# Energy Design Update

The Newsletter on Energy-Efficient Housing

VOL. 39, NO. 2 • MARCH 2019



## IN DEPTH

# Tackling a Sticky Topic: Adhesive Flashings in Construction

Bitumen. Butyl. Acrylic. Self adhered. Mechanically fastened. Fluid applied. Vapor permeable. All these descriptions apply to a single category of building components: adhesive flashings.

Often thought of as an accessory, adhesive flashings actually provide the vital seal to barriers and wraps used in the building enclosure, meaning that their performance is critical to prevent air and water intrusion and keep the envelope intact. They offer vital insurance and protection at seams, joints, interfaces, and corners, and have to guarantee that the building remains shielded from water and adverse conditions. This article will focus on the pressure sensitive adhesive tapes that are commonly used as flashings.

**Figure 1.** While adhesive flashings play a vital role in shielding seams and interfaces from water and air intrusion, their performance plays out hidden for years by exterior layers. Mock-up wall with window, ready for testing, at Construction Instruction's Phoenix, Arizona research facility. Photo courtesy Construction Instruction.

## Flashings Tapes 101

Flashing Tapes have a simple composition: a carrier sheet or facer, often made of polyethylene, polypropylene, or aluminum, and their adhesive layer. Some products may also use a release paper or protective liner to facilitate the tape's release from the roll.

Three main categories of flashing tape technology reign in the US market: traditional modified asphalt self-adhered flashings (rubberized/bitumen), butyl tapes, and acrylic tapes, which are most commonly used at seams or to bridge gaps or laps.

So which tape to use where? And when?

## The Crux of the Matter

Unfortunately, flashing tape lives out its life hidden behind exterior layers, meaning its performance and longevity remains a mystery – so long as nothing catastrophic occurs (see Figure 1).

"Tapes, flashing, seams are the biggest source of damage we see in building failures," noted David Nicastro, PE., Chief Executive Officer, Building Diagnostics.

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## Construction Instruction To Open New Campus

Mark LaLiberte, Justin Wilson, and Gord Cooke, partners at Construction Instruction® (CI), embody over 70 years of combined experience in investigating best building practice methods and the "house as a system" approach.

While known for their nationwide seminars, CI also has a facility in Phoenix, Arizona, permitting in-house testing and evaluations of systems and products. CI also uses the complex for small group, hands-on training events, allowing building professionals to walk away with leading-edge implementation plans and to engage in best practice application processes (see Figure 2).

CI plans to expand their applied research facility and double it in size when they open their Denver, Colorado office in 2020. Thermal, pressure, and water chambers are among the diagnostic tools they plan for the space.

**Figure 2.** In addition to hosting nationwide seminars, Construction Instruction (CI) also has a facility in Phoenix, Arizona. CI uses the complex for small group, hands-on training events, allowing building professionals to walk away with leading-edge implementation plans and to engage in best practice application processes. CI plans to expand their applied research facility and double it in size when they open their Denver, Colorado office in 2020. Photo courtesy Construction Instruction.

"We have all been training for many, many years, traveling the nation, hashing out the physics and applied principles of building science," says Justin Wilson, Partner at CI. "Yet where we really got some 'ah-ha' moments from people were when we slowed down and changed the game at a neutral location. How do builders make decisions? What are you going to implement? You have to familiarize yourself with physics and its problems for buildings, experience it, and those lessons apply to your scope to walk away with usable knowledge."

The whole goal of training at CI is for builders to physically forecast where their enclosure can go and how it can improve. "We walk through our laboratory and actually show what things like convection look like," says Wilson. "We let people build it; we provide a pile of everything they need and say, 'Let's experiment. Let's put whatever you want up on this wall and then let's test it.' Then we can tear it apart and see what went wrong and how to improve it."

As well as on-site training, the new facility in Denver will house multiple long-term applied research projects and host manufacturer evaluations.


# Energy Design Update

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***Energy Design Update*** (ISSN 0741-3629) is published bi-monthly by Wolters Kluwer Law & Regulatory, 76 Ninth Avenue, New York, NY 10011. (212) 771-0600. *To subscribe, call 1-800-638-8437. For customer service, call 1-866-529-6600. 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 Wolters Kluwer Law & Regulatory website at *https://lrus.wolterskluwer.com/policies/permissions-reprints-and-licensing/*. Printed in the U.S.A.





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Given its critical role in a building, there's a surprising lack of data concerning tape and its real-world performance. Does it last underneath the shell? Can it resist the shifting and settling of a structure? Can it resist moisture and maintain its stick?

What's a builder to do?

## Step 1: Standards

"There are industry standards and requirements, and builders need to be aware of these standards and verifying that products meet these standards," explains James D Katsaros, PhD. Katsaros leads product development programs and code/standard development for the Window & Door industries at DuPont Performance Building Solutions and is also the Chair of the American Architectural Manufacturers Association® (AAMA) Flashing Committee and the Fenestration Manufacturers Association (FMA)/AAMA/Window and Door Manufacturers Association (WDMA) Installation Committee.

The material standard for self-adhered flashing products used in windows and doors is AAMA 711, which was adopted into the International Residential Code® (IRC) and the International Building Code® (IBC). Similar material standards for mechanically attached flashing (AAMA 712) and liquid applied flashing (AAMA 714) followed that and are now also in the code.

"Those documents are now referenced in the code and describe minimum performance requirements including sealability, UV resistance, and durability, like thermal cycling and heat exposure," says Katsaros.

## Testing the Standards

One of the more prominent recent evaluations of flashing tape was conducted by the team at Building Diagnostics. "Defining and testing construction tape and flashing durability," was released in the December 14, 2017 issue of *The Construction Specifier.* Written by Anthony M. Garcia, PE, and Jorge M. Blanco, the authors performed hundreds of tests to evaluate different adhesive chemistries and durability on a variety of substrates (visit *https://www.constructionspecifier.com/defining-testing-construction-tape-flashing-durability/2/* for the full article).

"Every layer matters in a building's water-resistive barrier (WRB) or air barrier, so the importance of tapes cannot be overstated," Garcia and Blanco write. "Common in construction, tape failures lead to costly repairs. The testing confirmed typical field observations—when installed well, most tapes perform acceptably, a few are exceptional, but some perform very poorly."

All testing was conducted at The Durability Lab at the University of Texas, Austin. The test method used was based on the ASTM D3654 procedure for measuring adhesion in shear. Garcia and Blanco also tested the outdoor exposure of tapes, facing the testing rack to solar south and using a larger contact area than specified.

Over a 30-day testing period, the adhesive durability of seven acrylic, five butyl, and six rubberized asphalt tape products from eight manufacturers was scrutinized on CDX plywood sheathing (plywood); the 'smooth' side of oriented strand board (OSB) sheathing; the 'rough' side of OSB sheathing; OSB with integral WRB; glass mat-faced gypsum sheathing; and extruded polystyrene (XPS) insulation boards.

Tape-to-tape adhesion was additionally tested to evaluate lap performance.

### *Results*

Garcia and Blanco garnered extremely valuable and, in some cases, surprising data from the exposure tests. First, the authors were surprised when failure occurred at the interface between the tapes more than twice as often as when compared to other substrates at the same location.

They also noted that the carrier sheet played a prominent role in the durability of the tapes under both loaded and exposed conditions. The authors observed two failure modes: either the carrier sheet separated from the adhesive and slid vertically, or, the adhesive disbonded from the substrate.

Only 26 percent of the tapes reached the cutoff time of 30 days without failure. Almost half the specimens reaching this point were acrylic tapes. According to the report, across all combinations, butyl tapes had an average time to failure of 10 days; rubberized asphalt tapes had an average time to failure of six days. Modified asphalt tapes performed best on XPS insulation. Butyl tapes performed the best on gypsum sheathing, with an average time to failure of 13 days.

Garcia and Blanco ended their 2017 report requesting further testing on tape in 'real world' conditions, to better identify performance issues.

## Testing in the Real World

"We've been working on various tapes in the building sector as one long term project at our facility, with the intent to broaden the scope over the coming months," says Justin Wilson, Partner at Construction Instruction in Phoenix, Arizona, Denver, Colorado, and Toronto, Ontario (see Sidebar 1, Figure 2, on Page 2). Currently, Wilson and his team have been hot cycling tapes to AAMA 711 test standards, with a few modifications to the applied substrates.

"Tapes became a fascination some years ago; I've been looking at field performance for many years," Wilson told ***Energy Design Update.***

"What did happen in field? Why is it leaking? Builders have good hands-on experience, but can struggle to get to the bottom of why a failure happened," explains Wilson. "We are not chemists here at CI, but building scientists with a focus on applied research."

**Figure 3.** Heat taping testing in the oven at Construction Instruction's Phoenix, Arizona research facility. Photo courtesy Construction Instruction.

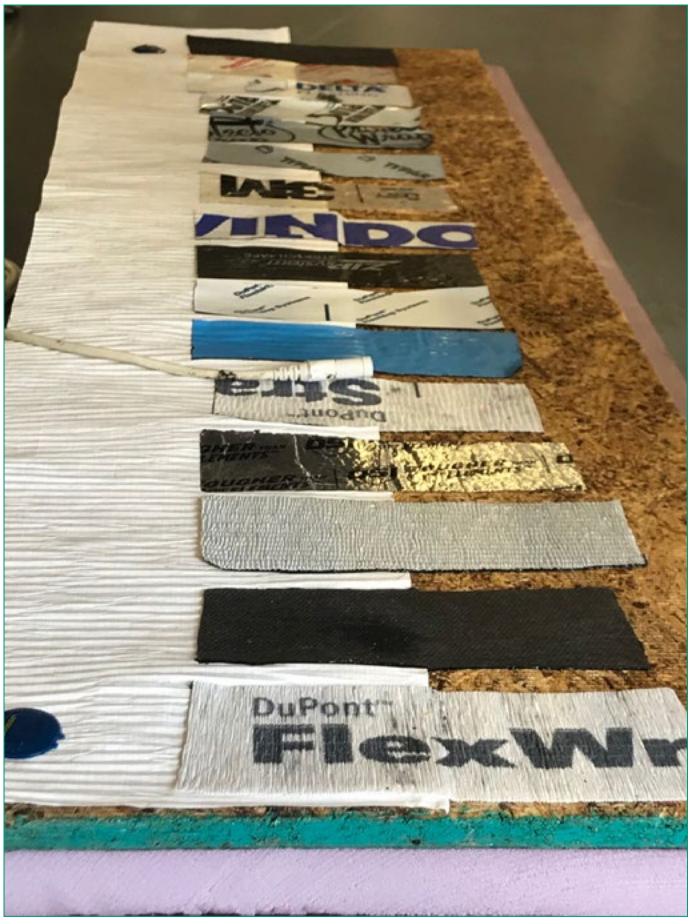


**Figure 4.** Photo from tape testing currently underway at Construction Instruction's Phoenix, Arizona research facility. Photo courtesy Construction Instruction.

Katsaros echoes the need for "in field" testing. "The AAMA standard has a heat aging test (see Figure 3), but the flashing products are heated in an oven where everything is at a uniform temperature," explains Katsaros. "We're learning that outside, with a hot sun beating down on the flashing, there's a temperature gradient at the interface. Flashing with adhesive tends to get hotter than the sheathing or WRB next to it, which creates a thermal gradient at the interface, and that can cause challenges that you didn't see in industry standard testing."

CI is striving to duplicate long term testing and cycling to get an accurate picture of what combination of forces cause tape to fail, and how to get it to succeed long-term. It's a complicated quest.

"There's a whole marriage of components," says Wilson. "I have a genuine concern, especially as we're going to taping sheathing joints, facing sealed assemblies, that we're relying entirely on tape. Where is the integration of elements?"

The materials that make up the top sheet and the adhesive will interact with each other and the substrate based on the forces imposed on them: heat, cold, water, and structural shifting. The main question becomes: what is stability in tape?

## *Real World Findings*

"We know that rubberized asphalt has poor adhesion, and tends to melt and flow under temperatures of 150°F to 160°F," explains Wilson. "What do we know about the real world? In cities like Denver, Indianapolis, and, of course, Phoenix, the enclosure is going to get hotter than that. So if you buy low performing tape what's left of it after 6 months on the building? Most likely nothing." When heated rubberized asphalt or bitumen tape is then cycled back to cold, the bitumen compound's life has been overextended, rendering the tape with limited pliability.

"Top sheets matter. A lot of top sheets actually can't take thermal cycling," Wilson says. For example, if a butyl rubber adhesive tape uses a quality top sheet, "the stability can be quite amazing. It can perform well above 200°F, if the top sheet is good," says Wilson. If the top sheet is poor, the adhesive can roll right off of it. "You get what you pay for," he concludes.

With more insulation placed in walls and the push to exterior insulation, we're creating a bigger thermal gradient across wall, cautions Wilson. Insulation is resisting conduction in the material, the siding surface temperature is increasing, and the aesthetic trend is to put darker colors on the outside, so this is exacerbating heat stress on tapes. "The ingredients things are made out of are what matters. Some will tolerate this stress, some won't," Wilson says.

Nails that occur underneath or are placed through tape cause a localized heat sink increase, preventing self-sealing and frequently creating a hole in the tape. "There's merely a blob of asphalt left," Wilson says.

In the field, Wilson notes that butyls tend to work quite well because they maintain pliability over high and low temperatures. However, butyls are hard to apply at low temperatures, particularly over an OSB substrate with a resin coating. "That adds a layer of complexity," says Wilson "Then the surface has to be cleaned with a harsh cleaner or activating chemical. In Portland where it's 40°F and 95% relative humidity, it's a challenge to get tape to stick." While thicker


**Figure 5.** Testing a mock-up enclosure for performance during a rain event. Where and how water can penetrate an assembly, and how that assembly dries, are critical questions for every wall. Photo courtesy Construction Instruction.

butyl tapes (above 20 mil of butyl) tend to cycle quite well, they're also slightly more expensive.

"There's a push to transition to acrylic tapes," Wilson says. Acrylics have advantages: they're thin, have good initial tack, "but again, top sheet formulation is critical," cautions Wilson. The top or facing sheet provides top side protection by ensuring the integrity of the drainage plane and barrier beneath, and also acts as the carrier for the adhesive. "It costs a lot of money to put a lot of acrylic on tape substrate," notes Wilson. "And you have a chemistry issue – a water-borne emulsion is how the acrylic adhesive is made. There's a curing process after applying it to the top sheet. You have to ask, how long does it get cured and at what temperature? If you don't get all the water molecules out, then by attraction they will find other water molecules on the building, altering or loosening the bond." Repositioning is another downfall of acrylics, repositioning is difficult. It can also struggle on a surface that's not planer. Per field testing, over time the acrylic wants to de-bond at that acute angle.

"We're always asking, how do we formalize the process and make these tests repeatable and replicable?" says Wilson. Next up, the CI team will subject tape to cold weather cycling and additional moisture cycling (see Figure 4).

## Lessons: What's a Builder to Do?

### *Lesson #1: Installation best practice matters*

Even if the best tapes are specified, installation is critical, Garcia and Blanco stressed. Wet or dirty substrates greatly impede flashing tape installation. Flashing tapes that are not stored in a cool, dry location suffer degradation that can render them almost useless. "One should use compatible primers when provided by the manufacturer, especially on OSB sheathing," conclude Garcia and Blanco. "Pressure should be applied with a roller in all situations. Tapes should only be used with the recommended substrates and WRBs."

"Pressure sensitive adhesives need around 20 to 40 lbs of force per square inch to embed in," echoes Wilson. "We have to ask, is this actually achieved in the field?"

### *Lesson #2: Different tape adhesive technology offers different benefits*

"All have benefits and different cost positions," says Katsaros. "Bitumen is more susceptible to heat exposure; it curls back, starts oozing and dripping. Butyl is more thermally stable but more expensive.

"That's the moral: bitumen, butyls, acrylics, each have a benefit on the building – pick and choose and look at several kinds," counsels Wilson. "I usually have, with an assembly, a variety of different technology on the enclosure."

### *Lesson #3: Pay attention to the top sheet AND the backer sheet*

"This is a big one in taking apart assemblies, where those tapes lap, it is very critical that the tape's adhesive bonds to that tape's top sheet," says Wilson. "We are seeing that this is a problem. If a tape doesn't have a backer sheet to prevent it from sticking to itself on the roll, avoid it." (See Figure 5.)

"Tape that doesn't have release liner is designed not to stick to its top surface," agrees Katsaros. "That's fine for removing the tape from the roll, but not good in terms of its ability to lap. AAMA 711 covers adhesion requirements for laps, and that is absolutely something that causes issues. At the important interfaces, for example, at the head of window, where the head flash laps over jamb flash, if that's not a good seal, water gets right in there."

### *Lesson #4: Know your standards*

"There are codes and standard governing tape," says Wilson. "Be aware of what they mean. Under AAMA 711, tapes are divided into three types, based on their performance under certain temperatures. A tape may be classified under AAMA 711, but there's a more than 50°F difference in temperature between Type 1, at 50 °C (122°F) and Type 3, at 80°C (176°F)."

"Also, effective installation at very low temperatures is a critical attribute in many regions," notes Katsaros, "the AAMA 711 standard requires that a flashing tape must pass the peel adhesion requirement of this standard at the low installation temperature claimed by the manufacturer. Thus, although some manufacturers claim very low temperature installation, such as 0 °F, it's important to confirm that this claim is backed up by appropriate testing per AAMA 711."

### *Lesson #5: Know what plays well together*

"Compatibility is always a key concern," says Katsaros. "Is the sealant compatible with Tyvek®, with the window flashing; there are so many different variations. That's the advantage of working with companies with a system-side approach."

### The Future of Adhesives in Construction

Are traditional adhesive tapes going away? Absolutely not. But there are always new developments on the horizon.

Permeability is a market watchword. "There are flashing products that offer excellent performance and breathability," says Katsaros. Fluid applied flashings, such as those based on Silyl Terminated Polyether Technology (STPE), are emerging in the US market. "STPE fluid applied materials are really catching on and offer a great balance of properties," Katsaros explains. "Europe also has flashing tapes that are breathable with an adhesive backing – that is something that is new and coming on."

"We definitely see a trend towards fluid applied in the future," says Katsaros. Fluid applied adhesives are covered by AAMA 714. "I like what fluid applied offers for seams in the wall. You have to be very careful that the seam seal is durable for the life of the building. If seams can move, whether because of thermal movement, or poor alignment during installation, traditional tape may not hold a water seal like it should. Fluid applied materials are elastomeric, and can move with joints better. It also allows for breathability."

Fluid applied adhesives offer additional advantages for flashing, Katsaros notes. "For more traditional self-adhered flashings, environmental conditions during installation, particularly if it is cold or wet, or dusty, can be a concern. Fluid applied flashings are easily conformable to different configurations and offer a more favorable range of installation conditions. Many fluid applied adhesives are also vapor permeable, which is vital for drying."

For Katsaros, a key industry challenge remains cold, wet, and dusty surfaces. "There is a trend towards factory built assemblies, in general, as that gets you out of the exterior environment and into a more controlled condition for installation."

# IN DEVELOPMENT

## Integrated Energy Recovery Ventilator Moves One Step Closer to Market

In a groundbreaking project for Building America℠ and the US Department of Energy (DOE), Steven Winter Associates, Inc., is developing an integrated energy recovery ventilator (ERV) designed to fit into mechanical closets (see Figure 6). The project represents the DOE's response to industry requests to simplify installation, and reaction to research results that highlight poor installed performance in previous systems.

The small-footprint ventilator will integrate with efficient forced-air systems and maintain ventilation rates regardless of heating and cooling operation over a wide range of system configurations.

***Energy Design Update*** spoke with Srikanth Puttagunta, PE, and Robb Aldrich, PE, of Steven Winter Associates, Inc. (SWA), to learn more about the technology and to call for input from the building community.

"This project started in 2016, as a way to improve balanced ventilation," explains Puttagunta. "We wanted to optimize how ERVs are integrated and installed, and wanted to provide the performance people believe they're buying." While SWA initiated the project, and conducted the bulk of research and development, industry partners soon were attracted to the effort. Therma-Stor® of Wisconsin is now a manufacturing partner.

"At the beginning, we reached out to developers and gathered feedback on what issues there were with ventilation systems, as well as what features there were of value," Puttagunta says.

"When we spoke with developers, we found that a majority of experiences people had with ERVs or heat recovery ventilators (HRVs) were bad experiences," Aldrich notes. "We wanted our research and development to lead to a product that will solve a lot of the issues noted in the field."

"As engineers, we want to have a product that can do it all, but the real question is what can the market afford and tolerate, what are the key features of importance?" says Puttagunta.

The integrated ERV system is currently undergoing monitored testing in the SWA office, providing heating, cooling, and ventilation (Figure 7). The team hopes to begin testing in occupied homes during spring or summer 2019. The prototype under analysis is designed to fit into mechanical closets. As previously noted, the small-footprint ventilator will integrate with efficient forced air systems. Electronically

commutated motor (ECM) fans maintain ventilation rates regardless of heating and cooling operation over a wide range of system configurations.

"The overlap between heating and cooling flow rates and ventilation flow rates are getting much closer," notes Aldrich. "With fan technology also becoming much more efficient and versatile, this pairing made sense."

A traditional ERV add-on is difficult to install, has a larger footprint and maintenance access requirements, offers inconsistent flow rates due to competition from the air handling unit (AHU), and can only be commissioned at a single AHU speed. SWA's integrated ERV design is compact, with a small footprint; offers minimized connections; consistently maintains desired flow rates (even during frost prevention), with the constantly modulating ECM fans ensuring the delivery of the desired amount of exhaust and outdoor air under ASHRAE; and, has low electrical power needs (see Figure 8).

### *SWA Integrated ERV Features:*

- Single Unit Specification: delivers ventilation flow rates from 40 cfm up to 120 cfm.
- Enhanced Frost Prevention: During very cold weather, ventilation flow rates are continuously maintained by mixing return air into the OA stream. There is no need for recirculation, unbalanced ventilation, or power hungry electric preheat.
- Energy Recovery: 70% sensible effectiveness, 50% total recovery efficiency at 120 cfm.
- High Filtration: Designed for at least MERV 13 filtration of outdoor air.
- Low Power: Prototypes delivered 120 cfm of ventilation with 40-80 Watts, including the AHU.
- Compact: Connects to the return side of an air handler. Fresh air is distributed throughout the home through heating and cooling ducts. All maintenance needs are executed through the front panel.
- Minimal Connections: Need only to provide ventilation inlet and outlet ductwork, resulting in two field connections (in addition to the normal AHU setup) instead of four connections typical of non-integrated ERV's.
- Versatile: The unit will be able to accommodate systems up to 2 tons. Exhaust air can be diverted from return air as shown or ducted separately to provide targeted exhaust.

The team at SWA, the DOE, and the Building America program is looking for feedback from the market on whole-house ventilation in general as well as on key features of our prototype. The team would greatly appreciate your feedback on this 3-part questionnaire, available at *https://forms.office.com/Pages/ResponsePage.aspx?id=SKgL82rMVUKqgaqBPQlHvxR2JNY9UxlOiVV9K63gB-hUNkJPWlU0RTEyOUhOMlA0SllOMzU4MkNVVy4u.*

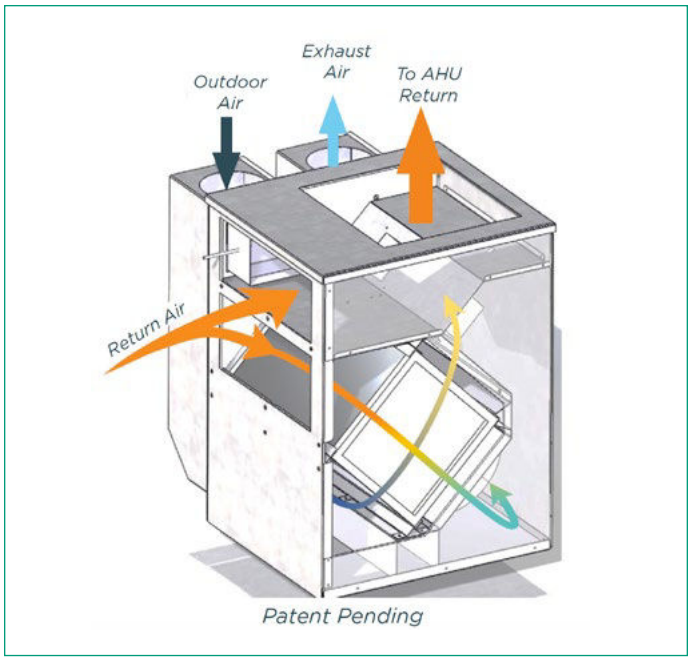


**Figure 6.** In a groundbreaking project for Building America℠ and the US Department of Energy (DOE), Steven Winter Associates, Inc., is developing an integrated energy recovery ventilator (ERV) designed to fit into mechanical closets. Schematic courtesy Steven Winter Associates, Inc.

**Figure 7.** Integrated energy recovery ventilator unit undergoing monitored testing in the Steven Winter Associates, Inc. office. Image courtesy Steven Winter Associates, Inc.

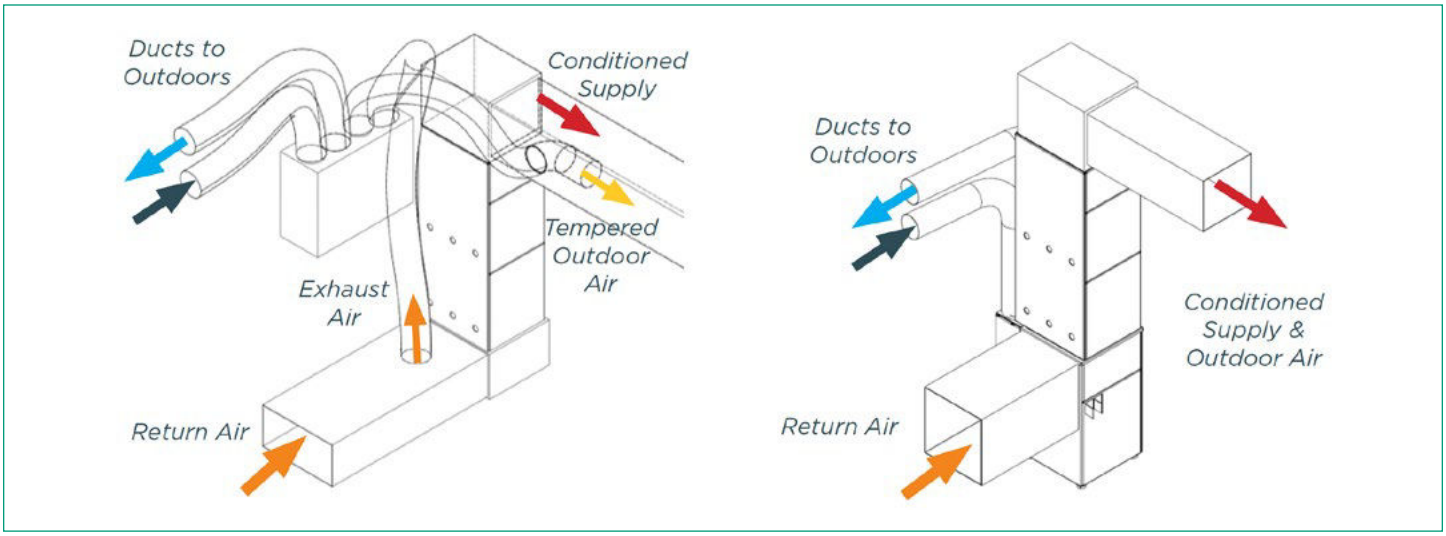


**Figure 8.** Traditional energy recovery ventilator (ERV) shown on the left; Steven Winter Associates, Inc. integrated ERV shown on the right. Schematic courtesy Steven Winter Associates, Inc.

*The questionnaire covers:*

1. General residential ventilation practices;
2. Desired features of the integrated energy recovery ventilator (ERV);
3. General information on the responder.

To review the informational document on the Integrated ERV prior to taking the survey, visit: *http://www.swinter.com/wp-content/uploads/VICS-v7.pdf.*

The results from this survey will be provided in a future SWA blog article.

"While we're obviously not 'on the shelf' yet, this is a very cool project. We've been working hard on it for over two years, and have yet to hit a deal breaker," says Aldrich. "While no system is foolproof – a bad design, poor duct layout, lack of maintenance, and incorrect installation can still kill performance – we are excited to offer a product with better integration possibilities, easier installation, and with features targeted to market demand."

# IN BRIEF

## Around the Industry…

### DOE Reveals Line-Up of New Research and Development Projects

On January 29, 2019, the US Department of Energy (DOE) announced up to $42 million in project selections to support early-stage research and development of innovative residential and commercial building technologies for energy efficiency.

A total of 46 research teams were selected as a result of three fiscal year 2018 funding opportunity announcements (FOAs) issued by the Office of Energy Efficiency and Renewable Energy's (EERE) Building Technologies Office.

Major focus areas under each FOA include:

- *Buildings Energy Efficiency Frontiers & Innovation Technologies* – 19 selections for $19.5 million
  - Advanced separation technologies for dehumidification
  - Innovative materials for thermal insulation
  - High performance windows
  - Advanced controls and automation in building energy management
  - Innovative technologies using natural gas
- *Solid State Lighting* – 11 selections for $11 million
  - Core technology research for LEDs and organic LEDs (OLEDs)
  - Proof-of-concept and prototype development for LEDs and OLEDs
  - Advanced manufacturing R&D focuses on chemistry and physics of LED/OLED panel fabrication
- *Building America* – 16 selections for $11.5 million
  - Development and validation of high performance residential envelope systems that provide moisture management and validation of high performance envelope specifications for performance and durability
  - Heating, ventilation and air conditioning (HVAC) installation and performance
  - Gap analysis of building industry standard practices

**Figure 9.** Building America℠ house in Albuquerque, New Mexico. Over the years, Building America research and development funding has driven advanced framing, low-e windows, controlled ventilation systems, ducts within the conditioned space, and improved insulation strategies to prevent heating and cooling losses. Photo by Warren Gretz and courtesy the National Renewable Energy Laboratory.

## A Closer Look at New Building America Research

The Building Technologies Office (BTO) announced it is investing up to $11.5 million in 16 projects to drive innovation and early-stage research and development that will improve the energy performance of building envelopes and heating, ventilation, and air conditioning (HVAC) systems in American homes (see Figure 9). In addition, projects will address key challenges impacting building industry design and construction practices.

Homes account for over 20 percent of total US energy consumption and 37 percent of total US electricity use, with household annual energy bills totaling $240 billion for the nation. For the average American household, that amounts to more than $2,000 in energy bills each year. More than 40 percent of this household energy use goes to heating and cooling homes. While building materials and HVAC equipment efficiency have improved over recent decades, a number of challenges continue to result in significant energy losses. With this funding opportunity announcement (FOA), BTO selected 16 project teams to study these challenges, and to test and validate emerging energy-efficient technologies and techniques aimed at addressing them.

**Figure 10.** Air is blown into a pressurized multifamily unit while an aerosol sealant "fog" is released in the interior to seal the envelope. Image courtesy The Center for Energy and Environment®.

The Building America FOA awards were distributed among three research topic areas, which include baseline in-situ fault analysis in residential HVAC systems, integration of advanced residential building envelope and HVAC systems, and gap analysis of building industry standard practices.

### *TWO BASELINE FIELD STUDIES OF RESIDENTIAL HVAC SYSTEM FAULTS*

- **University of Central Florida (Orlando, FL):** "Investigation of the Prevalence and Energy Impacts of Residential Comfort System Faults – Hot Humid and Hot Dry Climates." The research team will collect field data, sampling 100 homes with newly installed central HVAC systems. The sample will include homes throughout the hot humid climate regions, and will provide representative baseline data on the prevalence and severity of residential HVAC system installation faults.
- **University of Nebraska (Lincoln, NE):** "A Field Study to Characterize Fault Prevalence in Residential Comfort Systems." The research team will use a wireless fault monitoring system that it developed, along with site visit measurements, to build a database of fault data for 400-500 residential AC systems. These field measurements will be taken in seven cities throughout the US. The data will be used to develop fault prevalence functions; that is, the frequency of faults by type and by intensity.

### *EIGHT PROJECTS TO RESEARCH INTEGRATION OF ADVANCED RESIDENTIAL ENVELOPE AND HVAC SYSTEMS*

- **Center for Energy and Environment (Minneapolis, MN):** "Aerosol Envelope Sealing of Existing Residences." The research team will use an aerosol envelope sealing technology to improve envelope airtightness of existing buildings by up to 90 percent (see Figure 10). The process involves pressurizing the house or unit for an hour or two while applying an aerosol sealant to the building interior. As air escapes the building through leaks in the envelope, the sealant particles are carried to the leaks and seal them.
- **Boston University (Boston, MA):** "Development of Advanced Measurement and Modeling Standards for Zonal Infiltration and Compartmentalization in Multifamily Buildings." The research team will develop a simplified test method for measurement of air leakage in multifamily buildings. The simplified Zonal Multipoint Pressure (ZMP) testing method requires development of more robust models to better predict complex natural airflow and pressure mapping throughout these multi-zone buildings, based on long-term monitoring of natural pressure differences for low-, mid-, and high-rise housing in several climate zones.
- **New Jersey Institute of Technology (Newark, NJ):** "Re-Side Right: A Systems Approach to High Performance Re-Siding Projects." The research team will field test and validate an advanced new system for re-siding existing homes with

high-performance, graphite-infused rigid insulation, combined with a liquid flashing/sealing product, in climate zones 3, 4, and 5. Homes are typically re-sided only once every 25 years, usually without energy performance improvement. Thus, advanced re-siding is a unique opportunity to capture significant energy savings through air-sealing and exterior insulation that would otherwise be lost for decades.

- **University of Minnesota (Minneapolis, MN):** "Accelerating the Market Adoption of the Solid Panel Structural System and 'Perfect Wall'." The research team will conduct comprehensive structural testing of a solid panel wall system that includes superior energy performance at reduced cost compared to conventionally framed houses. This project will also explore how the advanced single-family structural solutions can be adapted to multifamily buildings, enabling construction of more energy efficient, affordable housing.
- **University of Alabama (Birmingham, AL):** "IoT Based Comfort Control and Fault Diagnostics System (i-COMFORT) for Energy Efficient Residential Houses." The research team aims to develop an innovative smart home energy management system including a low-cost sensor network, automated fault detection and diagnostics (AFDD) methods for both building envelope and HVAC systems that utilize the sensor network, and a prototype real-time smart home energy management system that integrates these components with smart controls to optimize home energy use and occupant comfort.
- **Steven Winter Associates Inc. (Norwalk, CT):** "Low-Load HDAC Comfort System." The research team will conduct research to develop a new integrated heating, dehumidification, and air conditioning (HDAC) system for high-performance homes. The prototype HDAC system will provide 1-ton of space conditioning system that can better meet the specific heating, cooling, and humidity control loads of energy-efficient multifamily dwelling units and low-load single-family homes.
- **New Ecology Inc. (Boston, MA):** "Optimizing Hydronic Heating for Comfort and Performance." The research team will develop and validate a new low-cost remote monitoring system to significantly improve energy performance of central heating systems in multifamily buildings. The innovative system obtains system and component performance data from on-board or supplemental data acquisition systems, then automates the boiler and distribution system to automate the optimization analyses and fault detection process to significantly lower energy and implementation costs.
- **Southface (Atlanta, GA):** "Optimizing Residential HVAC Performance Using Quality Installation Verification and Monitoring Tools." The research team will conduct a field study to validate new advanced HVAC installation verification and monitoring tools in DOE climate zones 2 through 7. The team will collect and analyze real-world data on installed HVAC systems both during service visits and during operation, documenting the effects of system faults and combinations of faults, improving operational performance and reducing costs.
- **University of Oklahoma (Norman, OK):** "Development and validation of a home comfort system for total performance deficiency/fault detection and optimal control." The research team will develop and validate a smart thermostat-integrated low-cost home energy management system, including a data connection framework; a computationally efficient, self-learning home thermal model; automatic fault detection and analysis algorithms; and home energy management information and controls based on in-situ measured efficiencies of heating and cooling equipment, the air distribution system, and the building envelope.

## *FIVE PROJECTS TO STUDY BUILDING INDUSTRY STANDARD PRACTICES*

- **University of Central Florida (Orlando, FL):** "Transitioning to Market Driven Residential Energy Codes: Model Residential Building Energy Code Effectiveness in a Changing Technological Environment – A New Paradigm." The research team will identify and quantify the impact of procedural and technical best practices in the residential building space on the international model energy code process. The research team will evaluate energy and cost data on the differences between residential code compliance methods, inventory compliance issues, technology gaps, and potential energy and cost impacts associated with in each compliance method, and create specifications for electronic tools that meet the needs of jurisdictions wishing to improve the code permitting and compliance verification process.
- **Home Innovation Research Labs Inc. (Upper Marlboro, MD):** "Residential Energy Code Compliance Path Implementation and Implications Survey." The research team will conduct nationwide studies to determine the prevalence and relative usage of various energy code compliance paths for new home construction. Additional data will be collected on a subset of these homes, including energy performance (utility bills), thermal comfort, and general satisfaction data. This data will be analyzed to evaluate the association between the chosen compliance path and resulting energy performance.
- **Institute for Market Transformation (Washington, DC):** "Utah and Arizona Energy Code Compliance Study." The research team will conduct residential energy-efficiency field studies in the states of Utah and Arizona. The team will use established methodologies to identify target measures with the greatest impact on energy efficiency in new single-family homes, as well as the associated energy and cost savings potential. This information has significant value and can inform ongoing industry education, training and outreach programs within each state.

- **National Association of State Energy Officials (Arlington, VA):** "An Energy Codes Gap Analysis Field Study in the Southwest." The research team will conduct residential energy-efficiency field studies in the states of Colorado and Nevada. The team will use established methodologies to identify target measures with the greatest impact on energy efficiency in new single-family homes, as well as the associated energy and cost savings potential. This information has significant value and can inform ongoing industry education, training and outreach programs within each state.
- **South-central Partnership for Energy Efficiency as a Resource (Austin, TX):** "Construction Trends, Code Compliance, and Building Performance." The research team will investigate the prevalence of various compliance paths, and the relationship between compliance path used and energy use intensity (EUI). This will be performed through a comparative analysis of prominent industry data sources used to demonstrate building energy efficiency.

All information courtesy DOE. For more information on these selections, visit *https://www.energy.gov/eere/articles/energy-department-announces-42-million-project-selections-innovative-buildings and https://www.energy.gov/eere/buildings/building-technologies-office.*

## ASHRAE® Approves Committee for Passive Building Standard

Standard Project Committee 227P, "Passive Building Design Standard," was approved during the 2019 ASHRAE Winter Conference in Atlanta in January. (To view the proposed standard, visit *https://www.ashrae.org/technical-resources/standards-and-guidelines/titles-purposes-and-scopes#spc227).*

The committee is now looking for members to create a standard that will help the industry further the use of this building design strategy that uses passive measures to reduce heating and cooling loads and energy bills. This standard's purpose is to provide requirements for the design of buildings that have exceptionally low energy usage and that are durable, resilient, comfortable, and healthy.

The committee's proposed chair Graham Wright, Ph.D., Member ASHRAE, said the passive building strategy "has been experiencing a revival and rapid growth."

"This growth has been driven by design guidelines," he said. "But for even wider adoption, it's important to go beyond voluntary and proprietary certifications and make an open standard that jurisdictions can adopt and make mandatory."

Wright, a senior scientist at Passive House Institute US, said the standard will be performance-based to allow for the most design flexibility as it will set targets on modeled energy use—particularly heating and cooling—and modeling protocol.

"It will not likely have a fully prescriptive compliance path. But it will have some mandatory best practices for construction quality as well as commissioning requirements," he said.

The standard's aim is not to be a holistic green building standard, he said, but it will focus on energy efficiency and the use of clean energy.

ASHRAE press release available at *https://www.ashrae.org/news/esociety/new-ashrae-passive-building-standard-to-boost-use-of-strategy.*

"We need to get a solid consensus, but we also want to move relatively quickly. Help us avoid process pitfalls," he said. "Also, while suppressing heating/cooling energy use is the main focus, there are other energy end uses that the standard should address. We would like the standard to lay out a path to net zero emissions or 100% renewable energy use."

Wright said the goal is to have the standard ready by 2021.

## NAHB® BIG Awards Highlight Green Builders, Sustainability

The National Association of Home Builders® (NAHB) announced the winners of its Best in Green (BIG) Awards on February 19, 2019, at a ceremony during the NAHB International Builders' Show in Las Vegas, Nevada.

In its fifth year, the BIG Awards bring recognition to the best of the best green certified projects in a variety of categories. Categories included single-family homes, multifamily projects, communities, and remodeling. Winners were chosen based on their innovative use of green features, aesthetics, functionality, amenities, and high performance certifications.

In addition to the top green projects, the BIG Awards also honored two Home Builders Associations who have long been advocates and leaders in the green and sustainable space.

"The Best in Green Awards are the industry's most prominent awards recognizing projects and individuals that are leading the way in high performance and sustainability," said Ray Tonjes, NAHB's 2018 Sustainability & Green Building Subcommittee Chairman from Austin, Texas. "This year's award winners are a particularly impressive group, representing the best of the best across several sectors of the building industry."

Winners for 2019 include:

- Best in Green 55+ Community: Mirabella, Bradenton, Florida, submitted by Koral & Gobuty Development, LLC
- Best in Green Community: Mahncke Park, San Antonio, Texas, submitted by Imagine Homes (see Figure 11)
- Best in Green Community: Caliza Courts Rowhouses, Alys Beach, Florida, submitted by Green$mart Companies
- Best in Green Multifamily Affordable Project: Elements Collection, Denver, Colorado submitted by Thrive Home Builders
- Best in Green Multifamily Market Rate Project: Ten at Clarendon, Arlington, Virginia, submitted by CBG Building Company

**Figure 11.** Best in Green Community: Mahncke Park, San Antonio, Texas, submitted by Imagine Homes, winner of Best in Green (BIG) Awards at the The National Association of Home Builders® (NAHB) International Builders' Show in Las Vegas, Nevada. Photo from *http://www.imaginehomessa.com/n-cottages-at-mahncke-park.php*.

- Best in Green Single-Family Custom Home: Historic Infill Home, Decatur, Georgia, submitted by SK Collaborative
- Best in Green Single-Family Production Home: Panacea Collection, Denver, Colorado, submitted by Thrive Home Builders
- Best in Green Remodeling Project: Norcross Remodel, Dallas, Texas, submitted by Ferrier Builders Inc.
- Best in Green NGBS Project of the Year, Historic Infill Home, Decatur, Georgia, submitted by SK Collaborative
- Best in Green HBA of the Year (two winners), Santa Fe Area Home Builders Association and Home Builders Association of Metro Portland

Information courtesy NAHB. To see the finalists and other additional information about the Best in Green awards, visit *http://www.nahbclassic.org/showpage_details.aspx?showPageID=43809.*

## DOE Unveils New Tools to Accelerate Energy Savings for Homes

On November 27, 2018, The US Department of Energy (DOE) announced new tools designed to improve energy savings in homes as a result of the completion of two Better Buildings Accelerators – the Home Energy Information Accelerator and Home Upgrade Program Accelerator.

The Home Energy Information Accelerator *(https://betterbuildingsinitiative.energy.gov/accelerators/home-energy-information)* expands the availability of reliable energy information to ensure consumers have access to energy cost information. Since 2015, Accelerator partners have provided training on home energy information to roughly 7,500 real estate professionals including REALTORS®, appraisers, brokers, and lenders. As a capstone resource, DOE developed the Home Energy Information Accelerator Toolkit *(https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/HEIA%20TOOLKIT%20081318.pdf)* for residential efficiency stakeholders to find examples and best practices learned by Accelerator partners.

The Home Upgrade Program Accelerator *(https://betterbuildingsinitiative.energy.gov/accelerators/home-upgrade-program)* leveraged data management strategies to reduce costs and expand services of home energy upgrade programs nationwide. Five Accelerator partners completed improvements to streamline data management processes that demonstrated reduced program costs for their home energy upgrade programs.

DOE, in cooperation with the Home Performance Coalition and the HPXML Working Group, introduced new online tools for software developers and an HPXML implementation guide to simplify data aggregation and analysis to lower contractor costs in home performance programs. HPXML is an open data standard that is comprised of a data dictionary and a standard data transfer protocol (xml) that promotes the efficient exchange of information and data among residential energy efficiency programs, home performance contractors, and other information trading partners.