BUILDINGENERGY BOSTON

Low-Carbon Envelopes: Insights from Moisture Data in Biogenic Material Walls

Diana A. Brito Picciotto, University of Massachusetts Amherst
Christopher Nielson, Bruner/Cott

Curated by Greg Bossie

Northeast Sustainable Energy Association (NESEA) | March 21, 2025

Attendees will be able to...

1. Define divergent objectives and priorities for developing enclosure design responding to criteria of durability, cost, and climate impact.
2. Measure and compare exterior wall assembly durability, cost, and climate impact
3. Understand the vapor movement within a double stud cellulose wall in the New England climate
4. Identify tools for measuring the embodied carbon of a building, and of wall assemblies.

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Diana Andrea Brito Picciotto, PhD

Dr. Brito's research focuses on energy-efficient buildings and Life Cycle Assessment (LCA) applied to both buildings and materials. Her vision is to advance current LCA methodologies by introducing higher-resolution approaches and gaining a deeper understanding of emissions' continuous impact on the atmosphere (cumulative effects over time), through dynamic LCA. Additionally, her research interests include establishing Carbon (GHGs) benchmarks through LCA studies at a portfolio level

Christopher Nielson, AIA CPHC LEED AP

Christopher is an associate with Bruner/Cott Architects. He uses architecture as an act of environmentalism, innovating sustainable and low-carbon approaches for both new buildings and historic structures to address climate change. It is Christopher's goal to make a positive impact on the built environment, while sharing his experience with future designers.

BRUNER / COTT ARCHITECTS

RW Kern Center
Hampshire College

17,000sf | Amherst, MA

Welcome Center: Admissions, Financial Aid, Café, Classrooms

Double Stud Cellulose Wall (stone and wood clad)

Living Building Challenge 2.1

Completed Summer 2016

23.33 kBTU/sf/year (measured)

Net Positive with PV array (measured)

336 kgCO2eq/m2 (modeled A1-A3, biogenic)

Aliki Perotti and Seth Frank Lyceum
Amherst College

20,000sf | Amherst, MA

Academic Building: Offices, Classrooms, Commons

Double Stud Cellulose Wall (stone and wood clad)

Targeted Net Zero Carbon (no certification pursued)

Anticipated Fall 2023

27.8 kBTU/sf/year (measured during 2024 commissioning)

14.5 kBTU/sf/year with PV array (modeled)

69 kgCO2eq/m2 (modeled A1-A3, biogenic)

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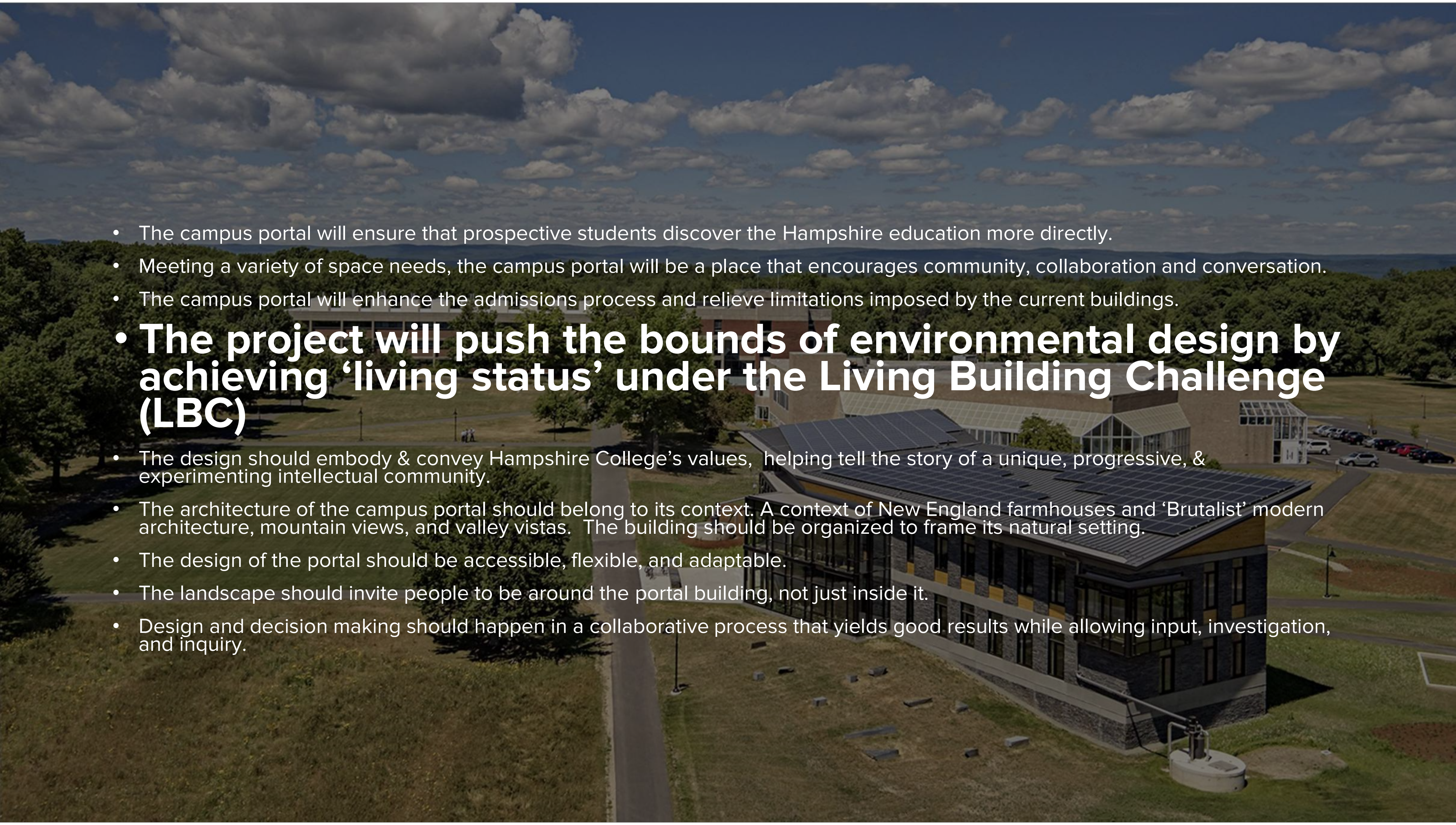
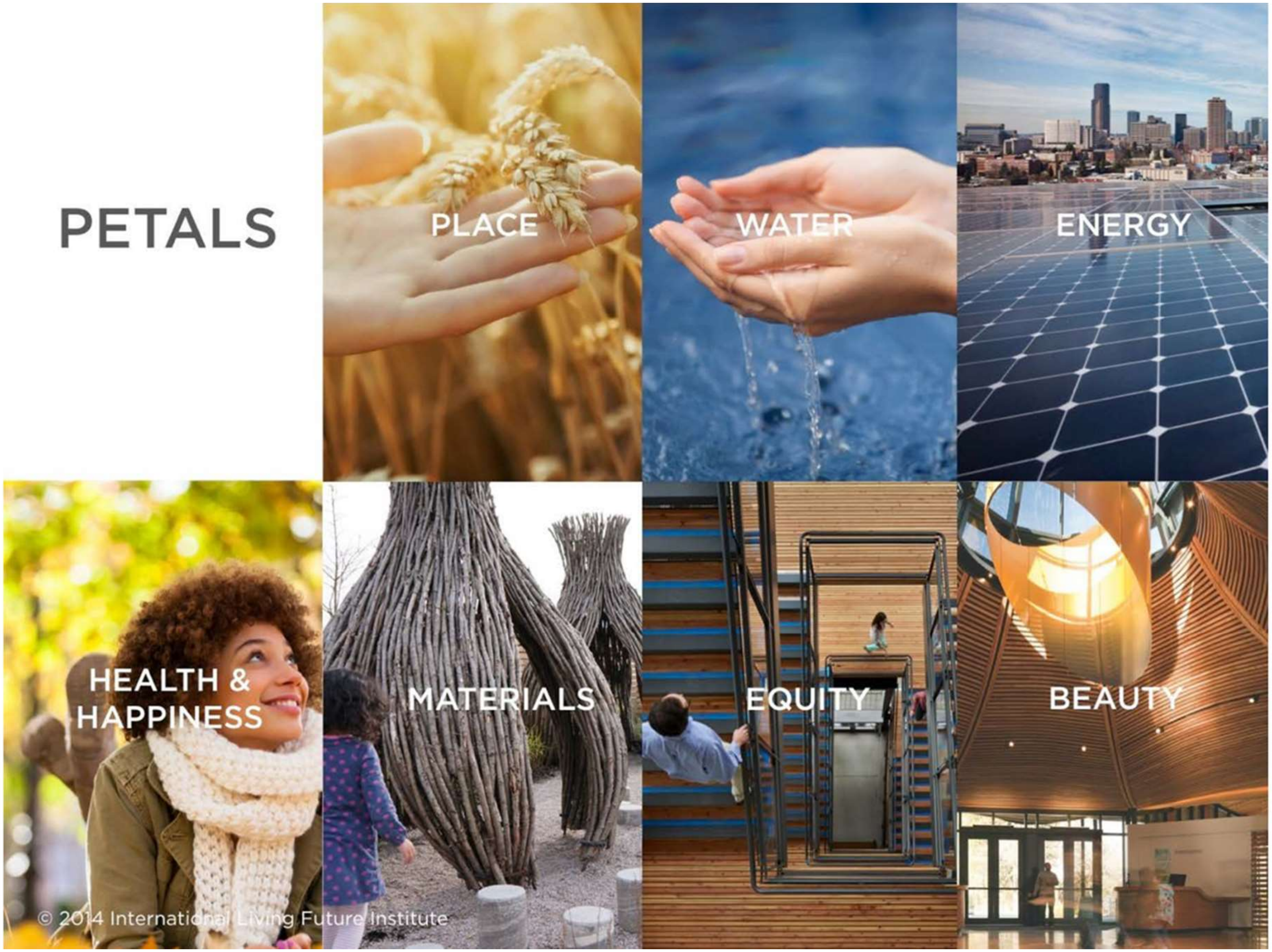


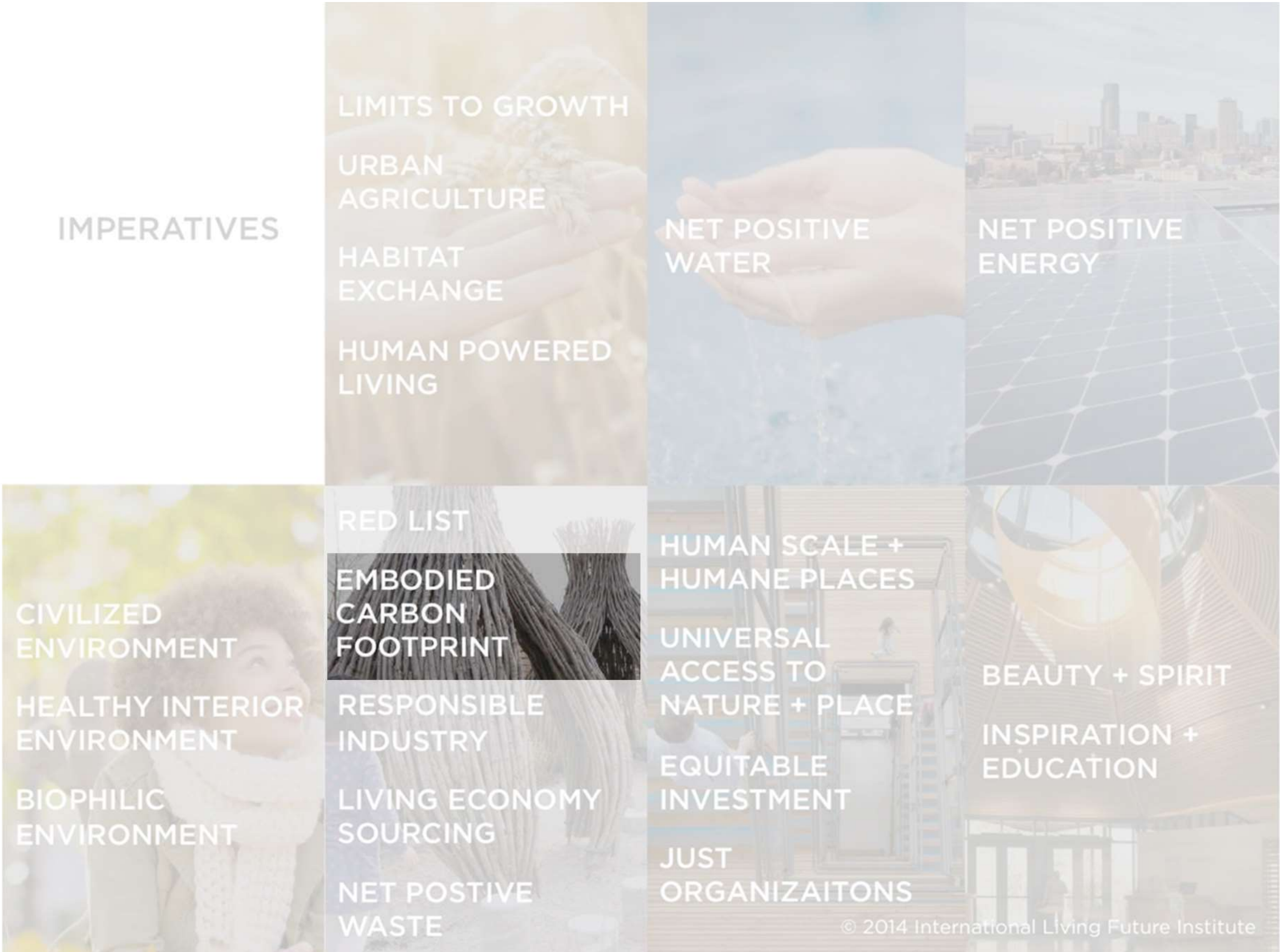
- The campus portal will ensure that prospective students discover the Hampshire education more directly.
- Meeting a variety of space needs, the campus portal will be a place that encourages community, collaboration and conversation.
- The campus portal will enhance the admissions process and relieve limitations imposed by the current buildings.
- **The project will push the bounds of environmental design by achieving ‘living status’ under the Living Building Challenge (LBC)**
- The design should embody & convey Hampshire College’s values, helping tell the story of a unique, progressive, & experimenting intellectual community.
- The architecture of the campus portal should belong to its context. A context of New England farmhouses and ‘Brutalist’ modern architecture, mountain views, and valley vistas. The building should be organized to frame its natural setting.
- The design of the portal should be accessible, flexible, and adaptable.
- The landscape should invite people to be around the portal building, not just inside it.
- Design and decision making should happen in a collaborative process that yields good results while allowing input, investigation, and inquiry.

PETALS


PLACE
WATER
ENERGY
HEALTH &
HAPPINESS
MATERIALS
EQUITY
BEAUTY

IMPERATIVES

IMPERATIVES

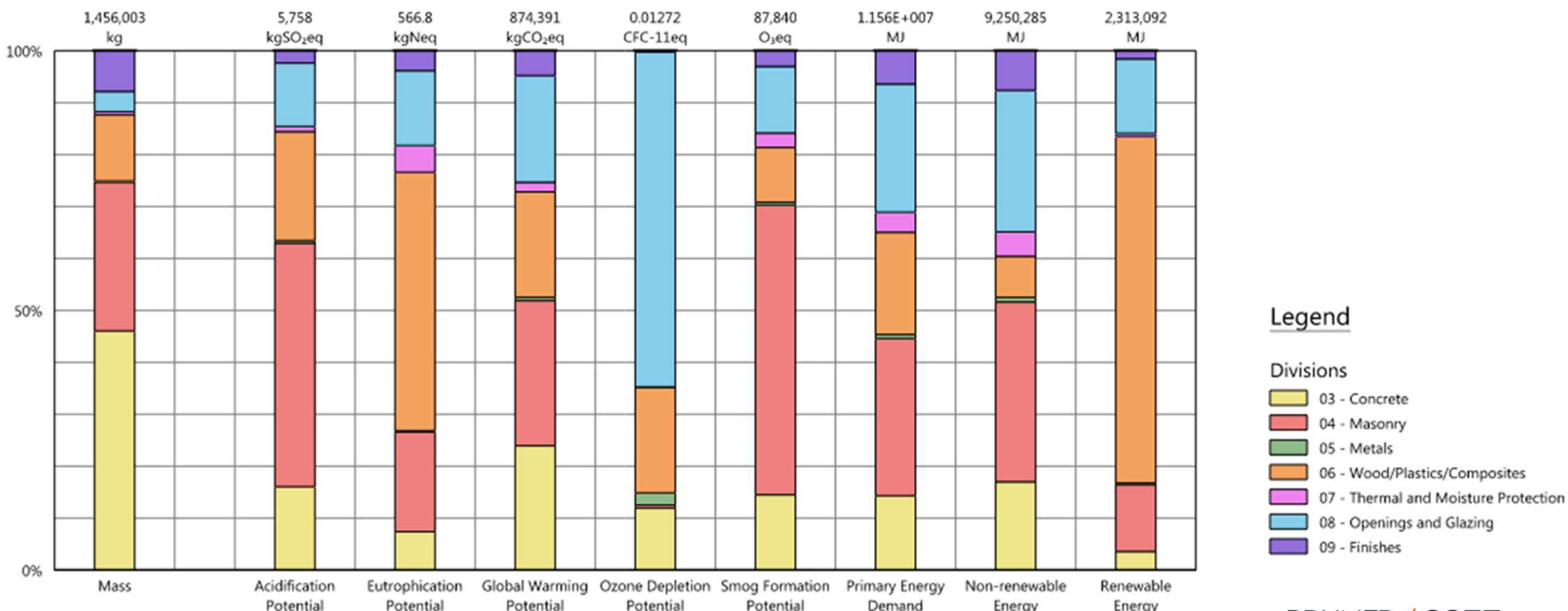


R.W. KERN CENTER

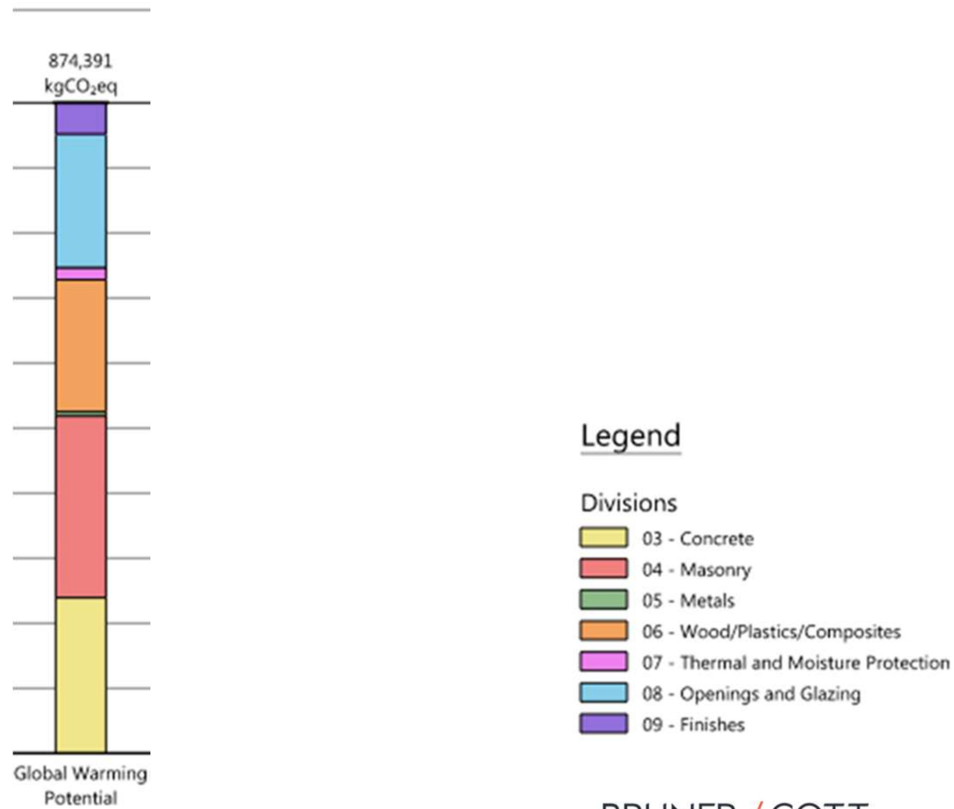
Full building summary

7/21/2017

Results per Division *A1-D, excluding A5*



BRUNER / COTT ARCHITECTS



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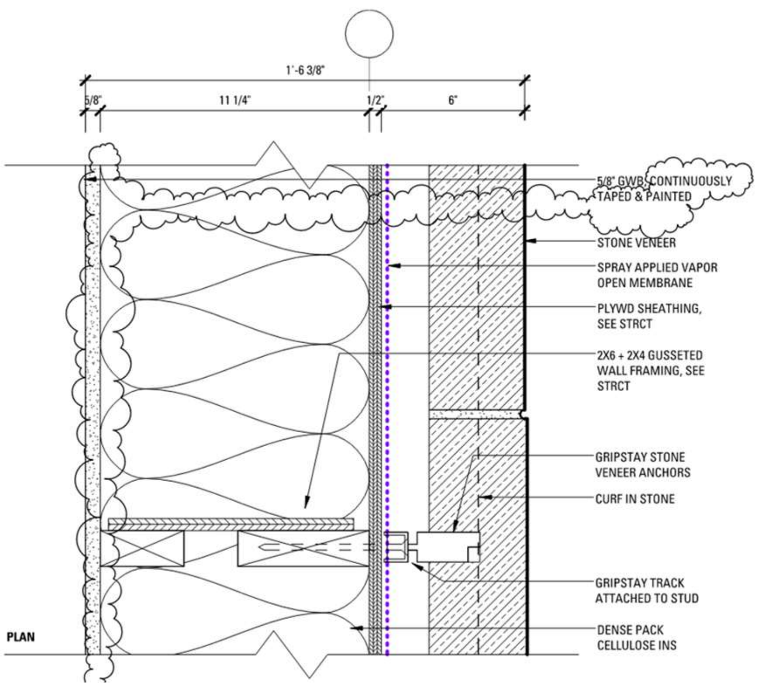

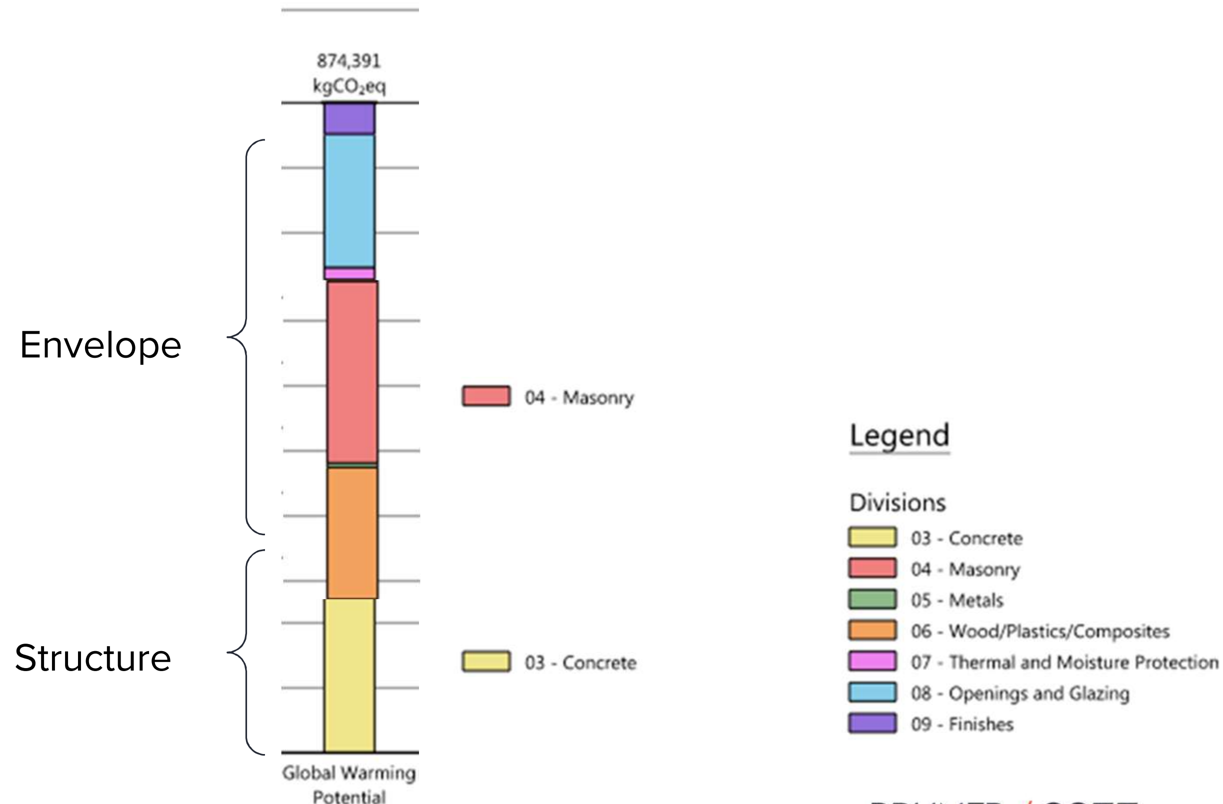

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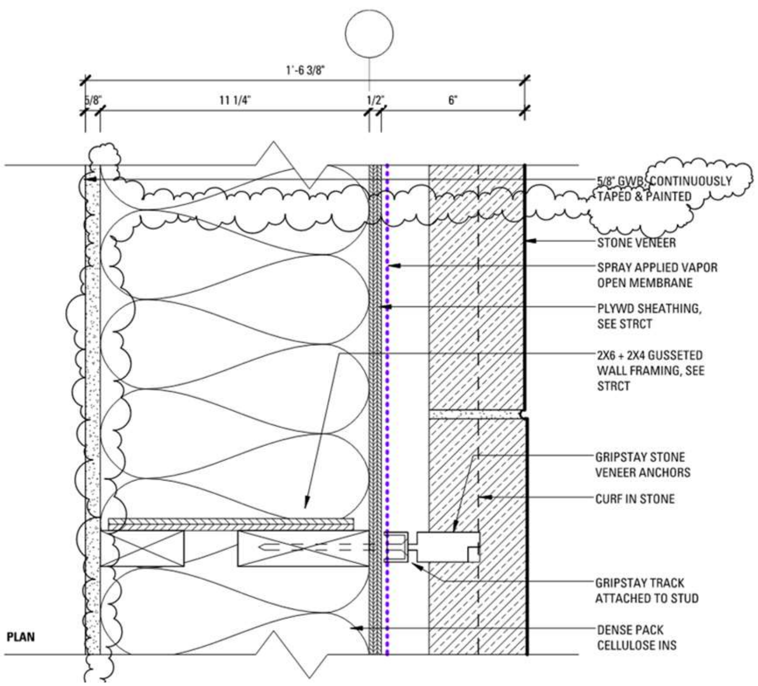

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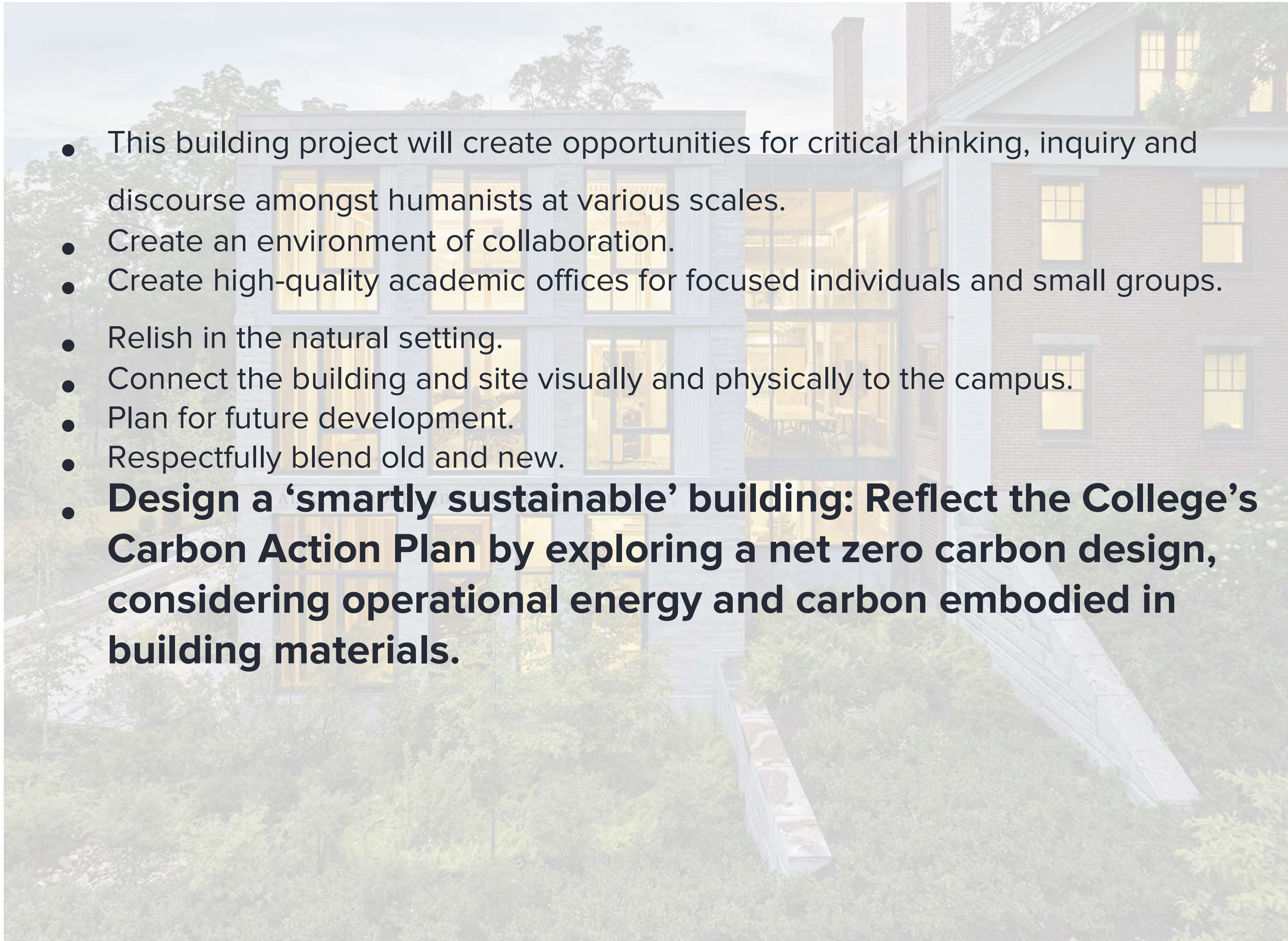
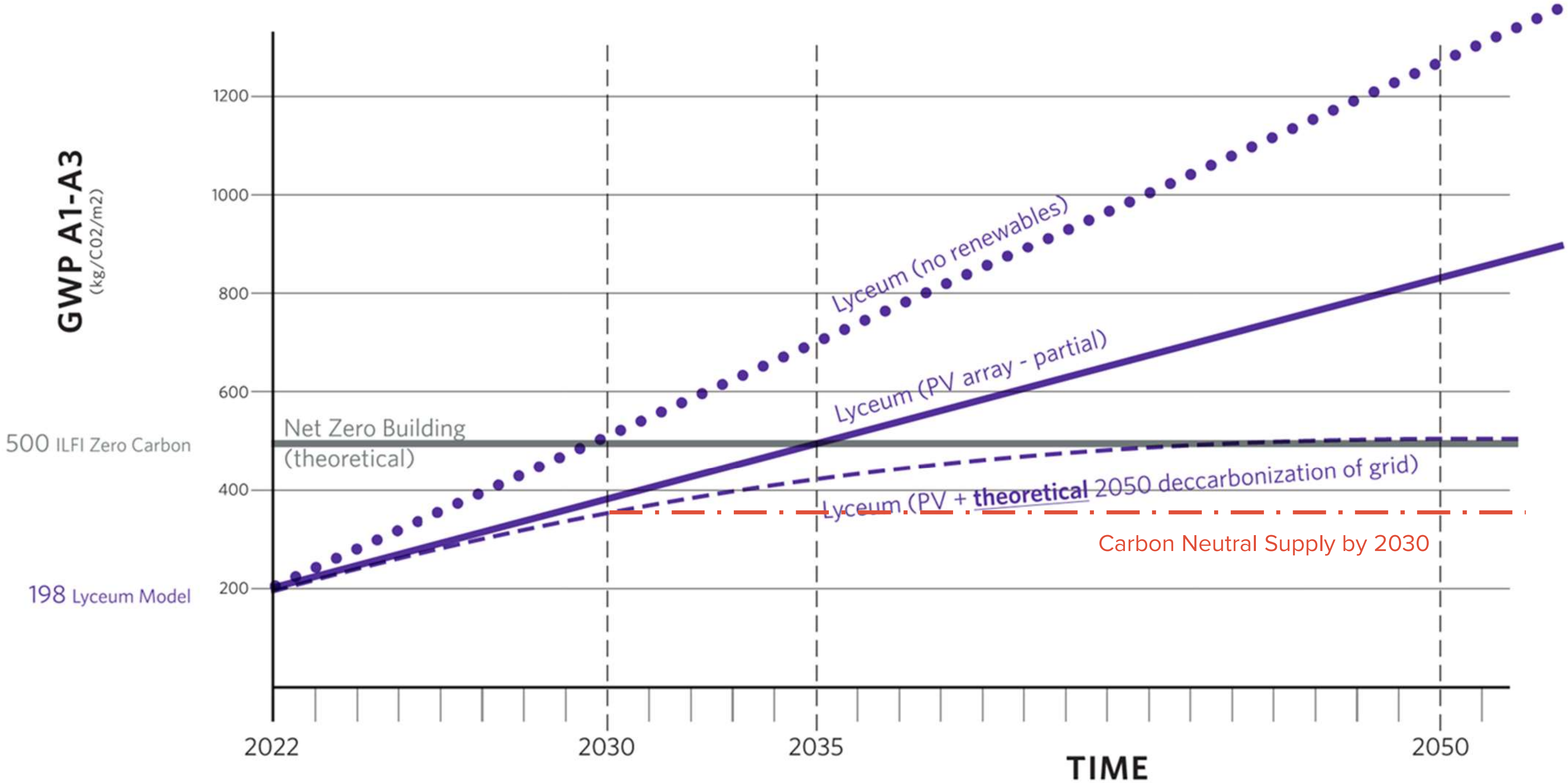
B/C

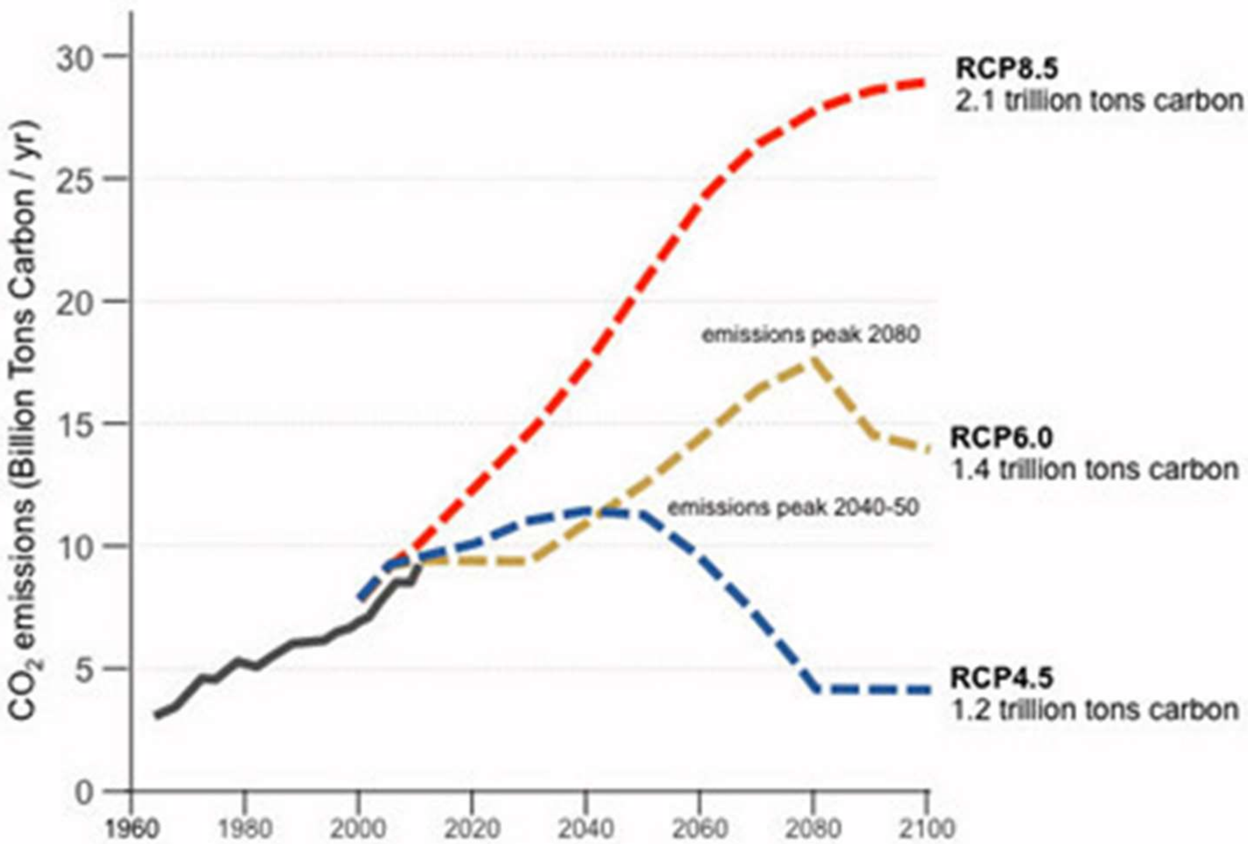


- This building project will create opportunities for critical thinking, inquiry and discourse amongst humanists at various scales.
- Create an environment of collaboration.
- Create high-quality academic offices for focused individuals and small groups.
- Relish in the natural setting.
- Connect the building and site visually and physically to the campus.
- Plan for future development.
- Respectfully blend old and new.
- **Design a ‘smartly sustainable’ building: Reflect the College’s Carbon Action Plan by exploring a net zero carbon design, considering operational energy and carbon embodied in building materials.**

SUSTAINABLE DESIGN

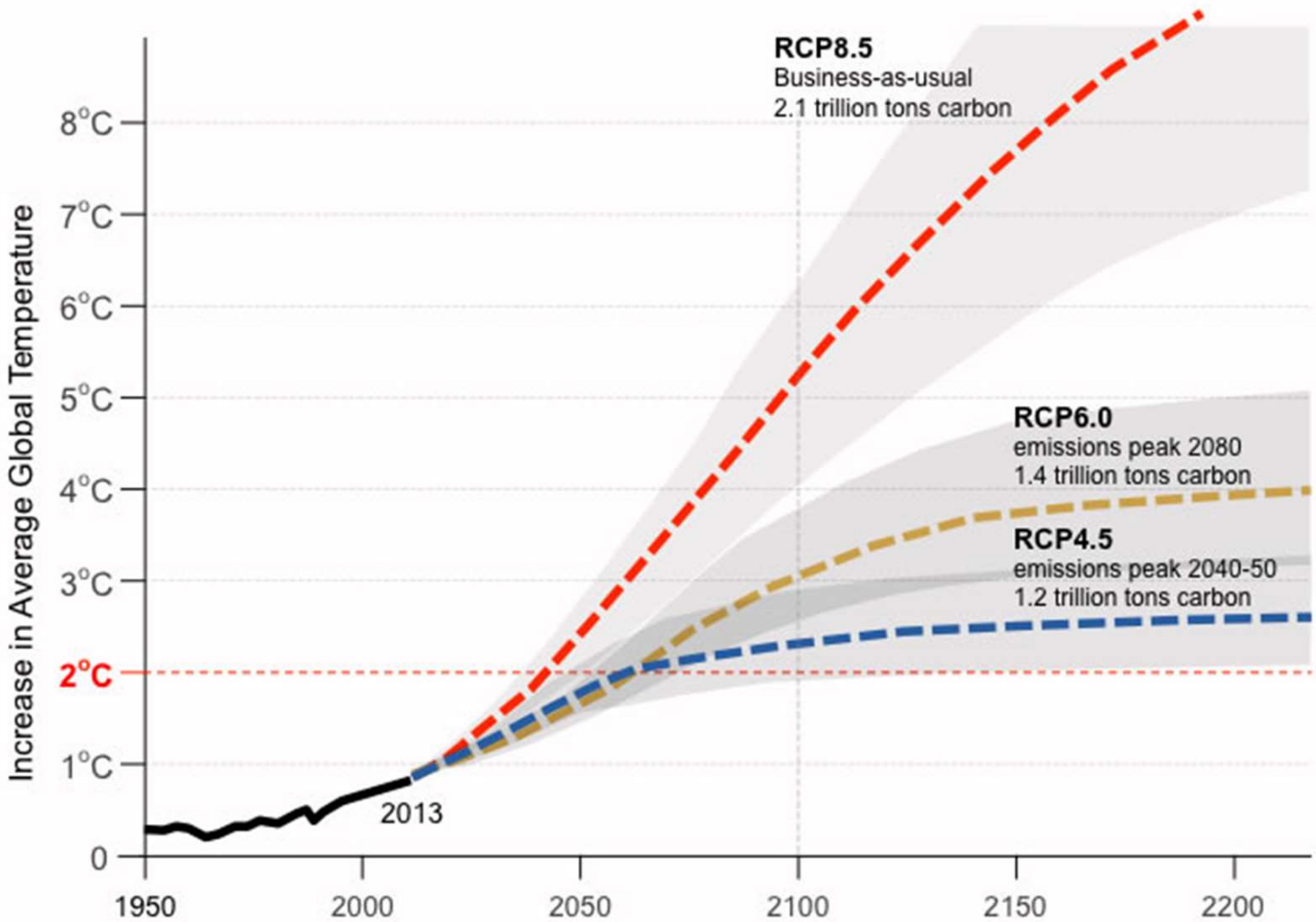
TOTAL CARBON OVER TIME





Pathways for Fossil Fuel CO_2 Emissions to 2100

Source: Architecture 2030: Adapted from the IPCC Fifth Assessment Report, 2013.

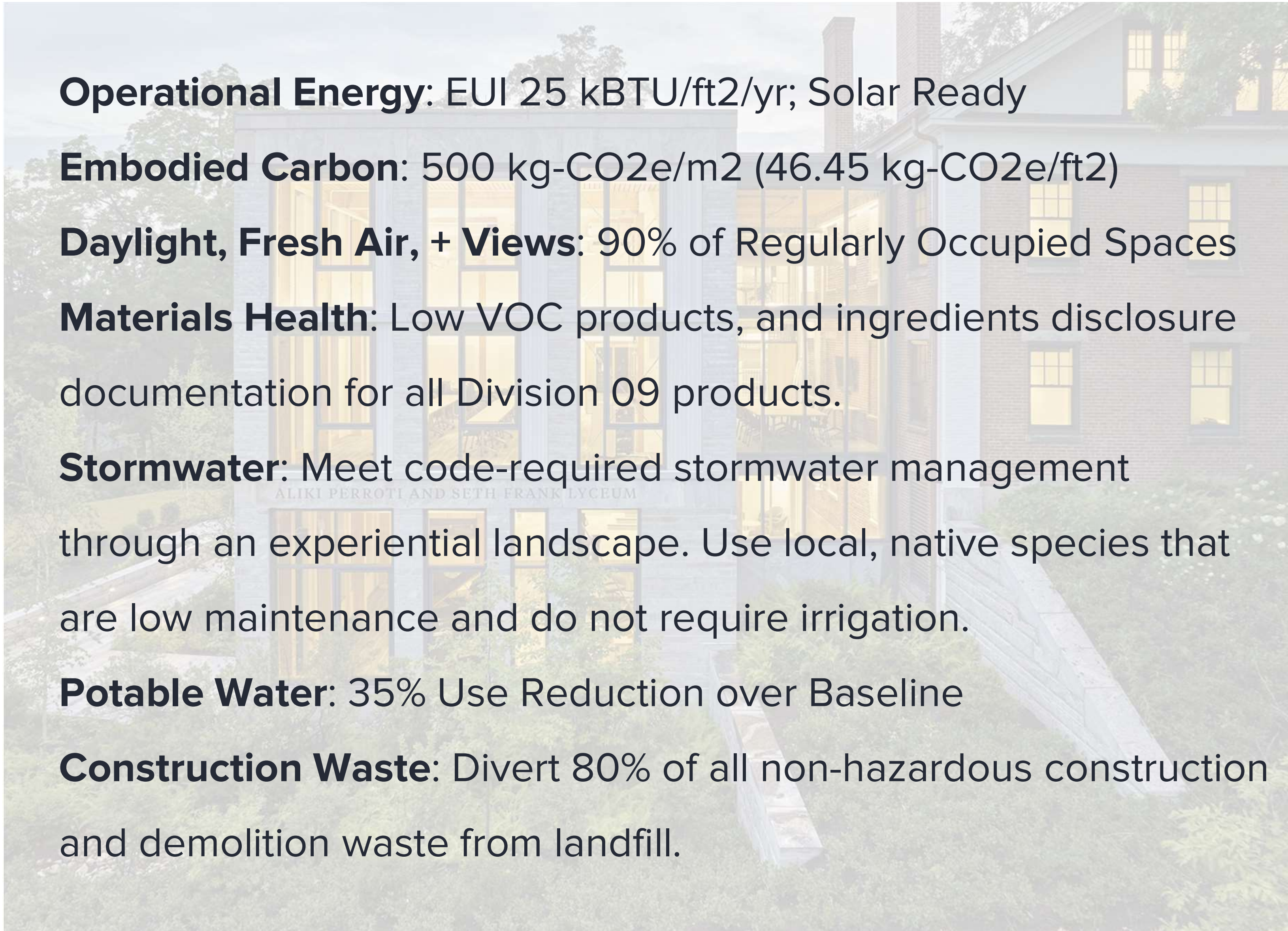


Global Temperature Projections for various RCP Scenarios

Source: Architecture 2030; Adapted from IPCC Fifth Assessment Report, 2013
Representative Concentration Pathways (RCP), temperature projections for SRES scenarios and the RCPs.


CLF
Carbon
Leadership
Forum
phius
ZERO CARBON
CERTIFICATION
ZERO ENERGY
CERTIFICATION
LIVING
BUILDING
CHALLENGE

B/C



Operational Energy: EUI 25 kBTU/ft2/yr; Solar Ready

Embodied Carbon: 500 kg-CO2e/m2 (46.45 kg-CO2e/ft2)

Daylight, Fresh Air, + Views: 90% of Regularly Occupied Spaces

Materials Health: Low VOC products, and ingredients disclosure documentation for all Division 09 products.

Stormwater: Meet code-required stormwater management through an experiential landscape. Use local, native species that are low maintenance and do not require irrigation.

Potable Water: 35% Use Reduction over Baseline

Construction Waste: Divert 80% of all non-hazardous construction and demolition waste from landfill.

SUSTAINABLE DESIGN

LOW CARBON - EMBODIED


WOOD STRUCTURE


CEDAR CLADDING


REGIONAL STONE

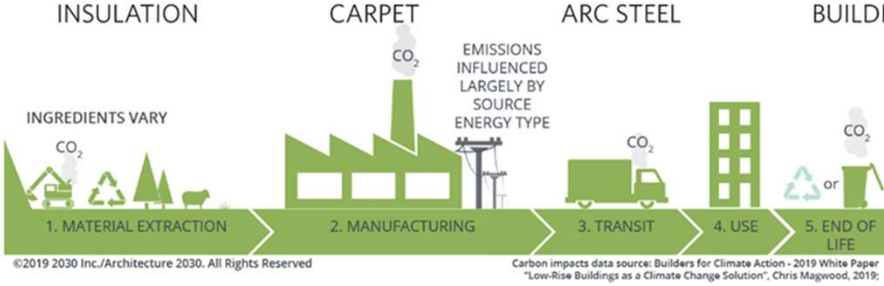

HFO FOAM


CELLULOSE INSULATION

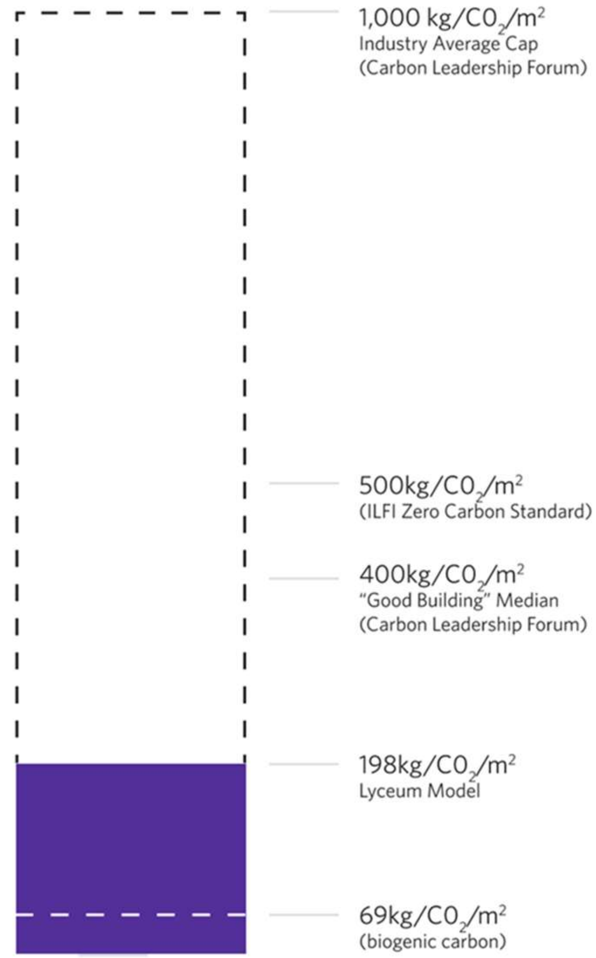

BIOPOLYMER CARPET


REGIONAL ELEC. ARC STEEL


REUSE MASONRY BUILDING



LIFE CYCLE



LYCEUM CARBON MODEL

Phases A1-A3, per Tally analysis of CD Model

SUSTAINABLE DESIGN

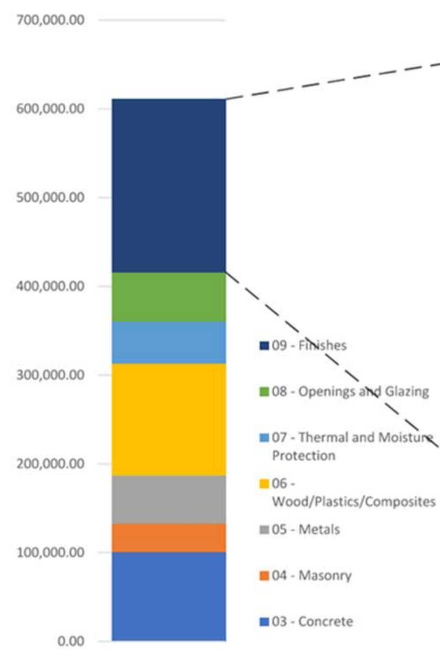
LOW CARBON - EMBODIED

Initial target of 500 kg-CO2e/m2 Global Warming Potential (GWP) follows International Living Future Institute guidance (from Zero Carbon Standard).

Note: measurements in this presentation include reductions for biogenic carbon (carbon storage).

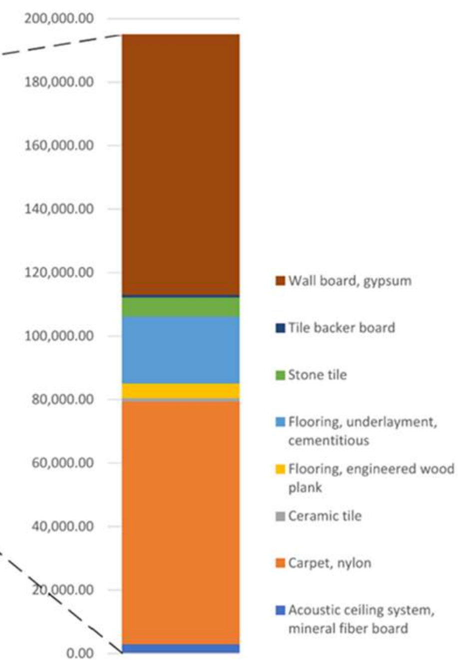
Construction Specifications:

- Provide 100% FSC for all wood products
- Request product specific EPDs for Primary Materials (structure, foundation, enclosure) and Finishes
- Provide HFO foam
- Provide regional steel from electric arc furnaces
- Provide high % Supplimenting Cement Materials (SCMs)
- Provide EPS rigid insulation
- Select Interface Embodied Beauty line (Carbon Negative)
- Select USG EcoSmart gypsum board (50% savings over baseline)



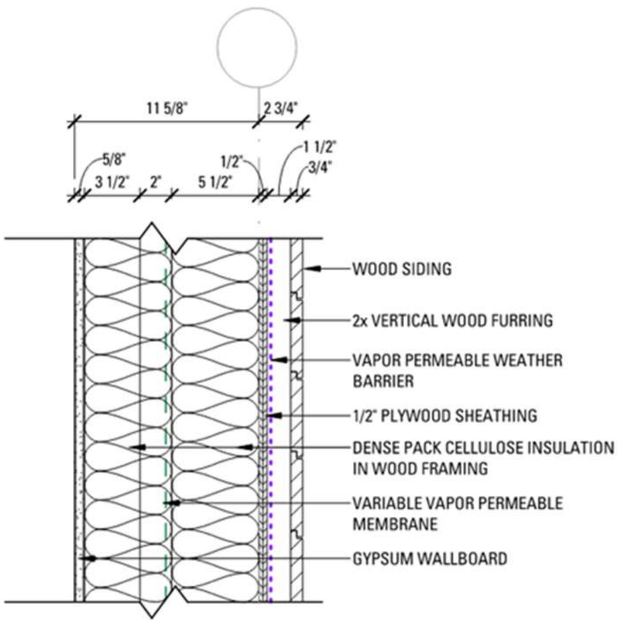
GWP BY DIVISION

Phases A1-C4, per Tally analysis of CD Model

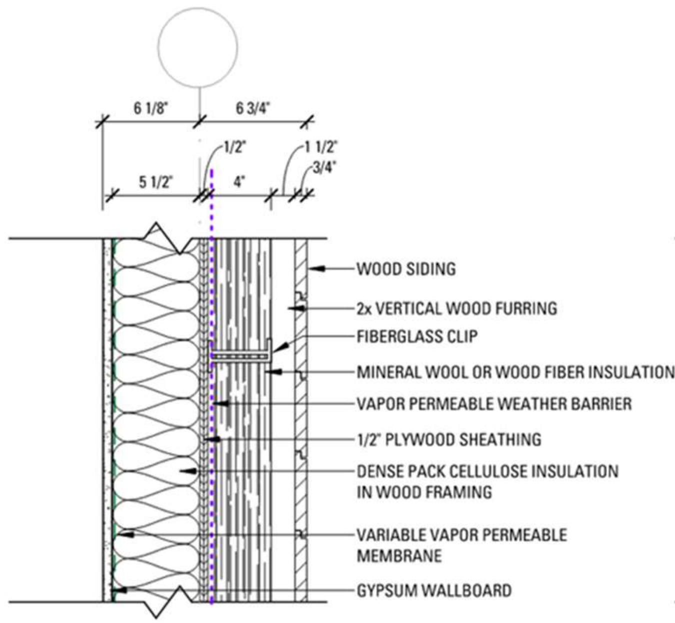


GWP OF FINISHES

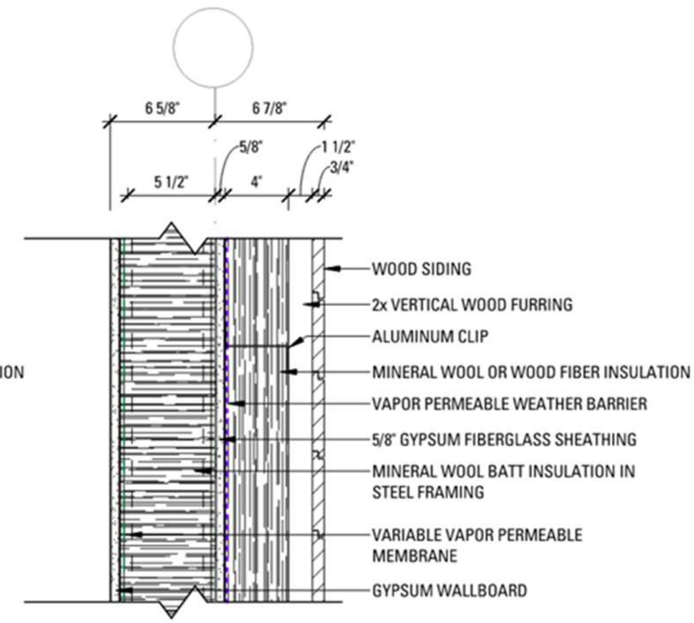
Phases A1-C4, per Tally analysis of CD Model



Wood Double Stud
Cellulose



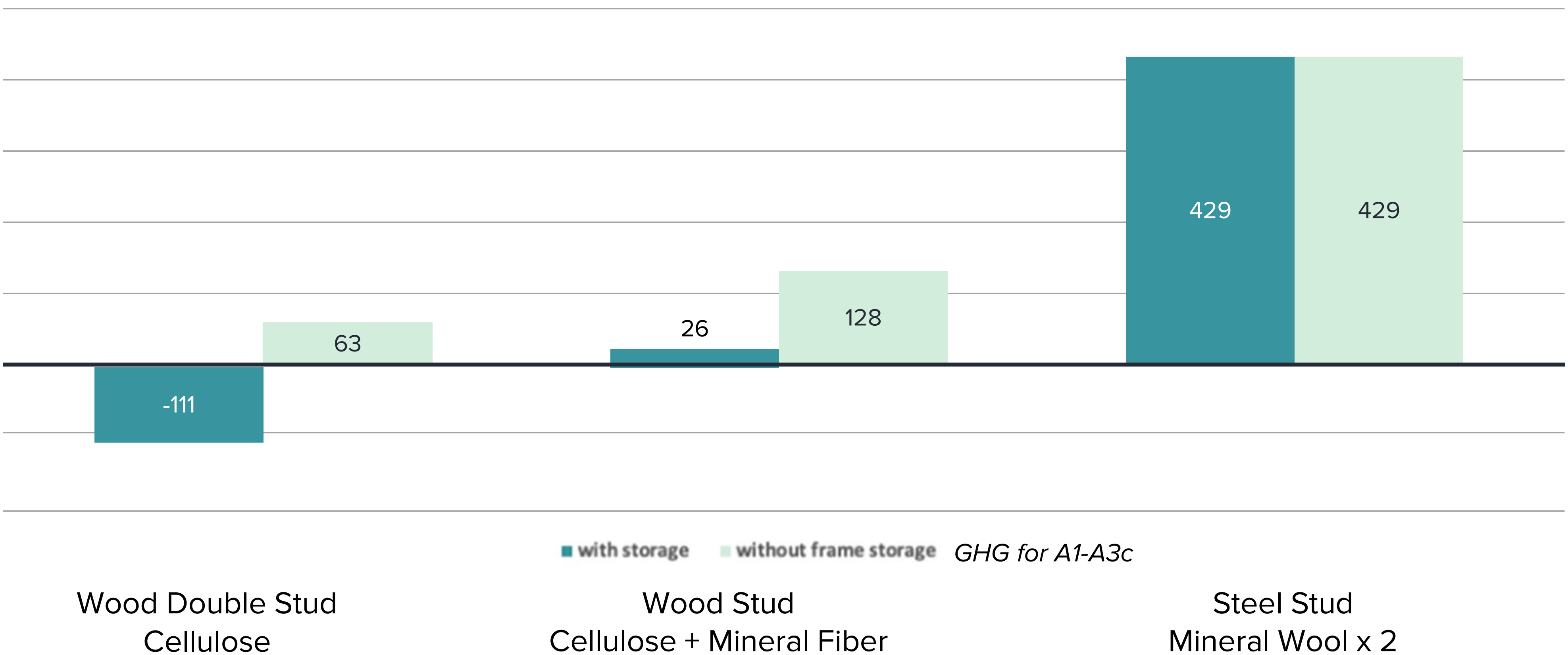
Wood Stud
Cellulose + Mineral Fiber



Steel Stud
Mineral Wool x 2

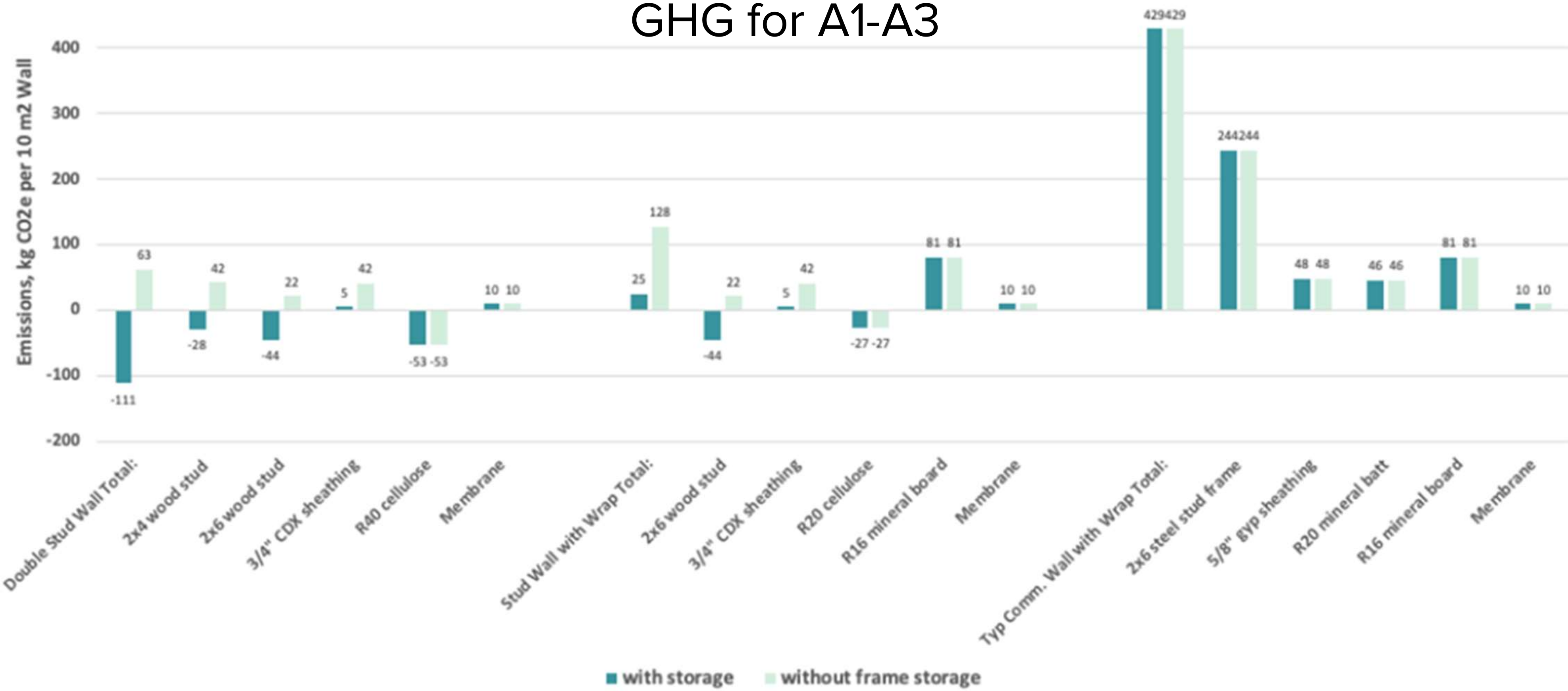
New Frameworks
BRUNER / COTT ARCHITECTS

GHG for A1-A3



New Frameworks BRUNER / COTT ARCHITECTS

GHG for A1-A3



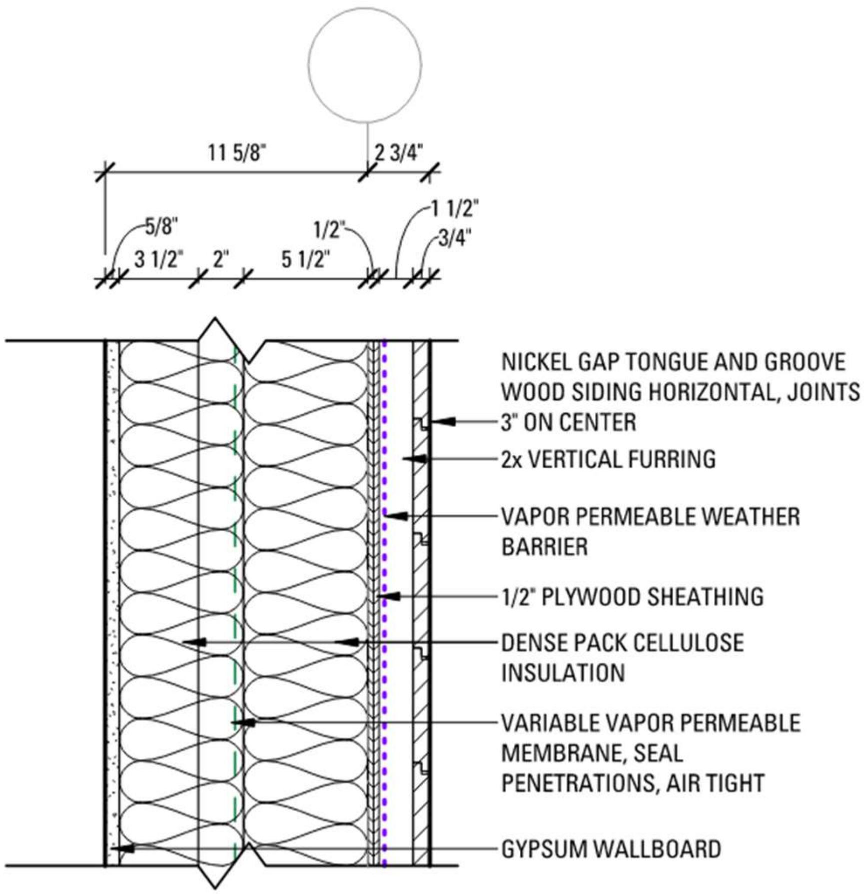
Wood Double Stud
Cellulose

Wood Stud
Cellulose + Mineral Fiber

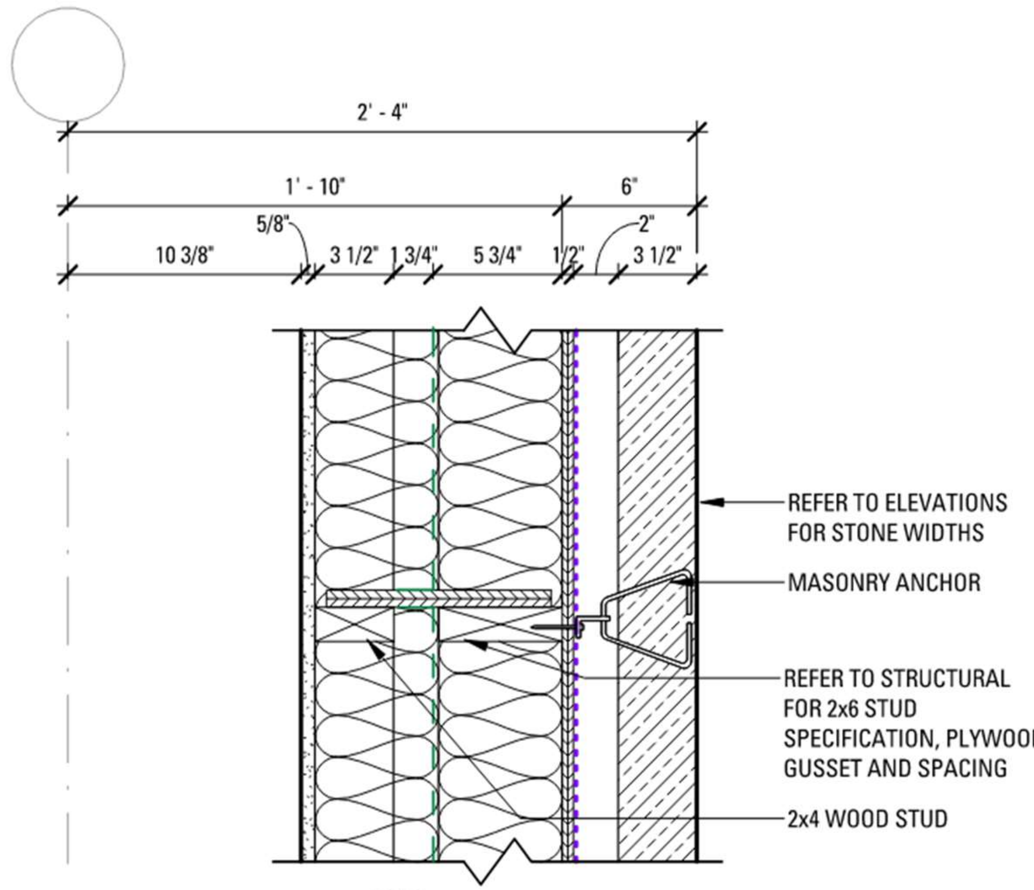
Steel Stud
Mineral Wool x 2

New Frameworks

BRUNER / COTT ARCHITECTS



SECTION



PLAN

Figure 2. Cellulose insulation netting install

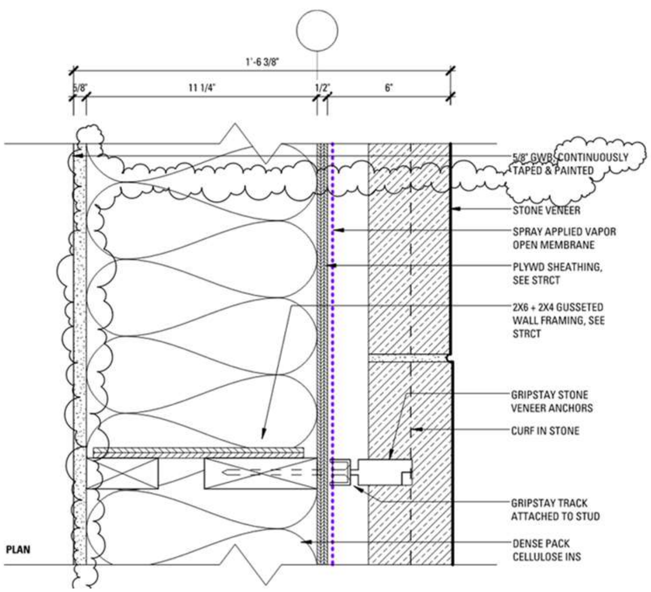
Figure 3. Stapling insulation netting

Figure 4. Location and spacing of netting staples

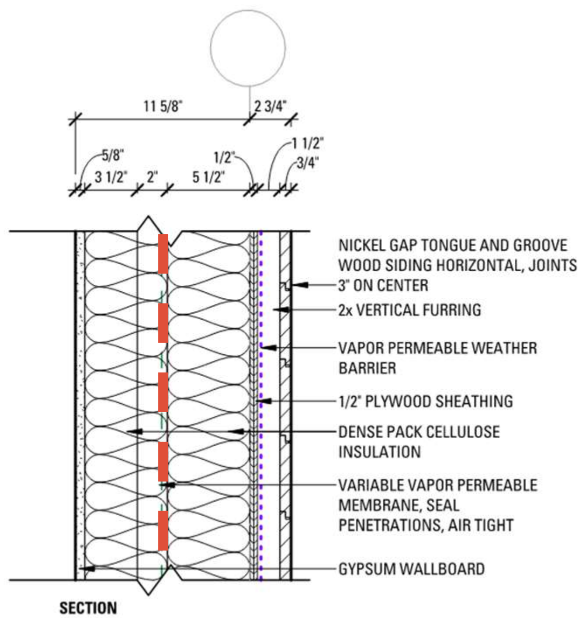
Figure 5. Location and spacing of netting staples


SIGA
Majrex®

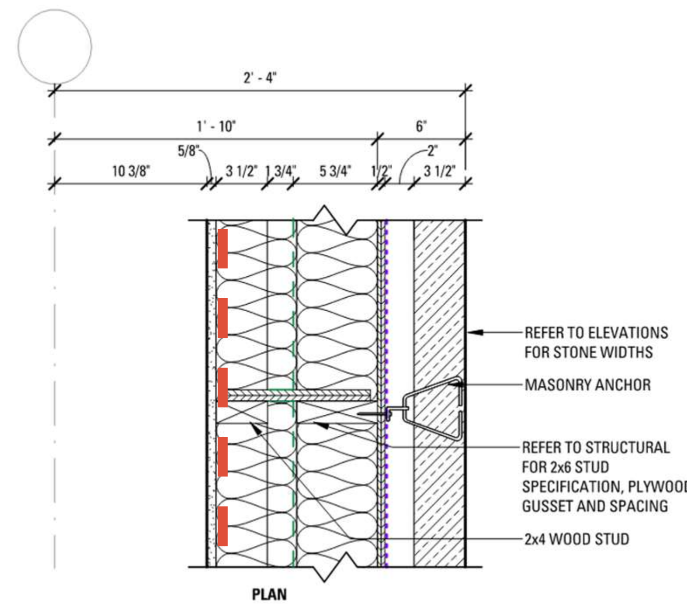
Paint as Vapor Retarder



Variable Vapor Retarder Middle



Variable Vapor Retarder Interior



RW Kern Center

Lyceum

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Moisture Data and Analysis

University *of* Massachusetts Amherst

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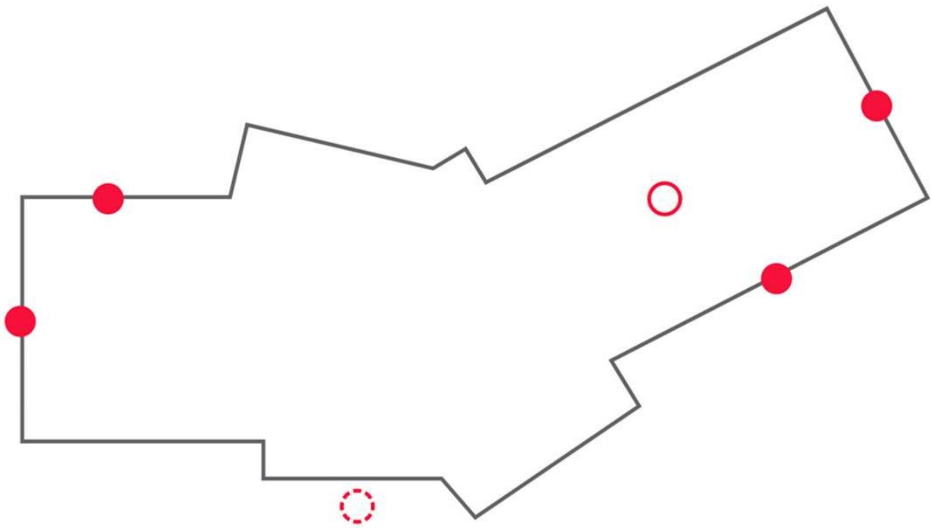
R.W. KERN CENTER

Availability of **3 years of post-occupancy data** to conduct the hygrothermal investigation.

Monitored areas of interest:
- Interior of the DSWW assembly.
- Interior Conditioned Space (interior boundary condition).
- Exterior Weather (exterior boundary condition)

R.W. KERN CENTER



Interior Control (Interior Conditioned Space **Air**)

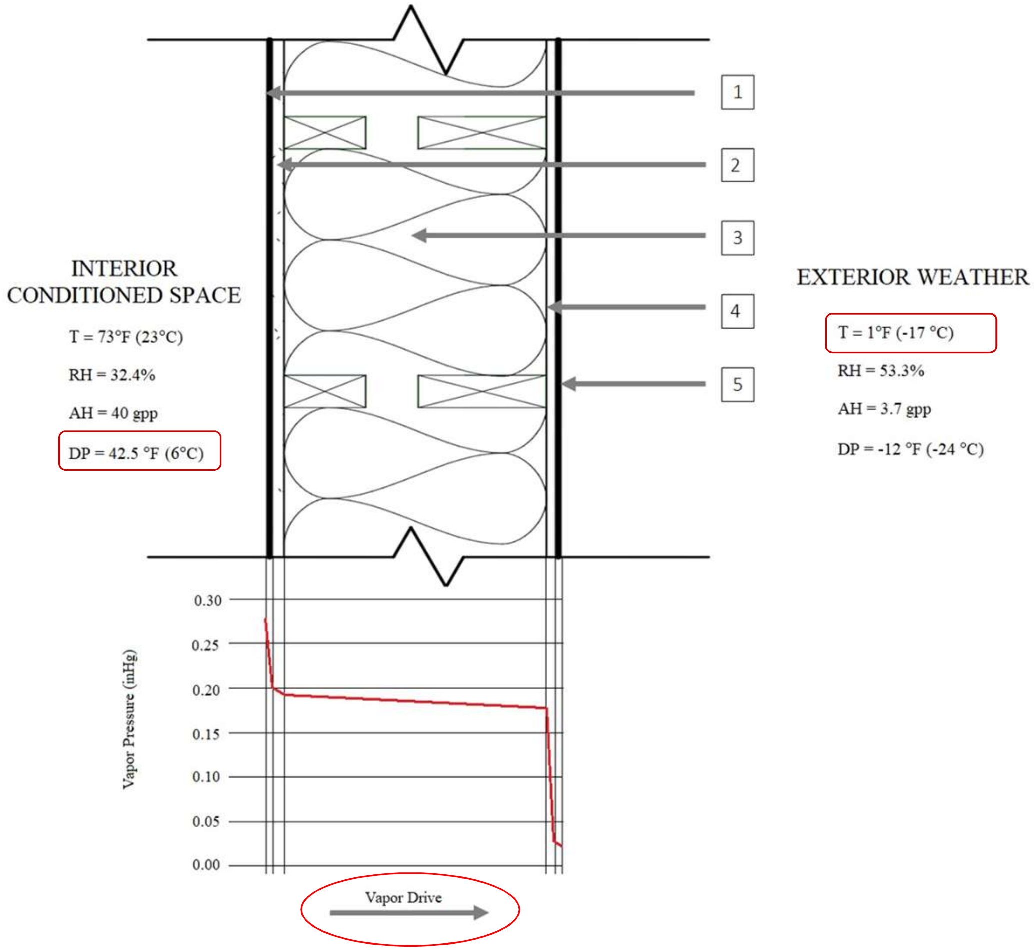
Exterior Control (Outdoors - Ambient **Air**)

Wall Sensor Set (2 sensors within the wall - **Wood**-mounted)

Water Vapor Profiles

Winter

Heating Design Day: December 16th, 2016			
Interior Conditioned Space: **T** = 73°F (23°C), **RH** = 32.4%, **AH** = 40 gpp, **DP** = 42.5°F (6°C)			
Exterior Weather: **T** = 1°F (-17°C), **RH** = 53.3%, **AH** = 3.7 gpp, **DP** = -12°F (-24°C)			
	Components****	**Permeance (perms)**	**VP (inHg)**
	Interior Conditioned Space (air)	250	0.27
1	Water-base coating (Class III Vapor Retarder)	2.5	0.20
2	5/8" Gypsum Wall Board (GWB)	19	0.195
3	11 ¼" Dense-Packed Cellulose Insulation	6.6	0.17
4	1/2" Plywood	1	0.03
5	Air/Water Barrier	14	0.02
	Exterior Weather (air)	100	0.02
	Total Change in Vapor Pressure		**0.25**



Water Vapor Profiles

Summer

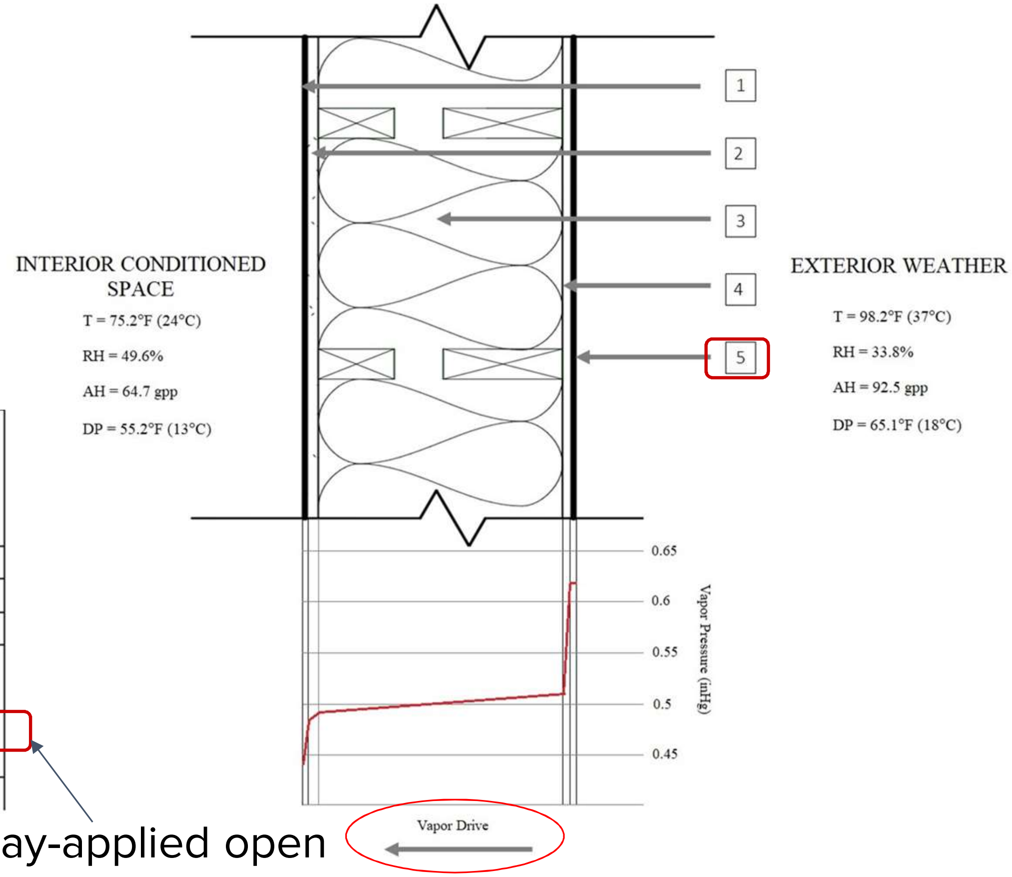
Typical Summer Day: July 21st, 2017

Interior Conditioned Space: **T** = 75.2°F (24°C), **RH** = 49.6%, **AH** = 64.7 gpp, **DP** = 55.2°F (13°C)

Exterior Weather: **T** = 98.2°F (37°C), **RH** = 33.8%, **AH** = 92.5 gpp, **DP** = 65.1°F (18°C)

	Component	Permeance (perms)	VP (inHg)
	Interior Conditioned Space (air)	250	0.44
1	Water-base coating (Class III Vapor Retarder)	2.5	0.48
2	5/8" Gypsum Wall Board (GWB)	19	0.49
3	11 ¼" Dense-Packed Cellulose Insulation	6.6	0.51
4	1/2" Plywood	1	0.62
5	Air/Water Barrier	14	0.63
	Exterior Weather (air)	100	0.63
	Total Change in Vapor Pressure		**0.19**

Spray-applied open membrane

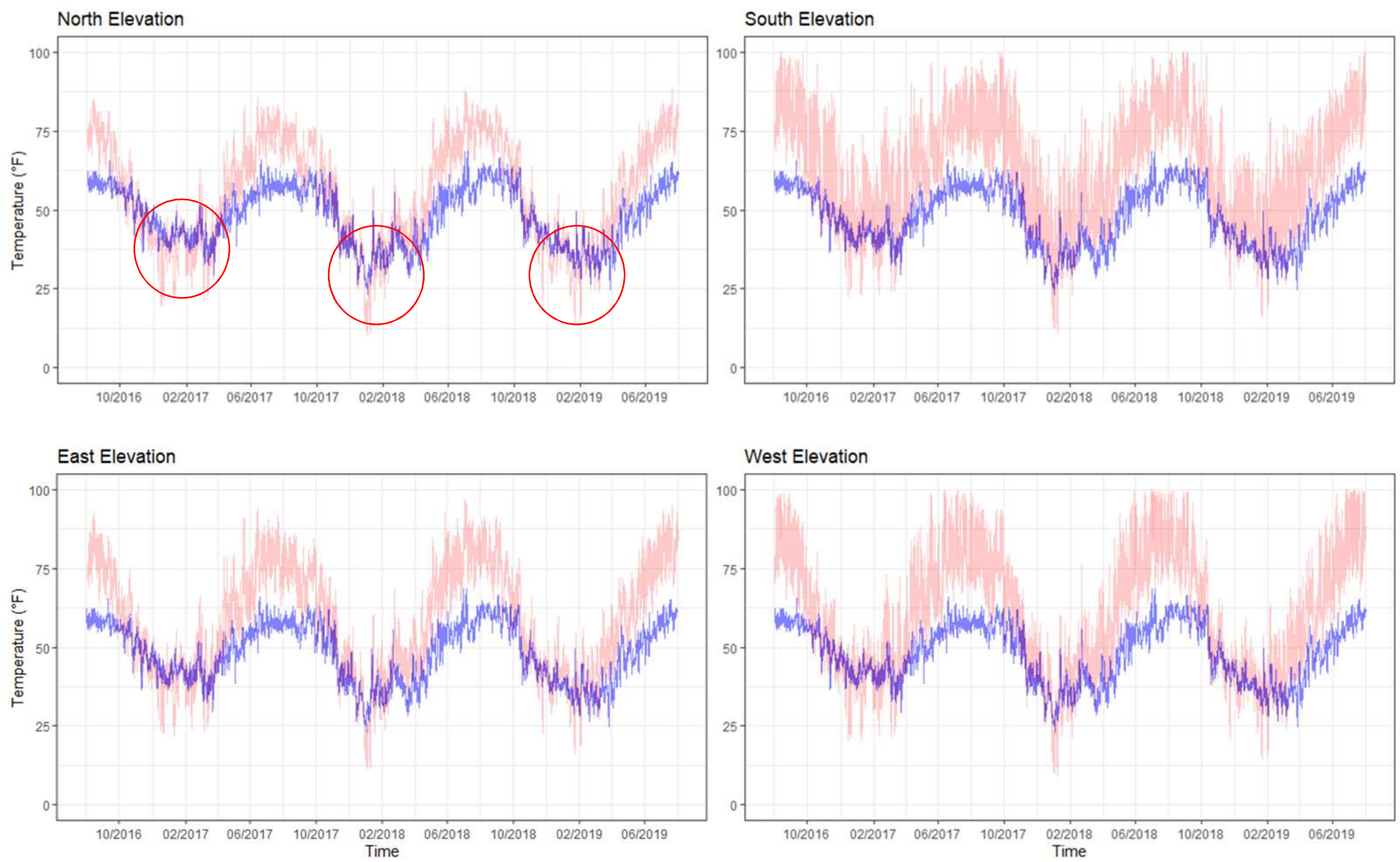


Winter Scenario

Condensation

Temperature of Exterior Sheathing
Dewpoint Temperature of Interior Conditioned Space **Air**

When the air temperature drops below its dew point, **excess moisture will be released** in the form of condensation.

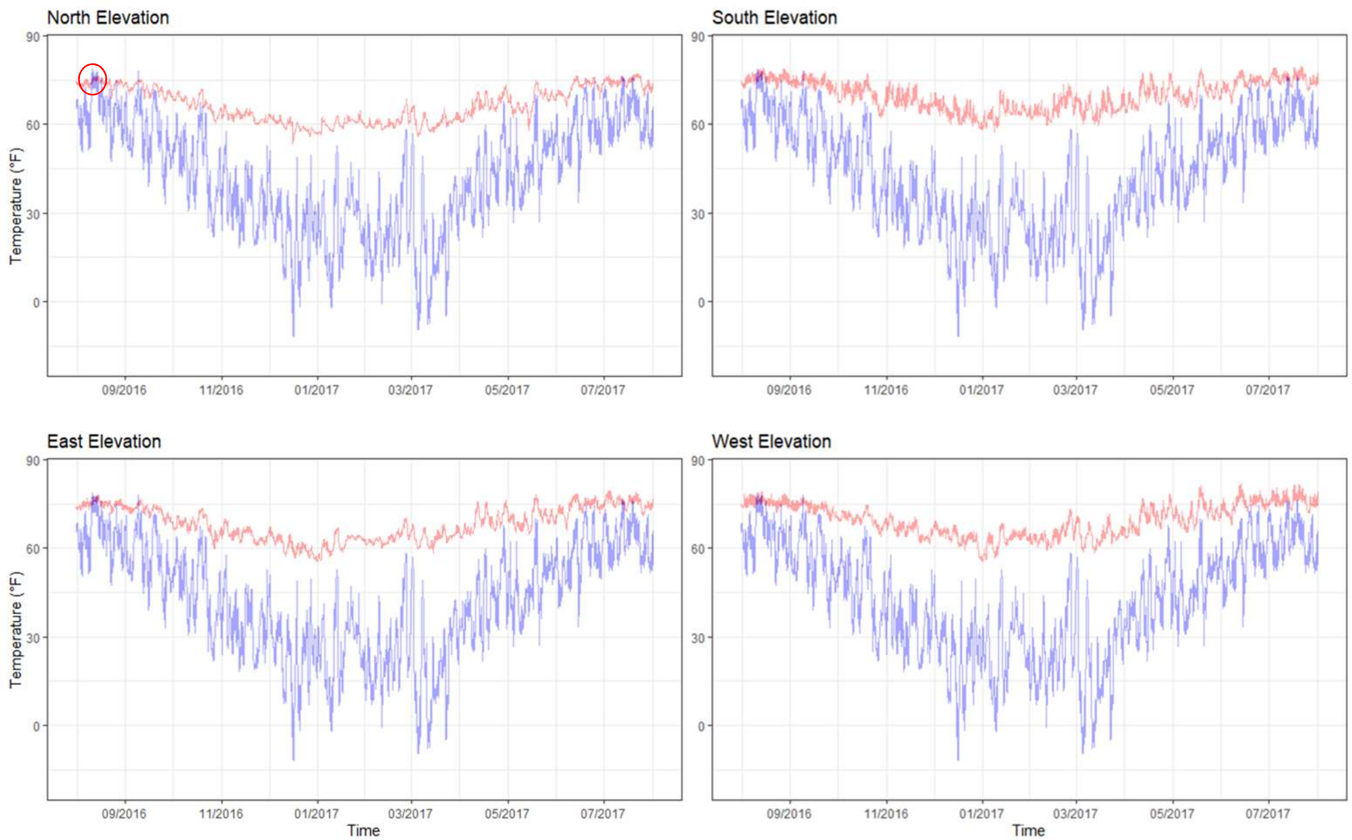


Summer Scenario

Condensation

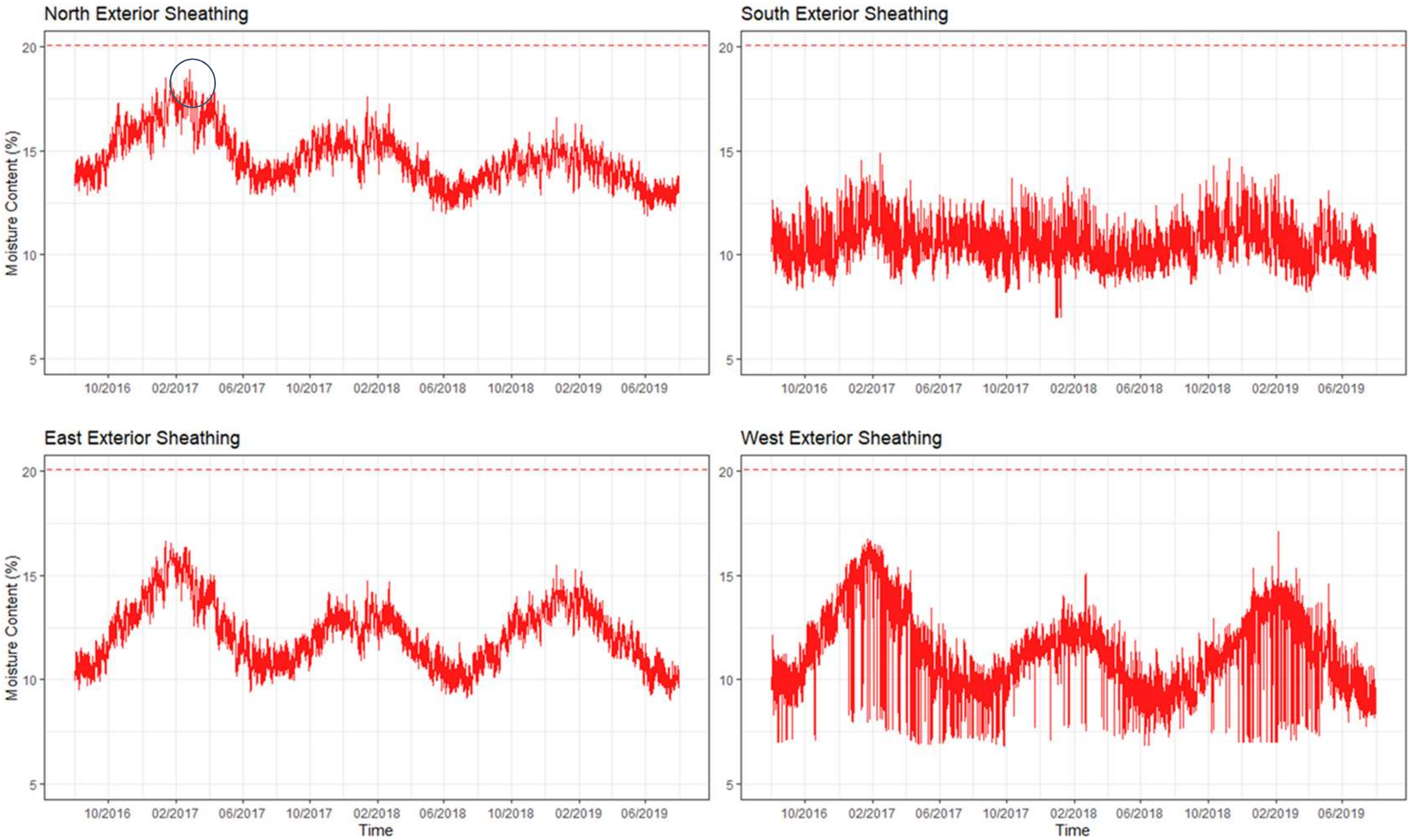
Temperature of Interior Stud
Dewpoint of Exterior Weather

First plane of condensation?



Indicators of Success

Moisture Content in **Wood**



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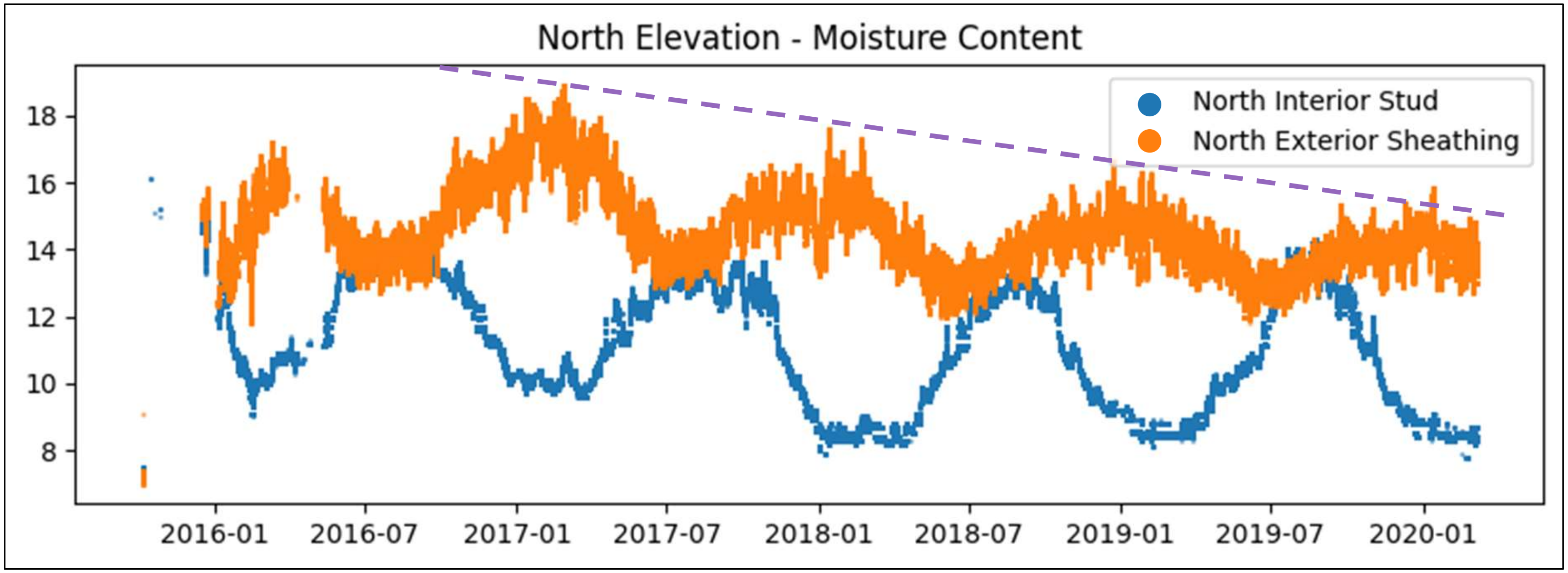
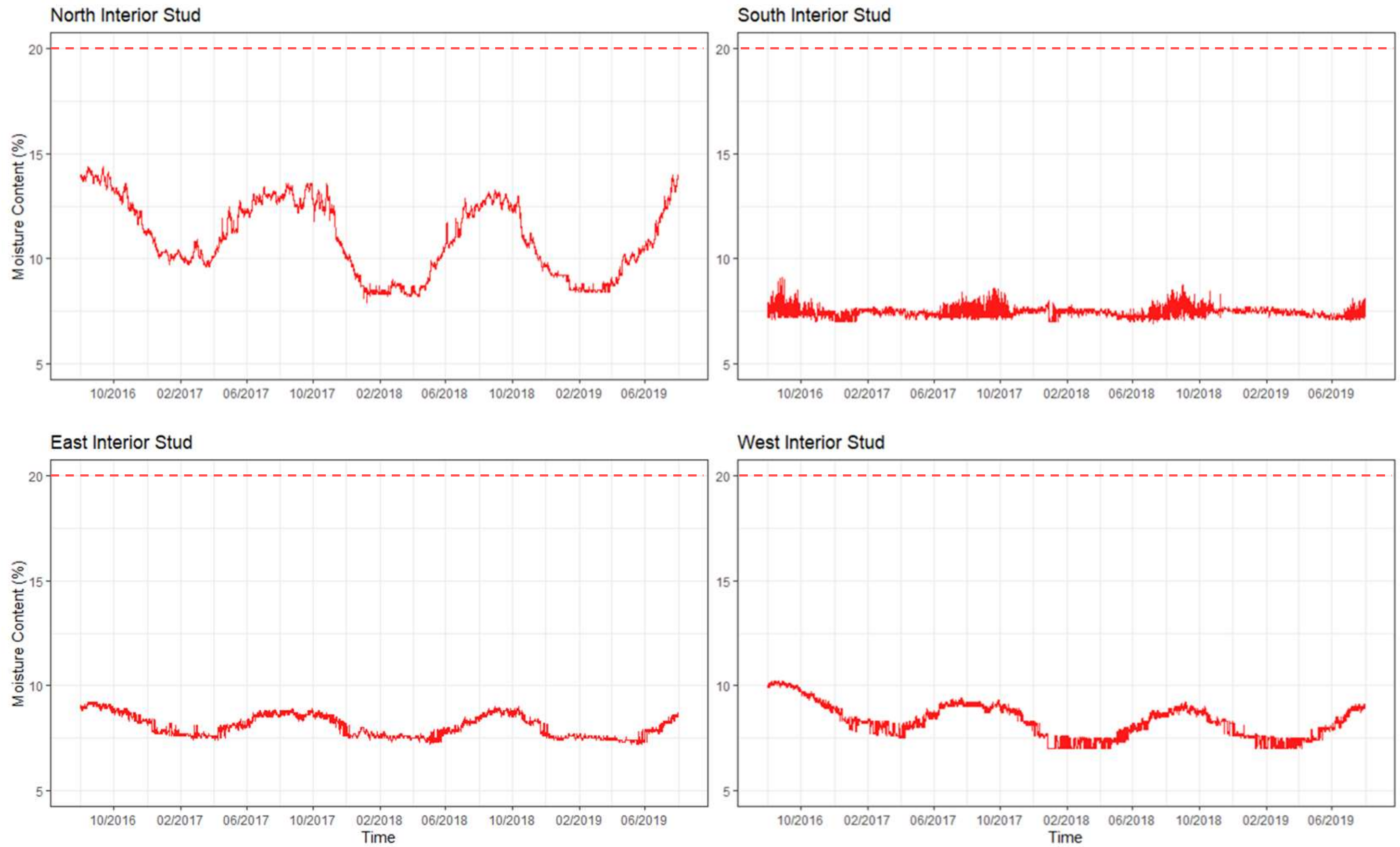


Would this suggest changes in seasonal temperature patterns, potentially linked to **Climate Change**?

Indicators of Success

Moisture Content in **Wood**



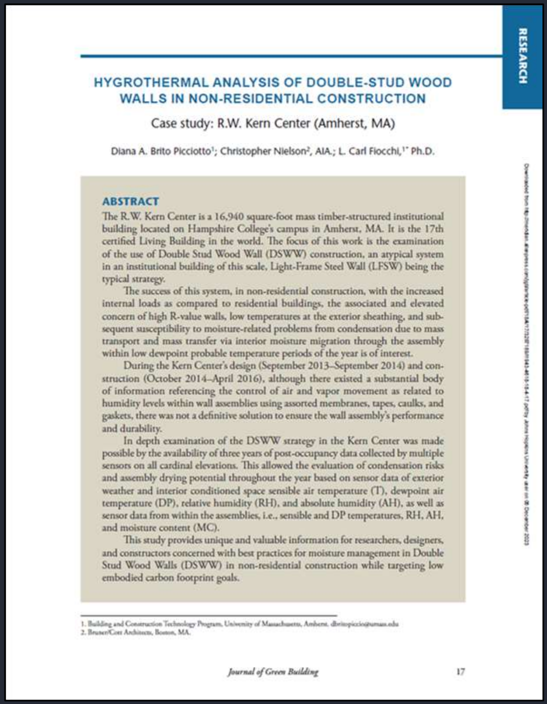
Key takeaways

R.W. KERN CENTER

- **Impact of Interior-Sourced Condensation**: Data clearly indicates that interior-sourced condensation occurred primarily from late fall to mid-spring, with varying frequencies depending on the building's orientation. The South and West elevations showed less condensation compared to the North.

- **Performance of the DSWW Assembly**: The exterior sheathing MC was identified as a key performance indicator. The North elevation, in particular, peaked near the 20% threshold in early years, possibly due to acclimatization of the plywood sheathing after installation.

- **Yearly Trends in Moisture Content**: A noticeable decrease in peak MC levels over time raises the question of whether these changes are a result of building acclimatization or reflect broader environmental shifts, potentially influenced by Climate Change.



RESEARCH

HYGROTHERMAL ANALYSIS OF DOUBLE-STUD WOOD WALLS IN NON-RESIDENTIAL CONSTRUCTION

Case study: R.W. Kern Center (Amherst, MA)

Diana A. Brito Picciotto[1]; Christopher Nielson[2], AIA.; L. Carl Fiocchi,[1*] Ph.D.

ABSTRACT

The R.W. Kern Center is a 16,940 square-foot mass timber-structured institutional building located on Hampshire College's campus in Amherst, MA. It is the 17th certified Living Building in the world. The focus of this work is the examination of the use of Double Stud Wood Wall (DSWW) construction, an atypical system in an institutional building of this scale, Light-Frame Steel Wall (LFSW) being the typical strategy.

The success of this system, in non-residential construction, with the increased internal loads as compared to residential buildings, the associated and elevated concern of high R-value walls, low temperatures at the exterior sheathing, and subsequent susceptibility to moisture-related problems from condensation due to mass transport and mass transfer via interior moisture migration through the assembly within low dewpoint probable temperature periods of the year is of interest.

During the Kern Center's design (September 2013–September 2014) and construction (October 2014–April 2016), although there existed a substantial body of information referencing the control of air and vapor movement as related to humidity levels within wall assemblies using assorted membranes, tapes, caulks, and gaskets, there was not a definitive solution to ensure the wall assembly's performance and durability.

In depth examination of the DSWW strategy in the Kern Center was made possible by the availability of three years of post-occupancy data collected by multiple sensors on all cardinal elevations. This allowed the evaluation of condensation risks and assembly drying potential throughout the year based on sensor data of exterior weather and interior conditioned space sensible air temperature (T), dewpoint air temperature (DP), relative humidity (RH), and absolute humidity (AH), as well as sensor data from within the assemblies, i.e., sensible and DP temperatures, RH, AH, and moisture content (MC).

This study provides unique and valuable information for researchers, designers, and constructors concerned with best practices for moisture management in Double Stud Wood Walls (DSWW) in non-residential construction while targeting low embodied carbon footprint goals.

1. Building and Construction Technology Program, University of Massachusetts, Amherst.
2. Bruner/Cott Architects, Boston, MA.

Journal of Green Building 17

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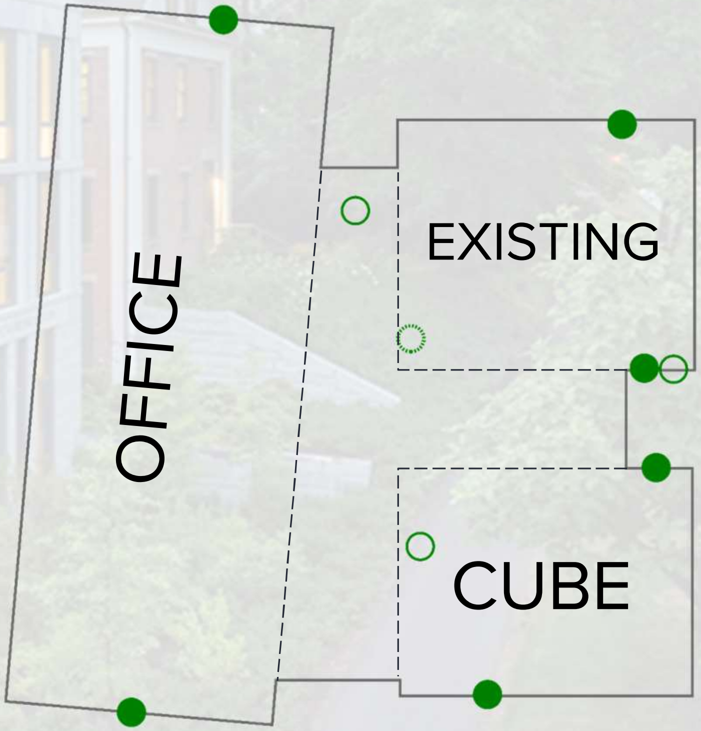
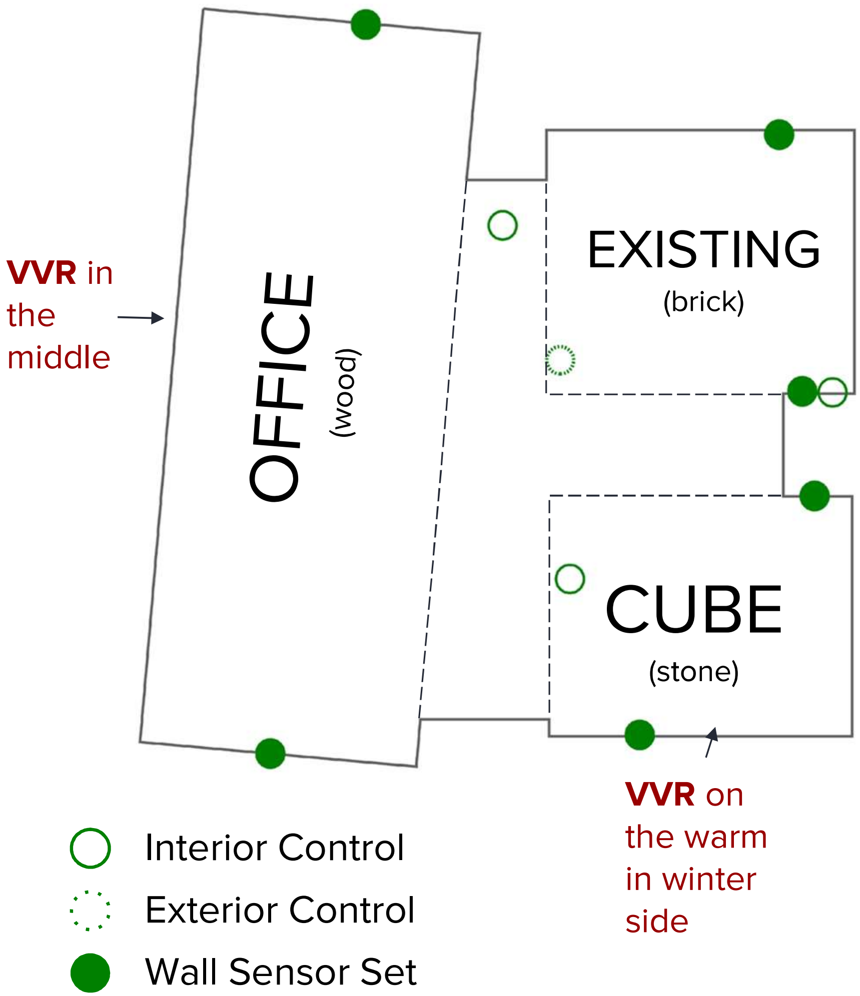
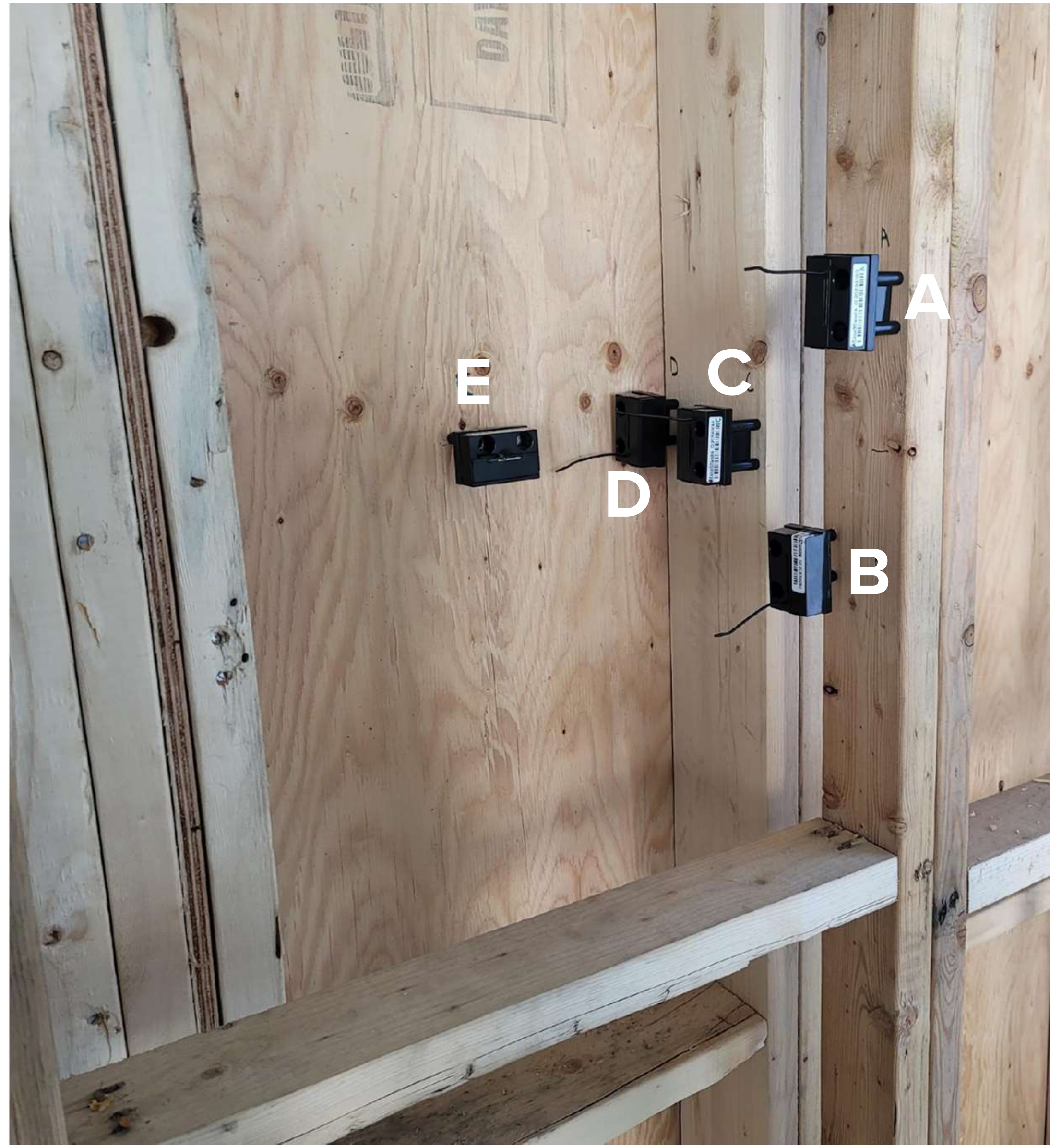
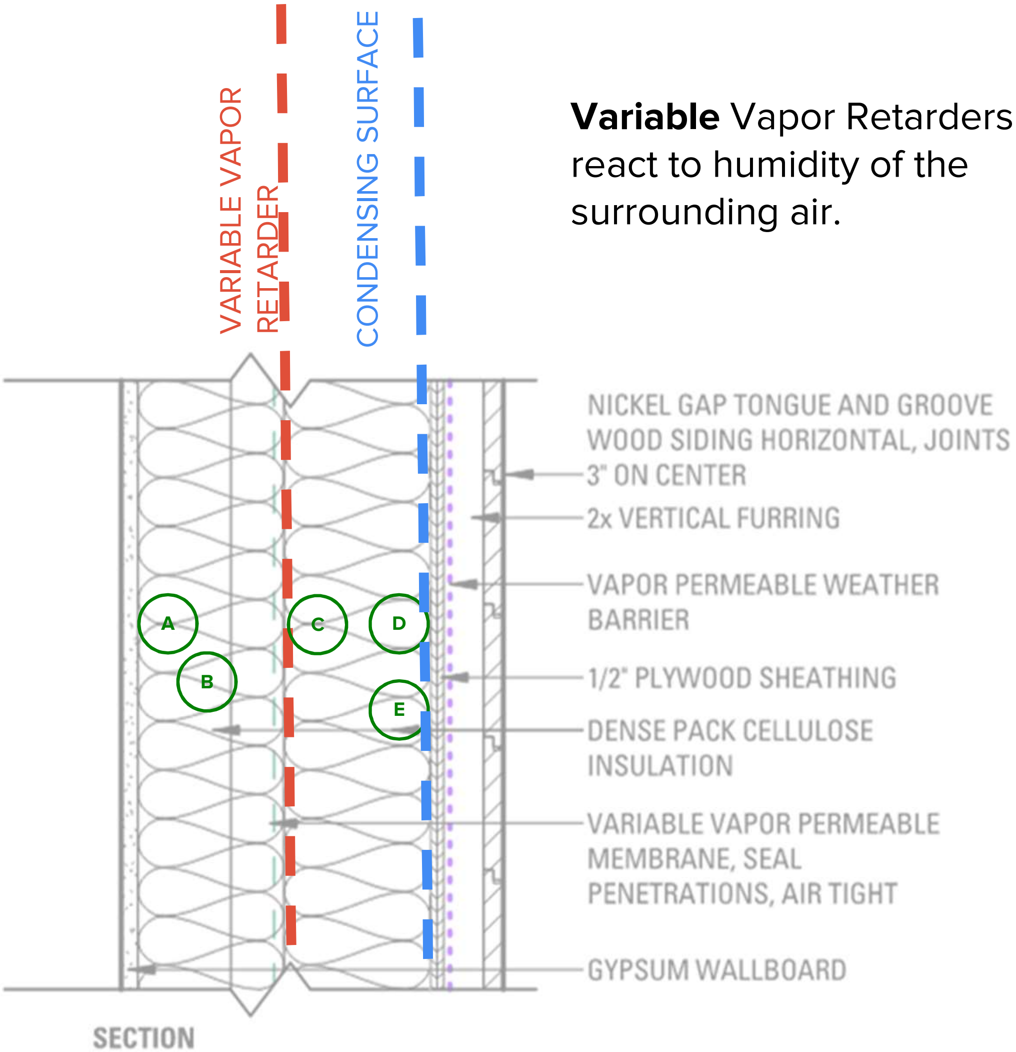
Amherst College



VVR = Variable Vapor Retarder







Variable Vapor Retarders react to humidity of the surrounding air.

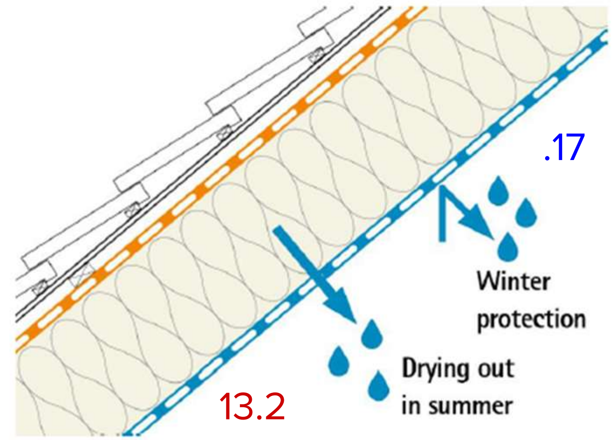
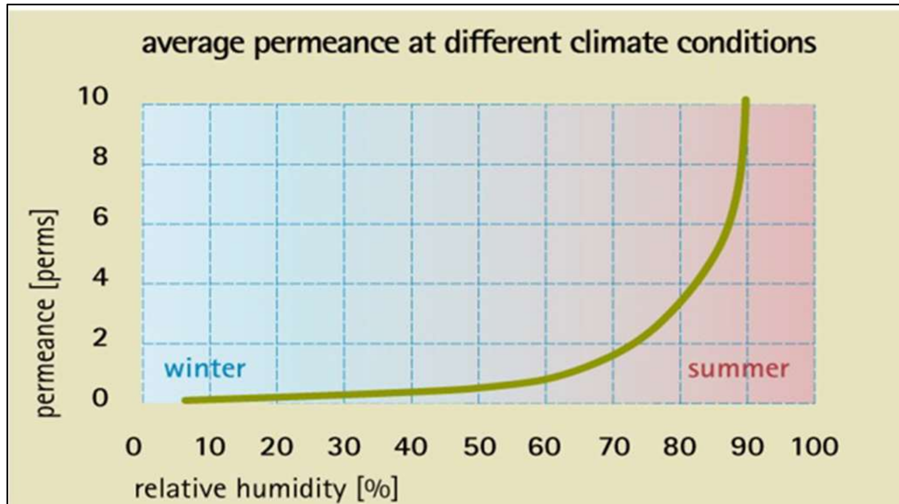


Figure 2: Moisture-variable membranes react to the humidity of the surrounding air

Winter [9]



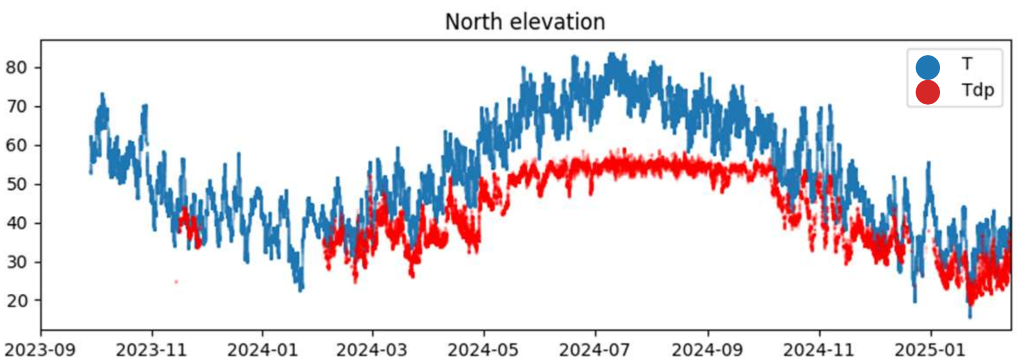
Winter Scenario

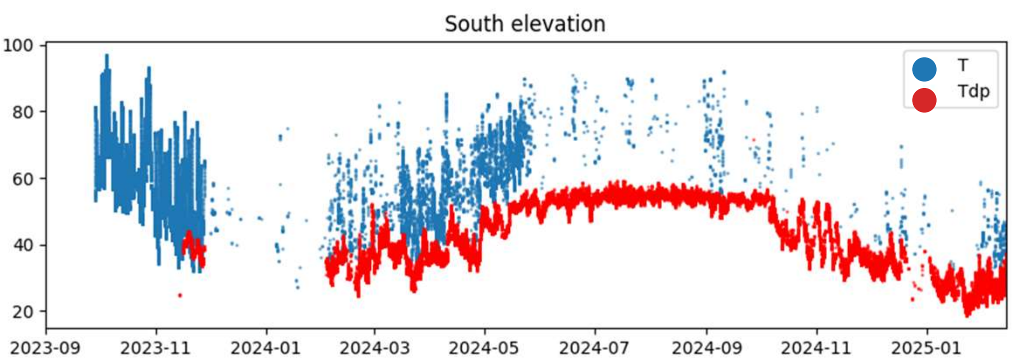
Interior-sourced Condensation within the DSWW

Temperature of **Exterior Sheathing**

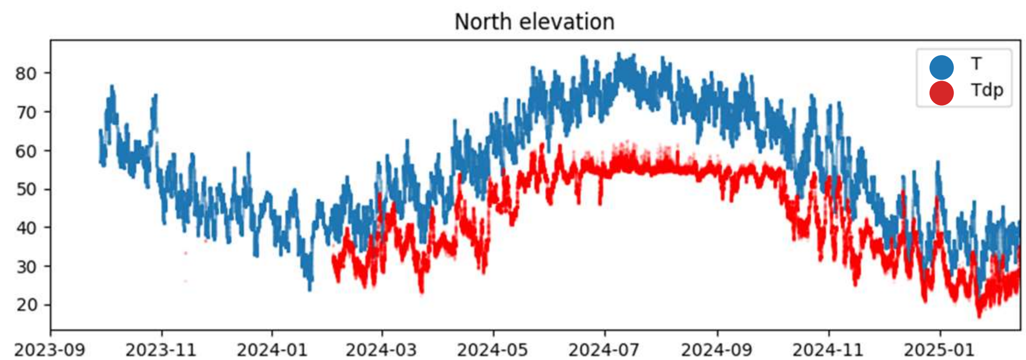
Dewpoint Temperature of Interior Conditioned Space (**Air**)

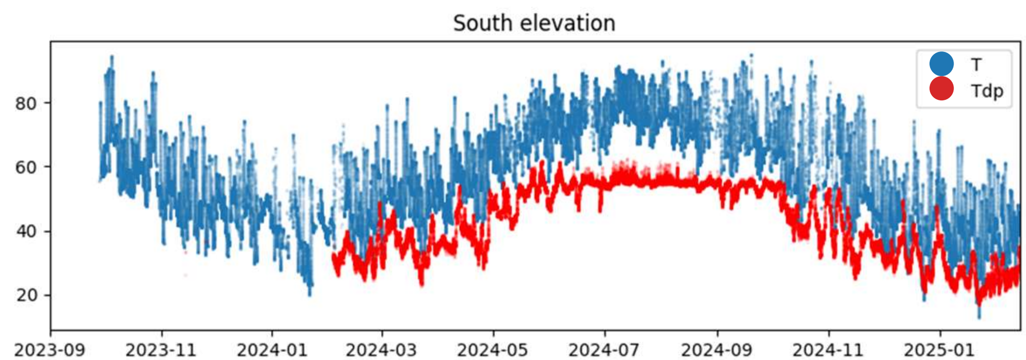
Office





Cube

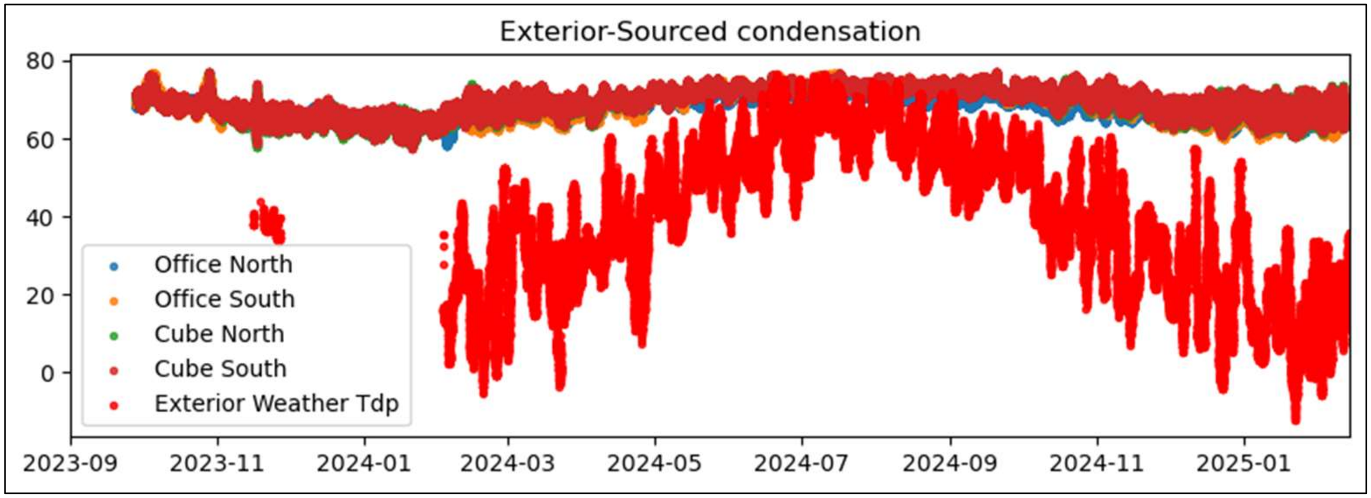




Summer Scenario

Exterior-sourced Condensation

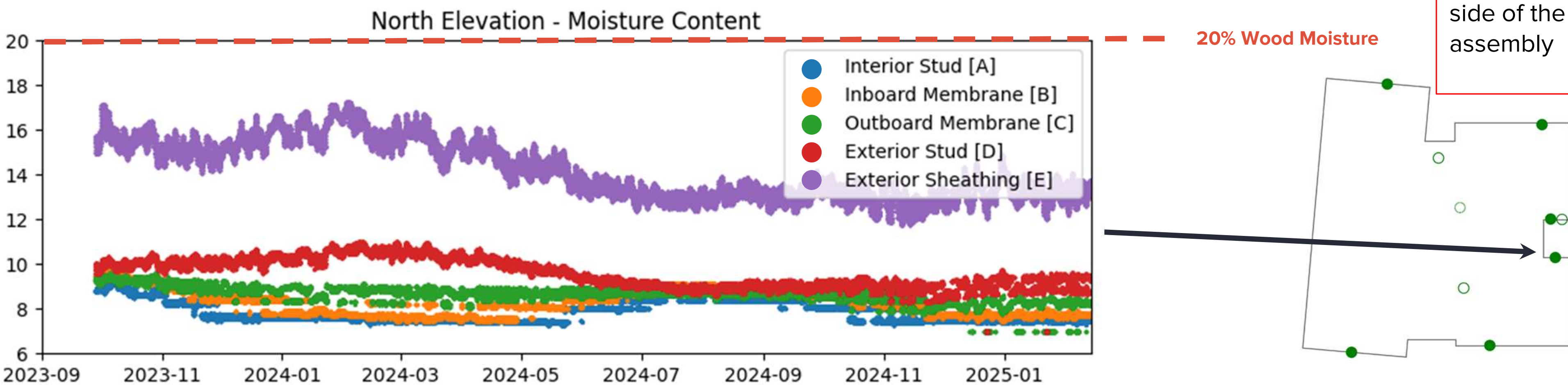
Sensor location: Interior Stud

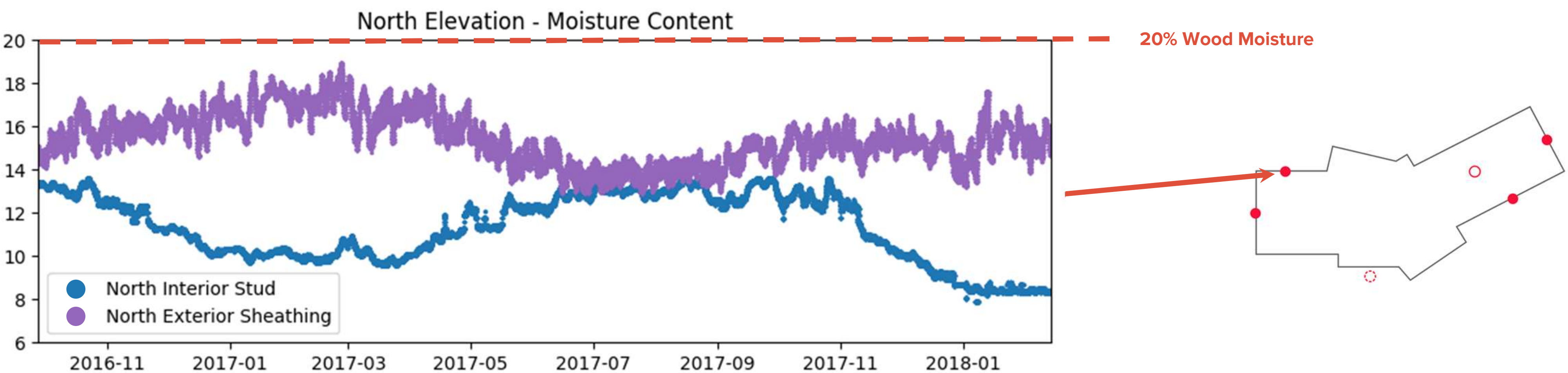


Moisture Content levels?

Wood Moisture: Variable VR or None

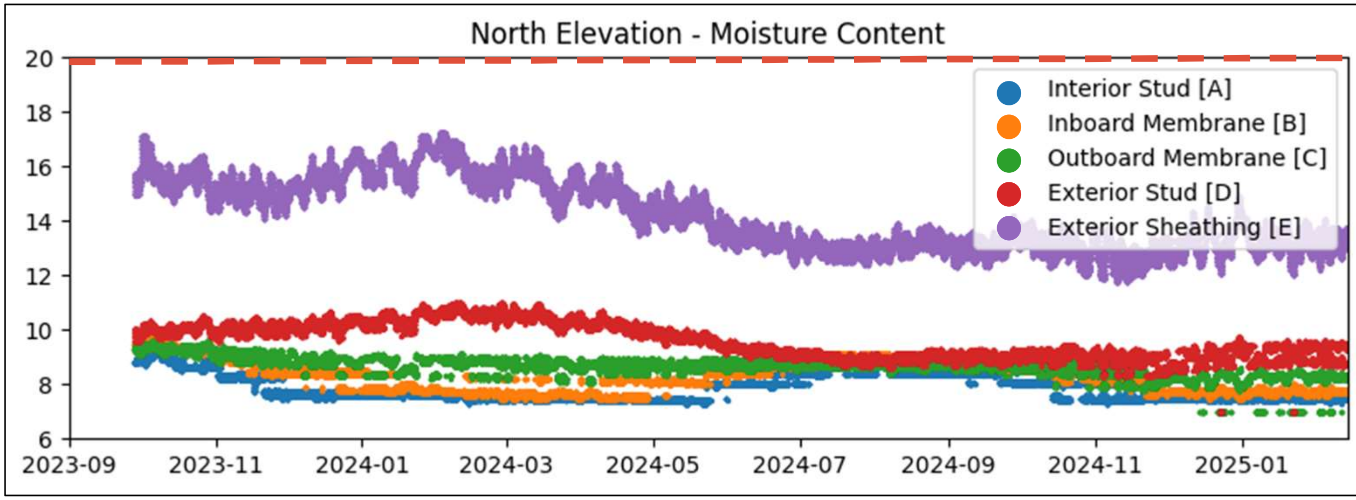
Note: VVR on the "warm-in-winter" side of the assembly





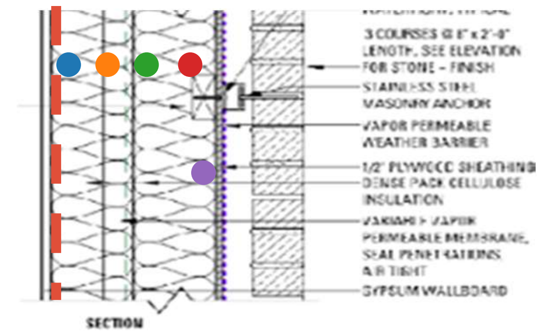
Amherst College Lyceum

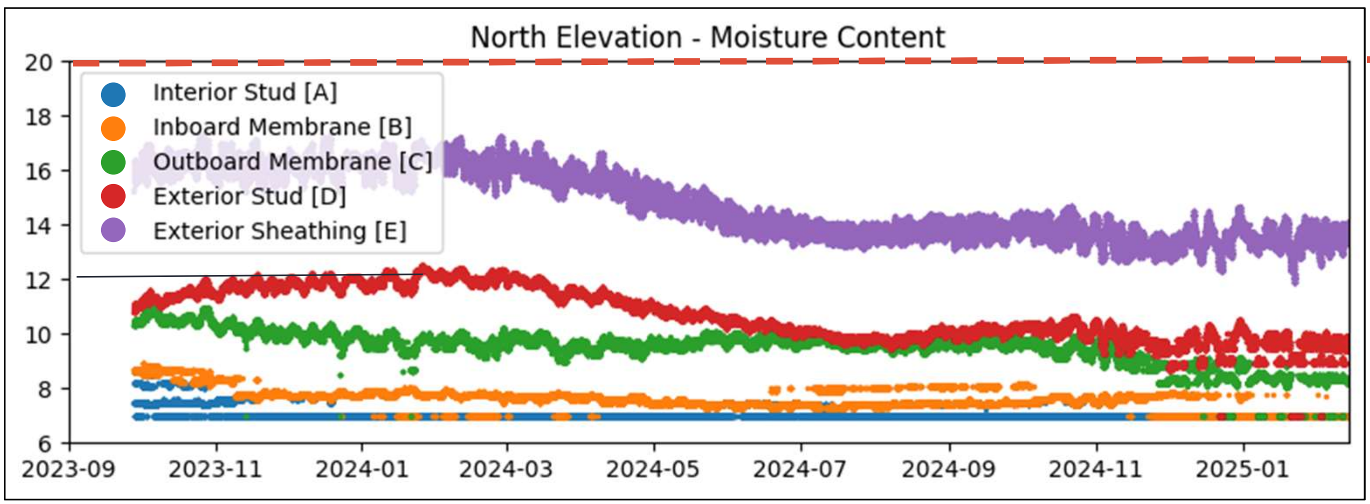
Wood Moisture: **Placement of Variable VR**



20% Wood Moisture

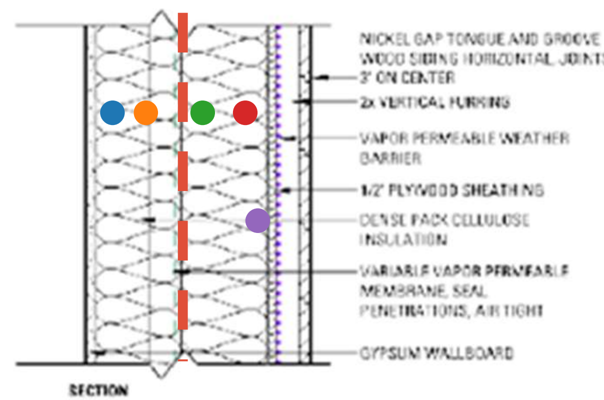
Cube





Office

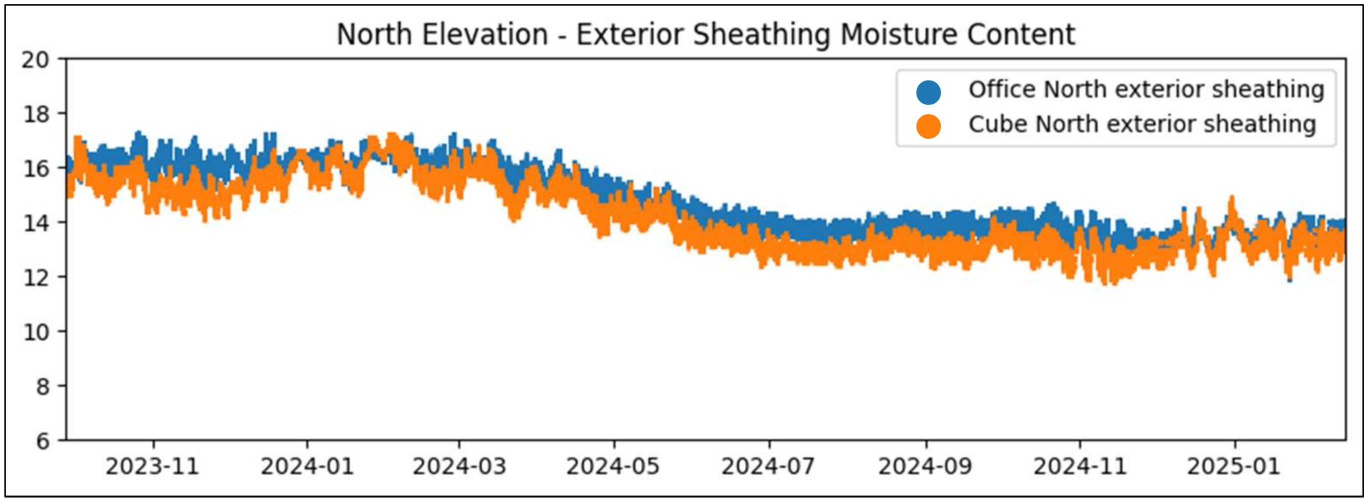
20% Wood Moisture



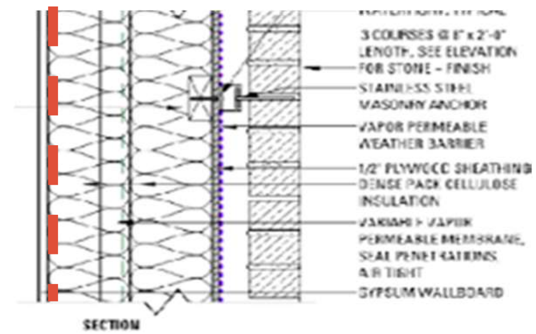
how are MC levels before and after the VVR?

Amherst College Lyceum

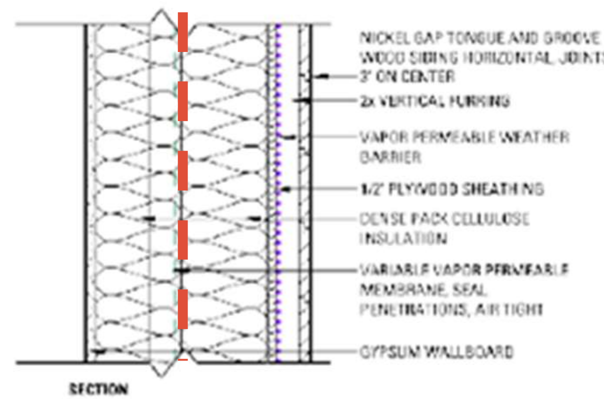
Wood Moisture: **Placement of Variable VR**



Cube



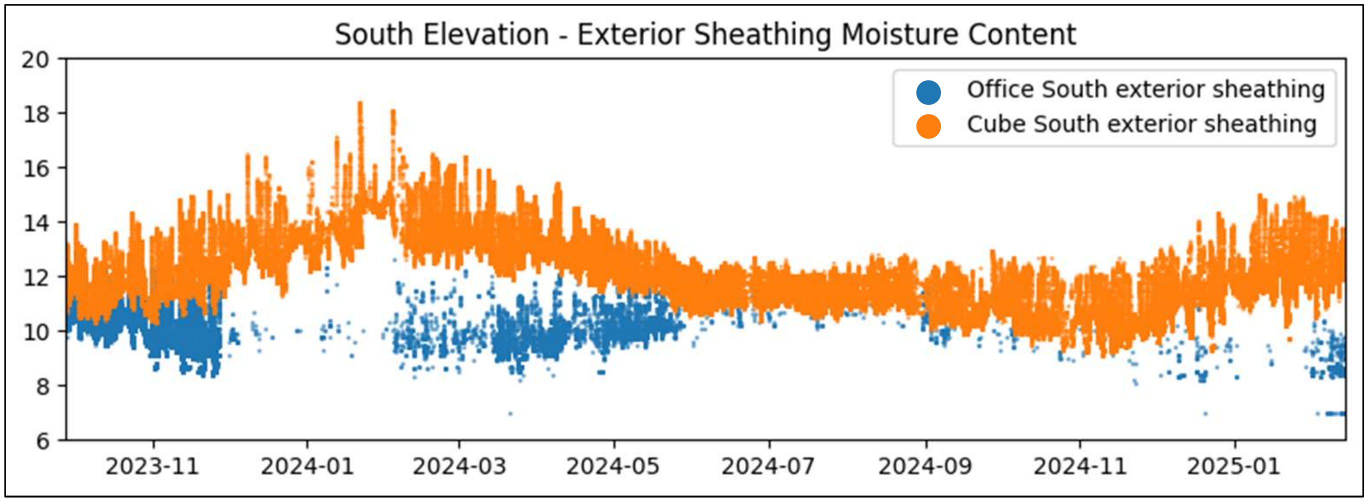
Office



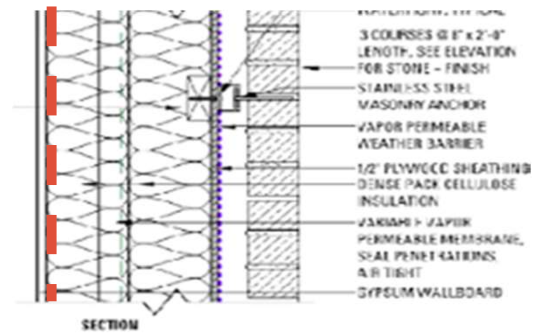
BRUNER / COTT ARCHITECTS

Amherst College Lyceum

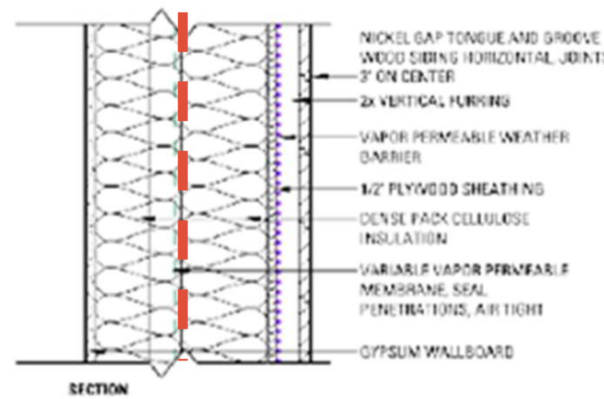
Wood Moisture: **Placement of Variable VR**



Cube



Office



BRUNER / COTT ARCHITECTS

Key takeaways from both buildings

- When comparing the two buildings, Moisture Contents (MC) peaked below the acceptable 20% threshold. The KC approach could be considered risky (19%), but evidence shows that over the years, the most vulnerable layer and elevation never exceeded the acceptable point.

- In the Lyceum, the "Cube," with a VVR positioned on the warm-in-winter side of the assembly, demonstrates slightly better moisture management than the office, particularly on the north elevation and across all sensor locations. This may be due to its ability to limit moisture ingress earlier in the assembly.

- The layer of greatest concern, the sheathing, showed no significant difference between the two Lyceum assembly types.

- On the south elevation, the “Office” was drier than the cube assembly, likely due to higher solar exposure on this facade.

- Overall, all three studied assemblies can be considered resilient against moisture-related degradation.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THANK YOU!

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