Designing a Low Energy House

lessons learned

5½ light bulbs
Super Low Energy House

Our Big Goal:
Create an extremely low energy house
Beyond Passive House

5½ light bulbs
Super Low Energy House

Two Strategies:

Passive House for saving energy

Solar Thermal for generating energy

5½ light bulbs
Super Low Energy House

Five constraints:

1. **Small 750 sf house**
   Harder to achieve PHPP because of Primary Energy, source energy
   Great environmental choice

5½ light bulbs
Super Low Energy House

Five constraints:

1 Small 750 sf house

2 All volunteers can’t necessarily count on each person can’t fire anyone

5½ light bulbs
Five constraints:

1. Small 750 sf house

2. All volunteers

3. Affordable non-profit
   $800K on these two houses
   Embrace linking green and affordable
   Took huge step here, ground breaking
   Need to keep costs constrained
   Creates long term affordability

5½ light bulbs
### Super Low Energy House

#### Five constraints:

1. **Small 750 sf house**
2. **All volunteers**
3. **Affordable non-profit**
4. **LEED and GPR**
5. **Link PH with green**

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### LEED for Homes Verification, Inspection and Accountability Checklist

**For Homes**

**Builder Name:** TBD  
**Project Team Leader:** ZIA  
**Home Address:** CLAM 2nd Unit

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### Project Description

<table>
<thead>
<tr>
<th>Building type:</th>
<th>Single detached</th>
</tr>
</thead>
<tbody>
<tr>
<td># of bedrooms:</td>
<td>1</td>
</tr>
<tr>
<td>Project type:</td>
<td>Custom</td>
</tr>
<tr>
<td>Floor area:</td>
<td>750</td>
</tr>
</tbody>
</table>

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### Innovation and Design Process (ID)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Calculation</th>
<th>Verification</th>
<th>Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Integrated Project Planning</strong></td>
<td></td>
<td></td>
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<tr>
<td>Preliminary Rating – conduct a preliminary LEED for Homes meeting, with provider participation and key members of the project team. Must confirm – award level target, target credits and parties accountable for meeting each credit.</td>
<td></td>
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<tr>
<td><strong>NOTES:</strong> Calculation None required</td>
<td></td>
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<tr>
<td>Verification Participate in the preliminary LEED for Homes rating, or verify participation by the LEED for Homes Provider.</td>
<td></td>
<td>X X</td>
<td></td>
</tr>
<tr>
<td>Inspection None required</td>
<td></td>
<td></td>
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<tr>
<td><strong>1.2 Integrated Project Team</strong> – Assemble and involve a project team to meet the three criteria: include team members, in addition to the builder and Green Rater, whose capabilities include at least three of the following skill sets: a) architecture, residential building, engineering, building science or performance testing, green building, sustainable design, landscape architecture, land use planning. b) include all project members in various phases of project, and c) conduct regular project meetings.</td>
<td></td>
<td>X X</td>
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</tr>
<tr>
<td><strong>NOTES:</strong> Calculation None required</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verification Present a list of project team members to the Green Rater.</td>
<td></td>
<td>X X</td>
<td></td>
</tr>
<tr>
<td>Verification Present a list of meeting dates or plans for regularly scheduled meetings to the Green Rater.</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Inspection None required</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>1.3 Professional Credentialed with Respect to LEED for Homes</strong> – One principal member of the project must be a LEED for Homes AP.</td>
<td></td>
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</tr>
<tr>
<td><strong>NOTES:</strong> Calculation None required</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verification Identify the Professional Credentialed with respect to LEED for Homes to the Green Rater</td>
<td></td>
<td>X X</td>
<td></td>
</tr>
<tr>
<td>Verification Verify participation of a Professional Credentialed with Respect to LEED for Homes on the project team.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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**5½ light bulbs**
Super Low Energy House

Five constraints:

1. Small 750 sf house
2. All volunteers
3. Affordable non-profit
4. LEED and GPR
5. No builder
   important part of team

5½ light bulbs
SUCCESS !! so far

Passes PHPP (tentative)

545 watts is the amount of energy required to heat the Blue2 House on the coldest day of the year
SUCCESS !! so far

Passes PHPP (tentative)

5.5 light bulbs

94% solar fraction for hot water and space heating
So if the sun was shining last week, then max load may be closer to 0 watts

5½ light bulbs
SUCCESS !! so far

Passes PHPP (tentative)

5.5 light bulbs

96% solar fraction

0.20 ACH50 before insulation and drywall
0.6 is requirement for PH certification.
The Lessons Learned

Architecture process and the PHPP
Designing the details
Integrated solar-mechanical design
Passive House and permits
Passive House and LEED / GPR
Low carbon insulation

5½ light bulbs
Architecture and PHPP

**ISSUES:**

Arch: design as process; general to specific  
PHPP: wants most at start

Arch: materials choices not definitive until built; things change.  
PHPP: wants to know pump specs and size, etc, up front

Arch: know we are meeting target early.  
PHPP: received PHIUS confirmation after foundation and slab and ground insulation installed and fully framed (2010.04.10).

5½ light bulbs
EXAMPLE, SOLAR-MECH:
Solar panel engineer added another panel last month and enlarged storage from 120 gallons to 160 gallons.

We have been changing this since the beginning.

Did not get the mechanical contractor on board until end March

Did not know we needed license until Feb
Architecture and PHPP

SOLUTIONS:

create the team early
architect
structural engineer
mechanical engineer
PH consultant
solar modeling consultant
builder
LEED or GPR consultants
model early

5½ light bulbs
Designing the Details

5½ light bulbs
Designing the Details

first

build the shell complete with all penetrations sealed, insulation, drywall

5½ light bulbs
then add

interior walls and
dropped ceiling and
second roof and
eaves

5½ light bulbs
then add interior finishes

5½ light bulbs
Completely insulated slab with no thermal bridge to footing and soil.

Advanced framing for more insulation less thermal bridges

Insulation layer for thermal break

Sill seal

Termite barriers

Radon vent

Designing the Details

5½ light bulbs
Designing the Details

air sealed at two planes.

eave rafters do not penetrate air seal, provide thermal break

blocking at penetrations for gluing

5½ light bulbs
Designing the Details

air sealed at two planes

air seal wraps ridge beam

blocking at joints for gluing

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DETAIL DESIGN ISSUES:

- not certain if we are passed PHPP before we started construction
- permit issues
- insulation changes
- no WUFI analysis
- green issues

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DESIGN and CONSTRUCTION ISSUES:

details changing as we go

costs changes required to be minimal

certain costs not included in bid (ie radon)

other architect
SOLUTIONS:

create the team early
   architect
   structural engineer
   mechanical engineer
   PH consultant
   solar modeling consultant
   builder
   LEED or GPR consultants
model early

5½ light bulbs
Integrated solar-mechanical design

5½ light bulbs
5½ light bulbs
CONCEPT:
Have high Primary Energy Demand.

Reduce PE with solar thermal as main energy load is hot water.

If have the system, then cost effective to add more panels and tank to heat space.

Problem is night and winter.

Graham Irwin
70% of life-cycle costs are committed before first 1% of costs are spent.

Model early
Design as if energy matters
Integrated design

5½ light bulbs
Integrated solar-mechanical system

**Daily Maximum Collector Temperature**

Chose drainback because we over-designed for summer.

Most manufacturers push glycol systems not drainback.
They can’t have overheating.

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Most solar thermals sold for DHW only.

Solar modeling is generally for DHW not space heating.

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Problem integrating PHPP modeling with solar thermal modeling.

PHPP relies on outside modeling for space heating.

Need accurate solar-thermal modeling that includes space heating and includes PHPP data.

Need accurate solar incidence and climate data.

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SOLAR OPTIONS EXPLORED:
glycol systems
drain-back into main heat tank
drain-back into small DB tank
SOLAR OPTIONS EXPLORED:
- small supplemental water heat tank
- on-demand water heater
- duct element
- stratifying tank with element on top

5½ light bulbs
SOLAR OPTIONS EXPLORED:
- wall radiators to deliver heat to space vs duct heat exchanger
- vs duct heat exchange in secondary loop

Integrated solar-mechanical system

CLAM 2 HOUSE
PROPOSED SOLAR THERMAL AND MECHANICAL SYSTEM
CONCEPT 6

Solar thermal panels

Solar storage tank

DHW tank

Heat recovery ventilator

P1

P2

ER1

ER2

Cold water supply

Hot water to house

Pre-heated supply water to DHW

Electric resistance backup DHW heater at top of tank; size?

Backflow preventer

Air filter

Air filter
CLAM 2 HOUSE
PROPOSED SOLAR THERMAL AND MECHANICAL SYSTEM
CONCEPT 7 DRAINBACK

SOLAR THERMAL PANELS

HEAT RECOVERY VENTILATOR
air filter

SOLAR STORAGE TANK

DRAINBACK TANK

DHW TANK

pre-heated supply water to DHW

backflow preventer

cold water supply

hot water to house

ER1 electric resistance backup DHW heater at top of tank; size?

OR

SOLAR STORAGE IS A STRATIFYING TANK AND HAS THE DHW INTEGRATED INTO IT

SOLAR OPTIONS EXPLORED:
different modeling software

5½ light bulbs
CLAM 2 HOUSE
PROPOSED SOLAR THERMAL AND MECHANICAL SYSTEM
CONCEPT 8 drainback

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My preferred solar-thermal design

SOLAR THERMAL PANELS

SP1
SP2
SP3

SP4: solar insolation panel

P1: drainback water pump

T1: SOLAR DRAINBACK TANK
10 gallon

T2: DHW TANK stratifying, with elect heater
120 gallon potable water

T1

from fan coil

to fan coil

P2: fan coil water pump

mixer valve

ON-DEMAND WATER HEATER electric

hot water to house

100 deg

90-180 deg

50-180 deg

50-180 deg

50 deg

cold water supply

DC

1

5½ light bulbs
Integrated solar-mechanical system

Final solar-thermal design

P1: drainback water pump

T1: SOLAR DRAINBACK TANK 10 gallon

T2: SOLAR STORAGE w/ HEATER TANK 80 gallon

to and from fan coil 120-180 deg

cold water supply

to house 100 deg mixer valve

SP1 SP2 SP3 SP4

SP4: solar insolation panel

P2: fan coil water pump

T3: SOLAR STORAGE w/ HEATER TANK 80 gallon

hot water

5½ light bulbs
5½ light bulbs

MECH OPTIONS EXPLORED:
Zhender

Ultimate Air RecoupAerator
has integrated heat exchange
has integrated electric element duct
simplifies controls
simplifies sizing
pumps already defined
SOLUTIONS:

Find/use mechanical engineer you trust needs to use PHPP energy modeling, not theirs. Needs to understand low flow and low energy needs. Needs to be able to model the solar or use data of solar firm that can solar firm needs to be able to input monthly space heat demands from PHPP.
LEED and GPR

5½ light bulbs
ADDITIONAL GREEN ELEMENTS:

All FSC framing and sheathing

OVE (advanced) framing

No tropical hardwoods that aren’t FSC
LEED and GPR

ADDITIONAL GREEN ELEMENTS:

Fly ash replacement in concrete (saved 2.2 tons CO2)

Radon elimination

Recycled content

No or low VOC adhesives and materials.

5½ light bulbs
ADDITIONAL GREEN ELEMENTS:

Structured plumbing with circulation pump to ensure that 1/2 cup max water at each faucet before hot appears

Gray water ready

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LEED and GPR

ISSUES:

radon tube changes

termite shielding changes
LEED and GPR

ISSUES:

insulation
  blown-in wet
  blown-in dry and QII
  behind fabric
  behind drywall
  can we use IR?

County
GPR
LEED
SOLUTIONS:

Set up Green meetings regularly

Convey green issues in plans so contractor certain to see and understand

Bring other decision makers in along way
Passive House and permitting

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ISSUES:

Framing
Roof insulation
Foundation insulation
Passive House and Permitting

**ISSUES:**

Title 24 Energy Calcs

Blue2 is 46% better than T24 model.

Broken

Prescriptive not specific goals.

Easy to circumvent.

Cannot be changed

Considering “major” change:

eliminate AC in coastal are

---

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Passive House and Permitting

ISSUES:

Ventilation of bathrooms and kitchen using E/HRV.

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Passive House and Permitting

ISSUES:

Air admittance valves

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Passive House and Permitting

ISSUES:

licensed mechanical system designers
licensed mechanical contractor
licensed plumbing contractor
licensed solar installer

or

licensed mechanical engineer

Solar System with Combination Tank

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Insulation and CO2

5½ light bulbs
ISSUES:

The CFCH propellants for some rigid foams have huge GHG implications.

GOALS:

not use CFCH propellant foams
not use petroleum based foams
WANTED TO USE:

Cellulose, as much as possible

Roxul as exterior thermal break

Foamglas under slab

Only cellulose in roof framing
Insulation and CO2

WHAT WE USED:

- EPS under slab
- Cellulose in walls and roof
- XPS as exterior thermal break
- Polyisocyanurate above roof

5½ light bulbs
LESSONS LEARNED

5½ light bulbs
Lessons learned

SOLUTIONS:

create the team early
architect
structural engineer
mechanical engineer
PH consultant
solar modeling consultant
builder
LEED or GPR consultants
model early

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BE AN ADVOCATE

5½ light bulbs
Carbon footprint reductions

www.noprop16.org

Voting ‘no’ allows competition

Prop. 16 just a power grab by PG&E

Plugging in a monopoly

No Rate Hikes
No Monopoly
No Prop 16

5½ light bulbs
james bill
licensed architect
LEED AP

zero impact architecture

integrating beauty with the science of deep sustainability

james@ZIArchitecture.com
415.785.4874

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