This Thousand Home Challenge webinar series is brought to you by the Pacific Gas & Electric Company's Energy Training Center & Affordable Comfort, Inc. (ACI).

Ducted & Ductless Mini-Splits for Cooling Existing Homes

Oct. 25, 2011 11 am-12:30 pm Pacific Time

Presented by:

Danny Parker, Florida Solar Energy Center, Cocoa Beach, FL

Dave Robinson, GreenEarthEquities, Fresno, CA & Round Hill, VA

Facilitated by: **Linda Wigington**, Affordable Comfort, Inc.

www.1000HomeChallenge.org www.affordablecomfort.org

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ACI Resources

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www.affordablecomfort.org

ACI Home Energy Trainer Conference 2011 Charlotte, NC Nov. 1-2, 2011

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Information about the Thousand Home Challenge

www.ThousandHomeChallenge.org

Introduction to the Thousand Home Challenge Webinar

Tuesday, Nov. 8, 2011: 10-11:30 am Pacific Time
Thursday, Dec. 8, 2011: 10-11:30 am Pacific Time

Contact: Linda Wigington lwigington@affordablecomfort.org

Upcoming THC Webinars

Dense Pack Wall Insulation & Air Sealing for California Homes (Parts 1 & 2)

Jim Fitzgerald
Center for Energy & the Environment
Minneapolis, MN

Part 1, Mon., Nov. 14, 2011: 11 am-12:30 pm Pacific Time
Part 2, Thurs., Nov. 17, 2011: 11 am-12:30 pm Pacific Time

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Learning Objectives

By attending this webinar, participants will:

1. Learn about both ***ducted & ductless approaches*** to installing mini-split heat pumps in existing U.S. homes.

2. Have a better understanding of how ***mini-splits can complement other energy upgrades*** to reduce cooling energy use & deliver comfort.

3. Be able to recognize ***homeowner perceptions & operational issues*** that may affect a successful mini-split installation.

4. Have a clearer understanding of ***what we know & do not know*** about energy use, cooling performance, & peak energy demand of mini-splits in cooling applications.

Webinar Outline

Linda Wigington

- Intro & Thousand Home Challenge

Danny Parker

- Intro to the technology
- Pros & cons of ductless vs. central systems
- Experience with systems in a cooling climate
- Zoning capabilities & comfort considerations

Dave Robinson

- Renovations with ducted mini-split heat pumps
- Market experience and overcoming the objections to mini-splits
- Installation details to “Hot Rod” the mini-split heat pump

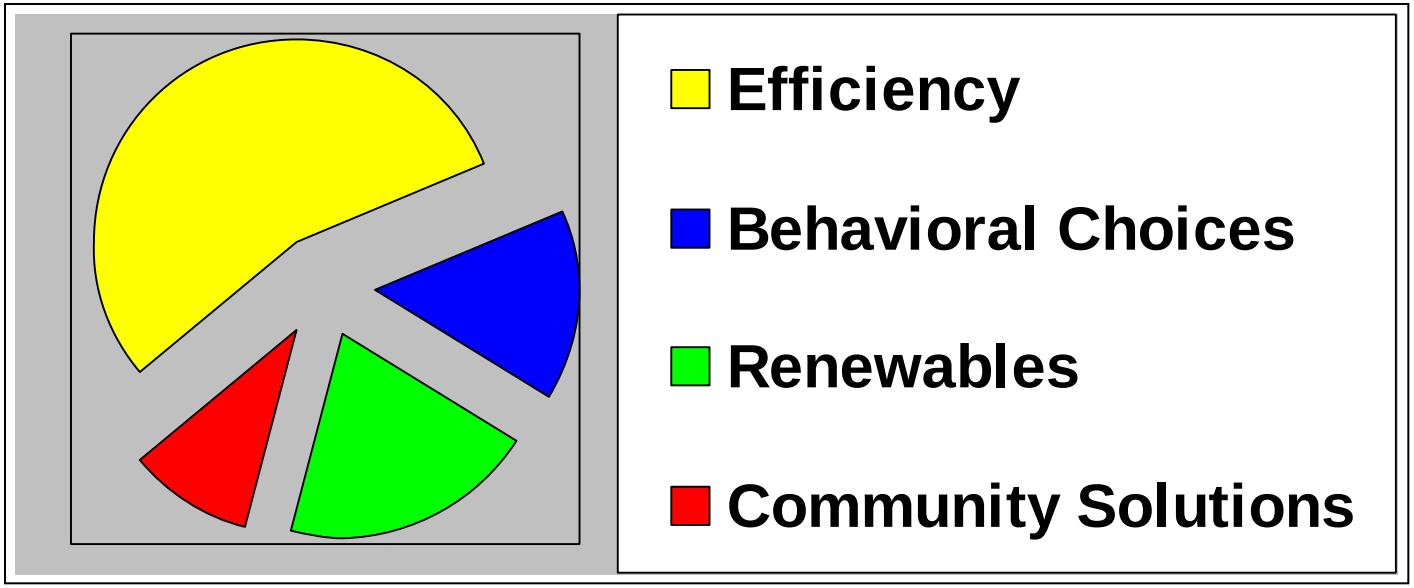
Discussion/Questions

- Post comments & questions under “Questions”

70%+ Deep Energy Reductions

The Thousand Home Challenge

Access & Integrate



Key Metric

Transparent & Direct

Include Occupants

Net Annual Household Site Energy

Credits/offsets: Solar & onsite renewables

Wood counts!

Each household has its unique threshold of performance to meet or exceed.

Thousand Home Challenge

Summary of THC Threshold Determination

OPTION A

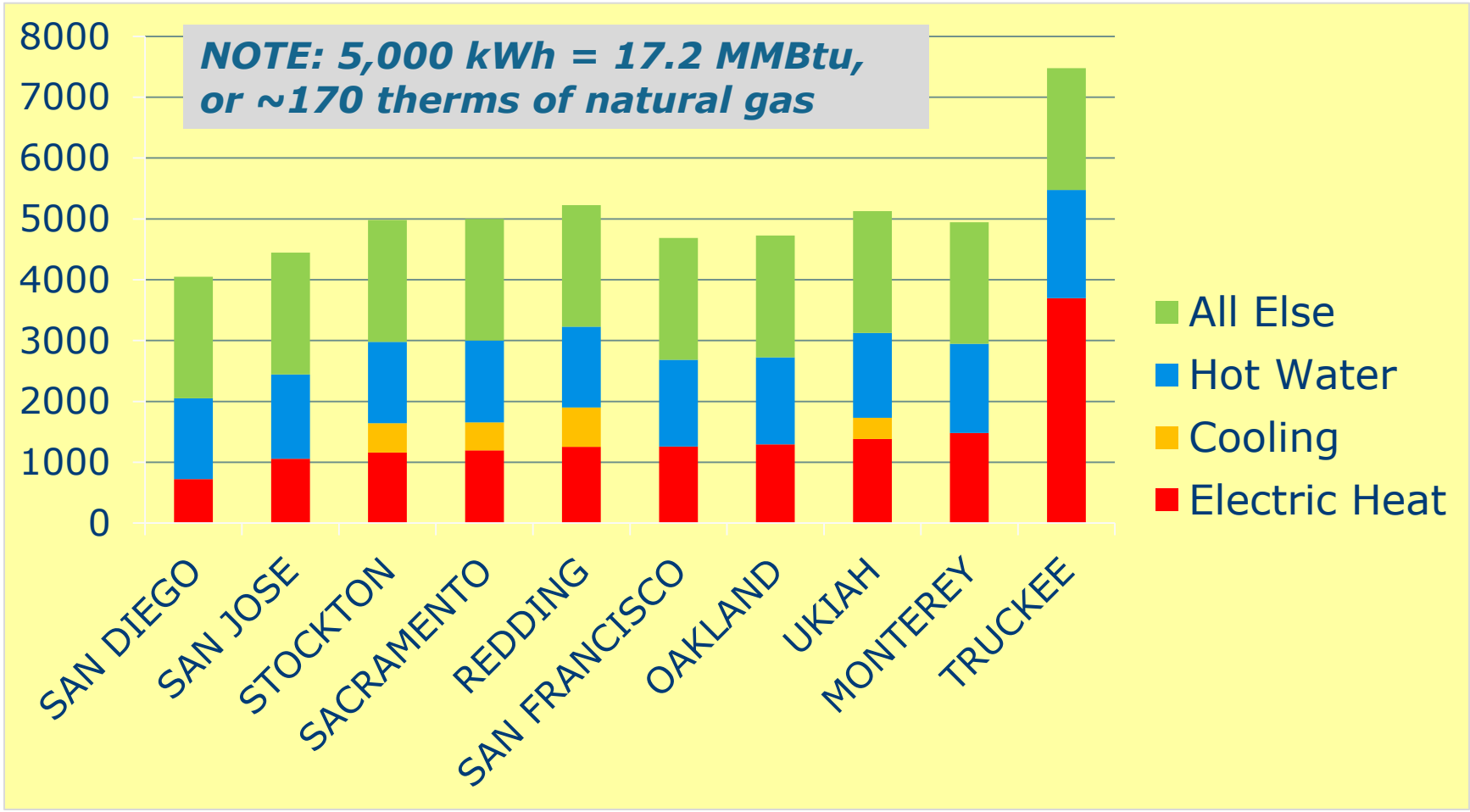
- 75% reduction in actual annual site energy use

OPTION B Inputs

- Climate (ZIP Code or best match weather station)
- House size (FFA), converted to surface area (5 sides)
- Number of occupants (including partial occupancy)
- Detached or attached
- Electric heat allowance = ½ fossil fuel or wood heat allowance

THC Option B Household Threshold

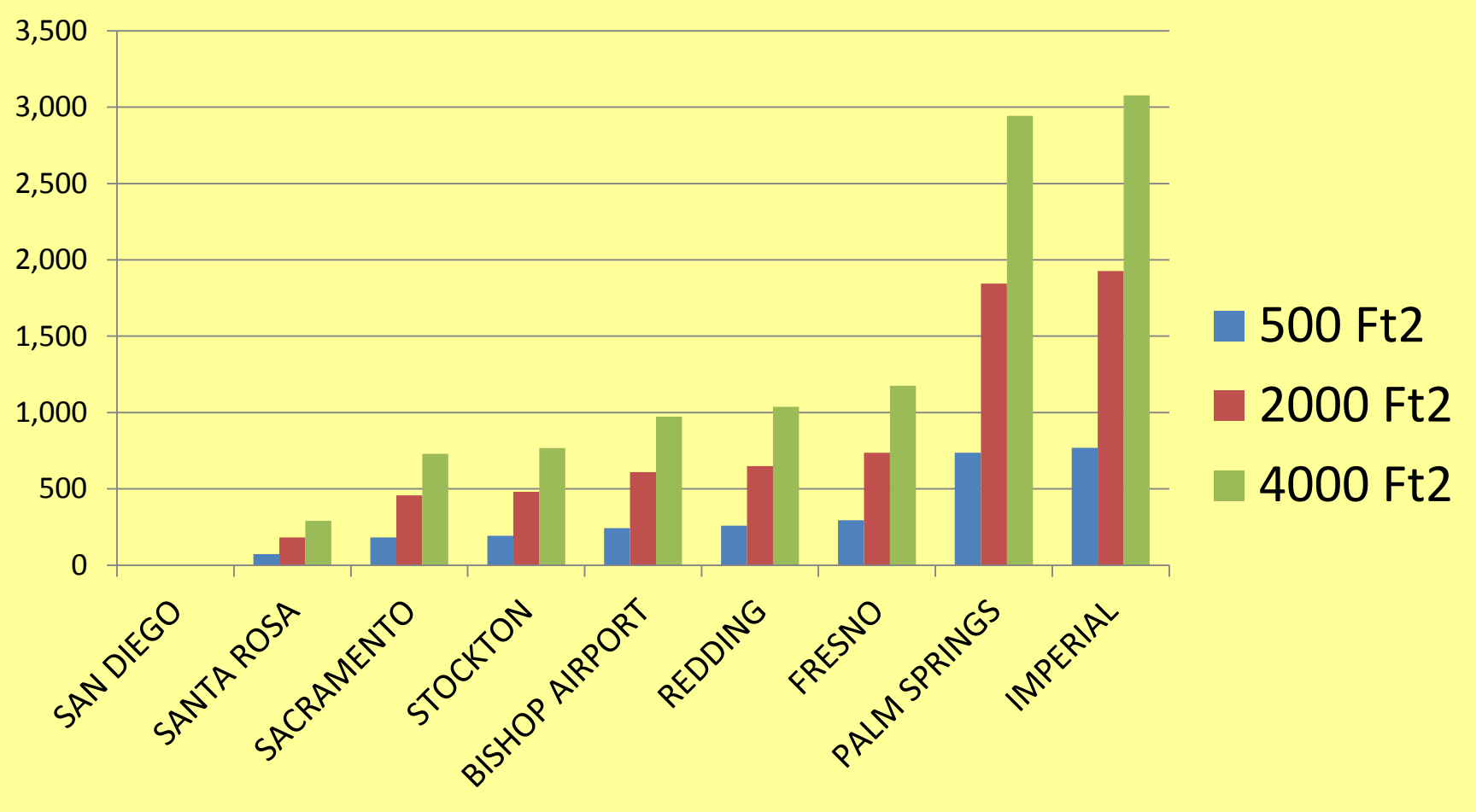
(kWh/yr. by end-use)



OPTION B Inputs: Detached; 3 in household; 2,000 ft^2 finished floor area (FFA); electric heat

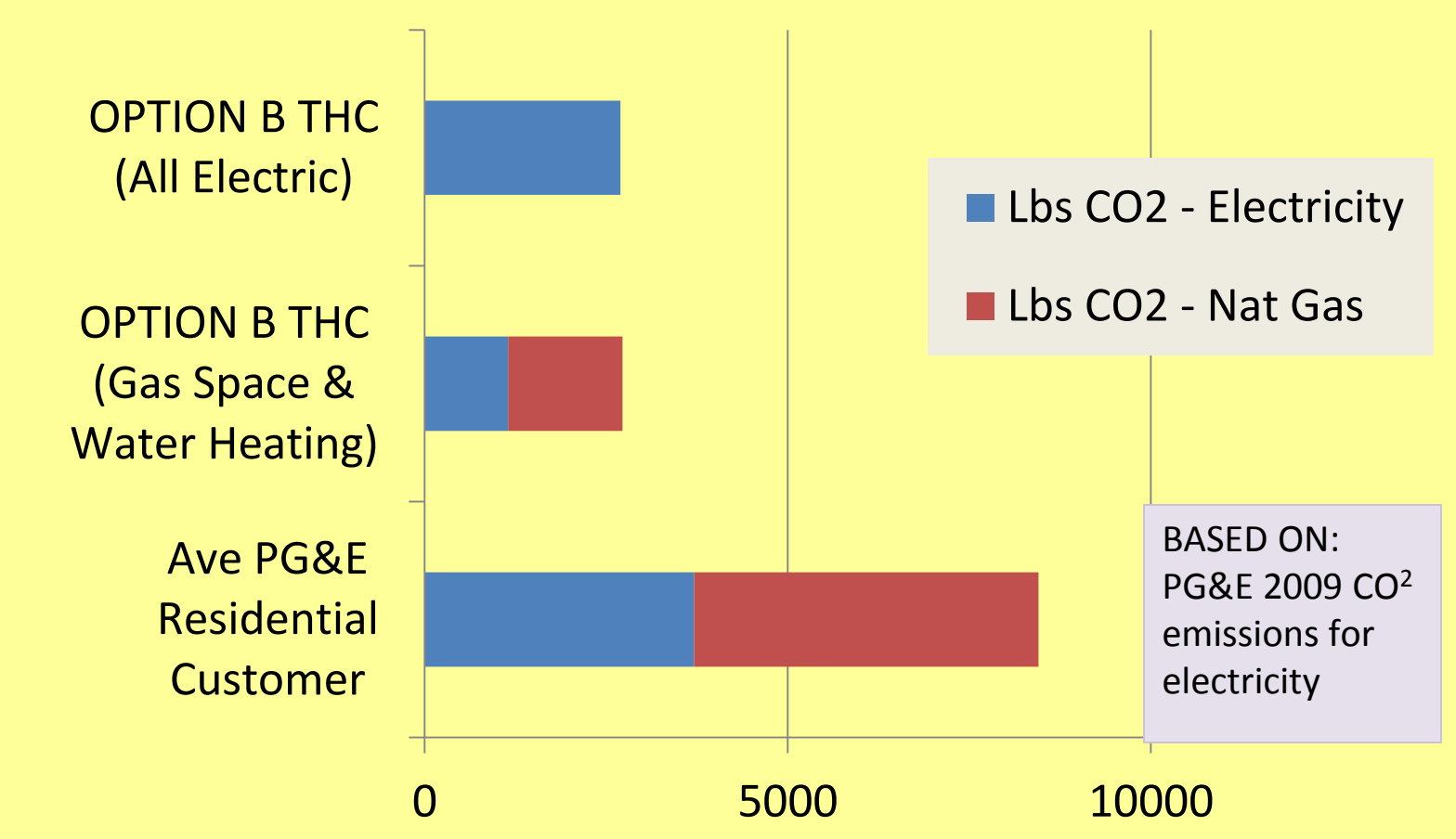
THC OPTION B Cooling Allowance

(kWh/yr. by location & house size)



Comparing CO^2 Emissions

http://www.pge.com/mybusiness/environment/calculator/



OPTION B Inputs: Detached; 3 in household; 2,000 ft² finished floor area (FFA)
CA Average Residential Customer Annual Use (includes multis): 405 therms
6,456 kWh

Key Questions for THC Projects

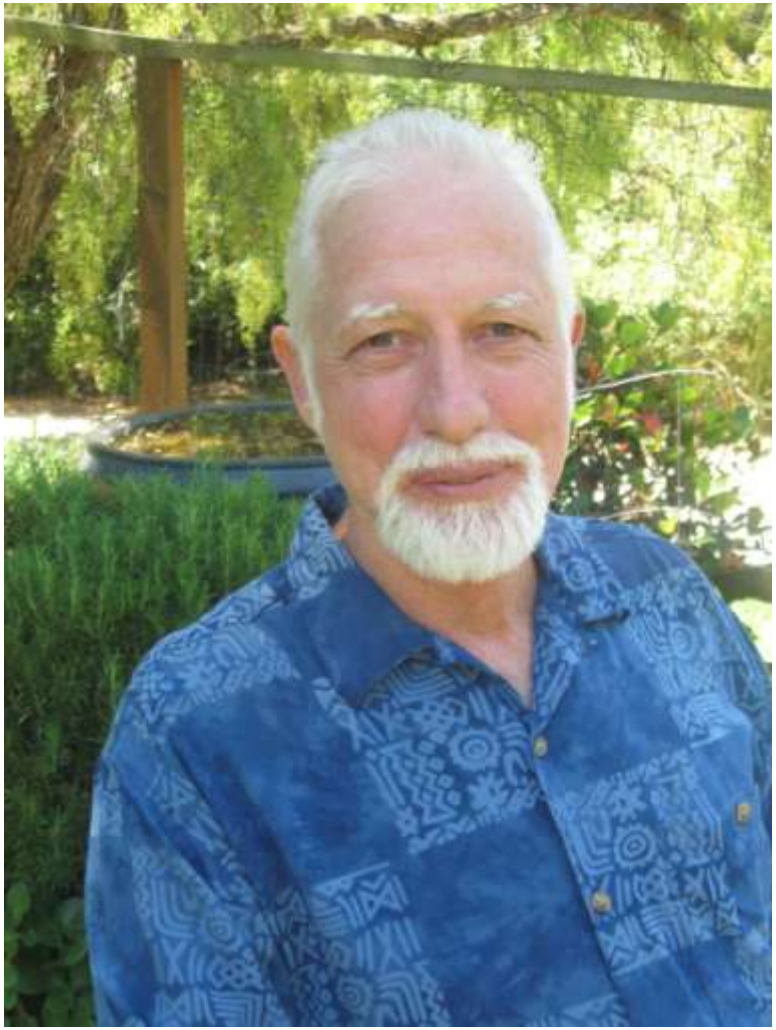
- What systems make sense for homes with ***low space conditioning loads*** (<100 therms/yr. or <3,000 kWh/yr.)?
- What systems respond well ***throughout the full range*** of operating/load conditions?
- What systems are ***on the path to deep reductions***, providing benefits to a household both pre-, & post-enclosure upgrades?

Pushing the Limits of Home Performance AND Marketability

Building on 30 years as a remodeling, HVAC, and home performance contractor, **Dave Robinson's** latest venture involves buying and conducting energy-wise retrofits of foreclosed homes. The 15 homes that his company, GreenEarthEquities, has "flipped" so far provide Dave the opportunity to field test various home energy upgrade strategies. Among other innovations, five homes are each heated and cooled by a two-ton mini-split heat pump, which Dave has installed using a combination of ductless and ducted configurations. In this webinar, Dave will share lessons learned to date, including his conviction to keep ducts within the building enclosure. In Fresno's hot (2,400 cooling degree day) climate, for both initial installation and monthly energy consumption, the mini-splits have performed well at a lower cost than conventional HVAC systems in similar homes.

(http://greenearthequities.com)

Combining Field Research with the Art and Science of Net Zero Living



Danny Parker is principal research scientist at the Florida Solar Energy Center (FSEC), working with DOE's Building America program to determine how to achieve net zero energy homes. He collects and analyzes measured data to determine how efficiency and renewable sources can dramatically lower buildings' energy needs. With 30 years of experience in building systems research, Danny has been involved in evaluations of advanced technologies in buildings, from laboratory studies to large-scale utility monitoring projects. He is very enthusiastic for the Zero Energy Home mission--he lives in one that is largely conditioned by a high efficiency mini-split heat pump. Online data at: www.infomonitors.com/dpr

Mini-split Heat Pumps for Cooling in Low Energy Houses: Experience & Promise

Danny Parker

ACI Webinar

October 25, 2011

Overview

- How they work
- Technology
- Potpourri of data on cooling
- Room temperature variation
- What we know; what we don't (e.g., zoning)

How do they work?

- *Outdoor unit connected to indoor unit by direct refrigeration line (no duct losses)*
- *Mini-split: Zoned control of space*
- *Multi-splits: Up to four units can be placed inside*
- *Multi-splits are generally less efficient, but can reduce the number of outdoor units*

Mini-Split Technology

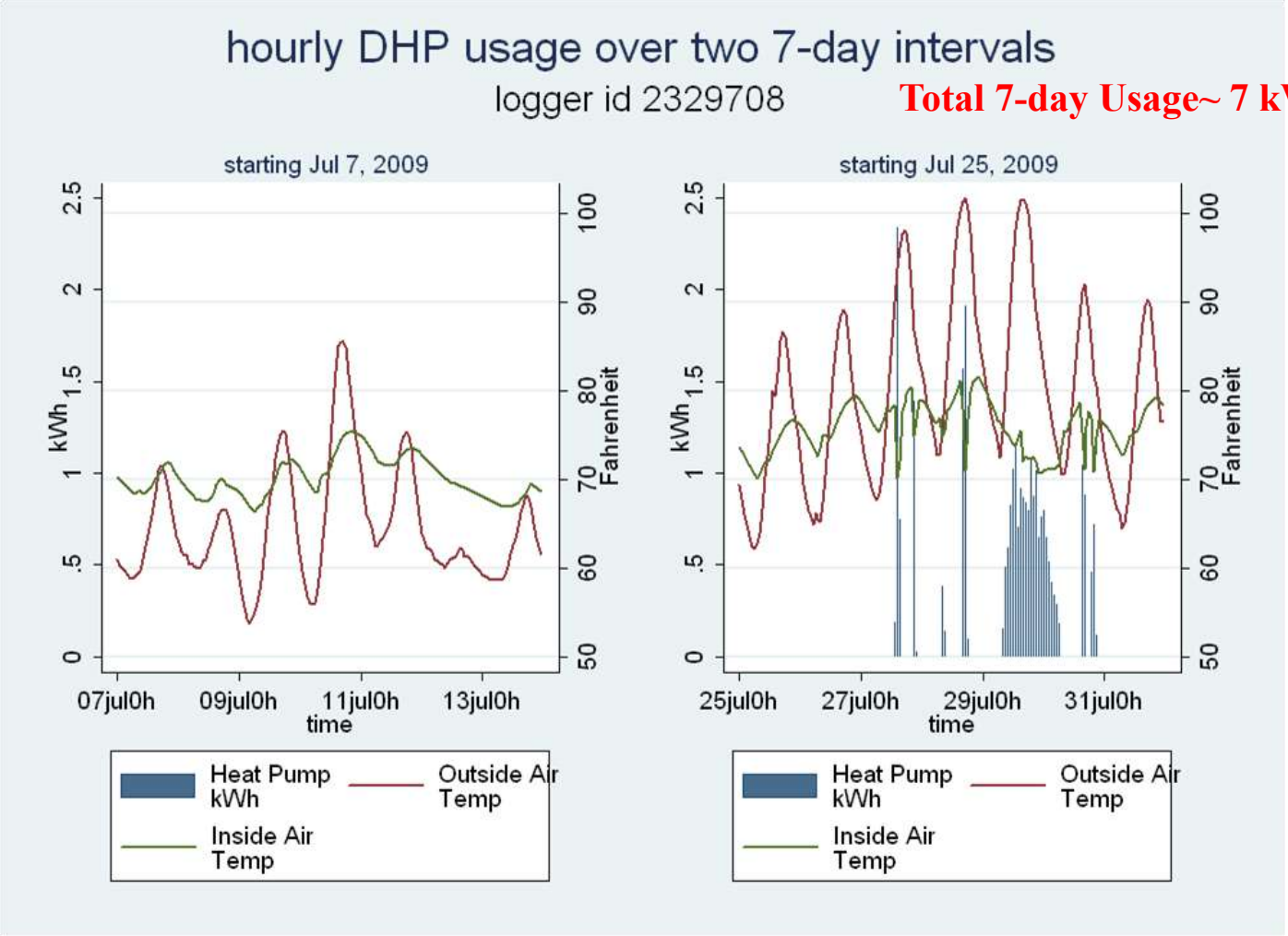
- Not new! Millions in use in Asia/Europe
- Small size; ideally suited to low-e homes
- Inverter controlled DC compressor speeds
- Higher efficiency
- Variable speed blower
- Electronic expansion vs. TXV; hi-tech defrost

4,000 – 24,000 Btu/hr

Very High Efficiency Inverter Controlled Heat Pumps

	9RLS Heat Pump	12RLS Heat Pump
	ENERGY STAR	ENERGY STAR
Nominal Cooling *BTU/h*	9,000	12,000
Min.~Max. Cooling *BTU/h*	3,600~12,000	3,800~14,500
Nominal Heating *BTU/h*	12,000	16,000
Min.~Max. Heating *BTU/h*	3,000~22,000	3,100~24,000
HSPF *BTU/hW*	12	12
SEER *BTU/hW*	26	25
EER *Clg/Htg*	17.31/15	14.46/13.33
Clg. Operating Range °F(°C)	14~115 (-10~46)	14~115 (-10~46)
Htg. Operating Range °F(°C)	5~75 (-15~24)	5~75 (-15~24)
Moisture Removal *Pt./h(l/h)*	2.8 (1.3)	3.8 (1.8)
Voltage/Frequency/Phase	208-230/60/1	208-230/60/1
Recommended Fuse Size *(A)*	15	15
Air Circ. *C.F.M. (m^3/h)*: Hi	430	430
Medium	353	353
Low	265	265
Quiet	177	177
Noise Level *dB(A)*: Hi	46/46	46/46
Medium	42/42	42/42
Low	34/34	34/34
Quiet	24/24	24/24
Outdoor Fan Speed *RPM Clg/Htg*	810/780	870/780

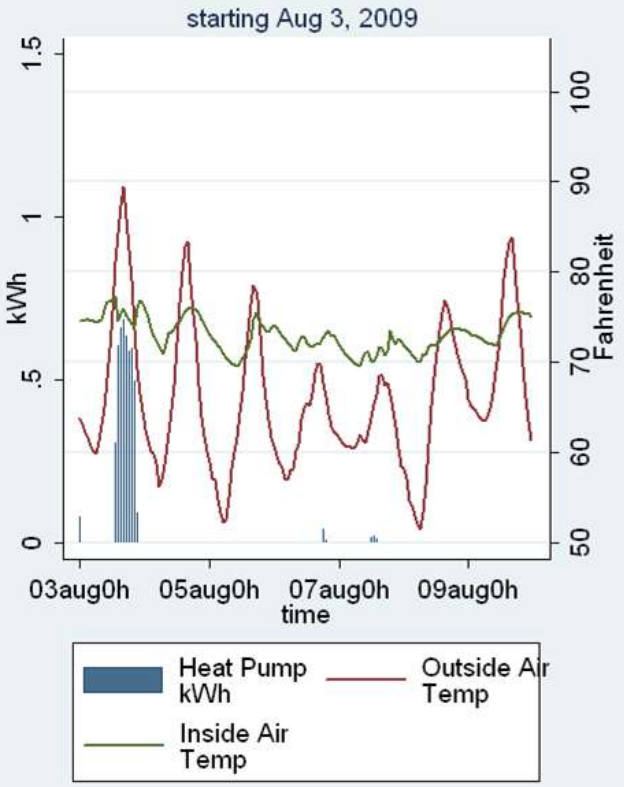
NEEA Ductless Heat Pump Study in the PNW: Ecotope

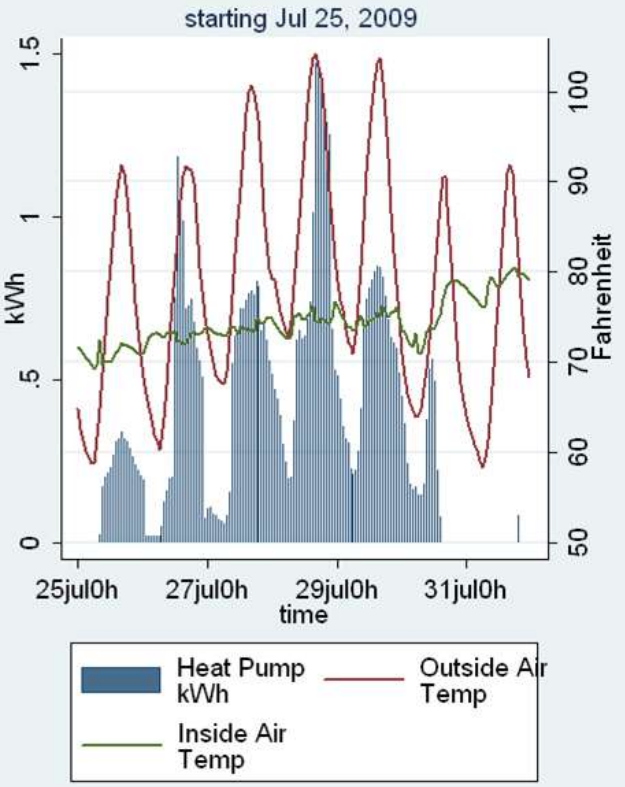


hourly DHP usage over two 7-day intervals

logger id 2329728

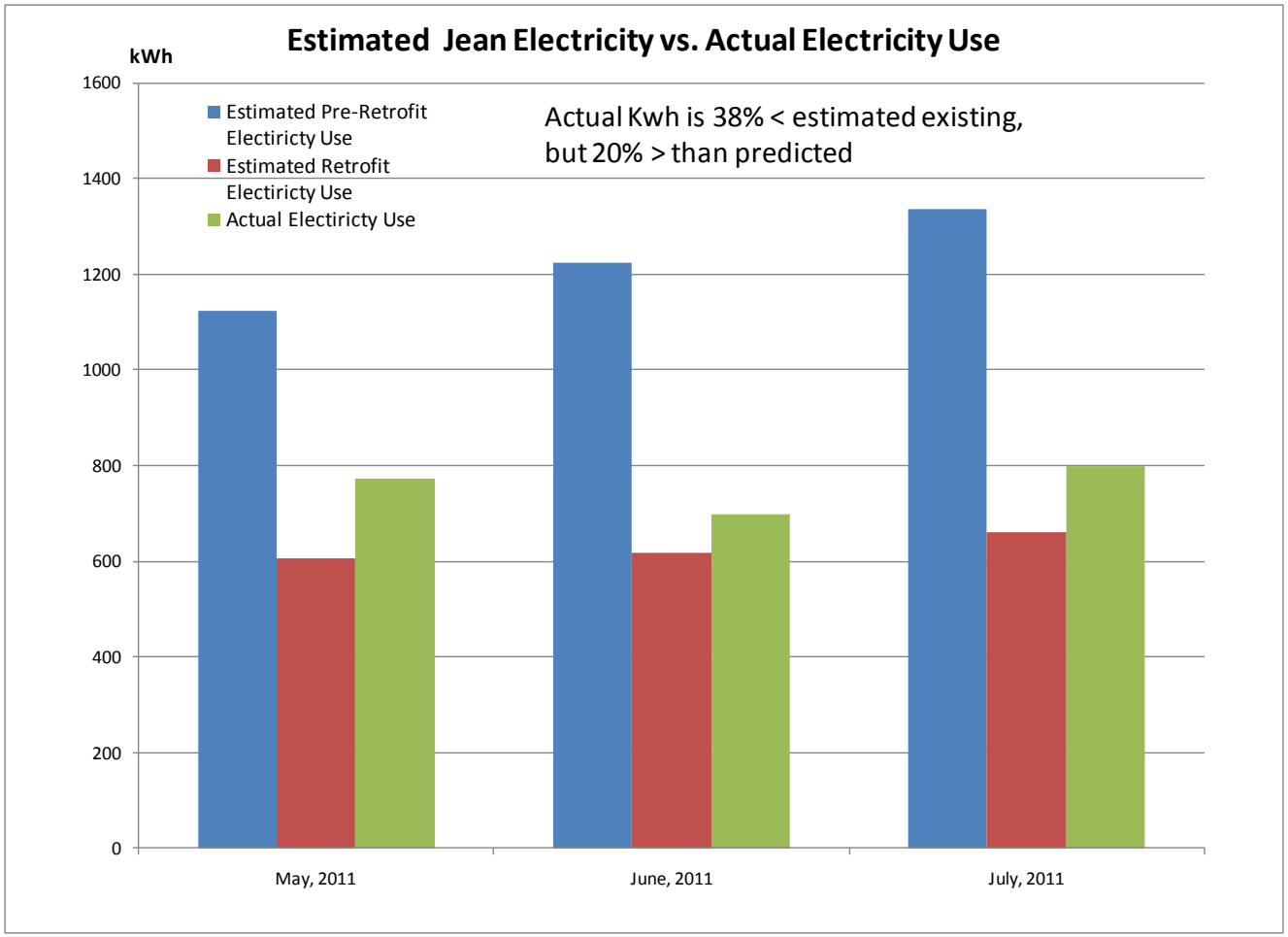
Total 7-day usage ~ 26 kWh!





SMUD Experience

- Good savings
- But some reliability problems
- Some aesthetic issues



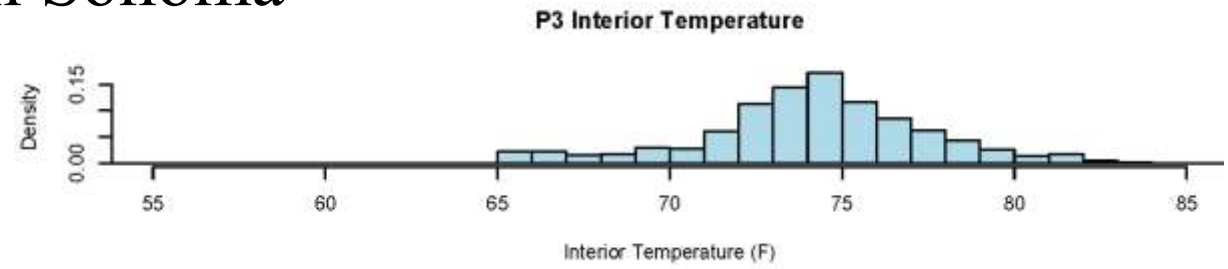
Ward Lutz Experience

- Fujitsu 9RLS
- 575 ft^2 bungalow
- Built in 1950
- Western Ohio
- Now super-insulated
- Used 2-3 kWh per day for cooling with temps above 90º F

Most cooling loads from internal sources

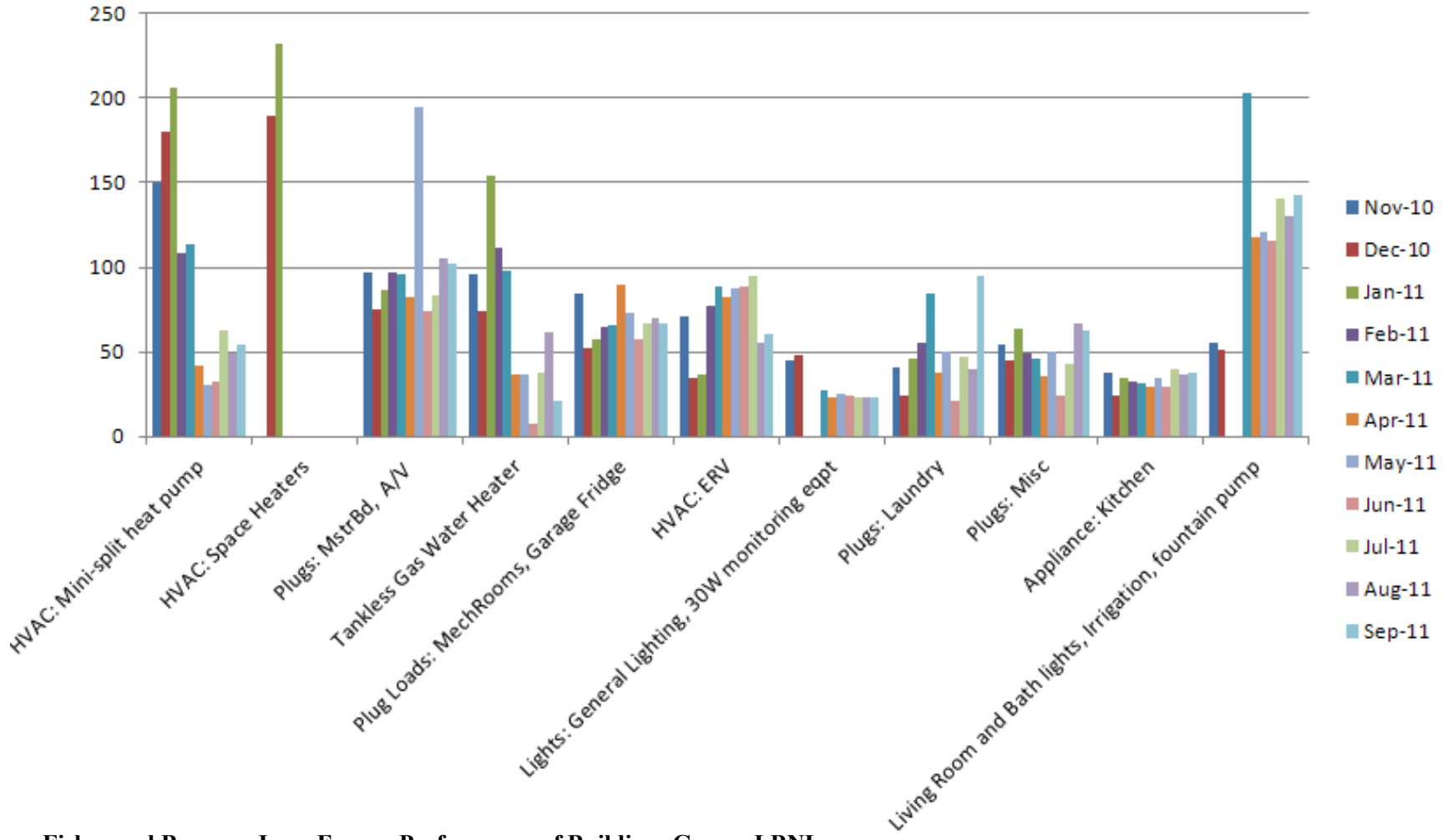
O'Neill House

- No compromise Passive House in Sonoma, California
- 2,400 ft^2: super insulated; super tight (0.38 ACH @ 50Pa)
- Mitsubishi Mr. Slim mini-split HP
- Low-energy cooling
- But little cooling in Sonoma (est. use 225 kWh/yr)



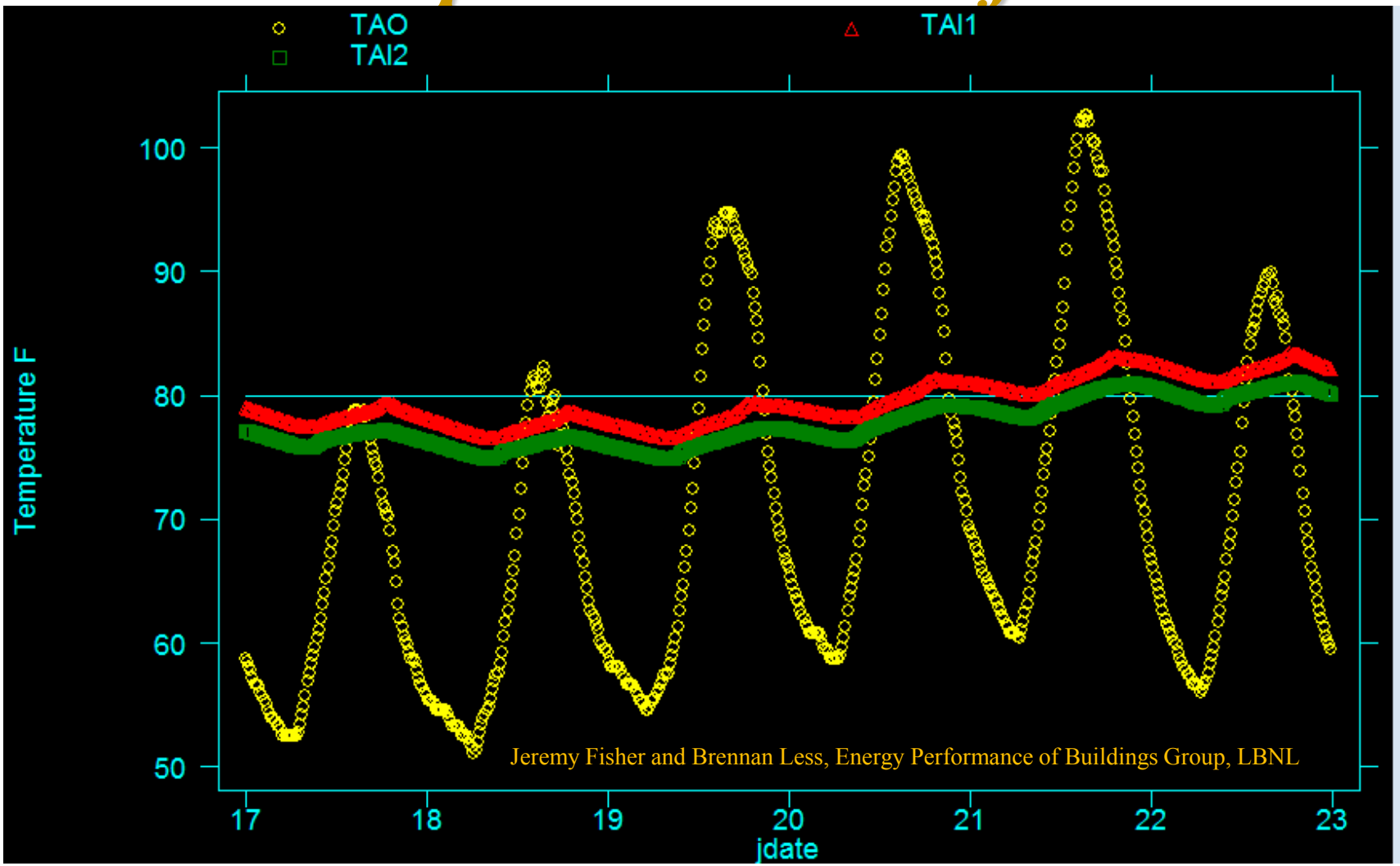
Data: Jeremy Fisher and Brennan Less, Energy Performance of Buildings Group, LBNL

O'Neill House (monitored kWh)



Jeremy Fisher and Brennan Less, Energy Performance of Buildings Group, LBNL

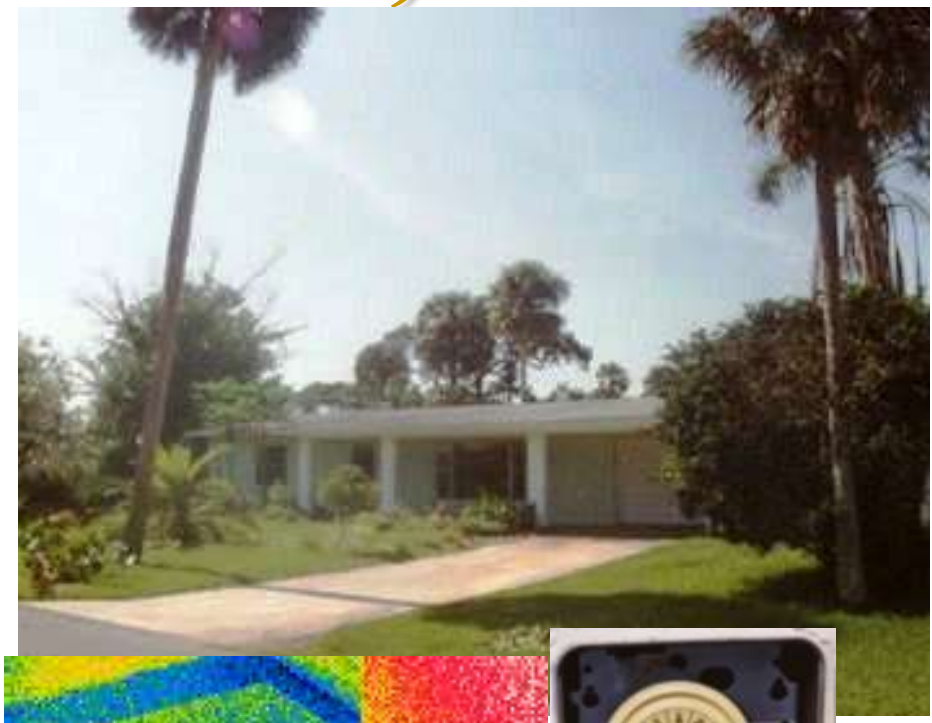
Summer Operation: Comfort

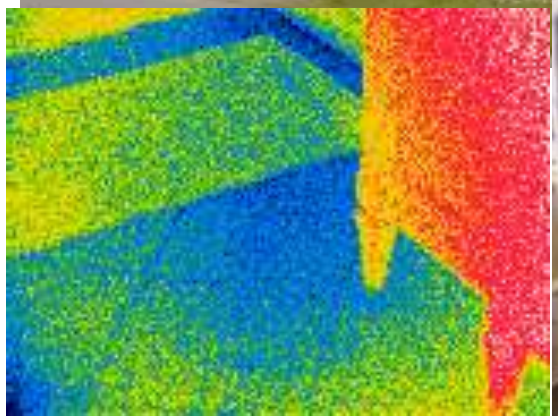


O'Neill Passive House: June 17 -22, 2011

My House: Cocoa Beach, FL

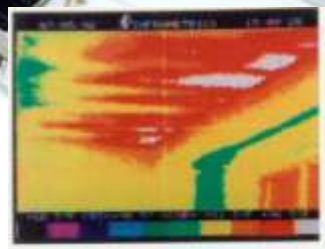
- Built in 1958
- 1,500 ft^2 with pool
- CBS construction: totally uninsulated
- Typical energy use for this housing type ~20,000 kWh/yr
- Millions like these in Florida
- Started retrofits after moving in: 1989
  - R19 ceiling insulation
  - Removed carpet for tile floor
  - Dropped pool pump to 4 hrs/day
  - Sealed ducts following summer

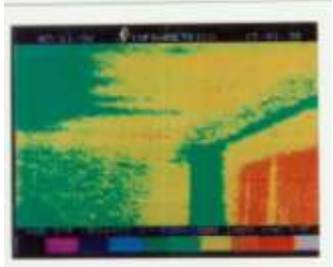


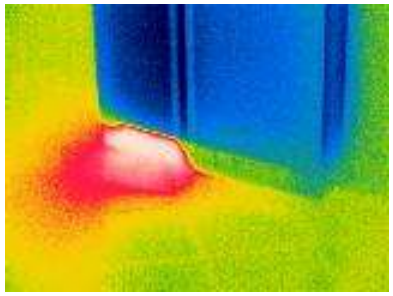


Scads of Retrofits

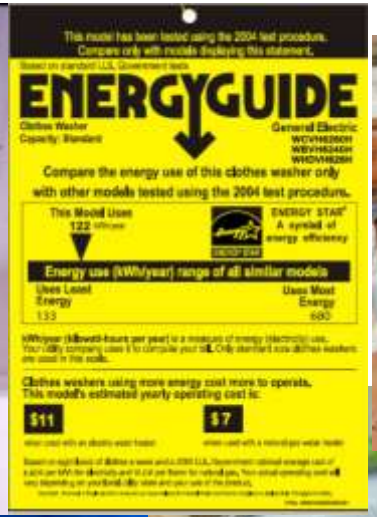
- Solar hot water with tankless gas backup
- PV DC pumped pool
- White metal roof
- Sun pipe interior lighting
- Low energy refrigerator

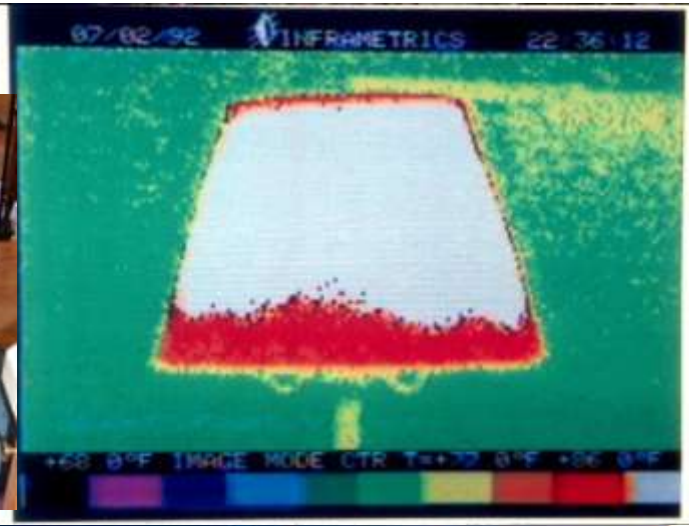


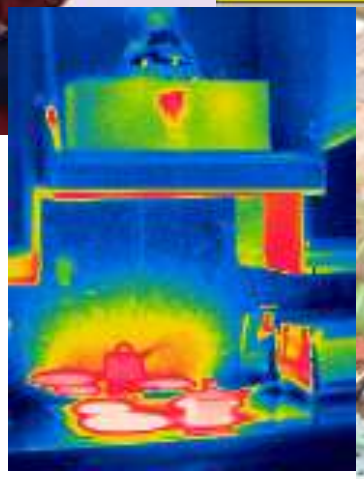


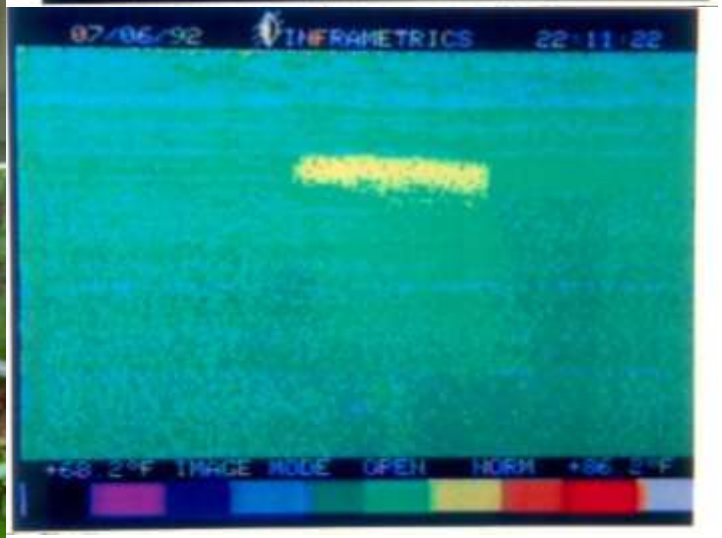


CFLs, Ventilation, WH Fan, Washer, Dishwasher…It Goes On



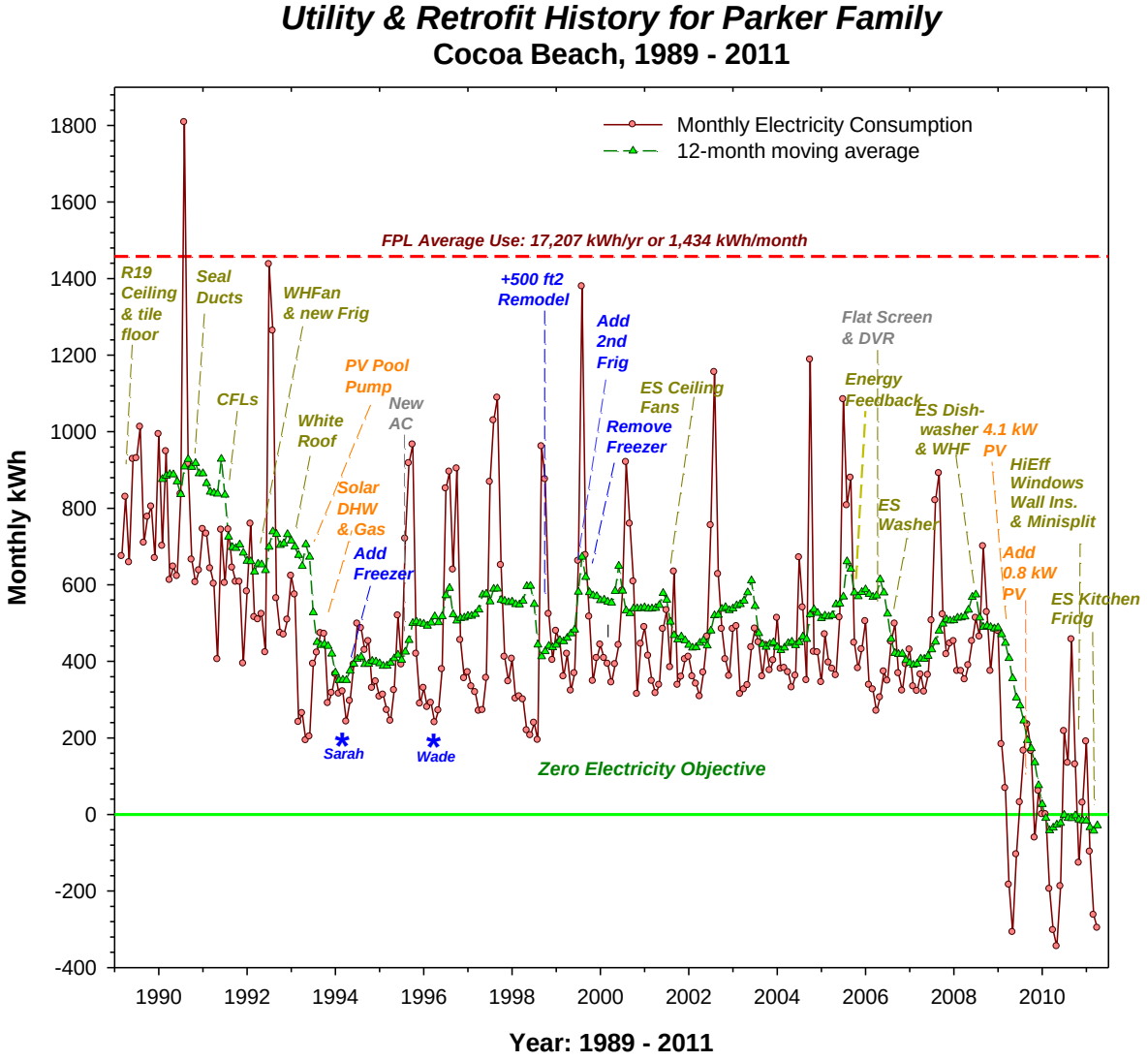






Long-term Electricity Consumption

- Utility records since 1989
- Big drop with early conservation measures
- Steady for a decade although adding 50% floor area & two more people!
- Zero in 2011



Very High Efficiency Mini-split

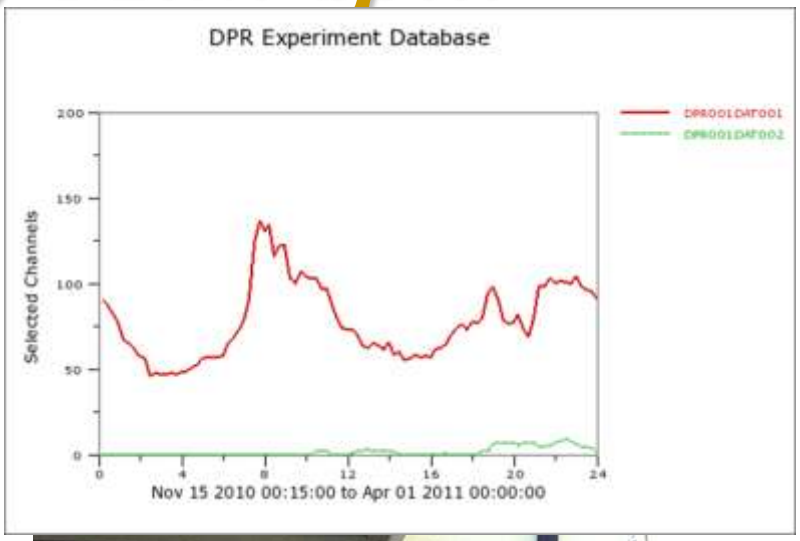
- SEER 26 mini split
- Heat Pump
  - HSPF= 12.0
- 9,000 Btu/hr output
- Abandon duct system

Features | Specifications | Dimensions | Downloads

SYSTEM	9RLS	12RLS	15RLS
CAPACITIES:			
Cooling BTU/h	9,000	12,000	15,000
Outdoor Design Temp F° DB/WB	95/75	95/75	95/75
Heating BTU/h	12,000	16,000	18,000
Outdoor Design Temp F° DB/WB	47/43	47/43	47/43
SEER	26	25	21
EER Clg/Htg	17.3/15	14.5/13.3	12.5/12.3
HSPF	12	12	11
Power Supply (V)	208-230	208-230	208-230
INDOOR UNIT:			
Noise Level db (A) *Cooling*			
Hi	46	46	46
Med	42	42	40
Lo	34	34	33
Quiet	24	24	25
Noise Level db (A) *Heating*			
Hi	46	46	46
Med	42	42	40
Lo	34	34	36
Quiet	24	24	26
Weight (lbs.)	24	24	18
OUTDOOR UNIT:			
Max Fuse Size (A)	15	15	20
Running Current Clg (A) *Rated*	2.6	3.9	5.2
Running Current Htg (A) *Rated*	3.7	5.5	6.4
Weight (lbs.)	88	88	89
REFRIGERANT PIPING:			
Max Ht. Difference (ft.)	49	49	49
Max Total or Combined Length (ft.)	66	66	66
Discharge Vapor Line (O.D.) inches	1/4	1/4	1/4
Suction (O.D.) inches	3/8	3/8	3/8

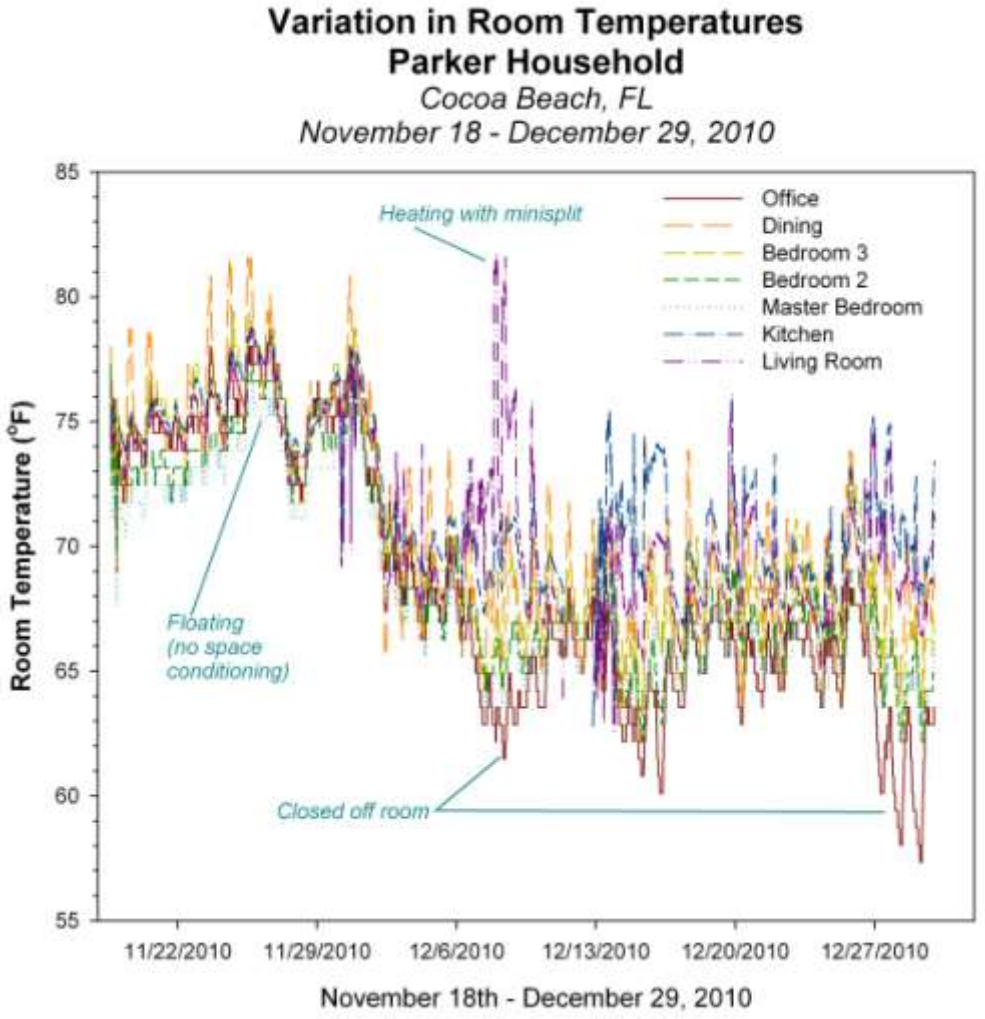
Very High Efficiency Mini-split

- Operate for space heating rather than natural gas
- Outdoor unit on west side of house
- Very quiet operation
- Only 196 kWh for space heat for all of 2010-2011
- Mini-split power was about the same as blower power on gas furnace!

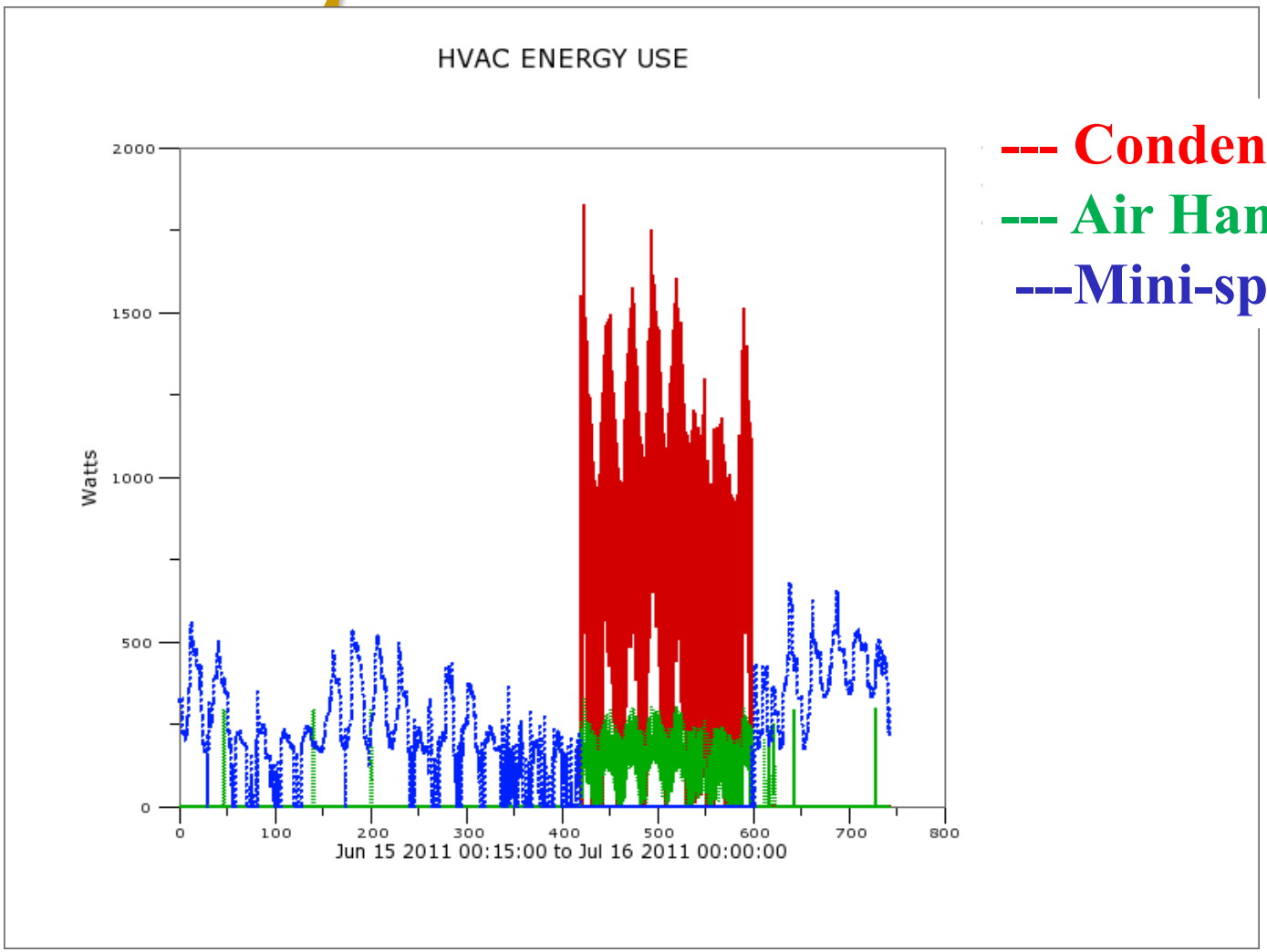


Variation in Room-to-Room Temperatures

- Used HOBO loggers to evaluate temperature variation
- Note wide temperature spread during heating season
- Even without space conditioning, lots of variation
- Impact of closing off rooms

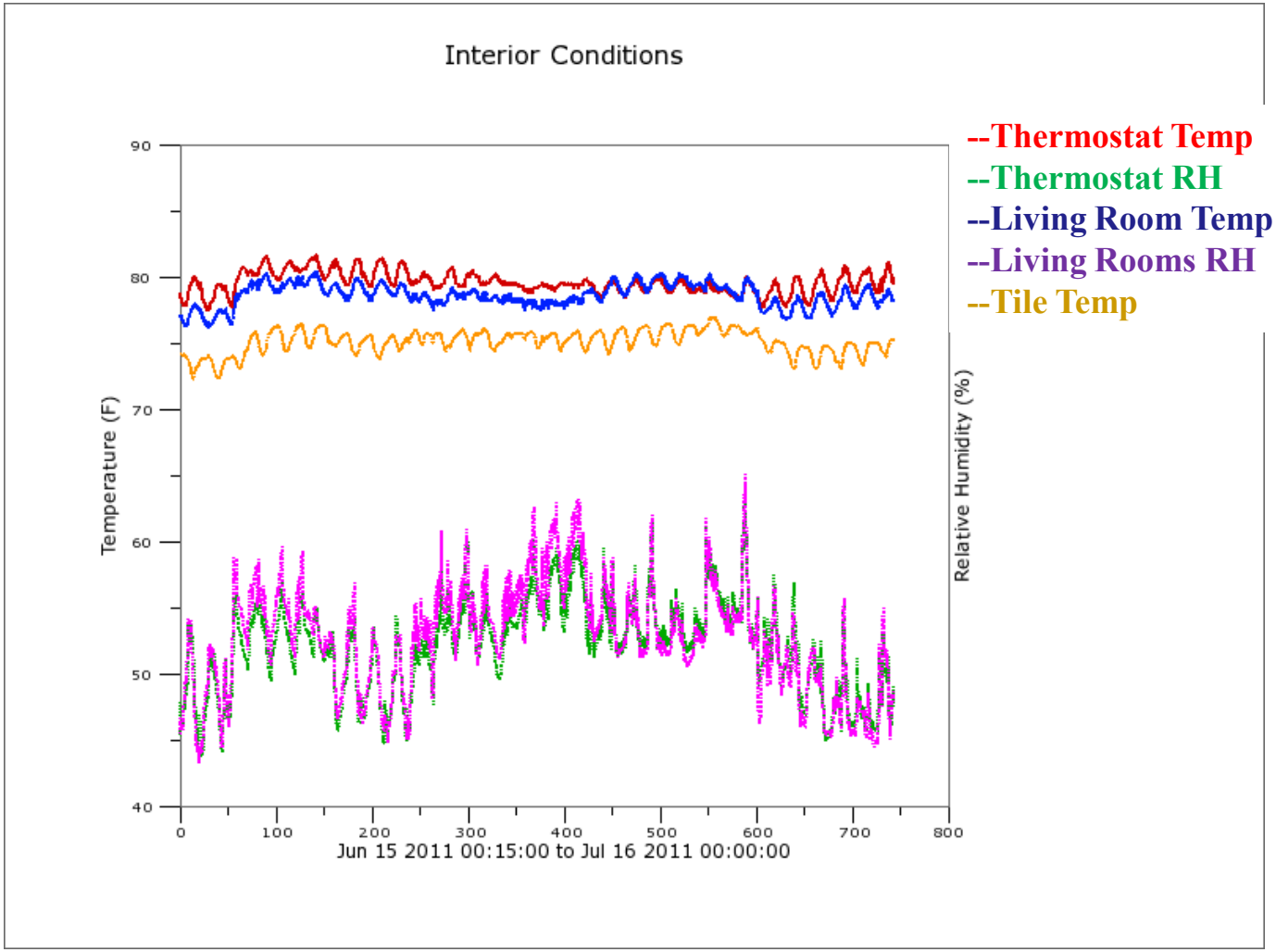


Summer Operation: Power



Contrast Mini-split with Central System

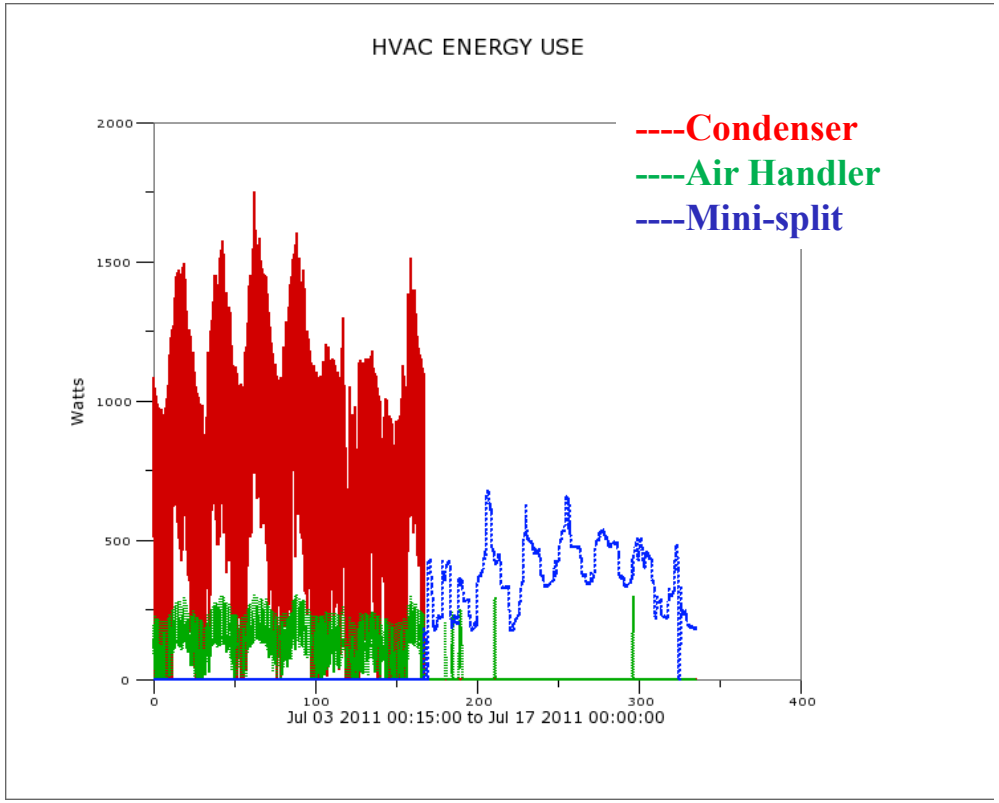
Summer Operation: Comfort



Contrast Mini-split with Central System

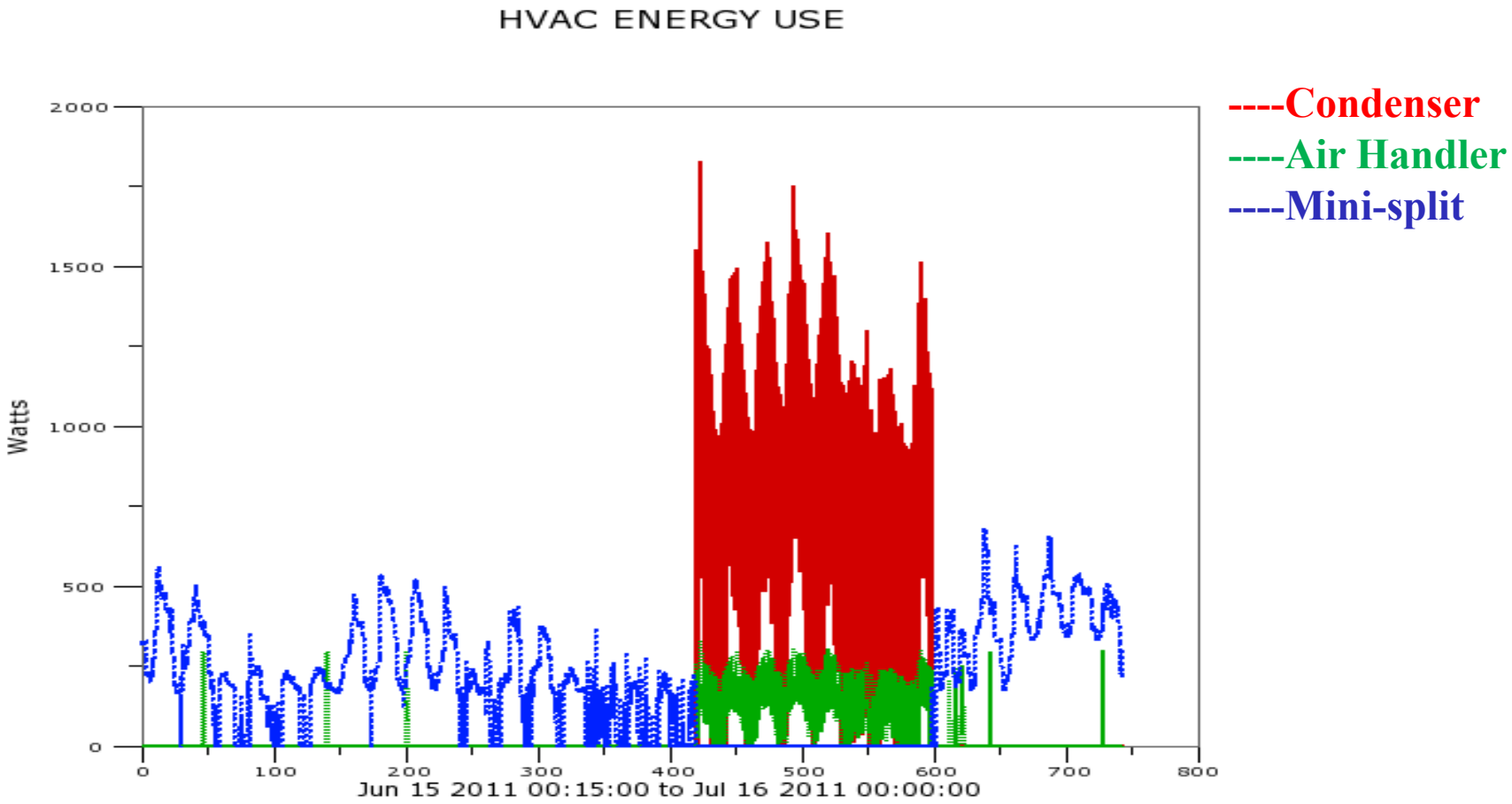
Energy Reduction from Using Mini-split

- Cooling energy July 3-9 with Central System:
  - 20.7 kWh/day (3.5 kWh/AHU)
  - Interior temp: 79.1º F
  - Ambient: 82.0º F (75.8-91.5)
- Cooling energy July 10-16 with Mini-split:
  - 8.9 kWh/day
  - Interior temp: 79.3º F
  - Ambient: 82.3º F (73.8 – 93.6)
- 57% savings, even though hotter in post period

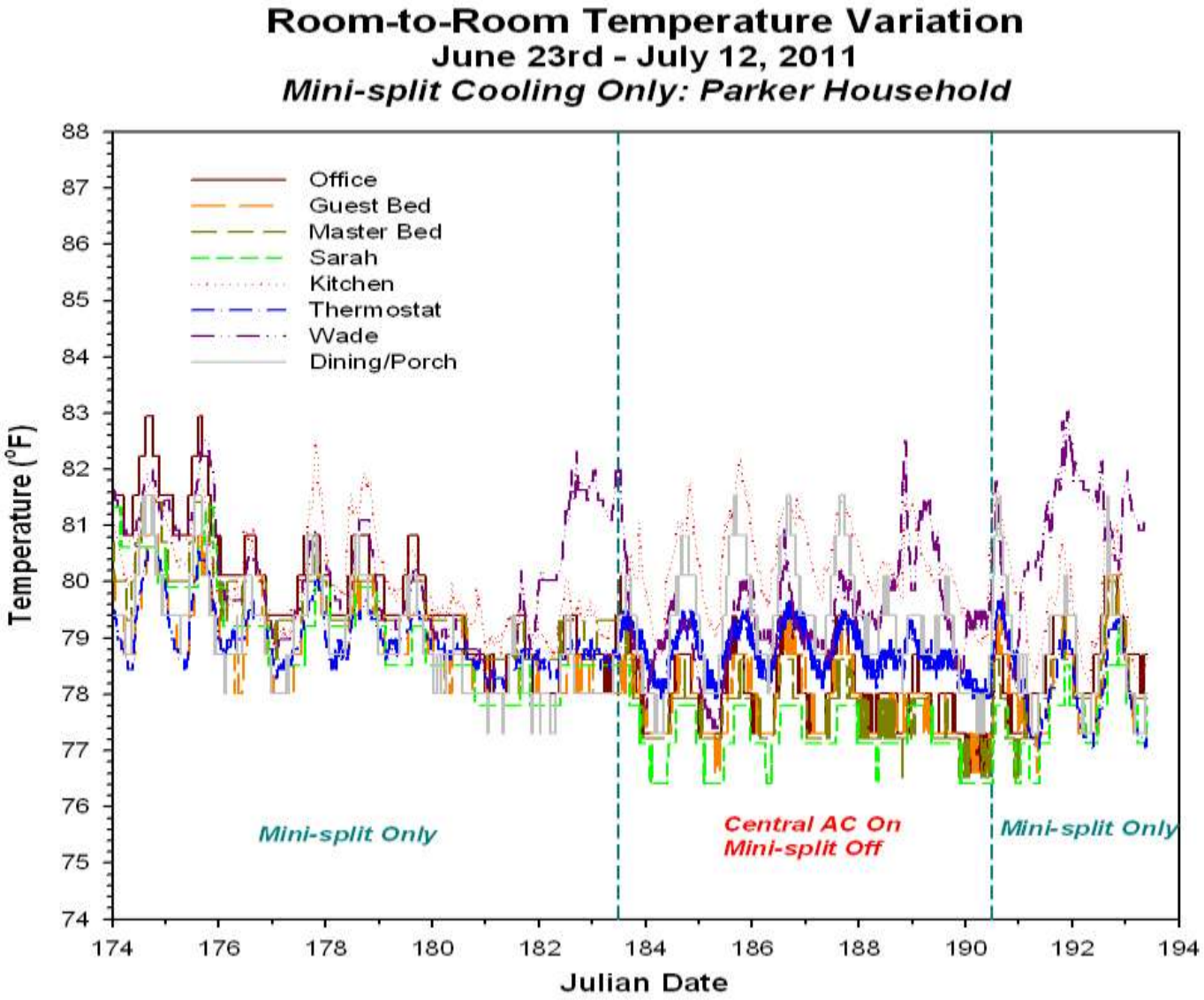


www.infomonitors.com/dpr

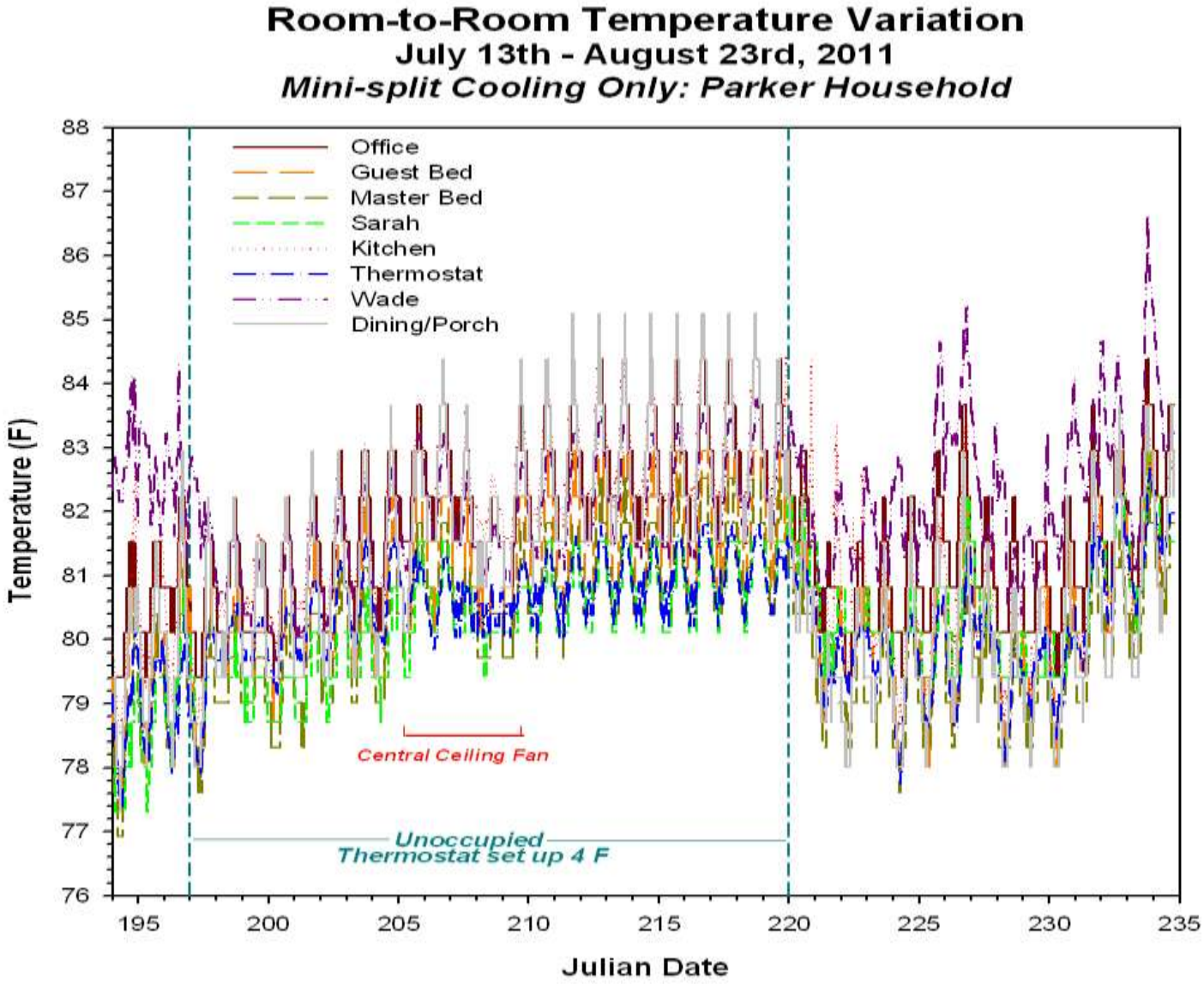
Summer Operation: Power



Contrast Mini-split with Central System



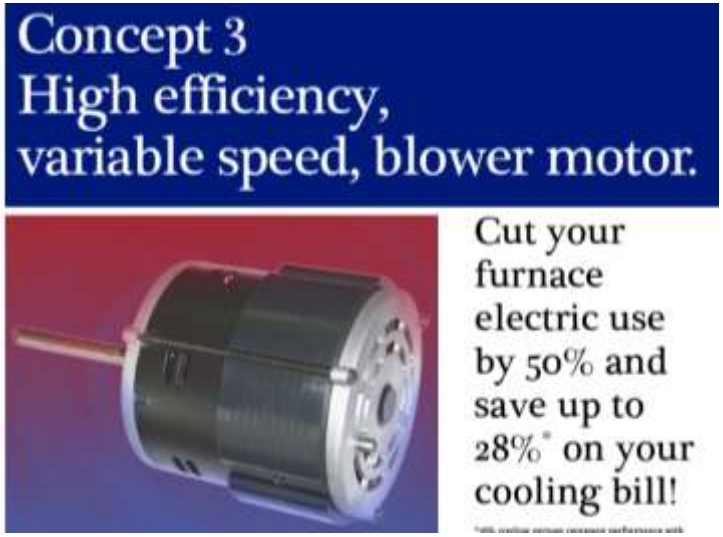
Contrast Mini-split with Central System



Mini-split with Central Fan

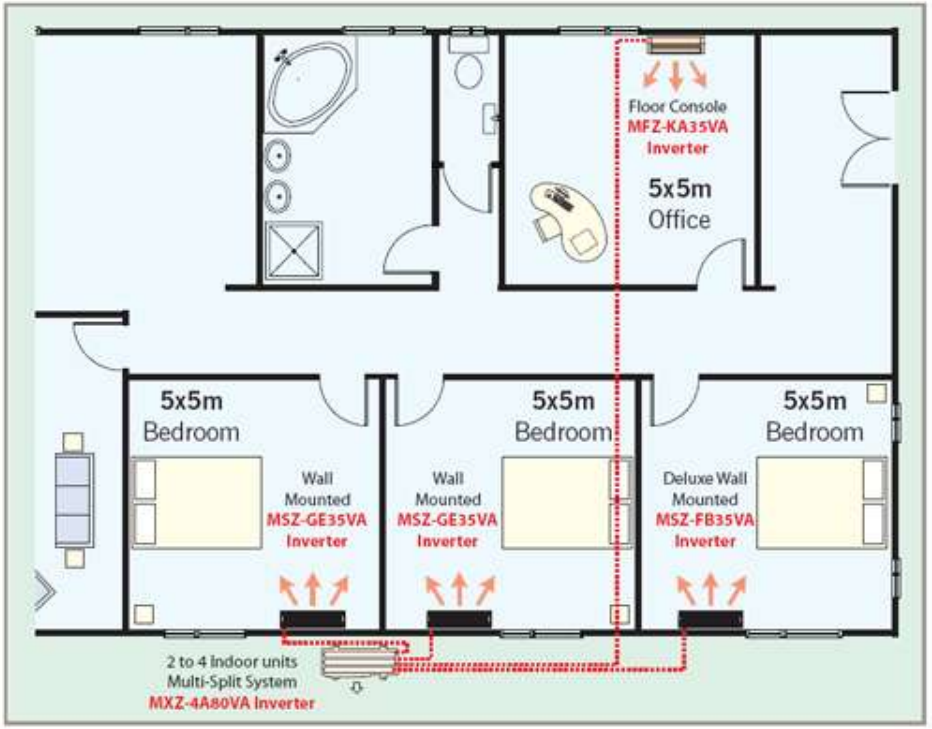
How to Equalize Room Temperatures?

- Multiple mini-split heads
- Circulation fans (*Panasonic Whisper Green* ceiling insert fans)
- Use existing air handler to circulate air
  - Consider low energy AHU motor (*Concept 3*)
- Small customized interior ducts, as Dave Robinson will show…



Cost

- Mini-splits: $2,500 - $4,000 installed per unit
- $1,000 + for multiple heads
- Multi-split with multiple heads tend to be ~20% less efficient
- Cost often reflects efficiency
- Cost for one mini-split per bedroom is similar to central system
- May be less if duct system does not exist, however
- How many are really needed?



State of Knowledge

- **What we know…**
  - Best efficiency mini-splits can cut cooling needs by 30%-70%
  - Hi-SEER with quiet operation
  - No duct leakage, conduction
- **And what we don't…**
  - What are zoning savings in real homes? Key issue…
  - What are room temperature distributions and how do they compare with central?
  - Peak load of multiple systems? Single distributed?

Can a single mini-split provide efficient cooling option for hottest days?

Conclusions: Mini-split Hi-efficiency

Advantages:

- Millions in use worldwide!
- Very quiet operation
- Efficiency > SEER 20
- Fractional ton sizes
- No duct losses (leakage/ conduction) = 20% reduction
- Zoning = 20% less energy
- Good RH control
- Easy to retrofit (no ducts)
- Good retrofit for window units & central systems

Conclusions (cont.)

- Distribution is important
  - One mini-split per bedroom?
  - Really needed? One per floor?
  - Distributed single systems?
  - Enhanced by good insulation/windows
- Disadvantages:
  - Expense similar to central
  - Condensate for each head
  - Some don't like appearance of indoor & multiple outdoor units)
  - U.S. AC trade may discourage