Keynote Presentation for
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Advanced Housing Renovation with Solar & Conservation
Meeting May 19, 2009

University of Waterloo

Low Energy Buildings Retrofits
Stories from the trenches

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Research Toward Zero Energy Homes

The Problem

- We have been living to excess for too long

Current crises:

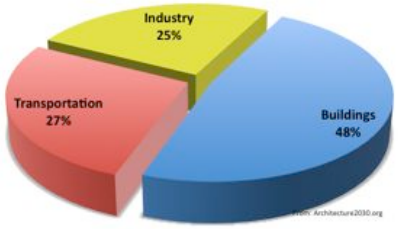
- **Carbon emissions**
- **Energy Security**

General on-going problems

- Excessive resource use
- Damaging emissions
- Habitat destruction, run-off etc

Buildings

- Buildings are a major contributor to the problem
- Low-energy / green is not a "style" "movement" etc, but a societal imperative



United Nations IPCC Mitigation Report May 2007

"Biggest & Cheapest CO2 reduction are in buildings"

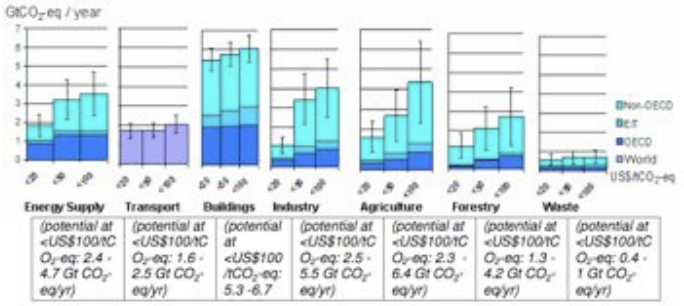


Figure SPM 6: *Estimated sectoral economic potential for global mitigation for different regions as a function of carbon price in 2030 from bottom-up studies, compared to the respective baselines assumed in the sector assessments. A full explanation of the derivation of this figure is found in 11.3.*

Reasonable Building Targets

- 30% reductions currently economic optimum for new buildings
- 50% reduction cost little today
- Long-term (25+ yrs)
  - 60-90% reductions for new and retrofit
  - Depends on technology/economics of generation vs production
- Renewables before conservation are irresponsible

New-build Office Kitchener

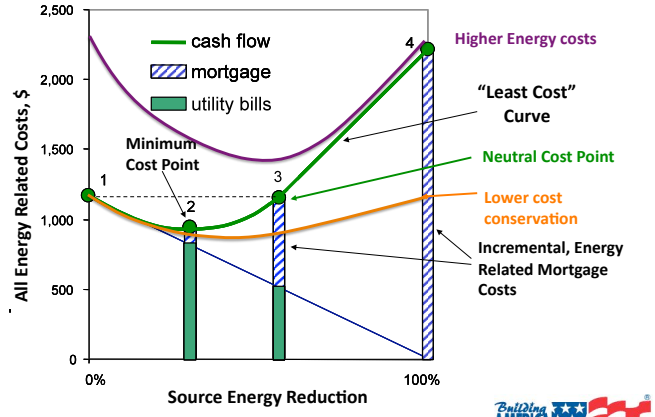
Market cost
Durable
Healthy
35% of energy
120 kWh/m²/yr

- Green doesn't have to look or feel different

Dorset St Green Office/MURB office

Market cost
Durable
Healthy
40% of energy
110 kWh/m²/yr

Capital Investment vs Operating Cost



Underlying Source: Dr Ren Anderson, NREL

Building America U.S. Department of Energy Research Toward Zero Energy Homes

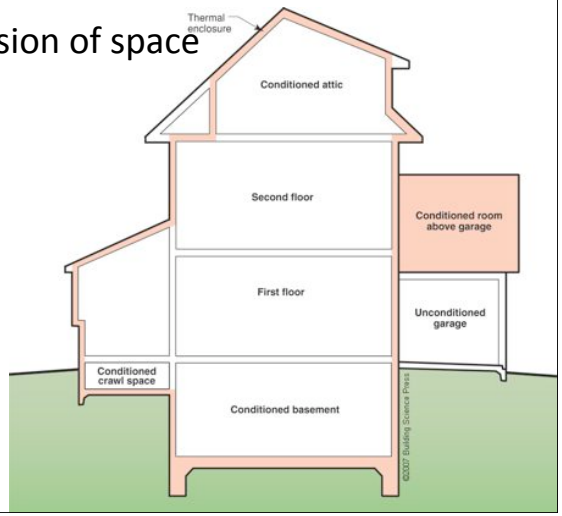
Deep Retrofit:

- Major proportion of emissions are from existing buildings
- Any comprehensive policy must deal with existing buildings
- Half measures should not forestall proper solutions
  - Leave more significant future upgrades open
  - EcoEnergy good, but .. we need more

Why Retrofits?

- Not just energy!
- Improve comfort!
- Fresh new look
  - Avg new kitchen is $25000
- Expand living space
- Improve air quality
- Improve durability safety

Expansion of space



Energy

- Space heating and DHW is often 60-80% of total energy
- Insulation, airtightening can save 50-75% of heating
- Better mechanicals/appliances save 20-40% of heating, DHW, and electricity
- Then .. renewables such as SHW and PV can reduce energy consumption further

Process

- Major issue in retrofits
  - People are usually living in home
- From exterior is much easier, safer, cheaper and more powerful
  - Huge benefits not understood
- Staging windows, mechanicals, enclosures
- Conservation economical now!
  - Renewables are still expensive, but get ready …
  - Beware climatic differences

Above grade walls

- Interior retrofit limits improvements to airtightness, rain control, thermal bridge
- Exterior allows excellent improvements and increased durability
- Windows should be done at the same time
- Installation cost $200+/- so get good windows, eg vinyl triple glazed for $30/sf

Windows

- Important choice!
- Improved R-value of course
  - Triple are still low volume = high cost
  - Starting to become more affordable
- Need better rain control

Mechanicals

- Air-to-water low temperature heat pump
  - System COP=2.3 @-10C, $4500
- High Efficiency HRV
  - 75% efficiency, 35W, 40 cfm, $500
- Ductwork
  - Low pressure drop, good filter, $2000

Underway

Better Durability
Much Healthier
Much more comfortable
Est **<70 kWh/m²/yr**

Energy / Economy

- Energy-related upgrades cost :$22-25K
  - Heatpump, ducts, HRV $4500+2000+500
  - Basement/walls insulation $5200+4200
  - Windows $5000+ 2500
  - Attic $1250
- Many other upgrades: bed, bath, flooring, basement double floor space (another 40K)
- Savings: ca $2000 / yr

Future

- Add active renewable energies
  - As their cost drops
- Purchase renewable energy
  - As it becomes available

Existing 1916 Four Square

www.buildingscience.com
search for "retrofit"

How a 100 year old house is renewed to last an additional 100 years

Mechanical Systems BEFORE

Heating	60% AFUE for the old boiler -gas -delivered by radiators
Cooling	9 EER for the window units
DHW	0.4 EF for hot water efficiency- AVERAGE summer efficiency is much worse winter efficiency would be about at 60% (since the boiler is heating the house already)

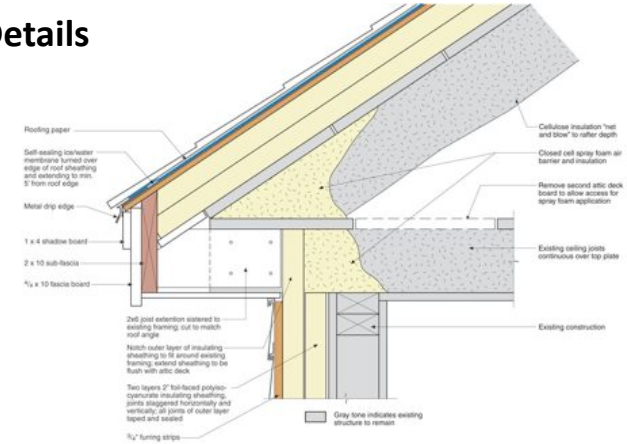
Mechanical Systems AFTER

Heat	Sealed combustion 92% AFUE gas boiler boiler in conditioned basement
Cooling	14+ SEER split system in conditioned space
DHW	0.82 EF side-arm storage tank
Ducts	R-4.2 flex runouts in dropped ceiling or in floor joists
Leakage	none to outside (5% or less)
Ventilation	Fan Cycler Supply-only system integrated with AHU 33% Duty Cycle: 10 minutes on; 20 minutes off 60-80 CFM continuous average flow
Return Pathways	Transfer grilles/jump ducts at bedrooms

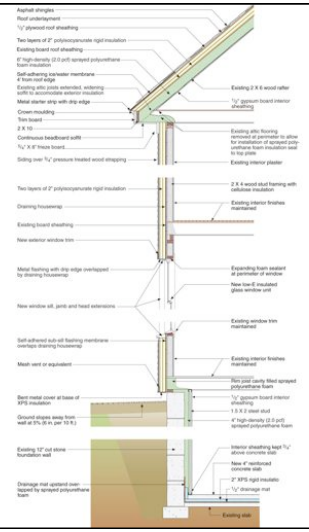
New Windows

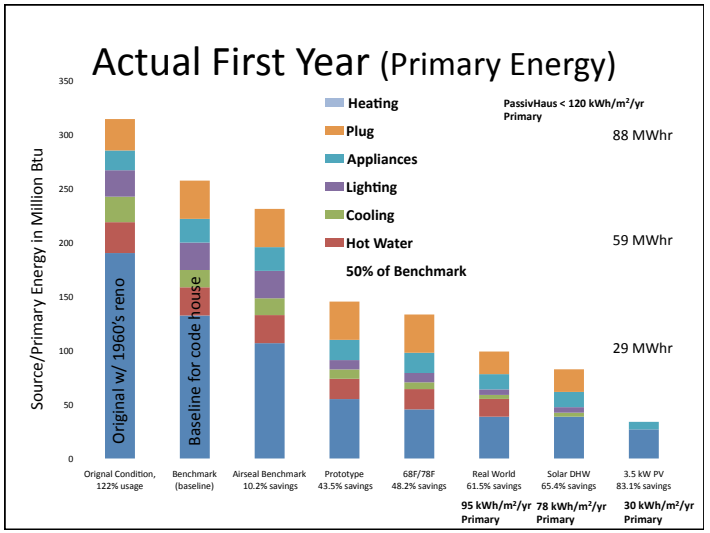
Photos courtesy of Dan Morrison, *Fine Homebuilding Magazine*

Details


Roofing paper
Self-sealing ice/water membrane turned over edge of roof sheathing and extending to min. 5" from roof edge
Metal drip edge
1 x 4 shadow board
2 x 10 sub-fascia
5/8 x 10 fascia board
2x6 joist extention sistered to existing framing, cut to match roof angle
Notch outer layer of insulating sheathing to fit around existing framing, extend sheathing to be flush with attic deck
Two layers 2" foil-faced polyiso-cyanurate insulating sheathing, joints staggered horizontally and vertically; all joints of outer layer taped and sealed
1½" furring strips
Cellulose insulation "met and blow" to rafter depth
Closed cell spray foam air barrier and insulation
Remove second attic deck board to allow access for spray foam application
Existing ceiling joists continuous over top plate
Existing construction
Gray tone indicates existing structure to remain

Building Section





Actual First Year

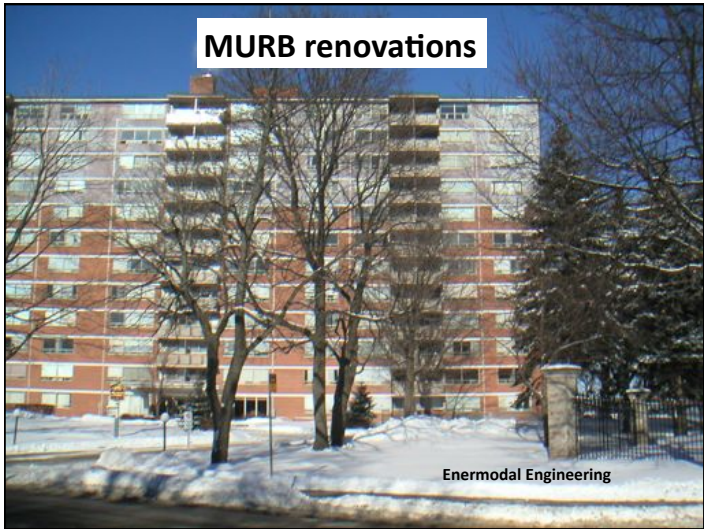
3200 kWh and 570 Therms gas (16700 kWh)
67 kWh/m^2/yr *Site* Energy

Electric @ $.15 /kWh Gas @ $1.50/therm
Electric $471 Gas $858
Electric/mth - $39 Gas/mth = $71
At *today's* rates:
Electric $576 Gas $998

Initial Cost Of Measures	Annual Savings	Annual Finance	Cash Flow
$75,000	$4005	$4832	($827)

If energy prices rise 20%, cash flow exceeds cost of measures

Energy Measures =
New Mechanical Systems, Insulation, and New Windows



- Easy, cheap
- Order matters

How far should we go?

- Reduction of ½- 3/4 can be easily achieved today
- Even Zero Energy house likely not the best goal
  - Need to pay for the grid, deal with intermittency
  - Take advantage of wind, hydro, cogen, etc
- PassivHaus seems too much conservation
  - Cost of RE generation is lower than the cost of extreme efficiency
    - PV dropping.. Soon <$0.20/kWh, wind <$0.10/kWh
- Design of v. low / zero energy buildings is brittle

Technology Needs

- Not many significant obstacles …
- Smaller heating systems
  - Particularly non-gas, and storage, ASHP
- Lower cost high performance windows
  - R5 becoming affordable
- Controlling plug loads / vampire loads
- Cladding attachment
- Codes and Setbacks

Conclusions

- Carbon emissions & energy security require buildings that use much less energy
- Economics argue for better buildings
- Technology exists for better buildings
- Missing links not really technological
  - Regulation, demonstration, trade knowledge, academic dissemination, banks, insurance, measured data paucity

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search for "retrofit"