Enclosures Standing Technical Committee

Strategic Plan, v2011a

Revised: December 2011

Committee Chair:

2011	Joseph Lstiburek Kohta Ueno Katie Boucher	Building Science Corporation

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Definitions

ARBI	Alliance for Residential Building Innovation
ARIES	Advanced Residential Integrated Energy Solutions
BA	Building America
BA-PIRC	Building America Partnership for Improved Residential Construction
BARA	Building America Retrofit Alliance
BIRA	Building Industry Research Alliance
BSC	Building Science Corporation
CARB	Consortium for Advanced Residential Buildings
CEDA	Community and Economic Development Association of Cook County, Incorporated
CEER	Habitat Cost Effective Energy Retrofit Program
CSE	Fraunhofer Center for Sustainable Energy Systems
GWP	Global Warming Potential
IR	Infrared
LBNL	Lawrence Berkeley National Laboratory
NAHBRC-IP	National Association of Home Builders Research Center Industry Partnership for High Performing Homes
NorthernSTAR	NorthernSTAR Building America Partnership
NREL	National Renewable Energy Laboratory
NYSERDA	New York State Energy Research and Development Authority
ORNL	Oak Ridge National Laboratory
PARR	Partnership for Advanced Residential Retrofit
PCM	Phase Change Material
PNNL	Pacific Northwest National Laboratory
SIPA	Structural Insulated Panel Association
SPF	Spray Polyurethane Foam
STC	Standing Technical Committee
VIP	Vacuum Insulated Panel

1. Enclosures STC Strategic Plan Overview

1.1 Committee Terms of Reference

Standing Technical Committees (STCs) focus on resolving key technical action items required to meet Building America performance goals. STC chairs lead each committee's activities in addressing specific research challenges, gaps in understanding, and new research opportunities. Committees include experts from the Building America research teams, DOE, national laboratories, and outside organizations that possess specialized knowledge or heightened interest in the topics being addressed.

The Strategic Plan is a living document maintained by the committee chair, who coordinates input and review by the committee. Planned revisions follow the three annual Building America meetings (technical, stakeholder and planning). The document should be referenced by other Building America teams when planning research and prioritizing opportunities. It will be used by DOE and other stakeholders when identifying market and research needs and setting priorities. In addition to clearly communicating and prioritizing current gaps (or market needs) and barriers, it serves as an archive of accomplishments and failures that inform all ongoing Building America efforts. The Strategic Plan is a living summary document and is NOT intended to be a compendium of all available knowledge.

1.2 The Importance of Enclosures for Energy Efficient Residential Buildings

Building enclosures are the assemblies, components and materials that together separate the interior environment from the exterior environment. Building enclosures provide separation by performing functions that may be grouped into three sub-categories, as follows:[1]

1. **Support functions**, i.e., to support, resist, transfer and otherwise accommodate all the structural forms of loading imposed by the interior and exterior environments, by the enclosure, and by the building itself. The enclosure or portions of it can be an integral part of the building superstructure—usually by design but sometimes not.
2. **Control functions**, i.e., to control, regulate and/or moderate all the loadings due to the separation of the interior and exterior environments—largely the flow of mass (air, moisture, etc.) and energy (heat, sound, etc.).
3. **Finish functions**, i.e., to finish the enclosure surfaces—the interfaces of the envelope with the interior and exterior environments. Each of the two interfaces must meet the relevant visual, esthetic, wear and tear and other performance requirements.

For energy efficient buildings, the control of heat and air are of critical importance. For the current stock of housing (see the Residential Energy Consumption Survey 2005, Table US14, **Figure 1**) space heating/cooling consumes more than half of the total site energy. In new construction, better thermal control has resulted in lower fractions (about 45%), as per Figure 2 (US Census Bureau, Annual Housing Survey[2]), but thermal control remains one of the lowest cost, most durable, easiest to predict, best developed means of reducing household energy use.

[1] Straube, John. "BSD-018: The Building Enclosure" Building Science Corporation, http://www.buildingscience.com/documents/digests/bsd-018-the-building-enclosure_revised?topic=doctypes/digests. Accessed December 22, 2011.

[2] US Census Bureau, Annual Housing Survey: http://www.census.gov/hhes/www/housing/ahs/ahs.html

	U.S. Households (millions)	Energy End Uses (million Btu of consumption per household)					
		All End Uses	Space Heating (Major Fuels)[4]	Air-Conditioning[5]	Water Heating[6]	Refrigerators	Other Appliances and Lighting
Type of Housing Unit							
Single-Family Detached	72.1	108.4	44.2	11.0	21.7	5.2	29.3
Single-Family Attached	7.6	89.3	41.7	6.7	19.0	4.0	20.9
Apartments in 2-4 Unit Buildings	7.8	85.0	48.5	6.3	15.6	3.5	16.3
Apartments in 5 or More Unit Buildings	16.7	54.4	25.0	6.6	12.2	3.0	11.8
Mobile Homes	6.9	70.4	26.1	9.2	13.3	4.2	21.4
Total	111.1	94.9	40.5	9.6	19.2	4.6	24.7

Figure 1: RECS 2005 Energy Consumption Data

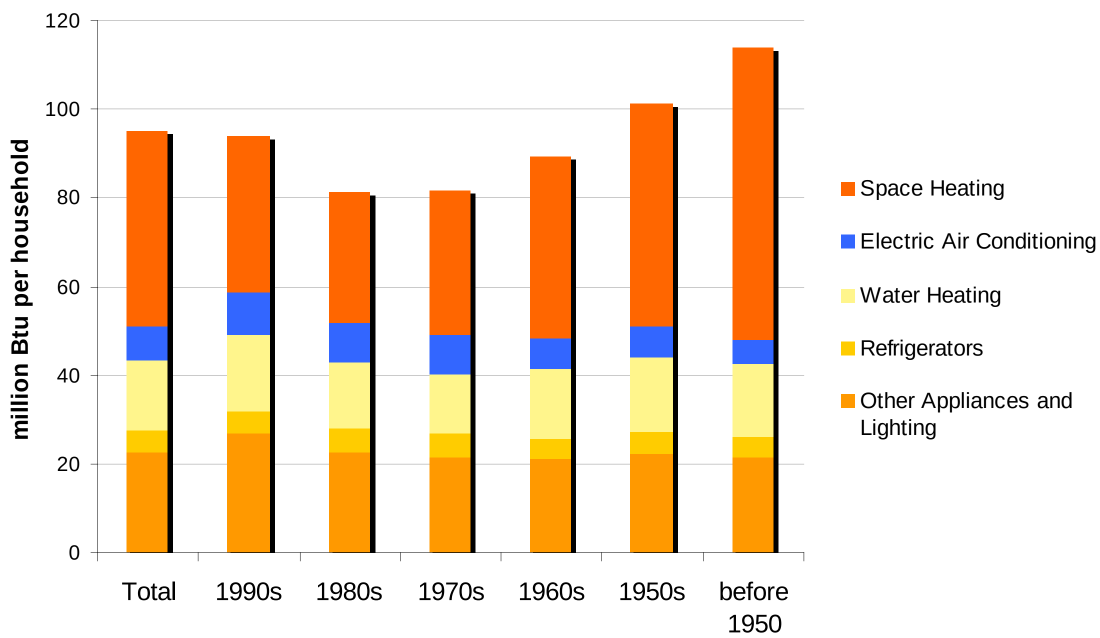


Figure 2: Total Btu consumption per household (US Census Bureau 2001)

Well-insulated and air tight-enclosures will reduce energy consumption for space heating and cooling in all climate zones. The impact of insulation and airtightness is largest in climates with cold temperatures for many hours, and smallest in climates with few hours per year at cold temperatures. However, high performance enclosures are still important for buildings exposed to the direct solar radiation in hot climates: the roof is the obvious example, especially if finished in dark colors that absorb solar radiation. Furthermore, fenestration (as a specific enclosure component) can dominate cooling loads.

The control of heat flow is important for more than just saving energy: by controlling interior surface temperatures, heat flow control helps ensure human comfort and avoid cold-weather condensation. As described later, controlling the temperature of various elements and layers within an enclosure assembly can be used to avoid condensation or enhance drying, both of which influence durability.

Thermal control is typically seen as being provided by insulation. However, air barrier systems, radiant barriers, solar control coatings, and thermal breaks are also part of any enclosure's thermal control system.

1.3 Enclosures STC Strategic Objectives

A 2010 Building America white paper, entitled "High R-value Enclosures for High Performance Residential Buildings in All Climate Zones"[3], identified several strategic research objectives for the development of high performance enclosures:

1. Research new materials and systems for high performance enclosures for new and existing buildings.
2. Develop affordable high performance enclosures for new construction in all climate zones.
3. Develop affordable high performance retrofit strategies for existing enclosures in all climate zones.
4. Identify and resolve barriers for implementation.

These objectives were taken as a starting point to organize the research needs identified by the committee. The following section, **Section 2. Enclosure Research Gaps**, lists and describes the specific research needs as identified by the Enclosures STC and participants from the residential construction industry. **Figure 3** provides an overview of these research gaps organized in relation to the strategic objectives listed above.

There are a number of different pieces of information illustrated in **Figure 3**. In the field of the chart, there are numbered bubbles of varying sizes, which each represent one of the research gaps identified by the committee. The size of the bubble provides a quick visual indicator of how popular the research gap was amongst respondents to the STC survey (i.e., number of votes out of 145 participants in the survey). The y- or vertical-axis is a timescale that plots the research gaps according to the estimated time of completion based on a survey of the current and proposed research projects within the Building America program. Generally, the bubbles that are closer to the top of the chart are research gaps that will be addressed in the very short term, and bubbles towards the bottom of the chart are research gaps that will be addressed some time in the future. The vertical position of the bubbles is also affected by the ranking of the research need by the committee, with those slightly closer to the top being more important or more pressing.

The x- or horizontal-axis organizes the research gaps by their relationship to one of the strategic objectives. This organization is modified horizontally if a research gap is related to more than one strategic objective. The horizontal arrangement, then, shows vertical clusters of research gaps above each objective, allowing at a quick glance a general impression of where further research is most needed (as seen by the committee and survey participants).

Solid and dashed lines with arrows have been placed on the chart to indicate necessary and related links (respectively) between identified research needs. This is a cursory analysis that only works with the information provided by the STC survey on research needs and does not take into account important and related research that has already been done in the Building America program or by other researchers. The Committee's intent is to take a "first pass" at understanding how the proposed research works towards addressing larger, longer-term strategic objectives for high performance enclosure research. This analysis could be refined and updated over time to allow the Committee to make recommendations regarding the timing of specific research projects.

[3] Straube, John et al.

Generally speaking, the arrows on all solid lines should be pointing towards future research (i.e., downwards in the chart) and arrows that are pointing towards previously completed research (i.e., upward in the chart) may indicate that an important research gap is not being addressed in a timely fashion.

As a final comment, it is noted by the Committee that all of the above is expected to be enlarged and refined over time.

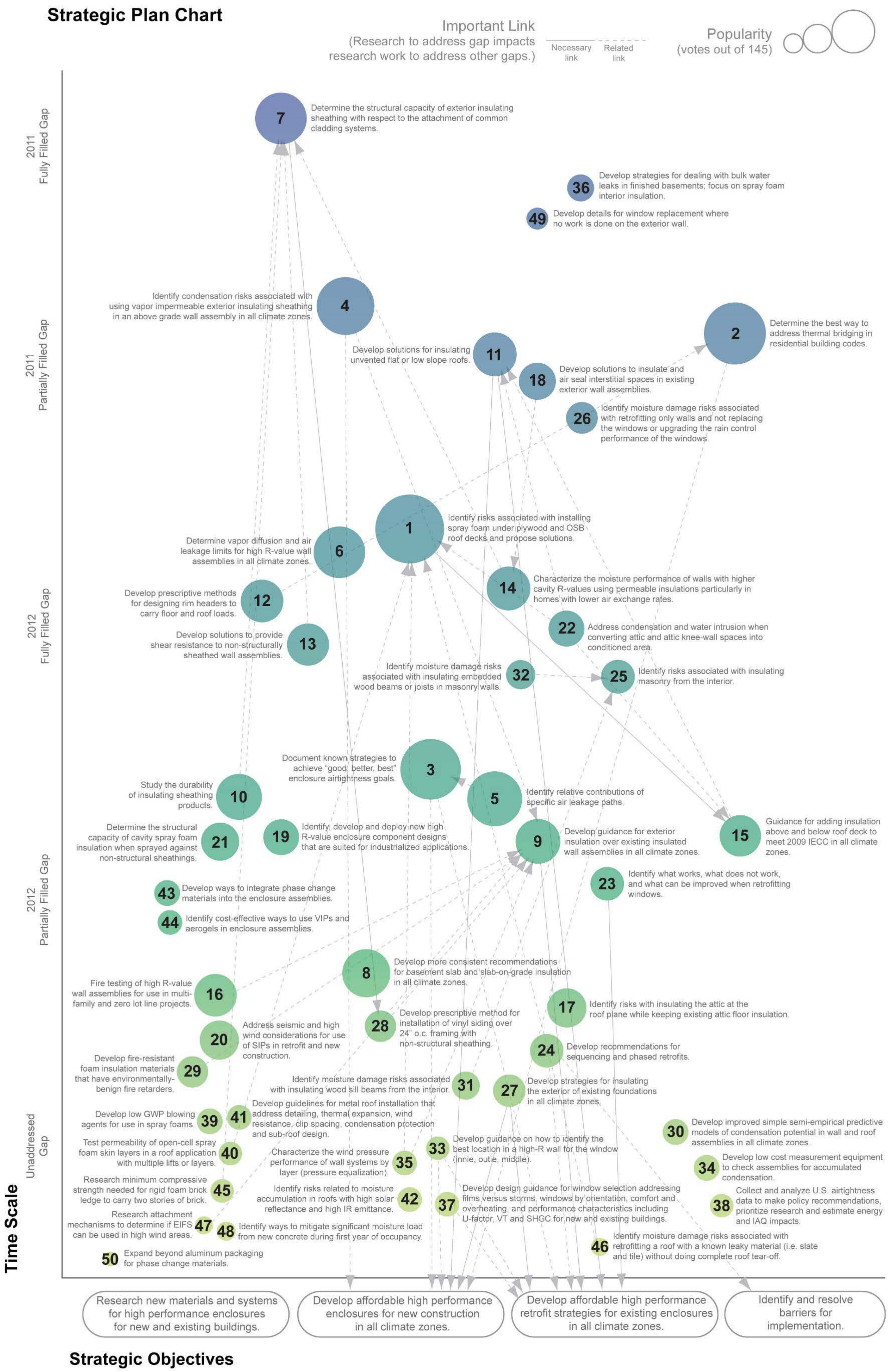


Figure 3: Strategic Plan Chart

1.4 Enclosures STC Summary of 2011 Activities

The Enclosures STC began meeting in May 2011 with the goal of identifying and prioritizing research gaps related to residential building enclosures. Once this was achieved, it was necessary to further define the research gaps in order to evaluate what would be needed to close the research gap. This was done through the creation of two page documents, called "**2-**Pagers", that provided more information related to the research gap. Small "Discussion Groups" were created to begin to critically review the 2-Pagers and provide feedback to the whole committee during scheduled All-Committee Meetings. The final committee activity involved combining and removing some research gaps as suggested by participants at the Annual Building America Planning Meeting.

More information on early committee activities can be found in section **2.1 Identifying and Prioritizing Research Gaps**; more information on the 2-Pagers can be found in section **2.2 "2-Pagers"**; removed or combined gaps can be found in **Appendix D**; final 2011 list of renumbered gaps can be found in **Appendix C**.

The following table summarizes the activities of the Enclosures STC in 2011. A list of meeting documents can be found in **Appendix F**.

Table 1: 2011 Activities

Date	Activity
2011-05-13	All-Committee #1 Webinar
2011-06-02 to 2011-06-17	Committee participants add research gaps to committee Google Doc
2011-06-10	All-Committee #2 Webinar
2011-06-29 to 2011-07-15	Committee participants and others vote for their Top 10 Research Gaps on survey posted on Survey Monkey
2011-07-15	All-Committee #3 Webinar
2011-08-11	All-Committee #4, Annual Building America Technical Update Meeting In-Person and Webinar
2011-08-23	First 30 voted gaps 2-Pagers posted to Google Docs
2011-09-12	Discussion Group #1 Roofs: Spray Foam Under Plywood and OSB Roof Decks Conference Call
2011-09-16	All-Committee #5 Conference Call
2011-09-30	Discussion Group #2 Walls: Thermal Bridging in Residential Codes Conference Call
2011-10-07	All-Committee #6 Webinar
2011-10-27	Annual Building America Planning Meeting In-Person

2011-11-09	Discussion Group #3 Airtightness: Airtightness Strategies Conference Call
2011-11-14	Enclosures STC Strategic Plan DRAFT posted to BSC file share site
2011-11-18	All-Committee #7 Webinar
2011-12-02	Discussion Group #4 Walls: Vapor Impermeable Exterior Insulating Sheathing Conference Call
2011-12-16	All-Committee #8 Webinar
2011-12-19 to 2011-12-20	Committee participants verify projects and comment on removed or combined gaps on Google Doc

2. Enclosure Research Gaps

2.1 Identifying and Prioritizing Research Gaps

The committee's early activities were to identify and prioritize research gaps. To allow committee participants to collaborate in real time (simultaneous addition of gaps to the document, and immediate visibility of new contributions), a Google Doc spreadsheet was chosen as the collaboration platform. Although the committee was identifying gaps that, when addressed, would improve the enclosure as a whole, the gaps were categorized mainly by enclosure component in order to more easily review research needs. A tab was created in the Google Doc spreadsheet for each of the following categories:

- Walls
- Roofs
- Foundations
- Fenestrations
- Materials
- Airtightness
- Other (for gaps that did not fit into the other six categories)

Before sending the Google Doc link to the committee, the committee chair populated the spreadsheet with research gaps identified at previous Building America meetings. The committee then had approximately two weeks to add research gaps to the list.

At the end of the two weeks, 72 research gaps had been identified throughout the seven categories. In order to prioritize the gaps, a survey was created on Survey Monkey and committee participants were asked to vote for their Top 10 Research Gaps (topics they felt were most important to the residential building industry). Participants were encouraged to send the survey link to anyone they felt would be interested: in the end, 145 people took the survey in a two-week time frame. The research gaps were then put in order from most to least popular and numbered from 01-72.

2.2 "2-Pagers"

With enclosure research gaps identified and prioritized, the next step was to create the two page documents that would further define the research gaps. 2-Pagers were created for the first 30 research gaps using information posted to the Google Doc spreadsheet and additional information from the committee chair. The 30 2-Pagers were posted to Google Docs for the committee to review. The 2-Pagers for the remaining 42 research gaps included information from only the Google Doc spreadsheet, and did not contain all 2-pager sections as described below.

However, it should be noted that the final committee activity was to combine or remove research gaps in order to consolidate the list of gaps. The 2-pagers included in this Strategic Plan reflect this consolidation.

The 2-Pagers include the following sections:

- **Gap Status and Gap Change:** Through the removal or combining of 22 of the 72 research gaps, the gaps have been renumbered from 01-50. The status of each gap is one of the following:
    - Critically reviewed by Discussion Group and revised by Committee Chair
    - Full 2-pager written by Committee Chair
    - Partial 2-pager with information from Google Doc

  Gap Change indicates the former gap number (out of 72), if the gap has been combined with another gap, and if projects from removed gaps have been added.
- **Problem Statement:** Describes the gap itself. What could the industry achieve if this wasn't a problem? What are the risks associated with ignoring this gap? What are the climatic considerations (e.g., is it isolated to a specific region)? Is the problem primarily cost effectiveness?
- **Key Customers and Stakeholders:** Lists the key customers and stakeholders.
- **Background Knowledge:** Lists the relevant background knowledge and reference key papers.
- **System Considerations:** Reference how this gap relates to other known gaps.
- **Planned or Ongoing Research:** The table in this section lists planned or ongoing research provided by committee participants. Project name, organization, calendar year and projected gap fulfillment are given if provided by the participants. Calendar Year indicates the year in which the majority of the work for the planned project will be completed. Projected Gap Fulfillment indicates if it is anticipated that the completion of a project will either partially fill or fully fill the research gap. Research projects that partially fill a gap will have some bearing on the gap but will not be sufficiently comprehensive or complete enough to fully address the gap.
- **Closing the Gap:** What is the goal and how do we know if it has been achieved? Define desired outcome in terms of relevant metrics that can be applied or measured.
- **Timeline:** What are the key milestones and critical path? When do milestones need to be accomplished for them to be useful to stakeholders? What is the realistic timeframe to substantially address the gap or barrier?
- **Cost-Value Matrix:** Cost is the estimated Building America funding required to research and develop solutions. Value is defined by the key stakeholders and customers including the likelihood of widespread adoption and potential benefits in the marketplace. The original 72 research gaps were divided into the three value categories and the cost of each of the first 30 gaps was estimated by the committee chair.

2.3 Gap Directory

The following directory lists each renumbered gap in order from highest to lowest priority. To navigate directly to a specific gap, press and hold the Ctrl key and click on the gap title.

1 GAP (Roofs): Identify risks associated with installing spray foam under plywood and OSB roof decks and propose solutions

Gap Status	Critically reviewed by Discussion Group and revised by Committee Chair
Gap Change	None

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	✓
Roof/Ceiling	✓	Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

1.1 Problem Statement

Identify risks associated with installing low-density open cell and high-density closed cell spray foam under plywood and OSB roof decks specifically moisture and durability issues. Are roof leaks a serious problem? Is delamination a serious problem?

Unvented roof strategies with spray foam have been used since the mid 1990's to provide durable and efficient building enclosures. However, there have been isolated incidents which raise some general concerns about potential pitfalls in overall hygrothermal performance of these systems. This project is intended to find, document, test, evaluate and report on those potential pitfalls and recommend strategies to avoid them.

Type of research: Field reviews, mock-up testing and modeling.

1.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Spray Foam Manufacturers and Installers
Plywood and OSB Manufacturers

1.3 Background Knowledge

Knowles 2010 (JLC)

Lyon/SGH 2010 (BuildBoston)

Smith et al 2009 (CUFCA report)

BSD-149: Unvented Roof Assemblies for All Climates
A brief description of different types of unvented roof assemblies and the benefits of unvented roof construction.
http://www.buildingscience.com/documents/digests/bsd-149-unvented-roof-assemblies-for-all-climates/view

IRC FAQ: Conditioned Attics
2009 IRC FAQ on making an attic into living space by moving the insulation to the underside of the roof deck between the roof rafters.
http://www.buildingscience.com/documents/guides-and-manuals/irc-faqs/irc-faq-conditioned-attics/view

RR-1001: Moisture-Safe Unvented Roof Systems
This paper describes a hygrothermal modeling study, including all of the U.S. climate zones, a range of interior humidity levels and numerous arrangements and types of insulation. The results showed that so long as airtightness is provided, and wintertime humidity is controlled, numerous unvented solutions using either or both spray foam (open and closed cell) and fibrous insulation (cellulose and mineral fiber) can be successful. Climate, the solar properties and exposure of the roofing, the air and vapor permeance of the insulation (s) and interior humidity are the most important factors to be considered in the design of moisture-safe unvented roof systems.
http://www.buildingscience.com/documents/reports/rr-1001-moisture-safe-unvented-wood-roof-systems/view

RR-1006: Building America Special Research Project – High-R Roofs Case Study Analysis
The following report is an excerpt from the 2010 Building Science Corporation Industry Team Building America Annual Report. The goal of this research is to find optimally designed, cost-effective roof insulation systems that can be included with other enclosure details to help reduce whole-house energy use by 70%. This report will compare a variety of roof insulating strategies and present their advantages and disadvantages according to several comparison criteria.
http://www.buildingscience.com/documents/reports/rr-1006-ba-high-r-roofs-case-study-analysis/view

1.4 System Considerations

Spray foams have advantages over alternative methods with respect to providing air sealing in complex assemblies–particularly roofs. In retrofit construction where mechanical systems are located in attics moving the air control layer and thermal control layer to the underside of the roof deck has advantages over sealing holes in attic ceilings and sealing ductwork. In addition, it might not be possible or practical to add roof vents at soffit locations. Accordingly, there may not be any practical alternative to moving the air control layer and thermal control layer to the underside of the roof deck.

1.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Application of Spray Foam Insulation Under Plywood and OSB Roof Sheathing	BSC	2012	Gap Fully Filled
Charleston – 6 variations including both open and closed cell SPF	ORNL		

1.6 Closing the Gap

Stage 1 – Field Review

Field reviews of installed low-density and high-density spray foam roof assemblies should be done via visual inspection, core samples, thermography and air leakage testing. The results of these field reviews should be used to determine a plan for further research if necessary. Existing “buzz” within the contractor sub groups makes it unclear whether this is a material related issue or an application issue or both or neither or if even if issues actually exist in sufficient numbers to be of concern. The field review should be designed to answer these fundamental questions.

Specifically, develop a field review protocol and examine approximately 50 installations—5-year old, 10-year old and 15-year old installations. Select a smaller subset to do more detailed investigation based on conditions.

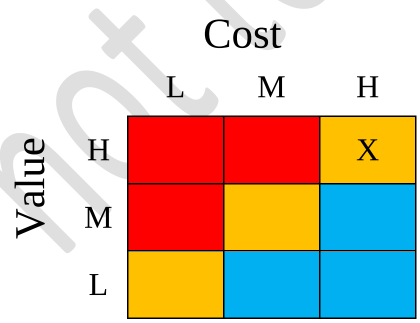
Stage 2 – Lab Mock Ups and Hygrothermal Modeling

Mock-ups should be constructed to determine the effect of flashing defects and roofing defects on rainwater leakage and redistribution of liquid phase water. The mock-up testing should be used to establish the boundary conditions for hygrothermal modeling. The hygothermal modeling should be used to determine drying potentials and relative risks in various climate zones of rainwater leakage.

1.7 Timeline

A field survey could be conducted and completed within a 6-month time frame. Mock up testing could be conducted and completed within a 6-month time frame. Modeling could be conducted and completed within a 3-month time frame after mock up testing has been completed.

1.8 Cost-Value Matrix



2 GAP (Walls): Determine the best way to address thermal bridging in residential building codes

Gap Status	Critically reviewed by Discussion Group and revised by Committee Chair
Gap Change	Combine with former #54 Develop a catalogue of residential thermal bridge Psi factors, demonstrate use, and develop means of validating Psi factors using IR thermography

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

2.1 Problem Statement

Thermal bridging greatly reduces the effective R-value of a wall; currently, the residential code does not accurately account for thermal bridging concerns. While current codes provide some equivalency between clear wall nominal R-Values and clear wall overall U-values, it does not effectively address edge effects of the assemblies at foundations, roofs, windows, wall corners, rim boards, balconies and decks.

Thermal bridging is well understood and can be reasonably accurately predicted for wood framed enclosures with existing two-dimensional steady-state models. Extensive research has already been completed to examine the impacts of these effects. Whole wall R-value research, completed in 1994, identified 14 basic edge effect details. From this research, it was determined that true performance may be upwards of 20% to 30% less than expected based on a clear wall value. Since performance is governed by these “edge effects,” building geometry will have a significant impact on the magnitude of the reduction. More complicated and articulated buildings will have proportionally poorer performance.

Wide dissemination of proven building techniques and the impact of thermal bridging along with code changes should be pursued. Tables in existing codes and standards should be modified to reflect thermal bridging. In addition, to ensure that systems performance is compared across an even playing field, there should be a U.S. standard (ASHRAE, ASTM or Model Codes) requiring inclusion of, and standard for, determining thermal bridging effects in U-factor calculations. These standards should be simple enough as to not discourage or exclude new systems and strategies from gaining code approval.

Type of Research: Code Development

2.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Codes and Standards Making Bodies
Builders
Insulation Manufacturers

2.3 Background Knowledge

ASHRAE Fundamentals, IRC, J.Kosny - How the Same Wall Can Have Several Different R-Values - Envelopes X Conference - 2007, J.Kosny - ASHRAE RP1145 -2002 Equivalent Wall; Title 24 Joint Appendix IV
http://www.energy.ca.gov/title24/2008standards/rulemaking/documents/pre-15-day_language/appendices/joint_appendices/JA%204%20-%20U-Factors%20-%20Rev%2014-15-day-1.pdf

BSI-005: A Bridge Too Far
An edited version of this Insight first appeared in the ASHRAE Journal. Thermal Bridges—steel studs, structural frames, relieving angles and balconies.
http://www.buildingscience.com/documents/insights/bsi-005-a-bridge-too-far/view

RR-0901: Thermal Metrics for High Performance Walls – The Limitations of R-Value
This document summarizes the theory behind thermal insulation and building system heat flow control metrics and presents a literature review of selected research into this area.
http://www.buildingscience.com/documents/reports/rr-0901-thermal-metrics-high-performance-walls-limitations-r-value/view

IMPACTS OF ARCHITECTURAL DETAILS ON THE WHOLE WALL THERMAL PERFORMANCE IN RESIDENTIAL BUILDINGS, J. Kosny and A.O. Desjarlais Oak Ridge National Laboratory
Building Thermal Envelope Systems and Materials Group February, 1994
http://www.ornl.gov/sci/roofs+walls/research/detailed_papers/wall_pap/content.html

New Whole Wall R-value Calculators As A Part Of The ORNL Material Database For Whole Building Energy Simulations
http://www.ornl.gov/sci/roofs+walls/AWT/home.htm

ORNL Online Simple Whole Wall R-value Calculator
http://www.ornl.gov/sci/roofs+walls/AWT/InteractiveCalculators/NS/SimCalc.htm

RR-1005: Building America Special Research Project: High R-Value Enclosures for High Performance Residential Buildings in All Climate Zones
The following report is an excerpt from the 2010 Building Science Corporation Industry Team Building America Annual Report. Many concerns, including the rising cost of energy, climate change concerns, and demands for increased comfort, have lead to the desire for increased insulation levels in many new and existing buildings. Building codes and green building codes are being changed to require higher levels of thermal insulation both for residential and commercial construction. This report will review, and summarize the current state of understanding and research into enclosures with higher thermal resistance, so-called "High-R Enclosures". Recommendations are provided for further research.
http://www.buildingscience.com/documents/reports/rr-1005-building-america-high-r-value-high-performance-residential-buildings-all-climate-zones/view

Paper describing the Whole Wall R-value concept
http://www.ornl.gov/sci/roofs+walls/research/detailed_papers/Whole_Wall_Therm/index.html

California Energy Commission Joint Appendices
http://www.energy.ca.gov/title24/2005standards/2004-10-26_400-03-001JAFM.PDF

2.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. High thermal resistance enclosures must address thermal bridging by definition.

2.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
NEEM	BA-PIRC	2011/2012	Gap Partially Filled

Unaware of any specific research currently planned or ongoing in this area for wood-framed housing. ASHRAE has sponsored research work to quantify three-dimensional thermal bridging in commercial assemblies.

2.6 Closing the Gap

This problem is more a dissemination of existing information problem than a lack of information problem. Some gaps do exist in the existing knowledge as noted, but these gaps can easily be closed by thermal modeling and publishing of the results.

A comprehensive guidance document should be developed and deployed. Modeling should be conducted to close the gaps in existing knowledge—particularly at window to wall interfaces in all buildings types, steel framed housing details, and retrofit details of masonry multi-family buildings.

New code tables and language should be developed to better account for the edge effects of various systems. The code tables and language must be simple enough for easy adoption by designers and builders. Any overly complicated analysis will be met with resistance from the industry.

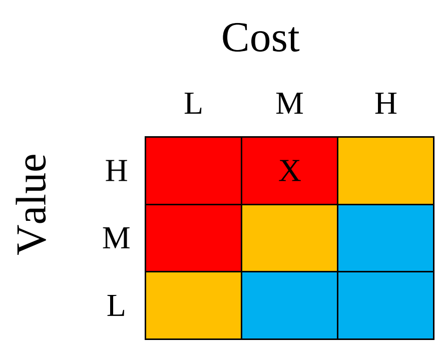
Standards for determining thermal bridging should be developed providing consistent results for determination of a whole wall R-Value and so that direct comparisons can be made between various enclosure designs.

A complimentary gap exists in the publication of material R-values measured at application temperatures. This information will be necessary before modeling results can be reliable.

2.7 Timeline

Modeling could be conducted and completed within a 3-month time frame. A comprehensive guidance document could be prepared within a 6-month time frame after the modeling has been completed.

2.8 Cost-Value Matrix



3 GAP (Airtightness): Document known strategies to achieve "good, better, best" enclosure airtightness goals

Gap Status	Critically reviewed by Discussion Group and revised by Committee Chair
Gap Change	None

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Airtightness	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

3.1 Problem Statement

Alongside the specification of higher levels of thermal insulation, it is equally important to achieve high-levels of airtightness in new construction. Methods and materials that can be easily deployed to achieve these high levels of airtightness need to be developed, demonstrated, documented, and disseminated to a wide range of designers, code officials, and builders. Numerous products, such as spray foam installed in stud bays, are sold on the basis of improved airflow resistance, but controlled measurements of houses insulated in this manner show that care and attention to all wood-wood joints in the enclosure must be applied to achieve their promised airtightness. The increased importance of ever-tighter construction alongside increased true R-values is not well understood by practitioners. The difference in performance between loose-laid air control layers (e.g., housewraps) and stiff or fully-adhered air control layers can be significant when tested under exfiltration rather infiltration, and little research has been conducted to investigate this. The lack of airtightness requirements in residential codes severely restricts the rate of deployment of airtightness, and airtightness already lags behind insulation in the marketplace.

Most of the recently developed materials and measures require significant disessmbly and reconstruction. Are there other measures that can be partly effective?

Type of Research: Design of details, field and laboratory testing

3.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Manufacturers

3.3 Background Knowledge

Info-408: Critical Seal (Spray Foam at Rim Joist)
The rim joist, band joist, or any area that connects building components, are particularly problematic to air seal properly.
http://www.buildingscience.com/documents/information-sheets/critical-seal-spray-foam-at-rim-joist/view

Info-401: Air Barriers–Airtight Drywall Approach
Several steps must be taken to create air barrier continuity at the perimeter of drywall assemblies, at all penetrations through the drywall, and, finally, in areas of the enclosure without interior drywall.
http://www.buildingscience.com/documents/information-sheets/air-barriers-airtight-drywall-approach/view

Info-405: Sealing Air Barrier Penetrations
Most air barrier systems will require supplemental air sealing to seal around penetrations.
http://www.buildingscience.com/documents/information-sheets/sealing-air-barrier-penetrations/view

BSD-014: Air Flow Control in Buildings
The control of air flow is important for several reasons: to control moisture damage, reduce energy losses, and to ensure occupant comfort and health. Airflow across the building enclosure is driven by wind pressures, stack effect, and mechanical air handling equipment like fans and furnaces. A continuous, strong, stiff, durable and air impermeable air barrier system is required between the exterior and conditions space to control airflow driven by these forces. Air barrier systems should be clearly shown and labeled on all drawings, with continuity demonstrated at all penetrations, transitions, and intersections.
http://www.buildingscience.com/documents/digests/bsd-014-air-flow-control-in-buildings/view

BSC-104: Understanding Air Barriers
Controlling heat flow, airflow, moisture flow and solar and other radiation will control the interactions among the physical elements of the building, its occupants and the environment. Of these four, airflow "merits major consideration mainly because of its influence on heat and moisture flow" (Hutcheon, 1953). Airflow carries moisture that impacts a materials long-term performance (serviceability) and structural integrity (durability). Airflow also affects building behavior in a fire (spread of smoke and other toxic gases, supply of oxygen), indoor air quality (distribution of pollutants and location of microbial reservoirs) and thermal energy use. One of the key strategies in the control of airflow is the use of air barriers.
http://www.buildingscience.com/documents/digests/bsd-104-understanding-air-barriers/view

Other documents to consider:

- Lawton & Quirouette, "CMHC research project testing of air barriers construction details"
- McKay, Chevrier & Quirouette, "Testing of air barriers II"
- Tamura
- Shaw
- US-Army Corps of Engineers, Bulletin No. 2009-29
- ORNL, "Spray foam in accessible spaces"

- Proskiw & Parekh, "Airtightness performance of wood-framed houses over a 14-year period"
- Yuill, "A field study of the effect of insulation types on the airtightness of houses"

Other sources to consider:

- ORNL and ABAA work to characterize AB systems
- GSA, BPI, CCMC, NRC/IRC
- ASTM E283, E1677

3.4 System Considerations

High levels of airtightness are a key to high performance buildings.

3.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Wind Washing; Air Sealing/Insulated Siding Retrofits; Select Test Home Projects; FRTF	BA-PIRC	2011/2012	Gap Partially Filled
Advanced New Construction Measure Guideline	BSC	2011/2012	Gap Partially Filled
	CEER		
Assessment of the Impact of Air Barriers on Energy and Moisture Control, Phase 2 of Air Barrier Assembly Evaluations at the Building Envelope System Testing (BEST) Facility	ORNL		
Laboratory tests on air barrier sub-assemblies	ORNL		
Field tests on airtightness and IAQ	ORNL		
Air sealing multifamily	ARIES		
Multifamily attic air sealing	CARB	2011	
Airtightness: Consistent high quality airsealing installation	BIRA	2011/2012	

3.6 Closing the Gap

This problem is more a dissemination-of-existing information problem than a lack-of-information problem. Some gaps do exist in the existing knowledge as noted, but these gaps can easily be closed by design of details, field testing of the details and publishing of the results. Three guidance documents should be developed to close this gap:

1. Controlling air leakage in new and retrofit residential buildings: This document should provide the reader with an understanding of the context and theory behind controlling air leakage. The document should include but not be limited to:
   - The impact of air leakage and efforts to control it

- On energy consumption (provide comparisons between air barrier systems and other energy efficiency measures
- On moisture control (a general discussion of how air leakage control for moisture differs from energy control)
- Ventilation and& combustion safety

  - A summary of methods for measuring the airtightness at the building, system, subsystem and material levels
  - Diagrams and explanations of typical air leakage paths.

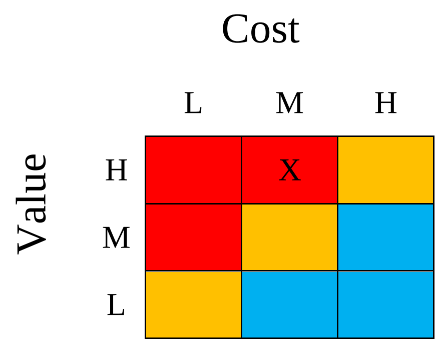
2. Airtightness strategies for new residential construction: This document should provide a summary of best practices for controlling air leakage in new residential buildings. The document should include but not be limited to:
    - Recommended air barrier materials, systems and details
        - Best practices for support of loose laid systems
        - Best practices for wood-wood joints for spray foam systems
        - Etc.
    - Recommended performance levels
    - Recommendations for commissioning the air barrier system
        - Testing after air barrier system is ‘complete’ vs immediately prior to occupancy vs testing at several times using appropriate methods
3. Airtightness strategies for residential retrofits
   This document should provide a summary of best practices for implementing retrofits to control air leakage in existing residential buildings. The document should include but not be limited to:
    - Recommendations for assessing existing building air tightness and identifying air leakage paths
    - Recommendations for establishing retrofit airtightness goals
    - Recommended air barrier materials, systems and details
    - Recommendations for commissioning the air barrier system

There is also a need to further develop and/or summarize studies, methods and protocols for assessing the airflow resistance / air leakage of subsystems in both the laboratory and in the field.

3.7 Timeline

Design of details and field testing can be conducted within a 6-month time frame. A comprehensive guidance document could be prepared within a 6-month time frame after the design of details and field testing has been completed.

3.8 Cost-Value Matrix



4 GAP (Walls): Identify condensation risks associated with using vapor impermeable exterior insulating sheathing in an above-grade wall assembly in all climate zones

Gap Status	Critically reviewed by Discussion Group and revised by Committee Chair
Gap Change	None

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

4.1 Problem Statement

What are the moisture-related risks in an above-grade wall assembly from vapor condensation and bulk water leakage when the wall assembly is constructed with vapor impermeable exterior insulating sheathing? Does drainage, and redistribution occur quickly enough to minimize the moisture-related durability issues to an acceptable level?

There is currently very little literature that compares the moisture-related performance (both wetting and drying) of high-R walls with exterior insulating sheathing to current construction practices in a side-by-side comparison. The drying capacity of different high-R assemblies in the field should therefore be measured and demonstrated alongside current standard construction walls. Ideally these walls will be compared with controlled wetting events to determine the hygric redistribution and drying potential. By conducting this testing, it is hypothesized that higher R-value walls may gain more market acceptance.

A distinction is necessary between walls with vapor impermeable insulated sheathing with the face of the insulation taped to serve as the drainage plane versus those with housewrap behind the insulated sheathing as a drainage plane—i.e. face-sealed versus water managed insulated sheathing.

Type of Research: Simulation, laboratory testing, and field testing.

4.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Insulation Manufacturers

4.3 Background Knowledge

Jablonka 2010 (Buildings XI)

IRC FAQ: Insulating Sheathing Vapor Retarder Requirements
2006 IRC High Performance Housing Insulating Sheathing Vapor Retarder Requirements FAQ Sheet
http://www.buildingscience.com/documents/guides-and-manuals/irc-faqs/irc-faq-insulating-sheathing-vapor-retarder-requirements/view

RR-0412: Insulations, Sheathings and Vapor Retarders
Two seemingly innocuous requirements for building enclosure assemblies bedevil builders and designers almost endlessly: keep water vapor out, let the water vapor out if it gets in.
http://www.buildingscience.com/documents/reports/rr-0412-insulations-sheathings-and-vapor-retarders/view

RR-0905: Modeled and Measured Drainage, Storage and Drying Behind Cladding Systems
This paper documents the experimental methodology, details, and results and discuss how this information can be applied to modeling drained wall systems. Practical applications and research questions arising from the work are presented.
http://www.buildingscience.com/documents/reports/rr-0905-modeled-measured-drainage-thermal-x/view

RR-1012: Residential Exterior Wall Superinsulation Retrofit Details and Analysis
This paper is from the proceedings of the Thermal Performance of the Exterior Envelopes of Whole Buildings XI International Conference, December 5-9, 2010 in Clearwater, Florida.
http://www.buildingscience.com/documents/reports/rr-1012-residential-exterior-wall-superinsulation-retrofit/

Guide to Insulating Sheathing
Residential housing design continues to move towards the development of high performance sustainable building systems. To be sustainable, a building must not only be efficient and durable but also economically viable. From this, new methods of enclosure design have been examined that provide high thermal performance and long-term durability but also take opportunities to reduce material use (including waste), simplify or integrate systems and details, and potentially reduce overall initial costs of construction.
http://www.buildingscience.com/documents/guides-and-manuals/gm-guide-insulating-sheathing/view

4.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. High thermal resistance enclosures are typically constructed with advanced wood structural frames and sheathed with impermeable or semi-impermeable insulating sheathings.

4.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Water Management of Insulating and Non-Insulating Sheathings	BSC	2011	Gap Partially Filled
	NAHBRC-IP		
Charleston Project – Report coming out in March	ORNL		
Retrofit Project	CEER		

Hygric Redistribution in Insulated Assemblies	BSC	2011	Gap Partially Filled
Guidance on Moisture Management for High-R Walls for New Construction	BSC	2012	Gap Partially Filled
Field research of full scale test walls	Steven Winter Associates		
Test hut research of full scale field test walls	BSC		

4.6 Closing the Gap

Side–by-side comparisons of standard assemblies and high thermal resistance assemblies with impermeable sheathings (both insulating and non insulating) should be conducted via field exposure drying/wetting testing in test huts or test walls. It is important for the field testing to assess the moisture related durability risks of the walls at normal operating conditions and when they become stressed to determine the moisture-related durability risks in service. Hygrothermal modeling should be conducted to supplement the field exposure testing.

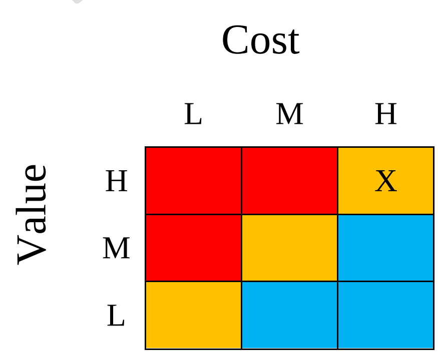
There is no standard for field testing of full scale wall systems, and organizations that typically conduct field testing should communicate their experimental program, and testing protocol, to ensure that useful results are achieved due to the lengthy time frame of most full-scale field tests.

A comprehensive guidance document should be developed and deployed regarding the moisture-related durability issues and benefits of constructing wall assemblies with exterior insulation in all climate zones.

4.7 Timeline

Field exposure testing can be conducted over a single winter season (November through April) followed by spring drying although there are benefits to testing through all seasons. Analysis of data and hygrothermal modeling can be conducted within a 3-month time frame after completion of the field exposure testing. A comprehensive guidance document could be prepared within a 6-month time frame after the field exposure testing and modeling has been completed.

4.8 Cost-Value Matrix



5 GAP (Airtightness): Identify relative contributions of specific air leakage paths

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Three projects added from former #21 Methodology for identifying impacts of air leakage reduction on ventilation, combustion safety in existing buildings

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Airtightness	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

5.1 Problem Statement

Identify relative contributions of specific air leakage paths. Although airtightness is theoretically easy to achieve in two-dimensional sectional drawings, once the Thermal Bypass Checklist has been followed, most of the remaining leaks occur through tortuous, small and often three-dimensional flow paths. The relative amount of leakage through walls, roof, windows and foundations of modern housing is essentially unknown. Contributions seal the big holes and get down from 8+ ACH50 to 3-4 ACH50; seal the known tortuous paths to get down to 2 ACH50; seal difficult & often building specific small, tortuous paths to get 1 ACH50. Identify the impact of specific details at partitions, light fixtures, electrical outlets, drywall to wood interfaces, etc.

Type of Research: Laboratory testing and field testing

5.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Manufacturers

5.3 Background Knowledge

Sherman & Chan 2004, Yuill 1997, Tamura 1975, Ober 1994

BSD-014: Air Flow Control in Buildings
The control of air flow is important for several reasons: to control moisture damage, reduce energy losses, and to ensure occupant comfort and health. Airflow across the building enclosure is driven by wind pressures, stack effect, and mechanical air handling equipment like fans and furnaces. A continuous, strong, stiff, durable and air impermeable air barrier system is required between the exterior and conditions space to control airflow driven by these forces. Air barrier systems should be clearly shown and labeled on all drawings, with continuity demonstrated at all penetrations, transitions, and intersections. In addition, enclosure assemblies and buildings should be vertically and horizontally compartmentalized, may require secondary planes of airtightness (such as those provided by housewraps and sealed rigid sheathing) and may need appropriately air impermeable insulations or insulated sheathing.
http://www.buildingscience.com/documents/digests/bsd-014-air-flow-control-in-buildings/view

BSI-036: Complex Three Dimensional Airflow Networks
An edited version of this Insight first appeared in the ASHRAE Journal. You build things that seem like they are obviously going to work and then the real world intrudes and reminds you that you are not as smart as you think.
http://www.buildingscience.com/documents/insights/bsi-036-complex-three-dimensional-air-flow-networks/view

BSD-109: Pressures in Buildings
Air flow in buildings is one of the major factors that governs the interaction of the building structure with the mechanical system, climate and occupants. If the air flow at any point within a building or building assembly can be determined or predicted, the temperature and moisture (hygrothermal or pyschometric) conditions can also be determined or predicted.
http://www.buildingscience.com/documents/digests/bsd-109-pressures-in-buildings/view

BSI-002: The Hollow Building
Buildings today are hollow and multilayered with numerous air gaps or void spaces. Chases, shafts, soffits and drops abound. Everything is connected to everything else, typically unintentionally. Buildings are complex three dimensional airflow networks. This is not good. Buildings once were solid and compartmentalized. They were heavy and massive and expensive because they were heavy and massive. Heavy and massive also constrained us in other ways—we couldn't go tall. To save money we made walls light; to go tall we made walls light. To make walls light, we made them hollow.
http://www.buildingscience.com/documents/insights/bsi-002-the-hollow-building/view

BSC: Attic Air Sealing Guide and Details
The Guide provides the background and approach for the prep work necessary prior to adding attic insulation - focusing on combustion safety, ventilation for indoor air quality, and attic ventilation for durability. The "Attic Air Sealing Details" section provides a scope of work and specification for the air sealing of many points of air leakage in common attic spaces.
http://www.buildingscience.com/documents/guides-and-manuals/gm-attic-air-sealing-guide/view?topic=doctypes/guides-and-manuals

5.4 System Considerations

High levels of airtightness are a key to high performance buildings.

5.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
FRTF; Sequential Unsealing and Testing	BA-PIRC	2011/2012	Gap Partially Filled
Retrofit Project – Staged / sequential; air seal and package without blower door	CEER		
Exterior Wall Project in New York – Comprehensive Retrofit	IBACOS		
Incremental Testing – Air barrier in lab; blower door tests	ORNL		
Dense Pack Wall and Roof Assemblies	BSC	2011	Gap Partially Filled
Wind Washing; Air Sealing/Insulating Siding Retrofits; Select Test Home Projects; FRTF	BA-PIRC	2011/2012	Gap Partially Filled
Measurement of Existing Homes for Retrofitting – Calibration of Multiple Homes	CEER	2011/2012	Gap Partially Filled
	NorthernSTAR		

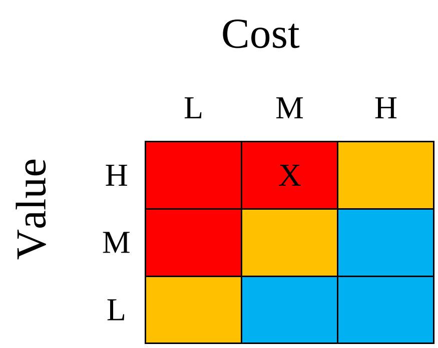
5.6 Closing the Gap

This problem is more a dissemination of existing information problem than a lack of information problem. Some gaps do exist in the existing knowledge , but these gaps can easily be closed by limited laboratory testing, field testing and publishing of the results. A comprehensive guidance document should be developed and deployed.

5.7 Timeline

Laboratory and field testing can be conducted within a 6-month time frame. A comprehensive guidance document could be prepared within a 6-month time frame after the laboratory and field testing has been completed.

5.8 Cost-Value Matrix



6 GAP (Walls): Determine vapor diffusion and air leakage limits for high R-value wall assemblies in all climate zones

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Combine with former #16 Identify condensation risks associated with various cavity insulation materials using a double stud wall in cold climate zones; 1 project added from former #16

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

6.1 Problem Statement

Determine vapor diffusion and air leakage limits for high-R value wall assemblies, especially for cold and hot, humid climates. Include various sheathing and interior finish combinations.

Increasing insulation levels in walls place wood-based sheathing and some sidings (particularly wood and fiber cement) at risk of moisture damage. Field experience with certain types of high-R enclosures (e.g. SIPS and double stud walls and dense-pack roof assemblies) have shown that wetting due to small errors (for example, convective loops or rain leaks) can occur and drying is very slow: as a result there is a heightened risk of damage if additional measures are not taken. This increased risk of moisture damage is well understood anecdotally by researchers, but it is not well understood by the code and building communities. More research must be done to examine and quantify these risks and to identify appropriate, lower-risk applications for these technologies. Well-documented measurements of moisture levels in airtight walls with 8, 10, or 12" of cavity insulation would be useful to strengthen recommendations and quantify the risk. Previous research has shown that back-ventilated claddings can reduce or entirely eliminate the moisture risk to exterior siding and sheathings. However, more research quantifying how much ventilation is required, how effective it is, and the role of insulation levels on the risk in different climates would be useful to empower change in codes and manufacturer recommendations.

Type of research: Hygrothermal modeling, test lab validation and field test validation

6.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Manufacturers

6.3 Background Knowledge

RR-1005: Building America Special Research Project: High R-Value Enclosures for High Performance Residential Buildings in All Climate Zones
The following report is an excerpt from the 2010 Building Science Corporation Industry Team Building America Annual Report. Many concerns, including the rising cost of energy, climate change concerns, and demands for increased comfort, have lead to the desire for increased insulation levels in many new and existing buildings. Building codes and green building codes are being changed to require higher levels of thermal insulation both for residential and commercial construction. This report will review, and summarize the current state of understanding and research into enclosures with higher thermal resistance, so-called "High-R Enclosures". Recommendations are provided for further research.
http://www.buildingscience.com/documents/reports/rr-1005-building-america-high-r-value-high-performance-residential-buildings-all-climate-zones/view

RR-0903: Building America Special Research Project—High-R Walls Case Study Analysis
Many concerns, including the rising cost of energy, climate change concerns, and demands for increased comfort, have lead to the desire for increased insulation levels in many new and existing buildings. More building codes are being modified to require higher levels of thermal control than ever before.
http://www.buildingscience.com/documents/reports/rr-0903-building-america-special-research-project-high-r-walls/view

BSD-012: Moisture Control for New Residential Buildings
Moisture accumulates when the rate of moisture entry into an assembly exceeds the rate of moisture removal. When moisture accumulation exceeds the ability of the assembly materials to store the moisture without significantly degrading performance or long-term service life, moisture problems result.
http://www.buildingscience.com/documents/digests/bsd-012-moisture-control-for-new-residential-buildings/view

6.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. High thermal resistance enclosures can be shown to have reduced drying potentials and therefore have increased risk of moisture related damage. Limits to wetting and drying are key to the long term durability of these assemblies.

6.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Guidance on Moisture Management for High-R Walls for New Construction	BSC	2012	Gap Fully Filled
High-R Wall Moisture Testing (Retrofit)	NAHBRC-IP	2011/2012	Gap Fully Filled
Dense Pack Wall and Roof Assemblies	BSC	2011	Gap Partially Filled
Hygric Redistribution in Insulated Assemblies	BSC	2011	Gap Partially Filled
Southern Climate Research – Test Hut in New Mexico	CSE		
Wall Tests Project	CEER		
Whole House – New Construction – Transformations, Inc.	BSC	2011/2012	Gap Partially Filled

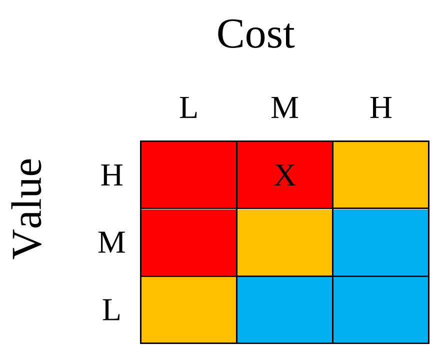
6.6 Closing the Gap

Side-by-side comparisons of standard assemblies and high thermal resistance assemblies with impermeable insulating sheathing should be conducted via field exposure testing in test huts or test walls. Hygrothermal modeling should be conducted to supplement the field exposure testing. A comprehensive guidance document should be developed and deployed.

6.7 Timeline

Field exposure testing can be conducted over a single winter season (November through April) for cold climates and over an entire year for hot-humid climates. Analysis of data and hygrothermal modeling can be conducted within a 3-month time frame after completion of the field exposure testing. A comprehensive guidance document could be prepared within a 6-month time frame after the field exposure testing and modeling has been completed.

6.8 Cost-Value Matrix



7 GAP (Walls): Determine the structural capacity of exterior insulating sheathing with respect to the attachment of common cladding systems

Gap Status	Full 2-pager written by Committee Chair
Gap Change	None

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

7.1 Problem Statement

Cladding attachment over thick layers of insulating sheathing is very poorly understood by builders and designer. What is allowed by code and by cladding manufacturers should be identified and then what needs to be done to ensure approved cladding attachment over thick exterior insulating sheathing must be defined. The structural capacity of exterior insulating sheathing with respect to cladding attachment (gravity) and wind loads (especially suction) should be quantified.

Although not found to be a problem in practice, uncertainty about cladding attachment and window/door installation for walls with thick layers of exterior insulation is a major challenge for the codes and the building design and construction community. There remain misconceptions about the need for “continuous support” behind vinyl siding, and the design of fastenings. The stiffness and strength of rigid foam and semi-rigid mineral fiber insulation when used to resist wind and gravity (shear) forces has not been scientifically established (although there is plenty of practical and anecdotal experience). These gaps are seen as a major obstacle to achieving high-R walls in the short-term, both in new and retrofit construction. The structural capacity (wind and gravity) and thermal resistance of cladding attachment using widely-available (preferably generic) components needs to be assessed, and the codes changed to allow siding attachment over more than 1” of sheathing (the current prescriptive limit). Some of this research work will likely be undertaken by the manufacturers of building materials (insulation materials, cladding materials, fasteners, etc.) but the systems-nature of this gap will require work from researchers concerned with the entire enclosure system.

There is confusion about the loading imparted by various cladding systems. Published weight/sq ft for manufactured stone cladding often does not include the weight of mesh and scratch and brown coats. These can increase the load by 20%-30%.

Type of research: Laboratory testing, code development

7.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Cladding Manufacturers
Insulating Sheathing Manufacturers
Fastener Manufacturers

7.3 Background Knowledge

Ueno 2010 "Residential Exterior Wall Superinsulation Retrofit Details and Analysis" Performance of the Exterior Envelopes of Whole Buildings XI. Atlanta, Geo.: American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc.

Lstiburek, J. "Building Sciences: Exterior Spray Foam" ASHRAE Journal, November 2010

IRC FAQ: Cladding Attachment Over Insulating Sheathing
2006 IRC High Performance Housing Cladding Attachment Over Insulating Sheathing FAQ Sheet
http://www.buildingscience.com/documents/guides-and-manuals/irc-faqs/irc-faq-cladding-attachment-over-insulating-sheathing/view

Baker, P. Building America 7.2.2 External Insulation of Masonry and Framed Walls Draft Research Report

7.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. High thermal resistance enclosures are typically constructed with thick exterior insulating sheathings. The cladding system must be integrated into the overall enclosure design.

7.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Cladding Attachment Over Thick Exterior Insulating Sheathing	BSC	2012	Gap Fully Filled
Wind Testing Project	NAHBRC-IP		
External Insulation of Masonry and Frame Walls	BSC	2011	Gap Partially Filled

The Foam Sheathing Coalition has ongoing work dealing with wind loading of vinyl siding installed over foam sheathing. However this work does not address thick insulating sheathing.

7.6 Closing the Gap

Additional work based on the output of the results of the BSC Task 7.2 work can fully address this gap or barrier. To date, this problem has been approached two different ways: through small-scale fastener/connection tests and full-scale wall tests. These approaches should be critiqued and a comparison made. A summary should be made of previous NYSRDA and foam coalition research. Testing should be identified and conduct to fill the gaps and extend the applicability. A comprehensive guidance document should be developed and deployed.

7.7 Timeline

Additional laboratory testing (beyond that planned under Task Order 2 – Task 7.2) can be completed in a 6-month time period. A comprehensive guidance document could be prepared within a 6-month time frame after the laboratory testing has been completed.

7.8 Cost-Value Matrix

Value \ Cost	L	M	H
H		X	
M			
L			

8 GAP (Foundations): Develop more consistent recommendations for basement slab and slab on grade insulation in all climate zones

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #09; Two projects added from former #62 Improve techniques for below grade hygrothermal analysis

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations	✓	Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

8.1 Problem Statement

Develop more consistent recommendations for basement slab and slab on grade insulation.

The heat loss through slabs, either below basements or on grade, is not very well characterized: sub-slab insulation is not even an option in the current version of EnergyGage USA. Consequently, many new highly insulated homes have no slab insulation at all, and some have sub-slab insulation that is equivalent to attic insulation levels! Better-documented field measurements combined with computer simulations are needed to develop better scientifically-based recommendations for High-R insulation levels below both radiantly heated and unheated slabs. The moisture-control and comfort benefits also are not well understood by the building community.

Type of research: Modeling and field measurement.

8.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Insulation Manufacturers
Modeling Programs, Developers and Users

8.3 Background Knowledge

Deru 2003, Mitalas 1983 (BASECALC), Beausoleil-Morrison & Mitalas 1997 (BASESIMP). Hagentoft (many sources, PhD thesis 1988)

Info-513: Slab Edge Insulation
For slab on grade construction, the slab edge represents a significant heat loss potential. This is important not only to the energy performance of a building but moisture management of the building as well.
http://www.buildingscience.com/documents/information-sheets/slab-edge-insulation/view

Info-511: Basement Insulation
Basements need to be dry for reasons of indoor air quality, pest control, and durability of the building.
http://www.buildingscience.com/documents/information-sheets/basement-insulation/view

IRC FAQ: Basement Insulation
2006 IRC High Performance Housing Basement Insulation FAQ Sheet
http://www.buildingscience.com/documents/guides-and-manuals/irc-faqs/irc-faq-basement-insulation/view

RR-1003: Building America Special Research Project – High-R Foundations Case Study Analysis
The following report is an excerpt from the 2010 Building Science Corporation Industry Team Building America Annual Report. Many concerns, including the rising cost of energy, climate change concerns, and demands for increased comfort, have lead to the desire for increased insulation levels in many new and existing buildings. Building codes are improving to require higher levels of thermal control than ever before for new construction. This report considers a number of promising foundation and basement insulation strategies that can meet the requirement for better thermal control in colder climates while enhancing moisture control, health, and comfort.
http://www.buildingscience.com/documents/reports/rr-1003-building-america-high-r-foundations-case-study-analysis/view

8.4 System Considerations

High performance buildings require high levels of thermal resistance by definition. Foundations are a key component of the enclosure comprising a high performance building.

8.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Under Slab Sensors at Lab House	IBACOS		
Monitoring Two Houses with Insulation Under Slab; Radiant Heat Slabs	ARBI		
Modeling Methods; Foundation Handbook Update	ORNL and NorthernSTAR		
Modeling Methods	NREL		
2013 Thermal Performance of Slabs	BA-PIRC		
Foundation Insulation Retrofit	BSC	2011	Gap Partially Filled
In-situ Foundation Insulation Testing at the CRRF	NorthernSTAR		
Retrofit Foundation Insulation Modeling and Analysis	NorthernSTAR	2011/2012	
Foundation Insulation Assessment/Analysis for New Construction	NorthernSTAR		

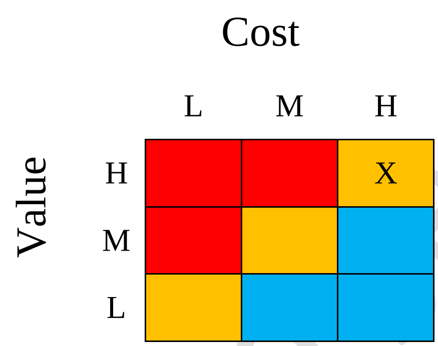
8.6 Closing the Gap

Development of more refined computer model modules for use by standard computer models is necessary. Existing field measurements contained in the literature as well as existing models contained in the literature should be used to develop these modules. These modules should then be incorporated into existing computer programs.

8.7 Timeline

Literature search of existing data could be completed in 3 months. The modules could be completed and tested in 9 months.

8.8 Cost-Value Matrix



9 GAP (Walls): Develop guidance for exterior insulation over existing insulated wall assemblies in all climate zones

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #10; Three projects added from former #29 Analyze the materials and methods for the exterior insulation of 1.5 story bungalows and cape cod houses in cold climates

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls	✓	Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

9.1 Problem Statement

There is a need for practical tools/models to evaluate the performance and potential risks of adding exterior insulation over existing insulated wall assemblies, based on a range of climate and interior conditions. The possibility of built-in moisture, existing air leaks, leaking windows, and low-permeance vapor barrier control layers in existing walls raises the risk of trapping moisture within retrofit assemblies. These risks need to be identified, explained and quantified. Decision-making tools need to be identified to evaluate the effectiveness of available overcladding techniques for existing buildings. Guidance for overcladding retrofits with various insulation materials should be developed.

Type of research: Modeling, laboratory testing and field testing

9.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Insulation Manufacturers

9.3 Background Knowledge

Quality Assurance Roadmap for High Performance Residential Buildings
BSC's Quality Assurance Roadmap outlines the approach to quality assurance in the construction process

as recommended by Building Science Corporation for new residential construction. Seven process steps are described from the assessment of current construction practice, through design and documentation changes, to training and quality control for on-site personnel. This document is intended to be used in lieu of a formal QA process to support high performance construction in Building America Research Prototype houses.
http://www.buildingscience.com/documents/guides-and-manuals/gm-building-america-quality-assurance-roadmap/view

BSD-144: Increasing the Durability of Building Constructions
The current building industry focus on durability is in part a reaction to the current perceived lack of it. Warranty claims and callbacks are viewed as increasing. Litigation and insurance costs are felt to be rising as a result. Another reason for the current focus on durability is the recognition that sustainability is not possible without durability. If you double the life of a building and you use the same amount of resources to construct it, the building is twice as resource efficient. Therefore durability is a key component of sustainability. It seems that one thing that both the development community and the environmental community can agree on is that durability is a good thing. What do we know about durability and how do we know it? The lessons of durability have come principally out of failure. Engineering is an iterative process of design by failure. Buildings are constructed. Problems are experienced. Designs and processes are changed. Better buildings are constructed. The building industry is in essence a reactive industry, not a proactive industry. It can be argued that the industry continues to do things until they become intolerably bad and then the industry changes. Examining failures gives us guidance on increasing the durability of building constructions.
http://www.buildingscience.com/documents/digests/bsd-144-increasing-the-durability-of-building-constructions/view

Info-310: Vapor Control Layer Recommendations
The current International Residential Code (IRC 2009) provides excellent guidance for the installation of vapor control layers.
http://www.buildingscience.com/documents/information-sheets/info-sheet-310-vapor-control-layer-recommendations/view

9.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. High thermal resistance enclosures are typically sheathed with impermeable insulating sheathings.

9.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Flat Roof Solutions	CSE	2012	Gap Partially Filled
Cladding Attachment Over Thick Exterior Insulating Sheathing	BSC	2012	Gap Partially Filled
Hygric Redistribution in Insulated Assemblies	BSC	2011	Gap Partially Filled
Project Overcoat for 1-1/2 Story Houses	NorthernSTAR	2011/2012	Gap Partially Filled
Whole House – Existing Construction – National Grid	BSC	2011/2012	Gap Partially Filled
Evaluation of Advanced Retrofit Packages in Test Homes	BSC	2011	Gap Partially Filled

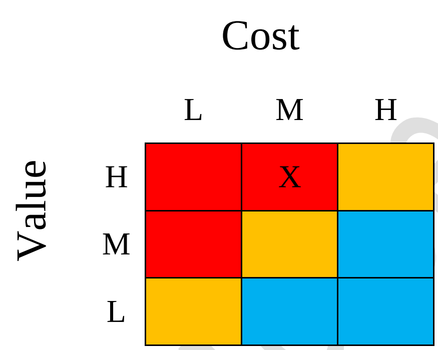
9.6 Closing the Gap

Side-by-side comparisons of typical existing wall assemblies and standard assemblies retrofit with insulating sheathings should be conducted via field exposure testing in test huts or test walls. Field studies should explore the impact of interstitial moisture through built-in wet layers and/or interstitial wetting systems. Hygrothermal modeling should be conducted to supplement the field exposure testing. A comprehensive guidance document should be developed and deployed.

9.7 Timeline

Field exposure testing can be conducted over a single winter season (November through April). Analysis of data and hygrothermal modeling can be conducted within a 3-month time frame after completion of the field exposure testing. A comprehensive guidance document could be prepared within a 6-month time frame after the field exposure testing and modeling has been completed.

9.8 Cost-Value Matrix



10 GAP (Materials): Study the durability of insulating sheathing products

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #11; project added from former #08 Develop Metrics for Material and System Durability

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Materials	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

10.1 Problem Statement

The durability of insulating sheathing products is not fully understood. Shrinkage of foam plastics have been observed over time, expansion and contraction due to temperature changes may be an issue, and insect or rodent damage have been postulated as potential failure mechanisms. There is a need to develop material durability and system durability metrics.

Type of research: Laboratory testing, field surveys, field exposure and field testing

10.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Manufacturers

10.3 Background Knowledge

Guide to Insulating Sheathing
Residential housing design continues to move towards the development of high performance sustainable building systems. To be sustainable, a building must not only be efficient and durable but also economically viable. From this, new methods of enclosure design have been examined that provide high thermal performance and long-term durability but also take opportunities to reduce material use

(including waste), simplify or integrate systems and details, and potentially reduce overall initial costs of construction.
http://www.buildingscience.com/documents/guides-and-manuals/gm-guide-insulating-sheathing/view

RR-0604: Incorporating Insulating Sheathing into the Design of the Thermal and Moisture Management System of the Building Enclosure
With rising utility cost, concerns over availability of natural resources, and environmental impacts of our energy production and use, a push has been made to design buildings to minimize energy consumption in an attempt to work towards more sustainable communities. Creating more thermally efficient building enclosures is a necessary part of achieving this goal. The thermal resistance provided by insulating a stud cavity is limited by the standard framing sizes currently used in the United States and Canada. The options therefore are to either increase the depth of the studs used, add insulation to the interior of the wall assembly, or to add extra insulation to the exterior of the assembly. Providing rigid insulating sheathing to the exterior of a wall assembly is a technique that has been used in cold climates for more than 40 years. Recently it has begun to be integrated into enclosure designs in all climates. As with any newly adopted technology, there can be concerns for its proper application. This paper examines methods of incorporating insulating sheathing into the thermal and moisture management systems of the building enclosure in a variety of climate zones across North America. This is done through examining the material properties of the various products and how these properties can be used to achieve an energy efficient and durable building enclosure design, while avoiding problems relating moisture accumulation and degradation of materials.
http://www.buildingscience.com/documents/reports/rr-0604-incorporating-insulating-sheathing-into-design-of-thermal-and-moisture-management-system-of-building-enclosure/view

RR-0603: Impact Resistance of Advanced Framed Wall Systems with Insulating Sheathing as the Primary Sheathing
Advanced framed wall systems that use a stud spacing of 24 inches on center and eliminate the plywood or OSB sheathing from the wall and replace it with insulating sheathing is a type of enclosure assembly that has been designed to be energy efficient combined with efficient material use.
http://www.buildingscience.com/documents/reports/rr-0603-impact-resistant-sheathing/view

BSD-144: Increasing the Durability of Building Constructions
The current building industry focus on durability is in part a reaction to the current perceived lack of it. Warranty claims and callbacks are viewed as increasing. Litigation and insurance costs are felt to be rising as a result. Another reason for the current focus on durability is the recognition that sustainability is not possible without durability. If you double the life of a building and you use the same amount of resources to construct it, the building is twice as resource efficient. Therefore durability is a key component of sustainability. It seems that one thing that both the development community and the environmental community can agree on is that durability is a good thing. What do we know about durability and how do we know it? The lessons of durability have come principally out of failure. Engineering is an iterative process of design by failure. Buildings are constructed. Problems are experienced. Designs and processes are changed. Better buildings are constructed. The building industry is in essence a reactive industry, not a proactive industry. It can be argued that the industry continues to do things until they become intolerably bad and then the industry changes. Examining failures gives us guidance on increasing the durability of building constructions.
http://www.buildingscience.com/documents/digests/bsd-144-increasing-the-durability-of-building-constructions/view

10.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. High thermal resistance enclosures are typically constructed with exterior insulating sheathings.

10.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Air Sealing/Insulating Siding Retrofits	BA-PIRC	2011/2012	Gap Partially Filled
Cladding Attachment Over Thick Exterior Insulating Sheathing	BSC	2011/2012	Gap Partially Filled
Guidance on Taped Insulating Sheathing Drainage Planes	BSC	2011/2012	Gap Partially Filled

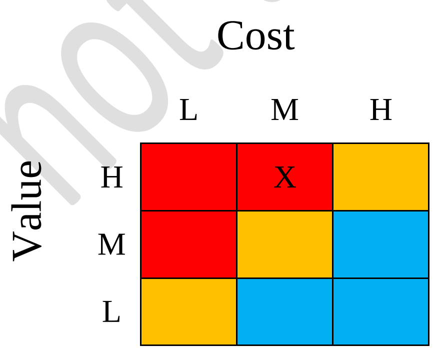
10.6 Closing the Gap

The use of insulating sheathing in the construction of building enclosures has been occurring for over four decades. Many failures and many successes have been reported over this time frame. A comprehensive survey of existing installations should be conducted to determine the factors of success and failure. The results of the survey should be used to establish the boundary conditions for performance metrics. The performance metrics should be refined using laboratory testing, field exposure and field testing.

10.7 Timeline

The survey of existing installations could be conducted over a 6 month period. The development of performance metrics and laboratory testing could be completed over 6-month period following the field survey. Field exposure and field testing to refine the performance testing can be completed over a 24-month to 36-month time period following the development of the performance testing and laboratory testing.

10.8 Cost-Value Matrix



11 GAP (Roofs): Develop Solutions for Insulating Unvented Flat or Low Slope Roofs

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #12

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	
Roof/Ceiling	✓	Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

11.1 Problem Statement

Affordable and durable solutions are required for insulating unvented flat or low slope roofs. Cellulose dense pack retrofits have high condensation risks; using spray foam is high cost. Are there alternate solutions with good energy, airtightness, and moisture performance? Weatherization contractors are experimenting with retrofits to existing, uninsulated, flat and low-slope roof assemblies. Proposed solutions include spray foam insulation air sealing of the perimeter wall; roof deck air seals with retrofit insulation installed above, or below the existing deck; and ceiling level air seals with combinations of dense-pack cellulose and loose-fill cellulose with air space and vapor diffusion ports. Contractors have suggested methods to retrofit existing assemblies from above and below by removing all finishes or by creating strategic openings. There is a need to have building scientists work with contractors to further understand, develop, and document these ideas.

Type of research: Modeling, field testing and demonstration.

11.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Insulation Manufacturers and Installers

11.3 Background Knowledge

Derome 2005 (J. Bldg Physics), Derome & Fazio 2000 (J. Arch Eng.), Lstiburek 2010 (ASHRAE J.)

BSI-043: Don't Be Dense–Cellulose and Dense-Pack Insulation
An edited version of this Insight first appeared in the ASHRAE Journal. I do not have a problem with dense packing walls. In fact, dense packing walls typically results in remarkable performance. It is the dense packing of unvented cathedral ceilings or unvented flat roofs that is the problem.
http://www.buildingscience.com/documents/insights/bsi-043-dont-be-dense/view

BSI-051: Decks–Roofs You Can Walk On
Decks are disarmingly simple. The ones we are going to deal with have conditioned space under them. They are nothing more than roofs that you walk on.
http://www.buildingscience.com/documents/insights/bsi-051-decks-roofs-you-can-walk-on/view

RR-0301: Unvented Roof Summary Article
This article was written to tie together and summarize the various papers on unvented conditioned cathedralized attics found on our website.
http://www.buildingscience.com/documents/reports/rr-0301-unvented-roof-summary-article/view

11.4 System Considerations

Many unvented flat roofs exist in older cities. Poorly insulated and air leaky roofs constitute a significant energy load for a building and often can be a very economical upgrade.

11.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Flat Roof Solutions	CSE	2011	Gap Partially Filled

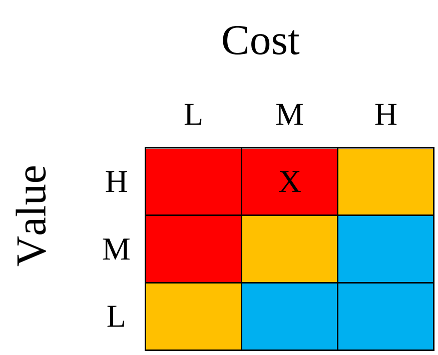
11.6 Closing the Gap

Proposed and experimental unvented flat and low slope insulation strategies should be documented and the underlying building science should be discussed. Hygrothermal simulations should be conducted to predict the likely performance and conduct sensitivity analyses. Moisture monitoring systems should be installed in several prototype roof assemblies to confirm field performance expectations.

11.7 Timeline

Modeling can be completed in a 3-month time period. Implementation, validation and demonstration of the solutions could be completed in a single winter season (November through April).

11.8 Cost-Value Matrix



12 GAP (Walls): Develop prescriptive methods for designing rim headers to carry floor and roof loads

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #13

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

12.1 Problem Statement

Prescriptive methods needed for rim header designs, to carry floor and roof loads.

Type of research: Laboratory testing, field testing, code development

12.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Dimensional Lumber Suppliers
Engineered Wood Manufacturers and Suppliers

12.3 Background Knowledge

Info-201: Common Advanced Framing Details
http://www.buildingscience.com/documents/information-sheets/information-sheet-common-advanced-framing-details/view

BSI-030: Advanced Framing
The current industry standard wall – a 2x4 frame at 16-inch centers with double top plates, three stud corners, jack studs, cripples and double headers – is being replaced by a 2x6 frame at 24-inch centers with single top plates, two stud corners, no jack studs, no cripples and single headers (and in many cases no

headers at all.
http://www.buildingscience.com/documents/insights/bsi-030-advanced-framing/view

12.4 System Considerations

Advanced wood frame structures are a key technology in high performance buildings as they reduce material use and increase thermal efficiency. Rim headers are a component of advanced wood frame structures.

12.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Advanced 2x6 Framing Packages	NAHBRC-IP	2011/2012	Gap Fully Filled
Measurement of Existing Homes for Retrofitting – Calibration of Multiple Homes	CEER	2011/2012	Gap Fully Filled
Advanced Framing Proof-of-Concept Testing	NAHBRC-IP		

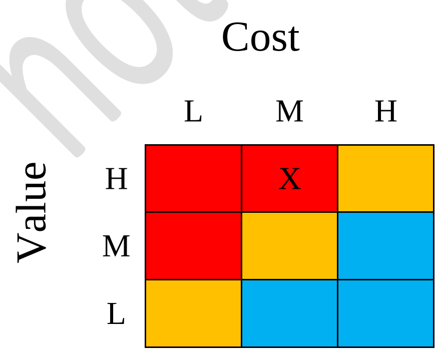
12.6 Closing the Gap

Engineering calculations should be used to develop test assemblies and a laboratory test plan. The assemblies should be tested in a laboratory and demonstrated in the field.

12.7 Timeline

Engineering calculations and a test plan can be completed in a 3 month period. Laboratory testing can be completed in a 6-month period. Field demonstrations can be completed in a 3-month period.

12.8 Cost-Value Matrix



13 GAP (Walls): Develop solutions to provide shear resistance to non-structurally sheathed wall assemblies

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #14

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

13.1 Problem Statement

Low-cost, easy-to-build solutions that will provide shear resistance to non-structurally sheathed wall assemblies are needed.

Type of research: Laboratory testing, code development

13.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Manufacturers

13.3 Background Knowledge

IRC FAQ: Wall Bracing Requirements for Insulating Sheathing
2006 IRC High Performance Housing Wall Bracing Requirements for Insulating Sheathing FAQ Sheet
http://www.buildingscience.com/documents/guides-and-manuals/irc-faqs/irc-faq-wall-bracing-requirements-for-insulating-sheathing/view

Future of Framing is Here
Smarter strategies can save money, speed construction, improve energy efficiency, and cut down on jobsite waste. Reprinted with permission from Fine Homebuilding, October/November 2005, pages 50-

55.
http://www.buildingscience.com/documents/published-articles/pa-future-of-framing/view

BSI-030: Advanced Framing
Insulating sheathing is not part of advanced framing. It is just that most folks that use advanced framing today also use insulating sheathing. With insulating sheathing the water control layer is the exterior face of the insulating sheathing taped. Insulating sheathing provides no "racking resistance" or "shear" properties. For that we need OSB or plywood "braced wall panels" (a.k.a. "shear panels") – and most builders build them into corners.
http://www.buildingscience.com/documents/insights/bsi-030-advanced-framing/view

13.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. High thermal resistance enclosures are typically constructed with exterior insulating sheathings that provide no shear resistance. Eliminating unnecessary wood sheathing will provide significant savings that can be used for more insulated sheathings, reducing the cost of higher thermal performance walls.

13.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Wind Resistance of Wall Systems with Rigid Foam Sheathing	NAHBRC-IP	2011/2012	Gap Fully Filled
High Performance Hybrid Assemblies	BSC	2011	Gap Partially Filled

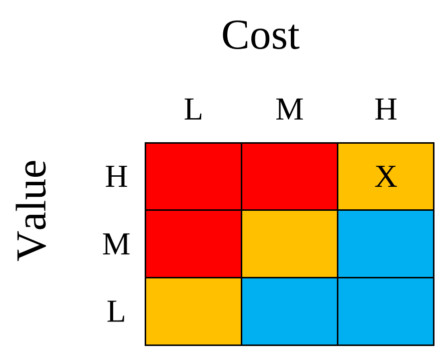
13.6 Closing the Gap

Laboratory testing should be conducted on walls sheathed with non structural insulating sheathing modified to provide shear resistance with several different methods based on generic components. The outcome of these tests should be used to develop code acceptance.

13.7 Timeline

Laboratory testing should be completed in a 9 month time period.

13.8 Cost-Value Matrix



14 GAP (Walls): Characterize the moisture performance of walls with higher cavity R-values using permeable insulations particularly in homes with lower air exchange rates

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #15

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

14.1 Problem Statement

The moisture performance of walls with higher cavity R-values using permeable insulations particularly in homes with lower air exchange rates, is poorly understood. Higher risks of air leakage, wetting, and reduced diffusive drying potentials are theoretically expected to increase moisture risk, but little research is available to better quantify this risk. Low ACH typically means high indoor humidity.

Type of research: Modeling and field testing

14.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Insulation Manufacturers and Installers

14.3 Background Knowledge

RR-1010: Innovative Passive Ventilation Water-Resistive Barriers—How Do They Work?
This paper is from the proceedings of the Thermal Performance of the Exterior Envelopes of Whole Buildings XI International Conference, December 5-9, 2010 in Clearwater, Florida. The issue of solar driven moisture that is associated with water absorptive claddings has often been raised, and it is

becoming increasingly relevant as the demand for improved energy efficiency buildings continues to rise. Improved energy efficiency building enclosures generally means an increase in R-value and reduced air leakage, which commonly reduces the drying potential of wall assemblies. This paper investigates the hygrothermal performance of wall assemblies with brick veneer cladding as well as manufactured adhered stone veneer with two different types of water resistive barriers. This paper demonstrates the beneficial effects of passively driven airflow through both solar and wind forces allowing small amounts of air flow to provide a significant increase in drying potential to walls that include dual ventilation water resistive barriers. Results show that the three-dimensional dual ventilated WRB not only provides enhanced drying potential by deploying passive solar energy, but it also provides a control layer against warm-weather inward vapor drives from the absorptive claddings, which have been implicated as reasons for numerous moisture related problems.
http://www.buildingscience.com/documents/reports/rr-1010-innovative-passive-ventilation-water-resistive-barriers-how-do-they-work/view

BSD-013: Rain Control in Buildings
Moisture is one of the most important agents leading to building enclosure deterioration. Understanding and predicting moisture movement within and through the enclosure is therefore of fundamental importance to predicting and improving building enclosure performance, particularly durability. Since driving rain deposition on walls and roofs is quantitatively the largest single source of moisture for most walls and roofs, it is no surprise that controlling rain penetration is one of the most important parts of a successful moisture control strategy. In fact, failure to control rain is likely the oldest and most common serious building enclosure performance problem. This document will consider rain control from a general to a specific level. The following sections will cover: basic moisture control principles that should be employed in the design of above-grade building enclosures; driving rain as a moisture load on walls; a classification system of the various rain control strategies available for walls; and finally, good design practices for walls.
http://www.buildingscience.com/documents/digests/bsd-013-rain-control-in-buildings/view

14.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. High thermal resistance enclosures can be constructed with permeable sheathings.

14.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
High-R Walls, High-R Wall Moisture Testing (Retrofit)	NAHBRC-IP	2011/2012	Gap Fully Filled
Moisture Management with Highly Permeable Sheathing Insulations over Existing Walls with Permeable Cavity Insulation	BSC	2012	Gap Fully Filled
Moisture Research on Wall Interiors	CARB	2011/2012	Gap Fully Filled
Monitoring Retrofit Packages	CEER		
Guidance on Moisture Management for High-R Walls for New Construction	BSC	2011/2012	Gap Fully Filled

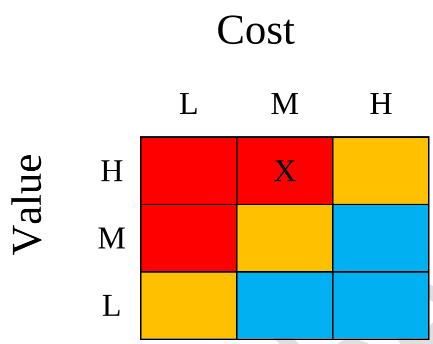
14.6 Closing the Gap

This problem is more a dissemination of existing information problem than a lack of information problem. Some gaps do exist in the existing knowledge—but these gaps can easily be closed by using hygrothermal modeling to demonstrate and compare performance and publishing of the results.

14.7 Timeline

Modeling could be conducted and completed within a 3 month time frame.

14.8 Cost-Value Matrix



15 GAP (Roofs): Guidance for adding insulation above and below roof deck to meet 2009 IECC in all climate zones

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #17

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	
Roof/Ceiling	✓	Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

15.1 Problem Statement

Standardize details to add insulation layer above roof deck ("over-roofing") and interior insulation below deck to meet 2009 IECC+ insulation levels in older, existing roofs. Many details such as insulation layers above and below the deck as well as complementary air sealing and attachment details need to be standardized for existing homes. In addition, consideration for overhangs, gutters, and other added durability features are needed.

Type of research: Demonstration, deployment, code development

15.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Insulation Installers

15.3 Background Knowledge

IRC FAQ: Conditioned Attics
2009 IRC FAQ on making an attic into living space by moving the insulation to the underside of the roof deck between the roof rafters.
http://www.buildingscience.com/documents/guides-and-manuals/irc-faqs/irc-faq-conditioned-attics/view

BSI-043: Don't Be Dense
Cellulose and Dense-Pack Insulation–Rigid Insulation Above Roof Deck: The amount of rigid insulation installed is climate dependent. The colder the climate, the greater the thermal resistance required. The existing roof membrane does not have to be removed. Think of this as a typical "over-roofing" approach—but with additional thermal resistance in the mix. The rigid insulation is typically mechanically attached as is the new roof membrane. The existing roof membrane becomes the "air barrier." The roof cavity is dense packed typically from underneath, but not always.
http://www.buildingscience.com/documents/insights/bsi-043-dont-be-dense/view

RR-1006: Building America Special Research Project: High-R Roofs Case Study Analysis
The goal of this research is to find optimally designed, cost effective roof insulation systems that can be included with other enclosure details to help reduce whole house energy use by 70%. This report will compare a variety of roof insulating strategies and present their advantages and disadvantages according to several comparison criteria.
http://www.buildingscience.com/documents/reports/rr-1006-ba-high-r-roofs-case-study-analysis/view

15.4 System Considerations

Roofs constitute a significant energy load for a building enclosure.

15.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Advanced New Construction Measure Guideline	BSC	2011/2012	Gap Partially Filled
Roof Retrofit Report	ORNL		
	NAHBRC-IP		

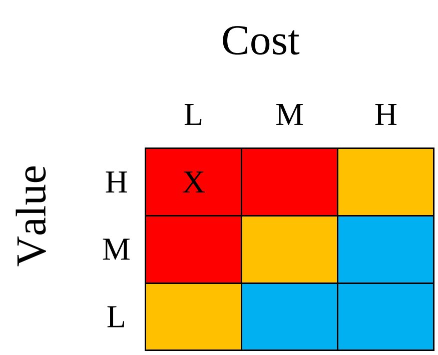
15.6 Closing the Gap

Develop standardized details for over-roofing. Validate and demonstrate the solutions in demonstration buildings. Develop code recommendations. A comprehensive guidance document should be developed and deployed.

15.7 Timeline

Development of standardized details can be completed in a 3-month period. Demonstration of the solutions could be completed in a 6-month period. A comprehensive guidance document could be prepared within a 6-month time frame after the field demonstration has been completed.

15.8 Cost-Value Matrix



16 GAP (Walls): Fire testing of high R-value wall assemblies for use in multi-family and zero lot line projects

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #18

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

16.1 Problem Statement

Fire test results and resistance ratings for high R-value wall assemblies are required to ensure they can be used in multi-family and zero lot line projects.

Fire resistance ratings of many new high-R enclosures are not listed. Such listings are often required for multi-family, especially high-density housing, and zero lot line homes. Many assemblies that require fire ratings are still specified as they were tested 25 or more years ago. As NIST and other government agencies no longer fire test assemblies for ratings, only specific “systems” manufacturers conduct fire testing, and this testing only applies to their specific products. More generic and widespread testing would aid the speedy deployment of high-R fire-rated enclosure assemblies.

Type of research: Laboratory testing, code development

16.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Material Manufacturers

16.3 Background Knowledge

Info-500: Building Materials Property Table
This table presents some of the key technical properties of many of the most common building materials.
http://www.buildingscience.com/documents/information-sheets/building-materials-property-table/view

16.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. High thermal resistance enclosures require fire ratings in order to be used in many jurisdictions and in many types of constructions.

16.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
China, CERC	ORNL		

Unaware of any specific research currently planned or ongoing in this area.

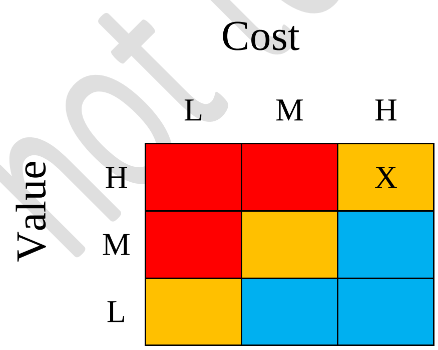
16.6 Closing the Gap

Standardized fire tests should be conducted on typical high thermal resistance wall assemblies. Listings should be sought with generic components.

16.7 Timeline

Standardized fire tests could be completed in a 9 month period.

16.8 Cost-Value Matrix



17 GAP (Roofs): Identify risks with insulating the attic at the roof plane while keeping existing attic floor insulation

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #19

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	
Roof/Ceiling	✓	Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

17.1 Problem Statement

Is there a benefit to keeping attic floor insulation intact while creating an unvented attic with spray foam in a retrofit situation? Are there condensation issues or moisture issues?

Type of research: Modeling and field measurement

17.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Spray Foam Manufacturers

17.3 Background Knowledge

Attic Air Sealing Guide and Details
Attics should be air sealed prior to adding insulation. Adding insulation alone does not save much energy and can lead to health and durability problems. The intent of this guide is to provide information for the preparation work necessary prior to adding attic insulation.
http://www.buildingscience.com/documents/guides-and-manuals/gm-attic-air-sealing-guide/view

A Crash Course in Roof Venting
Understand when to vent your roof and when not to, and how to execute each approach successfully.

Reprinted with permission from Fine Homebuilding, Aug/Sept 2011, pages 68-72.
http://www.buildingscience.com/documents/published-articles/pa-crash-course-in-roof-venting/view

BSD-149: Unvented Roof Assemblies for All Climates
Unvented roof assemblies, such as conditioned attics and unvented cathedral ceilings, are becoming common in North American construction. It is estimated that over 100,000 have been constructed since 1995. These assemblies are created by eliminating ventilation openings and moving the thermal, moisture and air control boundaries to the plane of the roof deck.
http://www.buildingscience.com/documents/digests/bsd-149-unvented-roof-assemblies-for-all-climates/view

17.4 System Considerations

Roofs constitute a significant energy load for the building and air sealing and insulating roofs can often be the least disruptive and lowest cost retrofit.

17.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Clark County – Attic Monitoring Results	CARB	2013/2014	Gap Addressed
Survey and Monitoring of Retrofit House	PNNL		

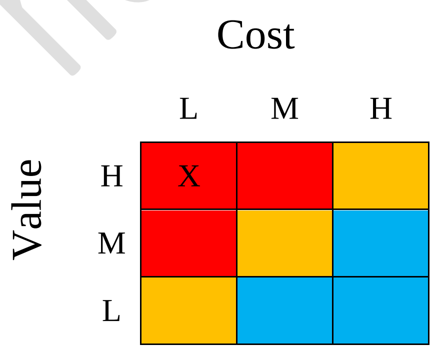
17.6 Closing the Gap

Use hygro thermal modeling to determine the risk of various solutions. Validate and demonstrate the solutions in test buildings.

17.7 Timeline

Modeling can be completed in a 3 month time period. Implementation, validation and demonstration of the solutions could be completed in a single winter season (November through April).

17.8 Cost-Value Matrix



18 GAP (Walls): Develop solutions to insulate and air seal interstitial spaces in existing exterior wall assemblies

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #20

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls	✓	Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

18.1 Problem Statement

Develop solutions to insulate and air seal inaccessible building enclosure details.

Type of research: Laboratory experimentation, field testing, demonstration, deployment

18.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Manufacturers

18.3 Background Knowledge

Info-407: Air Barriers—Tub, Shower and Fireplace Enclosures
To create an effective air barrier in a building, it is first necessary to cover the big holes.
http://www.buildingscience.com/documents/information-sheets/air-barriers-tub-shower-and-fireplace-enclosures/view

Info-408: Critical Seal (Spray Foam at Rim Joist)
In building air barriers, the field of the opaque wall typically does not contribute strongly to the building's overall air leakage. Instead, details that connect building components are often the cause of much of the air leakage, such as the roof-to-wall interface, wall-to-foundation interface, and other details (e.g.,

bathtubs, fireplaces, service penetrations).
http://www.buildingscience.com/documents/information-sheets/critical-seal-spray-foam-at-rim-joist/view

Attic Air Sealing Guide and Details
Details include attic hatch and pull-down stairs, kneewalls, balloon-framed gable wall, gable truss, dropped soffits, exterior top plate at soffit, two story wall, bath fan penetration, chimney chase, duct boot, electrical box, plumbing stack, recessed can ceiling light, duct chase, top plate joints and penetrations.
http://www.buildingscience.com/documents/guides-and-manuals/gm-attic-air-sealing-guide/view

BSI-048: Exterior Spray Foam
An edited version of this Insight first appeared in the ASHRAE Journal. Spray polyurethane foam (SPF), the high-density stuff, is the only product (so far) that can perform all of the functions of the principal control layers of the "Perfect Wall." The functions are water control, air control, vapor control, and thermal control.
http://www.buildingscience.com/documents/insights/bsi-048-exterior-spray-foam/view

18.4 System Considerations

High levels of airtightness are a key to high performance buildings.

18.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Dense Pack Wall and Roof Assemblies	BSC	2011	Gap Partially Filled
Measurement of Existing Homes for Retrofitting – Calibration of Multiple Homes	CEER	2011	Gap Partially Filled
Draft Report	ORNL		

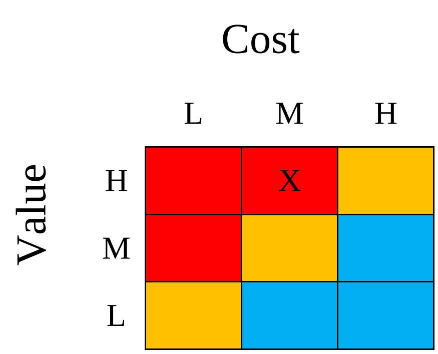
18.6 Closing the Gap

Details should be developed and tested in laboratory mock ups followed by field testing and publishing of the results. A comprehensive guidance document should be developed and deployed.

18.7 Timeline

Design of details, laboratory mock up testing and field testing can be conducted within a 9-month time frame. A comprehensive guidance document could be prepared within a 3-month time frame after the design of details, mock up testing and field testing has been completed.

18.8 Cost-Value Matrix



19 GAP (Walls): Identify, develop and deploy new high R-value enclosure component designs that are suited for industrialized applications

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #22

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

19.1 Problem Statement

There is a need to identify, develop and deploy enclosure component designs that are better suited for industrialized applications.

Type of research: Product development, prototype construction, testing and evaluation

19.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Modular Homes Manufacturers

19.3 Background Knowledge

Systems Building Research Alliance

RR-1102: San Francisco Bay Area Net Zero Urban Infill
This paper was first presented at the 2011 ASHRAE Annual Conference. A startup builder in the San Francisco Bay Area has a goal of producing factory built/modular houses with net zero energy performance. Their first prototype was a two-story, two bedroom, urban infill townhouse design. It has been in operation for roughly a year, and has been extensively measured and monitored, providing

information about its net zero performance
http://www.buildingscience.com/documents/reports/rr-1102-san-francisco-net-zero-urban-infill/view

19.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. Industrialized housing constitutes a large sector of the built environment.

19.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Zeta	ARBI	2011/2012	Gap Partially Filled
NEEM	BA-PIRC	2011/2012	Gap Partially Filled
Advanced Envelope Design for Factory Built Homes	ARIES	2011/2012	Gap Partially Filled
Gridstar Project	NELC		

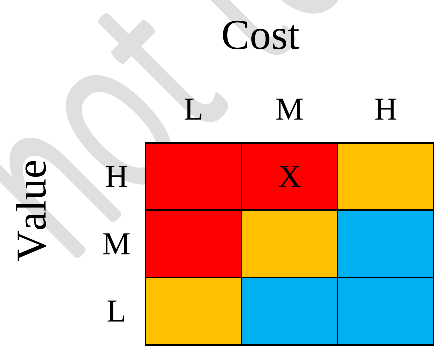
19.6 Closing the Gap

Identify, develop and deploy new envelope component designs that are suited for industrialized applications.

19.7 Timeline

Development of new enclosure component designs can be completed over a 6 month period. Construction, testing and evaluation can be completed over an additional 6 month period.

19.8 Cost-Value Matrix



20 GAP (Materials): Address seismic and high wind considerations for use of SIPs in retrofit and new construction

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #23

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Materials	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

20.1 Problem Statement

Address seismic and high wind considerations for use of SIPs in retrofit and new construction, especially at component connections, such as foundation-to-wall, wall-to-roof, and window-to-wall.

Type of research: Laboratory testing, code development

20.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
SIPs Manufacturers

20.3 Background Knowledge

Tompos, NTA (Certification Agency), Generalization of SIPS Test Data, BA mtg 2011

20.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. SIP construction is a popular method of constructing high thermal resistance wall assemblies in some regions.

20.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Retrofit Work with NYSERDA and SIPA	NAHBRC-IP		

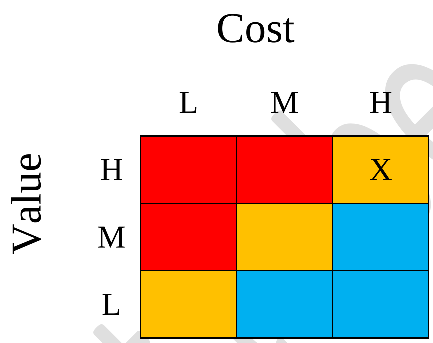
20.6 Closing the Gap

Identify, develop and test connection details that address seismic and high wind loads in retrofit and new construction.

20.7 Timeline

Development of connection details can be completed over a 6-month period. Construction, testing and evaluation of the connection details can be completed over an additional 6-month period.

20.8 Cost-Value Matrix



21 GAP (Walls): Determine the structural capacity of cavity spray foam insulation when sprayed against non-structural sheathings

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #24

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

21.1 Problem Statement

Determine the structural capacity of walls when open-cell and closed-cell spray foam insulation is sprayed within the cavity and against non structural sheathings.

Type of research: Laboratory testing, code development

21.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Manufacturers of Spray Foam

21.3 Background Knowledge

NAHBRC

IRC FAQ: Wall Bracing Requirements for Insulating Sheathing
2006 IRC High Performance Housing Wall Bracing Requirements for Insulating Sheathing FAQ Sheet
http://www.buildingscience.com/documents/guides-and-manuals/irc-faqs/irc-faq-wall-bracing-requirements-for-insulating-sheathing/view

BSI-048: Exterior Spray Foam
An edited version of this Insight first appeared in the ASHRAE Journal. Spray polyurethane foam (SPF), the high-density stuff, is the only product (so far) that can perform all of the functions of the principal control layers of the "Perfect Wall." The functions are water control, air control, vapor control, and thermal control.
http://www.buildingscience.com/documents/insights/bsi-048-exterior-spray-foam/view

21.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. High thermal resistance enclosures are typically constructed with exterior insulating sheathings that provide no shear resistance.

21.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
High Performance Hybrid Systems	BSC	2011/2012	Gap Partially Filled
Report	NAHBRC-IP		
High Performance Hybrid Assemblies	BSC	2011	Gap Partially Filled

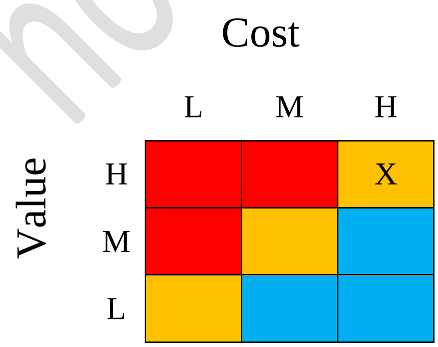
21.6 Closing the Gap

Laboratory testing should be conducted on walls sheathed with non structural insulating sheathing and modified with spray foam within the cavity to predict shear resistance. The outcome of these tests should be used to establish application guidelines and develop code acceptance.

21.7 Timeline

Laboratory testing should be completed in a 9 month time period.

21.8 Cost-Value Matrix



22 GAP (Roofs): Address condensation and water intrusion when converting attic and attic knee-wall spaces to conditioned area

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #25

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	
Roof/Ceiling	✓	Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

22.1 Problem Statement

There is a need to address quality control, condensation and water intrusion when converting attic and attic knee-wall space to conditioned area. Contractors have attempted numerous solutions (creating both vented and unvented roof assemblies) with varying degrees of success. There is a need to document the various solutions and evaluate them for comfort, energy and moisture performance. Air leakage control improvements and insulating at kneewall details are needed.

Type of research: Field measurement

22.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders

22.3 Background Knowledge

BSC: Attic Air Sealing Guide and Details
The Guide provides the background and approach for the prep work necessary prior to adding attic insulation - focusing on combustion safety, ventilation for indoor air quality, and attic ventilation for durability. The "Attic Air Sealing Details" section provides a scope of work and specification for the air

sealing of many points of air leakage in common attic spaces.
http://www.buildingscience.com/documents/guides-and-manuals/gm-attic-air-sealing-guide/view

22.4 System Considerations

Roofs constitute a significant energy load for a building enclosure.

22.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Whole House – Existing Construction – National Grid	BSC	2011/2012	Gap Fully Filled
CEDA, Illinois	BSC	2011	Gap Partially Filled

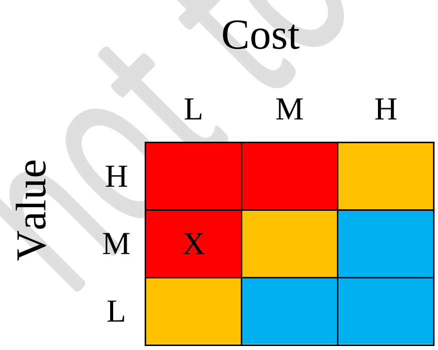
22.6 Closing the Gap

This problem is more a dissemination of existing information problem than a lack of information problem. Some gaps do exist in the existing knowledge – but these gaps can easily be closed by limited field testing and publishing of the results. A comprehensive guidance document should be developed and deployed.

22.7 Timeline

Field testing can be conducted within a 6 month time frame. A comprehensive guidance document could be prepared within a 6 month time frame after the field testing has been completed.

22.8 Cost-Value Matrix



23 GAP (Fenestrations): Identify what works, what does not work, and what can be improved when retrofitting windows

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #26; Combine with former #56 Standardize window retrofit practices to reduce cost, focus on cost and general applicability

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Fenestrations	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

23.1 Problem Statement

Develop comprehensive retrofit window solutions, including air control, water control, and thermal control transitions to between the window and the wall.

Type of research: Design, modeling, testing, deployment

23.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Window Manufacturers
Flashing Manufacturers

23.3 Background Knowledge

LBNL Fact Sheets

James et al. 1996 (VEIC), Klems 2002, Quach et al 2003 (Intl Glass Review), Drumheller et al. 2007 (Clearwater)

Remodeling for Energy Efficiency
Replacement Windows in Thick Walls: Tilt-in replacement frames are convenient because you don't have

to disturb the interior trim. But they don't improve on the existing windows' water resistance. You can integrate these windows into the drainage plane of your house with waterproof membrane.
http://www.buildingscience.com/documents/published-articles/pa-remodeling-for-energy-efficiency/view

Built Wrong From The Start
Reprinted with permission from Fine Homebuilding Magazine, April/May 2004, pages 52-56.
WINDOWS AND DOORS WITHOUT PAN FLASHING CREATE A WATER-INJECTION SYSTEM: There are only two kinds of windows in the world: windows that leak now and windows that will leak later. The only things that leak more than windows are doors. And the more expensive the door, the more it leaks—especially big French doors with sidelites. And sliding doors. I know, I know, I can hear the salesman already: "My windows don't leak. They were tested at the factory." Right, they didn't leak at the factory. But they will leak after …
http://www.buildingscience.com/documents/published-articles/pa-built-wrong-from-start/view

23.4 System Considerations

Windows are a key component of high performance buildings.

23.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Window Replacement Details	BSC	2011/2012	Gap Partially Filled
Window Repair, Rehabilitation and Replacement	BSC	2011	Gap Partially Filled

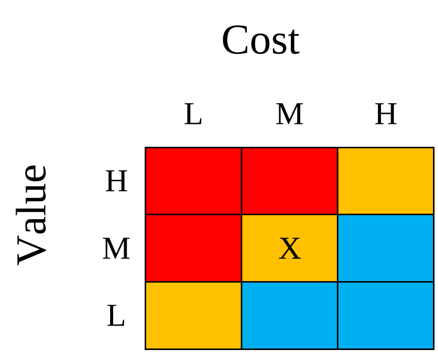
23.6 Closing the Gap

Additional work based on the output of the results of the BSC Task 7.5 Window Repair, Rehabilitation and Replacement work can fully address this gap or barrier. A comprehensive guidance document should be developed and deployed.

23.7 Timeline

Additional work (beyond that planned under Task Order 2 – Task 7.5) can be completed in a 6 month time period. A comprehensive guidance document could be prepared within a 6 month time frame after the laboratory testing has been completed.

23.8 Cost-Value Matrix



24 GAP: Develop recommendations for sequencing and phased retrofits

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #28

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Sequencing	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

24.1 Problem Statement

Consider and evaluate the options for a phased retrofit (various enclosure replacements over time; often needed for financial viability of a deep energy retrofit); what are the optimum recommendations for sequencing?

The optimal sequencing of retrofits requires more study. Owners may not have the funds to do a complete retrofit and hence will often conduct only pieces. It is critical to investigate the best sequence of retrofits for the many different conditions that may occur, and minimize lost opportunities, increased costs, or increased risks of failure. For example, HVAC retrofits are often first considered because of equipment age or failure, subsidy programs and the perception that these will address comfort as well as operating cost issues. Later retrofit of the enclosure results in HVAC systems that are often oversized. Given fixed upgrade budgets this is unlikely to change.

Type of research: Field testing and deployment

24.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders

24.3 Background Knowledge

BSI-028: Energy Flow Across Enclosures
http://www.buildingscience.com/documents/insights/bsi-028-energy-flow-across-enclosures/view

BSI-035: We Need To Do It Different This Time
http://www.buildingscience.com/documents/insights/bsi-035-we-need-to-do-it-different-this-time/view

BSI-039: Five Things
http://www.buildingscience.com/documents/insights/bsi-039-five-things/view

24.4 System Considerations

Existing housing constitutes a larger energy need than new construction. Sufficient resources are rarely available to complete a total deep retrofit. Phasing of resources and technologies is typically necessary.

24.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Measurement of Existing Homes for Retrofitting – Calibration of Multiple Homes	CEER	2013/2014	Gap Addressed
Envinity	NELC		

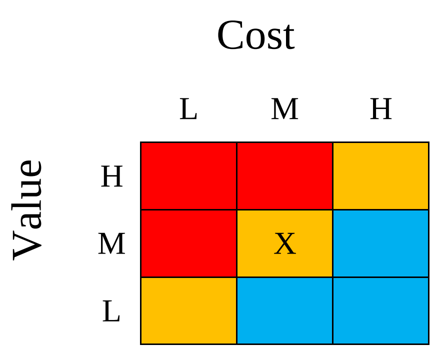
24.6 Closing the Gap

This problem is more a dissemination of existing information problem than a lack of information problem. Some gaps do exist in the existing knowledge, but these gaps can easily be closed by field testing and publishing of the results. A comprehensive guidance document should be developed and deployed.

24.7 Timeline

Field testing can be conducted over a single winter season (November through April). A comprehensive guidance document could be prepared within a 6-month time frame after the field testing has been completed.

24.8 Cost-Value Matrix



25 GAP (Walls): Identify risks associated with insulating masonry from the interior

Gap Status	Full 2-pager written by Committee Chair
Gap Change	Former #30

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls	✓	Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

25.1 Problem Statement

There is a need to identify and quantify moisture damage risks associated with insulating masonry from the interior. We need to develop and standardize a quantitative (not pass fail) method to assess the freeze-thaw resistance of masonry units (i.e. bricks, blocks, stones, etc.) from existing walls. We need to document methods to predict the moisture load on the assembly. We need to develop guidelines for assessing the conditions and exposure of the existing building. Air leakage, vapor diffusion, solar vapor drive, wind-blown rain redistribution, water accumulation at the interior insulation/mass wall interface from various sources should be considered. Three-D effects such as joist pockets also should be considered. Active application of heat (local sources of electric or hot water) in critical locations should be considered.

Type of research: Modeling, field testing

25.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Insulation Manufacturers and Installers

25.3 Background Knowledge

BSD-114: Interior Insulation Retrofits of Load-Bearing Masonry Walls in Cold Climates
This digest reviews the moisture control principles that must be followed for a successful insulated retrofit of a solid load-bearing masonry wall. Two possible approaches to retrofitting such walls are presented and compared.
http://www.buildingscience.com/documents/digests/bsd-114-interior-insulation-retrofits-of-load-bearing-masonry-walls-in-cold-climates/view

Mensinga et al 2010 (Buildings XI)

25.4 System Considerations

High thermal resistance enclosures are a key to high performance buildings. Mass wall assemblies are often of historical significance and can only be insulated internally.

25.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Internal Insulation of Masonry Walls	BSC	2011/2012	Gap Partially Filled
Habitat for Humanity	CARB	2011/2012	Gap Fully Filled
New Test Hut	CSE		
Guidance on Interior Retrofits of Load-bearing Masonry Structures	BSC	2012	Gap Fully Filled

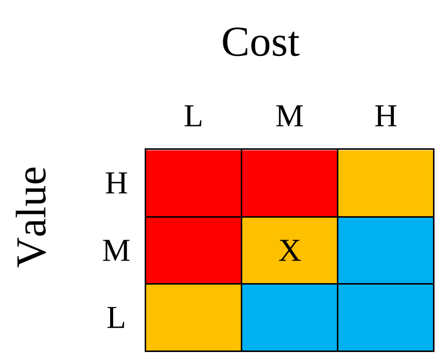
25.6 Closing the Gap

Additional work based on the output of the results of the BSC Task 7.3 work can fully address this gap or barrier. Work by researchers at BSC and University of Waterloo has demonstrated the potential to use frost dilatometry as the basis for a quantitative method to assess freeze-thaw resistance. Further work must be conducted to improve sample preparation and understand requirements for temperature setpoints and cycle times. A draft standard should be developed for the test method. Best practices should be established for site assessment and hygrothermal analysis intended to predict assembly loads and performance. A comprehensive guidance document should be developed and deployed.

25.7 Timeline

Additional work (beyond that planned under Task Order 2 – Task 7.3) can be completed in a 6-month time period. A comprehensive guidance document could be prepared within a 6-month time frame after the cited additional work has been completed.

25.8 Cost-Value Matrix



26 GAP (Walls): Identify moisture damage risks associated with retrofitting only walls and not replacing the windows or upgrading the rain control performance of the windows

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #31; Combine with former #51 Develop details for the retrofit of walls where the existing windows are retained

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls	✓	Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

26.1 Problem Statement

Identify moisture damage risks associated with retrofitting the walls, but not replacing the windows or upgrading the rain control performance of the windows.

Type of Research: Field survey, simulations

26.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders

26.3 Background Knowledge

Ueno 2010 "Residential Exterior Wall Superinsulation Retrofit Details and Analysis" Performance of the Exterior Envelopes of Whole Buildings XI. Atlanta, Geo.: American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc.

BSD-114: Interior Insulation Retrofits of Load-Bearing Masonry Walls in Cold Climates
This digest reviews the moisture control principles that must be followed for a successful insulated retrofit of a solid load-bearing masonry wall. Two possible approaches to retrofitting such walls are presented and compared. *The Potential for Moisture Problems in Retrofits*: Renovating any wall can disrupt the moisture balance and cases exist in which this disruption has resulted in damage or performance problems. The damage mechanisms of concern are primarily freeze-thaw and salt subfluorescence. Both of these mechanisms are only a problem in cold weather, and the most dangerous one, freeze-thaw, can only occur at temperatures well below freezing while the brickwork is essentially saturated. To avoid moisture related damage, the balance should be explicitly considered during the retrofit design process.
http://www.buildingscience.com/documents/digests/bsd-114-interior-insulation-retrofits-of-load-bearing-masonry-walls-in-cold-climates/view

RR-1012: Residential Exterior Wall Superinsulation Retrofit Analysis
This paper presents many of the lessons learned, including overall enclosure strategies, such as air barriers, drainage planes, and moisture control. Several case-specific solutions to particular problems are described, including exterior air barrier approaches, wall sill replacement, and several approaches dealing with window penetrations. In addition, detailing recommendations and economic analysis of these measures are presented. Hygrothermal simulations were run to evaluate the changes in sensitivity to moisture intrusion due to these retrofit measures.
http://www.buildingscience.com/documents/reports/rr-1012-residential-exterior-wall-superinsulation-retrofit/view

26.4 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
External Insulation of Masonry and Frame Walls	BSC	2011	Gap Partially Filled
Window Repair, Rehabilitation and Replacement	BSC	2011	Gap Partially Filled

27 GAP (Foundations): Develop strategies for insulating the exterior of existing foundations in all climate zones

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #32; Combine with former #44 Develop insect and moisture resistant exterior insulation strategies for new and existing foundations

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations	✓	Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

27.1 Problem Statement

Develop safe, cost-effective ways to insulate foundations at the exterior surface in retrofits.

27.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Codes and Standards Making Bodies
Builders
Insulation Manufacturers

27.3 Background Knowledge

Swinton & Kesik 2005 "Performance Guidelines for Basement Envelope Systems and Materials: Final Research Report," Institute for Research in Construction, National Research Council Canada, October 2005

RR-1012: Residential Exterior Wall Superinsulation Retrofit Analysis
Slab retrofit detail: One unexpected leak occurred at the Concord Four Square: the existing slab was retrofitted with a drainage spacer mat, rigid insulation, and a new slab. The drainage mat was terminated at the surface of the slab at the chimney penetration; during infiltration testing, significant air leakage occurred at the open drainage mat. This is evidence that the below grade portion of the building enclosure

has a nonnegligible contribution to air leakage. Details of this leakage are covered in Pettit (2009). http://www.buildingscience.com/documents/reports/rr-1012-residential-exterior-wall-superinsulation-retrofit/view

BSD-139: Deep Energy Retrofit of a Sears Roebuck House—A Home for the Next 100 Years
This posting is permission of ASHRAE. For an air barrier to be effective, it needs to wrap all six sides of the "conditioned cube," and all components need to be connected in a continuous manner. The new slab was connected to the basement walls with spray foam that extended from the new basement slab to the rim sill, directly under the first floor. The corrugated housewrap became the air barrier at the exterior wall above grade, helped by the two staggered layers of foam sheathing installed over it. The basement did not show any signs of ever having water leakage, but as a precaution, the interior face of the existing wall was drained at the bottom with the drainage mat that was turned up the wall from the floor. The drainage mat below the insulated slab will allow some water to be stored and will carry any excess water to an interior sump pit. This pit can be fitted with a sump pump in the future if there is any sign that the ground water level is changing. In addition, the drainage mat under the finish slab was turned up at the base of the masonry chimney; the testing showed that soil gasses could be pulled from the space between the two slabs to the interior, so it was capped off with concrete and fire-rated caulk. After addressing these worst leakage points, the house met the original airtightness target.
http://www.buildingscience.com/documents/digests/bsd-139-deep-energy-retrofit-of-a-sears-roebuck-house-a-home-for-the-next-100-years/view

27.4 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Excavationless Exterior Foundation Insulation Retrofit	NorthernSTAR		
Foundation Insulation Retrofit Demonstration Project	NorthernSTAR		

28 GAP (Walls): Develop prescriptive method for installation of vinyl siding over 24" o.c. framing with non-structural sheathing

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #34

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

28.1 Problem Statement

Develop prescriptive method for installation of vinyl siding over 24” o.c. framing with non-structural sheathing.

Type of Research: Lab testing, code/ICCES

28.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Vinyl Siding Manufacturers

28.3 Background Knowledge

RR-0907: Ventilated Wall Claddings: Review, Field Performance, and Hygrothermal Modeling
The vinyl siding profile tested allowed significant ventilation-induced drying with or without furring strips as it was inherently very leaky. Considerable flow occurs across the cladding, upward and downward and laterally: For a 1.22 m wide by 2.4 m high wall, contact-applied vinyl siding can be expected to be in the range of 0.6 to 2.7 lps/m2 for pressures of 1 to 10 Pa.
http://www.buildingscience.com/documents/reports/rr-0907-ventilated-wall-claddings-review-performance-modeling/view

RR-1011: Evaluation of Cladding and Water-Resistive Barrier Performance in Hot-Humid Climates Using a Real-Weather, Real-Time Test Facility

The construction of each of the wall systems took into account the local building practices. The walls were of 2 in. °—4 in. base construction. The stud space was insulated with an unfaced R-13 batt, and the interior was covered with gypsum wallboard painted with latex interior paint. In the final stage of the experiment, a vapor barrier wall covering was installed on the interior wall surface. The exterior side of 15 of the wall specimens was covered with orientated strand board (OSB) sheathing, one of four water-resistive barriers, and then one of four types of cladding. One wall specimen was an open stud wall system (no sheathing) common in the Southwest US. The four water-resistive barriers used in the testing varied by their reported vapor permeability and are listed in Table 1. The cladding types used during this phase of testing were as follows: painted fiber-cement siding, vinyl siding, brick, and stucco. Details of the wall assemblies are shown in Table 2. All wall specimens were duplicated on both sides of the container, allowing for them to be monitored with two exposures. Additionally, a limited number of wall assemblies were replicated on each side to determine specimen-to-specimen variability exposed to a single exposure. The replicated wall specimens were those with fiber-cement siding and vinyl siding each with water-resistive barrier WRB-A.
http://www.buildingscience.com/documents/reports/rr-1011-evaluation-cladding-water-resistive-barrier-performance-hot-humid-climates-real-weather-real-time/view

28.4 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
	NAHBRC-IP		

29 GAP (Materials): Develop fire resistant foam insulation materials that have environmentally-benign fire retarders

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #36

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Materials	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

29.1 Problem Statement

Develop fire resistant foam insulation materials that have environmentally-benign fire retarders.

29.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Insulating Sheathing Manufacturers

30 GAP: Develop improved simple semi-empirical predictive models of condensation potential in wall and roof assemblies in all climate zones

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #37

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Moisture	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

30.1 Problem Statement

Improved simple semi-empirical predictive models of condensation potential (considering, e.g., 3-dimensional air flow, R-values, permeabilities, storage, indoor/outdoor conditions), fit to observed data.

Type of Research: Modeling

30.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Modeling Programs, Developers and Users

30.3 Background Knowledge

BSD-148: Simplified Prediction of Driving Rain on Buildings: ASHRAE 160P and WUFI 4.0
Several approaches to predicting driving rain on buildings have been developed over the last 50 years. Field measurements have been collected on more than a dozen buildings in several different countries. This digest consolidates and summarizes this research to provide a practical method for predicting driving rain deposition for a wide range of purposes, but particularly to aid in WUFI modeling and ASHRAE 160P analysis.
http://www.buildingscience.com/documents/digests/bsd-148-wufi-simplified-driving-rain-prediction/view

31 GAP (Foundations): Identify moisture damage risks associated with insulating a wood sill beam from the interior

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #38

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations	✓	Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

31.1 Problem Statement

Identify moisture damage risks associated with insulating a wood sill beam from interior; sill beam will be colder (less drying potential), in retrofits, this member often has sustained water damage. Moisture loadings include air leakage, capillary rise, grade splashback, poor flashing details, and temperature/adsorption effects. Insulating and air sealing the interior or exterior at this component can reduce drying capacity and increase the risk of moisture damage. Techniques for assessing the risk, and practical solutions are needed.

Type of Research: Modeling, field surveys

31.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Modeling Programs, Developers and Users

31.3 Background Knowledge

Lstiburek, J. 2010 "Building Sciences: Rubble Foundations," ASHRAE Journal, March 2010.

Info-408: Critical Seal (spray foam at rim joist)
http://www.buildingscience.com/documents/information-sheets/critical-seal-spray-foam-at-rim-joist/view

32 GAP (Walls): Identify moisture damage risks associated with insulating embedded wood beams or joists in masonry walls

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #39

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls	✓	Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

32.1 Problem Statement

Identify moisture damage risks associated with insulating an embedded wood beam.

Type of Research: Modeling, field testing

32.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Modeling Programs, Developers and Users

32.3 Background Knowledge

Dumont et al. 2005

Morelli 2010

RR-1003: BA High-R Foundation Report
In this proposed wall system, it is possible to embed the framing members in the foam (similar to Case 10 on page 59) to increase the interior space. The framing should not be in contact with the foundation wall to limit thermal bridging, and potential moisture related issues with the framing members. Closed cell spray foam can be more expensive than other options, but reduces labor time over some of the other walls, and is applied by a skilled laborer so the system is very durable as a long term solution.
http://www.buildingscience.com/documents/reports/rr-1003-building-america-high-r-foundations-case-study-analysis/view

BSI-009: New Light in Crawlspaces
All this leads us back to Figure 5 and spray foam. Lots of folks are looking at this option due to the lack of tiny people with good workmanship. The spray foam clearly handles the warming the wood thing. Any foam will work for the wood warming—low density, high density, whatever. Recall, just by warming the wood you lower it's equilibrium moisture content. Where things get difficult are with the vapor drive across the floor sheathing and the floor finish. Unless you stick to carpet, and ventilated furniture and ventilated cabinetry you are going to have to use high-density foam—at least 2 lb/ft^3—due to its lower perm value. And at least 3 inches thick or thicker (gives you less than 1 perm at this thickness). Figure 8 shows a few configurations that pretty much work everywhere. Even Figure 8d, with vinyl flooring, works in mixed-humid and hot-humid climates. Having said that, I think you should just say no to vinyl—that makes things a whole lot easier. If you really like vinyl, go with Figure 6 or Figure 7 or even better Photograph 5 (the conditioned crawlspace or mini-basement).
http://www.buildingscience.com/documents/insights/bsi-009-new-light-in-crawlspaces/view

32.4 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Internal Insulation of Masonry Walls	BSC	2011/2012	Gap Fully Filled
Guidance on Interior Retrofits of Load-bearing Masonry Structures	BSC	2012	Gap Fully Filled

33 GAP (Fenestrations): Develop guidance on how to identify the best location in a high-R wall for the window (outie, innie, middle)

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #40

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows	✓	Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

33.1 Problem Statement

Research revolving around the best location in a high-R wall assembly for the window: exterior ("outie"), interior ("innie"), middle or somewhere in between.

Type of Research: Modeling, possible field testing/monitoring

33.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders

33.3 Background Knowledge

RR-1012: Residential Exterior Wall Superinsulation Retrofit Details and Analysis

Window Plane Location: Construction of walls with thick exterior rigid foam results in a thick wall; therefore, doors and windows require details to account for the resulting deep wells. A window requires some type of sill extension to account for the wall thickness: the window plane location in the wall can be towards the exterior (colloquially known as an "outie" window), or towards the interior ("innie" window). An exterior window is detailed with an extension "box," to provide solid attachment for the window in the plane of the nonstructural foam. An interior window requires exterior jamb, sill, and head extensions, which need to be exterior grade materials. Basic details of both of these options are shown in Figure 5; complete details with construction sequencing will be published in the future. Benesh (2009) and Holladay (2009) discuss of the pros and cons of the two options. It should be noted that the choice is also influenced by the location of the primary water control layer/drainage plane, as the connection between the window drainage system and the wall's drainage plane is critical.
http://www.buildingscience.com/documents/reports/rr-1012-residential-exterior-wall-superinsulation-retrofit/view

Guide to Insulating Sheathing

Includes water management details for installing window over foam or foam over window
http://www.buildingscience.com/documents/guides-and-manuals/gm-guide-insulating-sheathing/view

34 GAP: Develop low cost measurement equipment to check assemblies for accumulated condensation

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #41

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Moisture	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

34.1 Problem Statement

Develop and systematize low-cost, easy to install hardware to check assemblies over time for accumulated condensation.

Type of Research: Field testing methods

34.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Modeling Programs, Developers and Users

34.3 Background Knowledge

"Methodology and Design of Field Experiments for Monitoring the Hygrothermal Performance of Wood Frame Enclosures," Straube, Onysko, Schumacher 2002.

35 GAP (Walls): Characterize the wind pressure performance of wall systems by layer (pressure equalization)

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #42

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

35.1 Problem Statement

Characterize the wind pressure performance of wall systems by layer (pressure equalization).

Type of Research: Lab testing & analysis, code (IRC), new FSC/ANSI standard

35.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Modeling Programs, Developers and Users

35.3 Background Knowledge

BSI-004: Drainage, Holes and Moderation
This Insight explains building pressurization details.
http://www.buildingscience.com/documents/insights/bsi-004-drainage-holes-and-moderation/view

BSD-013: Rain Control in Buildings
A vented airspace also allows for both some degree of pressure moderation. Pressure moderation is the term given to the mechanism whereby wind pressure differences across the cladding are reduced by connecting an air space behind the cladding with the wind-induced pressure acting on the exterior (Figure 7). By reducing air pressure differences across the cladding, rain will not be forced across openings by this force, while the standard features of capillary break, drainage, and flashing deal with the other rain penetration forces. If the air pressure is completely eliminated (not practical in the field), the process is termed pressure equalization.
http://www.buildingscience.com/documents/digests/bsd-013-rain-control-in-buildings/view

BSD-030: Rain Control Theory
A pressure-equalized rain screen is a very special type of screened and drained system that equalizes (or moderates) air pressure differences acting on the screen to reduce the transmission fraction of the screen. Since all field measurements of pressures behind screens have shown that the pressure is rarely equalized, pressure-moderated rain screen would be a more accurate label for most practical systems. Some types of two-stage joints may also be pressure-moderated and should be labeled pressure moderated two stage joints.
http://www.buildingscience.com/documents/digests/bsd030-rain-control-theory/view

35.4 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
	NAHBRC-IP		

36 GAP (Foundations): Develop strategies for dealing with bulk water leaks in finished basements focus on spray foam interior insulation

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #43; Combine with former #59 Develop techniques to evaluate overall moisture loading and risks of an existing foundation wall, take into account seasonal and annual changes; 1 project added from former #59

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations	✓	Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

36.1 Problem Statement

Develop strategies for dealing with bulk water leaks in basements in association with finishing basement space to be used as living space.

Type of Research: Field survey, deployment

36.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Spray Foam Manufacturers

36.3 Background Knowledge

Rose 1997 "Details for a Dry Foundation" Fine Homebuilding Magazine, August/September 1997.

BSC 2011 (Task 4 Deliverable 4-1 Bulk Water Control Methods for Foundations)

RR-0202: Basement Insulation
Basement walls can be wetted by liquid water (bulk flow and capillary suction) and water vapor. Effective interior drainage can safely drain liquid water from the wall assembly. However, once materials become wet, they can typically dry only by the removal of water vapor either by evaporation or diffusion. Evaporation requires energy but insulation decreases the flow of energy. Insulated walls cannot dry as easily as uninsulated walls. Liquid water can enter materials by bulk flow or by capillary suction. Poorly graded land adjacent to buildings and non-functioning or absent gutters and downspouts may allow rain to flow down the foundation wall where it can enter cracks. This water may also temporarily raise the water table so that water enters the foundation wall because of increased hydrostatic pressure. Proper diversion of rainwater and effective foundation drainage can prevent the entry of liquid water by these processes. Includes details beginning on page 10.
http://www.buildingscience.com/documents/reports/rr-0202-basement-insulation-systems/view

RR-1003: Building America Special Research Project
High-R Foundations Case Study Analysis–Assessing moisture related durability risks involves three different moisture processes; wetting, drying and moisture redistribution. These three processes in combination with the safe storage capacity of each component will determine the risk of moisture damage to a basement assembly. This report only includes a brief overview of the wetting mechanisms (more detail by Joseph Lstiburek 2006 which is BSD-103: Understanding Basements).
http://www.buildingscience.com/documents/reports/rr-1003-building-america-high-r-foundations-case-study-analysis/view

36.4 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Foundation Insulation Retrofit	BSC NorthernSTAR	2011	Gap Fully Filled

37 GAP (Fenestrations): Develop design guidance for window selection addressing films versus storms, windows by orientation, comfort and overheating, and performance characteristics including U-Factor, VT and SHGC for new and existing buildings

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #45

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows	✓	Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

37.1 Problem Statement

Develop design guidance for window selection addressing films versus storms, windows by orientation, comfort and overheating, and performance characteristics including U-Factor, VT and SHGC for new and existing buildings.

Type of Research: Modeling, possible field testing/monitoring

37.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Window Manufacturers

37.3 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Window Selection for New Construction	NorthernSTAR		

38 GAP (Airtightness): Collect and analyze U.S. airtightness data to make policy recommendations, prioritize research and estimate energy and IAQ impacts

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #45

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Airtightness	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

38.1 Problem Statement

Building America's performance criteria recommends that air leakage should be less than 0.25 cfm/ft^2 of building enclosure surface area at 50 Pa. Prior research suggests that substantial variability in airtightness is expected in a housing stock, and air leakage tend to increase over time. Building America teams have collected blower door and duct leakage data. It is important to evaluate this data as a performance measure, and also for estimating energy saving and mechanical ventilation needs.

Type of Research: Data collection, analysis and synthesis

38.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Modeling Programs, Developers and Users
Energy Raters
Auditors
Energy, Retrofit and Weatherization Program Managers

38.3 Background Knowledge

Info-001: Residential Best Practices Criteria
Air leakage (determined by pressurization testing) must be less than 2.5 square inches/100 square feet surface area leakage ratio (CGSB, calculated at a 10 Pa pressure differential); or 1.25 square inches/100 square feet leakage ratio (ASTM, calculated at a 4 Pa pressure differential); or 0.25 CFM/square foot of building enclosure surface area at a 50 Pascal air pressure differential. The calculation of the building enclosure area includes the foundation or below-grade surface areas. If the house is divided into multiple conditioned zones, such as conditioned attics or conditioned crawl space, the blower door requirement must be met with the access to the space open, connecting the zones.
http://www.buildingscience.com/documents/information-sheets/residential-best-practices-criteria/view

RR-0413a: The Snapshot-A Quick Description
http://www.buildingscience.com/documents/reports/rr-0413-the-snapshot-a-quick-description/view

Info-401: Air Barriers—Airtight Drywall Approach
Details for installing airtight drywall
http://www.buildingscience.com/documents/information-sheets/air-barriers-airtight-drywall-approach/view

Many Building America teams identified airtightness as a priority in order to meet the energy objective of their projects. Over the years, new constructions tend to be built more airtight but variability remains. It is important to identify factors that are associated with excessive air leakage (Sherman and Dickerhoff 1998; Chan et al. 2005; McWilliams and Jung 2006). Homes also tend to become more leaky over time. Therefore, it will be useful to track the performance of homes longitudinally to observe such changes. Alternative, this "aging" factor has also been observed in large datasets of blower door data. Duct Leakage cause system inefficiency. Because of limited data available, it is difficult to quantify the impact of leakage in the duct system on the whole-house air leakage.

38.4 System Considerations

Analysis of Building America's blower door and duct blaster data is one way for the program to demonstrate value added. It allows projects to measure home performance and consistency. It will help benchmark airtightness strategies so that practices that work can be identified. Besides new construction, the analysis can also be used to characterize the effectiveness of retrofit measures for existing dwellings. Certain field testing problems (e.g. single-point method) will likely be identified from analysis of the blower door and duct blaster data. This analysis is necessary to model infiltration and predict the amount of mechanical ventilation that is required. It also forms the basis of estimating energy saving from airtightness improvements.

38.5 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
	LBNL		

We plan to request blower door data from all Building America teams, including additional parameters, if available, beyond standard test data reporting. Data from different new construction and retrofit projects will be included in the analysis. Time trend analysis will be performed to show the progress made in reducing air leakage by projects over the years. In addition, Building America project data will be compared with air leakage data from other sources in LBNL residential diagnostic database. This will indicate potential influence on the housing technologies market. We also plan to extend our analysis to duct leakage and other diagnostic data if available.

38.6 Closing the Gap

Data analyses and interpretations will be presented in a technical report. Findings will be shared with Building America teams and stakeholders in future meeting(s).

39 GAP (Materials): Develop low GWP blowing agents for use in spray foams

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #47

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Materials	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

39.1 Problem Statement

Develop low Global Warming Potential (GWP) blowing agents for use in spray foams. The GWP of the third-generation foam blowing agents is still very high, and can significantly offset some of the GWP-reducing benefits they offer. A fourth-generation of blowing agents is being developed, and is close to deployment, that has very low GWP. As with any new product, field experience will discover limitations and problems that are different than the last generation: for example, more difficulty spraying, increased shrinkage, lower R-value, temperature sensitivity during installation. It is important that these low GWP products be delivered to the market as quickly as possible and any problems in the field be discovered and solved quickly. Areas for short-term research include: application of low-GWP insulation materials as direct substitutes for conventional insulation materials, focusing on construction details and hygrothermal analysis.

Type of Research: Product manufacturer's work

39.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Spray Foam Manufacturers

39.3 Background Knowledge

A. Wilson, 2010 "Avoiding the Global Warming Impact of Insulation." Environmental Building News, June 2010.

J. Kosny - "A Procedure for Analyzing Energy and Global Warming Impacts of Foam Insulation in U.S" - ACEEE 1998.

39.4 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
3 types of SPF life cycle assessment	SPFA		

40 GAP (Materials): Test permeability of open cell spray foam skin layers in a roof application with multiple lifts or layers

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #48

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Materials	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

40.1 Problem Statement

Test the permeability of open cell foam skin layers in a roof application. This testing would better help the industry understand if any moisture absorption or condensation issues can occur with open cell foam in climates zones 5 and higher.

Type of Research: Lab testing

40.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Spray Foam Manufacturers

40.3 Background Knowledge

A Crash Course in Roof Venting
See page 72 beginning of last paragraph in first column)
http://www.buildingscience.com/documents/published-articles/pa-crash-course-in-roof-venting/view

RR-1006: – Building America Special Research Project: High-R Roofs Case Study Analysis
http://www.buildingscience.com/documents/reports/rr-1006-ba-high-r-roofs-case-study-analysis/view

41 GAP (Roofs): Develop guidelines for metal roof installation that address detailing, thermal expansion, wind resistance, clip spacing, condensation protection and sub-roof design

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #49

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	✓
Roof/Ceiling	✓	Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

41.1 Problem Statement

Anticipate more applications of metal roofing in retrofit. Develop guidelines that may be particular to metal roof installation such as detailing, thermal expansion, wind resistance, clip spacing, condensation protection and sub-roof design.

Type of Research: Deployment

41.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Codes and Standards Making Bodies

41.3 Background Knowledge

Metal Roofing Association has much material.

BSD-135: Ice Dams
http://www.buildingscience.com/documents/digests/bsd-135-ice-dams/view

42 GAP (Roofs): Identify risks related to moisture accumulation in roofs with high solar reflectance and high IR emittance

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #50

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	✓
Roof/Ceiling	✓	Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

42.1 Problem Statement

Case studies have suggested that the high solar reflectance combined with high IR emittance of white roof assemblies may cause them to remain cold. This effect can, under some conditions, lead to moisture accumulation in the roof assembly.

Type of Research: Modeling, survey, literature search

42.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Roofing Products Manufacturers
Modeling Programs, Developers and Users

42.3 Background Knowledge

"White Roofs and Moisture in the US Desert Southwest" 2007. W.B. Rose, Performance of the Exterior Envelopes of Whole Buildings X. Atlanta, Geo.: American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc.

Roof assemblies in the U.S. desert Southwest have been instrumented for temperature and humidity. The low-slope roofs are composed of R-38 insulation installed directly beneath wood product sheathing boards, and are covered with a built-up roof and topped with a very reflective white coating. The air temperature at the underside of the sheathing remained very cold from December through March, rarely rising above the outdoor air temperature even in the middle of the afternoon. Observations confirm the presence of water in the insulation of some of the roof assemblies. Measured values showed high humidity (average RH>80% for several weeks during the winter) at the interface between the insulation and sheathing in some of the roof assemblies. This report presents theory as well as measured and modeled values indicating the “white roof problem”. With highly emissive upward-facing surfaces in clear-sky areas, the infrared loss from a surface to the sky is great; indeed, with high solar reflectivity, the solar gain cannot compensate for the sky loss. Since infrared radiation balance measurements are not available for this site, local airport cloud-cover measurements are used as a surrogate. Measured values of temperature and humidity from winters 2004- 2005 and 2005-2006 are presented. Modeled values that account for sky radiation, solar radiation, conduction and surface convection are used to explain the measured values.

RR-9801: Vented and Sealed Attics in Hot Climates
The use of white roof tile instead of black shingles could save 6% on annual space conditioning energy use in Orlando. A peak cooling load reduction of 13% was shown when simulating white roof tile versus black shingles. The combination of white roof tile and the sealed cathedralized attic, compared to black shingles and vented attic, could save 12% on annual space conditioning energy use in Orlando. Results showed that, when compared to typically vented attics with the air distribution ducts present, sealed “cathedralized” attics (i.e., sealed attic with the air barrier and thermal barrier [insulation] at the sloped roof plane) can be constructed without an associated energy penalty in hot climates.
http://www.buildingscience.com/documents/reports/rr-9801-vented-and-sealed-attics-in-hot-climates/view

RR-0907: Attic Temperatures and Cooling Energy Use in Vented and Sealed Attics in Las Vegas, Nevada
Peak summer day simulations for Las Vegas showed that the temperature of black roof shingles did not vary by more than 8°F, whether the attics were sealed or vented. The maximum predicted black roof shingle temperature for the sealed “cathedralized” attic was 204°F. For white tile roofs, the tile top temperature was, at maximum, 3°F hotter for the sealed attic compared to the vented attic. The maximum predicted white roof tile temperature for the sealed “cathedralized” attic was 132°F. Temperature measurements showed that the top of the red roof tile did not vary by more than 3°F between the 1:150 vented and sealed attics. This agreed well with the 3°F modeled prediction for white tile roofs on the peak cooling day (110°F outdoor air). The measured temperature at the bottom of the plywood roof sheathing was, at maximum, 17°F hotter for the sealed attic roofs. Table 3 summarizes these roof temperature results. Figures 4 and 5 show the times series data for the comparison of tile top temperature and plywood bottom temperature for the sealed and vented attics.
http://www.buildingscience.com/documents/reports/rr-9701-measurement-of-attic-temperatures-and-cooling-energy-use-in-vented-and-sealed-attics-in-las-vegas-nevada/view

BSI-008: The Building Science of Bourbon
Explains how metal roof color and insulation work in older warehouse space but could be used as reference; Low Thermal Resistance/Low Reflectivity Warehouse – Dark (painted) metal cladding, dark metal roof, open wood frame, no thermal insulation. The warehouse is deliberately designed to get hot in the summer and cold in the winter. The roof and wall have high solar absorption gaining heat in the summer. The roof and the wall have high emissivity—increasing radiation heat loss during cold weather.

This is the opposite of the approach taken for Low E window glazing—this is a “High E wall and roof.” Low Thermal Resistance/High Reflectivity Warehouse – “Shiny” metal cladding, “shiny” metal roof, open wood frame, no thermal insulation. The thermal control is radiation and ventilation based. High solar reflectivity of the wall and roof “knocks” the peaks off the high temperature extremes—rejecting solar radiation in the summer. Low emissivity of the wall and roof “fills” the valleys in the low temperature extremes – reducing radiation heat loss during cold weather. Cross ventilation and stack ventilation further moderate the temperature. Translation, building does not get as hot as it could in the summer and as cold as it could in the winter.
http://www.buildingscience.com/documents/insights/bsi-008-the-building-science-of-bourbon/view

43 GAP (Materials): Develop ways to integrate phase change materials into the enclosure assemblies

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #52

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Materials	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

43.1 Problem Statement

Develop ways to integrate phase change materials (PCM) into the enclosure assemblies. The following forms of PCM are considered: PCM-enhanced cellulose, PCM-enhanced fiberglass, PCM-foam, PCM-plastic containers.

Cost-effectively integrating phase-change materials into enclosures assemblies requires more research as the current products and approaches are expensive or complex. However, there are very likely applications of PCMs that are near commercialization that should be investigated further. These include:

- PCM integration into windows or other translucent enclosure elements
- Cost-effective integration into enclosure components, such as sheathing, framing or foundation structure, cladding materials, etc.

Type of Research: Design details, deployment/test installations

43.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Phase Change Materials Manufacturers

43.3 Background Knowledge

W. Miller & J. Kosny –"Next-Generation Roofs and Attics for Homes" - ACEEE 2008

Prototype residential roof and attic assemblies were constructed and field tested in a mixed-humid U.S. climate. Summer field data showed that at peak day irradiance the heat transfer penetrating the roof deck dropped almost 90% compared with heat transfer for a conventional roof and attic assembly. The prototype assemblies exhibited attic air temperatures that did not exceed the peak day outdoor air temperature. The assemblies use a combination of strategies: infrared reflective cool roofs, radiant barriers, above-sheathing ventilation, low emittance surfaces, insulation, and thermal mass to reduce the attic air temperature and thus the heat transfer into the home. Field results were benchmarked against an attic computer tool and simulations indicated that retrofitting pre-1980 construction with prototype roof systems and improving ductwork by reducing air leakage and heat transfer to existing ducts in attics could yield annual savings of about $200. In the hot, dry southeastern region of California, the combined ceiling and duct annual load drops by 23% of that computed for a code-compliant roof and attic assembly

J. Kosny et al. – "Sustainable Retrofit of Residential Roofs Using Metal Roofing Panels, Thin-Film Photovoltaic Laminates and PCM Heat Sink Technology." Journal of Building Enclosure Design, 2011 Winter.

The main goal of this project was the experimental evaluation of PV-PCM roofs, a newly-developed sustainable re-roofing technology that consists of metal panels integrated with amorphous silicon PV laminates and PCM heat sink. Collected experimental results indicate that PV-PCM roofs acted as a passive solar collector during the winter, with the PCM storing solar heat throughout the day and increasing the overall attic air temperature at night. This could reduce technology heating loads.

RR-1005: Building America Special Research Project: High-R Value Enclosures for High Performance Residential Buildings in All Climate Zones

Phase Change Materials were first used in passive solar residential building applications in the 70's and early 80's, mostly based on paraffins, fatty acids, or Glauber's salt. These products where available encapsulated on tiles, sealed containers located in ceilings, or impregnated into gypsum board (Rudd 1993). Problems with separation, combustibility, have resulted in a second generation of compounds and new micro-encapsulation technology (Schossig 2005). Salt-hydrate PCMs, packaged in slim capsules, were used below the floor of the North House Solar Decathalon house to increase its solar-savings fraction.

ORNL [Kosny 2007] and others [Zhang 2005] have conducted significant research into the impacts of PCM on walls and roofs, and have shown that they can reduce heat flow little, but reduce daily peaks more noticeably: however, it is currently often less expensive and much easier to reduce the heat flow and peaks by increasing insulation thickness.
http://www.buildingscience.com/documents/reports/rr-1005-building-america-high-r-value-high-performance-residential-buildings-all-climate-zones/view

RR-9301: Phase-Change Material Wallboard for Distributed Thermal Storage in Buildings

Thus far, the PCM wallboard development work has experimentally shown that the concept is workable on a large scale and that phase-change material can be successfully integrated and distributed within a building with a significant thermal storage effect. However, to obtain the magnitude of storage required, more work is needed to identify or develop new materials with greater latent heat capacity while keeping the melting/freezing range between 72°F (22.2°C) and 79°F (26.1°C). A longer-term goal of this preliminary research and developmental work is to develop an interior building skin material that can effectively store both thermal energy and moisture to provide better management of cooling loads for conditioned spaces. New work has begun to develop moisture storage coatings that may be applied to the PCM wallboard.
http://www.buildingscience.com/documents/reports/rr-9301-phase-change-material-wallboard-for-distributed-thermal-storage-in-buildings/view

RR-9401: Development of Moisture Storage Coatings for Enthalpy Storage Wallboard
Two moisture-storage coating mixtures developed and tested between late 1990 and early 1991 could provide a low-cost, building-integrated method of managing indoor humidity in hot and humid climates.
http://www.buildingscience.com/documents/reports/rr9401-developement%20of%20moisture%20storage/view

43.4 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
	CSE	2011/2012	Gap Partially Filled
How to classify phase change materials	CSE		

44 GAP (Materials): Identify cost-effective ways to use VIPs and aerogels in enclosure assemblies

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #53

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Materials	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

44.1 Problem Statement

Develop ways to use vacuum insulated panels (VIPs) and aerogels in a cost effective way. VIPs and aerogels have not found wider application because they are too expensive and offer too modest a performance improvement relative to other products and systems. This trend is likely to continue for the next 5-10 years. Research is needed to solve issues with on-site handling and long-term performance (for VIPs) and cost effective applications (aerogels). These high R-value per inch products may find particular application in relatively thin layers (e.g., one or two inches) for retrofits that otherwise would have to settle for less R-value in the space available. Hybrid applications of VIP or aerogel in combination with lower-cost spray fibrous or air sealing spray foam should be investigated further. Also, given low-head room basements, high-R products such as VIPs and aerogels may be a solution for insulating slabs in retrofits.

Type of Research: Product manufacturers' work

44.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
VIP and Aerogels Manufacturers

44.3 Background Knowledge

J.Kosny Building Envelopes Conference X - 2007

RR-1005: Building America Special Research Project: High-R Value Enclosures for High Performance Residential Buildings in All Climate Zones

Numerous Vacuum Insulated Panel (VIP) products are now on the European market, a result of developments over the last 25 years [IEA 2001]. VIPs have been investigated with cores of aerogel, silica fume, glass fiber, and open cell foams. In all cases, these cores are wrapped with a vacuum-tight wrapper, usually of metal or metalized plastic film to maintain the vacuum. These products achieve R-values of 15 to over 30 per inch depending on the core and the level of the vacuum. Edge effects can results in significant reductions below this potential [Ghazi et al, 2004]. Other than cost, two challenges remain: the risk of puncturing the seal (the almost instantaneous loss of 80% or more of the R-value) and the slow loss of vacuum over many years. The former is being solved using thoughtful applications (such as including VIPs in concrete, or protecting the with heavy sheet metal), and the latter is the current subject of research. Recent work in Scandinavia has focused on integrating VIP into wood frame construction. Testing [Haavi et al 2010] has shown that walls with R-values of nearly 60 can be constructed of 2x8's (actually slightly smaller: 36 mm x 170 mm). The practical issues of inserting VIPS tightly between studs in the field has not yet been solved of course. Other European work has considered the use of VIP as thin exterior retrofits to existing buildings: the high performance of the VIP at relatively small thicknesses can allow for modest changes (e.g. 3" or so) in depth and [Nussbaum et al 2006]. Aerogels are a broad range of materials that were developed decades ago. Although these materials can produce products with a range of physical and thermal properties, there use has been investigated for building applications because of their high R-value per inch [Kosny et al 2007]. Aerogel research should focus on reducing production costs and indentifing applications, perhaps in retrofit, that justify its current high cost.
http://www.buildingscience.com/documents/reports/rr-1005-building-america-high-r-value-high-performance-residential-buildings-all-climate-zones/view

44.4 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
	CSE	2011/2012	Gap Partially Filled

45 GAP (Foundations): Research minimum compressive strength needed for rigid foam brick ledge to carry two stories of brick

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #58

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	
Foundations	✓	Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

45.1 Problem Statement

Research the minimum compressive strength needed for rigid foam to carry two stories of brick. If structurally acceptable, this will help create a continuous thermal break on the outside of a foundation when constructing a brick to grade detail. This may also help to reduce efflorescence with brick by allowing the foam to act as a capillary break.

Type of Research: Lab testing, mock up a test wall with brick

45.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Insulating Sheathing Manufacturers

46 GAP (Roofs): Identify moisture damage risks associated with retrofitting a roof with a known leaky material (ie. slate and tile) without doing complete roof tear-off

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #66

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	
Roof/Ceiling	✓	Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

46.1 Problem Statement

Identify moisture damage risks associated with retrofitting a roof with a known leaky material (ie. slate and tile), without doing complete roof tear-off (i.e., installation of new drainage plane under roof cladding). In the existing condition, enough heat and airflow through the assembly occurs to remove this leak water without it causing damage. In an energy retrofit, heat and airflow will be reduced, and hence the ability of such roofs to survive is unknown. One method of enhancing moisture removal is ventilation of the space under the roofing and sheathing. It is not known how much ventilation is needed, or how much drying can be achieved in this type of retrofit.

Type of Research: Deployment, field measurement

46.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Roofing Materials Manufacturers

47 GAP (Walls): Research attachment mechanisms to determine if EIFS can be used in high wind areas

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #67

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls	✓	Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

47.1 Problem Statement

EIFS cladding combines an exterior insulation and finish; in some high wind areas, use of EIFS may be limited due to the attachment mechanisms.

47.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
EIFS Manufacturers

48 GAP (Foundations): Identify ways to mitigate significant moisture load from new concrete during first year of occupancy

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #68

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations	✓	Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

48.1 Problem Statement

Curing concrete gives off significant amounts of moisture, and can off gas for more than a year. How can this significant moisture load be accounted for and mitigated during the first year of occupancy? Especially critical in tight, high-R enclosures.

Type of Research: Analysis, modeling, filed monitoring

48.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders

48.3 Background Knowledge

BSD-103: Understanding Basements

Basement walls should be insulated with non-water sensitive insulation that prevents interior air from contacting cold basement surfaces – the concrete structural elements and the rim joist framing. The best insulations to use are foam based and should allow the foundation wall assembly to dry inwards. The foam insulation layer should generally be vapor semi impermeable (greater than 0.1 perm), vapor semi permeable (greater than 1.0 perm) or vapor permeable (greater than 10 perm) (Lstiburek, 2004). The greater the permeance the greater the inward drying and therefore the lower the risk of excessive moisture accumulation. However, in cold climates or buildings with high interior relative humidity during cold weather, the upper portion of a basement wall may become cold enough that a vapour permeable insulation will allow a damaging amount of outward diffusion during cold weather. A semi-permeable vapour retarder or foam or a supplemental layer exterior insulation can be used in these situations. In all cases, a capillary break should be installed on the top of the footing between the footing and the perimeter foundation wall to control "rising damp." No interior vapor barriers should be installed in order to permit inward drying. Up to two inches of unfaced extruded polystyrene (R-10), four inches of unfaced expanded polystyrene (R-15), three inches of closed cell medium density spray polyurethane foam (R-18) and ten inches of open cell low density spray foam (R-35) meet these permeability requirements.
http://www.buildingscience.com/documents/digests/bsd-103-understanding-basements

RR-1003: Building America Special Research Project: High-R Foundations Case Study Analysis

Assessing moisture related durability risks involves three different moisture processes; wetting, drying and moisture redistribution. These three processes in combination with the safe storage capacity of each component will determine the risk of moisture damage to a basement assembly. This report only includes a brief overview of the wetting mechanisms (more detail by Joseph Lstiburek 2006; above BSD-103 reference).
http://www.buildingscience.com/documents/reports/rr-1003-building-america-high-r-foundations-case-study-analysis/view

49 GAP (Fenestrations): Develop details for window replacement where no work is done on the exterior wall

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #69; Combine with former #70 Identify options for replacing windows in a house on the historic registry, focus on IGU storms

Check all that apply:

BA Enclosures		BA Hot Water		House Type	
Walls		Test Standards		New	
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows	✓	Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other:		Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

49.1 Problem Statement

Recommendations and details for only replacing windows; how are they removed, replaced and flashed and then trimmed out.

Type of Research: Design, deployment

49.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Window Manufacturers

49.3 Background Knowledge

James B. et al. 1996 (VEIC) "Testing the Energy Performance of Wood Windows in Cold Climates: A Report to The State of Vermont Division for Historic Preservation Agency of Commerce and Community Development"

Klems 2002, "Measured Winter Performance of Storm Windows," Windows and Daylighting Group, Building Technologies Department, Lawrence Berkeley National Laboratory

Quach et al. 2003 "The forgotten market: maximizing energy efficiency in today's world" International Glass Review.

Drumheller et al. 2007 "Field Evaluation of Low-E Storm Windows" Performance of the Exterior Envelopes of Whole Buildings X. Atlanta, Geo.: American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc.

RR-1012: Residential Exterior Wall Superinsulation Retrofit Details and Analysis
Advantages/details of interior window replacement from three case study retrofits.
http://www.buildingscience.com/documents/reports/rr-1012-residential-exterior-wall-superinsulation-retrofit/view

49.4 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
Window Repair, Rehabilitation and Replacement	BSC	2011	Gap Fully Filled

50 GAP (Materials): Expand beyond aluminum packaging for Phase Change Materials

Gap Status	Partial 2-pager with information from Google Doc
Gap Change	Former #72

Check all that apply:

BA Enclosures		**BA Hot Water**		**House Type**	
Walls		Test Standards		New	✓
Roof/Ceiling		Distribution		Existing	✓
Foundations		Condensing/Tankless		Single Family	✓
Moisture		Heat Pump Water Heater		Multi Family	✓
Windows		Combined Space & DHW Heating		**DOE Emerging Technologies**	
Other: Materials	✓	Other:		Walls and Windows	
BA Space Conditioning		**BA Miscellaneous Loads**		Efficient Appliances	
Heating		Home Energy Management		Advanced Heating & Cooling Fluids	
Cooling		Lighting		Solar Heating & Cooling	
Dehumidification		Large MELs (pools, etc.)		Geothermal Heat Pumps	
Distribution		Small MELs (TVs, VCRs, etc.)		Solid State Lighting	
Ventilation		Other:		Bulk Purchase	
Other:				Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
Testing Methods/Protocols		**BA Implementation**			
House Simulation Protocol		Quality Control/Quality Assurance			
Lab Test Methods		Training		**DOE Deployment**	
Field Test Methods		Documentation/Resources		Labeling/Rating	
Analysis Methods/Tools		Needs Evaluation/Identification		Codes	
Analysis Tools		Other:		Standards	
Strategic Analysis				Large Scale Retrofit (Better Buildings)	
Other:					

50.1 Problem Statement

Aluminum package for macro-encapsulation in phase change materials is still not reliable; expand to a more general case rather than just aluminum packaging, PCMs/thermal mass side; code representation and cost.

Type of Research: Product manufacturers' work, code, thermal characteristics database for PCMs, improvement of simulation tools

50.2 Key Customers and Stakeholders

Building Owners and Occupants
Architects
Builders
Phase Change Materials Manufacturers

50.3 Background Knowledge

Several papers of J.Kosny team from Building Envelopes Conference X and XI

RR-1005: Building America Special Research Project: High-R Value Enclosures for High Performance Residential Buildings in All Climate Zones
Phase Change Materials were first used in passive solar residential building applications in the 70's and early 80's, mostly based on paraffins, fatty acids, or Glauber's salt. These products where available encapsulated on tiles, sealed containers located in ceilings, or impregnated into gypsum board (Rudd 1993). Problems with separation, combustibility, have resulted in a second generation of compounds and new micro-encapsulation technology (Schossig 2005). Salt-hydrate PCMs, packaged in slim capsules, were used below the floor of the North House Solar Decathalon house to increase its solar-savings fraction. ORNL [Kosny 2007] and others [Zhang 2005] have conducted significant research into the impacts of PCM on walls and roofs, and have shown that they can reduce heat flow little, but reduce daily peaks more noticeably: however, it is currently often less expensive and much easier to reduce the heat flow and peaks by increasing insulation thickness.
http://www.buildingscience.com/documents/reports/rr-1005-building-america-high-r-value-high-performance-residential-buildings-all-climate-zones/view

RR-9301: Phase-Change Material Wallboard for Distributed Thermal Storage in Buildings
Thus far, the PCM wallboard development work has experimentally shown that the concept is workable on a large scale and that phase-change material can be successfully integrated and distributed within a building with a significant thermal storage effect. However, to obtain the magnitude of storage required, more work is needed to identify or develop new materials with greater latent heat capacity while keeping the melting/freezing range between 72°F (22.2°C) and 79°F (26.1°C). A longer-term goal of this preliminary research and developmental work is to develop an interior building skin material that can effectively store both thermal energy and moisture to provide better management of cooling loads for conditioned spaces. New work has begun to develop moisture storage coatings that may be applied to the PCM wallboard.
http://www.buildingscience.com/documents/reports/rr-9301-phase-change-material-wallboard-for-distributed-thermal-storage-in-buildings/view

RR-9401: Development of Moisture Storage Coatings for Enthalpy Storage Wallboard
Two moisture-storage coating mixtures developed and tested between late 1990 and early 1991 could provide a low-cost, building-integrated method of managing indoor humidity in hot and humid climates.
http://www.buildingscience.com/documents/reports/rr9401-developement%20of%20moisture%20storage/view

50.4 Planned or Ongoing Research

Project	Organization	Calendar Year	Projected Gap Fulfillment
	CSE		

Appendix A: Change Log

Record of changes to the Enclosures Standing Technical Committee Strategic Plan. The first version of the Enclosures Strategic Plan is dated 2011-12-22.

Date	Plan Version	Gap Title	Change Description
2011-12-22	First Version - 2011		

Appendix B: Resolved Gaps

Record of resolved gaps identified in the Enclosures Strategic Plan. Gap resolution is determined by Enclosures STC Majority Vote and reviewed at annual Building America Planning Meeting.

Date Resolved	Gap Rank	Gap Title

Appendix C: Gap Status and Planned or Ongoing Research

The table below is a summary of the current status of renumbered gaps, gap changes, and Planned or Ongoing Research projects.

Gap	Gap Status	Gap Change	Project & Organization		Year	Projected Gap Fulfillment
(Roofs): 01 - Identify risks associated with installing spray foam under plywood and OSB roof decks and propose solutions	Critically reviewed by Discussion Group and revised by Committee Chair	Title	Application of Spray Foam Insulation Under Plywood and OSB Roof Sheathing	BSC	2012	Gap Fully Filled
			Charleston – 6 variations including both open and closed cell SPF	ORNL		
(Walls): 02 - Determine the best way to address thermal bridging in residential building codes	Critically reviewed by Discussion Group and revised by Committee Chair	Combine with #54 Develop a catalogue of residential thermal bridge Psi factors, demonstrate use, and develop means of validating Psi factors using IR thermography	NEEM	BA-PIRC	2011/2012	Gap Partially Filled
(Airtightness): 03 - Document known strategies to achieve "good, better, best" enclosure airtightness goals	Critically reviewed by Discussion Group and revised by Committee Chair	Title	Wind Washing; Air Sealing/Insulated Siding Retrofits; Select Test Home Projects; FRTF	BA-PIRC	2011/2012	Gap Partially Filled
			Advanced New Construction Measure Guideline	BSC	2011/2012	Gap Partially Filled
				CEER		
			Assessment of the Impact of Air Barriers on Energy and Moisture Control, Phase 2 of Air Barrier Assembly Evaluations at the Building Envelope System Testing (BEST) Facility	ORNL		
			Laboratory tests on air barrier sub-assemblies	ORNL		
			Field tests on airtightness and IAQ	ORNL		
			Air sealing multifamily	ARIES		
			Multifamily attic air sealing	CARB	2011	
			Airtightness: Consistent high quality airsealing installation	BIRA	2011/2012	

Gap	Gap Status	Gap Change	Project & Organization		Year	Projected Gap Fulfillment
(Walls): 04 - Identify condensation risks associated with using vapor impermeable exterior insulating sheathing in an above grade wall assembly in all climate zones	Critically reviewed by Discussion Group and revised by Committee Chair	Title	Water Management of Insulating and Non-Insulating Sheathings	BSC	2011	Gap Partially Filled
				NAHBRC-IP		
			Charleston Project – Report coming out in March	ORNL		
			Retrofit Project	CEER		
			Hygric Redistribution in Insulated Assemblies	BSC	2011	Gap Partially Filled
			Guidance on Moisture Management for High-R Walls for New Construction	BSC	2012	Gap Partially Filled
			Field research of full scale test walls	Steven Winter Associates		
			Test hut research of full scale field test walls	BSC		
(Airtightness): 05 - Identify relative contributions of specific air leakage paths	Full 2-pager written by Committee Chair	None	FRTF; Sequential Unsealing and Testing	BA-PIRC	2011/2012	Gap Partially Filled
			Retrofit Project – Staged / sequential; air seal and package without blower door	CEER		
			Exterior Wall Project in New York – Comprehensive Retrofit	IBACOS		
			Incremental Testing – Air barrier in lab; blower door tests	ORNL		
			Dense Pack Wall and Roof Assemblies	BSC	2011	Gap Partially Filled
			Wind Washing; Air Sealing/Insulating Siding Retrofits; Select Test Home Projects; FRTF	BA-PIRC	2011/2012	Gap Partially Filled
			Measurement of Existing Homes for Retrofitting – Calibration of Multiple Homes	CEER	2011/2012	Gap Partially Filled
				NorthernSTAR		

Gap	Gap Status	Gap Change	Project & Organization		Year	Projected Gap Fulfillment
(Walls): 06 - Determine vapor diffusion and air leakage limits for high R-value wall assemblies in all climate zones	Full 2-pager written by Committee Chair	Title	Guidance on Moisture Management for High-R Walls for New Construction	BSC	2012	Gap Fully Filled
		Combine with #16 Identify condensation risks associated with various cavity insulation materials using a double stud wall in cold climate zones	High-R Wall Moisture Testing (Retrofit)	NAHBRC-IP	2011/2012	Gap Fully Filled
			Dense Pack Wall and Roof Assemblies	BSC	2011	Gap Partially Filled
			Hygric Redistribution in Insulated Assemblies	BSC	2011	Gap Partially Filled
			Southern Climate Research – Test Hut in New Mexico	CSE		
			Wall Tests Project	CEER		
			Whole House – New Construction – Transformations, Inc.	BSC	2011/2012	Gap Partially Filled
(Walls): 07 - Determine the structural capacity of exterior insulating sheathing with respect to the attachment of common cladding systems	Full 2-pager written by Committee Chair	None	Cladding Attachment Over Thick Exterior Insulating Sheathing	BSC	2012	Gap Fully Filled
			Wind Testing Project	NAHBRC-IP		
			External Insulation of Masonry and Frame Walls	BSC	2011	Gap Partially Filled
(Foundations): 08 (fmr 09) - Develop more consistent recommendations for basement slab and slab on grade insulation in all climate zones	Full 2-pager written by Committee Chair	None	Under Slab Sensors at Lab House	IBACOS		
			Monitoring Two Houses with Insulation Under Slab; Radiant Heat Slabs	ARBI		
			Modeling Methods; Foundation Handbook Update	ORNL and NorthernSTAR		
			Modeling Methods	NREL		
			2013 Thermal Performance of Slabs	BA-PIRC		
			Foundation Insulation Retrofit	BSC	2011	Gap Partially Filled
			In-situ Foundation Insulation Testing at the CRRF	NorthernSTAR		
			Retrofit Foundation Insulation Modeling and Analysis	NorthernSTAR	2011/2012	
			Foundation Insulation Assessment/Analysis for New Construction	NorthernSTAR		

Gap	Gap Status	Gap Change	Project & Organization		Year	Projected Gap Fulfillment
(Walls): 09 (fmr 10) - Develop guidance for exterior insulation over existing insulated wall assemblies in all climate zones	Full 2-pager written by Committee Chair	Title	Flat Roof Solutions	CSE	2012	Gap Partially Filled
			Cladding Attachment Over Thick Exterior Insulating Sheathing	BSC	2012	Gap Partially Filled
			Hygric Redistribution in Insulated Assemblies	BSC	2011	Gap Partially Filled
			Project Overcoat for 1-1/2 Story Houses	NorthernSTAR	2011/2012	Gap Partially Filled
			Whole House – Existing Construction – National Grid	BSC	2011/2012	Gap Partially Filled
			Evaluation of Advanced Retrofit Packages in Test Homes	BSC	2011	Gap Partially Filled
(Materials): 10 (fmr 11) - Study the durability of insulating sheathing products	Full 2-pager written by Committee Chair	Title	Air Sealing/Insulating Siding Retrofits	BA-PIRC	2011/2012	Gap Partially Filled
			Cladding Attachment Over Thick Exterior Insulating Sheathing	BSC	2011/2012	Gap Partially Filled
			Guidance on Taped Insulating Sheathing Drainage Planes	BSC	2011/2012	Gap Partially Filled
(Roofs): 11 (fmr 12) - Develop Solutions for Insulating Unvented Flat or Low Slope Roofs	Full 2-pager written by Committee Chair	None	Flat Roof Solutions	CSE	2011	Gap Partially Filled
(Walls): 12 (fmr 13) - Develop prescriptive methods for designing rim headers to carry floor and roof loads	Full 2-pager written by Committee Chair	None	Advanced 2x6 Framing Packages	NAHBRC-IP	2011/2012	Gap Fully Filled
			Measurement of Existing Homes for Retrofitting – Calibration of Multiple Homes	CEER	2011/2012	Gap Fully Filled
			Advanced Framing Proof-of-Concept Testing	NAHBRC-IP	2012	
(Walls): 13 (fmr 14) - Develop solutions to provide shear resistance to non-structurally sheathed wall assemblies	Full 2-pager written by Committee Chair	None	Wind Resistance of Wall Systems with Rigid Foam Sheathing	NAHBRC-IP	2011/2012	Gap Fully Filled
			High Performance Hybrid Assemblies	BSC	2011	Gap Partially Filled
(Walls): 14 (fmr 15) - Characterize the moisture performance of walls with higher cavity R-values using permeable insulations particularly in homes with lower air exchange rates	Full 2-pager written by Committee Chair	None	High-R Walls, High-R Wall Moisture Testing (Retrofit)	NAHBRC-IP	2011/2012	Gap Fully Filled
			Moisture Management with Highly Permeable Sheathing Insulations over Existing Walls with Permeable Cavity Insulation	BSC	2012	Gap Fully Filled
			Moisture Research on Wall Interiors	CARB	2011/2012	Gap Fully Filled
			Monitoring Retrofit Packages	CEER		
			Guidance on Moisture Management for High-R Walls for New Construction	BSC	2011/2012	Gap Fully Filled

Gap	Gap Status	Gap Change	Project & Organization		Year	Projected Gap Fulfillment
(Roofs): 15 (fmr 17)- Guidance for adding insulation above and below roof deck to meet 2009 IECC in all climate zones	Full 2-pager written by Committee Chair	Title	Advanced New Construction Measure Guideline	BSC	2011/2012	Gap Partially Filled
			Roof Retrofit Report	ORNL		
				NAHBRC-IP		
(Walls): 16 (fmr 18) - Fire testing of high R-value wall assemblies for use in multi-family and zero lot line projects	Full 2-pager written by Committee Chair	Title	China, CERC	ORNL		
(Roofs): 17 (fmr 19) - Identify risks with insulating the attic at the roof plane while keeping existing attic floor insulation	Full 2-pager written by Committee Chair	None	Clark County – Attic Monitoring Results	CARB	2013/2014	Gap Addressed
			Survey and Monitoring of Retrofit House	PNNL		
(Walls): 18 (fmr 20) - Develop solutions to insulate and air seal interstitial spaces in existing exterior wall assemblies	Full 2-pager written by Committee Chair	Title	Dense Pack Wall and Roof Assemblies	BSC	2011	Gap Partially Filled
			Measurement of Existing Homes for Retrofitting – Calibration of Multiple Homes	CEER	2011	Gap Partially Filled
			Draft Report	ORNL		
(Walls): 19 (fmr 22) - Identify, develop and deploy new high R-value enclosure component designs that are suited for industrialized applications	Full 2-pager written by Committee Chair	Title	Zeta	ARBI	2011/2012	Gap Partially Filled
			NEEM	BA-PIRC	2011/2012	Gap Partially Filled
			Advanced Envelope Design for Factory Built Homes	ARIES	2011/2012	Gap Partially Filled
			Gridstar Project	NELC		
(Materials): 20 (fmr 23) - Address seismic and high wind considerations for use of SIPs in retrofit and new construction	Full 2-pager written by Committee Chair	None	Retrofit Work with NYSERDA and SIPA	NAHBRC-IP		
(Walls): 21 (fmr 24) - Determine the structural capacity of cavity spray foam insulation when sprayed against non-structural sheathings	Full 2-pager written by Committee Chair	None	High Performance Hybrid Systems	BSC	2011/2012	Gap Partially Filled
			Report	NAHBRC-IP		
			High Performance Hybrid Assemblies	BSC	2011	Gap Partially Filled
(Roofs): 22 (fmr 25) - Address condensation and water intrusion when converting attic and attic knee-wall spaces to conditioned area	Full 2-pager written by Committee Chair	None	Whole House – Existing Construction – National Grid	BSC	2011/2012	Gap Fully Filled
			CEDA, Illinois	BSC	2011	Gap Partially Filled
(Fenestrations): 23 (fmr 26) - Identify what works, what does not work, and what can be improved when retrofitting windows	Full 2-pager written by Committee Chair	Combine with #56 Standardize window retrofit practices to reduce cost, focus on cost and general applicability	Window Replacement Details	BSC	2011/2012	Gap Partially Filled
			Window Repair, Rehabilitation and Replacement	BSC	2011	Gap Partially Filled
(Other): 24 (fmr 28) - Develop recommendations for sequencing and phased retrofits	Full 2-pager written by Committee Chair	None	Measurement of Existing Homes for Retrofitting – Calibration of Multiple Homes	CEER	2013/2014	Gap Addressed
			Envinity	NELC		

Gap	Gap Status	Gap Change	Project & Organization		Year	Projected Gap Fulfillment
(Walls): 25 (fmr 30) - Identify risks associated with insulating masonry from the interior	Full 2-pager written by Committee Chair	None	Internal Insulation of Masonry Walls	BSC	2011/2012	Gap Partially Filled
			Habitat for Humanity	CARB	2011/2012	Gap Fully Filled
			New Test Hut	CSE		
			Guidance on Interior Retrofits of Load-bearing Masonry Structures	BSC	2012	Gap Fully Filled
(Walls): 26 (fmr 31) - Identify moisture damage risks associated with retrofitting only walls and not replacing the windows or upgrading the rain control performance of the windows	Partial 2-pager with information from Google Doc	Combine with #51 Develop details for the retrofit of walls where existing windows are retained	External Insulation of Masonry and Frame Walls	BSC	2011	Gap Partially Filled
			Window Repair, Rehabilitation and Replacement	BSC	2011	Gap Partially Filled
(Foundations): 27 (fmr 32) - Develop strategies for insulating the exterior of existing foundations in all climate zones	Partial 2-pager with information from Google Doc	Title	Excavationless Exterior Foundation Insulation Retrofit	NorthernSTAR		
		Combine with #44 Develop insect and moisture resistant exterior insulation strategies for new and existing foundations	Foundation Insulation Retrofit Demonstration Project	NorthernSTAR		
(Walls): 28 (fmr 34) - Develop prescriptive method for installation of vinyl siding over 24" o.c. framing with non-structural sheathing	Partial 2-pager with information from Google Doc	Title		NAHBRC-IP		
(Materials): 29 (fmr 36) - Develop fire resistant foam insulation materials that have environmentally-benign fire retarders	Partial 2-pager with information from Google Doc	None				
(Other): 30 (fmr 37) - Develop improved simple semi-empirical predictive models of condensation potential in wall and roof assemblies in all climate zones	Partial 2-pager with information from Google Doc	Title				
(Foundations): 31 (fmr 38) - Identify moisture damage risks associated with insulating a wood sill beam from the interior	Partial 2-pager with information from Google Doc	None				
(Walls): 32 (fmr 39) - Identify moisture damage risks associated with insulating embedded wood beams or joists in masonry walls	Partial 2-pager with information from Google Doc	None	Internal Insulation of Masonry Walls	BSC	2011/2012	Gap Fully Filled
			Guidance on Interior Retrofits of Load-bearing Masonry Structures	BSC	2012	Gap Fully Filled
(Fenestrations): 33 (fmr 40) - Develop guidance on how to identify the best location in a high-R wall for the window (outie, innie, middle)	Partial 2-pager with information from Google Doc	Title				
(Other): 34 (fmr 41) - Develop low cost measurement equipment to check assemblies for accumulated condensation	Partial 2-pager with information from Google Doc	None				
(Walls): 35 (fmr 42) - Characterize the wind pressure performance of wall systems by layer (pressure equalization)	Partial 2-pager with information from Google Doc	None		NAHBRC-IP		
(Foundations): 36 (fmr 43) - Develop strategies for dealing with bulk water leaks in finished basements focus on spray foam interior insulation	Partial 2-pager with information from Google Doc	Combine with #59 Develop techniques to evaluate overall moisture loading and risks of an existing foundation wall, take into account seasonal and annual changes	Foundation Insulation Retrofit	BSC	2011	Gap Fully Filled
				NorthernSTAR		

Gap	Gap Status	Gap Change	Project & Organization		Year	Projected Gap Fulfillment
(Fenestrations): 37 (fmr 45) - Develop design guidance for window selection addressing films versus storms, windows by orientation, comfort and overheating, and performance characteristics including U-Factor, VT and SHGC for new and existing buildings	Partial 2-pager with information from Google Doc	Title	Window Selection for New Construction	NorthernSTAR		
(Airtightness): 38 (fmr 46) - Collect and analyze U.S. airtightness data to make policy recommendations, prioritize research and estimate energy and IAQ impacts	Partial 2-pager with information from Google Doc	Title		LBNL		
(Materials): 39 (fmr 47) - Develop low GWP blowing agents for use in spray foams	Partial 2-pager with information from Google Doc	None	3 types of SPF life cycle assessment	SPFA		
(Materials): 40 (fmr 48) - Test permeability of open cell spray foam skin layers in a roof application with multiple lifts or layers	Partial 2-pager with information from Google Doc	None				
(Roofs): 41 (fmr 49) - Develop guidelines for metal roof installation that address detailing, thermal expansion, wind resistance, clip spacing, condensation protection and sub-roof design	Partial 2-pager with information from Google Doc	None				
(Roofs): 42 (fmr 50) - Identify risks related to moisture accumulation in roofs with high solar reflectance and high IR emittance	Partial 2-pager with information from Google Doc	Title				
(Materials): 43 (fmr 52) - Develop ways to integrate phase change materials into the enclosure assemblies	Partial 2-pager with information from Google Doc	Title		CSE	2011/2012	Gap Partially Filled
			How to classify phase change materials	CSE		
(Materials): 44 (fmr 53) - Identify cost-effecive ways to use VIPs and aerogels in enclosure assemblies	Partial 2-pager with information from Google Doc	Title		CSE	2011/2012	Gap Partially Filled
(Foundations): 45 (fmr 58) - Research minimum compressive strength needed for rigid foam brick ledge to carry two stories of brick	Partial 2-pager with information from Google Doc	None				
(Roofs): 46 (fmr 66) - Identify moisture damage risks associated with retrofitting a roof with a known leaky material (ie. slate and tile) without doing complete roof tear-off	Partial 2-pager with information from Google Doc	None				
(Walls): 47 (fmr 67) - Research attachment mechanisms to determine if EIFS can be used in high wind areas	Partial 2-pager with information from Google Doc	None				
(Foundations): 48 (fmr 68) - Identify ways to mitigate significant moisture load from new concrete during first year of occupancy	Partial 2-pager with information from Google Doc	None				
(Fenestrations): 49 (fmr 69) - Develop details for window replacement where no work is done on the exterior wall	Partial 2-pager with information from Google Doc	Combine with #70 Identify options for replacing windows in a house on the historic registry, focus on IGU storms	Window Repair, Rehabilitation and Replacement	BSC	2011	Gap Fully Filled
(Materials): 50 (fmr 72) - Expand beyond aluminum packaging for Phase Change Materials	Partial 2-pager with information from Google Doc	Title		CSE		

Appendix D: Removed or Combined Gaps

The table below is a summary of the removed or combined gaps. Planned or Ongoing Research projects listed under removed or combined gaps have been relocated as indicated in the Gap Status column.

Gap	Gap Status	Gap Change	Project & Organization		Year	Projected Gap Fulfillment
(Materials): 08 - Develop Metrics for Material and System Durability	Removed; Project added to new #10 Study the durability of insulating sheathing products	Remove - too vague, #11 is more specific	Guidance on Taped Insulating Sheathing Drainage Planes	BSC	2011/2012	Gap Partially Filled
(Walls): 16 - Identify condensation risks associated with various cavity insulation materials using a double stud wall in cold climate zones	Combined; Project added to new #06 Determine vapor diffusion and air leakage limits for high R-value wall assemblies in all climate zones	Combine with #6 Determine vapor diffusion and air leakage limits for high R-value wall assemblies in all climate zones	Whole House – New Construction – Transformations, Inc.	BSC	2011/2012	Gap Partially Filled
(Airtightness): 21 - Methodology for identifying impacts of air leakage reduction on ventilation, combustion safety in existing buildings	Removed; Projects added to new #05 Identify relative contributions of specific air leakage paths	Remove - BA position is that there is no specific airtightness target that would allow avoidance of addressing combustion safety and ventilation issues	Wind Washing; Air Sealing/Insulating Siding Retrofits; Select Test Home Projects; FRTF	BA-PIRC	2011/2012	Gap Partially Filled
		Move research projects to other airtightness gaps	Measurement of Existing Homes for Retrofitting – Calibration of Multiple Homes	CEER	2011/2012	Gap Partially Filled
				NorthernSTAR		
(Materials): 27 - New strategies to address code requirements for flame spread and smoke development of foam plastic insulation	Removed	Remove - not really an enclosure gap				
(Other): 29 - Analyze the materials and methods for the exterior insulation of 1.5 story bungalows and cape cod houses in cold climates	Removed; Projects added to new #09 Develop guidance for exterior insulation over existing insulated wall assemblies in all climate zones	Remove - gap is too broad and is covered within other more specific gaps	Project Overcoat for 1-1/2 Story Houses	NorthernSTAR	2011/2012	Gap Partially Filled
		Move research projects to other gaps	Whole House – Existing Construction – National Grid	BSC	2011/2012	Gap Partially Filled
			Evaluation of Advanced Retrofit Packages in Test Homes	BSC	2011	Gap Partially Filled

Gap	Gap Status	Gap Change	Project & Organization		Year	Projected Gap Fulfillment
(Foundations): 33 - Determine if moisture accumulation and biological activity at the interface between interior of foundation wall and insulation is an IAQ concern for the occupant or liability for the builder or designer	Removed	Remove - gap closed based on BSC basement work				
(Fenestrations): 35 - Standardize details for the installation of windows over 1.5" of exterior insulating sheathing	Removed	Remove - many details exist; with a multitude of windows out there, may not be able to have "standard" details				
(Foundations): 44 - Develop insect and moisture resistant exterior insulation strategies for new and existing foundations	Combined with new #27	Combine with #32 Develop strategies for insulating the exterior of existing foundations in all climate zones				
(Walls): 51 - Develop details for the retrofit of walls where existing windows are retained	Combined with new #26	Combine with #31 Identify moisture damage risks associated with retrofitting only walls and not replacing the windows or upgrading the rain control performance of the windows				
(Other): 54 - Develop a catalogue of residential thermal bridge Psi factors, demonstrate use, and develop means of validating Psi factors using IR thermography	Combined with new #02	Combine with #2 Determine the best way to address thermal bridging in residential building codes				
(Walls): 55 - Identify hold-down anchors to be used in advanced framed wood frame walls with non-structural sheathing	Removed	Remove - not a gap, solutions existing, may be communication issue.				
(Fenestrations): 56 - Standardize window retrofit practices to reduce cost, focus on cost and general applicability	Combined with new #23	Combine with #26 Identify what works, what does not work, and what can be improved when retrofitting windows				
(Foundations): 57 - Develop improved tools and models for foundations with high levels of insulation	Removed	Remove - should be listed in Analysis Methods and Tools STC				
(Foundations): 59 - Develop techniques to evaluate overall moisture loading and risks of an existing foundation wall, take into account seasonal and annual changes	Combine; Project added to new #36 Develop strategies for dealing with bulk water leaks in finished basements focus on spray foam interior insulation	Combine with #43 Develop strategies for dealing with bulk water leaks in finished basements focus on spray foam interior insulation		NorthernSTAR		
(Roofs): 60 - Research the thermal performance and building durability of the application of a blown in insulation in the upper portion of a Cape Cod attic	Removed	Remove - addressed by 2011 NREL research				

Gap	Gap Status	Gap Change	Project & Organization		Year	Projected Gap Fulfillment
(Walls): 61 - Develop decision tree for insulation strategy in wall stud bays	Removed	Remove - communication issue for best practice guide.				
(Foundations): 62 - Improve techniques for below grade hygrothermal analysis	Removed; Projects added to new #08 Develop more consistent recommendations for basement slab and slab on grade insulation in all climate zones	Remove - should be listed in Analysis Methods and Tools STC		NorthernSTAR		
			Retrofit Foundation Insulation Modeling and Analysis	NorthernSTAR	2011/2012	
			Foundation Insulation Assessment/Analysis for New Construction	NorthernSTAR		
(Foundations): 63 - Investigate and categorize existing foundation conditions for retrofits	Removed	Remove - addressed by NREL 2011 research work				
(Foundations): 64 - Determine the variability (reproducibility) of any radon measurement as a function of the sampling time, focus on how it affects energy-use reduction budgets and house design	Removed	Remove - not an enclosure gap, suggest moving to Test Methods STC				
(Other): 65 - Develop methods to determine heat flux for large assemblies such as whole basements or crawlspaces	Removed	Remove - should be listed in Analysis Methods and Tools STC				
(Fenestrations): 70 - Identify options for replacing windows in a house on the historic registry, focus on IGU storms	Combined with new #49	Combine with #69 Develop details for window replacement where no work is done on the exterior wall				
(Foundations): 71 - Address crawlspace excavation in crawlspace retrofit recommendations	Removed	Remove - addressed by NREL 2011 research work				

Appendix E: Contributors

The following people have contributed to the Enclosures STC.

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Appendix F: 2011 Meeting Schedule and Documents

Record of Enclosures STC meetings held in 2011. All meetings began at 1:00 pm ET and were approximately 1 hour in length except the in-person meeting in Denver in August at the Annual Building America Technical Update Meeting (All-Committee Meeting #4) and the Annual Building America Planning Meeting in October.

All meeting documents are listed below and can be found on BSC's file share site:

Website: www.buildingscienceconsulting.com/files/
Login: EnclosuresSTC
Password: Enclosures123

Meeting Date	Meeting Title	Meeting Type	Meeting Documents
2011-05-13	All-Committee #1	Webinar	• 2011-03-18 Technical Committee Kickoff Meeting • 2011-03-18 Technical Committee Notes • 2011-05-13 Enclosures STC Meeting 1 Agenda • 2011-05-13 Enclosures STC Meeting 1 Meeting Minutes • 2011-05-13 STC Process Slides • Major Gaps from July and November Meeting
2011-06-10	All-Committee #2	Webinar	• 2011-06-10 Enclosures STC Meeting 2 Meeting Minutes • 2011-06-10 Enclosures STC Meeting 2 PowerPoint
2011-07-15	All-Committee #3	Webinar	• 2011-07-15 Enclosures STC Meeting 3 Agenda • 2011-07-15 Enclosures STC Meeting 3 Meeting Minutes • 2011-07-15 Enclosures STC Meeting 3 PowerPoint • Enclosures STC Research Ideas_Survey Results
2011-08-11	All-Committee #4	In-Person and Webinar	• 2011-08-11 Enclosures STC Meeting 4 PowerPoint
2011-09-12	Discussion Group #1 Roofs: Spray Foam Under Plywood and OSB Roof Decks	Conference Call	• 2011-09-12 STC Foam Roof Conference Call Notes
2011-09-16	All-Committee #5	Conference Call	• 2011-09-16 Enclosures STC Meeting 5 Meeting Minutes
2011-09-30	Discussion Group #2 Walls: Thermal Bridging in Residential Codes	Conference Call	• 2011-09-30 STC Thermal Bridging Conference Call Notes

2011-10-07	All-Committee #6	Webinar	• 2011-10-07 Enclosures STC Meeting 6 Meeting Minutes • 2011-10-07 Enclosures STC Meeting 6 PowerPoint
2011-10-27	Annual Building America Planning Meeting	In-Person	• 2011-10-27 Enclosures STC Planning Meeting PowerPoint • 2011-10-27 Enclosures STC Strategic Plan Draft
2011-11-09	Discussion Group #3 Airtightness: Airtightness Strategies	Conference Call	• 2011-11-09 STC Airtightness Strategies Conference Call Notes
2011-11-18	All-Committee #7	Webinar	• 2011-11-18 Enclosures STC Meeting 7 Meeting Minutes • 2011-11-18 Enclosures STC Meeting 7 PowerPoint
2011-12-02	Discussion Group #4 Walls: Vapor Impermeable Exterior Insulating Sheathing	Conference Call	• 2011-12-02 STC Vapor Impermeable Exterior Insulating Sheathing Conference Call Notes
2011-12-16	All-Committee #8	Webinar	• 2011-12-16 Enclosures STC Meeting 8 Meeting Minutes • 2011-12-16 Enclosures STC Meeting 8 PowerPoint

Appendix G: References

The Enclosures STC used the following Google Doc spreadsheet to collaboratively brainstorm enclosures gaps, post survey results, sign up for Discussion Groups, and combine or remove gaps:

https://spreadsheets.google.com/spreadsheet/ccc?key=0Ath2LxUvgebtdENnSzRpSXNxdUNOVjUyX1pZRXlMdlE&hl=en_US&authkey=CJzJz64K