A + B = Zero

Zen and the Art of Zero Energy Design

Allen Gilliland
Allen@OneSkyHomes.com
Produce what you use
1. Mobile = Short-Term focus
2. Low Price vs. Quality/Durability
3. History of cheap, abundant energy
Ignorant and illiterate:

- Energy
- Building Science
- Building Performance
Building Practices

“Form ever follows function.”

Louis Sullivan, 1896
Building Practices

• Large Scale production home building dominates

• Cost over durability = poor craftsmanship

• Ignorance of building science = routine failures

• Disconnected to natural world ... e.g. ignore sun

• Unnecessary architectural complexity
UGLY, MARGINAL
Complexity of form

- 40 roofs x 12.5k kWh
- 0.5 mWh/yr lost power
- 1M roofs x 12.5k kWh
- 12.5 gWh/yr lost power
- 15 - 500 MW power plants
Lost Production Potential:

4,000sf x 25 kWh/sf/yr = 100,000 kWh
1 MWh/yr opportunity loss
Context for Reform: Culture, Knowledge, Building Practices… challenging!
Produce what you use

Key concepts …
ENERGY

• Think
• Conserve
• Optimize
• Model
• Produce
1. Think Energy

- **State of Mind**

- **Physics**: laws, thermal, solar, radiant, etc.

- **Climate**: insolation, HDD, CDD, humidity…

- **Loads**: heating, cooling, hot water, lighting…

- **Vocabulary**: UOMs, metrics, concepts…

- **Production**: PV, solar thermal, wind, …

- **More** …source, distribution, storage, tariff
2. Conserve Energy

Existing 3,000sf Home

40,000 kWh/yr

Optimized Passive House/ZE Design

12,000 kWh/yr

CONSERVED ENERGY

28,000

(60-70%)

Equipment

HVAC

20,000

LIGHTS/ PLUGS

2,000

HOT WATER/ COOKING

8,000

(65% Gas in CA)
3. Optimize (natural) Energy

Passive House “Energy Balance”

\[ (Q_S + Q_I) - (Q_T + Q_V) = Q_H \]
In God we trust, everyone else bring good data.

Danny Parker
Florida Solar Energy Center

Measure and verify!
5. Produce Energy

Profound impact on architectural design... orientation, shape, **roofs**, ...
ENERGY

- Think
- Conserve
- Optimize
- Model
- Produce
2. Conserve Energy

Follow the conservation potential:

1. HVAC
   - Building Envelope (PH)
   - Shading!
   - Mechanical Systems

2. Water Heating
   - Heat Pump
   - Solar Thermal

3. Lighting
   - LEDs & simple controls

4. Appliances / Electronics
   - Energy Star
(Q_S + Q_I) - (Q_T + Q_V) = Q_H

GAINS

- Occupants
- Lighting
- Electronics
- Appliances
- Mechanicals
- HW storage

LOSSES

- Insulation
- Thermal Bridging
- Windows/Doors
  - Glass U-val
  - Frames
  - Install
- Air Sealing
- HRV
Roof design for Production

❖ Simple, unobstructed planes
❖ 1sf = 15w; 25 kWh/yr (SF area)
❖ Target Min. 500sf for SFD

❖ Don’t forget transportation energy!
Production: Summary Load Metrics

SFD: 11,000 kWh/yr

- HVAC: 2,400
- Hot Water: 2,400
- Lighting: 1,200
- Appliance/Electric: 5,000

Total: 11,000 kWh/yr
Passive House Hair Dryer Home
Produced 116% of house demand.
Cooling: 15 kWh/day

23.5 °C Set Point

= ≈ 2300 kWh/yr

Heating: 20 kWh/day

22 °C Set Point

1200 kWh/yr

May - October

Dec - Feb

10 kWh/day – heating/cooling

= < $2/day

(2 outdoor, 4 indoor units)
Sunnyvale Marine Climate Deep Retrofit

A. German and A. Siddiqui, Alliance for Residential Building Innovation (ARBI)

June, 2014
Sunnyvale PH Retrofit: HVAC Energy

Bath heaters - 350 kWh
HRV - 166 kWh
Air Circ. - 128 kWh (0.35 kWh/day, 9%)

Annual HVAC Demand

Total HVAC Energy = 4 kWh /day, $18/mo.
Produce energy

- Think
- Conserve
- Optimize
- Model
- Produce

Real World – challenging!
Produce what you use

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