

ASSOCIATION FOR  
**LEARNING  
ENVIRONMENTS**

**CHICAGO**

**Learning SCAPES 2023**

# Actively Passive:

Realizing the first Passive House-designed school in Colorado

2023 A4LE  
LearningSCAPES  
October 14, 2023



BranchPattern

Cunningham



## Our Learning Objectives today

- Understand how and when you might consider Passive House design principles for educational facility design.
- Learn about materials and systems selection challenges when implementing this approach for a school.
- Hear about ways to engage a school community in a workshop environment to set regenerative design goals.

## About Us



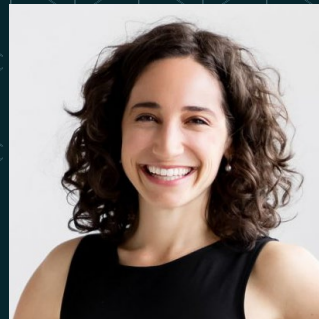
### Kari-elin Mock

Principal, Executive Director – Grow Studio  
Cunningham



### Paul Hutton

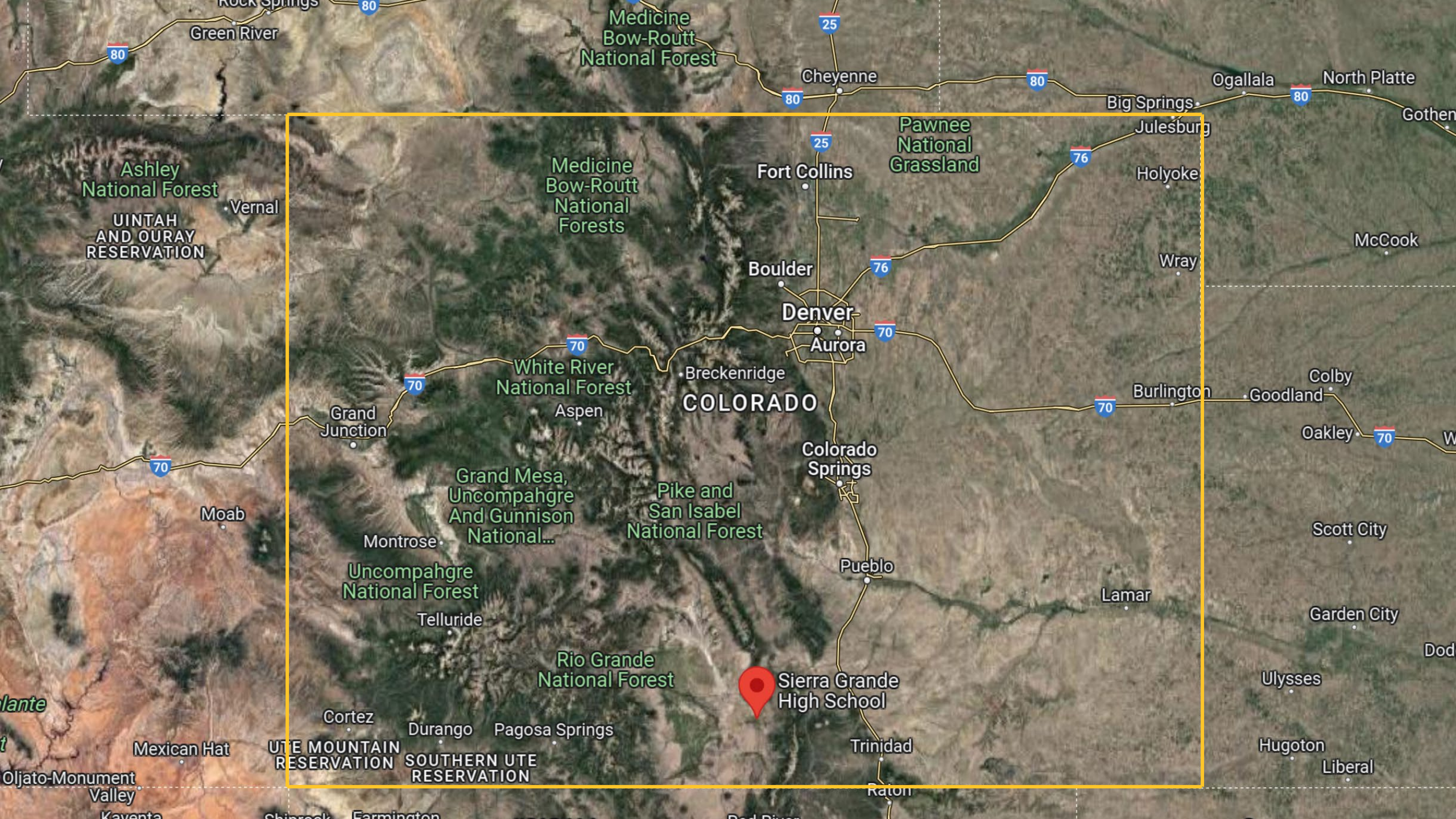
Principal, Director of Regenerative Design  
Cunningham



### Dannie Dilonno

Senior Associate – Net Zero Advocacy Manager  
BranchPattern

Charting a new  
path



COLORADO

Sierra Grande High School

Denver

Fort Collins

Boulder

Aurora

Breckenridge

Aspen

White River National Forest

Grand Mesa, Uncompahgre and Gunnison National Forest

Pike and San Isabel National Forest

Rio Grande National Forest

Uncompahgre National Forest

Montrose

Telluride

Cortez

Durango

Pagosa Springs

Pueblo

Colorado Springs

Trinidad

Raton

Lamar

Scott City

Garden City

Ulysses

Hugoton

Liberal

Oakley

Goodland

Colby

Burlington

Wray

Holyoke

Julesburg

Big Springs

Ogallala

North Platte

Goth...

McCook

Green River

Ashley National Forest

UINTAH AND OURAY RESERVATION

Vernal

Medicine Bow-Routt National Forests

Medicine Bow-Routt National Forest

Pawnee National Grassland

Cheyenne

Rock Springs

80

80

25

80

80

80

25

76

76

70

70

70

70

70

lante

Oljato-Monument Valley

UTE MOUNTAIN RESERVATION

SOUTHERN UTE RESERVATION

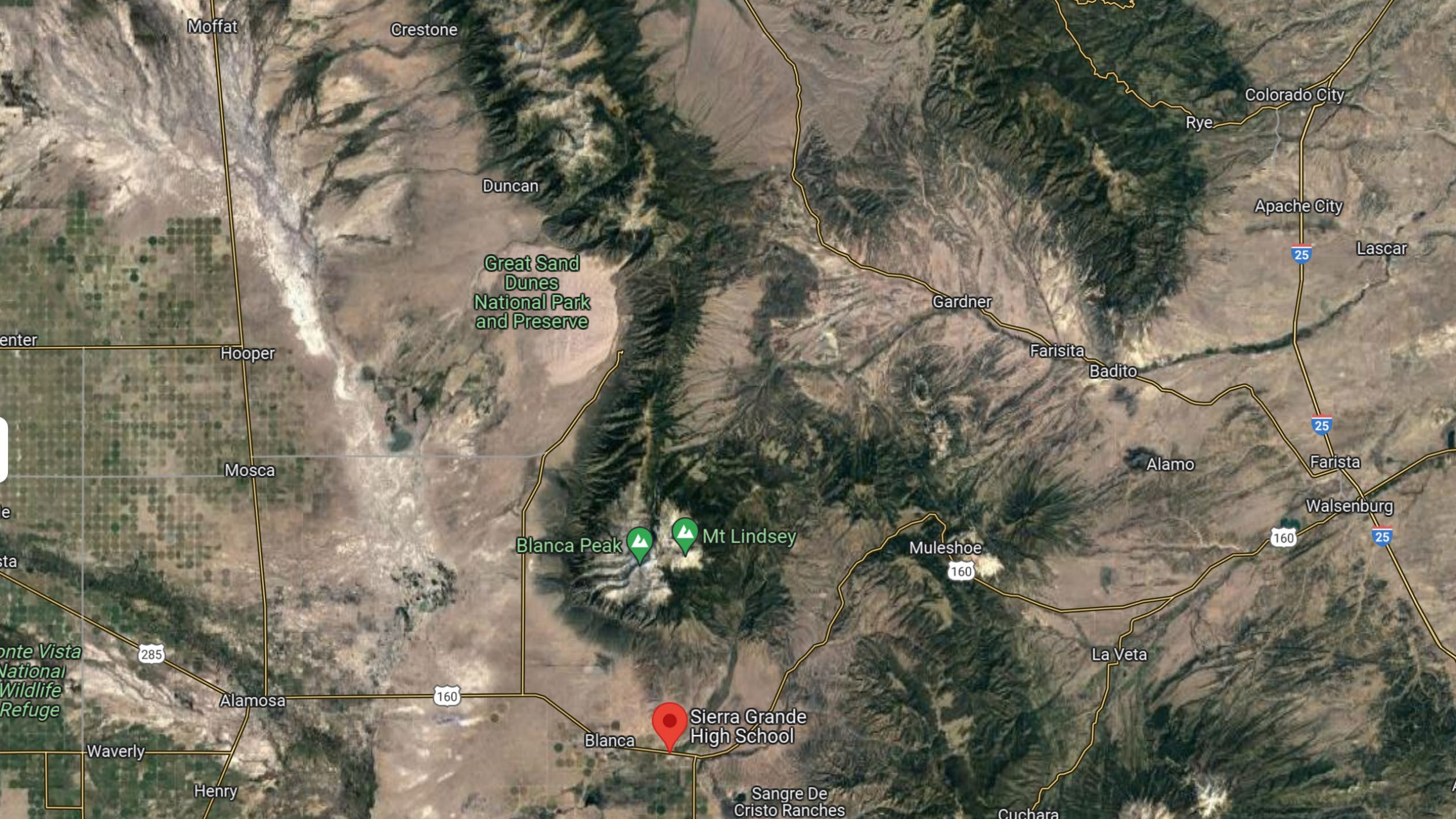
lante

Kayenta

Shiprock

Farmington

Red River



Moffat

Crestone

Colorado City

Rye

Duncan

Apache City

Lascar

Great Sand  
Dunes  
National Park  
and Preserve

Gardner

Farisita

Badito

Hooper

Alamo

Mosca

Farista

Walsenburg

Blanca Peak

Mt Lindsey

Muleshoe

Monte Vista  
National  
Wildlife  
Refuge

285

Alamosa

160

Sierra Grande  
High School

Blanca

La Veta

Waverly

Henry

Sangre De  
Cristo Ranches

Cuchara



Sierra Grande High School

Sierra Grande School District

Blanca/ Ft Garland Community Center

160

4th Ave





## Existing Conditions

- Concerns for main entry proximity to the highway
- Lack of visible and secure main entry
- Systems at the end of their useful life
- No access to natural gas, heated by propane



## Existing Conditions

- Narrow classrooms
- Noisy and ineffective mechanical system
- Poor indoor air quality
- Lack of quality daylight and views



## Existing Conditions

- Lack of spectator seating
- Noisy and ineffective mechanical system
- Poor indoor air quality
- Lack of quality daylight and views



## Existing Conditions

- Structures beyond end of useful life
- Inadequate water supply
- Interior and exterior spaces difficult to supervise



## Project Interview – Engagement Begins



## HIGHEST HOPES

- ~ LOOK FOR INNOVATIVE COMPLEX  
WELL-SUITED TO KIDS + COMMUNITY  
LAST LONG AS CURRENT FACILITY
- ~ TRANSPARENCY & HONESTY  
IN PROCESS
- ~ BEST ED. FACILITIES IN  
VALLEY & COLO.
- ~ LONG LASTING FUNCTIONAL  
SCHOOL HEAT WHEN NEEDED...  
WELL-BUILT & LOOKS NICE

# Back to School Night



# Design Workshop #01

- SAFE / WELCOMING
- NATURE / LANDSCAPE
- COMFORT - THERMAL TE
- OPEN / FLEXIBLE CLASSR
- FUN / HAPPY / QUALIT
- ORGANIZED
- UNIQUE EXPERIENCES MAKERS
- 21st CENTURY - MODE TECH!

WE SEE...

- We see interaction and
- We see happiness.
- We see Creativity.
- Welcoming Environment
- Outdoor Learning
- Athletic Areas
- Maker Space
- Safe
- Adapt School
- Natural
- Artwork
- Mr. Parril
- Awesome Library

- ## We See....
- 1) engaging environment
  - 2) Safe environment
  - 3) innovative spaces
  - 4) modern functional facility
  - 5) parent involvement
  - 6) Green Spaces

- ## We see.....
- 1) Natural light / windows
  - 2) Out door / green space
  - 3) Hands-on learning / engaging
  - 4) Flexible / adaptable spaces Custom
  - 5) Clean, safe, organized, modern environment
  - 6) Friendly, welcoming, collaboration

CREATING A SHARED VISION



# A Shared Vision

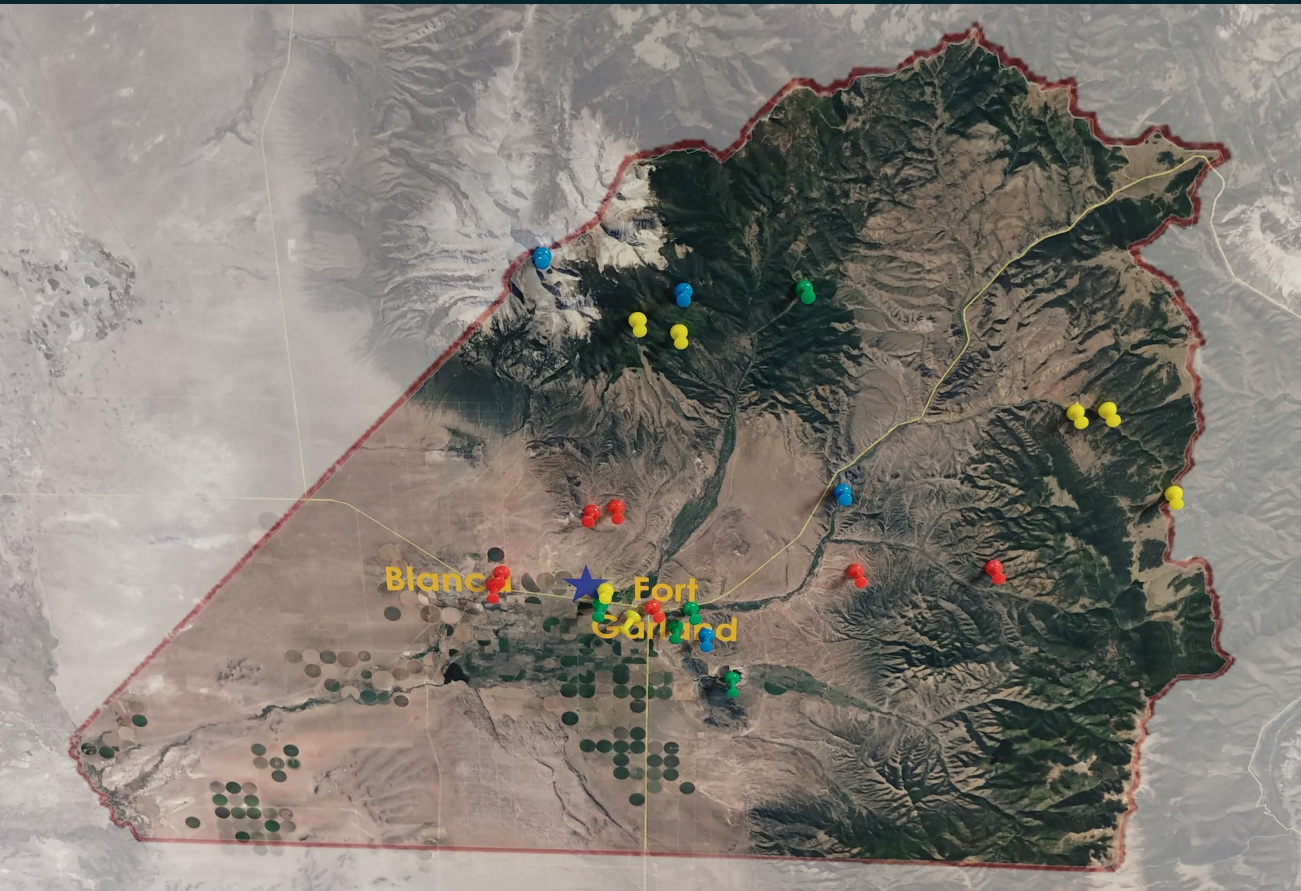
The vision of Sierra Grande School District is to create and build a new school that reflects the values and cultural diversity of our small, rural community. It is a beautiful, modern facility that is safe, reliable and fully integrated with technology advanced learning environments. The school has learning spaces that are flexible and adaptable to the ever-changing needs of our students and teachers. It is a place of natural beauty with lots of natural light from windows and skylights to bring the outdoors into our classrooms. Landscaped areas provide fun, outdoor learning spaces. It is a new school that is welcoming to everyone and brings pride to our community.





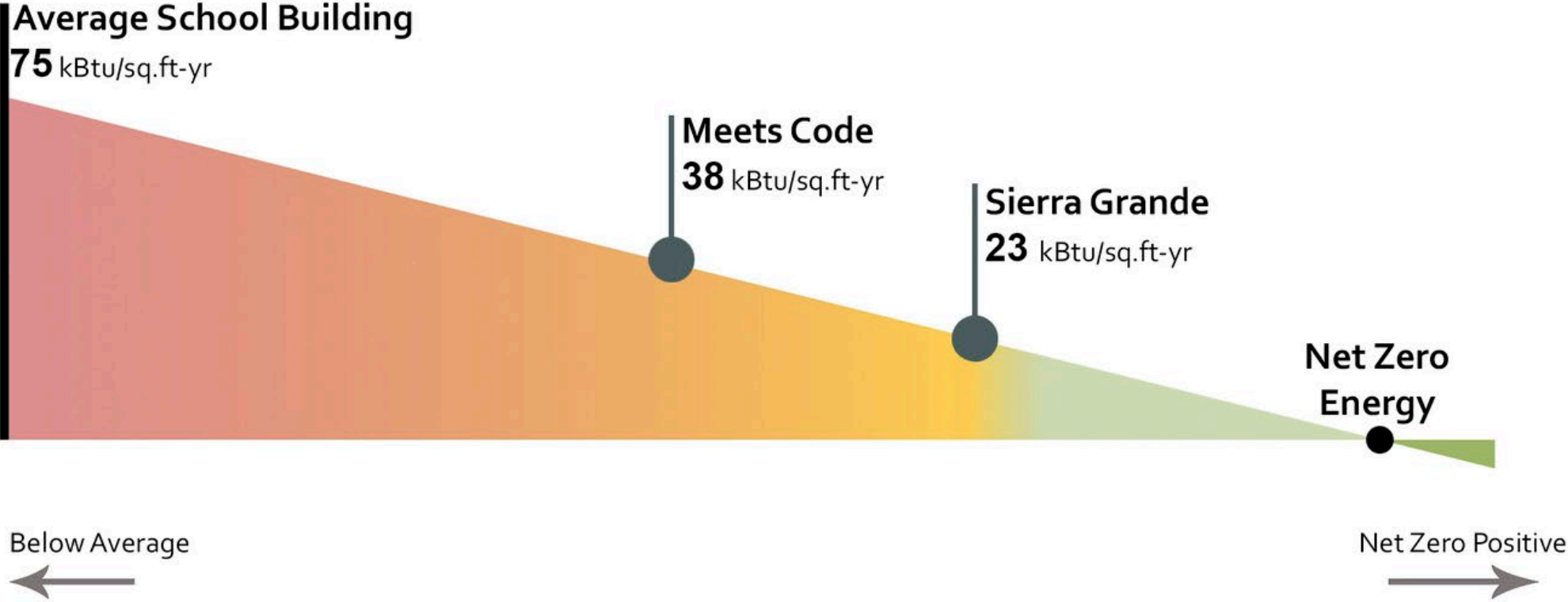
# Design Workshop #02

## Prioritizing Regenerative Design



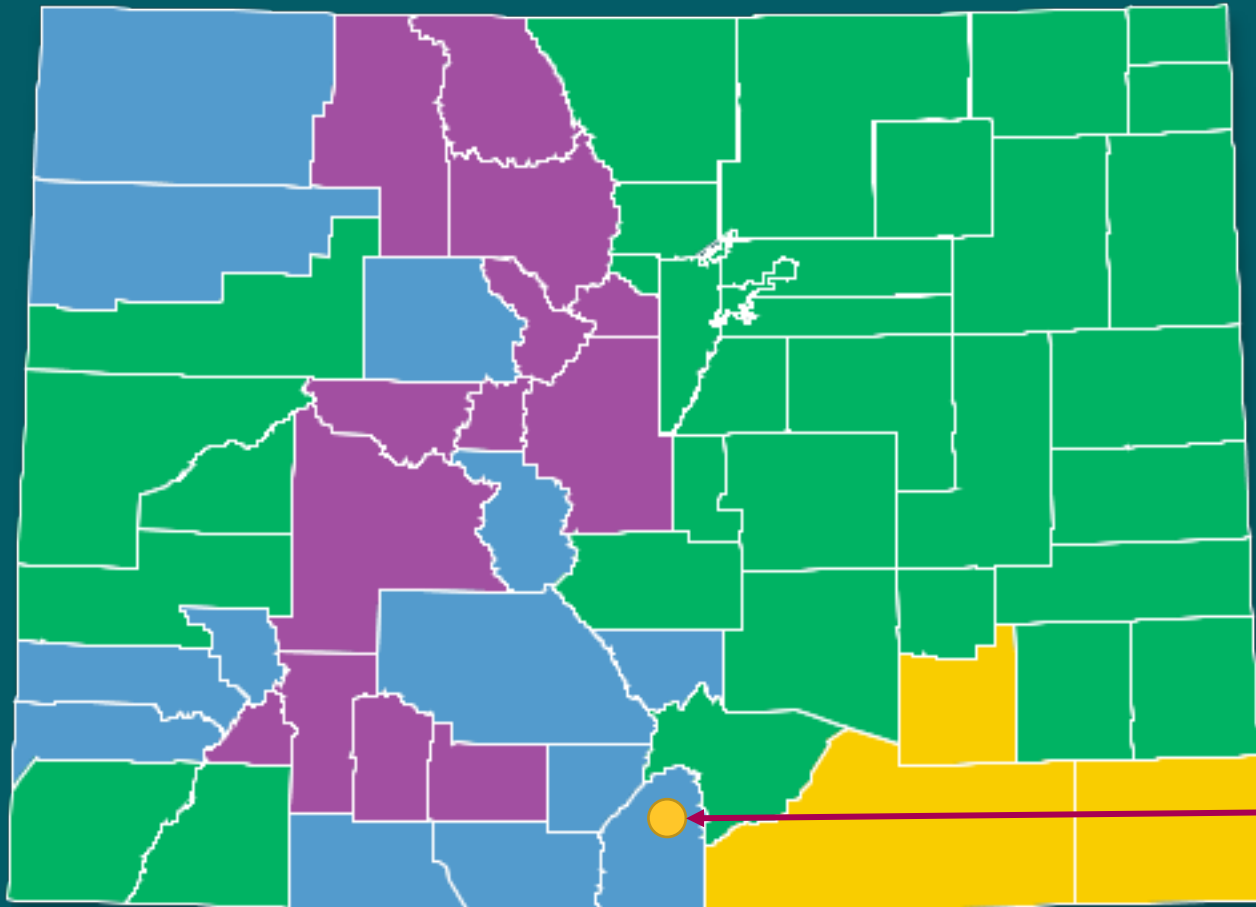
RESOURCE STEWARDSHIP	BUSINESS AS USUAL	HIGH PERFORMANCE	EXEMPLARY
ENERGY	ENERGY CODE COMPLIANT	MEET 2030 STANDARD	NET ZERO ENERGY
MATERIALS	TYPICAL MATERIALS	ELIMINATE VINYL	RED LIST COMPLIANT
WATER	ALL WATER FROM WELL	TURF FIELD	HARVEST ROOF WATER FOR TOILET FLUSHING
WASTE	CLASSROOM RECYCLING	ADD COMPOSTING FOR FOOD SERVICE	ZERO WASTE, NO BURN OR LANDFILL
HABITAT	MAXIMIZE OPEN SPACE	PRESERVE 1 ACRE HABITAT	PRESERVE MORE HABITAT
OCCUPANT WELL-BEING	BUSINESS AS USUAL	HIGH PERFORMANCE	EXEMPLARY
DAYLIGHT HARVESTING	CODE REQUIRED SKYLIGHTS	50% CLASSROOMS DAYLIGHTED	90% CLASSROOMS DAYLIGHTED
VIEWS TO NATURE	SOME SPACES HAVE VIEWS	ALL CLASSROOMS HAVE VIEWS	ALL STUDENT SPACES HAVE VIEWS
ACOUSTIC COMFORT	STANDARD CONSTRUCTION	ADDITIONAL SOUND TREATMENT	ALL SPACES MEET ALL S12.60
AIR QUALITY	CODE COMPLIANT FOR VOCs & CO2	REDUCE CO2 TO 850 ppm	REDUCE CO2 TO 700 ppm
CURRICULUM	BUSINESS AS USUAL	HIGH PERFORMANCE	EXEMPLARY
BUILDING AS A TEACHING TOOL	ENERGY DASHBOARD	VISIBLE BLDG. COMPONENTS	STUDENTS ENGAGED IN BLDG. MONITORING & OPERATION
OUTDOOR LEARNING	OUTDOOR CLASSROOM(S)	OUTDOOR AG DEMO. AREA	STUDENTS MAINTAIN NATURAL HABITAT
COMMUNITY ACCESS	SOME COMM. ACCESS AFTER HOURS	MAXIMIZE COMM. ACCESS	STUDENTS ACTIVE IN COMM. AFTER HOURS

# A Path to Net Zero



# Colorado Climate Zones

- Climate Zone 4 (Except Marine)
- Climate Zone 5 & 4 Marine
- Climate Zone 6
- Climate Zone 7 & 8



Latitude is same as:  
San Jose, CA  
Cape Girardeau, MO  
Norfolk, VA  
Syracuse, Sicily

Degree days:  
Heating – 8,587  
Cooling – 22

St. Cloud, MN – 8,879 DD  
Burlington, VT – 8,269 DD

Altitude:  
7,936 ft.

Project site – climate zone 6

WEATHER COLORADO

# Alamosa sets record high and record low temperature in the same day

—  
This isn't new for the southern Colorado city. It accomplished the same feat on four consecutive days in 2002.

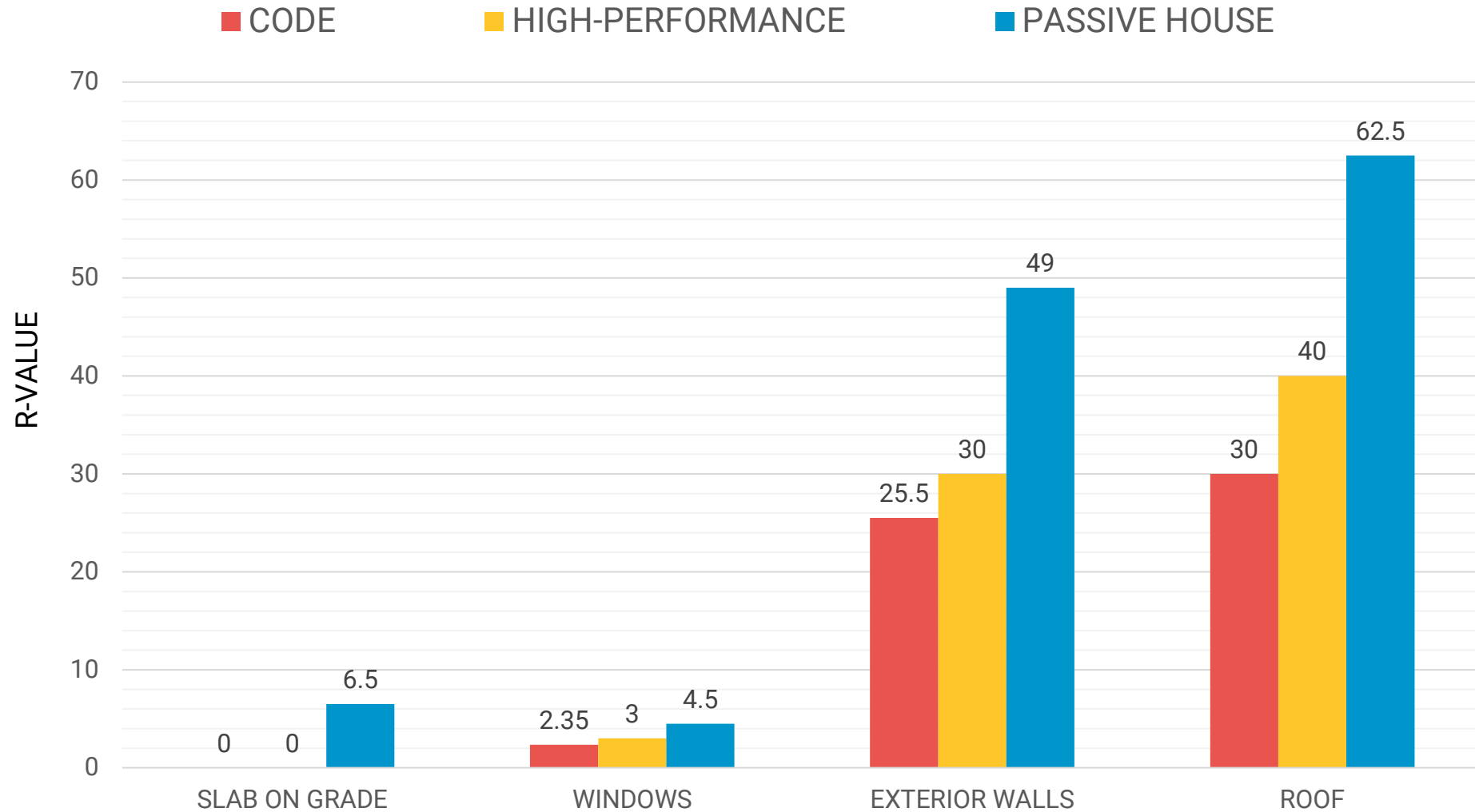


## Internal Team Research Questions:

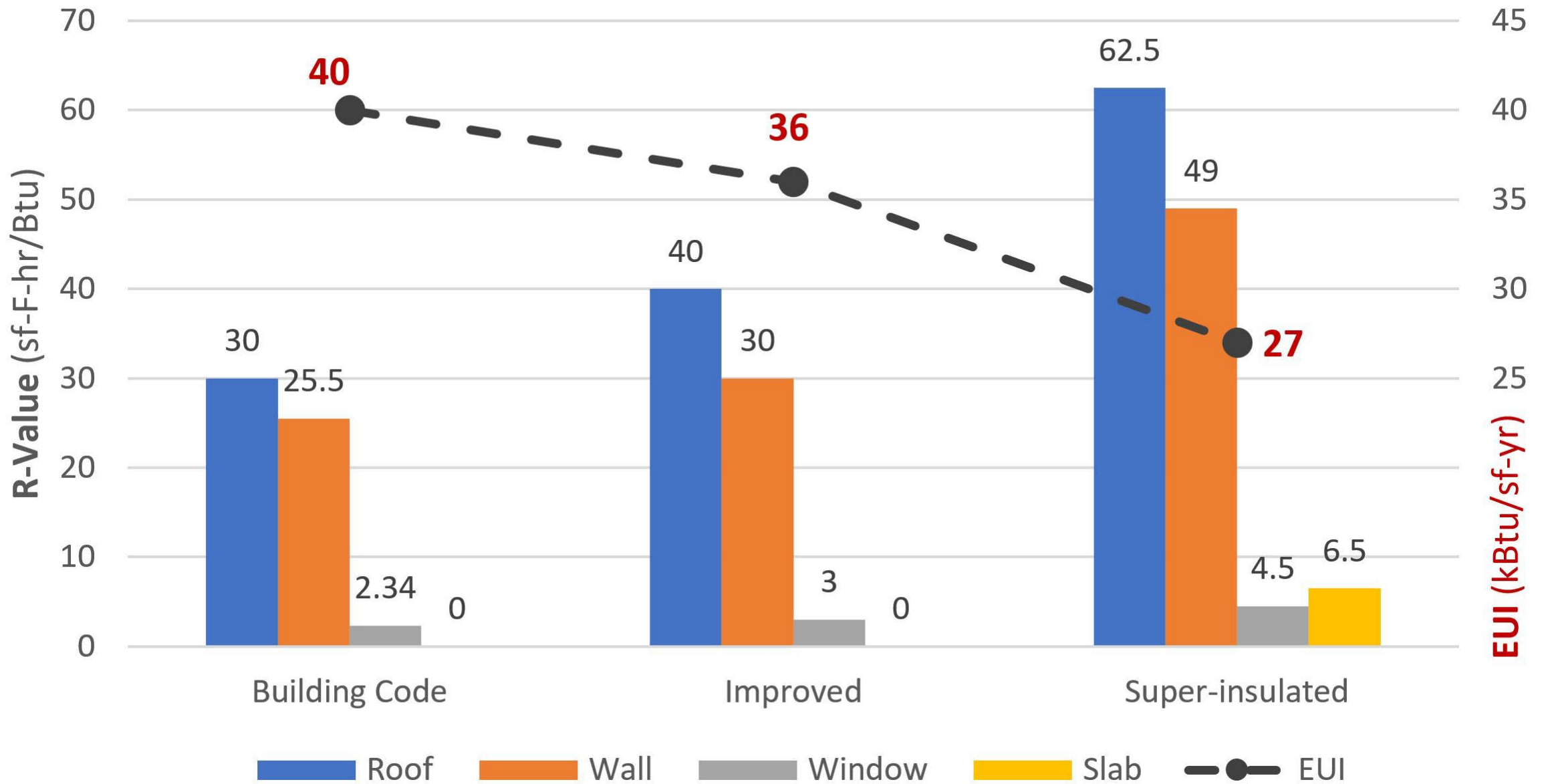
Can Passive House Design principles be applied here in order to simplify and reduce mechanical systems?

Can Passive House Design be accomplished on the already established budget?

# Comparative Insulation Values – Climate Zone 6



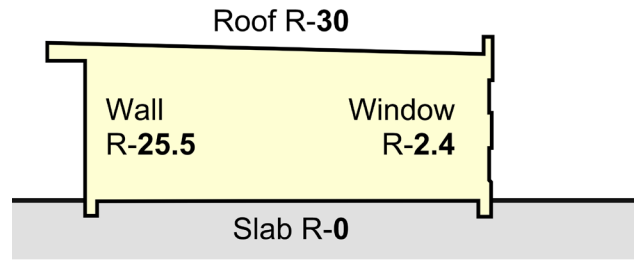




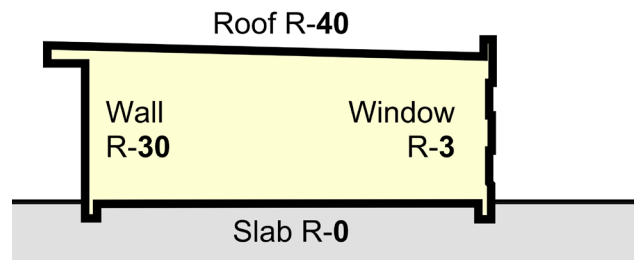
## Envelope vs. Energy Use

# Enclosure Design

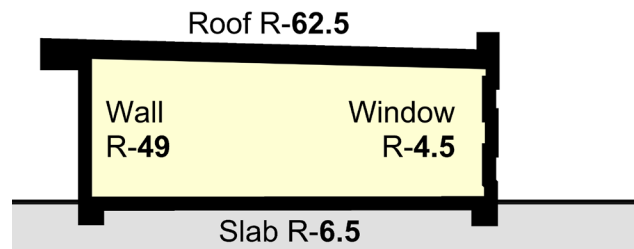
# Energy Performance



EUI: 40 kBtu/sf-yr



EUI: 36 kBtu/sf-yr



EUI: 27 kBtu/sf-yr



Envelope vs. Energy Use

# Envelope Analysis Summary

Material Description	Evaluated	Costed	Used as Basis of Design	Comments
<b>EXTERIOR WALLS</b>				
GreenGirt	Yes	No	No	
Vacuum Insulation Panels	Yes	No	No	Not available
Exterior Insulated Finish System	Yes	No	No	Durability issue
Spray Foam Insulation	Yes	No	No	Code concerns
Structural Insulated Panels	Yes	No	No	Code concerns
Insulated Concrete Forms	Yes	No	No	
Precast Insulated Concrete	Yes	Yes	Yes	Gym only
Insulated Metal Panels	Yes	Yes	Yes	
Phase Change Materials	Yes	No	No	Not available
<b>ROOF</b>				
R-40 Polyiso Insulation	Yes	Yes	No	
R-65 Polyiso Insulation	Yes	Yes	Yes	
1" Vacuum Panel Boards	Yes	Yes	No	High Cost
<b>SLAB ON GRADE</b>				
Uninsulated Slab on Grade	Yes	Yes	No	
R-20 XPS Insulation Board	Yes	Yes	No	Difficult to install
R-6 Insul-Tarp	Yes	Yes	Yes	
<b>GLAZING</b>				
Double Pane Low E Alum. Frame	Yes	Yes	No	
Guardian Vaccum Double Pane	Yes	No	No	Not available
Alpen Stretched Film with Krypton	Yes	Yes	Yes	Fiberglass frame

9 wall Systems

3 roof systems

3 slab systems

3 window systems



## Investigated 5 Envelope/HVAC Options:

Base Case – High Performance LEED/CHPS compliant

Option 1a – R-36 precast, R-50 metal panels, R-65 roof, R-20 underslab, HVAC system 1

Option 1b - R-36 precast, R-50 metal panels, R-65 roof, R-6 underslab, HVAC system 1

Option 2a - R-36 precast, R-50 metal panels, R-65 roof, R-20 underslab, HVAC system 2

Option 2b - R-36 precast, R-50 metal panels, R-65 roof, R-6 underslab, HVAC system 2

Option 3 - R-36 precast, R-50 metal panels, R-65 vacuum based roof, R-20 underslab, HVAC system 1

**Base Case**

ASSEMBLIES AND MECH SYSTEMS	ft <sup>2</sup>	\$/ft <sup>2</sup>	TOTAL \$
R-19.6 Precast Insulated Panels (Hayden Base Case)	29,066.50	\$ 85.00	\$ 2,470,652.50
R-21.6 Metal Panels on Metal Stud (Hayden Base Case)	19,555.30	\$ 71.00	\$ 1,388,426.30
R-40 Roof Assembly (Hayden Base Case)	59,782.75	\$ 19.00	\$ 1,135,872.25
Base Slab on Grade	59,808.50	\$ 8.00	\$ 478,468.00
High Performance IGU (Guardian) Glazing w/ 2nd and 4th surface coating U-value 0.2 CoG	11,002.00	\$ 50.00	\$ 550,100.00
Mechanical System Option 3	86,800.00	\$ 38.80	\$ 3,367,840.00
<b>TOTAL</b>			<b>\$ 9,391,359.05</b>

**PASSIVE HOUSE OPTION 1a - BOD for Schematic Design**

ASSEMBLIES AND MECH SYSTEMS	ft <sup>2</sup>	\$/ft <sup>2</sup>	TOTAL \$
R-36 Precast Concrete Wall (Gym Exterior)	16,926.20	\$ 100.00	\$ 1,692,620.00
R-50 Kingspan Karrier Panel (Brick/CMU)	12,140.30	\$ 78.00	\$ 946,943.40
R-50 Kingspan Optimo Panel (Metal Panel)	19,555.30	\$ 54.00	\$ 1,055,986.20
R-65 Polyiso (Roof)	59,782.75	\$ 23.00	\$ 1,375,003.25
R-20 Underslab Insulation (Floor)	59,808.50	\$ 12.50	\$ 747,606.25
Double 725 Series Alpen Fiberglass ZR-7 Fixed (76") U-value 0.14	11,002.00	\$ 49.00	\$ 539,098.00
Mechanical System Option 1	86,800.00	\$ 40.00	\$ 3,472,000.00
<b>TOTAL</b>			<b>\$ 9,829,257.10</b>

**PASSIVE HOUSE OPTION 1b**

ASSEMBLIES AND MECH SYSTEMS	ft <sup>2</sup>	\$/ft <sup>2</sup>	TOTAL \$
R-36 Precast Concrete Wall (Gym Exterior)	16,926.20	\$ 100.00	\$ 1,692,620.00
R-50 Kingspan Karrier Panel (Brick/CMU)	12,140.30	\$ 78.00	\$ 946,943.40
R-50 Kingspan Optimo Panel (Metal Panel)	19,555.30	\$ 54.00	\$ 1,055,986.20
R-65 Polyiso (Roof)	59,782.75	\$ 23.00	\$ 1,375,003.25
R-6 Underslab Insulation (Floor)	59,808.50	\$ 10.50	\$ 627,989.25
Double 725 Series Alpen Fiberglass ZR-7 Fixed (76") U-value 0.14	11,002.00	\$ 49.00	\$ 539,098.00
Mechanical System Option 1	86,800.00	\$ 40.00	\$ 3,472,000.00
<b>TOTAL</b>			<b>\$ 9,709,640.10</b>

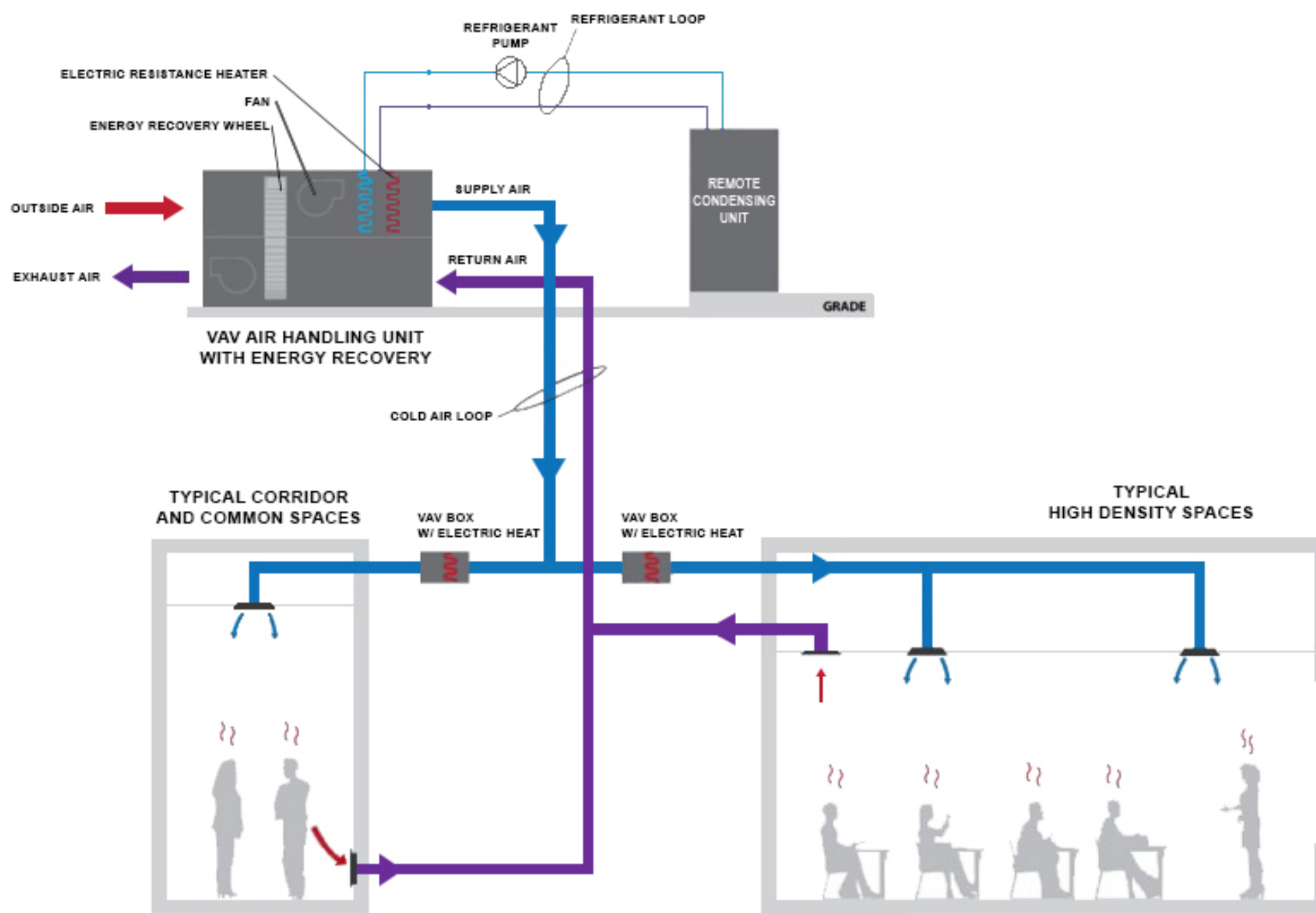
Isolated cost of Envelope + HVAC, assumed all else remains unchanged

## Conclusions: Option 2b was worth the investment.

### PASSIVE HOUSE OPTION 2b

ASSEMBLIES AND MECH SYSTEMS	ft <sup>2</sup>	\$/ft <sup>2</sup>	TOTAL \$
R-36 Precast Concrete Wall (Gym Exterior)	16,926.20	\$ 100.00	\$ 1,692,620.00
R-50 Kingspan Karrier Panel (Brick/CMU)	12,140.30	\$ 78.00	\$ 946,943.40
R-50 Kingspan Optimo Panel (Metal Panel)	19,555.30	\$ 54.00	\$ 1,055,986.20
R-65 Polyiso (Roof)	59,782.75	\$ 23.00	\$ 1,375,003.25
R-6 Underslab Insulation	59,808.50	\$ 10.50	\$ 627,989.25
Double 725 Series Alpen Fiberglass ZR-7 Fixed (76") U-value 0.14	11,002.00	\$ 49.00	\$ 539,098.00
Mechanical System Option 2	86,800	\$ 39.00	\$ 3,385,200.00
<b>TOTAL</b>			<b>\$ 9,622,840.10</b>

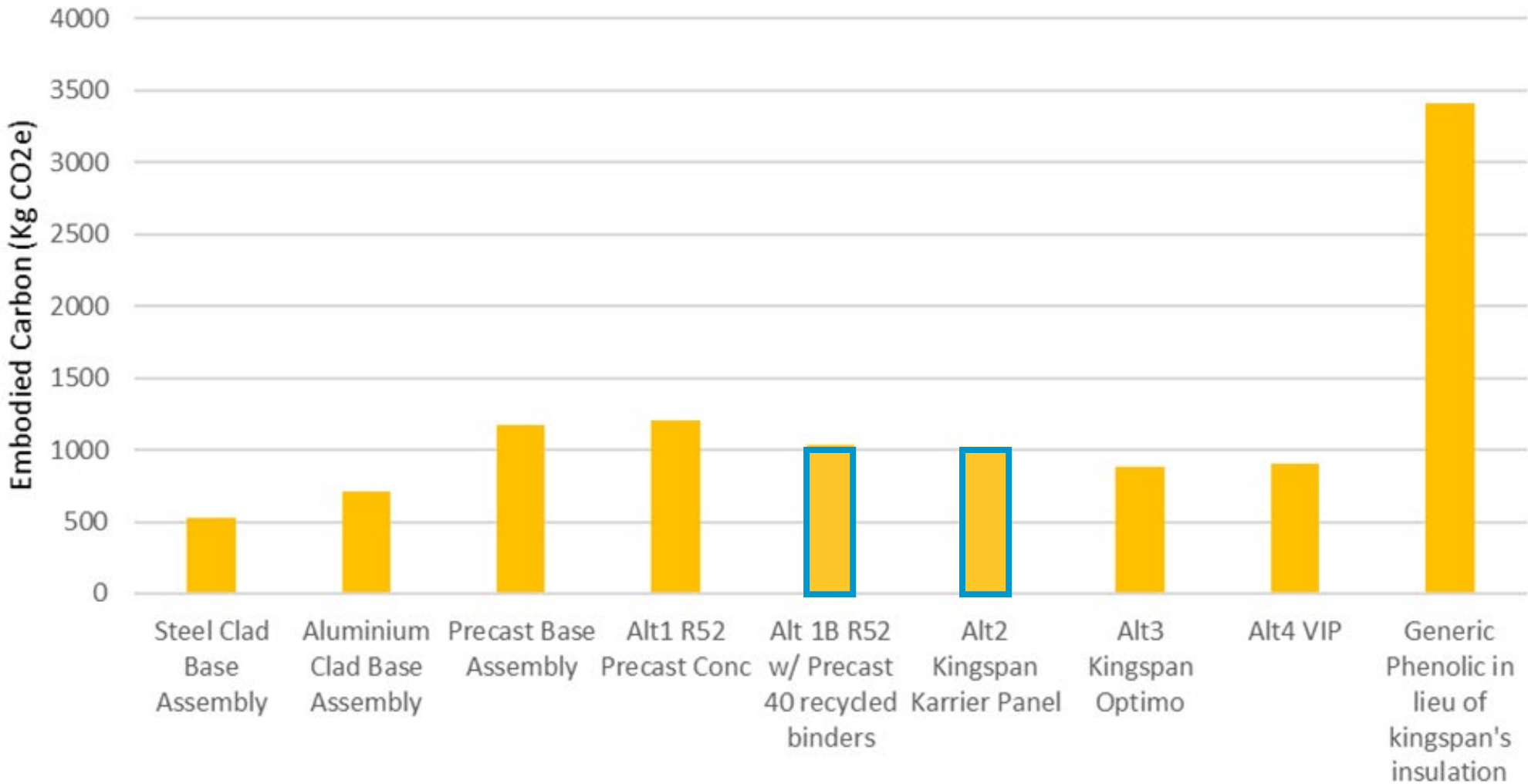
The extra cost over the Base Case was only \$231,481, less than 1% of the construction budget.





# Embodied Carbon Findings

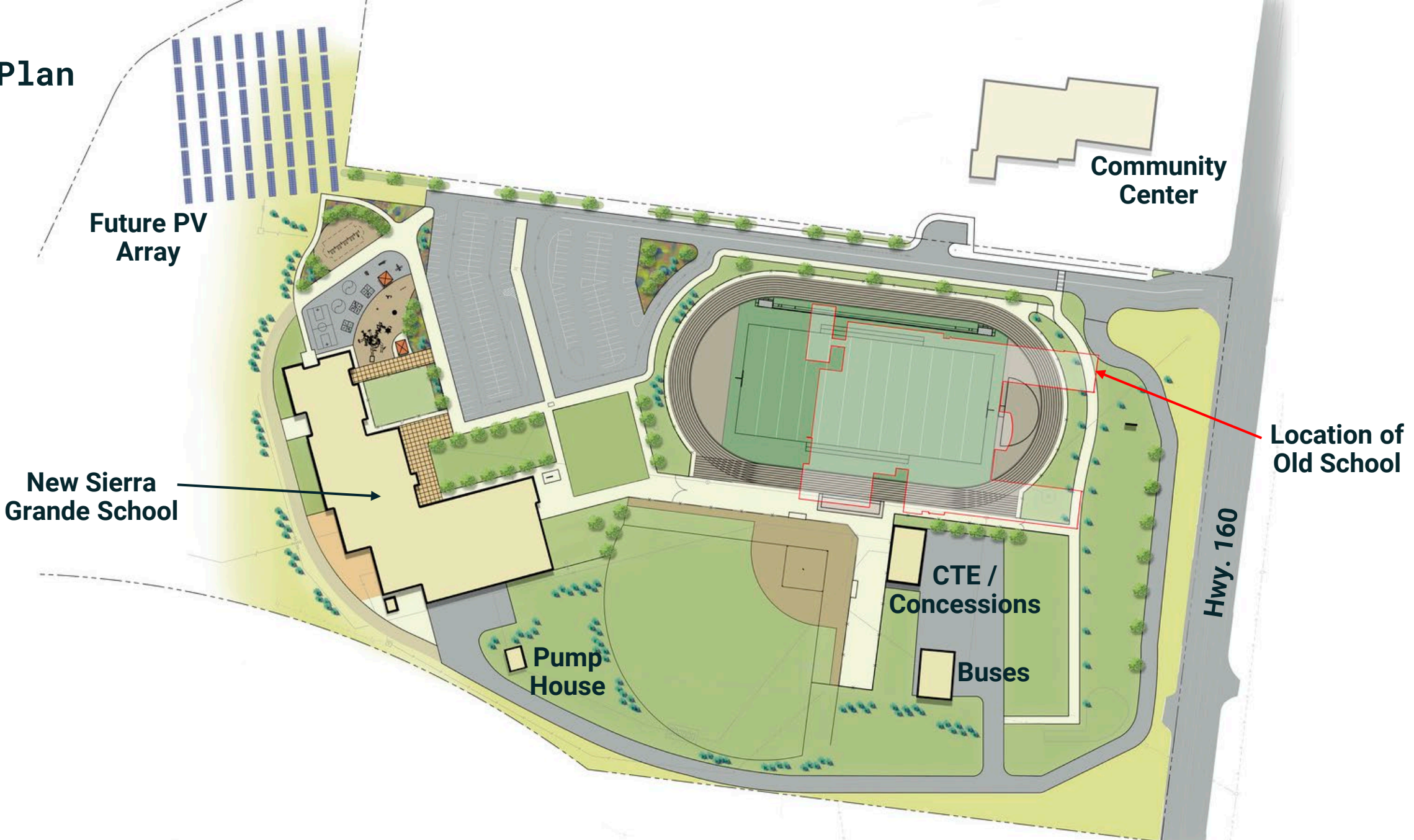
## Embodied Carbon Comparison - Envelope Assembly



Designing the  
future



# Site Plan



Future PV Array

Community Center

New Sierra Grande School

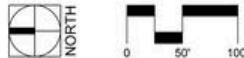
Location of Old School

Hwy. 160

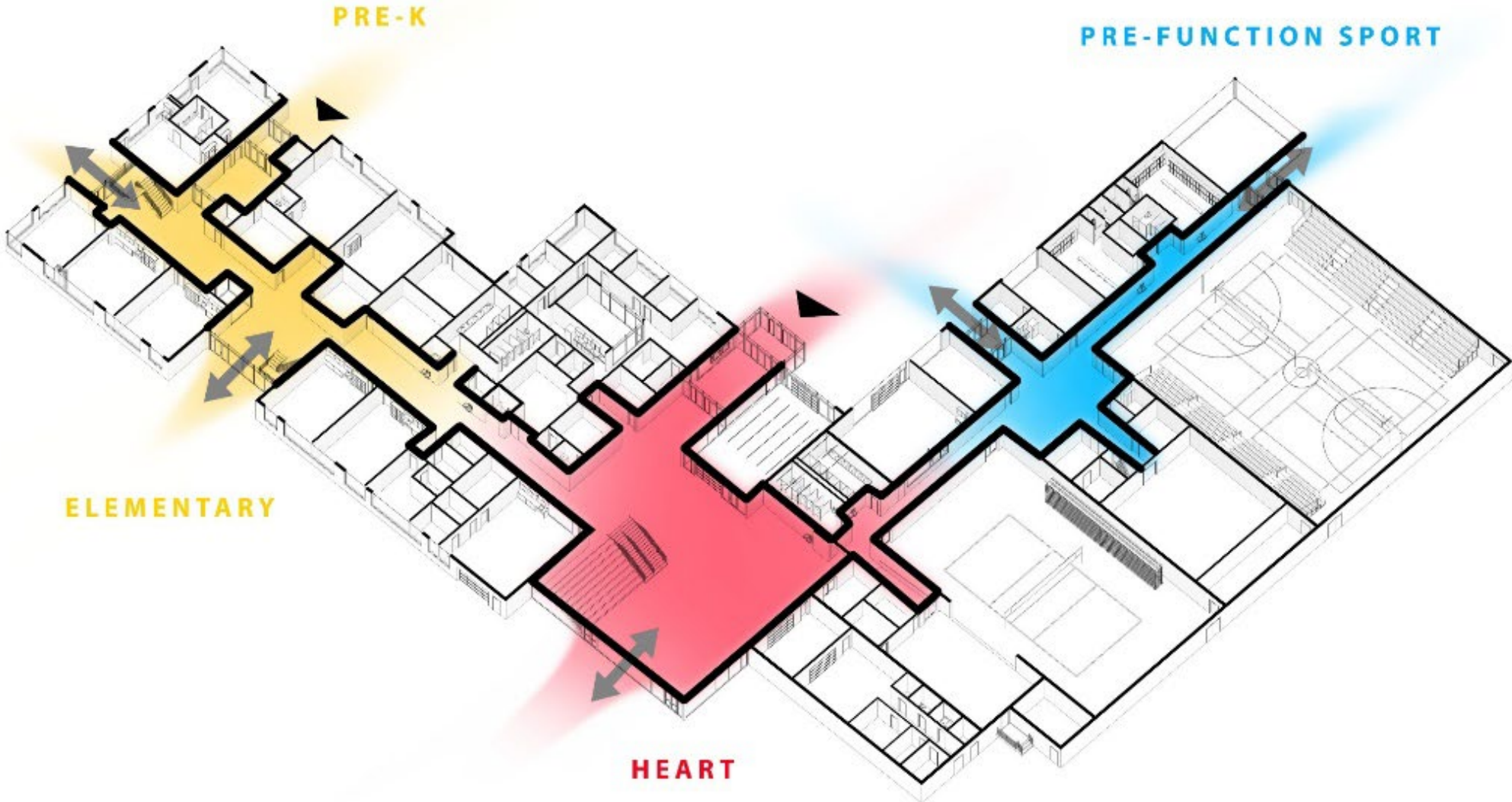
CTE / Concessions

Buses

Pump House



# Building Organization

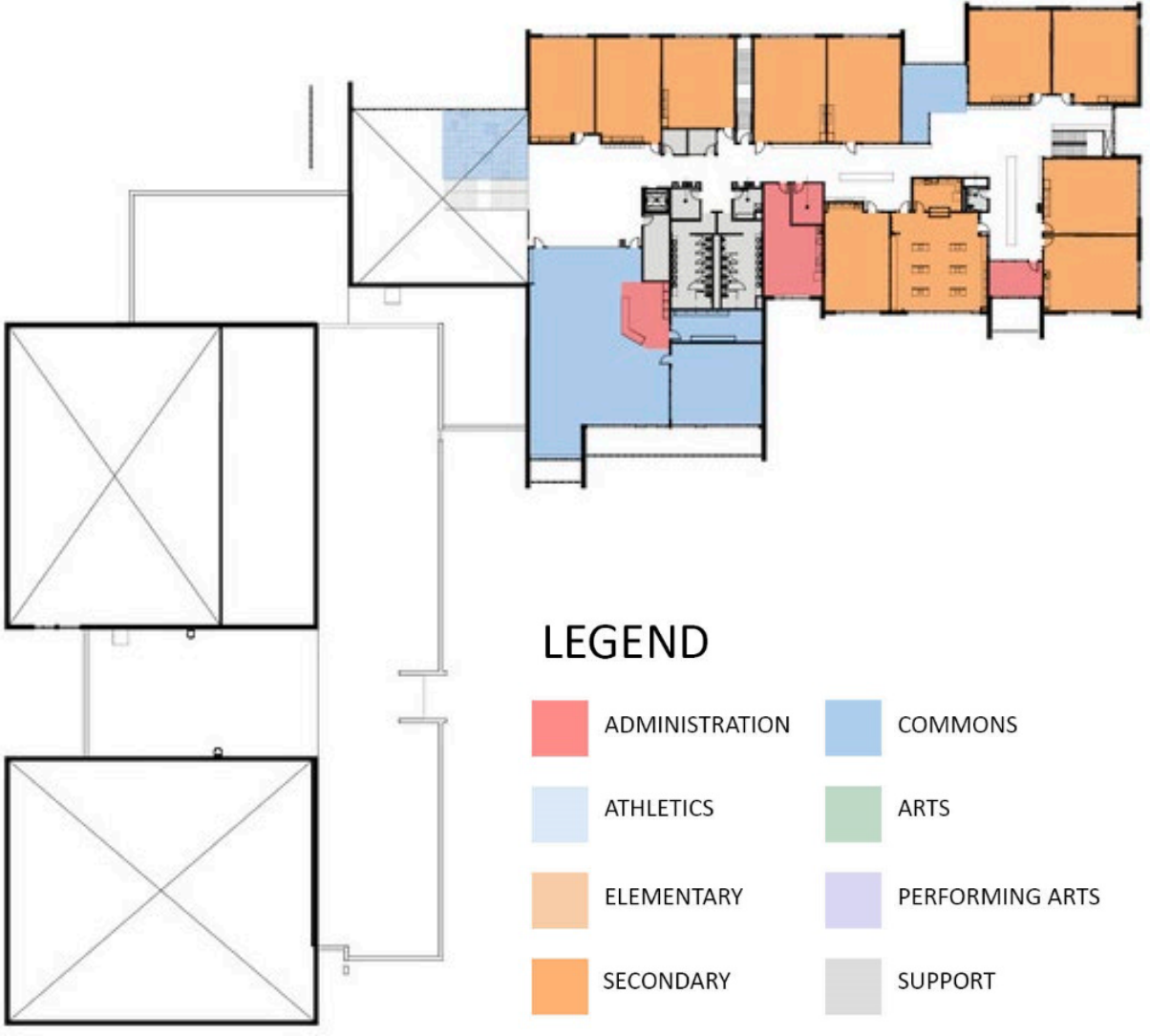


# Building Layout









## Level 1



## Level 2



### LEGEND

- |  |   |
|--|---|
|  ADMINISTRATION |  COMMONS         |
|  ATHLETICS      |  ARTS            |
|  ELEMENTARY     |  PERFORMING ARTS |
|  SECONDARY      |  SUPPORT         |

Building the Vision

## Construction – Windows



Stretched film  
center with gas  
filling – glass only  
R- 6, plus double  
thermal break  
alum. frames





# Construction Photos – Precast Walls



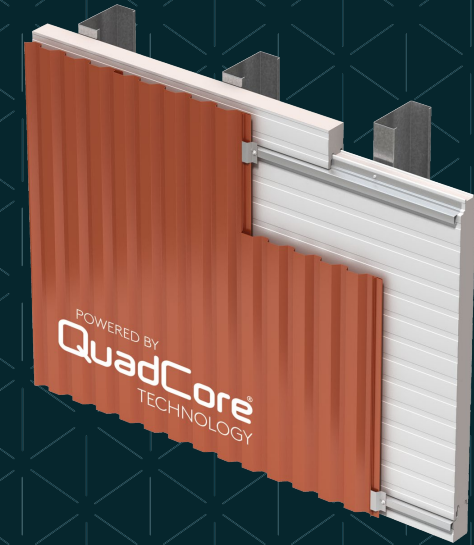
6" thick rigid  
insulation core –  
R-38



## Construction – Clad Walls



Insulated metal  
panel with R-8 per  
inch, total wall –  
R-50



# Passive House Construction



Specified Infiltration rate: 0.050

Blower Door Test results:  
recommended, but not conducted



# Spaces for Moving



Protected  
for play



Daylight  
in every  
learning  
space



Student-  
inspired  
spaces





Learning  
happens  
everywhere



# Final frontiers for going all-electric: Kitchen + Science



Dialing in  
performance

# Commissioning



CHPS required Enhanced Commissioning.

First year of operation had higher than expected utility bills.

Design team re-engaged to Re-Commission the entire building.

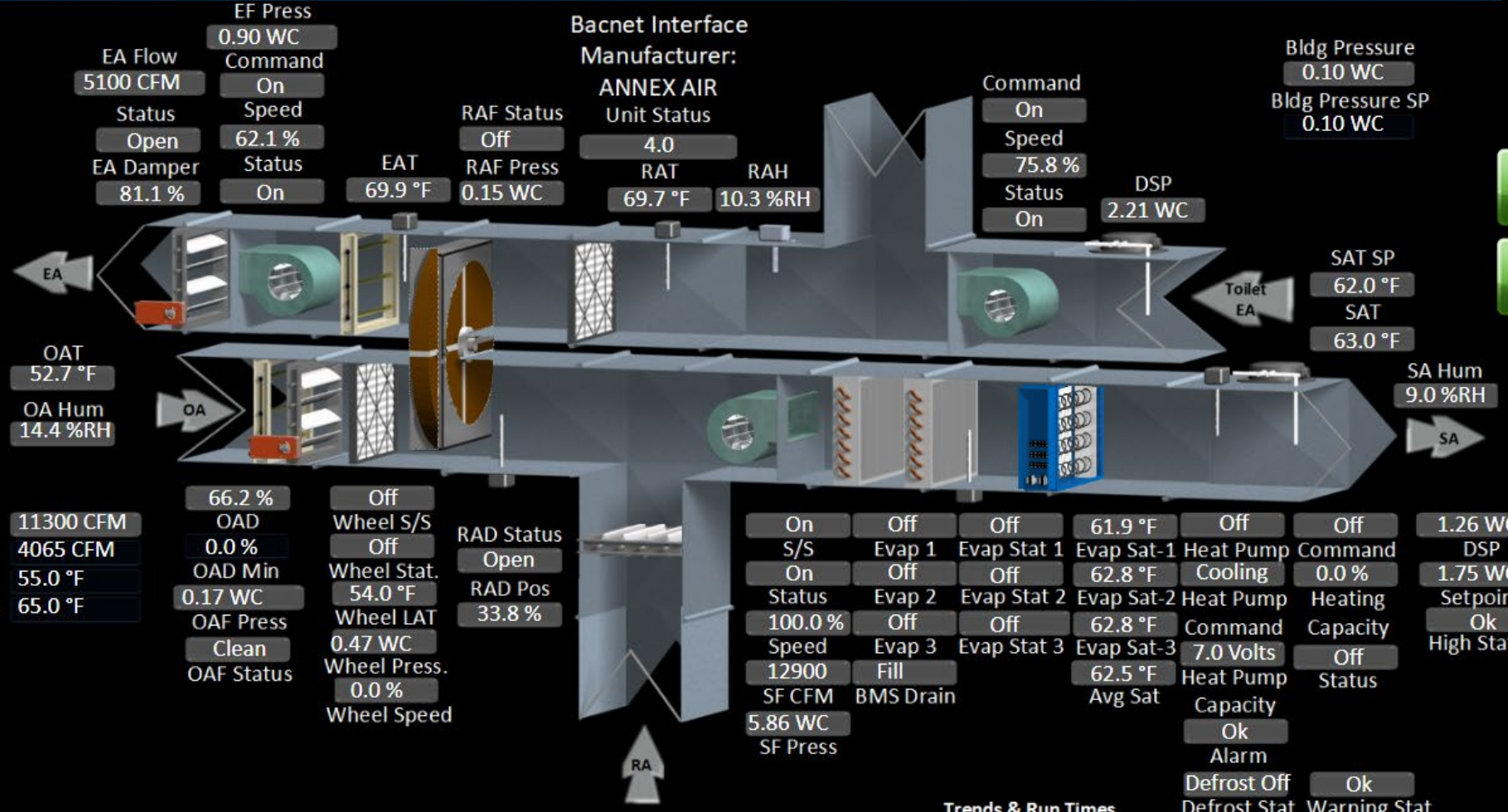
Many settings, especially, outside air intake and exhaust rates, were set far too high.

Energy use is finally coming into expected range.

Occupancy Mode **Occupied**  
 Emergency Shutdown **Disabled**

**Sierra Grande PK-12**  
RTU-3

54.0 °F



Control Temp **63.0 °F**  
 Return Humidity SP **55.0 %RH**  
 Active Alarm **Normal**  
 Shutdown **Ok**

**Trends & Run Times**

MPT 1 MPT 2 MPT 3 MPT 4 MPT 5

## Thermographic Imaging



Minimum delta T inside-outside:  
30 degrees F preferred, more is  
better

No direct sun on any surfaces, night  
photography is best

HVAC system should be in occupied  
mode to check for infiltration leaks

Avoid being perpendicular to  
reflective surfaces

Use manual calibration to adjust  
each image and maximize contrast  
in building components

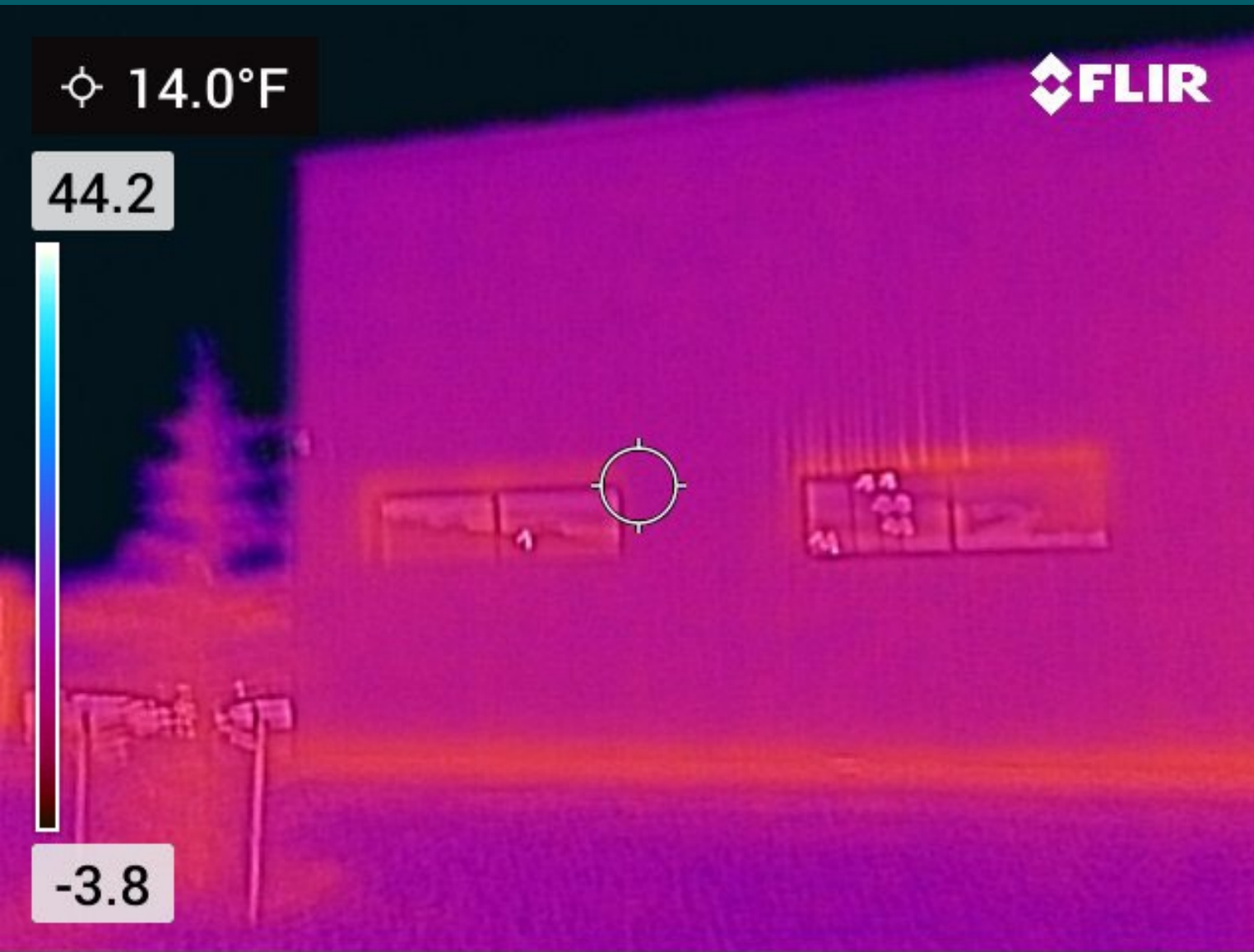
# Exterior Wall Assemblies



Precast Gym walls with locker rooms in foreground

Windows in Locker Rooms

## Exterior Wall Assemblies



Good news! Solid wall areas are very consistent temp.

No noticeable differences where structure is located

No difference at wall to deck transition

Windows are not leaking excessive heat



## Exterior Openings



Garage doors, even high quality units, have extreme heat loss through envelope and should be used sparingly

## Exterior Openings



Wall above garage door is 23.9 degrees F

Frames of doors are 54.2 degrees F – hottest spot on entire building!

Q + A

what are you  
curious about?

See the project come to life in the full Rocky Mountain PBS "Heart of a Building" episode that aired on Earth Day, 2023:



# Let's Connect!

2023 A4LE  
LearningSCAPES  
October 14, 2023



BranchPattern

**Cunningham**

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**THANK YOU!**