U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING TECHNOLOGIES PROGRAM

Summary of Gaps and Barriers for Implementing Residential Building Energy Efficiency Strategies

2010 Residential Buildings Energy Efficiency Meeting
Denver, Colorado – July 20 – 22, 2010

August 2010

Building AMERICA U.S. Department of Energy

Prepared by the National Renewable Energy Laboratory
For the U.S. Department of Energy Building Technologies Program

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Prepared for:

Building America

Building Technologies Program

Office of Energy Efficiency and Renewable Energy

U.S. Department of Energy

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MEETING BACKGROUND

The 2010 Residential Energy Efficiency Meeting was held in Denver, Colorado on July 20-22, 2010. This meeting summary report captures the key gaps and barriers to implementing residential energy efficiency strategies in the U.S. market identified in more than 25 sessions. The meeting brought together more than 220 professionals in the residential research and outreach industries to present on a wide variety of technical and market transformation topics, with the intent of creating a dialogue about successes, challenges, gaps and barriers in the area of residential energy efficiency.

Participants included:

Affiliated International Management, LLC	La Mirada Homes
Affordable Comfort	Lawrence Berkeley National Laboratory
Alliance for Sustainable Colorado	Levy Partnership
Applied Energy Technology Co.	Longs Peak Energy Conservation
Argonne National Laboratory	Masco Home Services
Arizona State University	Michael Tavel Architects
Black Hills Energy / City of Lincoln	Michigan State University
Blu Homes	NAHB Research Center
Boulder County	National Energy Technology Laboratory
Building Media	National Home Performance Council
Building Performance Institute	National Renewable Energy Laboratory
Building Science Corporation	Navigant Consulting
Built Green, LLC	NCFI Polyurethanes
CDH, Inc.	Newport Partners LLC
CEG/USCM	Newport Ventures, Inc.
Center for Energy and the Environment	NJIT Center for Building Knowledge
Cntr for Resource	Northwest Energy Works
Collaborative Integration	NTA, Inc.
Colorado Division of Housing	Oak Ridge National Laboratory
Confluence Communications	Owens Corning
Consol	Pacific Northwest National Laboratory
Continuum Advisory Group	Panasonic Home and Environment Co.
Davis Energy Group	PDActive
Douglas County	Penn State University
Dow Building Solutions	Populus Sustainable Design Consulting
Easley Associates	Pulte Group
EcoBroker	PVT Solar, Inc.
Ecosphere, Inc.	Quality Built
Energy and Environmental Building Association	ReCurve
Energy Center of Wisconsin	Renewable Funding
Energy Efficiency Business Coalition	RMI

EnergyLogic	RNL
Ferris State University	Rocky Mountain Institute
Field Diagnostic Services	Schweitzer + Associates, Inc.
Flatirons Habitat for Humanity	Sean Smith & Company, LLC
Florida Solar Energy Center	SIPA
Fraunhofer	Solar Spectrum
Fraunhofer Center for Sustainable Energy Systems	Southface
Gas Technology Institute	Steven Winter Associates, Inc.
General Electric	SWEEP
General Electric Appliances	Tempo Mechanical - TexEnergy Solutions
GEO	Tendril
Georgia Pacific	Texas HERO
Governor's Energy Office	The Levy Partnership, Inc.
Green Building Post	U.S. Department of Energy
GTI	U.S. Department of Energy's EECBG Program
Habitat for Humanity of Michigan	U.S. Environmental Protection Agency
Hearthstone Homes	U.S. Green Building Council Colorado
Heschong Mahone Group	UC Davis
Hunt Utilities Group, LLc	University of Colorado
Huntsman	University of Florida
IBACOS	University of Minnesota
ICF International	University of Nebraska
Independent Electrical Contractors	Washington State University
International Code Council	What's Working
iSOLAR1	WSU Energy Program
Johns Manville	YRG
Johnson Research LLC	

The meeting focused on multiyear performance goals associated with the U.S. Department of Energy's Building America Program (and associated residential buildings initiatives), stakeholder requirements, market transformation needs, and collaboration opportunities. The meeting sessions were organized into three tracks of 80 minutes each, with three presenters per session and a question and answer period:

- Track A: Stakeholder Needs and Market Transformation Requirements
- Track B: Innovative Energy Systems
- Track C: Test Homes and Community Scale Projects

Each session was facilitated by a member of a U.S. Department of Energy Building America research team, with the intent of focusing the outcome of the session on identifying key gaps and barriers associated with the session topics. Feedback from the meeting has been documented in this report to be used to help set future research areas, and to identify technology gaps and barriers that hinder the deployment of high performance efficiency measures in both new and existing homes.

MEETING SUMMARY: OPPORTUNITIES, BARRIERS, AND NEXT ACTIONS

Market Transformation and Stakeholder Involvement

Outreach and market transformation activities are critical to the delivery of energy-efficient homes both in the new construction and remodeling market, and stakeholder involvement is a core part of these activities. Stakeholders include consumers, professionals, utilities, government, insurance, educational institutions, and the real estate market. This track focused on presenting successes and challenges in addressing marketing transformation and stakeholder involvement issues, and in providing feedback to guide future research. The following sections summarize the sessions held in this track.

Contractor Education and Certification

Education and certification strategies to ensure properly trained professionals are a key issue in high performance housing. In this session, representatives from Building Media (Craig Savage), the U.S. Environmental Protection Agency's ENERGY STAR® for Homes Program (Sam Rashkin) and the Building Performance Institute/BPI (Jim Fitzgerald) discussed training and quality assurance strategies implemented through ENERGY STAR for Homes Version 3 specifications, a trainer's perspective on contractor education and certification, and certification processes under development through BPI.

The session identified the following key *opportunities*:

- New emphasis on retrofits and energy efficiency creates a greater need for training and new kinds of specific certification.
- New ENERGY STAR specifications have created the opportunity to require full building science training and performance on homes using the ENERGY STAR label.
- These points, along with other market factors, create an opportunity to provide high quality, on-demand training for builders and contractors doing the retrofit work.

The session identified the following key *gaps, barriers and/or issues:*

- Benefits of implementing energy savings are difficult to quantify – need to empirically document the incremental benefits.
- Quality is sometimes sacrificed for cost point – changing that culture is a paradigm shift, a cultural change.
- New government regulations (*e.g.*, EPA Lead Abatement Rule) will cause many difficulties for contractors.
- The structure of the incentive available determines how many retrofit measures people buy. The cost of access exceeds the value of the benefit.
- Information is out there, it's just not getting to the right people.
- Existing content needs to be aggregated, indexed and distributed.
- Compulsory training and certification should be required.

The session identified the following potential *next steps*:

- Develop strategies to train all of the necessary people who will be doing the work.
- Standardize the work that is performed and enforced by everybody on the team.

Financing Energy Efficient Housing

Quantification and financing of energy efficient features are critical to market penetration. In this session, representatives from the Appraisal Institute (Matthew George), Steven Winter Associates (Steven Winter), and the Bank of Colorado (Stephen Ponce-Pore) discussed strategies for increasing underwriters' willingness to finance energy retrofit projects, lender confidence in energy efficient projects, the need for consumer and real estate industry education, issues with appraisal, and energy efficient financing mechanisms.

The session identified the following key *opportunities*:

- Expand building energy efficiency dataset, using pilot projects with closer scrutiny, and to create a shared database for integration with other efforts.
- Use information to quantify energy efficiency more effectively on standard appraisal forms.
- Use public funds to provide permanent mortgage loan discounts.

The session identified the following key *gaps, barriers and/or issues:*

- Lack of reliability in energy savings (lender confidence).
- Energy efficient mortgages have not become popular.
- Energy efficient items are difficult to quantify in appraisals.
- Distinct difference between cost and value in market, driving supply and demand that reduces value of energy efficient features.
- Lack of consistent understanding of "green," and other confusing terms.

The session identified the following potential *next steps*:

- Create continuity in public funding/public support.
- Education/outreach for lenders, appraisers and public.
- Involve banking community in energy efficiency program development.
- Engage appraisal industry with tools that enable them to recognize energy efficient building features and compare similar properties with energy efficient design/features.

Retrofit Safety Requirements

Energy retrofit projects pose unique and significant risks that must be addressed effectively before, during and after construction. In this session, representatives from the U.S. Department of Energy (Julie Hughes), Steven Winter Associates (Lois Arena), University of Illinois at Urbana Champaign (Bill Rose), and Conservation Services Group (Jim Fitzgerald) discussed policy issues in addressing risks in retrofits, an overview of risk mitigation strategies, strategies to identify issues before work begins, and specific examples of risks encountered and resolutions employed during actual retrofit projects.

The session identified the following key *opportunities*:

- Risk is present whenever a retrofit takes place. DOE's Weatherization Assistance Program (WAP) is interested in adding to the "Do No Harm" approach by identifying opportunities to improve the health of a home.
- Retrofit opportunities are being created under the Neighborhood Stabilization Program under the Department of Housing and Urban Development.
- Increased number of energy retrofits will create additional opportunity to reduce other issues in existing homes.

The session identified the following key *gaps, barriers and/or issues:*

- The risks have not been completely mapped and, consequently, the solutions have not been identified.
- Auditors have differing opinions on proper retrofits and fund allocation.
- Estimates provided by retrofit subcontractors are high due to the lack of understanding of the requirements.
- Implementing new home strategies, such as mechanical ventilation, in retrofit applications is challenging.
- Retrofit contractors and subcontractors are not properly trained.
- Electrical code does not properly account for retrofit of cavities with knob and tube wiring.
- Documentation on how to remove lead paint from exterior systems is lacking.
- Energy efficiency retrofits of foundation, crawl spaces, walls in masonry buildings, and roof systems have aspects that need further research.
- Resolving health and safety issues do not have paybacks.
- Wood burning fireplaces cannot be made safe, but people love them.
- Liability issues may exist for someone who performs an audit.

Retrofit safety requirements (continued)

The session identified the following potential *next steps*:

- Assess scope and impact of the health hazards and the consistency in how crews respond.
- Identify the barriers that prevent DOE from remediating health hazards.
- Recommend policy, procedural and administrative solutions that will enable the federal government to address the weatherization and health hazards in more homes.
- Establish enhanced partnerships and referral networks to "braid" available services to allow more homes to be addressed.
- Set up training requirements for contractors.
- Produce training and train-the-trainer materials.
- Provide field testing/monitoring.
- Prepare guidelines on how to deal with electrical issues and paint removal in retrofits.
- Task the Building America (BA) teams to investigate insulation and air sealing in retrofits of the enclosure (foundations, crawl spaces, masonry walls and roof systems) where moisture issues could occur.
- After the research is performed, prepare guidelines on energy retrofit of enclosures with warnings related to moisture issues.
- Investigate easy ways to provide combustion air to mechanical rooms with atmospherically vented combustion appliances.
- Document issues with wood burning fireplaces; prepare guidelines on how to deal with them, including educational materials for homeowner.
- Identify documentation that informs and protects providers from liability issues.

Total Quality Assurance

Complete quality management strategies, systems and tools must be in place for builders and contractors to ensure efficient and effective high performance construction and remodeling projects. In this session, representatives from the National Association of Homebuilders (NAHB) Research Center (Amber Wood), IBACOS (Duncan Prahl) and QualityBuilt (Stan Luhr) discussed new quality management tools, operational models, research findings, strategies for affecting change and case studies of quality management systems.

The session identified the following key *opportunities:*

- Builders and remodelers need help with operational efficiencies and product quality/differentiation that can be addressed by total quality assurance.
- Significant energy improvements are possible, and require total quality management systems to be consistent, particularly in larger organizations.

The session identified the following key *gaps, barriers and/or issues:*

- Builders and remodelers often don't know where to start, and suffer from an inability to change organizational culture.
- Need to clearly define and measure quality with sound building science as a foundation (reference to DOE Builders Challenge Quality Criteria).
- Need to quantify risk in terms of cost/occurrence/legal risk – the industry doesn't understand the full impact of quality.
- Provide education and outreach – the industry needs new perception of quality.
- Checklists are both a good system for consistent level of performance and a liability.

The session identified the following potential *next steps*:

- Thoroughly understand the builder's position.
- Encourage change by both voluntary and mandated initiatives.
- Prove that Building America program work is successful (through measuring energy/money/CO2 savings).

Neighborhood Scale Retrofit Strategies

Successful retrofit strategies must be scalable and applicable to great numbers of homes. However, the variability in our nation's housing stock poses a challenge to creating these "neighborhood" or "community-scale" strategies. In this session, representatives from Performance Systems Development (Greg Thomas), What's Working (David Johnston), Symbiotic Engineering (Tim Hillman), and the National Home Performance Council (Kara Saul Rinaldi) discussed strategies to identify retrofit potential using aggregate utility bill data and other sources, to develop effective high performance building programs that are region-specific, and to address retrofit program barriers through legislative and stakeholder involvement.

The session identified the following key *opportunities:*

- Increasing demand for energy efficient upgrades, quality service and measurable results.
- Community awareness of the need for retrofit.
- Communities and utilities need accurate tracking procedures for efficiency efforts – there's a willingness of utilities to partner with tracking tools.
- Need for quality assurance and contractor training.
- Retrofit contractors/program managers in need of straightforward data transfer protocol.
- Opportunities for communities to become carbon neutral and grow local economies.
- Possibilities to have public/private/government cooperation and collaborative public policy.

The session identified the following key *gaps, barriers and/or issues:*

- Limited access to information (Energy Utility Data) for consumers and contractors.
- Limited funding (for both tenant and contractor).
- Need training, qualification, and accountability for third parties.
- No DOE leadership in standardizing XML data transfer.
- Quality assurance needs improvement.
- Retrofit process has many stakeholders and communication between parties is tedious and complex.
- PACE (Property Assessed Clean Energy) loans have been put on hold: an example of fleeting financing models and mechanisms.
- Need better education for public builders and contractors.
- Need standards for retrofit validation (test-in/test-out).
- Privacy concerns make it easy for utilities to refuse to share data.
- Need quality impacts and feedback for all stakeholders.

Neighborhood scale retrofit strategies (continued)

The session identified the following potential *next steps*:

- Bring stakeholders together in sustainable engagement.
- Create legislation to allow market driven growth.
- Develop a consumer "Right to Know" E-know law.
- Standardize a national average measurement of residential energy (yardstick approach); consideration should also be given to regional assessment.
- Lead development of an open market for residential energy audit tools.
- Estimate savings predictions for retrofits that are crucial for auditors and program-scale efficiency efforts.
- Develop proper financial instruments to fund projects and to get banks on board to free up financing options.
- Locate willing utility partners to help bear costs.
- Establish programmatic leadership in sharing consumption and characteristics data while addressing privacy concerns.
- Develop national standards for building performance to enhance education for all stakeholders.
- Target strategies to capture lowest hanging fruit for energy retrofits.

Homeowner Motivation in Energy Efficiency Investments

Homeowner and homebuyer motivation to invest in energy efficiency varies based on region, demographics and other criteria. In this session, representatives from Sean Smith and Company (Sean Smith), Lawrence Berkeley National Laboratory (Rick Diamond), and the Pulte Group (Walter Cuculic) discussed what motivates homeowners and homebuyers to invest in energy efficiency from a small builder, national laboratory and production builder perspective.

The session identified the following key *opportunities:*

- With savings accounts and CDs lucky to earn 1%-3%, and the stock market's up and down rollercoaster ride over the last few years, selling the benefits of energy efficiency by emphasizing the Rate on Investment should be an easy sell for homebuilders and a no-brainer for homebuyers.
- In most cases, energy efficiency improvements have positive cash flow if financed even over 10 years, let alone 30 years.

The session identified the following key *gaps, barriers and/or issues:*

- Saving energy may be low on the list of priorities when a homeowner decides to make changes to his/her home (usually comes after financial, comfort and other values).
- Homeowners want home improvements to be visible to neighbors and guests, which most energy improvements are not.
- Decisions to make changes to a home usually coincide with major life events (new children, new job, sending children to college, etc.). Policies related to energy retrofits should focus on aligning with personal decisions.
- Too many products are presented with claims of efficiency. Homeowners do not know how to distinguish between truly efficient products and those using efficiency claims solely as a marketing device.
- Homeowners do not want to be overwhelmed with number of metrics telling them how good or bad their homes are with energy efficiency. They need to be provided with a single energy label in a context that they can understand and assign some value to.
- Energy costs and mortgages are presented separately and the value of energy savings is overshadowed by the cost of mortgage payments.
- There is a general lack of funding options for energy efficiency improvements and the existing options are underutilized and still maturing.
- Supporters, such as realtors and appraisers, lack an education in energy efficient homes and have yet to establish a standard method of presenting the benefits of energy efficiency to their customers.
- Coordination between stakeholders to ensure MLS improvements meet collective goals.
- Preparation for, and inclusion of, future programs.
- Education and outreach.

Homeowner motivation (continued)

The session identified the following potential *next steps*:

- Design programs around the people, not the houses. Align energy benefits with homeowner preferences for comfort, convenience, health, functionality, security, economics and control.
- Provide information on retrofit costs and savings to sources that homeowners contact and trust, *e.g.*, contractors, home improvement outlets, etc.
- Start by addressing likely adopters; look at age group, income, and energy usage.
- Continue to investigate the renovation decision-making process in specific populations and contexts.
- Examine the role of contractors and home-improvement providers as information resources.
- Pursue an "action research" strategy with a strong emphasis on measurement and evaluation, and "cross-pollination" between activities.

Key Market Player Motivation in Energy Efficiency Investments

In addition to consumer motivation, key market players such as the real estate industry, trade contractors and energy raters must be motivated to move high performance housing forward. In this session, representatives from Lightly Treading (Paul Kriescher), Association of Energy & Environmental Real Estate Professionals (AEEREP, John Beldock), and GreenWorks Realty and Trails (Ben Kaufman) discussed issues in the real estate market including home ratings and the Multiple Listing Service (MLS), appraisal and energy financing alternatives for retrofits, as well as a discussion of strategies that are succeeding and those that face challenges.

The session identified the following key *opportunities:*

- Retrofits with super quality assurance are building trust.
- Retrofits with turnkey financing are making it work.
- Best contractors are offering performance guarantees.
- In some markets, like Seattle, the green housing market is performing with a price premium.
    - Green houses certified with BuiltGreen, ENERGY STAR or LEED ratings.
    - MLS added check boxes to designate green houses.
    - Green houses are smaller, selling faster and for more money.
    - Certified homes are viewed as more valuable.
    - Recent price gap exists between certified and non-certified homes – *i.e.*, non-certified homes are losing value because certified homes are more desirable.
    - ENERGY STAR homes hold the most value out of all certified homes.
    - Marketing is important – if agent markets house as 'green,' can increase premium by approximately14%.

The session identified the following key *gaps, barriers and/or issues:*

- Energy prices are too low – no motivation to make changes.
- Need to have a team of people for comprehensive improvements – homeowners don't know how to coordinate this.
- Consumers don't know value of audit – energy audits are not advertised well.
- Confusion about rebates/tax credits.
- No value added to the home – appraisers and assessors in CO will not always understand the value of a 'green' home.
- Distrust of the construction/insulation industry.
- Not embracing the 'makeover' concept – don't see reason to change.
- Contractor confusion/education.

The session identified the following potential *next steps*:

- Better educate homeowners on value of green, and educate real estate agents so that they may explain benefits and process of energy audits and the associated ratings.
- Develop MPG type score for homes - a national label could really move the market.
- Ensure that the label and/or other efficiency features are included in the real estate Multiple Listing Service publication.

Incentive and Partnership Programs

Utility program demand-side management incentives and state-sponsored programs provide significant motivation for investment in energy efficiency and renewable energy. In this session, representatives from Building Science Corporation (Ken Neuhauser), ReCharge Colorado (Mona Newton), and the ARIES Collaborative (Emanuel Levy) discussed significant utility program case studies: Building Science Corporation's work with the National Grid Program, and the Research Alliance's work with Pacific Gas and Electric (PG&E) and Sierra Pacific's rebate program, and the state-sponsored ReCharge Colorado program.

The session identified the following key *opportunities:*

- Millions of renovations occur every year and energy efficiency improving measures would be easy to incorporate during renovation. It is difficult to encourage energy efficiency improvements after major renovation.
- Energy retrofit incentive and partnership programs provide the opportunity to:
    - Conduct research and evaluate market development.
    - Create and retain jobs and develop energy resources.
    - Reduce greenhouse gas emissions.
- Factory built homes require different rebate programs, but it is a vastly underserved market.
- Many areas of the country are slow to embrace energy efficiency, but are generally the places and demographics that would benefit the most from lower energy bills.
- Key market players need to be educated on the benefits of energy efficiency to change selling habits for manufacturers and dealers.

The session identified the following key *gaps, barriers and/or issues:*

- Access to information and funding – even if consumers find a rebate that will help them, they may not have enough money to cover the remaining cost.
- Follow through on claiming rebates.
- Retailers must educate and sell buyers on benefits of ENERGY STAR. This is especially difficult since there is tremendous turn over in the manufactured housing industry. Educating sales people can be a futile effort.
- HVAC contractors/installers must complete installation of ENERGY STAR features correctly.
- All homes must be re-engineered to conform to new standard.
- Additional inventory will be required for manufacturers.
- There are limits on the availability of equipment and materials that will be needed to become ENERGY STAR.
- Additional cost for low-income housing.

The session identified the following potential *next steps*:

- Sell rebates more effectively and partner with other programs to promote to improve follow through rates..

Equipment Standards

Significant progress has been made in improving efficiency standards. In this session, representatives from the National Renewable Energy Laboratory (Jay Burch), Building Science Corporation (Armin Rudd), and Lawrence Berkeley National Laboratory (Alex Lekov) discussed new hot water heater test procedures, new appliance standards (recent and future) and suggestions for dehumidification and cooling equipment standards.

The session identified the following key *opportunities:*

- Domestic water heating – 13% of residential use, which increases in percentage as HVAC and envelope efficiencies are gained.

The session identified the following key *gaps, barriers and/or issues:*

- DOE test standards currently have issues.
- Need for supplemental dehumidification independent from cooling in low-sensible-gain houses in humid climates.
- Appliance products gaps:
    - HVAC: hours of operation, installation issues.
    - Water: usage and draw patterns, field performance, interactions, installation costs, venting designs and control strategies.
    - Appliances: field energy use, usage patterns, conditioned space impacts, repair/maintenance, efficiency and consumer preferences.
    - Electronics: field energy use, lighting levels (brightness/controls), power factor and early replacement frequency.

The session identified the following potential *next steps*:

- Develop simulated rating tool and spreadsheet tool to derive detailed specifications and inputs.
- Work on cost reduction of dehumidification equipment and more buy-in from cooling manufacturers.
- Establish more laboratory and field-testing of equipment to develop better maps.
- Develop new performance rating standard for dehumidification equipment.

Innovative Measures (Systems Research)

Advanced systems research focuses on the evaluation of interactions between building components and systems when they are introduced into whole buildings. The evaluation of advanced measures includes a review of cost/performance tradeoffs that improve overall system performance and value while minimizing increases in cost. The evaluation of tradeoff options also includes consideration of occupant comfort, occupant health and safety, building and equipment durability, system reliability, building code compliance issues, and building and equipment maintainability. This track focused on key issues associated with advanced systems in energy efficient housing, with the intent on presenting successes and guiding future research. The following sections summarize the sessions in this track.

Air Infiltration and Ventilation

The theories of air sealing and appropriate ventilation are straightforward – the practices are often not. In this session, representatives from Building Science Corporation (Joe Lstiburek), Steven Winter Associates (Dianne Griffiths) and Pacific Northwest National Laboratory (Subrato Chandra) discussed the practice of air sealing, economical, low-maintenance, durable and effective ventilation strategies and several case studies in both affordable cold-climate housing and production ventilation strategies in hot-humid climates.

The session identified the following key *opportunity:*

- The most important metric is the tightness of the enclosure, not the material or the assembly. Material air resistance is the easiest to measure.

The session identified the following key *gaps, barriers and/or issues:*

- Significant questions exist on the appropriate amount of ventilation that must be answered with a more scientific basis than currently exists.
- Filtration of ventilation air must be addressed.
- Implications of maintenance (or lack thereof) must be addressed, along with the role of air inlets or trickle vents.
- Wider understanding is needed of when and where exhaust only ventilation is (and is not) appropriate.

The session identified the following potential *next steps*:

- Invest in the determination of scientifically valid necessary ventilation rates in both new and existing homes.
- Develop a low cost ERV with own distribution system.
- Evaluate ventilation distribution systems.
- Evaluate exhaust-only ventilation strategies.
- Evaluate what will happen if A62.2 levels of ventilation are actually implemented in hot-humid climates.

High Performance Enclosures

Strategies to build high performance building enclosures have seen significant evolution over the past few decades and have created unique high performance strategies. In these sessions, representatives from Building Science Corporation (Joe Lstiburek and John Straube), University of Minnesota (Pat Huelman), NAHB Research Center (Vladimir Kochkin), Owens Corning (Achilles Karagiozis), and Fraunhofer (Jan Kosny) discussed advanced framing practices and thermal bridging, Structural Engineered Panels (SEP) and external moisture hygrothermal performance of building envelopes, high R-value walls and phase change materials.

The session identified the following key *opportunities:*

- Advanced framing/thermal bridging: Utilizing outside walls with 2x6 framing, 24-inch spacing and insulated sheathing is not new technology, but not widely practiced. This strategy creates opportunities, including:
    - 5%-10% reduction on board footage, saving approximately $1000 to $1500 per home.
    - Faster to construct, because of fewer pieces, after learning curve of 3-7 homes.
    - Reduced thermal bridging.
    - Higher R-value insulation possible.
    - Less drywall cracking.
    - Easier access for electrical and plumbing installations.
- High R-value Walls, main considerations:
    - Structural performance / Wind pressure / Bracing options.
    - Thermal and moisture performance.
    - Air tightness.
    - Construction details.
    - Enhanced durability and removes most risks in retrofit cases.
    - SEP construction results in a very tight, high performance house that is good for wind loads and can be used in any climate.
- Phase change materials:
    - Most of past safety/technical issues have been solved with micro-encapsulation technique.
    - Technology is ready for deployment in BA teams on exterior surfaces.

The session identified the following key *gaps, barriers and/or issues:*

- Previous retrofits efforts in Europe (dealing with IAQ, durability of materials and moisture issues) have had limited success
- Advanced framing/thermal bridging difficulties:
    - Must redraw plans; adjust for added thickness of walls; costs several thousand dollars.
    - Takes three years to make the transition from existing practice.
    - Deployment and implementation issues.
    - Framing crews have well-established methods of construction and are disinclined to modify their process.
    - Customers and marketing are usually in favor of the change.

High performance enclosures (continued)

  - Hygrothermal performance: risk of failure is higher in retrofits due to many unknowns. A deterministic approach may not be able to give accurate results due to many unknowns/uncertainties/non-homogeneous materials.
- High R-value walls, difficulties:
  - Retrofit major issues are related to handling moisture rather than reducing heat transfer through the building enclosure.
  - No metric for air tightness or measure for materials durability.
  - Code issues for cladding attachment of insulation foam.
- Phase change materials:
  - Aluminum package for macro-encapsulation still not reliable.

The session identified the following potential *next steps*:

- Move from deterministic approach to a probabilistic (stochastic) approach to deal with material/weather/workmanship/aging uncertainties in building envelopes.
- Provide guidelines describing when/where you can apply wet insulation (spray cellulose).
- Know seasonal variation of indoor air temperature and relative humidity.
- Document benefits of new R-40 wall system.
- Change building code to ease installation of new wall system.
- Find optimum design/location for phase change materials in high performance homes with R-30 walls and optimize for specific location.

Hot Water

Hot water is one of the largest and most variable residential energy uses. In this session, representatives from Affiliated International Management (Gary Klein), Gas Technology Institute (Neil Leslie), and Applied Energy Technology (Carl Hiller) discussed high performance hot water systems, advanced gas water heating systems, combination water/space heating systems, heat pump water heater technologies and their interactions with whole building energy use.

The session identified the following key *opportunity:*

- The future of water conservation programs depends on getting the structural considerations correct today.

The session identified the following key *gaps, barriers and/or issues:*

- We need systemic thinking to get high performance hot water systems. It is primarily a design, engineering and implementation challenge.
- Need to reduce waste in terms of both energy and waiting time.
- The supply of hot water ends at the fixtures and appliances, not at the customer's meter. We will need to think in the pattern of "begin with the end" uses in mind.
- Most of gas water heating market still driven by minimum efficiencies and natural gas prices.
- Shale gas development drives gas prices lower with more long-term supply. It poses challenges for energy efficiency investment decisions.

The session identified the following potential *next steps*:

- Nationwide recognition needed of source energy in codes, standards and regulations can strongly influence water heating fuel choices.
- Need to explore questions such as: Are heat pump water heater units reliable? Is there adequate testing? Are the infrastructures in place for successful market transformation?

Space Conditioning Systems

Providing high performance space conditioning system strategies and technologies while maintaining occupant comfort, health and building durability has been a significant challenge in the development of high performance building strategies. In this session, representatives from Field Diagnostics (Todd Rossi), Building Science Corporation (Armin Rudd), and Oak Ridge National Laboratory (Roderick Jackson) discussed fault detection and diagnostics for HVAC systems, advanced heat pump systems and results from research houses, and challenges and solutions of humidity control.

The session identified the following key *gaps, barriers and/or issues:*

- Existing systems – difficult to know expected efficiency; need library/database of performance expectations for different makes and models. Manufacturers don't have incentive to provide this information.
- Efficiency index uses some objective measurements/calculations to make a statement about operating efficiency. Needs data from a no-fault model.
- Dehumidification needed when little or no sensible cooling is needed, but humidity needs to be removed. Humidity control has been a corollary to sensible cooling, not a purpose of the equipment.

The session identified the following potential *next steps*:

- Standalone dehumidifier is needed. Conventional cooling equipment is not satisfactory for maintaining healthy indoor conditions.
- Gain a better understanding of factors of occupant behavior leading to moisture load & issues.
- Gain a better understanding of humidity control impacts of sensible heat gain reduction in mixed-humid climates.
- Develop more laboratory and field testing of cooling and dehumidifying equipment to establish better performance maps for simulation models.
- Create new rating standard needed for cooling/dehumidification equipment to aid in proper humidity control design and equipment selection.

Automated Home Energy Management Systems

To make control systems as effective as possible at saving energy in homes, the occupants need to be able to easily operate the control system and the various components and equipment in the home must work well together. In this session, representatives from the National Renewable Energy Laboratory (Lieko Earle), Tendril (Peter May-Ostendorp), University of Nebraska (Jonathan Shi), and Lawrence Berkeley National Laboratory (Richard Brown) discussed automated home energy management systems, goals and issues in system development, utility trends and markets, intelligent controls, interoperability and user-interface challenges and research needs.

The session identified the following key *opportunities:*

- Incentivize promising technologies to increase market awareness and penetration to bring costs down.
- Partnerships with utility programs.

The session identified the following key *gaps, barriers and/or issues:*

- Must combine data acquisition within homes and neighborhoods.
- Behavioral information/questions - people need to know how much they will save and have faith in the information.
- Need to determine how much sophistication people can/will use in Home Energy Management (HEMA) systems.
- Effective outreach to encourage people to opt in to utility programs for peak saving or other HEMA systems.
- Data exists in different forms and sources:
    - Building information in county assessor's office.
    - Energy consumption with utilities.
    - Climate and geographic data online.
- Field data collection and storage.
- Data calibration for quality and consistency.
- Incomplete building envelope information for old homes.

The session identified the following potential *next steps*:

- Gather and aggregate more detailed data.
- Perform effective outreach to improve adoption.

Forced Air Systems

Significant improvements in building enclosure performance have necessitated new strategies to address air distribution, dehumidification and equipment component energy use. In this session, representatives from Lawrence Berkeley National Laboratory (Iain Walker), Ferris State University (Brian Holton), IBACOS (Brad Oberg) and the National Renewable Energy Laboratory (El Hassan Ridouane) discussed blower motor energy use, duct system strategies for new and existing homes, and room air mixing and duct design in low load/high performance homes.

The session identified the following key *opportunities:*

- Better motors should be required

The session identified the following key *gaps, barriers and/or issues:*

- Poor blower efficiency is a barrier to mechanical ventilation due to high-energy use.
- Pressure drop ratings in AFUE and ARI are too low for testing furnace and AC performance. This results in poor prediction of performance.
- Return air systems should be designed and installed with the same concerns as supply ducts.
- Consumer focus on low prices results in poor duct design and installations.
- Difference in incentives between builder, mechanical contractor, building owner and renters.
- Highly competitive market.
- Lack of mechanical inspections.
- Lack of enforcement of existing codes.
- Many installations performed without required permit.
- Many systems sized by rule of thumb (no load calculations).
- High numbers of installations with minimum level of filtration.
- Manual D not up to date with current low flow systems on market.
- Design correlation equations to predict comfort based on operating conditions is lacking.
- Challenging duct applications include: heat pumps, zoned systems, and all units with variable airflows.

The session identified the following potential *next steps*:

- Require better blower motors.
- Verify paths to lowering air handler efficiency:
    - Better motor.
    - Better ducts design, filters.
    - Better installation.
- Avoid single-speed zoning.
- Develop bridge between CFD and whole building energy simulation models.

Onsite Renewable Energy Systems

Solar hot water systems have the potential to meet thermal loads cost effectively, but key market delivery challenges must be overcome. In this session, representatives from the University of Minnesota (Jane Davidson), the National Renewable Energy Laboratory (Tim Merrigan, Paul Denholm), and the University of Colorado (Mike Brandemuehl) discussed prospects for cost reductions in solar domestic hot water, advances in technology that are anticipated to lead to cost-effective heating and cooling systems and substantial energy savings in advanced efficient buildings, break-even cost for residential rooftop photovoltaic (PV) technology and the modeling and testing of full scale, building-integrated PV collectors.

The session identified the following key *opportunities:*

- Need for offsetting fossil fuel energy for hot water, space-conditioning uses.
- Material advancements are making solar more affordable and accessible, and technologies are well developed.

The session identified the following key *gaps, barriers and/or issues:*

- Need for more transparent case studies.
- Need for competent, trained installers and technicians.
- Financial incentives in U.S. are not on par with the international incentives.

The session identified the following potential *next steps*:

- Reach a solar thermal system with a cost of less than $1000.
- Assess space heating potential.
- Develop long term, high-density thermal storage.
- Make solar more cost effective.

Building Codes

In addition to technology, education and market barriers, code barriers provide a significant challenge in the world of high performance housing. In this session, representatives from Building Science Corporation (Joe Lstiburek), Gas Technology Institute (Larry Brand), and the International Code Council (Peter Kulczyk) discussed issues with current codes, ICC evaluation services, GTI testing capabilities and specific issues with gas-fired, high-efficiency space and water heating equipment.

The session identified the following key *opportunities:*

- The International Code Conference offers Evaluation Services (ES) as a mechanism for getting new/unique products approved for use. ES Reports generated by the ICC can be provided to local code official to facilitate their confidence in, and acceptance of, new products. ES Reports are generated from manufacturer's and third-party testing data. Product manufacturer pays the cost of the ES Report.
- GTI laboratories provides infrastructure to test new products and potential changes to the code related to gas burning appliances.

The session identified the following key *gaps, barriers and/or issues:*

- IRC currently discourages construction of walls with exterior insulated sheathing and vinyl siding (no OSB sheathing) due to structural concerns. These walls can only be constructed if a PE stamps the plans.
- ICC does not provide ES-like services for *processes*, only products. (One audience member asked Peter Kulczyk about this, stating that most of their "issues" with code officials stemmed from *process* of assembling/connecting readily-accepted products.)

The session identified the following potential *next steps*:

- Continue to push for code change allowing exterior insulated sheathing with vinyl siding.
- Increase awareness of, and enhance, code support addressing construction details and processes.

Prototypes (Whole-House) Research and Community-Scale Research

Whole-house research focuses on conducting test house research activities to develop the packages of measures required to achieve the targeted whole house energy savings goals in designated climate regions. Test house research activities include: evaluation of overall costs, identification of systems integration opportunities and benefits, as well as barriers and gaps from advanced energy saving technologies and onsite/renewable energy systems, focusing on measures available in the marketplace or expected to be available soon. Community-scale research is focused on extending the successes from individual test house evaluations to a more broad-based implementation.

These tracks focused on core issues and case studies associated with prototype home construction and monitoring, and presenting successful community-scale projects, with the intent of highlighting successes and guiding future research in this area. The following sections summarize the sessions in this track.

How to Monitor Test Homes

Designing, building and monitoring test homes with builder and program partners is a cost-effective, low risk way to evaluate energy savings strategies. Data gathered from these full-scale experimental facilities can be used to evaluate novel and innovative strategies in the real world. In this session, representatives from Oak Ridge National Laboratory (Jeff Christian), IBACOS (Brad Oberg) and the National Renewable Energy Laboratory (Dane Christensen) discussed two significant research home programs – Oak Ridge National Laboratory's Tennessee Valley Authority Retrofit Project, and IBACOS' Research Test House Project – along with successes and challenges with monitoring strategies in these projects, expected impacts and future goals.

The session identified the following key *opportunities:*

- Test homes invite novel approaches and allow for controlled (not occupied) system measurements and experimentation with things that we think should work based on our knowledge of building science. But, there is risk of failure. It is possible to run systems to point of failure.
- Simulation can help introduce options that you can't do in the real home.

The session identified the following key *gaps, barriers and/or issues:*

- Short-term testing has limitations - weather can't be controlled, and system could be incorrectly installed.
- Measurement challenges - HVAC supplied load, envelope R-values, ground heat transfer, ground moisture content, condensate flow rate, multifamily infiltration, load-disaggregation, and human behaviors.

The session identified the following potential *next steps*:

- Demonstrate to homeowners that energy efficient renovation is a good investment.
- Lower the cost for improving insulation in attics, crawlspaces, basements and ducts.
- Establish guidelines for homes /homeowners life stage retrofit optimization.
- Need home to interface with smart grid -- need to partner with willing utilities.
- Distinguish prototype houses (should achieve 50% energy efficiency savings) vs. lab houses (experimental systems and strategies).
- Occupants are key in prototype homes (real people affect monitoring results); focus on monitoring strategies.

Statistical Variability in Occupants, Evaluation Strategies

Performance data from large projects can be used to establish annual residential energy consumption baselines suitable for evaluating the impact of residential energy efficiency strategies and programs. In this session, representatives from the Florida Solar Energy Center (Eric Martin), ConSol (Rob Hammon) and the University of Florida (Pierce Jones) discussed monthly utility bills combined with property appraiser data to offer the opportunity to directly quantify household energy consumption patterns, dataset and sampling requirements, data automation and aggregation. They also presented a case study of evaluating/maximizing energy savings in a near-zero energy community.

The session identified the following key *opportunities:*

- Regression models, combined with appraisal information, can be developed as an alternative to building modeling in order to predict household energy consumption.
- House monitoring and questionnaires can verify energy savings of the Building America program and/or individual technologies.
- Energy efficiency within a community of houses can demonstrate significant reductions in peak electric load for utilities; this increases the value of energy efficiency.
- Availability of utility bills can provide rich data for improving our analysis methods.

The session identified the following key *gaps, barriers and/or issues:*

- The Paperwork Reduction Act requires OMB to approve of direct contact with homeowners when dealing with more than 10 participants. This makes it challenging to conduct interviews, audits and monitoring.
- It is difficult to actively recruit homeowners for participation in home evaluation programs, even with monetary compensation. (Three out of 115 homeowners responded to FSEC participation letters.)
- Measured household consumption can be dramatically impacted by external factors (like the 2008 economy), skewing predictions of energy use and savings.
- Utility bill predictions can significantly differ from actual consumption without additional housing characterization (some homes have second fridge, electric range instead of gas, energy-intensive hobby/business, pools, etc.).
- It can be difficult to perform analysis with control and non-control groups of houses due to inherent differences in occupants (*e.g.*, ZEH homes may tend to have wealthier, higher educated, more experienced homeowners than standard construction).
- Utility data can be difficult to obtain or incomplete.

The session identified the following potential *next steps*:

- Determine if the Building America program will receive program-wide, blanket OMB approval for basic homeowner questionnaire or program participation; or, if the process can be otherwise streamlined to facilitate characterization of the existing housing stock.
- Additional technologies related to occupant behavior should be evaluated in homes and communities such as: demand response, smart grid appliances and home energy management systems, etc.

Differences in Utility Bill Data vs. Simulations

The inherent differences between individual building performance simulations and the actual performance of large numbers of occupants in real buildings create a challenge for accurate comparisons between the two sets of data. In this session, representatives from the National Renewable Energy Laboratory (Craig Christensen), Fraunhofer (Kurt Roth) and Populus (David Neiger) discussed potential sources for discrepancies between software predictions and actual energy use. The representatives also discussed the utilization of energy simulation to analyze existing homes, including the challenges associated with accurate data collection and the limitations of energy modeling tools in characterizing conditions as assessed in the field.

The session identified the following key *gaps, barriers and/or issues:*

- Over-prediction may arise from the fact that existing homes energy savings predictions are a bit of a niche market; most commissioned energy modelers work in commercial buildings.
- Traditionally, software has been used for equipment sizing, commercial buildings and new buildings.
- Sizing/design analysis focuses on "worst-case," design conditions, where safety factors are often built into the assumptions; some of these assumptions have been carried over through the transition to energy savings predictions.
- Perception and some evidence exists that software over-predicts energy use and savings in older homes.
- BESTEST-EX does not require automated calibration.
- Calibration may not improve predictive power of models.
- Traditional sizing/design approaches assume "worst case" scenario and many of these assumptions have been translated into existing homes analyses.
- Current tools do not reliably predict:
    - Pre-retrofit energy use.
    - Retrofit energy savings.

The session identified the following potential *next steps*:

- Gather more accurate information about end-use consumption.
- Evaluate very large variation in occupant behavior from one house to another.
- Determine how occupant behavior impacts design option selections.
- Create energy savings opportunities from encouraging energy-saving behaviors.
- Consider new analysis approaches such as "investment under uncertainty analysis."
- Identify potential sources of discrepancies.
- Investigate/ resolve modeling issues.
- Validate improved inputs/models against field data.
- Develop analysis best practices.
- Update standard test procedures.

Climate-Based Case Studies

This climate-based case study track examined both new construction and retrofit projects (both individual prototype and community scale projects) in all climate zones. Case study presentations can be found on the Building America Web site here: http://www1.eere.energy.gov/buildings/building_america/test_homes.html.

This track identified the following key *opportunities:*

- Create energy efficient prototype home with a builder that uses some unique methods and serves to determine the effectiveness of simulation in that situation.
- Partners are getting better with experience and teaching communities about the benefits of deep energy retrofits.
- Some contractors are using pre and post retrofit monitoring along with a money back guarantee to boost sales of retrofits and have seen positive response from homeowners to this business model.
- For a long time we've been complacent; now, retrofits are a big priority for energy savings. Currently saving 15%-20% not enough.

The session identified the following key *gaps, barriers and/or issues:*

- Consumer not that interested in the incremental upgrade to 50% efficiency.
- In one case study (NAHB Research Center), steel frame construction tended to create significant thermal shorts in the wall assembly. More data analysis was needed to reconcile the weather differences between the simulated year and the measured year.
- Occupant behavior in multifamily student housing is a big unknown and will greatly affect the outcome.
- Simulation Accuracy for very tight buildings.
- High cost of U-0.15 or better windows.
- Need for small capacity heat and cooling systems.
- Uncertainties about zonal comfort in low load buildings.
- Large discrepancies between energy modeling tools for Passive House vs. Building America.
- High efficiency equipment has a larger footprint and may not fit where the old equipment was kept.
- Programmable thermostats were often too complex for homeowners.
- Inadequate attention paid to attic ventilation when improving attic insulation.
- Inadequate labeling on white shingles and roof coatings.
- Lack of consensus on how to integrate flashing with the drainage plane around windows.

Climate-based case studies (continued)

- Habitat for Humanity challenges:
  - Air infiltration
    - Air sealing.
    - Split level knee wall sealing.
    - Chimney chase air sealing.
    - Blower door didn't work because the homes were unable to be pressurized due to broken windows.
  - HVAC challenge
    - Cost is too big to fully evaluate.
    - Duct sealing is difficult.
    - Sizing systems is an additional cost.
- Builders are up against a lot of hurdles.
- Architects have limited knowledge on energy efficiency.
- Subcontractors are difficult to work with.
- Suppliers have limited information about and supply of required equipment.
- Housing costs often dwarf energy savings.
- Cost of closed cell foam.
- Complexity of solar-thermal system.
- Market need for small inexpensive packaged ERV.
- Typical home performance audits cost $500-$900 (in Great Lakes area), and performance audit is a non-value added activity (audit itself doesn't improve home performance, consumers must pay for retrofits after audit).

The session identified the following potential *next steps*:

- Develop system of mass scale new home construction without testing every home. Include QA and QC in the home-builder process to replicate the building efficiency on a larger scale. More exterior foam insulation would help with the thermal shorting issue.
- Create a multi-family tenant billing strategy, with a fixed monthly bill and a penalty for excess usage (*e.g.,* $/100 kWh). Attacking miscellaneous electric loads through one-switch, energy displays, education, and building competitions.
- Refine building simulations for very tight enclosures.
- Lower the cost of high performance windows.
- Improve the process of assessing the retrofit enhancements recommended by Habitat.
- Enhance effective volunteer communication with Habitat volunteers (this includes comprehensive training especially in air sealing).
- Determine how to effectively evaluate HVAC system in Habitat homes (especially when it is appropriate to upgrade the systems).

Climate-based case studies (continued)

- Establish a retrofit Benchmark evaluation procedure.
- Increase reliable equipment for upgrades, so that upgrade effectiveness depends less on experience of the worker (*i.e.,* get rid of spray foam) . Find more fail proof technologies for implementation.
- Create national level of standards.
- Improve low load HVAC distribution and comfort, insulation sheathing for seismic zone D_1 &D_2, low U-value – high SHGC windows (harder to find and more costly), cold-climate heat pump water heater (parasitic load, not as efficient), resistance to change and innovation, need better solar thermal infrastructure (design and installation).

Conclusion/Next Actions

The Fall 2010 Building America Research Planning Meeting will be held November 2–4, 2010 with the objectives of:

- Coordinating lab research activities
- Reviewing and update multi-year plan (MYPP) and developing detailed R&D plans
- Reviewing key milestones
- Kicking off new technical working groups.

Location:
DOE Headquarters, Forrestal Building, Washington, D.C.

Key Audience:
- Team leads
- National labs
- DOE.

PROGRAM BACKGROUND

Building America is part of the U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy (EERE), Building Technologies Program (BTP). Building America focuses on conducting the systems research required to improve the efficiency of the 500,000–2,000,000 new homes built each year, as well as the approximately 116 million existing homes.

Building America research accelerates the development of reliable and effective whole house packages of measures for highly energy efficient new and existing homes that are tailored for each major U.S. climate region and can be implemented on a broad basis, while also reducing risks, increasing durability, and providing a reasonable return on investment. These improvements are accomplished through multi-scale research, systems development, systems integration, large-scale field implementation and evaluation, and effective communication of key research results and system-based strategies. The near and long term performance targets for Building America are being updated to reflect current economic, grid integration, energy, and carbon-reduction performance targets, as well as to provide technical support for new residential initiatives including the Recovery through Retrofit Program.

In July of 2010, the U.S. Department of Energy announced the formation of 15 research and deployment partnerships to help dramatically improve the energy efficiency of American homes, through the Building America Program. These highly qualified, multidisciplinary teams will work to deliver innovative energy efficiency strategies to the residential market and address barriers to bringing high-efficiency homes within reach for all Americans.

Visit the Building America Web site for detailed information on Building America teams, partners, builders, and suppliers: www.buildingamerica.gov.

ABOUT THIS REPORT

The gaps and barriers identified in this report do not represent the opinion or positions of the U.S. Department of Energy (DOE) or the National Renewable Energy Laboratory (NREL), and NREL and DOE do not necessarily agree with all of the points made by the meeting presenters. This report is not intended to be a complete summary of important gaps and barriers, but to address a small segment of key topics that were chosen for the meeting agenda.

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