



BUILDING AMERICA TOP INNOVATIONS 2013 PROFILE

INNOVATIONS CATEGORY:

- 3. Effective Guidance and Tools
- 3.1 High-Performance Home Solutions

TOP INNOVATOR:

BSC, PHI,
NorthernSTAR

Exterior Rigid Insulation Best Practices

A whole-house “overcoat” approach to air sealing and insulating existing homes with rigid foam installed over the roof, walls, and foundations has yielded air leakage reductions as high as 81%. Building Energy Optimization analysis of the strategy indicates source energy savings above 50%. NorthernSTAR’s study found whole-house leakage reductions of 20% to 60% when the roof alone was retrofitted.

Field studies by Building America’s research teams show the most effective ways to take advantage of the thermal, air, and vapor resistance properties of rigid foam insulation on walls, roofs, and foundations.

Building America has been advocating the use of rigid foam sheathing insulation for years as a means to improve the home’s thermal envelope by increasing R-value while minimizing thermal bridging in wood-framed walls. Research by several teams has provided the critical scientific basis for acceptance of foam sheathing by the codes community and understanding of the best practices for implementation to ensure thermal performance as well as air barrier and drainage plane integrity.

Although rigid foam has long been recognized as one of the key Building America technologies for high-R walls, the practice lacked a precise engineering basis for the basic elements of the wall system such as foam thickness, connection schedules, and cladding requirements to resist wind loading. As prescriptive construction provisions in residential building codes came under increased scrutiny in building code forums, the need for a consistent, building-science-based methodology became apparent. Research by the Partnership for Home Innovation, led by the Home Innovation Research Labs (formerly the National Association of Home Builders Research Center) resulted in a design methodology for high-performance walls with exterior rigid foam sheathing under wind pressure loading. At the core of the design methodology is the development of pressure equalization factors for each layer of the wall assembly. These were developed through extensive laboratory testing of full-size wall specimens under high-pressure cyclic wind testing. The research provided a better understanding of the cause and effect of building envelope performance in extreme wind events, which will lead to more intelligent and cost-effective wall solutions that are resilient to disasters. The study formed the basis for the *ANSI Standard FS 100-2012: Standard Requirements for Wind Pressure Resistance and Foam Plastic Insulating Sheathing Used in Exterior Wall Covering Assemblies*. The Standard is now referenced in model building codes soon to be adopted across the US. Thus, the innovative design and construction knowledge from this work met an immediate need and is already positioned to promote structurally safe and efficient high-performance walls with continuous insulation.



BUILDING AMERICA TOP INNOVATIONS

Recognizing Top Innovations in Building Science – The U.S. Department of Energy’s Building America program was started in 1995 to provide research and development to the residential new construction and remodeling industry. As a national center for world-class research, Building America funds integrated research in market-ready technology solutions through collaborative partnerships between building and remodeling industry leaders, nationally recognized building scientists, and the national laboratories. Building America Top Innovation Awards recognize those projects that have had a profound or transforming impact on the new and retrofit housing industries on the road to high-performance homes.



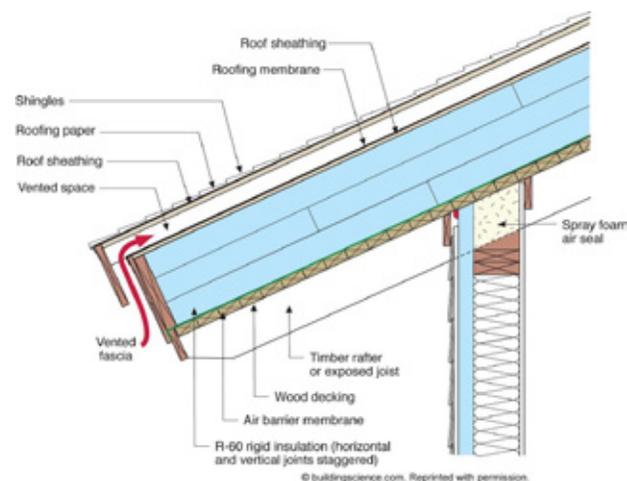
(Top left) NorthernSTAR Partnership’s Project Overcoat home retrofit includes adding rigid foam insulation to the walls and roof of the home.

Building Science Corporation has done several field and test facility studies of rigid structural sheathing. In one study, *Moisture and Structural Analysis for High Performance Hybrid Wall Assemblies*, BSC analyzed several combinations of wall materials looking for an assembly that would provide the most effective thermal, air, moisture, and water barrier systems as well as sufficient structural strength. Using Building Energy Optimization (BEopt), thermal, hygrothermal, and structural analysis, they determined that the optimal framed wall consists of 2 × 6 advanced framing with 1.5-in. closed-cell spray polyurethane foam in each stud bay plus 3-in. of cellulose insulation covered by 0.5-in. gypsum with latex paint finish, with diagonal metal strapping on the exterior covered by 1.5-in. foil-faced polyisocyanurate board insulation and exterior vertical wood strapping for cladding attachment. This wall had the lowest associated incremental cost, lowest associated air leakage condensation risk at less than 1% of the year in Minneapolis, the best structural performance—based on American Society for Testing and Materials (ASTM) E72—and the second best annual energy savings at 34% in Minneapolis and 29% in New Orleans.

In its *Guide to Insulating Sheathing*, BSC describes the use of exterior rigid insulation board in the enclosure assembly to act not only as insulation but also as the primary sheathing and, in certain areas, as the drainage plane and vapor control layer for the wall assembly. BSC discusses the thermal resistance, permeability, and UV resistance of EPS, XPS, and polyisocyanurate individually and the total R-value and condensation potential of various wall assemblies with rigid insulation as a component.

BSC's *High R-Value Retrofit Techniques for Roofs—Unvented Attics* describes the use of multiple layers of rigid insulation above the roof deck as a retrofit technique to insulate an attic and bring it into the thermal enclosure. Another report *Taped Insulating Sheathing Drainage Planes* describes this retrofit measure and proper flashing and drainage around windows and doors. *Hygrothermal Analysis of Spray Foam Insulation Under Plywood and OSB Roof Sheathing* was another study conducted by BSC that assessed the risks of rainwater and construction moisture in attics spray foamed on the underside with open-cell and closed-cell spray foam. They found no risks if the installation complies with the 2012 IRC, a fully adhered leak-free roof membrane is installed, the roof sheathing and framing have less than 18% moisture content before the spray foam is installed, and if a Class II vapor retarder is applied where required when open-cell spray foam is used.

NorthernSTAR Building America Partnership has been investigating the use of an external insulation retrofit approach for existing houses under the “Project Overcoat” label. The overall design intent is to put thermal, air, and moisture control layers over the exterior of an existing building, including the foundation, wall and roof. The approach uses a peel and stick membrane for an air barrier and layers of rigid foam for a thermal barrier to provide exceptional thermal and air barrier alignment and continuity in older homes with simple geometries. The work can be performed with little inconvenience to the interior and the occupants. NorthernSTAR found the approach worked well in 1-1/2 story homes, which are difficult to insulate under the roof due to lack of space and often have serious air leakage problems which can lead to ice dams.



Building Science Corporation prepared this detail showing a home with rigid foam wall sheathing and a vented roof over a heavily insulated sealed attic.

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