



# ROCKY MOUNTAIN INSTITUTE INNOVATION CENTER

NORTH AMERICAN PASSIVE HOUSE CONFERENCE  
SEPTEMBER 11<sup>TH</sup> – 12<sup>TH</sup> 2015

HAYES ZIRNHELT



RMI transforms global energy use to create a clean, prosperous, and secure future.





## RMI INNOVATION CENTER – BASALT, CO

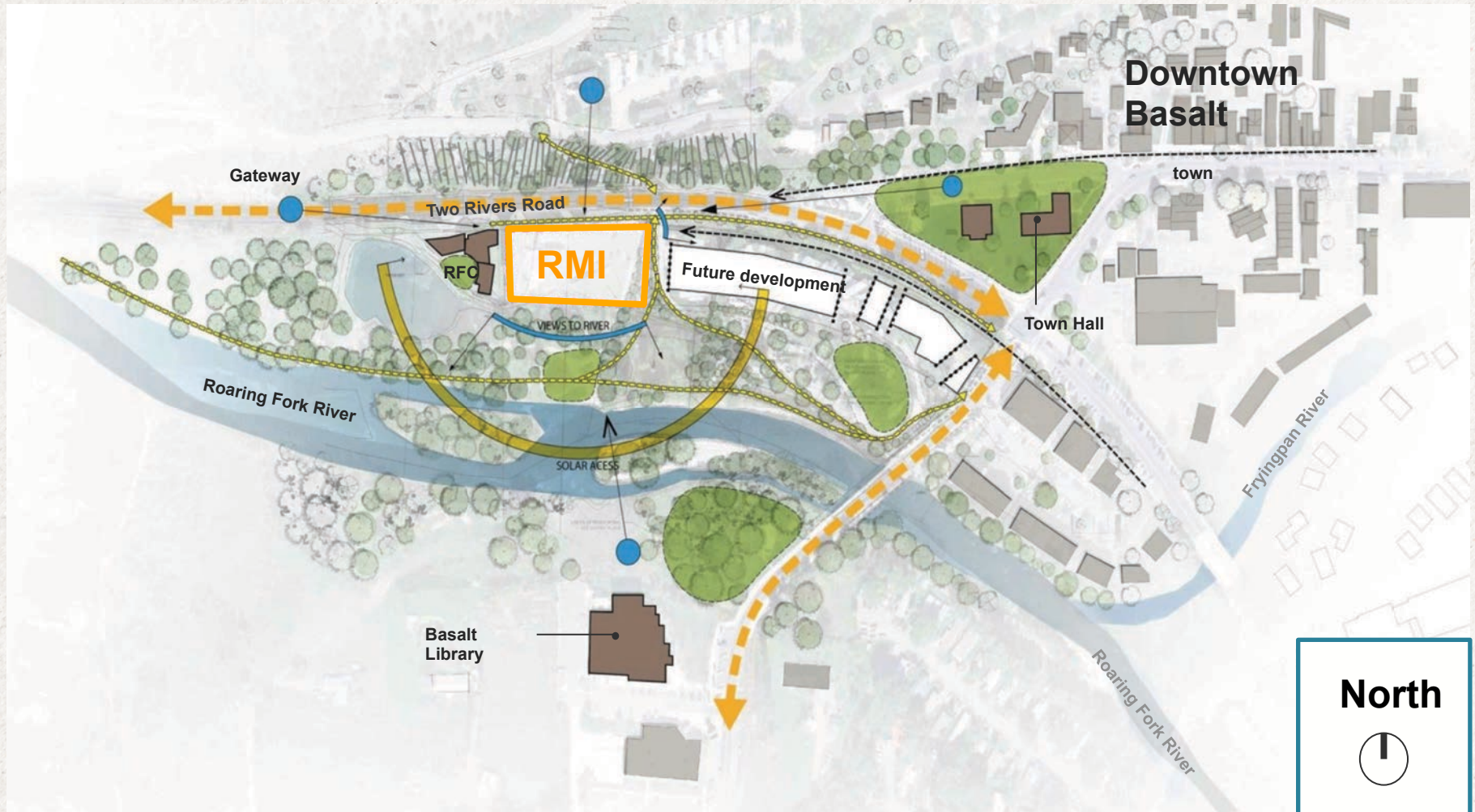
- 15,610 GSF
- EUI – 17 kBTU/ft<sup>2</sup>
- Net zero energy
- Using IPD
- PHUIS+, LEED Platinum
- Redefining thermal comfort
- Showcase of passive efficiency
- Occupancy end of 2015







# RMI INNOVATION CENTER SITE





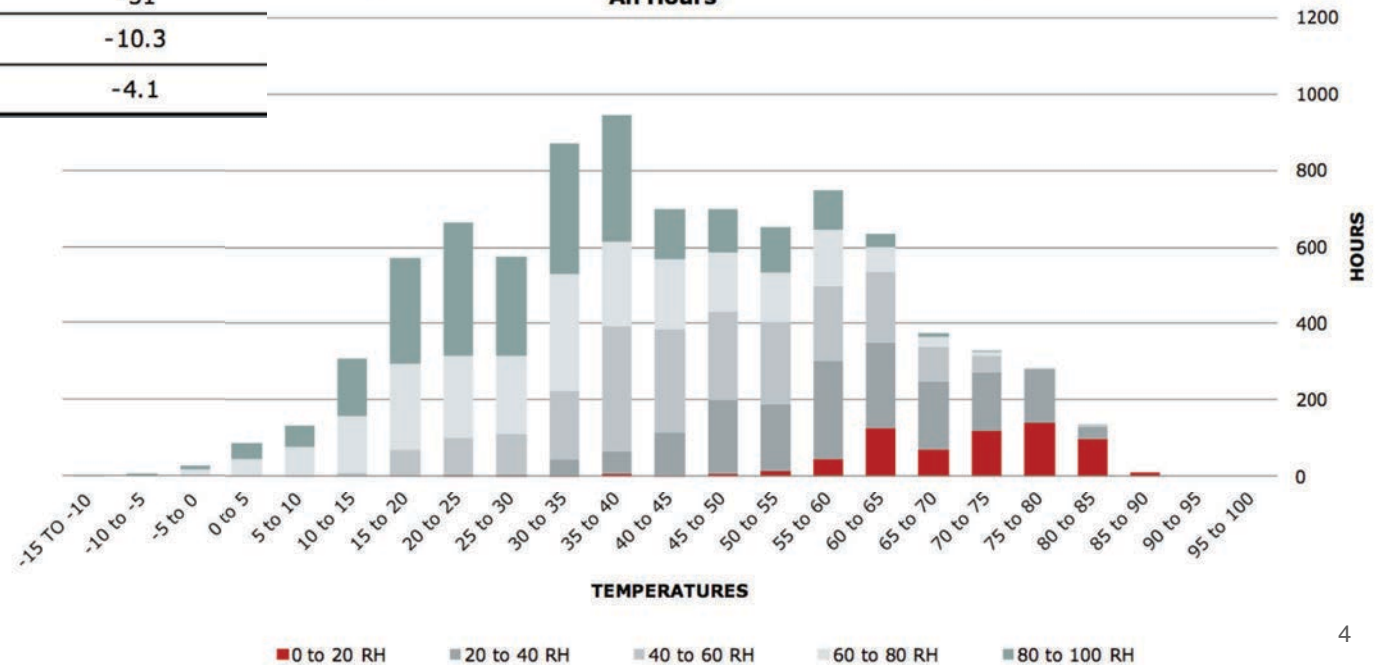


# RMI INNOVATION CENTER LOCATION – BASALT, CO

Summer		
Cooling Degree Days (55°F)-TMY3	950	
Cooling Degree Days (65°F) - TMY3	147	
50 Year Extreme	100	
0.4% DB/MCWB [°F]	88.2	57.5
1.0% DB/MCWB [°F]	85.9	56.8
Evaporation		
0.4% WB/MCDB [°F]	61.1	79.3
1.0% WB/MCDB [°F]	59.6	77.0
August Mean Daily Range [°F]	33.8	
Winter		
Heating Degree Days (55°F)-TMY3	4945	
Heating Degree Days (65°F)-TMY3	7795	
50 Year Extreme [°F]	-51	
99.6% [°F]	-10.3	
99% [°F]	-4.1	



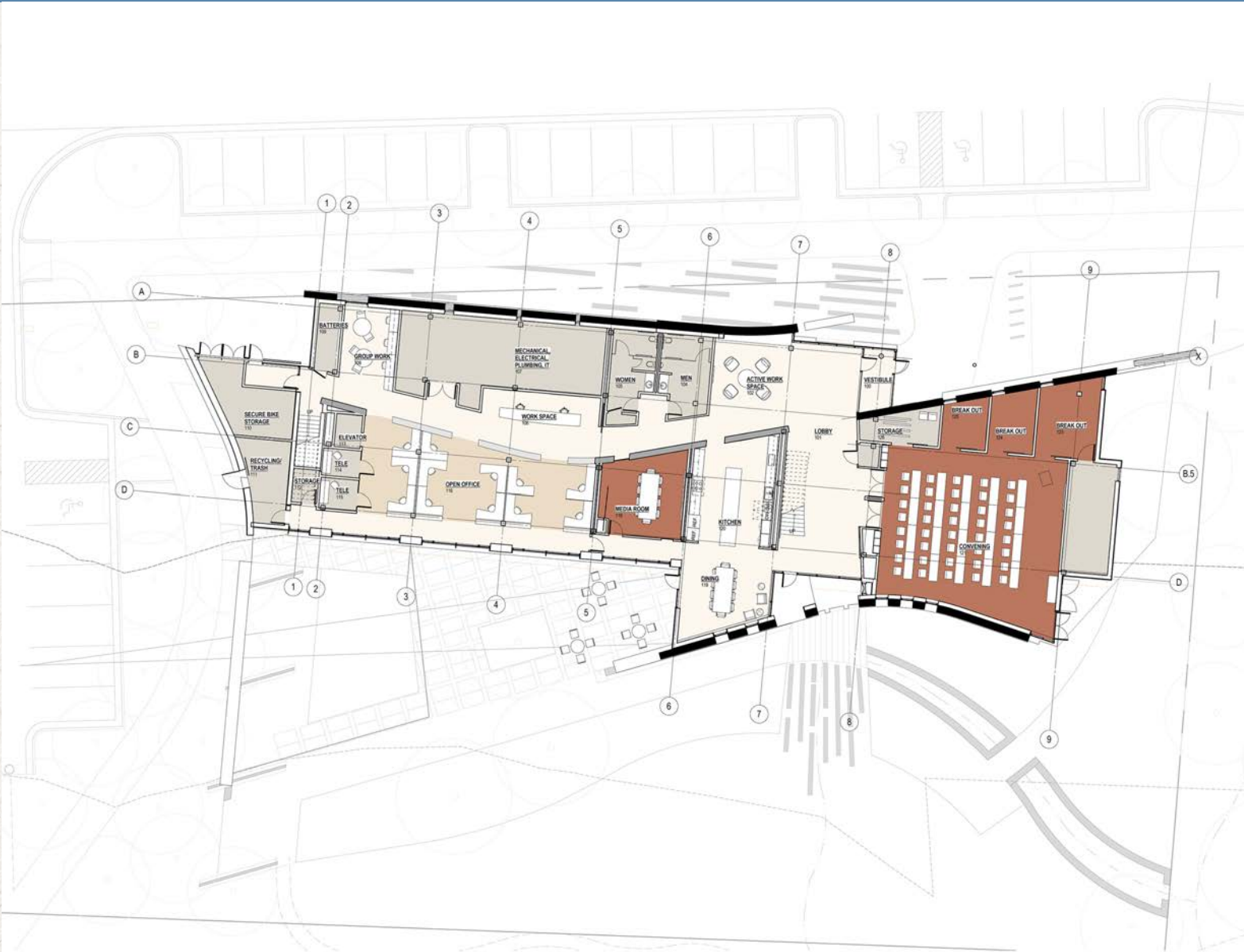
Temperature and Humidity Plot, Aspen, CO (TMY3 Data)  
All Hours







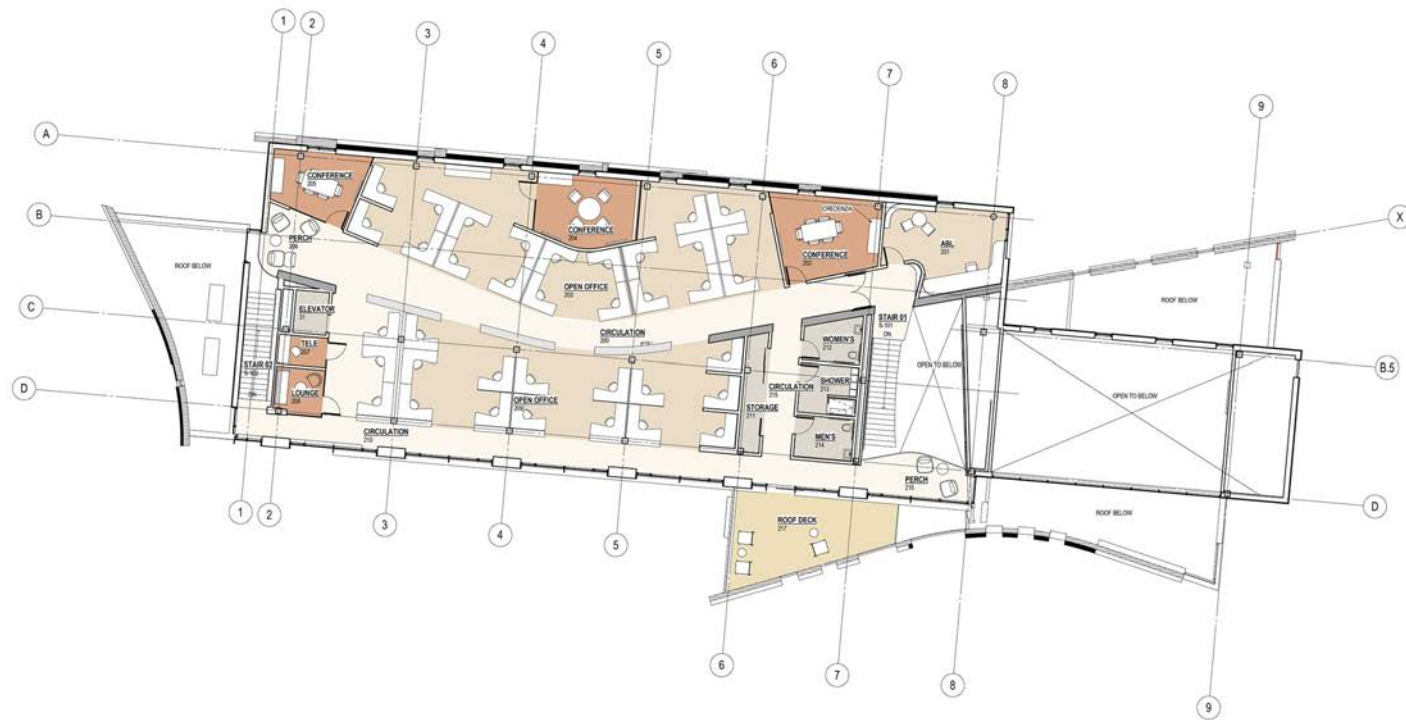
# FLOOR PLAN LEVEL 1







# FLOOR PLAN LEVEL 2

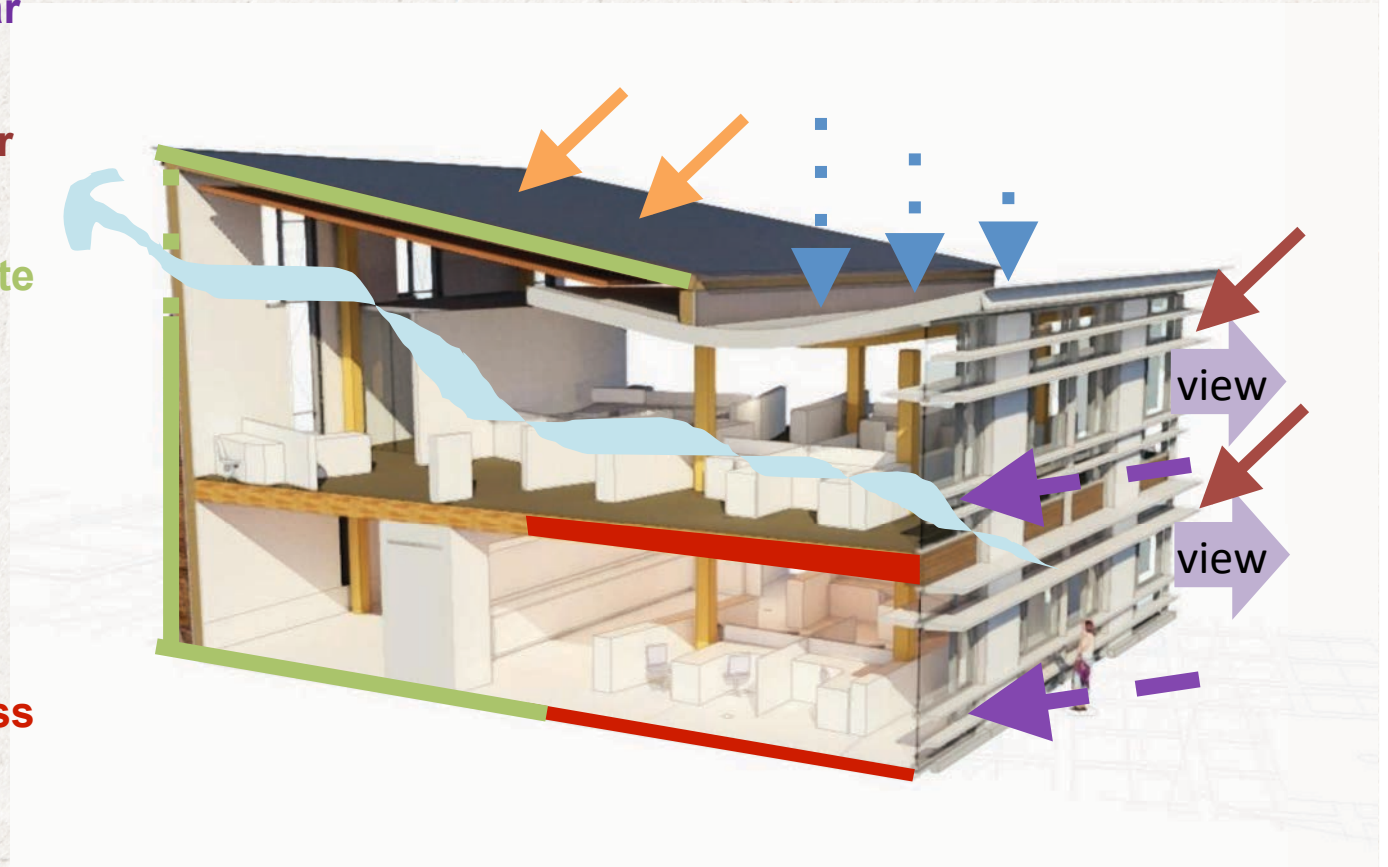






# PASSIVE PERFORMANCE – DOWN JACKET AND SUNGLASSES

1. Maximize View
2. Capture Winter Solar Gain
3. Shade from Summer Heat Gain
4. Aggressively insulate
5. Achieve Daylight Autonomy
6. Control Glare
7. Provide Natural Ventilation
8. Engage thermal Mass
9. Create Air Tight Weather Barrier
10. Collect Solar Energy

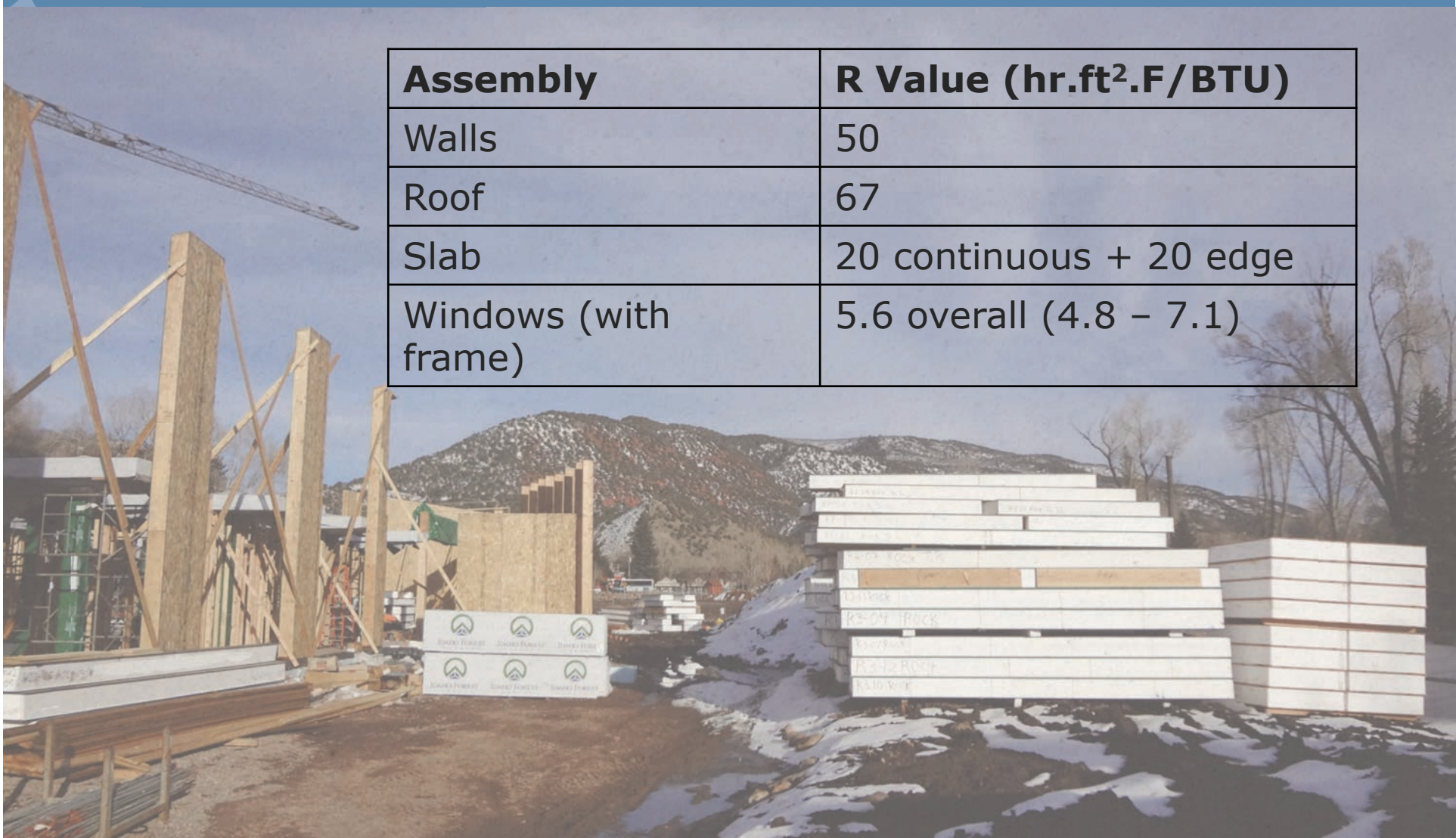






# ENVELOPE SPECS

<b>Assembly</b>	<b>R Value (hr.ft<sup>2</sup>.F/BTU)</b>
Walls	50
Roof	67
Slab	20 continuous + 20 edge
Windows (with frame)	5.6 overall (4.8 – 7.1)







# ENVELOPE SPECS

Passive House US requirement	0.6 ACH at 50Pa
RMI preliminary test	0.174 ACH at 50Pa 0.176 CFM/SF at 75 Pa
Army new construction requirement	0.25 CFM/SF at 75 Pa

- Equivalent leakage area of 0.5 SF
- Keeps construction quality very high
  - Walls: Fluid applied air barrier membrane over SIPS
  - Roof: metal roof over self adhering roofing underlayment over nail base insulation panel over SIPS panel
  - Slab: Slab on grade with under-slab air/vapor barrier over rigid insulation
  - Careful attention to window penetration details and sealing







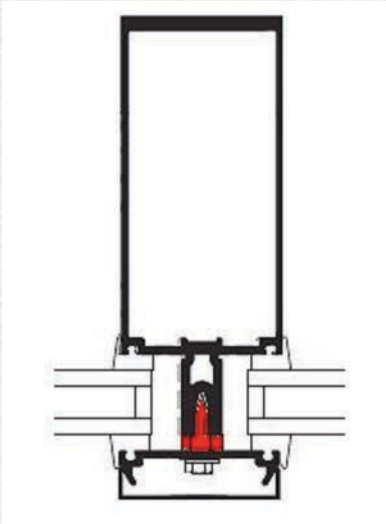
# ENVELOPE SPECS





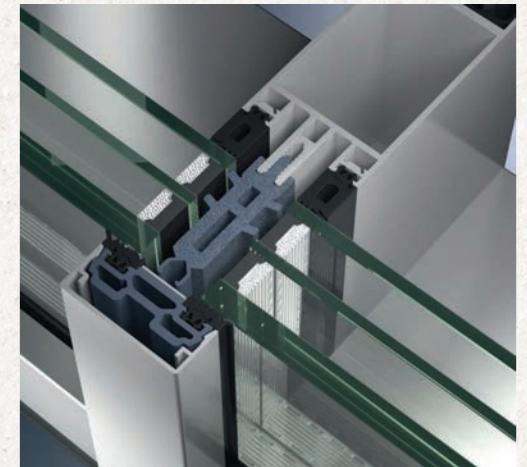
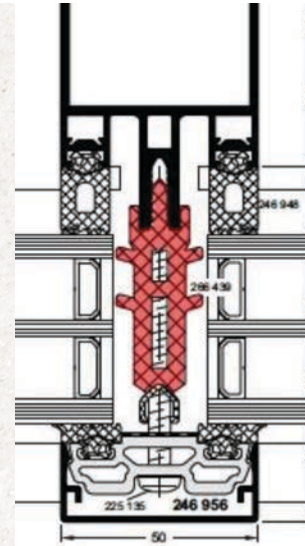
# WINDOW FRAME COMPARISON

## Typical – Kawneer 1600 Series



- Polyamide spacer - Much larger, stiffer thermal break than typical with foam to prevent convective heat transfer.
- Very low infiltration - One actuator to open/close, one to latch and seal. Schuco operable units actually measure infiltration (contrary to US brands)
- Schuco Frames: FW50+ SI system for fixed windows AWS 75 for casement mounted operable units. (first time this system was used in the US)

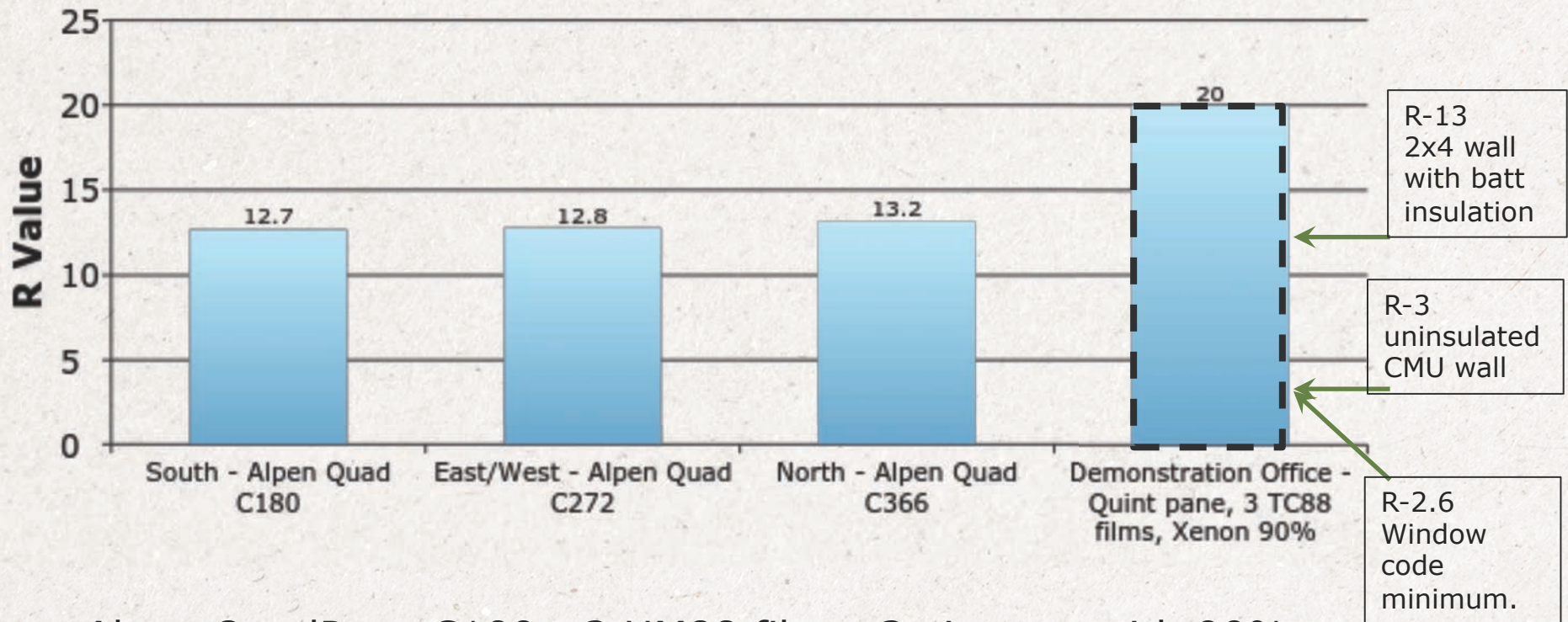
## Schuco FW50+-SI Series







# THE WINDOWS



- Alpen QuadPane C100 - 2 HM88 films, 3 air gaps with 90% Krypton
- **5x better than code**

Key players: Alliance Windows (Trade partner who pulled the whole order together), Alpen Windows (Gas fill), SIG (Glass and film), Schuco (Aluminum frames)





# THE WINDOWS

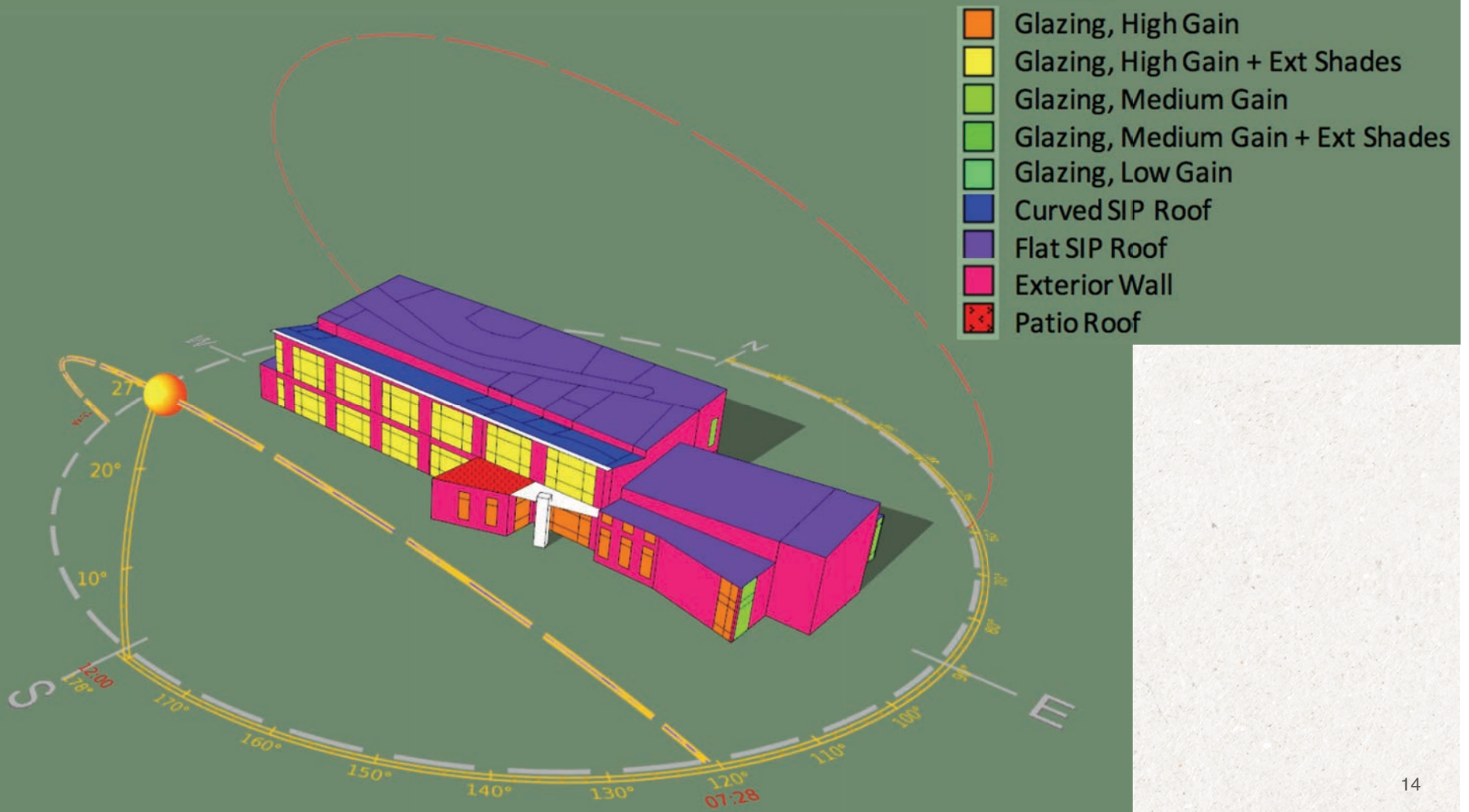


Aspect	Window to Wall Ratio
South	52%
North	18%
East	23%
West	13%
Total	29%



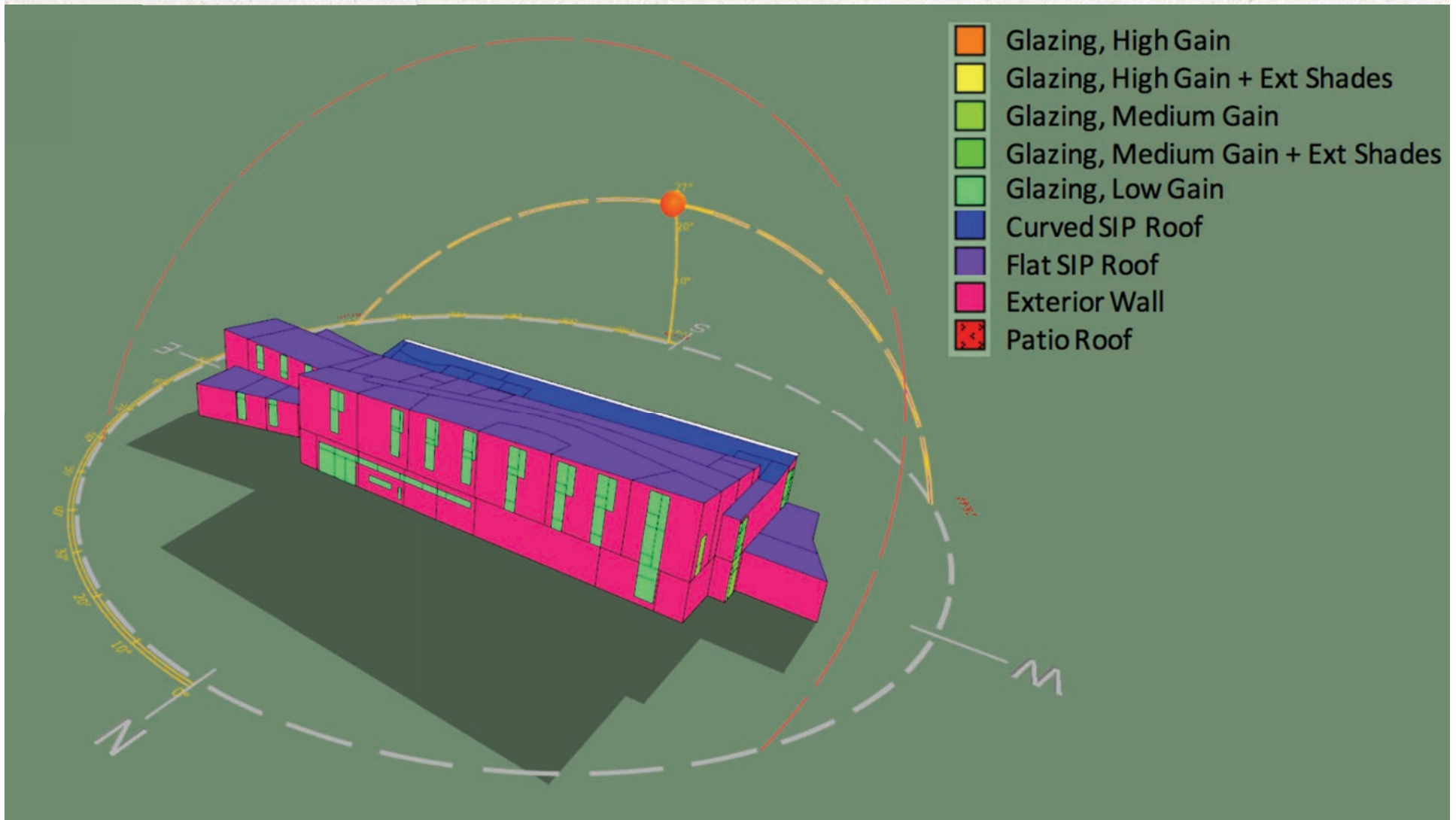


# GLAZING OPTIMIZATION





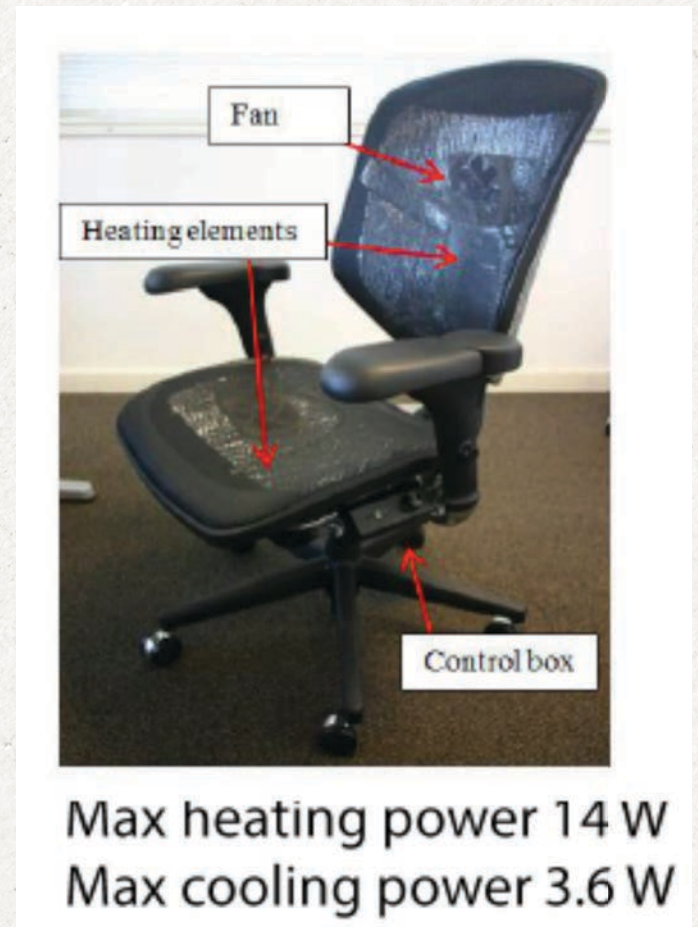
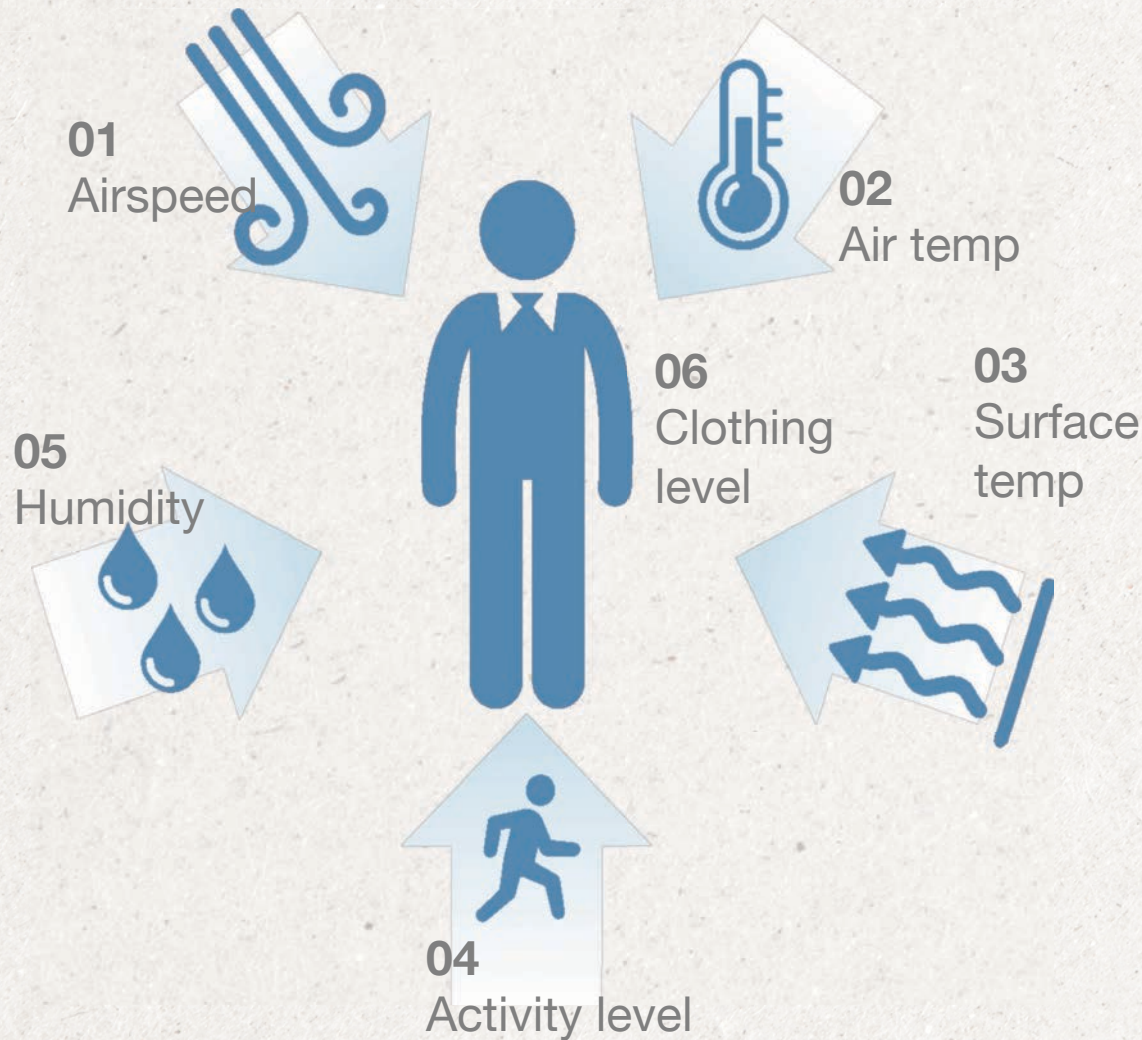
# GLAZING OPTIMIZATION







# 6 FACTORS THAT INFLUENCE COMFORT







# RMI IC – 6 FACTORS THAT INFLUENCE COMFORT

Comfort criteria	Design strategies	Interesting facts
Air velocity	<ul style="list-style-type: none"><li>• Fans overhead, USB and standing fans</li><li>• Fans in Hyperchair</li></ul>	Fans moving 160 fpm can offset temperature increase of 4.7F which extends ASHRAE comfort zone from 80F-84.7F (CBE study)
Surface temperature	<ul style="list-style-type: none"><li>• Super insulating windows and envelope</li><li>• Thermal mass</li><li>• BioPCM in walls, lightshelves (and furniture?)</li><li>• Predictive preconditioning by charging thermal mass with night flush</li><li>• Hyperchair</li></ul>	Our art program has been carefully designed to support thermal comfort (reds/oranges colored pictures during the winter, blues/greens during the summer).
Air Temperature	<ul style="list-style-type: none"><li>• Ambient air temperature fluctuates between 64F – 80F (17.8C – 27.8C)</li><li>• Natural ventilation, operable windows</li><li>• Distributed, radiant heating mats in floor</li><li>• Aggressive heat recovery (90% efficient) to preheat ventilation air</li></ul>	Individuals have direct controls over their immediate environment.  <b>Open office floor plan and hoteling program enables occupants to move where they are the most comfortable.</b>
Clothing Level	<ul style="list-style-type: none"><li>• Adaptive dress code for staff and event attendees</li></ul>	
Metabolic rate	<ul style="list-style-type: none"><li>• Stand-up desk options</li><li>• Active culture, stairs are central focus, elevator for backup</li></ul>	
Humidity	<ul style="list-style-type: none"><li>• Not actively controlled</li><li>• Near the river</li></ul>	ASHRAE has no lower bound – no humidification required.





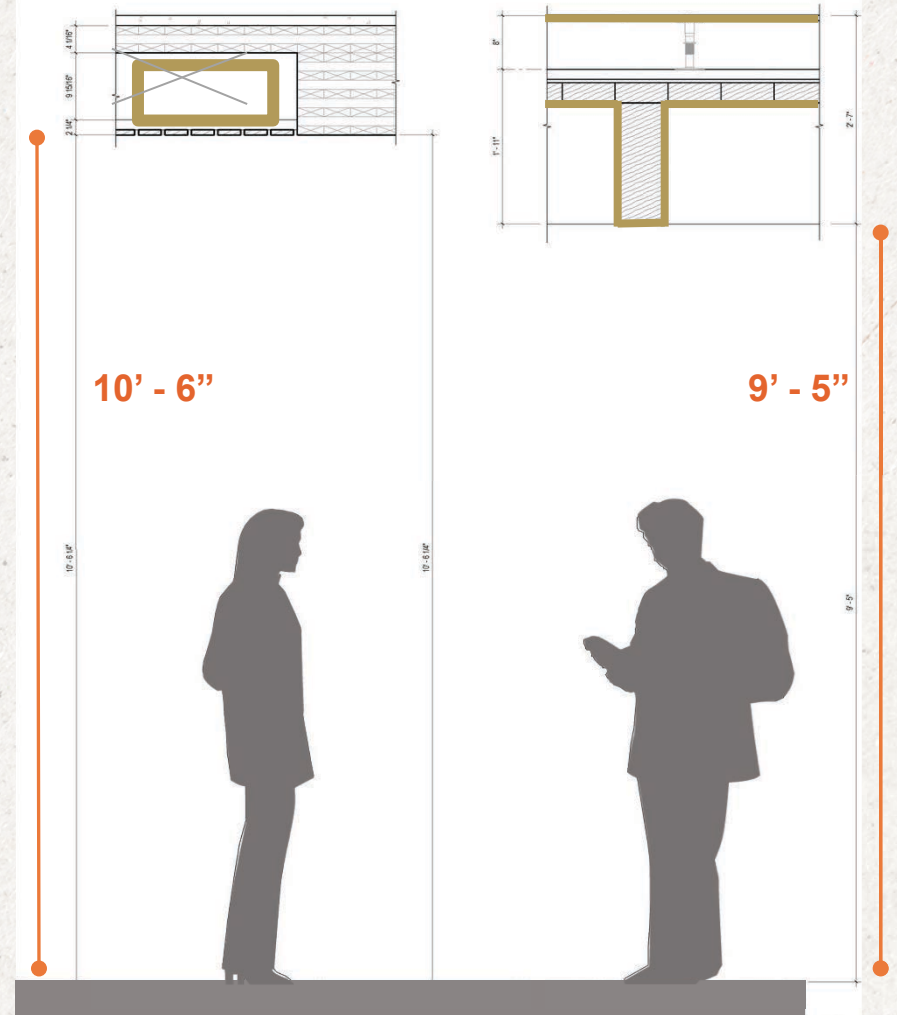
# RMI IC - 6 FACTORS THAT INFLUENCE COMFORT







# CROSS LAMINATED TIMBER (CLT) STRUCTURE



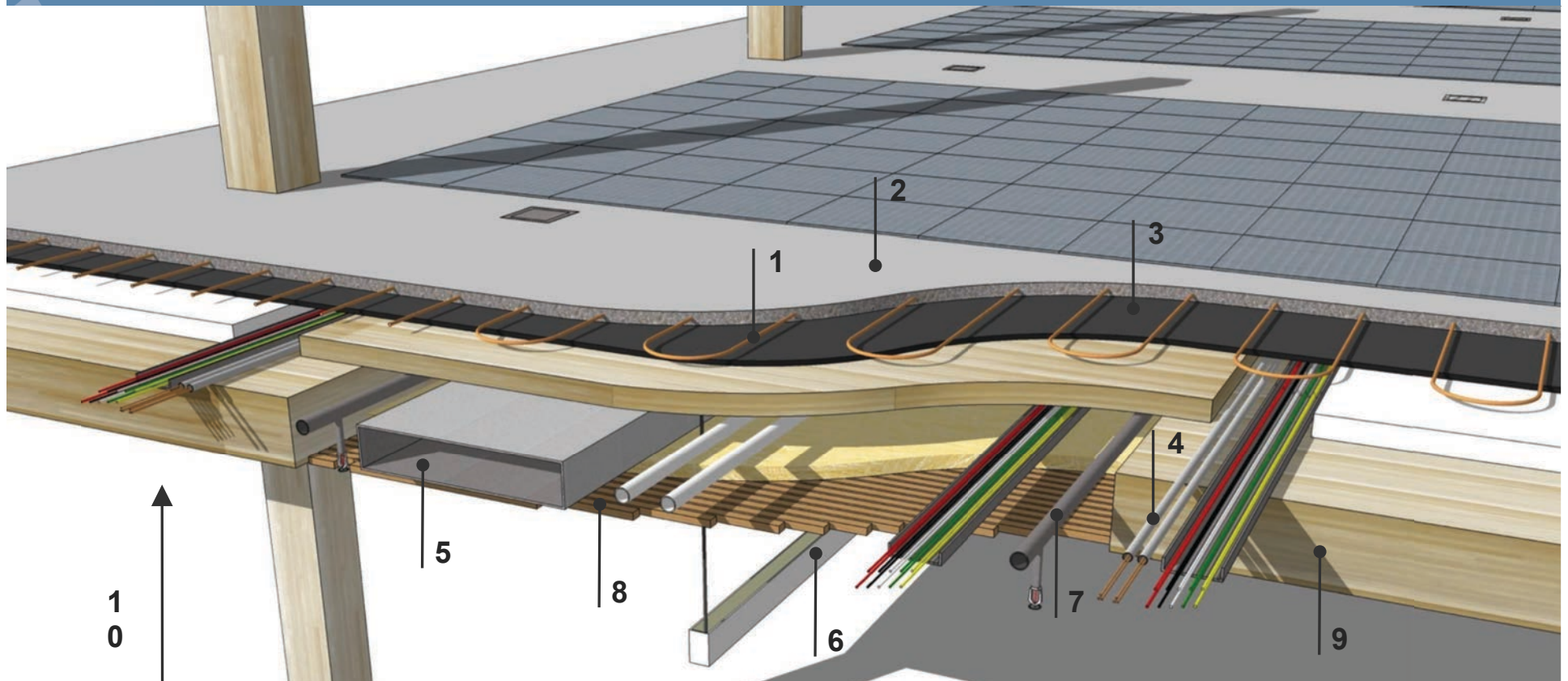
CLT UNDER FLOOR

GLULAM WITH RAISED FLOOR





# CROSS LAMINATED TIMBER (CLT) STRUCTURE



1. HEAT (RADIANT FLOOR)
2. THERMAL MASS (CONCRETE)
3. ACOUSTICS
4. CONDUIT FOR ELECTRICAL & IT
5. VENTILATION AIR
6. LIGHTING

11





# CROSS LAMINATED TIMBER STRUCTURE







# EXPOSED CONCRETE FLOOR

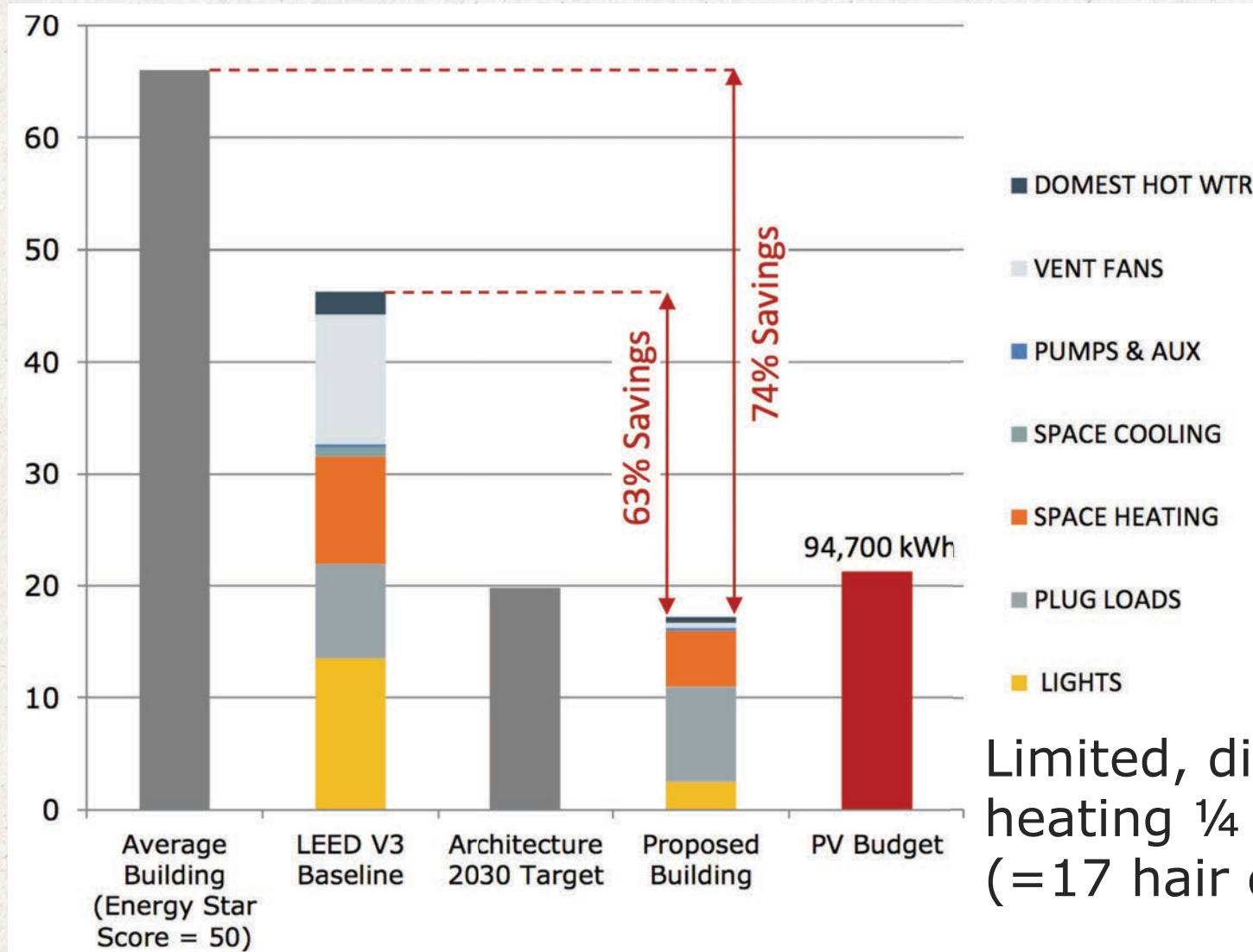






# WHERE IS THE ENERGY GOING?

EUI kBTU/ft<sup>2</sup>



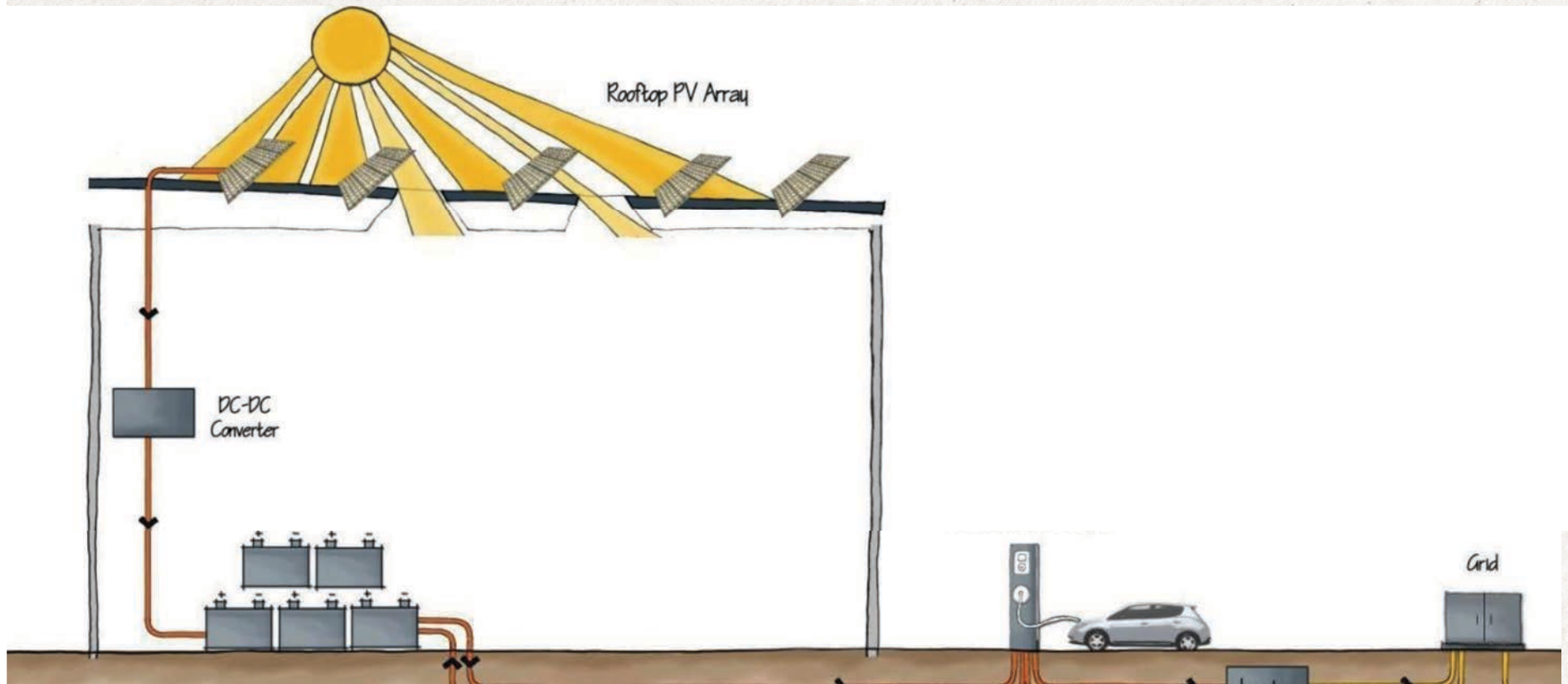
No cooling system

Limited, distributed heating 1/4 size of typical (=17 hair dryers)





# BUILDING AS A GRID ASSET

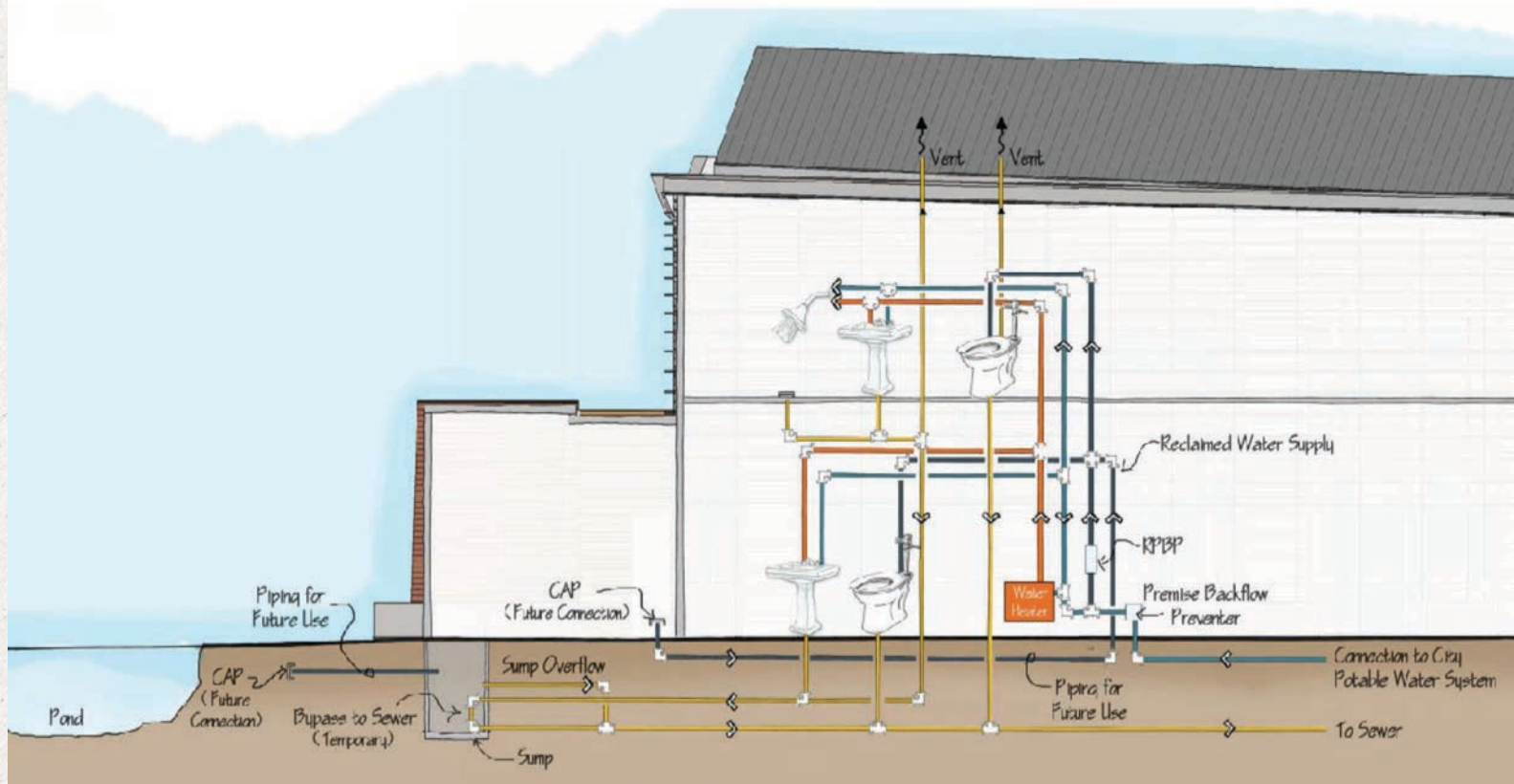




# PIONEERING GRAYWATER IN COLORADO



## Day 1 system

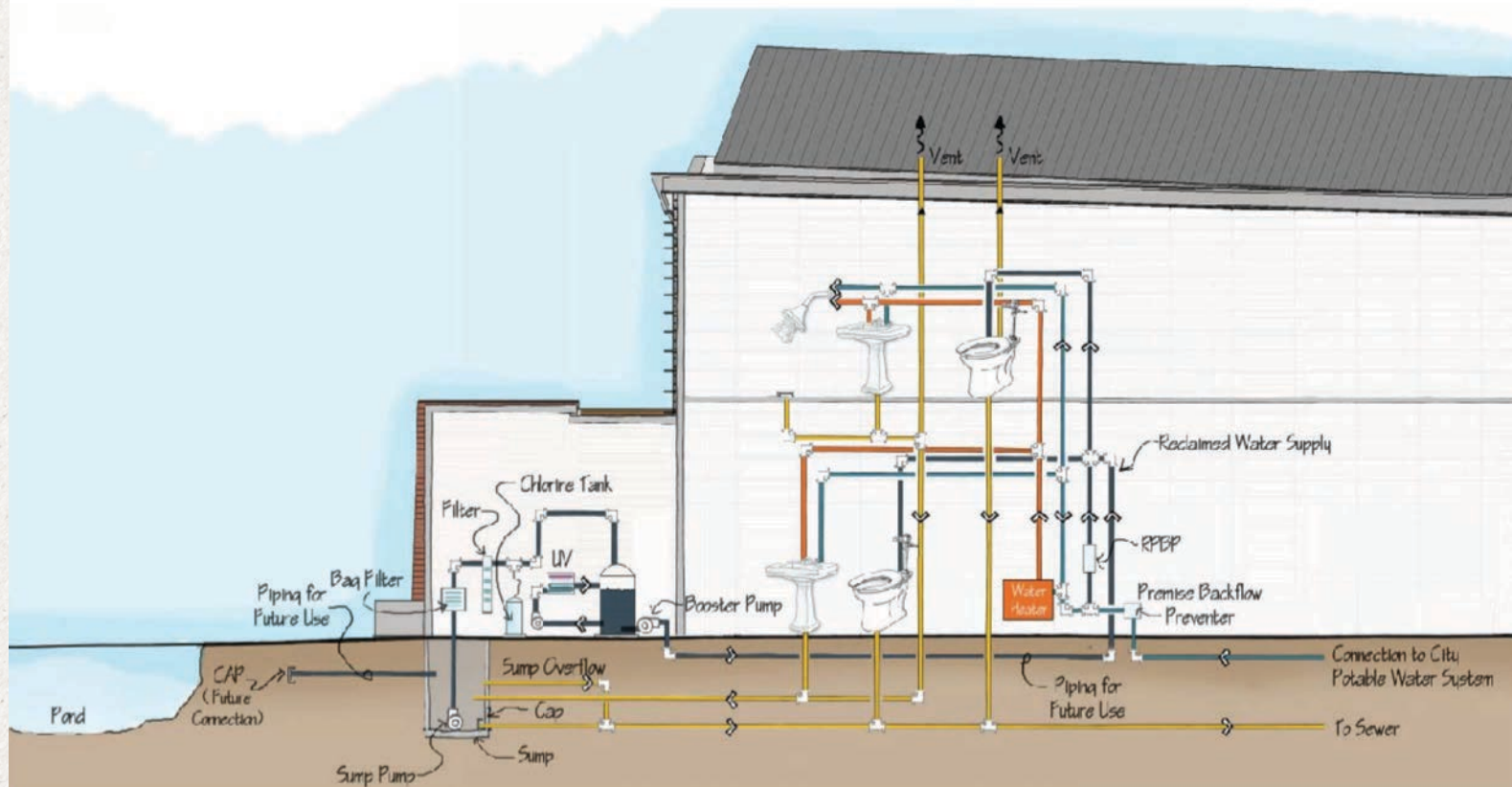






# PIONEERING GRAYWATER IN COLORADO

Once graywater is legal in the state of Colorado...



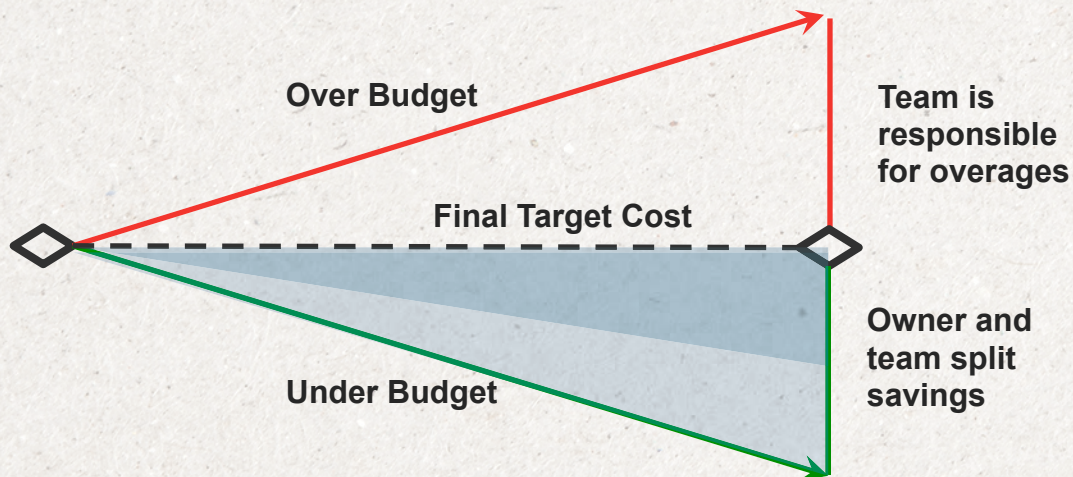
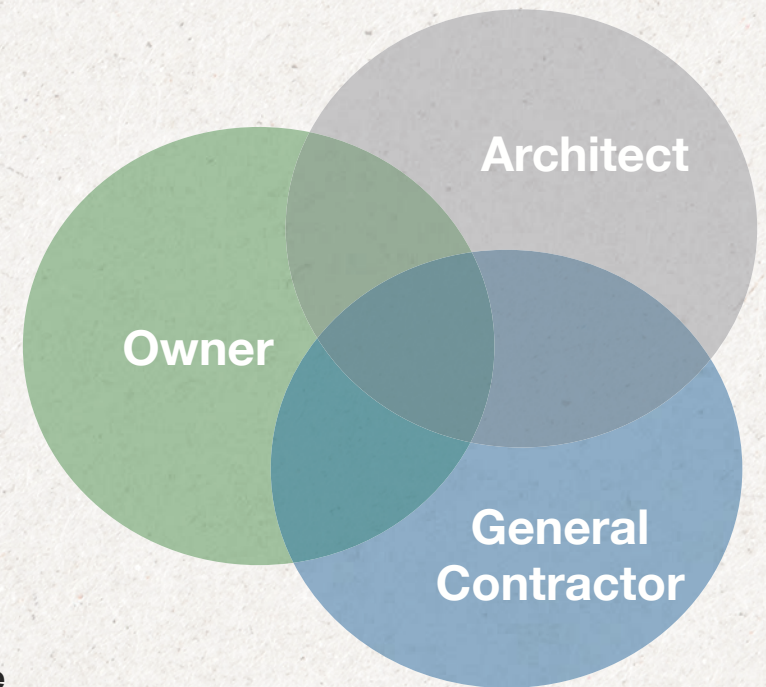




# INTEGRATIVE DESIGN AND IPD

“The team was so cohesive, I couldn’t tell who was from what discipline. The architect, contractor, engineers were all speaking the same language...”

– Peter Boyer, RMI Trustee, reflecting about RMI design workshop







# THE TEAM



**Design Team:**  
ZGF – Architect  
PAE – MEP  
Architectural Applications – High  
Performance Design  
RMI - Owner

9 whole team workshops  
between Apr – Sept 2013







# DEMONSTRATING THE RESULTS

- ENERGY USE** -----> **Net positive energy, passive**
- WATER USE** -----> **New water paradigms in CO**
- INDOOR ENVIRONMENT** -----> **Next generation workspace**
- OCCUPANT ENGAGEMENT** -----> **Staff as active stewards**
- SITE / LANDSCAPE** -----> **Connection to nature**
- BEAUTY + LONGEVITY** -----> **Biophilia, 100 year lifespan, flexible**

## CERTIFICATIONS

ARCH 2030  
CHALLENGE



LIVING BUILDING  
CHALLENGE  
PETAL CERTIFICATION



NET ZERO  
BUILDING  
CERTIFICATION



LEED NC 2009  
PLATINUM



PASSIVE HOUSE  
CERTIFICATION



ENERGY STAR  
(SCORE =100)





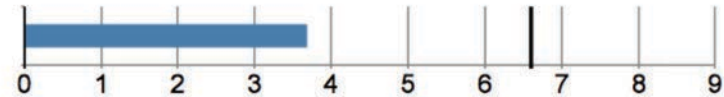


# PASSIVE HOUSE CERTIFICATION – WUFI PASSIVE REPORT



## Heating demand

specific: **3.69** kBtu/ft<sup>2</sup>yr  
 target: **6.6** kBtu/ft<sup>2</sup>yr  
 total: 64758.98 kBtu/yr



## Cooling demand

specific: **0.32** kBtu/ft<sup>2</sup>yr  
 target: **1** kBtu/ft<sup>2</sup>yr  
 total: 5639.3 kBtu/yr  
 latent: 0 kBtu/ft<sup>2</sup>yr



## Heating load

specific: **3.58** Btu/hr ft<sup>2</sup>  
 target: **4.3** kBtu/ft<sup>2</sup>yr  
 total: 62996.38 Btu/hr





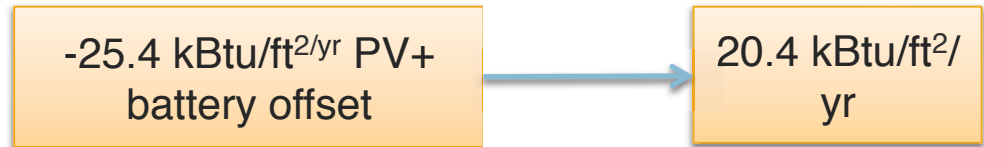


# PASSIVE HOUSE CERTIFICATION – WUFI PASSIVE REPORT



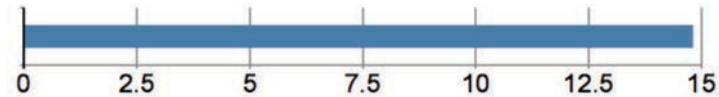
## Primary energy

specific: **45.77** kBtu/ft<sup>2</sup>yr  
 target: **38.04** kBtu/ft<sup>2</sup>yr  
 total: 804332.44 kBtu/yr



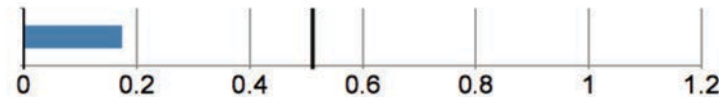
## Site energy

total: 14.81 kBtu/ft<sup>2</sup>yr  
 building systems: 48.56 kBtu/yr  
 photovoltaic savings: 0 kBtu/ft<sup>2</sup>yr



## Air tightness

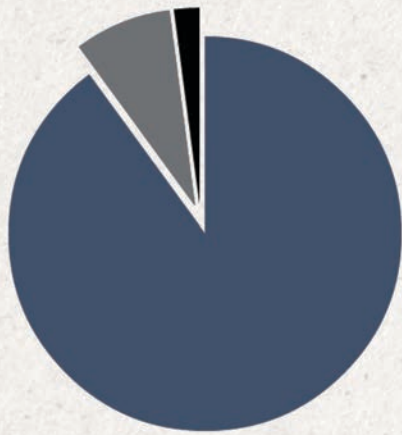
ACH50: **0.17** 1/hr  
 target: **0.51** 1/hr  
 CFM50 per envelope area: **0.02** cfm/ft<sup>2</sup>  
 target: **0.05** cfm/ft<sup>2</sup>



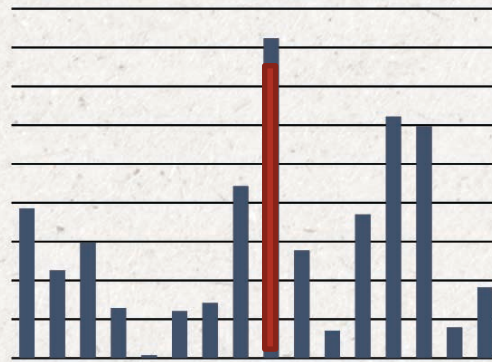




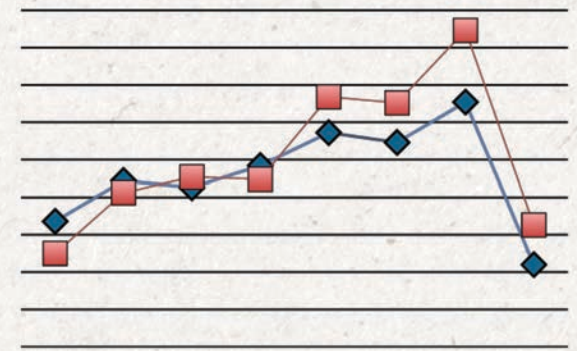
# REPLICABILITY



**90%**  
OF COMMERCIAL  
BUILDINGS ARE UNDER  
**25,000 SF**



**OFFICES**  
ARE THE BIGGEST USE  
OF COMMERCIAL  
BUILDINGS UNDER  
**25,000 SF**



**HALF**  
OF COMMERCIAL  
BUILDINGS UNDER  
**25,000 SF** ARE  
OWNER OCCUPIED

BY 2035, ABOUT THREE-FOURTHS OF U.S. FLOOR SPACE WILL BE NEW OR RENOVATED.



































# Groundbreaking October 14<sup>th</sup> 2014





Nov 12<sup>th</sup>, 2014







Dec 10<sup>th</sup> 2014





January 20<sup>th</sup>, 2015






Jan 28<sup>th</sup> 2015





February 4<sup>th</sup>, 2015 





February 11<sup>th</sup>, 2015







April 15, 2015





May 13, 2015





June 19, 2015





# THANK YOU

**Contact:** Hayes Zirnhelt [hzirnhelt@rmi.org](mailto:hzirnhelt@rmi.org)

Further resources will be available at:

[www.rmi.org/rmi\\_innovation\\_center](http://www.rmi.org/rmi_innovation_center)



RMI transforms global energy use to create a clean, prosperous, and secure future.