Zero-Net-Energy (ZNE) Home Design Basics

The case for all-electric Homes & Communities

Jennifer Love, Beyond Efficiency, Berkeley, CA

Dietmar Lorenz, dsa architects, Berkeley, CA

Sean Armstrong, Redwood Energy, Arcata, CA

Carmel Passive House,
Carmel Building & Design + Justin Pauley Designs

REBUILD GREEN EXPO

Santa Rosa
Veteran's Memorial Building
February 23, 2018
Dining Room 11am & 2:30pm

ZERO-NET-ENERGY (ZNE) HOME DESIGN BASICS THE CASE FOR ALL-ELECTRIC HOMES & COMMUNITIES

Beyond Efficiency

Jennifer Love
jen@beyondefficiency.us
415.236.1333x3

What IS "zero energy"?
Why is it the goal?

ZNE

emissions

all-electric

energy costs

site energy

source energy

Zero net energy

renewables offsets

time-of-use

PROJECT BOUNDARY

TIME BOUNDARY

Beyond Efficiency

ZNE – By Force or Finesse?

Source: Jennifer Love

Source: costofsolar.com

Beyond Efficiency
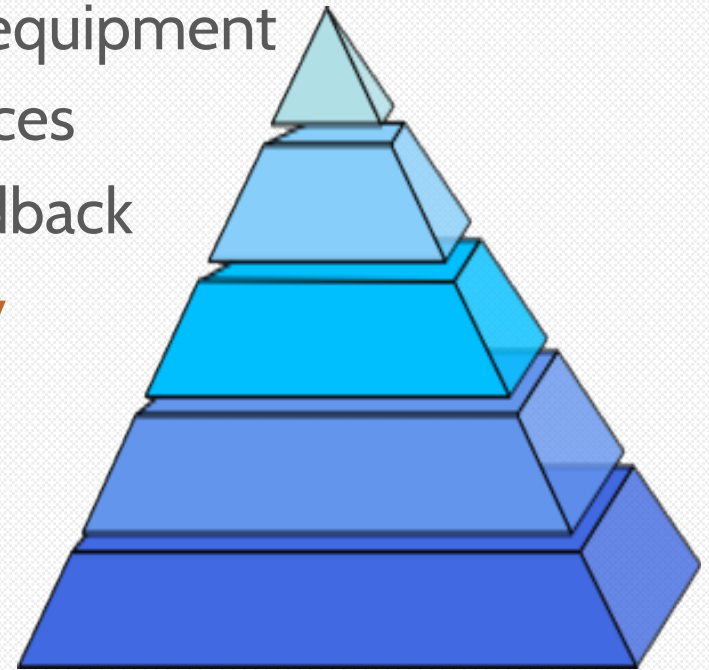
Zero-net energy logic

- **1. Minimize** energy demand
  - Heating
  - Cooling (try to eliminate)
- **2. Optimize** energy use
  - High-efficiency HVAC and DHW equipment
  - Energy-efficient lighting + appliances
  - Controls, monitoring, habits + feedback
- **3. Offset** with renewable energy

"Minimize-Optimize- Offset"

Beyond Efficiency

What is heating *demand?*

Heat Losses — **Heat Gains** =

| Ventilation | HEATING DEMAND |
Roof + Floor	
Air Leakage	Internal Gains: Hot Water, Lighting, Cooking, Plug Loads, Breathing!
Windows + Walls	Solar Radiation

Beyond Efficiency

Envelope Design

- Compact, efficient shapes
- Lots of insulation
- Minimized thermal bridging
- Properly placed & shaded windows in moderation
- High-performance windows & doors
- Very good air tightness detailing

Beyond Efficiency
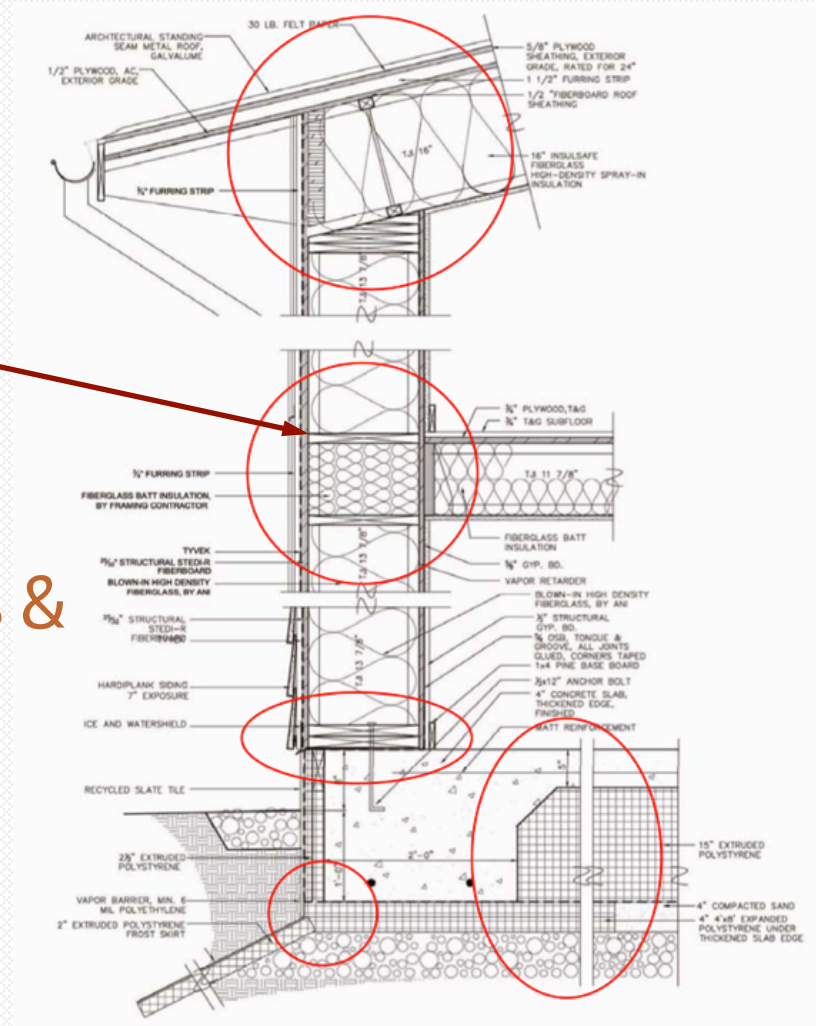
"Lots" of Insulation

Coastal California:
R-23 whole assembly
1.5" rigid cork insulation
fully-adhered water-resistive barrier (WRB)
plywood sheathing
2x6 wood framing w/ cellulose insulation
drywall

Beyond Efficiency
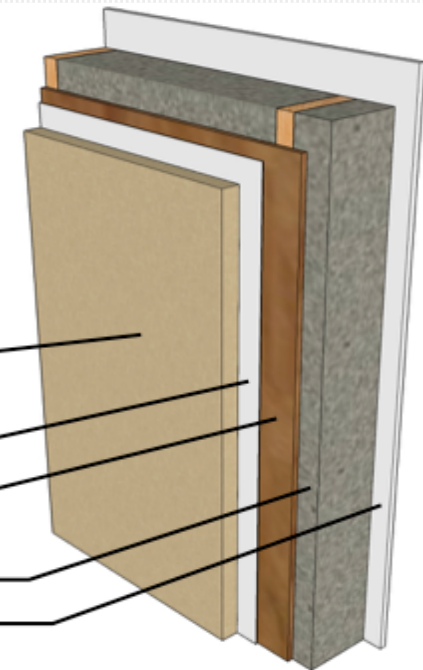
# Work WITH nature not against it

- Optimize shape & orientation
  - Passive solar gain & shading
  - Orient longer side along east-west axis
- Window configuration – control solar radiation
  - Majority of glazing on south
  - Less glazing on north
  - *Thoughtful* glazing on
    east & west
  - Thermal mass?
- Night flushing- nature's AC

Oikos

Beyond Efficiency
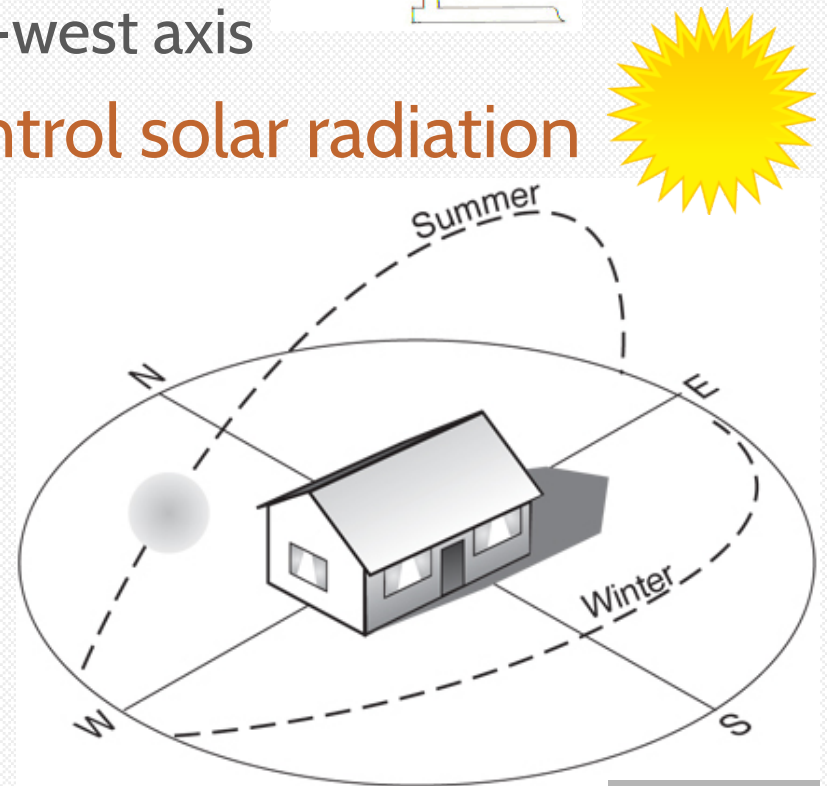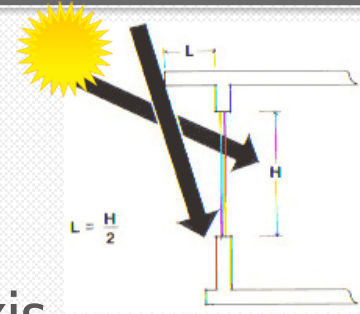
Build Tight and Ventilate Right
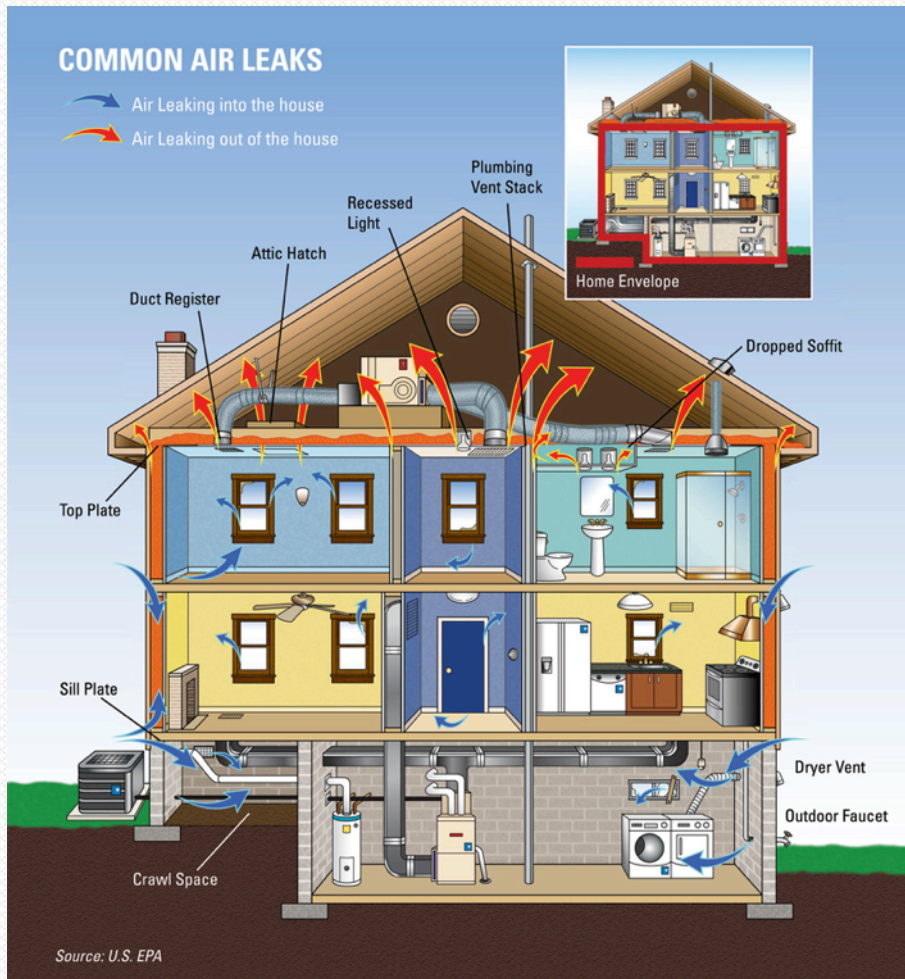
- Seal it up <1 ACH$_{50}$
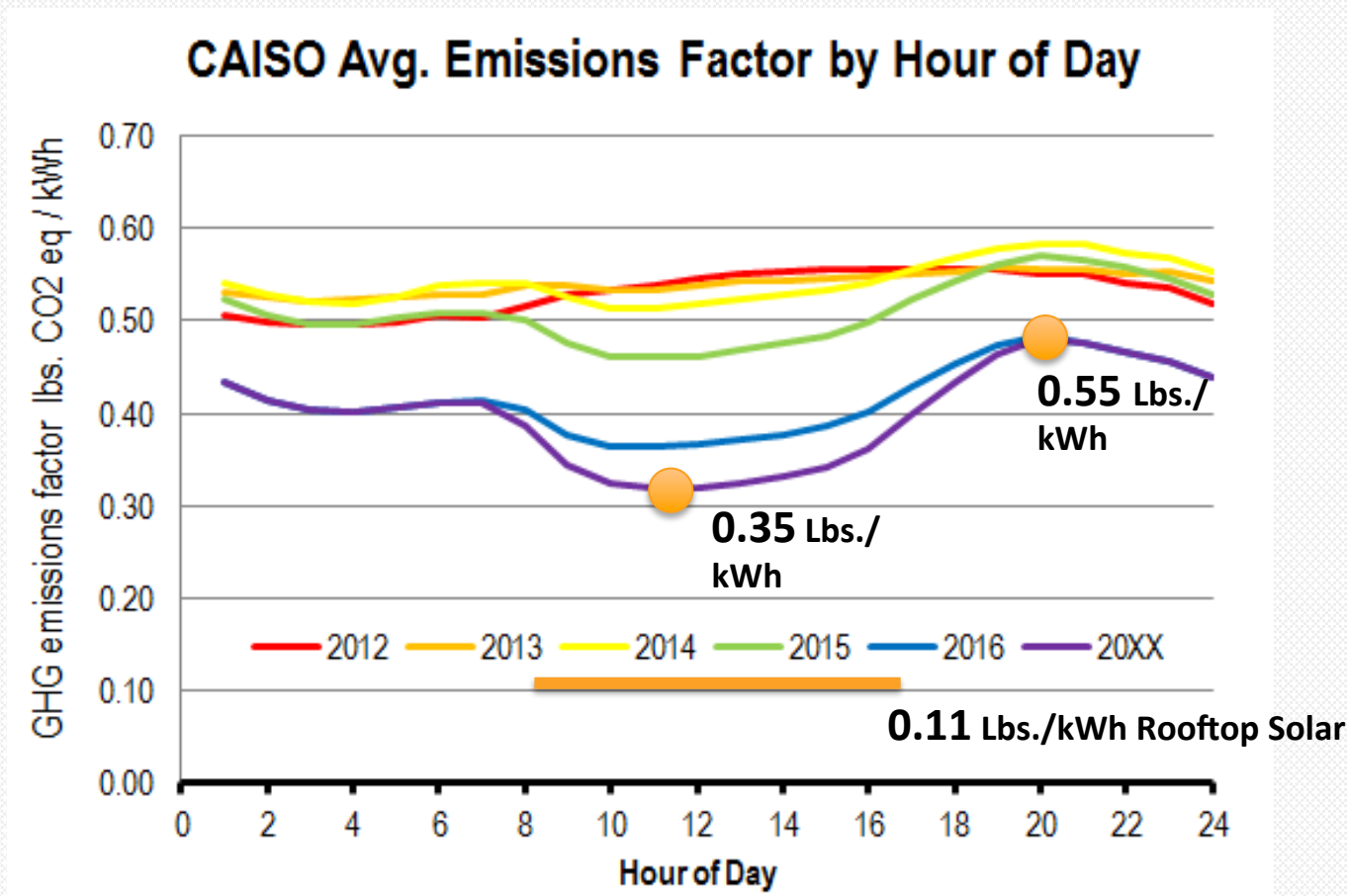- Supply filtered fresh air

Beyond Efficiency
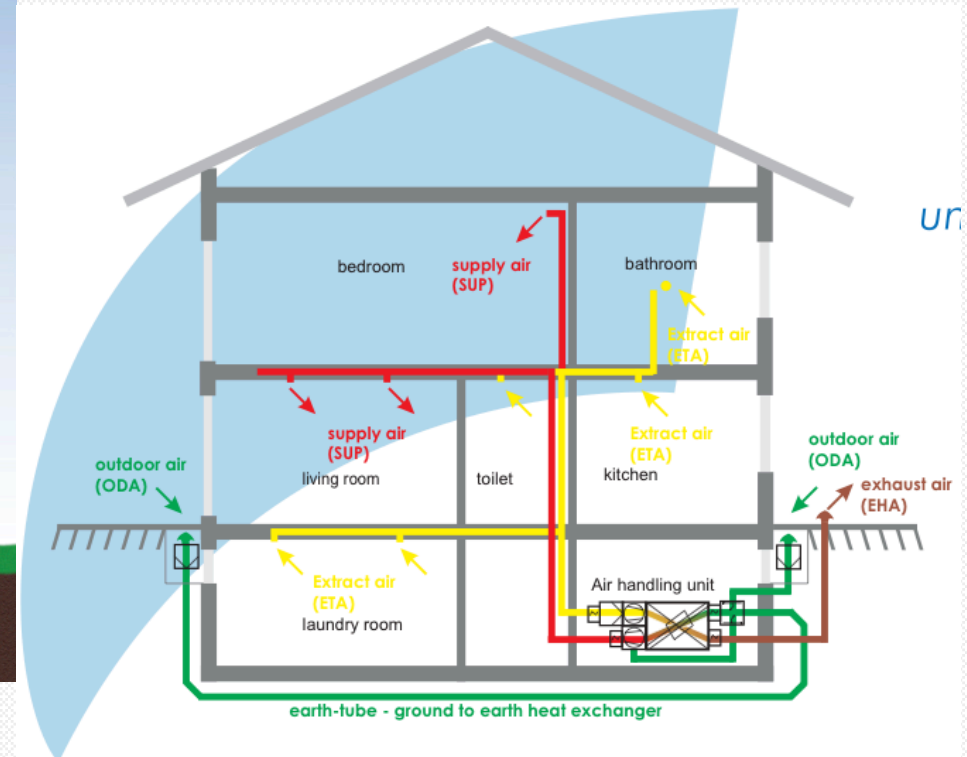
Minimization Results

- CA-Code Built Home – Heating and Cooling Loads
  - Apartments, 6 BTU/hr.ft^2 (~1.8 W/ft^2)
  - Single-family, 9 BTU/hr.ft^2 (~2.6 W/ft^2)
  - Remodeled house, 12 BTU/hr.ft^2 (~3.5 W/ft^2)
- Eliminate/minimize cooling
  - Good Design
  - Exterior and Site Shading
  - Night flushing & Ceiling fans
  - Behavior – close the drapes
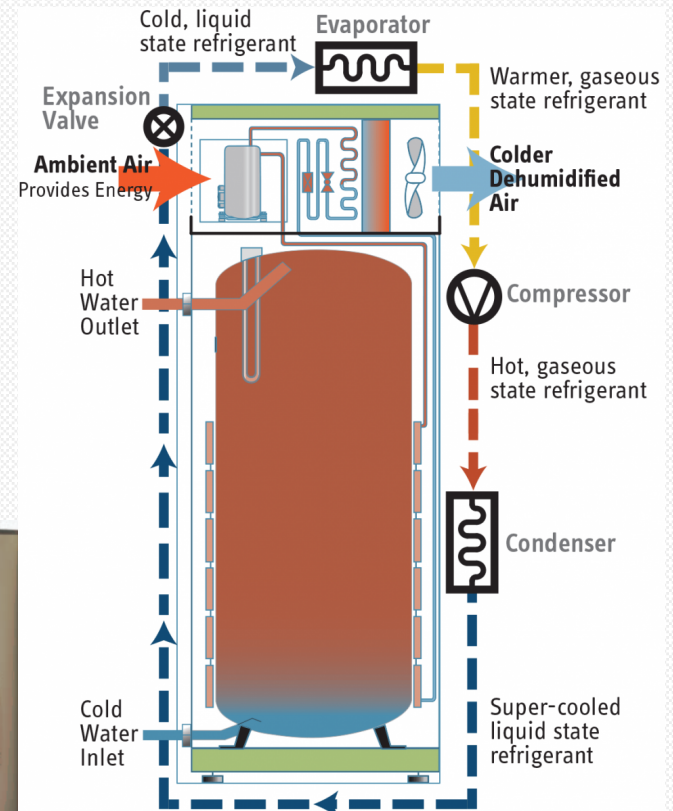
Time to OPTIMIZE with ELECTRICITY!!!

Beyond Efficiency

California Grid Getting Cleaner

CAISO Avg. Emissions Factor by Hour of Day

0.55 Lbs./ kWh

0.35 Lbs./ kWh

0.11 Lbs./kWh Rooftop Solar

Heat Pumps for HVAC and DHW

Heat Pump Water Heaters

- Lower GHG emissions
- Cost competitive: install and operation
- HP continue to increase in efficiency, Gas has no where to go.

MiniSplit Heat Pump

Cold, liquid state refrigerant

Evaporator

Warmer, gaseous state refrigerant

Expansion Valve

Ambient Air Provides Energy

Colder Dehumidified Air

Hot Water Outlet

Compressor

Hot, gaseous state refrigerant

Condenser

Cold Water Inlet

Super-cooled liquid state refrigerant

Stiebel- Accelera

Mitsubishi

Sanden – ECO$_2$

Beyond Efficiency

Optimize: Electric Appliances

Whirlpool – Heat Pump Dryer

HEAT PUMP   CONDENSED WATER

Samsung – Induction Cooktop

Heat & Glo Gas Fireplace

Beyond Efficiency

The Duck Curve Caveat

Shift Electricity Use to Midday

- Lots of thermal energy for DHW and space cooling/heating
- Run heat pumps at midday – "charge" home's thermal battery
- Distributed and Utility Renewables = cleanest electricity

California Independent System Operator Duck Curve[1]