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IN DEPTH

Hot, Humid, and Still Cool

Corey Saft, Saft Architecture and Eric Helton, Bloomfield Research Labs LLC

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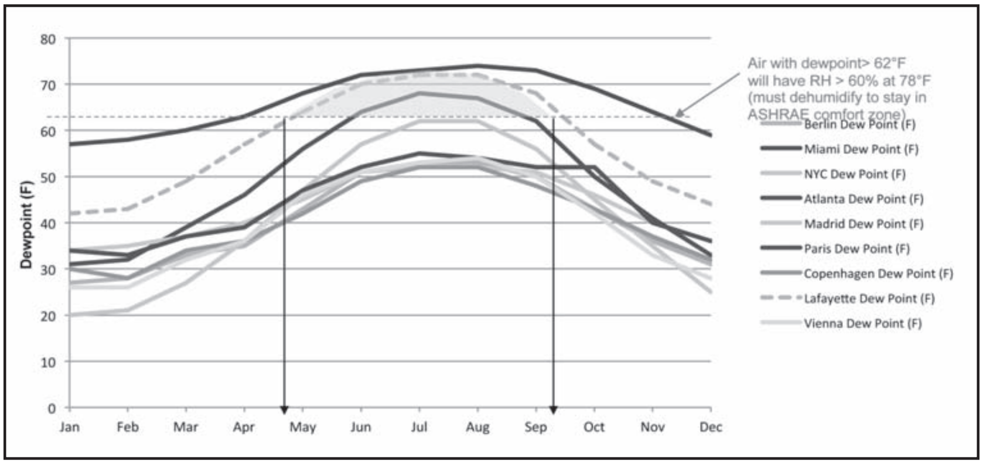

Figure 1. Monthly average dewpoint temperature comparison of various locations in the US and Europe. It is based on a diagram that Henry Gifford shows and developed to its current form by C. Saft and Z. Smith.

Overview

Passive House is optimized for heating dominated climates. By minimizing conduction and infiltration losses and controlling solar gain, the heating requirements for a building can largely be taken care of by internal gains (people and equipment). All a heating system need do is to temper required ventilation air. Passive House is not optimized for climates where cooling and dehumidification loads dominate. Developed in the low humidity, temperate climate of central Europe, the Passive House envelope and a conventional cooling system do not adapt well to hot/humid climates. The US Deep South is a cooling dominated climate marked by significant sensible and an extreme latent load. The energy required to manage the latent loads can be 6, 7, or 8 times that of the sensible load. And while peak loads in the Deep South can easily be similar to some more northerly climates, the yearly cumulative load remains comparatively extreme, as shown in Figure 1.

The issue of energy demand caused by the latent load of the ventilation air is fundamental, and these loads must be handled separately to be able to efficiently provide comfort. From a Passive House perspective, this is complicated because conventional cooling systems are not designed for majority latent load management. While an energy recovery ventilator (ERV) is able to recover 80–90% of energy required to temper intake air during the heating season,

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during the cooling season, ERV efficiencies are typically much smaller: 35–50%. This is due to smaller DT and higher latent load. The achievable dehumidification performance of a stand-alone dehumidifier is much less than the 16 SEER (that is, 16 kBtu/kWh) or higher performance numbers we are used to thinking about for cooling systems. A "high-performance" residential-scale dehumidifier may be rated at 2.4 liters/kWh, which translates to just 5.5 kBtu/kWh. Then the cooling system must extract the heat the dehumidifier has deposited in the building, requiring more energy consumption.

Ventilation Load Index (VLI) indicates that, in the Deep South, over 80% of the load for ventilation air is latent, not sensible [Harriman]. If we use a good-performing dehumidifier to handle most of the latent load and the conventional AC system to handle mostly sensible loads, we predict that ventilation loads alone for our test 120 m^2 house will be 15 $kWh/m^2/yr$, before we even get to loads due to the envelope or internal gains from occupants. We estimate that meeting total cooling loads (latent + sensible) could exceed 30 $kWh/m^2/yr$. The PH target for annual site energy for heating (15 $kWh/m^2/yr$) is based on what was achievable with good design and best equipment. For hot-humid climates, this same criteria has yet to be quantified.

LeBois

The LeBois house is a 120 m^2 three bedroom, two bath home with a large double height space that was completed in January 2010 in Lafayette, Louisiana. The volume of this small two-story home has a volume comparable to a 186 m^2 (2,000 SF) house with eight-foot ceilings. There is a 1.5-ton mini-split heat pump with single head in the living room and an ERV that provides 70 cfm of continuous tempered outside air to the bedrooms and living room. The ERV exhausts stale air from the bathrooms and kitchen. The home has been occupied by three college students for the past 2.5 years.

The home was monitored with 12 Onset H08 and H14 temperature and humidity loggers on 3–6 minute intervals set throughout the house/basement/exterior, and in each of the four ERV ducts. One Onset logger used a current transducer to estimate the energy use of the ERV. A four-channel The Energy Detective (TED) system measured and recorded grid energy, PV generation, and the mini-split energy. Eric Helton, of Bloomfield Research Labs LLC, and co-author of this paper, was jointly retained by Corey Saft and the PHIUS as a third-party analyst of the data.

The home was modeled and certified using the Passive House Planning Package (PHPP), and was predicted to need 8 $kWh/m^2/yr$ heating, 15 $kWh/m^2/yr$ cooling, and 116 $kWh/m^2/yr$ annual source energy consumption. We have now collected 18 months of energy and comfort data, and present a first round of the analysis here.

Results: Comfort

Average monthly indoor and outdoor temperature, relative humidity, and dewpoint temperature are shown in Figure 2a, 2b, and 2c. Thermal comfort in the LeBois house is characterized by two distinct thermal areas within the house: open/public areas and closed/private spaces. The thermostat in the public area was set lower than ideal to maintain comfort in the bedrooms. In the summer, the mini-split heat pump was frequently operated to keep the open spaces up to 5 or 6°F (2–3 C) cooler than the bedrooms. While both zones could be kept in the ASHRAE comfort zone, the public areas generally were a bit cooler than optimum, and the private areas a bit warmer. The public space was typically near the center-left of the ASHRAE comfort zone with temperatures in the mid-70's°F (low-mid 20's C) and RH mid-50%. The bedroom spaces often hovered at the far right side of the ASHRAE comfort zone, with temperatures occasionally hitting 80°F (27 C) and RH typically in the lower 50%. The ERV- and dehumidifier-pretreated ventilation air was the main conditioning for

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Managing Editor: Vicki Dean

Publisher: Paul Gibson
Designer: Chris Tankiewicz

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Editor's Contact Information: Amanda Voss, Energy Design Update, 9019 Hunters Creek Street, Highlands Ranch, CO 80126, 303-663-2009, avitaproverum@gmail.com.

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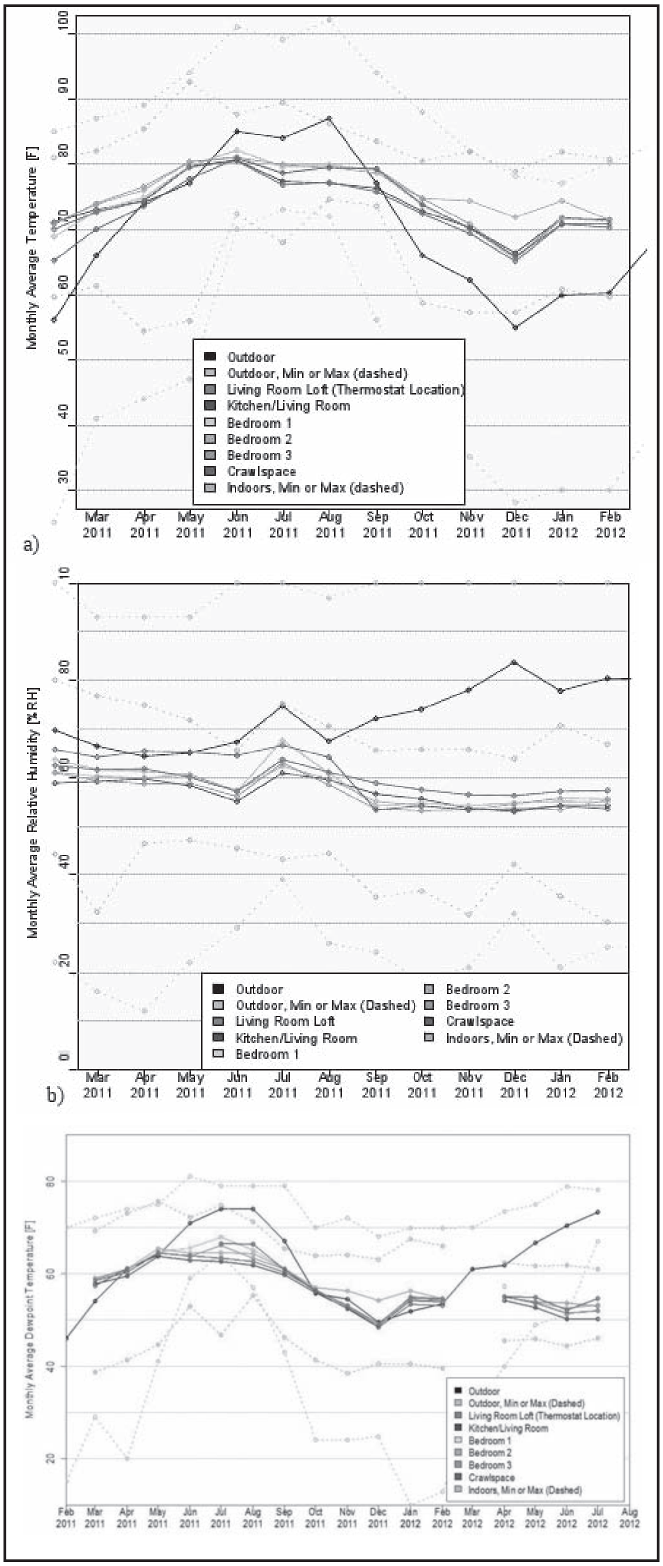

Figure 2. Monthly average a) temperatures, b) %RH, and c) dew point temperature.

the bedrooms, especially when the doors were closed. Convection never balanced the thermal comfort of the house. There is little that can be done to equalize temperatures between the two space types.

Table 1

	Total Energy Use [kWh]	Mini-Split [kWh]	Net Energy [kWh]	PV Generation [kWh]
Mar 2011	576	1	178	-398
Apr 2011	715	113	281	-434
May 2011	555	94	30	-525
Jun 2011	694	262	235	-458
Jul 2011	669	249	296	-373
Aug 2011	822	284	328	-493
Sep 2011	988	207	557	-431
Oct 2011	621	61	199	-422
Nov 2011	652	24	360	-292
Dec 2011	439	14	227	-212
Jan 2012	735	17	480	-255
Feb 2012	720	15	502	-218
12-Month Total [kWh/a]	8,185	1,342 (cool=1,271 heat=71)	3,674	-4,511
Specific 12-Month Total [kWh/m2a]	68.3	11.2 (cool=10.6 heat=0.59)	30.7	-37.7

Table 1. Monthly total electrical energy use and generation.

Results: Energy

Monthly and annual energy use and generation are shown in Table 1 and Figure 3. Comparisons to the PHPP modeling are presented in Table 2.

Heating was rarely required, and the actual use was about 7% of the predicted need. Cooling was more significant, but still only 70% of the predicted need. Primary energy was approximately 50% greater than predicted by the PHPP. Annual latent is estimated to be 15 kWh/m^2/yr (compared to no quota). The total energy used by the mini-split for the 12-month test period was 1,342 kWh/a, of which approximately 1,271 kWh/a were used for cooling and 71 kWh/a were used for heating.

A number of factors contribute to the larger than expected primary energy number for the house:

- The addition of the stand-alone dehumidifier in August 2011;
- While the ERV is critical to performance, the measured performance (35%) is less than rated, and the ERV suffered a few operational issues over the

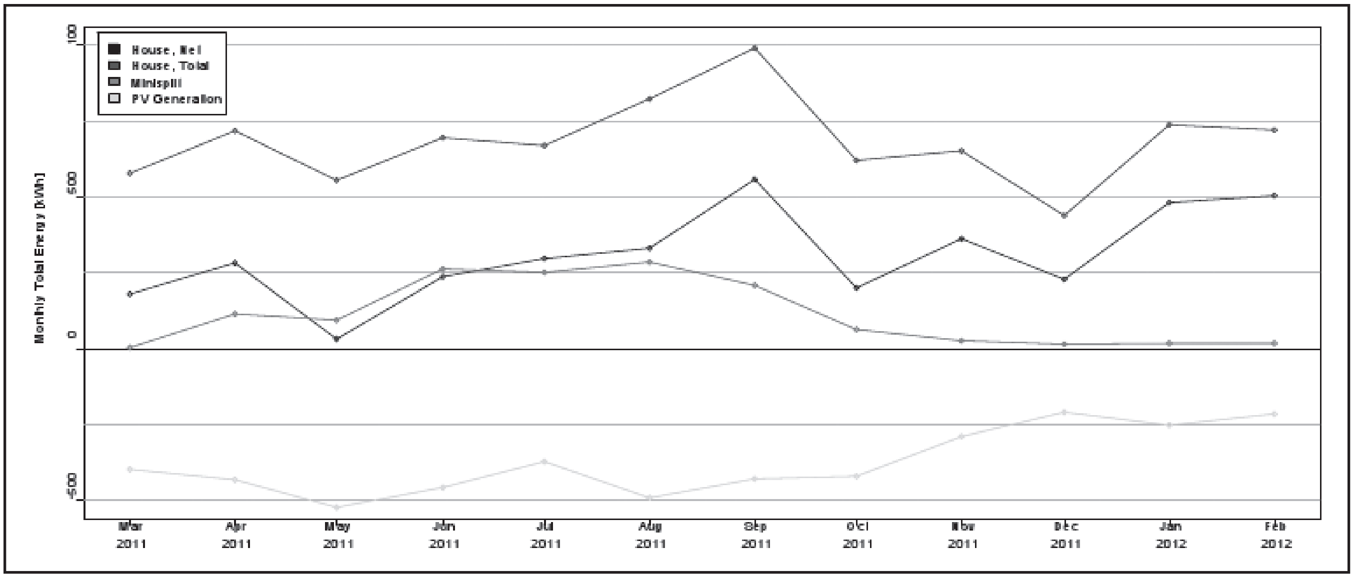

Figure 3. Monthly total energy use and generation.

course of the study, such as an extended period with an increasingly blocked intake duct;

- The consequences of the house being a rental;
- The irregular/inconsistent student lifestyle; and
- The occupants maintained a large electronics collection, including computers, video games, stereo equipment, an extra mini-fridge, projector, and amplified musical instruments.

Conclusions

- The house exceeded the primary energy modeling by the PHPP for 12 months of data.
- The 12-month measured heating and cooling energy totals were below the PHPH model.
- The PHPP model may not realistically model the high cumulative latent loads induced by ventilation air in the hot/humid climate.
- Comfort was marginally maintained during the summer, but temperature uniformity between the open and private spaces was impossible.

Table 2

	PHPP Specific Energy Use [kWh/m²a]	Measured Specific Energy Use (Mar 2011 - Feb 2012) [kWh/m²a]
Primary Energy	116	184
Cooling	15	10.6
Heating	8	0.6

Table 2. PHPP modeling and 12-month measured energy data.

Future Work

- The next major modification to the data collection project will be dedicated monitoring of the dehumidifier energy consumption separately from the ERV and the mini-split.
- Investigate improved comfort by delivering dehumidified air adjacent to the mini-split head.
- Work with the PHIUS/PHPP software team to ensure latent loads are handled realistically.
- More flexible and realistic energy requirements by setting a Total Source Energy and allowing each building to adapt this total, as appropriate for the climate, to heating/cooling/dehumidification.

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- Z. Smith, AIA, LEED AP BD+C, Director of Sustainability and Building Performance, Eskew+Dumez+Ripple, New Orleans, Louisiana
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Corey Saft, RA, LEED AP
Associate Professor, Undergraduate Coordinator
School of Architecture and Design
University of Louisiana at Lafayette
saft.corey@gmail.com

Corey Saft has taught in the School of Architecture and Design at the University of Louisiana at Lafayette since 2002, while also maintaining a small design and research practice. He teaches design, theory, and fabrication. His practice is responsible for one of the first ten passive houses in the United States, and the first in the hot and humid southern United States. He earned his master's degree in architecture from the University of Oregon in 1999. He moved to Louisiana in 2001, and is a native of Philadelphia, Pennsylvania.

Eric Helton
eric.helton@bloomfieldresearchlabs.com

Eric Helton is the owner of Bloomfield Research Labs LLC, which specializes in monitoring, analysis, and research for the building science community. As a mechanical engineer, tinkerer, measurement geek, and father, he spends his time measuring and thinking about the world around him. Eric has worked in the building science and renewable energy fields since the late 1990's.

IN DEVELOPMENT

Perspectives: Can AHEMs Modify Occupant Behavior to Create Energy Efficiency?

Stand-alone home energy management systems (HEMs). Networked HEMs. In-home displays. GE Nucleus™. Nexia™. Nest®. Iris™ home control system. Cevia© Energy Display. With the emergence and proliferation of automated home energy management systems (AHEMs), ***Energy Design Update*** contacted experts across this industry to ask them a simple question: can these systems realize energy efficiency gains? While no firm answers exist yet from data, the diverse perspectives raise some valuable points moving forward.

Olga Sachs, Ph.D., Building Energy Efficiency Group, Fraunhofer Center for Sustainable Energy Systems CSE, Cambridge, Massachusetts

Our experience on this question has been primarily limited to research on programmable thermostats and home energy displays. We conducted two separate studies that may help explain the effectiveness of these types of home energy management technologies.

Our first study focused on programmable thermostats. Our project was based on prior research by Lawrence Berkeley National Laboratory (LBL), which tested and found a wide range of usability among thermostats. Some models they found were very easy to use, and easy to interact with. Others were hard even to set the time on. From the LBL laboratory evaluation, we developed the hypothesis that poor usability may prevent effective use of energy saving features in programmable thermostats, or realization of their energy potential. We tested our hypothesis in a realistic field situation, and predicted that home users with higher usability thermostats will be more likely to use their energy saving features, such as nighttime setbacks, daytime setbacks, and vacation holds.

We selected two thermostats based on LBL evaluations: the high usability model we selected was Honeywell's VisionPRO, the low usability model was another Honeywell model, just a basic thermostat. Both thermostats had the same default settings that insured the full use of nighttime and daytime setbacks, and were installed in a multi-family building along with temperature sensors and heating, ventilation, and air conditioning (HVAC) sensors to give us data about temperatures in each apartment, and to infer which thermostat settings were used. Following the installation, we monitored home occupant interaction with the programmable thermostats throughout last year's heating season, January to March. Our analysis focused on four types of occupant interaction: use of night setbacks, use of day setbacks, vacation holds, and reprogramming events. We were able to infer interactions from the sensor data we collected.

We found that thermostat usability did not influence energy saving behavior, and found no significant difference in temperatures maintained between apartments with high and low usability thermostats. The proportion of households that used the thermostat to achieve energy savings was very low, overall only 3%. We found that many households used the permanent hold feature to maintain a high temperature, rather than to keep it low when absent. The thermostat was used to keep a desired temperature, not save energy. From analysis of reprogramming, this activity did not result in meaningful lowering of temperature or energy savings.

It is key to highlight that our results were limited to the very specific study sample we used. The building in the study was a mix of affordable housing and market rate apartments; thus, a very specific demographic. We used specific thermostat models based on LBL work; there could be another high usability model not tested by LBL that could produce different results.

Overall, our interpretation of the findings is that thermal comfort seems more important to home occupants than energy efficiency or savings. Installing a programmable thermostat alone does not lead to energy savings.

Our second study evaluates providing another opportunity for energy efficiency – Home Energy Displays (HEDs), as displays provide feedback on energy consumption making it visible and tangible. A recent ACEEE meta-analysis of energy feedback research by Karen Ehrhardt-Martinez highlighted the high potential of this technology to achieve energy savings on the order of 4–12%. However, it is still unclear what factors influence the persistence of feedback-driven behavior changes in saving energy. We hypothesized that the level of engagement with technology may influence persistence of energy savings. This, in turn, could be influenced by the way feedback is presented to home occupants – as a stand-alone display, or as a combination of display and a Web portal that provides more processed and relevant information to home occupants. We did laboratory testing prior to field testing, and conducted three user research studies to identify user feedback preference, and found that users value flexibility in data access, such as access through multi-media, smart phone, and the Web; that people value clarity, intuitiveness, and want content that is easy to grasp (they don't want to interpret graphs or read text); and that there is a significant gap between basic model cost and how much people are willing to pay for this technology.

Our Phase 2 goal was to test the actual level of interaction with feedback. The goal was for one group of residents in a multi-family apartment building to receive the stand-alone display, and for another group to receive a supplemental Web portal besides the display. One thing we found out is that only 8% of building tenants opted to participate in the study. We also encountered problems with the technology, including unconfigured parts, gateway miscommunications, display malfunctions, and other issues.

A lot of research cited about home energy management systems seems to be conducted using self-selected early adopters. The conclusions that are drawn from this type of a sample may not be relevant to the population as a whole. What we're trying to do now is to choose a different, more reliable technology for this evaluation, and are now conducting research at Harvard University with Web feedback only. Specifically, we are looking at the role of regular electricity consumption alerts in driving people's engagement with feedback. Will alerts increase engagement, as opposed to regular feedback?

Another conclusion that we drew from focus groups and surveys is that home energy displays may be better used as problem-solving tools; participants used displays to figure out what consumed the most energy and, once that was established, they used the display much less. Maybe a rental program could be designed to raise awareness of household consumption patterns.

Craig Savage, Building Media Inc., Santa Barbara, California

For our Pueblo Way net-zero energy retrofit project, in Las Vegas, NV, we partnered with Green Builder Media to design, upgrade, and showcase a green demonstration home for the builder show in Vegas 2009. The DOE Building America team, CARB, provided the EE analysis.

The Pueblo Way house was built in 1963, a mid-century modern style by Palm Springs architects, Crisel and Palmer. A classic energy hog, it had been "remuddled" several times as progressive owners tried to deal with the heat and intense direct sunlight at certain times of the year. The post and beam constructed roof consisted of only 2x6 tongue and groove decking over exposed 2x8 rafters.

We went in and did a deep-energy retrofit as unobtrusively as possible. We took off the roofing, sheathing, and stucco siding, cleaned out the rafter and stud cavities, upgraded mechanicals, and filled the entire building envelope with urethane foam (see *http://buildingmedia.com/revisionhouse* for further details on the home). We put in energy efficient windows, doors, and HVAC, water-saving fixtures, and LED lights.

In the process, we brought in Lutron lighting. Lutron made the case that their automated lighting system would save energy, and insisted that we should monitor the energy usage of the house at the circuit level. At the main panel, we installed the Powerhouse Dynamics monitoring system. The system uses simple-to-install "cuffs" or "CT's" on every breaker to aggregate the reporting of all of the energy usage information. According to CARB, the LEDs and CFLs can save 500 kw hrs per year using Lutron management controls.

How does this drive energy efficiency? From my perspective, its zero. You get all kinds of useful information. You can have it send information directly to you. Alerts can affect behavioral change. From our standpoint, we just want to monitor appliance function and have verification of savings taking place. However, I'd have to say that we're a special case. Our house has been turned into a vacation rental, and the home monitoring system has proven to be a valuable tool to check on the house remotely, not so much as a way to save energy, but we can see if appliances are functioning, make sure the pool pump is operating, and even check on energy usage when the house is not being rented.

Brett Worthington, Director of Business Development for Nexia Home Intelligence

What has been the catalyst of change in this segment? Energy management is such a broad brushstroke; energy management to a utility is very different to us than it is to a builder, than to a consumer. Energy management buzz is very different regionally due to cost structures from utilities, programs, and what consumer behaviors are being forced to change.

What are the big macro trends? Time of use rates from utilities, increasing rate structures, and utility programs: these things are pocketed regionally in the US and with the big IOU's like in California, New York, Florida, and deregulated markets like Texas. Not until middle America starts to see the impact of time of use rates – which will happen – along with things like metered water and gas, will sticker shock be created that will change behavior, just like behavior at the gas pump.

What we've seen in the realm of occupant behavior in the industry is that a subsidized programmable thermostat is not going to change behavior because first, it's not the consumer's choice, and second, the consumer may not understand it. What we see right now under energy management is an indirect impact. We have to ask whether that something being measured is actionable. Does the homeowner understand it? Does a kWh display in the interface mean anything? Do they know how to read it? How do they respond to usage models? If it's not actionable, then we're not focusing on it right now.

Instead of asking how do we change behavior, how do we build around comfort and convenience? The industry cannot just be energy centric. When you add devices to a management system, it starts to become a sticky concept – i.e., when you provide a homeowner with a way to control door locks, view a camera, capture a video, control lights, that's a convenience factor. It's use with mobile devices/tablets and connecting with your home away

Figure 4. Home energy management systems are looking beyond energy management to home management tools, such as applications monitoring and controlling door locks and lighting systems remotely. Image courtesy Nexia™.

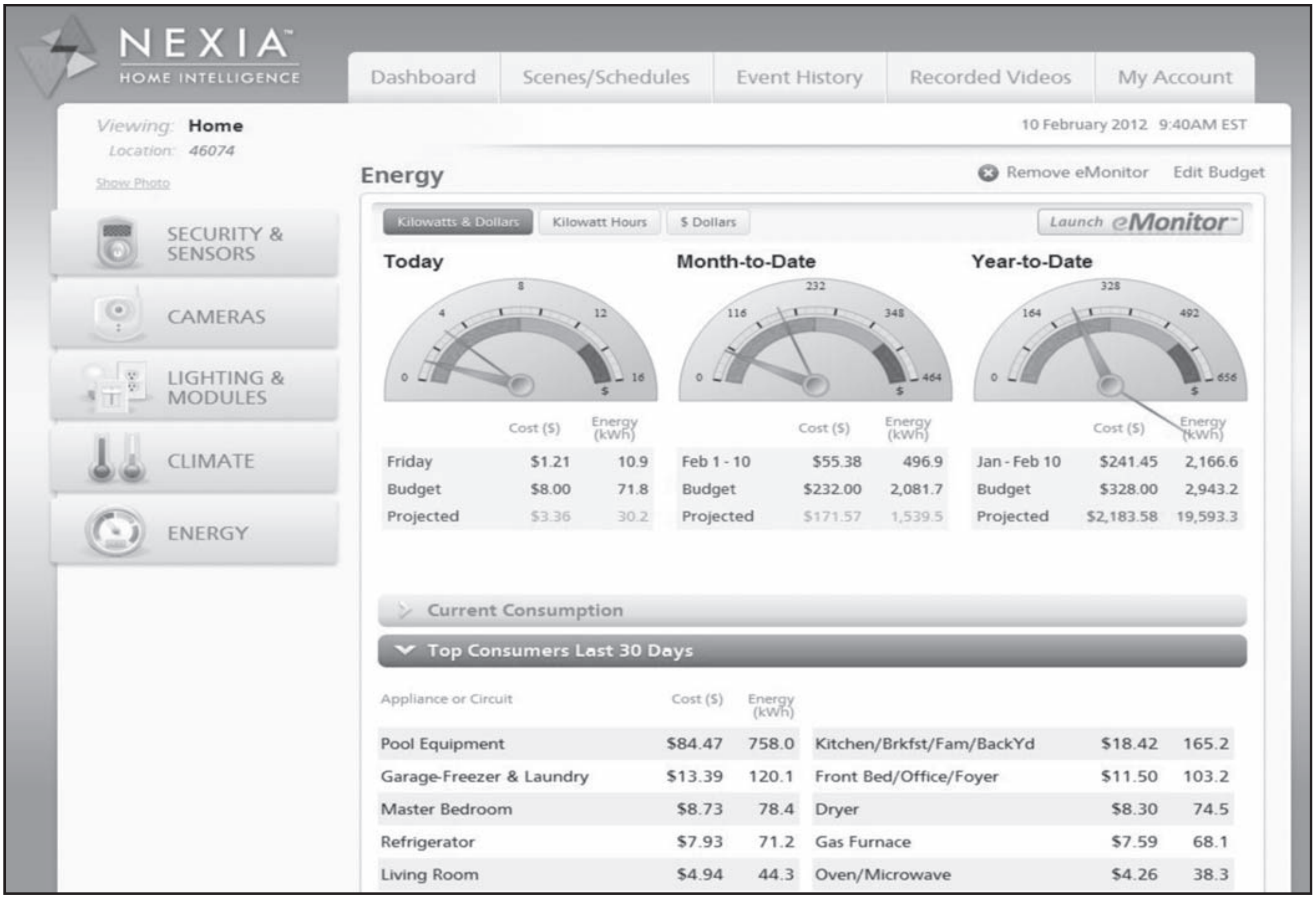

Figure 5. Dashboard screenshot. According to Brett Worthington, the vision for home energy management systems includes interoperability, ease of use, and increasing functionality. Image courtesy Nexia™.

from home (see Figure 4). Once they have it, people don't want to be without it. Just by changing all outdoor lights to dawn and dusk control, people are totally happy and have affected energy savings. That same use case can happen when you lock the front door and tie the thermostat to that lock: a homeowner punches the lock code and the system makes sure all lights turn off and adjusts the thermostat down 3 degrees. This is convenience, control, and simplicity. Simple steps lead directly to energy savings. By using a suggested thermostat "energy savings" schedule, you can realize, according to the DOE, a 15% savings every month. We're finding that's where the behavioral change occurs, showing a different type of interaction with apps and convenient scheduling and control vs. a thermostat on the wall. For the HEM industry, it's more of a migration path. The utility programs were trying to feed people through a fire hose with devices that were put into the home that most homeowners only engage with for a certain period of time. It was not "sticky" because it was not their choice. The challenge is not getting a homeowner to use it for 90-days, but make it a part of their life, and that is why it has to be more than energy. Utilities don't interface well with consumers, the consumer won't log into the utility portal, and doesn't want to worry about the data. The HEM's job is to offer a different twist for interacting with stuff. It's a migration path, spoon feeding the customer, pushing out functionality.

You can't just be a "my stuff only" solution on the platform. We've spent a lot of time learning these things, what the market is saying, what are behaviors in the home (visit *http://www.nexiahome.com* for more on this system). The average home, once they start, gets 6 or 7 devices hooked in, and there is a good stickiness to the technology. Once homeowners engage based on their choice, they stay on the system because they love the convenience and ability to add devices that they interact with every day. We want masses, and the product needs to have a targeted price point and offering to that everyday, median household market. That's always been our vision: interoperability, ease of use, increasing functionality. I think what has sped up the market acceptance is the explosion of smart phones and tablets. Now, in HEM, we make an app that people can interact with, design it really around the screens in their home, and reach people through the mobile lifestyle (see Figure 5).

Comfort and efficiency can drive behavioral change. For example, the filter in the HVAC: each air handler has "x" number of hours before its efficiency is affected; people don't realize how this impacts efficiency. On Nexia, we send the homeowner a text message when they need to change their filter. The Nexia thermostat has a screen that you can't get away from until the filter is changed. We frame this filter alert to deliver the message that this is costing you money now, and now the homeowner is driven to change. Let's look at how you control water. A homeowner doesn't want geek speak, it's got to be simplistic, i.e., set valves to "x". What if your system also delivered a text that you have a leak? That is resource management applied to everyday life, real world use cases. That's what everyday people care about. They don't want to be bogged down by load shedding; the mistake is discounting consumer behavior. Our homes are the dumbest buildings out there, and yet they contain the most valuable things in our life; but they are dumb – the places where we work and shop are smarter. When are we going to drive that change to the place we value most?

What about adoption behavior? We're seeing different consumer adoption in different ways; people who shop at Amazon will adopt this technology more quickly. Traditional retail is still a struggle. Major retailers want to get in the game, but the retailer is lagging because they can't solve basic problems: their associates can't explain the technology, or they don't offer a full turnkey solution to people. They'll get there, but today they're lagging. Service providers are now playing in this space. Verizon has to figure out the market in a different way: are people going to want Verizon controlling their thermostat? Cable companies, how do we play in this space? They are lumped into the utility bucket. Progress is being made, and the more the merrier, but it will take that to move the market. I see a migration in the market to ask, "Now how do we continue to add more functionality?", but each company can't spend massive amounts of money. Who will be the standard bearer, who can attract the independent app developers in three to five years?

What are we seeing in adoption from builders? Now that we're seeing life in new construction, and are starting to see people beat their forecast, builders are looking at what's next, how do they differentiate their home from the inventory in the marketplace. Builders are more savvy about tightening envelopes on homes, and we're seeing different standards on HVAC and insulation. How do they get beyond that: with net zero, with solar, with water management? These are all great trends. Lennar asked how do we add basic functionality that will wow people? People are walking into homes with smart phones, and can immediately interact with the home, if it has a home energy management system. Meritage is using Nexia's system in homes incorporated with an eMonitor from Powerhouse Dynamics. Meritage is also measuring and doing a case study in Phoenix, Arizona to see how this system interacts with solar production. We're seeing a lot more activity in the builder space. It doesn't cost that much to move to this system. A builder is getting home automation for literally less than $200.

CR Herro, Vice President of Environmental Affairs, Meritage Homes

For a couple of years, we have been focusing on the way our homes work, focusing on energy efficiency, water savings, and home performance. This is great and right, but it's all hidden. We needed to find something that demonstrated the function and smartness of our homes. This evolved into using home energy controls and monitors to demonstrate how well a Meritage home performs. It helps the consumer understand how smart it is. It engages homeowners emotionally and analytically. We also wanted something ready to scale nationally, with a really good "DIY" feel, so consumers would be able to bolt on and customize.

HEM offers the opportunity to really demonstrate advanced function; the eMonitor in the background allows people to understand at a fuse level and choose behavior styles that benefit them and evaluate cost per benefit. One-two punches are great. The Nexia control via smart phone – that's an example of good sexy advanced controls that give you more than you think you can have. Put that on top of a really compelling value argument and that supports the message of energy efficiency.

Homeowners selecting HEM are definitely a self-selecting group. They tend to have what are a cluster of behaviors: a very analytical person, they see data and finances. Home energy controls engage people who are already into innovation, who like the technical, and gadgets; we are finding that people already into sustainability or energy efficiency adopt this really quickly, are good at change, and are motivated. The average consumer is slowly warming up to it. It tends to be innovative, early adopters who gravitate first to any advance. The average consumer is coming in and being surprised a home could even do that. They are surprised it is cost effective. Selling home energy management to everyone is about inspiring people to have more than they thought they could.

While television networks like HGTV have showed advanced systems that cost thousands, the awareness of price point is a brand new value proposition. No one is demanding HEM on a mass scale yet, so we have to engage in education about this new opportunity. We're driving consumers.

What does this all enable? Where are we going? The implication is occupancy control, as technology allows a house to respond to personal preferences, and can also respond to behaviors so that the house will optimize itself to your personal lifestyle. Now you're going to have your home prepping the AC, hot water, creating security, creating environments for entertaining or a relaxed night alone – the house will adjust for you. I see a really neat potential where the house becomes interactive, and participates in occupant behavior. We are just starting to see what the potential of AHEM is.

Bob Hetherington - Editor of HomeToys.com Home Technology eMagazine and AltEnergyMag.com Alternative Energy eMagazine

So far, many of the solutions I have seen are more monitors than managers. I'm not sure that the average homeowner would be interested enough over a period of time to really do much with the information, unless they can save big dollars. For a very large home with high energy use, a system could save money, but the cost recovery may be tough to sell.

Programmable thermostats have become a standard commodity, and they work. Perhaps occupancy sensor systems will follow suit, and they could be put to many uses – one of which is energy management via temperature and lighting control. But they need to be simplified and less expensive. I thought this product was interesting, and it may be something that works – *http://www.nest.com/* – I have not had a chance to try one out yet.

A few months ago, the local utility came by and installed a "Smart Meter." What a lost opportunity for them and for us as consumers of energy. The meter helps them reduce manpower and balance the grid, which is a great thing. But they did not take the opportunity to capture my imagination, or make me more attentive to my energy use. All they had to do was give me a $25 device to sit on the table or hang on the wall that would feed me some information about my energy use, and they would have had my attention. It would just need to show dollars peeling off a wad as lights and appliances come on – and then give me some ideas on how to get those dollars back on the pile. Simplistic maybe – but I think more effective for an average soul.

Now, if you want to get my attention as an energy user – try this. We just installed a small solar system and, on a sunny day, I can go out and watch the meter run backwards. Awesome.

One of the advances I would like to see is a system that helps the homeowner manage not only the outputs of energy, but the inputs as well. The system would offer you the option of turning on the dishwasher when rates are lower (demand metering), but also, if you have a solar system or wind generator, then the system would tell you when energy was being generated and turn on that dishwasher or clothes dryer for you. The scenario would be – when you start your laundry, dishwasher, pool circulator, air conditioner – whatever – then the system would offer you the option to delay the start until energy was available.

EDU sincerely thanks all of our contributors on this AHEM issue.

IN BRIEF

Wilson Residence Becomes First Home Certified Under New DOE Challenge Home

In a press release from the US Department of Energy (DOE) Building Technologies Program, DOE announced the first home to qualify for certification under the new DOE Challenge Home standards.

"The Wilson Residence, a modern take on the Key-West/South Florida style, is the first home to qualify for the DOE Challenge Home certification. This home comes in at an impressive HERS Index Score of –7. Its rigorous specifications include a high SEER heating, ventilation, and air conditioning (HVAC) system, autoclaved aerated concrete walls, spray foam insulation, strategically placed high performance vinyl windows and large overhangs, a passive cooling tower with motorized transom windows for ventilation, LED low voltage lighting, a lighting control system, and a 13.5 KW solar electric array."

The builder, Rob Smith, with e2 Homes, noted that construction of this home led to several new business leads. He believes that net-zero energy performance, along with quality construction, green materials, and good design, appeals to homebuyers.

When asked about meeting the challenge, Rob wrote, "Thankfully, many of my client's desires for the home were in-line with the DOE Challenge Home certification requirements. [My client] was very particular in his wants for the home and this helped achieve the exclusive certification. I helped by value engineering several aspects of the project to achieve his goals, while bringing construction expenses down to within his budget."

For further details on the home, including photos, building blog, and conceptual drawings, visit *http://www.e2homes.com/custom-homes/*.

7th Annual North American Passive House Conference

The annual Passive House Institute US (PHIUS) North American Passive House Conference, in its seventh year, was held in Denver, Colorado on September 28 and 29, 2012, with pre-conference workshops on September 27 and Passive House project tours on September 30. Joe Lstiburek issued the keynote address, "Passive Getting Active," and applauded Passive House practitioners "who were told no, but did it anyway." Lstiburek took attendees down memory lane, citing the igloo house as the nascent passive house, and highlighting past projects, including solar house projects on the MIT Campus by Neil Hutcheon, the 1976 Provident house, 1977's Leger House featuring R-40/R-60 airtight construction and an air-to-air heat exchanger, and the Parade of Homes Saskatoon 1980, forerunner to Canada's R-2000 program.

Pre-conference workshops addressed PHIUS+ and Quality Assurance, introduced WUFI Passive Energy Balancing and Hygrothermal Modeling, and climate-specific design optimization strategies. During the main conference, attendee sessions included "Climate Dependency of Models and Monitored Verification," discussed by Bruce Kruger, Kara McKernan, Peter Schneider, and Carsten Steenberg; "Large-Scale Retrofits," taught by Ross Elliott, Sam Hagerman, Ryan Abendroth, and John McCreery; and "Evaluation of Mechanical Systems on Performance and Affordability," covered by Jason Morosko, Ludwig Rongen, and John Semmelhack.

For more information on the conference, access to presentation slides, and for access to further information on PHIUS, visit *http://www.passivehouse.us/passiveHouse/PHIUSHome.html*.

Wood Predicted to Gain Ground This Winter as Home Heating Source

In a report from *National Geographic News* on October 22, 2012, wood as a heating source is predicted to grow in use this winter given high fuel costs. Lending credence to this prediction, for the first time ever, the US Energy Information Administration (EIA) energy forecasters included an analysis of firewood and pellets in the annual Winter Fuels Outlook (*http://www.eia.gov/forecasts/steo/report/winterfuels.cfm*).

For the winter of 2012–2013, EIA expects households heating with natural gas to spend an average of $89, or 15%, more this winter than last winter. The increase in natural gas expenditures represents less than a 1% increase in the average US residential price from last winter, and a 14% increase in consumption, given forecasted temperatures. The EIA expects households heating primarily with heating oil to spend an average of about $407 (19%) more this winter than last winter as a result of a 2% increase in prices and a 17% increase in consumption.

Meanwhile, the EIA reports that wood consumption in homes has risen over the past 10 years, reversing a trend seen during the 1980s and 1990s. According to the EIA report, in 2009, US households consumed about 0.5 quadrillion Btu (quads) of wood. Household fuel oil consumption, by comparison, was only slightly higher at 0.6 quads. In homes across the United States, wood is most commonly used as a secondary source of heat, and is second only to electricity as a supplemental heating fuel. In New England, 20% of homes (1.1 million) used wood for space heating, water heating, or cooking in 2009 (EIA, Residential Energy Consumption Survey, 2009).

Chip Berry, who manages the EIA's Residential Energy Consumption Survey (RECS), found that about 12% of American homes use wood, primarily as a secondary source of heat in homes that use heating oil or propane.

Besides the northeast, Colorado and the Pacific northwest are centers of wood use, the EIA found. Other organizations confirm that the practice is growing. "The American Community Survey (US Census Bureau) estimates that households using wood as a main source of heat increased from 1.87 million in 2005 to 2.47 million in 2011," EIA's Berry noted.

The EIA research also found that 6% of wood users rely on pellets, with the bulk relying on traditional firewood or wood scraps.

To read the *National Geographic News* article, go to *http://news.nationalgeographic.com/news/energy/2012/10/121022-wood-for-heating/*.

DOE to Offer Free Online PV Training

On October 1, 2012, the US Department of Energy (DOE) announced free online training for building and electrical code officials performing inspections on residential photovoltaic (PV) solar energy installations. DOE hopes that the new training will facilitate more consistent and simplified PV inspection processes, which will save time and reduce consumer costs.

The Photovoltaic Online Training (PVOT) program is divided into seven modules, using videos and photographs to outline correct techniques and code practices. Subjects include roof and ground mounted PV arrays, electrical requirements, equipment ratings, and expedited permitting. The final module offers a virtual walk along a roofline, similar to what an inspector sees in a real-world situation, to help integrate principles from the previous six lessons. The PVOT program tracks each participant's progress and test scores, and meets professional licensing requirements for ongoing education in most cities and states, and complies with National Electrical Code requirements.

PVOT training modules are hosted on the Department's National Training & Education Resource, an open-source online learning platform, at *https://www.nterlearning.org*. PVOT was developed by the Interstate Renewable Energy Council as part of the SunShot Initiative's Solar Instructor Training Network.

FTC Updates Green Guides

Kenneth F. Gray and Matthew D. Manahan, of Pierce Atwood LLP, reported on Green Advertising and upcoming US Federal Trade Commission (FTC) 2012 Green Guides updates on October 10, 2012. After a multi-year process and numerous consumer surveys, the FTC recently approved revisions to its guidelines governing advertising for environmental and energy claims, better known as the "Green Guides." Under Section 5 of the FTC Act, the FTC has authority to seek penalties for deceptive advertising and marketing, which helps to define fair and unfair marketing practices.

Along with updates to the Green Guides, the FTC added several new sections on the use of carbon offsets, "green" certifications and seals, and renewable energy and renewable materials claims. Gray and Manahan repot that, "Of particular concern to the FTC are statements that are general, such as 'biodegradable' or 'recyclable.' Broad, unqualified general environmental benefit claims like 'green,' 'eco-friendly,' or 'environmentally friendly' are not allowed. These types of claims are difficult, if not impossible, for consumers or others to substantiate. The Green Guides goes into detail on how certain terms may be used, or misused."

According to FTC staff, the Green Guides will have six new sections: Environmental certifications and seals of approval; Carbon offset claims; "Free-of" claims; "Non-toxic" claims; "Made with renewable energy" claims; and "Made with renewable materials" claims.

To access the revised FTC Green Guides, go to *http://www.ftc.gov/os/2012/10/greenguides.pdf*.

IN PRACTICE

High Performance Window Installation – Challenges for Durability and Opportunities for Thermal Performance – Part 1

Florian Speier

This summer saw both the recognition of the Passive House Standard by the US Department of Energy (DOE) as the strictest home energy standard, and its principles integrated with DOE's Challenge Home program. With ultra high performance construction moving from niche to mainstream, a little more insulation and a little better air sealing is not enough anymore. Suddenly, the overall performance of a house hinges on the attention given to the weakest spots of the building envelope – even if those are only a tiny percentage of the envelope's surface area.

The junction of window and wall is quickly becoming one of the most important, if not the most important, remaining weak spot. In a Passive House, the difference between a traditional install and a high performance install can easily reduce the overall space heating needs by 10% or more. But a high performance install means the end to nailing flanges, outside flush installs and pans to set the window on. A new set of tools and techniques is required, and we need to understand the implications on moisture management, as well as the required training for installers. The goal should be an install system that is highly thermally efficient, more durable than traditional installs, and that is easy and foolproof to execute for the installation contractor.

Sidebar 1: Focus on High Performance Windows – Zola Windows

Florian Speier, Swiss Architect, President of Zola Windows

Swiss-trained architect Florian Speier founded Zola Windows in 2011. Unsatisfied with the selection of windows available to his architecture clients, Florian partnered with European manufacturers to design extremely energy efficient and airtight windows and doors appropriate for Passive House and Net Zero Homes.

Zola Windows boast overall U-values as low as 0.123; have triple seals that provide outstanding airtightness up to European Level 4; utilize triple, argon-filled glazing of up to 54 mm; and boast Tilt & Turn operation. Patented, German-engineered Purenit™ can be used throughout the window frames as an insulating material, and Zola offers three frame qualities – 68 mm depth (Classic Wood and Classic Clad), 88 mm depth (Thermo Clad, Thermo Wood, and Thermo PVC), or 88 mm with an integrated layer of Purenit™ insulation (ThermoPlus Clad, recognized for Passive House windows).

All 88 mm frames come with 1 7/8" triple glazing that features a glass U-Value of 0.088 BTU/hr/ft^2/F (0.5 W/m^2/k). Combined with the Purenit™ insulated frame, an overall window U-Value of 0.14 BTU/hr/ft^2/F (0.8 W/m^2/k) is achieved. Warm edge spacers are standard. The custom-crafted windows and doors are made with 100% FSC® certified pine, oak, or meranti.

What sets the performance of Zola Windows apart?

When compared to the US product market, overall, we are looking at between two to three times the performance of what is currently recognized as an ENERGY STAR® window in the US (refer to Table 3). Our frames insulate a lot better, and glass insulates a lot better, getting us a much lower U-value. These windows allow very little heat to pass through. At the same time, we can achieve this performance with the glass being very clear. It doesn't obscure the client's view. Typical US high performance windows on the market are made out of fiberglass; our windows use wood, or aluminum clad window frames, which are highly durable. In European longevity studies, wood clad frames last at least 50 to 60 years without any major maintenance.

Window design has to achieve two things at the moment: first is to get the insulation value of the frame up, which pushes us to deeper frames from inside to outside, and adds insulation (see Figure 6). With Zola windows, we developed a layer of Purenit™ into the frame prior to cutting, so that the Purenit is layered into the source material. That allows us to create a full thermal break, which goes all through the frame. Purenit is a patented German material, a recycled wooden polyurethane composite, that has two times the R-value of wood. So, every inch of Purenit is equal to 2 inches of wood, in terms of insulation value.

At the same time, a deeper frame is necessary because, as glass technology evolves, in the European market they are going for thicker and thicker glazing. Not only does this thickness reflect the shift from double- to triple-glazing, and the thickness of the glass, but also the space between glass panes (refer back to Figure 6). This thickness increase has happened a lot less on the US market. This could be because of specifications of temperature differentials between inside and outside; the US has pushed to optimize glass to an 85 degree temperature differential. What makes sense is using a slightly lower temperature differential, which results in deeper space, which is more efficient than thinner spaces. Our latest thicker glazing packs require a frame at least 3 ½" deep to carry it.

The emissivity of Low E coatings is lower in Europe, and therefore more efficient, while at the same time there is a lot less color shift. Low E coatings are responsible for the color shifting you see in glass, pink or blue tints. Our coatings are on Surface 2 and 5, the 2 inside surfaces of the outer panes. On the US market, you have hundreds of different glazing combinations for each manufacturer, while, in Europe, we really deal with just two. I'm surprised the US hasn't found one optimum glazing strategy, though this could be because of the wider variety of US climate zones.

High performance windows are not just defined by U-value and solar heat gain coefficient (SHGC), but also by air tightness. As a basic rule, European windows never slide on their seal because there isn't a seal then. There are basically no sliding windows in Europe. Tilt and turn is the main operational window strategy; the mechanics give you an inside awning and a casement in the same unit. A 90 degree turn creates an awning, another 90 degree turn operates the unit with a casement opening. This is a very practical set up. In doors, the same thing applies – you don't want to slide on your seal, so sliding doors are built differently: tilt slide operation and lift slide operation. A tilt slide door is built similar to a tilt and turn window; the tilt operates like a minivan door, pushing the door out and away from the seal, and having it operate from that position. This is the most airtight door that can be done. The other option is a lift slide, which, when a homeowner turns the handle, the entire door is lifted up ¼" out of the seal and can roll to the side. The benefit with a lift slide door is you can make very flush thresholds, and can construct very large doors, with a 40" door not considered difficult. A third type of door we can do is a breeze panel, essentially a folding glass wall. This can be made to high performance standards; but, as it has so many more seals and seal area, it cannot be made quite as airtight.

That brings us to an important question – how should airtightness be measured? Neither the US or European standards are helpful for builders. In Europe, we use class 1, 2, 3, or 4 to rate airtightness. All our products are rated to class 4, the best performance you can get. But airtightness numbers don't communicate the full picture; for a building undergoing a blower door test, we need to know how many cubic feet per minute that assembly will leak at test pressure. At this point, no one is providing those values.

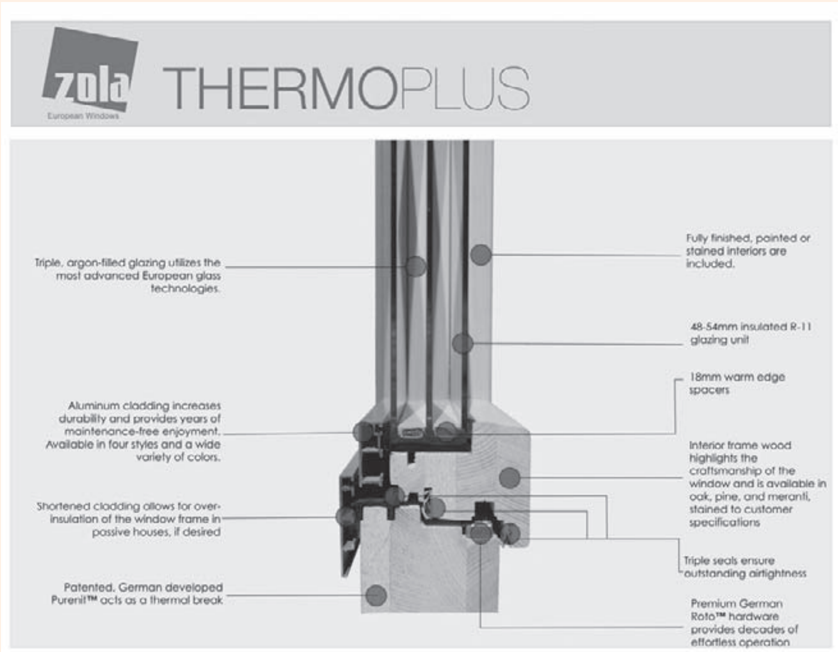

Figure 6. Detailed cutaway of a Zola Window. Figure courtesy Zola Windows.

Recently, we delivered a fenestration package to New Mexico and, when the builder ran the blower door test, the reading was 0.18 ACH 50, or three times exceeding the Passive House standard. These units can be very airtight. We generally assume minimal air losses.

The Passive House Institute (*http://www.passivehouse.us/passiveHouse/PHIUSHome.html*) and Passive House Alliance (*http://www.phaus.org/home-page*) are great resources to help a builder in decision making.

What made you decide to start Zola Windows?

By training, I am an architect; I studied in Switzerland and New York, and then started an architectural office in Berkeley, California in 2007. When designing energy efficient homes, trying to get good windows for clients, I was very disappointed in available US windows. There were a few super high end European imports, but they were way out of budget. Domestic manufacturers were simply not getting the energy performance we needed. I grew up in Europe, and knew great windows are out there. I decided to start a relationship with a European factory to get good windows for clients.

Early in 2011, I realized the Passive House market was really growing, and I was having a lot of interest from Passive House builders and architects in Colorado to procure windows through us. That's the genesis of Zola Windows.

As an architect, I still have some houses under construction, but am doing more windows than architecture right now. To me, it is very fulfilling to bring in a higher performance, affordable product that isn't in the US market. I believe we have the best product on the market, at a fairly reasonable price. What becomes more and more important, if working in super high performance building, is that the window manufacturer needs to provide help to the architect and builder on how to install, how to optimize that unit. The installed value of the window is what counts. We are very involved with this process, and will run a wall-by-wall heat flow analysis for clients, with our windows in.

To learn more about the Zola Window products, visit *http://www.zolawindows.com/videos/*.

Zola European Windows	Overall U-Value & R-Value	Frame U-Value & R-Value	Glass U-Value & R-Value	Glass SHGC	Visible Light Transmission (VT)
Zola ThermoPlus Clad Triple glazed, aluminum clad wood with Purenit™ insulation	U=0.123 R-8.1	U=0.159 R-6.3	U=0.09 R-11	0.5 *0.29 and 0.62 available upon request	71%
Zola ThermoClad Triple glazed, aluminum clad wood	U=0.14 R-7	U=0.193 R-5	U=0.09 R-11	0.5 *0.29 and 0.62 available upon request	71%
Zola Thermo Wood Triple glazed, all wood with aluminum rain guards	U=0.14 R-7	U=0.193 R-5	U=0.09 R-11	0.5 *0.29 and 0.62 available upon request	71%
Zola Thermo uPVC Tripe glazed, high performance for projects on a budget	U=0.14 R-7	U=0.193 R-5	U=0.09 R-11	0.5 *0.29 and 0.62 available upon request	71%
Zola Classic Clad Double glazed, aluminum clad wood	U=0.21 R-4.7	U=0.228 R-4.4	U=0.176 R-5.7	0.62 *0.3 available upon request	80%
Zola Classic Wood Double glazed, all wood with aluminum rain guards	U=0.23 R-4.3	U=0.245 R-4	U=0.176 R-5.7	0.62 *0.3 available upon request	80%
Energy Star	U=0.30-0.60 R-1.7-3.3	n/a	n/a	Varies from 0.2-0.4	n/a
Standard American Window	U=0.31-0.88 R-1.1- 3.2	n/a	n/a	0.2-0.5	15%-60%

Table 3. Comparative window performance. Data courtesy Zola Windows.

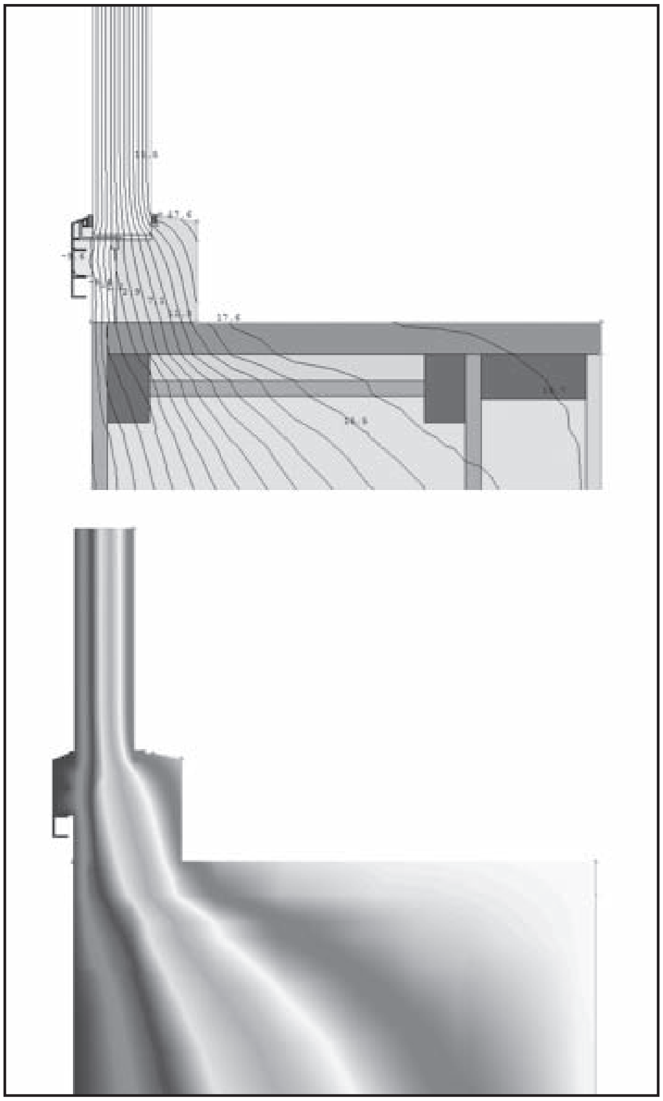

Figure 7. Outside flush install. The Psi install is calculated at 0.023 BTU/hr*ft*F. Image courtesy Zola Windows.

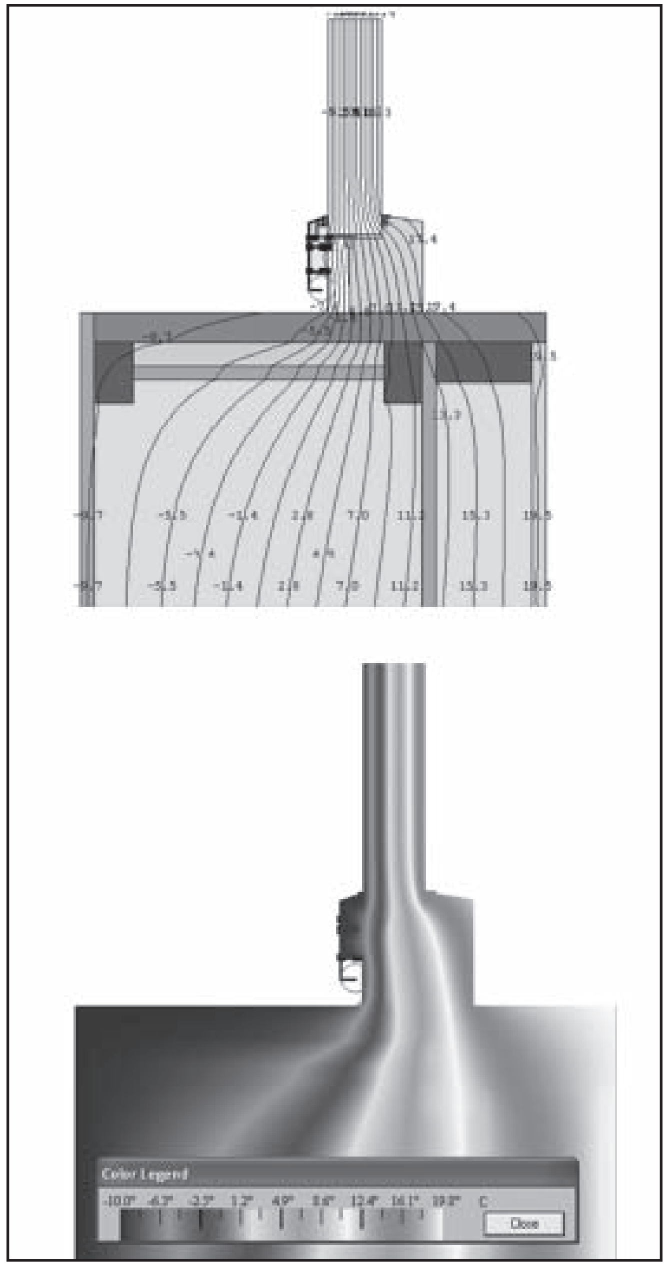

Figure 8. The same wall assembly and window, but with the window centered over the insulation. The PSI install drops to 0.014 BTU/hr*ft*F as calculated by THERM. Image courtesy Zola Windows.

In this article, I will look at the overall performance implications of windows and their installation first, before discussing materials and techniques for installation (see Sidebar 1 for Speier's biography and information on his company).

The heat finds the path of least resistance to the outside – and this path, if not carefully designed, will have vastly higher impact on the house performance than whether the wall is an R-50 or R-80.

Windows will always be a weak spot – but with better solar gains, at least the correctly oriented glass may level out or be beneficial in the overall energy balance of the building. Frames, however, have no solar gain, and result in one of the biggest losses for the entire building.

To illustrate how important the concept is that the heat travels the path of least resistance, Portland- and Seattle-based contractors Hammer & Hand calculated this simple, but convincing example:

If we assume an R-50 wall with a 15% glazing percentage and install an ENERGY STAR® level R-3 window, our whole wall performance drops to R-15 – this is a 70% performance reduction.

If we then try to solve the problem by adding insulation to the wall and bring the wall to R-100, our overall wall performance only increases from R-15 to R-17, a marginal improvement, considering that we doubled the wall insu-

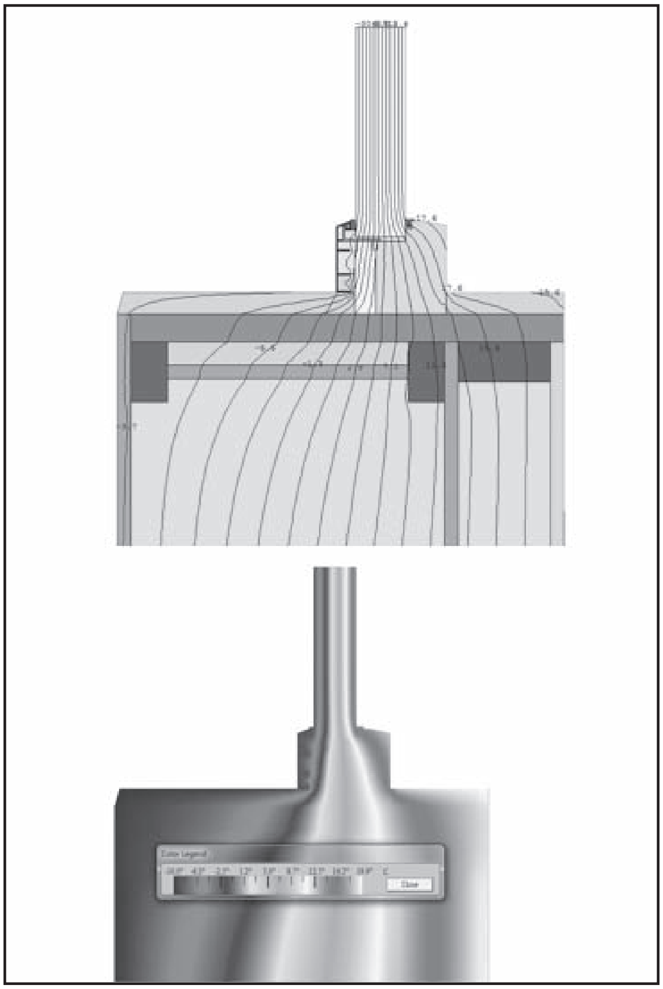

Figure 9. If we add ½" of over-insulation inside and outside, the PSI install becomes negative: -0.005 BTU/hr*ft*F. The overall wall is now performing better than the simple sum of wall and window. Image courtesy Zola Windows.

lation. It shows that, if the building envelope is made up of vastly disparate elements in respect to their thermal performance, the weak components will govern the overall performance. If we want to build a better building, we have to improve the weak spots. This concept is not exclusive to windows. Designers must focus on structural intersections, such as wall to foundation and roof to wall connections, to ensure a thermal bridge free design. If steel or concrete are penetrating through the envelope, there is a problem.

To get back to our example, if we, instead of bringing the wall from R-50 to R-100, change the R-3 ENERGY STAR® window to an R-8 Passive House window, our overall wall performance rises from R-15 to R-37. We plugged the leak. "You don't fix a leaking bucket by making its walls thicker. You start by plugging the hole," said Sam Hagerman, co-owner of Hammer & Hand and President of the Passive House Alliance US. "When building a high performance wall assembly, a low-performing window creates a hole in the bucket, so you need to start there before adding insulation around the leak."

Window performance is made up of four components: glass performance (Ucog), glass spacer performance (Ψspacer), frame performance (Uframe), and install performance (Ψinstall).

Ψinstall is the measure of the linear thermal bridge at the junction of the wall and the window frame, and accounts for all additional losses or unexpected gains that make the installed window performance differ from the simple calculation of X square feet of wall @ R-50 and Y square feet of window @ R-8 equals a total performance of the assembly of R-37 (as in the above example).

A positive Psi install means that there are additional losses, a zero Psi install means the system is behaving exactly like in the simple calculation, while a negative Psi install means that the installed performance of the window is actually better than our simple calculation.

So why do we need this adjustment factor? Why is our simple calculation incorrect? The window is an area where the thermal envelope is condensed into a much thinner layer. The Psi install calculations below show that centering the window over the installation layer makes for a much higher performance install than a flush outside install (see Figure 7 and Figure 8).

Additionally, any window install position has heat flows that we did not expect in the simple calculation – like shortcutting through the wall just around the window frame. On the other hand, a highly over-insulated window frame (this means that additional insulation, typically foam based, is mounted on the outside and inside of the window frame to increase its performance) can act even better than our simple calculation because, in effect, we layer the wall and the window on top of each other (see Figure 9).

As we see, a centered, over-insulated install results in vastly increased thermal performance of the building. In a building with high performance walls and windows, it is also one of the areas that give you the best return on investment.

Energy Design Update extends a huge thanks to Florian and Hammer & Hand for lending their experience and expertise in this article. Part 2 of this article, which will detail actual window installation phases, will appear in our upcoming December 2012 issue. For more on Florian and his company, please visit *http://www.zolawindows.com/about-zola/*.