U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Affordable, Solid Panel "Perfect Wall" System

University of Minnesota – Northern*STAR* Building America Team

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Project Summary

Timeline:

Start date: July 1, 2016

Planned end date: June 30, 2019

Key Milestones:

1. MN House Designs & Analysis (completed)
2. Energy & Moisture Modeling (completed)
3. MN Field Training & Observation (completed)
4. MN Commission, Measure, Monitor (in-progress)
5. CO House Design & Analysis (in-progress)
6. CO Field Training & Observation
7. CO Commission, Measure & Monitor
8. Comparative Analysis & Final Report

Budget:

Total Project $ to Date :

- DOE: $663,204
- Cost Share: $177,851

Total Project $:

- DOE: $897,860
- Cost Share: $232,578

Key Partners:

Habitat for Humanity – Twin Cities	Huber Engineered Woods*
Urban Homeworks	Cobalt Creed*
Thrive Builders	
Building Knowledge	* Cost Share Only

Project Outcomes:

This project will validate the efficiency, moisture performance, constructability, costs, and market viability of an innovative solid panel building and delivery system.

This novel, moisture-managed, high-performance, site-fabricated building system is designed to explicitly meet DOE Zero Energy Ready Homes program requirements. The current two-story home is 40% more efficient than the MN Energy Code and meets the MYPP 60% reduction target. In addition, it can be built quicker and is more robust with less QC errors reducing builder risk, callbacks, and costs.

NorthernSTAR Building America Team

University of Minnesota

- Cold Climate Housing Program => Project leadership & management
  - Pat Huelman (PI) – Team lead
  - Tom Schirber – Project manager
- Center for Sustainable Building Research => Research design
  - Garrett Mosiman – Field protocols & measurement
  - Dan Handeen – Field measurement & monitoring
  - Rolf Jacobson – Modeling & field monitoring





Field Support and Rating Partner

- Building Knowledge, Inc. => Technical support, field verification, ratings
  - Ed vonThoma & Pat O'Malley – Commissioning & ZERH raters

Builder Partners

- Twin Cities Habitat for Humanity => 3 house comparison study; cost feedback
- Urban Homeworks => structural panel study; constructability, cost feedback, and system optimization study
- Thrive Builders (Denver, CO) => structural panel study with a leading ZERH builder

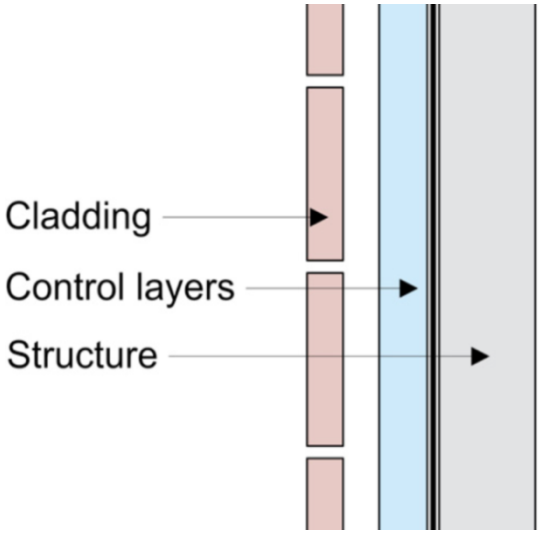
Cost Share Partners

Huber Engineered Woods => Technical & engineering support for enclosure system
Cobalt Creed (formerly Unico) => Consulting & design support for the HVAC systems

Challenge

Background: For decades, the "perfect wall" has been recognized as an optimal path to robust, high-performing, moisture managed, and highly efficient walls.

- Critical control layers (water, air, vapor, thermal)
- Placed on the exterior of the structural system
- Same wall can work in all climate zones



Problem: Very slow adoption of the "perfect wall" by the home building industry due to:

- Perceived complexity
- Trades and labor challenges
- Higher initial construction costs

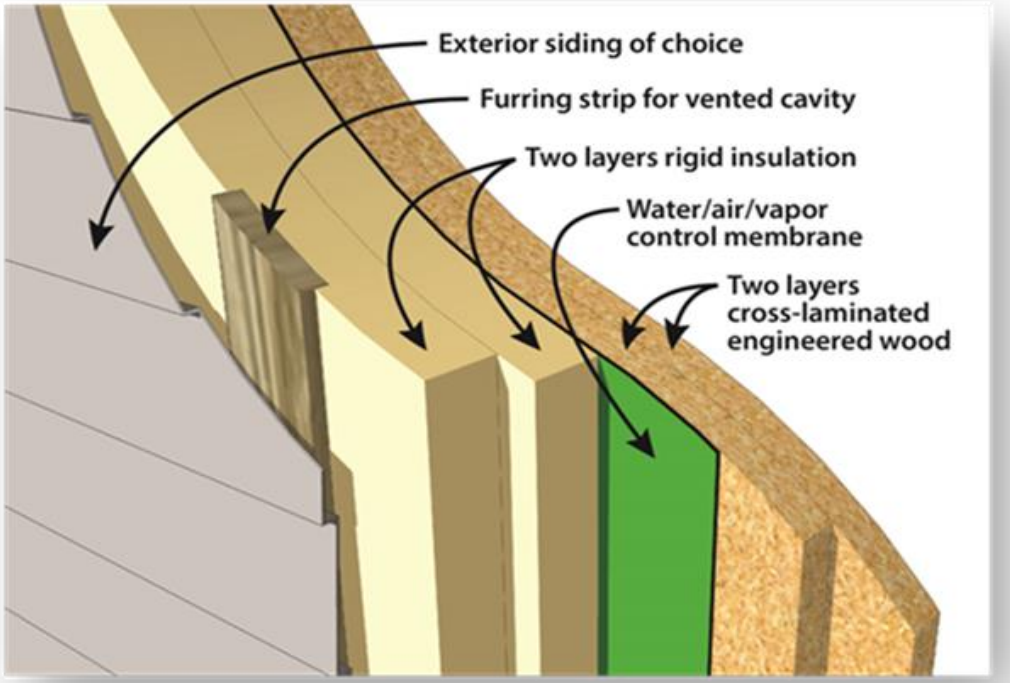
Solution: An innovative building/structural system and delivery approach based on "perfect wall" principles that is easier and less expensive to build.

- Labor savings gained from the building system and its delivery approach
- Pays for high-performing control layers and
- Provides a more robust and resilient home.

“Solid Panel System” Enables the Perfect Wall

The “Perfect Wall”

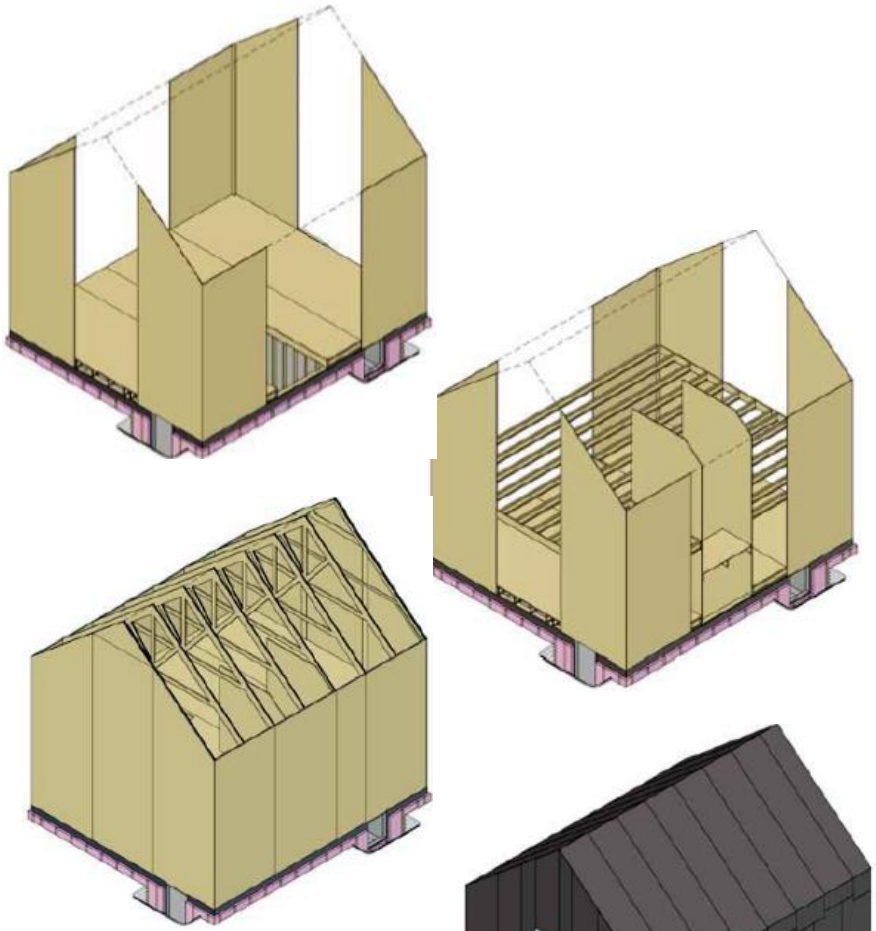
- Structure is kept warm/dry
- Continuous exterior insulation
- Control layers are simplified
- Critical materials are protected
- Back-ventilated cladding
- Sensitive materials can dry
- Can be used in any climate



The Solid Panel System

- Reduces costs of the “perfect wall”
- Simplifies application of exterior insulation
- Requires less skilled labor
- Speeds enclosure time (especially to dry-in)
- Extremely robust and resilient

SPS Supports a Single Enclosure Contractor



Building process developed by MonoPath

- speeds overall construction time
- reduces installation errors
- single line of accountability and margins
- further reducing overall construction cost

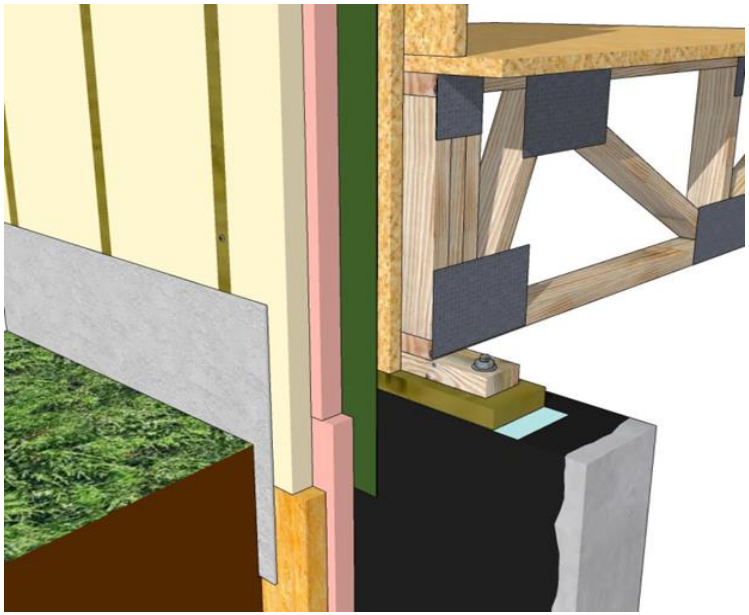
More consistent performance outcomes

- reliable insulation quality and performance
- improved moisture management
- remarkable and repeatable airtightness
- robust and resilient structure

Approach: Solid Panel System

The Structural System

- Uses large format OSB panels (nominal: 1-⅛” x 8’ x 24’)
- Site fabricated & crane installed
- Exterior vertical panels extend from sill plate to top chord of roof truss
- Interior horizontal panels run between the floor and roof trusses



The Control Layers

- Self-healing adhered membrane (peel & stick)
- 2 layers of 2” XPS insulation (staggered seams)
- Furring strip fastened to the structure supports cladding and provides drainage and drying

Approach: Solid Panel System

Exterior Finishes

- Can support all standard siding and trim

Interior Finishes

- Can use standard wall and floor finishes or
  - OSB floor can be sanded and finished
  - OSB walls can have a knock-down finish
- Interior walls can be framed or OSB panels

Electrical

- Deep and wide baseboard chase for exterior walls
- Extended furring around exterior doors

Mechanicals

- High-performance heating, cooling, water heating, ventilation, filtration, and make-up air systems
- Active subslab depressurization for radon

Approach: Research Plan

Can the SPS system provide better performance at lower cost?

Research hypotheses: This solid panel system …

- Outperforms conventional and hybrid wood-frame construction at a lower cost,
- Ensures better QA/QC and lowers builder risk, and
- Can deliver cost-effective Zero Energy Ready Homes for affordable housing.

Validation of this innovative enclosure and delivery system

- Project is modeling, measuring, and comparing solid panel system and stud frame evaluating:
  - performance (energy, moisture, air)
  - constructability and quality control
  - costs (materials, labor, etc.)
- Demonstrate market acceptance
  - with a focus on affordable housing

Approach: Field Validation, Monitoring, Analysis

Field Support, Verification, and Data Collection

- Visual documentation of sequencing/steps (w/ time-lapse camera back-up)
- Data collection for time studies and quality control steps

Constructability

- Review of time studies for optimization of sequence/steps
- Analysis of construction quality control (errors/redo/etc.)

Cost Analysis

- Three wall comparison study (Twin Cities – Habitat for Humanity):
  - 1 Base case (Energy Star 2x6), 1 Opti-MN (2x4 hybrid wall), 3 SPS houses
- System optimization & cost reduction opportunities for SPS
  - Urban Homeworks: 2 - 5 houses / Thrive Home Builders: 1 - 3 houses

Performance Monitoring

- Energy consumption: space heating, water heating, ventilation, make-up air
- Temperatures and relative humidity: outdoors and **interior on** each floor
- Critical moisture content: wall and interior sheathing

Impacts

Modeling and preliminary data has indicated strong potential for the “solid panel system”:

- Quicker construction: especially to closed-in, secure, and weathertight (<5 days)
- Robust moisture management (during construction & operation)
- Superior energy-efficient performance levels (HERS <45)
- Continuous insulation with remarkable airtightness (<0.5 ACH at 50Pa)
- Easily meets Zero Energy Ready Homes program requirements
- Competitive costs will improve with optimization and learning curve

Emerging competitive advantages:

- Industry stakeholders have emphasized three critical and growing concerns within the homebuilding industry:
  - labor availability, especially shortage of skilled labor
  - rising prices of lumber and other building materials
  - faster dry-in to reduce risk and cycle times.
- The “solid panel system” can directly address each of those concerns.

Progress

Completed

- **Two house designs (Cedar 2.0 & Maple 2.0)**
- **Energy and moisture modeling for three walls**
- **Construction of wall comparison homes (TC-HfH)**
  - Base Case (Energy Star v3. 2x6)
  - Opti-MN (2x4 hybrid)
  - Solid Panel System
- **Initial field validation process and procedures**
- **Installation of monitoring equipment in the three wall comparison houses**

In-Progress

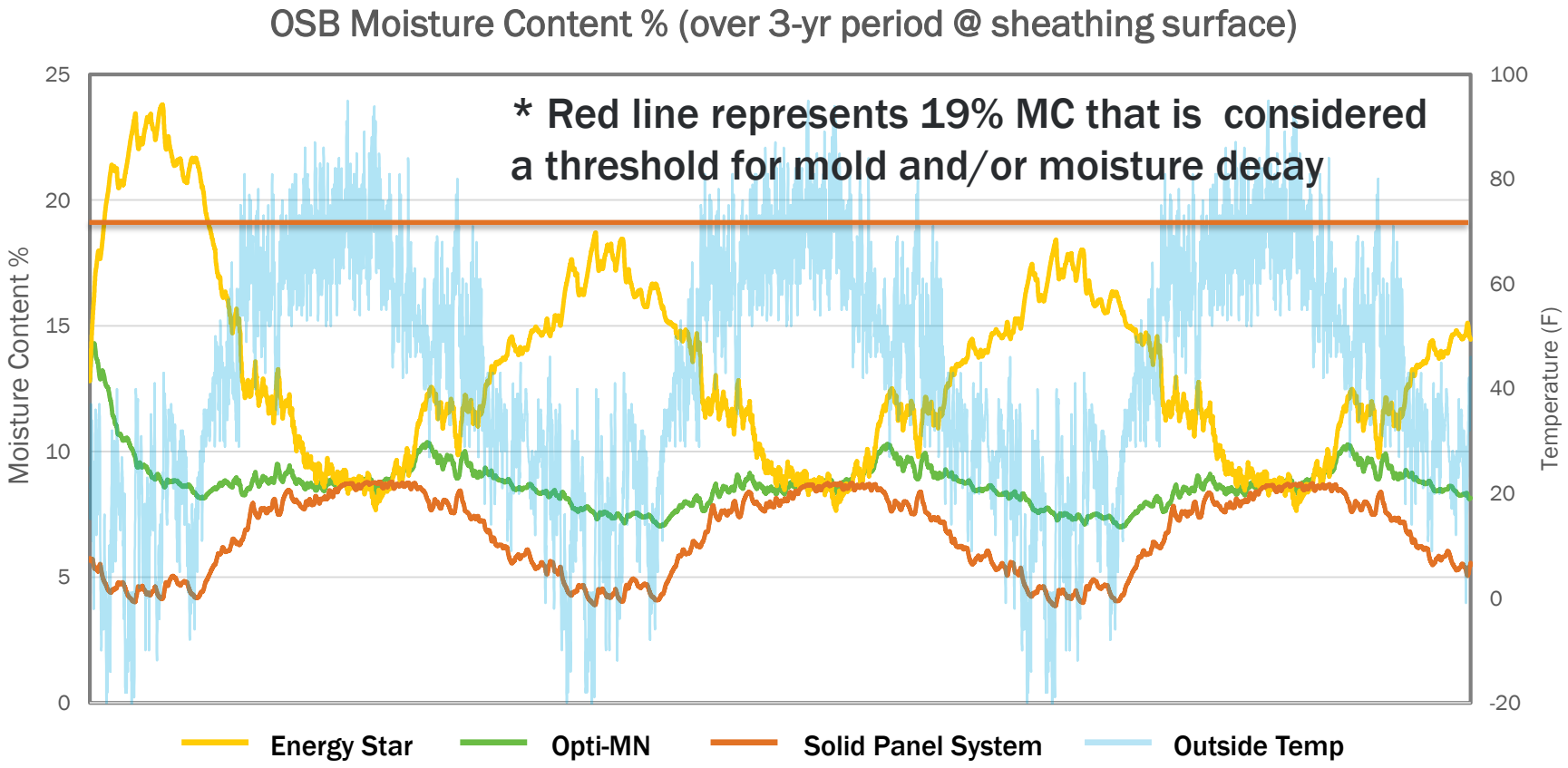
- **Construction of remaining solid panel houses**
  - TC-HfH (2 houses in-progress)
  - Urban Homeworks (2 houses in-progress)
- **House design and engineering for Thrive Builders**
- **Cost and performance analysis**

Temperature, Relative Humidity, and Moisture Content Sensor

Gas Submeter

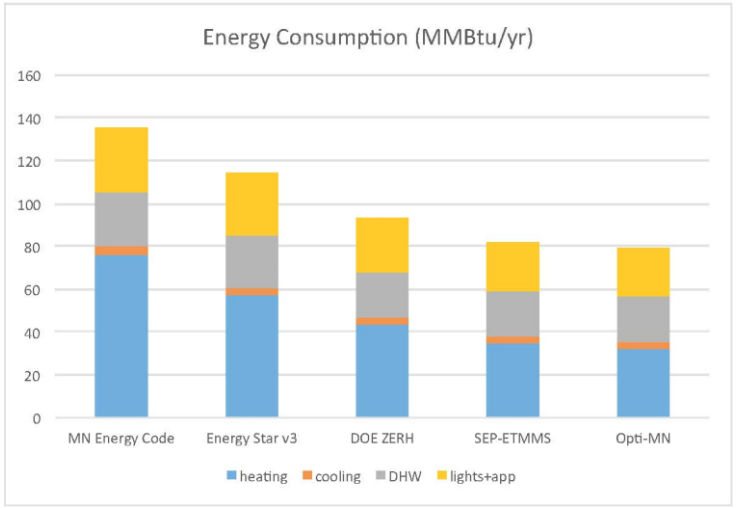
Moisture Modeling: WUFI Analysis

Outstanding modeled moisture performance for both Opti-MN and Solid Panel System with OSB staying below 10% MC, while the base case OSB sheathing approaches 19% MC in winter.

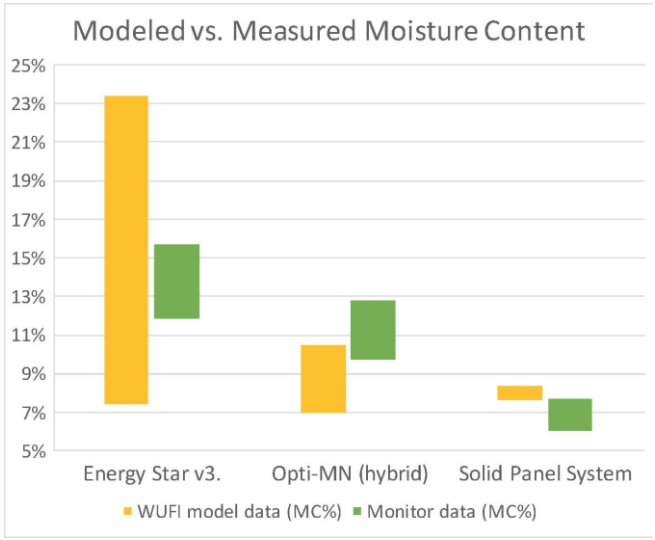


Comparison of Three Wall Systems

Driven by continuous insulation and superior airtightness, the SPS provides better energy and moisture performance at a competitive cost.



	Solid Panel "Perfect Wall" System	OptiMN "Hybrid" System	Energy Star 2x6 Assembly
Construction cost	$60,630	$64,195	60,526
Airtightness (ACH)	0.25-.40	0.85	1.38
Airtightness (CFM50)	88-140	290	489
HERS rating	39-41	43	48



Preliminary Results

While we have experienced some construction setbacks and delays, there have been many positive notes:

- Crane time for erection is going down with subsequent builds
- Crews with limited carpentry skills are able to successfully erected these houses
- Field evidence suggests closed-in, secured, and weathertight is possible in a week
- Remarkable airtightness is built into the system (<0.5 ACH@50Pa)
- Easily meets Zero Energy Ready Homes program requirements

System delivery lessons learned

- While the system is conducive to a single enclosure contractor, this requires a new contractor model with a predictable volume.
- We continue to identify areas to improve cost competitive**ness.**

Potential changes in direction

- The code hurdles and customized engineering requirements have been a little larger than expected.
- Currently evaluating a hybrid approach where the interior horizontal panel (between floors) is replaced by 2x4 stiffeners.

Remaining Project Work

Budget Period 3

- **Completion of Solid Panel System Houses**
  - Habitat for Humanity (2 houses)
  - Urban Homeworks (2 houses)
- **Conduct System Optimization Study**
  - Urban Homeworks (up to 3 houses)
- **Construction of Houses w/ Thrive Builders**
  - Complete engineering of their modified panel approach
  - Construction of 1 to 3 houses
- **Finish Energy & Moisture Monitoring**
  - Three comparison houses
  - Three additional solid panel houses
- **Finish Data Collection, Analysis, & Report**
  - Energy & moisture performance
  - Cost data analysis
  - Market response

Stakeholder Engagement

Key Partners: Our team fully integrated several affordable housing providers as research partners to demonstrate market validation and adoption.

Trade Allies: We are also engaging other developers, builders, enclosure contractors, and trades during the design and construction process.

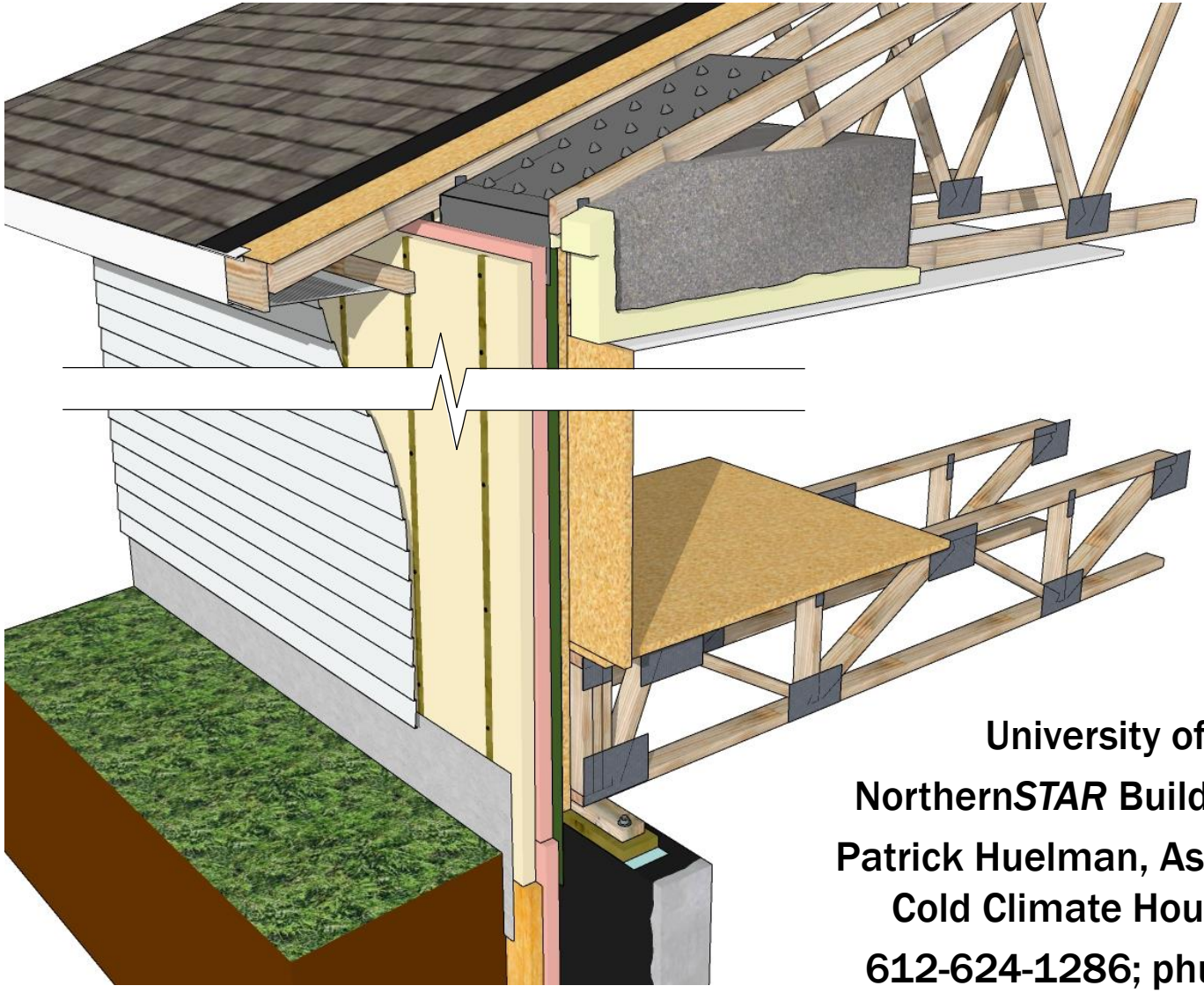
- Identified new potential enclosure contractors
- Discussion with large light-frame panel producer who services national builders in MN

Homebuilding Community: We continually reach out to members of the broader homebuilding industry to plant the seeds for the "perfect wall" with its benefits and solicit valuable feedback from potential users of the solid panel system.

Related Presentations:

- EEBA Home Summit; Penn State Design & Housing Conference
- Energy Design Conference (MN) & Better Buildings; Better Business Conference (WI)
- Five seminars for local Minnesota builder associations
- National affordable housing networks (NeighborWorks, MI-HfH)

Thank-You



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REFERENCE SLIDES

Project Budget

Project Budget: The budget by activity and by partner has been reasonably close. However, our housing partners are moving much slower than anticipated. Therefore, the spend rate is much slower than originally projected.

Variances: Between BP-1 and BP-2 budgeted funds were redistributed to bring on a new affordable housing partner. Midway through BP-2 an original partner withdrew from the project and will need to be replaced. This will be reflected when we submit a revised work plan and budget for BP-3.

Cost to Date: Approximately 80% of the total budget will be expended at the end of BP-2. However, at this time we expect BP-2 to extend beyond June 30, 2018.

Additional Funding: Currently there are no other funding sources directly supporting this building and delivery system. However, we continue to look for partners who would be interested in further market development and adoption.

Budget History

June 16, 2016 – FY 2018 (past)		FY 2019 (current)		FY 2020 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$628,539	$165,770	$269,321	$66,808	$0	$0

Project Plan and Schedule

Project Timeline:

Start Date: July 1, 2016

End Date: June 30, 2019

Phase		Milestone Schedule For our project, the quarters start on July 1, 2016 which is our fiscal year. So Q1 is July 1 to Sept 30. Sorry for any confusion.	
		Past Work	
1	M	Complete the Project Management Plan.	M6
1	M	Complete the Research Test Plan.	M6
		Current Future Work	
End Budget Period 1		Go/No-Go 1: 1) Complete construction documents for each of two single-family house designs, with modeled OSB moisture levels verified to not exceed 18% and energy use verified to meet or exceed ZERH targets. 2) At least one builder trained to execute MonoPath house construction.	M12
2	M	Complete optimized sets of construction documents for one multi-family (3-plex) design, including energy and moisture analysis.	M15
2	M	Complete optimized sets of construction documents for each revised design, and complete energy and moisture analysis for revised designs as needed.	M15
	M	At least one additional builder trained to execute MonoPath house construction.	M15
2	M	Construction process documentation per protocol developed in Task 4 complete for all houses completed to date.	M15
2	M	Energy monitoring protocol deployed in all complete houses, with	M18
2	M	Enclosure and system commissioning per protocol developed in Task 5.0 complete and documented for all complete houses. HERS ratings and ZERH certification complete for all complete houses.	M18
2	M	Data required for comparative analysis is secured in a consistent format for all houses at a level appropriate for their level of completion.	M21
End Budget Period 2		Go/No-Go 2: 1) One additional builder trained to build SEP-ETMMS houses. 2) Minimum of four houses either complete or under construction. 3) All measurement and monitoring protocols are deployed in houses in a manner consistent with their level of completion.	M24
3	M	Construction process documentation per protocol developed in Task 4 complete for all houses completed to date.	M27
3	M	Energy monitoring protocol deployed in all complete houses, with data collection verified.	M30
3	M	Enclosure and system commissioning per protocol developed in Task 5.0 complete and documented for all complete houses. HERS ratings and ZERH certification complete for all complete houses.	M30
3	M	Comparative analysis studies complete and documented.	M30
3	M	Complete the final report and documentation.	M30