DEEP ENERGY RETROFITS: CALIFORNIA CASE STUDIES
LBNL Deep Energy Retrofit Monitoring

- Goal 1: Demonstrate feasibility of deep savings
- Goal 2: Guidance on best approaches
- 10 single-family homes aiming at 70% or more energy savings
- Detailed end-use energy monitoring & diagnostics
- 1 year minimum monitoring period
- All retrofits carried out by owners
P1 Retrofit Description

1904 Craftsman Bungalow
Berkeley, CA

Pre: 960ft²  ➔  Post: 1,630ft²

- The existing home was un-insulated with one natural gas floor heater on the 2nd level
- The house was lifted, and the ground floor was rebuilt to legal height
- The retrofit was guided by the European Passive House design principles
- 4 bedroom, 2 bath, 4 occupants, home office
**Walls:** Blown cellulose 2X6 downstairs, and 2X4 plus 2” exterior XPS upstairs

**Floor:** Stem wall with 2” exterior XPS, Slab with 3” polyiso on top.

**Ceiling:** 10” cellulose in attic floor, 3.5” polyiso in attic rafters

**Windows:** New aluminum clad ext. wood int. U-0.35, SHGC 0.32, VT 0.54
P1 Retrofit Description

Envelope Leakage: Aggressive air sealing to 1.1 ACH@50pa

Ventilation: Balanced mechanical ventilation with ERV
**Heating:** Electric baseboard heaters

**DHW:** Tankless gas water heater

**Appliances:** All new Energy Star appliances

**Lighting:** 100% CFL
P1 Retrofit Achievements

- Conditioned entire home, greatly improving comfort
- Doubled usable space
- Addition of home office
- Addition of 2 teenage occupants
- Aesthetic improvements
- Pioneered Passive House retrofit techniques in the Bay Area
- Significant energy reductions
P1 Monthly Energy Use
Pre- and Post-Retrofit Comparison

- **October**: 14.9% Reduction
- **November**: 6.6% Reduction
- **December**: 37.8% Reduction
- **January**: 23.6% Reduction
- **February**: 33.6% Reduction
P1 – What’s Working

- Low electrical baseload
- Affordable, robust heating system
- Relatively low heating use, passive house strategies appear to be working
- Low energy lifestyle with high occupancy
1936 English Tudor Revival-Style Home
Palo Alto, CA

Pre: 2,780ft²    Post: 2,780ft²

- The existing home was considered architecturally significant, and efforts were made throughout the project to maintain its historical character.

- 5 bedroom, 3 bath, variable occupancy, home office
P2 Retrofit Description

**Walls:** 2 x 4 walls with dense packed cellulose (~R13)

**Floor:** 6.5” open cell spray foam under sub-floor (~R24)

**Ceiling:** 6.5” open cell spray foam between rafters, unvented (~R24)

**Windows:** Interior double pane storm windows to preserve historic single pane units
P2 Retrofit Description

**Envelope Leakage:** 2144 cfm @ 50 Pascal; ~5.8 ACH50

**Ventilation:** Air Handlers with integrated HRV, bath and kitchen exhaust fans
**Heating and Cooling:** 2 air handlers with hot and cold water coils, Integrated HRV, air to water heatpump-replaced 1/21/11 by an improved air to water heat pump

**DHW:** First combisystem system wasn’t meeting demand, temporary electric tank was installed, now re-integrated with heat pump.

**Lighting:** CFL, Halogen and LED

**Appliances:** All new Energy Star appliances

**Renewables:** 4.3kW PV
P2 Retrofit Achievements

- Conditioned entire home, adding cooling
- Maintained historical character
- No expansion of building footprint
- Major energy improvements have been realized resulting from a commissioning effort

![Graph showing kWh per Month with HDD values]

- Dec-10: 389 HDD
- Jan-11: 456 HDD
- Heat Pump replacement occurred mid-January
- Feb-11: 412 HDD
- Hydronic pump fix
P2 Historical Utility Bill Data

Before Retrofit

After Retrofit

60.9% Annual Reduction!
P2 – What’s Working

- Envelope improvements
- PV
- Significant energy reductions from January’s adjustments to HVAC
P2 Questions and further opportunities

- Plug load issues with A/V and server rack
- Overly complex DHW/Heat Pump system failed
- Envelope air tightness could still be improved
Final Thoughts

- Deep savings are achievable using a variety of current technologies – including Passive Haus retrofit
- Simple approaches are better than complex ones
- Low energy user behavior is essential to success
- Once you reduce heating, cooling and hot water, discretionary energy should be targeted for reduction
- Intervention at retrofit/remodel time is key for achieving deep energy savings