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

Patrick Huelman, Associate Professor & Cold Climate Housing Coordinator

612-624-1286; phuelman@umn.edu

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: $537,681
- Cost Share: $149,286

Total Project $:

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

Key Partners:

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

Project Outcomes:

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

This novel moisture-managed, high-performance building system is designed to meet DOE Zero Energy Ready Homes program requirements. The current two-story model meets the current BA EUI target of 35 kBtu/sf and is 40% more efficient than the 2015 MN Energy Code. In addition, it is more robust and can be built quicker 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 and cost feedback
- City of Minneapolis => system optimization study
- Thrive Builders (Denver, CO) => structural panel study with a leading ZERH builder

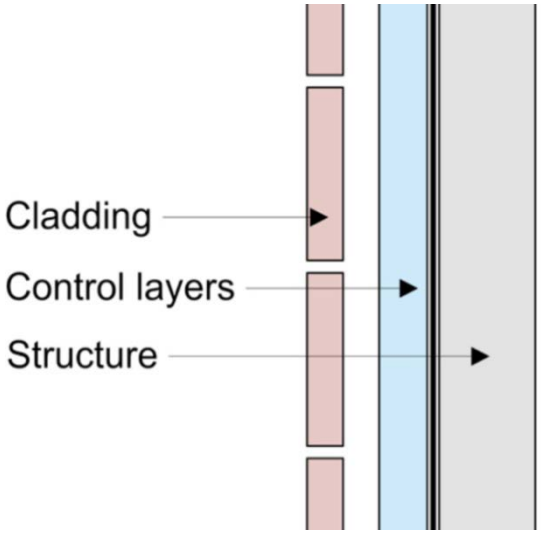
Cost Share Partners

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, highly energy-efficient walls.

- Critical control layers (water, air, vapor, thermal)
- Placed on the exterior of the structure
- 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
- trade challenges and labor shortage
- higher initial construction costs

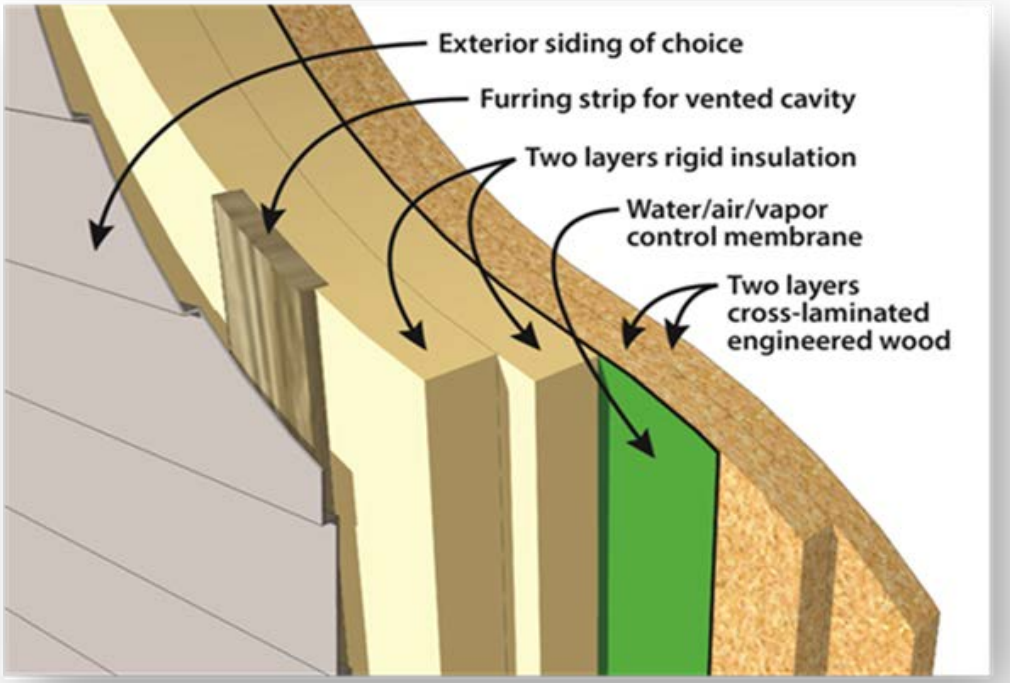
Solution: An innovative building/structural system and delivery approach based on "perfect wall" principles, that is easier and less expensive to build.

- The 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”

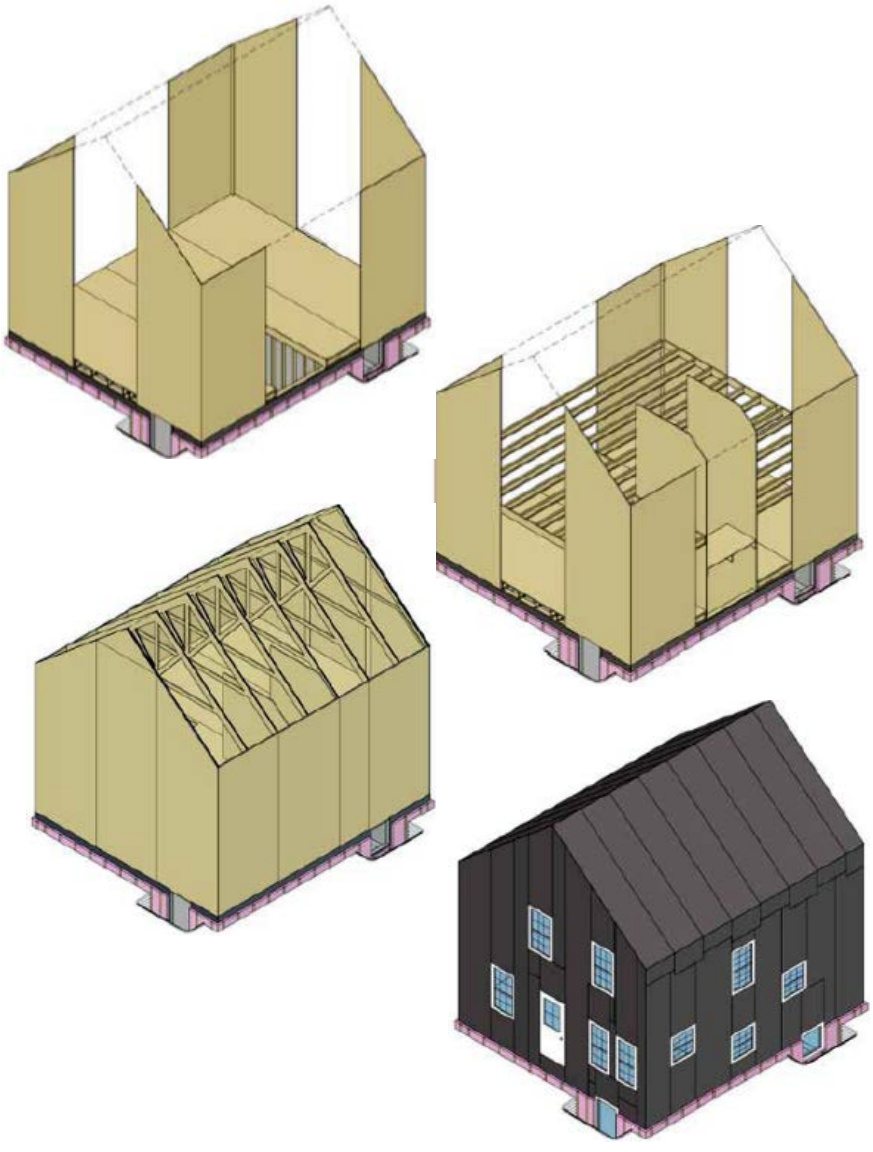
- Structure is kept warm/dry
- Continuous exterior insulation
- Control layers are simplified
- Critical materials are protected
- Back-ventilated cladding
- Sensitive materials can dry
- Can be used in any climate



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

System Supports a Single Enclosure Contractor

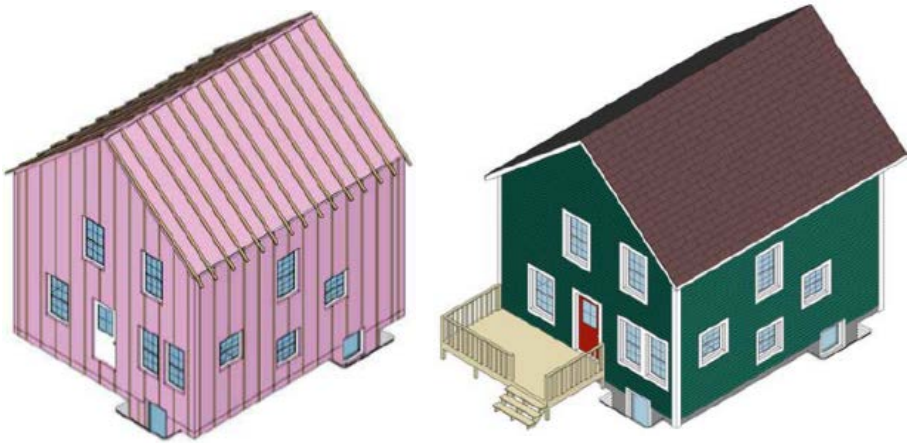


Building process developed by MonoPath

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

More consistent performance outcomes

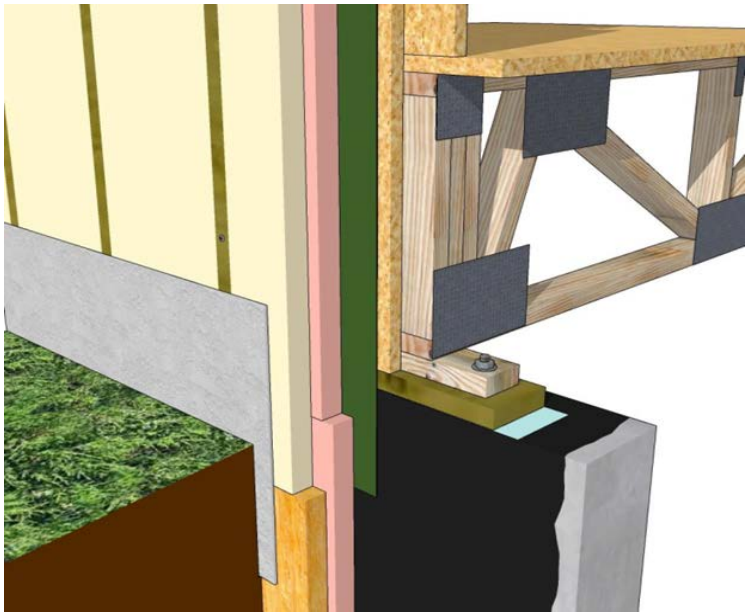
- reliable insulation quality and performance
- improved moisture management
- remarkable and repeatable airtightness
- robust and resilient structure



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 in 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 use knock-down finish

Electrical

- Deep and wide baseboard chase for exterior walls
  - interior walls can be framed or OSB panels
- 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 better design, better systems, and a better delivery approach provide better performance at lower cost?

Research hypotheses: This solid panel system …

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

Validation of this innovative enclosure and delivery system

- Project will model, measure, and compare 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

Constructability

- Review of time studies for optimization of sequence/steps
- Construction quality and analysis of quality control (errors/redo/etc.)

Cost Analysis

- Three house comparison study (Twin Cities – Habitat for Humanity):
  - Base case (Energy Star 2x6), Opti-MN (2x4 hybrid wall), Solid panel system
- Identify strategic cost reduction opportunities for solid panel system

Performance Monitoring

- House Comparison Study (Twin Cities – Habitat for Humanity)
  - Energy Consumption: space heating, water heating, ventilation, make-up air
  - Temperatures & 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” directly addresses those concerns.

Progress

Completed

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

In-Progress

- Installation of monitoring equipment in three comparison houses
- Cost analysis for comparison houses
- Construction of next solid panel houses
  - Urban Homeworks (house in-progress)
  - Twin Cities–HfH (starts in May & June)
- House design for Thrive Builders

Temperature, Relative Humidity, and Moisture Content Sensor

Gas Submeter

Energy Modeling: Comparison

Excellent energy performance driven by continuous insulation, airtightness, and equipment efficiency!

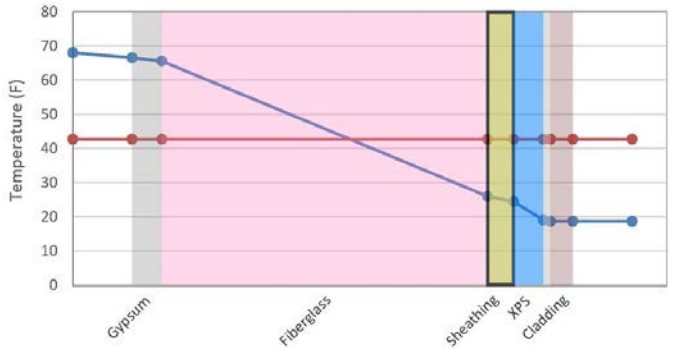
	HERS	Total Energy		Heating & Cooling	
Plan = Cedar 2.0		Energy (MMBtu)	Cost ($)	Energy (MMBtu)	Cost ($)
2015 MN Energy Code	70	135.6	$2140	80.0	$729
Energy Star v3. (minimum requirements)	60	114.0	$1935	60.6	$579
DOE - ZERH (minimum requirements)	49	92.8	$1689	47.2	$476
Opti-MN (hybrid)	43	79.3	$1521	35.5	$385
Solid Panel System	44	81.5	$1536	37.7	$400

Moisture Modeling: Temperature Profile Method

For Minneapolis/St. Paul, MN

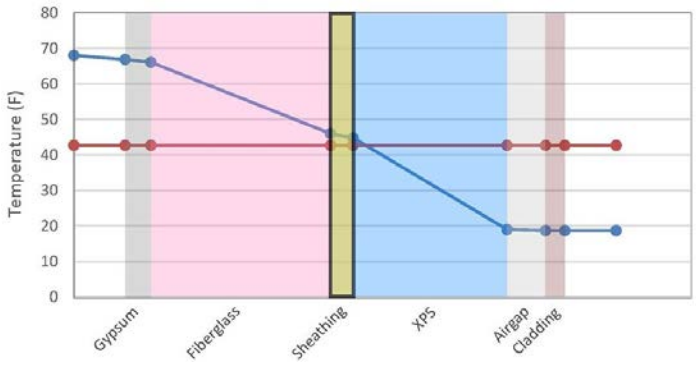
- Outdoor temp = 19º (January average)
- Indoor temp = 68º; RH = 35%
- Indoor dewpoint temp = 42º (red line)
- Wall temperature profile (blue line)

Temperature Profile – Energy Star



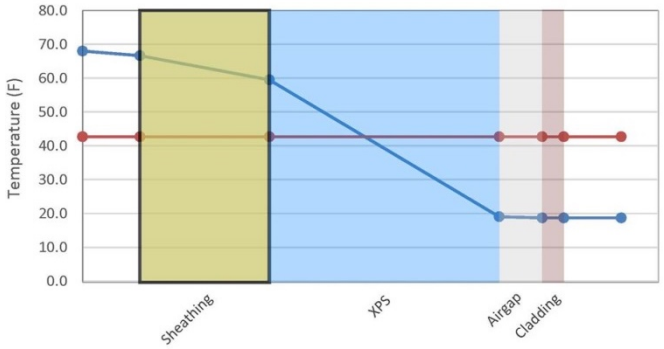
- **Base Case (Energy Star 2x6 wall)**
  - Indoor dewpoint temperature falls within the cavity insulation making the sheathing and framing susceptible.

Temperature Profile – Opti-MN



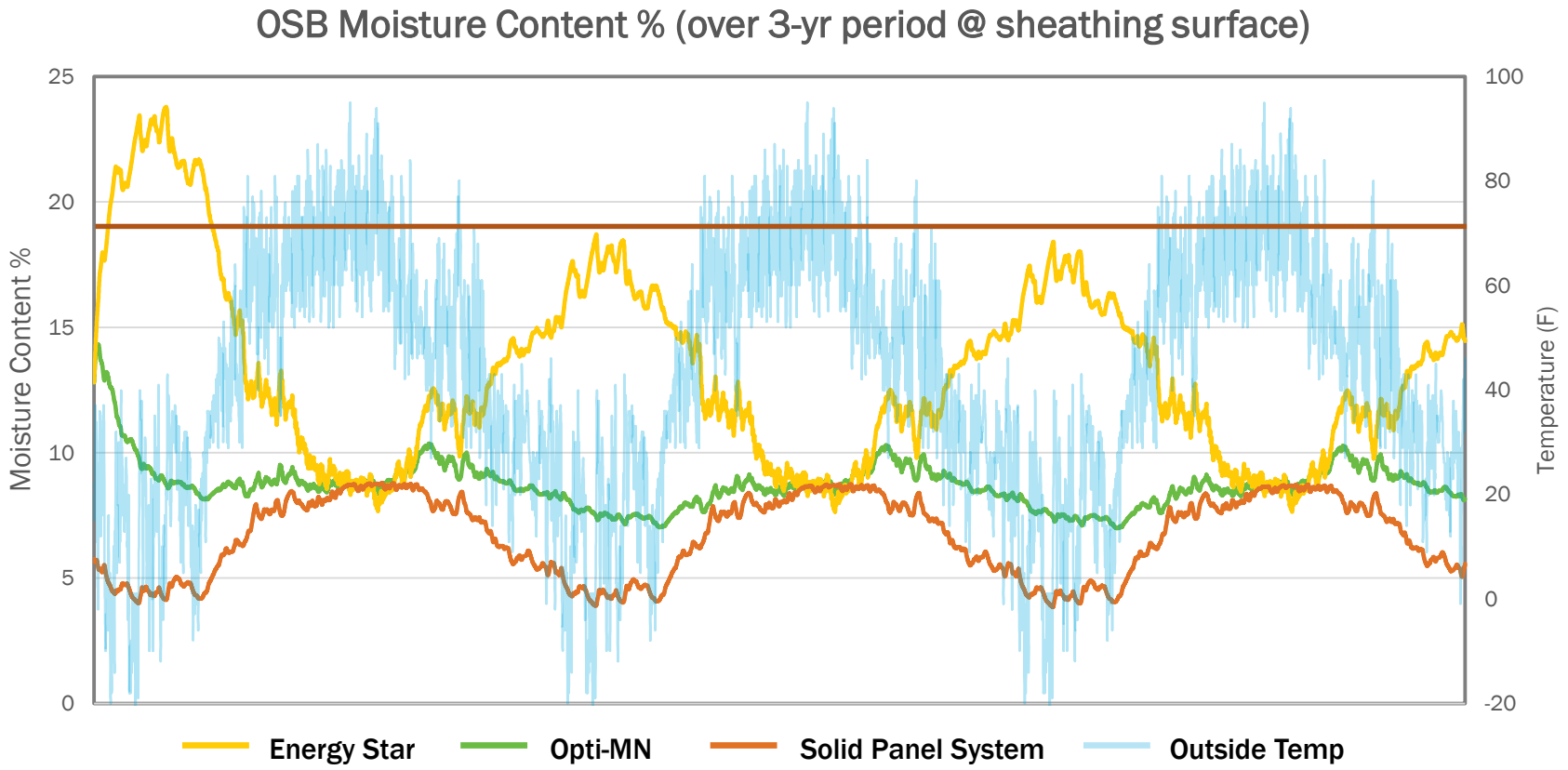
- **Opti-MN (2x4 hybrid wall)**
  - Indoor dewpoint temperature lands just beyond the wall sheathing; plus interior can dry inward and exterior can dry outward.
- **Solid Panel System**
  - Indoor dewpoint temperature is well within the exterior insulation keeping panel warm and dry.

Temperature Profile - Solid Panel System



Moisture Modeling: WUFI Analysis

Outstanding moisture performance predicted 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.



* Red line represents 19% MC considered a threshold for mold and/or moisture decay

Stakeholder Engagement

Key Partners: Our team 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 design and construction process.

- Identified new potential enclosure contractors
- Working with large stud framing 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 & Better Buildings; Better Business (WI)
- Three seminars for local Minnesota Builder Associations
- National affordable housing networks (NeighborWorks, MI-HfH)

Remaining Project Work

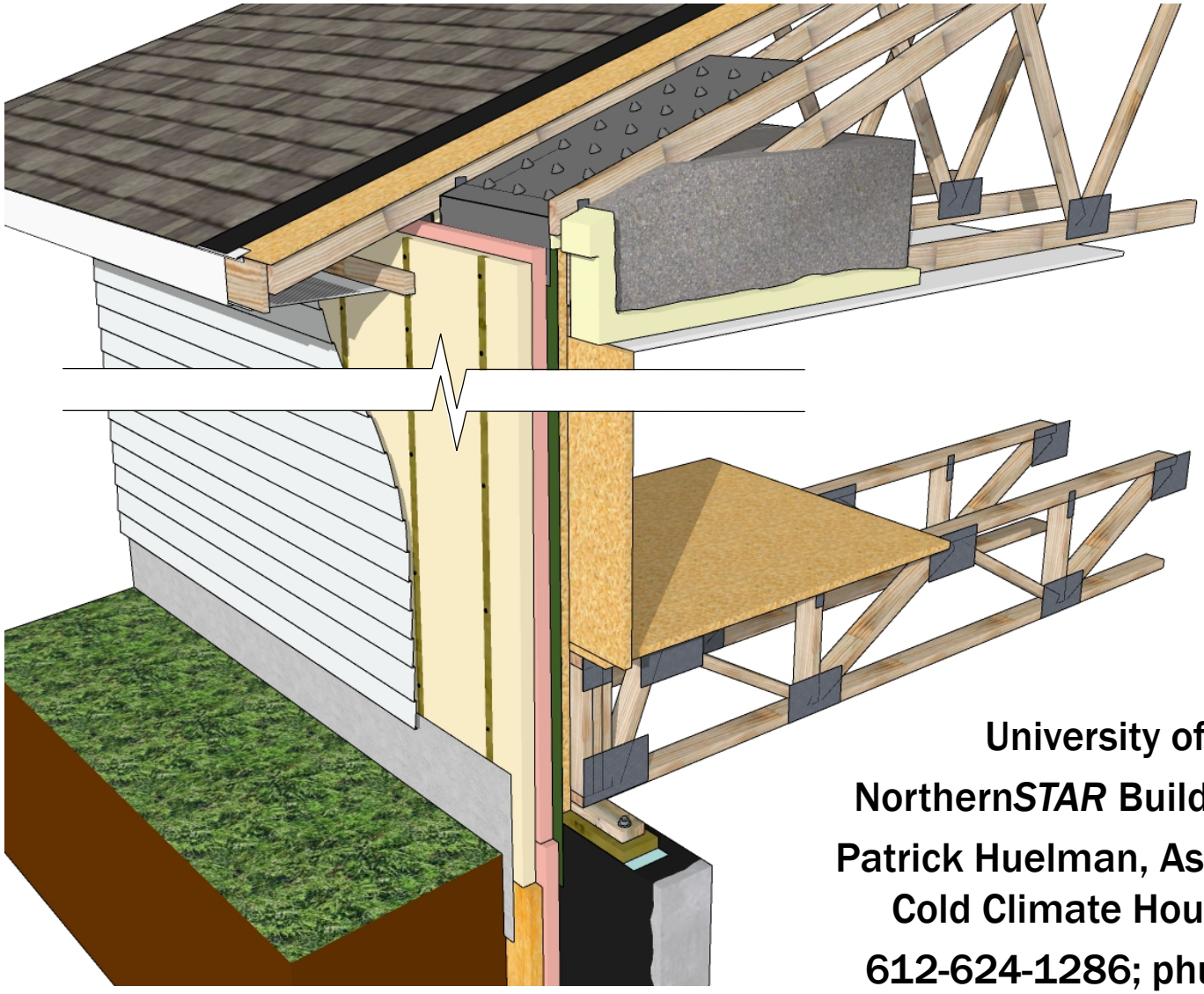
Budget Period 2

- Monitoring of three comparison houses
- Construction of solid panel system houses
  - Urban Homeworks (1 house)
  - City of Minneapolis (2 houses)
- Finish house design for Thrive Builders
  - Bring on new engineering consultant(s) to assist design team

Budget Period 3

- Construction of solid panel houses in CO
  - Thrive (2 to 4 houses)
- Conduct system optimization study
  - City of Minneapolis (up to 7 houses)
- Complete house monitoring and analysis
- Finish performance and cost data analysis

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 2017 (past)		FY 2018 (current)		FY 2019 – June 30, 2019 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$400,053	$107,197	$310,737	$79,760	$187,071	$45,622

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