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

BUILDING TECHNOLOGIES PROGRAM

Summary of Prioritized Research Opportunities

Building America Program Planning Meeting
Washington, D.C. – November 2-4, 2010

February 2011

Building America
U.S. Department of Energy

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

Summary of Prioritized Research Opportunities

Prepared for:

Building America

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in collaboration with Newport Partners, LLC

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Executive Summary

The U.S. Department of Energy Building America Program (www.buildingamerica.gov) is a private/public partnership that conducts systems research to improve overall housing performance, reduce energy use, increase housing durability and comfort, and increase energy security for America's homeowners. Research program activities focus on cost-effective solutions for new and existing homes. National laboratories, building science teams and other stakeholders meet three times per year to update, inform, and plan research and development.

This report outlines the results of brainstorming sessions conducted at the Fall 2010 planning meeting, in which Building America teams and national laboratories identified key research priorities to incorporate into multi-year planning, team research agendas, expert meetings, and technical standing committees. Key findings include research priorities for systems and measures—foundations, walls and windows, attics and roofs, space conditioning and hot water, lighting, appliances and miscellaneous electric loads and home energy management—as well as pathways analysis, test homes and pilot communities, and implementation tools.

Background

Since 1995, the U.S. Department of Energy (DOE) Building America Program, an industry-driven research program, has worked with national laboratories and building science research teams to accelerate the development and adoption of advanced building energy technologies in new and existing homes. The research teams conduct systems engineering research to:

- Develop retrofit strategies for existing homes that achieve significant energy savings and ensure the safety and qualify of homes
- Produce new homes on a community scale that use on average 40% to 100% less energy while improving indoor air quality and comfort; helping homebuilders reduce construction time and waste; implementing innovative energy and material-saving technologies; improving builder profitability; and providing new product opportunities to manufacturers and suppliers.

Historically, DOE held quarterly meetings in Washington, D.C., to review projects, plan research and coordinate with internal and external research and technology development initiatives. Beginning in 2010, with the addition of 10 new building science research teams, the National Renewable Energy Laboratory (NREL) and DOE will hold three Building America meetings each year. Each of these meetings will have a different focus:

1. Building America Stakeholder Meeting—Spring: At this event, industry stakeholders will have the opportunity to inform the residential research and outreach community about key issues needed to advance residential energy efficiency. Presentations will focus on product development, in-field application, and market delivery strategies. The first of these meetings will be held on March 16-18, 2011, in Atlanta, Georgia.
2. Residential Energy Efficiency Meeting—Summer: The purpose of this meeting is to gather U.S. building industry leaders to present the state-of-the art technologies and practices in residential energy efficiency. The first of these meetings was held in Denver, Colorado, on July 20-22, 2010. The report, *Summary of Gaps and Barriers for Implementing Residential Building Energy Efficiency Strategies*[1], outlines key gaps and barriers to implementing residential energy efficiency strategies as identified at this meeting.
3. Building America Research Planning Meeting—Fall: This is a closed meeting for Building America research teams and national laboratories to identify research needs for preparation of annual and multi-year plans. This report summarizes the results of the first of these meetings, which was held on November 2-4, 2010, in Washington, D.C.

This report outlines the results of brainstorming sessions conducted at the Fall 2010 planning meeting, in which Building America teams and national laboratories identified key research priorities. The participants had the benefit of reviewing the “Gaps and Barriers” report from the Summer 2010 meeting. For the brainstorming sessions, the teams were broken into smaller groups to identify research opportunities that could meet short and long-term Building America goals. The results of these sessions will be incorporated into multi-year planning, team research agendas, expert meetings, and technical standing committees.

[1] http://www.eere.energy.gov/buildings/publications/pdfs/building_america/49162.pdf

Key Findings and Cross-Cutting Issues

The following key research topics arose as priorities in more than one session:

Systems and Measures: Make them smarter, more durable, and able to leap tall knee-walls in a single bound

- Foundations
  - Develop and test retrofit moisture control strategies
  - Improve tools and models
  - Investigate and categorize existing foundation conditions
  - Develop and test energy-saving foundation strategies for new/existing
- Walls and Windows
  - Understand process for insulating and air-sealing existing walls from the outside, inside, or middle
  - Develop solutions for insulating and air sealing inaccessible places
  - Develop retrofit window and cladding attachment solutions
  - Develop solutions for exterior thermal and moisture management in foundations and mass walls
- Attics and Roofs
  - Develop solutions for insulating unvented flat or low slope roofs
  - Address quality control, condensation and water intrusion when converting conditioned space and attic knee-walls
  - Study durability of foam insulation
- Space Conditioning and Hot Water
  - Develop distributed space conditioning strategy
  - Explore air-based central space conditioning retrofits
  - Study and document IAQ control and ventilation strategies
- Lighting, Appliances and Miscellaneous Electric Loads
  - Develop smart cooperative controls and demand response for LAMELS
  - Establish baseline for MELS energy consumption (issue of variability)
  - Improve feedback and visibility
  - Target an increased number and type of regulated products
- Home Energy Management
  - Develop life cycle home management solutions
  - Study home automation system development and integration in the field
  - Standardize communications
  - Develop “responsive” homes

Pathways Analysis: Data, Data, Data

- Develop standards and protocols for data collection and exchange (data fusion, data-mining, and data granularity) to better predict savings and improve tools
- Develop protocols for assessing common errors
- Address modeling gaps (e.g., hygrothermal)
- Develop a standardized vocabulary

Test Houses and Pilot Communities: HU4&Y (Who? For? & Why?)

- Develop the cost-effective and accurate "Drive-By Audit" and prioritize home attributes to determine if a blower door is necessary
- Develop self-assessment tools (DIY Smart Phone Audit; photogrammetry)
- Testing and monitoring equipment that is better, faster, more accurate
- Test for concealed system evaluation and characterization
- Streamline and reduce time to test-in / test-out (energy, health and safety, comfort, durability, IAQ)
- Develop a macro/community scale model for portfolio analysis

Implementation Tools: What is the value proposition?

- Develop better customer interaction and feedback tools
- Develop and continually improve handbooks, guides and training
- Map the value stream, document business models and best practices and determine information delivery mechanisms

Participants

BA Coordination (NREL)

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Michael Gestwick
Stacey Rothgeb

Facilitators (Newport Partners)

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U.S. Department of Energy

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Ed Pollock
Sam Taylor
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Building America Teams

	Team/Institution
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David Springer	ARBI/Davis Energy Group
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National Laboratories

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Max Sherman	Lawrence Berkeley National Laboratory
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Roderick Jackson	Oak Ridge National Laboratory
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Marye Hefty	Pacific Northwest National Laboratory
Marylynn Placet	Pacific Northwest National Laboratory

National Laboratory Research Planning: 50%+ savings levels (Tuesday AM)

Opening Remarks

David Lee (DOE) welcomed the national labs and noted that the retrofit goal is 1.3 million homes by the end of 2013.

- Building codes – cost justification of code goals
- Not funding behavior studies before coordinated effort at higher level could be achieved.
- Important to know where money has gone and what the deliverables are.
- Lab reviews will start happening soon.

Laboratory White Papers

Marcus Bianchi presented the format and use of the white papers.

- Template follows format from July meeting. Three streams of information will feed into the multi-year plan
- Inventions are not short term solutions
- Suggested addition to template – recommendations (maybe under opportunities)
- Suggested addition to template – stakeholders and partners
- Suggested addition to template near term action items – could be under multi-year milestones
- End of Nov. – 1st draft – submitted to NREL; End of Dec – final draft; Input and feedback between drafts
- ARRA money – issue is getting it on the streets
- How does it fit into markets?
- 10 page estimate – long won't be read
- Multi-year milestones – cost and effort – define milestones relatively
- R&D questions – by topic – would make sense to have a short definition with each item to convey what is meant.
- Overlap is fine
- Teams are not doing white papers – brainstorming exercise instead to identify questions to answer.

LBNL's White Papers

Max Sherman presented LBNL's white paper topics:

- One paper on MELs; one on deep energy retrofits – have an outline; one on residential indoor air quality – Healthy Efficient Homes – funded by DOE/EPA/HUD – have already completed paper on this (needs to be reformatted)
- Deep energy retrofit – case study (started as part of 1000 homes project) – providing tech input and monitoring and analysis. Working to transfer the knowledge and lessons learned.
- MELs – two tracks. Field methods for assessing energy use of MELs in the field. NREL doing work on automated home energy management systems. Better understanding the problem and develop methods of assessment. Develop control strategies – a lot of work to be done. Needs coordination between emerging technologies and other areas.
- IAQ – trying to find health based approach in looking at ventilation. Feeds into BetterBuildings and the recovery through retrofits concept.
- The overall goal of white papers is to build synergies
- Combustion is being addressed in deep energy retrofits by eliminating atmospherically vented combustion equipment.

- Combustion more broadly is a bigger concern in IAQ. Contaminants are a longer concern.
- Kitchen equipment – may not be as big a deal – need to ventilate.

ORNL's White Papers

Jeff Christian presented topics for ORNL's white papers:

- Deep energy retrofits
- HVAC
- High performance envelopes (walls, foundations and moisture)
- Envelope materials
- Smart grid – makes a lot of sense with electric utility as a major sector to carry on retrofits after ARRA funds
    - Have smart meters in whole Campbell Creek neighborhood (30 plus homes)
- HVAC – sizing, capacity, thermal distribution, sealing and insulation
- Deep Energy Retrofits
    - Validation of energy audit software
    - Quantification of energy savings with priority list of measures
    - Partnership models
    - Integration of emerging techs into energy audit and simulation software
    - Remodeling opportunity for energy retrofits
- Heat pumps and AC for new and retrofits
- 2x4 walls is king in zone 4, IECC 2012 changes will force market to 2x6 walls, which is significant
- Look beyond thermal in envelope materials
- How is cost-effective defined? – 10 year loan at 6% for incremental cost.
- Payback needs to be apart from what would be done for maintenance
- Homeowner motivation may be different than DOE cost effectiveness definition
- Utility motivation is different.

PNNL's White Papers

Michael Baechler and Subrato Chandra presented PNNL's white paper topics:

- Solid State Lighting
- High R windows volume purchase
- Commercial building partnerships and energy alliances
- Developing technology and seeing market transformation at the end – there are gaps in between
- Defining metrics in a common way
- Consistent vocabulary
- Focus limited research on leverage points to overcome barriers in the market and influence the market
- Tasks under manufactured housing column could be applicable to any housing
- Lab homes – What are non-economic benefits? Enhancing comfort.

National Laboratory Research Planning: Brainstorming 50%+ savings

Ren Anderson introduced the brainstorming process. He noted that the brainstorming will provide guidance to the development of the Multi-Year Plan (MYP). Details can be adjusted as the program moves forward. The IECC 2009 is new construction benchmark. Reports will be run out in a formal peer review process. He also stated that actual savings depend on the starting point for individual projects. After this opening, representatives from NREL, ORNL, PNNL and LBNL brainstormed and prioritized topics for research and development to achieve 50%+ savings levels. They voted and identified gaps and barriers to the top three priorities. These gaps and barriers represent research opportunities.

Gaps and Barriers for Prioritized Research Opportunities

Smart cooperative controls for MELs

- Interoperability standards (manufacturer resistance)
- What energy-using appliances and devices do people have and how do they use it?
- Education gap in consumers use of energy
- Fire and safety issues
- Yet to be incorporated into products (tech transfer / market adoption)
- Few designs of chips are smart enough to accomplish cooperative controls and be used in many products
- Feedback devices – usability and customer acceptance/demand elements
- Smart Grid barriers include a lack of utility acceptance, implementation, and an understanding of what it will eventually look like
- Hardware – need device that doesn't draw energy but can wake up on a signal – or parasitically powered (vibration, thermal, inductive, light, etc)
- Increasing saturation of MELS.

The Drive-By Audit - Low cost automated integrated accurate diagnostic energy audit

- Less intrusive and less expensive measurement diagnostic techniques
- Tension between accuracy and expense
- Accuracy in general
- Individual privacy
- Consumer has to opt in (targeted via monthly loads/utility bills?)
- Benchmark data
- DIY with Smart Phones
- Distinguish between technology and behavioral components of loads (Asset vs. Operation).

Exterior thermal and moisture management in foundations and mass walls

- Aesthetics
- Access
- Application
- Fire resistance depending on solution
- Durable and environmentally benign
- Termite resistance
- Need way to inject the mortar with something that won't crumble during freezing and thawing – freeze/thaw proofing mortar

- Existing hygrothermal ground coupling models are not sufficient. Also need data on ground properties around the country. (Soil, water content, conductivity, groundwater flow)
- Code
- HOA/Historical Buildings
- Destructive excavation.

Prioritized Research Opportunities

Priority	Votes	Topic
1	14	**Smart Controls**. Cooperative control of misc loads; get manufacturers on board; codes? learns whole house and devices–wake-up on signal device with energy consumption proportional to service provided.
2	11	**Drive-By Blower Door**. Integrated diagnostic audit tool. (low cost, automated, accurate) – Next generation. Smart data sensors. Pulse pressure test. Characterize loads to ID remainder
3	6	**Exterior thermal and moisture management** for foundation retrofit & masonry walls
3	6	**Data-fusion and data mining**. Cross-databasing (automated) of Google earth/street data, thermography, and utility bills to get a sense of whole-house efficiency. Tax assessment data is another source. Include other government/utility/NGO programs' information.
4	5	Efficient multi-zoning systems – retrofit emphasis
5	4	Fuel-fired-furnace or heating system (Heat Pump?) that outputs 150% of input BTU.
5	4	Cooling systems that can separately control latent and sensible loads
	3	Improved, market-ready, and cost-effective HVAC systems that can be downsized after retrofit – capacity adjustable – multi-split is an example. (High part load efficiency)
	3	Need accurate, whole-house analysis that is doable by average homeowner.
	3	Clear Ventilation Guidance
	2	Fire resistant exterior foams
	2	Community-scale ground source loops (as well as district heating and cooling)
	1	Foam that is structural member
	1	Increase consumer demand for 50%
	1	From picture to panel – integrated siding/structure/air/moisture/water barrier systems for retrofit
	1	Polymer solar hot water systems for cold climates
	1	Better customer interaction tools
		Cost effective LED packages
		A package for efficient retrofit of hot water distribution (and/or structured plumbing)
		Low-VOC-emitting interior foams
		Better panelized wall systems
		Existing retrofit – drill and fill with eyes (drill & fill w/o opening cavity, with immediate feedback as to completeness & quality)
		Immediate quality feedback for air sealing and insulation measures
		Low cost High-R dynamic windows
		Low cost dynamic opaque walls
		Fire resistant phase change materials
		Low-cost residential ac that combines economizer, evaporative cooling, DX and ventilation
		Misc loads – infrastructure needs in house to enable control. Integration of MELs package that could be part of whole-house retrofit.
		Demand control ventilation
		Whole-house DC power
		Dispatchable electric and thermal storage of house and electric car (utility buy down)/smart grid
		Thermal energy storage – ventilation, improving efficiency and load shift
		Rate structures which incentivize energy savings
		PV Grid Parity
		Energy storage (Lithium Ion, cars, etc)

Residential Integration Goals and Program Updates (Tuesday PM)

Welcome and Introduction

Presentation: Overview of Building America and Builders Challenge (PDF 1.2 MB
George James, DOE, kicked off the Building America Research Planning Meeting with introductory remarks. He welcomed the Building America team representatives and gave an overview of the program, teams, process, and documentation initiatives.

Multi-year Goals and Milestones

David Lee recognized George James and Ed Pollock for their accomplishments with the Building America program. He then offered the following insights:

- Goal is 1.3 Million homes retrofitted by end of 2013
- Research to support cost-effectiveness relative to increase in code stringency
- In retrofit opportunities, utility programs and private sector are the most significant
- HERS rating costs are too high
    - Vice president to announce tool for home assessment. A lot of wiggle room in this tool but it is $100 to $120 rather than $500.
    - Fast, safe, and quality
    - Technician and contractor certification and accreditation
- Code stringency
- Builders Challenge/ENERGY STAR alignment
- Goals, targets – 20%, 30%, 50%
- 20% in 2010 in mixed dry, hot dry, and marine – we need to identify these challenges
- Are these cost effective solutions? How is it defined for existing homes?
    - Answer – Ren posted a set of rules for cost-effectiveness. It will be laid out.
- What incentives or market models are necessary?
    - Answer – in existing homes, hopefully the BetterBuildings program will give us 35 experiments. LBNL put together a paper on successful programs. On new homes, ENERGY STAR has been successful, especially with utilities.
    - Two large builders want to use the E-scale.

Technical Pathways for 30% Savings in Existing and New Homes

Ren Anderson, NREL, presented technical pathways to achieving 30% savings in existing and new homes. He addressed questions and noted the following:

- 2nd week in March is tentatively next meeting (stakeholder meeting) to look at market drivers and successes. Summer meetings are focused on our research. This meeting is on planning.
- NREL will send out measure packages for achieving goals. It has assumptions built in. These are a starting point. BEopt can analyze many of the variations in technical pathways and answer cost-effectiveness v. energy savings questions.
- Packages are generated by least-cost curve
- PV fill the efficiency gap if it is more cost effective than energy conservation
- Same process for existing homes
- If PV is available for 18 cents or less per KW, why wouldn't we count that?
    - Answer – encourage the use of PV. We are dealing with a category issue in terms of focus of the program. There is a PV program. We are funded to improve the efficiency.
- Why is clothes dryer not included?

  - Answer – we are using a standard electric dryer in most cases. The efficiency comes from using less water in the washer. **That is a gap. We need better clothes dryers**.
- Is degradation of equipment accounted for?
  - Answer – we are considering it in actual vs. rated performance.
- Why the CFL difference between existing and new?
  - Answer – assumption built in assuming fixtures wouldn't all accept CFLs
- Ducts in conditioned space does not include things like costs of aesthetics
- This tool can do point of failure analysis
- On retrofits, 30 and 50% energy savings are in comparison to the actual home
- Why using percent saved as opposed to an absolute target?
  - Answer – The percentages are easier to communicate but the BA percentage is also based on long-term targets for BTUs saved.
- What level of granularity is in the data?
  - Answer – this is for BetterBuildings grantees; we want to figure out what level of data makes sense. We want as much data as we can get.

Performance Evaluation Protocols

Presentation: Performance Evaluation Protocols (PDF 106 KB)

Cheryn Engebrecht, NREL, presented performance evaluation protocols. Some highlights of the discussion include:

- Three documents are being combined into one that covers everything from the benchmark for new homes to simulation protocols for existing homes, and operating conditions.
- The benchmark was updated to 2010 standard practice
- No credit for health safety and comfort – these are required
- Existing – pre and post metrics – want to use reality whenever possible. Have default values but urge against that.
- A revised BEopt will be released this week.
- Operating conditions are standard
- Do we still assume 100% hot water?
  - Answer – We do still assume hot water only. We have not found sufficient research that describes the percentage of clothes washed in warm or cold water.
- In terms of operating needs, do you want that research in our plans?
  - Answer – there is a value in the Benchmark that is supposed to reflect reality and you have or can easily collect data to further define or correct this value, then we will gladly accept submissions. The general rules for changing values in the benchmark is that the new work is published (peer reviewed), has as large a sample size as possible, and the experimental setup is consistent with the rest of the Benchmark (i.e. raw data is not displayed as an average).
- Is there going to be BEopt training for new teams?
  - Answer – we have a training session in mind. That's the first thing they will work on as soon as BEopt is released. It will have modules so you can go at your own pace
- New protocol will include dehumidification – does BEopt do that? Is it DOE-2 based?
  - Answer – BEopt will have DOE-2 and Energy Plus options. The dehumidification model is coming soon.

Planning Update: Residential Energy Codes

Presentation: Building Energy Codes Program: Overview and Energy Efficiency Goals (PDF 821 KB)

Bob Dewey, DOE, gave an overview of the code process and the expected direction of residential energy codes in the future. Highlights include:

- DOE's code program functions:
  - Updates to 90.1 and IECC
  - Also stretch codes such as the forthcoming IGCC – only commercial
  - 189.1
  - Determination of energy efficiency improvements from updated code
  - Technical assistance
  - Manufactured homes
  - Federal buildings energy code
  - Energycodes.gov – codes resource page
- Code updates every 3 years
  - ICC develops
  - Next year starts the 2015 code cycle
- 30% improvement over 2006 code was achieved
- Next step is 50% above 2006 IECC
  - Reaching point of diminishing returns on the envelope
  - Performance plus option to achieve 50%
  - Maybe outcome based compliance methods
  - Capacity constraint approach
- Building America research can be real world support for future code changes
- Is ICC still reticent about expanding the scope to regulate appliances?
  - Answer – NAECA is the barrier.
- Could you elaborate on technical assistance?
  - Answer – DOE provides funding for training for DOE code officials.
- There is a greater emphasis on enforcement in retrofit situations.
- IGCC has been difficult to reference portions of standards from ASHRAE. Why has IGCC chosen to set such a high standard for mandatory language?
  - Answer – Not aware of that. There have been issues in definitions.

July Meeting: Findings

Presentation: July 2010 Meeting Results (PDF 299 KB)

Stacey Rothgeb, NREL, presented key findings from the July research meeting. She noted that the "Gaps and Barriers" report was on the Building America website and encouraged teams to review it before the brainstorming sessions.

- Findings
  - Building America research not accessible
  - Need to standardize
  - How to deal with the unpredictable (example – confidence in energy savings; simulated occupancy)
  - Deployment issues
- Next steps
  - This meeting

- Target audiences – consumers vs. practitioners?
    - Answer – focus is on transparency – peer review of research available readily

Builders Challenge

Presentation: Builders Challenge 2012 Update (PDF 520 KB)

Ed Pollock, DOE and James Lyons, Newport Partners, gave an overview of how the Builders Challenge with be aligned with ENERGY STAR V.3. An analysis that compares the Builders Challenge, ENERGY STAR V.3 and the ENERGY STAR Concept Home is available upon request.

- The Secretary of Energy has asked for super-ENERGY STAR. As we update for 2012, it makes sense to increase ENERGY STAR and Builders Challenge
- Working with Appraisal Institute – launching green or high performance certification for appraisers. There is a way of adding and recognizing value of High Performance Homes.
- Intent to stay ahead of ENERGY STAR in terms of performance
- Need to think about how new homes label fits with existing homes label
- Any U in hot or any SHGC in cold may be less stringent
- Recommendations to stick with ENERGY STAR windows
- Ducts in conditioned space still problematic for some
- Support for staying with performance approach
- Want better quality assurance in ratings
- Set prescriptive at floor
- Appliances – no heartburn on ENERGY STAR appliances from builders
- Set prescriptive minimums in prescriptive path

Open Discussion

- Potential for Building America and BetterBuildings programs to work together.
- Retrofit – what if we make it more durable, safer, healthier, are there points accounted for?
    - Answer – looking for ways to account for that. Looking for guidance from teams.
- January 13 IBS Excellence in Building Science Education meeting
- What ideas are there for working with Home Performance with ENERGY STAR?
- Challenge of retrofits – convincing masses of consumers
- Interview follow-ups on retrofit case studies
- Joint EPA/DOE/HUD project on health and safety impacts of Energy Efficiency. Draft protocols will go up for review.

Brainstorming Sessions

For each topic, breakout group participants identified gaps and barriers, research opportunities and needs related to that topic. Due to time limitations, participants were asked to prioritize through voting. Priority research projects and milestones were then identified. Each group used the same prioritization criteria.

CRITERIA FOR PRIORITIZATION

Breakout groups were asked to identify research opportunities related to the topics of each session. Participants were asked to keep in mind the following priorities while brainstorming:

- Energy Savings
- Impact on Market
- Ease of Implementation
- Timeframe (NT = near-term; MT = mid-term; LT = long-term)
- Cost-effectiveness

BRAINSTORMING BREAKOUT SERIES 1

A. Analysis Methods and Tools for Homes and Multi-family Buildings

Eighteen building scientists gathered to discuss and prioritize research opportunities related to analysis methods and tools to achieve Building America goals. Members of this group emphasized that multi-family housing should be included – not just single family new and retrofits. This group determined that the greatest needs are validation of software, software calibration, home attribute prioritization and they also identified a number of modeling gaps. Finally, they are interested in a method for community scale modeling to identify how much energy savings are available for certain homes to reach an overall goal. Some participants noted that it was difficult to begin by identifying research opportunities and suggested we begin with identifying gaps and barriers that could become research opportunities in the next session. They also noted that this category was not directly addressed in the "Summary of Gaps and Barriers for Implementing Residential Building Energy Efficiency Strategies" from the July 2010 meeting in Denver. They also suggested that a number of issues be included in the Implementation discussion.

Modeling Gaps

- Empty cavity walls
- Storm windows
- Sensitivity analysis
- MELS and lighting heating loads
- Heat pumps
- Furniture / interiors
- Moisture
- Geothermal
- Internal temperature distribution
- Hybrid insulation
- Better infiltration modeling
- Infiltration and heat recovery
- Party walls
- Mean radiant temperature
- Comfort quotient
- Occupancy behavior
- Ground coupling

Research Opportunity Priorities:

Develop method for validation of software to ensure accuracy, credibility and capability

- Facilities
- Houses not occupants
- Lots of field data of occupied homes

Develop a standard method to calibrate software

- Smart Meters to get granularity
- Utility bill data

Prioritize home attributes to accurately model

- Is a blower door necessary?
- When and where?

Develop / enhance models for identified gaps (see gaps above)

Parking Lot

- Recommend that marketing be addressed in Implementation session
- Knowledge "how to use"
- What is data?
- Don't lose information – include in MYP and standing technical committees
- What are teams currently working on?

Develop macro-community scale model for portfolio analysis

- Determine which homes best represent retrofit opportunities
- Some homes deeper than others
- Model across a group of houses to achieve goal
- Energy saved /$1

Analysis Methods and Tools Research Opportunities

Priority	Votes	Topic
1	10	Validation of software. Standards for DOE recognition of audit software tools. Define accuracy. Accuracy, credibility and capability.
2	7	Standard method to calibrate. Smart Meters to get granularity. Utility bill data
2	7	Prioritization of home attributes to accurately model. Is a blower door necessary? When and where?
2	7	Develop and/or enhance models for gaps
3	6	How do we model neighborhoods? Macro/community scale modeling Portfolio analysis- model across a group of houses to achieve goal; energy saved per $1
4	3	Assessment of occupant behavior; feedback mechanism
4	3	Multi-family
4	3	Methods to integrate more granular data to inform. Automate. Occupancy, temperature, light.
5	1	Hand book for auditors
5	1	Standards for data exchange formats: vocabulary, definitions, automate into a simulation tool
5	1	Accurate modeling of dual fuel
5	1	Model old equipment
5	1	Degradation analysis – Standards for snapshot degradation
5	1	Protocols for common errors – gather what's gone wrong
5	1	Deep retrofits analysis and models; screen for candidates; standard on deep; 70% LAMELS modeling; how include a home energy management method?
		Validation of accuracy of field and experimental tools. Prediction of savings. Data to support. Data mining. Data to improve tools.
		Better understanding of gaps in tools
		What is the market penetration of programs?
		Why choose or buy a particular retrofit? Assess
		How use a particular energy saving devise / equipment? Analyze
		New data sources. Smart Phone-occupant conducted with imagery. Merge appraiser and utility data
		Develop new models of emerging technologies
		Seasons (4 models)
		Tool to manage house as situations change; demographic change; how manage the house to create a caveat on performance
		Time
		How do we project the future in modeling?
		Standard of acceptance risk of not meeting goals

B. Testing Methods and Protocols

During the Testing Methods and Protocols brainstorming session, participants identified gaps and barriers that could become research opportunities. They felt many items also belonged in the Implementation discussion.

Research Opportunity Priorities:

Develop better wireless sensors
- New testing and monitoring equipment that is better, faster and more accurate
- SBIR and ARPA-E

Test for concealed system evaluation and characterization
- Identify needs and prioritize what is truly concealed (NT)
- Use micro/nano-bots to explore (NT)
- Find solutions (MT)

Streamline and reduce time to test-in / test-out (Who? For? & Why?)
- Standardize energy, health and safety (NT)
- Develop comfort and durability protocol (MT)
- Investigate existing IAQ protocol (MT)

Standardize data sets and monitoring protocols for labs and prototype homes
- Develop documents (units-how recorded) – What? How? Levels of information (NT)

HU4&Y (Who? For? & Why?)
- Determine audiences and purposes (NT)
- Identify targets for accuracy levels (NT)
- Developing protocol set (NT)
- Go back to #1 (or go to jail; do not pass go; do not collect $200)

Testing Method and Protocol Gaps and Barriers

Priority	Votes	Topic
1	7	Standardization of data sets; defining what tests need to be down; lab v. occupied home
1	7	Comfort protocol / pass or fail
1	7	HU4&Y (Pennsylvania License Plate) Set of testing protocols for varying levels of accuracy depending on the audience
2	6	Concealed system evaluation and characterization
3	3	Measure IAQ and what indicators are needed
4	2	Active / real time monitoring online; verify that producing desired effect
4	2	Protocol for Infra-red – improved, more rapid, more feasible/practical
5	1	Test method for degradation of equipment
5	1	Wireless methodology
5	1	Central repository for results / clearinghouse
5	1	Protocols for blower-doors; depressurization protocols for multi-family
5	1	Testing protocol for pressure / map pressures
5	1	Alternative method for duct leakage testing
5	1	Alternative to the tape measure – photogrammetry / 3-D laser scanner
5	1	Residential flow hood accuracy; supply and return airflow measurement
		Onboard v. external HVAC air flow measurement
		Speed of assessment; customer time and money
		Monitoring protocols for lab and prototypes
		Refrigerator charge accuracy measured by a technician
		Protocol for pre and post testing for BA and practitioners
		Durability protocol
		Protocol for system or package level testing
		Blanket human factor research approval
		Alternative test method to blower doors
		WHAT IS THE VALUE PROPOSITION?
		Data fusion leveraged testing

C. Implementation and Program Partner Tools

The Implementation and Program Partner Tools group spent time describing what was meant by implementation, defining end-users and finally brainstorming research opportunities, gaps, and barriers to implementing Building America research.

The group determined that their goal was to design tools that can be implemented by the end customers. Much of the work is related and follows a process that is roughly laid out in terms of the priorities.

Prioritized List of End Customers – Who is needed to achieve 1.3 million retrofits?

- Utility / program sponsors (8 votes)
- Homeowner / property owner (7)
- Builders and remodelers (5)
- Installing Technicians / crew leaders (4)
- Financial institutions (3)
- Better Business Grantees (2)
- Accreditation and standard setting organizations (2)
- Universities (1)
- Retailers (1)
- REALTORS and Appraisers
- Co-owners
- Government – city / county / state

Research Opportunity Priorities:

Map Value Stream (NT)

- Identify stakeholders
- Identify / create financial mechanisms
- Identify products
- Draft for stakeholder meeting
- Hold preliminary peer review at stakeholder meeting
- Identify non-value items and revise map to reflect
- INVITE FROM OUTSIDE THE BOX – Review process from different industries

Research and Document End-User Business Best Practices (NT)

- Product of value stream
- Identify best practice
- Identify critical failure
- *Identify repeatable, simple and scalable practices*
- System measure

Determine Information Delivery Mechanisms

- Identify end-users (NT)
- Identify deployers (NT)
- Review other industries (NT)
- Characterize various types of mechanisms (NT)
- Evaluate effectiveness (MT)
- Develop tools and products (MT)
- Develop process for continued improvement (MT)
- Deploy (LT)
    - Consider commercial entity?

Review Business Models of BetterBuildings and Other Retrofit Programs

- Identify success / <u>failure</u> criteria (NT)
- Identify and evaluate programs (NT)
- Document outcomes (MT)

Implementation Opportunities, Gaps and Barriers

Priority	Votes	Topic
1	12	Capture range of audiences and needs – who? • From builder to consumer • Identify value proposition • Consumer brand / cost / quality analysis • Map value stream • Who incentivizes / motivates?
2	11	Business Best Practices • Replicability • Simplicity • Scale • Identify and categorize • Work with organizations to document critical failure points
3	7	Look at different delivery mechanisms for messaging / information delivery (e.g., video)
4	6	Review business models of BetterBuildings and other retrofit programs
5	4	Training and credentialing • Based on research • Understand failure • Align with BPI – feed in / out • BA certification
6	2	Impact study of Building America
6	2	Vetting process – peer reviewed and published in a journal
6	2	Active market research with stakeholders – focus groups
7	1	Building America participation in standards committees; integrate into documents
7	1	Behavior change research
7	1	NREL/DOE define implementation
7	1	Review existing Building America guidelines for application – how many used?
		Program Partner needs and tools – behavior modification
		Partner with financial institutions
		Process map retrofit – value stream map; identify products
		Property owner self-assessment tools
		Partner needs and tools – Home Depot Home Performance Department
		Do we want to encourage or discourage DIYs?
		Point of use training • Field training • In the cab training • Design so can't be installed wrong • Hot Spot training • Bar codes with installation instructions
		Inventory of existing implementation tools and review guidelines
		Feedback loop for consumers
		Standardized vocabulary
		Leverage Building America relationships with team partners to take advantage of insights

BRAINSTORMING BREAKOUT SERIES 2

A. Foundations

This group identified significant foundation research gaps and specific research opportunities, selecting projects that addressed the top four priorities. The group also identified needed innovations that could come through manufacturers or research partners.

Research Opportunity Priorities:

Develop and test retrofit moisture control strategies.

- Develop and test multiple interventions/scenarios; e.g., evaluate moisture implications of insulating existing foundations (NT)
- Establish guidelines for safe amounts of moisture (NT)

Develop improved tools and models

- Develop diagnostic tools that identify and predict moisture transport in foundations; e.g., capillary transport (MT)
- Develop hygrothermal engine for DOE2/Energy Plus for at least crawlspace and basements. (NT)
- Develop worse case boundary condition to minimize failure. (NT)
- Develop investigative tools to test performance. (MT)

Investigate and categorize existing foundation conditions

- Broad field analysis in a variety of climates/foundations/moisture conditions to test drainage plane between insulation and vapor retarder. (NT)
- Market study of acceptability on health, safety durability. Develop better understanding of perceptions among the following stakeholders (NT)
    - Homeowners
    - Builders
    - Engineers
- Test to failure (MT)
- Forensic investigation in failed foundations to identify conditions that led to failure. (NT)
- Survey nature and extent of moisture issues. (NT)
- Design and test new solutions and strategies for both new and existing (MT)
    - Lab test new designs
    - Field test in prototype homes
    - Evaluation of where "diaper" solution works and where it doesn't.
    - Evaluation of research already completed by builders/contractors.

Foundations Gaps

Understanding transport of moisture into basements

- Understanding role of capillary transport.
- Understanding and evaluation of basements
- Implications of adding thermal control
    - What are impacts and dangers of retrofits?
- Understanding of "diaper" solution
- Is more moisture a problem?
- Guidelines for when mold is OK – consumer expectations and the interaction with building science.

Models are not adequate

- Thermal engine for DOE2/Energy Plus for crawlspace and basements
- Understanding of loads

Insulating Monolithic and Post-Tension Slabs

- Support of brick/stone veneers

Inadequate Rules for Conditioned Crawl Space

- Better understanding of crawl space behavior
- Review of existing research
- Termite mitigation and interactions with insulation
- Impacts of climate variation
- Insulation or encapsulation of crawl spaces

- Develop strategies for implementing a removable "diaper" solution – investigate possible impacts and dangers. (NT)

Develop and Test Energy Saving Strategies for New/Existing

- Develop products and strategies for preventing thermal bridging in monolithic and post -tension slabs. (NT)
- Identify low cost perimeter insulation strategies. (MT)
- Design and test new methods in the field. (MT)
- Design and perform lab and field testing of waffle insulation pattern on bottom – explore structural concerns. (NT)
- Design and perform lab and field testing on assembly including regular slab with OSB on top. (NT)
- Develop rules for conditioned crawlspace (MT)
  - Establish best practices for crawls spaces and what can/should be placed in them (including retrofit strategies)
  - Evaluate the impacts of air moving between the crawlspace and the house.
  - Develop methods for integration of termite mitigation into crawlspace solutions
  - Develop design guidelines by climate for when crawl spaces should be treated as if they were basements.
  - Develop rules for insulation and encapsulation of crawl spaces – identify problems and solutions and how they vary across different crawl space designs.

Innovative Ideas

1. Smart foam / system that changes with humidity
2. Develop bug-proof board
3. Insulate slab on grade on problem soil
4. Develop new composite materials that are more durable (moisture and thermal)

Prioritized Foundation Opportunities

Priority	Votes	Topic
1	11	Retrofit control solutions and strategies
2	8	Improving and validation of modeling for foundations • Water and moisture control
3	6	Monolithic concrete slab insulation – combine with below
3	6	Rules for all foundation systems – new and existing
4	5	Electronic source book (Handbook)
5	2	Exterior insulation of basements with brick veneer
6	1	Interaction between rims and foundations
		New foundation systems

B. Walls and Windows

In the walls and windows session building scientists discussed significant research gaps and identified specific research opportunities and projects that addressed the priorities. They also identified needed innovations.

Research Opportunity Priorities:

Insulating and air-sealing existing walls – outside, inside or middle.

- Adding insulation from outside
  - Perform full-scale fire tests for foam applied from outside of frame/concrete block (NT)
  - Develop new exterior system materials + products that are cost effective – R6 to R10 (NT)
  - Identify attachment and fastener solutions for foam above 1.5" thickness, with buy-in from cladding manufacturers (NT)
  - Develop affordable thinner insulation products. (LT)
- Adding insulation from inside
  - Evaluating systems that can encapsulate, insulate and air seal (ready-made walls) (MT)
    - Identify systems, lab test and analysis for moisture
  - Develop thinner systems (MT)
  - Develop pre-manufactured, insulated retrofit curtain wall (MT)
- Adding insulation in middle
  - Drill and fill with eyes, snake through and find the voids, have lights and vision. (LT)
  - Work with product manufacturers to eliminate wall blow-out and shrinking problems with foam (LT)
  - Establish method for evaluating failure
  - Field and lab testing of walls with various insulation configurations. (NT)

Walls and Windows Gaps

Understanding Existing Walls
- Knowledge of existing walls – application, vintage, health/safety

Insulating and Sealing Existing Walls
- How to add insulation from the outside for frame/concrete block
- How to fasten/attach cladding through exterior thick foam
- How to add insulation from the inside for frame/concrete block
- Achieving air tightness without being vapor-closed
- Thickness and fire-resistance issues

Need for Better Insulation Products
- Affordable smart foam without shrinking or blow-out problems
- Affordable thin insulation that takes up less floor space
- Develop products that can diagnose and fix at the same time

Insulating and Air Sealing Inaccessible Places

Windows and Window Attachments
- Everything from films to shades to storm windows
- Total/complete window system
- Better information and testing on existing products

Insulating and air sealing inaccessible places

- Develop methods to identify problem areas and fix them at the same time (NT)
  - White paper that assesses problem and quantified value (NT)
  - Enhance cost-effectiveness (MT)

Innovative Ideas

1. Idiot Proof Window
2. Break thru exterior insulation products
3. Develop a wall skinner to make it safe and easy to insulate cavities and inaccessible areas
4. Drill and fill reality show

- Develop prototype applications for retrofit industry using existing remote operational technologies. Push through manufacturers. (LT)
    - Develop a wall skinner to make it safe and easy to get to cavities (smart robots) – avoid contractor exposure to lead, etc. (LT)
    - Develop robotics for fast lead paint and other contaminant removal. (LT)
    - Develop "paint on" lead removal technology – for use by unskilled labor (LT)

Develop window and cladding attachments, especially related to retrofit.

- Develop low-cost insulating storm window. (NT)
    - Evaluate and test various products to determine effectiveness. (NT)
    - Develop new products like the inexpensive interior storm window. (MT)
- Integrated window/wall system. (MT)
- Develop and test shutters/blinds with R-value and air tightness. (NT and MT)
- Idiot proof, one system fits all, cost-effective cladding and flashing details with acceptable aesthetics. (MT)
- Evaluate and test existing products for effectiveness. Publish results (NT)

Prioritized Windows and Wall Research Opportunities

Priority	Votes	Topic
1	10	Insulating and air sealing existing walls
2	9	Developing specific solutions for insulating and air sealing inaccessible places
3	8	Window and cladding attachments, new and existing, glazing, frames, total system
4	5	Cost-effective window retrofit
5	3	Dynamic walls – things that change. Surface properties, mass changes, R-value changes. Stimulated by temperature changes, humidity level triggers.
6	2	Structural enhancement
7	1	Window installation
		External shading systems

C. Attics and Roofs

Participants in the attics and roofs brainstorming session quickly added roofs to the previously identified "attics" research opportunity category. They prioritized the opportunities and identified gaps as well as innovative ideas for manufacturers.

Research Opportunity Priorities:

Insulating unvented flat (or low slope) roofs

- Establish protocol for insulating through the top (NT)
- Identify moisture limits – identify failure points of dense pack. (NT and MT)
- Develop cost effectiveness strategies (NT)
- Develop residential over-roof strategy – use lessons learned from commercial applications (MT)
- Develop testing method for testing the air leakage at the ceiling plane (NT)

Conversion to conditioned space and attic kneewalls (including issues of condensation and water intrusion)

- Identify quality control methods; evaluate dense pack concerns (NT)
- Development of new and appropriate application of existing systems and materials with limited thickness (MT)
- Identify home owner acceptable approaches that limit or eliminate space encroachment while increasing R-value (MT)
- Enhance understanding of moisture management (NT)
- Field evaluation of unvented attics with insulation at the ceiling plane (NT)
- Guideline for diffusion vents (MT)
- Hygrothermal models for attics and roofs (MT)

Conduct durability study on foam insulation

- Field evaluations (NT)
  - Shrinkage
  - Pests
  - Rotted structure/moisture content
  - Impact of roof leaks
- Accelerated lab testing (NT)
  - Accelerated wet/dry
  - Adhesion
  - Shrinkage

Attics and Roofs – Research Gaps

Insulating Unvented Flat/Low Slope Roofs

- Do you go through the top? Build an over-roof?
- Moisture Issues
- Methods and quality concerns on dense-pack

Conversion to Conditioned Space and Attic Knee Walls

- Access and Quality Issues
- Limited accessibility
- Space encroachment
- Moisture Issues

Durability of Foam Insulation

- Accelerated aging tests and/or field test existing installations

Methods for Air-sealing Existing Insulated Attics

- Access and Quality Issues
- Insulating and air-sealing existing (old) recessed lighting
- Strategies for air sealing, including analysis of sealing with/without removal of insulation

Condensation and Water Intrusion

- Testing, models, and guidelines

Innovative Ideas

1. Vapor permeable shingles
2. Sustainable strategy for recycling worn shingles
3. Duct integrated roof/attic
4. Dynamic (seasonal) cool roofs
5. Passive positive pressurization systems
6. Method for testing leakage at the ceiling plane

- Material specifications (MT)
- Long-term aging, structural variety (MT)

Prioritized Attic and Roof Research Opportunities

Priority	Votes	Topic
1	8	Insulating residential flat roofs and water removal strategies (dense-packing)
2	7	Conversions to conditioned space • Condensation problems in attics • Insulating and sealing knee walls
3	6	Durability study on foam in attics
4	4	Dynamic attics
5	2	Conflict between water intrusion and thermal performance
5	2	Dealing with recessed lighting in existing building
5	2	Integrating Re-roofing with energy upgrades and air sealing
6	1	Rules for dealing with existing insulation • Identify insulators with health/safety problems
6	1	Retrofit and new radiant barriers study
		Integrating PV and solar Re-roofing without remodel of PV
		Better descriptors and tools of energy performance of attics and walls

BRAINSTORMING BREAKOUT SERIES 3

A. Space Conditioning and Hot Water

Building scientists in this session discussed space conditioning, hot water, and other mechanical equipment, then prioritized research opportunities and identified gaps.

Research Opportunity Priorities:

Distributed space conditioning strategy

- Develop and test prototypes (NT)
- Air distribution design guide (examples – placement of point sources; mini/micro hydronic fan coil; simplicity) (NT and MT)
- Training of workforce and development of market infrastructure (MT)
- Implementation of dramatic modeling Changes (NT, MT, and LT)

Air-based central space conditioning retrofits

- Develop design and Installation guide (NT and MT)
- Perform field evaluation of retrofit systems and existing systems (NT)
- Technical development and Analysis of Spray foam in cold and humid climates (NT)

IAQ control and ventilation

- Develop and enhance demand control ventilation (MT)
- Develop low cost IAQ Sensor (NT)
- Update 62.2 for 2013 code cycle (NT)
- Establish valuation criteria for IAQ and Ventilation (NT and MT)
- Perform field evaluations of strategies (NT and MT)
- Develop strategies for reducing risk (example – Atmospherically Vented Systems) (NT, MT, and LT)
- Develop and analyze innovative, emerging technology in ventilation (MT)
- Document health/safety of retrofitted homes (EPA protocols; look at BA homes) (NT)

Space Conditioning and Hot Water Gaps

Distributed Space Conditioning Strategy

- Hydronic fan coil or hydronic to air
- Mini-splits
- Vented high efficiency fuel-fired condensing point source higher than 0.82
- Point Source
- Lack of mini/micro hydronic fan coil distribution on market (500-2000 btu)
- Lack of design info on air distribution and sizing
- Lack of qualified workforce and market transformation
- Dramatic changes in modeling homes
- Dual fuel system
- Occupant interaction required
- Ensuring simplicity of function in residential
- Lack of smart adaptive controls

Air Based Central Space Conditioning Retrofits

- Design guidelines for various Scenarios
    - Design and install properly sized ducts, post retrofit
    - Properly sized HVAC after retrofits
    - Understanding matching
    - Cost effective retrofit options
    - Application of knowledge
- Space constraint
- Moving ducts into conditioned space
- Sealing inaccessible ducts (lowered cost and strategy)
- Lack of data on performance of spray foam in cold and humid climates

IAQ Control and Ventilation

- How do we value?
- Lack of low cost VOC sensor
- Demand control ventilation (mid term)
- Table 42 of 62.2 – intermittent ventilation
- Field evaluation – lack of controls
- Risk and Contractor Liability
- Lack of low cost retrofit options
- “Smart holes”
- Health and safety concerns

Space Conditioning and Hot Water Opportunities

Priority	Votes	Topic
1	10	Distributed Space Conditioning • Low-cost hydronic distribution using forced air • Mini-split Design Criteria • Point Source Space Conditioning • High efficiency fuel-fired space conditioning
2	9	Air Based Central Space Conditioning Retrofits • Fix duct work in retrofits; size matching ducts after retrofitting furnace
3	8	IAQ control and Ventilation (also, how to value)
4	7	Dehumidification and Humidity Control
4	7	Field evaluation (everything); monitoring performance
5	5	On-board diagnostics (automatic?)
5	5	Combi systems with tankless hot water
6	4	PV integrated space conditioning and hot water
6	4	Design of relatively low-temperature air distribution systems
7	2	Three function heat pump • 4 function with dehumidification
7	2	Optimization of air source heat pumps in cold climates
7	2	Condensing Boilers – improved performance and system design
7	2	Evaporative Condensers
7	2	Ceiling radiant distribution
7	2	Zoning linked to system capacity
8	1	Ground Source – low-cost ground coupling design
8	1	Proper installation
8	1	Active thermal storage
8	1	Hot Water distribution
8	1	Prescriptive protocol for health and safety in retrofits
		Heat Pump water heater and Gas water heater performance evaluation
		Control integration supply heat mini-split
		High velocity duct systems – compact
		“Hot Rodding” A/C low cost retrofit
		Solar thermal hot water

B. Lighting, Appliances and Miscellaneous Electric Loads (LAMELS)

This group of building scientists developed priorities for LAMELS based on research opportunities and then identified gaps and barriers for these opportunities.

Research Opportunity Priorities:

Smart controls and demand response

- Establish energy use of savings potential (NT and MT)
- Demand and distribution controls Response for a wide range of loads (MT)
- Develop retrofit measures that are easily installable (possibly flexible) for consumer or contractor (NT and MT)
- Develop solutions for diversity of load – integration of systems and strategies (MT)

Baseline for MELS energy consumption (issue of variability)

- Establish data collection protocol – variability in MELs (NT)
- Collect statistically meaningful field data on usage and quantity – Variability in MELS (NT)
- Using field data – establish trends (MT)
- Develop standard signature for feedback device categories (LT)
- Measuring load curves (NT and MT)

Feedback and visibility

- Improve functionality of real time feedback (NT)
- Enable better understanding of energy consumption (NT)
- Catalog good feedback models (NT)
- Disaggregate end use data (MT)
- Improve retrofit ease of implementation for consumers (NT)

Increased Number and Type of Regulated Products

- Target increase of number and type of regulated products (MT)

LAMELS Gaps

Comprehensive lighting retrofits with daylighting interaction

Cost and usability of system set-up

Low energy homes – variability and trends in

MELS – how to design around

Smart controls and auto circuits

- Need to increase number and categories of regulated products
- Lack of understanding of energy savings potential to drive change
    - Non-energy benefits
    - Current cost
    - Diversity of load/controlling divers loads – integration of systems and strategies
    - Smart electric panel
    - Reduced cost – next generation (near and mid)
- Lack of easily installable and flexible retrofits for consumer or contractor
- Charging station

Retrofitability – ease of implementation for consumers

Lack of baseline for MELS energy consumption

- Lack of data collection protocols
- Lack of statistically significant data
- Lack of standard signatures for device categories

Feedback and visibility

- Lack of functionality of real time feedback
- Lack of understanding of energy consumption
- Lack of good feedback models

Lighting, Appliances and Miscellaneous Electric Loads: Opportunities

Priority	Votes	Topic
1	13	MELS, Lighting, and Appliance Controls • Automatic circuits or device – easily turned off when leaving the home • Smart Power Strips • Easily affordable retrofit controls • Demand response; load profile management
2	9	Baseline • Peak vs. off peak • Are new/retrofit baselines different?
3	7	Feedback and Visibility • Display systems • Non-invasive load monitoring • Visibility to consumer (gas and electric) • Consumer Education
4	6	High efficiency dryer; heat exchange recovery dryer
5	4	Low cost LED
6	3	Lighting Controls
6	3	Whole house DC power
7	2	Volume purchase for retail devices
8	1	Comprehensive lighting retrofits with day lighting interaction
		Home Energy Management (recognized as covered by another session • Real time pricing • Electric car and smart grid • Demand response
		Low cost, no (or low) power control/power supply – senses need for use
		High efficiency power supplies (computer and wall wart)
		Auto off consumer electronics or MELS
		Appliance marketing, programs rebates and incentives
		Increasing enabling of power management • Computers and monitors • Standardization • Language • Set top box • Manufacturer action

C. Home Energy Management

This group brainstormed and prioritized home energy management opportunities and identified gaps and barriers related to these opportunities.

Research Opportunity Priorities:

Life Cycle Home Management
- System development (MT)
- Field study (NT and MT)
- Integration (data fusion/analysis) (MT and LT)

Home Automation
- System development (MT)
- Field study (NT and MT)
- System integration (MT and LT)
- Value proposition (NT and MT)

Standardization in Communications
- Standardization/creation of standards (MT and LT)
- Drive in common understanding (MT)

Responsive Home (price, weather, etc.)
- Response to rate structure, and price signals (NT and MT)
- Develop default demand response profiles or options (MT)
- Aligning utility and consumers (LT)

Home Energy Management Gaps

Lifecycle Home Management
- Diagnostics for lifecycle energy management
- Regulatory
  - Design of program
  - Decoupling of net metering and real time pricing
- Long term info storage, retrieval, protection
- Remote Access
- Feasibility/false positives
- Lack of cost-effective
- Feasibility/false positives
- Value proposition (laying out the benefits)
- Large amounts of data
- New "stuff" (equipment, etc.)
- Expandable/flexible
- Artificial Intelligence

Home automation
- Study and data
- Value proposition/product integration
- Human factors vs. automation detail

Standardization in communications and data format
- Interoperability
- Privacy
- Lack of standardization
- Lack of common understanding and consensus
- Lack of enabling technology
- Homeowner
- Purchase trigger
- Lack of Integration

Responsive home
- Price
- External factors
- Security
- Lack of understanding response to rate structure and pricing signals
- Price signals – barrier
- Price response devices – policy and recommendations
- Lack of default and demand response profiles – communication or options
- Lack of alignment between goals of utilities and consumers
- Policy Factors
- Human Factors

Home Energy Management Opportunities

Priority	Votes	Topic
1	9	Lifecycle energy management of home • Monitoring of real time power use – Energy Audit/"The Constant Audit" • Long term energy management – super diagnostics • Lifecycle energy management of the home • Warranty management • Product maintenance • Not buying it for the energy management capabilities, but as an added benefit • It's a product add-on because it can't sell itself • Effective sensing in home
2	6	Home Automation (Everything) • Integration with other systems • Self learning • Sensors (occupancy is main item) • Hybrid car • Ease of use, non-intrusion
3	5	Standardization, project communication, home area technology, wireless, remote access, residential BACnet equivalent, privacy, security
3	5	Response to externals/Responsive Home • Community scale demand response/feedback to utility (aid in implementation) • Price response devices - grid response or control • Tariff rates and policy feedback – education, regulations, and best practices • Demand Response (home and community scale and multi-family) • Utility Meters as Gateway
4	4	Human factors – usability; standardization
5	2	Job-creating home service contract • Retrofit and maintenance access point • Energy efficiency and health
		Consumer feedback • Whole House • Major Loads
		Self learning/artificial intelligence
		Product integration
		Regulations – decoupling, net metering and real time pricing
		Proper program design
		Effective sensing in home
		Non-intrusive devices
		Monitoring of real time power use – Energy Audit/"The Constant Audit" • Operational goal/short term • Long term utility information/program opportunity goals • Diagnostic goal/medium term • Capital investments in the house/new equipment/decision making tool
		Service access point (EE & health)

Next Steps and Wrap Up

Ren Anderson, NREL, wrapped up the session.

How does this impact the research program?

This planning meeting is an annual process that will guide research progress. NREL will be tracking progress through the research plan.

Much of what we are looking for relates to the implementation priorities that were outlined.

Action Items:
- Attend EVHA
- Utilize social networks to facilitate work (form interest groups; use Base Camp or Google; market it to make it useful)
- Create an expertise map – who we have and what their areas of expertise are

The next meeting will be for stakeholders and we are expecting 200-400 people. It will be held on March 16-18, 2011, in Atlanta, Georgia.

How can we improve the planning meeting process?

There should be enough people from each team to participate in all the breakouts. Keep the breakout groups to no more than 8-10 participants. Identify topics ahead of time so teams can send the correct people. There needs to be more specific definition of groups.

What is Building America's mandate/vision in the space of research vs. deployment?

- Where are we in the 1.3 million?
- What time frames and savings level?
- Add SEP programs and block grant programs to BetterBuildings program
- Program evaluation to identify successes and failures in the program – our role is continuous evaluation

Appendix A – Brainstorming Participants by Breakout Session

Session A: Wednesday, November 3, 2010, 8:15-9:45 AM

	BREAKOUT 1	BREAKOUT 2	BREAKOUT 3
	Analysis Methods and Tools / Evaluation of Gaps	Foundations	Space Conditioning and Hot Water (Mechanical Equipment)
1	John Carmody	Mark Berman	Michael Baechler
2	Glenn Cottrell	Jeff Christian	Larry Brand
3	Abe Cubano	Cheryn Engebrecht	Subrato Chandra
4	Jordan Dentz	Marye Hefty	Dane Christensen
5	Mike Gestwick	Pat Huelman	Deane Evans
6	Kenvin Grosskopf	Tom Kenney	Dianne Griffiths
7	Roderick Jackson	Jan Kosny	Rob Hammon
8	Ely Jacobsohn	Joe Lstiburek	Bill Haslebacher
9	Ron Judkoff	Craig Savage	Emanuel Levy
10	Ryan Kerr		Terry Logee
11	Peter Khaemba		Arn McIntyre
12	Eric Martin		Duncan Prahl
13	Mike Mazor		Kurt Roth
14	Dave Riley		Stacey Rothgeb
15	Dave Roberts		Armin Rudd
16	Sam Taylor		Jonathan Shi
17	Steve Winter		David Springer
18	Amber Wood		

Session B: Wednesday, November 3, 2010, 12:30-2:00 PM

	BREAKOUT 1	BREAKOUT 2	BREAKOUT 3
	Testing Methods and Protocols	Walls and Windows	Lighting, Appliances and Misc Electric Loads
1	Michael Baechler	John Carmody	Mark Berman
2	Larry Brand	Jeff Christian	Subrato Chandra
3	Abe Cubano	Glenn Cottrell	Dane Christensen
4	Pat Huelman	Jordan Dentz	Deane Evans
5	Roderick Jackson	Cheryn Engebrecht	Mike Gestwick
6	Ely Jacobsohn	Dianne Griffiths	Rob Hammon
7	Ron Judkoff	Kevin Grosskopf	Ryan Kerr
8	Emanuel Levy	Bill Haslebacker	Peter Khaemba
9	Eric Martin	Marye Hefty	Terry Logee
10	Arn McIntyre	Tom Kenny	Kurt Roth
11	Duncan Prahl	Jan Kosny	Steve Winter
12	Dave Riley	Joe Lstiburek	Amber Wood
13	Dave Roberts	Mike Mazor	
14	Stacy Rothgeb	Armin Rudd	
15	Jonathan Shi	Craig Savage	
16	David Springer		
17	Sam Taylor		

Session C: Thursday, November 4, 2010, 8:30-10:30 AM

	BREAKOUT 1	BREAKOUT 2	BREAKOUT 3
	Implementation Tools / Program Partner Tools and Needs	Attics	Home Energy Management
1	Michael Baechler	Mark Berman	Dane Christensen
2	Larry Brand	Subrato Chandra	Cheryn Engebrecht
3	John Carmody	Jeff Christian	Rob Hammon
4	Abe Cubano	Glenn Cottrell	Roderick Jackson
5	Jorden Dentz	Mike Gestwick	Ryan Kerr
6	Deane Evans	Pat Huelman	Peter Khaemba
7	Dianne Griffiths	Ron Judkoff	Emanuel Levy
8	Kevin Grosskopf	Tom Kenney	Dave Riley
9	Marye Hefty	Jan Kosny	Kurt Roth
10	Ely Jacobsohn	Terry Logee	Jonathan Shi
11	George James	Joe Lstiburek	David Springer
12	Eric Martin	Mike Mazor	
13	Arn McIntyre	Armin Rudd	
14	Duncan Prahl		
15	Dave Roberts		
16	Stacey Rothgeb		
17	Craig Savage		
18	Sam Taylor		
19	Amber Wood		

Appendix B – Background Materials

Meeting Objectives

- Review multi-year program goals
- Identify key opportunities, barriers and performance risks that must be addressed to achieve program goals
- Relative to specific opportunities, barriers, and risks, identify the specific questions that must be answered to achieve program goals
- Key Meeting Endpoint: Develop multi-year milestones to track critical research progress.

Agenda

	Tuesday, November 2	Wednesday, November 3	Thursday, November 4
AM	National Laboratory Research Activities	Brainstorming: Breakout Groups	Brainstorming: Breakout Groups (continued) and Next Steps
PM	Residential Integration Goals and Program Updates	Brainstorming: Breakout Groups (continued)	

Program Goals

The overall goal of Building America is to develop strategies and systems that can be implemented in entire neighborhoods and developments to take advantage of economies of scale. Building America's research activities provide the technical support and cost/performance documentation that builders and remodelers require to accelerate the adoption and implementation of highly efficient building practices. Building America's research and development addresses not only building system and subsystem improvements, but also improvements in design, construction, and remodeling processes and management.

Building America acts as a national residential energy systems test bed for new and existing homes, where different system options are evaluated, designed, built/retrofitted, and tested to confirm that all requirements for risk minimization, durability, quality control, and energy performance are met. To accelerate progress towards multi-year goals, research is conducted in parallel at different energy savings performance levels, facilitating rapid use of new system solutions at all performance levels. Evaluations of individual measures, individual test houses, and community scale housing validate the reliability, cost-effectiveness, and marketability of the packages of energy measures, when integrated in new production housing and groups of retrofits.

Building America residential systems research tasks are designed to evaluate performance of measures at three major scales:

- Individual measures and systems
- Packages of measures in individual test houses
- Average savings of measures when implemented in pilot communities (multiple houses on a neighborhood scale)

These research activities are supported by two additional activities:

- Pathways Analysis (analysis tools)
- Implementation Tools (documentation, analysis and construction quality assurance)

The preliminary multi-year energy savings goals for Building America are summarized in Tables 1 and 2. For existing homes, energy savings calculations are based on simulated energy use before and after retrofit, using standard operating conditions consistent with realistic usage patterns of typical occupants. For new homes, energy savings goals are relative to the B10 Benchmark, which is consistent with the 2009 International Energy Conservation Code (IECC), federal appliance standards in effect as of January 1, 2010, and lighting and miscellaneous electric loads most prevalent in 2010. Requirements for performing energy savings calculations are documented in the House Simulation Protocols (HSPs) available on the Building America website (http://www1.eere.energy.gov/buildings/building_america/perf_analysis.html). Climate Regions are also defined on the Building America website (http://www1.eere.energy.gov/buildings/building_america/climate_zones.html). Several Climate Regions are grouped for the purpose of documenting achievement of program targets.
Current Best Practices are defined as the most cost and savings effective energy efficiency packages that can currently be implemented in volume in the new construction and existing home retrofit markets. Final multi-year percent savings goals will be defined based on a review of the energy savings achievable in the marketplace.

Table 1. Multi-Year Energy Savings Goals for Existing Homes

Energy Savings	Mixed-Dry, Hot-Dry and Marine	Mixed-Humid, Hot Humid	Cold, Very Cold, and Subarctic
Current Best Practice (15% or above)	2011	2011	2011
30%	2012	2013	2014
50%	2015	2016	2017

Table 2. Multi-Year Energy Savings Goals for New Homes

Energy Savings	Mixed-Dry, Hot-Dry and Marine	Mixed-Humid, Hot Humid	Cold, Very Cold, and Subarctic
Current Best Practice (20% or above)	2010	2011	2011
30%	2011	2012	2013
50%	2014	2015	2016

Building America's near term goal is to reduce total average source energy use in existing homes by up to 30% compared to the home's current simulated energy use. The Building America program also has longer-term goals for "deep retrofit" research that contributes to reducing existing home energy use by 50% or more. The goal for new homes is to provide similar levels of savings in new homes compared to typical new homes built in 2010, according to the same timetable. All activities performed by the Building America Research Teams shall be conducted in support of these multi-year goals.

Goal achievement will be judged based on development of Measures Guidelines resulting in proven energy savings levels. Goals are for efficiency measures only, and do not include site electricity generation.

National Laboratory Research Planning: 50%+ savings levels (Tuesday 8:00 – noon)

- Only national laboratories and DOE will participate in this activity
- 8:00-8:15: Welcome and Introductions (David Lee)
- 8:15-8:45: Planning for residential lab program review (David Lee)
- 8:45-9:00: Review of white paper template (NREL)
- 9:00-9:20: LBNL White Paper Outline (LBNL)
- 9:20-9:40: ORNL White Paper Outline (ORNL)
- 9:40-10:00: PNNL White Paper Outline (PNNL)
- 10:00-10:15: Break
- 10:15-11:45: Opportunities, Gaps, and Barriers to 50%+ Savings Levels
    - 15 minutes: Brainstorm / list opportunities to 50%+ savings levels
    - 10 minutes: Prioritize (dots) and Summarize top opportunities
    - 15 minutes: Identify/list gaps and barriers
    - 10 minutes: Prioritize gaps and barriers (dots)
    - 15 minutes: Develop solution paths
    - 25 minutes: Draft 50% + MYP milestones (could even break into groups of 2-3 to draft, hand in, read and comment)
- 11:45-12:00: Discussion of current and future opportunities for lab research collaboration

Residential Integration Goals and Program Updates (Tuesday 1:00 PM – 5:30 PM)

The objective of this session is to give an overall view of the research process to the teams. Following is the tentative agenda:

- 1:00-1:15: Welcome and Introduction (George James)
- 1:15-1:45: Multi-Year Goals and Milestones (David Lee)
- 1:45-2:30: Technical Pathways for 30% Savings in Existing and New Homes (Ren Anderson)
- 2:30-3:00: Performance Evaluation Protocols (Cheryn Engebrecht)
- 3:00-3:15: Break
- 3:15-4:00: Planning Update: Residential Energy Codes (Bob Dewey)
- 4:00-4:30: July Meeting: Findings (Stacey Rothgeb)
- 4:30-5:00: Builders Challenge (Ed Pollock)
- 5:00-5:30: Open Discussion / Q&A

Brainstorming Activity (Wednesday-Thursday)

Rules of a Good Brainstorming Activity

1. Don't allow criticism
2. Encourage wild ideas (think outside the box)
3. Go for quantity (capture ideas as you think of them)

4. Combine and/or improve on others' ideas
5. One conversation at a time
6. Stay focused on the topic

Objectives

Identify, related to achieving program goals,

- Key opportunities
- Key gaps and barriers
- Key performance risks
- Key multi-year milestones (NT = near-term; MT = mid-term; LT = long-term)
- Specific questions that must be answered to achieve program goals

Key Meeting Endpoint

High level summary of priority projects and multi-year milestones to track critical research progress.

Topic Areas

Systems and Measures

- Space Conditioning (ventilation, indoor air quality, dehumidification)
- Hot Water
- Enclosures
- Lighting, Appliances, Miscellaneous Electric Loads (LAMELs)
- Home Energy Management

Pathways Analysis

- Analysis Methods and Tools
- Evaluation of Research and Technology Gaps

Test Houses and Pilot Communities

- Testing Methods and Protocols
- Program Partner Tools and Needs

Implementation Tools

- Research Implementation
- Quality Management
- Curriculum Development

Brainstorming Agenda – Wednesday, November 3

Wednesday, Nov 3	BREAKOUT 1	BREAKOUT 2	BREAKOUT 3
8:00-8:30 AM	Announcements and Introduction to Brainstorming Process		
8:30-10:00 AM	Analysis Methods and Tools / Evaluation of Gaps	Foundations	Space Conditioning and Hot Water (Mechanical Equipment)
10:00-10:15 AM	BREAK		
10:15-10:45 AM	Report out: Analysis Methods and Tools / Evaluation of Gaps		
10:45-11:15 AM	Report out: Foundations		
11:15-11:45 AM	Report out: Space Conditioning and Hot Water (Mechanical Equipment)		
11:45-1:00 PM	LUNCH		
1:00-2:30 PM	Testing Methods and Protocols	Walls and Windows	Lighting, Appliances and Miscellaneous Electric Loads
2:30-2:45 PM	BREAK		
2:45-3:15 PM	Report out: Testing Methods and Protocols		
3:15-3:45 PM	Report out: Walls and Windows		
3:45-4:15 PM	Report out: LAMELS		
4:15-5:00 PM	Wrap-Up		

Brainstorming Agenda – Thursday, November 4

Thursday, Nov 4	BREAKOUT 1	BREAKOUT 2	BREAKOUT 3
8:00-8:15 AM	Announcements		
8:15-9:45 AM	Implementation Tools / Program Partner Tools and Needs	Attics	Home Energy Management
09:45-10:00 AM	BREAK		
10:00-10:30 AM	Report out: Implementation Tools / Program Partner Tools and Needs		
10:30-11:00 AM	Report out: Attics		
11:00-11:30 AM	Report out: Home Energy Management		
11:30-12:00 PM	NEXT STEPS AND WRAP UP		

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