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EMERGING INSULATION PRACTICES for RESIDENTIAL USE: DEEP ENERGY RETROFIT

Description:

In 2008, residential homes accounted for 22 per cent of the annual energy consumption in the United States.[1] Out of the total energy consumption in an average household, 50 per cent goes to space heating, and four per cent goes to air conditioning.[2] There are 94 million homes in the United States that were built before 1991, which is when energy codes of any sort took effect—needless to say, there is great opportunity to improve the energy-efficiency of existing housing stock across the country. Of particular interest is housing stock in the Northeast United States, due to the area's high dependence on space heating.

The Northeast is vulnerable to high space-heating needs due to colder-than-average winter seasons. In addition to this high need, many Northeast communities are rural in nature and do not have natural gas pipeline supplies as an energy source. By default, then, fuel oil becomes the energy source of choice, and fuel oil is the most vulnerable to price fluctuations because of its connection to the cost of a barrel of crude oil on the open market as well as its place in a global economy and political environment. Performing a "deep retrofit" and eliminating a heating system that relies on fuel oil can reduce a homeowner's vulnerability to price swings.

Deep energy retrofitting will drastically improve the energy performance of an existing home, providing multiple benefits and a significant, long-lasting solution to rising energy costs. The term "*deep*" energy retrofit refers to a practice that goes well beyond the current common practice of performing energy-efficiency work. This practice involves:

- Substantially improving the exterior building envelope with aggressive, emerging insulating practices (*e.g.* installing polyurethane rigid panel insulation, or applying open-cell polyurethane spray foam insulation after build-out),
- Installing new, energy-efficient windows or relocating existing ones,
- Sealing the building's below-grade foundation to the wall connections, and
- Sealing the roof to the wall connections with insulation that also provides an air barrier.

The following mechanical practices are then implemented to complete the overall retrofit:

- Incorporating whole-house ventilation, and

- Down-sizing the mechanical plant (HVAC, etc.) typically found in residential buildings.

Performing this retrofit comprehensively, with attention to detail, will typically reduce the whole-building energy load by 40 – 60 percent.

References:

[1] Energy Information Administration (June, 2009), "Energy Consumption by Sector Overview," Figure 2.1a, *Annual Energy Review 2008*. Washington, DC: U. S. Department of Energy. http://www.eia.doe.gov/aer/pdf/aer.pdf.

[2] Energy Information Administration (June, 2009), *Annual Energy Review—2008*, #DOE/EIA0384(2008). Washington, DC: U. S. Department of Energy. http://www.eia.doe.gov/aer/pdf/aer.pdf.

Benefits:

For consumers, including older adults and younger individuals with disabilities:

- A well-insulated building, with detailed air-sealing:
  - Enhances residents' comfort-level and is effective in controlling the conditioned space (both heating and cooling operations); that is, the home's shell will maintain a stable temperature within the home over a greater period of time.
  - Reduces dependence on the home's mechanical systems (HVAC, fans, etc.) to provide heating and cooling, thereby saving household expenses.
  - Maintains the embodied energy of the existing building.

- Whole-house ventilation provides a healthier living environment for residents by providing constant air-exchange, eliminating stale air, and providing better respiratory activity.

For the community:

- Reduces the need for energy-generation; when such generation uses fossil fuels, less use of such fuels reduces carbon emissions, creating a cleaner, healthier outdoor environment.

- Deep energy retrofitting builds local economies by utilizing labor and skill rather than expensive technology.

Impediments or barriers to development or implementation:

- There is limited understanding by the workforce of newer insulation methods and materials, or of the synergy between envelope improvements and reduced dependence on mechanical systems.

- Deep retrofit work and materials are perceived by homeowners to be cost-prohibitive, with a long time-period for a return on the initial investment perceived.

- Lending institutions often lack appraisers who have the knowledge or experience to value a deep retrofit improvement project, and there are too few financed deep retrofit projects available that can serve as comparables for appraisers.

- Providing these retrofitting services requires a significant investment in training and education, requiring a longer lead time to develop contractor-capacity than is required to develop contractor-capacity for equipment (widget) based programs.

- Workforce-capacity includes training the entire network: contractors performing the work, mechanical suppliers, building code officials/inspectors, lending institutions, etc.

- Typically, energy-efficiency solutions that are offered do not even consider the elements of deep energy retrofitting work in their strategies—for example, the burden of mechanical over-sizing of new systems, or replacement window salesmen that are energy raters, so every offered solution involves a window.

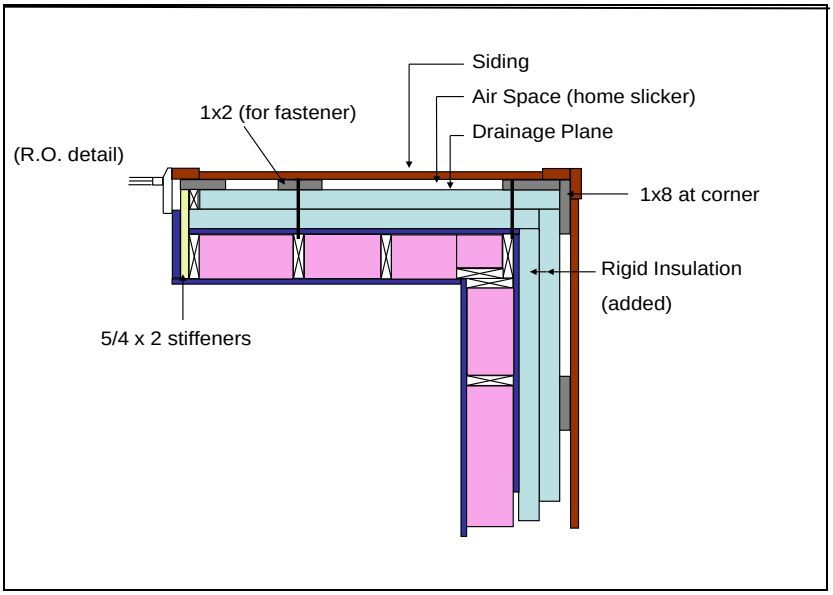
Resource—examples:

- *Cador-Price-Jones project, Somerset, Massachusetts*—a retrofit of a 4,066 sq. ft. 1914 two-family wood frame house, including original windows, siding, and trim. Total Annual Energy Use before the retrofit: 205,500 KBtu/yr (includes heat, hot water, electricity); Project objective: with work performed, reduce this total by 65–70 per cent, or 61,600 KBtu/yr.

Framing using 2x's laid flat is built to create an insulation / air barrier cavity.
5" cavity is sprayed using closed cell foam improves R-value, air sealing, and structural integrity.

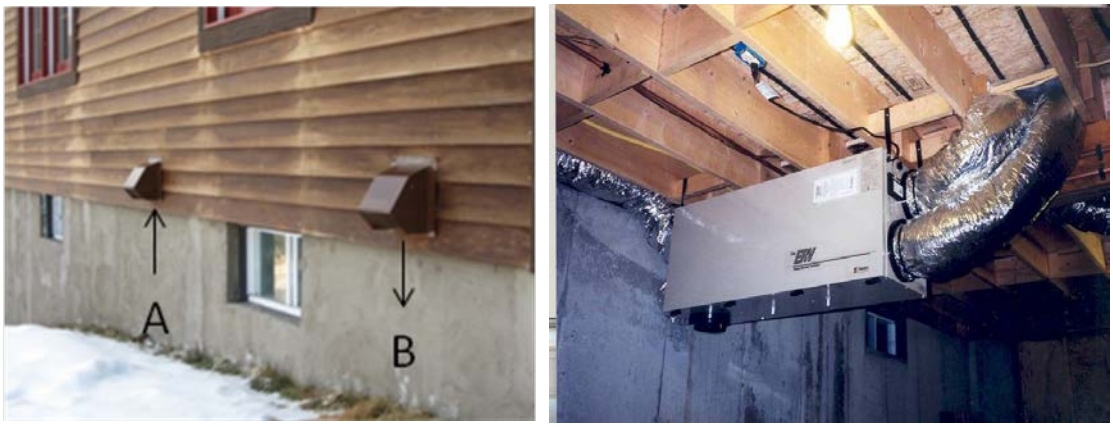
- *Application of rigid polyisocyanurate insulation to the exterior of a residential building:*

2" Polyurethane rigid panel is applied to the exterior of the building sheathing, overlapping the seams of previous layered application, providing a thermal barrier and eliminating "bridging" from the wood material to exterior. Window and door rough openings are trimmed with 5/4 material for finish. Siding is reapplied, leading to drastically improved insulation (R-value) and reduced air infiltration.



Detail for application of the two (2" each) rigid polyurethane panels applied to the exterior sheathing of the building. Note the strapping detail for fasteners and drainage plane. Window and door openings are handled with 5/4 material installed for stiffening the structure and plane.

- *Whole house ventilation installed, in this case using a 300 CFM Energy Recovery Ventilation (ERV) Unit:*



Energy Recovery Ventilator installation includes unobstructed fresh air inlet (A) and return-air outlet (B), with dual core exchange for continuous whole house ventilation, moving 5 CFM constantly throughout the home. Individual timers in high moisture return areas (*e.g.,* bathrooms, kitchens) allows for system to be switched into high speed (30 CFM) to clear the area. This strategy eliminates the need for individual bath fans and exhaust hoods by including these returns into the ERV system. Providing continuous exchange of fresh air into the "tightened" building is mandatory in terms of building and occupant health.

Resource—written and web:

- *Deep Energy Reductions: Links to a series of articles, white papers, presentations, and other resources on deep energy reductions, by Linda Wigington, Director, Deep Energy Reduction Initiatives, Affordable Comfort, Inc., Moon Township, Pennsylvania.* *http://www.affordablecomfort.org/content/deep-energy-reductions*.

- Now House Project, Windsor Near Zero Energy Homes—retrofitting both privately owned and public buildings in World War II era communities across Canada: http://www.nowhouseproject.com/news.php.
  http://www.nowhouseproject.com/.
  Now House Windsor 5: http://www.nowhouseproject.com/news.php.

- Betsy Petit (Spring, 2009), "A Home for the Next 100 Years," *High Performing Buildings*, Vol. 2. A case study of a deep energy retrofit of a Sears Roebuck Kit Home (a staple in American communities between 1908 and 1940). To view online: http://www.buildingscience.com/documents/digests/bsd-139-deep-energy-retrofit-of-a-sears-roebuck-house-a-home-for-the-next-100-years.

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