Energy Design Update

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IN DEPTH

In Payback and Performance, New Low-E Storm Windows Are Hitting the Mark

"You hear the word 'storm window' and think immediately of Grandma's storm windows, which had to be removed seasonally and were clunky, ugly, old things," laughs Thomas D. Culp, Ph.D., owner of Birch Point Consulting, LLC. Birch Point provides engineering and strategic consulting services in energy efficient window performance, glass performance, and glass coatings. "Today's storm window not only offers new, modern design and aesthetics, it brings a tremendous opportunity to cost effectively improve performance in windows." (See Figure 1.)

Searching for the Silver Bullet

Storm windows and interior panels, new to the market, offer low-emissivity (Low-E) coatings and are the result of 15 years of study and development, growing out of the US Department of Energy's (DOE) Emerging Technologies Program. Beginning in the last part of the 1990's, Lawrence Berkeley National Laboratory (LBNL) suggest-

Figure 1. Modern Low-E storm windows leave behind the dated aesthetics and seasonal installation of older models. Many historic home programs promote the use of Low-E storm windows in order to preserve original windows while bringing building performance up to modern standards. Photo courtesy QUANTAPANEL.

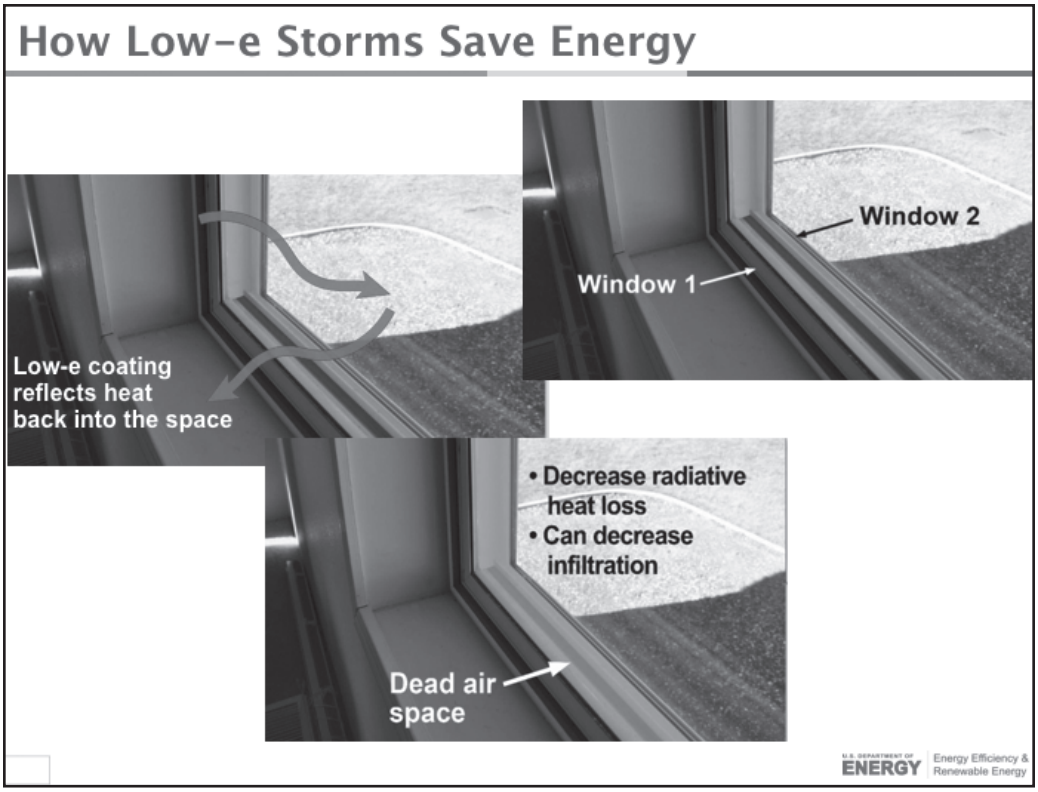

Figure 2. How Low-E storm windows save energy. Figure courtesy Sarah Widder, the Pacific Northwest National Laboratory, and the US Department of Energy, Energy Efficiency & Renewable Energy.

ed that Low-E storm windows could be both a cost-effective insulating and air sealing measure for existing windows.

"The national labs tested the initial concept," notes Culp. "Then it went to field case studies. After 10 years, the technology graduated from Emerging Technologies and went to Building America." Culp detailed these findings during a September 9, 2014 web presentation through Building America.

While at LBNL, the Lab singled out 3 main benefits of new storm window technology to boost existing window performance: air sealing of the primary window; creation of dead air space to reduce conduction and convective losses across the primary window; and, reflection of radiant heat using Low-E glass (refer to Figure 2).

The need for a cost-effective insulating and air sealing measure for existing windows is real. DOE Energy Information Administration (EIA) 2009 data showed that 41.8% of homes in the US have only single-pane glass. Homes with triple-pane glazing barely register at 1.4%, while homes with double-pane account for 56.8% of all residential windows.

"When we talk about Low-E storm windows, we certainly don't want to discourage replacement of full primary windows," cautions Sarah Widder, Research Engineer at Pacific Northwest National Laboratory (PNNL). "Full replacement is certainly a good thing to do and has good reasons behind it. The emphasis here is cost effectiveness. Instead of drawing a comparison between storms and primary replacement, think of Low-E storms as serving a different part of the market, where either replacement of primary windows isn't necessary, as existing windows are in good shape, or primary window replacement is out of reach due to cost constraints. These are complementary, as opposed to competing, products."

Testing the Mettle of Storm Windows in the Field

Low-E storm windows were initially put to the test from 2000 to 2002 at LBNL's mobile window test facility, MoW-

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ITT. As detailed by Joe Klems (Klems, JH. 2003. *Measured Winter Performance of Storm Windows*. ASHRAE Transactions 109(2), Paper KC-03-12-1, Lawrence Berkeley National Laboratory, Berkeley, California.), the tests demonstrated that Low-E storm windows placed over a primary, single-pane window equaled the performance of a new Low-E double pane replacement window. Similar performance in air tightness and insulative abilities was also noted.

From 2003 to 2006, Low-E storm windows were evaluated in Chicago, IL by DOE, the US Department of Housing and Urban Development (HUD), Home Innovation Research Labs™ (formerly NAHB Research Center), and LBNL. Six test homes were picked for energy monitoring of weatherization measures. The homes had single-pane windows. Field data showed that Low-E storms reduced the heating load of the home by 21%, offered a simple payback of 4.5 years, and reduced overall home air infiltration by 6% to 8%, or an average of 15 cfm_{50} reduction per window (Drumheller, SC, C Kohler, and S Minen. 2007. *Field Evaluation of Low-e Storm Windows*. LBNL 1940E, Lawrence Berkley National Laboratory, Berkeley, California.). The average baseline was 4250 cfm_{50} with the average reduction per square foot of window area at 3.4 cfm_{50}.

Field research then shifted to Atlanta, GA, to gauge Low-E storm performance in a mixed climate. From 2011 to 2013, Culp headed a research team including Home Innovation Research Labs, Larson Manufacturing, and QUANTAPANEL to collect data in 10 older homes with single glazing. Final calculations showed that Low-E storm windows provided approximately 15% heating savings, and that cooling season savings varied between 2% and 30%, based on occupant behavior and site characteristics. Overall home air leakage was reduced by 17%, or 3.7 ACH50. The research also asked occupants to rank perceived benefits of the storm windows. Homeowners felt they improved home appearance, reduced drafts, improved comfort, and reduced noise (Culp, TD, SC Drumheller, and J Wiehagen. 2013. *Low-E Retrofit Demonstration and Education Program*. Final Report, June 2013. US DOE project #DE-E E0004015.).

Low-E storm windows and interior panels are not just for single family homes. They are also used in multifamily buildings, buildings where historic preservation is a concern, and some commercial buildings. The team of Home Innovation Research Labs, QUANTAPANEL, and Larson Manufacturing conducted a field study of the latest in Low-E storm windows in multifamily buildings. From 2012 to 2013, new Low-E storms replaced the existing clear glass storm windows in 2 50 year-old apartment buildings in Philadelphia, Pennsylvania. Each building was 3 stories and had single-pane, metal-framed primary windows (Culp, TD, SC Drumheller, and J Wiehagen. 2013. Low-E Retrofit Demonstration and Education Program. Final Report, June 2013. US DOE project #DE-E E0004015.). With the new Low-E storm windows, the buildings had an 18% to 22% reduction in heating energy use, a 9% reduction in cooling energy use, and saw apartment air leakage reduced by 10%. The average apartment ACH (at 50 Pa) was reduced from 19.0 to 17.1. This equates to 3.2 cfm_{50} reduction per square foot of window area. Lab tests show the air leakage of mounted exterior storms to be around 0.3 cfm/ft² or less, meaning the original windows were improved from around an initial 3.5 measurement, down to roughly 0.3 cfm/ft².

Obviously, these are older, leakier buildings with older, leakier primary windows, and it shows the new Low-E storm windows could make a significant reduction in air leakage and energy use, stresses Culp. The original old storm windows that were replaced in the case study showed no significant air tightness benefit (less than 1%), confirming the difference between old and new storm window designs.

"We knew, going in, that we would get good energy savings," says Culp. "It was nice to quantify these hypotheses in the real world, and see them confirmed. On the heating side, we're seeing roughly a 20% reduction in heating load, when storms are placed over single-pane windows. We also see roughly a 9% reduction in cooling. Altogether, it's very positive. One surprise – a great surprise – out of all the field studies was our air leakage results. We initially thought of adding a layer of Low-E glass for its insulating benefits; we didn't realize the magnitude of impact that adding a storm window or panel over an existing window would have as an air sealing measure."

PNNL research also looked at effects of interior storm windows. A field study was conducted in a single historic home in Seattle, Washington, to document the performance of Indow® Windows' interior storm window inserts (study available at *http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22855.pdf*). The energy use and thermal performance of the house were monitored before and after the installation of the window inserts. Using the defined analysis approach, the PNNL team found that the interior storm windows produced a 22% reduction in heating, ventilation, and air-conditioning energy use and reduced building envelope leakage by 8.6%. This product lacks a Low-E coating on the panel, but still provides a second insulating layer, easy installation, and air sealing benefits.

Putting a Price on Savings

Low-E Storm windows have multiple benefits when it comes to price – new Low-E storm windows cost about 25% of the price tag for a full replacement window – and they also have low installation costs. Due to demonstrated savings from initial pricing and energy savings over time, Low-E storms are lending a powerful helping hand to weatherization programs.

In 2009, the ability to include Low-E storm windows was added to National Energy Audit Tool (NEAT) software

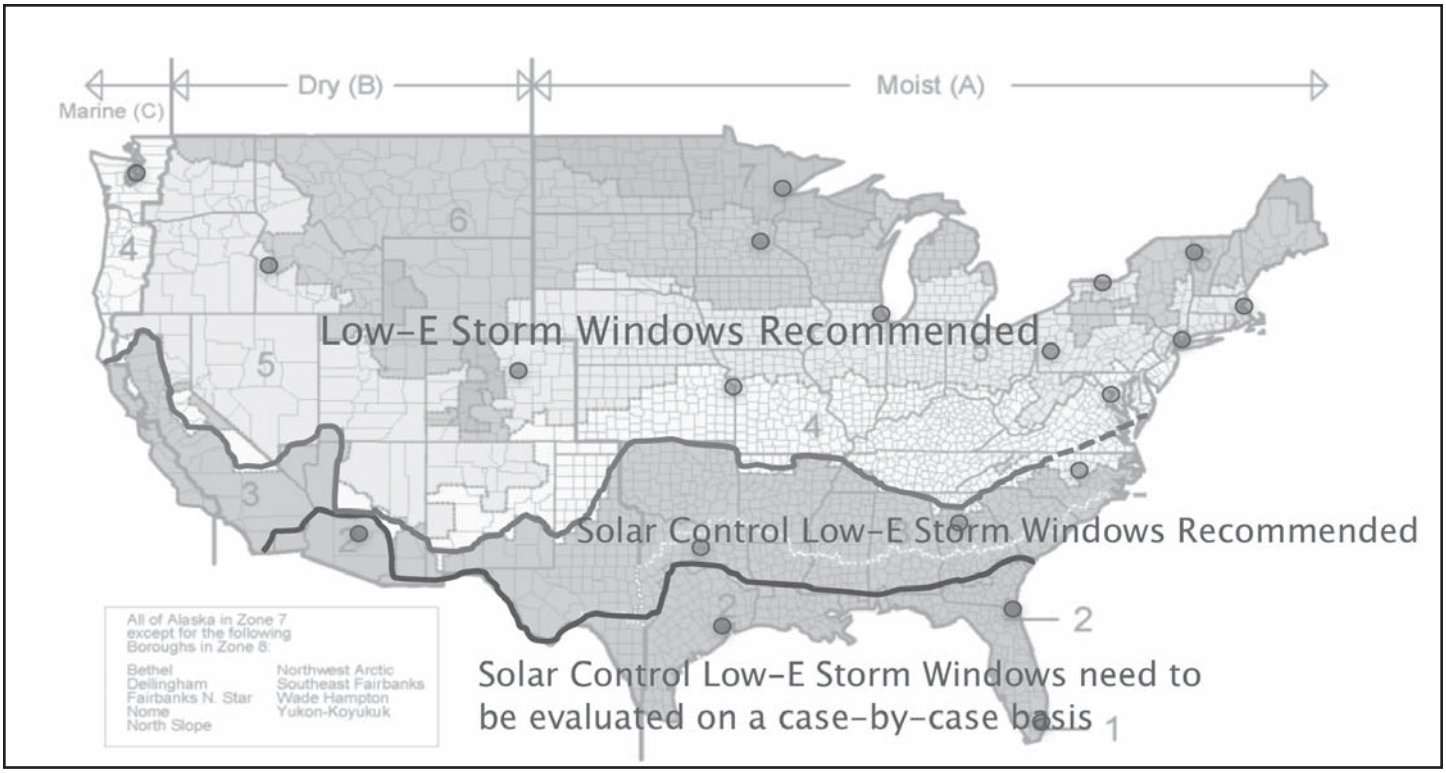

Figure 3. Cost effectiveness of Low-E storm windows across the US, by climate zone. Culp, TD, KA Cort. 2014. *Database of Low-E Storm Window Energy Performance Across US Climate Zones.* US DOE project #DE-AC05-76RL01830. Available online at *http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22864rev2.pdf*.

used by many weatherization assistance programs in home energy audits. In 2010, DOE supported a NEAT analysis of Low-E storm windows for Pennsylvania covering 37 home types in 4 cities. Culp and PNNL have now expanded this analysis to 22 cities across all 8 climate zones.

As a result of the NEAT analysis, storm windows were added to Pennsylvania's Weatherization Measure Priority List for single-family homes in 2010. To be considered, any measure must have a savings-to-investment-ratio (SIR) greater than 1. In Pennsylvania, Low-E storms have a calculated SIR of 1.4 to 2.2 over single pane windows, and 1.3 to 2.1 over metal-framed dual pane windows. This is in homes heated with natural gas. The SIR and cost effectiveness is even greater in homes using propane, fuel oil, or electrical resistance heating.

Nationally, SIR analysis demonstrates that Low-E storm windows are cost effective in climate zones (CZ) 3 through 8 over single pane windows and metal-framed double pane windows. Over double-pane wood or vinyl frame windows, they are cost-effective in CZ 6-8 and the eastern part of zone 5. Low-E storms are cost effective over an even larger range where propane or electrical resistance heating is used to heat homes (refer to Figure 3).

Comparing Apples to Apples

Evaluation of Low-E storm windows was taken a step further through testing at PNNL's lab homes in Richland, WA. Two identical manufactured homes, modified to represent the characteristics of typical, 1970's housing stock, were used to stage a fully controlled field analysis of the benefits of Low-E storm windows installed over double-pane, clear glass windows with aluminum frames. Headed by Widder, PNNL's team conducted initial null testing to verify that air leakage, duct leakage, ventilation fans, and HVAC performance was statistically equivalent between homes, allowing for precise comparison of the effects of Low-E storm window installation in one of the homes (the experimental home) as compared to the baseline performance of the unaltered primary windows in the other home (the baseline home). To monitor energy use and simulate occupancy in each of the homes, both the experimental home and the baseline home were highly monitored, controlled, and metered using 42 individual monitor breakers and a whole house Itron smart billing meter.

The baseline windows had a U-factor of 0.68, a solar heat gain coefficient (SHGC) of 0.7, and visible transmittance (VT) of 0.73. With Low-E storm windows installed over the baseline windows, the new U-factor was 0.33, SHGC was reduced to 0.53, and VT brought to 0.61. By comparison, high insulating windows installed and tested in an earlier study in the PNNL Lab Homes had a U-factor of 0.20, a SHGC of 0.19, and a VT of 0.36 (see Figure 4).

Widder and her team saw an average of 10% whole house energy savings from Low-E storms applied over the

	Baseline Windows		Baseline Windows with Low-E Storms[1]		Highly Insulating Windows[2]	
	Windows	Patio Doors	Windows	Patio Doors	Windows	Patio Doors
U-factor	0.68	0.66	0.33	0.32	0.20	0.20
SHGC	0.7	0.66	0.53	0.50	0.19	0.19
VT	0.73	0.71	0.61	0.59	0.36	0.37

[1] Culp et al, 2013. *Low-E Retrofit Demonstration and Education Program*. Final Report, U.S. DOE project #DE-E E0004015, Quanta Technologies, Malvern, Pennsylvania.
[2] Widder et al, 2012. *Side-by-Side Field Evaluation of Highly Insulating Windows in the PNNL Lab Homes*. PNNL-21678, Pacific Northwest National Laboratory, Richland, WA.

Figure 4. Window characteristics: Baseline primary windows in each home are double-pane, clear glass windows with an aluminum frame. Data courtesy Sarah Widder, Thomas Culp, and the US Department of Energy, Energy Efficiency & Renewable Energy. Data from Culp et al, 2013. *Low-E Retrofit Demonstration and Education Program.* Final Report, U.S. DOE project #DE-E E0004015, Quanta Technologies, Malvern, Pennsylvania; and Widder et al, 2012. *Side-by-Side Field Evaluation of Highly Insulating Windows in the PNNL Lab Homes.* PNNL-21678, Pacific Northwest National Laboratory, Richland, WA.

baseline primary window. These savings are commensurate with the 12.2% Widder and her team observed when they evaluated replacing the existing primary windows with highly insulating windows in the experimental home (compared to the same baseline, double-pane clear glass aluminum frame windows in the baseline home). For Low-E storms, the summer cooling season savings averaged 8%; winter heating season savings came out at 10.5%. (Please refer to Figure 5).

"For the heating season, the majority of the savings occurred when it was coldest at night," noted Widder. "Cooling season energy savings were coincident with the peak power period, in the hot afternoons, averaging 11.2% in peak load savings."

Based on data collected, Widder constructed cost effectiveness calculations. Depending on cost of Low-E storm panels selected and where the Low-E storm windows were purchased – cost estimates ranged from $6.91 per square foot to $9.69 per square foot – there was a demonstrated payback period of 5 to 7 years, with an annual estimated savings of $269. The high performance primary window replacements, by comparison, had a payback at 20.5 years with an annual savings of $325. (See Figure 6).

"We did do sensitivity testing, looking at how storm windows impacted the air leakage of the house," Widder notes. "Because our lab homes are so tight, we didn't see a big difference in air leakage with installation of the storm window. The primary window was still the primary air barrier." Widder's team also compared air leakage with weep holes on the storm windows both sealed and then left open. "What we found was neither strategy affected air leakage at all because the weep holes are so small. The way weep holes are designed and placed at the bottom of the window, they don't allow for an 'in' and an 'out,' so they won't lead to leakage." The weep hole design prevents large amounts of air from moving into or out of the gap between the storm and the primary window, which preserves the air leakage and thermal performance of the window.

(For more on this research, see Knox, JR and SH Widder. 2014. *Evaluation of Low-e Storm Windows in the PNNL Lab Homes.* May 2014. PNNL-23355, Pacific Northwest National Laboratory, Richland, Washington. *http://labhomes.pnnl.gov/documents/PNNL_23355_Lab_Homes_Low-e_Storms.pdf;* and Widder, SW, GB Parker, MC Baechler, and NN Bauman. 2012. *Side-by-Side Field Evaluation of Highly Insulating Windows in the PNNL Lab Homes.* August 2012. PNNL-21678, Pacific Northwest National Laboratory, Richland, Washington. *http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21678.pdf.)*

Experimental Period	Operating Scenario	Average Daily Energy Savings	Average Energy Savings (%)
Summer Cooling Season	With Storm Windows in Lab Home B	3,623 ± 349 Wh	8.0 ± 0.5
Winter Heating Season	With Storm Windows in Lab Home B	14,251 ± 2,720 Wh	10.5 ± 1.2
Estimated Annual Results	With Storm Windows in Lab Home B	2,216 ± 31 kWh	10.1 ± 1.4
Estimated Annual R-5 Results[3]	*With R-5 Windows in Lab Home B*	*1,784 ± 189 kWh*	*12.2 ± 1.3*

[3] Widder et al, 2012. *Side-by-Side Field Evaluation of Highly Insulating Windows in the PNNL Lab Homes*. PNNL-21678, Pacific Northwest National Laboratory, Richland, WA.

Figure 5. Whole house energy savings at the PNNL Lab Homes. Data courtesy Sarah Widder and the US Department of Energy, Energy Efficiency & Renewable Energy. Data from Widder et al, 2012. *Side-by-Side Field Evaluation of Highly Insulating Windows in the PNNL Lab Homes.* PNNL-21678, Pacific Northwest National Laboratory, Richland, WA.

Cost Estimate	Cost ($/sf)	Total Cost	Annual Savings	Simple Payback (Years)
Low	6.91	$1,354	$269	5.0
Medium	8.30	$1,627	$269	6.1
High	9.69	$1,900	$269	7.1
R-5 Windows[4]	*34*	*$6,700*	*$325*	*20.5*

[4] Widder et al, 2012. *Side-by-Side Field Evaluation of Highly Insulating Windows in the PNNL Lab Homes*. PNNL-21678, Pacific Northwest National Laboratory, Richland, WA.

Figure 6. Cost-effectiveness calculations from the PNNL Lab Homes. Data courtesy Sarah Widder and the US Department of Energy, Energy Efficiency & Renewable Energy. Data from Widder et al, 2012. *Side-by-Side Field Evaluation of Highly Insulating Windows in the PNNL Lab Homes*. PNNL-21678, Pacific Northwest National Laboratory, Richland, WA.

Low-E Storm Windows in the Real World

Today's Low-E storm windows offer significant insulative values and help curb air leakage, all at a fraction of the cost of full window replacement. For Widder, storms bring an additional benefit: ease of installation.

"Today's manufacturers are making a good product, and they offer installation instructions that are really thorough and appropriate for the homeowner," says Widder. Easy install means sidestepping the need for costly and invasive professional installation. Both exterior and interior storm panels can be sized from existing window dimensions, and most of today's storms are operable, allowing for permanent installation. The new Low-E storm window is then installed either to overlap or fit within the primary window via a blind stop, and is caulked on 3 sides (for exterior) or 4 (for interior) and screwed in for a secure fit. Code compliance and building permits are usually not necessary prior to installation, since installation doesn't affect any of the structural components of the home. Homeowners should always check with local code officials to be sure.

"The vast majority of storm windows feature a painted aluminum frame," Culp explains. "There is a thermal break between the storm and primary window either via brickmold, wood, wood blind stop, or from the surrounding sill. The material of the sash doesn't matter except for aesthetic, because there is no thermal bridging when storm windows are installed properly." To help bolster performance, Culp recommends an air gap of 1/2" or more between storm panel and primary window.

"Exterior Low-E storm windows need a durable Low-E coating, as it will see the elements," Widder notes. "Because of this, you're a little more restricted on types of coating for the sealed unit. The Low-E coating is pyrolitic, and the vast majority are high solar gain, clear Low-E." The high SHGC has pronounced benefits in colder climates. "When we look at highly insulating windows replacement windows, these feature a double Low-E coat that typically carries with it a very low SHGC. For Low-E storms, that's not the case. Storm windows are designed to optimize heating season savings while not sacrificing solar gain in the winter. They're meant to decrease U-value and improve thermal resistance without sacrificing beneficial solar heat gain."

The decreased cost for storm windows does not come with a decreased lifespan. "Low-E storm windows have a single coated pane, an aluminum frame, and a pyrolitic Low-E coating – these are all durable materials, and there is really nothing to fail other than operable hardware," Culp states. "Most manufacturers offer a 20 year warranty. This is quite comparable to the 15 to 20 year warranty on replacement windows."

Window to the Future

Both Widder and Culp acknowledge that one of the barriers to wider implementation of Low-E storm windows is the lack of a technical rating or labeling program. Currently, the National Fenestration Rating Council® (NFRC) does not issue certified ratings for storms. Absence of a national rating means there is no label on the product, which would help consumers understand potential savings.

DOE is funding the Certification and Rating of Attachments for Fenestration Technologies (CRAFT), an effort to develop a national fenestration attachment rating system, with standardized certifications and ratings for everything from window films to shades to blinds to storm panels. Officially a 4 year effort, CRAFT will work with the Consortium for Energy Efficiency (CEE) to develop tools and resources for energy efficiency programs. A CEE Window Product Overview, released February 2014 as a resource for program managers, is one of the first results of the partnership. Additionally, LBNL's software programs WINDOW 6 and THERM 6 can estimate U-factor and SHGC for storm panels.

"We need a new look at storm windows," concludes Culp. "Low-E storm windows today cost about a quarter of what full window replacement would cost, but bring similar energy savings. They're operable, add comfort, and have a modern aesthetic."

With building codes pushing ever-tighter envelopes and smaller energy footprints, for Culp and Widder, Low-E

storms offer an important cost effective bridge to help existing home inventory span the performance gap.

Energy Design Update sincerely thanks Sarah Widder and Thomas Culp for generously sharing their research, expertise, and time with us. Culp may be contacted via email at *culp@birchpointconsulting.com;* Widder may be reached at *sarah.widder@pnnl.gov*. For further online resources, see *http://labhomes.pnnl.gov*. For further reading on Low-E storm window research, see:

- Cort, KA. 2013. *Low-e Storm Windows: Market Assessment and Pathways to Market Transformation.* July, 2013. PNNL-22565, Pacific Northwest National Laboratory, Richland, Washington. *http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22565.pdf*
- Culp, TD and KA Cort. 2014. *Database of Low-e Storm Window Energy Performance across U.S. Climate Zones*. September 2014. PNNL-22864, Rev2, Pacific Northwest National Laboratory, Richland Washington. *https://basc.pnnl.gov/resources/database-low-e-storm-window-energy-performance-across-us-climate-zones.*
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- Culp, TD, SC Drumheller, and J Wiehagen. 2013. Low-E Retrofit Demonstration and Education Program. Final Report, June 2013. U.S. DOE project #DE-E E0004015.
- Knox, JR and SH Widder. 2014. *Evaluation of Low-e Storm Windows in the PNNL Lab Homes*. May 2014. PNNL-23355, Pacific Northwest National Laboratory, Richland, Washington. *http://labhomes.pnnl.gov/documents/PNNL_23355_Lab_Homes_Low-e_Storms.pdf*
- Widder, SW, GB Parker, MC Baechler, and NN Bauman. 2012. *Side-by-Side Field Evaluation of Highly Insulating Windows in the PNNL Lab Homes*. August 2012. PNNL-21678, Pacific Northwest National Laboratory, Richland, Washington. *http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21678.pdf.*

- For further information on installation, visit these Building America Solution Center links:
- Exterior storm windows: *https://basc.pnnl.gov/resource-guides/low-e-exterior-storm-windows.*
- Permanent interior storm windows: *https://basc.pnnl.gov/resource-guides/low-e-permanent-interior-storm-windows.*
- Removable interior storm windows: *https://basc.pnnl.gov/resource-guides/removable-interior-storm-windows#block-views-guide-static-blocks-block-1.*
- Installation video: *http://youtu.be/DeU6wn0psrU.*

IN BRIEF

2014 Housing Innovation Awards Announced

The US Department of Energy (DOE) presented Housing Innovation Awards to 28 industry leaders on September 23, 2014 during the Energy and Environmental Building Alliance's (EEBA) Excellence in Building Conference in St. Louis, Missouri. The recipients are commercializing and deploying cutting-edge technologies and helping to significantly reduce the energy costs of the nation's homes.

"The Housing Innovation Awards recognize forward-thinking contractors and builders for delivering extraordinary energy efficiency while ensuring superior comfort, health and durability in new and existing homes," said Dr. David Danielson, Assistant Secretary for Energy Efficiency and Renewable Energy.

Housing Innovation Awards are presented to builders in the DOE's Zero Energy Ready Home program who are changing the way homes are designed and constructed. Zero energy ready homes represent a whole new level of home performance, with rigorous requirements that ensure outstanding levels of energy savings, comfort, health, and durability.

The following industry professionals were presented with Housing Innovation Awards:

DOE Zero Energy Ready Home Leading Builders

Custom Builders

- Amerisips Constructors, LLC, Charleston, South Carolina
- BPC Green Builders, Wilton, Connecticut
- Cobblestone Homes LLC, Saginaw, Michigan
- CVH Inc., Coupeville, Washington
- Imery & Co, LLC, Athens, Georgia
- John Hubert Associates, LLC, Wyncote, Pennsylvania
- One Sky Homes, San Jose, California [Grand Award Winner]
- Promethean Homes, LLC, Steeles Tavern, Virginia
- Sterling Brook Custom Homes LLC, Double Oak, Texas

Production Builders

- AquaZephyr, LLC, Ithaca, New York
- Brookside Development LLC, Woodbridge, Connecticut
- Greenhill Contracting Inc., Esopus, New York
- KB Home, Los Angeles, California

- M Street Homes, LLC, Houston, Texas
- Mandalay Homes, Phoenix, Arizona
- New Town Builders, Denver, Colorado [Grand Award Winner]

Affordable Builders

- Caldwell & Johnson, Inc. Custom Builders & Remodelers, North Kingstown, Rhode Island
- Green Extreme Homes CDC & Carl Franklin Homes, LC, Lewisville, Texas
- Habitat for Humanity South Sarasota, Inc., Venice, Florida
- Southeast Volusia Habitat for Humanity Inc., New Smyrna Beach, Florida
- Southern Homes (Clayton), Double Springs, Alabama
- TC Legend Homes, LLC, Bellingham, Washington [Grand Award Winner]

Zero Energy Ready Leadership

- Palo Duro Homes, Inc., Albuquerque, New Mexico

Lifetime Achievement

- Jerry Wade, Artistic Homes, Albuquerque, New Mexico

Home Performance with ENERGY STAR®

Housing Innovation Awards are also presented to Home Performance with ENERGY STAR® participating contractors who excel in the following categories: Customer Relations, Industry Leadership, High Energy Savings, and Sales & Marketing. The program's participating contractors apply a whole-house approach to deliver significant home energy savings.

- Green Energy Improvement, Chicago, Illinois – Customer Relations and Sales & Marketing
- Isaac Home Energy Performance, Rochester, New York – Industry Leadership
- Neil Kelly Home Performance, Portland, Oregon – Industry Leadership and Customer Relations
- Quality Insulation Installers, Milwaukee, Wisconsin – Industry Leadership and High Energy Savings

Announcement courtesy DOE. To view the full press release online, go to *http://energy.gov/eere/articles/energy-department-announces-winners-housing-innovation-awards*.

Industry Growth Forum, Clean Energy Venture Awards to Highlight Energy Startups

Thirty clean energy startups will present their business cases and compete for the 2014 Clean Energy Venture Awards during the 27th annual Industry Growth Forum, October 28-29, 2014. The Forum, hosted by the Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) in Denver, Colorado, has become a premier clean energy investment event showcasing new technologies to a wide range of investors. The 2014 Forum will specifically explore how new technologies, partnerships, and stakeholders are influencing the way energy is delivered and consumed.

The two-day program will feature presentations by all 30 emerging clean energy companies, as well as panel and technology breakout sessions, and organized networking opportunities. Overarching themes in the program aim to dissect the challenges and opportunities of integrating technologies into a clean energy economy.

The 30 emerging clean energy startup companies were selected through an application and review process and will compete for the 2014 NREL Clean Energy Venture Awards. Since 2003, presenting companies have raised more than $5 billion in investment.

"The Industry Growth Forum plays a critical role by creating opportunities that connect the key players in the clean energy business community," said Kate Cheesbrough of NREL's Innovation and Entrepreneurship Center, which organizes the event. Cheesbrough's comments were released via an NREL press release. "We are bringing entrepreneurs directly together with financiers, policymakers and technology experts. By doing this, we lay the foundation for the future conversations, partnerships and eventual business decisions that will strengthen the industry as a whole."

For more information, including the agenda, a list of participating companies, a list of sponsors, and registration information, visit *http://www.industrygrowthforum.org/*.

The 30 companies selected to present are as follows:

- 75F (Minnesota, USA) - 75F offers a HVAC control solution that addresses the wide temperature imbalances in light commercial buildings. This system offers per room individual temperature control while saving 40% in energy costs.
- AeroValve LLC (Missouri, USA) - AeroValve is a pneumatic valve company with an innovative air-recycling technology. The AeroValve solution reduces wasteful venting to atmosphere because the downstream air is recycled.
- Airex Energy (Quebec, Canada) - Airex Energy has successfully developed an exciting new technology for biomass torrefaction. Based on a unique patented cyclonic bed reactor, CarbonFX enables large scale biocoal production from a variety of feedstock, including woody biomass and agricultural wastes.
- Argil, Inc. (California, USA)- Argil, Inc. is a Silicon Valley based start-up founded in 2012 to develop printed electrochromic devices on flexible substrate enabling numerous applications in architectural, automotive, health care and electronic industries.
- Aurora Control Technologies (British Columbia, Canada) – Aurora Control offers inline measurement and control systems for solar cell manufacturing.

- BuildingIQ (California, USA) - BuildingIQ is a cloud-based software platform that addresses the fundamental shortcomings of HVAC systems in commercial buildings to improve energy efficiency and reduce operating costs.
- ClearCove Systems (New York, USA) - ClearCove Systems is a renewable energy company focused in resource recovery technology for wastewater space.
- Cleargrid Innovations (New York, USA) – Cleargrid offers a real-time monitoring system for electric distribution wires to prevent power outages and repair lines faster.
- Cool Energy (Colorado, USA) - Cool Energy produces equipment that captures wasted heat from industrial processes and produces clean electricity.
- Dioxide Materials (Illinois, USA) – Dioxide Materials provides energy efficient conversion of CO2 into industrial chemicals.
- Ecorithm (California, USA)- Ecorithm software as a service uses a proprietary algorithm to analyze the massive data flows available from modern building management systems to detect faults and diagnose root causes so that large commercial buildings can become more comfortable and more energy efficient every day.
- Eonix (New York, USA) – Eonix developed an electrolyte that increases energy density of ultracapacitors.
- GELI (California, USA) – GELI offers software to analyze, design, and operate energy storage and microgrids.
- Go Electric, Inc. (Indiana, USA) - Blinkless is a patented microgrid and advanced uninterruptible power system technology that seamlessly integrates renewables, batteries and generators with the grid.
- Graphenix Development (New York, USA) - Nanostructured carbon ultracapacitor electrode with 30% higher energy density than current market leaders.
- HiQ Solar (California, USA) - New generation PV string inverter with micro inverter features.
- Nines Photovoltaics (Dublin, Ireland) - Development/design & build of process equipment to be used in the manufacture of C-si PV Solar Cells.
- NOHMs Technologies, Inc. (New York, USA) - Ionic electrolytes and high capacity cathodes for lithium ion batteries.
- OpenAlgae, LLC (Texas, USA) - A disruptive, liquid-liquid separation technology developed for the algae industry has found near term application in the water-energy synergy market by separating oil from oily water at the well-head or disposal site without requiring settling or chemical additives.
- SineWatts, Inc. (North Carolina, USA) - Single IC photovoltaic inverter for mainstream power generation.
- Siva Cycle (California, USA) - The Siva Atom converts the momentum of cycling (and other kinetic sources) into usable, storable electricity.
- SROV Systems (Florida, USA) - SROV systems is driving the emergence of the infrastructure restoration automation (IRA) market. SROV's technology is a modular infrastructure restoration robot with an artificial intelligence backbone to coordinate & manage independent parts.
- Sunamp (East Lothian, United Kingdom) - Highly compact thermal energy stores (Heat Batteries) incorporated into renewable heating systems that save users over 50% of running costs.
- ThermoVolt Solar (New Jersey, USA) - ThermoVolt Solar is bringing to market a cogeneration solar module that produces electricity and hot water in a single system.
- Urban Electric Power LLC (New York, USA) - To serve the growing market for energy storage UEP has developed the ultra-low cost zinc-manganese dioxide (Zn-MnO2) rechargeable battery.
- Ventana Cleantech Inc. (California, USA) - Ventana technology converts low grade waste plastics to petroleum fuels similar to diesel and gasoline at a $50-$65 per barrel cost point.
- WattJoule (Massachusetts, USA) – WattJoule stores electrical energy in a liquid.
- Wetzel Blade (Texas, USA) – Wetzel Blade develops field-assembled component-based rotor blades.
- xF Technologies Inc. (New Mexico, USA) - xF Technologies has developed a family of furoate esters for use as an oxygenating blend component (5%-20%) in both gasoline and diesel fuels as well as several non-fuel uses (including oilfield chemicals, corrosion inhibition, and other specialty chemical applications).
- Xtrls International, Inc. (California, USA) – Xtrls International provides a micro-grid control system solution.

Presenters list courtesy NREL.

IN REFERENCE

Construction Instruction® Releases Mobile-Driven Ci-HD 3.0

On August 14, 2014, Construction Instruction® *(http://www.constructioninstruction.com/)* announced the release of Ci-HD 3.0, available for iPhone and iPad devices (see Figure 7). The newly updated application is a mobile-first platform for applied building science information. Uniquely tailored to mobile devices, beyond linking to the Construction Instruction website, the app boasts its own animation library, technical articles and videos, and a product section. The app's technology platform is also unique; it senses the device, its connectivity (wifi versus cellular), and the quality of reception so that videos and animations play seamlessly.

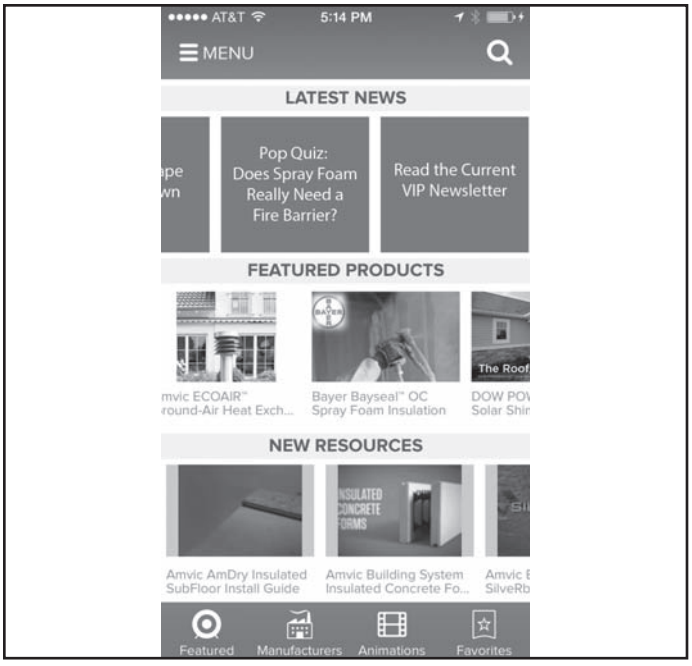

Figure 7. Home screen for Ci-HD 3.0, as displayed on an iPhone. Image courtesy Dan Morrison and Construction Instruction®.

"This app grew from seminars given by our team of Construction Instruction consultants," explains Dan Morrison, Media Director at Construction Instruction. "We found that, in many of these seminars, as much as instructors would focus on how to build a house properly and the physics involved, attendees would always ask: How do I do it? And what do I use? The Ci-HD app is built to address those 2 main questions."

To answer the "How," Construction Instruction offers articles, videos, and animated details like installation guides, to help builders beat code. The "What" is addressed by inviting manufacturers of selected and approved products to upload technical documents, installation guides, architectural specs, MSDSs, and any other relevant information that would be useful to builders and subcontractors (see Figure 8 and Figure 9).

Figure 8. Ci-HD 3.0 offers easy access to a list of available products from participating manufacturers. Image courtesy Dan Morrison and Construction Instruction®.

"From a media standpoint, it's exciting that we can work with product manufacturers," Morrison notes. "We have a panel of building science experts who invite people and companies doing great stuff to become a part of the app. Though a house, at the end of the day, is not about products but process, builders are ultimately interested in the 'with what.' Ci-HD helps builders make choices, and shows how different systems can work together. This is not a marketing arm; we are simply showing what really works."

For builders looking to go deeper and answer the "Why," Ci-HD also contains over a hundred technical articles and building science videos, backed up with animations.

The search feature is also unique to Ci-HD. Users can search by construction sequence, rather than being limited to topical or alphabetical strings.

Future updates for Ci-HD plan to drive custom guides straight to builders. "I'm excited about the ability of Ci-HD to deliver particular packages: for example, to deliver a best practice guide for a particular climate zone," Morrison states. "This means builders in Texas to don't have to wade through stuff about how to insulate in Minnesota. In each climate zone, there are different products that work better than others. I think we can expand our offerings quite a bit."

Ci-HD is offered through iTunes at: *https://itunes.apple.com/us/app/construction-instruction-hd/id405587255?mt=8&utm_source=Editorial+Outreach&utm_campaign=21f14dd0db-Letter_to_editors8_26_2014&utm_medium=email&utm_term=0_ee394e14d8-21f14dd0db-83884997* or can be accessed at Construction Instruction® *(http://www.constructioninstruction.com/)*.

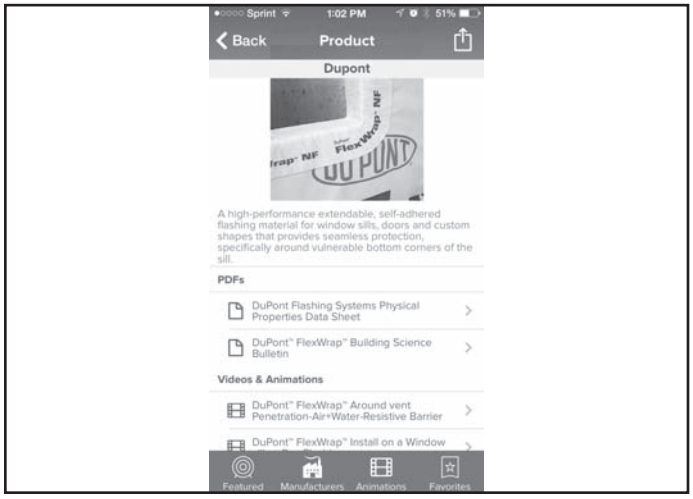

Figure 9. Ci-HD 3.0 screen shot from iPhone displays what you get after selecting a particular product: a photo, description, and technical data from the manufacturer as well as articles, videos, and animations from Construction Instruction®. Image courtesy Dan Morrison and Construction Instruction®.

WaterSense® Uses Energy Action Month to Spotlight Showerheads

October ushers in the US Department of Energy (DOE) Energy Action Month, an event where the DOE promotes taking simple actions to save energy and money through reductions in utility bills. In cooperation with the DOE, the US Environmental Protection Agency's (EPA) WaterSense® program has declared October to be Shower Better Month.

"By taking action to save water, you will also save the energy that is used to heat and deliver that water to your tub, tap, or shower," notes Karen E Wirth, WaterSense Program, EPA.

According to EPA data, most indoor water use happens in the bathroom. Showers can make up 17% of that indoor water use. By switching to WaterSense labeled showerheads, the average family can save 2,900 gallons of water annually, and reduce yearly water and energy costs by more than $70 (see Figure 10).

"It's not just about water," cautions Jonah Schein, WaterSense Program, EPA. Moving, treating, and heating water uses energy too. "Nationally, 3% to 4% of our energy is consumed by treating and moving water. Every gallon of water has an energy footprint from treatment, delivery, and heating." California consumes 20% of its energy in the water sector, according to Schein.

Replacing existing showerheads with WaterSense labeled models can save 4 gallons of water every time a homeowner takes a shower. It also means energy savings by avoiding heating all that extra water.

WaterSense labeled showerheads are independently certified for both efficiency and performance for spray force and water coverage.

Evaluation factors for all potential WaterSense labeled products include:

- Potential for significant water savings on a national level.
- Equal or superior product performance compared to conventional models.
- State of technology development—product categories that rely on a single, proprietary technology will not be eligible for the label.
- Ability to measure and verify water savings and performance.
- Cost-effectiveness.

For showerheads in particular, the WaterSense specification is aimed at ensuring both sustainable, efficient water use and a high level of user satisfaction with showerhead performance.

General requirements for all WaterSense labeled showerheads mandate that each showerhead conform to applicable requirements in ASME A112.18.1/CSA B125.1. If the showerhead has more than one mode, all modes must meet the maximum flow rate requirement outlined in WaterSense Section 3.1.1, and at least one of the modes, as specified by the manufacturer, must meet all of the requirements outlined in the WaterSense specification. The showerhead must not be packaged, marked, or provided with instructions directing the user to an alternative water-use setting that would override the maximum flow rate, as established by this specification. Any instruction related to the maintenance of the product, including changing or cleaning showerhead components, must direct the user on how to return the product to its intended maximum flow rate.

Figure 10. The US Environmental Protection Agency (EPA) estimates that if every home in the United States installed WaterSense labeled showerheads, more than $2.2 billion in water utility bills could be saved, as well as more than 260 billion gallons of water annually. In addition, US consumers could avoid about $2.6 billion in energy costs for heating water. Image courtesy WaterSense® and available at *http://www.epa.gov/watersense/products/showerheads.html.*

To determine water efficiency, the rate of each showerhead is tested in accordance with the procedures in ASME A112.18.1/CSA B125.1. According to the standard, "The manufacturer shall specify a maximum flow rate value (rated flow) of the showerhead. This specified value must be equal to or less than 2.0 gallons per minute (gpm) (7.6 liters per minute [L/min])."

"The maximum flow rate shall be the highest value obtained through testing at flowing pressures of 20, 45, and 80 ± 1 pounds per square inch (psi) (140, 310, and 550 ± 7 kilopascal [kPa]), when evaluated in accordance with 10 CFR 430 Subpart F, Appendix B, Step 6(b). This maximum flow rate shall not exceed the maximum flow rate value specified in Section 3.1.1.

The minimum flow rate, determined through testing at a flowing pressure of 20 ± 1 psi (140 ± 7 kPa) and when evaluated in accordance with 10 CFR 430 Subpart F, Appendix B, Step 6(a), shall not be less than 60 percent of the maximum flow rate value specified in Section 3.1.1.

The minimum flow rate shall be the lowest value obtained through testing at flowing pressures of 45 and 80 ± 1 psi (310 and 550 ± 7 kPa), when evaluated in accordance with 10 CFR 430 Subpart F, Appendix B, Step 6(a). This

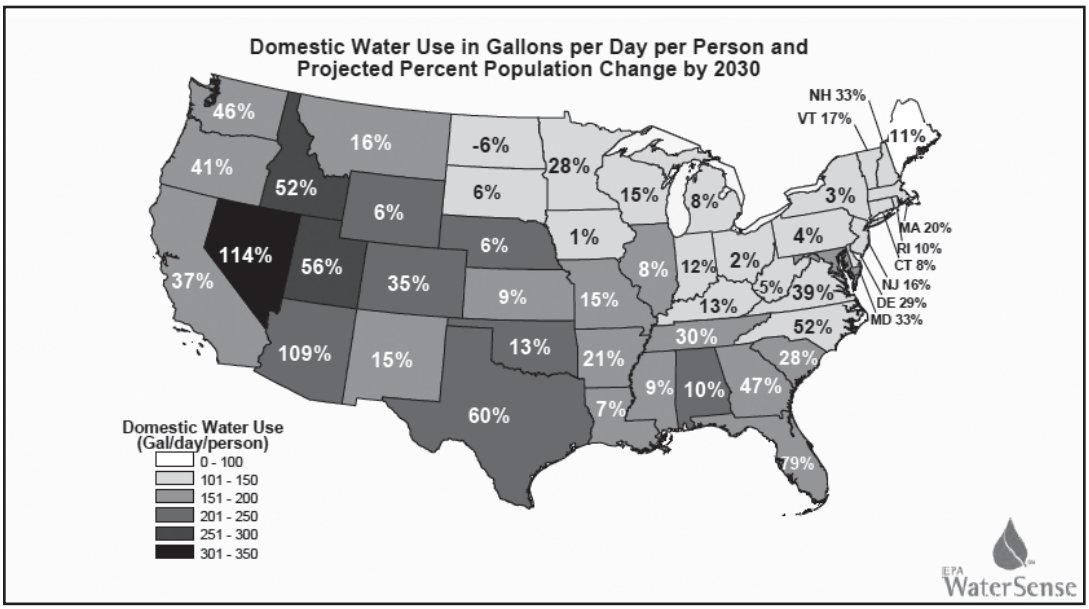

Figure 11. Domestic water use in gallons per day per person and projected percent population change by 2030. According to Jonah Schein of the US Environmental Protection Agency (EPA), demand for water is happening in many areas that can least afford it. Data from US EPA WaterSense®. Slide available online at *http://www.epa.gov/region2/webinars/pdfs/irrigation_03-03-10.pdf*.

minimum flow rate shall not be less than 75 percent of the maximum flow rate value specified in Section 3.1.1."

Beyond water efficiency criteria, WaterSense also has detailed standards for spray force and spray coverage that must be met by any qualifying showerhead.

Under spray force, "The spray force of the showerhead shall be tested in accordance with the procedures outlined in Appendix A and shall meet the following criteria: The minimum spray force shall not be less than 2.0 ounces (0.56 newtons [N]) at a pressure of 20 ± 1 psi (140 ± 7 kPa) at the inlet when water is flowing.

Under spray coverage, "The spray coverage of the showerhead shall be tested in accordance with the procedures outlined in Appendix B and shall meet the following criteria: The total combined maximum volume of water collected in the 2- and 4 inch [in.] (50-, 101-millimeter [mm]) annular rings shall not exceed 75 percent of the total volume of water collected, and;

The total combined minimum volume of water collected in the 2-, 4-, and 6-in. (50-, 101-, 152-mm) annular rings shall not be less than 25 percent of the total volume of water collected."

(For further technical and program information, visit *http://www.epa.gov/watersense/products/showerheads.html*.)

The highlight of WaterSense, according to Wirth, is that the program takes into account not just efficiency, but real-world performance. "The most important message for builders is that their homeowners can take the shower they want and still use less water," said Wirth.

WaterSense, launched in 2010, is the first national new home labeling program for water efficiency. "Even multi-attribute programs like LEED® were a little weak on water use," commented Schein. A qualifying WaterSense new home reduces that home's water use by at least 20%. Additionally, the program promotes educating homeowners about continued water efficiency behaviors and encourages community-wide infrastructure savings.

"There is a great need for water efficiency," Schein stated. "The US population is growing and water demand is booming; often this demand grows in an area that can least afford water demand growth." Schein noted that non-drought water shortages are expected in at least 40 states (see Figure 11). The potential problem is exacerbated when coupled with an aging water infrastructure, which government estimates project may need an investment of more than $700 billion by utilities over the next 20 years to update.

Beyond efficiently managing water as a resource, WaterSense is also concerned with protecting consumers' pocketbooks. "What will water cost in 20 years?" asks Schein. When plotted against the consumer price index (CPI), water and sewer jump grossly above the CPI, outpacing even gasoline. "Most people believe we have not seen the major increase yet," Schein cautions.

For additional resources, including inspection guidelines and audits, and general information about the WaterSense program, go to *http://www.epa.gov/watersense/new_homes/index.html*.