ACEEE
American Council for an Energy-Efficient Economy

Net-Zero Energy Residential Buildings ~~Overview~~ Vision

NIST Workshop:
Net Zero Energy Home Strategies
September 14, 2011

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What is a Net – Zero House?

- Concept is clear and easy
- Details get into arcane “theology”
  - Any year or some specific year?
  - How big is the spatial box around the site (building, property line, or community)?
  - What about anomalous uses?

Some Anomalous Uses

Home-grown “data centers” and “server farms”

Improper HVAC use: open bedroom windows while the furnace is running.

Specialty agricultural applications

Anomalously high electricity use.

What do we think we know about Residential Building Energy use?

- "Identical" houses vary enormously.
  - How much is construction variability vs.
  - Resident preferences and equipment?

We *think* that the most efficient houses vary less – at least in absolute terms.

- That is, we can largely remove the construction variability as a cause of usage variability.
- But, *quality* is very hard work with conventional construction methods.

We still build in outstanding *inefficiencies.*

Why would you put the HVAC outside the thermal envelope?

- Attic-based systems – with hip roofs, no less!
- “Weatherized” systems with outdoor equipment.

And how do we do the boundary between the foundation and the walls?

Why do we think we can inspect-in quality?

Is moving energy around with air obsolete?

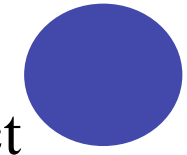
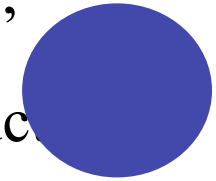
Ducts & Equipment in Attic

Air Distribution Issues

Short-cut to assure air gets back to the furnace.

Opposite end of spectrum from usual open, 2-story, w/o zoning.

Transporting 100 Tons 100 Feet

Transport Medium	Conduit Size	Design Spec.	Required Power	Heat Penalty
40,000 cfm Hi. Vel. Air	44” Duct 	0.3 in. wtr. per 100 ft.	2.2 kW × 2 for S&R	0.63 Tons × 2 for S&R
40,000 cfm Lo. Vel. Air	54” Duct 	0.1 in. wtr. per 100 ft.	0.75 kW × 2 for S&R	0.21 Tons × 2 for S&R
240 gpm chilled wtr.	4 in. pipe 	4 ft. wtr. per 100’	0.29 kW × 2 for S&R	0.08 Tons × 2 for S&R
150A/460 VAC-3 ph.	3-00AWG 0.365” x 3 	0.008 Ω per 100’	0.3 kW	0.08 Tons

Some Assertions

In new construction, efficiency is cheaper than renewables.

Existing stock is really heterogeneous.

- For some existing stocks, particularly where shell work is really hard, renewables may play a larger share.
- In many cases, redevelopment at higher density may be more profitable and sustainable than retrofits.

Therefore, building correctly is paramount.

Let's define "building correctly"*

- Cost-effective
- Desirable
  - Comfortable
  - High amenity
  - "Custom" → individually styled and sized.
- Climate-appropriate.
- Scalable (can do many, with consistent quality)
- *Can't be put together wrong.*

*from the public policy perspective

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What about Existing Houses?

- Delivery mechanisms are immature – one-on-one sales.
- “Deep Retrofits” are really hard
- Behavior really matters.

Two major retrofit efforts

DOE's Building America Program

- Reorientation from new construction is extremely important and promising.
- Excellent teams and approach.

Affordable Comfort, Inc (ACI)

- "Deep Retrofits" aim for 60% - 80% energy use reduction.
- Explicitly includes behavior aspects

Key Concept: Mass Customization*

In general, factory work is less expensive and higher quality than site work.

With rich information content, factory production does not mean “sameness”.

But it may not arise spontaneously.

*with credit to Burton Goldberg, NAHB-RC

“Mass customization” Characteristics

Information-rich design (BIM) directly translates into manufacture.

SIPs-like advanced “continuous” panels

- Pre-wired
- Pre-plumbed
- Pre-hung doors and windows
- Free-standing, outer wall to outer wall?
- Design-for-Assembly in “can’t put together wrong” sequence.

Commercial Construction Analogue

"**Project Frog**" http://www.projectfrog.com/

Focus on *project delivery.*

- *Precision parts kits* for fast, accurate, field assembly
- Project speed and process predictability
- Reduce "as designed" vs. "as built" performance gap.

Project Frog *Claims*

- 20 – 45% cheaper to build
- 6 – 8 month cycle; assemble during summer
- 40%-50% better life cycle performance –
- 70% better with PV.
- And, ongoing continuous commissioning
- Faster learning, higher scores, smarter kids, and fewer cavities (just kidding on that one).

(http://www.projectfrog.com/buildings/k-12_education/)

Drivers of the transition

- Work force issues
- Demographics and the not-so-big house
- Urban and inner core redevelopment.
- Higher density zoning “frees up” land value and drives neighborhood-scale replacements.

Kick-starting the transition

Mass purchase contracts as a key

Multi-year, declining price, increasing volume

DOD, HUD, …

Contracts can leverage start-up at high enough volume (20,000/yr?)

Profitability from augmenting government sales with private sector contracts.

So what's in it for NIST?

Design-manufacturing protocols, BIM-based, are critical

Do we need new metrics for some products?

- Insulation Aging?
- Time-dependent HVAC and glazing degradation?
- Dimensional stability of shell components?

Sensors for performance and IEQ

A few barriers in the road…

Technical: How to do foundations?

Codes: Moving to post-construction performance basis for energy codes.

- Billing Analysis
- “Co-Heating” or “STEM”

Market realignment of private sector builders’ role, to one more like consultant or automobile dealer.

Some Personal Conclusions

I'm more concerned about measurement methods for processes and outcomes:

Photometric processes to automate specification and fabrication of exterior insulation, for quality and productivity.

Automated, IAQ-sensitive, mechanical ventilation control (more than CO_2)

Adaptable control "dashboard" for occupants.

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