Energy Design Update

The Monthly Newsletter on Energy-Efficient Housing

VOL. 34, NO. 11 • NOVEMBER 2014

Wolters Kluwer
Law & Business

IN DEPTH

Treading the Edge of Innovation: Behind the Scenes at The Emerging Technologies Program

Being at the cutting edge of energy efficiency usually means being comfortable with your status as an early adopter. It also entails a willingness to test, trial, and spread the word to others in the industry about nascent technologies preparing to enter the market.

Sometimes great ideas need the right boost to emerge from their nest. Helping to jumpstart this first flight is the primary job of The Emerging Technologies (ET) Program of the Building Technologies Office (BTO). ET supports applied research and development for technologies, systems, and models that contribute to reducing building energy consumption. ET enables the funding and further research that cost effective, energy efficient technologies need for development and introduction into the marketplace. By 2030, such efforts should achieve about 35% in primary energy savings, relative to an energy efficient building in 2010.

The ET Program provides research and development support in 5 core areas: Solid-State Lighting; Heating, Ventilation, & Air-Conditioning (HVAC, includes water heating and appliances); Sensors & Controls (includes transactive controls); Windows & Envelope; and Modeling & Tools. Funding is distributed competitively through solicitations or directly to national labs for core funding.

To get a picture of what's coming next, ***Energy Design Update*** spoke with Karma Sawyer, Technology Analysis and Commercialization Manager and Physical Scientist in the Emerging Technologies (ET) Program within the Department of Energy's Building Technologies Office (BTO).

"Broadly, we are really focusing on emerging technology that offers cost effective, easy to install solutions for both new and existing homes," Sawyer explains. "We are thinking less about how to get the highest performance products into a home and instead are asking how to get high performance products that are also mass market palatable." For Sawyer, this means critically evaluating what the proposed product looks like when it is installed, and asking how builders and service technicians might interact with it.

"How does this product change the way a builder designs a home, or plans a retrofit, to make it more energy efficient?" asks Sawyer. "Consider something like a window film application. A window film product doesn't require 10 different, difficult steps to install it, which could slow down a retrofit process; rather, the product makes the construction process easier." Sawyer sees many opportunities for making performance retrofits easier. "Buildings stay around for a long time. We need efficient products that can be easily added to a building's portfolio to achieve meaning-

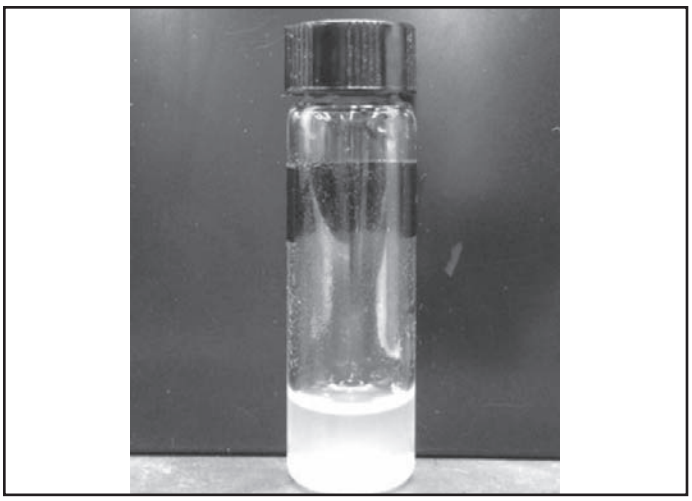

Figure 1. Image of vacuum capsules in water (4 mg/ml) used for dip coating. Image courtesy National Renewable Energy Laboratory.

ful savings." This strategy helps determine priority projects in the pipeline at ET – window films and attachments are at the leading edge. Exterior insulation applications and shading systems are also receiving preeminence.

"From a cost perspective, labor is a substantial fraction of expenses," Sawyer adds. "We're hoping that the strategies we've selected make a quick difference in a very real performance problem."

ET has experienced recent, significant wins through this approach. EnerLogic® window film (*http://www.enerlogicfilm.com*), a low-emissivity (Low-E) film easily added to existing commercial and residential windows, graduated from the ET program and is enjoying considerable market success. According to RESFEN calculations, the product adds 92% more insulating power to existing single-pane, clear glazed windows, and offers 15%-30% savings during heating season and 10%-20% savings during cooling season. Expected return on investment (ROI) averages 2.75 years.

Notable Developments in Fenestration

Transparent Vacuum Insulation

"I'm really excited about this effort, which is the development of an essentially transparent insulation," notes Sawyer. "This would replace older window technology which uses gas, like argon, in an insulated glass unit." The project addresses both the large installed windows retrofit market and the inexpensive, high performing new windows markets, by aiming to substantially improve fenestration and building envelope energy consumption. Highly insulating transparent film would be a game changer for windows, resulting in substantial energy and CO_2 reductions.

"The team has been working on this technology for about a year at this point, doing a lot of analysis to characterize materials," Sawyer adds. "In highly insulating materials, you have to deal with environmental challenges as well as get a verifiable measurement technique to properly assess the material's performance. The team has made a lot of strides and was able to hit the big milestone for thermal conductivity. The work in films, to this point, has been done on a laboratory scale. Now we're moving forward, past looks and performance, and progressing with market strategy."

The research team at the National Renewable Energy Laboratory (NREL) is developing novel evacuated materials that are so small as to be invisible and integrating this material with Low-E coated plastic films (see Figure 1). The ultimate goal is to develop transparent materials that have R-10 to R-20 insulation values and have the correct qualities for easy integration with installed windows. If successful, this insulating film would offer an alternative to full window replacement by bringing existing window performance above or equal to the most advanced replacement windows readily available today. NREL estimates the vacuum insulation could save 2 to 3 quads of energy annually.

"There are a lot of things this insulating material has to do," Sawyer says. "It presents both a hard science and engineer-

Energy Design Update

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Energy Design Update (ISSN 0741-3629) is published monthly by Aspen Publishers, 76 Ninth Avenue, New York, NY 10011. (212) 771-0600. One-year subscription costs $595. *To subscribe, call 1-800-638-8437. For customer service, call 1-800-234-1660. POSTMASTER: Send address changes to Energy Design Update, Aspen Publishers, 7201 McKinney Circle, Frederick, MD 21704*. Permission requests: For information on how to obtain permission to reproduce content, please go to the Aspen Publishers website at *www.aspenpublishers.com/permissions*. Printed in the U.S.A.

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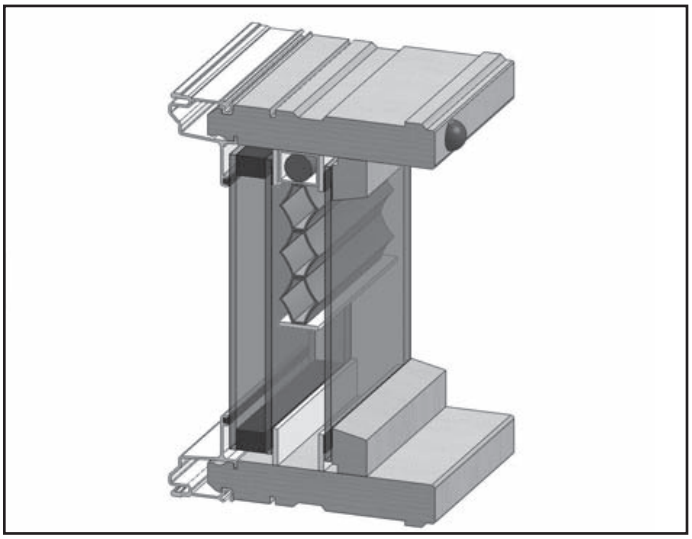

Figure 2. Residential Smart Window with integrated sensors, control logic, and a motorized shade between glass panes. Image courtesy Lawrence Berkeley National Laboratory.

ing problem." The research has set several main goals for the insulation material: use basic processes and materials to form smooth vacuum capsule layers with structure that minimizes thermal conductivity; maintain most of the properties typically associated with thin flexible plastic sheets used for applications like tinting; and make it inexpensive and scalable to high throughput, such as the production lines at plastics and insulation manufacturing companies. The team will work with companies to identify and measure vacuum capsules that have the light transmission, strength, and evacuation and vacuum properties requisite for the new insulation. When possible, the product will use commercially available materials and Low-E coated films from retail suppliers.

By September 30, 2014, the project met its first key milestone: to assess vacuum insulation materials with less than 0.007 W/m-K thermal conductivity. A year from that date, by September 30, 2015, the vacuum insulation, combined with Low-E, is scheduled for external testing.

For more on this technology, including a link to its peer review presentation, visit *http://energy.gov/eere/buildings/downloads/vacuum-insulation-windows*.

Highly Insulating Residential Windows using Smart Automated Shading

Currently halfway through its 3-year research term, the Smart Shading research has developed a highly insulating residential window with integrated sensors, control logic, and motorized shades (see Figure 2). The research team, lead by Lawrence Berkeley National Laboratory (LBNL) built a prototype in collaboration with Pella® Windows.

Chief among the effort's accomplishments is its unique control algorithm. Integrated sensors in the window monitor interior and exterior temperature, exterior solar irradiance, and occupancy sensor. The algorithm evaluates if the home is in heating, cooling, or neutral mode.The control algorithm optimizes performance by linking to data from elements like the utility meter, home automation system, thermostat, and internet. Fully automated operation is provided by an intelligent, networkable sensor/microprocessor package that is installed and calibrated in each window.

The default control algorithm in the window minimizes heating and cooling energy consumption by allowing solar gains when beneficial, and by blocking solar gains to reduce cooling loads.

The prototype Pella window is installed at LBNL's MoWiTT testing facility (visit the window online at *http://smarterwindow.lbl.gov*) where the team is monitoring and evaluating the unit and its annual heating and cooling energy consumption. This design will then be used to fabricate 25 windows, which will be demonstrated in a cold and mixed climate house. The windows will function autonomously and in a networked configuration. LBNL is aiming toward a mature market cost increment of $\$12/ft^2$ of window.

"We've been making some good progress with this research," Sawyer states. "We recently installed our test window at MoWITT and are gathering data. The team has been working closely with Pella on fine-tuning design techniques for the window, shade, and design specifications."

In addition to building a market-ready smart shade window, the team is also working to garner energy code recognition for dynamic products, like the shade and electrochromic coatings.

For more information on this project, visit *http://energy.gov/eere/buildings/downloads/highly-insulating-residential-windows-using-smart-automated-shading*.

Dynamic Window Film

"e-Chromic Technologies, Inc (Boulder, CO) approached NREL to take this idea to the point where we could get private sector investment. e-Chromic able was able to secure venture capital and seed funding, so the project is now largely transitioning out to private development," summarizes Sawyer.

e-Chromic raised concerns about dynamic window film technology. Currently, expense, aesthetics, and durability limit the technology. Research work focused on addressing key market barriers to the adoption of dynamic windows by improving performance and functionality of existing products, developing a lower cost manufacturing paths, and introducing next generation products.

A key development from the team is a prototype with reversible reflectance switching. The prototype switches between transparent and diffusely reflective states. Previously demonstrated in a partial device format and on rigid glass

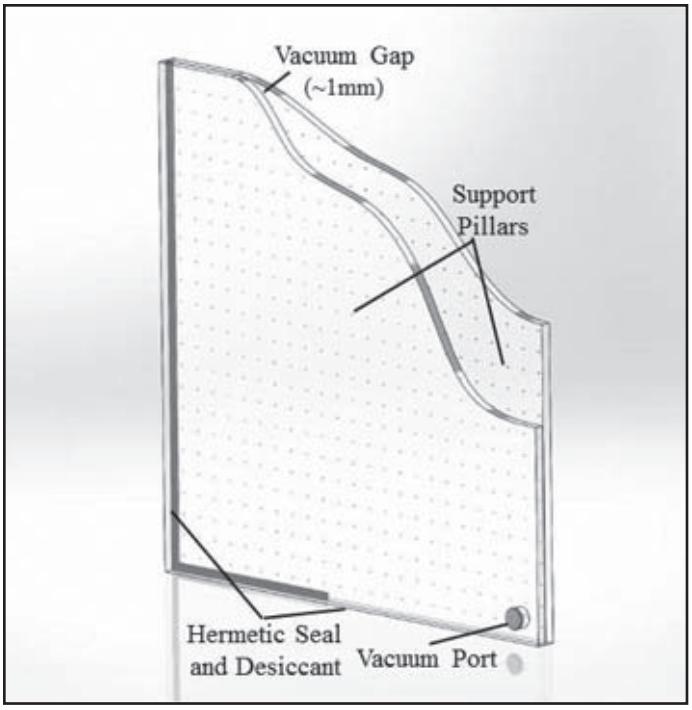

Figure 3. PPG developed and commercialized the Intercept® Spacer System that revolutionized the manufacture of double-pane insulated glazing units (IGUs) 25 years ago. Over 125 PPG-licensed Intercept Spacer Systems are in operation in the US. In this project, PPG is working with GED Integrated Solutions, as well as Oak Ridge National Laboratory and Gyrotron Technology, Inc., to bring manufacturing and materials solutions to enable wide-spread adoption of highly-insulating vacuum insulating glazings (VIG). A typical VIG-construction is illustrated here. Image courtesy Roy Hummel, PPG Industries, Inc., Cheswick, PA.

substrates, the new prototype integrates that technology into a flexible prototype structure. Each application was evaluated for an improved visual appearance, increased switching kinetics, and for increased device efficiency and durability to simultaneously improve energy and cost savings. Research on the prototype included full characterization of the specular and diffuse optical performance in the visible and near-infrared.

To read more about this project, go to *http://energy.gov/eere/buildings/downloads/dynamic-windows*.

Sawyer also highlighted several initiatives new to ET, including a project with PPG to fabricate on-demand vacuum glazing (refer to Figure 3). The research will launch at the manufacturing demonstration facility at Oak Ridge National Laboratory (ORNL).

ET will be funding development of a novel thermal break for R-7 commercial windows. This is the next step after the successful commercialization of the Traco OptiQ™ Ultra Thermal Windows Series (Phase I in 2012, Phase II in 2013). These R-5 commercial windows have an architectural structural rating (AW) and a thermal performance 30% better than comparable high-structural windows.

Notable Developments in Envelope

Automated Process for the Fabrication of Highly Customized Thermally Insulated Cladding Systems

One of the newest technologies funded by ET is from Poly-Cel, Inc (Marlborough, MA). Poly-Cel is creating a new fabrication process for the manufacturing of highly customized retrofit cladding systems with integrated thermal insulation.

The problem driving this effort is that existing buildings are often poorly insulated, meaning the structure consumes significant amounts of energy for both heating and cooling. Simply adding insulation to an existing structure brings many challenges – the best design needs to be airtight, to deter moisture, and be durable and low cost.

The proposed Poly-Cel approach involves a semi-automated documentation and design phase followed by a computer numerically controlled fabrication phase. The proposed technique accommodates a production environment that integrates all phases of a typical façade retrofit project, including the documentation, design, fabrication, installation, and maintenance phases. The technique allows fabrication of large façade panels that are dimensionally tailored to a particular project, resulting in a high performing retrofit system.

Simply put? "This is both an envelope and a manufacturing play as well," Sawyer stresses. "Poly-Cel came up with an automated process to fabricate a cladding system that is both customized and highly insulating. The idea is to do a laser scan of the existing home with all of its nooks and crannies. This digital image is put in to create a CAD drawing. Through 3-D printing, they manufacture exterior insulative pieces that fit perfectly. Because of the exact fit, the system gets around any thermal bridging issues and is ideally suited for complicated situations like windows." While this product is specifically aimed at retrofits - tackling existing envelope insulation from the exterior - Sawyer feels the process could transition into new construction as well.

Phase I will conduct an experimental study demonstrating technical feasibility of the most critical fabrication processes proposed. To stay up with this research, see *http://energy.gov/eere/buildings/downloads/automated-process-fabrication-highly-customized-thermally-insulated*.

Sawyer spotlighted several other promising developments at ET for building envelopes. NanoPore, Inc (Albuquerque, NM) and ORNL are partnering to develop and manufacture modified atmosphere insulation (MAI) in a process that would replace vacuum insulation panels (VIPs). Using MAI will also change the way composite panels are manufactured. "VIPs have many process steps to get out the door," summarizes Sawyer. "Through clever engineering, NanoPore is able to get rid of up to 70% of the process." Besides updating a manufacturing process that hasn't changed much since the 1970's, the NanoPore product

has extremely low thermal conductivity, so panels can perform even if punctured. (More information is available at *http://energy.gov/eere/buildings/downloads/modified-atmosphere-insulation.*)

Also under development is a bio-based, inexpensive phenolic foam. "Phenolic foams have been around, but have caused issues in the past by being acidic and causing corrosion," Sawyer explains. Among the plastic foams, phenolic foam is the only insulation that can reach or even exceed R-8.0 per inch. It also satisfies the fire safety codes without the need for fire retardants. Installation of the phenolic foam wall sheathing involves similar low-labor and easy installation methods as required for commonly used plastic foam board products. Spearheaded by the Fraunhofer Center for Sustainable Energy Systems in Boston, Massachusetts, research centers on use of lignocellulose, which would reduce acidity (see Figure 4). Lignocellulose is the abundant waste product from both the pulp and paper industry. For additional information see *http://energy.gov/eere/buildings/downloads/development-bio-based-inexpensive-noncorrosive-nonflammable-phenolic-foam*.

Other efforts underway in Envelope technologies include accelerated aging of roofing materials, cool asphalt shingles, building integrated heat and moisture exchange, and a study on materials that improve cost effectiveness of air barrier systems.

Sawyer was quick to emphasize the role that builders and the building science community have to play in emerging technologies. "Our program is about taking risks that are hard for the private sector to do, and to launch promising technologies more quickly and effectively into the market. The last thing we want to do is develop technology in a vacuum. We are always happy to hear feedback and to listen to wish-lists from builders on what they'd love to see."

Figure 4. Inside the lab of Fraunhofer Center for Sustainable Energy Systems (CSE) in Boston, MA. Photo by Trent Bell and courtesy of Fraunhofer CSE.

The next several years hold the promise for a new wave of energy efficient building products, which will offer easier installation, wider application, and cost savings for both consumers and the building industry.

IN DEVELOPMENT

Evaluating and Expanding Research in Highly Insulated Walls

In the September 2013 issue of ***Energy Design Update*** (Vol. 33, No. 9), Lois Arena, Senior Building Systems Engineer, Steven Winter Associates, Inc. (SWA), detailed SWA's work to verify the field performance of highly insulated walls. This work is under funding from the US Department of Energy's (DOE) Building America program. The goals were to: 1) monitor moisture levels in an actual high R-value wall assembly to determine the accuracy of the moisture modeling, done in WUFI® (Wärme und Feuchte instationär; *http://www.wufi.de/index_e.html*); 2) evaluate the design guidelines from ASHRAE Standard 160 *Criteria for Moisture Control Design Analysis in Buildings*; and 3) make recommendations to ensure durable, efficient assemblies.

The wall assembly monitored and analyzed in this study was an R-40, double-stud, dense-packed cellulose assembly in Climate Zone 5A. Two test bays were identified in the newly constructed home, one on the North and one on the South façades. Data recorded during the study included:

- temperature, relative humidity (RH), and moisture content (MC) of the studs at different heights and depths within the exterior walls;
- MC, temperature, and RH of the sheathing in the center of the bay as well as temperature and RH in the center of the wall cavity and just behind the sheetrock;
- interior temperature and RH;
- exterior temperature and RH;
- and, insolation on the South wall.

Long term modeling results indicated that the test wall assembly would dry out over the course of the year and would experience decreasing peak MC levels for the fol-

Figure 5. A view of EcoVillage in Ithaca, New York. Photo courtesy Steven Winter Associates, Inc.

lowing years. Data collected from July 2012 to July 2013 indicate reasonable agreement with the modeling. The rate at which the MC increased and decreased over the monitoring period was faster than predicted, resulting in less time spent at elevated moisture conditions, a positive for that wall assembly. Measured data for the South wall showed good agreement with predicted peak MC levels, which remained below 20%, a typical threshold used to evaluate the potential for mold growth. For Arena, these were major indicators that the wall was durable and showed good hygrothermal performance.

"The assembly appears to dry out annually, and measured data show reasonable agreement with predicted peak MC levels using ASHRAE 160 design assumptions. This should give designers a sense of confidence when using this guideline," Arena explained in an interview with ***EDU***. Collected data from the experiment also indicate good agreement with predictions from WUFI when using the actual boundary conditions. This suggests that, for this wall construction, modeling was quite accurate and can be assumed to be reliable for designers and practitioners analyzing hygrothermal performance, Arena noted.

Taking Moisture Research to the Next Step

However, the monitoring highlighted several remaining gaps in knowledge. Peak MC levels in the North wall were slightly higher than predicted and reached 21%. A parametric study indicated that the North wall may have experienced moisture intrusion from wind-driven rain. The condensation potential at the exterior sheathing, while lower than predicted, was still high, and both South and North walls failed the ASHRAE 160 design criteria, which currently requires that the 30-day running average RH at any point in the wall remain lower than 80% while the temperature of that material is between 41°F and 104°F.

Additionally, while the exterior sheathing and wall studs dried out as predicted, "We did notice that MC in the bottom plates tended to increase," Arena said. "These areas increased in moisture content until they leveled out at approximately 15%; all the other wood components dried out to approximately 10% MC." High MC in the bottom plates compared to the other wood studs in the wall suggests the need to verify moisture content of these materials before closing up the walls and allowing them to dry adequately if levels are high. Additionally, Arena cautions that a complete capillary break must be provided between any bottom plates and concrete components. Protection from splash-back and landscaping water should also be detailed in the plans and inspected during construction.

While the reliability of WUFI modeling and the ASHRAE 160 design analysis criteria were proven in this situation, more data for high-R wall assemblies is needed. SWA wanted to evaluate even higher performance assemblies in different climate zones. The potential for moisture to cause problems increases as insulation increases and as climates get colder. Though some hygrothermal analysis has been conducted on these high performance walls, there are few published works

Figure 6. Typical cluster of temperature, relative humidity, and moisture content sensors. Photo courtesy Steven Winter Associates, Inc.

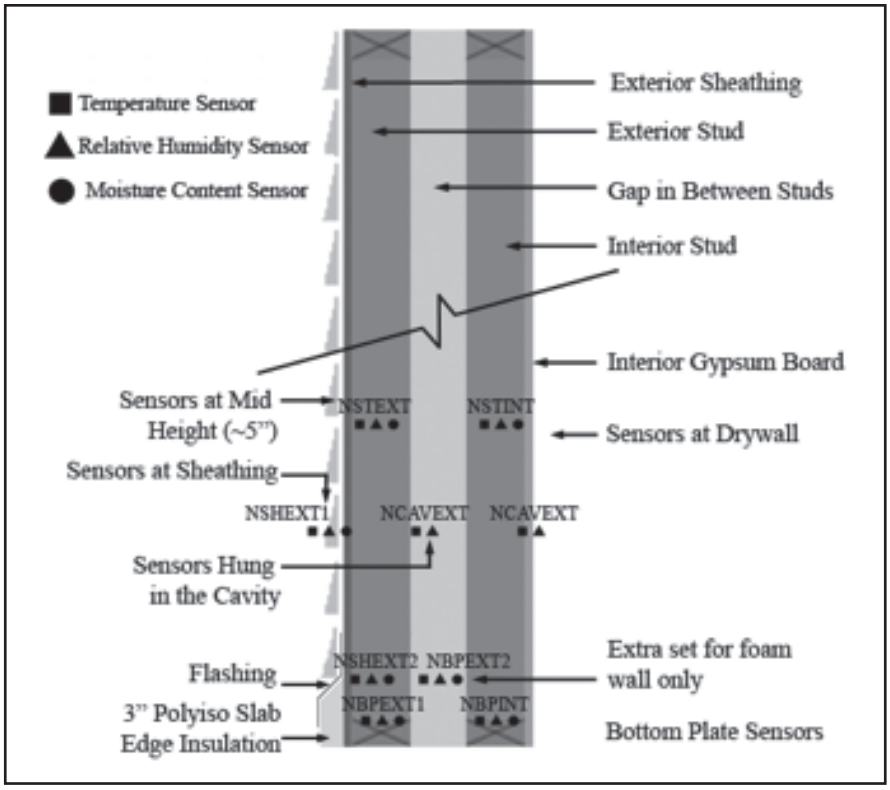

Figure 7. Sectional view of North Bay showing sensor locations in a full length wall. Diagram courtesy Steven Winter Associates, Inc.

on moisture performance of high R-value walls, and there has been even less field research to validate predicted results. Exacerbating problems are the increased use of foam insulation, various vapor barrier applications, the drastic increase in retrofit activities, and the increasing thickness of walls, which can slow or even inhibit drying mechanisms in walls.

Bringing Hygrothermal Modeling to Passive House Assemblies

Launched at the end of 2013 in cooperation with the New York State Energy Research and Development Authority (NYSERDA), SWA is now in a year-long process to monitor 2 different high R-value wall assemblies in Ithaca, New York (Climate Zone 6). (Refer to Figure 5.) Climate 6 was selected for its combination of challenges: a heating season, a cooling season, and periods of high humidity at various temperatures throughout the year. The tested walls are a 12" double stud wall assembly dense-packed with cellulose (R-43), and a 12" double stud wall assembly with 3.5" of ccSPF in the outer stud and the remainder of the cavity dense-packed with cellulose (R-52).

"We started with WUFI and THERM modeling, and had a builder partner who allowed us to monitor and take measurements at the start of construction," Arena said. The SWA team installed sensors for long-term data collection after construction was completed, taking note of measured RH, temperatures, and MC (see Figures 6, 7, and 8).

"With Ithaca, we're monitoring thicker walls, 12" as compared to the prior 10", and looking at 2 different configurations," Arena detailed. "The walls are true vented assemblies, with venting between the outside sheathing and the exterior siding." The homes with R-52 wall assemblies are pursuing Passive House Certification. SWA is monitoring walls at northern and southern exposures on both homes. "The highest MC we saw over the winter was 14%," Arena stated. "Bottom plates performed the same way here as in our previous test walls, with a MC that kept creeping up as summer came, but then leveled off at approximately 13% in August 2014." These results offer an initial, but as yet incomplete, snapshot of wall performance.

"The reason for this research is that we're getting into high R-value walls across the board, with a drastic increase in major retrofits, and a growth in programs like Passive House and Zero Energy Ready Homes," noted

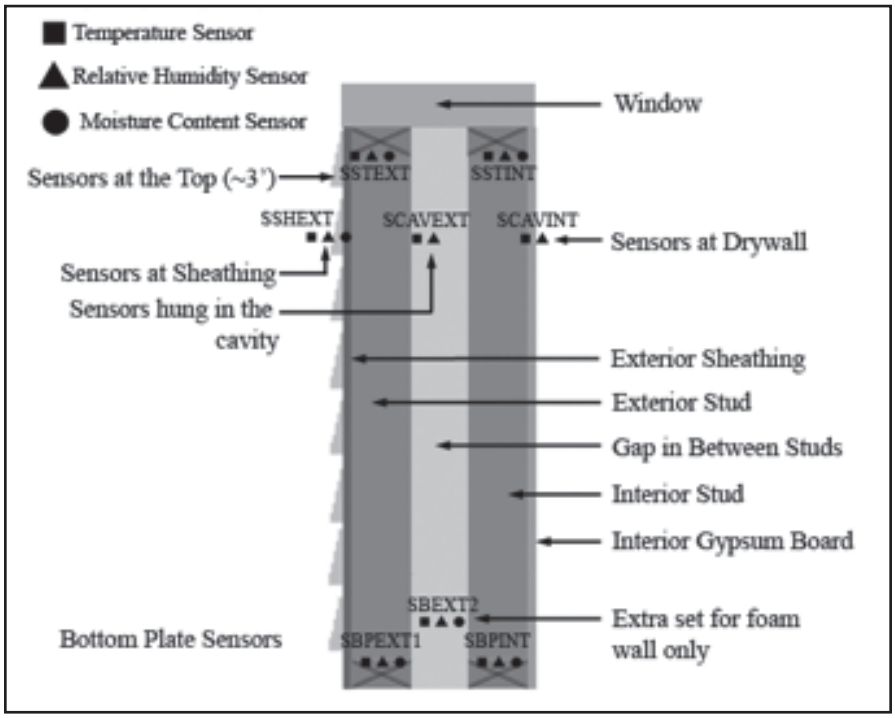

Figure 8. Sectional view of South Bay showing sensor locations under a window sill. Diagram courtesy Steven Winter Associates, Inc.

Arena. "We're also seeing an increase in the use of hybrid insulation strategies, novel assemblies, and new insulation products. Increasing insulation requirements in building codes will also result in high R-value assemblies, especially in climate zones 6 and higher."

"As we did in the previous study, we'll compare both modeling predictions and field data against accepted failure criteria." One of the desired results, Arena hopes, is that the data offers a clearer picture to guide builders when evaluating high-R walls (without exterior rigid insulation) with respect to condensation potential (see Figure 9). "Generally when we look at condensation potential, we're looking at a worst case scenario of surface temperatures and interior air dew point temperatures to determine what percentage of the year the materials experience the potential for condensation due to an air leak from the interior of the home. That failure criteria, while discussed extensively in reports, is quite ambiguous; there's no real guidance on what percentage of time condensation is okay at a particular surface."

The goals of the new SWA study at Ithaca reach beyond searching out condensation potential, mold growth, and thresholds for decay in these types of wall assemblies to validating the accuracy of WUFI in non-standard wall types. Additionally, when completed, SWA hopes this research will help the ASHRAE 160 technical committee evaluate potential new failure criteria.

Recommendations from the Field

Based on what she has seen so far, Arena noted several best practice approaches for builders. "If you're presented with unusual materials or conditions, use WUFI or THERM to evaluate on a case-by-case basis," Arena counseled. "Use several criteria for assessing success." Modeling predictions and actual performance of real walls has held up across several evaluation cycles.

Arena advised going above and beyond to prevent interior moisture from getting into walls: "Do everything you can to air seal!"

Figure 9. "With Ithaca, we're monitoring thicker walls, 12" as compared to the prior 10", and looking at 2 different configurations," Lois Arena notes. Homes with R-52 wall assemblies are pursuing Passive House Certification. SWA is monitoring walls at northern and southern exposures on both homes. Photo courtesy Steven Winter Associates, Inc.

Additionally, Arena recommends vented cladding for high-R assemblies when exterior rigid insulation is not a part of the wall system.

Finally, Arena issued a word of caution when it comes to bottom plates. "Make sure that whatever material you use, it is a true capillary break for the full width of the stud at the sill plate." Based on SWA work, the team will issue a guideline at the end of 2014 with details advising best practices.

Energy Design Update thanks Lois Arena, PE and her team for sharing their research and report with us.

Lois Arena is a Certified Passive House Designer. She serves at Steven Winter Associates, Inc, where she also works on the Department of Energy's Building America^{SM} program and conducts advanced systems research. She received her MS in engineering from the University of Colorado's Building Science Program and possesses over 19 years experience in the building science field. Arena may be reached at Steven Winter Associates, Inc, 61 Washington Street, Norwalk, CT 06854, via phone at 203-857-0200, ext. 214, or via email at *larena@swinter.com*.

IN PRACTICE

This guest article is in response to the issuance on March 13, 2014, of the Initial Priority Products and Candidate Chemicals list by the California Department of Toxic Substances Control (DTSC), available at *http://www.dtsc.ca.gov/SCP/PriorityProducts.cfm*. According to DTSC, a Priority Product is a consumer product that contains one or more chemicals – known as Candidate Chemicals – that have a hazard trait that can harm people or the environment. This initial Priority Products list is the first set of product-chemical combinations to be named for consideration by DTSC to be regulated under the Safer Consumer Products regulations. The Initial Priority Products and Candidate Chemicals:

- Spray Polyurethane Foam (SPF) Systems containing unreacted diisocyanates
- Children's Foam Padded Sleeping Products containing Tris(1,3-dichloro-2-propyl) phosphate or TDCPP
- Paint and Varnish Strippers, and Surface Cleaners with methylene chloride

Spray Polyurethane Foam: A Net Zero Solution for California and Beyond

State Agency Reviewing the Product for Safety, Industry Stakeholders Disagree with Process and Facts Presented

by Rick Duncan, Ph.D., P.E.

Technical Director of the Spray Polyurethane Foam Alliance (SPFA)

Figure 10. Closed-cell SPF insulation applied inside a metal clad building. Photo courtesy Richard Duncan, Ph.D., P.E. and Spray Polyurethane Foam Alliance (SPFA).

Spray Polyurethane Foam, or "SPF," is a material utilized for both building envelope and roofing applications. The material has the ability to insulate, air and water seal, and control moisture throughout the structure, acting as a single-source solution, reducing the need for multiple products (see Figure 10).

The building enclosure will either enhance or hinder the energy efficiency of the structure. Depending on the materials and the methods of construction used, energy loss via air leakage may occur at various points throughout the roof, walls, and ceiling. Thus, air sealing is extremely beneficial when trying to improve energy efficiency.

As a thermal insulator, SPF forms in place and fully adheres, almost completely eliminating the cracks and gaps that allow escape of conditioned air. It may also be installed in a continuous layer, eliminating many thermal bypasses typically found with cavity insulations (see Figure 11). SPF boasts one of the highest R-values per inch of all available insulation options, offering exceptional thermal performance.

In roofing, SPF both acts as a protective roofing solution and as an insulator. The effectiveness of insulation – whether in roofing or in walls and floors – is measured through a combination of factors including moisture control, air leakage, health, safety, durability, comfort, and energy efficiency – with SPF scoring exceptional marks in all categories.

However, despite its high performance characteristics and the continued growth in demand among contractors and builders for the SPF product, it has recently come under the spotlight in the state of California. The scrutiny of the product is counter-intuitive, as SPF is arguably one of the most effective building materials available in the marketplace in its ability to assist California in meeting its aggressive zero net energy (ZNE) goals.

California's Safer Consumer Products Regulation – A Threat to the Building Industry

In 2013, the state of California announced a new program under its Department of Toxic Substances Control (DTSC), an agency whose stated mission is to protect consumers and the environment from the harmful effects of toxic substances. DTSC's Safer Consumer Products program was designed as a means to require "manufacturers or other responsible entities to seek safer alternatives to harmful chemical ingredients in widely used products, offering California the opportunity to lead the way in producing safer versions of goods already in demand around the world."

In March 2014, DTSC released the first Priority Products List, a proposed list of three product-chemical combinations that contain one or more chemicals considered hazardous to the environment or to people. "Spray Polyurethane Foam (SPF) systems containing unreacted diisocyanates" is one of the products targeted. As part of this initial list, the DTSC published a number of documents, including a Priority Product Profile riddled with misconceptions and inaccuracies about the chemicals included in SPF and the safety risks of SPF to consumers.

"One of our core issues with the DTSC including SPF in this process is that the product is not installed by consumers, however it is being evaluated by a program designed specifically to review consumer products," said Kurt Riesenberg, executive director of the Spray Polyurethane Foam Alliance (SPFA). "Potential exposure to unreacted diisocyanates occurs only in a short window during and within a few hours after professional installation and thus we have always believed this to be a worker issue. Our industry has extensively and proactively collaborated with US Environmental Protection Agency (EPA), US Occupational Safety and Health Administration (OSHA), and National Institute for Occupational Health and Safety (NIOSH) on this exact concern, and we believe those agencies are better suited to address any SPF related concerns (see Figure 12). Additionally, the SPFA has created a Professional Certification Program, which is widely utilized and promotes best practices and safety as a preventa-

Figure 11. Installation of spray foam insulation – wood frame walls. Photo courtesy Richard Duncan, Ph.D., P.E. and Spray Polyurethane Foam Alliance (SPFA).

tive measure to the occurrences of exposure, which happen very rarely in our industry."

The SPFA, a national industry association representing SPF contractors, manufacturers, and others active in the industry, is not the only party with major concerns about SPF's inclusion in the Priority Products Initiative. The organization is joined by partner organizations representing a resolute coalition of home builders, building performance professionals, and chemical and systems manufacturers who stand by the product's performance benefits and believe the information and process used by the DTSC to select SPF for evaluation under this initiative was faulty.

"All of the parties actively disputing this evaluation of SPF by DTSC agree this is not the right venue. The facts have been misrepresented, and any regulation of this product will cause irreparable harm to the economy in California, as well as to the state's ability to achieve major energy efficiency initiatives," added Riesenberg. "We are also concerned additional states may adopt similar initiatives, basing them on the DTSC efforts, which are founded on inaccuracies and a problematic process."

The industry's major areas of contention have been communicated at multiple points in the state agency's formal process. Since the initiative was formally announced in a March 13 press conference, that process has included a series of public workshops held at different locations in the state where DTSC staff, industry stakeholders, and interested citizens assembled to discuss the initiative and the facts about the first three chemical-product combinations under scrutiny, as well as to provide a forum for increased education about the products involved via industry participant voiced opinions and shared research.

Some of the industry's major points of disagreement with the DTSC's publicly available documents about the SPF chemical-product combination have since been corrected and include:

- The definition of SPF systems, which prior to correction included roof coatings and one-component SPF systems sold in cans (both have since been removed).
- The inclusion of HDI, or Hexamethylene Diisocyanate, and TDI, or Toluene Diisocyanate, in their Chemicals of Concern (both were since removed because they are not chemicals utilized in two-component SPF systems).
- The statement in multiple locations in the public documents that "diisocyanates are the leading attributable cause of asthma in the workplace" (since revised).
- The use of images and graphics in public documents and presentations that depict incomplete or non-existent safety measures and/or personal protective equipment in the installation of SPF.

Despite some of the corrections, which were made in September 2014, the industry still holds many points of contention with the initiative and the process through which it has been enacted. These include:

- No industry stakeholders – whether association or individual company manufacturers, contractors, or others – were contacted prior to the kick-off of the initiative. The SPFA was only made aware one hour prior to the March 13 press conference, despite the Department's claims that all stakeholders were included in the product selection and Product Profile development process.
- A considerable bank of independent, objective research reports on the performance and safety of SPF were not considered by the Department in the development of their SPF Product Profile. Because of the omission of these reports, the SPF industry contends that inaccurate conclusions and technical flaws were drawn and published about the product and are now being utilized by SPF competitor product manufacturers and distributors as negative campaign marketing materials to the unfair detriment of the SPF industry. Additionally, many California businesses have lost contracts and significant revenue due to the falsehoods published about the product.
- Any chemical hazards associated with Isocyanates used in SPF are well understood and the safe use of these chemicals is already sufficiently and effectively addressed by several other state and federal agencies. In 2009, the SPFA and SPF industry at-large voluntarily engaged in a five year cooperative program with US EPA, OSHA, NIOSH, and CPSC, resulting in the multi-agency review of the SPFA's comprehensive, ISO 17024-compliant national Professional Certification Program. Furthermore, the US EPA influences the safe use of Isocyanates through their Chemical Action Plan. In addition, US OSHA has established

a National Emphasis Program on the use of Isocyanates in the workplace, which includes the installation of SPF. Cal-OSHA is actively participating in this program, extending health and safety compliance requirements down to companies. These requirements are both comprehensive and enforceable.

While some corrections made by the DTSC to public documents are helpful, the industry stands together in its mission to have "Spray Polyurethane Foam (SPF) systems containing unreacted diisocyanates" removed, or de-listed, from the Safer Consumer Products Initiative altogether. The likelihood of this may be small; however, there are other actions that would also satisfy the SPF industry to varying degrees.

For example, the industry would prefer continuation of the SPF product and chemical evaluation by Cal-OSHA, since it is believed that exposure to unreacted diisocyanates is a worker issue, not a consumer issue. Additionally, industry stakeholders would prefer that the impending two-year Alternatives Analysis Assessment, a next step in the Department's formal initiative process, where industry is tasked with the time and cost to come up with alternative chemicals for SPF to replace unreacted diisocyanates, result in installation regulation rather than a total product ban.

California's Zero Net Energy Goal and Why SPF is Important to Achieving It

Other than a notable disruption to the building and SPF industries, there is another significant impact that DTSC's product review is having in California. In July 2014, California initiated the revision process to the 2016 version of Title 24, California's building energy efficiency codes, which are designed to move the state's residential and commercial buildings toward zero net energy (ZNE). Under Title 24, all new residential construction is to be ZNE by 2020, and all new commercial buildings are to achieve the same goal by 2030. While aggressive, these goals are achievable with the right design implementation and accessibility to proper building materials.

The design of a ZNE building focuses first on the reduction of energy consumption via the utilization of innovative, energy efficient technologies. Secondly, the structure must generate its own renewable energy (such as via solar panel solutions).

Long-term zero net energy begins with the design and construction of a quality building enclosure. High performance attics and wall systems are a key focus of 2016 Title 24. High performance, unvented attics make a significant impact in the efforts to reduce peak cooling demand in structures. Because of SPF's unique attributes (outlined earlier in this article), the material is widely recognized by California builders and the California Energy Commission staff as an optimal solution for high performance unvented attics.

Additionally, these characteristics are integral to SPF's ability to superbly insulate the walls and roof of the building, sealing it and greatly enhancing the overall energy efficiency of the structure. There is no one product comparable to SPF in its ability to provide so many energy efficiency solutions. But with the product under DTSC scrutiny in California, many builders have cancelled their SPF contracts – albeit displeased to do so. Not only have product manufacturers and contractors in the state felt the deep economic sting of the Department's focus on SPF, but builders are left wondering how they will be able to achieve zero net energy goals if SPF is ever made unavailable in the marketplace.

"Other agencies have already addressed any relevant safety concerns with Spray Polyurethane Foam, with the industry's leading stakeholders having collaborated with those agencies to address them, leaving the Department's scrutiny of the product redundant and counter-productive," said Riesenberg. "In fact, the Professional Certification Program we created to ensure industry best practices

Figure 12. Installer of spray foam for a roofing application shown in full personal protective equipment. Photo courtesy Richard Duncan, Ph.D., P.E. and Spray Polyurethane Foam Alliance (SPFA).

in the installation and use of SPF has become widely adopted and is designed to prevent the very few incidences of exposure that do occur. The potential job site hazard involved with spray foam is similar to that posed by a circular saw used by a carpenter on the same site. Both could cause harm but both are clearly understood by the skilled operators and neither poses any risk to others or to the eventual homeowner."

The Spray Polyurethane Foam Alliance Professional Certification Program, an internationally recognized program built for those involved in the installation of SPF in roofing and insulation applications, offers various levels of certification for individuals, as well as contractor and supplier companies. The standards driven program was created by industry stakeholders in collaboration with OSHA, NIOSH, and EPA and is available online, as well as in Spanish.

"The success of this Certification Program is testament to the industry's diligence in protecting our workers, and their customers from any harm, and we hope the DTSC soon recognizes this, as well as all of the facts that have been presented, and removes SPF from its initiative," added Riesenberg.

Rick Duncan is the Technical Director of the Spray Polyurethane Foam Alliance (SPFA), the industry's leading organization representing contractors, material and equipment manufacturers, distributors and industry consultants. The SPFA promotes best practices in the installation of spray foam and offers a Professional Certification Program to all those involved in the installation of the product.

IN REFERENCE

Solar Energy Prices Saw Double-digit Declines in 2013; Trend Expected to Continue

A jointly written report on PV pricing trends, released October 20, 2014 from the US Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) and Lawrence Berkeley National Laboratory (LBNL), shows that distributed solar photovoltaic (PV) system prices dropped by 12-19% nationwide in 2013. In addition, 2014 prices are expected to drop another 3-12%, depending on system location and market segment. Industry analysts expect this trend to continue over the next couple of years, keeping the nation on track to meet the DOE SunShot Initiative's 2020 targets.

The report shows that the general downward trend in PV system pricing continued in 2013, and is expected to continue through 2016. Other key findings include:

- Modeled utility-scale PV system prices fell below $2 a watt in 2013, and have continued to decline in 2014, to roughly $1.80 a watt, which is 59% below what modeled pricing showed in 2010.
- There is a difference of roughly $2 a watt between the median reported price of the lowest- and highest-priced states for residential and commercial systems (less than 10 kW in size); a similar price range also exists within individual states.
- There is a wide-range in analysts' PV pricing estimates, however a number of analysts are now projecting long-term pricing in line with the targets set by the SunShot Initiative for 2020. At these pricing levels, PV is expected to reach widespread grid parity in the U.S. without federal or state subsidies.

Press release and details courtesy of NREL. The report, "Photovoltaic (PV) Pricing Trends: Historical, Recent, and Near-Term Projections (2014 Edition)" is available at *http://www.nrel.gov/docs/fy14osti/62558.pdf?utm_source=Solar%20Energy%20Prices%20See%20Double%2Ddigit%20Declines%20in%202013%3B%20Trend%20Expected%20to%20Continue&utm_medium=email&utm_content=nrel&utm_campaign=NewsRelease*. Visit NREL online at *http://www.nrel.gov*. For further details about this story, contact Heather Lammers at *heather.lammers@nrel.gov*.