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

Spring 2012 Case Study Webinar Series

WEBINAR 4: Second CA Home to Meet the THC - Bergamaschi:

Focus on Plug Loads, Behavior, & PV

May 9, 2012 10-11:30 a.m. Pacific Time

Presented by: **Frank Bergamaschi,** Architect, San Francisco
Rick Chitwood, Chitwood Energy Management, Inc., Mt Shasta
Facilitated by: **Linda Wigington**, Affordable Comfort, Inc.
Respondents: **Don Fugler,** Ottawa, Ontario & **Gary Klein**, Elk Grove, CA

www.1000HomeChallenge.org www.affordablecomfort.org
http://homeenergypros.lbl.gov/group/1000homechallenge

1000 Home Challenge Webinar/ETC Archives

Spring 2012 Webcasts & Resources Posted

- http://thousandhomechallenge.com/spring-2012-case-study-webinar-series

Home Energy Pros – THC Group Webinar Discussion

- http://homeenergypros.lbl.gov/group/1000homechallenge

2010-2011 THC/ETC Webcasts

(hot water, baseload, ductless heat pumps, dense pack)

- *www.1000HomeChallenge.org/resources*

MARK YOUR CALENDAR!

ACI California – Sacramento, CA – June 5-6, 2012

Check out the Presenters & Agenda http://www.acicalifornia.org

Sessions include:

- **Indoor Air Quality** for Standard & Low Energy Homes
- **HVAC Systems** for Low Energy Homes
- **High Performance Details** for California Climates: Lessons Learned
- **6th Side Debate** – House to Ground: Getting to Low Energy, Healthy Homes
- Wringing Out the Wastes in **Hot Water Systems**
- **Mini-splits:** Measured Performance & Implications for California Housing Stock
- **Passive House** in California: Toward Affordable Sustainability

And many more!

PG&E's 2012 Classes – Free!

Sampling of Offerings Related to
Deep Energy Reductions in Existing Homes

For the full class schedule, visit **www.pge.com/energyclasses**

5-11, 5-25 PG&E's ZNE Homes Class Series (Parts 5 & 6) - *Rick Chitwood & Ann Edminster*

5-24 Deep Energy Reductions – The Thousand Home Challenge - *Linda Wigington*

6-6 Combined Hydronic Space & Water - *Rick Chitwood*

6-12 The Passive House Approach to Zero Net Energy Homes - *Graham Irwin*

6-13 High Performance Residential Hot Water - *Gary Klein*

6-26 Go Ductless California, Try Mini-Splits! - *Dick Rome*

Pacific Gas and Electric Company

ENERGY TRAINING CENTER ETC STOCKTON

Disclaimer

The information in this document is believed to accurately describe the technologies addressed herein and are meant to clarify and illustrate typical situations, which must be appropriately adapted to individual circumstances. These materials were prepared to be used in conjunction with a free educational program and are not intended to provide legal advice or establish legal standards of reasonable behavior. Neither Pacific Gas & Electric (PG&E) nor any of its employees and agents: (1) makes any written or oral warranty, expressed or implied, including but not limited to the merchantability or fitness for a particular purpose; (2) assumes any legal liability or responsibility for the accuracy or completeness of any information, apparatus, product, process, method, or policy contained herein; or (3) represents that its use would not infringe any privately owned rights, including but not limited to patents, trademarks or copyrights. Furthermore, the information, statements, representations, graphs and data presented in this report are provided by PG&E as a service to our customers. PG&E does not endorse products or manufacturers. Mention of any particular product or manufacturer in this course material should not be construed as an implied endorsement.

www.pge.com/stockton

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Learning Objectives for Today

By attending this webinar, participants will

- Find out how a focus on **baseload energy management** helped this project meet the Thousand Home Challenge
- Learn about the **energy performance results** of this project
- Hear about **additional opportunities** to improve energy performance

Webinar Outline Today

Linda Wigington

- Intro & Thousand Home Challenge

Frank Bergamaschi & Rick Chitwood

- Project presentation

Gary Klein & Don Fugler

- Comments & Questions

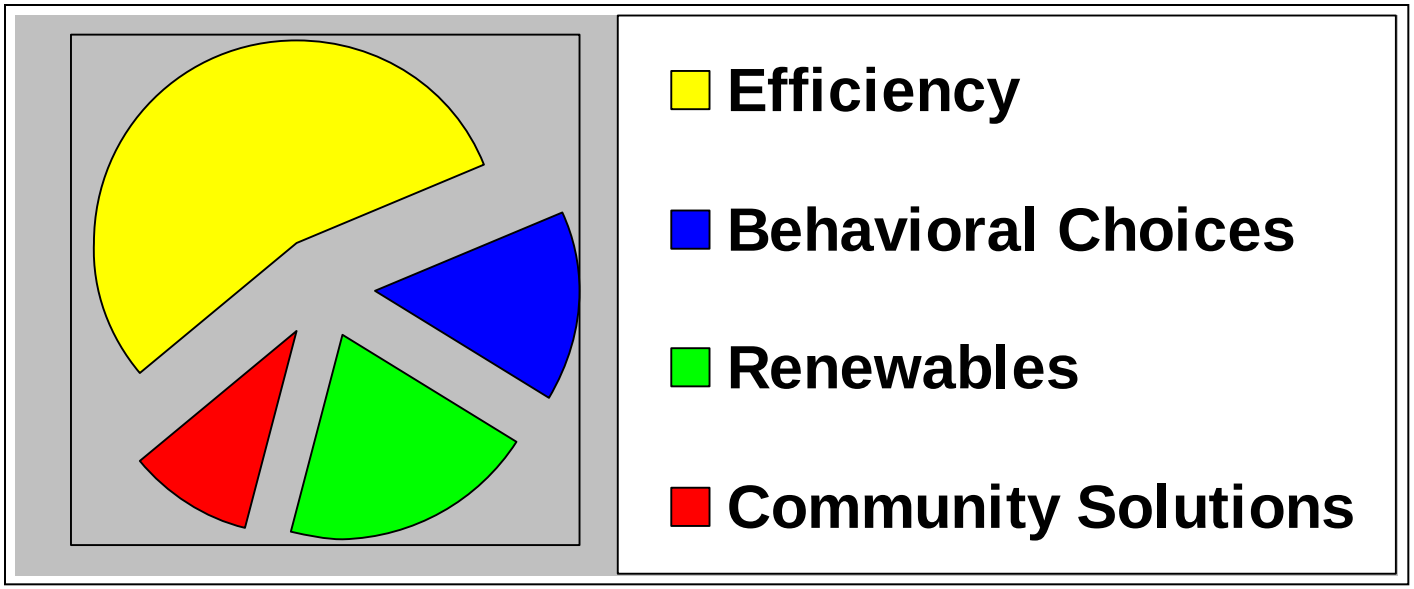
Discussion & Questions

- Post comments & questions under “Questions” or send to (lwigington@affordablecomfort.org)

The Thousand Home Challenge

70%+ Deep Energy Reductions

Access & Integrate



What Is the Thousand Home Challenge (THC)?

- A new **vision** for what's possible
- **Integrates** human & technical solutions
- Stimulates **innovation**
- Builds **capacity**

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

Key Metric

Transparent & Direct

Include Occupants

Net Annual Household Site Energy

Credits/offsets: Solar & on-site renewables

Wood counts!

Thousand Home Challenge Threshold Determination

OPTION A

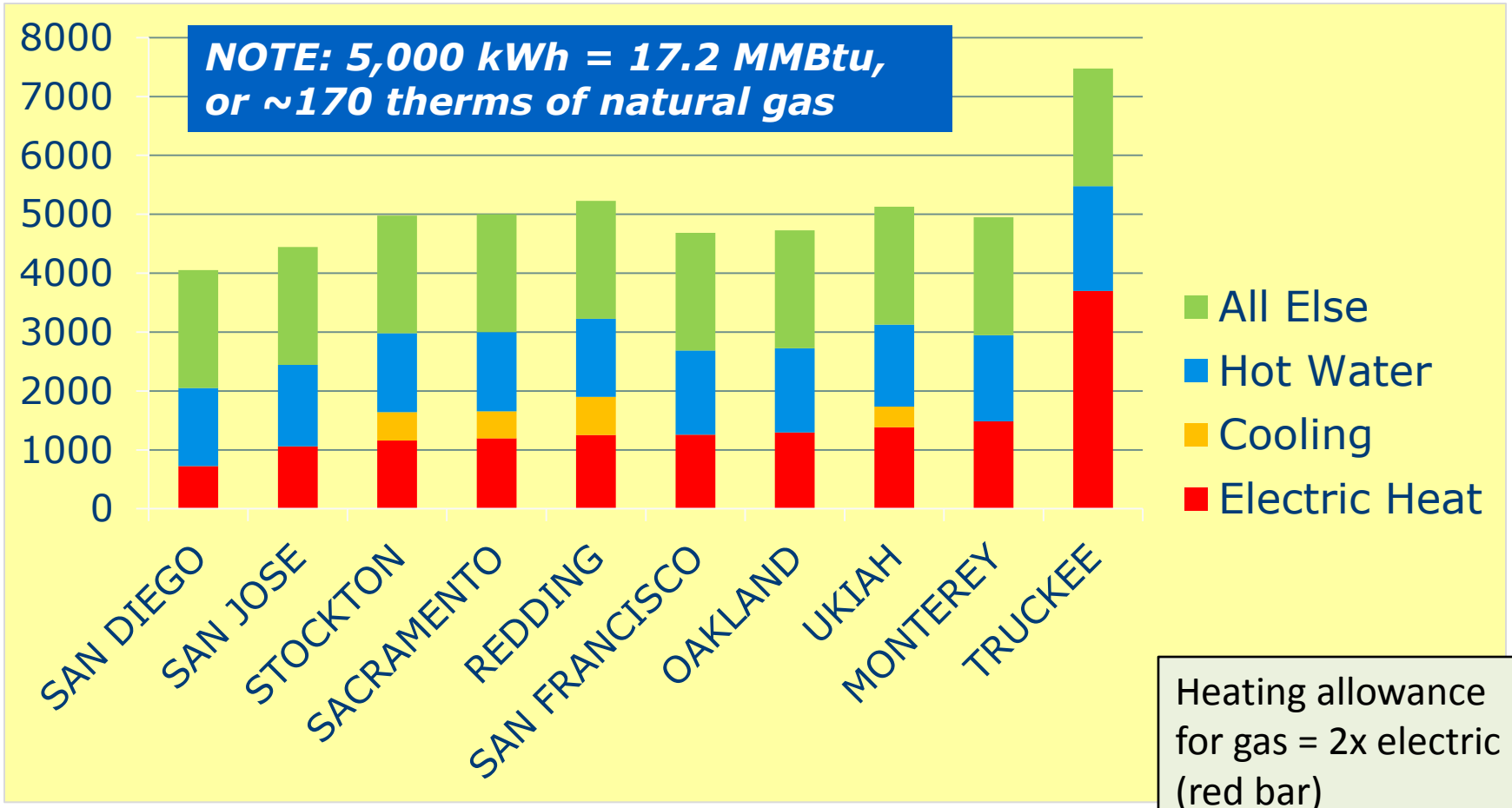
- 75% reduction in actual annual site energy use

OPTION B

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

THC OPTION B Household Threshold

(kWh/yr. by end use – electric heat)



Heating allowance for gas = 2x electric (red bar)

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

Thousand Home Challenge

Everything Else Allowance

OPTION B (includes gas cooking, clothes drying)

- 400 kWh/yr.: Base/home
- + .2 kWh/yr.: Per ft^2 (FFA)
- + 500 kWh/yr.: Person 1 & 2
- + 200 kWh/yr.: Person 3+

Annual Everything Else Threshold Allowance

House Size	1,200 Ft^2	1,200 Ft^2	3,600 Ft^2	3,600 Ft^2
Occupants	kWh/year	kWh/day	kWh/year	kWh/day
1	1,140	3.1	1,620	4.4
2	1,640	4.5	2,120	5.8
4	2,040	5.6	2,520	6.9

Interested in Participating in the 1000 Home Challenge?

Dates for upcoming Intro to the Thousand Home Challenge webinars:

- *Thursday, May 17, 2012 10-11:30 AM (Pacific time)*
- *Thursday, June 14, 2012 10-11:30 AM (Pacific time)*

For the THC FAQ, info on the webinars & to register:

http://thousandhomechallenge.com/join-us

Free! - One-day PG&E Class – Santa Rosa, May 24

Deep Energy Reductions – The Thousand Home Challenge

www.pge.com/energyclasses

Slides Out of Synch Today?

Or Slow Internet Connection???

ecoffman@affordablecomfort.org

Content Related Questions/Comments:

Use Question Box

Link to Presentation & Recording:

http://thousandhomechallenge.com/spring-2012-webinar4

Home Energy Pros – THC Group *Webinar Discussion*

http://homeenergypros.lbl.gov/group/1000homechallenge

Don Fugler & Gary Klein, Respondents

Don Fugler was trained as a mechanical engineer and spent **25 years** doing housing research for **Canada Mortgage and Housing Corporation (CMHC).** One of his last projects was the **performance monitoring of the CMHC EQuilibrium homes, houses designed to be net zero and healthy.** He retired from CMHC in 2011, and currently undertakes contract research into ventilation, IAQ, energy retrofitting, and other issues.

Gary Klein has been intimately involved in energy efficiency and renewable energy **since 1973**. His firm, **Affiliated International Management LLC,** provides consulting on sustainability through their international team of affiliates. At present, the focus is on water/energy/carbon footprint issues, with a particular emphasis on hot water.

Presenters: Frank Bergamaschi & Rick Chitwood

Frank Bergamaschi is a registered California architect and LEED accredited professional. He has practiced in San Francisco since 1988. He specializes in residential design, with an emphasis on energy conservation and sustainability.

Rick Chitwood has been a longtime building performance contractor, even before it was called that, and even owned a blower door in the 1980s. He spends most of his time teaching for the California Building Performance Contractors Association, doing research, and helping with the updates to the California energy code.

Second home in California to officially meet the Thousand Home Challenge

The Accidental Participant

One architect's circuitous voyage to the Thousand Home Challenge

FRANK A. BERGAMASCHI, ARCHITECT
LEED ACCREDITED PROFESSIONAL
(415) 398-9520
WWW.FABARCHITECTS.COM

The Bergamaschi/SooHoo Residence

Description

- Finished in 1999
- Two story, 3,200 ft^2
- 10' ceilings
- Moderately Insulated
- Raised floor
- Two conditioning zones
- Gas furnaces
- Gas hot water
- Gas kitchen
- Construction costs $135/$ft^2$
- Mild climate zone
- Designed by me

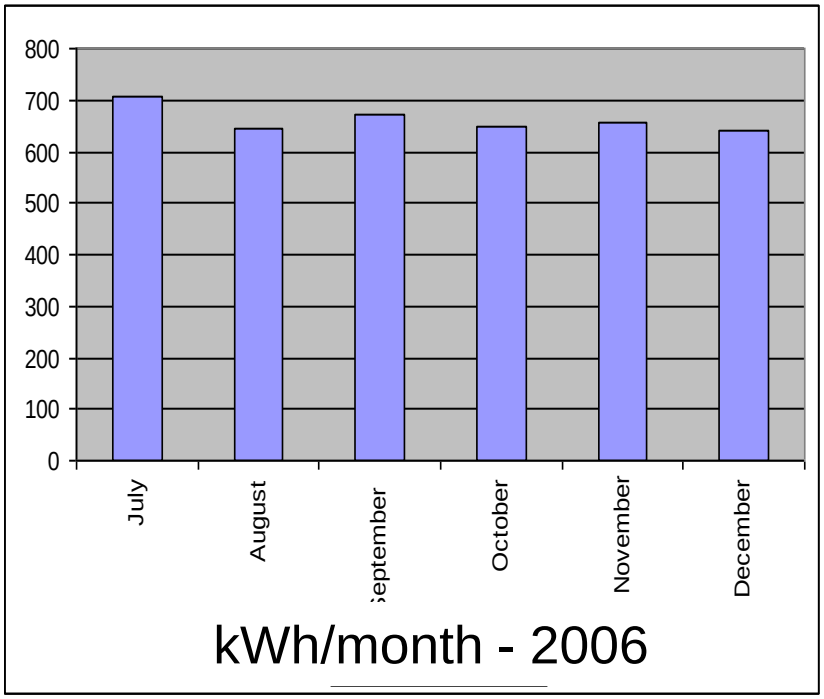
The Bergamaschi/SooHoo Residence

The Bergamaschi/SooHoo Residence

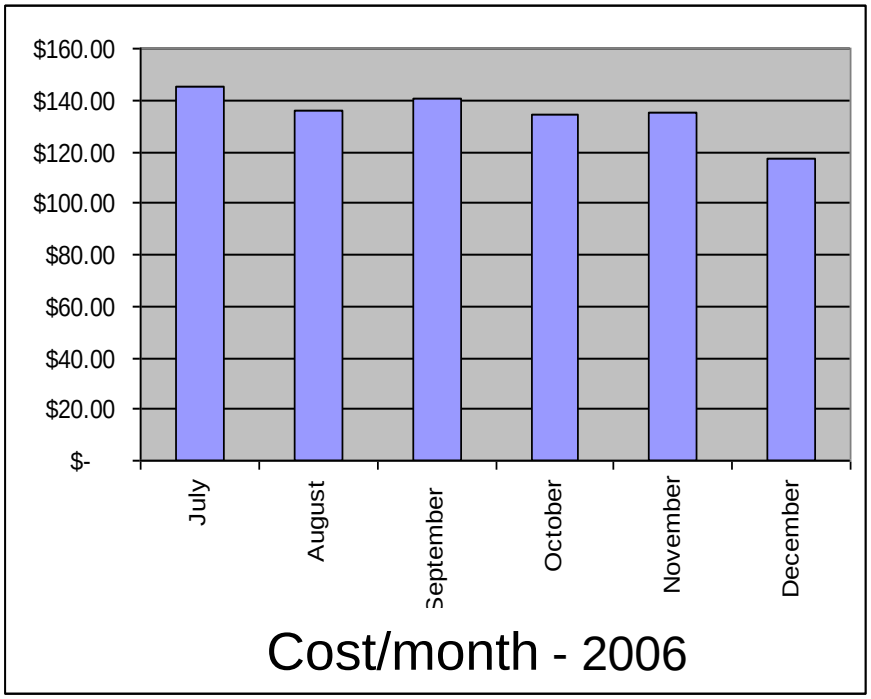
The Bergamaschi/SooHoo Residence

In 2006 We Decide to Add Solar PV

Here is where we started:~ 650 kWh/mo.; ~$135/mo.



kWh/month - 2006



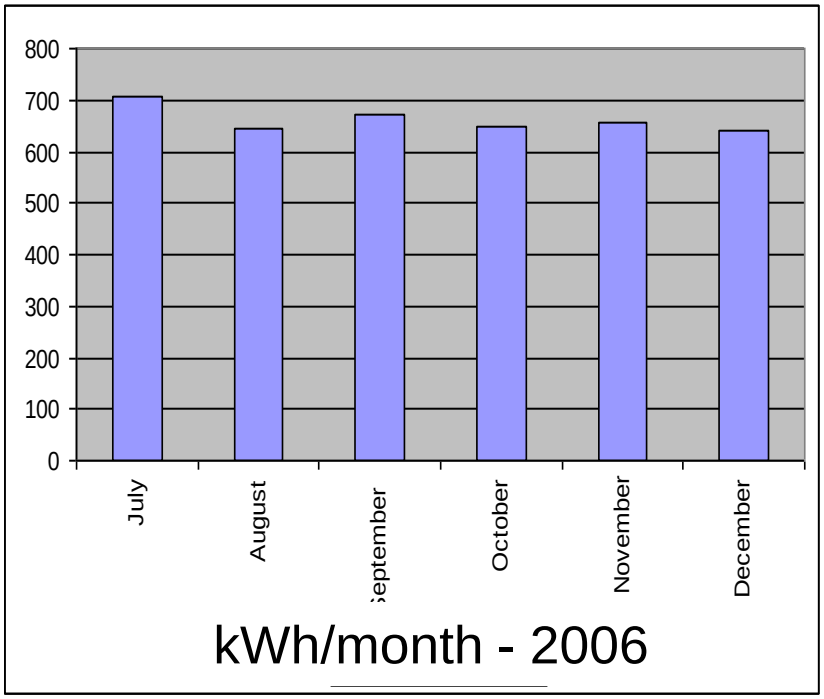
Cost/month - 2006

Goal – to offset electric portion of home's energy use

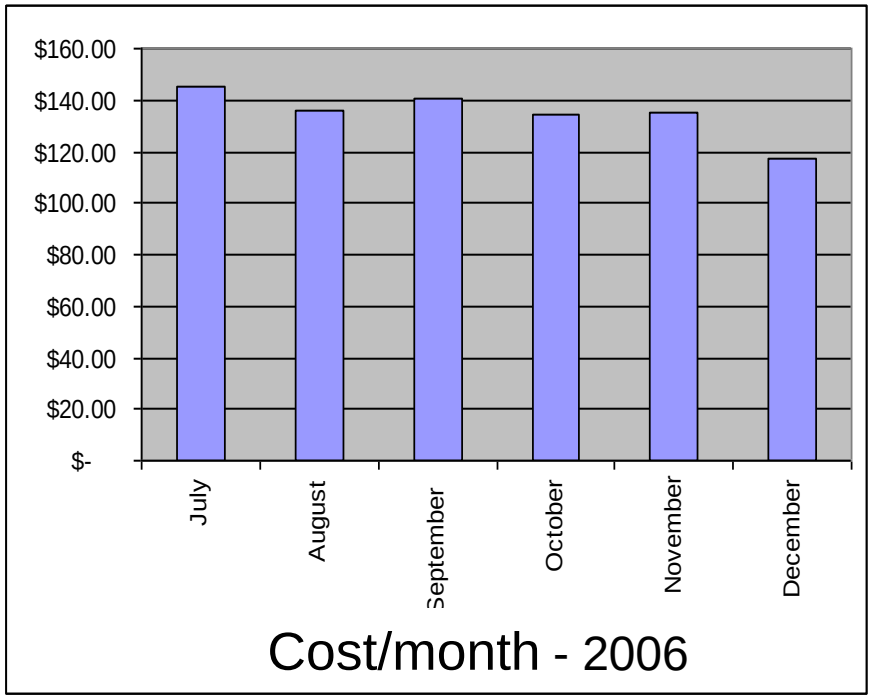
In 2006 We Decide to Add Solar PV

YIKES!

First estimate comes back at
$44K for a 6 kW system



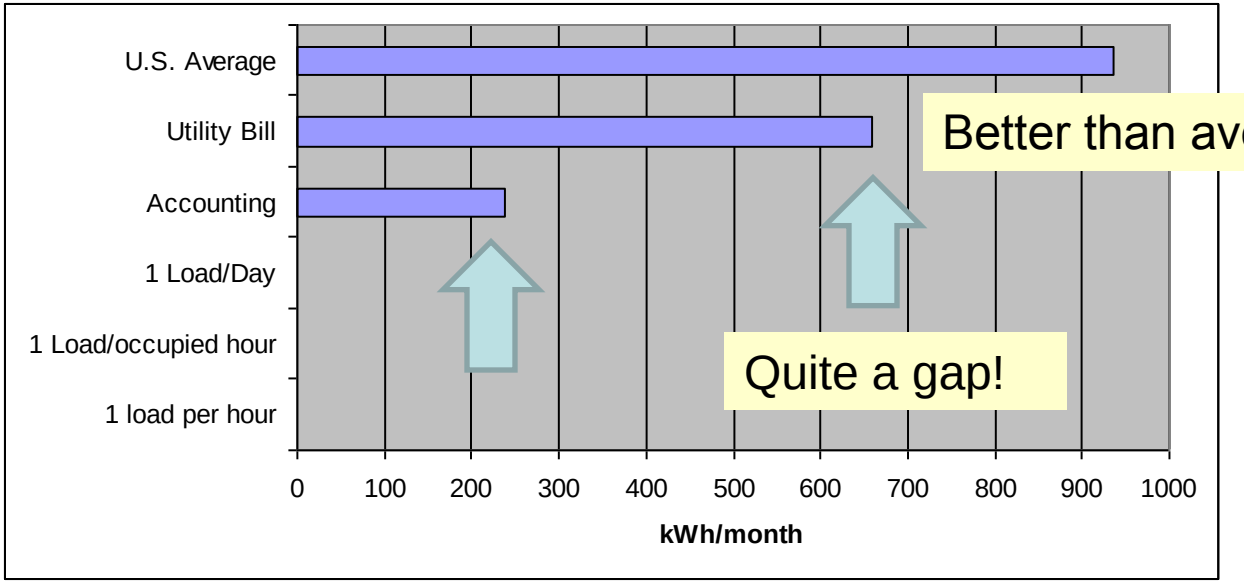
kWh/month - 2006



Cost/month - 2006

Goal – to offset electric portion of home's energy use

Accounting for Usage

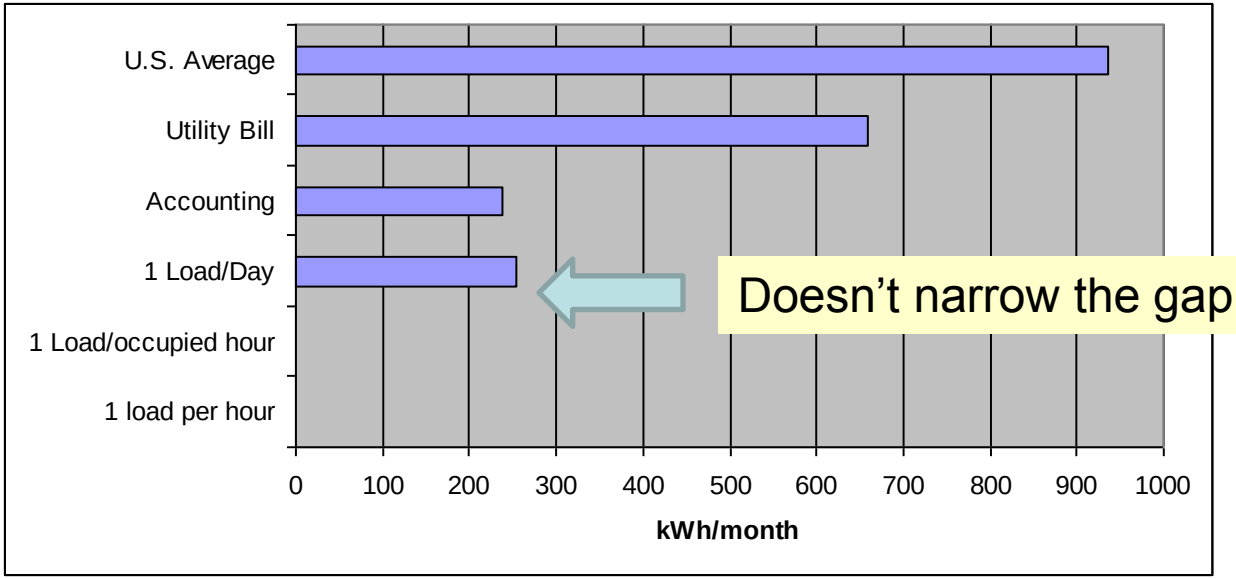


Lights	420 watts
TV & cable box	250 watts
Laptop	30 watts
Desktop	100 watts
Refrigerator	60 watts
Total	**860 watts**

But that only adds up to 236.6 kWh

And our usage averaged 660 kWh/month

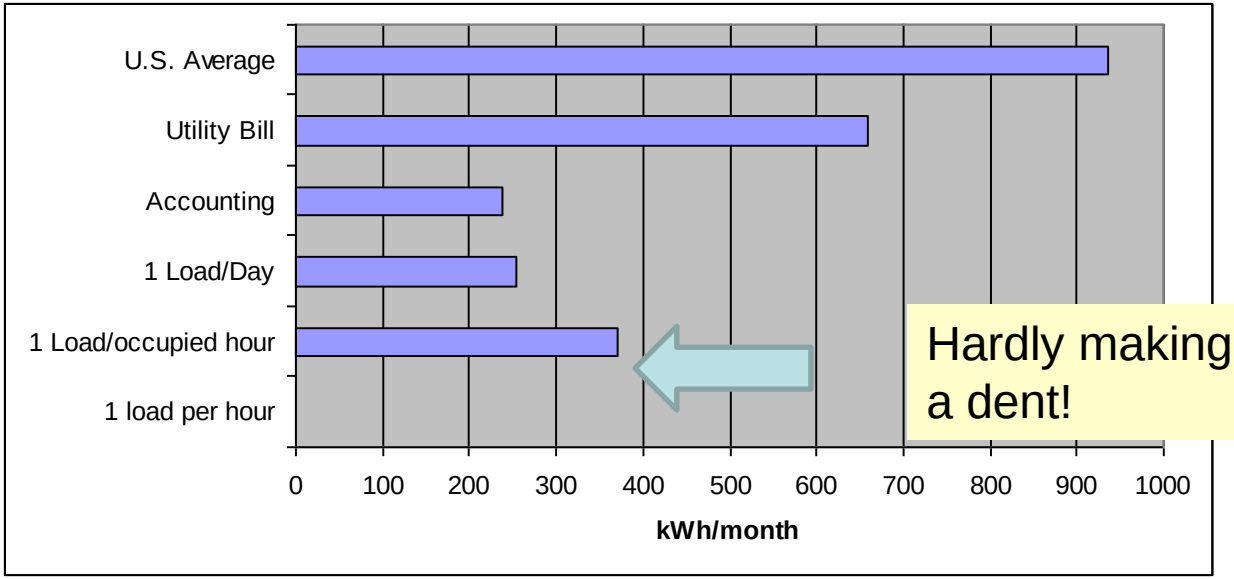
Accounting for Usage



Accounting for Usage:

1 load of laundry every day adds	7.9 kWh
1 load of dishes every day adds	9.3 kWh
New Total	**253.9 kWh**

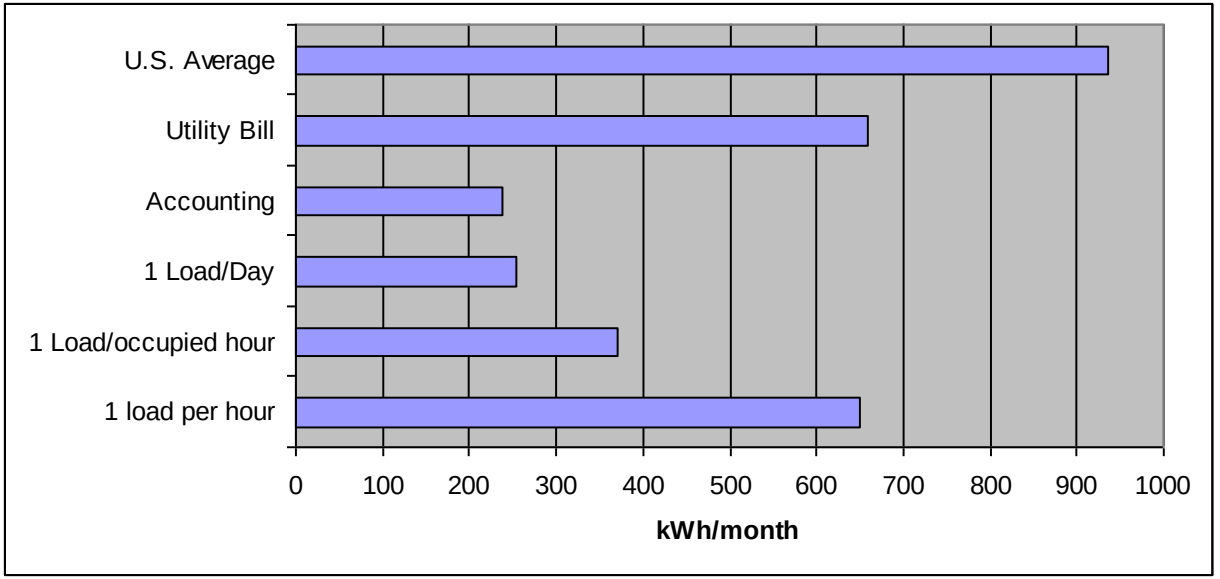
Accounting for Usage



Accounting for Usage:

1 load of laundry every occupied hour	61.5 kWh
1 load of dishes every occupied hour	72.0 kWh
New Total	**370.1 kWh**

Accounting for Usage



Accounting for usage:

1 load of laundry every hour 24/7	190.5 kWh
1 load of dishes every hour 24/7	223.2 kWh
New Total	**650.3 kWh**

Where is all this electricity going?

Measuring Plug Loads & Whole House Electricity Use

Kill-A-Watt

The Energy Detective (TED)

Part I: Define Electricity Flows

1. Examine historical utility records
2. Map electrical system by circuit
3. Put home in “sleep state”
4. Measure “snapshot” current flows by circuit
5. Allocate usage beyond “sleep state” by estimation

Take what we know

Part I: Define Electricity Flows

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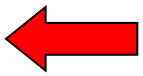
3. Put home in “sleep state” 
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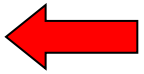

Do some simple measuring

Part I: Define Electricity Flows

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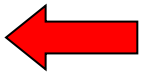

Guess at the rest

Part I: Define Electricity Flows

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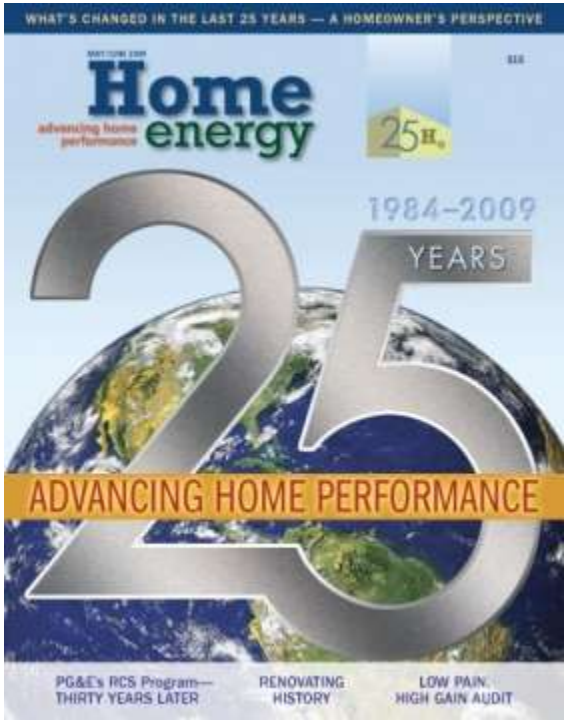
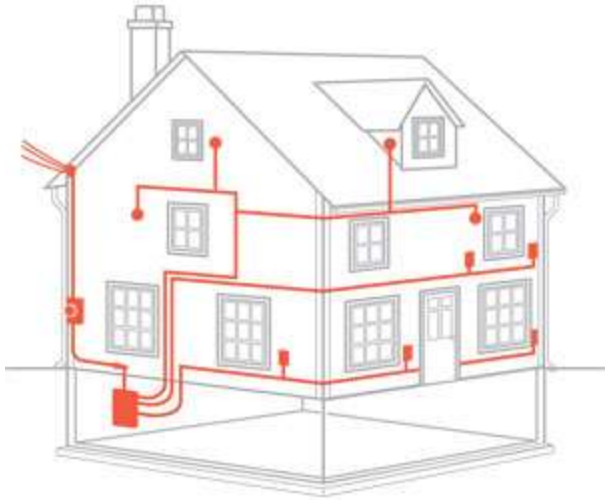


For a .pdf copy email:
fberg@FABArchitects.com

Define Electricity Flows



Map electrical system by circuit
Put home in “sleep state”

Measure “snapshot”
current flows by circuit

Safety Matters!

Do not do this yourself.

PG&E does not & will not endorse any procedure not performed by a licensed electrician!

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Building a Spreadsheet to Allocate "Snapshot" Current Flows by Circuit & Task

Panel A
Unadjusted
Amperes

Circuit #	Lighting	Entertain.	Outlets	Building Svc	Appliances	Misc	Contributing Devices
1							Spare
3							Spare
5		0.29					Electronics stack (Family Room, music accessories)
7a		0.51					Electronics stack (Family Room TV stack)
7b				0.09			Basement Furnace
9a				0.04			Includes tankless water heater
9b				0.26			Telephone panel, wireless router etc.
11					0.05		Microwave
13a				0.02			Vaccum system
13b	0.06						Entry lights
15a		0.31					Electronics stack (Family room computer, phone)
15b							Garage lights
17							Powder room
19			0.17				Includes garage door operators
2							Dishwasher/Disposer
4							Spare
6	0.06						Family Room Lights
8							Family Room receptacles
10					0.12		Countertop appliances/misc.
12	0.07						Living Room lights
14					0.72		Refrigerator
16							Living Room receptacles
18			0.09				Includes hood and range
20					0.39		Countertop appliances/chargers

List the Contributing Devices

Panel A
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Ampheres

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Organize Breakout by Function

Panel A
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Ampheres

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Most Circuits Used Electricity 24/7 !!!

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End-use Breakout

(Projected with Adjustment)

	Lighting	Entertain.	Outlets	Building Svc	Appliances	Misc
Passive Amps	0.28	1.11	1.00	0.59	1.28	0.01
Passive Watts	33.96	132.84	119.40	71.04	154.08	1.44
Active Adjustment	NA	0.50	0.50	0.50	0.50	0.50
Active Watts	145.42	66.42	59.70	35.52	77.04	0.72
Proj. Monthly kW hours	130.94	145.46	130.74	77.79	168.72	1.58
Total projected kWh/month						655.23

End-use Breakout

(Projected with Adjustment)

	Lighting	Entertain.	Outlets	Building Svc	Appliances	Misc
Passive Amps	0.28	1.11	1.00	0.59	1.28	0.01
Passive Watts	33.96	132.84	119.40	71.04	154.08	1.44
Active Adjustment	NA	0.50	0.50	0.50	0.50	0.50
Active Watts	145.42	66.42	59.70	35.52	77.04	0.72
Proj. Monthly kW hours	130.94	145.46	130.74	77.79	168.72	1.58
Total projected kWh/month						655.23

End-use Breakout

(Projected with Adjustment)

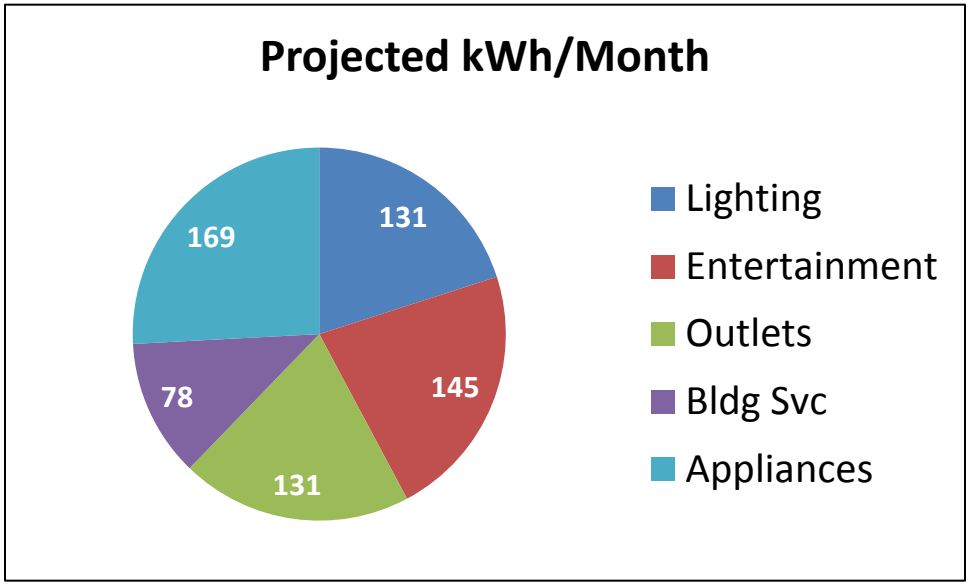
	Lighting	Entertain.	Outlets	Building Svc	Appliances	Misc
Passive Amps	0.28	1.11	1.00	0.59	1.28	0.01
Passive Watts	33.96	132.84	119.40	71.04	154.08	1.44
Active Adjustment	NA	0.50	0.50	0.50	0.50	0.50
Active Watts	145.42	66.42	59.70	35.52	77.04	0.72
Proj. Monthly kW hours	130.94	145.46	130.74	77.79	168.72	1.58
Total projected kWh/month						655.23

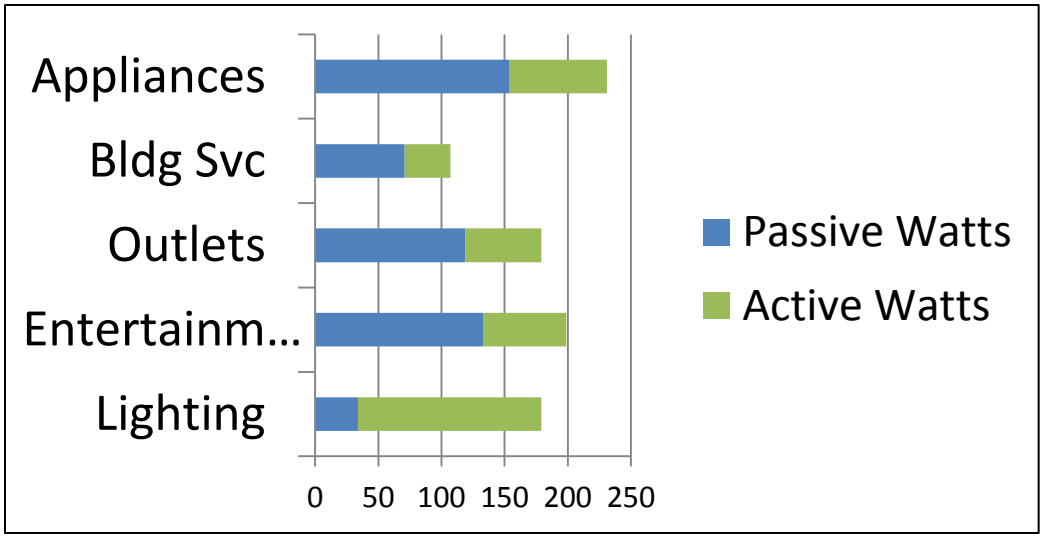
End-use Breakout

(Projected with Adjustment)

	Lighting	Entertain.	Outlets	Building Svc	Appliances	Misc
Passive Amps	0.28	1.11	1.00	0.59	1.28	0.01
Passive Watts	33.96	132.84	119.40	71.04	154.08	1.44
Active Adjustment	NA	0.50	0.50	0.50	0.50	0.50
Active Watts	145.42	66.42	59.70	35.52	77.04	0.72
Proj. Monthly kW hours	130.94	145.46	130.74	77.79	168.72	1.58
Total projected kWh/month						655.23

End-use Breakout (Projected)





PART II: Analysis

1. Evaluate usage for conservation potential
2. Implement conservation strategies
3. Verify with new utility records

Spreadsheet B				kWh				
	Wattage		Daily	Monthly			Monthly	
Action	savings	Total	Hours of	Potential	Cost		Utility	
Action	per unit	units	Operation	savings	per unit*	Total cost	Savings	ROI
Switch Electronics stack (Family Room TV stack)	61.1	1	22	40.9	$ 10.00	$ 10.00	$ 9.28	1113.2%
Switch furnace #1	10.3	1	12	3.8	$ 1.00	$ 1.00	$ 0.85	1025.9%
Switch Electronics stack (Study computer stack)	50.6	1	24	36.9	$ 10.00	$ 10.00	$ 8.39	1006.8%
Switch Electronics stack (Family Room, music accessories)	34.9	1	24	25.5	$ 10.00	$ 10.00	$ 5.79	694.3%
Switch furnace #2	5.9	1	12	2.1	$ 1.00	$ 1.00	$ 0.49	584.5%
Switch Electronics stack (Family room computer)	30.8	1	22	20.6	$ 10.00	$ 10.00	$ 4.68	562.0%
Switch Electronics stack 4 (master bedroom TV stack)	26.0	1	24	19.0	$ 10.00	$ 10.00	$ 4.31	517.7%
Replace 60W incandescent with 10W CFL (Primary lighting fixtures)	50.0	9	6	82.1	$ 5.00	$ 45.00	$ 18.64	497.0%
Switch Electronics stack 5 (Guest bedroom TV stack)	17.9	1	24	13.0	$ 10.00	$ 10.00	$ 2.96	355.5%
Switch microwave	6.4	1	24	4.6	$ 10.00	$ 10.00	$ 1.05	126.4%
Replace 100W incandescent with 18W CFL (occasionally used fixtures)	82.0	10	0.25	6.2	$ 5.00	$ 50.00	$ 1.42	34.0%
Remove X10 Switch	3.0	12	24	26.3	$ 25.00	$ 300.00	$ 5.96	23.9%
Remove X10 Receptacle	2.2	7	24	11.0	$ 25.00	$ 175.00	$ 2.51	17.2%
Switch Garage door openers	6.5	2	12	4.7	$ 50.00	$ 100.00	$ 1.08	12.9%
Install 3.3 KW solar PV system (with rebate and tax credit)		1		400.0	$ 16,200.00	$ 16,200.00	$ 90.83	6.7%
Install 3.3 KW solar PV system (without rebate)		1		400.0	$ 26,000.00	$ 26,000.00	$ 90.83	4.2%
*CFL conversion costs do not include replacement of some halogen fixtures to receive CFLs			Total					
*Solar system cost estimated								

PART II: Using What We Now Know

1. Evaluate usage for conservation potential
2. Implement conservation strategies
3. Verify with new utility records

Spreadsheet B				kWh				
	Wattage		Daily	Monthly			Monthly	
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*Solar system cost estimated								

PART II: Using What We Now Know

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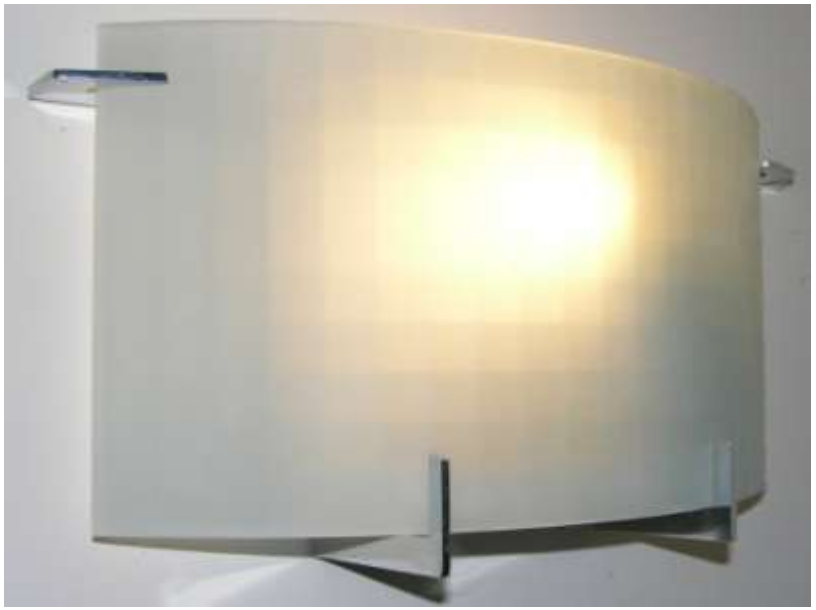
Install 3.3 KW solar PV system (with rebate and tax credit)		1			$ 16,200.00	$ 16,200.00	$ -	0.0%
Install 3.3 KW solar PV system (without rebate)		1			$ 26,000.00	$ 26,000.00	$ -	0.0%
*CFL conversion costs do not include replacement of some halogen fixtures to receive CFLs			Total	296.8				
*Solar system cost estimated								

Physical Changes



Halogen luminaire conversion

Do not do this yourself. PG&E does not & will not endorse any procedure not performed by a licensed electrician!

Additional Physical Changes

Halogen pendant

Add switch leg to garage door operator

Add power strips

Remove automated switches

Remove automated receptacles

Remove electronic timer switches

Use mechanical timer switches

Installed line drying

Additional Changes

Behavioral Changes

- Remember to use the physical changes (e.g., power strips)
- Adapt to the minor inconveniences
- (powering up a computer to log onto the web)

Concurrent Changes Not Related to PV

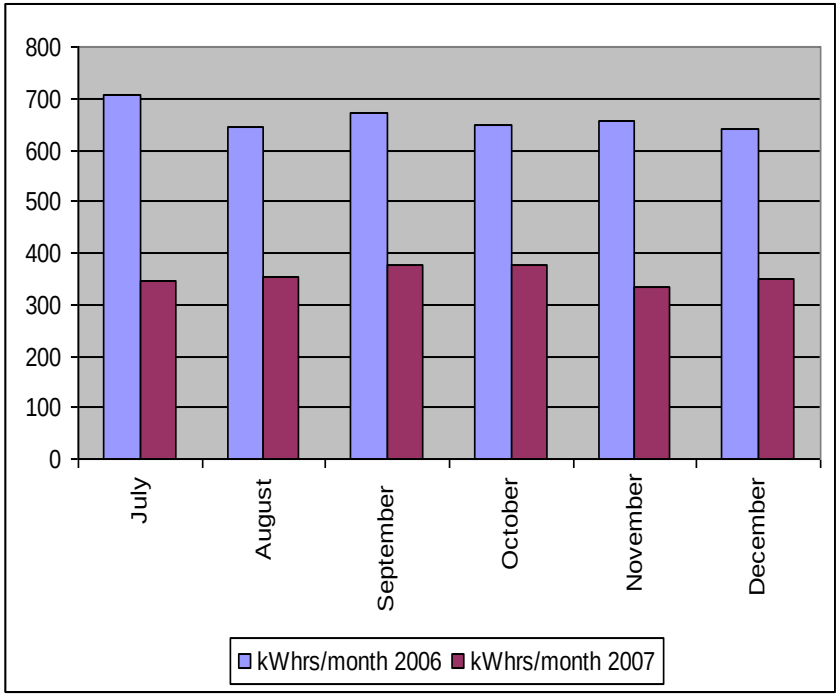
- Dress appropriately to the weather/season
- Let temperature of the house float

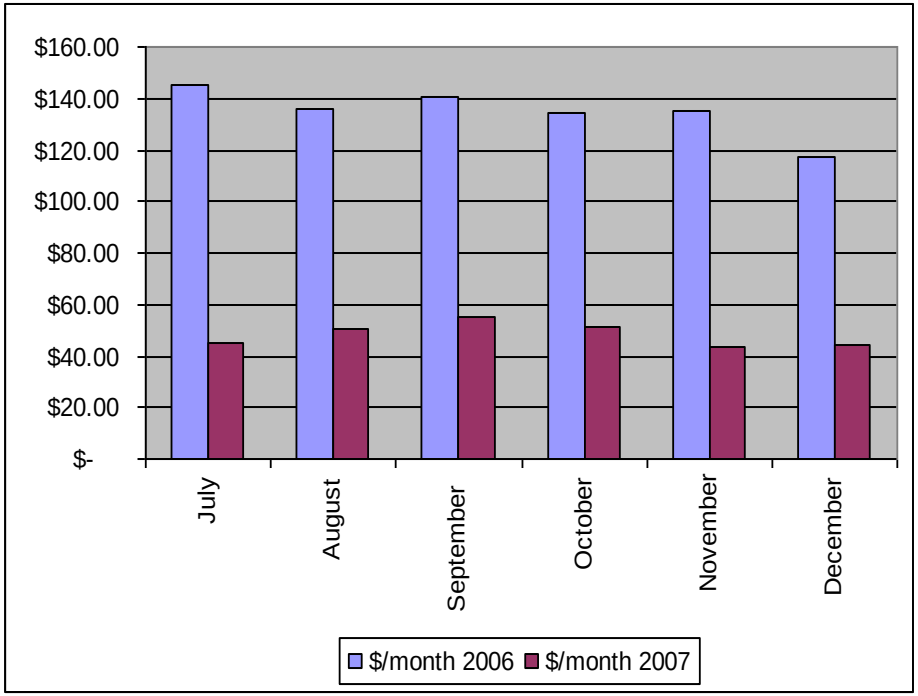
Other

- Replace tank style water heater with tankless

2006-07 Comparison

kWh & Cost





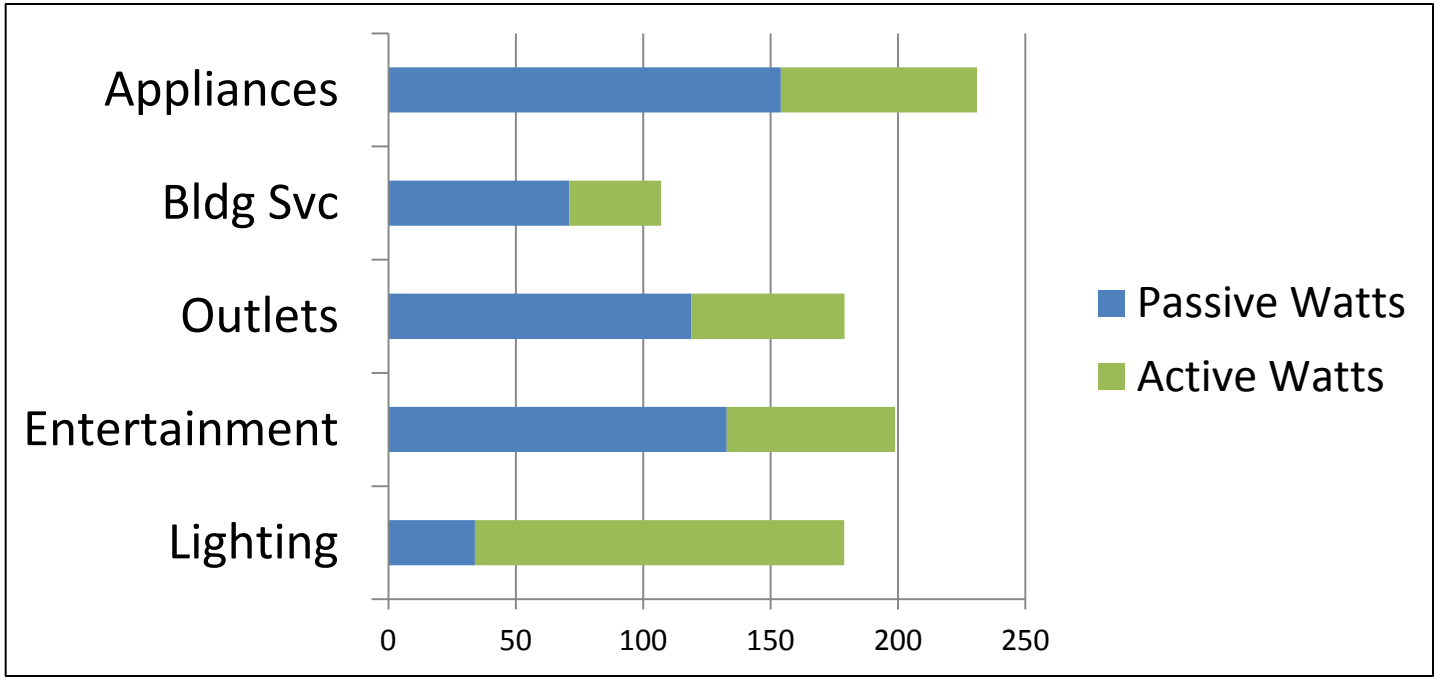
2006-07 Comparison
kWh & Cost

Spreadsheet C

	Kilowatt hours		Total Electricity Charges	
	2006	2007	2006	2007
July	705	347	$ 145.48	$ 44.76
August	644	354	$ 136.13	$ 50.22
September	673	378	$ 140.26	$ 54.83
October	648	375	$ 134.35	$ 51.59
November	657	333	$ 135.36	$ 43.61
December	639	351	$ 117.09	$ 44.33
Average	661	356	$ 134.78	$ 48.22
Savings		46.1%		64.2%

Depth of the Problem

Why is this so high?



Embedded 24/7 Leaks

The High Cost of Convenience

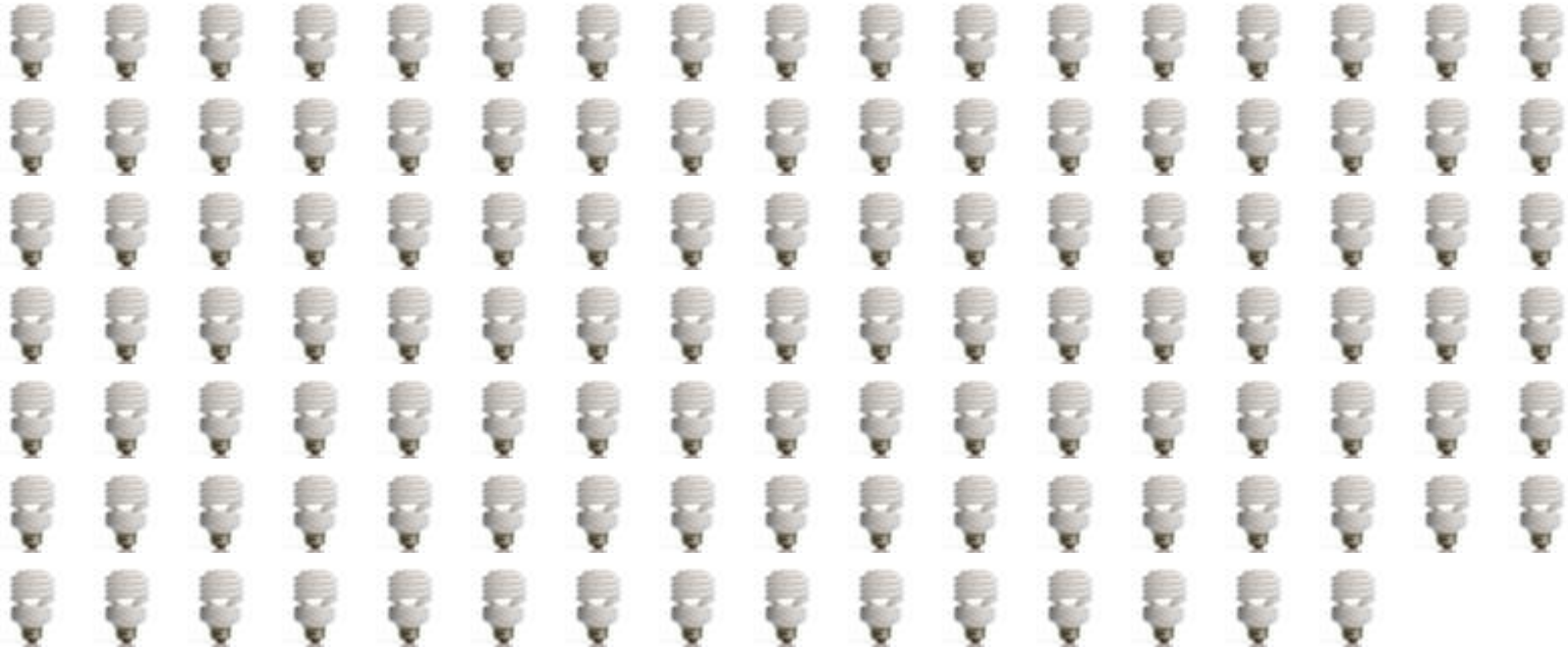
- Furnaces
- Water heaters
- Phone systems
- Intercoms
- Sprinkler systems
- Lighting controls
- Gate operators
- Computers
- Printers
- Scanners
- Copiers
- Fax machines
- Televisions
- Appliances
- Garage door operators
- Air fresheners
- Vacuum systems
- Electric toothbrushes
- Coffee makers
- Automated receptacles
- Ground fault receptacles
- Smoke detectors
- Security systems
- Conveying systems
- Internet access
- Cable boxes
- Stereo systems
- Clock radios
- Ionizers
- Doorbells
- Battery chargers
- Timers
- Microwave ovens
- Toasters

Cycling Components

- Refrigerators
- Freezers
- Terrariums
- Aquariums
- Spas

What is One Leak Worth??

24 hours x  = 1 hour x



What Is This Leak Worth??

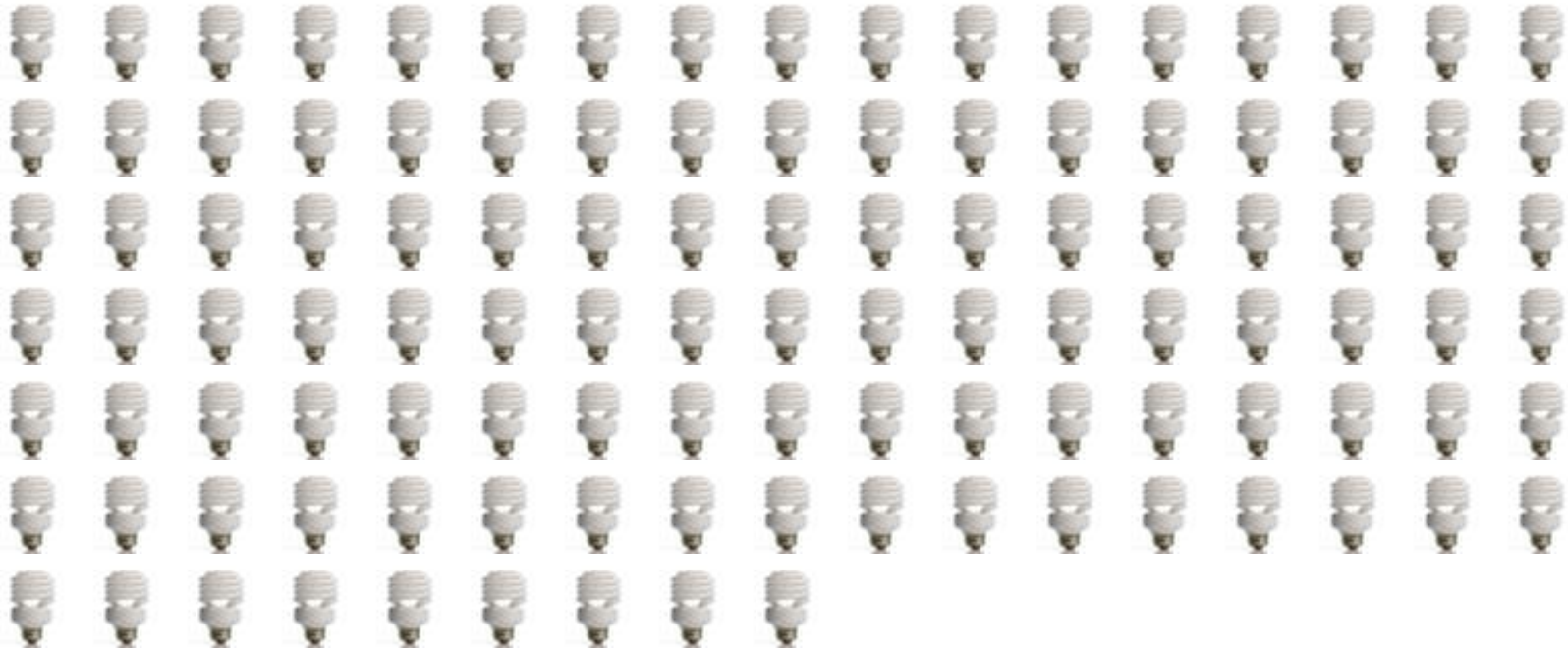
24 hours x  288 watt unused stack =

Plus This Many

Plus This Many Again

Plus This Many Yet Again

Plus This Many - For 1 Hour



Present Status

Last annual true-up period: 713 excess kWh
- Same period: ~140 therms natural gas

- We use the furnace infrequently, AC virtually never
- Biggest users: refrigerator, cable box, router, aquaria

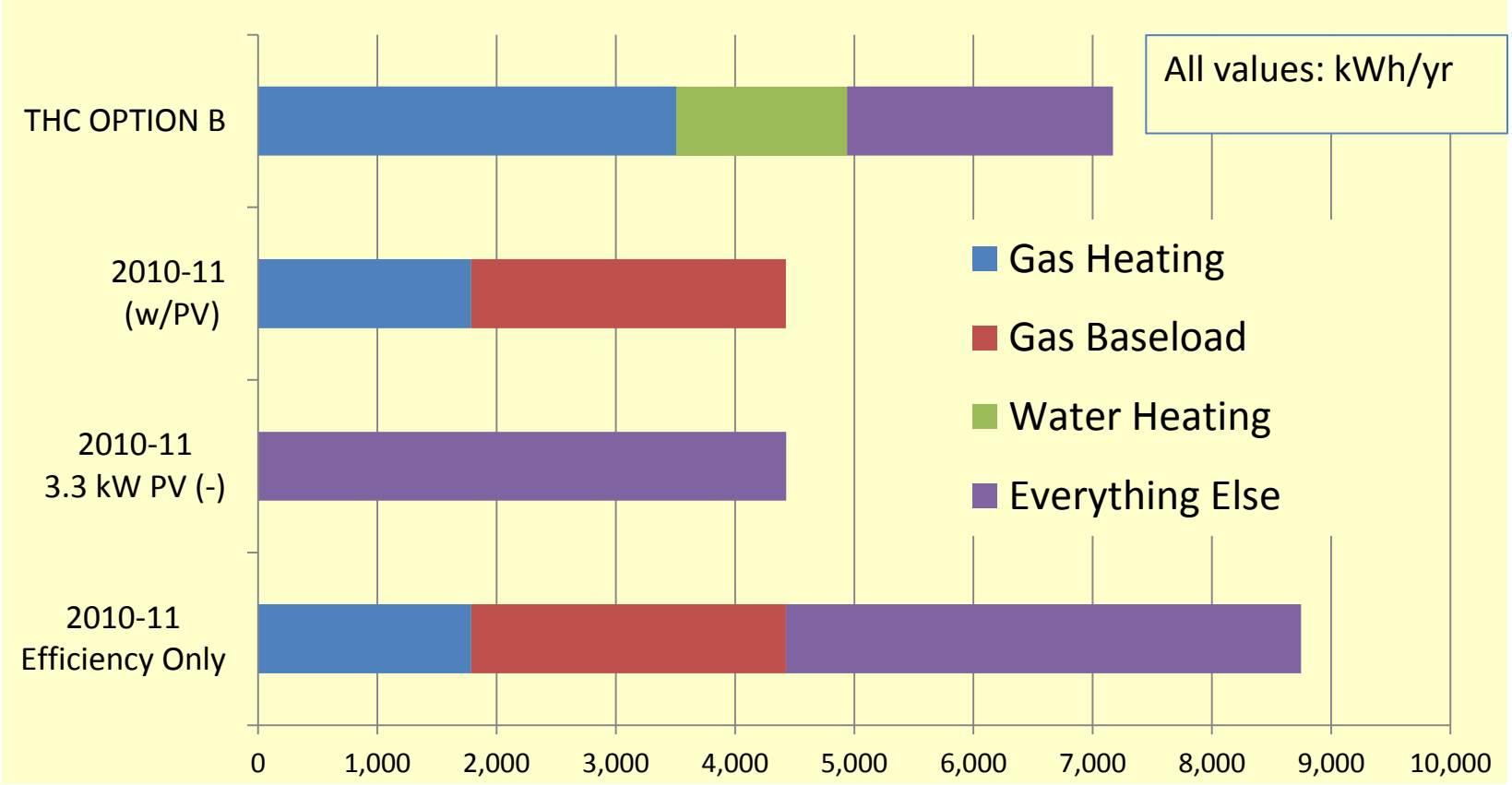
- Other leaks still in system:
  - Water heater
  - Furnaces (cycled seasonally)
  - Alarm system
  - Phone system/answering machine
  - Central vacuum
  - Smoke detectors

Present Status

Lessons Learned

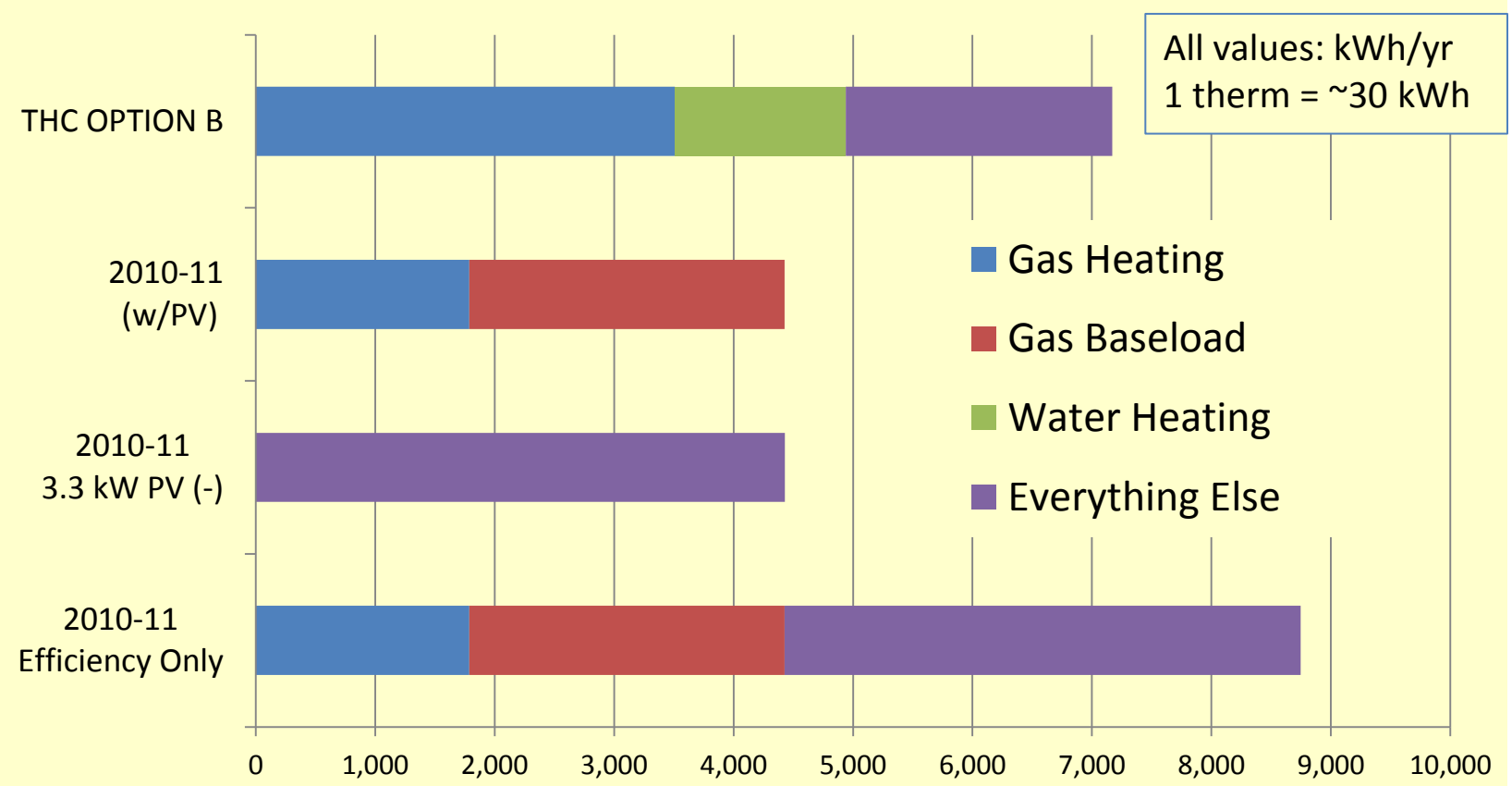
- Fully investigate specified items
- Be suspicious of manufacturers' claims
- Switch on the line voltage side
- Use mechanical/manual switching
- Be relentless about reducing losses
- Keep systems simple
- Demand better energy performance

Total Annual Energy Use Compared to THC Threshold OPTION B (kWh/yr.)



OPTION B Assumptions: 3,200 f^2 FFA; 2,726 HDD Oakland, CA weather station; 3 occupants; gas heat; single-family detached home

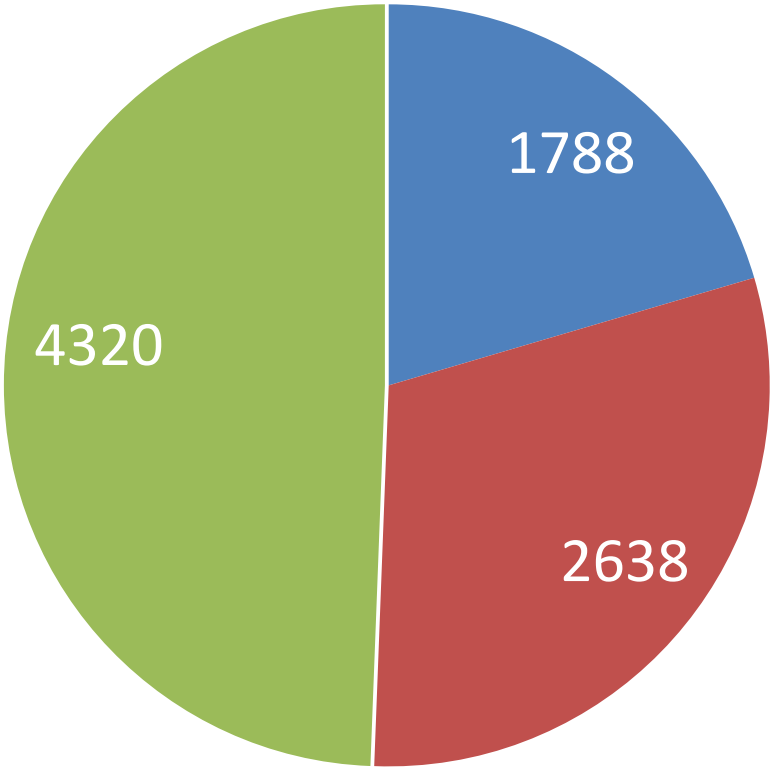
Total Annual Energy Use Compared to THC Threshold OPTION B (kWh/yr.)



NOTE: 2010-11 Gas Baseload = ~ 90 therms; Gas heat ~ 60 therms

OPTION B Assumptions: 3,200 f^2 FFA; 2,726 HDD Oakland, CA weather station; 3 occupants; gas heat; single-family detached home

2010-11 Actual Use Efficiency Only (in kWh/year)



2010-11 Summary (in kWh)
Total use: 8,746
PV production : 4,430
Net: 4,316

- Gas Heating
- Gas Baseload (DHW/Cook/Dryer)
- Everything Else

NOTE: 1 therm = ~ 30 kWh

The Bergamaschi/SooHoo Residence

The Bergamaschi/SooHoo Residence

+

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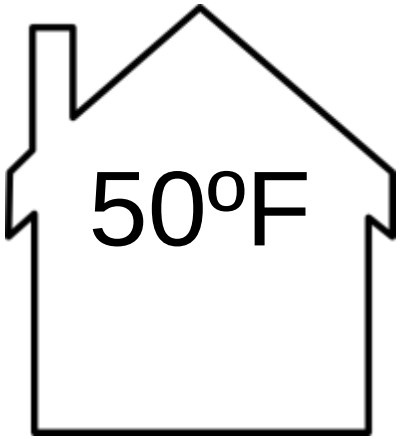


The Bergamaschi/SooHoo Residence

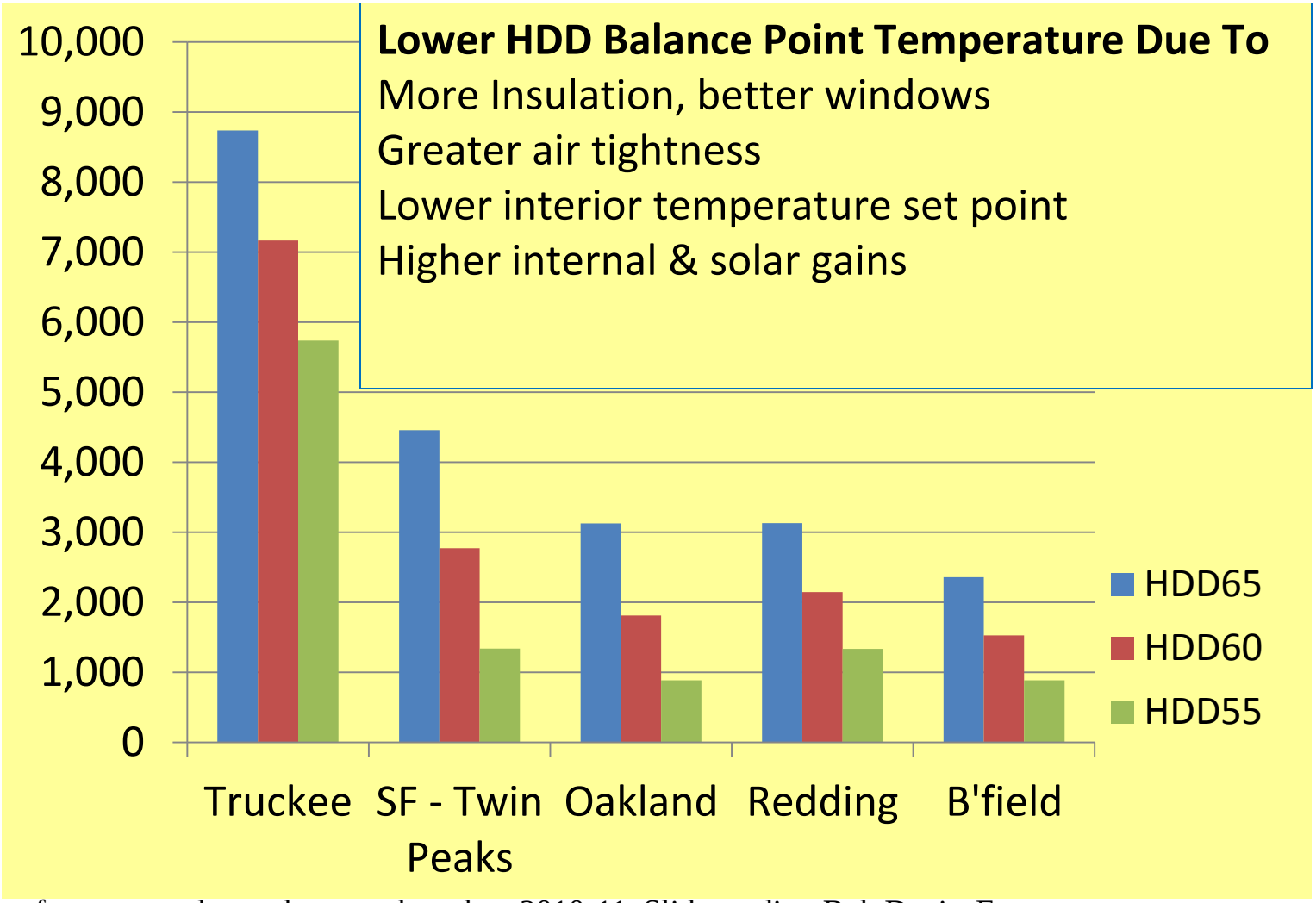
Mount Shasta Degree Days

Base 75 F	Base 55°F
9,606	3,670

62% Reduction

Heating Degrees Days (HDD)

Depends on Assumptions (Base 65, 60, or 55)



Lower HDD Balance Point Temperature Due To

More Insulation, better windows

Greater air tightness

Lower interior temperature set point

Higher internal & solar gains

Degree days from www. degreedays.net; based on 2010-11; Slide credit – Bob Davis, Ecotops

…and the **HVAC** & **insulation** guys don't need to do anything to meet the Thousand Home Challenge?

rick@chitwoodenergy.com

Heating & Cooling

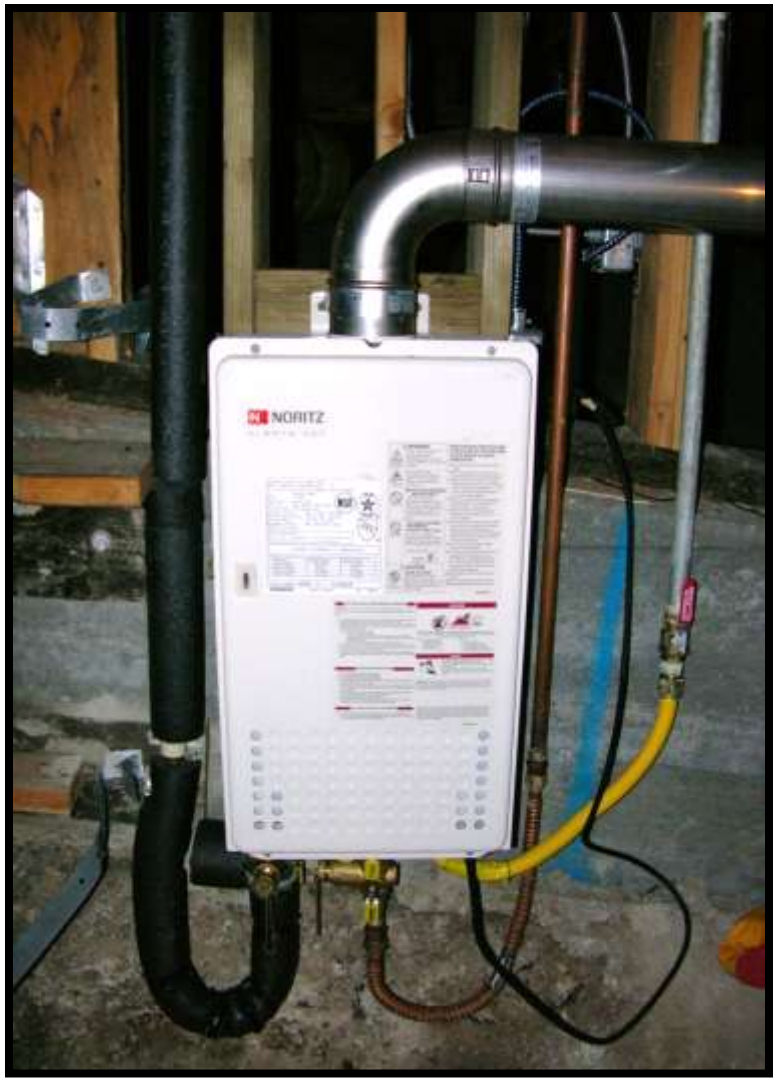
<u>Crawl Space System</u>
80,000 Btu/H (90+ AFUE)
2.5 tons AC (SEER 12)
Floor supply grilles
Ducts R-4.2

<u>Attic System</u>
80,000 Btu/H (80% AFUE)
3.0 tons AC (SEER 12)
Ceiling supply grilles
Ducts R-4.2

Insulation & Enclosure

Ceiling R-30
Shafts R-13
1st Floor Walls R-19
2nd Floor Walls R-13
Floor R-30
Windows, Double Clear

Water Heating



Natural Gas Tankless

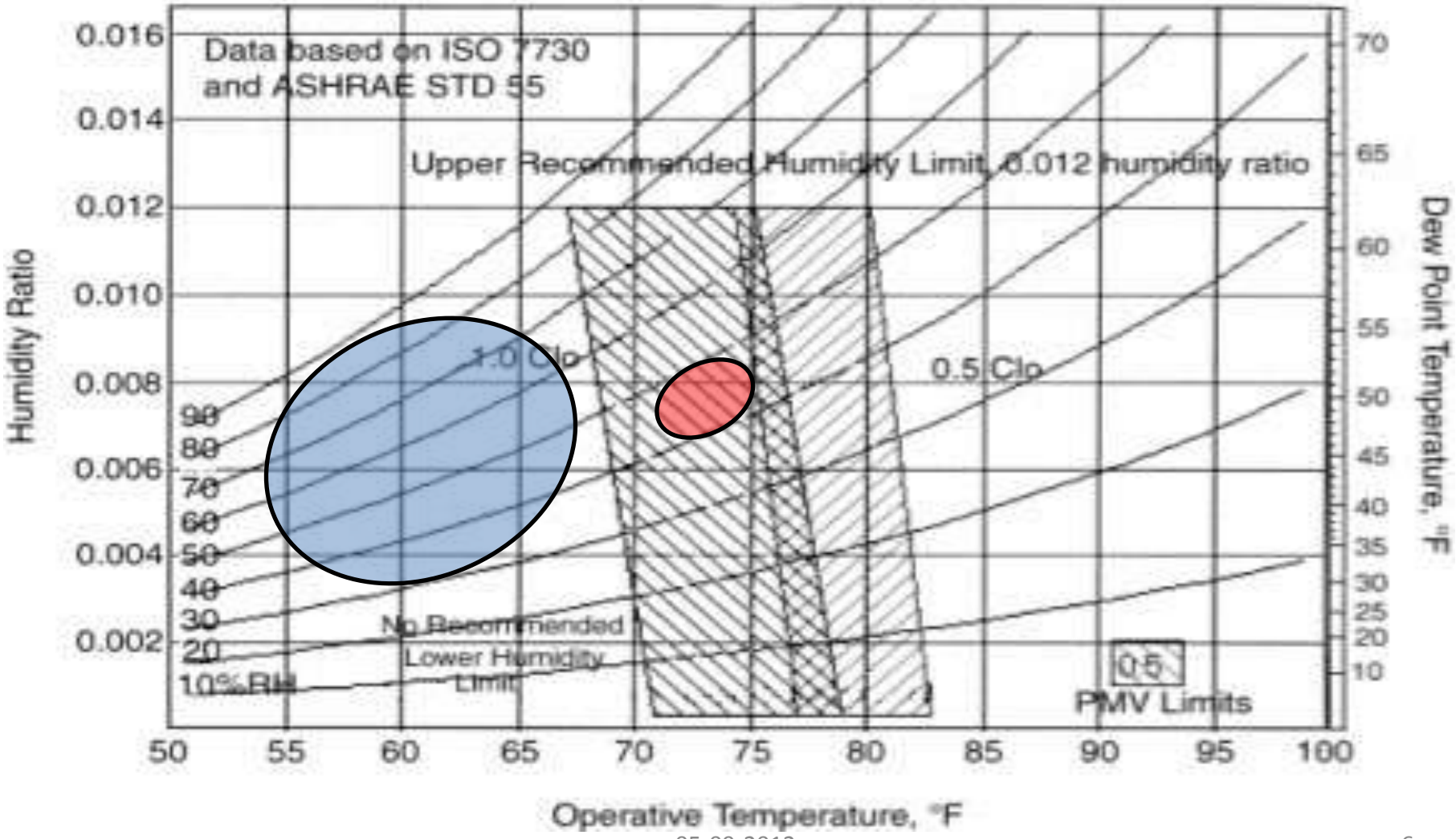
Other Gas Appliances:

- **Clothes dryer**
- **Cooking**

Can Comfort Be Enhanced with Efficiency Improvements?

ASHRAE STD 55 (Comfort)

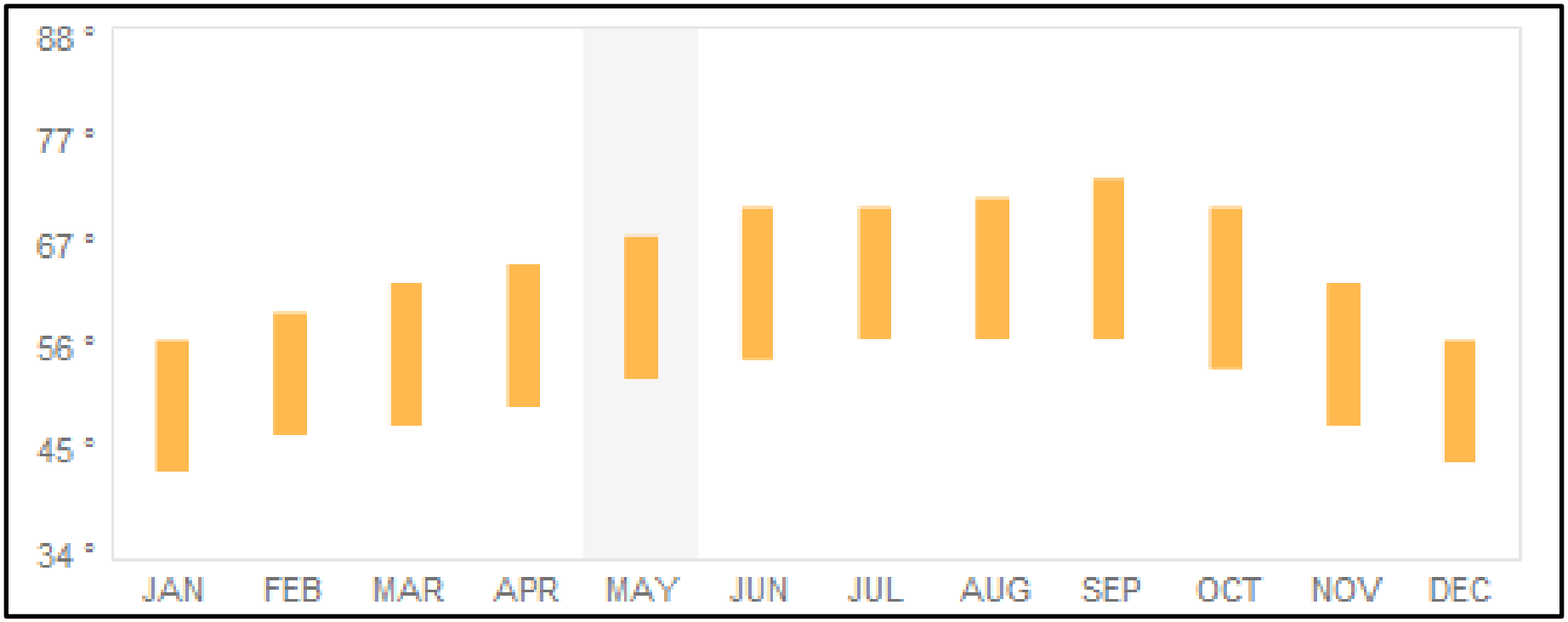
0% to 85% RH & 66°F to 83°F



Quantifying the Opportunities


Photo credit: Judy A. Roberson

Site (Oakland, CA) Monthly Average Temperatures



September Average High Temperature	**69°F**
January Average Low Temperature	**42°F**

HVAC Performance Factors

1. Duct Leakage (H/C)
2. Duct Conduction (H/C)
3. Refrigerant Charge (C/HP)
4. Low Airflow (C/HP Mostly)
5. Over-sizing (H/C)
6. Room-to-Room Air Delivery (H/C)
7. Equipment Efficiency (H/C)
8. Equipment Defects (H/C)

Duct Leakage

Duct leakage downstairs

254 CFM_{25}
(199 CFM_{25} to outside,
36% of airflow)

Duct leakage upstairs

261 CFM_{25}
(258 CFM_{25} to outside)


Photo credit: Judy A. Roberson

Duct Conductive Losses

1. R-4.2 duct insulation
2. All ducts in unconditioned attic & crawl space
3. Delivery temperatures varied from 140^{o} F to 115^{o} F due to duct length
4. 14 supply grilles on the downstairs system (3 supply grilles would have been better)

Low Airflow

1. **Low airflow impacts air conditioners the most, but also impacts furnaces**

2. **The airflow was so low that the furnace cycled off on high temperature limit**

3. **System static pressure was 1.0" WC (or more than double what it should be)**

Over-sizing

1. Two 80 kBtuH furnaces
2. 5.5 tons of cooling
3. Proper sizing would provide long run times at design conditions
4. Over-sizing on this house may be good

Room Air Delivery

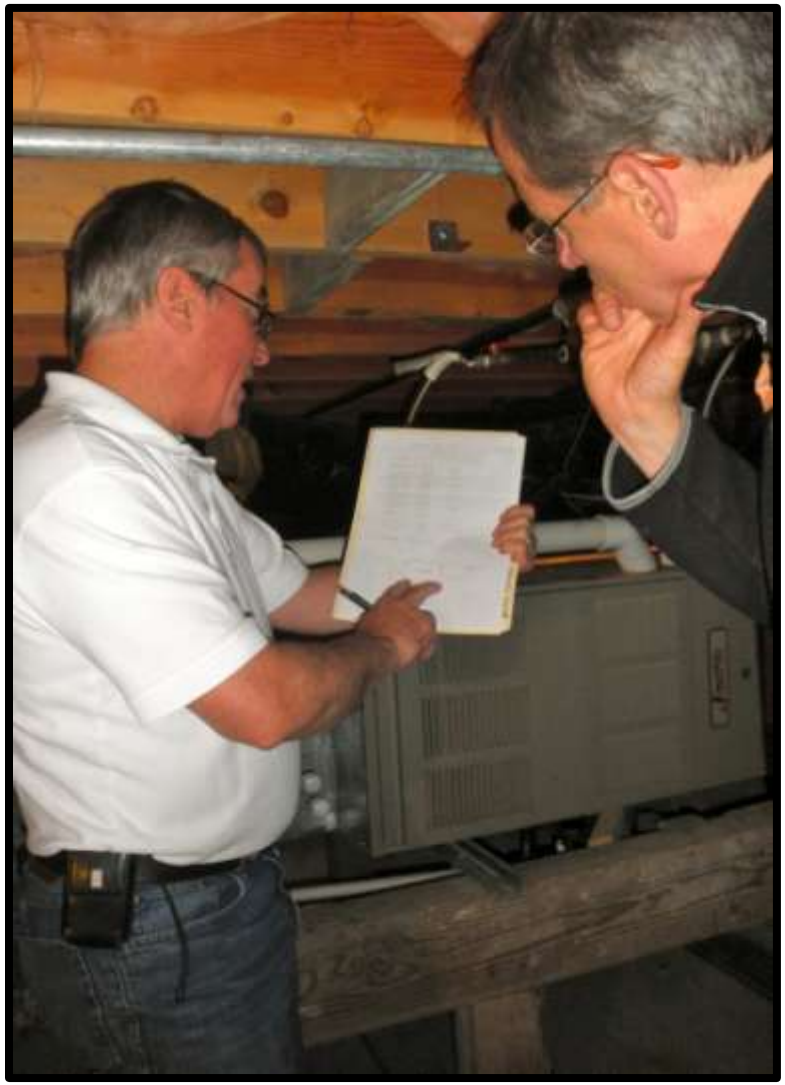
1. **Delivery velocities were too low for good room air mixing**

2. **4" x 14" grilles used with an average airflow of 50 CFM: this yields velocities of less than 300 feet per minute (FPM), or less than half of the desired velocity**

1st Floor Heating Efficiency

1. **The furnace efficiency was 95% (AFUE)**

2. **When the Btus actually delivered to the house were measured, we found the NET efficiency to be only 53%**



Envelope Performance Factors

1. **Infiltration**
2. **Insulation Levels**
3. **Insulation Performance**
4. **Glazing Performance**

Infiltration

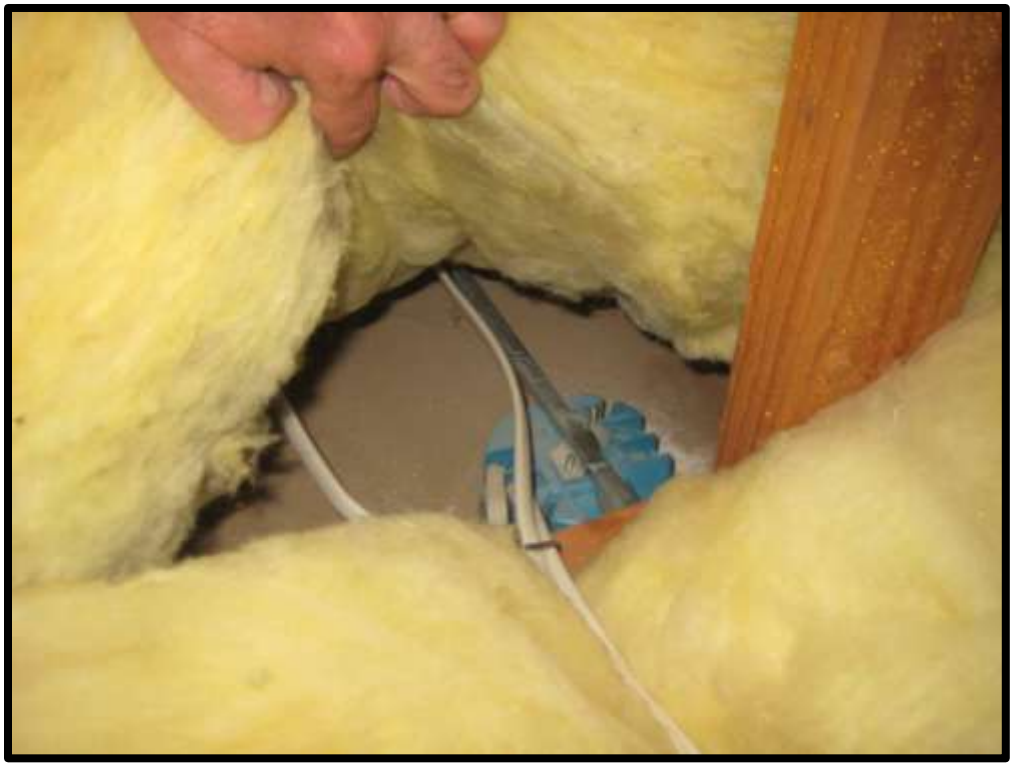
Blower door test result:

2,674 CFM_{50}
5.0 ACH_{50}
< 1 CFM_{50} per ft^2
(of floor area)

Insulation Performance

1. **Insulation performance was found to be industry standard (not very good)**

2. **Insulation not in contact with its air barrier**



Infiltration & Insulation Opportunities

Whole House Approach

- Baseload Electrical Consumption (1)
- Envelope:
  - Air Infiltration (2)
  - Doors & Windows (3)
  - Insulation Performance (4)
- HVAC:
  - Distribution System (5)
  - Equipment Efficiency (6)
- Water Heating & Distribution (7)
- Renewables (8)

Whole House Approach

- **Baseload Electrical Consumption** (1)
- Envelope:
  - Air Infiltration (2)
  - Doors and Windows (3)
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  - Distribution System (5)
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- **Water Heating** & Distribution (7)
- **Renewables** (8)

Whole House Approach Description

"Identify & quantify the opportunity for improvement in every category."

- Frank's project encompassed 2.5 out of our 8 categories of measures, hardly what we would call "whole house"
- …**but added one powerful force: committed occupants**

Can Frank's Approach Work in Other States or Even Other Parts of California?

YES, IT CAN

- Occupants have tremendous control over their energy usage
- It's easy to put on a sweater
- Baseload electrical consumption is typically the largest category of energy consumption
- Renewables are getting less expensive

NO, IT CAN'T

- This site has a mild climate
- This site has a simple & efficient architectural design
- The envelope on this house is pretty good
- "Typical" occupants won't sacrifice this much comfort
- "Typical" occupants aren't this motivated

Conclusion (from the HVAC & insulation guy)

The success of this project could be much less **"occupant dependent"** if HVAC & insulation opportunities were pursued. Some of these include:

- 1st floor HVAC system improvement, i.e., airflow, distribution efficiency, & room air delivery
- Air sealing opportunities
- Attic & crawl space insulation improvement

1st Floor HVAC System Improvement

1. Keep existing over-sized furnace & AC
2. Increase airflow by adding a second return & increasing the supply duct sizes
3. R-8.0 duct, half of the duct surface area (eliminate at least half of the supplies), & no duct leakage
4. New nondiffusing supply grilles for better room air mixing (delivering at 600 FPM)

Attic & Crawl Space Air Sealing Opportunities

1. Expose leakage sites in the floor assembly & the ceiling assembly
2. Use gun foam & high temperature caulk to seal all of the penetrations
3. Goal: Reduce infiltration by 50% (to 2.5 ACH_{50})

Attic & Crawl Space Insulation Improvement

1. After air sealing, reinstall all fiberglass batts to be in contact with their air barrier (plywood subfloor or ceiling drywall)
2. Properly install skylight batts & wrap skylights with PFSK duct wrap
3. Dam attic hatch, equipment platform, & fireplace flues
4. Install R-19 loose fill cellulose in attic over existing insulation & ducts