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IN DEPTH

Cool Energy House Case Study: Measuring Whole House Dehumidification and Heat Pump Water Heater Performance

Can a large 1995 builder spec home in Florida slash its energy costs by 50%? Can this energy savings be achieved both cost effectively and unobtrusively in a retrofit situation? Building America's® Cool Energy House, a joint project for Building America Retrofit Alliance (BARA) and the Consortium for Advanced Residential Buildings (CARB), which was unveiled during the 2012 International Builder's Show, set out to test drive the optimization of energy efficient and affordable measures choices, and implementation of energy efficiency guidelines, cost tracking, and best practices (see Figure 1). ***Energy Design Update*** covered the Cool Energy House in our March 2012 and October 2012 issues, evaluating whether or not the whole home met its stated performance goals. Now, we focus on measuring the performance of specific systems.

Laying a Baseline

The BARA and CARB teams aimed for a deep energy retrofit with 50% energy savings as the overall retrofit goal. BARA and CARB also sought a low-impact retrofit project that is designed to be as non-intrusive as possible to exterior and interior finishes. The guinea pig for this testing was a 1990s spec house located in Windermere, Florida, measuring in at 3,900 sq ft, 4 bedrooms, and 2 ½ stories. Prior to refurbishment, BEopt™ analysis revealed that the existing home is a big energy consumer, using 30,156 kWh annually in site energy. The home had logged energy bills of between $200 and $600 per month while sitting vacant; and energy analysis estimated bills up to $800 per month during the summer. Cooling the home took the greatest percentage of the energy load.

Figure 1. Building America Retrofit Alliance (BARA) and the Consortium for Advanced Residential Buildings (CARB) undertook a deep energy retrofit on a large 1995 builder spec home in Florida, to see whether 50% energy savings could be achieved both cost effectively and unobtrusively. We revisit two specific systems to check on their performance. Photo courtesy Steven Winter Associates, Inc.

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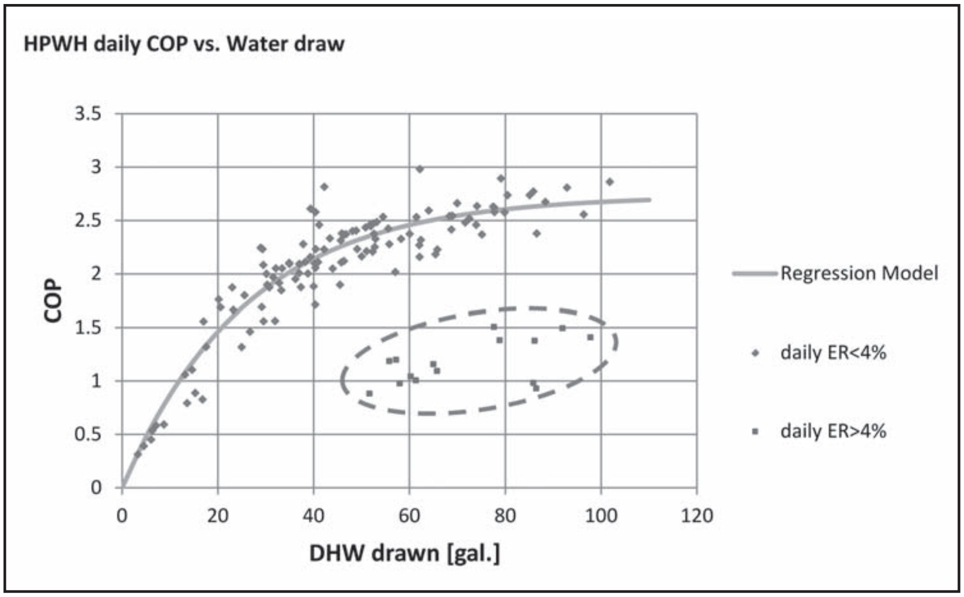

Figure 2. HPWH daily COP vs. Water draw. Data and figure courtesy Jim Williamson at Steven Winter Associates, Inc.

In addition to air sealing, upgrading the heating, ventilation, and air conditioning (HVAC) systems was a high priority for this retrofit, as BEopt predicted a 23.4% energy savings just by increasing the efficiency of these systems. "The increased level of efficiency in equipment was quite significant," remarked Srikanth Puttagunta, Senior Building Systems Engineer with Steven Winter Associates, Inc. For a six-month period, CARB monitored the performance of one of two GE Geospring™ heat pump water heaters (HPWHs), as well as the performance of the combined whole-house dehumidification and air conditioning (WHD-A/C) system, composed of two Lennox A/C systems coupled with a Honeywell DH150 TrueDRY™ whole-house dehumidifier.

GE Geospring™ Heat Pump Water Heater Data

CARB analyzed the performance of the HPWH in terms of energy efficiency and operating costs. The daily coefficient of performance (COP) of the HPWH was plotted against total daily hot water draw, in gallons, for each day. As part of the study, CARB also compared field data against hourly energy simulation analysis using the National Renewable Energy Laboratory's (NREL's) BEoptE+™ v1.3 software. BEopt had estimated that the HPWH should save 64% annually ($113/year) on utility costs over a standard electric resistance water heater (ERWH), and up to $120/year when the predicted space conditioning impacts of cooling and dehumidification were included.

The data over the monitoring period showed field conditions with average water inlet temperature at 82°F, average water outlet temperature at 117°F (with the HPWH set to a 120°F heating set point), and average hot water usage of 48.8 gallons per day. Other recorded conditions during the study included an average ambient air temperature of 74°F and an average ambient relative humidity of 55% around the HPWH. In addition to operational energy savings, HPWHs can provide cooling and dehumidification, although intermittent because operation is dependent on hot water usage and not a thermostat/humidistat, that can be beneficial in hot-humid climates. During the heat pump's operation, the air stream across the heat pump experienced an average decrease in temperature from 75°F to 60°F, and a humidity ratio from 0.011 to 0.009 lbmw/lbmda.

According to CARB's data, the HPWH performance monitoring showed that the DHW draw profile (both volume and frequency) was a primary factor that affects the system's operating efficiency. If a large

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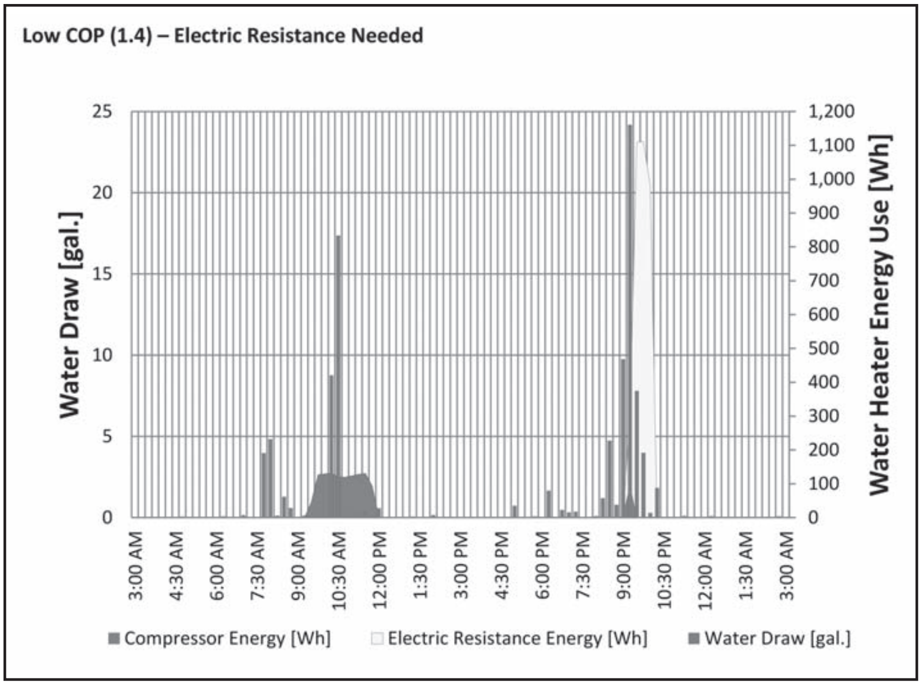

Figure 3. Low COP (1.4) – Electric Resistance Needed. Data and figure courtesy Jim Williamson at Steven Winter Associates, Inc.

amount of water was drawn over a short period of time, the unit reverted to electric resistance mode in order to support the high heating demand. Without having the home's family of six change their usage pattern, which typically ranged from between 15 to 85 gallons of daily hot water usage, the HPWH achieved a total COP of 2.2, with 23% of the unit's total energy use (not thermal energy fraction) associated with the auxiliary electric resistance heating elements.

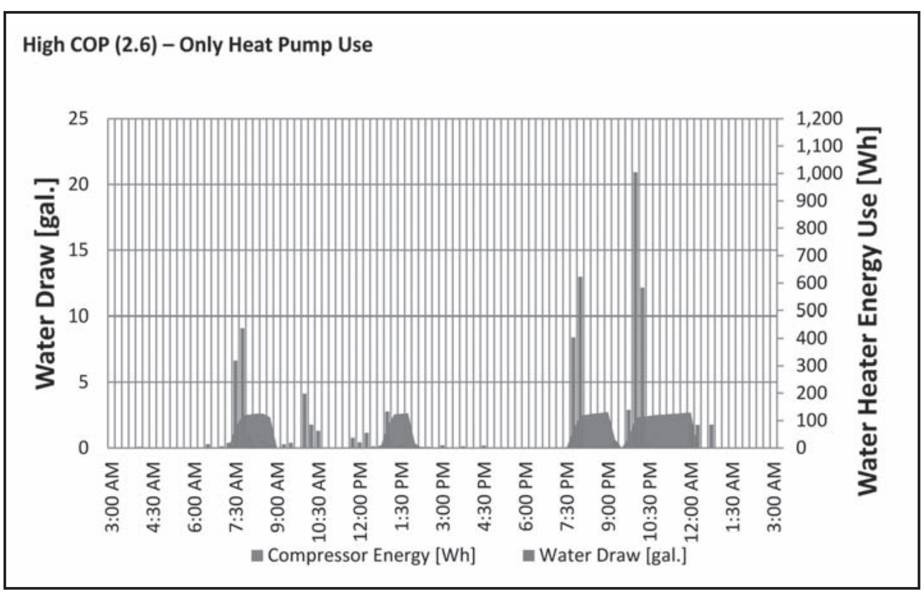

Figure 4. High COP (2.6) – Only Heat Pump Use. Data and figure courtesy Jim Williamson at Steven Winter Associates, Inc.

When operating in heat pump mode, the performance of the system was affected by expected factors, such as water draw, tank losses, ambient conditions, and set point temperatures. Results from CARB's study showed that the HPWH unit can achieve higher COP values at larger volume draws if the heat pump's recovery rate is not exceeded. Larger, frequent volume draws will result in the HPWH switching to electric resistance. Although the unit performed at a total COP of 2.2, the maximum daily COP reached as high as 3.0.

Field data also highlighted the impact of water draw profiles, both frequency and volume, on performance. Water draw profiles were the primary factors affecting the operational performance of this unit, according to CARB. Jim Williamson, Mechanical Engineer at Steven Winter Associates, Inc., elaborated on the data results. "There are three figures that are most useful for demonstrating the effect that water draw profile has on HPWH performance; the first is HPWH daily COP vs. Water draw (Figure 2)." Three distinct scenarios occurred via data:

- Too much water is drawn in a short period of time and the HPWH must use electric elements to support the load. These points are shown in Figure 2. This scenario results in a low COP because supplying heat through electric resistance is much less efficient than supplying it with the vapor compression cycle (heat pump).
- Only a small amount of water is drawn and the unit performs with a low COP; these points are where water draw is less than 20 gallons. Here, a large portion of the heat transferred to the water is lost back into the surroundings through tank losses.

Larger amounts of water are drawn (not all at once) and the unit performs with a high COP;

refer to the points with values greater than ~50 gallons. Since the water draw is greater and more distributed, tank losses do drive down the efficiency.

Williamson further outlined COP data, and how draw frequency affects performance, as shown in Figure 3 and Figure 4. Both of these days use similar amounts of water, nominally ~ 95 gallons. However, their COPs are drastically different. As shown in Figure 3, "Low COP (1.4) – Electric Resistance Needed," there is a large, long-lasting water draw between 8:45 pm and 10:15 pm that the heat pump cannot keep up with. As a result, it must revert to electric resistance mode to supply adequate hot water. As shown in Figure 4, "High COP (2.6) – Only Heat Pump Use," even though the water draw volume is similar to the previous case (~95 gallons), the COP is much higher. Inasmuch as the draw frequency is distributed throughout the day, and the volume draws are smaller, the unit can comfortably supply all of the heat through heat pump mode.

While inlet air conditions to the HPWH can also have a significant impact on performance, the HPWH that was studied was located within an unvented attic, where conditions were fairly constant (ranging from 68°F to 83°F).

CARB data also isolated an interesting inverse effect that is associated with HPWHs in the hot-humid climate zone. While the cooling/dehumidification benefits and higher COPs of a HPWH are advantageous in the hot-humid climate, the mains water temperature tends to be higher. The mains water temperature ranged from 75°F to 85°F over the monitoring period, meaning that less water heating is required, and resulting in the overall water heating cost being minimized. While energy consumption was minimized, this negatively impacted the cost benefit of the HPWH.

As HPWHs are still fairly new to the market, there is a first cost premium for this technology. As the HPWH market continues to mature, it is anticipated that these costs will continue to go down. However, CARB's research demonstrates that HPWHs can drastically reduce utility bills for electric water heating over electric resistance water heaters. CARB's monitored HPWH performed with 144% more efficiency than a standard ERWH, saving approximately 64% ($113) on water heating annually. The savings resulted from a predicted cost of $177 for an electric tank model, versus $64 for the HPWH. By comparison, a gas tank DHW heating method was expected to cost $138 annually, and gas tankless was predicted to cost $81.

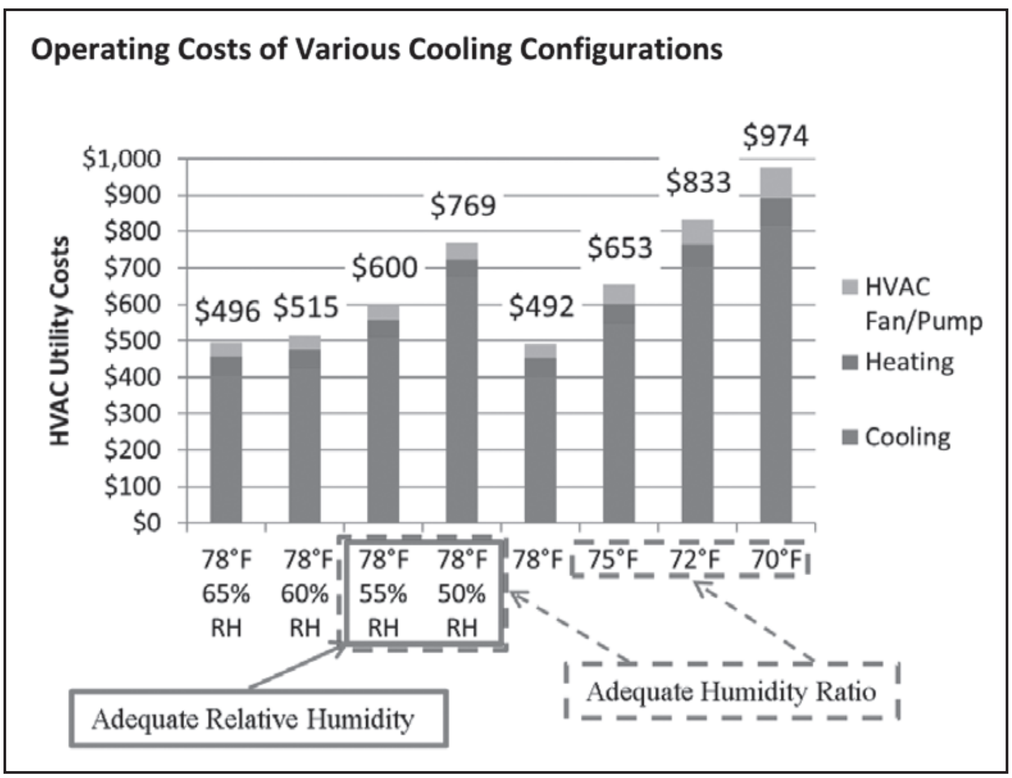

Figure 5. Operating Costs of Various Cooling Configurations. This graph, which was generated with BEopt™ results, shows operating costs of various cooling configurations. However, not all configurations are effective in maintaining adequate comfort levels. Data and figure courtesy Jim Williamson at Steven Winter Associates, Inc.

Combined Whole-House Dehumidification and Air Conditioning Data

Cooling was the heaviest energy load for the Cool Energy Home, pre-retrofit. Not only was CARB interested in the realized energy savings of the air conditioning system at Cool Energy House, they also wanted to address whether or not coupling a dehumidifying element would help achieve indoor comfort. Could improvements in comfort be achieved, while reducing utility costs, by using a whole house dehumidifier (WHD) to control moisture levels (latent cooling) and optimizing a central A/C to control temperature (sensible cooling)? For this study, CARB defined indoor comfort as achieving indoor conditions that are maintained below 60% relative humidity (RH) and 0.012 lbm/lbm, while at common dry bulb set point temperatures of 74–80°F. The combined WHD-A/C system (a Honeywell DH150 TrueDRY whole-house dehumidifier coupled with two Lennox A/C systems) was studied for a six-month period.

Overall, CARB projected that the system would create an 8.2% reduction in cooling, with a projected energy cost savings of $54 per year. With the dehumidifier humidistat set to 65% RH and the A/C thermostats set to 78°F, monitoring results showed that the system was able to adequately control moisture in the home to sub-60% RH levels for 99.86% of the monitoring period. Indoor temperature was maintained within the indoor comfort defined limits of 74°F to 80°F for 91.5% of the monitoring period. The percentage is actually 99.3%, when only looking at the cooling portion of the monitored period.

Both scenario testing results and energy modeling simulations rank the scenarios in the following order (from most energy consumptive to least energy consumptive): (1) 78°F and 50% RH, (2) 75°F and dehumidifier off, and (3) 78°F and 60% RH. According to CARB, integrating a whole-house dehumidifier with a traditional air conditioning system (set to 60% RH and 78°F, respectively) achieved lower energy consumption, while improving comfort conditions in hot-humid climates, over a traditional A/C only system (set to 75°F). Most telling is that the homeowner noted the ability to set the home's thermostat to a higher temperature without affecting expected comfort levels. Figure 5 details BEopt modeling results that predict the yearly operating costs of the system.

According to Williamson, the combined system can maintain better comfort than an A/C alone. "Therefore, a simple payback that uses incremental cost and yearly savings will be an inaccurate metric to explain the benefits. As a result, the true benefit of the system is not in the savings, but in the improved comfort," Williamson said. BEopt results show a predicted savings of $53 per year when using a combined 78°F, 55% RH over an A/C only at 75°F. However, the combined system will also keep the house comfortable for a greater percentage of the year.

The results of this study show support for the use of HPWHs, as well as combined A/C and WHD cooling systems, in hot-humid climates. The HPWH was able to achieve high COPs, while also providing some space conditioning benefits to the home. Additionally, adding a WHD to the home's cooling system achieved improved indoor comfort, while saving energy.

Data from the Cool Energy House study is being condensed into a report, "Technical Report; Systems Evaluation of the Cool Energy House," and is expected to be published later this year. Once published, it will be available through the Building America Program Publication and Product Library site: *http://www1.eere.energy.gov/library/default.aspx?page=2&spid=2.*

For more information on other work by Steven Winter Associates Inc., please see: *http://www.carb-swa.com/* and *http://www.swinter.com/*

Energy Design Update thanks Jim Williams and Srikanth Puttagunta for sharing these results with us.

Jim Williamson is a Mechanical Engineer with Steven Winter Associates, Inc., in Norwalk, CT. He has experience in data analysis of field monitoring for various residential energy systems. To contact via phone, call 203-857-0200 x231, or e-mail *jwilliamson@swinter.com*.

Srikanth Puttagunta is an Senior Building Systems Engineer with Steven Winter Associates, Inc., in Norwalk, CT. He has experience in designing/evaluating/monitoring residential energy systems, with specific emphasis on hot water and HVAC systems. To contact via phone, call 203-857-0200 x275, or e-mail *sputtagunta@swinter.com*.

IN DEVELOPMENT

A Stormwater Primer (Part 2)

In the January 2013 issue of ***Energy Design Update***, we asked Jane Clary, LEED AP, CPESC and Senior Water Resources Scientist, at Wright Water Engineers, Inc., for guidance on developing a stormwater management, plan to meet LEED requirements. This month, Jane talks about stormwater best management practices.

Let's pick up right where we left off: A small home builder comes into your office seeking guidance on stormwater plan-

Sidebar 1

Common BMPs

Stormwater BMPs include practices like grass buffers, grass swales, bioretention/rain gardens, and permeable pavement. Given LEED's emphasis on volume reduction, practices that enable infiltration and include vegetative components, or that enable stormwater reuse (where allowed), are most likely to help meet LEED requirements.

Treatment BMPs

- *Grass Swale*: An important Low Impact Development (LID) practice, a swale is a densely vegetated trapezoidal or triangular channel with slopes designed to slowly convey runoff, aiding in filtering water and preventing erosion.
- *Grass Buffer*: Dense strips of grass providing sheet flow filtration of sediment, enabling infiltration, and slowing runoff. Is effective at targeting sediment and metals pollutants.
- *Bioretention/Rain Garden*: A specifically designed and engineered landscape area that captures, filters, and/or infiltrates runoff. Can function as LID/Volume Reduction, for water quality capture volume (WQCV) capture, and WQCV and flood control.
- *Green Roof*: Green spaces below, at, or above grade with either shallow or deep (extensive or intensive) substrate. Provides capabilities for LID/Volume Reduction and WQCV capture. Can generate a variety of Leadership in Energy and Environmental Design® (LEED) credits that are not limited to stormwater management.
- *Extended Detention Basin*: A sedimentation basin designed to detain stormwater for longer periods of time, typically a recommended WQCV of 40 hours, allowing for thorough removal of solid pollutants.
- R*etention Pond*: A permanent pool of water designed with capacity to hold runoff and slowly release its WQCV over 12 hours.
- *Sand Filter Basin*: This BMP can serve either for filtering or infiltrating, and is designed with a surcharge zone underlain by a sand bed and, when necessary, an underdrain system. Functions for LID/Volume Reduction, WQCV, and flood control, and is effective for most targeted pollutants.
- *Constructed Wetland Pond*: A pond constructed to enhance stormwater quality, slow runoff, allow for sedimentation, filtering, and biological uptake, and allow growth of wetland plants.
- *Constructed Wetland Channel*: A channel designed and constructed with vegetation to slow runoff and improve water quality.
- *Permeable Pavement Systems*: A pavement system that allows movement of water into subsurface layers beneath the pavement surface. Systems can be designed to treat and provide slow-release of runoff. Permeable pavements allow for a multiple-use BMP, and can generate LEED credits. Examples include interlocking concrete pavers, bricks, and porous gravel.

Descriptions adapted from the Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices (Urban Drainage and Flood Control District, Denver, CO). Go to *http://www.udfcd.org/downloads/pdf/critmanual/Volume%203%20PDFs/USDCM%20Volume%203.pdf* online, Chapter 4 and Chapter 5, for a thorough discussion of advantages and limitations to each BMP.

The International Stormwater BMP Database offers excellent resources and references for further information regarding BMP performance and approaches for monitoring and evaluating performance. Visit *www.bmpdatabase.org*. The BMP Database contains performance data for over 510 BMP studies, including over 265,000 water quality records, along with precipitation and flow data.

Other key sources of information in various parts of the country include the Low Impact Development Center (*http://www.lowimpactdevelopment.org/*), the Center for Watershed Protection (*http://www.cwp.org/*), the Washington Stormwater Center (*http://www.wastormwatercenter.org/low-impact/*), the University of New Hampshire Stormwater Center (*http://www.unh.edu/unhsc/*), and the Low Impact Development Mid-Atlantic Research Consortium *(http://www.bae.ncsu.edu/stormwater/LID-MARC/*).

ning for an upcoming energy efficient home. They are thinking about LEED certification for the project. What are key elements they must pay attention to?

For whatever portion of runoff that you can't address by disconnecting and minimizing impervious surfaces, you want to implement best management practices (BMPs) that help to reduce runoff rates and volumes and treat runoff water quality (see Sidebar 1 for lists, descriptions, and references on BMPs). For a home, this might mean designing a rain garden or other bioretention area (see Figure 6), where rain water can be detained, either infiltrating into the soil or slowly released through an underdrain, providing both runoff quality and quantity benefits. There are many types of BMPs.

In order to effectively design stormwater quality BMPs, it is important to understand the impacts of urbanization on receiving waters, as well as to understand the federal and state regulatory requirements under the Clean Water Act. In the Denver metro-area, we describe this as a four-step process: employ runoff reduction practices, implement BMPs that provide a water quality capture volume (WQCV) with slow release, stabilize drainageways, and implement site-specific and other

Figure 6. Aesthetic Bioretention area on UNI Campus in Iowa. Photo courtesy Andrew Earles, Wright Water Engineers.

source control BMPs. Physical site characteristics that determine appropriate BMPs include soils type, watershed size, groundwater, base flows, and watershed development activities or erosive conditions.

Pollutants from stormwater may be removed or treated via sedimentation, straining, filtration, adsorption/absorption, and/or through biological uptake. More information on these considerations can be obtained from *www.udfcd.org*; really understanding your site conditions is fundamental to effective BMP selection and design.

There are two keys with any kind of stormwater management. The first is safety. Whatever structure you are using should be safe and designed appropriately. Second, you must have the ability to maintain that stormwater facility, particularly if you install a BMP underground, or that relies on infiltration. How would you plan to maintain this structure, and how would a subsequent owner maintain the facility? Life cycle costs should be considered. When planning for stormwater, a builder needs to recognize maintenance requirements for any stormwater facility, both during construction and down the road. For example, infiltration-oriented BMPs need to be protected during construction from excessive sediment loading so they don't clog. All BMPs will require ongoing maintenance and repair/rehabilitation, as necessary.

For builders seeking more in-depth education, some excellent online resources are the International Stormwater BMP Database (*http://www.bmpdatabase.org/index.htm*) and the Urban Storm Drainage Criteria Manual (*http://www.udfcd.org/downloads/pdf/critmanual/Volume%203%20PDFs/USDCM%20Volume%203.pdf*). While the manual was developed for Colorado, it offers excellent general information on stormwater and systems.

What key site considerations should a builder keep in mind?

The builder needs to look at the constraints of their site: are there expansive clay soils? Infiltration-oriented practices can be problematic in these areas, and need input from qualified structural engineers. Do you have to confront shallow bedrock or high ground water? What is the distance from the foundation? These physical constraints are important. Early in the design process, you really need to have an engineer involved to integrate a stormwater management approach that is appropriate for site conditions and constraints. Also, in different parts of the country, there are different rules related to water rights. For example, in Colorado, regulations are very strict about how long you can detain water on site, and how you can use it. If you don't own associated water rights, you can't take runoff and store it in a cistern for irrigation; yet, in many areas out east, you can. There is a lot of variation around the country with regard to what's feasible.

What is the big picture for a builder? You need to be aware of local and regional criteria, local climate and hydrology, and site-specific land characteristics. You can make a well-rounded decision from there that balances environmental benefits with site constraints and costs to the developer.

What movements are you seeing in standards and certifications that we need to be aware of?

Currently, there is a big push by the Environmental Protection Agency (EPA), that we will probably see reflected in LEED, related to retention of stormwater on site. There are controversial aspects related to precisely defining "retain on site" at a national level. For example, what size storm should be retained? Should BMPs be designed to retain/treat a 95th percentile storm, or an 80th percentile storm? Using the Denver area as an example, there is a big difference between ½" of rainfall, which is roughly an 80th percentile runoff depth, and 1.0 to 1.5 inches of rainfall, which would be a 95th percentile storm. It requires different space to deal with different amounts of rainfall. The devil is in the details when it comes to criteria. Also, different parts of the country have different hydrology; Washington state storm events versus Denver storm events are vastly different. Not only do regional climate differences present a challenge, even individual sites in a county can differ dramatically in specific conditions. This makes it very hard to set a national criterion that works everywhere.

When you visit the EPA Web site (*http://cfpub.epa.gov/npdes/home.cfm?program_id=6*), you will see they're in the process of developing a new stormwater rulemaking, and are trying to establish national requirements. The main challenge with any standards development is balancing and creating reasonable criteria, but not overly prescriptive ones.

Energy Design Update thanks Jane Clary for sharing her stormwater expertise with us. To contact Wright Water Engineers, Inc., mail to 2490 W. 26th Ave., Suite 100A Denver, CO 80211, call 1-303-480-1700, or e-mail *clary@wrightwater.com*.

Jane Clary is a senior water resources scientist with WWE, where she has focused on water quality issues, stormwater, watershed management, and water conservation for over 19 years. Over the past 15 years, Clary has helped develop and manage the International Stormwater BMP Database (*www.bmpdatabase.org*), which includes both conventional and green infrastructure stormwater management practices. She has served as co-author and contributor to the Urban Storm Drainage Criteria Manual (Volumes 1-3) for the metro-Denver area, Denver Water Quality Management Plan, and Denver Storm Drainage Criteria Manual. She also led the development of the GreenCO water resources protection BMP Manual (2009) and training program, working with a diverse advisory committee. Clary has a B.S. in Economics, M.S. in Environmental Science, and holds LEED Accredited Professional (LEED AP) and Certified Professional in Erosion and Sediment Control (CPESC) credentials.

IN BRIEF

Arizona Developer Puts National Green Building Standard to Test

Developer Nathan Day, of Scottsdale, Arizona, hired a certified home energy rating team to compare whether his new community, Sterling at Silverleaf, the first single-family new construction project in Arizona to achieve Gold-level National Green Building Standard certification, actually saves money. While the luxury homes at Silverleaf may cost 12% more than comparable new construction, the energy raters found that the certified homes saved 74% in energy costs, bringing in $256 in monthly savings, when compared to a traditional new construction home.

In an interview with *EcoHome*, Day cited spray foam, LED lighting and dimming applications, a hybrid water heater, and dual-pane, low-E windows as key in generating energy savings. The builder used Gaco Wallfoam (*http://www.gacowallfoam.com/*) and Eternal® hybrid water heaters (*http://www.eternalwaterheater.com/*) in each home.

To read more, visit *http://www.ecohomemagazine.com/news/2012/12-december/green-developer-puts-his-homes-to-the-test.aspx*.

PHIUS Releases New Climate Data for Certification

On January 8, 2013, Passive House Institute US (PHIUS) announced the release of new and updated climate datasets, available to the public at *http://www.passivehouse.us/PHIUS%20Climate%20Data%20122112/*. PHIUS+ Certification staff generated over 1,000 climate data sets, primarily for Canadian and US locations, that can be used in WUFI Passive and Passive House Planning Package (PHPP) for PHIUS+ design and certification purposes. The new PHIUS+ Climate Data Sets were generated using the DRY data method within the software Meteonorm, and are available in .XLS format. As a rule of thumb, PHIUS recommends that builders select a data set nearest to, and no more than 50 linear miles away from, their project. According to PHIUS, if no existing data set is within 50 linear miles, or there are microclimate issues or possible impacts from geographical features, such as substantial altitude changes between the project site and the data set location, a builder can request a custom data set. To request a custom data set, e-mail *certification@passivehouse.us*.

To read the PHIUS blog on the climate data release, go to *http://passivehouse.us/blog/?p=561*.

AIA Releases Home Design Trends Survey Results

On December 17, 2012, the American Institute of Architects (AIA) announced findings from the Home Design Trends Survey for the third quarter of 2012 that are focused on community and neighborhood design. The findings demonstrate a growing interest in neighborhood amenities, and a preference for infill locations. To access the survey, go to *http://www.aia.org/practicing/AIAB096884*.

A combination of housing market conditions, changing lifestyle preferences, and shifting demographics has led to a re-shaping of our communities in recent years. There has been a move away from automotive-centric locations, along with a strong desire that households have employment and entertainment options in closer proximity to where they live. There has also been a preference for lower maintenance and more energy-efficient properties.

Residential architecture firms across the country are reporting improving business conditions, with remodeling activity leading the way, and some segments of new construction also seeing growth. These findings are from the American Institute of Architects (AIA) Home Design Trends Survey for the third quarter of 2012 that focused on community and neighborhood design.

"In many areas, we are seeing more interest in urban infill locations than in remote exurbs, which is having a pronounced shift in neighborhood design elements," said AIA Chief Economist, Kermit Baker, PhD, Hon, AIA. "And regardless of city or suburban dwellers, people are asking more from their communities in terms of access to public transit, walkable areas, and close proximity to job centers, retail options, and open space."

Baker noted, "The market for remodeling and alteration projects has been quite strong going back several quarters, but it is encouraging to see positive business conditions for both the move-up and first-time buyer sectors."

Refer to Table 1, Table 2, and Table 3 for AIA Home Design Trends Survey highlights.

The AIA Home Design Trend Survey is conducted quarterly with a panel of over 500 architecture firms that concentrate their practice in the residential sector. Residential architects are design leaders who shape how homes function, look, and integrate into communities, and this survey helps to identify emerging trends in the housing marketplace. Business conditions are also monitored on a quarterly basis. Future surveys will focus on kitchen and bath trends (February 2013), overall home layout and use (June 2013), and specialty rooms and systems (September 2013). To access the full press release, go to *http://www.aia.org/press/releases/AIAB096902*.

Table 1 — Community Design Elements

Community design elements	2012	2011
Infill development	64%	65%
Access to public transportation	59%	47%
Multi-generational housing	50%	44%
Higher density housing	50%	38%
Mixed-use developments	45%	37%
Community gardens	41%	n/a
Dedicated open space	40%	33%

Table 1. Community Design Elements (% of respondents reporting popularity of feature "increasing" minus % reporting "decreasing;" Q3). Data courtesy American Institute of Architects (AIA), *http://www.aia.org/press/releases/AIAB096902*

Table 2 — Popular Home Exterior Features

Popular Home Exteriors Features	2012	2011
Low maintenance exterior materials	70%	68%
Front porches	41%	40%
Sustainable roofing	29%	23%
Windows (number and size)	24%	19%
Contemporary design	23%	10%
Single story homes	17%	24%

Table 2. Popular Home Exterior Features (% of respondents reporting popularity of feature "increasing" minus % reporting "decreasing;" Q3). Data courtesy American Institute of Architects (AIA), *http://www.aia.org/press/releases/AIAB096902*

Building America Announces Solution Center Launch

On January 14, 2013, the US Department of Energy (DOE) and Building America® announced the launch of the Building America Solution Center. This new tool provides simple and free access to research compiled by Building America and its teams, as well as detailed guidance for applying the measures needed to meet desired certifications, such as the DOE Challenge Home. The

Table 3 — Specific Construction Segments

Specific construction segments	2012	2011
Additions/alterations	58%	35%
Kitchen and bath remodeling	51%	37%
Move-up home market	8%	-36%
First-time buyer/affordable home market	5%	-37%
Custom/luxury home market	-0.80%	-27%
Townhouse/condo market	-8%	-35%
Second/vacation home	-39%	-61%

Table 3. Specific Construction Segements (% of respondents reporting sector "improving" minus % reporting "weakening"; Q3). Data courtesy American Institute of Architects (AIA) *http://www.aia.org/press/releases/AIAB096902.*

content will be continuously improved with new best practice guidance developed by Building America and feedback from the broad community of users.

Several of the Solution Center's features were highlighted in a press release from the DOE. The Solution Center's user-friendly interface offers multiple options for accessing hundreds of high-performance topics, ranging from air sealing and insulation to HVAC components, walls, and windows. Resources include:

- Contracting documents or specifications,
- Step-by-step installation guidance,
- CAD drawings,
- "Right" and "wrong" photographs,
- Training videos,
- Climate-specific guidance,
- Codes and standards, and
- Reference libraries.

A mobile field kit feature allows users to save any of these elements for downloading to a mobile device for easy access at the worksite To access the Solution Center, visit *http://www1.eere.energy.gov/buildings/residential/ba_solution_center.html*.

DOE Announces $29 Million Investment for PV, Solar Forecasting

On December 7, 2012, the US Department of Energy (DOE) released details on a planned $29 million investment in solar energy through the SunShot Initiative. The first piece of the program will fund designs of plug-and-play photovoltaic (PV) systems that can be purchased, installed, and operating in one day, to expand acceptance of solar technology among homeowners. The investment aims to reduce the cost of non-module hardware, which currently to represents the majority of costs in a residential system. Fraunhofer USA's Center for Sustainable Energy Systems and North Carolina State University will lead the project. Fraunhofer will oversee the research and development of residential PV technologies appropriate for plug-and-play, while the North Carolina team will work on creating standard PV components and system designs that can adapt quickly to any residential roof, and improve installation and grid hookup.

The DOE will use $8 million in funds to improve solar forecasting technologies, enabling utilities and grid operators to better predict and capture solar power production. According to the DOE press release, the University Corporation for Atmospheric Research, based in Boulder, Colorado, will research methods to understand cloud impact, and will develop short-term prediction techniques based on this work. In Armonk, New York, the IBM Thomas J. Watson Research Center will lead a new project based on the Watson computer system that uses big data processing and self-adjusting algorithms to integrate different prediction models and learning technologies. These projects are working with both DOE and the National Oceanic and Atmospheric Administration (NOAA) to improve the accuracy of solar forecasts and share the results of this work with industry and academia.

The DOE SunShot Initiative program aims to make solar energy competitive with other forms of energy, without subsidy, by the end of the decade. To access the press release, go to *http://energy.gov/articles/energy-department-announces-new-sunshot-investment-solar-energy-grid-solutions*.

Government Reports Construction Starts Fall, Permits Rise at Year's End

On December 19, 2012, the US Department of Housing and Urban Development (HUD) and the US Census Bureau reported a 3% decline in nationwide housing starts, down to a seasonally adjusted annual rate of 861,000 units in November. Single-family housing starts declined 4.1%, and multi-family starts declined 1.0%. In the northeast, combined starts declined 5.2%, while, in the west, starts declined sharply by 19.2%. The midwest and south had gains in starts of 3.3% and 2.9%.

Conversely, the data showed a 3.6% rise in new construction permits. All regions of the United States, except for the northeast, showed gains in permits. In a press release from the National Association of Home Builders (NAHB), NAHB Chief Economist David Crowe remarked that "The starts report for November reflects a readjustment to a more sustainable level of production following significant gains in the previous two months. That said, starts in this quarter are still running well ahead of the third quarter, and we are on track for a projected 25 percent improvement in housing production for all of 2012. Moreover, the fact that issuance of building permits hit its fastest rate since July of 2008 in November is indicative of the continued, modest growth that we expect to see in new home construction through 2013."

Builder confidence in the market for newly built, single-family homes also rose for an eighth consecutive month in December 2012, to a level of 47% on the National Association of Home Builders/Wells Fargo Housing Market Index (HMI), which was released on December 18, 2012. This score marked the highest level the index has attained since April 2006.

For further information, go to *http://www.nahb.org/news_details.aspx?newsID=15644*.

ASHRAE: Chiller Efficiency Improvements Proposed For Standard 90.1

Chiller efficiencies for air- and water-cooled chillers would be boosted to more than 20% under a proposed addendum to the ASHRAE/IES energy standard, announced December 12, 2012.

Proposed addendum ch to ANSI/ASHRAE/IES Standard 90.1-2010, Energy Standard for Buildings Except Low-Rise Residential Buildings, changes the requirements for air- and water-cooled chillers, as defined in section 6.4.2.1, and the efficiency requirements listed in table 6.8.1C. According to Dick Lord, a member of the committee that developed the proposal through a working team of the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) chiller section, this change is a continuation of the efficiency improvements that were implemented in 2010 by further improving the efficiency requirements.

Addendum ch is open for public review from November 30, 2012 to January 14, 2013. For more information, visit *www.ashrae.org/publicreviews*.

In 2010, a Path B was added to the standard for part load intensive water-cooled chillers. Proposed addendum ch would expand Path B by adding requirements to include air-cooled chillers. Also as part of this change, efforts were made to bring the efficiency requirements for water-cooled positive displacement and centrifugal chillers together while considering the available technology, and to chillers to be applied at other application conditions where one technology may be better suited than the other. If approved, the new efficiency requirements would go into effect on January 1, 2015. The proposed efficiency requirements in addendum ch increase annual energy savings to 23.1% versus Standard 90.1-2004, and 8.3% versus Standard 90.1-2010. In 2010, the overall weighted average savings resulted in a 16.2% improvement in chiller annualized energy use versus Standard 90.1-2004.

Lord noted that the average payback was calculated at 6.3 years, given that some units exceed the scalar limits. Chiller manufacturers are aware of this, and know that redesign and cost reduction will be required, but do support the proposal, he said. Lord also noted that we are reaching maximum technological limits at a component level, and that, in the future, the industry will have to look at the full HVAC system for further improvements. AHRI is in the process of forming a new working group to address system approaches for efficiency improvements, and will work closely with Standard 90.1.

In addition, improvements also were made to the requirements to clarify their use. AHRI has recently updated the AHRI 550/590 rating standard that is used for the rating of chillers, and its certification program. As part of this effort, AHRI developed a hard metric standard with slightly different rating conditions than the inch pound (I-P) ratings, and has released it as AHRI 551/591. For the International System of Units (SI) rating, the change was reflected in the ratings, as well as revising the reference to the AHRI rating standard to include AHRI 551/591.

The Standard 90.1 committee also opted to exclude chillers when the leaving condensing temperatures are greater than 115°F from the equipment efficiency requirements of Table 6.8.1C. This proposed clarification stems from the fact that high-lift, heat reclaim chiller applications often use a different compressor, and sometimes a different refrigerant. The intention of using heat reclaim chillers is to increase system efficiency, but the effect on overall system efficiency cannot be assessed at standard cooling design conditions, Lord said. AHRI is developing rating requirements, test procedures, and certification for heat reclaim chillers, as well as heat pump chillers.

Also open for public comment from November 30, 2012 through January 14, 2013 is addendum aq, which makes minor changes to improve clarity and address issues identified in sections 6.5.1.3.a and 6.5.3.2.1.

In addition, 15 proposed addenda were open for public review from November 30 until December 30, 2012. These addenda were:

- Addendum bs reduces the occupancy threshold for demand controlled ventilation from greater than 40 people per 1000 ft^2 to equal to or greater than 25 people per 1000 ft^2, with exemptions for certain occupancies.
- Addendum ca requires that vestibule heating be locked out when outside air is above 45°F, the same temperature that lockout of freeze protection or ice melting systems is required in section 6.4.3.8.
- Addendum cb removes the 10,000-cfm threshold for optimum start, and adds a threshold for systems controlled by DDC. The addendum also expands the requirement beyond air-based systems so that convectors and radiant systems would be included.
- Addendum cc adds minimum efficiencies for both axial and centrifugal fan evaporative condensers with R-507A as the test fluid to Table 6.8.1G.
- Addendum cd clarifies what to do with piping system accessories that are not in series with the piping circuit that do not have the same heat losses/gains and pressure drop.

- Addendum ce establishes package single zone systems as the baseline HVAC system type for all retail occupancies of two stories and less.
- Addendum cf enables the establishment of a window-to-wall ratio for retail strip mall buildings.
- Addendum ck requires the use of dual maximum control for variable air volume zone control when the building has DDC controls.
- Addendum cl updates the IEER values for air-cooled and water-cooled air conditioners and heat pumps above 65,000 Btu/h. Depending on the cooling capacity and product classes, the new IEERs are between 7% and 13% better than the values they are replacing. The new IEERs will become effective on January 1, 2016. Note that the IEER is a new metric that was developed by AHRI and first implemented in the 2010 standard, and is a better representation of the annualized refrigeration system energy use of a typical commercial packaged air conditioner.
- Addendum cn allows laboratory designs that incorporate strategies to reduce peak airflows and minimum unoccupied airflows to document the energy savings associated with reduced outside air volumes.
- Addendum co modifies the Lighting Power Densities in Table 9.5.1 to match the recommended light levels in the 10th Edition of the IES Lighting Handbook.
- Addendum cp corrects a value in table 5-5 for steel joist floors.
- Addendum cr modifies Table 9.6.1 to correct the required light levels for hospital corridors, assisted living dining spaces, and retail sales spaces.
- Addendum an allows the option to use energy rates either from actual local rates or EIA state data, where approved by the building official, when using Appendix C.
- Addendum ar corrects the definitions for walk-in coolers and walk-in freezers.

Press release courtesy of ASHRAE.

REM/RATE V14.0 Released

In correlation with the launch of its Building America Solution Center, the recent release of the REM/Rate V14.0 rating homes for Department of Energy (DOE) Challenge Home allows for easier, faster, and more reliable certification. According to the DOE press release, V14 automatically programs the "Target Home," which sets the bar for the design home's energy efficiency. Additional features include a new page listing the mandatory items for DOE Challenge Home within REM/Rate, which is similar to how checklists for ENERGY STAR® Homes are handled. The DOE Challenge Home Report, which generates the home's certificate, lists where the design is falling short if it fails to qualify. The DOE stressed that this REM/Rate update does not yet upload DOE Challenge Home Reports for qualifying homes to the RESNET National Buildings Registry. Until this automatic link is live, raters will need to e-mail the certificates for qualifying homes to DOE at *doechallengehome@newportpartnersllc.com*.

DOE is also working on a similar update with EnergyGauge rating software, which will also automate DOE Challenge Home compliance.

NAHB 2013 International Builders' Show®

The annual National Association of Home Builders (NAHB) International Builders' Show® (IBS), the largest annual light construction show in the world, was held January 22-24, 2013, in Las Vegas, Nevada, at the Las Vegas Convention Center.

Educational tracks for the 2013 Show included 50+ Housing; Business Operations; Custom Building; Design; Development, Construction, and Codes; Economics, Financial, and Legal; Green Building and Sustainability; Multifamily; Remodeling; and, Sales, Marketing, and Customer Focus. Under Green Building and Sustainability, educational sessions will address deep energy retrofits, solar, liabilities in green construction, building science, and "myth" conceptions in green building. The 2013 New American Home®, built by Blue Heron and previewed in the September 2012 issue of ***Energy Design Update***, will also be discussed and toured as part of the Green Building track.

IBS changed 2013 educational formats to include advanced-leveled sessions for seasoned industry professionals, as well as Master sessions: in-depth, full-day intensive programs that dig deeper into a specific industry topic. Scheduled Master sessions included Technology Trends, Tools & Strategies: Draw Customers In & Enhance Their Home Buying Experience held on Tuesday, January 22, From Feeble Financials to Exceptional Earnings (January 23), and Lean Design: Eliminate Non-Value Waste & Achieve Breakthrough Profits (January 24). Tracks also included Speed Learning sessions, fast-paced, 45-minute programs designed to provide quick insights and ideas that can be applied immediately. Daily Keynote sessions have also been brought back.

For more information, go to *http://www.buildersshow.com/Home/*.

Correction: Sam Hagerman is the current President of Passive House Alliance US (In Depth, Page 1, January 2013).

IN PRACTICE

Taking Stock of Heat Pumps: Steve Kavanaugh Talks Measuring Real Ground Source Heat Pump Costs and Performance Against Projected Cost and Performance

Ground source heat pumps (GSHP, also known as geothermal heat pumps) are gaining market share as the costs of energy and equipment maintenance rise. Heat pumps have historically comprised 20–25% of US unitary space-conditioning equipment sales (*http://www1.eere.energy.gov/geothermal/pdfs/gshp_overview.pdf*); however, from 2004 to 2009, heat pump market share rose to approximately 35% (AHRI, Appliance Magazine). When properly designed and installed, GSHPs can reduce energy use and lower maintenance costs, as well as extend equipment life because they have no exposed outdoor equipment. Savings are often in the range of 30% to 60% of space-conditioning energy consumption, depending on GSHP efficiency, technology replaced, climate, and application, according to a study commissioned by the US Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE), and the Geothermal Technologies Program, and released February 3, 2009 ("Ground-Source Heat Pumps: Overview of Market Status, Barriers to Adoption, and Options for Overcoming Barriers," *http://www1.eere.energy.gov/geothermal/pdfs/gshp_overview.pdf*). GSHPs can provide significant primary unit energy savings, as compared to typical air source heat pumps (ASHPs) or typical furnaces with air conditioners (see Figure 7).

Yet the DOE report also identified several key barriers facing GSHPs:

- High equipment costs compared to ASHPs;
- Cost and difficulty of evaluating the suitability of individual installation sites;
- Installation-specific design and engineering of the ground loop is generally required; and
- Space requirements for ground coupling can be problematic in densely built areas.

Costs pose a pivotal brake point for GSHPs. When payback is drawn out over 10 years or more, the mar-

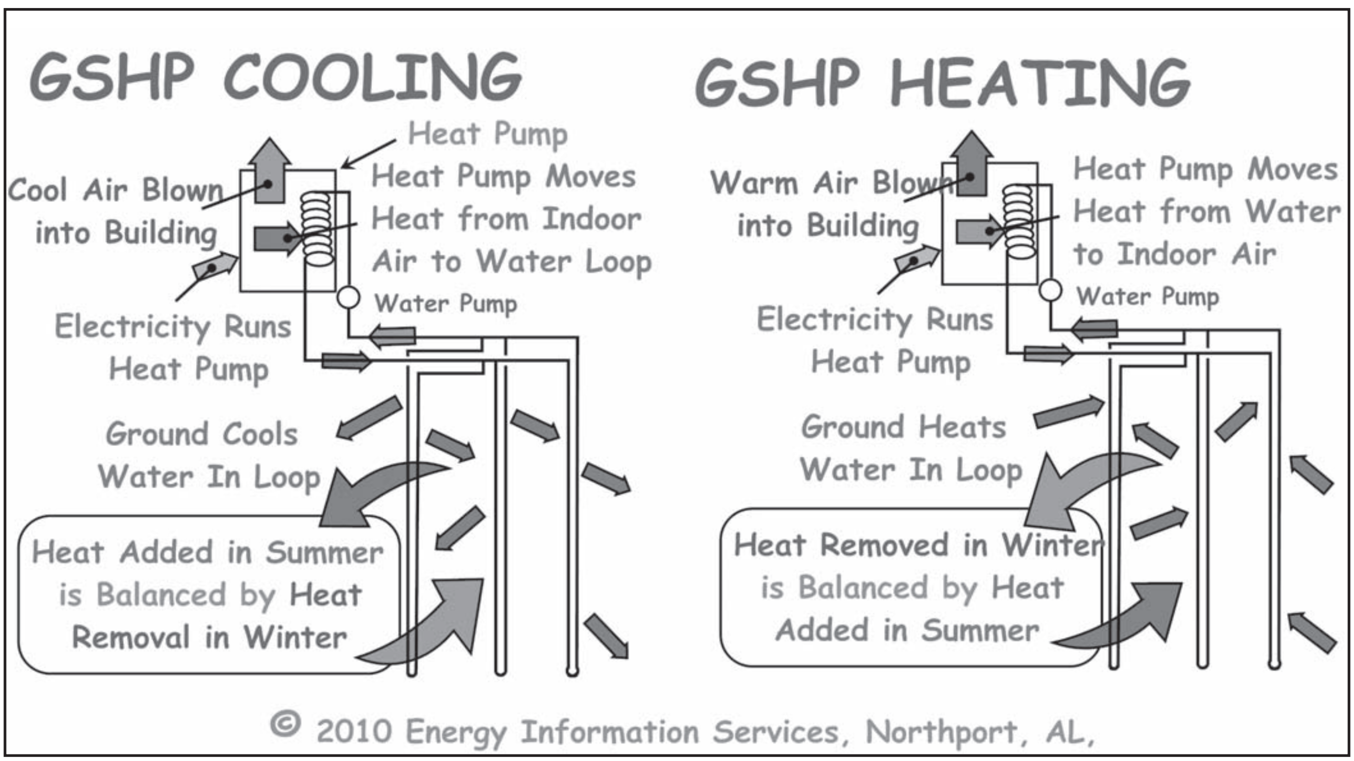

Figure 7. Ground source heat pumps (GSHP, also known as geothermal heat pumps) in both cooling and heating modes. Graphic courtesy Steve Kavanaugh and Energy Information Services.

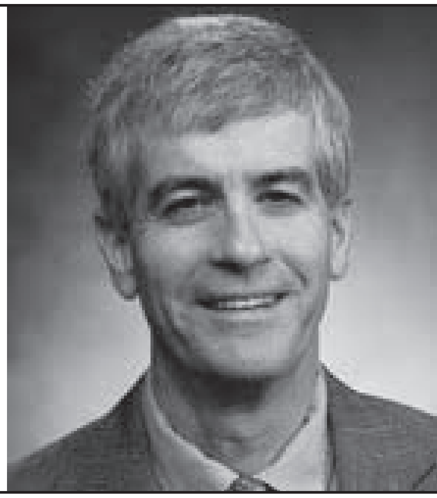

Figure 8. Dr. Steve Kavanaugh is a Professor Emeritus of Mechanical Engineering at the University of Alabama. He has been involved with ground source (or geothermal) heat pump research and development for 30 years. He is of author of Ground Source Heat Pumps (ASHRAE, 1997), HVAC Simplified (ASHRAE, 2006), and has published several articles in the American Society of Heating, Ventilating, and Air-Conditioning Engineers (ASHRAE) Transactions and Journal. Photo courtesy Steve Kavanaugh.

ket penetration of a given technology falls. In Part 4 of a 7-piece study published in the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Journal, Steve Kavanaugh updated cost information on these systems from data first released in 1995.

In collaboration with the Electric Power Research Institute (EPRI), Southern Company (SoCo), and the Tennessee Valley Authority (TVA), performance and cost surveys were collected and site visits performed at 40 commercial locations. From these data, the team found that the increase in HVAC component costs of GSHP systems, since the 1995 study, has been 177%, while the increase in the ground loop portion for GSHPs was 52%. Based on these 2011 data, the ground loop portion of GSHPs systems account for 26% of total costs, while the HVAC component comprised 74% of total costs (ASHRAE Journal October 2012, Vol. 54, No. 10 pp 26–36; *http://geokiss.com/tech-notes/LongTermGSHPsPt4.pdf*).

Average costs found in the 2011 data study were $20.75/ft^2 for GSHP, which included $15.46/ft^2 for HVAC and $5.29/ft^2 for the ground loop component. In 2000, those costs were $13.08/ft^2 for system, 9.32/ft^2 for the HVAC portion, and $3.76/ft^2 for the ground loop. Overall, the percentage of ground loop costs to total systems declined from 1995 to 2000, and again from 2000 to 2011.

Based on this latest ASHRAE research, ***Energy Design Update*** spoke directly with Steve Kavanaugh (Figure 8), to see what advice he has for residential builders evaluating GSHP potential.

Extrapolating from your research, what do these report results mean for residential builders?

The economics in the commercial building sector are much better than those in residential. I really have some concerns, and am disappointed for the residential sector because heat pump technology is primarily restricted to high-end applications, because of economics.

It's also disappointing to me because people have worked so hard to improve the building's envelope and lighting, and then here we are with this equipment that appears to be much better, but, in fact, its efficiency improvement is non-existent, or only offers a modest improvement, for a very high cost. It is often not a good bargain for the average customer. That is disappointing.

In the 2009 DOE report by Navigant, the ground loop was found to be the single most expensive component, accounting for about 30% to 35% of the installed cost (depending on whether the ductwork is included). Ground loops for four demonstration homes in New York State cost between $1,000/ton and $1,800/ton [Henderson 1998]. Based on these factors, the report assumed that loop figure as 35.5% of the installed cost, and then calculated the associated installed costs to be between $2,800/ton to $5,100/ton, or a $3,000/ton installed estimate for a typical-efficiency GSHP. What has your research indicated about costs?

For GSHP technology, the gist of it is, in the commercial sector, the cost of the ground loops, over the past 15 years, has gone up 52%, despite the fact that it has come down as a total percentage of system cost. The cost of the stuff inside the building has gone up 177%, and the cost of those inside components is 74% of total. My conclusion, which is the opposite of the industry, as the industry is calling for the cost of the loop to come down, is that, considering inflation, the cost of the loop has come down in areas with mature, competitive markets, and can't go much further. Equipment costs, meanwhile, are going through the ceiling. When you have the premium on the ground loop, which is unavoidable, and then have a premium on the inside equipment that does not have to be there, the economics are often not attractive in the mid-price range residential sector.

When the ground loop is designed and installed correctly, it does the work, and is a simple device.

Simple heat pumps with good size heat exchangers, simple controls, efficient constant speed compressors, and improved fan wheels are all that is needed because the ground will provide the efficiency. Yet, what has happened is that manufacturers are promoting premium equipment with multi-capacity and variable-speed compressors. In some cases, price issues are addressed by suggesting loops can be smaller and less costly because equipment efficiencies are higher. The problem is the equipment efficiency improvements are at part-load, when right-sized ground loops are not taxed. Full load efficiencies are typically lower than good constant capacity units, making right-sized loops even more important. I am not aware of any recent, detailed cost surveys in the residential sector, but I'm concerned that the commercial sector inside the building 15-year, 177% increase may be even worse in the residential sector.

There is a great need for field studies and owner verified, itemized installation costs and energy performance information with this technology.

There has been some controversy over the trustworthiness of energy efficiency ratings on these systems. What has your research shown?

There is deception in ratings; this doesn't get large play, but I believe that the GSHP industry has created a deceptive rating system to counter the deceptive air-source heat pump rating system. I feel it really hurts the industry, as it promises unrealistic energy efficiency numbers when, in fact, they are less efficient units than what the ratings suggest.

In a nutshell, let's examine the standard. For water source heat pumps, their efficiency is governed by ISO Standard 13256-1. They have a full load rating system for single speed and for multi- and variable-capacity equipment. The multi- and variable capacity equipment have additional rating points that allow manufacturers to advertise very high efficiency numbers. But peel back what computations they are using. On the inside air side, they use a temperature of 80.6°F as the return air temperature, with a 66.2°F wet bulb temperature, which is outside the comfort zone. Additionally, to calculate performance on these multi- and variable-capacity models, the standard calls for water temperature in the loop to be 68°F, which is ridiculous, because loops operate at much higher temperatures in cooling. Essentially, what you have there is something similar to rating the efficiency of a car or truck (miles per gallon, MPG) when it's rolling down the hill. If the evaporator coil is 80.6°F and the water coil (condenser) is 68°F, you can get a ridiculously high efficiency reading. On top of that, these calculations assume that the fan has no static pressure. Ratings assume almost no pressure drop across the filter, like the air is blowing through the building by itself. People don't recognize how significant that assumption is; it takes a lot of power to circulate air through a building. When you take that piece out of the rating, you get a very deceptive, high efficiency rating.

At full load, water source heat pump models are rated using 77°F water in cooling. However, there is also a measurement done at 86°F water; this is the one I recommend people look at for a more true cooling efficiency. If your primary concern is cooling, look at the equipment's efficiency with water at 86°F. This rating is still a little higher than what you really get because the fan and pump power required to circulate fluid through the systems are not calculated in there. For heating, it's a little bit better. Models provide you with a rating point at 32°F entering liquid temperature, and 50°F entering liquid temperature. If you live in a southern climate zone and are interested in heating, look at coefficients of performance (COP) at the 50°F rating. If you're up north, look at the COP with 32°F entering water. If you live in between, average the two COPs.

In defense of water source heat pump manufacturers' desire to use this deceptive rating system, it is important to understand the system used by competing air source heat pumps. In cooling, the SEER, if it's a single speed machine, will be determined when the inside air temperature is at 80°F and the outside air is 82°F. With these conditions, you honestly might as well open your windows. They make similar assumptions about the low power requirements for fans. Almost no power is calculated into the equation in order to circulate air through the building. Again, efficiency assumptions for multi- and variable-capacity units are even worse; we are seeing SEERs of 19–22, yet what they get to do is use Bin Method Energy calculations, so that, again, inside air is rated at 80°F, while outdoor air temperatures used in the calculations consist of 1,000 hours of weather data. Yet, of those 1,000 hours, 660 hours are at temperatures below 80°F, with very few hours above 90°F. That allows them to play tricks with computations. If you look at the high temperature rating, and they do have a high temperature rating at 95°F, usually, if you compare a 14 or 15 SEER air heat pump, its EER is almost always higher at 95°F than the EER of 20 SEER heat pumps. The variable that is shown through this dichotomy is that, going up to full speed with a variable model means those things consume more power than their high SEER suggests. At equal points, and at higher temperatures, multi- and variable-capacity models use more energy than an efficient single speed machine, despite the fact that the single speed model is lower rated in efficiency.

On the heating side, most of what you see HSPF are typically between 35°F and 47°F outside. The issue with that calculation parameter is the way people are building buildings today. By following recommendations, most of those well insulated envelopes don't need much heat at 47°F outdoor air temperature, or even 35°F. Thus, you have a rating point that you don't get that many hours. Bin calculations for most hours are above 37°F. Plus, we really want to know what the machine is doing while cold, and while manufacturers report COP at 17°F, they don't have to report capacity, so you really don't know how much strip heat the machine will need.

Equipment manufacturers are playing games, getting really high COP and SEER, which all are really inflated. If you peel back the manufacturer data and look at what machines are really doing at 75°F inside temperature and 95°F outside temperature, you just can't generate that same performance information. I see this as a very deceptive push toward higher "performance" pieces of equipment, which are much more complicated, their service is more expensive, and many of their control components are proprietary.

So how can a builder best arm him or herself with information to make a decision? What reports or data should we be paying attention to?

Generally, there is a lack of information. My take on this is for owners to ignore efficiency ratings except for the following:

- A minimum EER of 14 Btu/whr at ISO 13256-1 WLHP conditions (86°F/30°C Entering Water Temperature). Data should be in ARI Directory, not in manufacturer's literature.
- A minimum COP of 4.0 at ISO 13256-1 GWHP conditions (50°F/10°C) entering water temperature.
- A maximum head loss of 12 ft of water at 3 gpm per nominal ton.
- Extended range capability to operate with an entering liquid temperature of 100°F in cooling, and in heating at 32°F.
- Ignore the part-load rating values.

Owners have to be really careful when someone quotes them COP or EER. Ratings have huge gaps in them, and don't include pump operation, either. Some designers and installers do sloppy work and end up putting huge pumps on to compensate for poor piping plans. The big pumps take a huge chunk out of potential efficiency. For suggestions on pipe arrangement and pumps, see the ASHRAE 2011 Applications Handbook, page 34.25, and *http://geokiss.com/res-design/GSHPDesignRec2.pdf*.

The most important thing to be looking at is hard to find. We need measured data, reports of what these machines actually do in the field. The electric utilities and their research arm, the Electric Power Research Institute, are beginning to evaluate advanced air and water source heat pump equipment in field studies and in test labs. Hopefully, results will soon be available to the public to add to the existing, limited data set. My sense is that the improvements in ratings are much more impressive than improvements in actual installations.

Those types of things are really what we should be searching out. Physical results are likely to be counter to what the industry has been pushing. A more complicated system with unknown service life and only modest, or non-existent, efficiency improvement is not likely to be what most homeowners need. Do anything you can do to find other studies, and beware of advertised standard ratings!

Energy Design Update thanks Steve for his work, research, and for sharing his data with us.

Dr. Steve Kavanaugh is a Professor Emeritus of Mechanical Engineering at the University of Alabama. He has been involved with ground source (or geothermal) heat pump research and development for 30 years. He is the author of Ground Source Heat Pumps (ASHRAE, 1997), HVAC Simplified (ASHRAE, 2006), and has published several articles in the American Society of Heating, Ventilating, and Air-Conditioning Engineers (ASHRAE) Transactions and Journal. He is the former chair of ASHRAE Technical Committee 6.8 on Geothermal Energy, has served as a consultant to many electric utilities, and has conducted over 140 GSHP and HVAC design seminars for professional engineers.