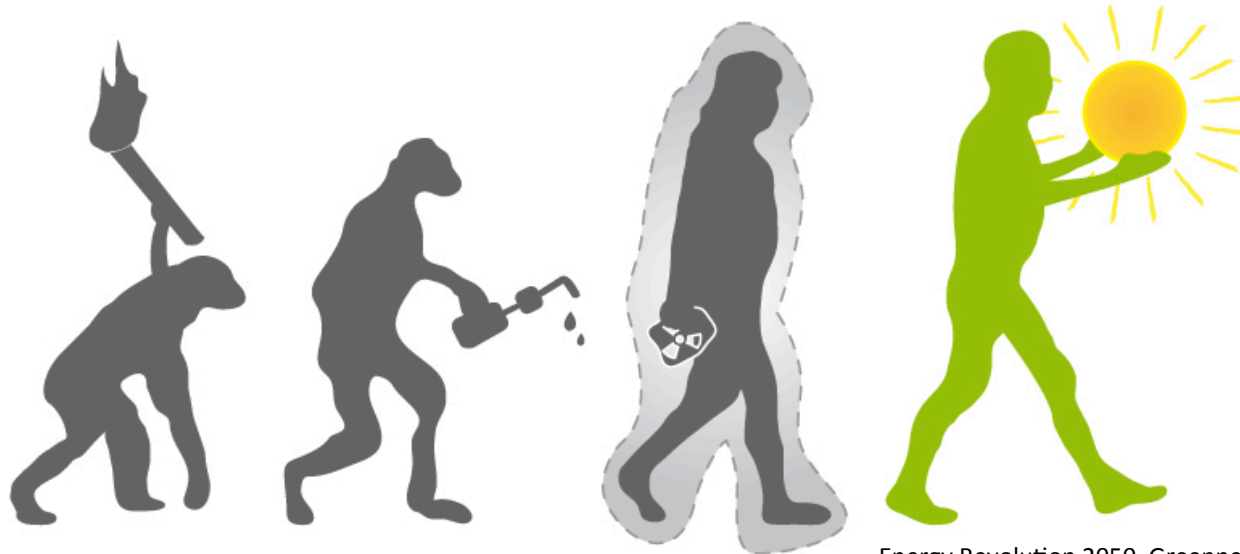


Getting Real About Renewables

Passive House & The Future of Energy



- Energy Revolution 2050, Greenpeace

11th Annual North American Passive House Conference

Philadelphia, PA September 23, 2016

Graham Irwin

Principal, Essential Habitat Architecture

www.essentialhabitat.com

ESSENTIAL
HABITAT
ARCHITECTURE



Conversation with a 4 Year Old

(Returning home to a dark house)

Luke: Why's it so dark in here?

Daddy: Because it's a waste of power to have the lights on when you don't need them.

Luke: Why don't we just get solar on the roof?

Daddy: It would still be a waste of power to have the lights on when you don't need them.

Luke: But it's from the sun!

Daddy: Not at night.

Luke: Oh, that's a problem.



Grid = “~~Big Battery?~~” Fuel Cell”



Yes

- Renewables offset fossil fuels
- Current grid economics support this view

No

- “Storage” is unused fuel (except ~7% hydro)
- No “back feed” from distribution upward

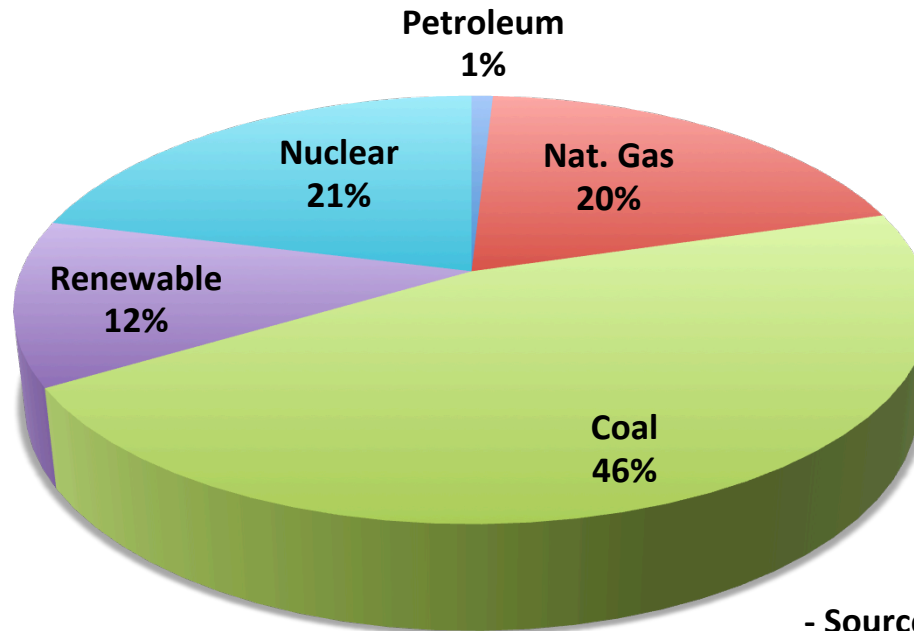


How Much “Storage?”

101 of 115 Trillion kWh in 2011



US Electrical Grid Source Energy (2011)



- Source: US EIA

**It's not just a fuel change plus batteries,
a renewable grid requires a new way of thinking.**

Think About Power, Not Energy!

kW

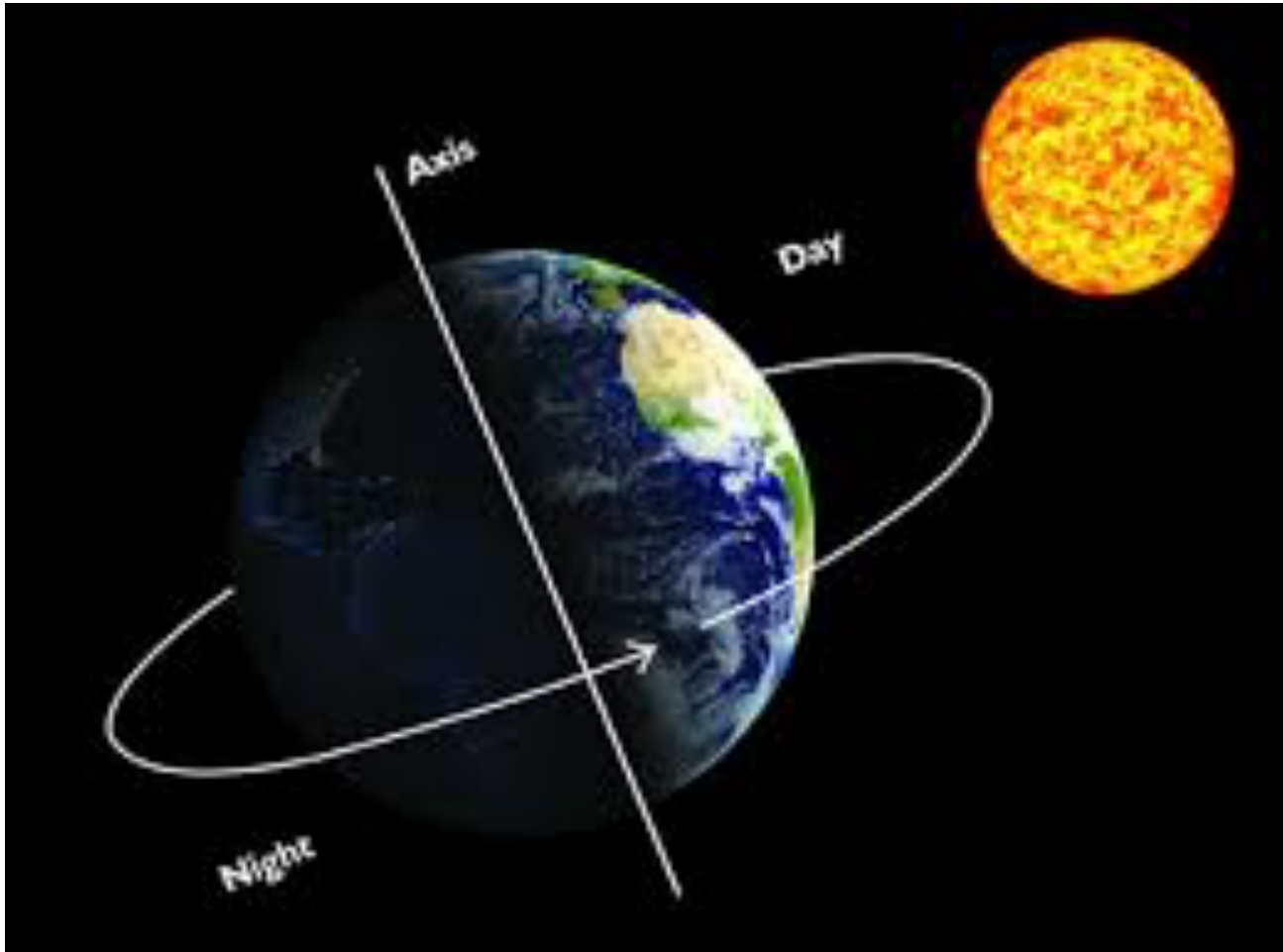
Understand The Challenges

Recognize The Opportunities

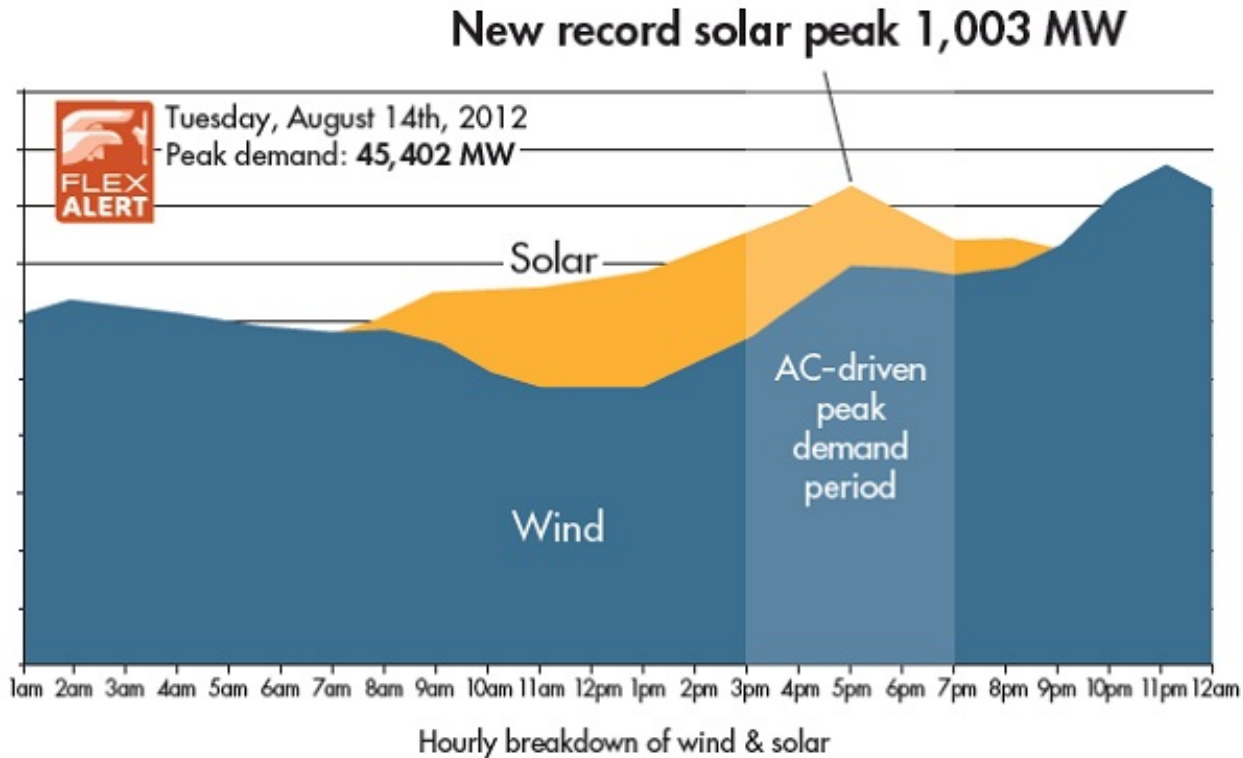
Challenges



1st Challenge – No Sun At Night



Solar's a Near Miss!



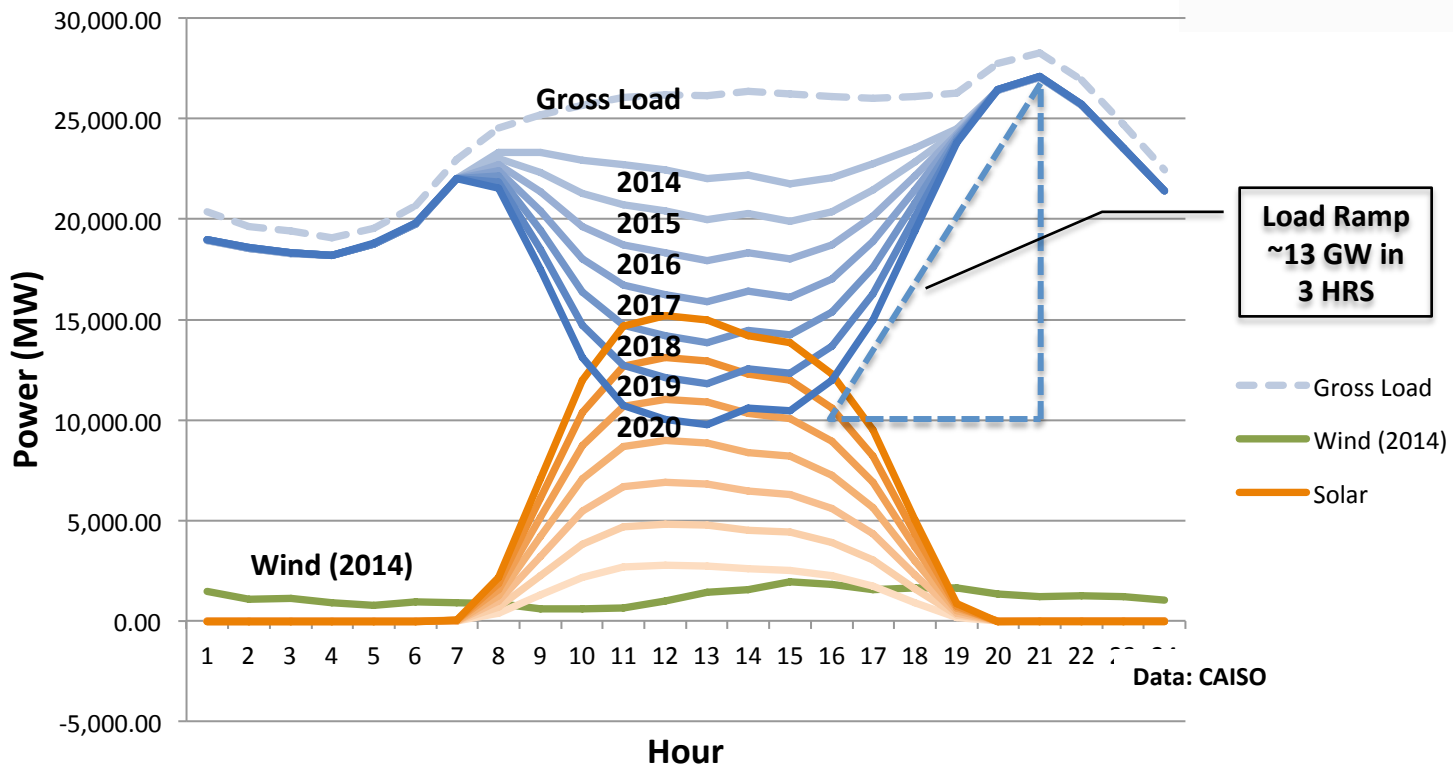
Source: CAISO

The “Duck Curve”

Solar Only, No Demand Reduction



California Grid Load (March 31)



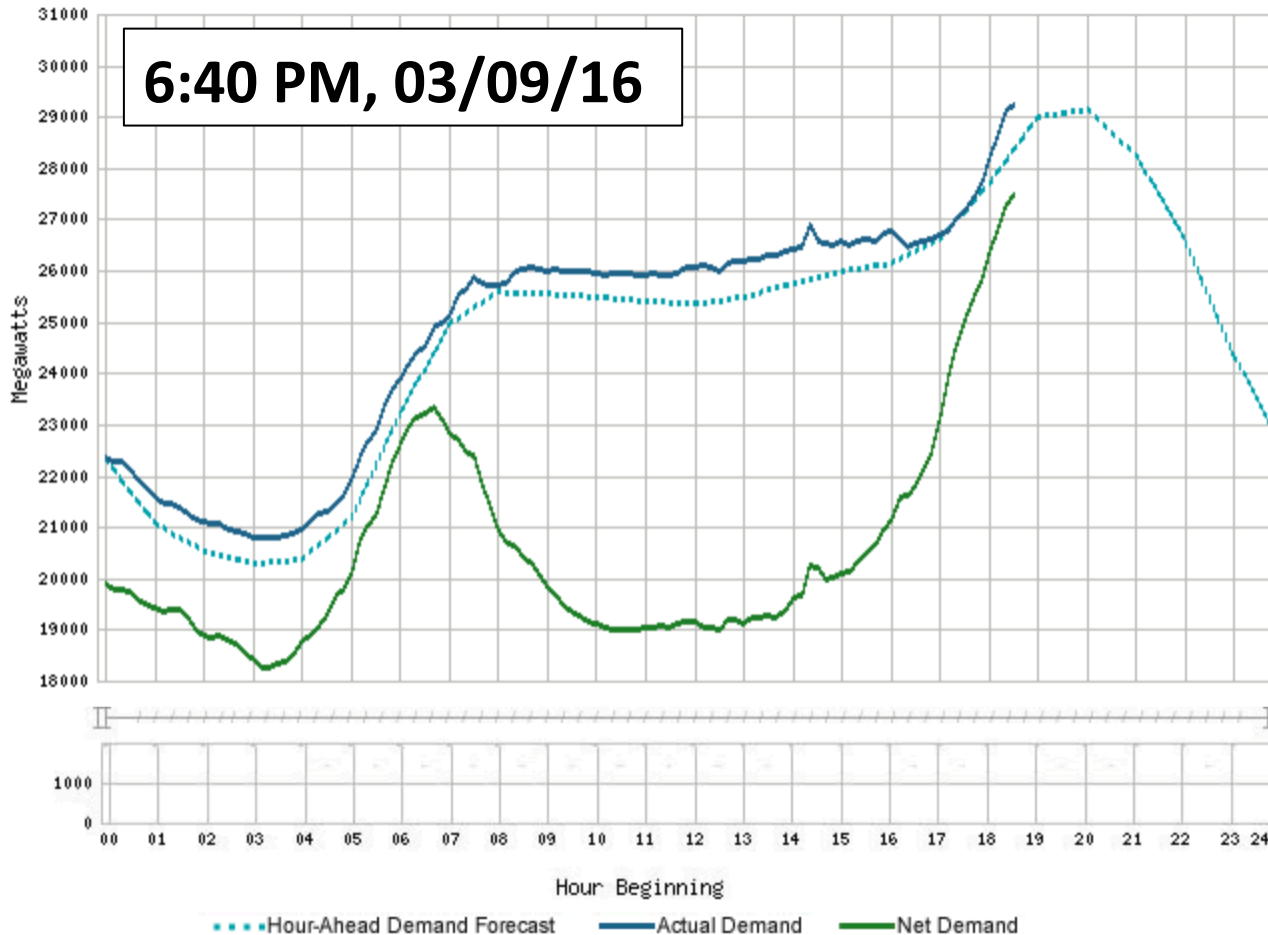
Energy: $13 \text{ GW} \times 3 \text{ hrs} / 2 = 19,500,000 \text{ kWh} / 10 \text{ kWh} / 70\% = 2,790,000 \text{ Tesla } 10 \text{ kW Powerwalls}$

Power: $13 \text{ GW} / 2 \text{ kW} = 6,500,000 \text{ Tesla } 10 \text{ kW Powerwalls}$

California: 12% Renewable in 2014, 33% by 2030, 50% Renewable by 2050

The “Duck” Curve

It is Happening NOW! – Tom Kabat



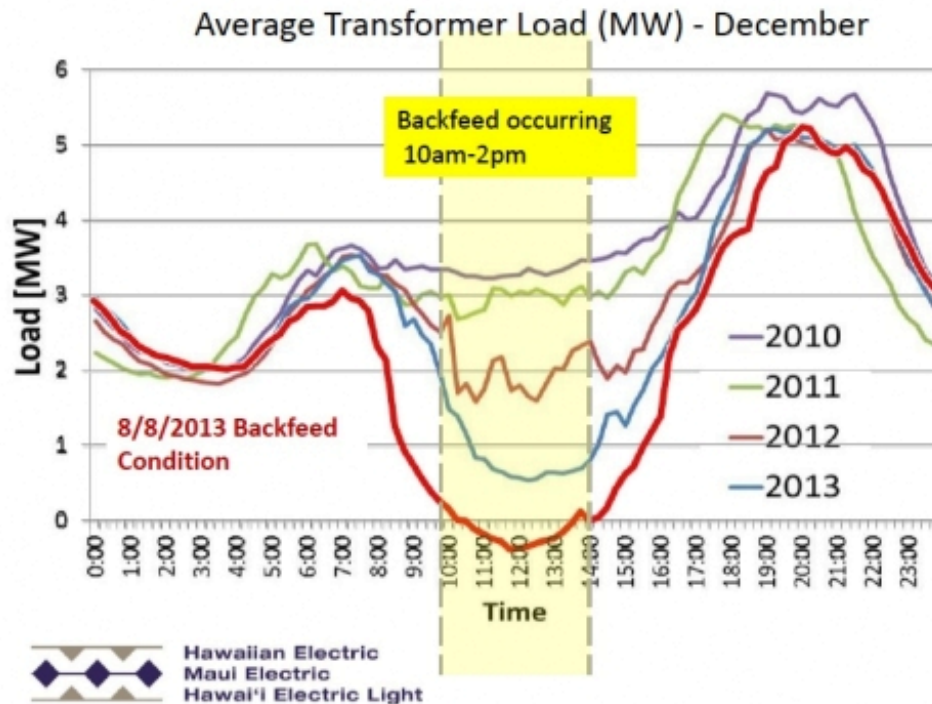
www.caiso.com/outlook/SystemStatus.html or “ISO Today” Smartphone App

The “Nessie” Curve

Overloading at the Distribution Level



Tracking Change – 46kV Level



- instituteforenergyresearch.org/solar-energys-duck-curve/

Hawaii: Backfed with 11% Rooftop PV (15-18% overall); 100% Renewable by 2045

The “Ente” Curve

Negative Wholesale Electrical Prices



EPEXSPOTAUCTION



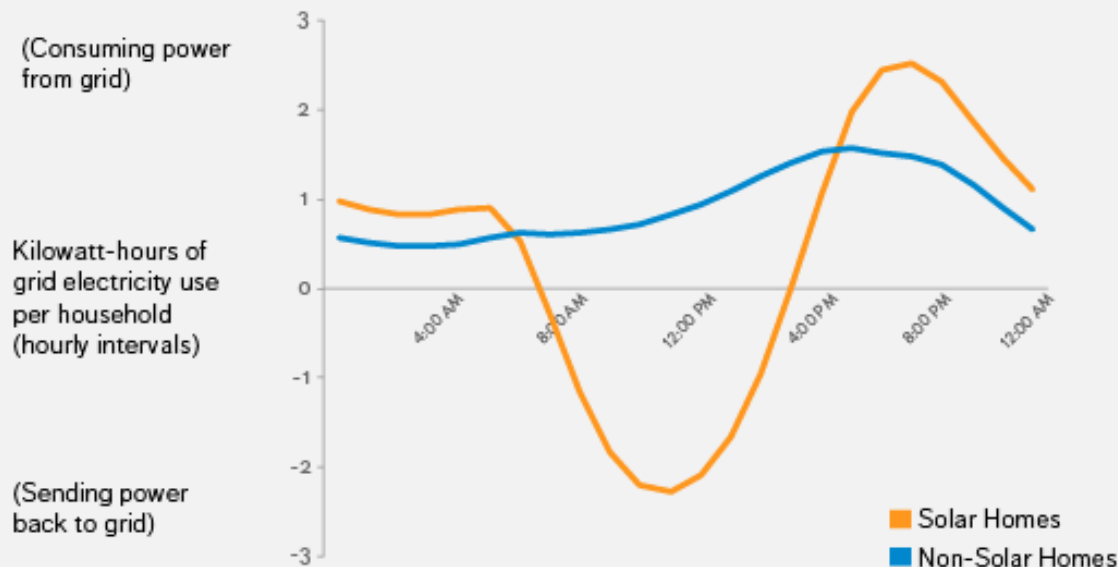
- energytransition.de/2014/05/german-power-prices-negative-over-weekend/

Germany: Negative Prices with 27% Renewable in 2014; 80% Renewable by 2050

Net Zero: Who Benefits? & What Behavior is Encouraged?



Hourly grid electric use on a hot day in the west:
Solar Homes versus Non-Solar Homes



n= 25,171 solar homes and 1,183,555 non-solar homes in the western US on a hot spring day (May 14, 2014). OPOWER 2014

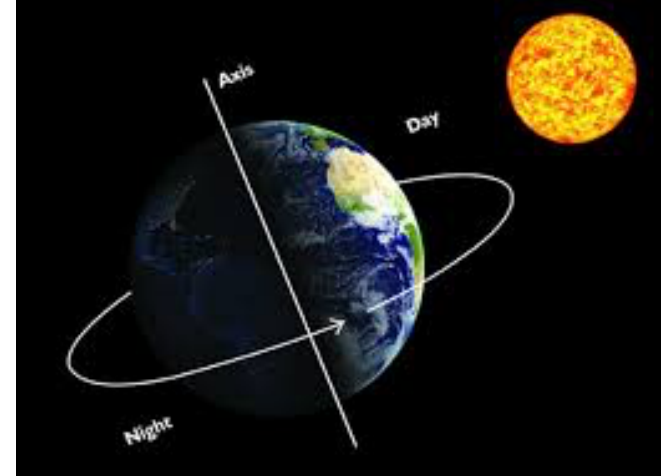
<https://blog.opower.com/2014/12/solar-homes-utilities-love/>

So What About Storage?

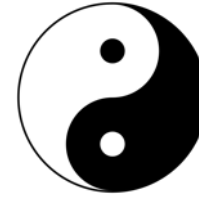


Daily Storage

- **Pumped Hydro**
- **Concentrated Solar Plants (CSP)**
- **Solar Thermal (Small Tank)**
- **Interruptible Tariff/Direct Load Control**
- **Dynamic Demand Appliances**
- **Smart Inverters (Curtailement & Correction)**
- **Batteries**
- **Passive House**

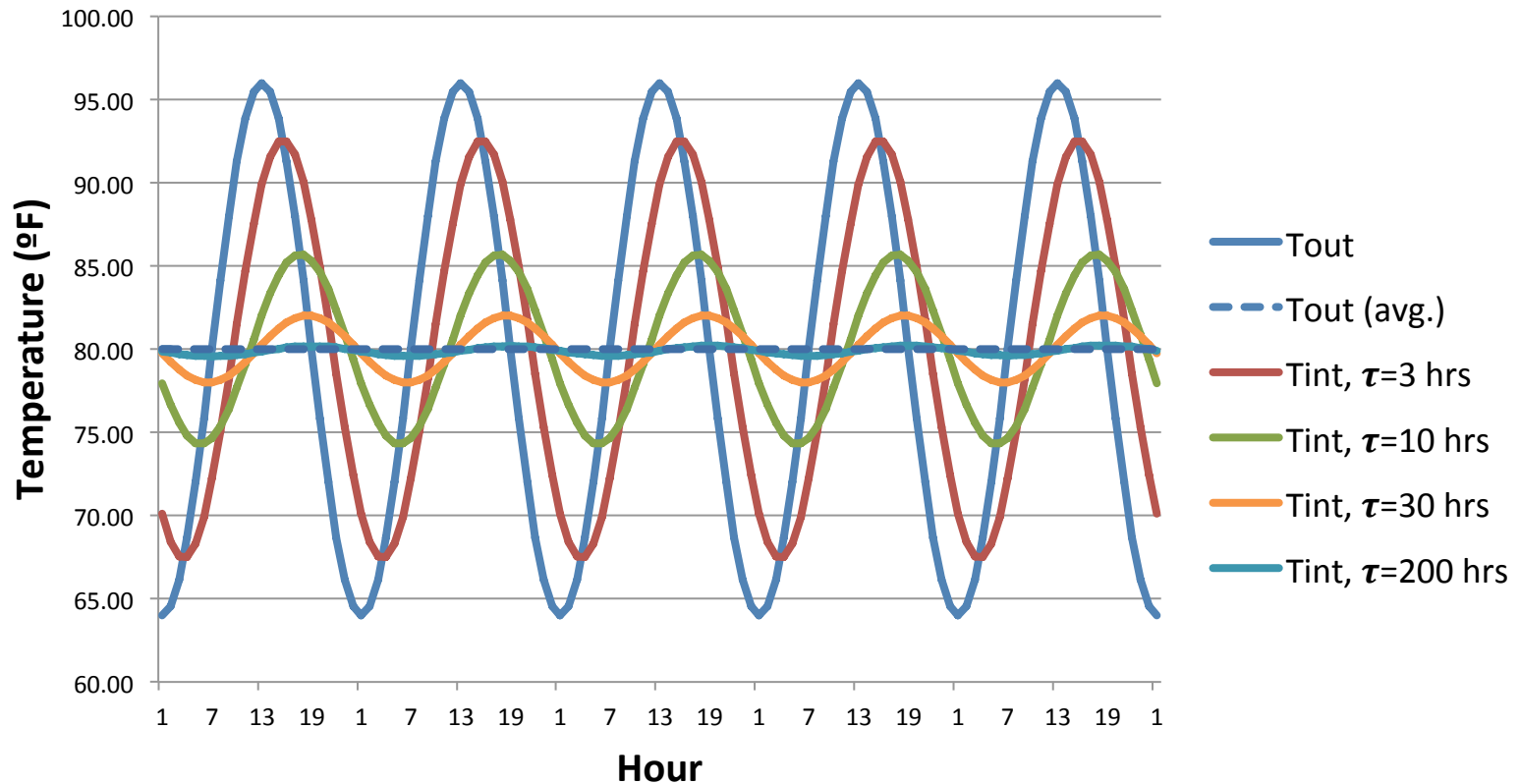


The Dao of Tau



萄 of τ

Unheated Building vs. τ (Philadelphia, PA, July)



- Time Constant (τ) = Thermal Mass (Wh/K)/Conductance (W/K)
- τ + solar & int. gains + air changes = “reaction speed” of building to ΔT .
- Passive House: $\tau = 5-30+$ days (120-720+ hrs.) - *Heating load in Passive Houses*, Passipedia

Proof in Practice:

a Passive House in a heat wave.



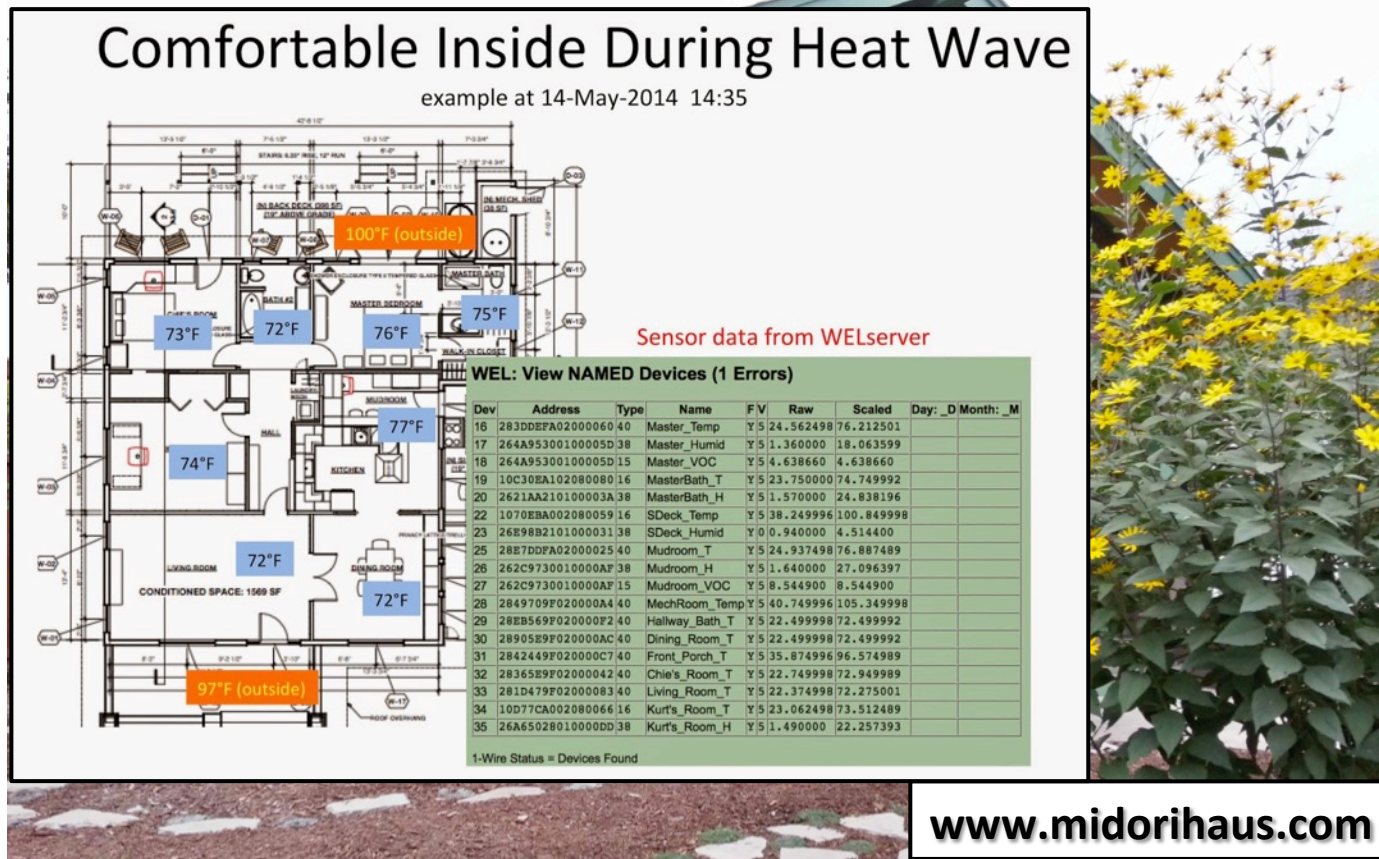
www.midorihaus.com

Midori Haus, Santa Cruz, CA

Summer Comfort without Air Conditioning!

Proof in Practice:

a Passive House in a heat wave.



Midori Haus, Santa Cruz, CA

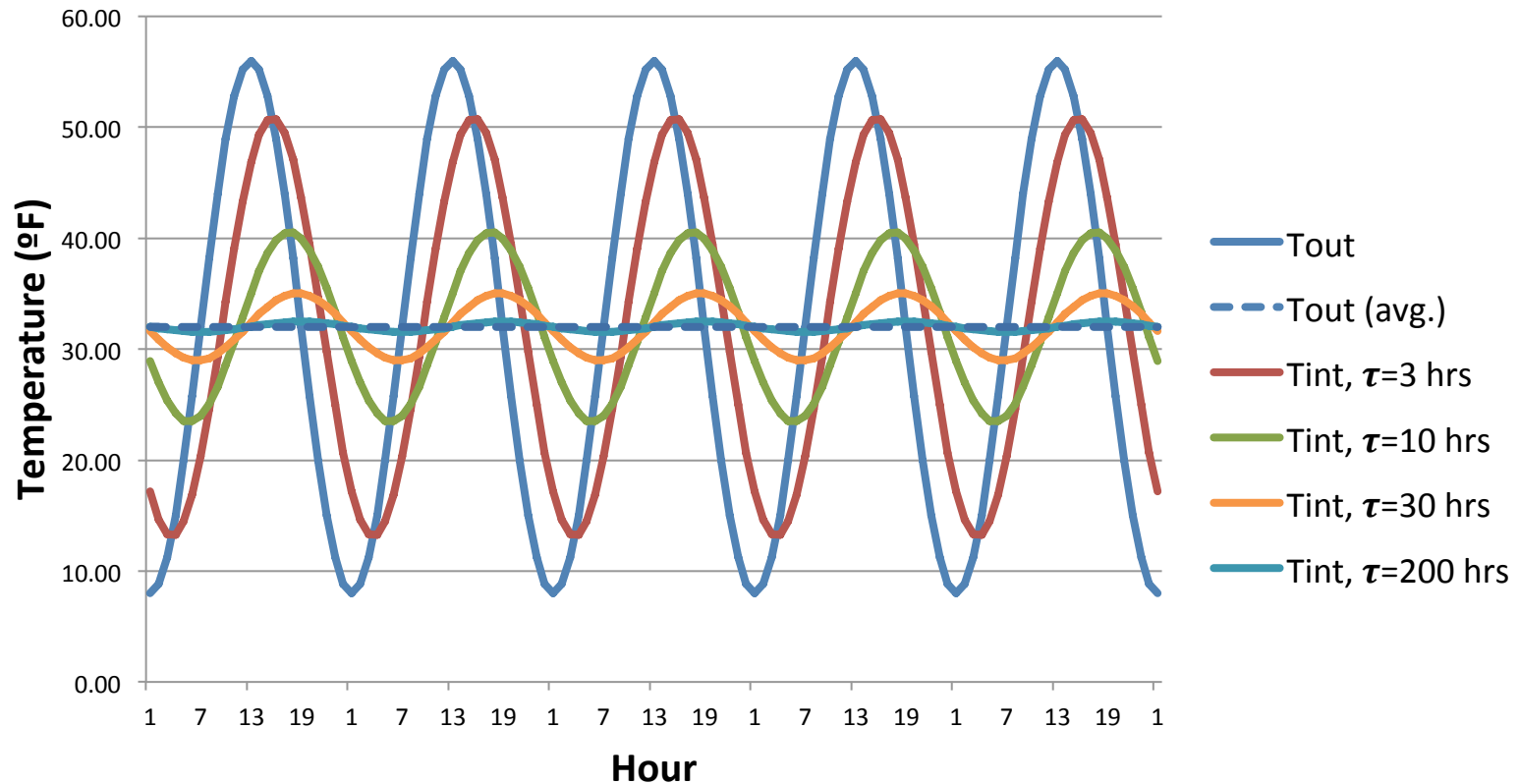
Summer Comfort without Air Conditioning!

The Dao of Tau



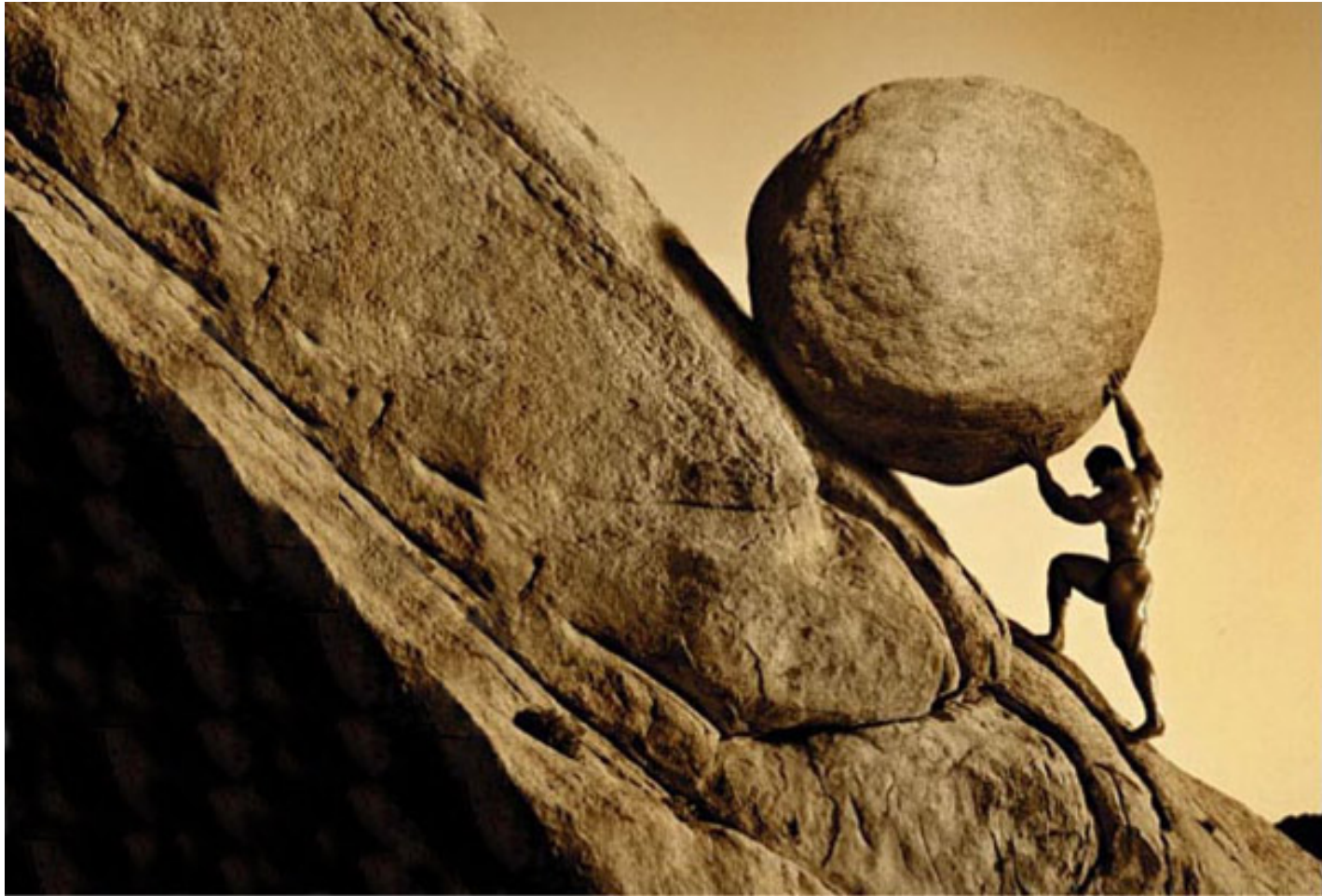
萄 of τ

Unheated Building vs. τ (Philadelphia, PA, January)

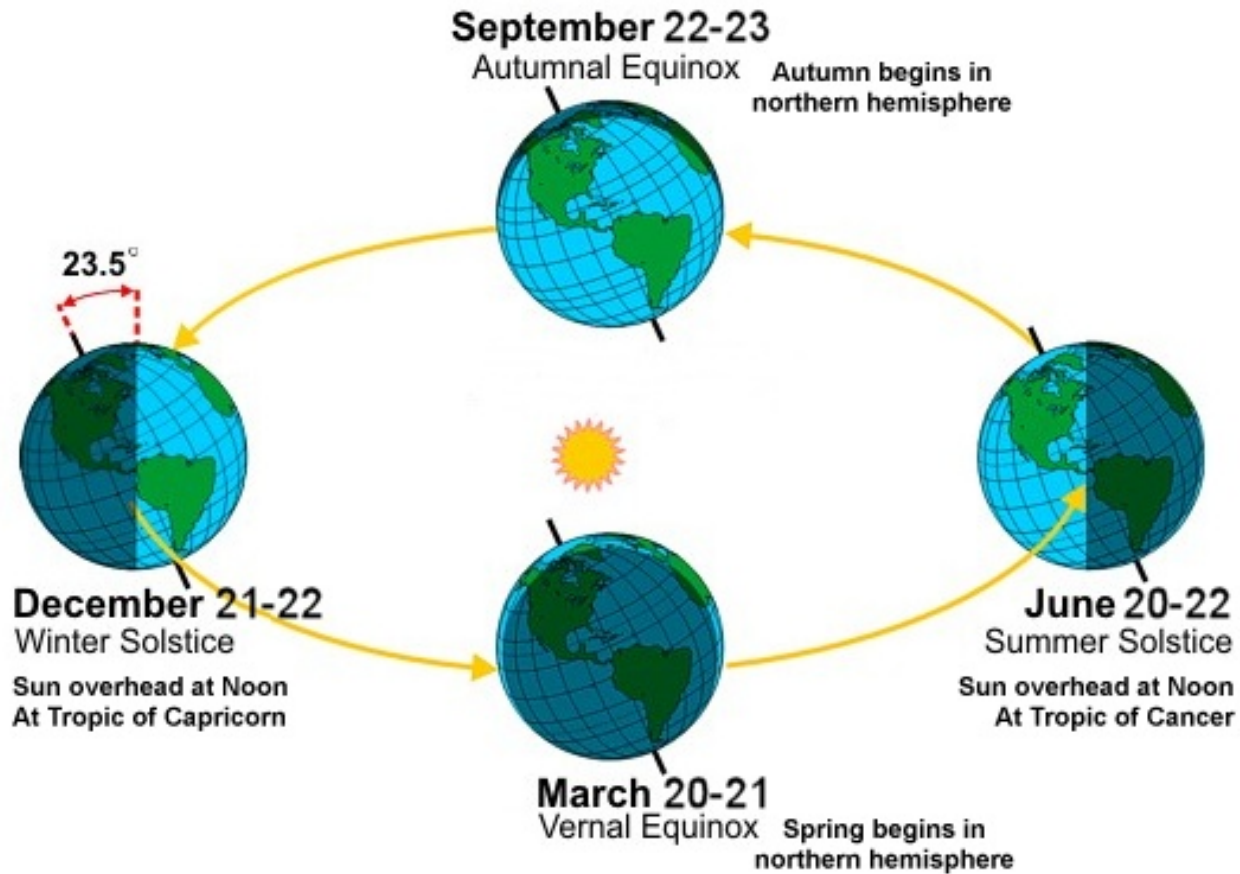


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Now for the Hard Part...



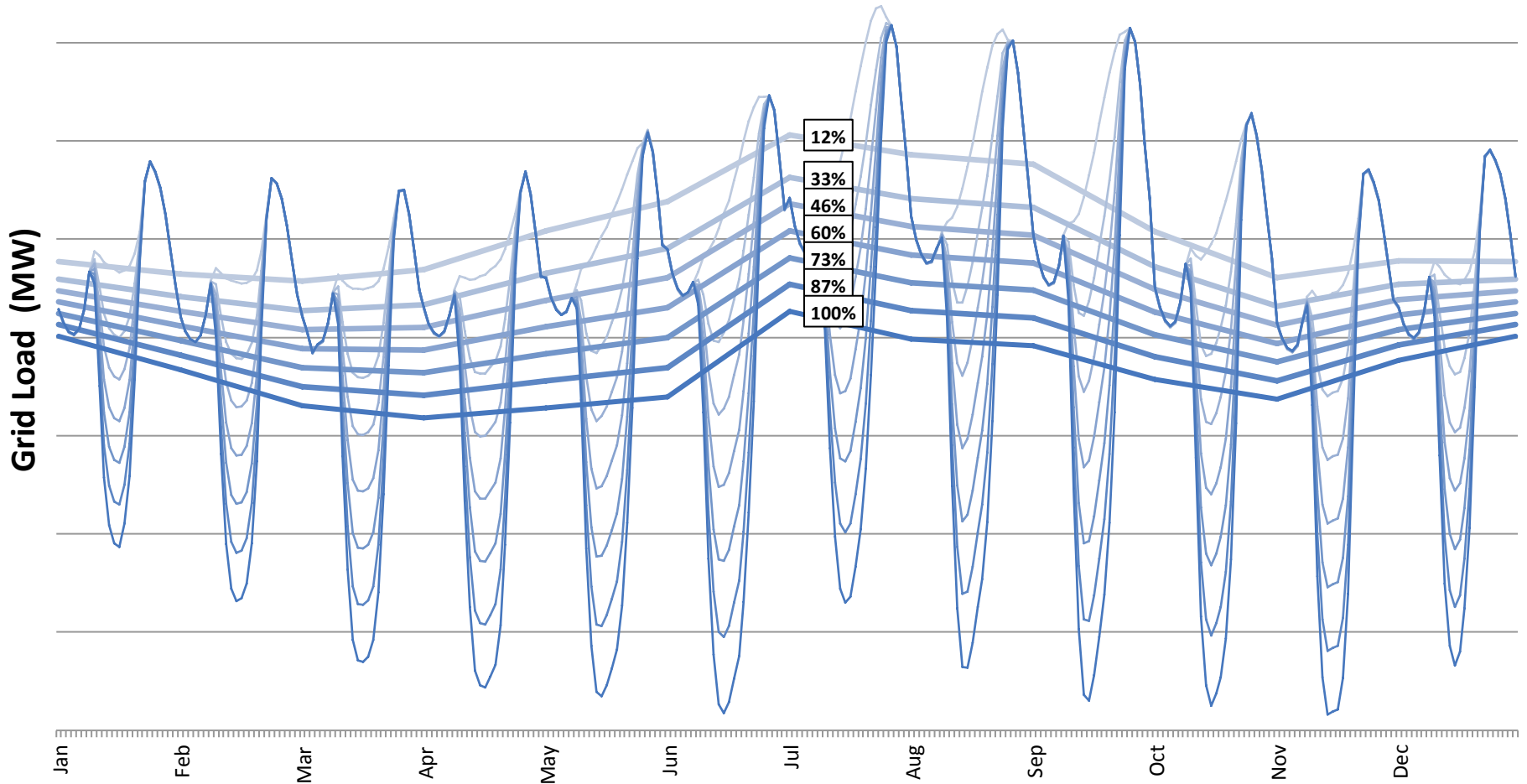
2nd Challenge – Long Nights in Winter



Monthly CA Grid Load



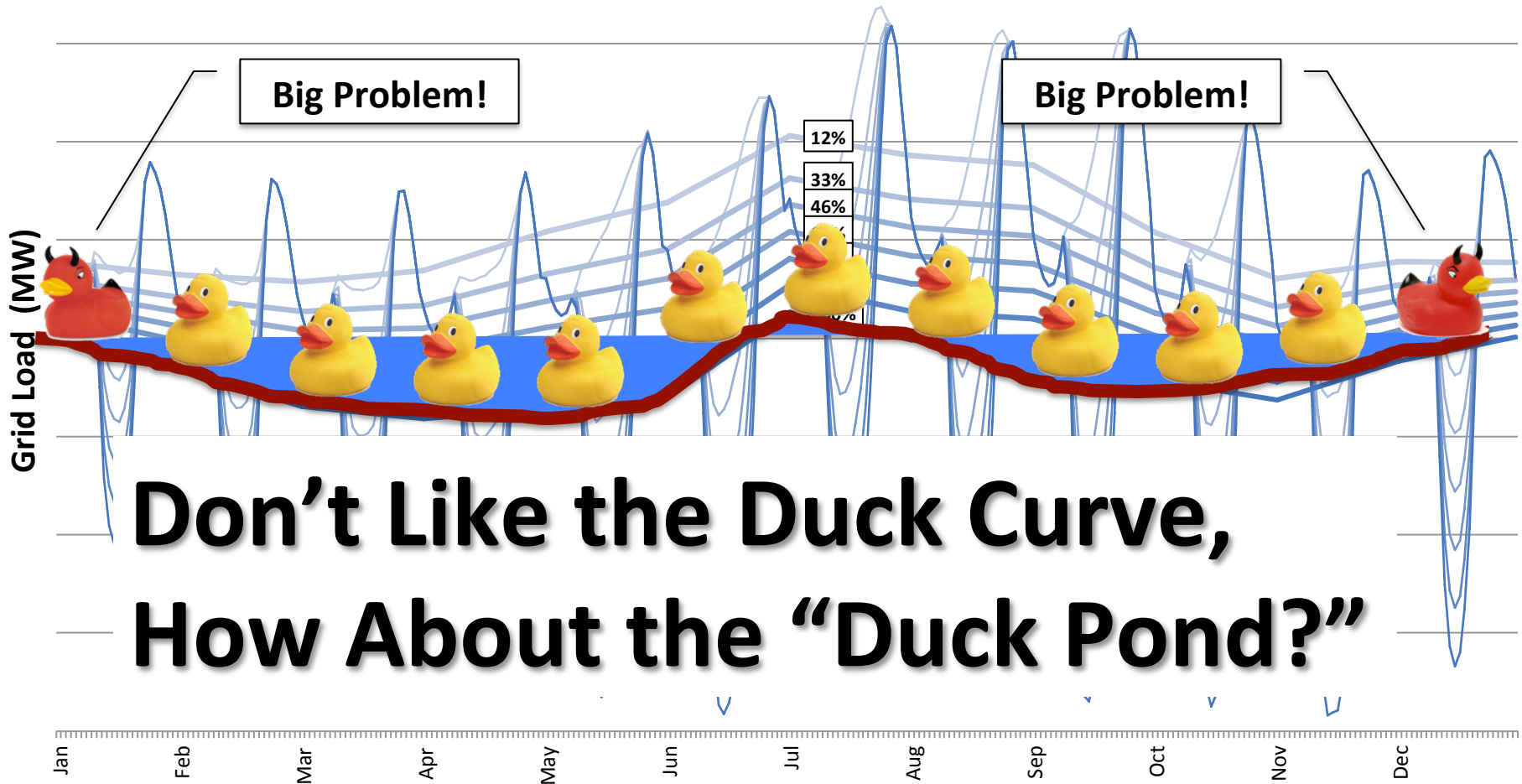
Typical Daily Grid Load vs. % Solar Energy



Monthly CA Grid Load



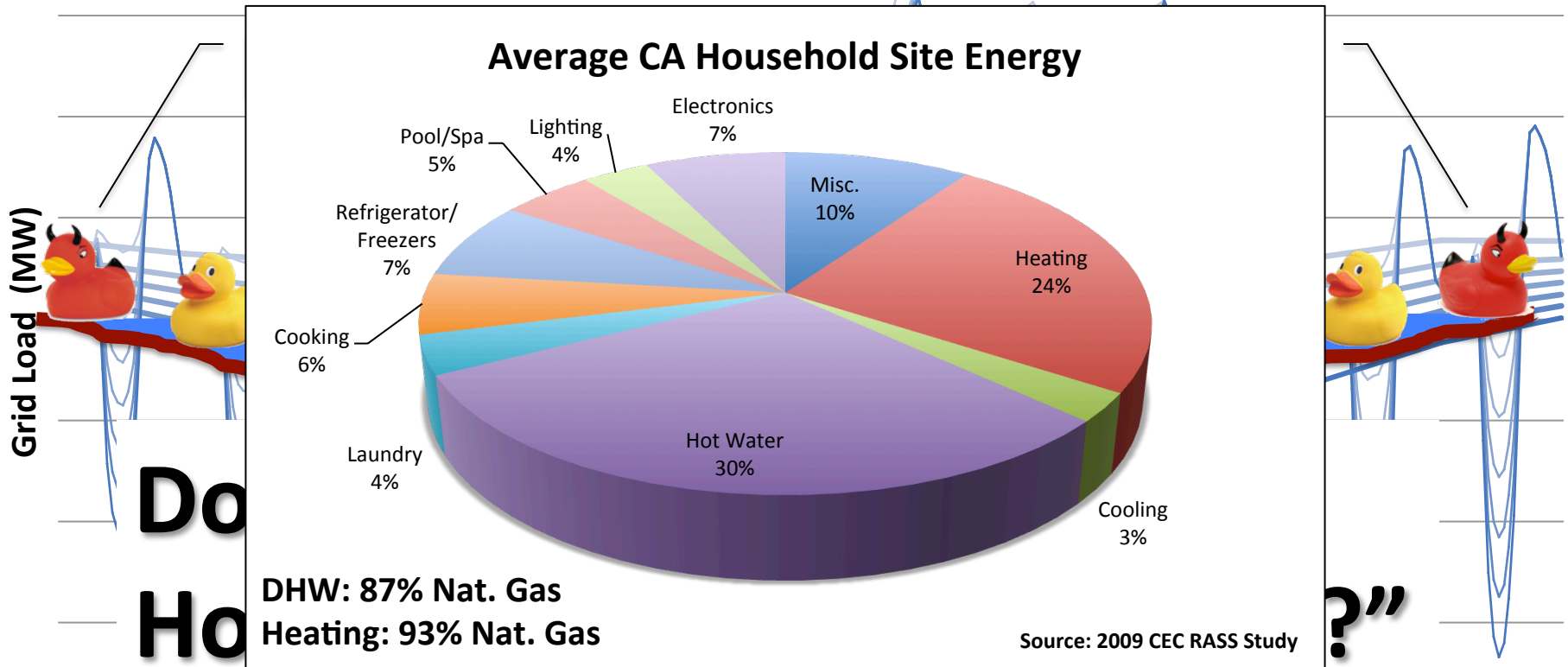
Typical Daily Grid Load vs. % Solar Energy



Monthly CA Grid Load

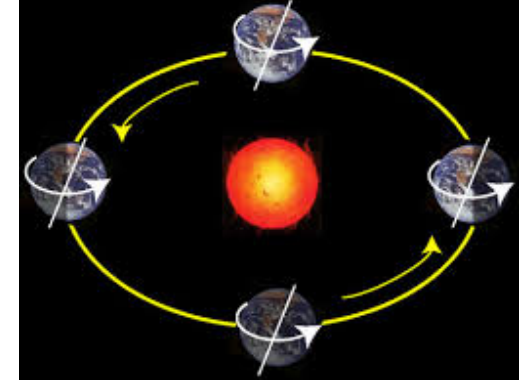


Typical Daily Grid Load vs. % Solar Energy



What About Heating & DHW?

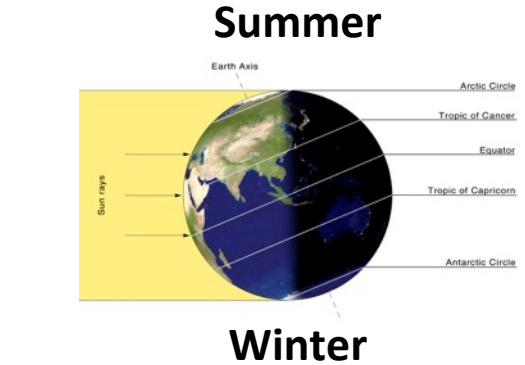
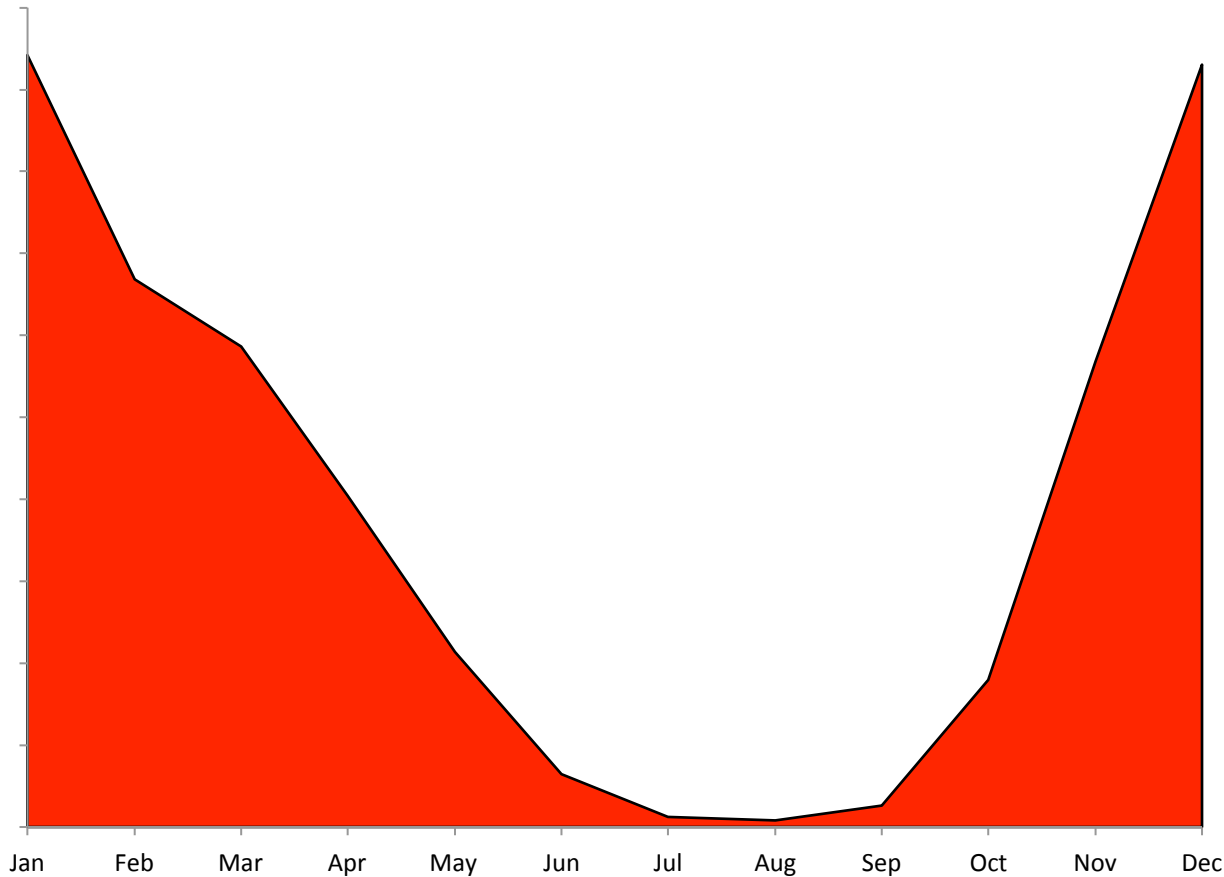
Seasonal Storage



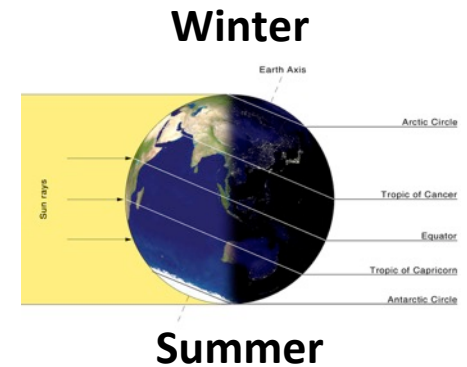
- Pumped Hydro
- Biomass
- Solar Thermal (LARGE Tank, Sand Pit, etc.)
- Synthetic Methane (“Power to Gas”)
- Ground Tempering/Ground Source HP
- Passive House

Winter Heating Demand

Solar's Biggest Challenge

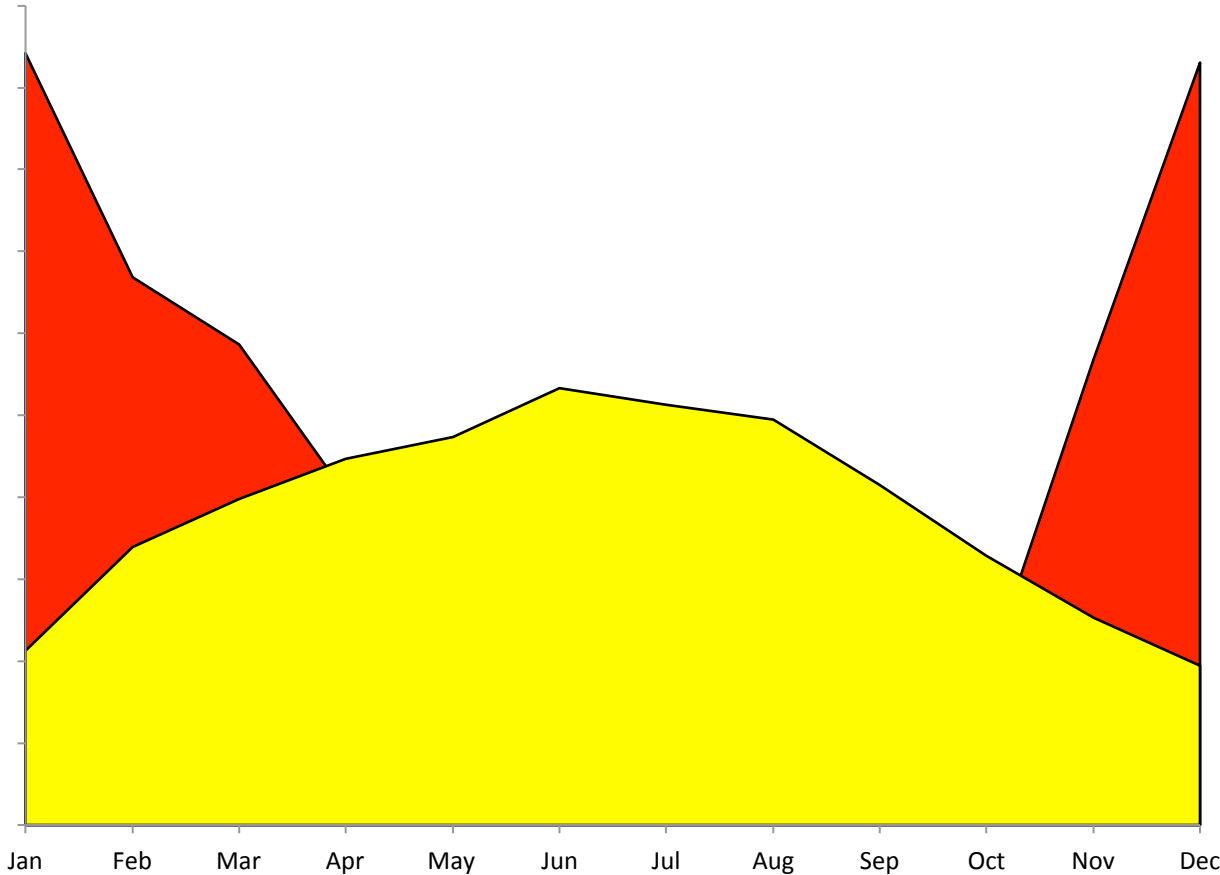


■ Heating Demand

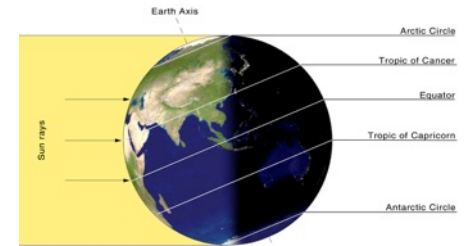


Winter Heating Demand

Solar's Biggest Challenge



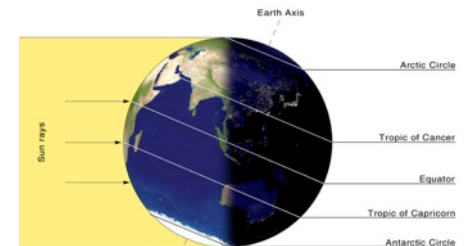
Summer



Winter

- Heating Demand
- Solar

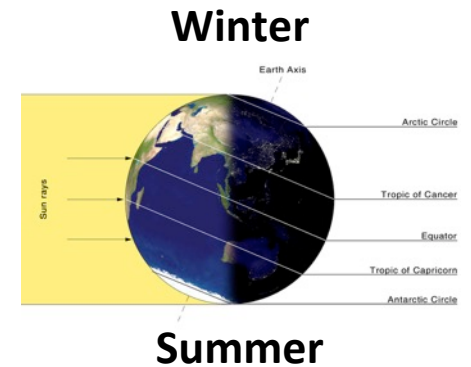
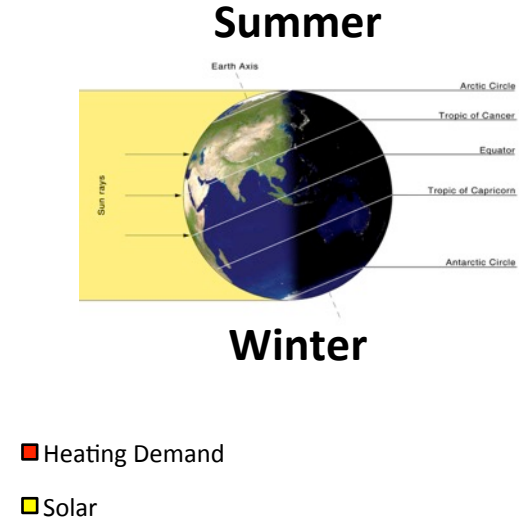
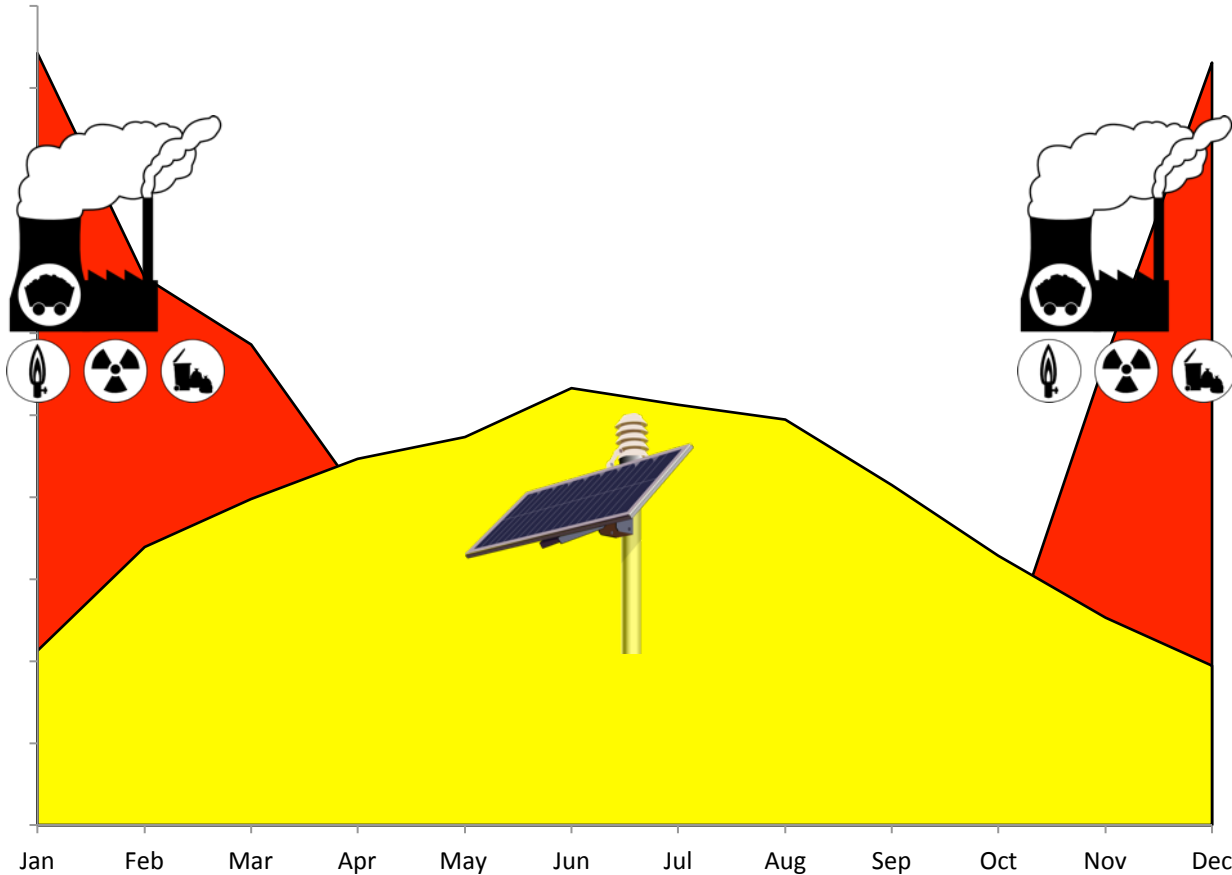
Winter



Summer

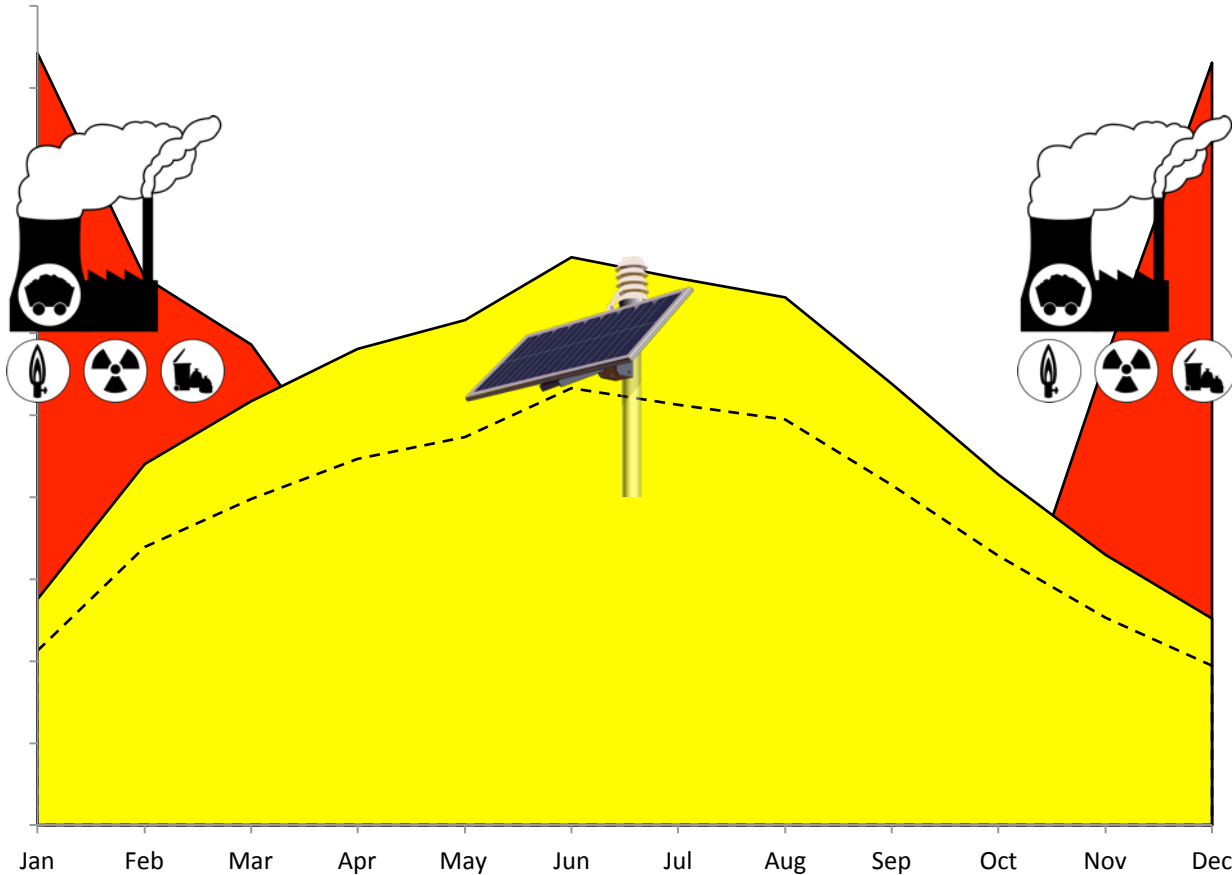
Winter Heating Demand

Solar's Biggest Challenge

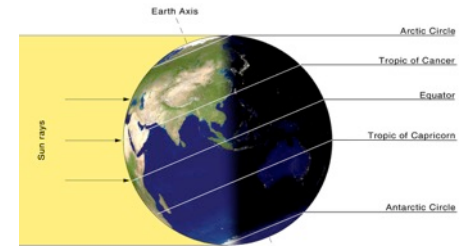


Winter Heating Demand

Solar's Biggest Challenge



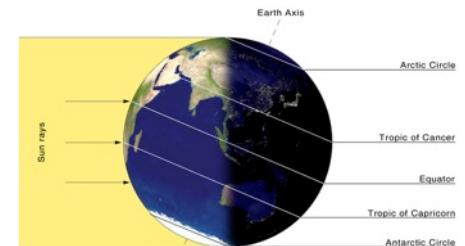
Summer



Winter

- Heating Demand
- Solar

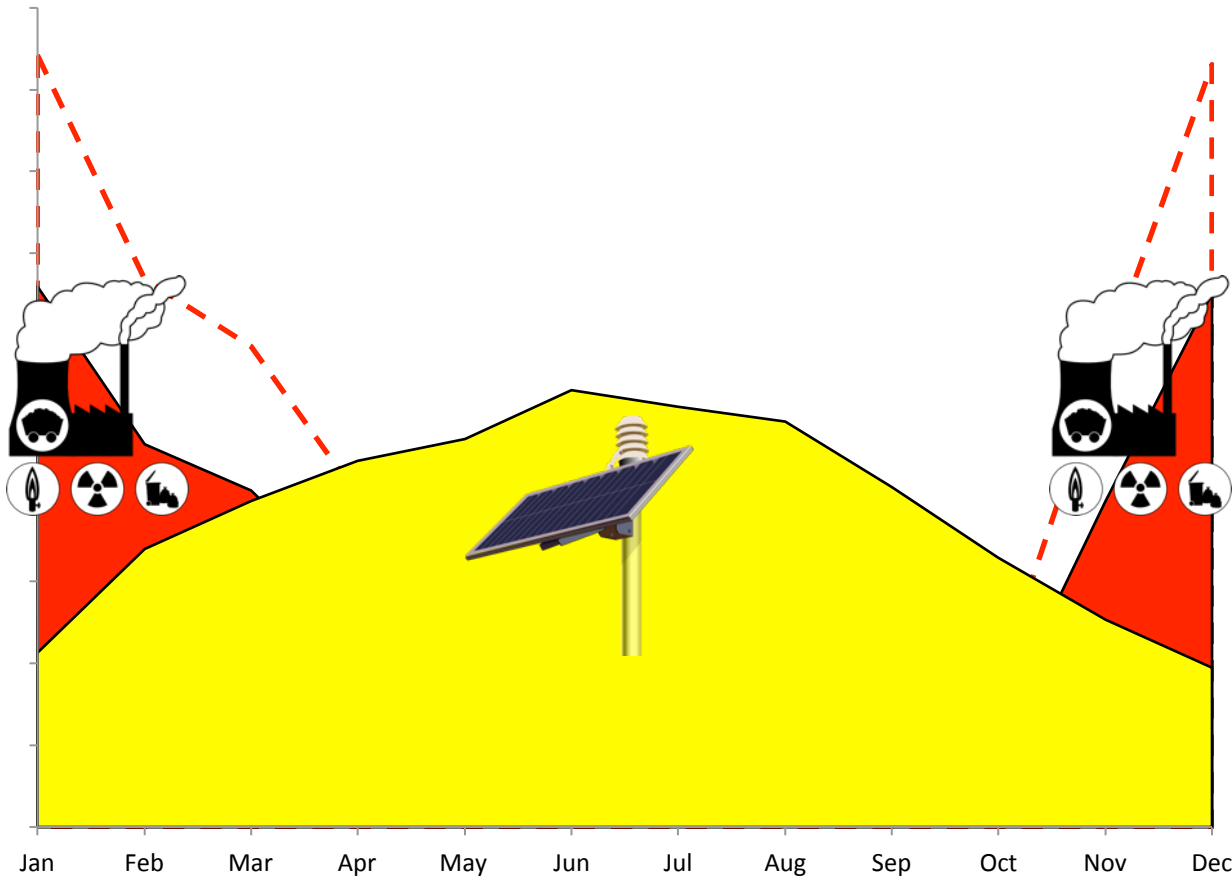
Winter



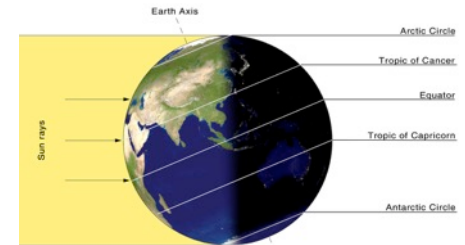
Summer

Winter Heating Demand

Solar's Biggest Challenge



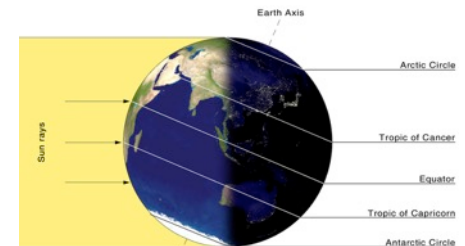
Summer



Winter

- Heating Demand
- Solar

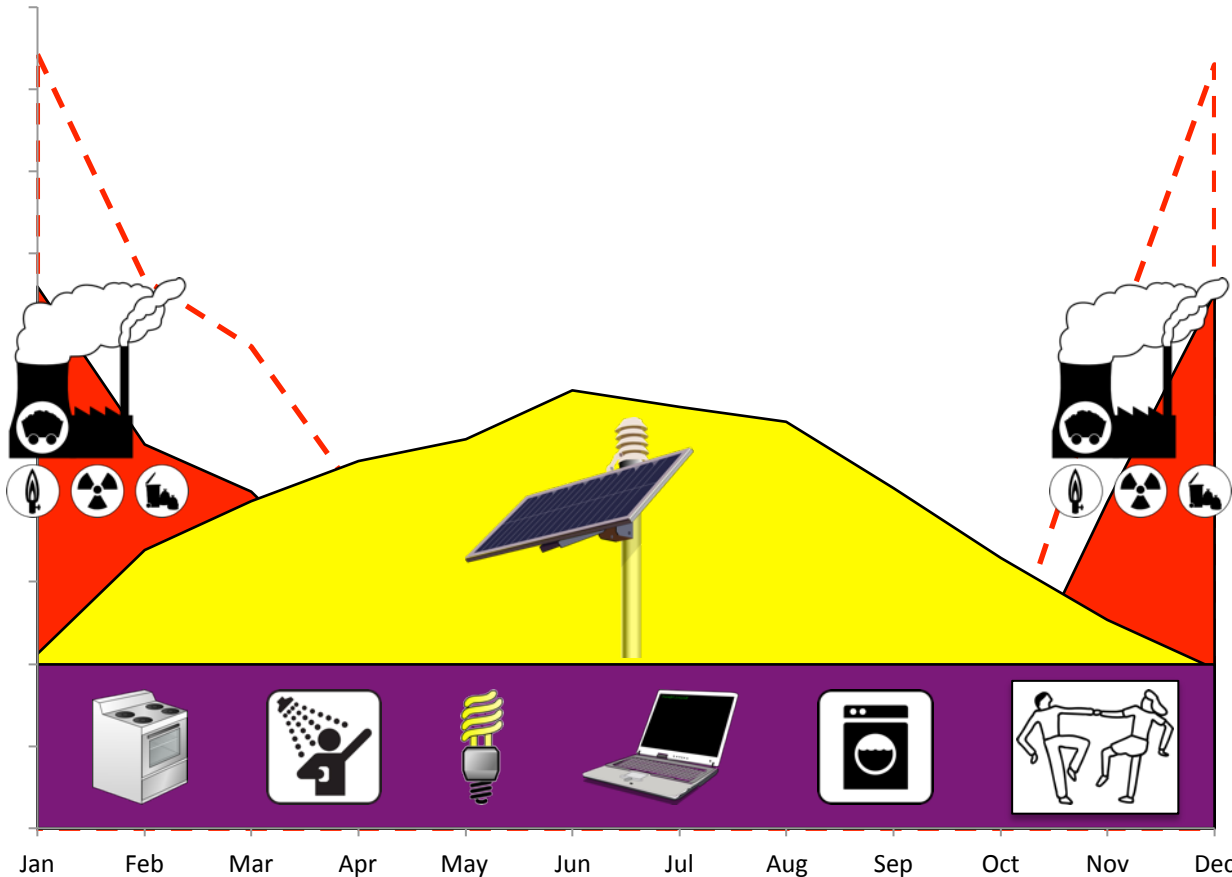
Winter



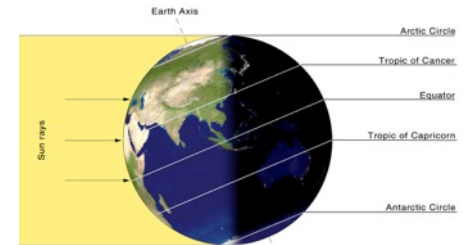
Summer

Winter Heating Demand

Solar's Biggest Challenge



Summer



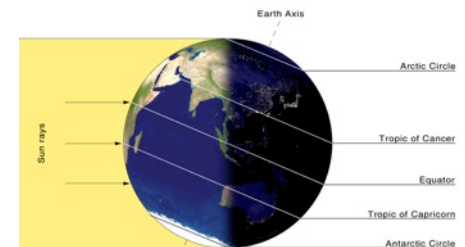
Winter

■ Heating Demand

■ Solar

■ Internal Heat Gain

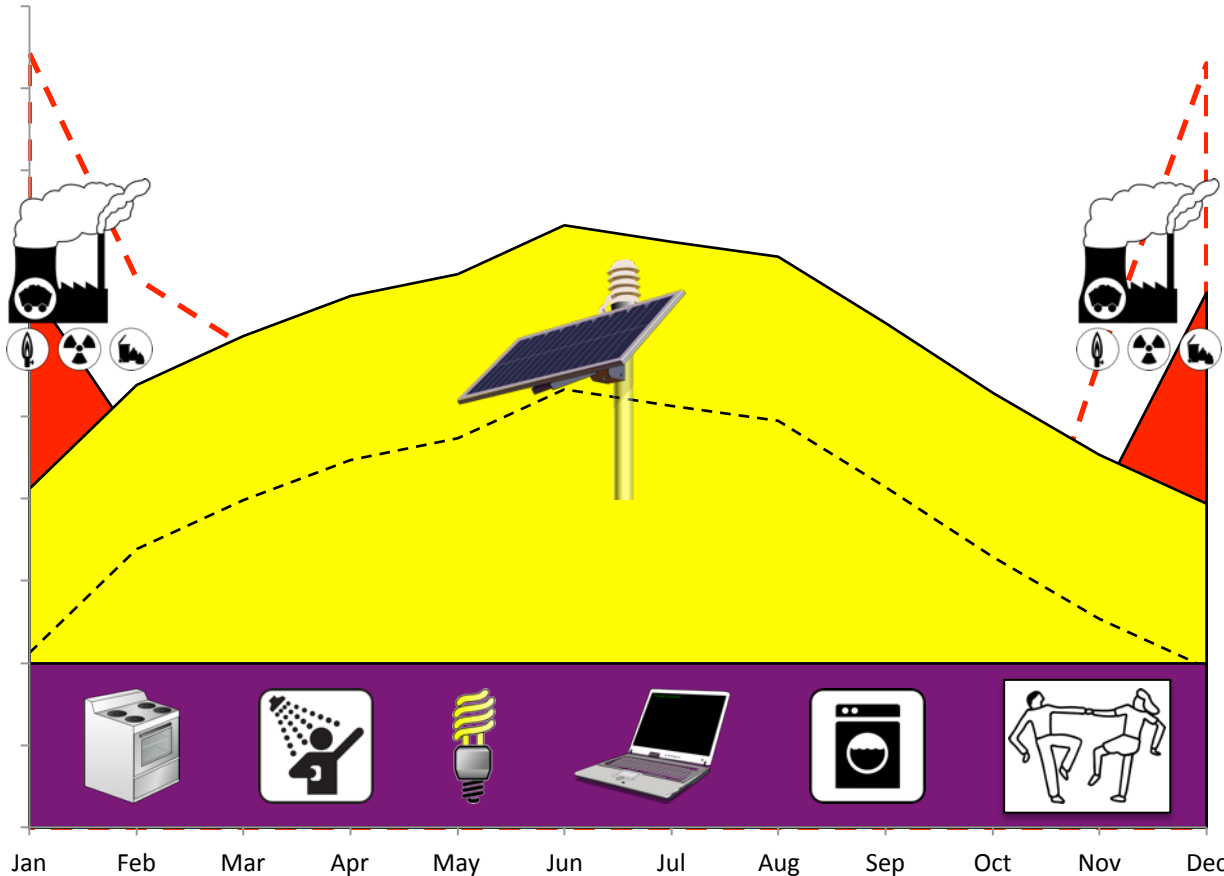
Winter



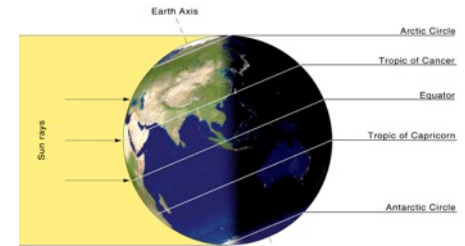
Summer

Winter Heating Demand

Solar's Biggest Challenge



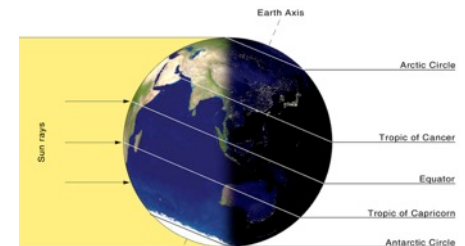
Summer



Winter

- Heating Demand
- Solar + IHG
- Internal Heat Gain

Winter



Summer

Proof in Practice:

Passive House Seasonal Energy Use.

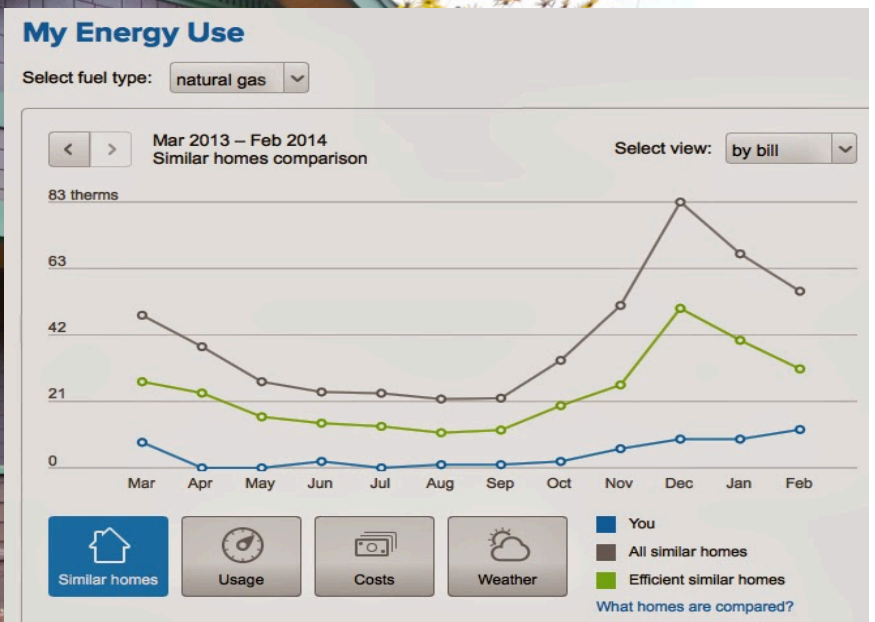
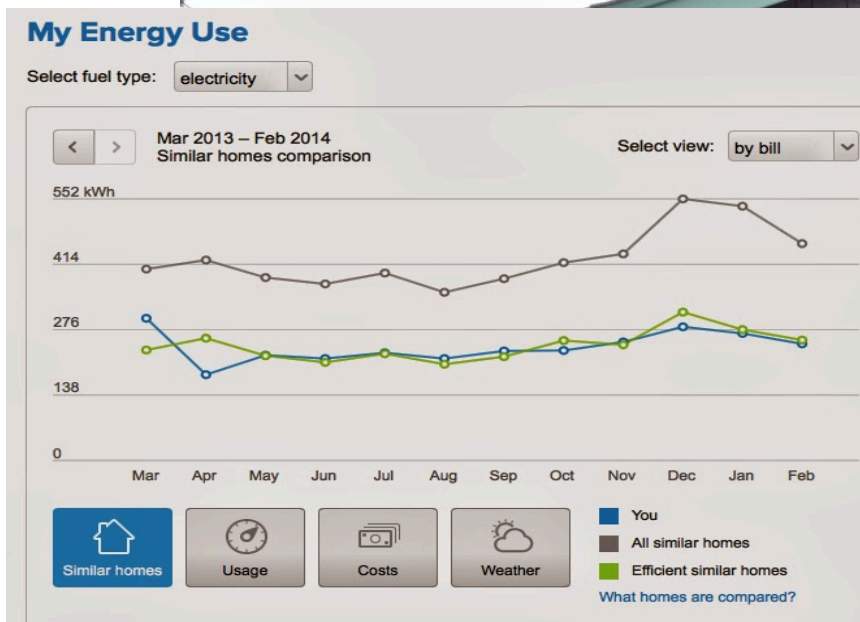


2869 kWh Elec. + 50 Therms (1,465 kWh) Nat. Gas = 4,334 kWh (before PV!)

Before Retrofit 21,928 kWh/yr, Similar CA Home 19,596 kWh/yr

Proof in Practice:

Passive House Seasonal Energy Use.



www.midorihaus.com

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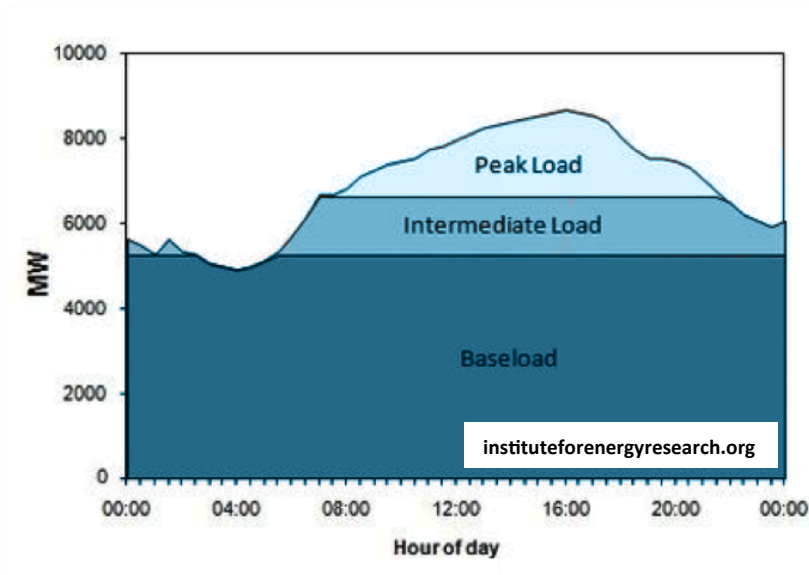
Opportunities



Where's the Money?



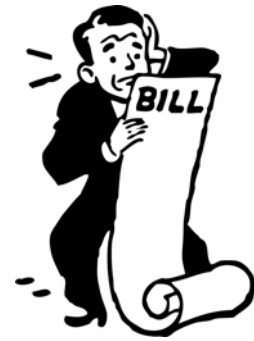
It's in the power (kW)



...not the energy (kWh).

An Expensive Problem

Meeting Peak Demand is Costly



TDV Multipliers, CZ3 (Oakland) Residential

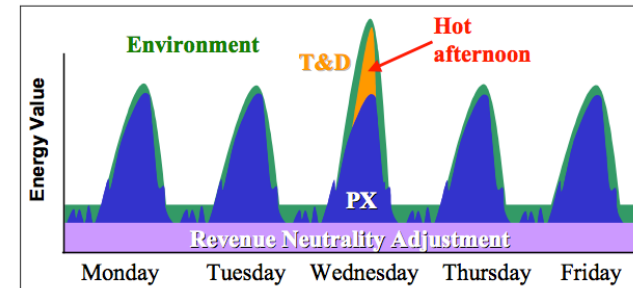
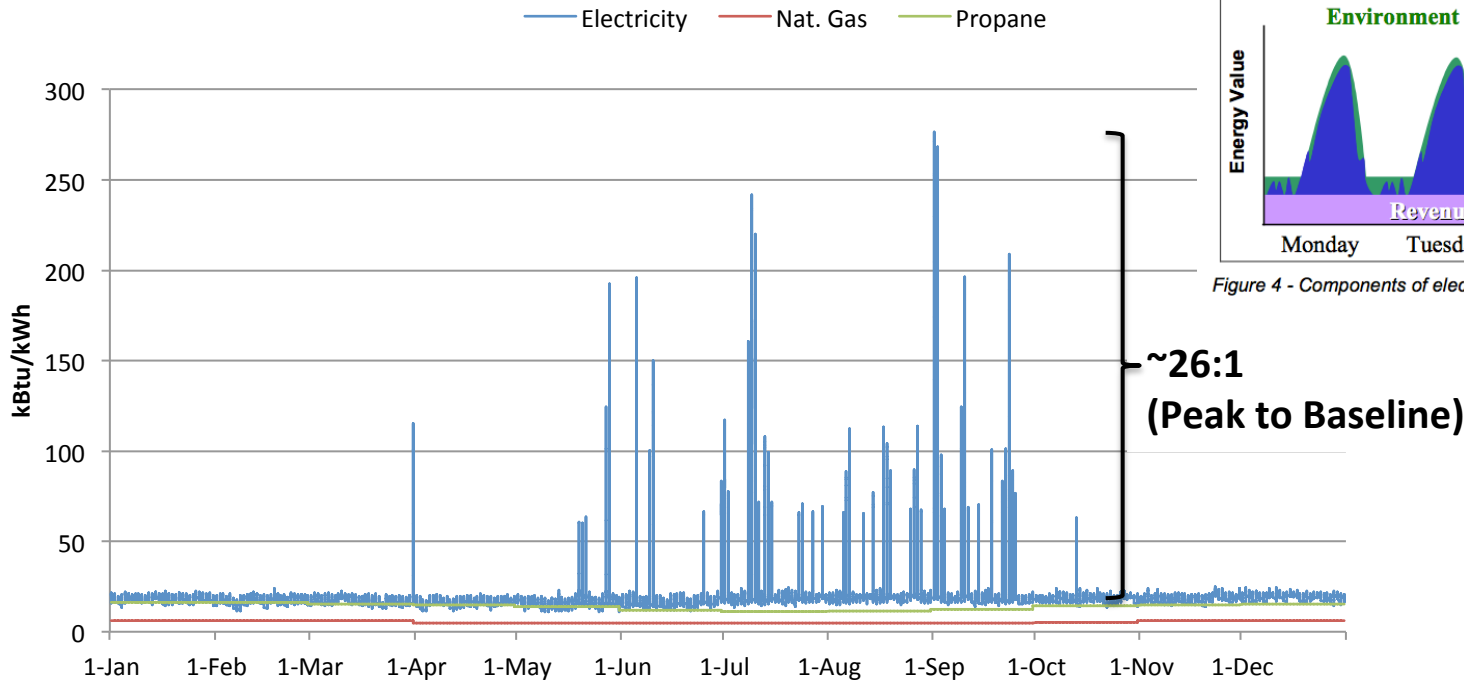


Figure 4 - Components of electricity TDV values during a hot summer week

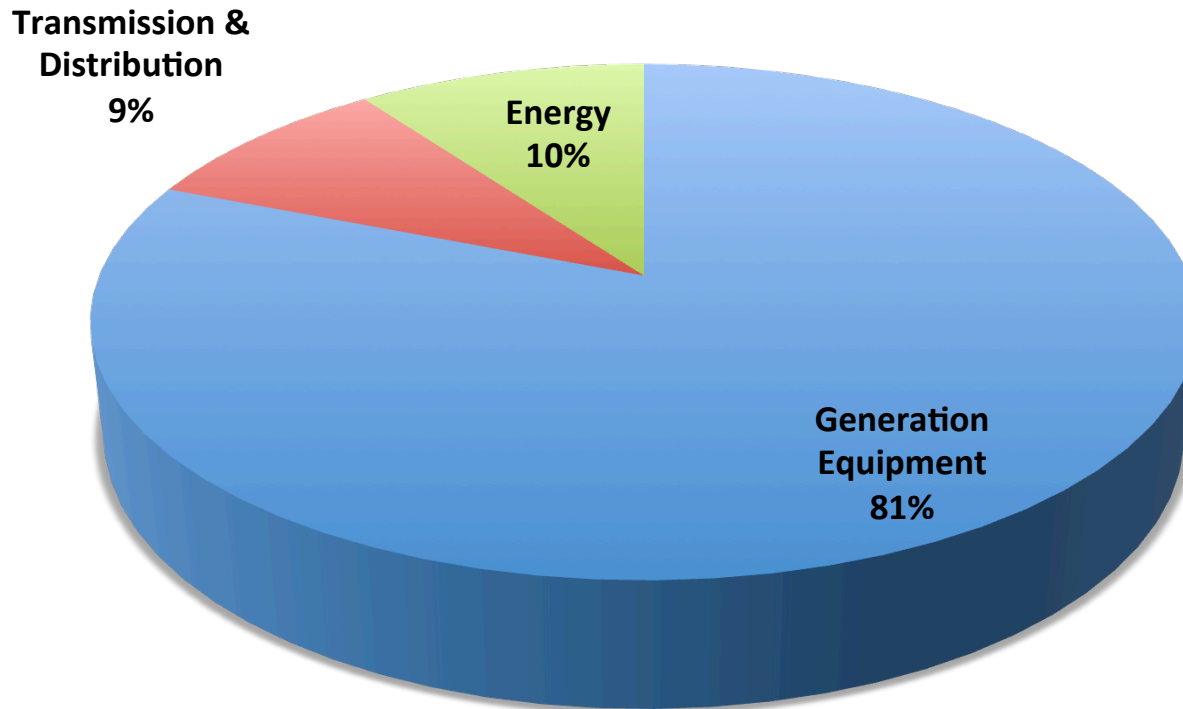
Time Dependent Valuation (TDV) hourly multipliers mostly tied to cost.

CZ3 (Oakland): Max 276.54 (Aug. 30 5:00 PM), Min 10.68 (May 7 4:00 AM) = 26 to 1!

How Expensive?

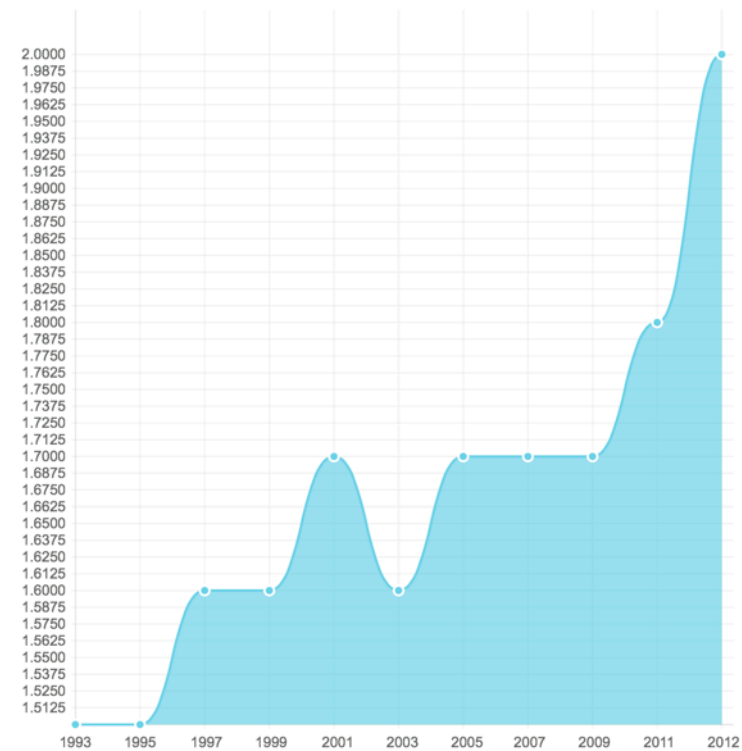


A 5% reduction in US peak load is worth \$3 Billion/yr



In the Future?

**It's getting worse.
Solar won't help.
We need lots of solar!**



Peak-to-Average Demand Ratio (New England), 1993-2012¹

[1] Kennedy, J. Peak-to-average Electricity Demand Ratio Climbing Across The U.S. Today in Energy, youenergyblog.com, February 26, 2014.

What Happens to Net Zero

When the Price for Your Power is Negative?



How is this possible?

- Nuclear plants operate continuously at full power.
- Hydroelectric - water flow for fish, etc.
- Eligible renewable generators get a \$22/MWh tax credit.
- Maintenance & fuel costs to stop & start large steam turbines.

Grid Business Model

- **Buy Power Wholesale**
 - 1 Day Ahead
 - Price Varies Hourly
- **Sell Energy Retail**
 - Bill Monthly
 - Priced After the Fact
- **Barter (Net Metering)**
 - Trade Cheaper Baseline Power for Near Peak Solar
- **Not for Long!**
 - Now consumers buy energy; soon we'll buy (& sell) power on an hourly basis. (TOU \$ in CA by 2019)

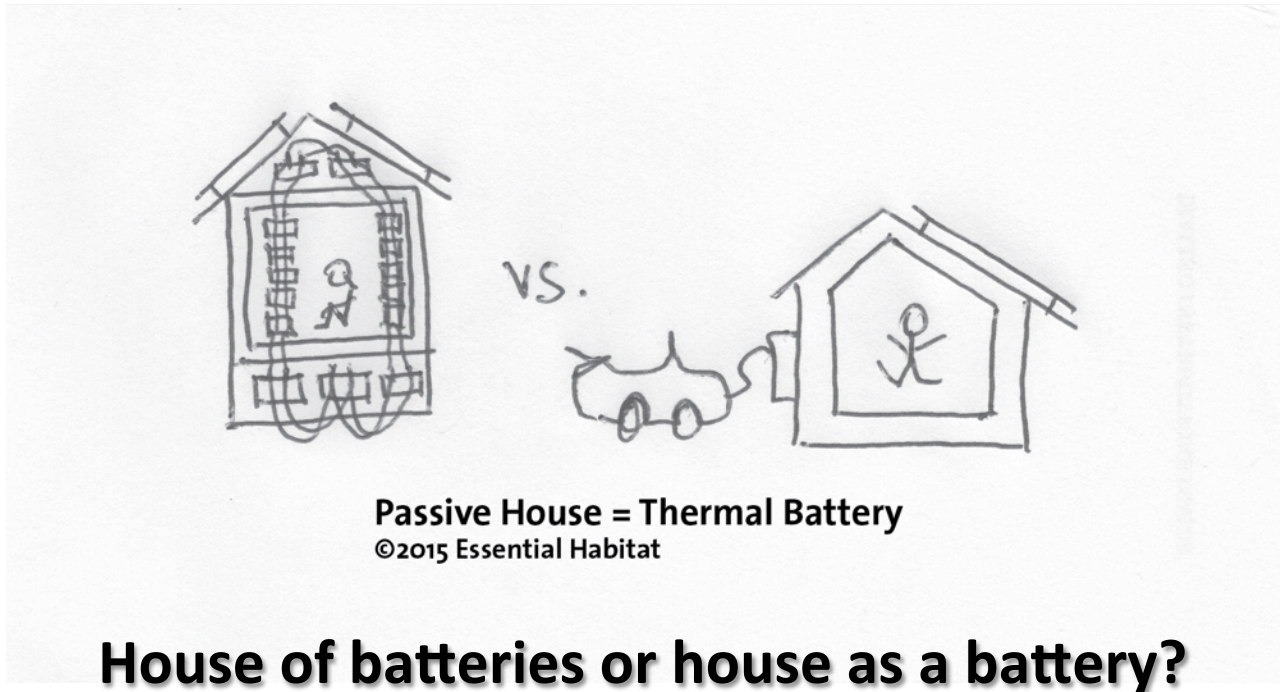


EMBRACE CONTRARIAN DEMAND:

GO PASSIVE HOUSE!



Thank You! Questions?



Graham Irwin

Principal, Essential Habitat Architecture

www.essentialhabitat.com

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