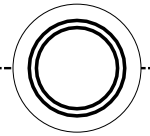
Portland State
UNIVERSITY

What kind of occupants do ZNE buildings require?

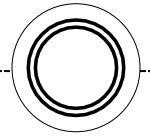


LOREN LUTZENHISER
HUAFEN HU
MITHRA MOEZZI

PORTLAND STATE UNIVERSITY

BECC 2012 – SACRAMENTO, CA

What is "Zero Net Energy?"



The PG&E Zero Net Energy (ZNE) Pilot Program launched in 2010 and supports the *2008 California Long Term Energy Efficiency Strategic Plan* zero net energy goals that all new residential construction in California be ZNE by 2020 . . .

. . . ZNE Pilot Program is focused on achieving maximal energy efficiency and load reduction by leveraging advanced design, construction and building operations before the addition of on-site renewable energy generation, such as solar PV. A zero net energy building is one that produces as much clean, renewable, grid-tied energy on-site as it uses when measured over a calendar year.

A big, bold idea? Lots of questions

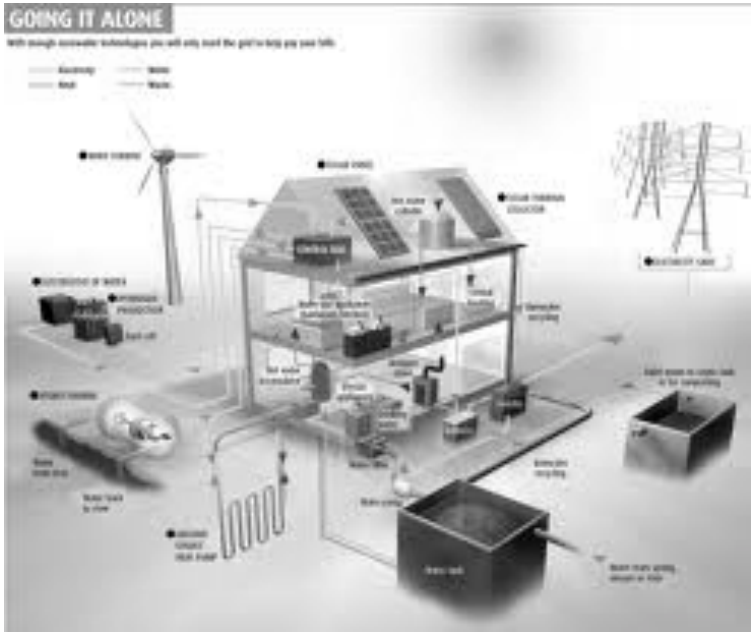
ZNE Pilot Program Technical Studies and Research

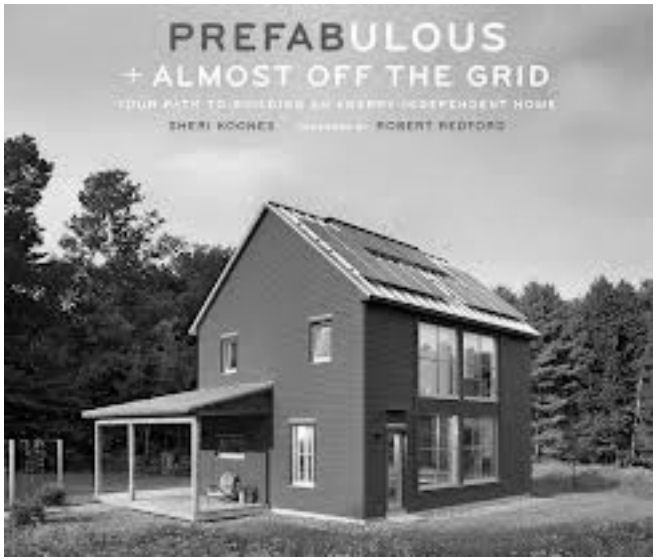
. . . provides support and coordination for a number of technical assessments of ZNE building materials and applications.

. . . currently supporting *two major research efforts*: One on the technical feasibility of zero net energy buildings for various building types, and specific to California climates; and another study that will serve as a broad-based policy and market inquiry on pathways forward to the 2020 and 2030 ZNE goals.

West Village (2010) and Amory's house (1982)

Not a new idea – off the grid



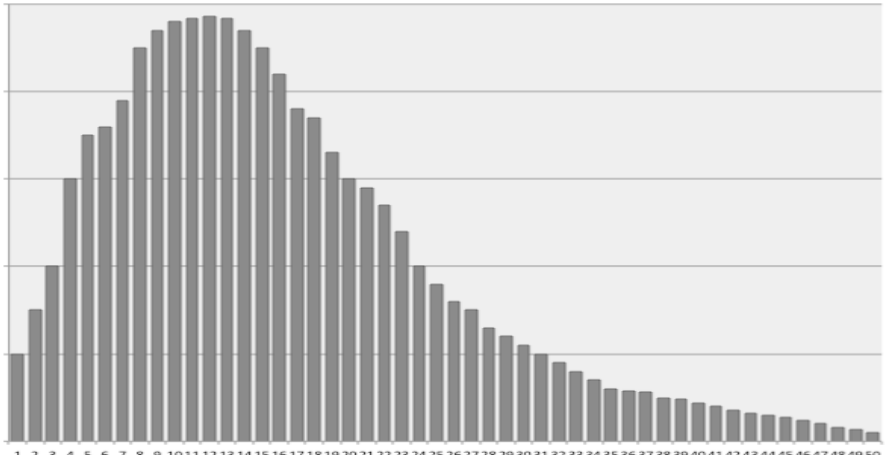


Passivhaus

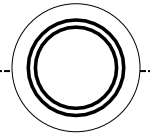
Lots of PV

Why should behavior matter?

- Enormous variability in the population
- Our studies of thermostat effects – *extreme differences*
- Research on audits (Mithra)
- Modeling results
  - California prototypes: Behavior = 70-80% of demand (vs. weather & building design)
- Can ZNE actually work in light of the enormous diversity in demand?



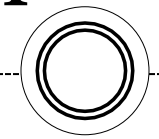
Specific questions about ZNE



- ZNE designers say “We can nearly eliminate the space conditioning loads. What’s left are the people and the plug loads.” Is this actually true?
- Is ZNE possible for the highest energy users?
- How frugal does the occupant have to be for ZNE to “work?”

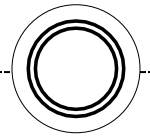
- No large population of ZNE cases. How to study?

Explore these questions, using . . .



- Best available *behavioral data*
  - California RASS survey
- Best building *energy simulation* software
  - EnergyPlus (DOE)
- Best ZNE *house design*
  - Arup/Davis Energy Group – THANK YOU !!!

Research strategy

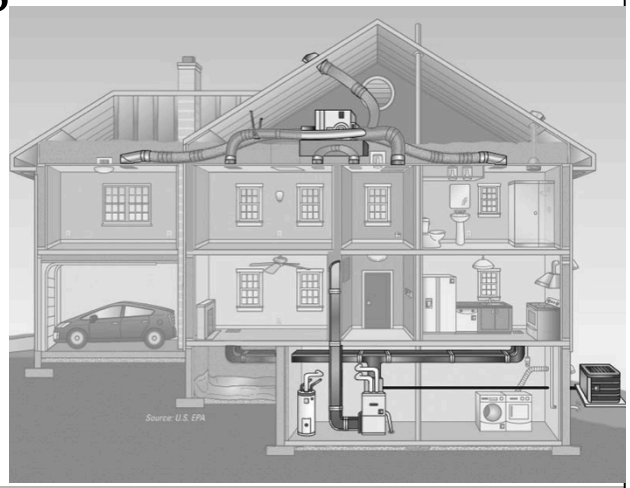


- Sample – single family, newer, CZ12 (Sacramento)
- 636 cases with complete behavioral data
- Simulate building energy use (electricity and natural gas) for each case *in a ZNE house*
- Estimate available annual solar energy (kWh)
  - PV
  - Water heating
- Compare households' demands and their solar "budgets"
- Compare "over-budget" and "under-budget" cases

Exemplar building features

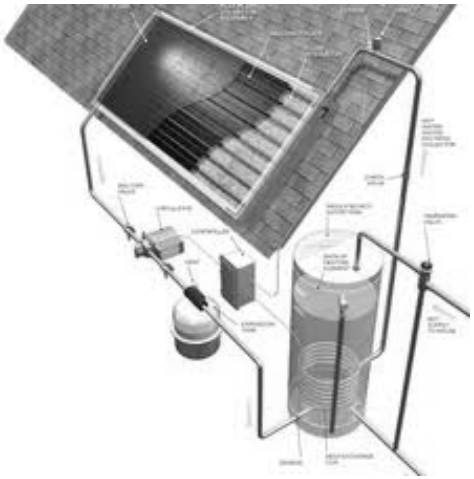
- High levels of insulation (attic, walls, pipes)
- High performance windows
- High efficiency heating, cooling, water heating systems
- Increased interior/exterior thermal mass
- Intelligent automated night venting
- All LED lighting
- High efficiency appliances

- Super-house, but off-the-shelf



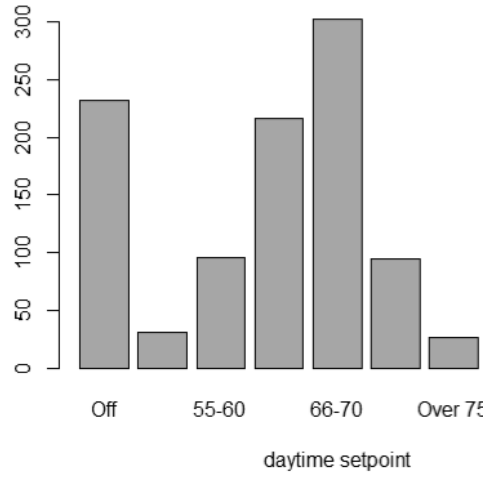
Solar budget

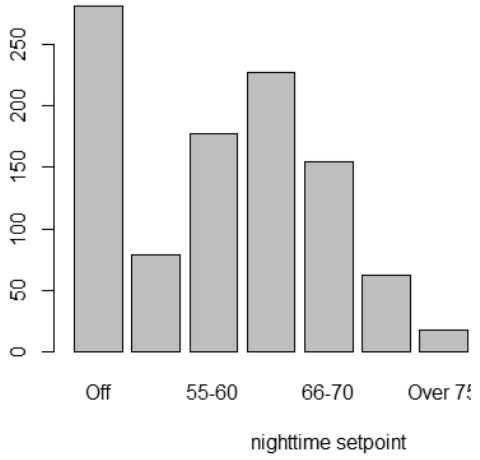
- Roof area available (and South wall if needed)
- Commercially available arrays
- Current efficiency of conversion (10-12%)
- With and without solar hot water



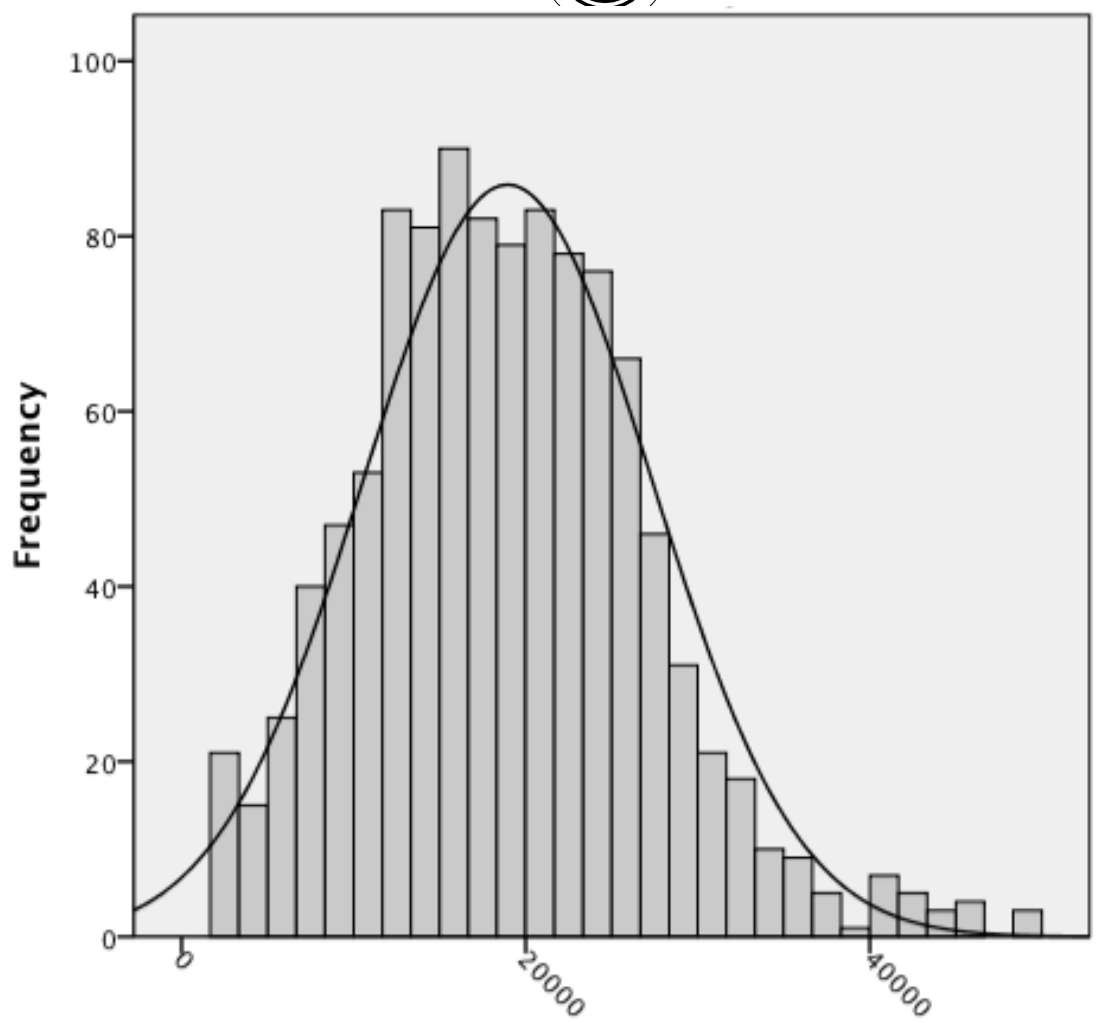
Specifying behavior

- Heating and cooling thermostat settings (morning, day, evening, night)
- Loads of laundry, washing/drying
- Dish washer loads
- Baths and showers
- Number of HH members

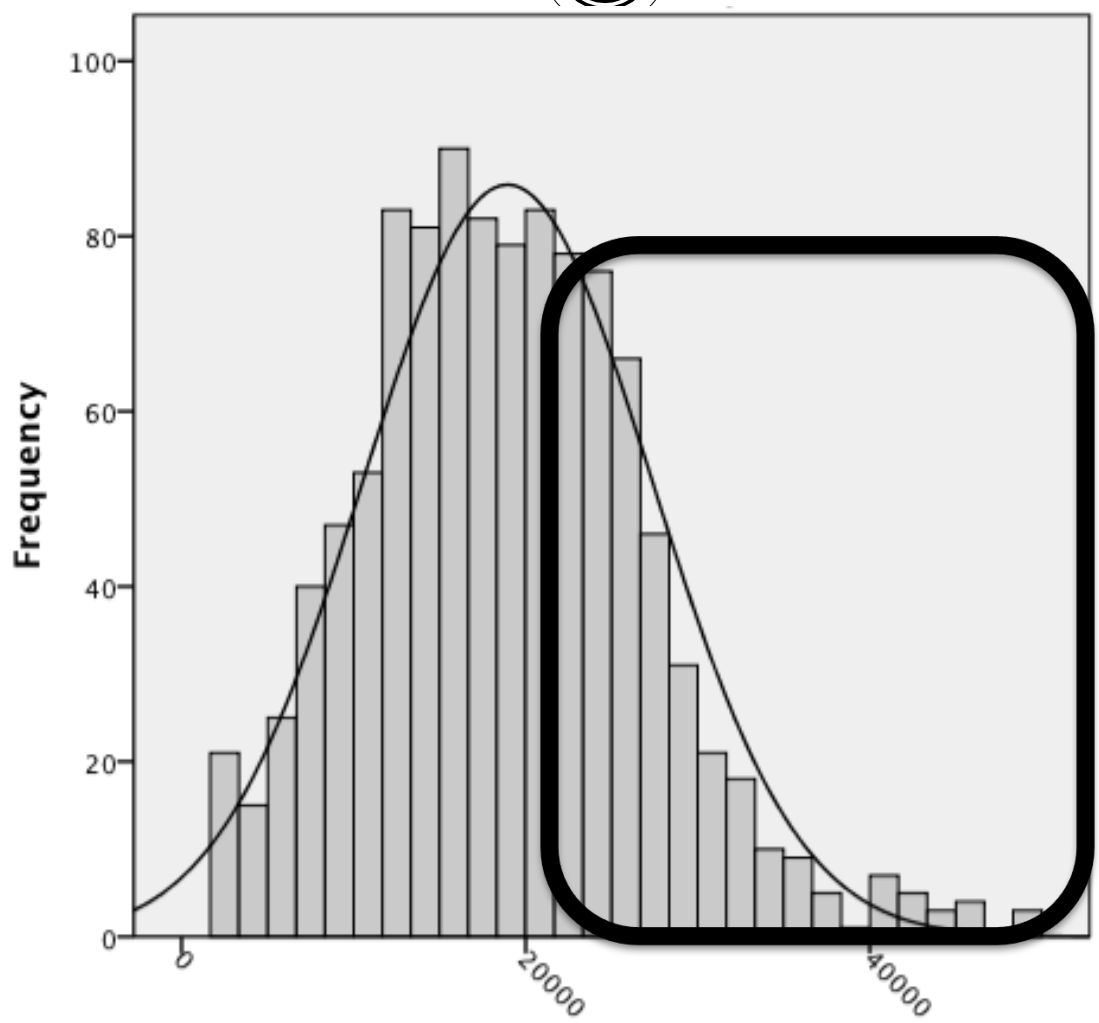




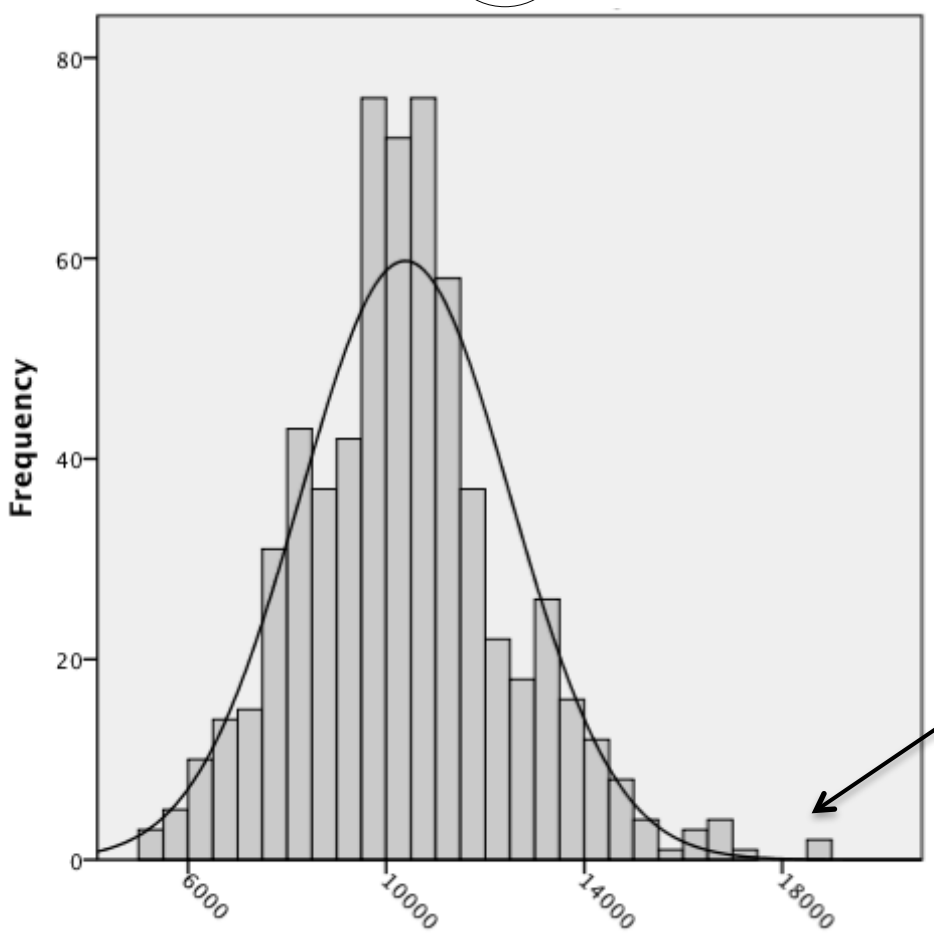
What does the population look like?
Considerable *variability* (8x) in single climate



What we expected to find: ZNE failures



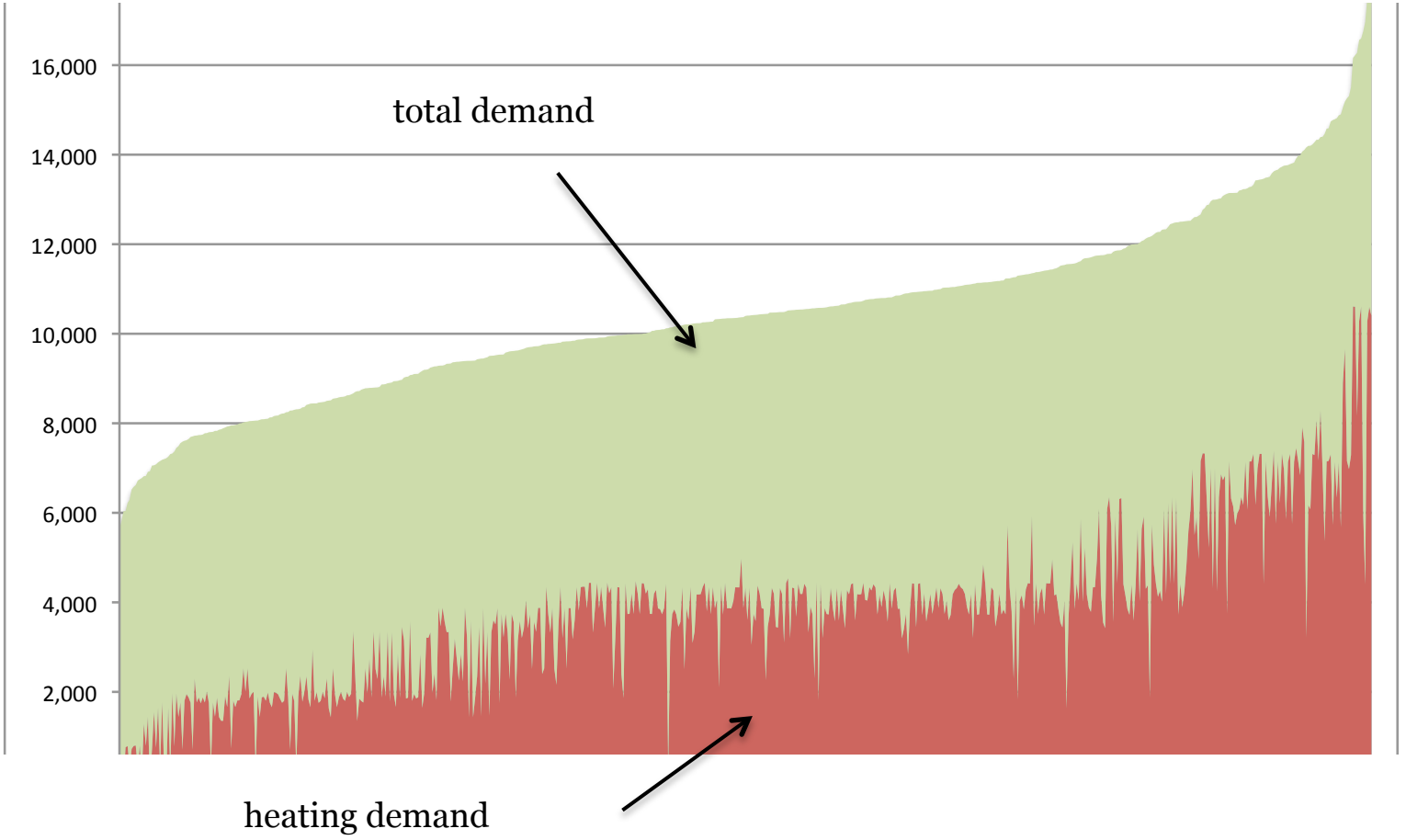
Indeed lots of variation in ZNE house (3x)



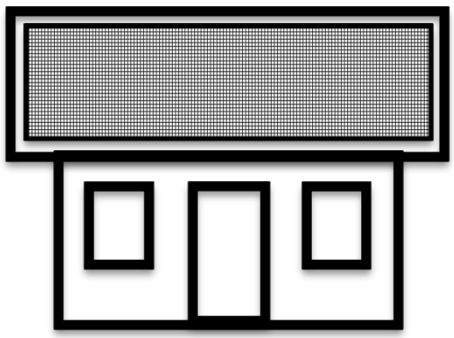
But total demand drastically reduced

20,000 vs 40,000+ kWh at the top of the range

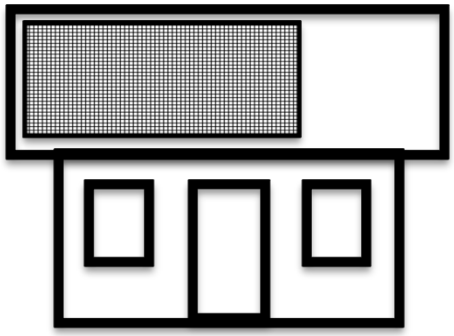
Heating still matters (a lot)



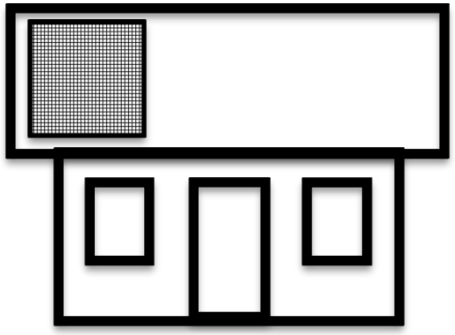
BUT plenty of solar real estate on the roof



18,000 kWh/yr



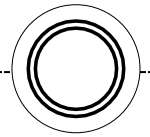
12,000 kWh/yr



6,000 kWh/yr

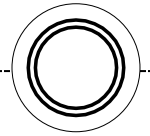
- Solar Hot Water Heating reduces total energy use another 1,000-2,000 kWh/yr (10-15% reduction)
- Caveat: 2-story design closer to the limits

In sum . . .



- ZNE can “work” with a wide range of occupants and behaviors
- But even high performing buildings and systems are significantly affected by occupant behavior
- It’s not just plug loads – heating & cooling are still important (and highly variable; need to understand)
- Frugal usage patterns (particularly heating, cooling and hot water) can dramatically minimize the need for on-site generation

Fundamentally new views/understandings

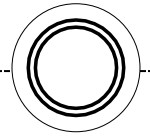


- Widely distributed generation is easily imaginable
- Future neighborhoods needn't be at all like the past
- The grid could easily become a *storage utility*
- With climate change and extreme weather, ZNE could contribute considerably to *resiliency*
- Downsizing ZNE designs can easily be imagined
- Also retrofitting to near-ZNE

Exciting – opens new doors of possibility

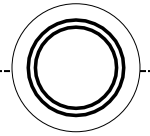
- Very low energy ways of living
- ZNE suburbs and neighborhoods

Moving forward . . .

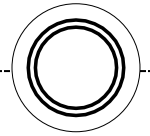


- Little behavior changes may be less important than reconfiguring large systems
- Behavioral science and technology development/ architecture can work together to produce extremely low energy, integrated/sustainable designs
- More than the occupants – it's the behavior of designers, developers, contractors, realtors, code negotiators, manufacturers, policy makers, and utilities that need to be better understood (and changed) as they shape and resist change in the built environment

Taking action. Let's . . .



- Get serious about getting the buildings right
- Focus on how people and buildings really interact
- Consider shooting high (rather than low)
- Start thinking creatively about new ways to build suburbs and rebuild existing neighborhoods
- Experiment with redistributing supply and demand with climate change resilience in mind



the end

Loren Lutzenhiser
llutz@pdx.edu