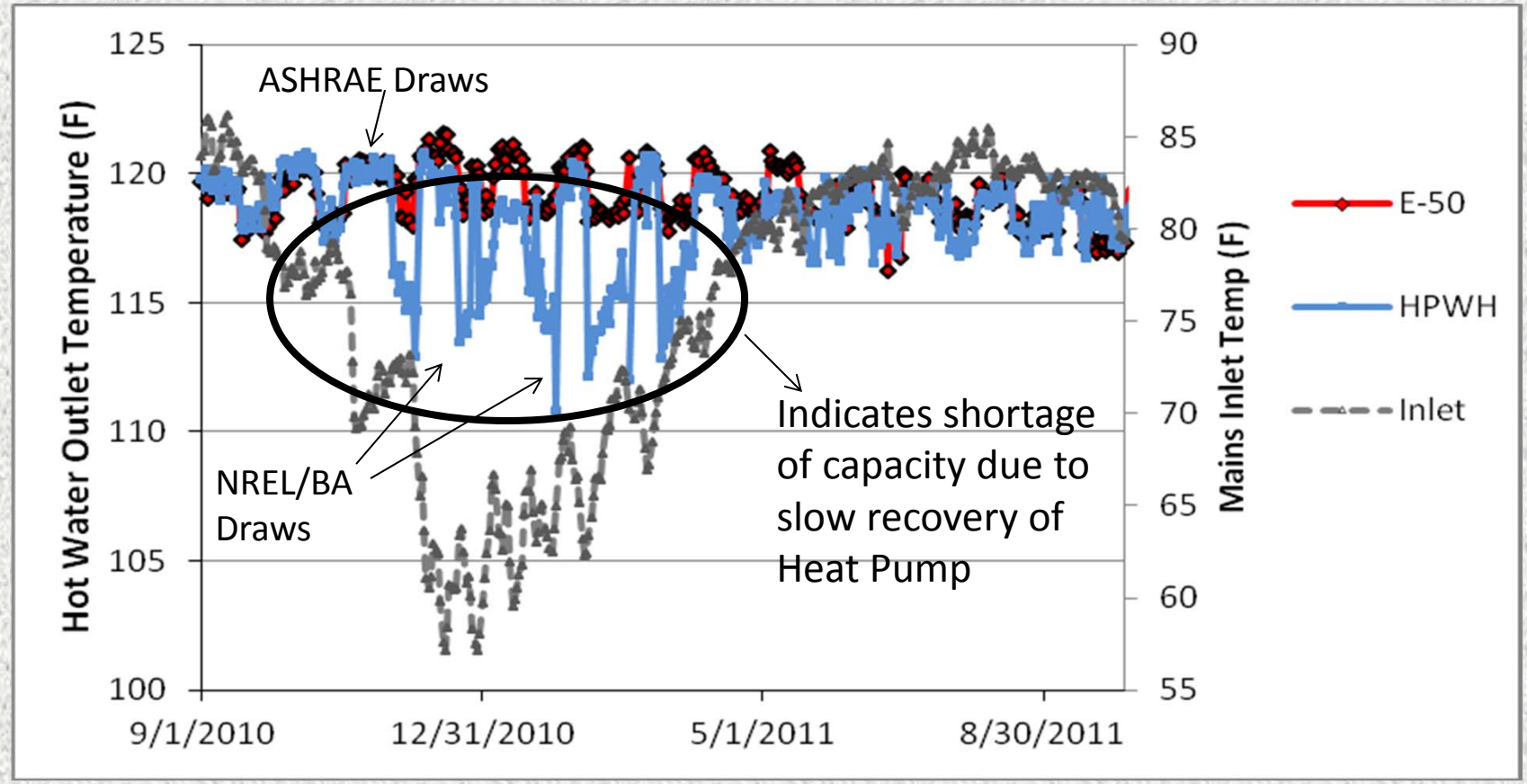


Heat Pump Water Power Consumption



Standard Electric vs HPWH (50 gal.)

Daily Outlet Temperatures Compared (2010-2011)



* Temperatures are weighted averaged by volume

HPWH Recovery &Laboratory Facts

- FSEC Lab Florida Summer

  June 21, 2010:

  Ambient 85 ^{o}F , 58% RH
- Cold Fill (85^{o}F inlet)HPWH Start
  - Compressor operated **2hrs-15 min.** to heat tank (45.5 gal) to 120^{o}F
  - Cold air discharge 67.5^{o}F (17.5 Δt cooling)

Typical Cooling: 3000 – 4500 Btu/hr.
SHR = 0.87

- Northern Climate Lab

67 ^{o}F ambient air& 58 ^{o}F Inlet water

  - Compressor took 6^{+} hours to heat tank to 135 ^{o}F

Lessons learned from Multi-Family Housing Installations

Transfer Grills facing kitchen and laundry

Service Door common exterior hallway

HPWH in confined small volume closet (<100 ft^3)

HPWH Survey Response
Five Multi-Family Complexes

- 720 HPWH Units installed in Multi-family homes throughout Florida
- All 5 Multi-family complexes reported tenant complaints mainly **Fan noise**
- Some complaints of insufficient hot water
- One tenant requested to change to electric-heat mod
- Few ask higher T'stat set +5 deg (125 ^{o}F)

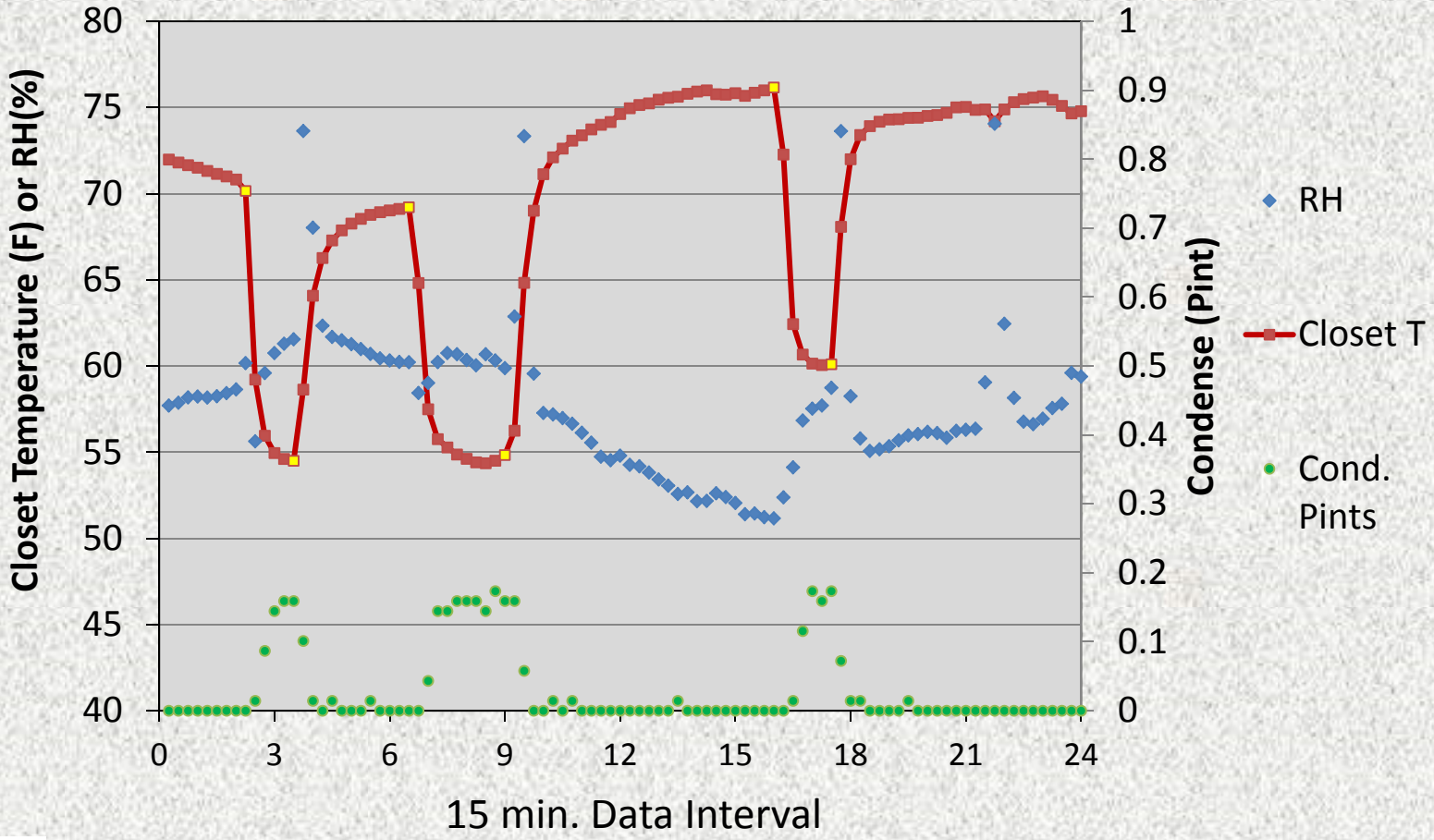
- Condensate Issues both at unit overflow and drainage
- One case reported having turn space heat ON because of cold air by HPWH

Other : Quarterly maintenance for air Filter, Drainage check

Laboratory Testing to Re-create Field installations in confined space

Manufacturer Spec : Variable (170 – 100 cfm)
Lab Measured (post 20 gal draw) : 130 cfm

Confined HPWH in less than optimal Volume Space



HPWH Confined in Closet Performance analysis

	Days	Avg. kWh/day	Avg. COP	Avg. Inlet (F)	Avg. Outlet (F)
HPWH in conditioned lab	6	2.050	2.64	74.78	118.47
HPWH in conditioned + confined space (92.5 ft^3)	7	2.342	2.30	74.21	117.49
Percent increase of electric use	14.27%	0.292	Volume Draw		
Percent COP reduction	12.78%		50 gal./day		
Average outlet temperature reduction	0.98°F				

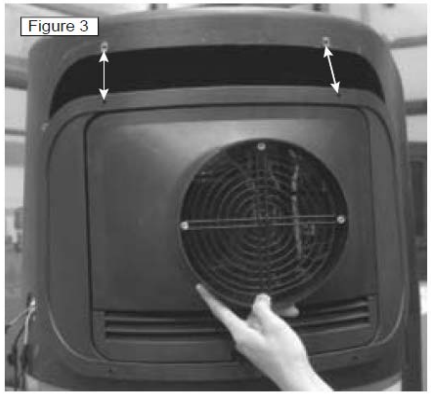
Heat Pump Water Heater Airflow

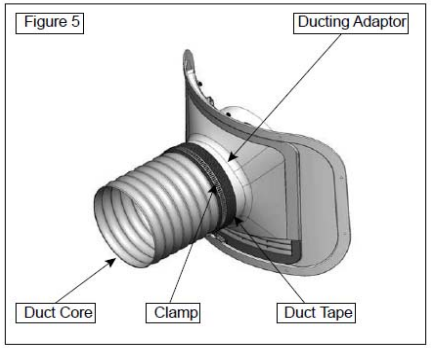
From Manufacturer Specs:

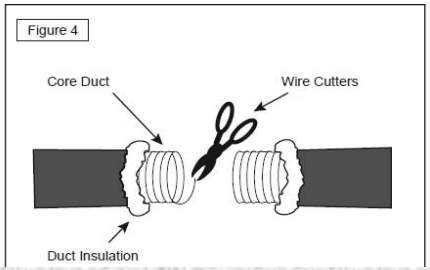
- GE GeoSpring : **Variable***
  175 to 100 cfm
- Rheem HP50: **100 cfm**
- AO Smith HPT-80:
  475 cfm
- Airtap 66: **300 cfm**

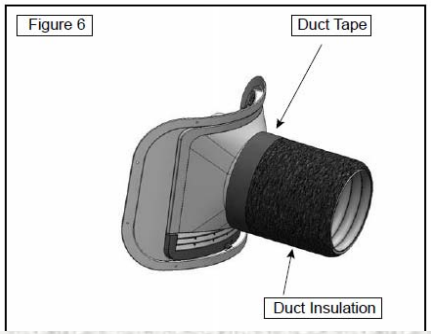
***Laboratory measurement after 15 Gallon draw : 132 cfm**

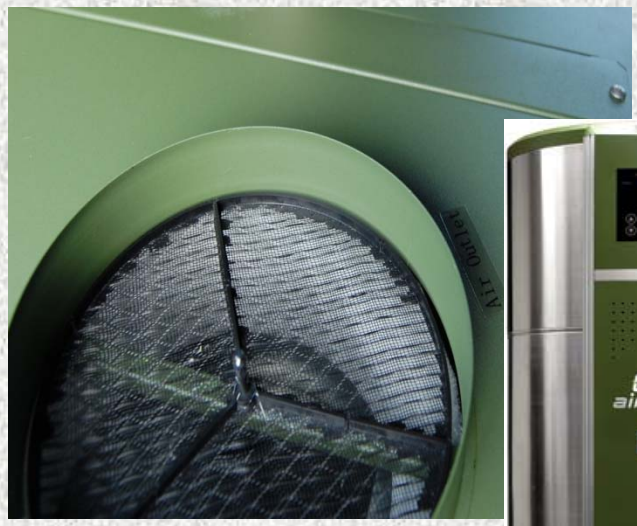
HPWH Air Ducting











Air Generate provides for easier standard Connections on Intake and Supply

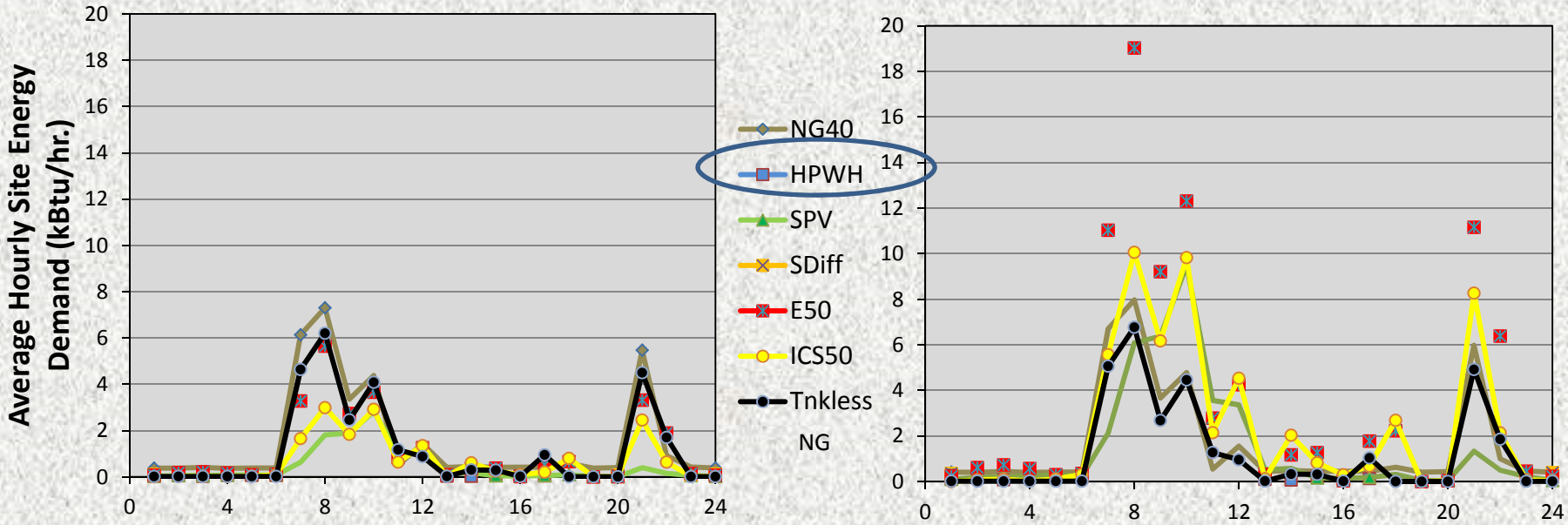
*AO Smith literature: Not to exceed 10 ft. total

Site and Source Demand From Florida Lab Results Perspective

Derived from Family-realistic draw schedule

Site Energy Demand

Source Energy Demand



Multiplier Factors: Me = 3.365 , Mg = 1.092

HPWH Improvements

- Larger storage tanks:
  True 55 – 65 gals. Capacity
- Quiet Fan
  - Will ducting help with fan Noise?
- Larger Compressor ?
- Design improvements for easy attachment of air ducts
- Easy access to maintenance: condense drain, filter.

- Real time clock (RTC) Timer –

  "However, switching devices which cut power from 240V to 0V on a periodic basis are acceptable"-- HPWH Manual

- Software – Compressor to start operation sooner following recovery with electric resistance

Summary

- HPWH installation: Consider Building location very important.
- Proper Condensate drain
- When ducting air, intake from garage not recommended
- Generally compressor operation is limited with ambient temperatures below 50 ^{o}F.
- HPWH is ideal for southern U.S. region
- Results from simulations vary by location, may be slightly conservative
- HPWH best technology for water heating in an all electric home
- HPWH can demand the minimum source energy but only under favorable (southern) conditions.

HPWH Reports/References

Laboratory Performance Evaluation of Residential Integrated Heat Pump Water Heaters
B. Sparn, K. Hudon, and D. Christensen **Technical Report** NREL/TP-5500-52635 Sep. 2011

GE Heat Pump Water Heater Report
January 7, 2011 Advanced Energy.

Interim Report and Preliminary Assessment of
GE GeoSpring Heat Pump Water Heater
12 July 2011 Prepared by Ecotope Inc for
Boneville Power authority

Side by side Testing of Water Heating Systems: Results from the 2010-2011 Evaluation
C. Colon FSEC , July 2012

NEEA Report: Laboratory Assessment of General Electric GeoSpringTM Hybrid Heat Pump Water Heater, B.Larson and M.Logsdon, Ecotope, Inc. , Sep 2012

Questions / Discussion ?

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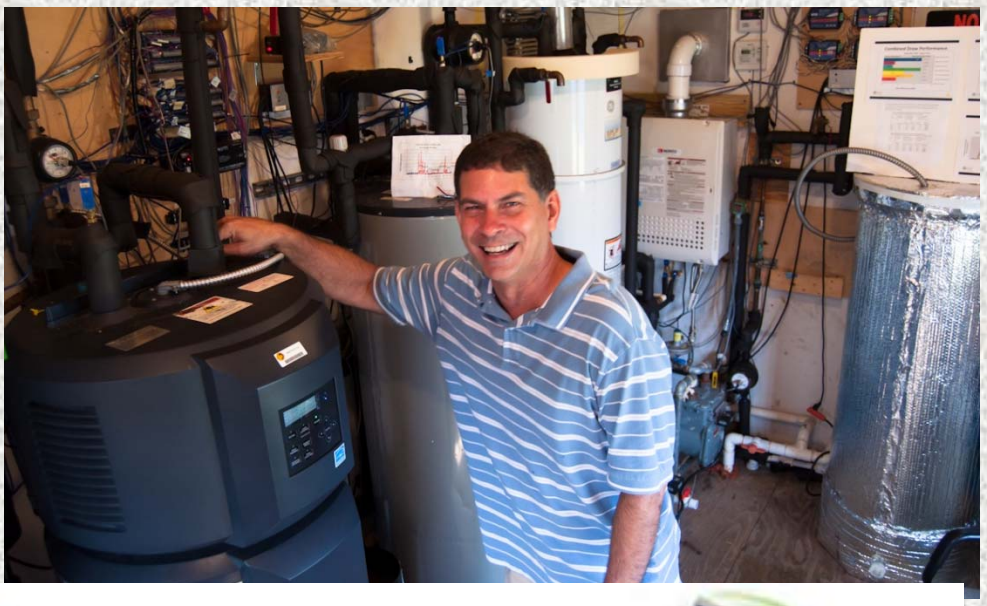

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