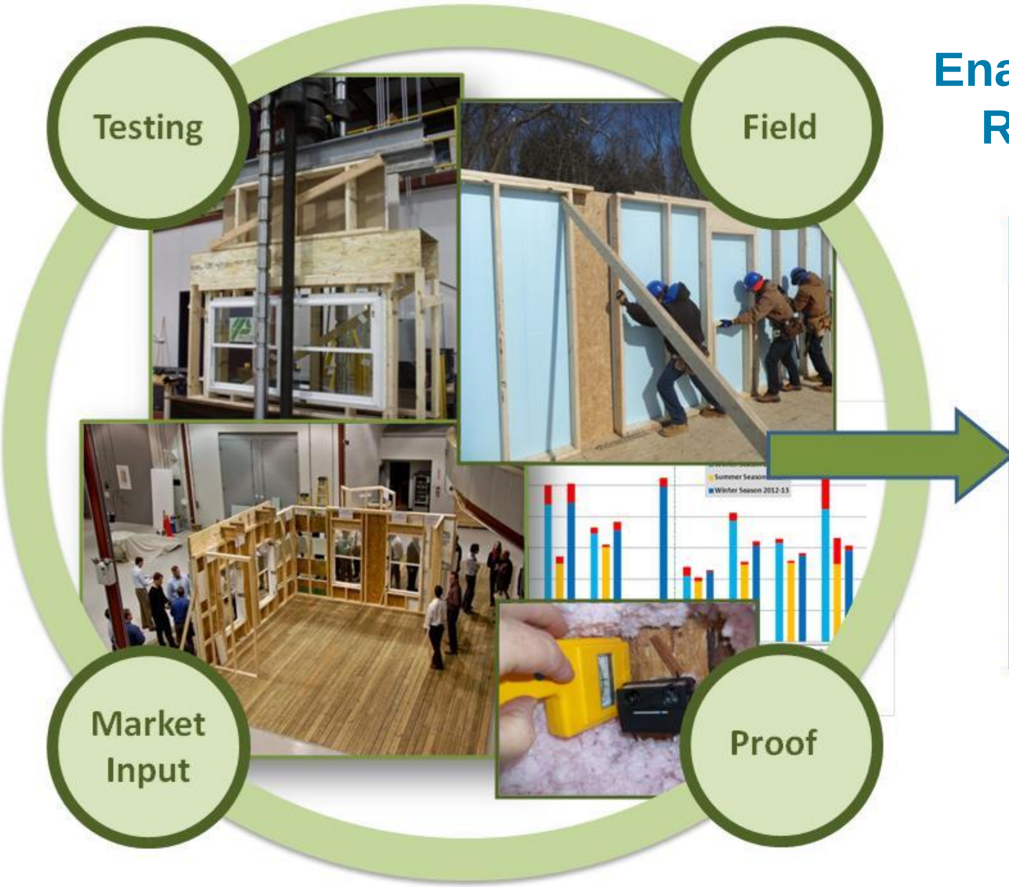
Partnership for Home Innovation

2014 Building Technologies Office Peer Review



Enabling High Performance by Reducing Transition Risks

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

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Home Innovation Research Labs

Project Summary

Timeline:

Start date: January 2013

Planned end date: January 2015

(BA Teams operate on a CY timeline though funded with FY funding, this review includes FY13 & FY14)

Key Milestones (general BA project milestones)

1. Project Planning and Go/No-Go; previous Q3 – Q4
2. Detailed Project Test Planning & Review; Q2
3. Project Execution and Ongoing Evaluation; Q2 - Q4
4. Reporting and Communication; Q1 subsequent

Budget:

FY13 DOE $: $7,200k for all 10 BA industry partnerships (average $720k per team excluding cost share)

FY14 DOE $: $8,135k for all 10 BA industry partnerships (average $814k per team excluding cost share)

Total future DOE $: TBD (program up for re-solicitation)

Target Market/Audience:

Residential building industry stakeholders - developers, builders, trade partners, architects, whole house contractors, utilities and other program developers with focus on "above code" market actors.

Key Partners:

Southface Energy In.	Forest Products Lab
Amer. Chem. Council	NAHB
Quality Council	Greenbelt Homes
Winchester Homes	K-Hovnanian
NYSERDA	Dow
Str. Insul. Panel Assoc.	Albany Housing A.

Project Goal:

•Develop and demonstrate **market-ready** building solutions that improve the energy efficiency of new and existing homes, with increasing comfort, health, safety, and durability.

•Conduct research with manufacturing and building partners to verify performance of new equipment/technology and aid in the advancement of newer, better, more cost-effective options.

•When fully deployed, proven solutions would reduce building-related energy use by **30 percent and 25 percent, respectively, in new and existing residential building stock by 2020, and 50 percent and 40 percent by 2030.**

Building America Purpose and Objectives

Problem Statement:
Home building and remodeling markets do not invest enough in a continuous improvement process with a focus on innovation or optimization. Research is needed to catalyze the process and enable change by demonstrating risks are negligible or manageable.

Target Market and Audience:
At the individual project level, we focus on the innovators and early adopters that want to distinguish themselves from their competition. At the program level, our audience is all residential building industry stakeholders.

Planned Contribution to Energy Efficiency:
BA program outputs **enable** 30% near-term and 50% long-term source energy savings in new and existing homes. BA teams develop and demonstrate marketable system packages that **reliably** achieve these savings targets. Successful demonstrations are documented and disseminated via technical reports, measure guidelines, the Solution Center, trade journal articles, conference presentations, webinars, and videos.

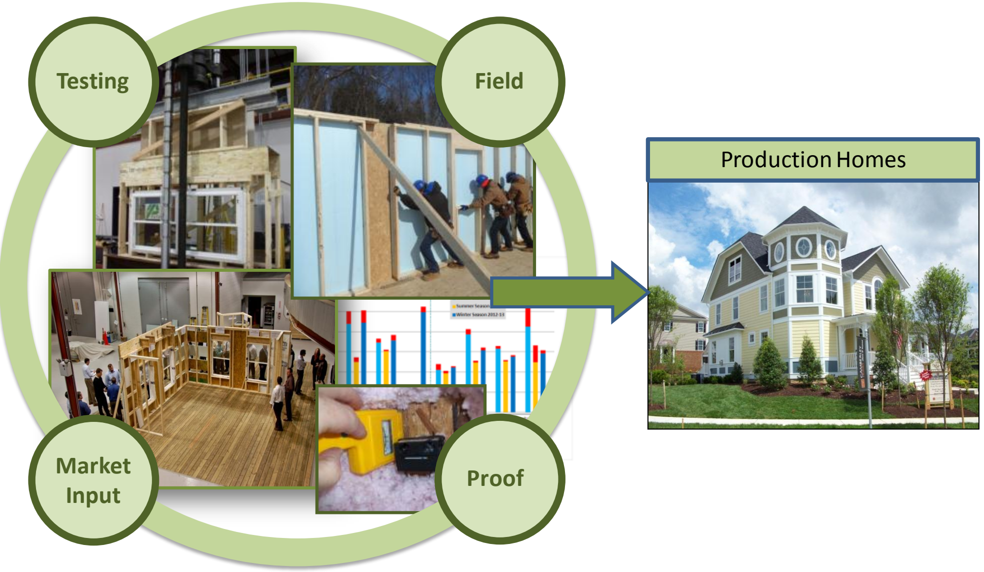
Team Portfolio – Planned Contribution to Energy Efficiency

Enable market transformation to high performance homes by reducing transition risk to builders via:

- Stakeholder-driven research
- Demonstrating proven technologies
- Providing level of details ready for implementation
- Understanding and addressing barriers
- Integrating Tried & True with Innovative
- Cost-optimized and value added solutions (system)
- Understanding and addressing unintended consequences

Team Portfolio – Approach

- Stakeholder Input and Feedback
- Laboratory Evaluation
- Test Homes/Field Monitoring
- Communication Vehicles
- Standard Practice



Key Issues:

- Develop EE solutions that can be integrated into 30-40%+ whole-house energy saving packages

Distinctive Characteristics:

Solutions that are Performance-Based, System-Optimized, and Value-Driven with a demonstrated low risk of transition

Team Portfolio – Progress and Accomplishments

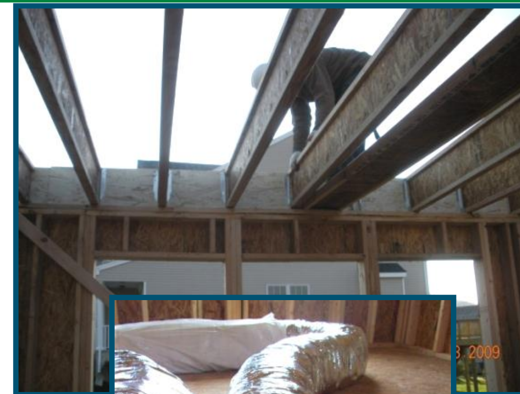
***High-R Walls (Top Innovations, 2015 IRC Code Changes)**
- NexGen Advanced Framing
- Durability Performance Data
- Exterior Foam Sheathing Systems
- EP&B Wall (R23+)

QMS Tools (Top Innovation)
- Hot Spot Guide, Tools, Training
- Primer on QMS for Residential Construction
- Economics of Quality

***Compact Buried Ducts (3rd generation design)**
- Reduce reliance on spray foam
- Improve performance via compact design
- Design specifications and guidance (ACCA, RemRate)

Air Sealing (multiple strategies)
- Standardized options at rough-in
- Limit cost increase

***Greenbelt (Pilot Project for a 1,600 unit community)**
- Market driven community upgrade with high performance
- Enclosure and HVAC




*** Covered in more detail in the presentation**

Team Portfolio – Progress and Accomplishments

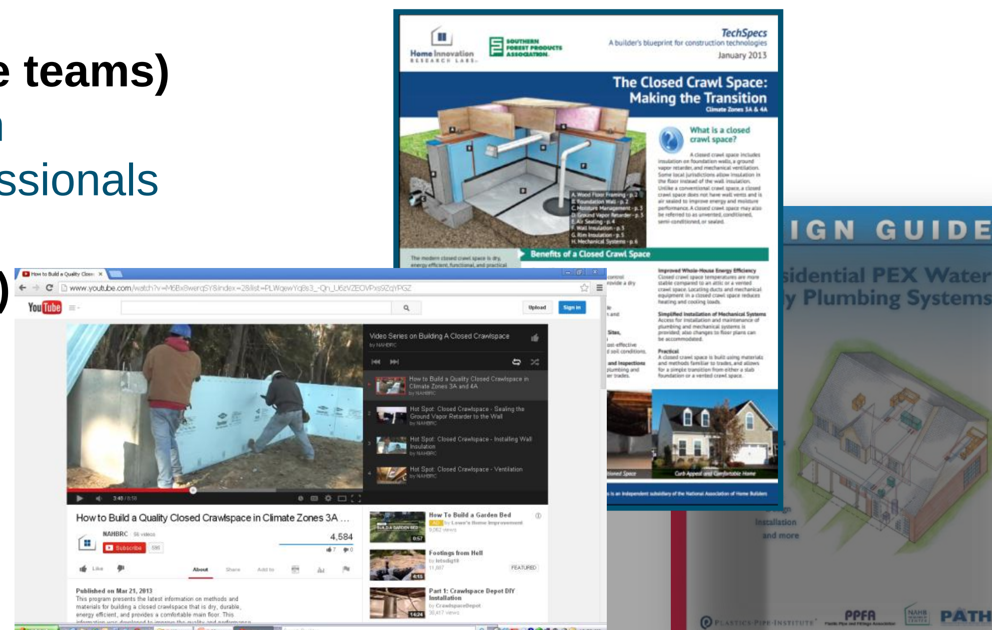
Retrofit Nailbase Panel (Multifamily retrofit site) →
- Incorporating wall upgrade into residing
- Installation Guide for trades

Ducted HPWH (field performance evaluation)
- Broaden applicability and improve performance

***Builders (Winchester, K-Hov, Nexus, LCCTC)**
- Individual technologies and whole-house solutions (30%, 40%+)
- Zero Energy Ready Home (Challenge Home)
- Production Homes

Student Design Competition (33 college teams)
- Building science in college curriculum
- Next generation of construction professionals

Guides, TechNotes and Videos (Recent)
- Closed Crawlspace (6,500 views)
- Ventilation
- Air tightness
- PEX Guide v2 (hot water systems)



* **Covered in more detail in the presentation**

Partnerships – Leverage and Impact

We form targeted partnerships to leverage funding, expertise, resources, reach

- **Southface** – CZ 2&3, builders, climate specific technologies
- **NAHB** – co-funded enclosure and durability efforts, access to membership
- **Forest Products Laboratory** – co-funded durability work and structural efforts
- **American Chemistry Council (ACC)** – co-funded enclosure work
- **Western University and IBHS** – wind engineering capabilities
- **Foam Sheathing Coalition (FSC)** – ANSI Standard on walls with foam sheathing
- **Greenbelt Homes** – financing retrofits
- **NYSERDA** – co-funding of Nailbase Panels and EP&B projects
- **Struct. Insulated Panel Assn.** – providing product, training, resource development
- **Quality Council** – assess to technology decision makers of top production builders
- **Builder Partners** – Winchester, K-HOV, Nexus, LCCTC
- **LCCTC** – educating future trades in high performance **(≈150 students/year)**
- **Product Mfcrs** – co-funding, donations, support (Norbord, Dow, Weyerhaeuser, OC)
- **ACCA** – HVAC design standards (compact buried ducts)
- **Plastic Pipe Institute** – PEX piping, hot water
- **Trades** – training, implementation, QC, practical feedback
- **Builder, Professional Builder** – reach to industry at large

High Performance Wall Systems (High-R Walls)

Problem Statement:
- Low Market Penetration of EE Wall Systems
- Lack of Standardization for EE Wall System
- Lack of Integration between Individual Materials
- Viewed as a High-Risk Technology by Builders

Target Market and Audience:
- Builders
- Code officials
- Product manufacturers

Planned Contribution to Energy Efficiency:
- A Package of Solutions for CZ 3, 4, 5, and 6
- Durability Performance Data
- Innovative Wall System: R25+
- Design Guide: ready-to-use solutions

→ ***Builders transitioned to these technologies***

FRAMING	2001	2006	2012
2x4 @ 16" o.c.	74%	73%	51.0%
2x4 @ 24" o.c.	2%	3%	3.7%
2x6 @ 16" o.c.	22%	22%	40.1%
2x6 @ 24" o.c.	2%	2%	4.8%
Other	1%	0%	0.4%
TOTAL	100%	100%	100.0%

Oversheathing	2006	2011	2012
Shares of Homes with 2nd Layer of Foam Sheathing	7%	9%	11%

Source: Annual Builder Practices Survey by Home Innovation Research Labs

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Approach – High-R Walls

Work Directly with Industry Stakeholders

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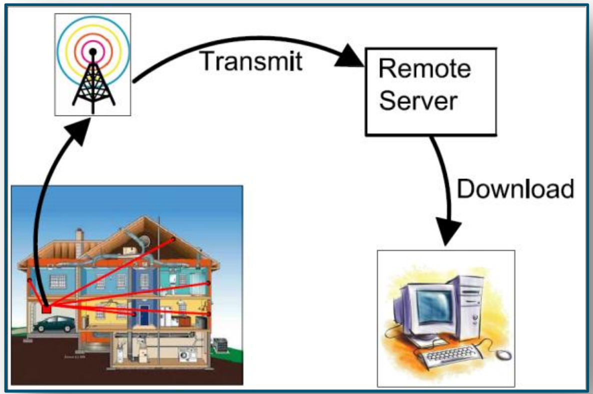
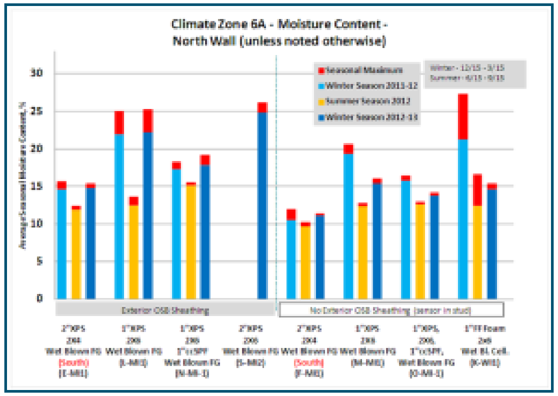
Approach – High-R Walls (continued)

Laboratory Testing of Structural Performance

Field Moisture Performance Monitoring





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Approach – High-R Walls (continued)

Assist Builders with Implementing a High-R Package

Example:

Winchester Homes (regional production builder ≈ 500 homes/year) implemented high performance framing package across ALL plans following a Building America test home project:

- 2x6 framing at 24” oc
- Rim headers
- Continuous drywall and insulated corners
- Floor joists at 24” oc with punch-outs to facilitate ducts in floors

→ System value

High Performance Wall Systems – Builder Magazine


Design and Construction // Edited by Rich Binsacca // www.builderonline.com/buildsmart

Build Smart

How To.................. Page 162
Redline 164

1 **Rim headers** Eliminate traditional headers with a double rim board and joist hangers above the opening. The resulting cavity allows for more insulation and an effective thermal break.

2 **No jack studs** For large openings with a rim header, use only double king studs and toe-nail the horizontal members of the window/door rough opening to create more space for insulation and reduce thermal transfer through the wall.

3 **Single king stud** For smaller window or door openings, a single king stud (without jack studs) will often suffice.

Advanced Framing Enhanced

Recently, the NAHB Research Center, in partnership with the DOE's Building America program and iLevel (an engineered framing supplier), revisited advanced framing to update and evolve the practice to further improve its impact on building envelope performance, as well as materials and cost savings. Look for more details soon at the Research Center's technical website at www.toolbase.org.

Illustration: NAHB Research Center

JANUARY 2011


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Energy-Efficient Construction

BUILDER 2013 May 29, 2013

BUILD IT RIGHT

Mystery Inspector 8: Energy-Efficient Framing Detail for Intersecting Walls

By Dan Morrison

I hadn't seen this detail in the field before it showed up here, but I am pretty excited to see it now. Usually when we talk about interior walls intersecting with exterior walls in the context of energy-efficient framing, we talk about ladder backing as nailers rather than 3-stud wall bucks. And we talk about continuous sealant at the top and bottom plates and along the edges of the stud.

This is much easier and far better.

The end of the interior wall doesn't touch the exterior wall, so there is no need for ladder backing or wall bucks—just room for insulation. Also, the space between the walls, which looks to be conveniently sized at 1 1/2 inches, allows the drywallers to slide a full sheet behind the wall, which will significantly boost the air-sealing potential of the drywall. A break in the drywall at wall intersections creates ... down, and 1/2-foot over) at each wall.

But if the interior wall is spaced an inch and ... how is it attached?

Of course, the bottom plate is nailed to the floo... top.

These guys use metal straps to connect the wa... that are specified in Advanced Framing (a.k.a., ... which calls for (among other things) single top p...


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Codes and Standards

BUILDER June, 2011 June 09, 2011

Advanced Framing, Continued

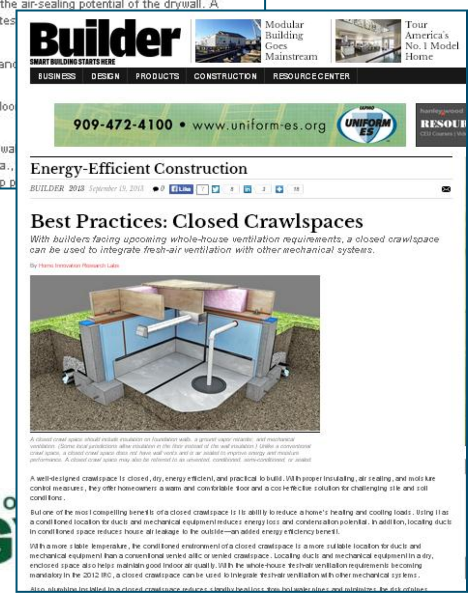
By Rich Binsacca

The NAHB Research Center has amended and extended advanced framing practices to further improve building envelope performance, including a new technique that reduces thermal bridging at the intersection of exterior and interior walls.

THIS TECHNIQUE REDUCES THERMAL BRIDGING

1 Continuous Drywall To allow full sheets of wallboard along perimeter walls, mitigating air leaks and thermal transfer, leave a 1-inch gap between intersecting interior walls. Connect the intersecting top plates with a flat metal connector.
2 Wall Framing 2x6 studs spaced 24 inches on-center create larger cavities for insulation to reduce thermal transfer through the wall and enable "warm" corners without affecting the attachment of drywall or exterior cladding
3 Lower Ratio Typical wall framing has a wood-to-insulation ratio of about 25 percent. Advanced framing reduces that share to 16 percent to 18 percent, leaving more room for insulation and improved energy performance.

Photos: Peter Sucheski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Energy-Efficient Construction

BUILDER 2013 September 19, 2013

Best Practices: Closed Crawlspaces

With builders facing upcoming whole-house ventilation requirements, a closed crawlspace can be used to integrate fresh-air ventilation with other mechanical systems.

By Home Innovation Research Labs

A well-designed crawlspace is closed, dry, energy efficient, and practical to build. With proper insulating, air sealing, and moisture control measures, they offer homeowners a warm and comfortable floor and a cost-effective solution for challenging site and soil conditions.

But one of the most compelling benefits of a closed crawlspace is its ability to reduce a home's heating and cooling loads. Using it as a conditioned location for ducts and mechanical equipment reduces energy loss and condensation potential. In addition, locating ducts in conditioned space reduces house air leakage to the outside—an added energy efficiency benefit.

With a more stable temperature, the conditioned environment of a closed crawlspace is a more suitable location for ducts and mechanical equipment than a conventional vented attic or vented crawlspace. Locating ducts and mechanical equipment in a dry, enclosed space also helps maintain good indoor air quality. With the whole-house fresh-air ventilation requirements becoming mandatory in the 2012 IRC, a closed crawlspace can be used to integrate fresh-air ventilation with other mechanical systems.

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Approach – High-R Walls (continued)

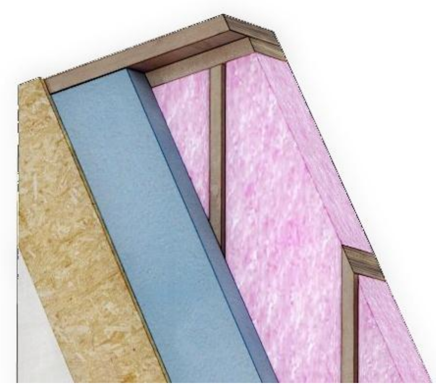
Testimonials:

“Through our participation in the Building America Program we have learned that instituting energy efficiency improvements which are closely aligned with traditional building practices, such as converting to advanced framing, can provide significant advantages over those alternatives which require a more radical departure from main stream industry practices.” *Randy Melvin, Director Research and Standards, Winchester Homes*.

“The students take this practical experience into their careers, but the educational component goes beyond a more knowledgeable work force. Houses with this level of energy efficiency are not common in this market. These houses are open to public inquiry during construction, and there is a high level of interest from vendors and manufacturers to participate in these high visibility projects. The Building America program has been instrumental for the school’s Construction Technology program, and beneficial by accelerating energy efficient construction into the community.” *Michael Dodson, Sr., LCCTC - a vocational high school with a Construction Technology program that prepares students for careers in the construction trades*

High-R Wall – Extended Plate and Beam

Streamline Framing via an Innovative Wall System (R25-R35)



- 2x4 studs/2x6 plates
- Reverse installation of foam and OSB
- Construction more similar to conventional walls
- Can be panelized
- Durable

Cost Comparison

	Wall System Type	R-Value Nominal	Total Cost[1]	Cost per SF	Cost/SF increase	Cost per R-value per SF
Fiber Cement Siding						
	2x4 @ 16" o.c.	13	$3,788.30	$18.94		$ 1.46
	2x6 @ 24" o.c.	20	$3,798.80	$18.99	reference	$ 0.96
	2x6 @ 16" o.c.	20	$3,865.80	$19.33	$ 0.34	$ 0.98
	Ext P&B 2x4/2x6	23	$4,224.00	$21.12	$ 2.13	$ 0.93
	2x4 w/2" ext foam	23	$4,333.64	$21.67	$ 2.67	$ 0.96
	2x6 w/2" ext foam	30	$4,464.34	$22.32	$ 3.33	$ 0.75
	Ext P&B 2x6/2x8	29	$4,436.50	$22.18	$ 3.19	$ 0.78
	Ext P&B 2x6/1.5x7.5	30	$4,332.20	$21.66	$ 2.67	$ 0.73
	2x4 dbl stud w/ 1" gap	29	$4,283.25	$21.42	$ 2.42	$ 0.74

[1] Total Cost for 200 SF wall section, rim, 3050 dbl window, interior/exterior finishes

Project Integration and Collaboration – High-R Walls

Project Integration and Leveraged Funding:

Advanced Framing – FPL, NAHB, Weyerhaeuser, Production Builders

Walls with Foam Sheathing – NAHB, ACC, FSC ANSI Committee, UWO, IBHS

Moisture Monitoring – FPL, NAHB, Builders, ASHRAE 160

EP&B – NYSERDA, LCCTC, Dow

Design Guide – A broad Stakeholder Group, ACC

Communications:

Building America Conferences, ASCE Conference, Wind Engineering Conference, NAHB events, ACC meetings, ANSI FSC Committee Meetings, Expert Meetings, Quality Council of High Production Builders, Builder Magazine, GreenExpo365

Awards/Recognition:

2015 IRC approved code changes

Two Top Innovation Awards for High-R Walls

Next Steps and Future Plans – High-R Walls

- Communication vehicles – Builder's Guide
- Optimize the EP&B system
- Moisture performance of walls with limited amount of ext. foam
- Monitor performance of retrofitted building
- Educational sessions on practical solutions for high-R walls: new and existing homes
- Provide content for the BA Solution Center

Greenbelt Homes – Making the Decision to Invest in Energy Efficiency

Problem Statement: Provide Greenbelt with convincing evidence to invest in unsubsidized energy efficiency improvements as part of a community upgrade plan

- Housing cooperative
- 1,600 units
- 3 unit types
- Built 1930s-1940s
- High utility costs
- Comfort complaints

Target Market and Audience:

- Community membership (General assembly approval)
- Community Board (Investment Decision)
- Contractors (What, How, Building Science Principles)
- Product manufacturers (Use of Existing Products, New Technologies)
- Property management organizations

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Planned Contribution to Energy Efficiency:

- Positive Decision to Upgrade 1,600 homes
- Case Study for other Communities
- Energy and Cost Savings Realized
  - Both savings and higher comfort level
- Recommended Envelope Improvements
  - Tailored to construction type
  - Minimize interior disruption
- HVAC Improvements (Value/Benefit)
  - Define optimum for each technology
  - Understand benefits despite long payback

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Greenbelt Homes Pilot Project – Approach

- Quantify and catalogue condition of existing homes (28 units)
- Analyze / Optimize / Decide (multi-phase)
- Review retrofit details for each building type
- Deploy monitoring equipment prior to upgrades
- Work with contractors to assist with EE features
- Work with community leaders: decisions and communication
- Analyze/summarize improvements and change in energy use

Key Issues: Cost effectiveness (individual vs. co-op), relevance to future home buyers, member preference on selected options, minimum disruption, durability and reduced maintenance

Distinctive Characteristics: Market-driven energy upgrades incorporated into planned maintenance based on added value

Greenbelt Homes: Progress and Accomplishments

Discoveries:

- **Standard contractor bidding process is a mismatch for EE upgrades**
- **Contractor training and capability to take on EE upgrades is key to success**
- **More clear metrics for quantifying benefits encourage acceptance**

Accomplishments and Contributions:

Crawlspace

Attic

Windows/Walls

HVAC (in progress)

Attic insulation improvements while preserving storage space

CI and window upgrades

25% EE improvement from envelope upgrades

Project Integration and Collaboration

Project Integration

- Information link between Co-op staff, members, research, and building science
- Architectural/Engineering – review of EE details
- Trades Contractors – work to ensure quality
- Product Manufacturers – solicited for options applicable to uncommon housing types

Communications

Numerous meetings with GHI board and committees, including GHI members to evaluate the project scope, EE technologies, installation, and eventually occupant feedback

Next Steps and Future Plans

Goal is a Community-wide EE upgrade for 1,600 homes

1. Monitoring results following the latest winter period will be evaluated in light of the baseline data to determine real energy savings and predict long term savings.
2. Installation of the HVAC options selected and energy use data following the 2014-2015 winter period.
3. Development of final envelope retrofit packages applicable to the different housing types in the community.
4. BA support in developing a set of details and quality procedures based on results of pilot program.
5. BA support in setting up a monitoring protocol that can be used by the community going forward.
6. Case studies – educate other real estate management organizations

Compact Buried Ducts

Problem Statement:

Moving ducts from the attic into Conditioned Space is expensive, creates implementation challenges for many house types, and often leads to tortured duct runs contributing to losses and poor performance → **builders seeking solutions**

Target Market and Audience:

Builders: Another option: more cost-effective, practical, and universal solution

Trades: Detailed design criteria and installation specifications

Planned Contribution to Energy Efficiency:

- Simplified duct systems that is nearly on par with ducts in conditioned space
- Integrated compact duct design to reduce cost and energy losses
- Reduce reliance on spray foam
- Large energy savings vs. duct in unconditioned space

Field Testing of Buried Ducts

Approach: Work with a production builder to develop optimized compact buried duct designs and monitor in-service performance

Key Issues: Develop an optimized solution acceptable to a broad range of builders and is ready for inclusion in design standards and energy simulation software

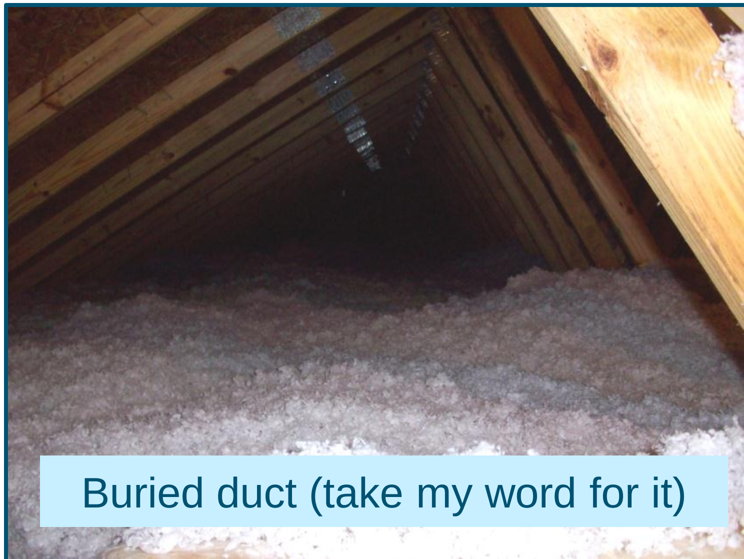
Distinctive Characteristics:

System: Reduce reliance on spray foam and integrate with compact design

Performance monitoring: Direct comparison with a system fully in CS, air T loss and delivery, RH and dew point at condensing surfaces

Integration & Collaboration: Other BA teams, production builder, ACCA, manufacturers

Ongoing Work & Next Steps: Standardized design specifications, design guidance on sizing (ACCA) and energy modeling (eg, RemRate)



Buried duct (take my word for it)

Challenge Home Support

Support to Builder and Rater:

- Provide builder with overall concept and major performance goals
- Identify shortfalls in overall energy use estimates to meet program goals
- Identify additional features necessary to comply with program
- Identify shortfalls in meeting certification requirements and options
- Inspection/test/review support following initial effort

Builders – System Integration – General Takeaways

- Each builder is different in their decision-making process
- Builders need a clear tie to their business value proposition
- Technology/Trade divide is limiting deployment
- Builders continue to perceive high risk in changing to certain technologies
- Some of the ‘low-hanging’ fruit still needs work
- Builders look for high-impact/minimum-change technologies
- Builders prefer options - No one perfect solution

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Questions?

Project Budget

Project Budget: Building America is a multi-year research program. FY13 and FY14 face-value contract amounts have been summarized here (excluding overhead burden and management).
Variances: Budgets are executed as planned.
Cost to Date: Projects are accrued linearly and managed on a calendar year cycle. For FY14, approximately 30% of project cost has been accrued.
Additional Funding: All BA team contracts have at least 20% cost-share from industry partners.

Budget History					
January 2013 – FY2013 (past)		FY2014 (current)		FY2015 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$7,200k	20%	$8,135k	20%	TBD	TBD

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Project Plan and Schedule

Building America Team Project Planning and Execution:

- BA teams are funded under a multi-year Task Ordering Agreement managed by NREL. Project portfolios are selected on an annual basis. 2014 is the final year of this agreement.
- All BA Teams go through rigorous annual project proposal and review process, including review and coordination by NREL technical and DOE program management.
- Each project has the following deliverables: detailed test plan, report, case study and BA Solution Center content. Test plans are reviewed by technical program managers and all other publications undergo a peer review process before being communicated to the broader residential industry.

Project Schedule

Project Start: January 2013		Completed Work
Projected End: January 2015		Active Task (in progress work)
	◆	Milestone/Deliverable (Originally Planned)
	◆	Milestone/Deliverable (Actual)

	FY2012	FY2013				FY2014				FY2015	
Task	Q4 (Jul - Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan - Mar)
Past Work											
FY12 Project Reporting and Communication			◆								
FY13 Project Planning & Go/No-Go	◆										
FY13 Project Detailed Test Planning & Review			◆								
FY13 Project Execution & Ongoing Evaluation						◆					
FY14 Project Planning & Go/No-Go					◆						
FY13 Project Reporting and Communication							◆				
FY14 Project Detailed Test Planning & Review							◆				
FY14 Project Execution & Ongoing Evaluation										◆	
FY14 Project Reporting and Communication											◆