Energy Design Update®

The Monthly Newsletter on Energy-Efficient Housing

ASPEN PUBLISHERS

Vol. 33, No. 8 August 2013

IN DEPTH

Pushing Boundaries on Performance & Design: the ClimateMaster Trilogy® 40 Q-Mode™ Geothermal Heat Pump - Part I

Introduced July 9, 2012, and available for limited order in December 2012, the ClimateMaster Trilogy® 40 Q-Mode™ Geothermal Heat Pump, the outcome of a 5 year collaboration between ClimateMaster, Inc., and Oak Ridge National Laboratory (ORNL), is an ultrahigh-efficiency geothermal heat pump that provides space heating, cooling, and water heating. Based on field tests, laboratory evaluation, and modeling by ORNL, the Trilogy 40 Q-Mode can save 55% to 61% of annual energy use and cost for space conditioning and water heating in residential applications versus new minimum efficiency (SEER 13) air-source heat pumps and electric resistance storage water heaters. The Trilogy series also became the first geothermal heat pumps ever certified by the Air Conditioning, Heating, and Refrigeration Institute (AHRI) to exceed 40 EER at ground-loop (GLHP) conditions (see Figure 1).

"Historically, residential ground-source or geothermal units would do all the space conditioning, with a desuperheater providing a small part of the hot water and resistance elements in the tank providing the rest," said Patrick Hughes, Director of Buildings Program, Building Technologies Research & Integration Center (BTRIC), Oak Ridge National Laboratory. "The Trilogy 40 Q-Mode product will give you all of your hot water on-demand, very efficiently. A ground source geothermal system is a premium installation. If you have the ground loop you certainly want all the cost savings it can provide through ultrahigh-efficiency space heating, cooling, and water heating. This unit does that."

The Trilogy 40 Q-Mode reduces energy consumption by combining 3 variable speed technologies: an inverter-

Figure 1. The ClimateMaster Trilogy® 40 Q-Mode™ Geothermal Heat Pump, the outcome of a 5 year collaboration between ClimateMaster, Inc. and Oak Ridge National Laboratory (ORNL), reduces energy consumption by combining 3 variable speed technologies: an inverter-driven compressor, indoor air blower, and water pump. Photo courtesy ClimateMaster, Inc.

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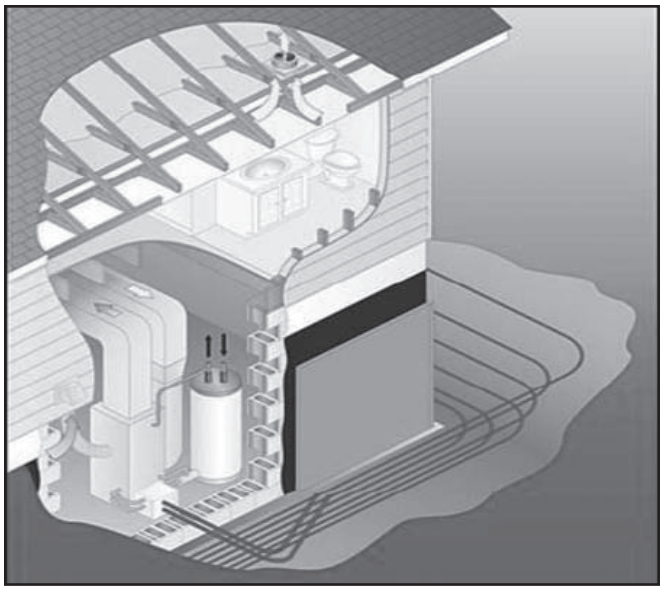

Figure 2. Conceptual installation of the residential ground-source integrated heat pump. Graphic courtesy Oak Ridge National Laboratory.

Variable-Speed GSIHP in 2600 ft^2 (242 m^2) House				
Primary Delivery Function	Fractional Energy Savings from Base	Normalized Base Power Per Unit Load	Fraction of Total Delivered Energy	% of Total Energy Savings
Atlanta				
Space Heat	0.447	1.37	0.410	25.0%
Space Cool	0.482	0.96	0.391	18.2%
Water Heat	0.735	3.88	0.199	56.8%
Houston				
Space Heat	0.477	1.53	0.203	14.8%
Space Cool	0.341	1.14	0.626	24.4%
Water Heat	0.770	4.62	0.171	60.8%
Phoenix				
Space Heat	0.514	1.42	0.148	10.8%
Space Cool	0.376	1.35	0.707	35.8%
Water Heat	0.783	4.70	0.145	53.4%
San Francisco				
Space Heat	0.316	0.80	0.545	13.7%
Space Cool	0.492	0.70	0.011	0.4%
Water Heat	0.719	2.69	0.445	86.0%
Chicago				
Space Heat	0.434	1.57	0.688	46.8%
Space Cool	0.575	0.91	0.120	6.3%
Water Heat	0.678	3.62	0.192	47.0%

Figure 3. Breakdown of Energy Savings for Prototype 1 in Residential 2-Ton (7kW) Cooling Application. Data courtesy Oak Ridge National Laboratory.

driven compressor, indoor air blower, and water pump, all of which feature permanent magnet electric motor technology, enabling greater efficiency at part-load conditions. This system concept uses one variable-speed (VS) modulating compressor, a VS indoor blower, a VS pump for ground heat exchanger (GHX) fluid circulation, and a VS pump for hot water circulation. A 50 gallon (~189 l) WH tank is included (see Figure 2).

"The Department of Energy set a vision for 50% energy savings in buildings by 2030, compared to the 2030 baseline predicted in EIA's 2010 Annual Energy Outlook, which is based on incremental improvement to today's best common practice," said Hughes. "A major need we have to address, in order to achieve these savings, is to dramatically reduce the energy used for space conditioning and water heating. One path was to ask whether we could develop a single piece of highly efficient equipment that provides both space conditioning and water heating functions. We will never meet the 50% goal if we continue to throw energy away outdoors with our cooling equipment, while at the same time buying new energy to heat our water."

Out of the Cradle and Into the Lab...

In 2005, ORNL developed a general concept for such a multi-function appliance, called the integrated heat pump (IHP). In 2008 ClimateMaster, Inc. (CM) joined ORNL as an industry partner in the endeavor.

Between October 2008 and May 2013 ORNL and CM engaged in a Cooperative Research and Development Agreement (CRADA) to develop a ground source

Editor: Amanda Voss **Designer: Chris Tankiewicz**

Energy Design Update (ISSN 0741-3629) is published monthly by Aspen Publishers, 76 Ninth Avenue, New York, NY 10011. (212) 771-0600. One-year subscription costs $595. *To subscribe, call 1-800-638-8437. For customer service, call 1-800-234-1660. POSTMASTER: Send address changes to* ***Energy Design Update,*** *Aspen Publishers, 7201 McKinney Circle, Frederick, MD 21704.* **Permission requests:** For information on how to obtain permission to reproduce content, please go to the Aspen Publishers website at *www.aspenpublishers.com/permissions.* Printed in the U.S.A.

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

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Loads and Energy Use by Mode; OVF House, 2010 Season				
Loads from Base Simulation		1-Speed Base	1st Generation GSIHP	
Operation Mode	kWh	Energy Use kWh (I^2R)	Energy Use kWh (I^2R)	Reduction from Base(%)
Oak Ridge, TN				
space heating	12759	5602	3060	45.4%
resistance heat		(921)	(79)	
space cooling	6111	1821	1002	45.0%
water heating	2506	2797	729	73.9%
resistance heat		(2797)	(0)	
ventilation fan		144	144	
totals	21376	10364	4934	52.4%

Figure 4. Projected Prototype 1 Energy Savings versus baseline systems at ZEBRAlliance site 2 in 2010 Season. Data courtesy Oak Ridge National Laboratory.

integrated heat pump (GS-IHP) system that ultimately resulted in the Trilogy 40 Q-Mode. ORNL was funded by the Department of Energy Building Technologies Office (DOE BTO) and CM was self-funded and provided over half of the overall investment.

By 2010 an initial, or 1st generation, prototype was designed with the assistance of ORNL's Heat Pump Design Model (HPDM).

"Early on in the process, Shawn Hern and ClimateMaster did steady state testing, and ORNL took that data and calibrated HPDM to look at internal controls in terms of how to get the best performance, and how to vary the pump and indoor blower as a function of compressor speed. This design guidance was fed back to ClimateMaster to work into the prototype's control scheme," said Keith Rice.

Lab prototypes were fabricated by ClimateMaster, lab-tested, and modeled in TRNSYS 16 (SOLAR Energy Laboratory, et al., 2010) against 2 major indices of performance. The first index was annual performance relative to a baseline suite of equipment meeting minimum efficiency standards (combination of air-source heat pump (ASHP) and electric resistance storage water heater); and second, a state-of-the-art two-capacity ground-source heat pump with desuperheater water heater (WH) option (GSHPwDS) (see "Ground Source Integrated Heat Pump (GS-IHP) Development – Final Report," CRADA NFE-07-01000).

Through TRNSYS, predicted total annual energy savings for the first prototype, while providing space conditioning and water heating for a 2600 ft² house, ranged from 52% to 59% savings, averaging 55%, relative to the minimum efficiency suite. The system was measured in 5 US climate locations: Atlanta, Houston, Phoenix, San Francisco, and Chicago.

According to the ORNL report, annual energy use simulations for a baseline suite of individual systems (13 SEER heatpump, 0.90 EF electric WH, and ventilation per ASHRAE standard 62.2 (ASHRAE 2007) requirements) and the GS-IHP were performed using the TRNSYS 16 platform (Solar Energy Laboratory, et al. 2010). A vertical ground heat exchanger (GHX) consisting of two parallel u-tube pipe loops in separate bores was assumed for the GS-IHP. Annual, sub-hourly simulations were performed for the baseline system and IHP for the 5 locations. Set points for space heating and cooling were 71 °F and 76 °F (21.7 °C and 24.4 °C), respectively. The water heating set point was 120 °F (48.9 °C) and total daily hot water use of ~65 gallons (~245 l) was assumed.

Predicted energy use for water heating was reduced by 68% to 78% relative to the resistance storage WH. Predicted total annual savings for the GSHPwDS relative to the same minimum efficiency suite baseline averaged 22.6% with water heating energy use reduced by 10% to 30% from desuperheater contributions (refer to Figure 3 for a detailed breakdown of predicted energy savings).

...and Into the Field

The first prototype design for the GS-IHP was finalized in 2010 and manufactured by CM for field testing at ORNL. Two of these first units were installed in 3700 ft² houses at the ZEBRAlliance site in Oak Ridge, Tennessee. Field testing on the first prototypes occurred through 2011.

The first generation GS-IHP prototypes fully provided space conditioning needs for the 2 test houses over 2011. However, they only provided partial water heating needs due to reversing valve technical issues. Simulation of the 1st generation prototypes' performance using HPDM and TRNSYS indicate that they could have achieved >52% savings versus baseline

Table 1

	SC COP	SH COP	WH COP
Baseline ASHP	3.36	2.28	0.9
1st Gen. GSIHP	6.1	4.17	3.44

Table 1. Projected Seasonal COPs for Prototype 1 at ZEBRAlliance site in 2010 Season. Data courtesy Oak Ridge National Laboratory.

minimum efficiency HVAC/WH equipment at the ZEBRAlliance site, with a SEER of 20.8 Btu/Wh and an HSPF of 14.2 Btu/Wh (refer to Figure 4 and Table 1).

"The projected annual energy savings at the field site correlated quite closely to Atlanta data simulations," stated Van D. Baxter.

1st generation prototype field testing efforts illuminated a number of system hardware and control issues that led to an improved second generation design, the Trilogy 40 Q-Mode. Shawn Hern, Product Engineer at ClimateMaster, discussed lessons from the first prototype. "Solving reliability problems was the biggest issue after field testing the first time. Prototype 1 worked 50% of the time, if that. As we looked into the final type of design for the product, after prototype 1, we also were trying to think about how to implement this product into current applications – how to install a GS-IHP at both new and retrofit locations. With retrofits in mind we ultimately changed heat exchangers to more compact designs so the final production model would fit in the same cabinets as our standard products."

According to "Ground Source Integrated Heat Pump (GS-IHP) Development – Final Report," CRADA NFE-07-01000, Van D. Baxter, Keith Rice, Richard Murphy, Jeff Munk, Moonis Ally, Bo Shen, and William Craddick, 10 major changes were made to the second generation prototype:

- Change air coil from tube-and-fin to microchannel design.
- Move hot water condenser into a true parallel circuit and eliminate desuperheating function since it adds little value and creates charge compensation problems.
- Reduce the water heating reversing valve (RV) size to eliminate switching problems. Problems with this RV resulted in poor performance by the 1st generation units in water heating modes throughout the entire 2011 test year, becoming increasingly worse with time.
- Change refrigerant-to-water heat exchanger (HX) for hot water production to a double-walled brazed plate type as it is more compact and efficient.
- Change refrigerant-to-water HX for ground loop to a brazed plate type; primary reason to reduce unit size to fit into a standard 2-ton cabinet.
- Change the brine loop pump to a newer, more efficient version.
- Upgrade to a more robust inverter design.
- Upgrade the controls to address small zone temperature offset (~1-2 °F) seen at test site.
- Other small tweaks to make service easier and provide easier access to some components such as the inverter.
- Changed check valves to one with a reduced seat leakage. The previous valves were found to be problematic during development of the second version. Using check valves with a consistent low seat leakage was critical to improved performance.

Hern discussed development and monitoring of control algorithms for the 4 operating modes that took place during the first prototype's testing. "Obviously there are a lot of components here, and some of them are variable speed and have many potential operating states within a broad range. We needed to figure out how to control all the pieces to work as efficiently together as possible in each of the 4 operating modes. Not only that, we had to understand what happens in the go-between transition modes, for example, when the system is operating in cooling mode for space conditioning but then there is a need for hot water. Field testing meant examining transition modes to make sure the system turned on the pumps properly, and was able to switch reversing valves properly. Most of those evaluations had started with laboratory analysis, but it's really hard to get a true, transient test until you get out in the field. We were logging data every few seconds, so you could look at the data from the houses at ORNL, and watch the transitions. It was a very iterative process."

The Second Generation Unveiled

The second generation prototype was released by ClimateMaster (CM) in 2012. Field test verification units were installed at the ZEBRAlliance site in Oak Ridge in May 2012 and at several sites near CM headquarters in Oklahoma. Field testing of the units continued through February 2013.

In February 2013, prototype 2 won the "Heating" category of the 2013 AHR Expo Innovation Awards. Based on field tests and analysis, the new Trilogy 40 Q-Mode was predicted to save about 60% of annual energy use and cost for space conditioning and water heating in residential applications.

Annual performance simulations for the prototype 2 design were run with the same 2600 ft^2 house and range of climates as for the first prototype. Predicted yearly energy savings across the 5 selected US locations ranged from 57% to 61%, averaging 59% relative to the minimum efficiency suite (SEER 13). Based on the demonstrated steady-state and field

Variable-Speed GSIHP in 2600 ft^2 (242 m^2) House				
Primary Delivery Function	Fractional Energy Savings from Base	Normalized Base Power Per Unit Load	Fraction of Total Delivered Energy	% of Total Energy Savings
Atlanta				
Space Heat	0.516	1.29	0.410	27.2%
Space Cool	0.531	0.91	0.391	18.8%
Water Heat	0.743	3.65	0.199	53.9%
Houston				
Space Heat	0.551	1.43	0.203	15.9%
Space Cool	0.395	1.07	0.626	26.4%
Water Heat	0.780	4.32	0.171	57.6%
Phoenix				
Space Heat	0.599	1.31	0.148	11.6%
Space Cool	0.443	1.24	0.707	38.8%
Water Heat	0.794	4.31	0.145	49.7%
San Francisco				
Space Heat	0.405	0.77	0.545	17.0%
Space Cool	0.570	0.67	0.011	0.4%
Water Heat	0.716	2.60	0.445	82.6%
Chicago				
Space Heat	0.513	1.43	0.688	50.6%
Space Cool	0.615	0.83	0.120	6.1%
Water Heat	0.684	3.31	0.192	43.3%

Figure 5. Breakdown of Energy Savings for Prototype 2 in Residential 2-Ton (7kW) Cooling Application. Data courtesy Oak Ridge National Laboratory.

performance of the test units it was projected that the second prototype units would achieve ~58% energy savings relative to the minimum efficiency suite at the ZEBRAlliance site with horizontal GHX as compared to the 52% savings predicted for the 1st generation prototype design. The unit was also predicted to provide the total yearly domestic water heating needs of a typical residence while consuming less than one-third of the energy used by conventional electric storage water heaters.

The rated performance of the prototype 2 design (per ISO 13256-1 at part load conditions) was over 40 EER, a value quite a bit larger than the 29.2 EER received by prototype 1. This performance leap may be attributed to the ISO rating procedure assumptions, prototype 2's lower minimum compressor speed of 35 Hz, and the shutdown of the RH control system during rating.

The variable speed technology provides an extremely wide range of heating and cooling capacities, with the ability to match loads to as low as 30% of maximum. The second prototype also produced year-round domestic hot water on demand, even when space conditioning was not required.

Higher energy savings were coupled with greater predicted comfort conditions in space conditioning for prototype 2, due to closer approach temperatures, lower minimum airflows, and higher heating capacities. Delivered supply temperatures in space heating were 3° to 4°F higher, with SHR levels in space cooling reduced from up to 0.85 to a narrower range between 0.76 and 0.79. Additionally, the number of hours with RH above 60% was lower. When compared with the baseline system, prototype 2 had a water heating efficiency COP increase of 310% to 450%, averaging 380%. COPs for space conditioning predict average performance increases of 210% in space heating and 240% in space cooling. (Refer to Figure 5 and Table 2 for further details.)

Field measurements corroborated performance predictions. During July and August 2012, collected data demonstrated that average cooling-only COPs for prototype 2 ran about 10% to 15% higher than prototype 1, at similar entering water temperatures (EWT). January and February 2013 data showed heating-only COPs were about 2% to 5% higher in prototype 2 than those of prototype 1. Based on a combination of modeling using new calibrated performance maps and field data analysis, the

Table 2

	Proto 2 GSIHP SC COP	Baseline SC COP	Proto 2 GSIHP SH COP	Baseline SH COP	Proto 2 GSIHP WH COP	Baseline WH COP
Atlanta	8.56	3.62	5.18	2.55	3.42	0.9
Houston	6.55	3.6	5.96	2.69	3.84	0.89
Phoenix	5.7	2.09	7.18	2.93	4.06	0.89
San Francisco	9.93	3.48	5.1	3.04	3.03	0.9
Chicago	10.65	3.61	4.2	2.09	2.79	0.9

Table 2. Predicted COPs for Prototype 2 GSIHP in Five US Climates, contrasted with Predicted COPs for Baseline ASHP with Resistance WH in Five US Climates. Data courtesy Oak Ridge National Laboratory.

Predicted Loads and Energy Use by Mode; OVF House, 2012 Season				
Loads from GSIHP Simulation		1-Speed Base	2nd Generation GSIHP	
Operation Mode	kWh	Energy Use kWh	Energy Use	Reduction from
Oak Ridge, TN				
space heating	8765	3265	1690	48.2%
resistance heat		(127)	(29)	
space cooling	5202	1539	768	50.1%
water heating	2313	2605	610	76.6%
resistance heat		(2605)	(0)	
ventilation fan		109	109	
totals	16280	7519	3177	57.8%

Figure 6. Projected Prototype 2 GSIHP Energy Savings versus baseline systems for ZEBRAlliance site House 2 in 2012 Season. Data courtesy Oak Ridge National Laboratory.

By reducing the speed of the pump and blower motors when heating or cooling demand is low, the heat pump reduces electricity consumption by 80% or more during much of the year. The compressor can be run at increased speeds when the heating demand is high, allowing the system to minimize or eliminate the use of electric resistance backup heat in cold climates.

predicted annual HVAC/WH savings at the field test site are 57.8%. Space conditioning savings alone are predicted at 50%, with water heating savings exceeding 76% compared with the baseline 0.90 EF electric resistance storage water heater. (Refer to Figure 6 and Table 3 for further data.)

"Between the annual simulations and field tests, there was a reasonably good correlation," said Keith Rice, ORNL. "In simulations over a year we looked at 5 different climates with the constant of a well-insulated, tight house appropriate for each location. Because the homes were well insulated and tight, the water heating load was a larger fraction of the total energy usage than in typical homes. That's where this product can give maximum % savings. You are getting 70% or more savings on the water heating portion. Dollar-wise, overall energy savings will vary based upon the house and individual user patterns, but annual average savings were around $600. The largest we saw for this house was $950 in Chicago, with a low of $420 for Houston."

Hern summarized the difference in performance ratings between prototype 1 and 2. "Mostly, the performance improvements in prototype 2 are due to more efficient heat exchangers in the updated system. The original prototype was also not able to slow itself down as far as prototype 2. Consequently minimum capacity levels were higher in the first prototype, at 45 Hz, than in the second, at 35 Hz."

Table 3

	SC COP	SH COP	WH COP
Baseline ASHP	3.38	2.68	0.89
Prototype 2 GSIHP	6.77	5.19	3.79

Table 3. Projected Prototype 2 seasonal COPs at ZEBRAlliance site in 2012 Season. Data courtesy Oak Ridge National Laboratory.

Rice added, "CM widened the operating envelope on the second prototype."

Limited issues were noted in the field with prototype 2.

"The only real issues we saw were temperature control items," said Hern. "In our second round of test homes we had an after-market zoning system required to be installed in the homes. The system had to interface with that and run a zoning system off of our control as well. Some of the temperatures weren't consistently reading right. We also had 2 control boards that got damaged in the second field trial. After speaking with the supplier, we changed the design of the interface board slightly. We did have a refrigerant leak in 1 unit, but that was due to an extra port not normal in the system, but needed for field test instrumentation."

The Trilogy development program also made some advances in basic design for variable speed units. "The unit has an inverter-driven compressor, and since everything is in an indoor packaged unit box, to keep the inverter cool, we ran a suction line through the back plate on the inverter to cool the inverter with the refrigerant as it went back to compressor," noted Hern. "Most normal inverters will have an air heat sink to keep the electronics cool. For an air source heat pump, this is not as difficult when the unit is running. But our packaged water-to-air units are often installed in closed closets or other confined indoor areas, and dumping heat into that smaller area can warm the ambient temperatures around the unit, which then limits the electronics as they get too warm."

"Overall, we achieved a higher level of performance out of our components," noted Hern. "When we looked at VS pumps initially, we were so impressed that we rolled them from the prototype into our standard residential product line. The Trilogy's success came from a combination of using really efficient components properly controlled, plus the innovative refrigerant charge

control. We pushed reversing valves beyond their usual applications, and had to work to get valves operating reliably under switching modes."

Energy Design Update thanks the team at ClimateMaster, Inc., and at Oak Ridge National Laboratory (ORNL) for allowing us special access to research and information on the ClimateMaster Trilogy® 40 Q-Mode™ Geothermal Heat Pump.

Part 2 of this article will appear in the September 2013 issue of *Energy Design Update*.

IN BRIEF

Field Assessment of Energy Audit Tools for Retrofit Programs Released

The official report on the Center for Energy and the Environment's (CEE) evaluation of the Department of Energy's (DOE) Home Energy Score has been approved and released by the National Renewable Energy Laboratory (NREL). ***Energy Design Update*** covered the study's findings in the July 2013 issue (Vol. 33, No. 7, "In Development"). The paper, "Field Assessment of Energy Audit Tools for Retrofit Programs," is available online at *http://www.nrel.gov/docs/fy13osti/56762.pdf*.

Home Energy Score is a home energy ratings tool to promote energy retrofits in existing homes, and designed to give a complete home performance assessment while simplifying the building measurements to between 36 to 67 data inputs, for the pilot version, depending on a home's configuration. The Home Energy Score rates a home's asset performance on a scale of 1 to 10, with 10 being the best score, and corresponding to the lowest energy use. The rating scale depends on a home's climate zone, but the Score is not adjusted to account for a home's size or age. The generated Home Energy Score report shows a home's potential score if homeowners complete the recommended retrofit upgrades, as well as potential and annual dollar savings if recommended cost-effective upgrades are made. The report provides two types of recommendations: measures to invest in immediately, that are specific to the home, as well as general recommendations for future equipment replacement. All improvements that are recommended immediately have a payback of 10 years or less. Cost information is taken from the National Renewable Energy Laboratory's (NREL's) National Residential Efficiency Measures Database.

CEE's study focused on the use of home energy ratings as a tool to promote energy retrofits in existing homes. A home energy rating provides a quantitative appraisal of a home's asset performance, usually compared to a benchmark such as the average energy use of similar homes in the same region. Home rating systems can help motivate homeowners in several ways: ratings can clearly communicate a home's achievable energy efficiency potential, provide a quantitative assessment of energy savings after retrofits are completed, and show homeowners how they rate compared to their neighbors, thus creating an incentive to conform to a social standard. The authors consider several important issues, including how rating tools for the retrofit market will integrate with existing home energy service programs. For residential programs that target energy savings only, home visits should be focused on key efficiency measures for that home. In order to gain wide adoption, a rating tool must be easily integrated into the field process, demonstrate consistency and reasonable accuracy to earn the trust of home energy technicians, and have a low monetary cost and time hurdle for homeowners. Along with the Home Energy Score, this project also evaluated the energy modeling performance of SIMPLE and REM/Rate™.

Department of Energy Launches New Buildings Performance Database

On June 17, 2013 The Buildings Technology Office of the Department of Energy (DOE) unveiled a new Buildings Performance Database (BPD). The BPD contains actual data over 60,000 commercial and residential buildings. The database includes buildings' location; age; size and function; electricity and fuel consumption; equipment information and operational characteristics. The data can also be used to compare performance trends among similar buildings, identify and prioritize cost-saving energy efficiency improvements, and assess the range of likely savings from these improvements. An application programming interface (API) will allow external software developers to incorporate analytical results from the database into their own tools and services.

The Buildings Performance Database was developed for the DOE's Building Technologies Office by Lawrence Berkeley National Laboratory and

Building Energy Inc. The Department's Office of Energy Efficiency and Renewable Energy (EERE) accelerates development and facilitates deployment of energy efficiency and renewable energy technologies and market-based solutions that strengthen U.S. energy security, environmental quality, and economic vitality. The site launched in March 2013 for test users.

Access the new site at *https://bpd.lbl.gov/*.

R&D 100 Awards Recognize Top New Innovations

Winners of the 2013 R&D 100 Awards, presented by *R&D™ Magazine*, were notified in the first few weeks of July 2013. The Awards recognize significant innovations across many fields, including energy. A selection of 2013 awards appears below.

High-efficiency, cost-effective solar cells

TetraSun, now a division of First Solar Inc., was recognized for developing an innovative cell architecture and manufacturing process that allows for a greater percentage of incoming sunlight to be converted to electricity. The National Renewable Energy Laboratory (NREL) partnered with TetraSun and performed characterization and reliability measurements on the product. NREL also teamed with the company to improve product performance and reliability by developing and implementing modifications to the measured modules.

Beyond altering the cell's architecture for improved performance, TetraSun reduced the typical manufacturing cost by using a more streamlined, simplified process flow. The company also chose to use a metallization process to replace silver with copper, lowering the materials cost.

"There has been tremendous focus on improving cell efficiency and cost in the solar industry. Often, technical advancements that offer efficiency improvements are significantly more complex and costly to manufacture while innovations that serve to reduce cost result in marginal improvements to efficiency," said NREL Senior Project Manager Harin Ullal, in a press release from *R&D Magazine*. "TetraSun's technology is special because it offers improvements in both performance and production cost at the same time."

Leading the team for TetraSun were: Oliver Schultz-Wittmann, Denis DeCeuster, Adrian Turner and Doug Crafts. NREL's team included Harin Ullal, Peter Hacke, Chunsheng Jiang, Richard Mitchell, Mowafak Al-Jassim and Martha Symko-Davies. To read the full release, go to: *http://www.rdmag.com/news/2013/07/nrel-research-earns-three-prestigious-r-d-100-awards*.

Solar Glare Analysis

Among several awards for 2013, Sandia National Laboratories was recognized for its work on the Solar Glare Hazard Analysis Tool (SGHAT). SGHAT addresses new federal guidelines requiring quantified assessments of glare from proposed solar installations. The assessments must quantify proposed impacts on the environment around the installation, including effects on drivers and pilots in the area. According to *R&D Magazine*, the web-based tool can quickly locate a site, outline the proposed array, and identify glare throughout the year, calculating the glare's intensity and size to predict potential ocular hazards. The tool also can predict annual energy production of proposed arrays and evaluate alternative designs, layouts, and locations to identify those configurations that maximize energy production while mitigating glare impact. For further information, go to *http://www.rdmag.com/news/2013/07/sandia-wins-three-2013-r-d-100-awards*.

Universal Smart Window Coating

Chronicled by ***Energy Design Update*** in June 2013 (Vol. 33, No. 6, "In Development"), the Universal Smart Window Coating was invented by a team of Lawrence Berkeley National Laboratory researchers, headed by Delia Milliron of the Lab's Molecular Foundry. The award recognizes groundbreaking research on a new transparent electrochromic film that modulates near-infrared (NIR) solar heat gain without affecting visible light transmission. While traditional dynamic window coatings – photochromic, thermochromic, gasochromic, and electrochromic – can provide a range of solar control, they primarily modulate visible light. LBL's prototype plasmonic electrochromic coatings may offer a unique opportunity to selectively control the transmission of NIR without affecting visible transparency. While this technology enables dynamic control over how much of the sun's heat and light enters a building through its windows, unlike competing technologies, the Universal Smart Window Coating can block heat-producing near-infrared solar radiation without blocking visible light. As stated by *R&D Magazine*, "this independent control is unique in the smart-window market and means occupants can have natural lighting indoors without unwanted thermal gain, reducing the need for both air-conditioning and artificial lighting. The same window can

also be switched to a dark mode, blocking both light and heat, or to a bright, fully transparent mode."

Not only does the breakthrough coating offer unique energy advantages, it is low cost, with minimal power requirements. For more information, go to *http://www.rdmag.com/news/2013/07/berkeley-lab-wins-eight-2013-r-d-100-awards*.

Architects, USGBC Commend Mayors for Renewing Commitment to Green Building and Sustainability

The American Institute of Architects (AIA) and the US Green Building Council (USGBC) on June 25, 2013, commended the US Conference of Mayors (USCM) for passing a slate of sustainability resolutions that renew its commitment to local green building and clean energy efforts that help spur economic savings and protect the environment.

The 10 measures passed include the support of resilient communities, stronger building energy codes, Tiger grants and improving infrastructure. The resolutions represent a powerful endorsement of support for implementing a sound sustainability agenda and were strongly supported and encouraged by AIA and USGBC, which are working together to advance local green building policy as part of their six-year strategic alliance.

"The passage of these resolutions reflect the ardent dedication of all our mayors who are working to revitalize the economy through infrastructure investment and clean energy programs as well as green building and smart transportation improvements," said Paul Mendelsohn, AIA's vice president of government and community relations. "They are taking a smart, integrated approach across all sectors of the economy to drive sustainability, improve health and advance the triple-bottom line."

"Once again, mayors are showing courage and leadership by embracing a strong sustainability and green building policy agenda that helps communities save money, save energy and create jobs," said Jason Hartke, vice president of national policy at USGBC. "As the first responders on the frontlines in the battle to combat climate change, they are seeking out effective solutions and smart public policy that will help strengthen their local economies."

The resolutions that passed this week include:

- #9 Wellness in Real Estate, which commits to promoting buildings that "use a combination of criteria and features that will enhance the well-being of occupants and address growing preventable health concerns and costs."
- #19 Transit-oriented Development as an Economic Growth and Economic Development Strategy.
- #29 Supporting and Advancing Resilient Communities, which commits to "support efforts by communities across the nation to advance sound resiliency policies and programs that (1) identify and plan for the risk and challenges posed by a changing climate, (2) deploy a skilled workforce to modernize critical infrastructure in the energy, communications, buildings, water, and transportation sectors, (3) strengthen the

Table 4

	Manufacturer-Rated Performance		Measured Performance*	
Window AC	Rated Capacity (Btu/h)	Rated EER (Btu/Wh)	Estimated Capacity (Btu/h)	Estimated EER (Btu/Wh)
Frigidaire (…)	10000	9.8	9300	8.9
Frigidaire (…)	10000	10.7	10000	11.5
Haier	5000	9.7	4800	8.8
GE (old)	6000	9.7	3500	4.3
EER = energy efficiency ratio; GE = General Electric				
*NREL is not a certified ratings laboratory, and variation is expected between laboratories and between test articles. Test article performance measured at NREL falls within the expected variation range so is deemed consistent with the rated performance.				

Table 4. Amended and updated data, replacing Table 1, *Energy Design Update*, In Depth, Page 2, July 2013, Vol. 33, No. 7. Test article performance measured at NREL falls within the expected variation range so is deemed consistent with the rated performance. NREL is not a ratings laboratory, and the table data cannot be used to state product compliance or non-compliance.

community as a whole to be a safer, healthier place to live."

- #38 Support to Double the Nation's Energy Productivity.
- #42 Endorsing the Maximum Achievable Building Energy Efficiency Improvements in the 2015 International Energy Conservation Code.
- #50 In Support of the renewal of the Federal Brownfields Tax Deduction.
- #82 In Support of the Federal Historic Tax Credit.
- #95 In Support of a Strong American Infrastructure, which commits to support "efforts by Congress, the Administration, and State governments to upgrade, expand, and strengthen American infrastructure by making the appropriate financial investments and by partnering and coordinating with local governments and stakeholders."
- #97 In Support of Tiger Grants.
- #98 A New Era for Urban Streets and Urban Infrastructure.

These 10 resolutions passed unanimously in Las Vegas this week at the 81st USCM Annual Meeting, which sets the national agenda for US Mayors. Together, the resolutions reflect the ongoing mission of mayors to accelerate investment in green building, promote smart growth, and fortify critical city infrastructure. To view the press release online, go to *http://www.aia.org/press/AIAB099447*.

Corrections & Addendum

Energy Design Update has updated information for Table 1 of our In Depth article, July 2013, Vol. 33, No. 7, "NREL Evaluates Window Air Conditioner Performance." Please see Table 4. The National Renewable Energy Laboratory (NREL) notes that NREL is not a certified ratings laboratory, and variation is expected between laboratories and between test articles. Test article performance measured at NREL falls within the expected variation range so is deemed consistent with the rated performance. NREL is not a ratings laboratory, and the table data cannot be used to state product compliance or non-compliance.

IN REFERENCE

Spring 2013 UT Austin Energy Poll on US Consumer Attitudes

The latest results from the University of Texas at Austin Energy Poll on US Consumer Attitudes were released July 24, 2013, in concert with the US Department of Energy (DOE) Better Buildings Neighborhood Program webcast. Data for the most recent poll was gathered between March 11 and 20, 2013, with 2,113 respondents participating. Responses were weighted to reflect US census demographics. The UT Energy Poll *(http://www.utenergypoll.com/)*, developed by the McCombs School of Business and conducted biannually, seeks to provide an impartial, authoritative look at consumer attitudes and perspectives on key energy issues (see Figure 7). "We want these results to work to improve communication between scientists, policymakers, and the public," stressed Sheril Kirshenbaum, Director of the Energy Poll.

For the March 2013 poll, general topics included energy prices and availability, energy concerns, satisfaction with government, consumer behaviors, and voting preferences. A special hot topic section dealt with consumer attitudes on energy. For the spring 2013, 33% of respondents identified themselves as Republican, 40% as Democrat, with 27% citing other political affiliation. Of respondents, 52% were female, and 48% were male.

When asked who was trustworthy to provide information on how to conserve energy, respondents most frequently cited academic institutions and the scientific community, at 49%. The next highest cited responses for trustworthiness of information related to energy conservation were environmental groups, at 46%, renewable energy companies, at 39%, and the respondent's utility provider, at 36%. Broken down by political affiliation, 39% of Republicans voiced trust in the academic and scientific communities, as opposed to 55% of respondents self-identifying as Democrats. Self-identified Republicans, with 26%, were more likely than Democrats, at 16%, to trust the business community to provide information on how to conserve energy.

The UT Energy Poll has historically asked participants how likely they were to install or purchase energy efficient measures within the next 5 years. The numbers obtained from surveys taken in September 2012 were also compared to responses from September 2011. Forty-five percent of respondents in September 2012 reported that they were likely to use a smart meter versus 28% of respondents in September 2011. Thirty-six percent of respondents in September 2012 reported willingness to purchase a hybrid vehicle, versus 30% in September 2011. When asked whether they would install solar panels in their home, 28% said yes in September 2012, versus 21% in September 2011. When asked whether, in the next 5 years, they were likely to own a fully electric vehicle, 24% of partici-

pants in September 2012 said yes, in contrast to 17% in September 2011. "We're seeing significant increases in the likelihood of participation in various energy conservation and efficiency measures," said Kirshenbaum.

For the March 2013 data collection period, 51% of respondents reported that they were likely to purchase an energy efficient appliance within the next 5 years; 46% said they would purchase energy efficient light bulbs; 38% were likely to improve insulation in their home; 30% would have a home energy audit; and, 21% reported they were likely to install an attic ventilation system or fan.

The results reveal certain patterns through analyzing individual questions via demographic categories. When divided by gender, men and women both reported, at 51%, that they were likely to purchase an energy efficient appliance within the next 5 years. When separated by US region, respondents from the West region were most likely, at 54%, to purchase an energy efficient appliance. The Northeast region was next most likely, at 52%, with the South at 51% and the Midwest at 47%. Divided by political identification, Libertarians, at 57%, were most likely to report plans to purchase an energy efficient appliance within the next 5 years. When grouped by income, people earning more than $50,000 annually more frequently reported willingness to make the purchase.

Applying the same demographic lens to the question, "Are you likely within the next 5 years to improve your home's insulation?", more men than women reported that they were likely to improve insulation in the next 5 years. Regionally, the Northeast and South had the highest likelihood, but responses across US regions were very similar, percentage-wise. Based on political identification, Independents more likely to report plans to improve insulation. Income levels did not differ statistically in their response.

Analysis of the likelihood the respondent was willing to install solar panels in the next 5 years followed a similar pattern. Men were more likely than women to indicate willingness to install solar panels in the near term. Regionally, respondents from the West were far more likely, at 36%, to plan to install solar panels. All other regions of the US reported likelihoods of 24% to 25%. Politically, Libertarians were more likely to install solar than either Democrats or Republicans. Those households making more than $50,000 annually were 6 percentage points more likely to install solar panels.

When asked how likely they were to upgrade to more energy efficient light bulbs, 48% of men and 44% of women reported they planned to. Regionally, 51% of respondents from the West reported they would plan to, versus a low of 42% among respondents in the Northeast. Libertarians were most likely to plan to upgrade lighting, at 59%, versus Democrats at 47% and Republicans at 41% of respondents. There was no significant difference between income levels.

Men, at 35%, were more likely to perform a home energy audit within the next 5 years, while both men and women equally, at 45% and 44% reported they would use a smart meter. Those respondents from the South, and those identifying as Democrats were more likely to perform a home energy audit. Participants with household incomes above $50,000 annually were, at 35%, more willing to perform an audit than those with incomes less than $50,000, at 27%. The Northeast region had the greatest anticipated use of smart meters, at 49%, versus the lowest rate of 39% in the Midwest. Democrats and Independent were more likely to use a smart meter than Libertarians and Republicans. Among demographic trends for anticipated hybrid vehicle ownership, 38% of men and 44% of Libertarians, the highest in their respective categories, felt they were likely to own a hybrid vehicle within the next 5 years. Among respondents with household annual income above $50,000, 41% felt they were likely to own a hybrid, and regionally, the West was again more likely to think they would own hybrid, at 44%, versus 31% in the Midwest.

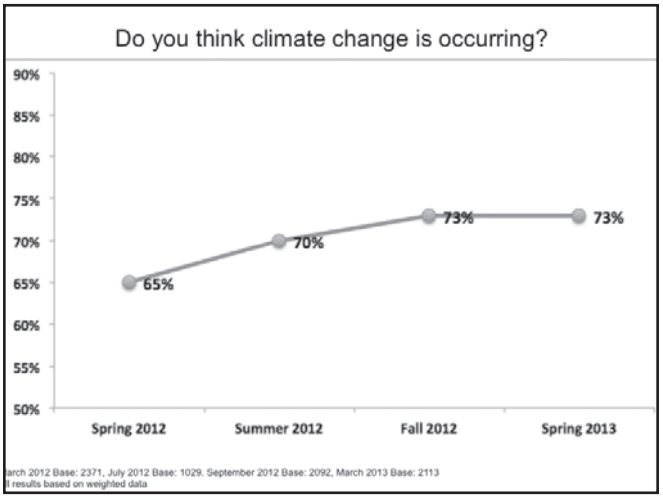

Figure 7. An example of data collected during the University of Texas at Austin Energy Poll on US Consumer Attitudes. Slide from University of Texas at Austin Energy Poll on US Consumer Attitudes July 24, 2013 presentation, Better Buildings Neighborhood Program webcast *(https://www1.eere.energy.gov/buildings/betterbuildings/neighborhoods/webcasts.html)*.

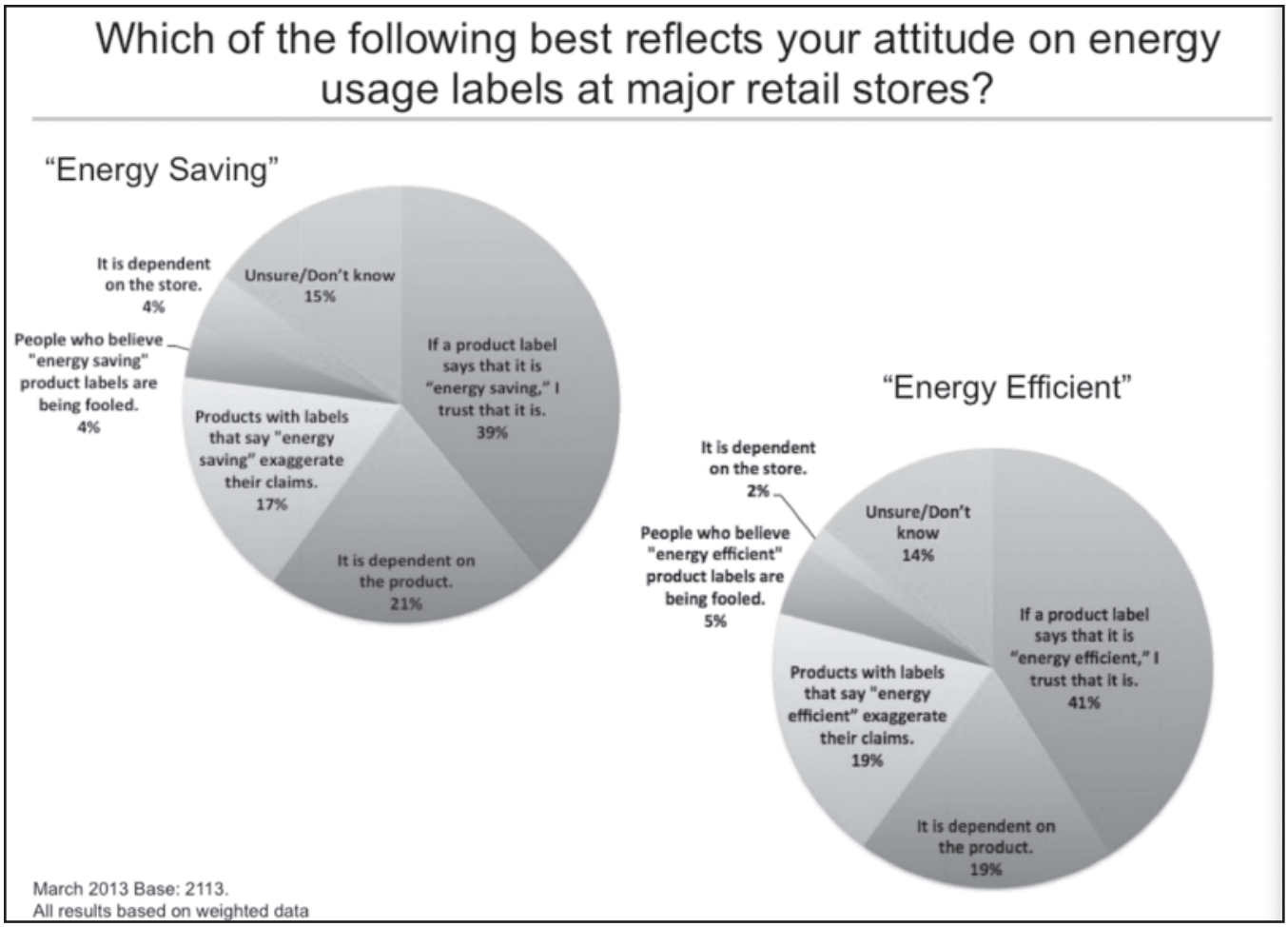

Figure 8. In cooperation with marketing faculty, the University of Texas tested whether labeling something as "energy saving" or "energy efficient" would change survey responses. To help gauge responses to this different phrasing in the Spring 2013 survey, participants were asked, "Which of the following best reflects your attitude on energy usage labels at major retail stores?" Comparative answers appear here. Slide from University of Texas at Austin Energy Poll on US Consumer Attitudes July 24, 2013 presentation, Better Buildings Neighborhood Program webcast *(https://www1.eere.energy.gov/buildings/betterbuildings/neighborhoods/webcasts.html)*.

When asked which of the following is more likely to lead you to reduce your overall electricity consumption, 46% of respondents to the March 2013 survey reported that a significant increase in electricity rates was most likely to motivate them to change behavior. Of those surveyed, 5% would be most motivated to change if they discovered their household used significantly more electricity than their neighbors', 33% of participants said both cost increase and use comparison would motivate them, and 9% said neither factor would motivate them to change.

"We were interested in what would make people change behavior," said Kirshenbaum. Indices that successfully motivate change are important to isolate.

When asked which would shift electricity consumption from the peak period of the day to an off-peak period, 42% said they would be most motivated by a significant increase in rates. Four percent reported that a comparison with their neighbors would motivate change, 31% of survey respondents reported both factors combined would be most motivational, and 13% reported neither rates nor comparative behavior would be most motivational.

"For March 2013 we developed a unique question focused on the impact of language," Kirshenbaum said. "In cooperation with marketing faculty, we tested whether labeling something as 'energy saving' or 'energy efficient' would change survey responses." In The Spring 2013 survey, participants were asked, "Which of the following best reflects your attitude on energy usage labels at major retail stores?" Half of the respondents were asked to identify attitudes related to the term "energy efficient" while the other half were asked the same question related to "energy saving" on a label (see Figure 8). Of the top 3 responses, 41% percent of those presented with the term "energy effi-

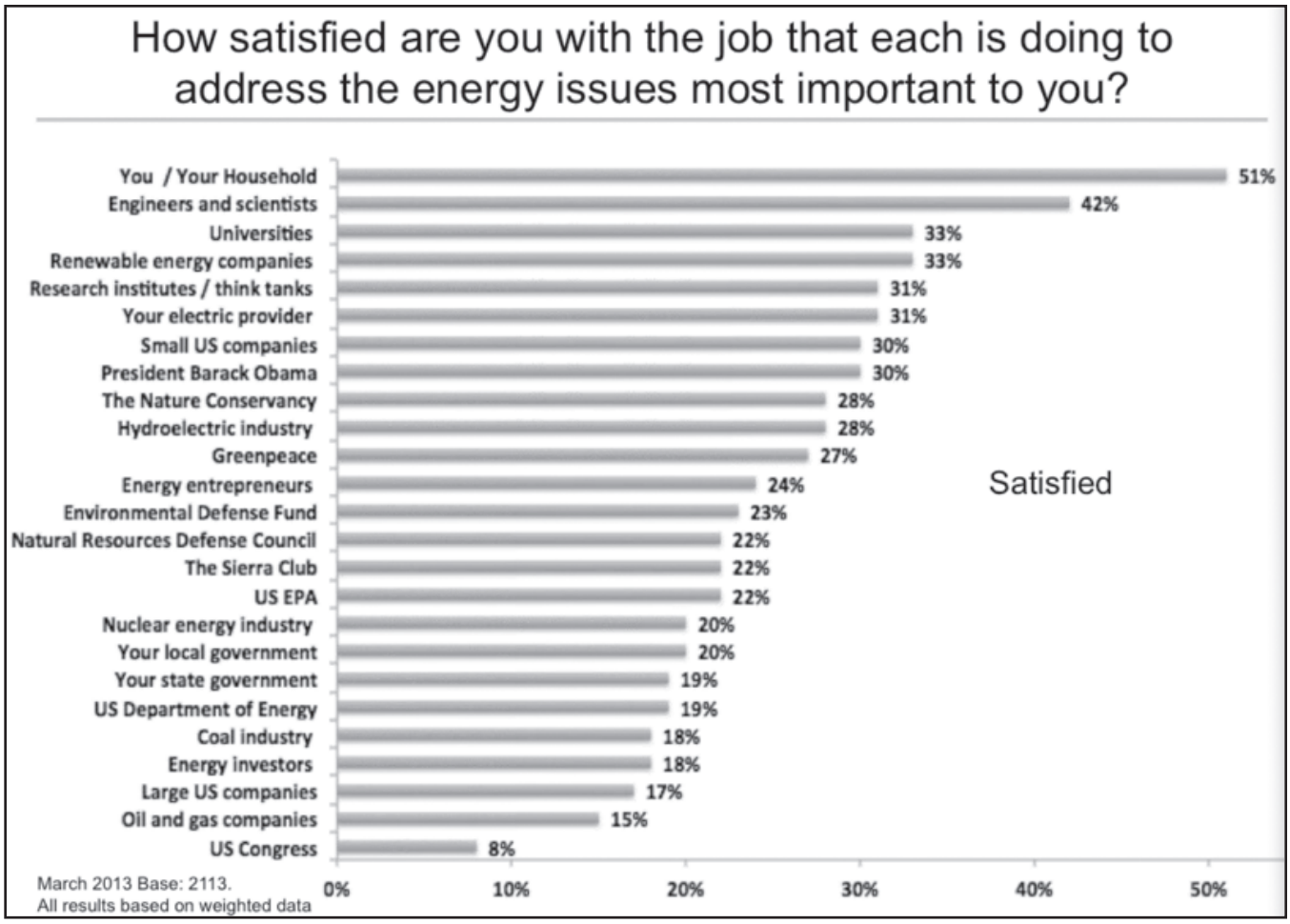

Figure 9. A question from the Spring 2013 survey: "How satisfied are you with the job that each is doing to address the energy issues most important to you?" Slide from University of Texas at Austin Energy Poll on US Consumer Attitudes July 24, 2013 presentation, Better Buildings Neighborhood Program webcast *(https://www1.eere.energy.gov/buildings/betterbuildings/neighborhoods/webcasts.html)*.

cient" felt that "If a product label says that it is 'energy efficient,' I trust that it is." Nineteen percent felt products labeled with energy efficient language exaggerated their claims; 19% said their trust in the statement was dependent on the product, and 14% were unsure. When presented "energy saving," 39% felt that "If a product label says that it is 'energy saving,' I trust that it is," 21% felt it was dependent on the product, and 17% felt the label exaggerated. "Given the similarity in answers, the difference in language did not seem to be effective," noted Kirshenbaum.

Among questions related to energy policy, less than half of the nation thinks that, given current energy policy, choices for affordable clean energy will improve. Broken down by political identification, 54% of Democrats think choices will improve, and 32% of Republicans believe clean energy choices will improve. From the past four polls taken by UT, there has been a slight rise in those who believe climate change is occurring (refer back to Figure 7). Regionally, 78% of those in the South think climate change is occurring, as do 75% of those in the Northeast, 73% of those in the West, and 64% of those in the Midwest. When March 2013 survey respondents were asked what is a significant fact contributing to global climate change, 76% selected deforestation, 66% chose oil, 56% reported coal, and 43% cited natural forces.

A majority of survey takers, 64%, were more likely to support a presidential candidate who supports increased funding for scientific and university research into new energy technology. Sixty-three percent would support a candidate requiring utilities to obtain a certain percentage of electricity from renewable, with 60% supporting a candidate pledging to expand domestic natural gas development and to expand financial incentives for companies investing in renewables. Forty-four percent supported a candidate approving the Keystone pipeline, 40% supported expanding offshore oil development in the Gulf Coast, and 26% supported a position to offer loan guarantees to nuclear power.

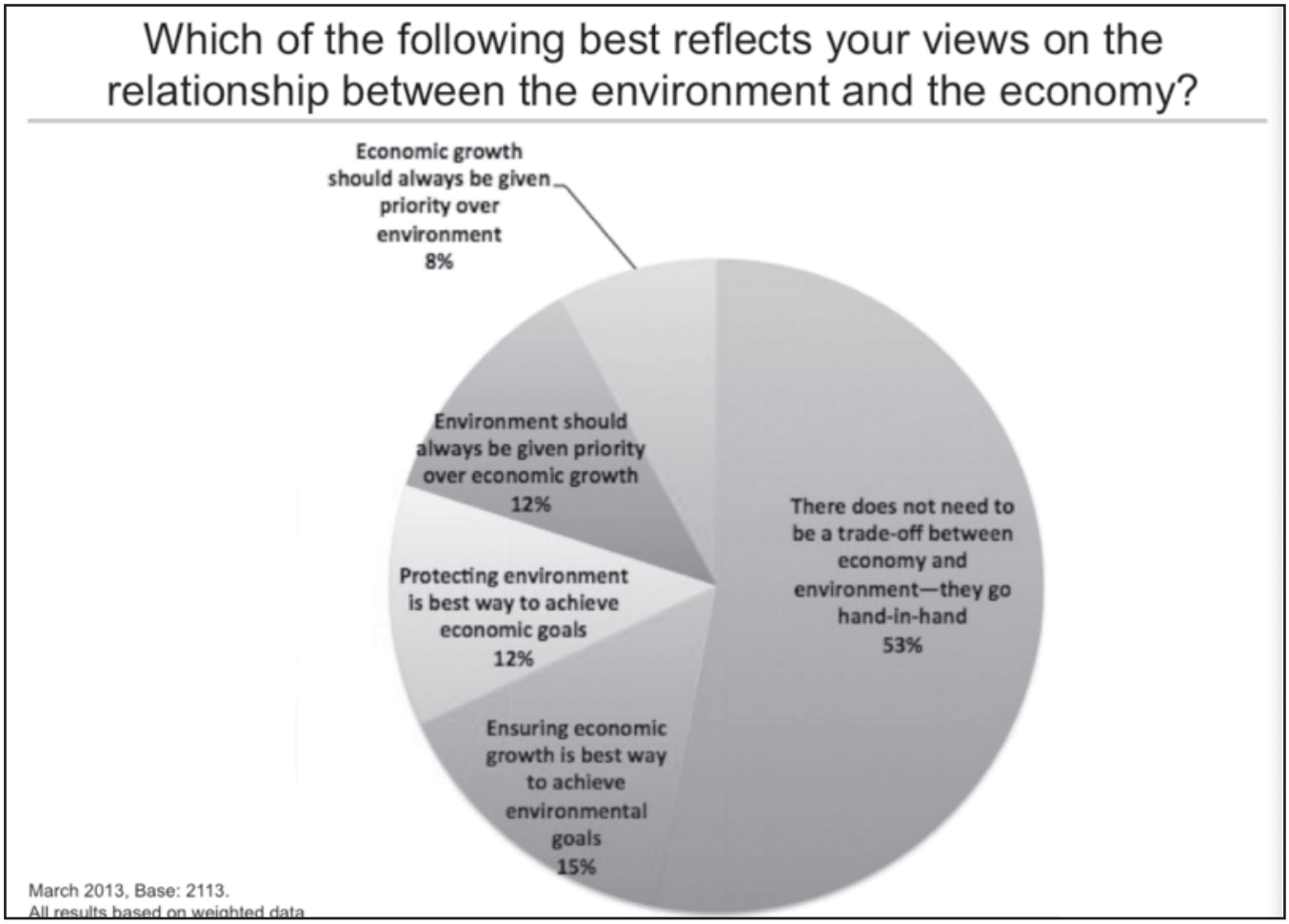

Figure 10. A question from the Spring 2013 survey gauging public opinion on the relationship between environment and economy. Slide from University of Texas at Austin Energy Poll on US Consumer Attitudes July 24, 2013 presentation, Better Buildings Neighborhood Program webcast *(https://www1.eere.energy.gov/buildings/betterbuildings/neighborhoods/webcasts.html)*.

When asked where it is most important for the US Government to spend tax dollars, the top answer was job creation, at 30%, with Social Security at 15%, and military defense at 14%. Spending on environment earned 4% of votes as the top priority for tax dollars, with energy, ranked last, with 2% of the vote. Only 22% of respondents in the March 2013 survey felt the country is headed in the right direction when it comes to dealing with energy issues facing our nation. A strong majority, 68%, felt energy issues are relevant to them, with only 9% responding that they are not relevant. Kirshenbaum noted that renewables, while seen as environmentally friendly, are not identified with job growth the way traditional energy sources are. When asked which benefits they associated with natural gas production, 75% of respondents said job creation, 70% said energy security, and 69% felt it boosted US manufacturing. When asked which benefits are most associated with renewables, 66% said a clean environment, with only 41% citing job creation, 31% citing economic growth, and 20% citing American innovation as a benefit.

When asked how satisfied they were with the job that each group is doing to address energy issues, Congress received only 8% approval (see Figure 9). A majority, 51% of respondents, were most satisfied with how their own household was addressing important energy issues. Rounding out the top five, 42% of participants approved of steps taken by engineers and scientists; 33% supported universities, 33% approved of renewable energy companies, and 31% approved of steps taken by research institutes and think tanks.

The UT Energy Poll also sought public opinion on the relationship between environment and economy (see Figure 10). More than half of respondents, 53%, felt that there does not need to be a trade-off between economy and environment, that they go hand-in-hand. "When respondents were not given that answer option, the economy is prioritized," Kirshenbaum stated. "There is a lesson in messaging there." Fifteen percent of respondents felt that ensuring economic growth is the best way to achieve environmental goals, and 12% that protecting the environment is the best way to achieve economic goals.

When asked to self-analyze their own knowledge of how energy is produced, delivered, and used, 41% of March 2013 respondents felt they were neutral when compared to most people. Just 33% felt they were more knowledgeable than average, with males being more than twice as likely to say that they are more knowledgeable about how energy is produced, delivered, and used. Women were much less confident in their knowledge of energy.

An overwhelming majority – 90% – of survey takers were concerned with the cost of gasoline, 81% were concerned about the cost of electricity, 77% about the portion of their home budget spent on energy, 73% about the consumption of oil from foreign sources, 70% about developing renewable sources of energy, 68% about the depletion of water resources, and 50% about the impact of hydraulic fracturing. Other frequently reported concerns were the energy efficiency of the respondent's home (69%), and the impact of domestic oil drilling and production on the environment (57%).

"We hope the results from the poll can be used to obtain a picture of public perspectives," said Kirshenabum. "Each Energy Poll is a broad, collaborative effort between UT, academic organizations, polling companies, non-government organizations, energy producers, and consumers." First developed in 2010, and launched in October 2011, the poll is now conducted biannually through a third party service to rate leadership on energy issues, measure consumers' energy priorities, and track knowledge and energy consumption behaviors.

For more information, go to *www.utenergypoll.com* or email questions and suggestions to *sheril.kirshenbaum@mccombs.utexas.edu*. To view slides from Kirshenbaum's discussion, go to *https://www1.eere.energy.gov/buildings/betterbuildings/neighborhoods/webcasts.html*.

NREL Field Test Best Practices Website

Field testing is, in essence, capturing and characterizing actual systems performance under real world circumstances. Yet the knowledge supporting effective field testing is more an art than a rote exercise, meaning that the quality of field tests, which professionals rely on for data capture and information feedback, can vary widely. It can be difficult to find good general guidelines, to find examples of well-written field test plans, and to find information on instrumentation options. Because of these difficulties, field tests may take longer and cost more than initially estimated.

"We kept reinventing the wheel," said Lieko Earle, a researcher in the Advanced Residential Buildings group at the National Renewable Energy Laboratory (NREL). "There was no easily-accessible central repository for best practices knowledge, so we were repeating each other's mistakes, or would find ourselves starting from scratch each time we wrote a data-logger program."

The NREL Field Test Best Practices website *(https://buildingsfieldtest.nrel.gov/)*, nominated for a Building America® Top Innovations Award for 2013, was created to step into the breach and compile the best of knowledge in residential field tests, accessible to all (see Figure 11).

Earle elaborated on the nature of the problem the Field Test Best Practices website is designed to address. "I coordinate the field testing effort in our Residential Buildings group, and what we were finding is that, over the course of history of Building America, many people had gained expertise in various areas of field testing, but a lot of this knowledge is the type you can only learn by doing. Instructions on a piece of equipment are accessible, but the art of field testing is almost folklore." This vast knowledge base was scattered across a diverse group of experts throughout the building science community.

The genesis of the Field Test Best Practices website came when NREL began a task of gathering documentation of field test protocols and realized that a flexible web resource was better suited for this type of constantly-evolving information. "We looked at our extensive list of topics, and the more we thought about it, the more we wanted it to be a dynamic resource, not a giant manual," said Earle. "We wanted to adapt to the constant change that is a part of building science, to new methods and new hardware." The NREL team began weighing the website approach. The team sought recognized experts to fill in the blanks as NREL compiled data supporting best practices in residential field testing tools and techniques. "We started asking how to best collect knowledge from others in the building science community," said Earle. "This led to the concept of a dynamic website, where people can get a user log-in to contribute their own content. The concept is similar to the Wikipedia model, but more monitored and facilitated, with an established process for editorial and technical review."

The NREL Buildings Research Field Test Best Practices website, soft-launched in late 2011, offers

detailed information on planning and executing a field test, and selecting equipment, and knowing when and how to use it. Information includes guidelines and examples of well-designed tests (see Figure 12). The site allows for three different angles for finding information: via a chronological approach to field test design that walks people through the steps of each test; through a particular building component, such as a water heater; or by a specific measurement, such as measuring a temperature.

"One unique feature of our website is that content is purposely organized not in the more common tree structure, but rather each piece of content on the site lives by itself, and there are multiple ways to get to that content," Earle stated. "The three different search angles may lead to the same piece of content, depending on the questions asked."

Beginning in Fall 2013, NREL will actively start recruiting users. Development is underway for a facilitated forum for informal exchange among users.

"We are really accelerating our effort to increase content," Earle stressed. "Not everything needs to be written all over again. Our guiding principle is that if this stuff is already documented somewhere, we simply need to link to it from the website. We ask contributors to point to relevant papers, photos, videos, and any other resources. We're excited about our next big thing, the facilitated forum. We think it will be really useful and enhance technical guidance and recommendations between experts."

"The infrastructure is there, the next step is to get people involved," said Earle, discussing what is ahead for the website. "We are looking for input and interaction from building scientists. We want to hear from them on the expertise they have, or the expertise that they feel our site needs. We are trying to fill in the gaps on our site."

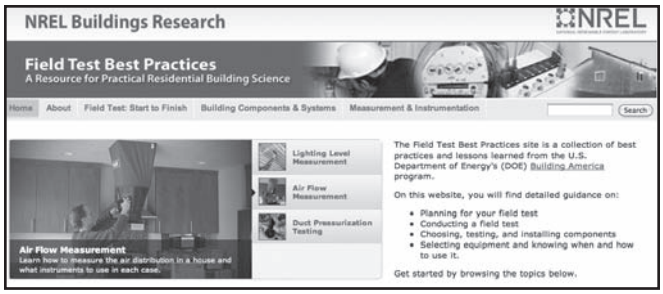

Figure 11. The National Renewable Energy Laboratory's (NREL) Field Test Best Practices main page. To go to the site, use *https://buildingsfieldtest.nrel.gov/*.

Figure 12. NREL Field Test Best Practices website offers detailed information on planning and executing a field test, and selecting equipment, and knowing when and how to use it. From the Home page, a user can select a topic of interest, in this example, "Air Flow," and navigate to that topic page. Information includes guidelines and examples of well-designed tests. See *https://buildingsfieldtest.nrel.gov/air_flow.*

New users can sign up at *https://buildingsfieldtest.nrel.gov/user/register/* for an account. No additional paperwork is necessary. Pictures and PDF files may be uploaded directly; videos and offsite locations can be linked through uniform resource locators (URLs). Emails may be sent to *buildingsfieldtest@nrel.gov.*

How can the building community get involved? "If people go to the site *(https://buildingsfieldtest.nrel.gov/)* and feel like they can add or expand to content, we want to know. We want to make the contribution as easy as possible. We are evaluating how we can streamline the process, make it less intimidating for people to participate. The bottom line is that the more people use it, the more useful it will become."

Energy Design Update thanks Lieko Earle for showing us behind the scenes of the NREL Field Test Best Practices web resource.

Lieko Earle, Ph.D., is a Research Engineer in the Advanced Residential Buildings group in the Buildings and Thermals Systems Center at the National Renewable Energy Laboratory (NREL). Earle's research focuses include Lead on Building America field testing program; laboratory and field-based evaluations of Automated Home Energy Management (AHEM) systems; Non-Intrusive Load Monitoring (NILM) techniques; and, retrofit field studies. Earle specializes in field instrumentation and experiment design; advanced monitoring; sensors and controls for building energy management. Earle may be reached at *lieko.earle@nrel.gov*.