Thermal Retrofit: Planning for Negawatts

Presentation to Post Carbon Toronto

By Peter Shepherd
Green City Construction
peter.shepherd@sympatico.ca

May 31, 2011

What is Retrofitting?

- By current practice, it’s to upgrade the thermal envelope of a building by:
- Air Seal (foam, caulk, new windows and doors) & Insulate
- Heating, Ventilation and Air Conditioning (HVAC) Upgrade/ Replace

When to Retrofit

- Is your place:
- Cold and drafty in winter?
- Hot and humid in summer?
- Do you have:
- High energy costs?
- Moisture Problems?
- Opportunity during renovation?

Scheduling Retrofits

- During: Upgrading of an existing house
- Best twinned with renovation plan following a full energy audit
- Based on a plan using blower-door & heat-load calculations to prioritize the most cost-effective, doable actions.

Shallow Retrofits

- So far, most under Energuide are shallow retrofits
- Planning is essential
- Can do retrofit in stages room by room, but hard to get to deep retrofit this way.

Deeper Retrofits

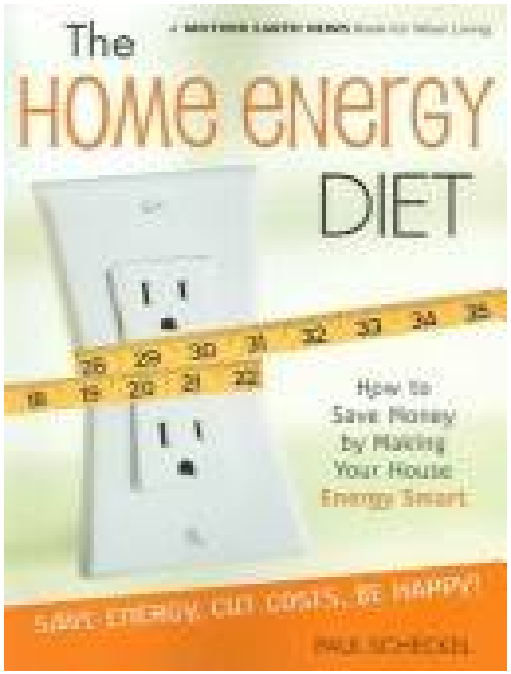
- Costs: could be between $90,000* to $300,000 for an average sized house, including HVAC.
- Best to get Greg, David, or other designer familiar with deep retrofit. The good news is that design-work is happening very quickly, so much less trial & error than before.
- *Massachusetts Superinsulation Project http://superinsulating.blogspot.com/2008/11/media-attention-and-vip-visits.html

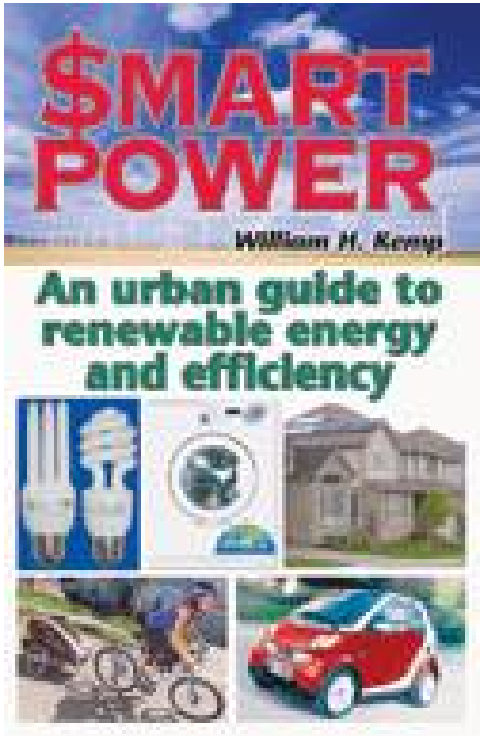
Steps

- Step 1 : AUDIT
- Step 2: Design, Cost & Schedule
- Step 3: Get to Work

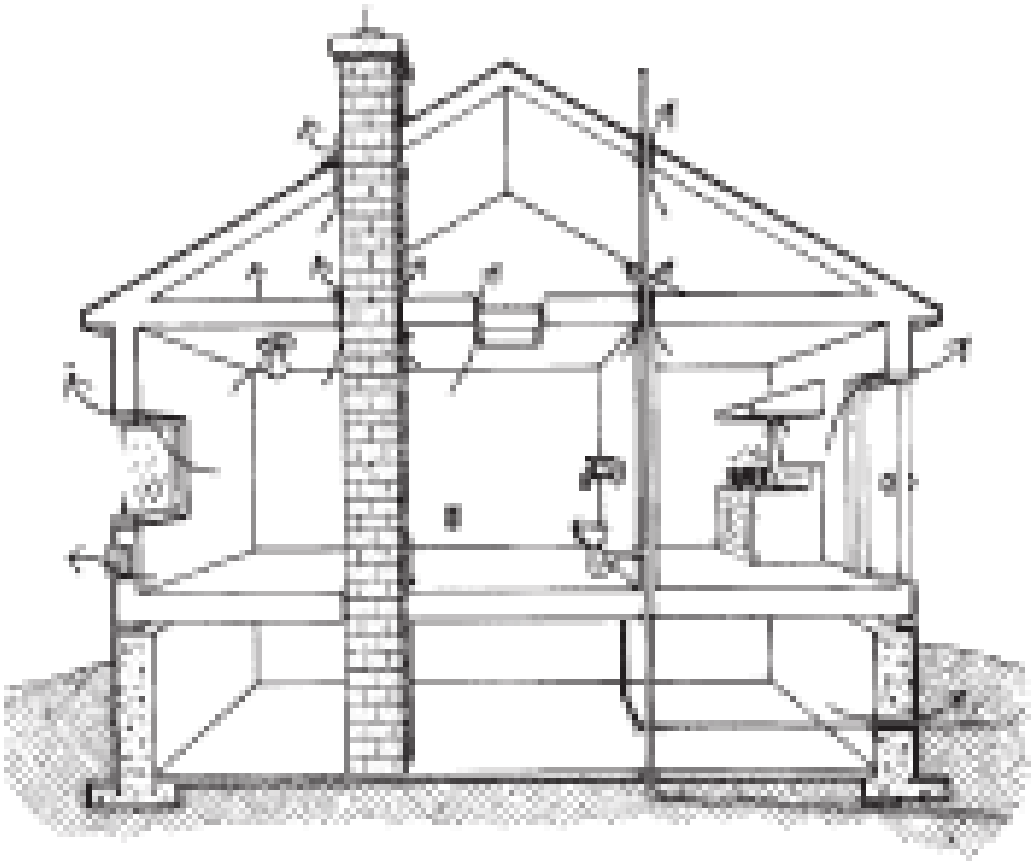
First Phase: The Audit (How To's)

- "The Home Energy Diet" by Paul Scheckel, 2005 (US)
- "Smart Power" by William Kemp, 2006 (Canada)
- Ecoenergy audit when program restarts

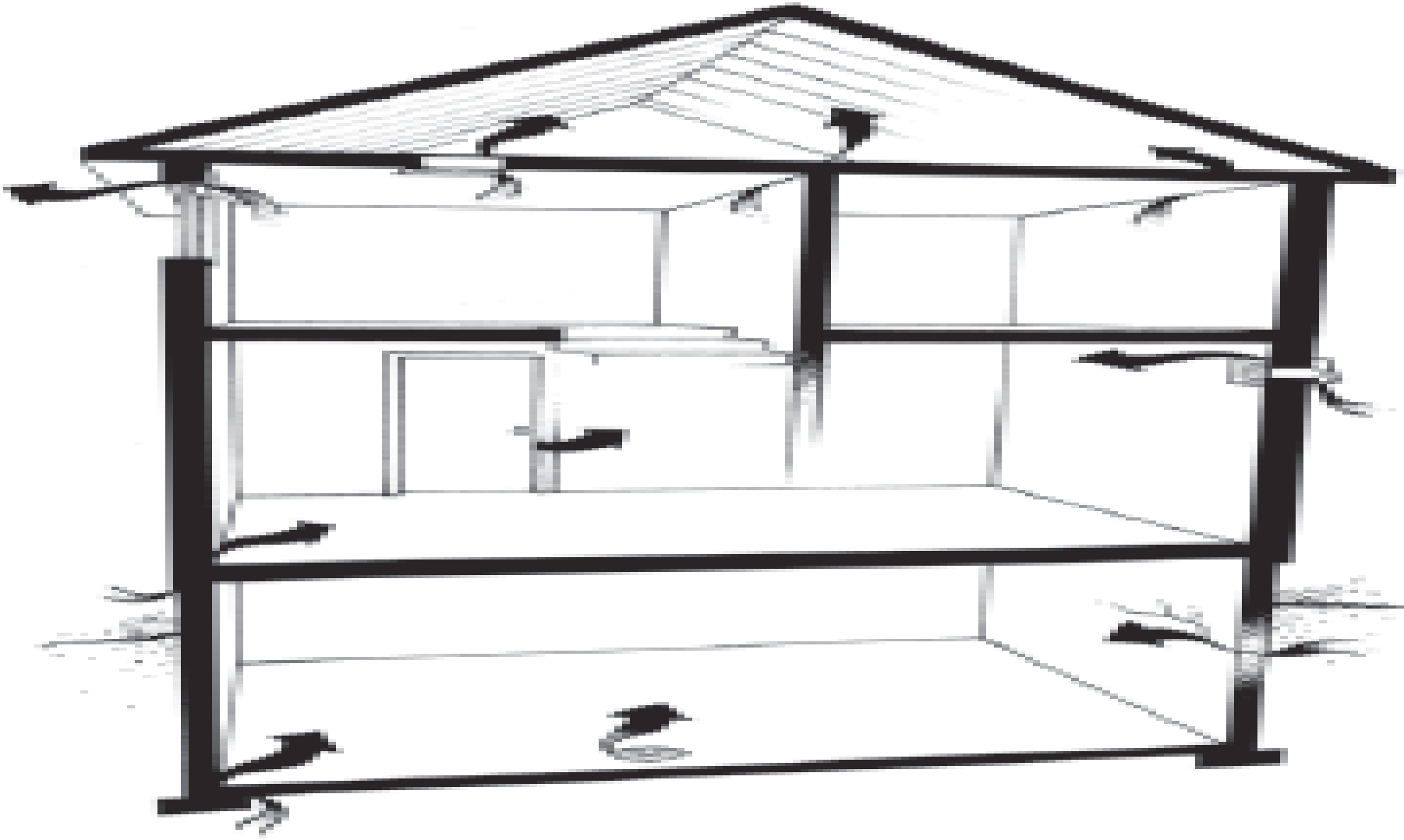




Typical leakage areas



Typical leakage areas



Toronto Example from Riverdale

- 2007 A second-floor room retrofit in a brick semi-detached, then 2010 foaming inside of third floor N. wall
- 2007: front bay window wall

& adjacent wall with a chimney

Specifications

- Owner specified minimum insulation level to R-18, and R22 where possible, no EPS or XPS foam board, or spray- polyurethane foam (SPF).
- New housing is now built to Energuide 78 rating, environmentalists lobbied to make it 80
- R-2000 meet minimum Energuide 80

Demolition phase

- Demolished plaster walls and brick strapping to maximize space to be insulated
- Prior to this, a decision had to be made: NRCAN suggested merely scratching the old painted wall to avoid having a ‘double’ vapour barrier

What was decided:

- We removed plaster wall ENTIRELY
- Why: because there was a lot of wallpaper, and the paint was likely lead paint (used turbine respirator)& the occupant 8 years old
- By doing so, 1 ¾” of floor space was gained

Thickening Walls

- Most new inner walls became 5 ½” thick
- Bay window added only 2 ½”

Opportunity to insulate floor above

- I cut a ceiling channel above the wall to be insulated
- A convenient time to insulate joist space to stop convection currents and heat loss

Here I sealed the mortar joints with foam

Creating wind & moisture barrier

- I then put house wrap into joist space, and 15 lb felt paper onto the wall
- I sistered the ceiling joists with metal studs to make ceiling flat

Ceiling joist bays were insulated 16” deep with Roxul, making floor above warmer

Stapling housewrap below bay window

- I filled stud cavities with fibreglass before adding a new 2 ½” thick steel stud wall in front of existing framing
- New windows are triple-glazed, double low-e, and argon filled

Adjacent Wall

- I added a new 2 x 4 wall in steel stud, and offset it 5 ½” from inside of brick wall to make space for insulation.

Potential for Wiring Upgrade

- We took this opportunity to map local circuits, rewired to balance electrical load between adjacent rooms, and added two more receptacles

Vapour Barrier

- I insulated the wall and covered it with a rated, six mil * virgin polyethylene vapour barrier, sealed at joints with red tuck tape
- Buildingscience.com has persuaded U.S. code authority that this isn't needed in a climate like Toronto's, however with direct-vent furnaces there's now more humidity in houses.

- * (0.006" = 6/1,000 of an inch).

Dec 2010 Spray-foam

Split-jamb operation

Joseph Lstiburek's permeable 'slick design'

Chimney after foaming

Case #3: Toronto West End: Exulating a basement foundation after exterior damp-proofing

- This was initiated as we'd had our basement floor lowered slightly the previous year (and done interior damp-proofing), but I was concerned about the structural stability of our brick house after discovering a patch of weak soil. Thus we decided to damp-proof the outside for good measure, and insulate the outside, hence 'exulation'.

Gravel bed over weeping tile, then insulation will go over membrane

Propping insulation against wall

Tamping gravel bed down over weeping tile

Exulating foundation after full exterior damp-proofing

- I would now chose fibre-type drain-cladding or EPS insulation over this extruded board, as the blowing agent for extruded has an extremely high GHG potential and low environmental payback.

Better foundation retrofit design:

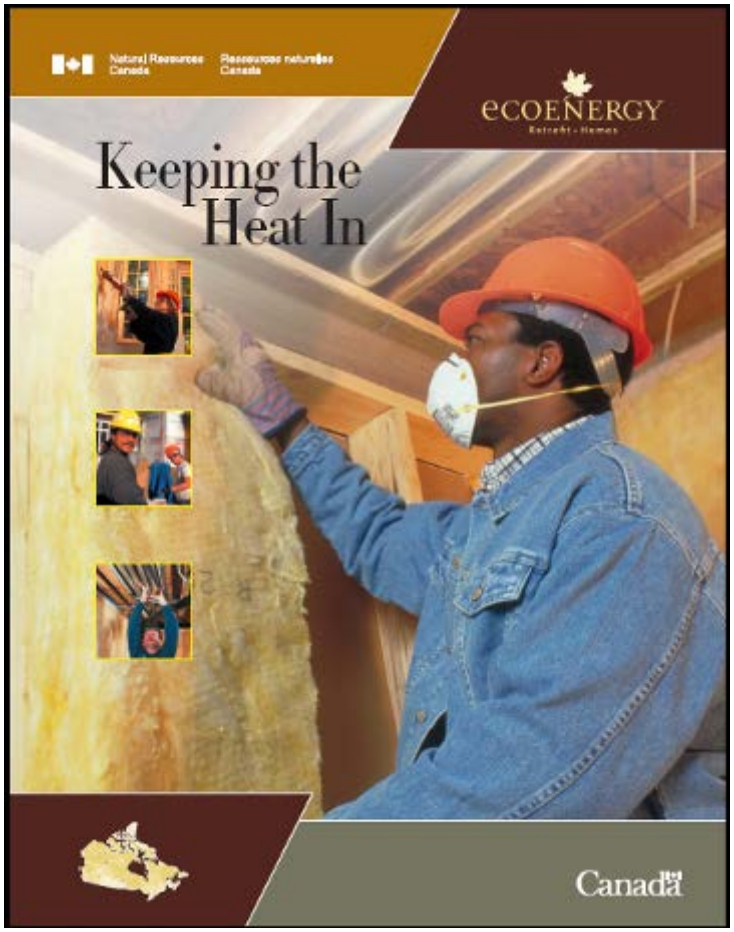
- Out west Pressure-treated Wood Foundations (PWF) can be used as soil drains better. In Toronto there's too much loam (except High Park) & unsorted glacial till, so better to use Roxul Drainboard or EPS Type I (first 2") + Type II (8"), rising from footings to 12" above grade.

Chainsaw Retrofit time-lapse Day 1 in 2.5 minutes

http://www.youtube.com/watch?v=Kp4cBUXnH-k

Wrapping entire bungalow in super-six poly

Canadian Guide to Retrofitting:



"Keeping the Heat In"

http://www.oee.nrcangc.ca/publications/infosource/pdfs/heat_in.pdf

Passive Buildings Canada, R-2000 Standards; Netzero - CMHC & Coalition links

- http://www.passivebuildings.ca
- http://oee.nrcan.gc.ca/residential/personal/new-homes/r-2000/standard/current/purpose.cfm?attr=4
- https://www03.cmhc-schl.gc.ca/b2c/b2c/init.do?language=en&shop=Z01EN&areaID=00000000142&productID=0000000142000000015
- http://www.netzeroenergyhome.ca/

Retrofit links

- CMHC www.energy**retrofits**forhouses.com October 2009 retrofit conference with presentations
- Time lapse chainsaw retrofit http://www.youtube.com/watch?v=Kp4cBUXnH-k
- Canada's First Net Zero Energy Show Home - 2010 http://verecohome.com
- Two super upgrades one in Saskatoon and one in Edmonton, Photos by Ian MacLeod http://www.facebook.com/#!/album.php?aid=258200&id=504662648
- Photos by Dale Rowe http://www.facebook.com/#!/album.php?aid=251466&id=620869193&fbid=461648609193
- Peter Burstyn's tips for home dwellers http://janetsplanet.ca/?p=1192

Retrofit links ctd.

- http://www.buildingscienceconsulting.com/presentations/documents/2011_Canadian_Conference_Science_Technology_Keynote_Straube.p
- Poly-iso-cyanates in Spray Polyurethane Foam (SPF), http://www.greenbuildingadvisor.com/blogs/dept/green-building-news/waiting-epa-action-spray-foam-insulation?utm_source=email&utm_medium=eletter&utm_content=20110511-off-grid-photovoltaic-systems&utm_campaign=green-building-advisor
- “The agency said it also might consider regulating consumer products containing one or the other of two di-isocyanates in particular – methylene diphenyl diisocyanate (MDI) and toluene diisocyanate (TDI).”

- 1. How Do You Retrofit an Old Building to be Energy Efficient And Durable? Joe Lstiburek http://www.greenbuildingadvisor.com/blogs/dept/building-science/insulation-retrofits-old-masonry-buildings-building-science-podcast
- 2. Interior Insulation Retrofits of Load-Bearing Masonry Walls in Cold Climates, Bldg Sci Dig 114; bsd114_masonry_retrofit.pdf (application/pdf Object)
- 3. Final Report on the Expert Meeting for Details for Deep Energy Retrofit, Building Science Corporation Industry Team March 12, 2010 bsd114_masonry_retrofit.pdf (application/pdf Object)
- 4. BSC Information Sheet 401 Air Barriers–Airtight Drywall Approach for All Climates
- www.buildingscience.com/.../information-sheets/...air-barriers/air-barriers-airtight-drywall-approach/.../bscinfo_401_airtight_drywall_approach.pdf

- To begin to calculate risk of 9% ice expansion to Riverdale 3rd floor brick wall with 4.5” foam inside:
- Toronto (Zone B Canada) likely is in same (Zone 6 USA &) latitude as Portland Maine (Toronto half as wet), which Joe Lstiburek said he might limit R-value to 10 = 1.5” SPF
- Toronto January average 55 mm precip, mean temp – 4.5 C (http://www.toronto.ca/toronto_overview/climate.htm)
- Portland Maine January: 19 F average temp = - 6 C; precip 4.04” = ~ 103 mm; (http://www.great-maine-vacations.com/weather-portland-maine.html)
- So Portland Maine has about twice the winter precipitation that Toronto does.
- A driving rain can saturate the outer wythe of a solid brick wall within minutes of a heavy rainstorm. Danny’s North wall would be most susceptible to freeze-thaw in February if mainland & Toronto Island have similar wind direction.
- http://www.windfinder.com/windstats/windstatistic_toronto_island.htm

Windfinder - Wind & weather statistic Toronto Island - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.windfinder.com/windstats/windstatistic_toronto_island.htm

Windfinder - Wind & weather statisti...

sms tools wind statistics weather reports forecasts waves/ocean webcams directory news

Wind & weather statistics > North America > USA Great Lakes > Toronto Island

Find weather

Wind legend

= North
= North northeast
= Northeast

Configuration

Change units

Surfspot

Tide forecast
Surf- & sailing schools
Surf- & sailing shops
Kite- & windsurf spotguide
Weather & surf webcams

Homepage weather

» Wind forecast for your website
» Set up your own weather station
» Set up your own webcam
» Contribute weather data

Past weather

» Historical weather data

Windfinder - Wind & weather statistic Toronto Island

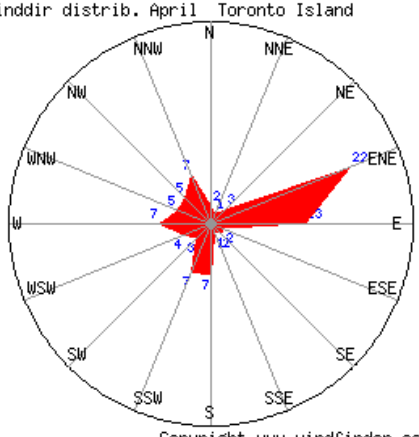
Wind statistic | Wind report | Forecast | Super Forecast | Local forecasts

Toronto Island (TORONTOI)

Statistics based on observations taken between 2/2007 - 10/2010 daily from 7am to 7pm local time.

Month of year	Jan 01	Feb 02	Mar 03	Apr 04	May 05	Jun 06	Jul 07	Aug 08	Sep 09	Oct 10	Nov 11	Dec 12	SUM 1-12
Dominant Wind dir.													
Wind probability > = 4 Beaufort (%)	53	42	42	47	36	26	14	21	26	34	41	49	35
Average Wind speed (Knots)	12	11	11	11	10	8	7	8	8	9	11	12	9
Average air temp. (°C)	-2	-1	2	8	13	19	22	22	18	12	6	0	9
Select month (Help)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year

Winddir distrib. April Toronto Island



Wind direction Distribution April(%)

Done

start | RetrofitStudy | Integated Plan for ... | How Do You Retrof... | Windfinder - Wind ... | 11:30 AM

- Toronto is in a mixed humid climate, http://en.wikipedia.org/wiki/Geography_of_Toronto
- Köppen climate classification Dfa to be precise [though this particular www has an AGW denialist spin.]
- ----------
- Weathering of Building Infrastructure and the Changing Climate: Adaptation Options. Heather Auld, Joan Klaassen, Neil Comer
- http://pyr.hazards.ca/Docs/images/Weathering_of_Building_Infrastructure-1568988253.pdf
- Preliminary studies indicate that in much of Canada, freeze/thaw cycles are happening more frequently during the year (CCME, 2003). Most of the stronger trends have been found in southern Ontario (Klaassen, 2001). The weakest have been in British Columbia. At Trenton, Ontario, thaw/freeze
- events (defined for changes from -2°C to +2°C) have been increasing at the rate of 3.2 days per decade. At Swift Current, Saskatchewan, the rate is 3.9 days per decade. An interesting exception is the city of Toronto, where thaw/freeze cycles have been decreasing, likely influenced by urban heat effects associated with the city's growth, with a leveling out of the effect observed in the past two decades, as urban development in the downtown core has peaked. (Klaassen, 2001.

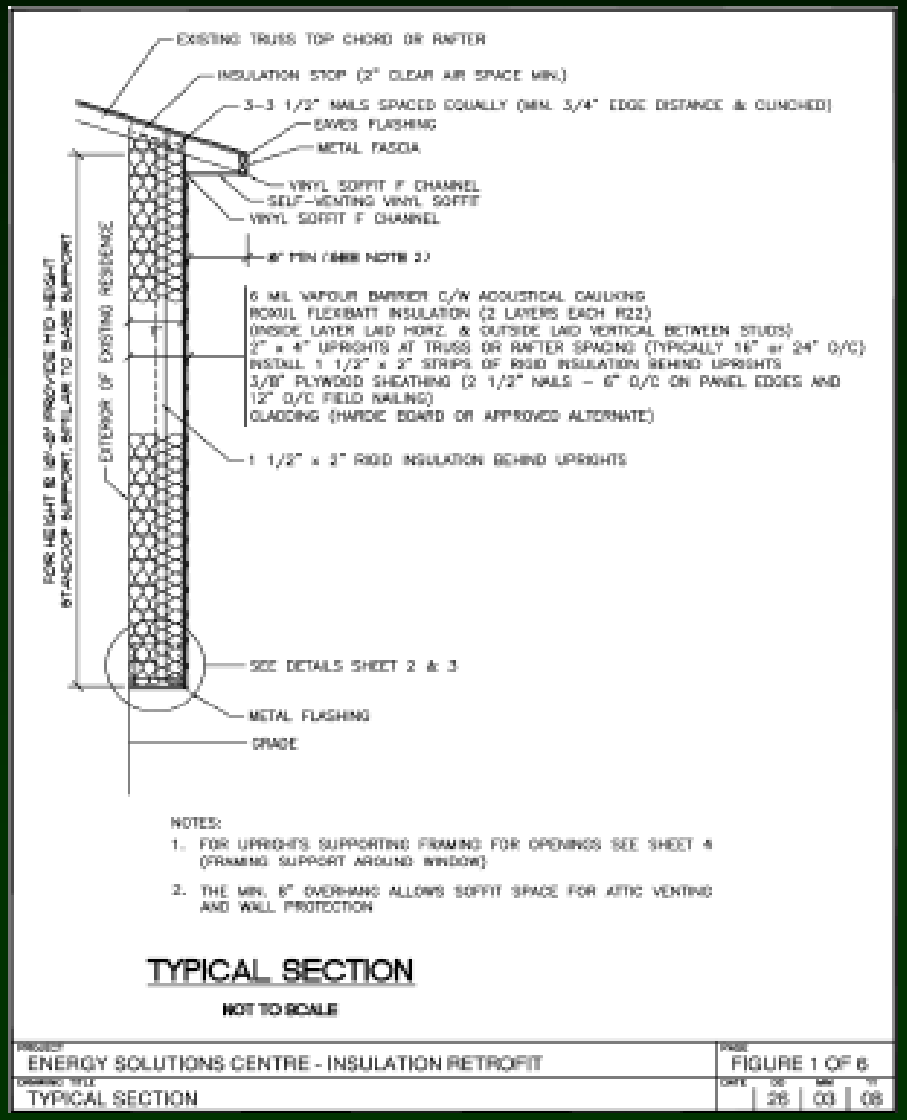
- The dominant drying mechanism in a solid brick wall is: capillary flow, which is essentially unaffected by insulation, though diffusion drying capacity & surface evaporation is reduced due to lowered temperature of brick compared to the cold air.
- It's best to reduce the external wetting mechanisms at least proportionally to the reduction in drying capacity, and to ensure permeance to the inside to allow for drying in that direction. [from Straube's "Interior Insulation Retrofits of Load-Bearing Masonry Walls in Cold Climates]

- In http://www.buildingscience.com/documents/reports/rr-9910-wood-durability Joe L says:

- A polyethylene vapor diffusion barrier and air barrier should only be
- used in very cold hygro-thermal regions. If it is used in other regions it reduces drying potentials to the interior more than it reduces wetting potentials from the interior.
- Flow through design (drying to both the interior and exterior) should be applied in mixed-humid hygro-thermal regions.
-

- [Peter]:My preference is to super-insulate brick from the outside where possible, especially at back & sides of a house where looks & preservation could be less valued. The draw-back of a hybrid inside/outside design is the intersection between them – how can you complete the critical air-seal?
- See http://www.buildingscience.com/documents/insights/bsi-047-thick-as-brick/ to evaluate brick quality.

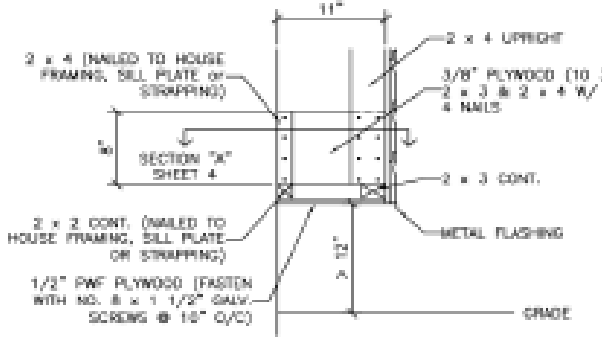
http://www.nrgsc.yk.ca/



TYPICAL SECTION

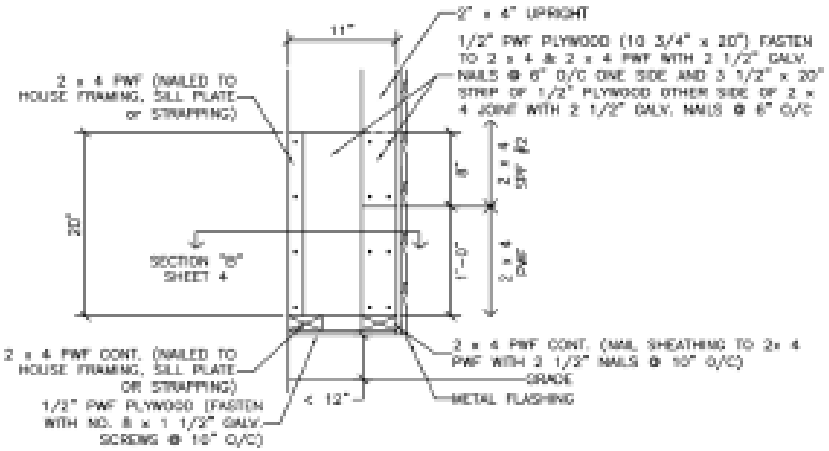
NOT TO SCALE

PROJECT: ENERGY SOLUTIONS CENTRE - INSULATION RETROFIT | PAGE: FIGURE 1 OF 6
DRAWING TITLE: TYPICAL SECTION | DATE: DD 26 | MM 03 | YY 08



BASE DETAIL 1 -) 12" ABOVE GRADE

NOT TO SCALE



BASE DETAIL 2 - (12" ABOVE GRADE

NOT TO SCALE

PROJECT: ENERGY SOLUTIONS CENTRE - INSULATION RETROFIT | PAGE: FIGURE 2 OF 6
DRAWING TITLE: BASE DETAILS ABOVE GRADE | DATE: DD 26 | MM 03 | YY 08