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 3: First US Passive House Retrofit - O'Neill:

The PH Approach to Deep Energy Reductions

May 2, 2012 10-11:30 a.m. Pacific Time

Presented by: **Graham Irwin,** Essential Habitat & **Rick Milburn,** PassivWorks
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

Spring 2012 Case Study
The Last One!

May 9 - Webinar 4: **Second CA Home to Meet the THC - Bergamaschi:** Focus on Plug Loads, Behavior, & PV

- Catch up on what you missed – Archives & resources posted
  - http://thousandhomechallenge.com/spring-2012-webinar1
  - http://thousandhomechallenge.com/spring-2012-webinar2

Archives 2010-2011 THC/ETC webinars

(hot water, base load, ductless heat pumps, dense pack)

- *www.1000HomeChallenge.org/resources*

ACI Resources

MARK YOUR CALENDAR!

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

PG&E SCHOLARSHIPS! http://www.acicalifornia.org/scholarships

Applications due Monday, May 7

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

Presenters include: Bronwyn Barry <> Sharon Block <> Tom Downey <> Jeff Farlow <> Allen Gilliland <> Gavin Healy <> Katy Hollbacher <> Graham Irwin <> Mary James <> Gary Klein <> Bruce Manclark <> Mike MacFarland <> Rick Milburn <> George Nesbitt <> Terry Nordbye <> Dan Perunko <> Gary Richardson <> Dick Rome <> Andy Simms <> Brett Singer <> Iain Walker <> Peter Waring <> Linda Wigington <> Dwight Williams

and many others…

PG&E's 2012 Classes – Free!

Sampling of Offerings (from May to June)
Related to Deep Energy Reductions in Existing Homes

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

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

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

Ventilate Right, Build Tight - *Judy Roberson*

Window Selection for New and Existing Homes - *Steve Easley*

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

Balanced Ventilation for High Performance Homes - *Dan Perunko & Gavin Healy*

Auditing Electricity Use in Existing Homes - *Chris Hunt*

Integrating Energy Efficiency & Renewables in Home Retrofits - *Pete Shoemaker, +*

PG&E's ZNE Homes Class Series (Parts 4, 5, & 6) - *Rick Chitwood & Ann Edminster*

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Learning Objectives for Today

By attending this webinar, participants will

1. Have a better understanding of the **construction practices deployed** to achieve the energy, comfort, & durability performance required of certified Passive House projects
2. Learn about the **energy performance results** of this project, & how they compare with the OPTION B threshold for the Thousand Home Challenge & current building codes
3. Hear **insights** into the efficacy of the measures employed & **possibilities for additional cost optimization** in future projects

Webinar Outline Today

Linda Wigington

- Intro & Thousand Home Challenge

Graham Irwin & Rick Milburn

- Project presentation

Gary Klein & Don Fugler

- Comments

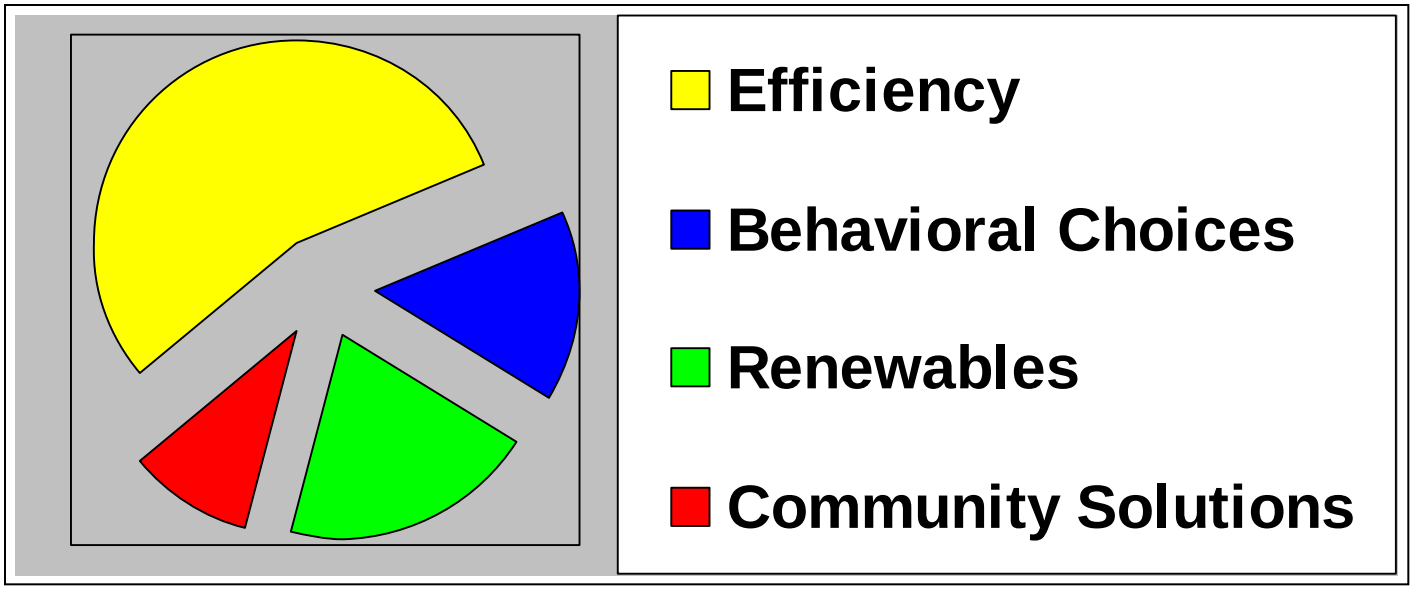
Discussion & Questions

- 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

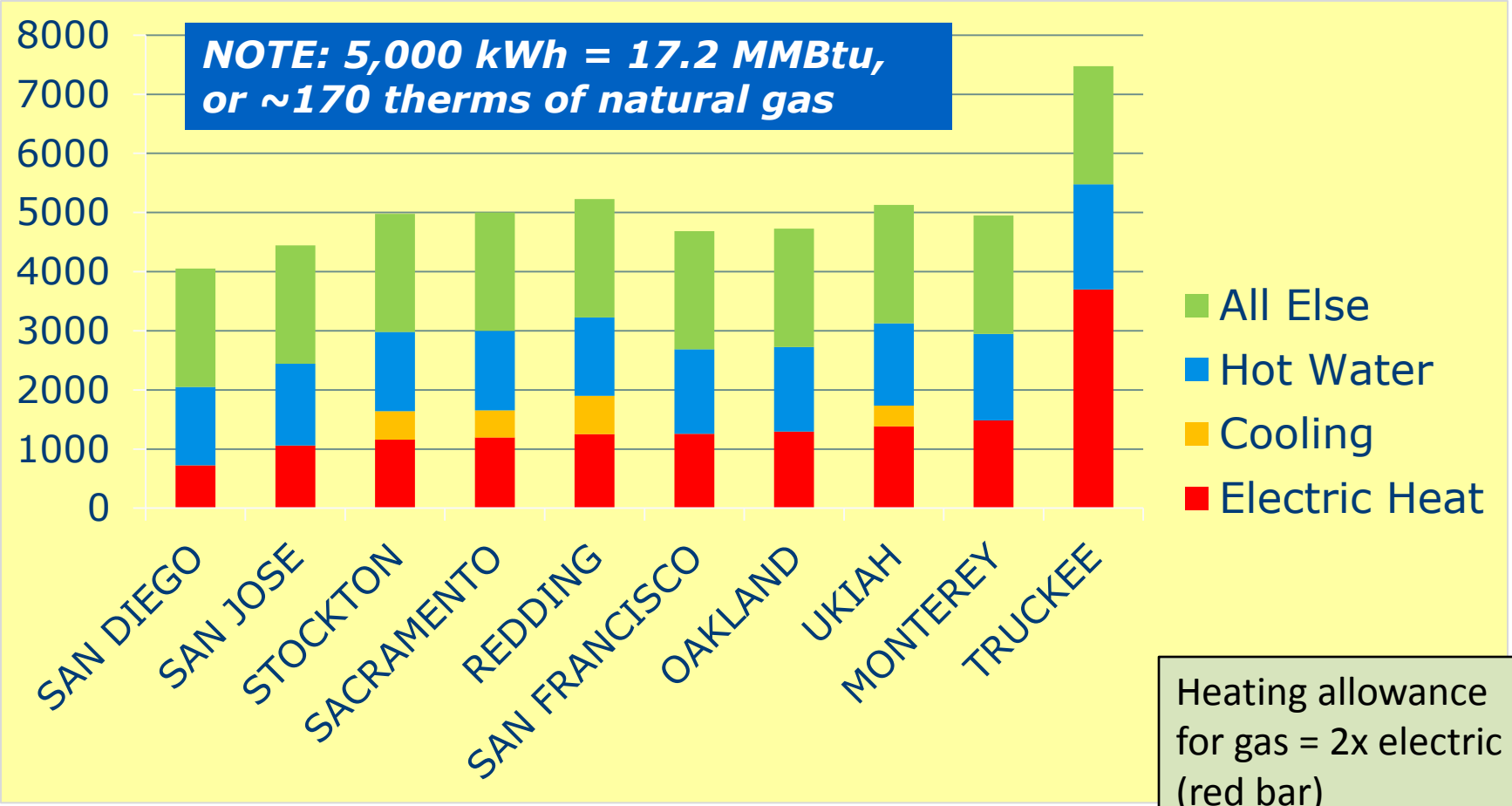
- 75% reduction in actual annual site energy use

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

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-webinar3

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: Graham Irwin & Rick Milburn

Graham Irwin, CPBD, CGBP, LEED AP, certified Passive House consultant, has been working in the construction industry since 1991. Long committed to sustainability, he was one of the first Passive House consultants trained in the U.S. Graham's firm, Essential Habitat, provides design assistance to architects, builders, and homeowners with an emphasis on Passive House methodology.

Rick Milburn, owner of PassivWorks, Inc., is the first builder in California to become a certified Passive House consultant, the first to complete a Certified Passive House in California, and the first to complete a certified Passive House retrofit in the United States. Passive House is a simple process of achieving the goal of “better buildings."

The O'Neill Residence Passive House Retrofit

Graham Irwin, Principal, Essential Habitat
Rick Milburn, Owner, PassivWorks

PASSIVWORKS Better Buildings.

ESSENTIAL HABITAT healthy spaces for humans

1000 Home Challenge

ACI

PH

Before (2009)

1,933 Ft^2

3 BR/2 BA

Built in 1960

Borders "pocket park" in Sonoma, CA

Foreclosed property (no previous utility data)

Dated & dilapidated

Motivated client

Project Challenges

Uninsulated slab on grade

Setbacks & expansive soil: keep slabs & walls

8’ plate height: limited floor insulation

Limited solar access

Single story, u-shaped layout

North orientation

No one in the US had done this successfully!!!

After (2010)

2,342 ft^2

2 BR/2.5 BA

1st Certified Passive House in California

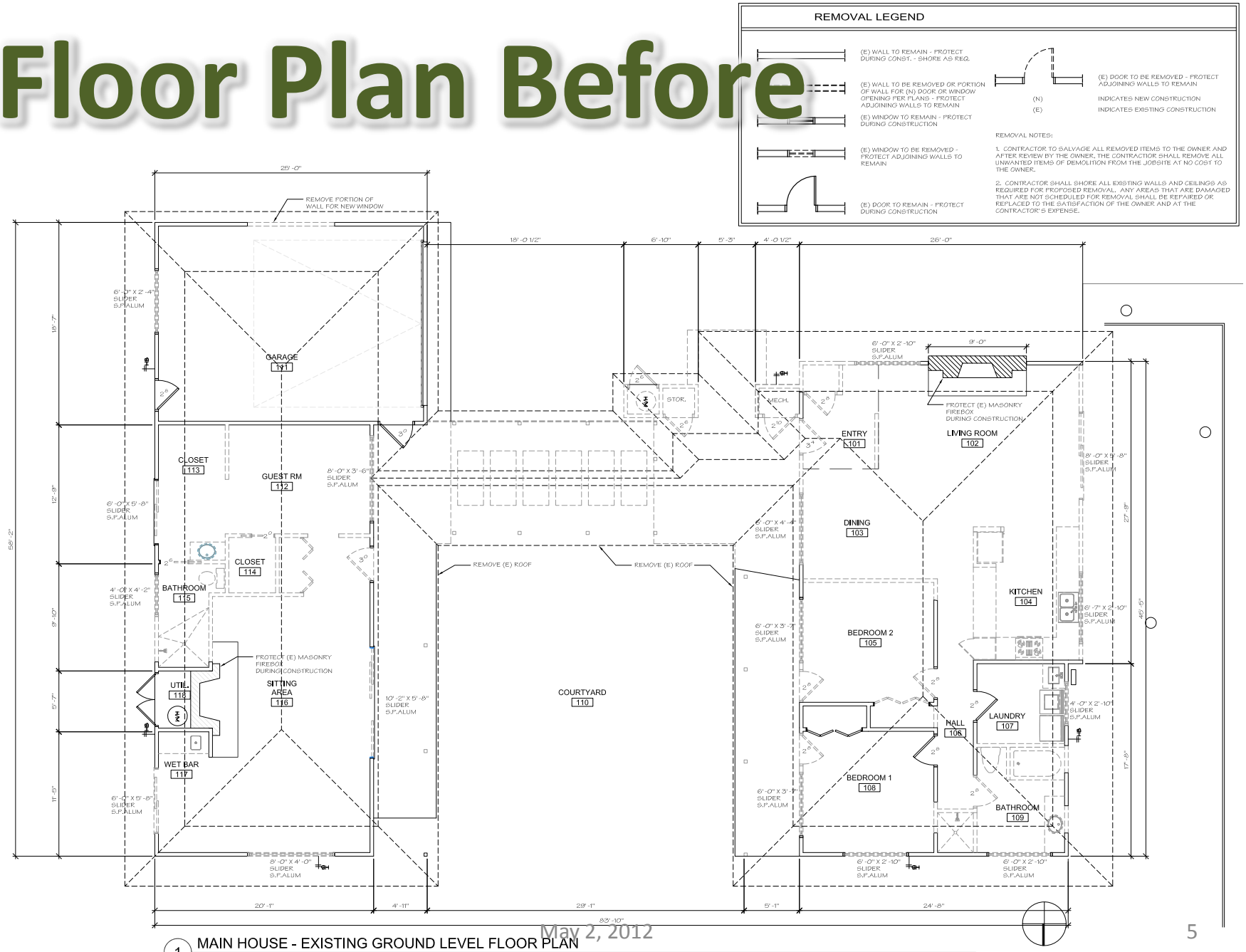
1st Certified Passive House retrofit in US

Satisfied homeowner:

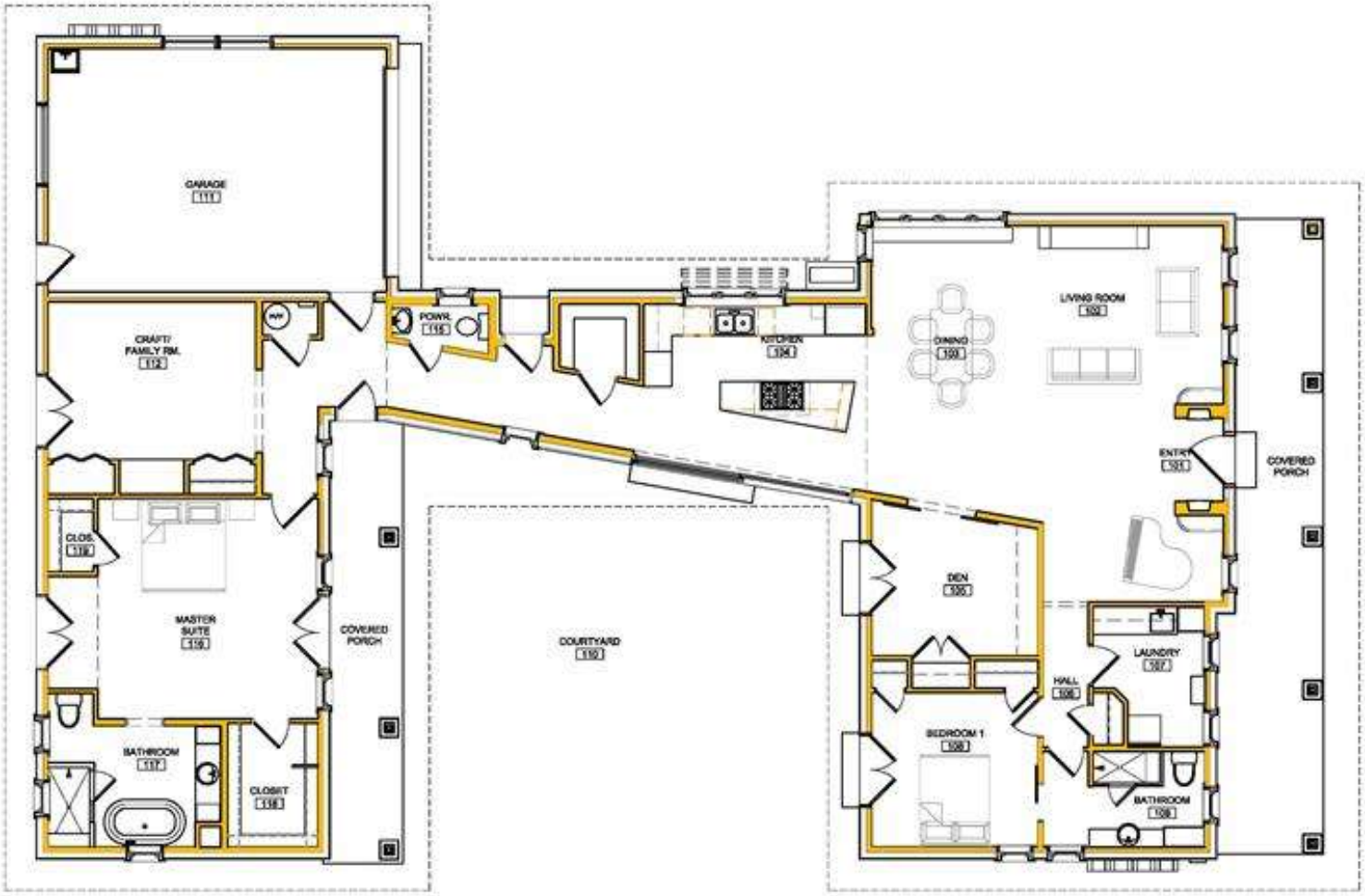
"This house is highly energy efficient and it is also aesthetically pleasing. It is an heirloom that I will pass down to the next generation."

- Cathy O'Neill, owner

Floor Plan Before



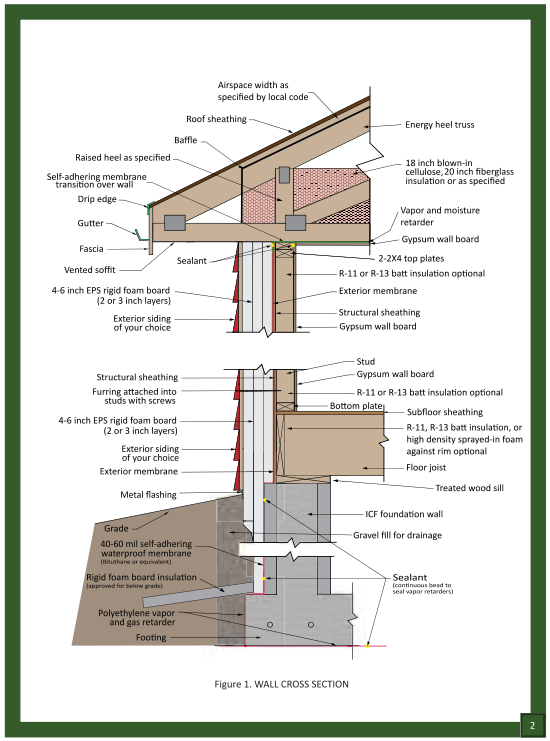
Floor Plan After



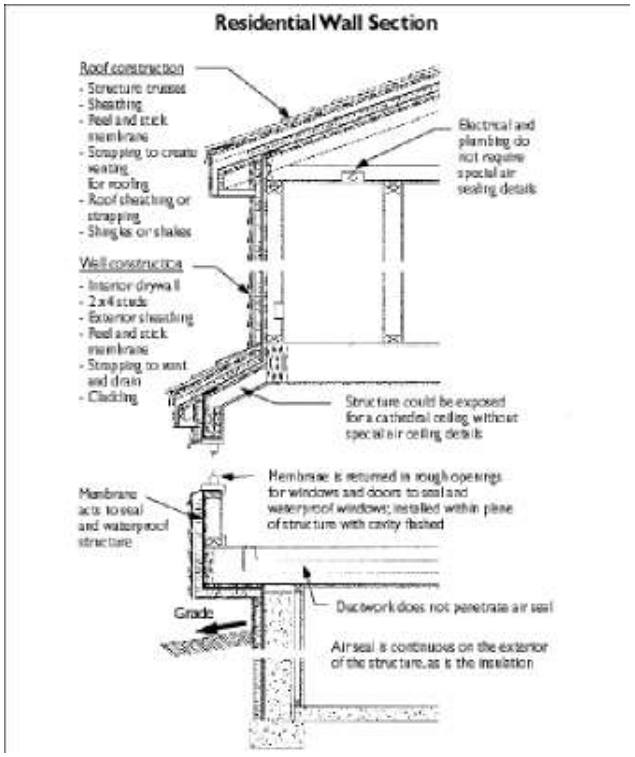
Retrofit: Air Barrier

PERSIST/REMOTE System (Canadian/Alaskan)
Air & vapor barrier @ exterior sheathing
Exterior insulation for dew point/condensation concerns

The Journal of Light Construction (JLC), **May 2009**



Remote, A Manual
Cold Climate Housing Research Center, Jul 2009



Wrap It Up, **Home Energy Magazine Nov/Dec 1999**

Retrofit: Air Sealing

Grace Ice & Water Shield® over wall & roof sheathing

Interior chases for mechanical & electrical

Protecto-Wrap Super Stick Building Tape® @ mudsill

All penetrations booted & foamed

151 CFM_{50} = 0.4 ACH_{50} (PH Limit 0.6 ACH_{50})

Retrofit: Envelope

New (scissor truss) vaulted, unvented roof

Existing 2x4 walls, new walls 2x6 OVE framing

Insulation on top of existing slab, @ slab edge

Blown-in fiberglass in wall & roof cavities

Expanded polystyrene (EPS) on walls, roof & slab

PH certified (~R-7) triple-pane windows & doors

Retrofit: Mechanicals

Energy recovery ventilator (ERV) “fresh air furnace”

Solar thermal for DHW & space heating

EcoSmart unvented bioethanol fireplace

Tankless natural gas water heater for DHW backup

Shading & night flushing for cooling

Mini-split heat pump for heating & cooling backup

Energy Recovery Ventilator

Solar Tank

Bioethanol Ventless Fireplace

Air to Air Heat Pump

Retrofit: Appliances

Refrigerator: Sub-zero Energy Star BI-36U

ASKO clothes washer & condensing dryer

Recirculating vent hood w/ERV intake @ ceiling

100% CFL & LED lighting, gas cooktop, electric ovens

Kitchen

Mechanical Room

Retrofit: Renewables

72 ft^2 solar thermal drainback system (70% of DHW)

2.15 kW photovoltaics

CUDO rainwater catchment system

Passive House

Rigorous, voluntary energy efficiency standard
Formalized by European scientists ~1990
Based on super-insulated, passive solar & "low-energy" buildings
25,000+ worldwide: Residential, commercial, institutional buildings

World's 1st Passive House
Kranichstein Passive House
Darmstadt, Germany (1990)

1st Passive House in US
Smith House
Urbana, Illinois (2003)

1st Passive House in CA
Tahan Residence
Berkeley, California (2007)

1st Certified PH in CA
O'Neill Residence
Sonoma, California (2010)

How Does PH Work?

The Ventilation System Is the Main Mechanical System
Emphasizes Efficiency, Reduces Mechanical & Renewable Requirements

Minimize Losses

Maximize Gains

1. Super-insulation
2. Airtightness
3. Passive solar
4. Heat recovery ventilation
5. Efficient equipment, appliances, & lighting

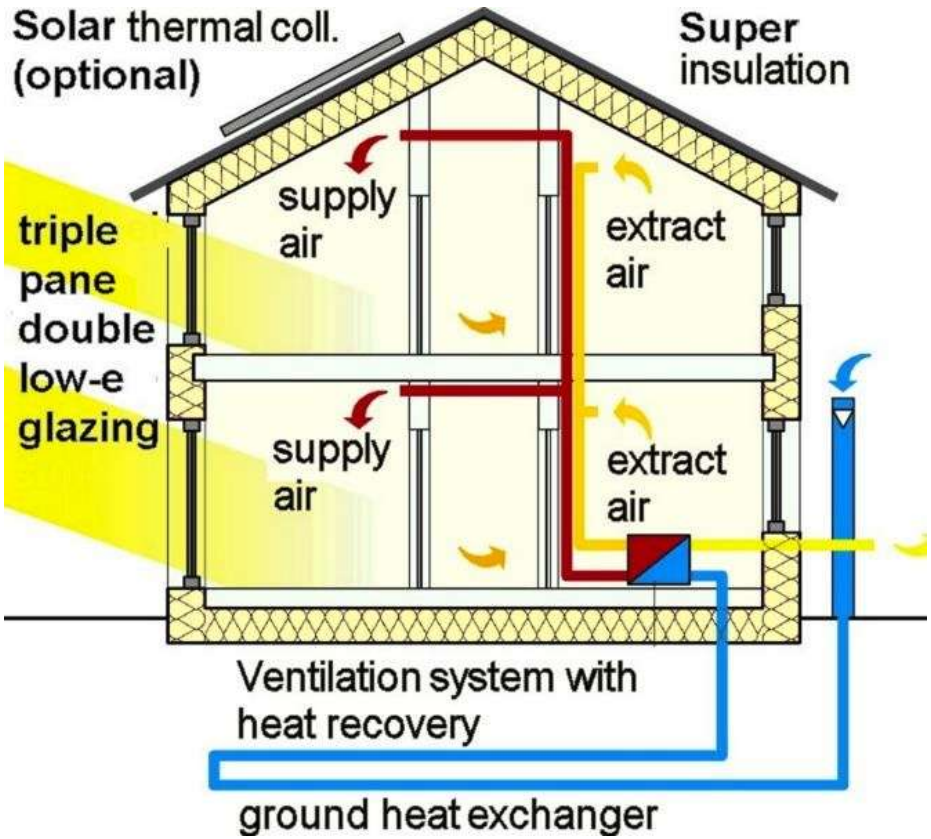


Image Source: Passivhaus Institut (PHI)

The Passive House Standard

Measured

1. Maximum Air Leakage: 0.6 ACH_{50}

Modeled (PHPP)

2. Max. Heating or Cooling Demand
   15 kWh/m²/yr. (4.75 kBtu/ft²/yr.)
   OR Max. Heating Load
   10 W/m² (3.17 Btu/hr./ft²)

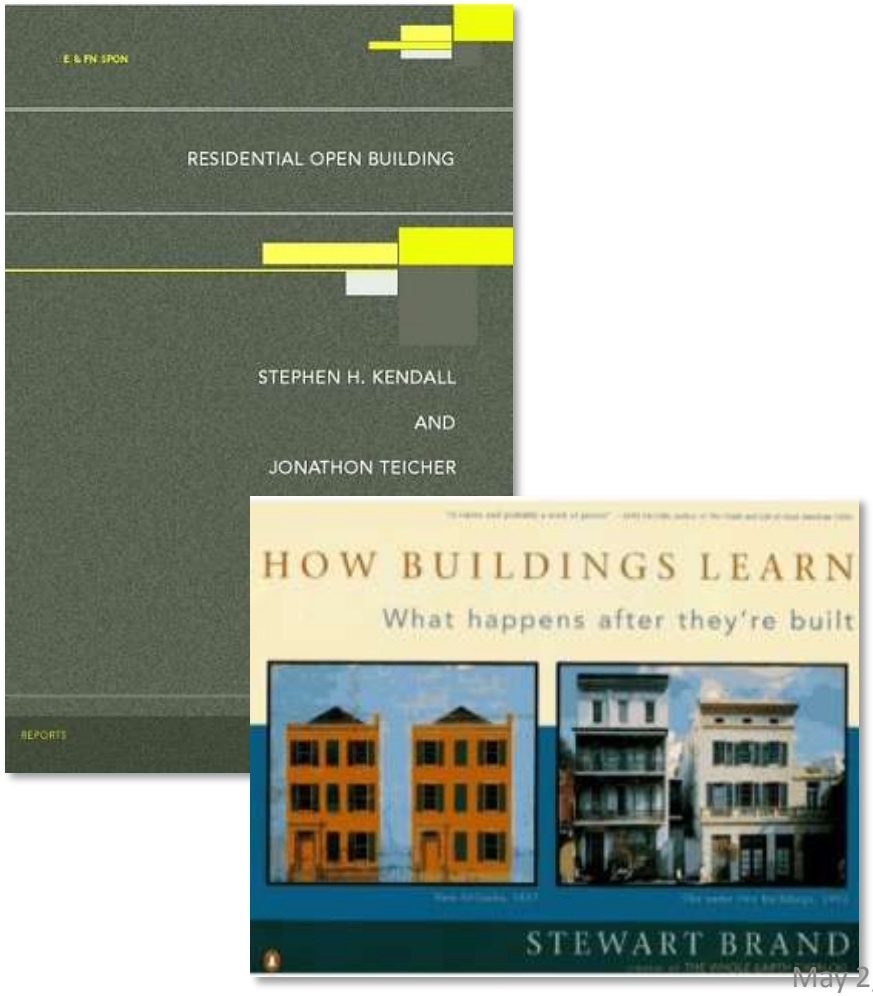
Shell Efficiency

3. Max. Primary Energy Demand*
   120 kWh/m²/yr. (38.1 kBtu/ft²/yr.)

Source Energy

**Before application of PV*

Open Building: The Shell Matters!!!



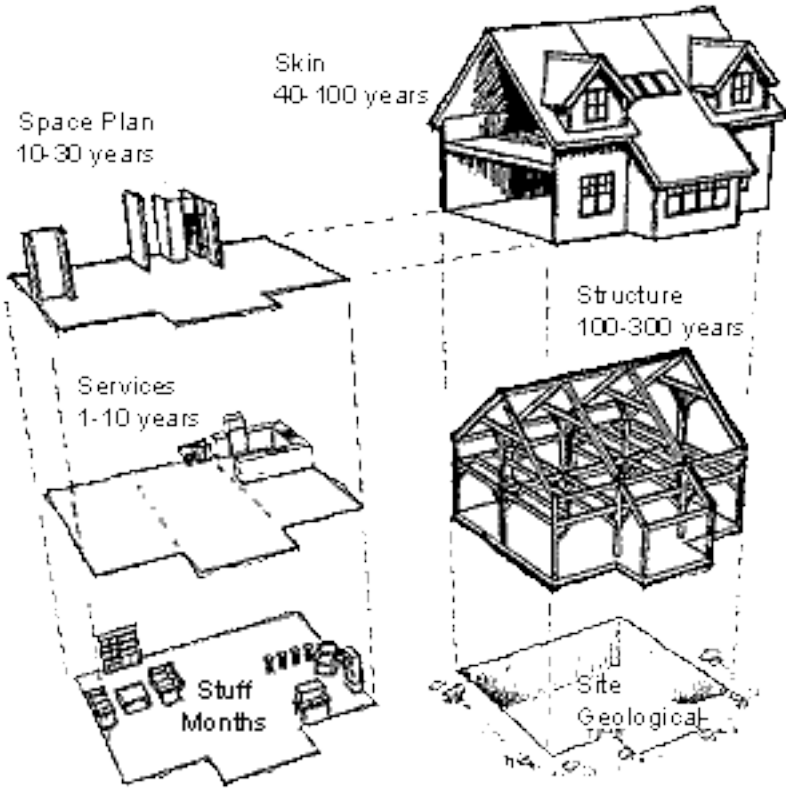
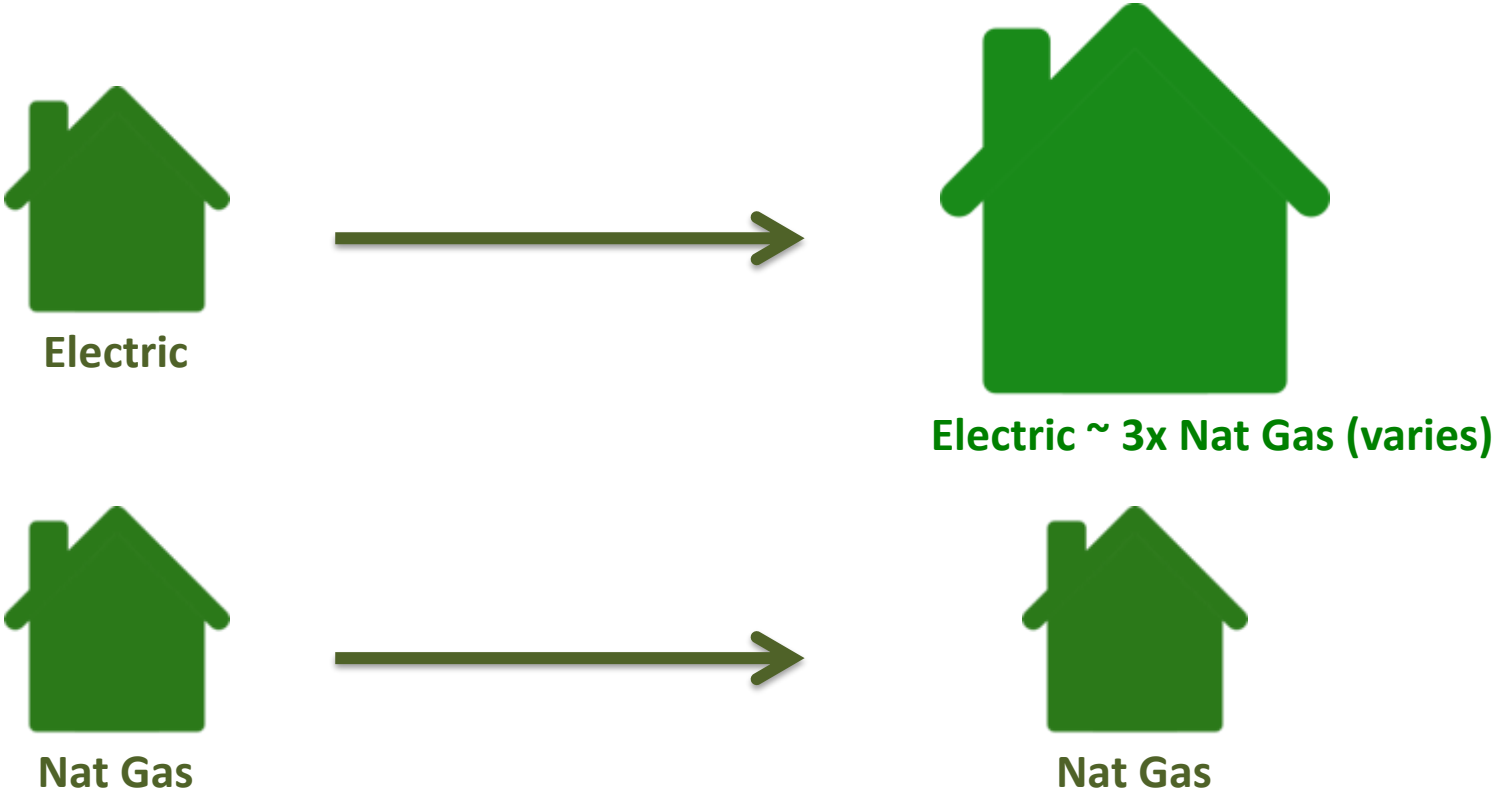


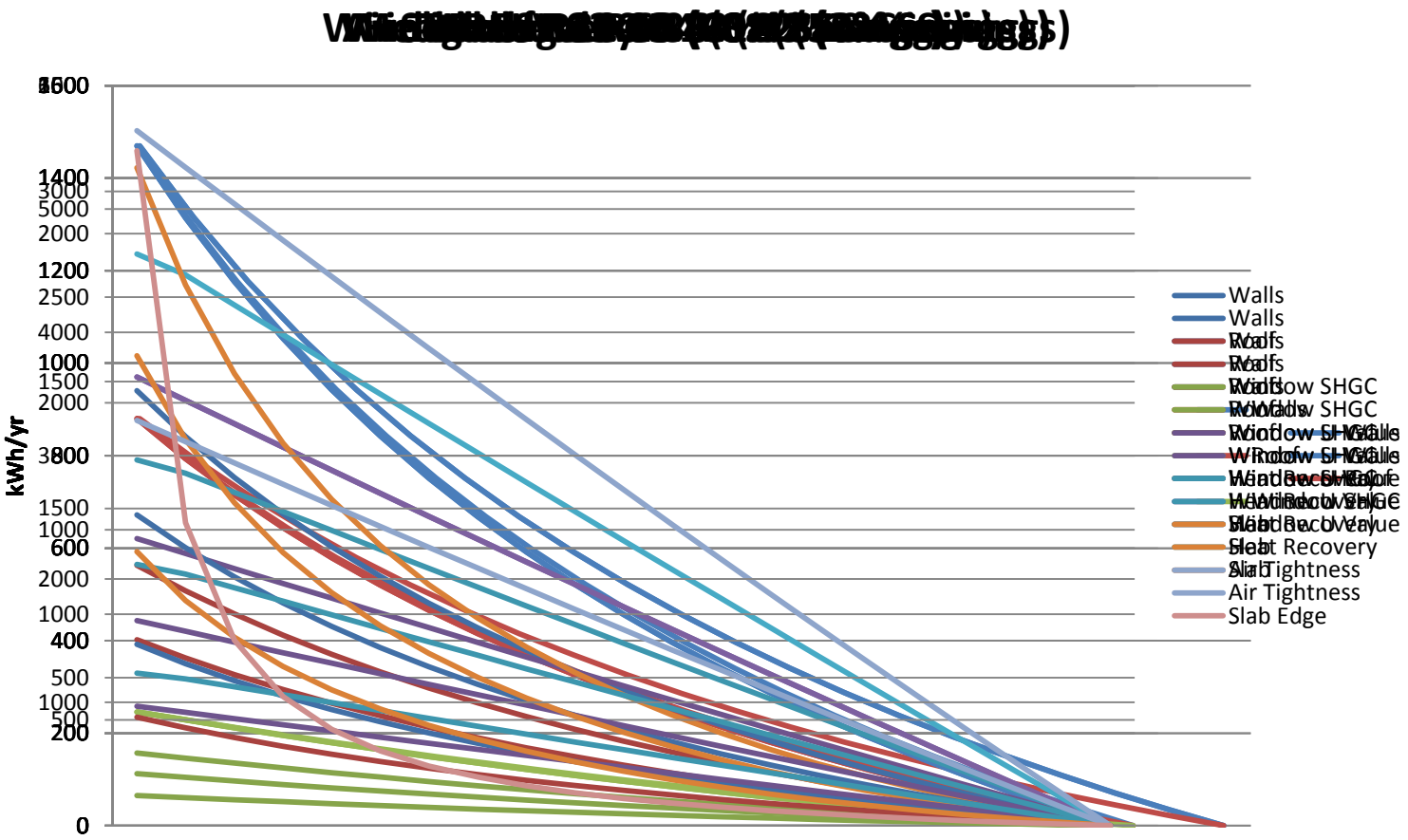
Image Source: *OPEN Prototype Home - Building the Future*
www.MadeForOne.com

Global Warming: Source Energy Matters!!!

Site Energy | **Source Energy**



Heating & Cooling Savings



Code Minimum → **Design Value**

O'Neill Retrofit Vs. Code

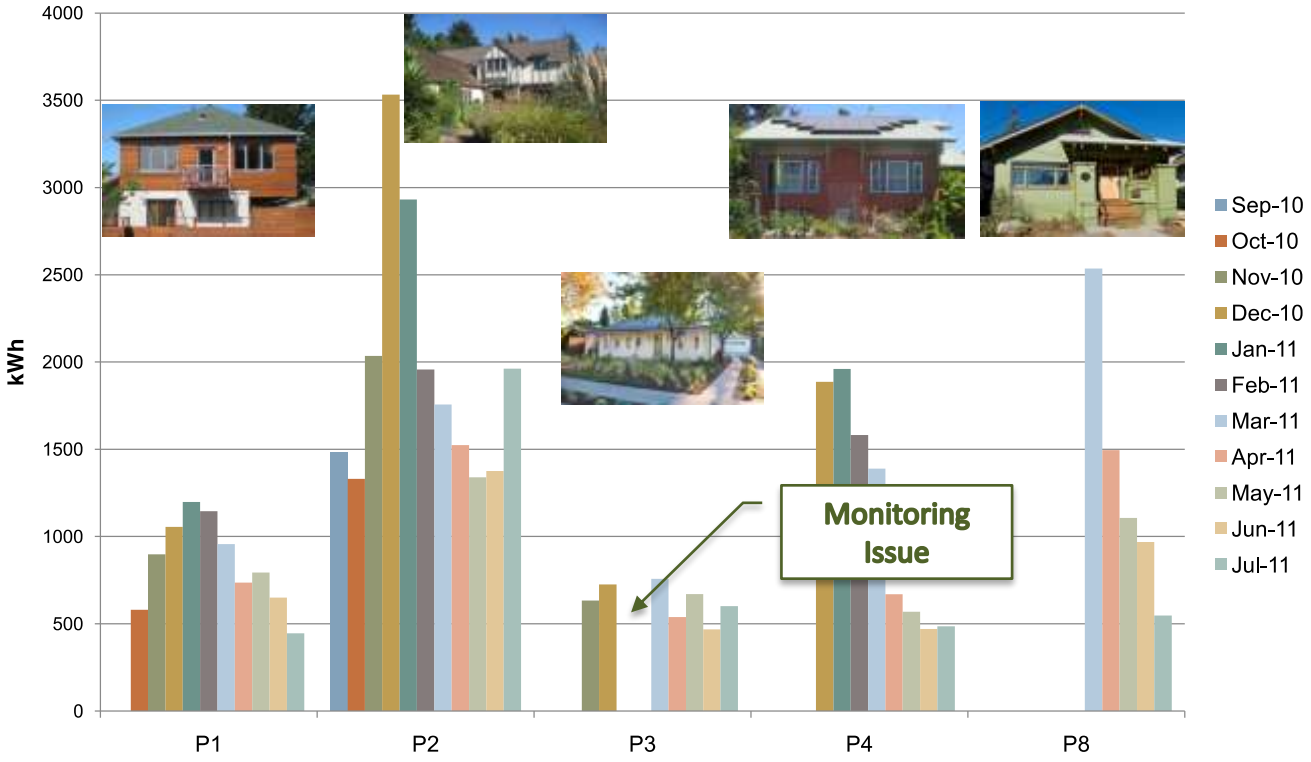
Envelope Measure	Code Minimum	O'Neill Residence
Roof	R30	R64
Walls	R13	R34
Slab Edge	R0	R16
Slab	R0	R16
Window U-value	0.4	0.15
Window SHGC	0.3	0.52
Airtightness	None (6 ACH_{50})	0.38 ACH_{50}
Heat Recovery	None (0%)	83%

Code Progress??? (1960-2012):

Can still build 1960s pre-retrofit energy hog!!! (w/double-pane windows)

Measured Results

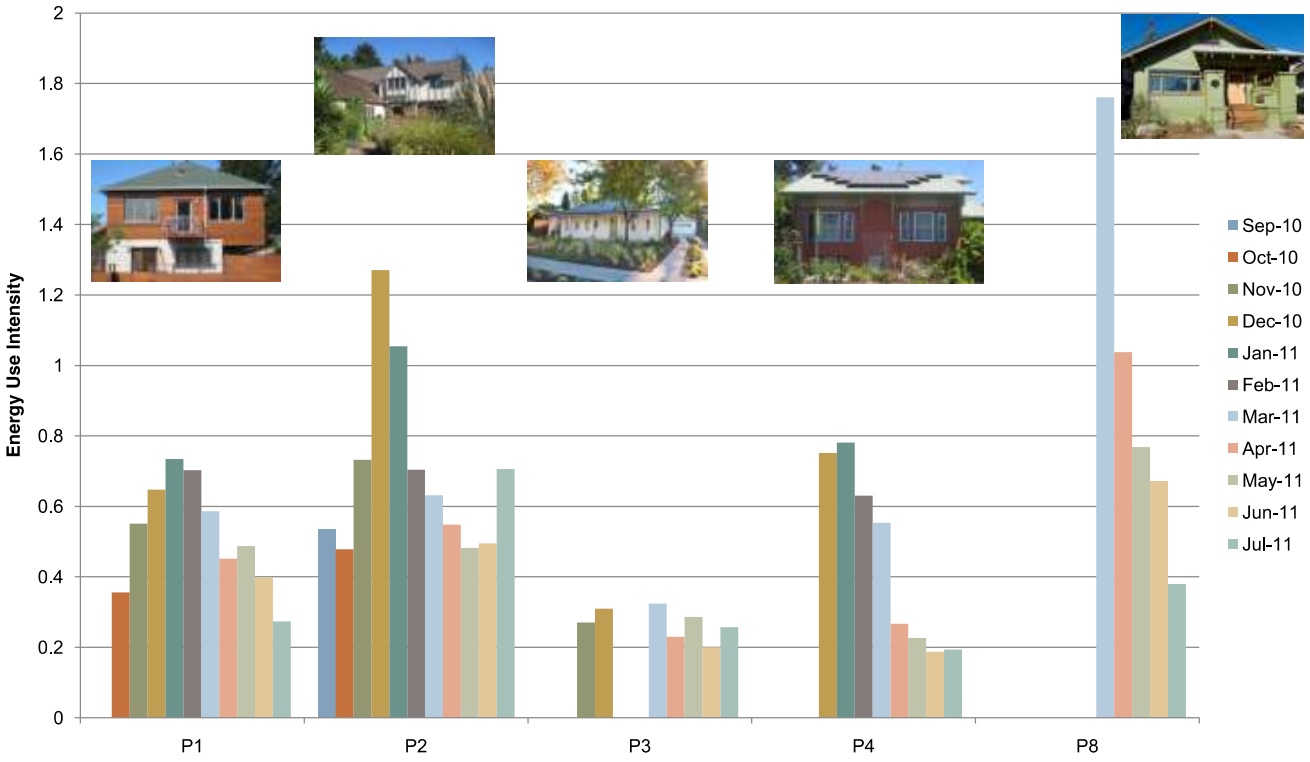
Total Energy Consumption



Source: **DEEP ENERGY RETROFITS: CALIFORNIA CASE STUDIES**
Jeremy Fisher & Brennan Less – LBNL Aug 16, 2011

Measured Results

Energy Per Square Foot



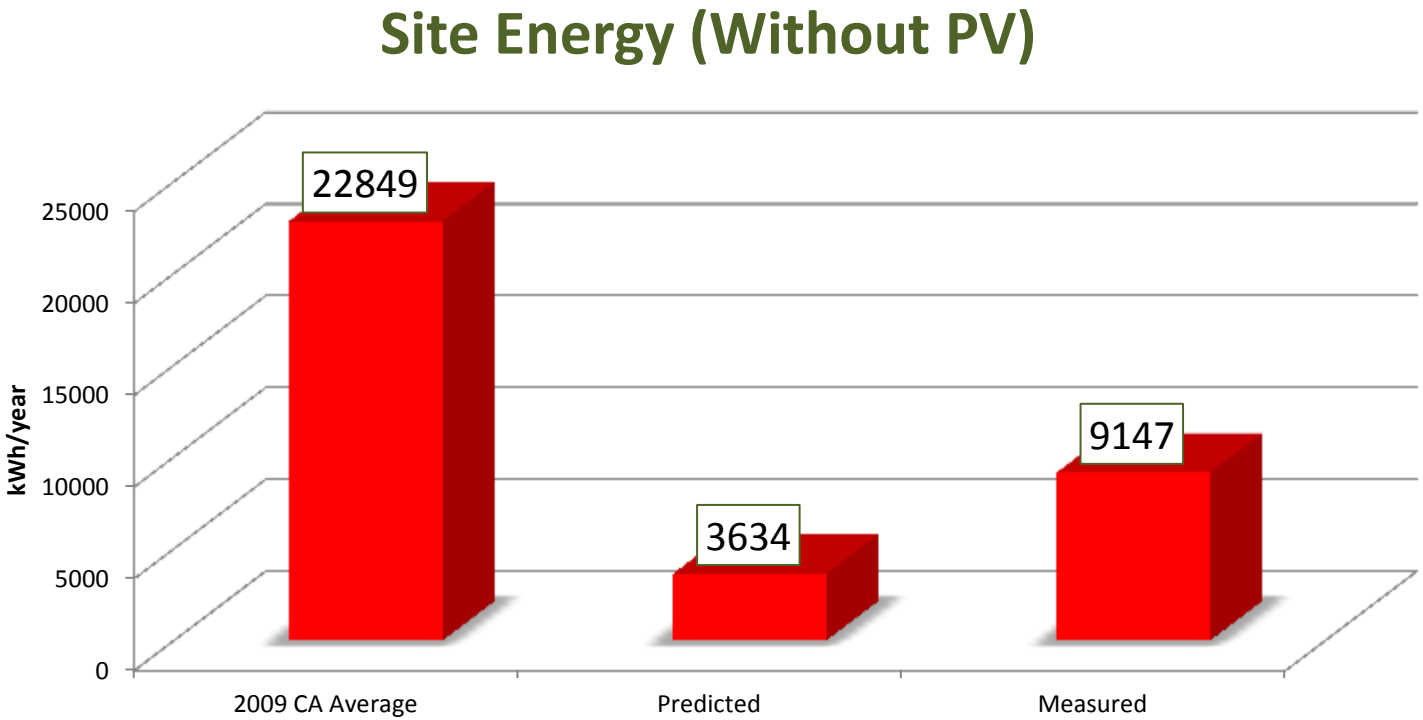
Source: **DEEP ENERGY RETROFITS: CALIFORNIA CASE STUDIES**
Jeremy Fisher & Brennan Less – LBNL Aug 16, 2011

Measured Results

Energy Per Occupant

Source: **DEEP ENERGY RETROFITS: CALIFORNIA CASE STUDIES**
Jeremy Fisher & Brennan Less – LBNL Aug 16, 2011

Measured Vs. Modeled

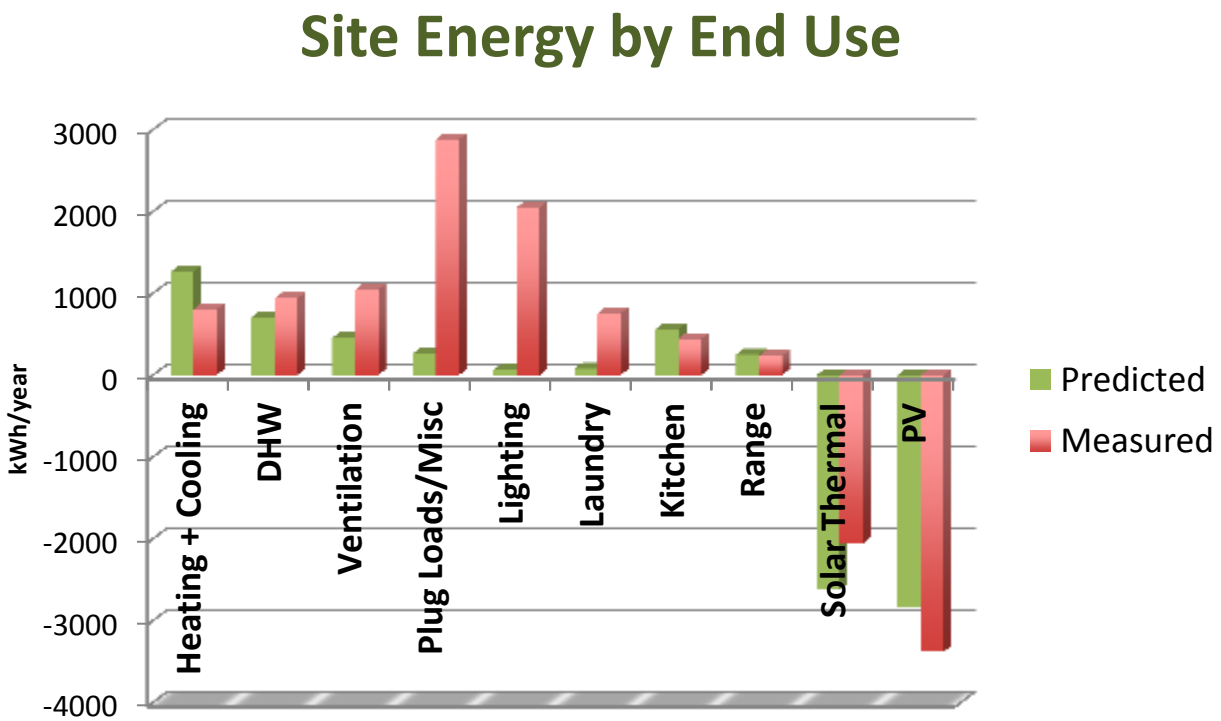


40% of average California household*

***Based on 2009 RASS CEC Study**

2.5x predicted value (PHPP w/2 occupants)

Measured Vs. Modeled



Heating & Cooling: 64% of predicted value
Plugs & Lighting: 11x, 32x predicted value
(Larger IHGs affect heating & cooling)
(Heat pump SEER & HSPF not climate adjusted)
Solar space heating (40%) not modeled

Why the Discrepancy?

Plug Loads

2 DVR's (on timers, still energy hogs)

Central AV System (this is a drag)

Extra fridge in garage (not Energy Star)

Outdoor fountain pump (pig)

Lighting

Too many lights (3 lighting designers, big disconnect in lighting design process)

Ventilation

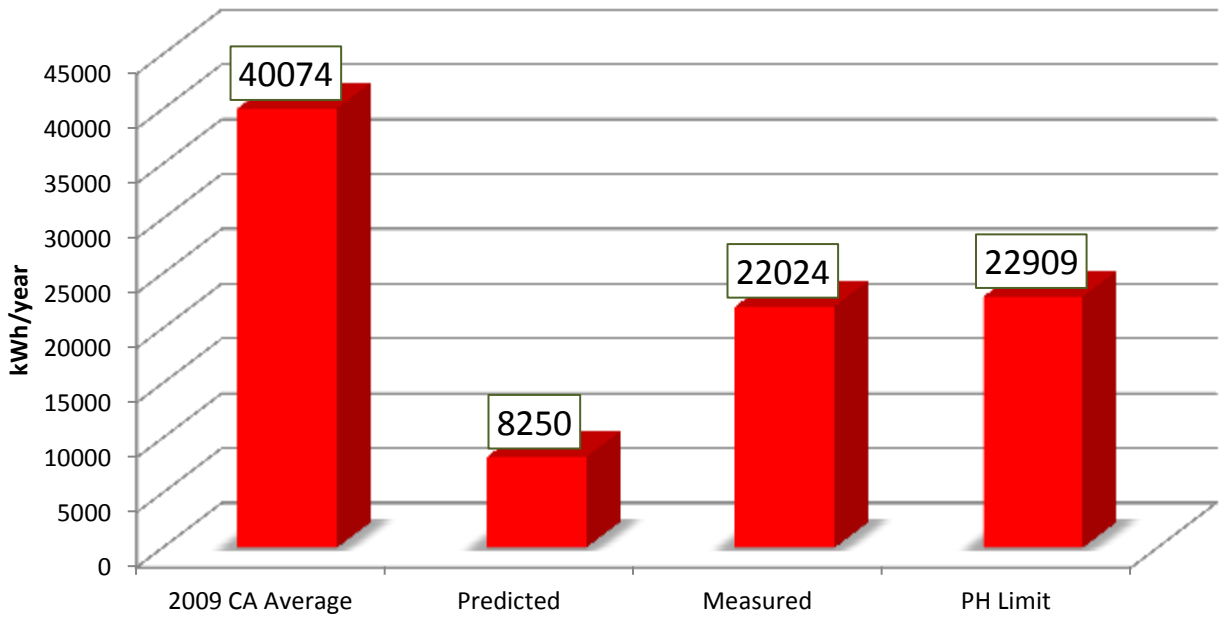
Leaves clogged ERV intake

In General

German vs American expectations???

Measured Vs. Modeled

Source Energy (PV Not Included)



55% of average California household source energy
2.7x predicted value (21% of CA average)
96% of Passive House limit (1.1x gas, 2.7x electricity)

Thousand Home Challenge

1000 HC Thresholds (Net Site Energy, includes PV)

OPTION A (75% reduction): NA

OPTION B* (0.75 occupants): 4,796 kWh/yr. limit

OPTION B* (1 occupant): 5,056 kWh/yr. limit

***Napa Airport weather station (3,107 HDDs), electric heat, adjusted shell area calculation**

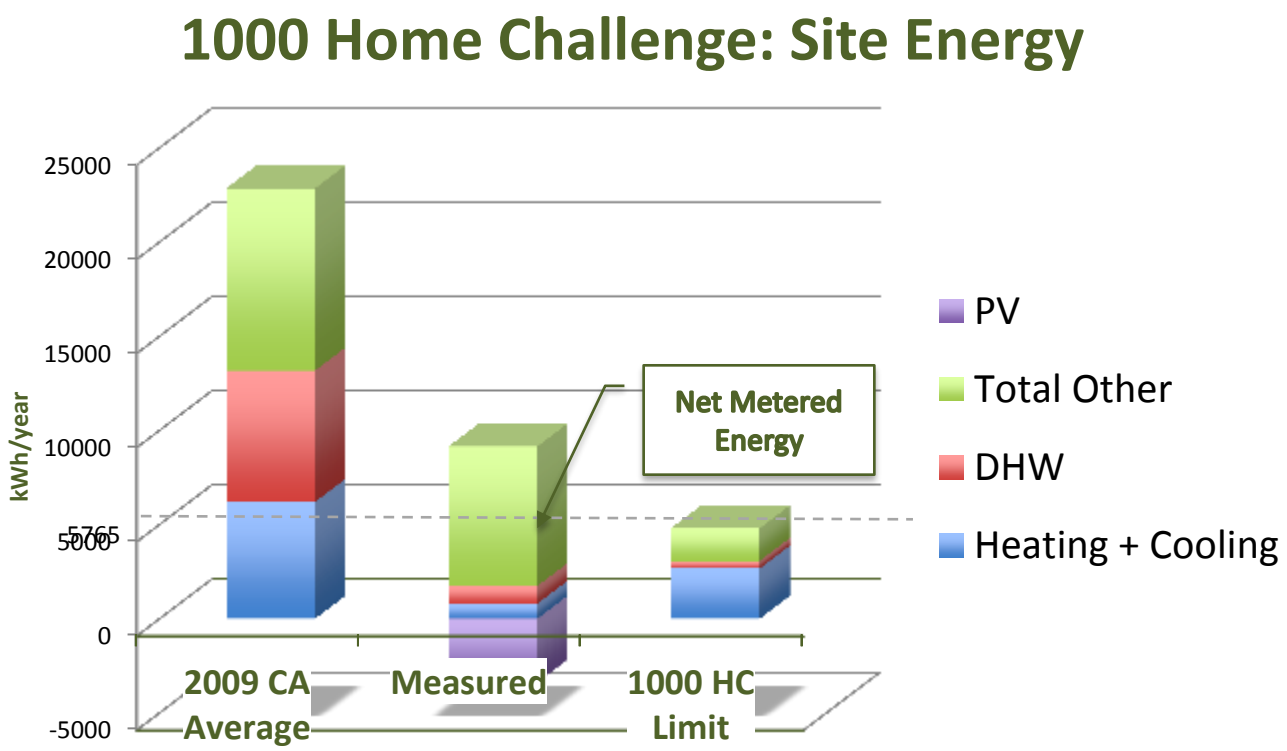
1000 HC Qualified?

9,147 - 3,382 (PV) = 5,765 kWh/yr (25% of CA average)

OPTION A: No actual utility data available

OPTION B: 5,765 kWh - 4,796 kWh = 969 kWh/yr. over

Thousand Home Challenge

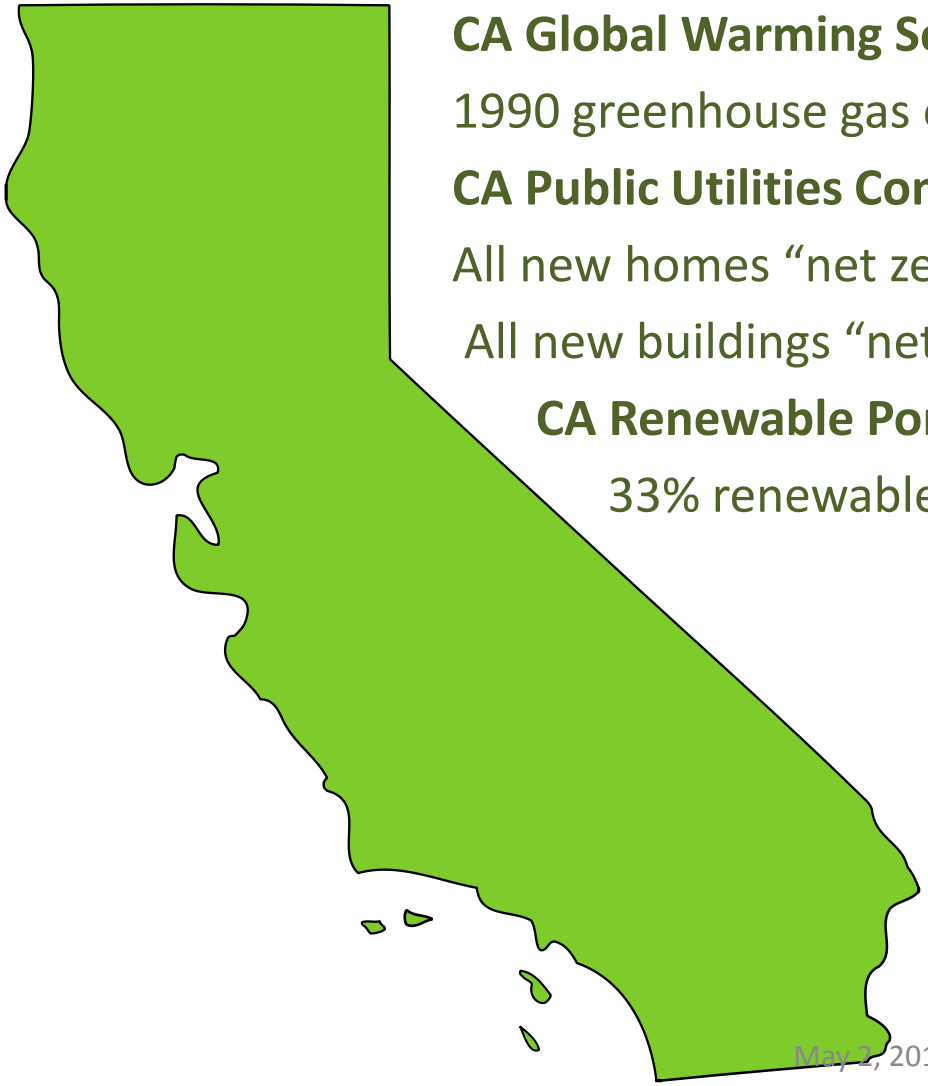


969 kWh/yr. over OPTION B threshold

Just add PV??? (2.15 kW system), add occupants???

DHW limit VERY small (house has 70% solar fraction)

California's Goals



CA Global Warming Solutions Act:

1990 greenhouse gas emissions by 2020

CA Public Utilities Commission (CPUC) Mandate:

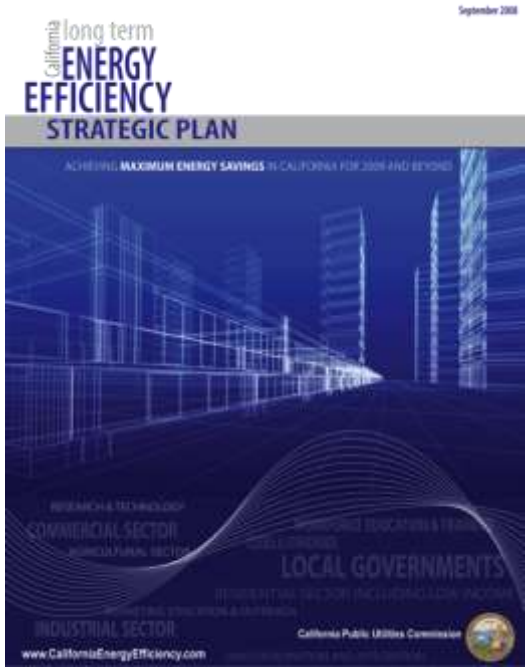
All new homes "net zero energy" by 2020

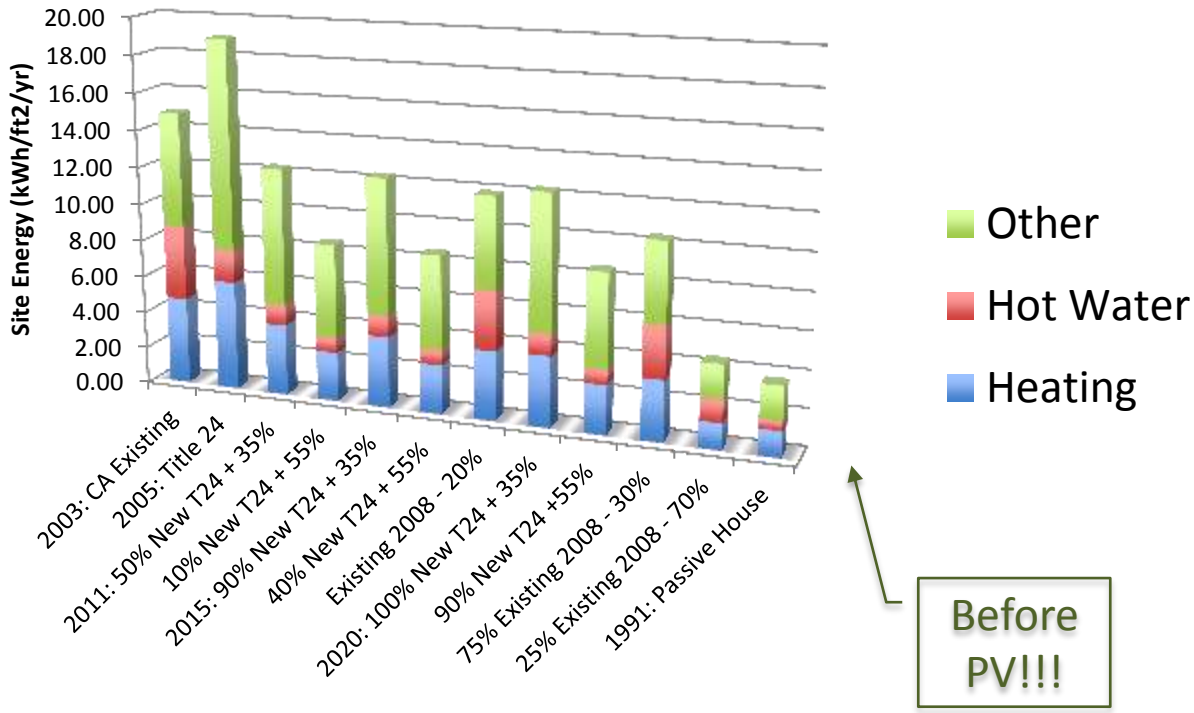
All new buildings "net zero energy" by 2030

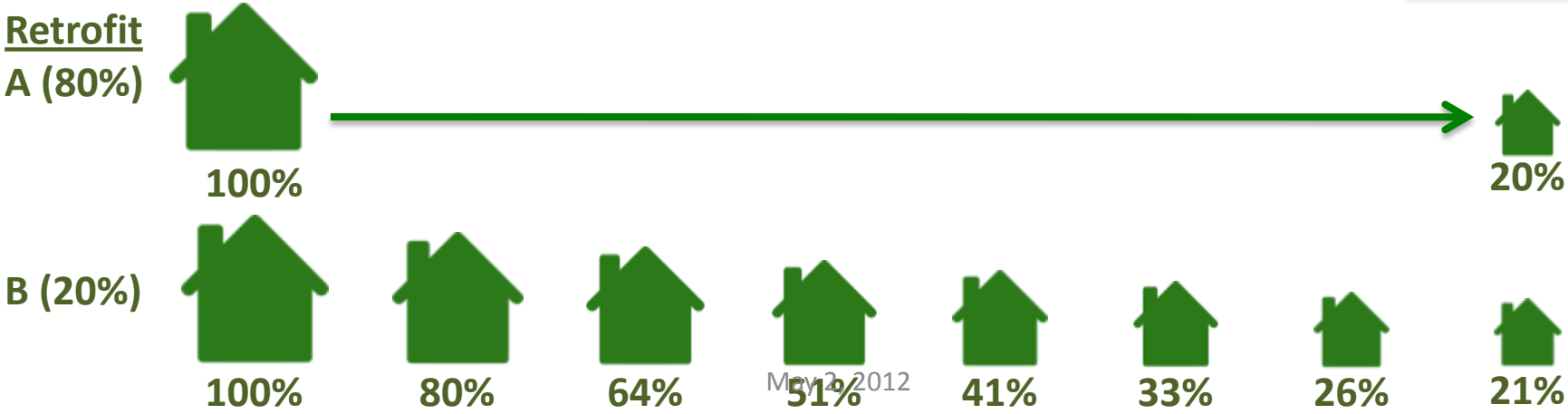
CA Renewable Portfolio Standard (RPS):

33% renewable electricity by 2020 (11.6% now)

California's Strategic Plan







Lessons Learned

1) Keep it simple (equipment & construction)

2) Apply standard techniques (everyone can build double stud walls with energy heel roof trusses)

3) Monitoring is the only way to know what is & isn't working

4) Consider user behavior before they move in

5) AV systems & lighting (limit quantity)

6) Constant focus on efficiency ("Eyes on the Prize")

7) Involve the ENTIRE team in the effort

Steps to Improvement

Faster!

Easier!!

Cheaper!!! (+15% for PH)

Current Project: 30% less for shell

Insulation, tape, & HRV go a long way for little cost!!!

More Efficient!!!

Project Team

Jarrod Denton, Architect, Signum Architecture

Rick Milburn, Builder, PassivWorks

Graham Irwin, PH Consultant, Essential Habitat

Edwin Shank, Mechanical Engineer

Architectural Rendering: Perchara Studio, Inc.

Landscape Architecture: Chandler & Chandler

Landscaping: Dexter Estate Landscapes

Interior Design: Jann Capone

Thanks!!! Questions???

Graham Irwin, Principal, Essential Habitat

ESSENTIAL HABITAT
healthy spaces for humans

graham@essentialhabitat.com

Rick Milburn, Owner, PassivWorks

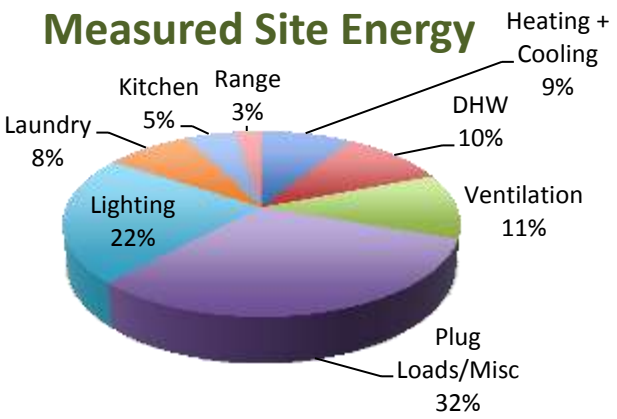
PASSIVWORKS
Better Buildings.

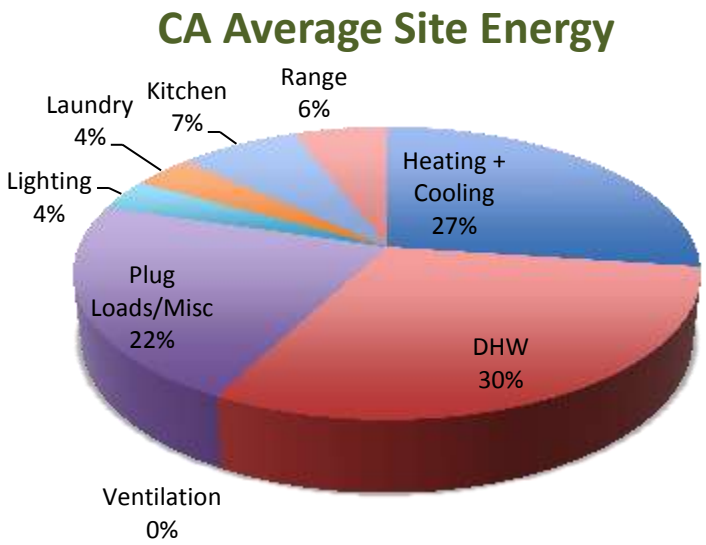
rick@passivworks.com

Archived Webinar:

http://thousandhomechallenge.com/spring-2012-webinar3

Measured Vs. CA Average





9,147 kWh/yr.

22,849 kWh/yr.

40% of average CA household site energy

w/ PV: 9,147 - 3,382 = 5,765 kWh/yr. (25% of CA avg.)

Perils of Incrementalism

DOE "Building America" Analysis

BEopt Energy Model

(Ignores solar space heating & heat recovery)

Window Upgrade Payback (2nd best upgrade)

- **1 pane to 2 pane: 45 years**
- **1 pane to 3 pane: 55 years**
- **(18% increase for 23% utility savings: $1,631 vs.1,320)**
- **2 pane to 3 pane: 293 years!!!**

The Shell Is What Will Be with Us Longest!!!

Clean the Grid w/Efficiency!!!