Energy Design Update

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IN DEPTH

Good Intentions, Unintended Consequences

Florida Retrofit Challenge Mechanical Standard Offers Perspective and Lessons on Raising the Bar for Retrofit Codes (Part Two)

Are older homes doomed to languish in the dust of newer construction, or can an old home be taught new tricks? What are the consequences, both in energy consumption and livability, from upgrading existing homes? To navigate the potential mine field in a performance retrofit, what strategies ensure effective and clear goal communication to contractors?

Florida offers an ideal testing ground for these questions. From the 1970's through the 2000's, housing starts were strongest in the South and ranged from 4.6 to 5.9 million, nearly twice as many starts as any other region across all

Description	Scenario 1 Efficiency Enhancement Package (No Replacements)	Scenario 2 Efficiency Enhancements and Higher Performance Replacements	Scenario 3 Scenarios 1 and 2 Plus HVAC and Window Efficiency Upgrades at Replacement
HERS Index Pre-Retrofit	131	131	131
HERS Index With Minimum Replacements (where applicable)	NA	130	113
HERS Index Post-Retrofit	94	96	69
HERS Index Improvement (over minimum, if applicable)	28%	26%	39%
Projected Annual Energy Cost Savings (% over minimum if applicable)	20%	19%	28%
Estimated Full Costs	$2,880	$12,221	$23,379
Estimated Efficiency Cost Premium	$2,880	$1,921	$5,538
Annual Mortgage (7% @ 30 years)	$232	$155	$446
Projected Annual Energy Cost Savings	$505	$490	$644
First Year Cash Flow	$273	$355	$198
Simple Payback (years)	5.7	3.9	8.6

Figure 1. Scenario 3, a comprehensive implementation of the best practices in an average home (a home that, pre-retrofit, earned a HERS Index score of 131) represents the likely practical threshold for achieving deep retrofits in central Florida pre-code homes that generate positive first year cash flow. The base house closely approximates the average HERS Index score and characteristics found in the Phase 1 field study. Full implementation of the best practices in Scenario 3 resulted in a 39% improvement in the HERS Index score and 28% in projected annual energy cost savings comparing the post-retrofit to the minimum retrofit scenario. To reiterate, the minimum retrofit scenario includes minimum replacements at change out. Note, for instance, the HERS Index score for the minimum retrofit scenario is 113, significantly better than the as-found score of 131, because even the minimum efficiency replacements are significantly better than the as found conditions. Comparing the post-retrofit HERS Index score to the pre-retrofit, which was the Phase 1 metric, produces a 47% improvement in the HERS Index. Data and figure from *Applying Best Practices to Florida Local Government Retrofit Programs*, J. McIlvaine and K. Sutherland, Building America Partnership for Improved Residential Construction (BA-PIRC), December 2013, NREL Contract No. DE-AC36-08GO28308.

decades, according to Janet McIlvaine, Senior Researcher at Florida Solar Energy Center (FSEC). For McIlvaine, all those aging homes represented a serious performance gap. But she also contends this performance gap doesn't have to be the end of the story.

The Retrofit Challenge Initiative, launched by the Building America® Partnership for Improved Residential Construction (BA-PIRC) and the FSEC in 2014, selects key building science principles seen in new homes and targets these practices toward retrofits. The Retrofit Challenge's Best Practices Checklist *(http://www.ba-pirc.org/retrofit)* was compiled after a 4-year study that completed 70 comprehensive affordable housing renovations (see Figure 1).

To date, the Retrofit Challenge field study has secured some great wins: A key finding was that by applying an analogous set of replacement specifications, efficiency enhancements, and systems engineering strategies, similar post-retrofit whole house efficiencies were achieved in homes of widely disparate pre-retrofit efficiencies (see Figure 2). On average, the homes in the study posted a Home Energy Rating System (HERS) Index score improvement of 34%. The average HERS Index score was 83 – similar to Florida homes built from 2000 to 2010. In essence, Florida homes from the 60's and older can be made "as good as new," at least from a whole house efficiency perspective.

Retrofit Challenge measures are experiencing performance success in the field. Yet the burgeoning promise of "old as new again" performance must meet the harsh reality of code and existing home conditions. These things often result in troublesome consequences, despite the best of intentions.

To combat performance retrofit challenges, McIlvaine shared several key takeaways from the Retrofit Challenge pilot program and field studies:

- Learn climate appropriate strategies – both the theory and implementation. If the reasoning behind a practice is not well understood, there is a risk that it will receive a lower priority or be ignored, possibly increasing risk. Do a few trial installations of unfamiliar details and strategies before mandating them.
- Develop clear, standardized language for communicating specifications and expectations to contractors and subcontractors and other program stakeholders.
- Clear communication is necessary to ensure that high performance specifications translate into high performance results.

Lesson #1: Educate, educate, educate!

Infiltration and duct leakage are complex concepts compared to setting heat pump or window criteria, McIlvaine asserted, and that distinction is important. "You can write a list of specifications but when it comes to controlling air flow, it is so much more complex than picking out a piece of equipment. One of the big conclusions we drew from the field study and pilot was that lack of exposure to building science is going to hold up wider adoption of best practices for high performance renovations." If a program manager or contractor doesn't understand a recommendation, it may not be completed correctly, or may even be skipped. Adopting master specifications is not enough.

This problem is acute in Florida. "In a lot of areas of the country there is a strong home performance industry. We don't have that in Florida; we have home energy raters, but the demand for high performance renovations is very low, and there is very limited funding for it in the general market place. We are working with the Solar and Energy Loan Fund that does offer performance financing in parts of Florida, but that's the main reason we are focusing on affordable housing programs. We have found many that are already doing comprehensive renovations that want to add performance and efficiency measures," McIlvaine noted.

Energy Design Update

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For the Retrofit Challenge pilot, McIlvaine and her team used direct education with a project manager to overcome this hurdle in understanding. To support building science education, the partner is encouraged to hire a local home energy rater to conduct an audit and preliminary analysis for a home in the program. This approach more effectively engaged staff in the pilot study, rather than an approach focused on simply providing analysis. Additionally, BA-PIRC has developed a half-day Building Science 101 training session that partners can host for the contractors they work with. It's not free, but it's affordable. "While a half-day session only scratches the surface, we want to give people a sense of the risks they are taking by not addressing complex issues during a renovation, and what the possible impacts are. Although a half-day event doesn't necessarily give enough information to solve all the problems seen in a renovation, it does offer enough knowledge for people to say, 'Here's a problem,' to the project manager," said McIlvaine. "A trainer with field experience wins the crowd over. From presentation of forensic building science in failed houses, participants are able to see the real world consequences of what can go wrong."

McIlvaine cites this training gap as a key hurdle in advancing building performance in renovations. "Addressing exposure and lack of awareness will take more than just simple training. There's a more general problem of quality control, since the industry doesn't really have a quality assurance paradigm for things falling outside or crossing over each trade contractor's scope of work. Many air, heat, and moisture flow strategies require that kind of coordination. Nevertheless, the training approach is a step in the right direction."

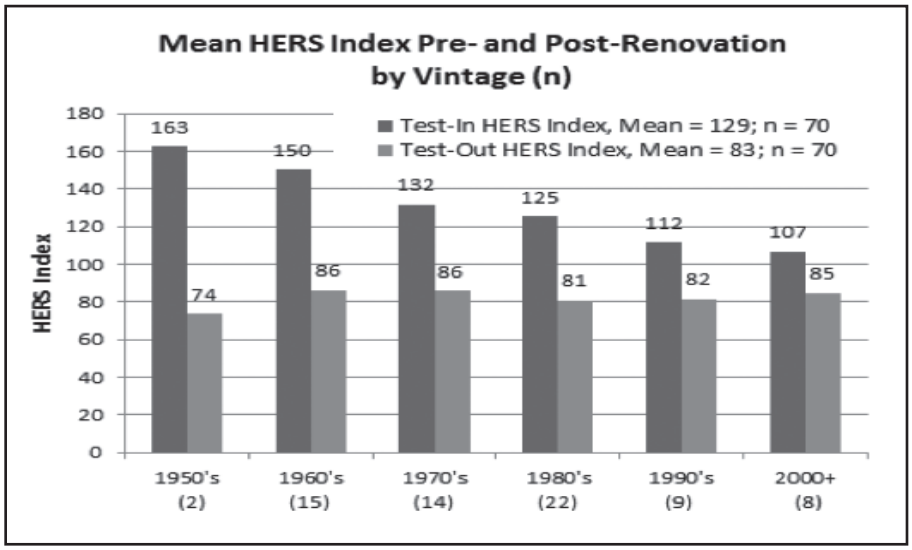


Figure 2. Mean Home Energy Rating System (HERS) Index at pre- and post-retrofit by decade vintage. Data courtesy Janet McIlvaine and Karen Sutherland and the Building America Partnership for Improved Residential Construction.

Lesson #2: Use Clear, Standardized Language

The ideal degree of specificity in a best practices list is clearly illustrated by the requirements targeting whole-house air tightness. There is a measured leakage goal of 6 or less ACH at the test pressure of 50 pascals (ACH50 ≤ 6.0). "Although new construction codes in Florida do not address infiltration directly, we know from high performance programs like ENERGY STAR® for New Homes, that checklists can be powerful tools. We added a list of sealing points to our best practices, to help contractors meet the target on their first try," McIlvaine said. Experience confirms that sealing these points will usually result in achieving the target. The Challenge now lists infiltration targets directly under the criteria for air leakage:

"Seal with code-approved sealant the following common air infiltration points:

- Windows
- Doors – replace weather-stripping if missing or degraded
- Lighting fixtures and ceiling fans (drywall gap behind cover/trim)
- Kitchen exhaust fan chase (at ceiling)
- Switches and outlets – if replacing covers, seal boxes to drywall
- Plumbing penetrations through interior and exterior walls (e.g. under sinks)
- Plumbing access panels – secure tightly and/or weather-strip
- Attic hatch or stair – weather-strip
- Enclose all open wall cavities, including those in air handler closets
- Interior AHU closet – seal all edges and seams of walls, ceiling, and ducts
- Soffits over cabinets or housing lighting – add air barrier above
- Holes in drywall
- Frame floor penetrations for plumbing and electrical"

Clearly spelled out requirements based on the program's master specifications are included in bid documents for each home (see Figure 3). Partner organizations that adopt the best practices can create specific performance-related language for bid documents. However, they are not locked into including the master specs in every home. In the bid documents, they can make exceptions for individual homes if there is compelling evidence that the investment of time and money is not justifiable and/or that the implementation is impractical for that house.

Trade: 21 HVAC

Spec Number	Specification	Quantity	Units	Unit Price	Total Price
5932	CENTRAL HVAC SYSTEM -15 SEER Remove existing heating and/or cooling equipment. Install new central A/C heat pump system with a minimum SEER of 15.0, Goodman or equal. Unit to have heat strips for emergency heating. Indoor/ outdoor coil match- up must be ARI listed. Install new foil covered ducts to all rooms with white supply/return air grills and apply mastic where box penetrates through the ceiling to prevent leakage. Include new thermostat, compressor pad & all necessary connections including properly sized circuit breakers for each unit. Unit shall be sized to efficiently heat and cool residence. Include GFI outlet as required by code. Line inside of return air box with new duct board. Seal all gaps and penetrations with mastic to insure that intake air flow goes through the air filter as designed. **8 - Hall**	1.00	EA	_____	_____
				Total for 21 - HVAC:	_____

Figure 3. Excerpt from bid document incorporating some of the best practices for heating, ventilation, and air conditioning (HVAC) equipment. In the Phase 1 field study, researchers often observed scopes of work and bid documents written by local government partners that stated "all work shall be executed in accordance with prevailing codes." This language was not sufficient to ensure that the mechanical system would be brought up to new construction code requirements in existing homes. One of the refinements in Phase 2 was to add specific language modeled after individual provisions of the code requirements for new construction addressing flex duct installation, AHU closet and return plenum construction, air distribution system sealing, and passive return air pathways. Text from *Applying Best Practices to Florida Local Government Retrofit Programs*, J. McIlvaine and K. Sutherland, Building America Partnership for Improved Residential Construction (BA-PIRC), December 2013.

"Clear communication with contractors is necessary to ensure that high performance specifications translate into high performance results. Standardized language in bid documents can foster consistent results across a community-scale retrofit program because contractors will see it over and over again for individual houses," McIlvaine emphasized. "Getting specific essentially means that bid documents can serve as a quality control checklist prior to contractor payment."

Lesson #3: Make Sure Measures Have Buy-In

A few criteria in the Retrofit Challenge were pulled due to lack of understanding and an inability for details to be successfully reproduced in the field with the current labor pool. Passive ventilation was one such item.

"We really liked the idea of including the passive outside ventilation strategy, which has proven reliable and low risk in hundreds of Building America homes in the hot-humid climate over the past 10 years. It adds a small amount of outside air (~50 cfm) when the AHU is operating, to create a small positive pressure to a home. This further limits infiltration during AHU runtime. Yet, we saw in the pilot study that project management and trade contractors didn't have a good enough grip on the concept and objectives to look at a situation and gauge whether the detail could be done right in a given home. Again, the spatial limitation of existing AHU closets was a factor. Because installers did not fully understand it, there seemed to be less emphasis on implementation in the field. It was dropped from the criteria to avoid the potential risks that incorrect implementation would create. If typical post-retrofit natural infiltration levels had been lower, this strategy would have been pursued more diligently," McIlvaine concluded.

Ultimately, the Retrofit Challenge Initiative underscored the delicate balancing act of good intentions versus unintended consequences. What it did prove is that in certain areas, given specificity of code requirements and implementation of training, that retrofits in the affordable housing market can be made much more energy efficient, providing the homeowner with a better quality of life. Nevertheless, there is a danger in making blanket prescriptions for improving existing homes, particularly when issues like climate and construction style are ignored.

Energy Design Update thanks Janet McIlvaine, the Building America® Partnership for Improved Residential Construction (BA-PIRC), and the Florida Solar Energy Center (FSEC) for sharing their research and expertise with us. Groups interested in taking The Retrofit Challenge may go to *http://www.ba-pirc.org/retrofit/PDFs/Pledge%201-27-14.pdf* to take the pledge. The Retrofit Challenge website is online at *http://www.ba-pirc.org/retrofit/index.htm*. FSEC and BA-PIRC invite partners from the remodeling, renovation, and affordable housing sectors to join them in this research.

IN BRIEF

Zola Windows' ZNC™ First to Meet Passive House Institute US and Passive House Institute Germany certification

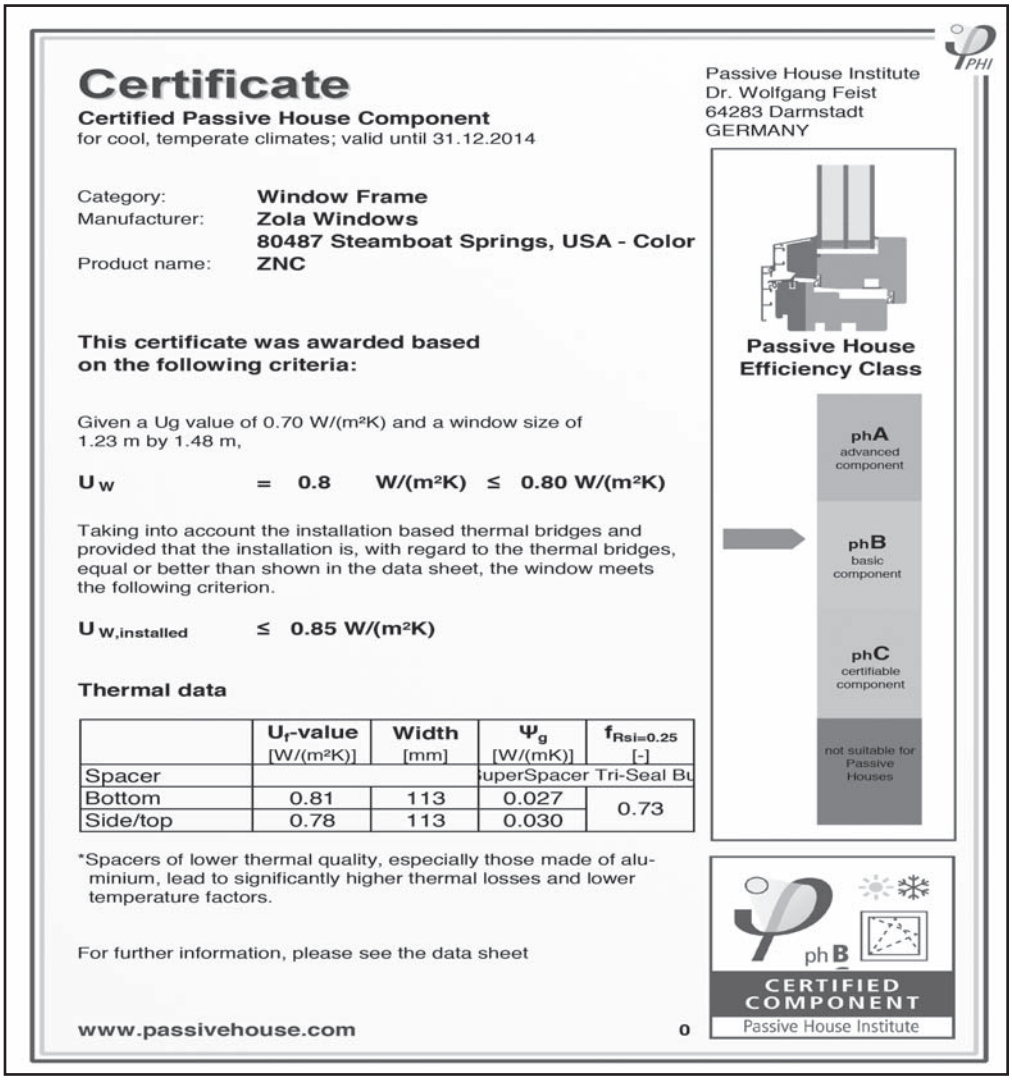
Zola European Windows' latest product line, the Zola No Compromise (ZNC™) window, became the first window to receive both Passive House Institute US (PHIUS) and Passive House Institute Germany (Passivhaus Institut, *http://passiv.de/en/*) certifications (see Figure 4).

Available with R-15 quad, or four-pane, glazing and coming standard in R-11 triple glazing, ZNC Fixed Windows can be as large as 8' wide and 10' high, and Tilt & Turn operable windows may measure as large as 5' wide by 9' high.

Additional features of the line include a slim profile design: 4.5" operable and 3" for fixed windows; a super spacer tri-seal warm edge spacer; and a precision crafted structural wood frame from responsibly harvested wood. ZNC windows come standard with concealed premium tilt and turn hinges. The exterior of the window is clad with a powder coated aluminum exterior for longevity, with a fully welded main seal for water tightness. Rail-mounted rainscreen cladding, as well as both head and jamb designed for over-insulation, are also standard design elements of the series (see Figure 5). Fully integrated screen systems are available. To learn more, visit *http://www.zolawindows.com/znc/*.

According to Zola, the ZNC window line was born out of the company's unwavering belief that a passive house window must not only boast outstanding thermal performance and be extremely airtight, but should also use responsibly sourced materials and be available in a myriad of standard finish and color options. Zola feels they have positioned and priced this window to be extremely competitive in the high performance window market.

For further information on PHIUS certification, visit *http://www.passivehouse.us/passiveHouse/CertifiedWindowData.html*.



Certificate

Certified Passive House Component
for cool, temperate climates; valid until 31.12.2014

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
GERMANY

Category: Window Frame
Manufacturer: Zola Windows
80487 Steamboat Springs, USA - Color
Product name: ZNC

This certificate was awarded based on the following criteria:

Given a Ug value of 0.70 W/(m²K) and a window size of 1.23 m by 1.48 m,

U_w = 0.8 W/(m²K) ≤ 0.80 W/(m²K)

Taking into account the installation based thermal bridges and provided that the installation is, with regard to the thermal bridges, equal or better than shown in the data sheet, the window meets the following criterion.

$U_{w,installed}$ ≤ 0.85 W/(m²K)

Thermal data

	U_f-value [W/(m²K)]	Width [mm]	Ψ_g [W/(mK)]	$f_{Rsi=0.25}$ [-]
Spacer			uperSpacer Tri-Seal Bu	
Bottom	0.81	113	0.027	0.73
Side/top	0.78	113	0.030	

*Spacers of lower thermal quality, especially those made of aluminium, lead to significantly higher thermal losses and lower temperature factors.

For further information, please see the data sheet

www.passivehouse.com

Passive House Efficiency Class

phA advanced component
phB basic component
phC certifiable component
not suitable for Passive Houses

phB CERTIFIED COMPONENT Passive House Institute

Figure 4. The Zola No Compromise (ZNC™) window became the first window to receive both Passive House Institute US (PHIUS) and Passive House Institute Germany (Passivhaus Institut, *http://passiv.de/en/*) certifications. Figure courtesy Zola European Windows.

NREL, LBNL Report Reviews Estimates of Costs and Benefits of Compliance with Renewable Portfolio Standards to Date

On May 30, 2014 a new report, "A Survey of State-Level Cost and Benefit Estimates of Renewable Portfolio Standards," was released detailing costs and benefits of compliance with Renewable Portfolio Standards (RPS). Prepared by analysts from the US Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) and Lawrence Berkeley National Laboratory (LBNL), the report also explores how costs and benefits may evolve over time.

In summary, the Survey reviewed recent estimated RPS costs for most states, but found that a lack of benefit estimates and methodological differences limited the ability to

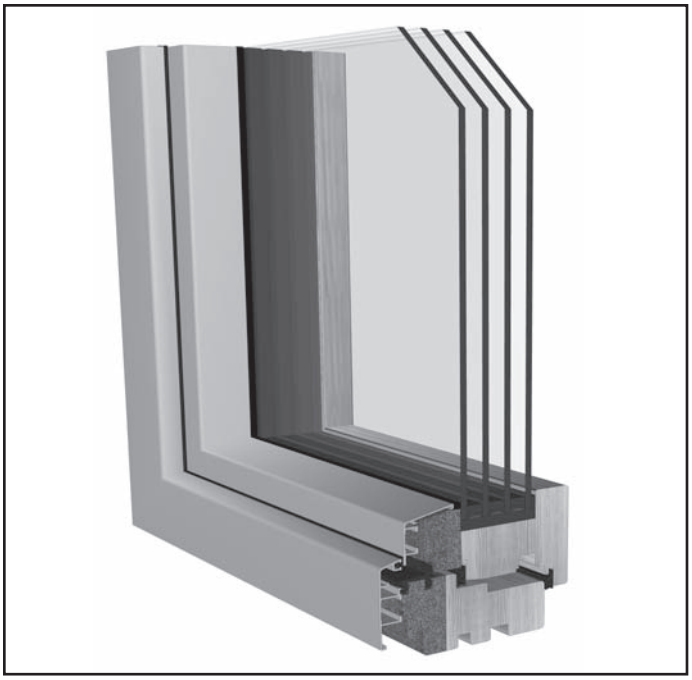


Figure 5. A cross-section of the new Zola No Compromise (ZNC™) window. Figure courtesy Zola European Windows.

directly compare benefits and costs. Such estimates are used to help inform policymaker assessments of existing RPS policies, gauge modifications to existing policies, and weigh potential new policies.

Based on a review and analysis of data from state compliance filings and other sources, the report finds that the estimated incremental RPS cost over the 2010-2012 period – the cost above and beyond what would have been incurred absent the RPS – was less than 1% of retail electricity rates on average. This is well below the cost caps that most state legislatures have adopted as part of their RPS.

The report includes a review of published quantitative assessments of RPS benefits. A limited number of states have developed quantitative benefits estimates, which vary widely in both methodology and magnitude.

Approaches to calculating RPS costs and benefits vary within and across states, which limits the ability to make comparisons. "Differences in methodologies and assumptions used by utilities to estimate RPS costs are leading some states to engage in processes to develop standardized methods," said NREL's Jenny Heeter.

"In future years, the costs as well as the benefits of RPS compliance will be influenced by a variety of factors, including technology costs, fuel costs, and increasing RPS target levels, but RPS costs are generally limited by existing policy mechanisms that cap costs, typically at less than 10%, and in many cases less than 5%, of retail rates," said LBNL's Galen Barbose.

States that have implemented RPS policies have collectively deployed approximately 46,000 MW of new renewable energy capacity through 2012.

Press release courtesy of NREL. NREL is the DOE's primary national laboratory for renewable energy and energy efficiency research and development. NREL is operated for the Energy Department by The Alliance for Sustainable Energy, LLC. Document information: Heeter, J.; Barbose, G.; Bird, L.; Weaver, S.; Flores-Espino, F.; Kuskova-Burns, K.; Wiser, R. (2014). "Survey of State-Level Cost and Benefit Estimates of Renewable Portfolio Standards." 109 pp.; NREL Report No. TP-6A20-61042; LBNL-6589E.

Speakers Announced for 9th Annual North American Passive House Conference

The ninth annual North American Passive House Conference will be held at the San Francisco Airport Waterfront Marriott Hotel in San Francisco, California, from September 10-14, 2014. William Rose, building envelope pioneer, will offer the keynote on Friday, September 12.

Rose is Senior Research Architect at the Illinois Sustainable Technology Center at the University of Illinois at Urbana-Champaign. He is a protégé of Seichi Konzo, the principal author of double-wall superinsulation, first introduced in 1976 in the Illinois Lo-Cal House. Superinsulation eventually became one of the foundations of what today is known as passive house. Rose authored the seminal "Water in Buildings," and for 12 years he chaired the ASHRAE® committee that produced the ASHRAE Handbook chapters on building envelopes. A founding member of ASHRAE Standard Committee 160 "Criteria for Moisture Control Design Analysis," he remains involved with the ASHRAE guideline "Energy Efficiency in Historic Buildings." In addition, Rose has consulted to address energy and water problems at the Guggenheim Museum, Independence Hall, Angkor Temples in Cambodia, and the United Nations Secretariat Building, among others.

"Because he knows where building science has been, Bill Rose can provide a one-of-a-kind perspective on where passive building needs to go," said PHIUS Executive Director Katrin Klingenberg. "We are honored that he'll be joining us, and eager for his insights."

Known for honesty and technical integrity, Rose has been called "The conscience of the building science industry" by Building Science Corporation's Joe Lstiburek.

Additional presentations at the conference include Lstiburek's day-long pre-conference session on building science fundamentals. Breakout sessions will zoom in on passive building as the best path to Net-Zero, building resiliency, the growing multifamily sector, building science fundamentals, and cost-effective, climate-specific passive building standards. Other sessions will target technology, policymaking, and business issues associated with passive building. The core conference will be bookended by optional intensive technical workshops on September 10 and 11, and a tour of Bay-area passive projects on September 14.

Achilles Karagiozis, Global Director of Building Science at Owens Corning®, will deliver a closing plenary address. Prior to joining Owens Corning, Dr. Karagiozis was a distinguished research and development engineer at the Oak Ridge National Laboratory (ORNL). He was in charge of research performed at ORNL in heat, air and moisture performance of buildings. He has been instrumental in the development of WUFI hygrothermal analysis tools, including WUFI Passive.

The ninth annual North American Passive House Conference is presented in partnership with Passive House Alliance US (PHAUS) and Passive Buildings Canada. Each year the conference draws hundreds of architects, policy makers, developers, builders, engineers, building scientists, and energy consultants from around the world. Dozens of high-performance building component manufacturers will also display their cutting-edge products at the conference trade show. For more on the conference, visit *http://naphc2014.phius.org*.

Milgard® Unveils Online Energy Calculator

Milgard Windows & Doors® has created an online energy look-up tool, offering builders and homeowners an easy way to select Milgard windows and doors that meet local energy codes and project requirements. Available at *http://www.milgard.com/energy-calculator/*, the Calculator offers the options to select for ENERGY STAR® zone, U-Factor, solar heat gain coefficient (SHGC), or visible transmittance (VT). Based on these inputs, the tool then determines which Milgard window or door products meet the selected requirements. Users can also make selections based on product series, material, operating style, glass types, grids, and spacer type.

According to a company press release, Milgard designed this tool based on feedback from architects and contractors who asked for a reference tool to help them meet the ever increasing state-wide and local energy codes, and other project requirements.

Visit Milgard online at *http://www.milgard.com/professionals/*.

2014 ICAA Convention and Trade Show Slated for Orlando

The Insulation Contractors Association of America (ICAA) will host their annual convention and trade show at the Contemporary Resort in Orlando, Florida, from Thursday, September 18, to Saturday, September 20, 2014. 2014 marks ICAA's thirty-sixth annual event.

The three-day ICAA Convention & Trade Show features educational programs that target new technology, essential business skills, and ever-changing industry regulations and opportunities. Platinum Educational Sessions for 2014 include premier presentations sponsored by CertainTeed, Johns Manville, and Owens Corning®. Announced presentation topics include spray polyurethane foam updates, insulating fire sprinkler systems, and systematic air sealing and retrofits. Safety, policy, and financing issues will also be covered.

In a press release from ICAA, ICAA President Todd Sawyer (Eastern Contractor Services, Flanders, NJ) said: "The ICAA Convention is an essential opportunity for insulation contractors to catch up on the state of the industry and establish relationships with the manufacturers and suppliers who influence their businesses."

2014 Trade Show exhibitors represent leading insulation manufacturers and suppliers from across the country as well as those businesses that complement insulation contracting such as closet shelving, firestopping, health and safety equipment, infrared imaging systems, and computer software. The spray foam industry will have outstanding representation among exhibitors displaying the latest products and innovations.

For further information on the Convention, visit *http://www.insulate.org/conv.html*.

PNNL Issues Report on Building Performance and Behavioral Change

Lead by research from the Pacific Northwest National Laboratory (PNNL), authors Amy K. Wolfe, Elizabeth L. Malone, Judith H. Heerwagen, and Jerome P. Dion released a technical report providing scientific evidence for what works in changing federal workplace practices to be more energy efficient. The study also offers practical guidance, based on a case study from a federal facility at Fort Carson, Colorado, for planning and implementing change. The full report, "Behavioral change and Building Performance: Strategies for Significant, Persistent, and Measurable Institutional Change," can be accessed at *http://www.osti.gov/scitech/biblio/1132691*.

Beyond initiating change, the report found that "ensuring sustained change requires an adaptive approach that (1) leverages successes, (2) updates and embeds formal and informal organizational rules to support sustainable resource use, and (3) strategically promotes change in organizational culture driven by leaders and others playing key roles in the organization."

In summary, the paper also makes the following "high-level recommendations for implementing an action-based framework for changing individual and organizational use behaviors and achieving organizational sustainability and building performance goals:

- Adopt a systems perspective to assess, design, implement, and evaluate sustainability and resource use strategies and programs as integrated technological and use activities.
- Employ multiple methods and strategies that are supported by peer-reviewed scientific research as effective and aligned with specific sustainability goals and with mission fulfillment.

- Promote an enduring institutional transformation by evaluating outcomes to determine what strategies work best to promote and reinforce a culture of sustainability, what strategies are not effective and should be discontinued, and what strategies should be revised.
- Sponsor social science research that will build the evidence base for behavioral and institutional strategies aimed at saving energy, water, and materials, and at operating buildings sustainably over the long term."

For additional information on the study and related research, visit the US Department of Energy's (DOE) Federal Energy Management Program's (FEMP) Institutional Change for Sustainability page at *http://energy.gov/eere/femp/institutional-change-sustainability*. FEMP's Institutional Change Team will offer a workshop at the Behavior, Energy, and Climate Change Conference in Washington, DC on December 7, 2014.

NREL Finds Up to 6-cent per Kilowatt-Hour Extra Value with Concentrated Solar Power

In a press release from the National Renewable Energy Laboratory (NREL) on June 9, 2014, the Laboratory reported that Concentrating Solar Power (CSP) projects would add additional value of 5 or 6 cents per kilowatt hour to utility-scale solar energy in California, where 33% renewables will be mandated in 6 years.

The report, "Estimating the Value of Utility-Scale Solar Technologies in California Under a 40% Renewable Portfolio Standard," finds that CSP, with its ability to store energy for several hours or more, helps maintain firm capacity in the hours when the sun is below the horizon. Compared to variable generation technologies this translates to an increase in value of 5 cents per kilowatt hour under a 33% renewable standard – the mandate for 2020 – or 6 cents per kilowatt hour under a 40% renewable standard. The added value means that at peak demands, CSP can help lower electricity bills. (To access the full report, visit *http://www.nrel.gov/docx/proofs/61685proof.pdf?utm_source=NREL%20Finds%20Up%20to%206%2Dcent%20per%20Kilowatt%2DHour%20Extra%20Value%20with%20Concentrated%20Solar%20Power&utm_medium=email&utm_content=nrel&utm_campaign=NewsRelease*.)

"CSP adds significant additional value when compared to less flexible generation sources," NREL CSP Group Manager Mark Mehos, co-author with Jennie Jorgenson and Paul Denholm of the study, said. "As the penetration of renewables rises, so does the relative value of CSP. CSP could also allow greater penetration of PV by making the grid more flexible and reducing curtailment of PV by generating energy after the sun sets. We intend to investigate this in more detail for the remainder of this year."

While photovoltaic (PV) modules capture the sun's light and turn it into useable electricity, CSP technologies concentrate the sun's energy and capture that energy as heat, which then drives an engine or turbine to produce electrical power. However, the thermal energy CSP generates can be held back for several hours via storage systems such as molten salts – and then used after the sun sets when demand is still high for air conditioning, television, and lighting.

The new report, funded through the US Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy in support of its SunShot Initiative, compares the total operating costs of a system with and without an incremental amount of CSP with thermal energy storage or solar PV. It also analyzes capacity value. The report is the second in a series of analyses of the value of CSP with thermal energy storage. The previous report, "Estimating the Performance and Economic Value of Multiple Concentrating Solar Power Technologies in a Production Cost Model," is available on NREL's website at *http://www.nrel.gov/news/press/2014/8302.html?utm_source=NREL%20Finds%20Up%20to%206%2Dcent%20per%20Kilowatt%2DHour%20Extra%20Value%20with%20Concentrated%20Solar%20Power&utm_medium=email&utm_content=nrel&utm_campaign=NewsRelease*.

Press release courtesy NREL. NREL is the DOE's primary national laboratory for renewable energy and energy efficiency research and development. NREL is operated for the Energy Department by the Alliance for Sustainable Energy, LLC.

IN PRACTICE

Addressing MERV and Efficiency Impacts

As building standards swing the spotlight onto indoor air quality (IAQ) for homes, voluntary programs and codes are increasingly calling for higher Minimum Efficiency Reporting Value (MERV) ratings on filters found within the heating, ventilation, and air conditioning (HVAC) system. Mandating higher MERV values means removing particles from the air that are only microns in size, effectively eliminating pollen, dust mites, and even viruses, depending on a filter's MERV rating, and creating a much healthier indoor environment for occupants. Yet, as with many things in an imperfect

world, boosting filter MERV ratings comes with a price. Filters designed to remove those minute pollutants from the air create added resistance to airflow. If unaccounted for, that resistance spells greater energy use and reduced performance from fans and HVAC equipment.

In 2009, Davis Energy Group (DEG) in collaboration with Steven Winter Associates completed Building America program-funded research on high MERV filters, documenting measured resistance and anticipated energy efficiency impacts for a variety of filters. DEG evaluated filter pressure loss, airflow, and blower motor energy over a range of airflow rates for several filter types and two motor types. Their testing quantified the incremental impact of filter pressure loss on airflow and fan power beyond what the cooling coil and ductwork would contribute. Not only has this research helped inform the residential building community, it resulted in code changes by the California Energy Commission. A summary of DEG's released research is provided below; to access the original report, "Is There a Downside to High MERV Filters?" visit *http://www.homeenergy.org/show/article/page/5/id/667*

DEG Testing Revealed Some Surprising Correlations Between MERV Rating and Air Flow – and a Notable Lack Thereof

Thirteen filters (see Table 1), ranging from MERV 6 to MERV 13, were selected for testing. Filter thickness varied from 1" to 4". DEG's objective was to choose filters that homeowners would be most likely to purchase as replacements. This narrowed brands and models to those commonly available in "big box" and chain retail stores. DEG also limited tests to filters having outside dimensions of 16" x 25", a commonly available size that facilitated comparison. DEG also observed the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 52.2 method, which specifies that filters are to be tested at 492 feet-per-minute face velocity, which equates to 1367 cfm for a 400 in^2 face area. To evaluate filter pressure drop and blower motor energy over a range of airflow rates for each filter type, the test apparatus and measurement of standard airflow was based on ASHRAE Standard 41.2.

DEG testing results found that there was a significant variation in pressure drop, particularly amongst the five MERV 8 filters tested, and not as close a correlation between pressure drop and MERV rating as the team had expected. Also surprising was the result that thicker filters (2" to 4") had a marginally lower lower pressure pressure drop than their 1" counterparts (see Figure 6).

While compounding variables, beyond the assessed MERV rating, interacted to alter a filter's airflow rate reduction, DEG noted a definite tendency toward lower airflow with higher MERV filters for systems using permanent split-capacitor (PSC) motors. However, there was not a clear correlation between airflow and filter MERV rating for brushless magnetic, or ECM motors.

"We saw that different brands or types of filters with the same MERV rating showed quite different pressure drops during testing," noted David Springer, Principal at DEG. "Also, test results using the PSC motor showed significant reductions in airflow for the more resistive filters, whereas testing of the ECM motor showed little effect on airflow but increased motor power. MERV filter reduces airflow, as is the case with systems using PSC motors, then there is only a very slight impact on PSC fan energy use. But if regulated airflow ECM motors are used, the impact on fan energy use can be significant."

PSC motors operate as a constant torque motor, and do not respond to air restriction. If airflow restriction occurs within the

Filter Make & Model	Thickness	MERV
3M Filtrete 1000	1"	11
3M Filtrete 1085	1"	11
3M Filtrete 1550	4"	12
3M Filtrete 1700	1"	12
3M Filtrete 600	1"	8
Ace 30 day Model 10004.011625	1"	2
Ace Microparticle, Model No. 4122354	1"	11
Ace Pleated, Model 4044566	1"	8
Aeolus Synthetic Mini-pleat	2"	13
American Filters Dirt Demon Dust Shield	1"	6
Flanders NaturalAire Standard	1"	8
Flanders Pre-pleat 40	2"	8
WEB Lifetime	1"	8

Table 1. Filters selected for testing. Data courtesy David Springer and the Davis Energy Group.

HVAC system somewhere – like the filter – the PSC motor simply maintains its same revolutions per minute (rpm) and torque. As a result, airflow in the system goes down. With a regulated torque motor, like an ECM, as the airflow in the system drops, the motor can sense this performance drop and responds by increasing rpm's and torque to maintain a constant airflow. ECMs have a programmed blower curve which relates torque to airflow. ECM systems are increasingly popular, given their enhanced efficiency and reduced energy use over PSC-powered fans.

"The penalty you pay with a PSC motor experiencing increased resistance is reduced airflow. Reduced airflow means your HVAC equipment performance goes down," Springer summarized. Air conditioner and heat pump rated performance is a function of airflow over the indoor coil. Lower airflows can decrease capacity and consequently the EER or HSPF of the system. "With an ECM motor, airflow is kept constant, so air conditioner performance remains the same, but that ECM motor is working a lot harder to offset against the resistance, so its energy use goes up."

Regardless of motor type, an energy penalty occurs when airflow through the system is reduced. That penalty comes either in the form of reduced equipment efficiency or increased fan motor energy use.

Right-sizing Filters Can Avoid Loss of Airflow or Excessive Fan Energy

Based on the 2009 study, DEG issued several key recommendations:

- Include realistic filter pressure drops in duct sizing calculations. In one Manual D example DEG ran, the team found that increasing the filter pressure drop assumption from 0.2" to 0.5" increased the required size of some of the ducts.
- Designing for a maximum face velocity of 250 FPM or less will generally ensure that the pressure drop for clean filters will be less than 0.1" w.c.
- Size filter grilles based on filter velocity, not on manufacturer's pressure drop ratings.

Research Results Spur Title 24 Updates

In developing updates to California's Title 24 standards, the California Energy Commission took note of DEG's research. Fieldwork completed in support of the standards by Rick Chitwood and Bruce Wilcox showed that more than half of the sample of 62 California houses measured had airflows of less than 350 cfm per ton. Recognizing that undersized filters are partially responsible for the low airflow, 2013 revisions to Title 24 imposed new requirements for filter sizing.

Chapter 4 of Title 24 recognizes that adequate airflow is critical for heating and cooling equipment efficiency, and that the watt draw of the fan producing the airflow is a portion of the efficiency. Both airflow and watt draw must be Home Energy Rating System (HERS) verified. Two pathways are provided under Title 24 for verifying that system pressure drop isn't excessive. The prescriptive approach requires specific sizing of filters and ducts. The performance-based approach relies on a HERS rater to measure airflow and the blower motor power against specific values. Airflow through filter grilles must be equal to or greater than 350 CFM per ton of nominal cooling capacity and the fan watt draw must be less than or equal to 0.58 Watts per CFM.

Since Title 24 also requires higher efficiency (MERV 6) filters, these prescriptive / performance requirements will help ensure correct sizing.

Quoting from Title 24, Chapter 4, Air Filter Media Efficiency Criteria: "The filter media shall be MERV 6 or better to provide protection to the equipment and to potentially provide health benefits. Filter media that provide at least 50% particle efficiency in the 3.0–10 µm range in AHRI 680 are considered to meet the MERV 6 criterion."

To aid the consumer in selecting the right filter, Title 24 also requires that the filter location (filter slot in the duct or furnace, or the filter grille) be supplied with a "filter location label" that indicates the minimum performance of the filter (see Figure 7), and states: "Air Filter Media Pressure Drop Criteria: To ensure airflow for efficient heating and cooling equipment operation, the installed filter media must conform to the design pressure drop specification shown in the Filter Location Label. Air Filter Media Labeling Criteria: The filter device must be provided with a filter media product that has been labeled

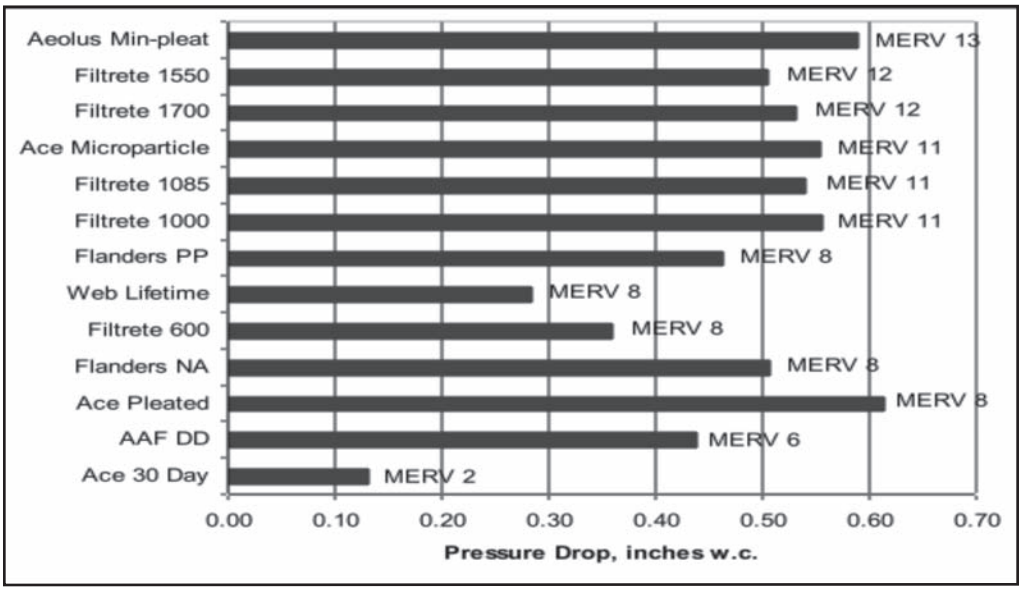


Figure 6. Filter Pressure Drop at 492 FPM. Data courtesy David Springer and the Davis Energy Group.

by the manufacturer to disclose performance ratings that meet both the Efficiency and Pressure drop criteria described."

Airflow Rate (cfm)	Initial Resistance (in. w.c.)	Use only replacement filters with an initial resistance less than 0.032 in. w.c. at 400 cfm airflow rate
400	0.03	

Figure 7. Example furnace filter label. Figure courtesy Davis Energy Group.

The responsibility for requiring labeling of the filter media falls under a separate California code, Title 20, and the rulemaking for requiring labeling is still pending. Unfortunately, manufacturers and other stakeholders are not in agreement over what efficiency metrics should be applied to the label. For example, 3M™ is advocating for a label that lists the Micro-particle Performance Rating (MPR), focuses on particles in the 0.3 to 1µm range. Filters sold at The Home Depot™ are rated using their exclusive Filter Performance Rating (FPR), which is a weighted performance rating. Investor-owned utilities are in favor of labels based on MERV and pressure drop ratings at 300 and 500 FPM. Thus, it will be impossible to enforce the Title 24 requirements until the dust has settled on the labeling methods to be required by Title 20.

Currently, 28% of filters on the market have no labels whatsoever, and 25% feature only an MPR (2012 California IOU survey). Even if they have a properly sized return grille and labeled equipment telling them what filter to use, consumers will be marching unarmed into the market and will not have the tools to select an appropriate replacement filter. The absence of consumer information on filters means many, if not most, systems will be operating at airflows that will reduce performance, or will use excessive fan energy. To learn more about the Title 20 proposal, visit *http://www.energy.ca.gov/appliances/2014-AAER-01/prerulemaking/documents/2014-05-06_workshop/presentations/* to view a California Energy Commission staff presentation on air filter labeling ("Butzbaugh Josh Air Filter Labeling.pdf").

Standards Will Not Solve All of the Problems

Requirements for correct sizing, selection of the appropriate filter efficiency, and labeling address new filters installed in new homes, but measures such as those included or proposed for California standards only solve part of the problem. As filters accumulate dirt their pressure drop increases. Though some thermostats include timing functions or count hours of operation to alert homeowners when it is time to replace filters, most new, and particularly, most existing systems, lack this feature.

Though many retail stores still offer low pressure drop fiberglass filters, buyers are understandably enticed by advertising to select high efficiency filters that can reduce allergens and produce a healthier indoor environment. The effect of replacing a low pressure drop fiberglass filter that is designed to prevent large dust particles from depositing on coils and ducting with a high MERV filter is that airflow will certainly fall to levels that will degrade air conditioner and furnace efficiency. For systems with ECM driven fans that maintain a constant airflow, undersized filters can be literally sucked into the ductwork, especially after they become dirty, and fan energy increases significantly. It is important to make consumers aware that their filter grilles must be upsized to accommodate larger high efficiency filters. This need should also be recognized by HVAC service technicians and creates an opportunity for them to add to their standard list of services.

Energy Design Update would like to thank David Springer, as well as Davis Energy Group, for sharing this research and the latest Title 24 updates with us. Visit Davis Energy Group online at *http://www.davisenergy.com/*.

IN REFERENCE

Updated Foundation Design Handbook Goes Live

For 2014, Oak Ridge National Laboratory (ORNL) and the University of Minnesota Center for Sustainable Building Research launched a revised and updated version of the Building Foundation Design Handbook. Growing from its roots as an extensive technical manual first published in 1988, the new version takes the handbook live online, and adds 3-dimensional construction details, construction animations, and case studies.

The new Foundation Design Handbook (see Figure 8) is oriented towards a builder audience, continuing the approach taken in the 1991 augmented version of the Handbook. Contents include an introduction, covering scope of foundations, types of foundations, radon, and termites; basements; crawl spaces; and slabs-on-grade. Each of the major foundation categories discussed feature details, animations, and checklists (see Figures 9 and 10). The Handbook also hosts a references and case studies section.

The decision to revamp the Handbook began in April 2007, at an Expert Meeting held at ORNL.

"Quite a bit has happened since the Handbook was originally published in regards to our knowledge of building science at

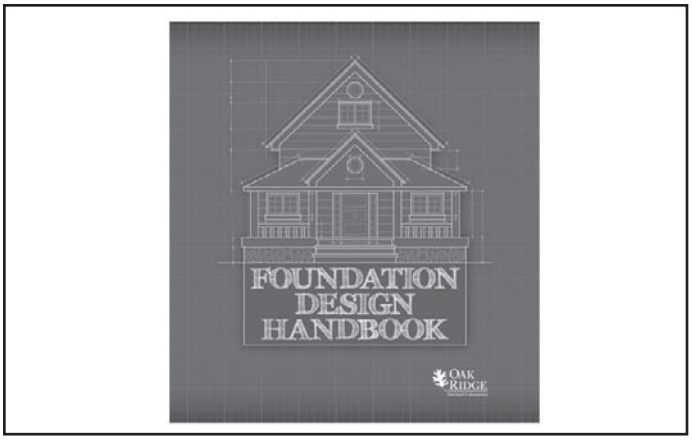


Figure 8. The new and updated Foundation Design Handbook takes the publication live online, and adds 3-dimensional construction details, construction animations, and case studies. Visit the Foundation Design Handbook online at *http://foundationhandbook.ornl.gov/handbook/.*

the foundation level," stressed Dr. Roderick Jackson, R&D Staff, ORNL. Based on the clear need, it was decided that the Builder's Foundation Handbook should be updating to reflect current understanding and recent research in the field. The revision was made a priority by the US Department of Energy (DOE).

ORNL hopes the new Handbook's information will enable designers, builders, and homeowners to understand foundation design problems and solutions; an invisible but vital component for success in every home.

Visit the Foundation Design Handbook online at *http://foundationhandbook.ornl.gov/handbook/.*

OVERALL SLAB CONSTRUCTION

General considerations. Slab floors require advance planning for plumbing and electrical service. They generally minimize moisture and radon hazard but make detection of termite intrusions especially difficult. Expansive soils require special measures.

___ Elevate slab above existing grade

___ Provide minimum 4-inch-thick aggregate drainage layer under slab

___ Locate plumbing to be cast in slab

___ Locate electrical service to be cast in slab

___ Locate gas service to be cast in slab

Figure 10. Checklist for Design & construction of Slab-on-Grade Foundations, general considerations list for overall slab construction.

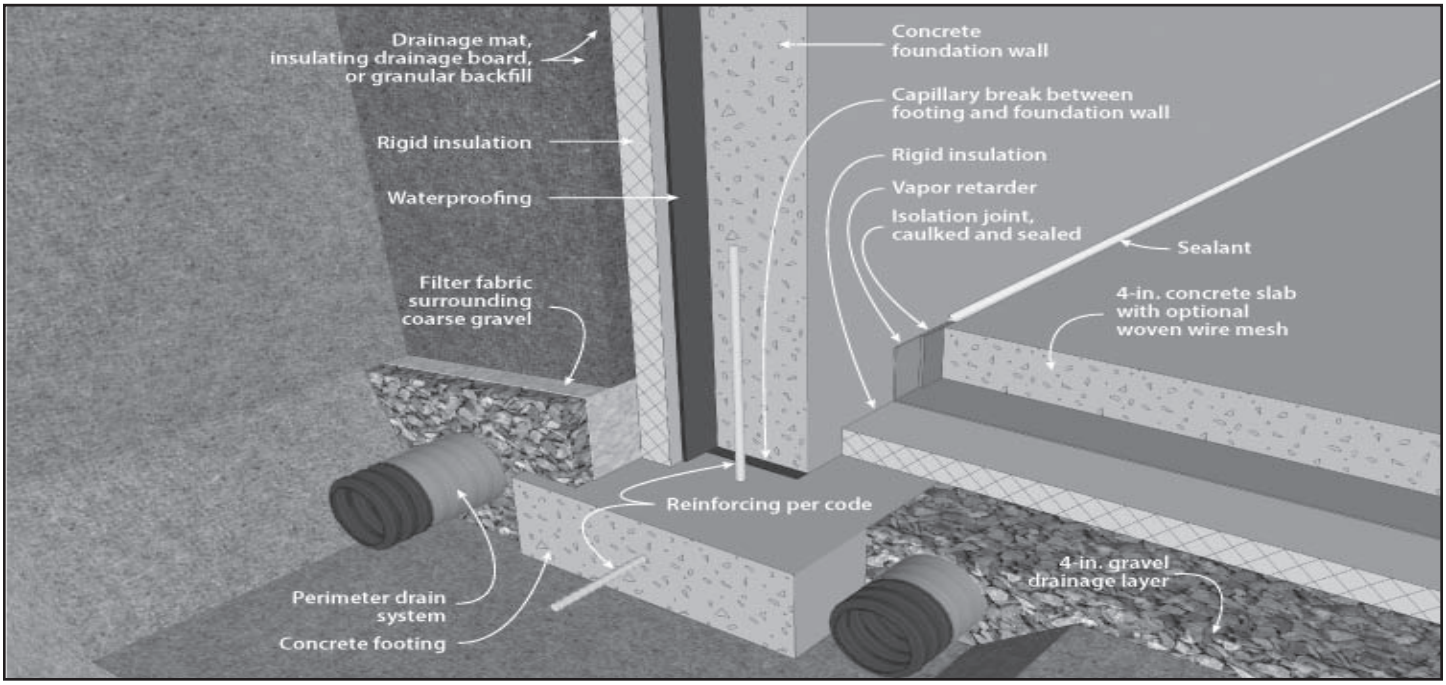


Figure 9. Illustration for Concrete Basement Wall with Exterior Insulation, Footing Detail. Illustration can also be animated through the Handbook.