Project Overcoat:
Moving Exterior Insulation to Existing Homes

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- Prologue: Brief Introduction to Building America
- Act 1: Moving Towards High-Performance Homes
- Act 2: ETMMS (Exterior Thermal & Moisture Management System)
- Act 3: Project Overcoat for Existing Homes

Building Technologies Program

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

Building America

National Renewable Energy Lab

Introduction to Building America

- Focus is to reduce energy use by 50% in new houses and 30% in existing residential buildings.
- Promote building science solutions using a systems engineering and integrated design approach.
- “Do no harm” => we must ensure that safety, health, and durability are maintained or improved.
- Accelerate the adoption of high-performance technologies.

Industry Research Teams

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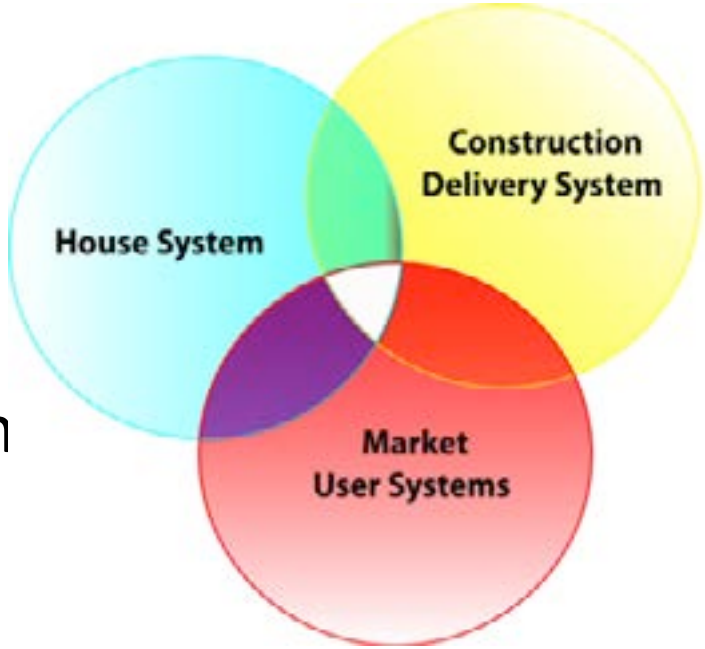
- Exploring the next generation of high performance homes for cold climates, using
  - building science as our compass
  - research as our guide

- Taking a total systems approach
  - House (physical) system
  - Construction delivery system
  - Market (consumer-user) system



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- Research and deployment of a whole-house, systems engineered, integrated design approach to select the least cost and highest value features including:
  - Climate-specific designs
  - Highly-efficient walls, foundations, roofs
  - Super-efficient windows & doors
  - Passive solar space & water heating
  - State-of-the-art heating & cooling systems
  - Advanced hot water, appliances, lighting
  - Solar thermal and solar electric systems
  - Moisture resistant construction
  - Healthy indoor air

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- Research Team Lead: University of Minnesota
  - Cold Climate Housing Program – Pat Huelman
  - Center for Sustainable Building Research – John Carmody

- Research Team Partners
  - Center for Energy and Environment – David Bohac
  - Building Knowledge, Inc. – Ed VonThoma
  - Energy Center of Wisconsin – Dan Cautley

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- University Research Partners
  - Advanced Building Systems Group (BBE)
  - Initiative for Sustainable Enterprise (IonE/IREE)
  - Energy Systems Design Program (BBE)
  - Mechanical Engineering (CSE)
  - Clean Energy Resource Teams (CFANS)
  - Natural Resource Research Institute (UM-D)

- University Support
  - College of Food, Agricultural & Natural Resource Sciences
  - Initiative for Renewable Energy and Environment
  - University of Minnesota Extension

- External Research Partners
  - Building Green
  - Conservation Technologies
  - Hunt Utilities Group
  - McGregor Pearce
  - Verified Green
  - Wagner Zaun Architecture

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- Building Enclosure
  - CertainTeed
  - DuPont - Building Innovations
  - Johns Manville
  - BASF
  - Dow
- Windows and Fenestration
  - Andersen Corporation
  - Cardinal Corporation
  - Marvin Windows and Doors
- Mechanical Systems
  - AIM
  - A.O. Smith
  - Panasonic
  - RenewAire
  - Venmar Ventilation
- Builders/Remodelers/Suppliers
  - Christian Builders
  - JET Construction & Remodeling
  - Lumber Dealers Supply
  - Nor-Son Construction
  - Northway Construction
  - TDS Custom Construction
  - Thompson Homes
  - Wausau Supply Company
  - Cobblestone Homes
  - Amaris Custom Homes
  - Cocoon Home Performance Solutions
  - Lambert Lumber
- Professional/Community
  - MN Office of Energy Security
  - NARI

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- Current Research Portfolio
  - Foundation Insulation Systems
    - Full-scale testing of interior systems at the CRRF
    - Exploring innovative retrofit options for masonry
  - Project Overcoat
    - Exterior insulation systems focused on airtightness of 1-1/2 story roof applications
  - Integrated Space & Water Heating Systems
    - In-situ monitoring in WX homes

- Future Research Plans
  - Integrated Space & Water Heating
    - Laboratory optimization
  - Project Overcoat
    - Cost reduction (materials & labor)
  - Foundation Insulation for Existing Homes
    - Testing insulation system performance at the CRRF
    - Demonstrate “excavationless” method for exterior retrofit
  - Simplified Test Method for Combustion Safety

Act 1: Moving Towards High-Performance Homes

- Robust vs. Fragile
  - The demands of high-performance homes
- The X-Factor
  - The critical role of execution
- Evolution vs. Revolution
  - A path a forward

High-Performance Homes: Making the Case for Robust

- We must ensure our high-performance houses meet our expectations today and into the future?

- High-performance houses will push the envelope (mechanical systems, occupants, etc).
  - This will require more robust designs.
  - It will demand systems with forgiveness/tolerance.
  - We must have a more predictable delivery system.
  - The owners/occupants will need to be in the loop.

High-Performance Homes: Making the Case for Robust

- Robust
  - Strong, healthy, and hardy in constitution
  - Built, constructed, or designed to be sturdy, durable, or hard-wearing
  - A system that is able to recover from unexpected conditions during operation

- Things that simply seem to work regardless what your subs, nature, or client throw at them!

High-Performance Homes: Making the Case for Robust

- Fragile
  - Easily broken; not having a strong structure
  - Unlikely to withstand severe stresses and strains

- Things that make perfect sense on paper, but seem to be "too fickle" to handle the real life situations they encounter.

High-Performance Homes: Making the Case for Robust

- When push comes to shove, will your home's response be one of robustness or fragility?
  - Climate extremes
  - Abnormal interior conditions
  - Execution errors
  - Unusual operations
  - Neglected maintenance

High-Performance Homes: Making the Case for Robust

- Can it be evolution or must it be revolution?
  - It seems that small incremental steps (evolution) got us in this predicament
  - And bigger, bolder steps (revolution) might be needed to get us back out!

Evolution or Revolution?

- We need high-performance homes now!
- But it will demand a new approach. We must …
  - design and engineer (not just build) our homes.
  - build forgiveness/tolerance into all systems.
  - build redundancy into critical materials.
    - or make it easy to repair and/or replace key components
  - develop a more predictable delivery system.
  - provide continuous feedback to the occupant.

Act 2: Intro to ETMMS
(Exterior Thermal & Moisture Management System)

- Thinking Outside the Box
  - A new look at an old approach
  - Several examples in new construction

Where do the structural components belong?

- You have 5 choices
  - Outside
  - Both sides
  - Middle
  - In-between
  - Inside

- What if your structural materials
  - Change dimensionally with temperature / humidity and
  - Are subject to deterioration, if kept moist over time?

Where do the moisture control layer(s) belong?

- In a heated and air-conditioned building with air and vapor permeable cavity insulation, where do the moisture control layers belong?

- You have 4 choices
  - Outside
  - Inside
  - Both sides
  - Middle

Two-Sided vs. One-Sided Walls

- Is it possible to use a single material in a single plane as the air barrier, vapor retarder, and moisture barrier (or WRB)?
  - Absolutely
  - And with the right material selections, it can be a universal wall for all climates.

A Better Way to Build

- Step 1: Put the structure on the inside
  - Light-frame construction
  - Timber frame
  - Concrete masonry
  - SEP = Structural Engineered Panel (studless construction)

A Better Way to Build

- Step 2: Put the thermal and moisture control layers on the outside.
  - PERSIST (Makepeace)
  - REMOTE (Alaskans)
  - PERFORM (Texans)
  - Out-sulation (???)
  - Perfect Wall
    - (Lstiburek, w/ credit to bright Canadians in CBD)
  - Exterior Thermal & Moisture Management System

First ETMMS Project:
25 Unit Townhouse Complex

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SEP-ETMMS Four House Study

- **Goals of *House One* Pilot**
  - **Healthy**
  - **Affordable**
  - **Durable**
  - **Energy efficient**
  - **Socially and culturally responsive**
  - **Design excellence**

ETMMS: Foundation, Walls, & Roof

- Build the entire structure;
  - foundation, floor systems, walls, and roof
- Wrap the entire envelope with a “peel & stick” membrane integrated with openings / penetrations
- Add rigid foam insulation
  - 2 to 3” on foundation
  - 3 to 4” on walls
  - 6 to 8” on the roof
- Add furring strips, overhangs, etc.
- Install trim; siding; roof sheathing and roofing


Researching New Construction Technology
Project 30-30
A Joint Research Project

House 2


GAF
Perm-A-Barrier


Researching New Construction Technology
Project 90-30
A Joint Research Project
Sponsored by
Greater Frogtown Community Development Corporation

New Technology – Old Look

House 3


Perm-A-Barrier


A/C
Dryer
Elec Service
Hose Bib

House 4


STERLING
4 11:54AM


L S
722 2345


GRACE
Bituthene
Perm-A-Barrier


METROPOLITAN

House Tightness Testing @ 50 PA

	cfm	ACH	cfm/sf
• House One:	207	0.90	0.12
• House Two:	369	1.25	0.23
• House Three:	145	0.45	0.08
• House Four	259	0.70	0.21

Current Outcomes

- Houses perform extremely well
- Houses are very tight,
  - reduced heat loss/gain; limited condensation risk
- House are well-ventilated
- Low energy consumption
- The system shows great potential for high wind loads and seismic resistance.
- Designs are efficient, appealing, and well-received
- The SEP-ETMMS can be built in any climate.

Current Costs

- After three houses, costs were about 12% higher than conventional construction
  - research houses have high performance systems.
  - House Four was 8% higher with prevailing wage and double-layer wall.
- Lumber costs are much lower
- Membrane and insulation cost are much higher
- Labor is higher, but improving
  - House Four cost for labor was much lower
- Operational costs are lower
- Maintenance costs should be lower

Current Challenges

- Reduce costs
  - labor costs will decrease with improved technology and construction methodology
- Improve HVAC system
  - fewer choices for small, very efficient houses
  - must simultaneously address make-up air issues
- Increase off-site component manufacturing

Act 3: Project Overcoat

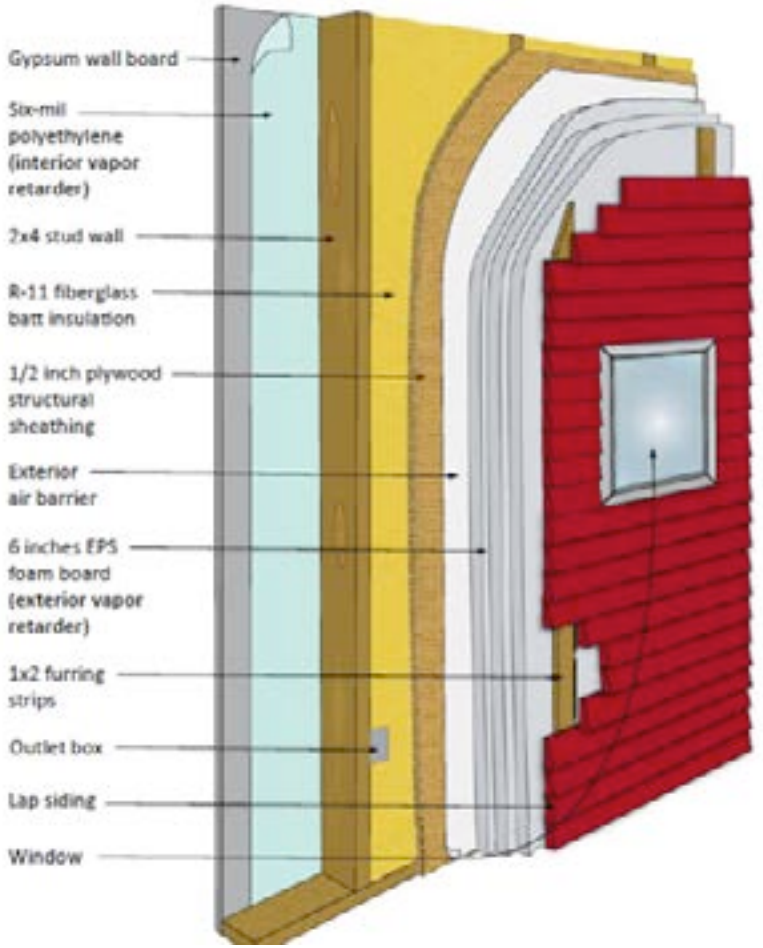
- Moving Exterior Insulation to Existing Homes
  - Potential application to existing homes
  - Challenges & opportunities
  - Current focus on 1-1/2 story houses

New vs. Existing Homes

- It is apples and tofu!

- While the technologies may look similar, they are fundamentally …
  - Different problems
  - Different strategies
  - Different delivery systems
  - Different economics
  - Different market interface

New vs. Existing Homes



ETTMS: Application to Retrofit

- Performance Potential is Clearly There!
  - You can have your cake and eat it, too
    - increase energy efficiency
    - while enhancing building durability
- Most work can be completed from the outside
- However, you must take care of mechanicals
  - Sealed combustion
  - Mechanical ventilation
  - Pressure management

ETTMS: Application to Retrofit

- Sizing up the potential
  - What fraction of our existing homes with limited wall insulation are good candidates?
  - What fraction of those homes will have good access around the entire exterior perimeter?
    - stoops, garages, patios, decks, meters, etc.

ETTMS: Application to Retrofit

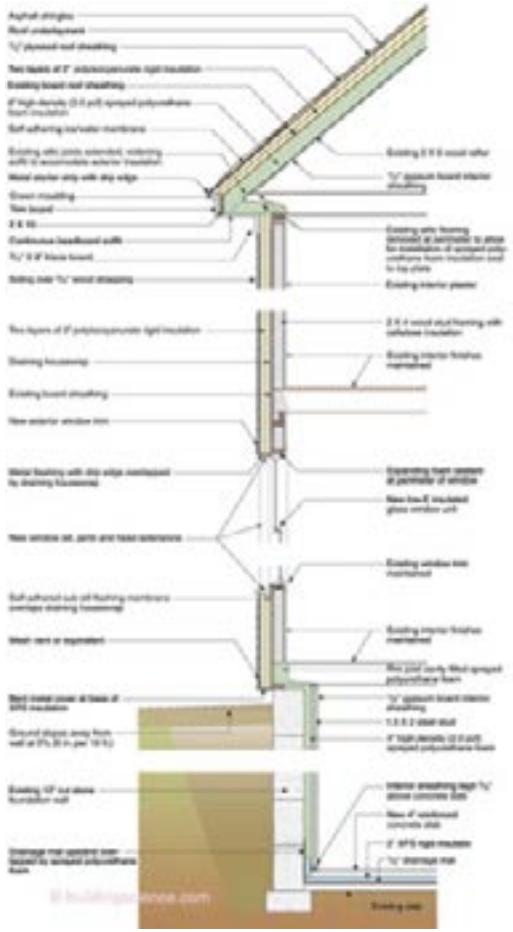
- Low Hanging Fruit
  - Simple house shapes with limited overhangs
  - Homes with good exterior access
    - detached garages with limited patios and decks
  - Homes with nice interior finishes
  - Homes in need of
    - siding, roof, and windows

ETTMS: Application to Retrofit

- Poor Candidates
  - Exterior is too complex
  - Pre-existing moisture has caused serious mold issues in structural cavities
  - Bad attic conditions
  - Wet foundation (especially crawl space)
    - unless that can be fixed a the same time

ETTMS: Application to Retrofit

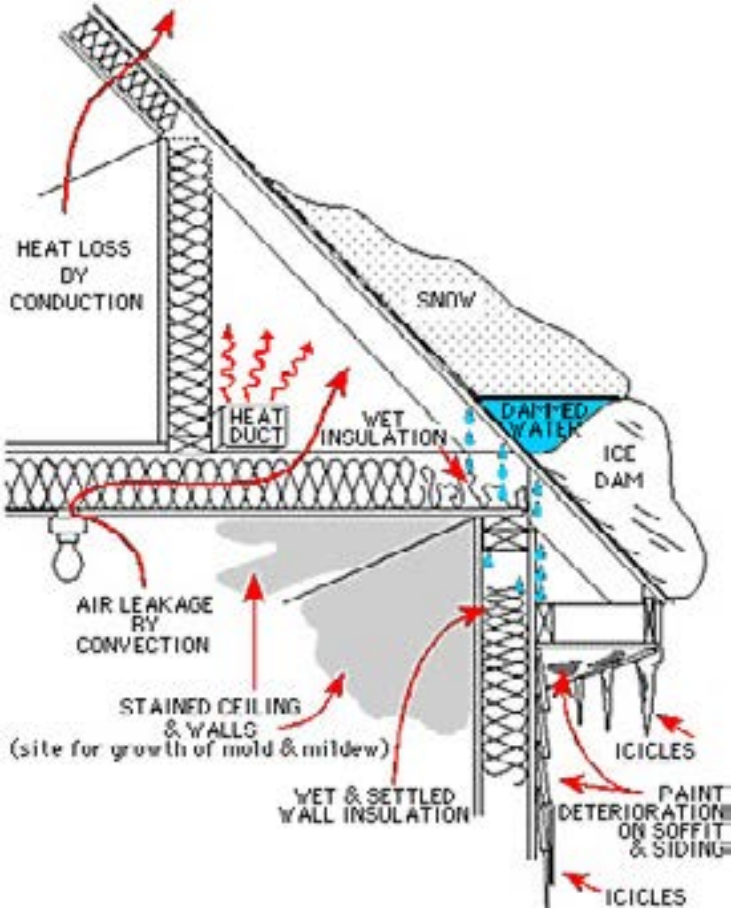
- Walls versus Walls + Roof
  - Walls-only is seductive
    - connection at top is not easy
    - house becomes a chimney
      - must address attic air seal
  - For many homes the attic/roof is a bigger problem than the walls
    - 1-1/2 story walk-up attics
      - especially finished



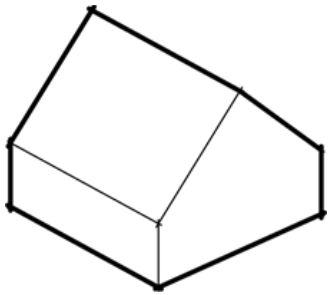
ETTMS: Application to Retrofit

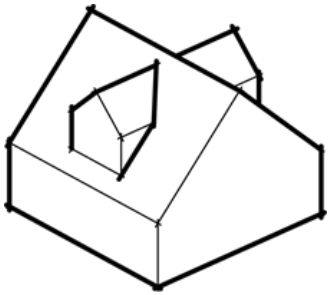
- Current NorthernSTAR BA Research
  - Roof only
  - Focus on 1-1/2 story homes
  - Particularly those with recurring ice dam issues

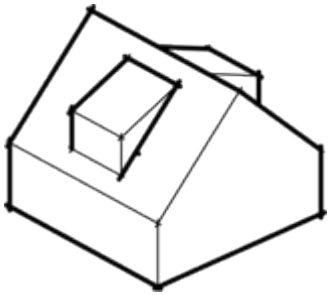
Anatomy of an Ice Dam

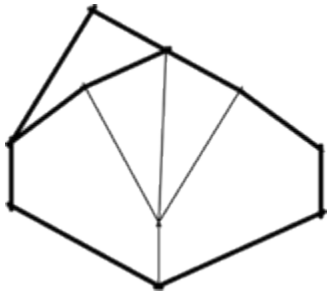


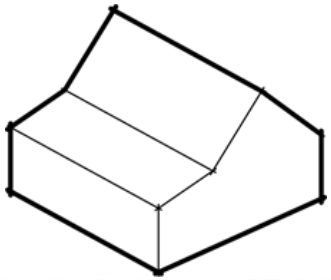
Roof Geometry





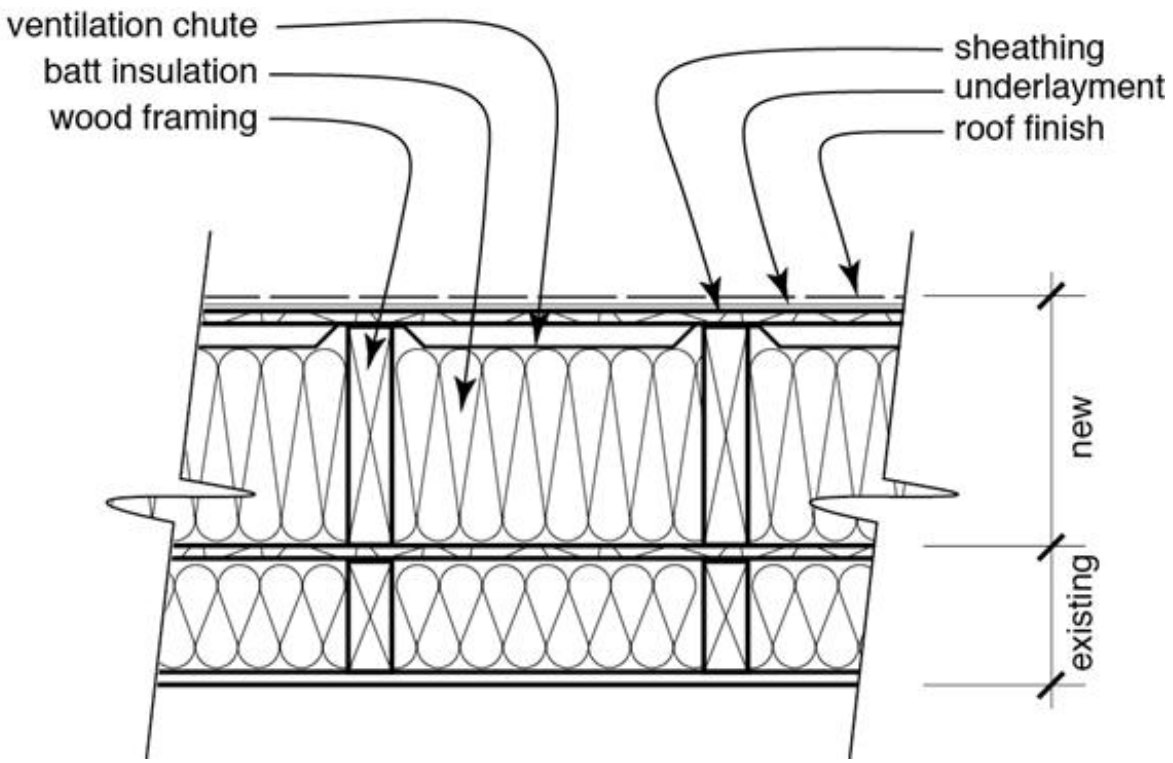






Market Potential

Exterior Insulation Strategies



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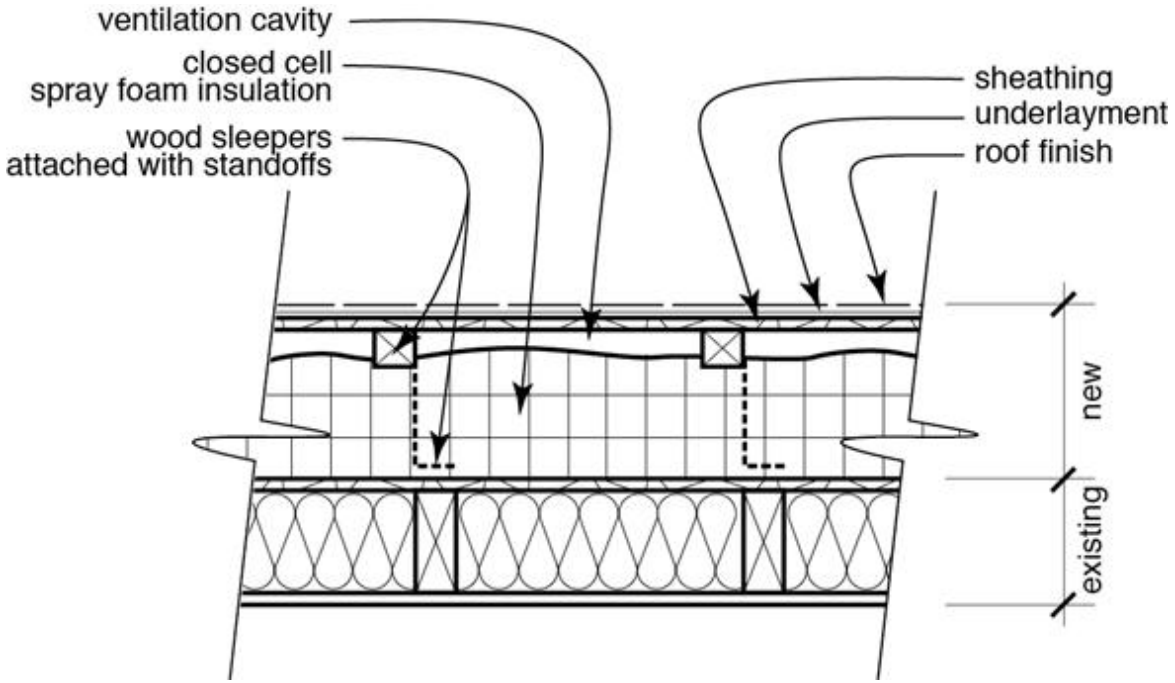

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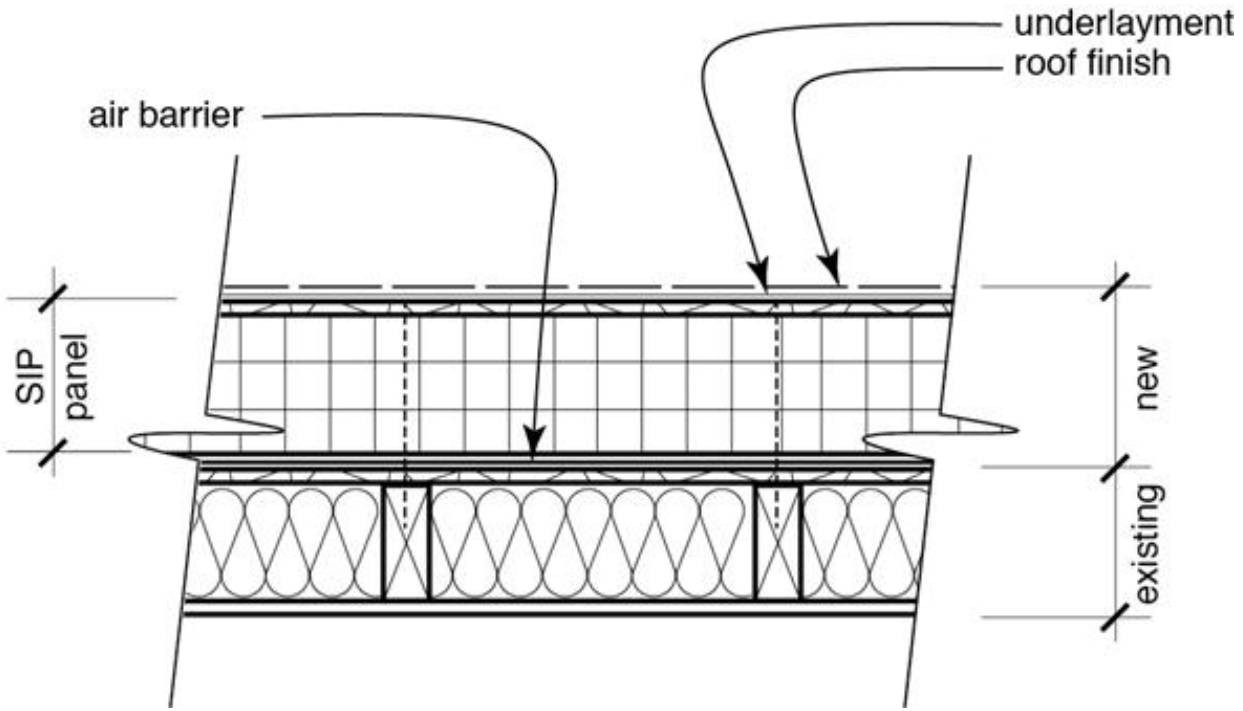

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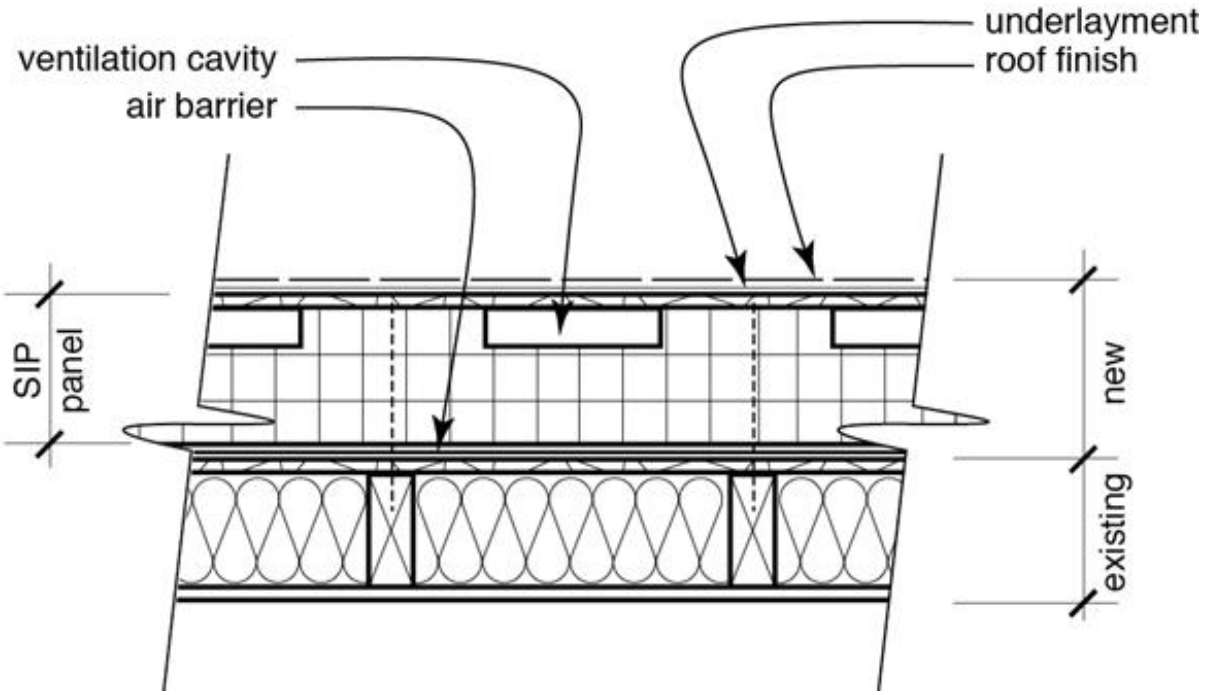

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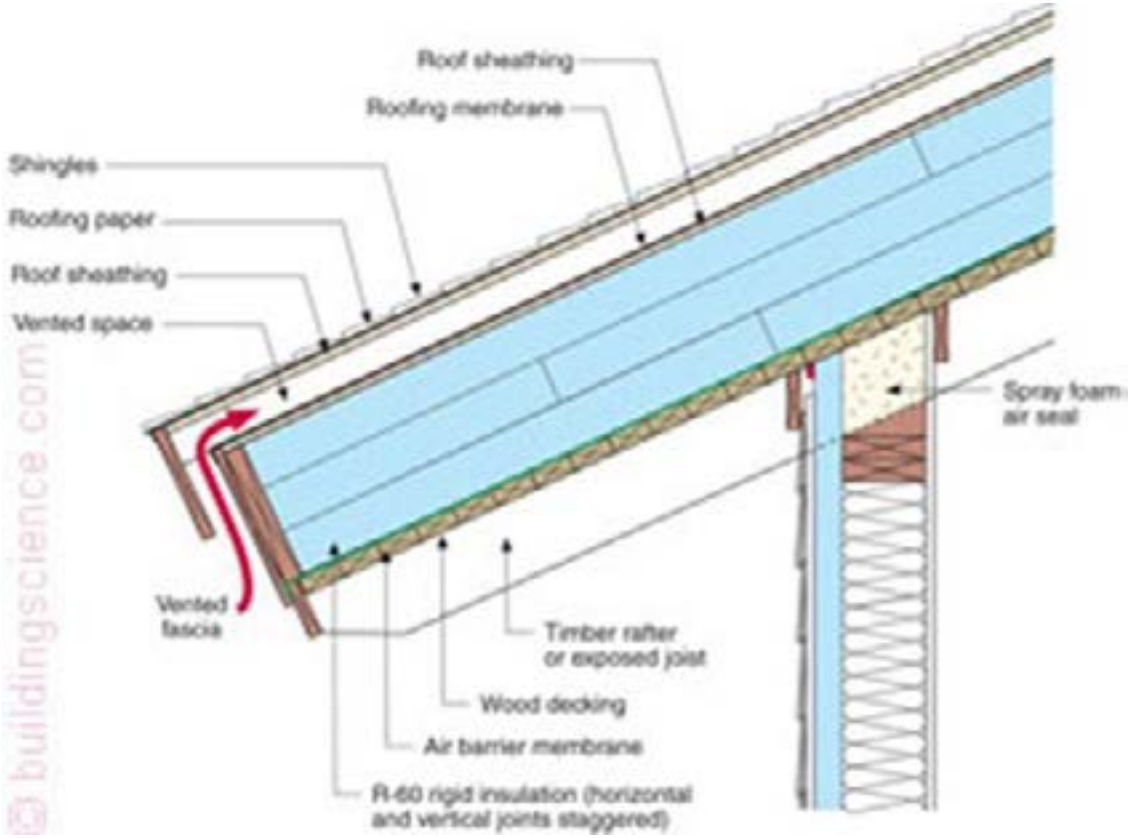

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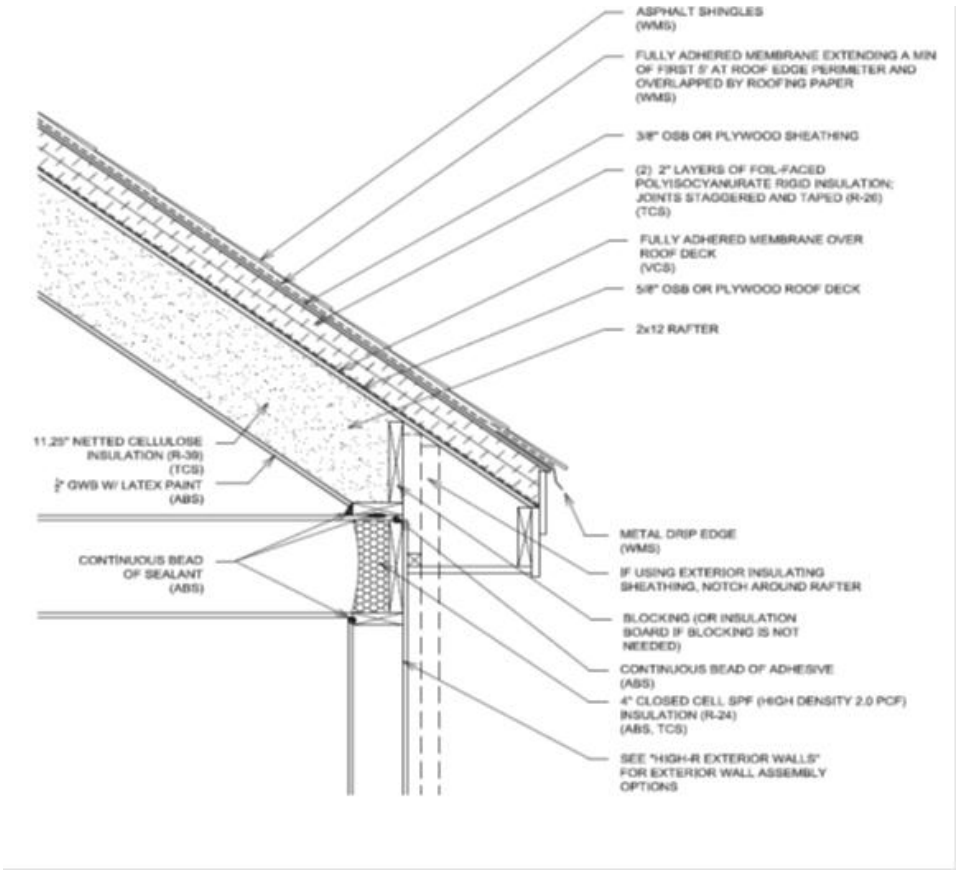

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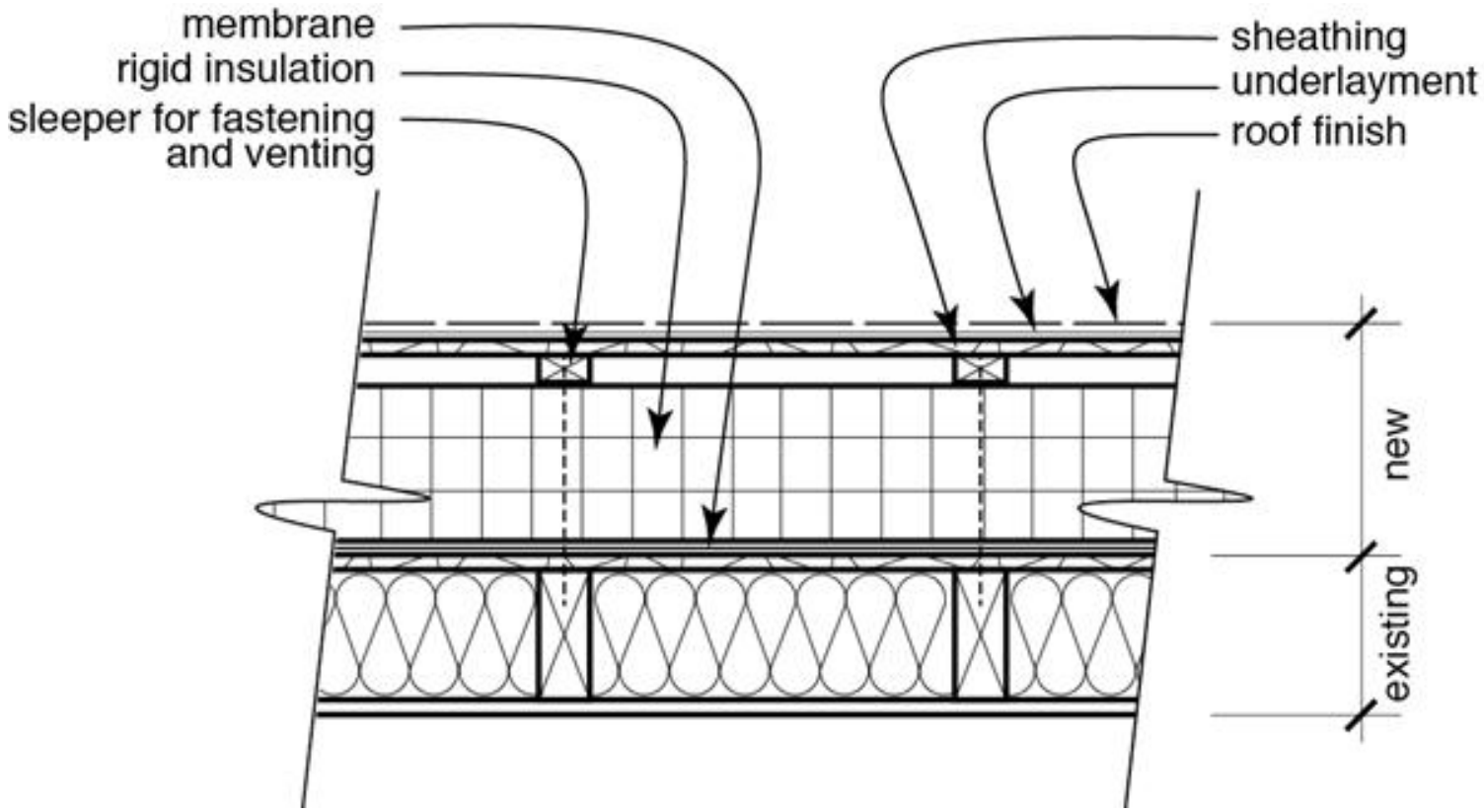
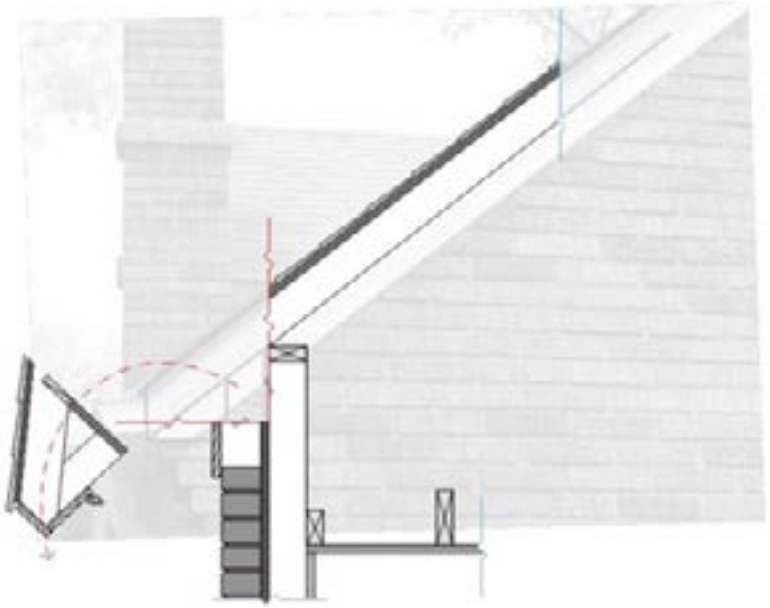


Project Overcoat:
1-1/2 Story Roof Application



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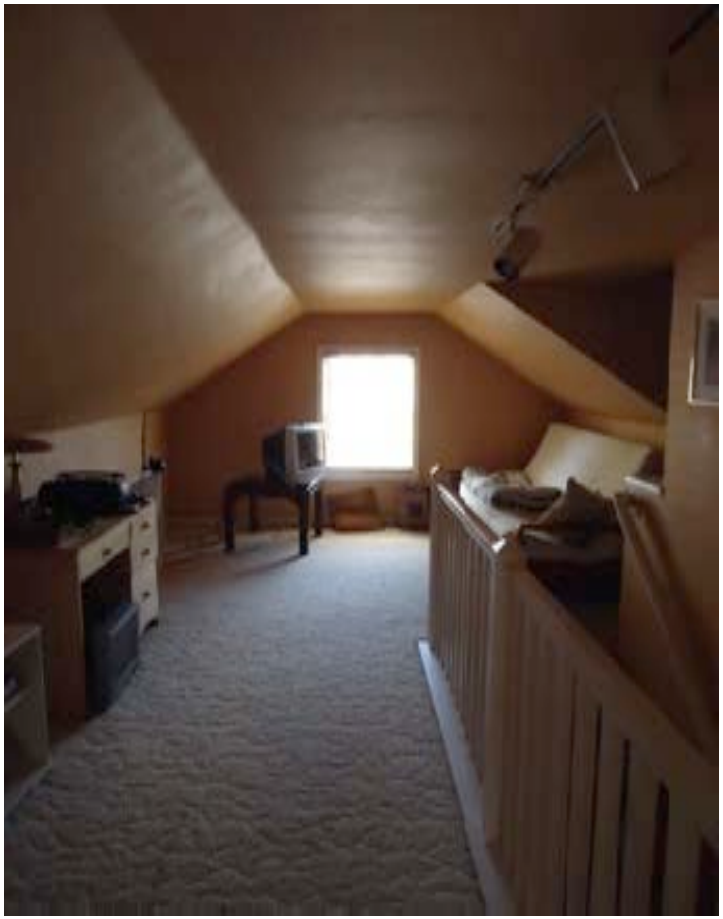

- Blower Door Results
  - Pre = 2925 cfm @ 50Pa
  - Mid 1 = 2774 cfm @ 50Pa
  - Mid 2 = 1607 cfm @50 Pa
  - Final = ???

World Class Research…

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JUST RELEASED!

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Project Overcoat:
Moving Exterior Insulation to Existing Homes

- Questions?

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