~~John F. Straube~~ Kohta Ueno

# Low Energy Design in New England:

## How Low Can You Get?

February 10, 2011

Building Science Corporation

BETTER BUILDINGS BY DESIGN | 2011

Efficiency Vermont

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Efficiency Vermont

## Learning Objectives

At the end of this program, participants will be able to:

- *Learn recommendations and priorities for designing and building very low energy buildings, such as PassivHaus and NetZero Energy Homes, in the cold climates of the northeast*

- *Prioritize air sealing, ventilation, windows, renewable energy and mechanical system choices*


## Overview: Low Energy Design Approaches

- Why are we fighting?
- Okay, a few things we disagree on…
  - But the more I read, the less difference I saw.
- Degree of passion on this topic
  - Lack of dog in the fight
- Debating skills (and lack thereof)

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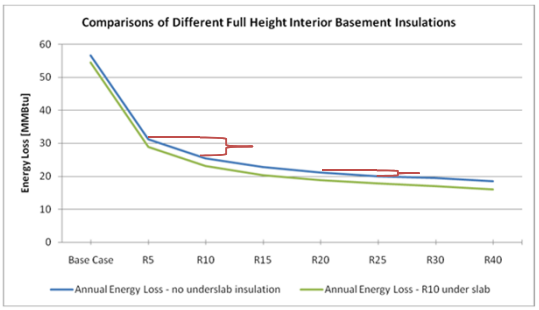


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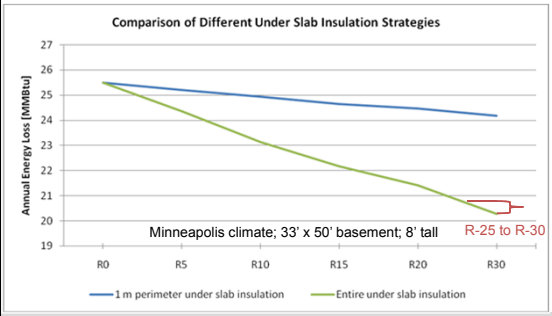
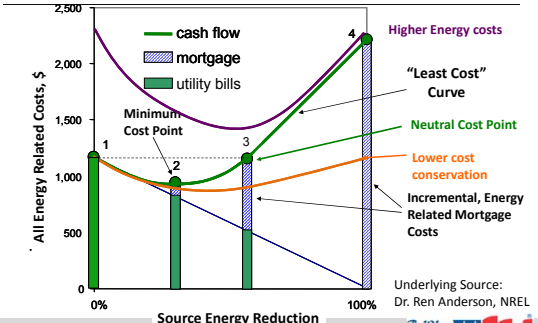
## Diminishing Returns (Basement Slab)






## Capital Investment vs. Operating Cost




Underlying Source: Dr. Ren Anderson, NREL

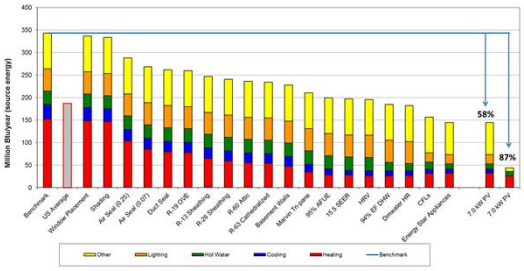


## But Yes, Insulation Works…

- Doesn't need maintenance
- Doesn't break down (lasts a really long time)
  - (Hopefully)
- Difficult and expensive to retrofit later
- Analysis that accounts for this?



## Parametric Simulations






## Cost Effectiveness: Beyond Simple Payback

| | Extended Cost Effectiveness Analysis | | | |
|---|---|---|---|---|
| Cost | Savings [$10^6$ Btu / yr] | $ per $10^6$ Btu Saved (1 year) | Estimated Lifetime [yr] | $ per $10^6$ Btu Saved (Lifetime) |

Energy saved over lifetime of measure

Component lifetime

"Cost per unit of energy saved"

Cost of upgrade

Source Energy Savings (from typical analysis)

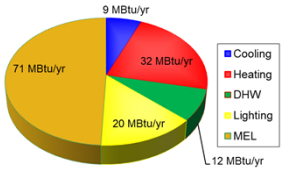


## Cost Effectiveness: Beyond Simple Payback

| | Extended Cost Effectiveness Analysis | | | |
|---|---|---|---|---|
| Cost | Savings [$10^6$ Btu / yr] | $ per $10^6$ Btu Saved (1 year) | Estimated Lifetime [yr] | $ per $10^6$ Btu Saved (Lifetime) |
| Basement Slab R-25 to R-30 | | | | |
| $1,452 | 0.61 | $2,394 | 100 | $23.94 |
| 4 kWp Photovoltaic System | | | | |
| $28,000 | 69.19 | $405 | 25 | $16.19 |

## But What About the Other Loads?

- Domestic hot water
- Plug ("miscellaneous end use loads"/MELs)
- Yes, heating is the biggest energy load in a cold climate.
  - But…






## 0.6 Air Changes per Hour @ 50 Pa

- 0.6 ACH 50
- How difficult and costly?
  - 3 ACH 50 easy in production setting
  - 1.5 ACH 50 effort, training, materials
- And how effective?
  - Depends on climate
- Restrictions on building geometry? (i.e., simple shapes only)
  - Maybe a good thing—simpler = easier to air seal
  - Living within "climate limitations"
  - How many people will accept it?



## Ventilation

- Energy benefit of heat recovery:
  - Depends on ventilation rate (ASHRAE 62.2?)
  - Depends on outdoor climate
- Basic off the shelf HRV: 0.6 W/CFM, 63% efficient
- High end HRV: 0.75 W/CFM, 80% efficient motor
- Δ savings=$11/year (@ $1.65/therm & $0.15/kWh)
- $1000-1200 premium for high end HRV



University of Waterloo

## Decathlon- North House

University of Waterloo, Ryerson University, Simon Fraser University

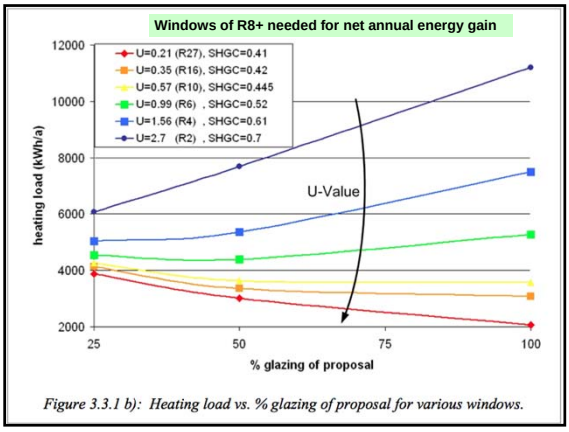



*Figure 3.3.1 b): Heating load vs. % glazing of proposal for various windows.*


## Net Zero Buildings

- With enough money, we can build net zero or net positive houses that look “funky cool” or “normal”
- We have the technology
- Is the expense worth it?
  - Depends. Today it is expensive.
  - How many tens of thousands of $ to save that last $50/year?
- Is net positive the best solution? What about off-site wind, hydro, biomass, natural gas, etc.

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## Conclusions

- Any building is a set of allocation of a limited set of resources—financial, societal, etc.
- PassivHaus tells people not to pile PVs on a bad house to “make up for their sins.”

| Climate Zone | Wall | Vented Attic | Compact Roof | Basement Wall | Exposed floor | Slab edge[1] | Windows (U/SHGC) | Sub-slab[2] |
|---|---|---|---|---|---|---|---|---|
| 1 | 10 | 40 | 35 | 5 | 10 | none | yes | none |
| 2 | 15 | 50 | 40 | 10 | 20 | 5 | 0.35/<.25 | none |
| 3 | 20 | 50 | 45 | 10 | 20 | 7.5 | 0.30/<.3 | 5 |
| 4 | 25 | 60 | 45 | 15 | 30 | 7.5 | 0.30/<.35 | 7.5 |
| 5 | 30 | 65 | 50 | 15 | 30 | 10 | 0.24/<.50 | 7.5 |
| 6 | 35 | 75 | 60 | 20 | 40 | 10 | 0.18/-- | 10 |
| 7 | 40 | 90 | 65 | 25 | 45 | 15 | 0.15/-- | 15 |
| 8 | 50 | 100 | 75 | 35 | 50 | 20 | 0.15/-- | 20 |

Table 0.2: Current Recommended “True” Minimum R-value (+/- )[3] including thermal bridging

Research Report – 1005: Building America Special Research Project: High R-Value Enclosures for High Performance Residential Buildings in All Climate Zones