

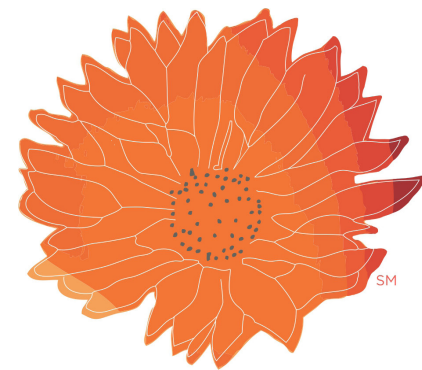
PASSIVE

LIVING

PARKS

*Exploring Synergies between the Passive Building Standard,  
the Living Building Challenge and National Parks*

NORTH AMERICAN PASSIVE HOUSE CONFERENCE 2017  
*Will Ives, AIA CPHC*



LIVING  
BUILDING  
CHALLENGE<sup>SM</sup>

+



Passive House Institute US

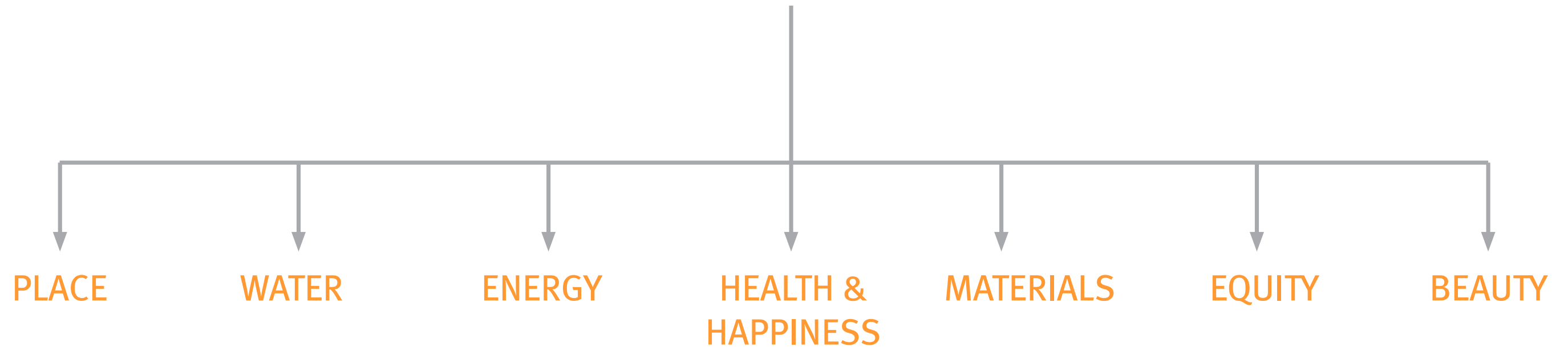








LIVING  
BUILDING  
CHALLENGE™





LIVING  
BUILDING  
CHALLENGE™

PLACE

WATER

ENERGY

HEALTH &  
HAPPINESS

MATERIALS

EQUITY

BEAUTY

IMPERATIVE: NET POSITIVE ENERGY

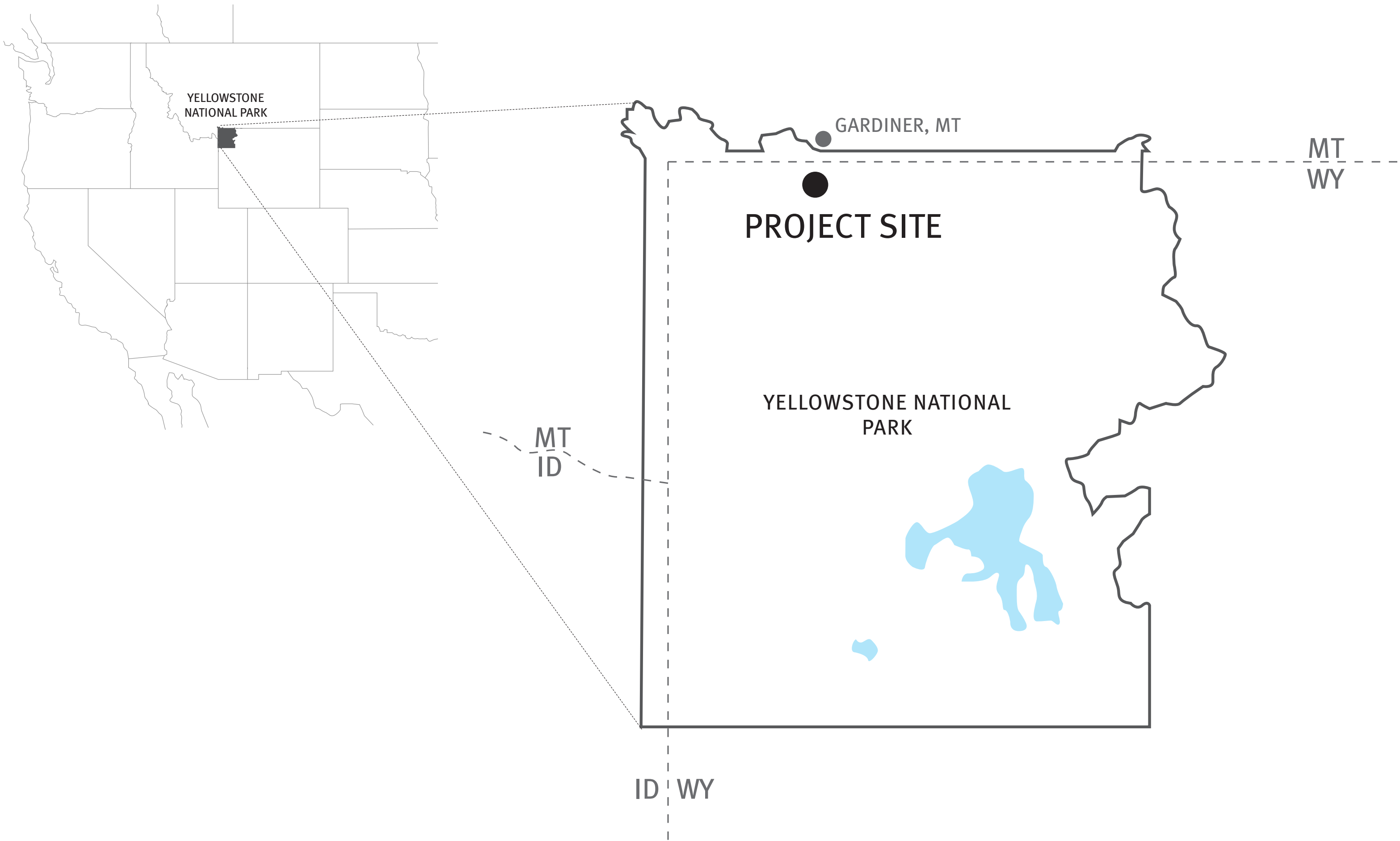




YCC CACHE

YELLOWSTONE PARK





YELLOWSTONE  
NATIONAL PARK

GARDINER, MT

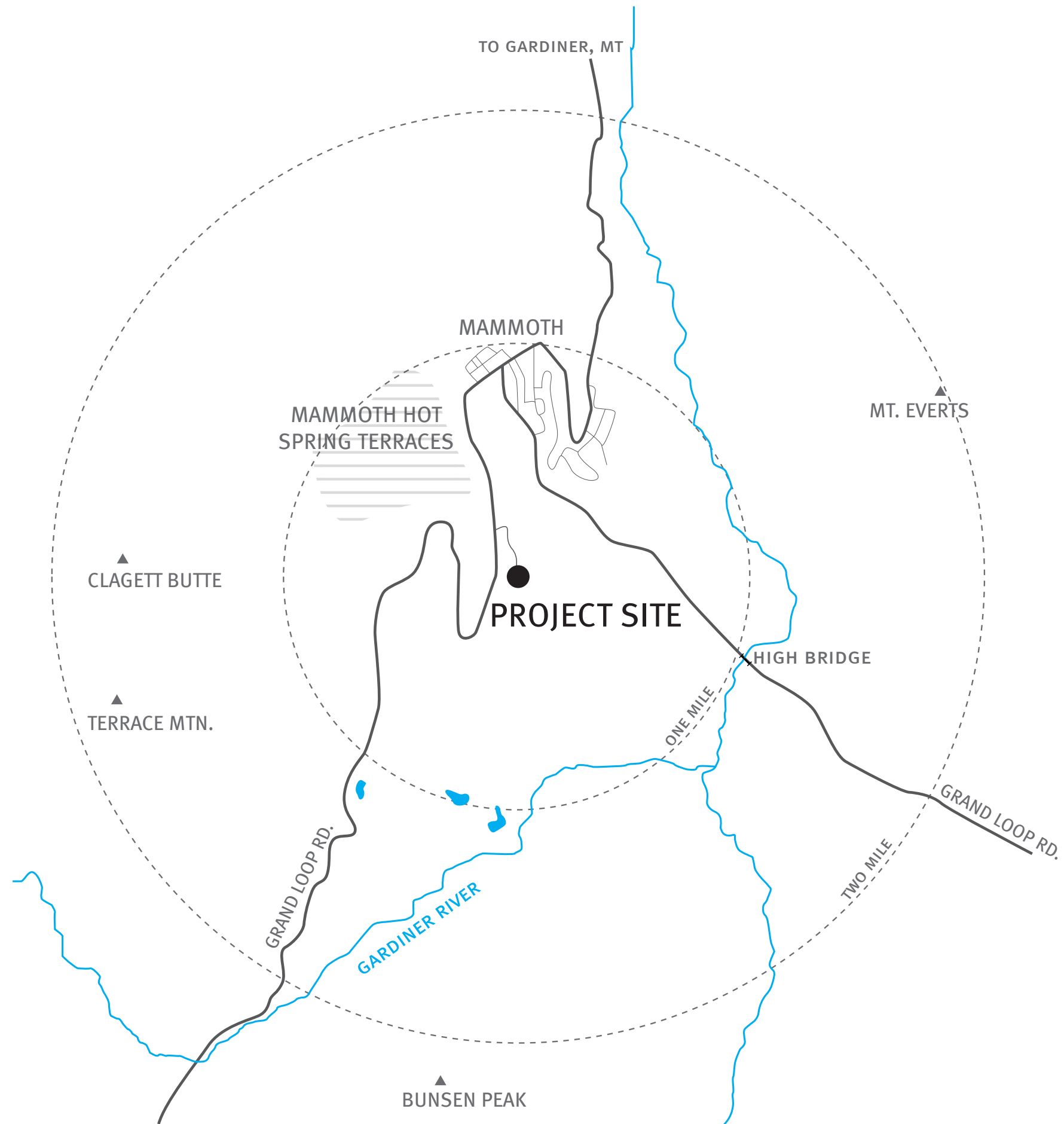
MT  
WY

PROJECT SITE

YELLOWSTONE NATIONAL  
PARK

MT  
ID

ID WY













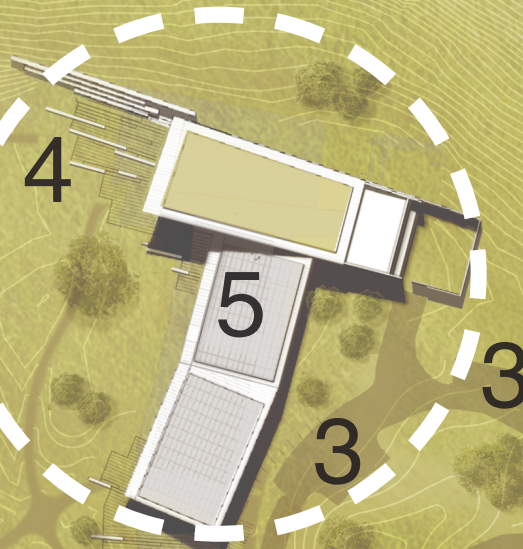




GRAND LOOP ROAD

10

1



3

2

3

7  
12

8 8

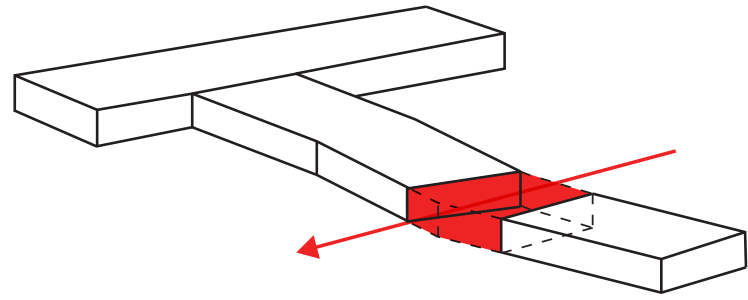
### SITE PLAN

- historic entry gate 1
- campus entry 2
- car parking 3
- outdoor classroom 4
- commons building 5
- classroom building 6
- wastewater treatment & gear cache building 7
- staff housing building 8
- dormitory building 9
- fire pit 10
- play court 11

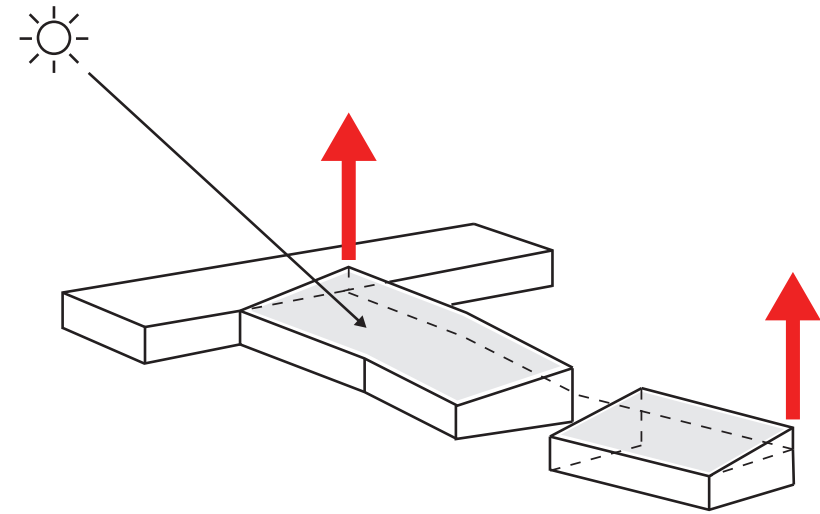
wastewater treatment wetland 12



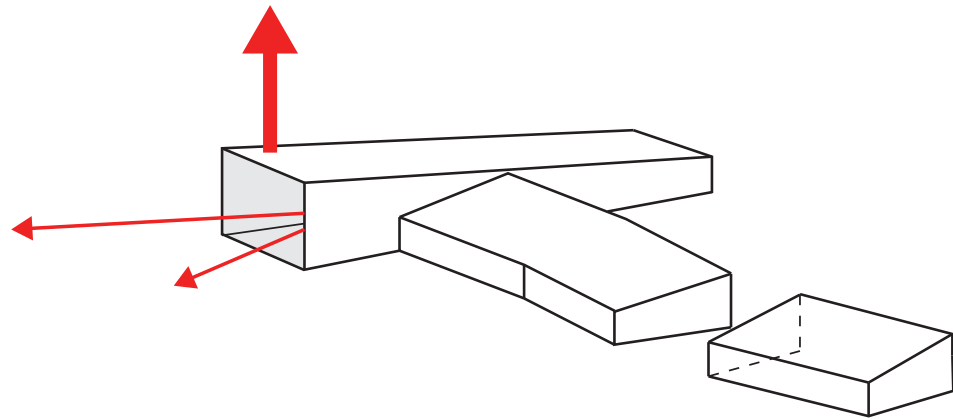
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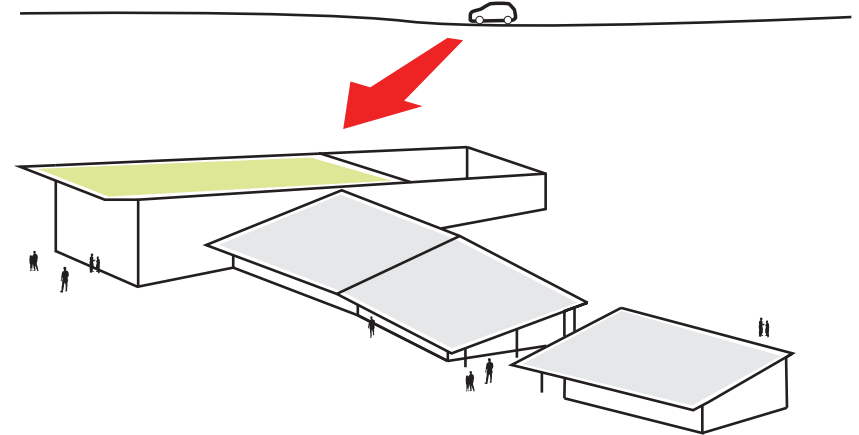
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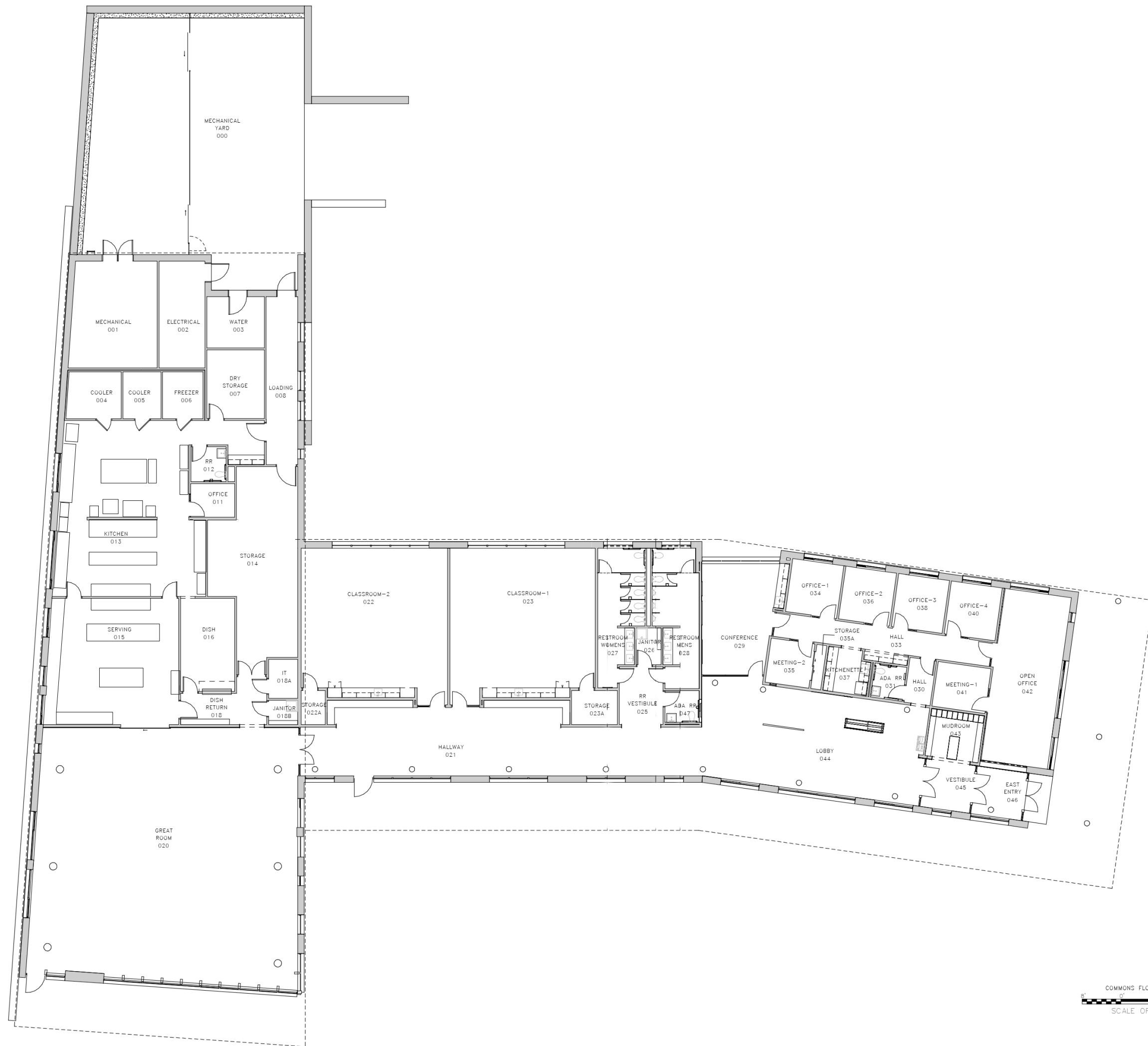


3



4





## YELLOWSTONE YOUTH CAMPUS

<b>COMMONS</b>	15,620 gsf
<b>CLASSROOM</b>	3,770 gsf
<b>DORMITORY (X5)</b>	4,455 gsf
<b>STAFF HOUSING</b>	(6-unit) 5,929 gsf; (4-unit) 4,692 gsf
<b>WASTEWATER TREATMENT &amp; GEAR CACHE</b>	2,047 gsf
<hr/>	
<b>TOTAL</b>	<b>51,955 GSF</b>

<b>LOCATION</b>	Mammoth, Wyoming (climate zone 6, elevation of 6,300 ft)
<b>SITE AREA</b>	~16 acres
<b>PROJECTED EUI</b>	17 - 30 kBtu/sf/yr
<b>STRUCTURE</b>	Wood Frame/Timber
<b>WALLS</b>	Wood Frame Rainscreen R53
<b>ROOF</b>	Cross Laminated Timber R75
<b>FLOORS</b>	Slab on Grade Concrete R24 continuous insulation Cross Laminated Timber with crawlspace with R32 Cross Laminated Timber exposed (two-level buildings)
<b>WINDOWS</b>	Andersen Windows E-Series aluminum clad wood windows Triple pane glazing with krypton fill Center of glazing u-value of .10 Installed u-value of .16 - .18



**1 ROOF DESIGN**

**2 ENVELOPE DESIGN**

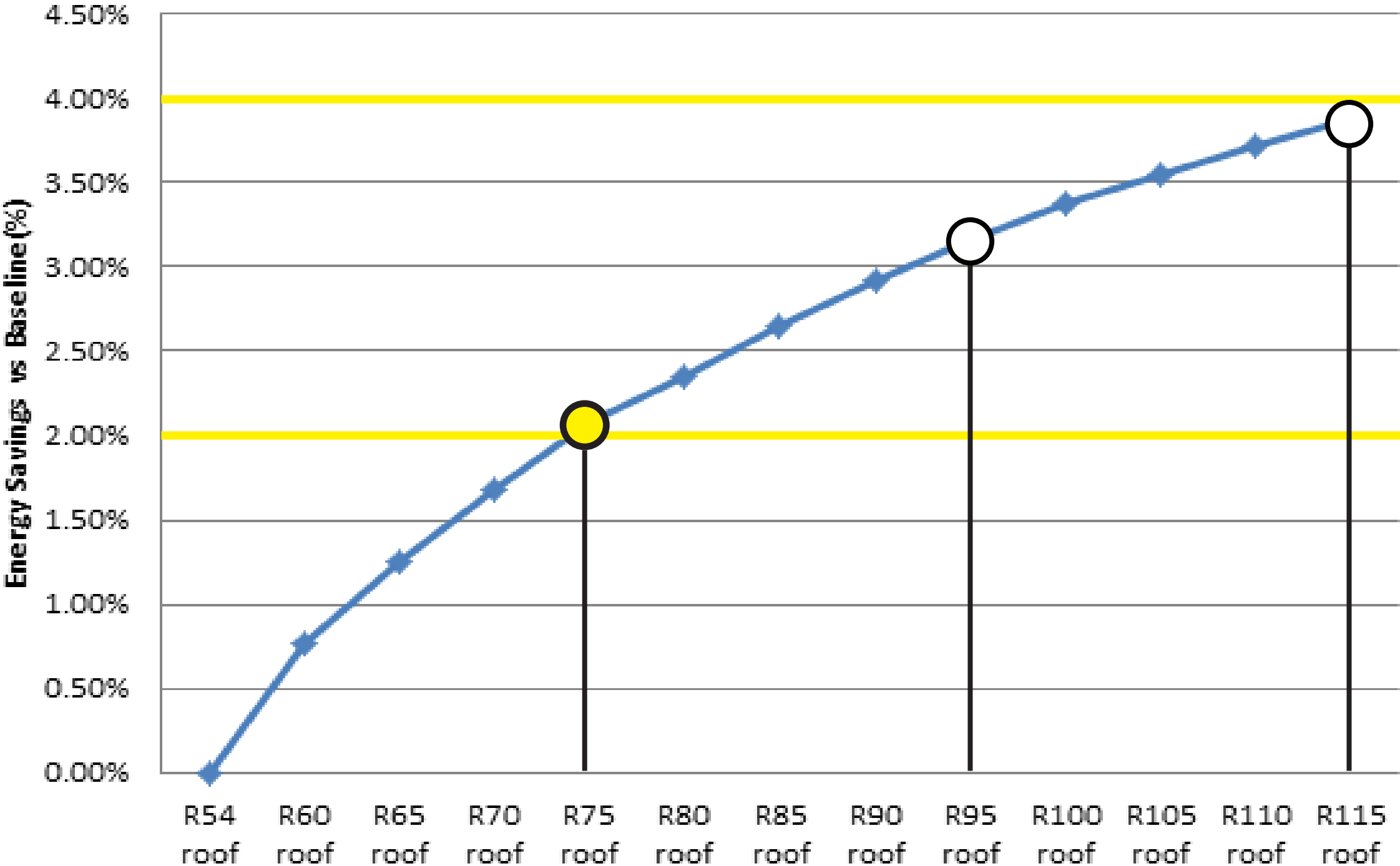
**3 SPACE CONDITIONING  
& VENTILATION**

# ROOF DESIGN

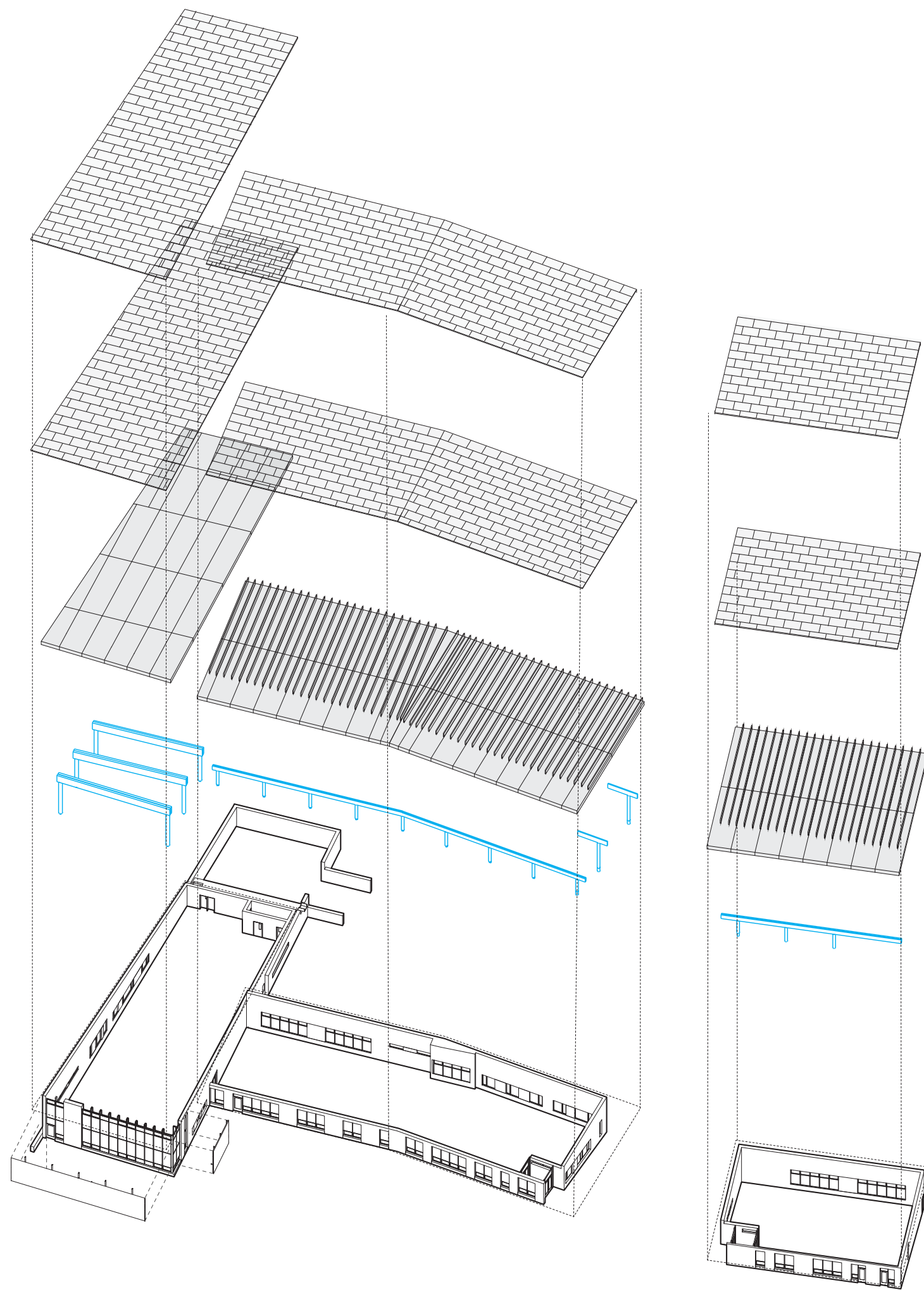
# PRIMARY ROOF DESIGN GOALS

- 1 Simple & durable construction inspired by western park architecture
- 2 Continuous air and thermal barrier
- 3 Maximize opportunity for rooftop solar electric production

# ROOF ASSEMBLY OPTIMIZATION

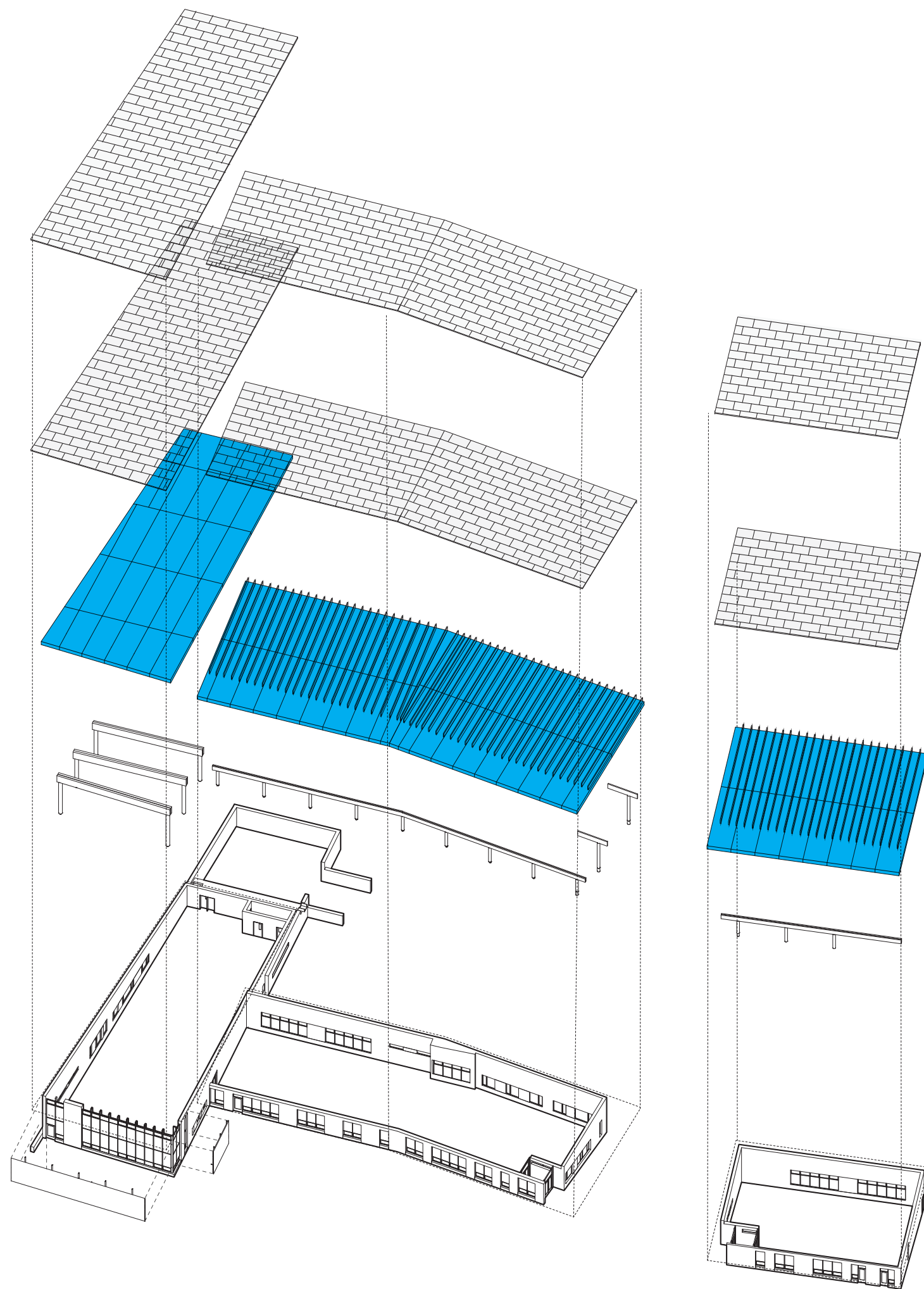


# ROOF ASSEMBLY



● — EXPOSED TIMBER STRUCTURE

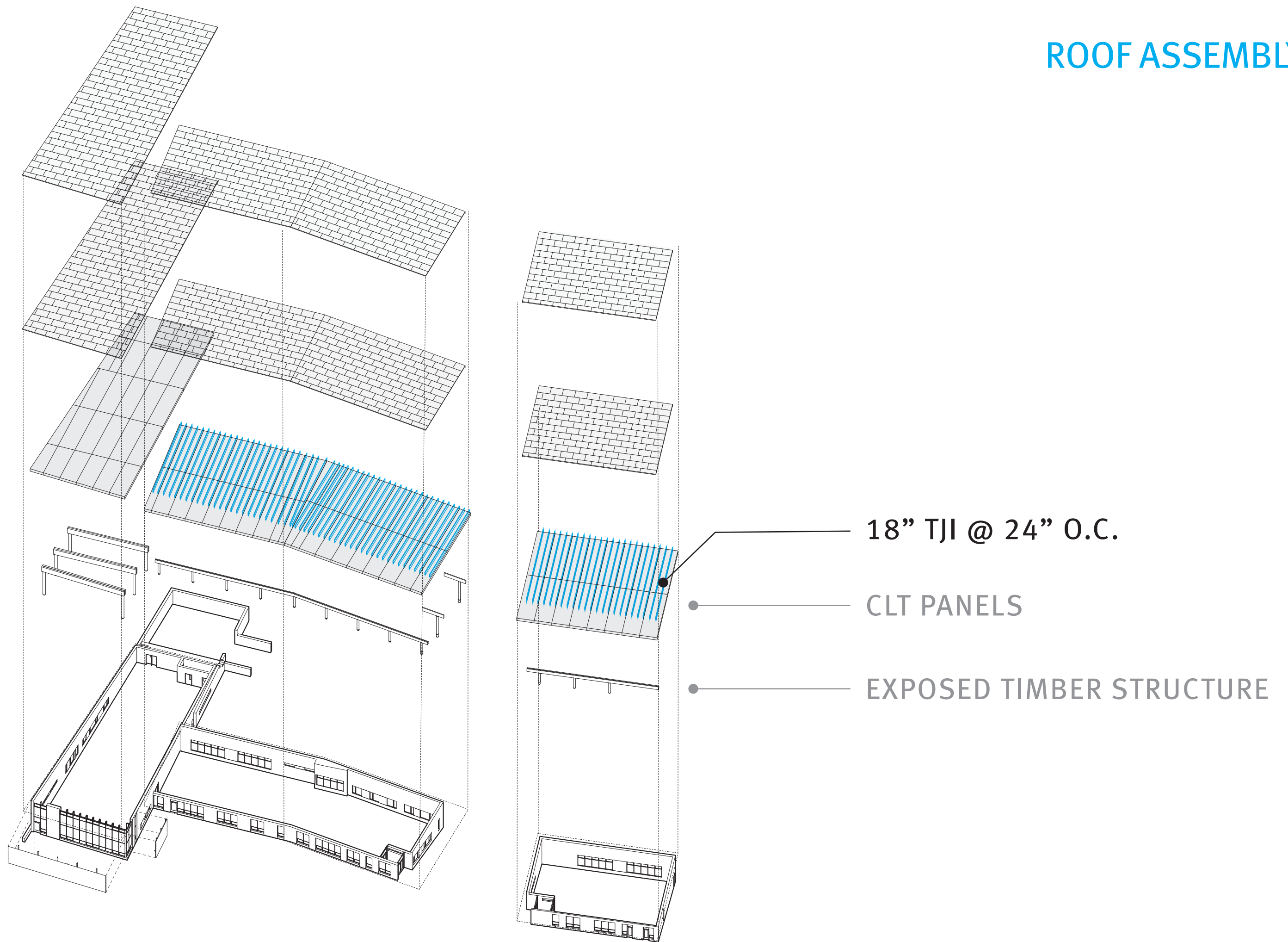
# ROOF ASSEMBLY



CLT PANELS

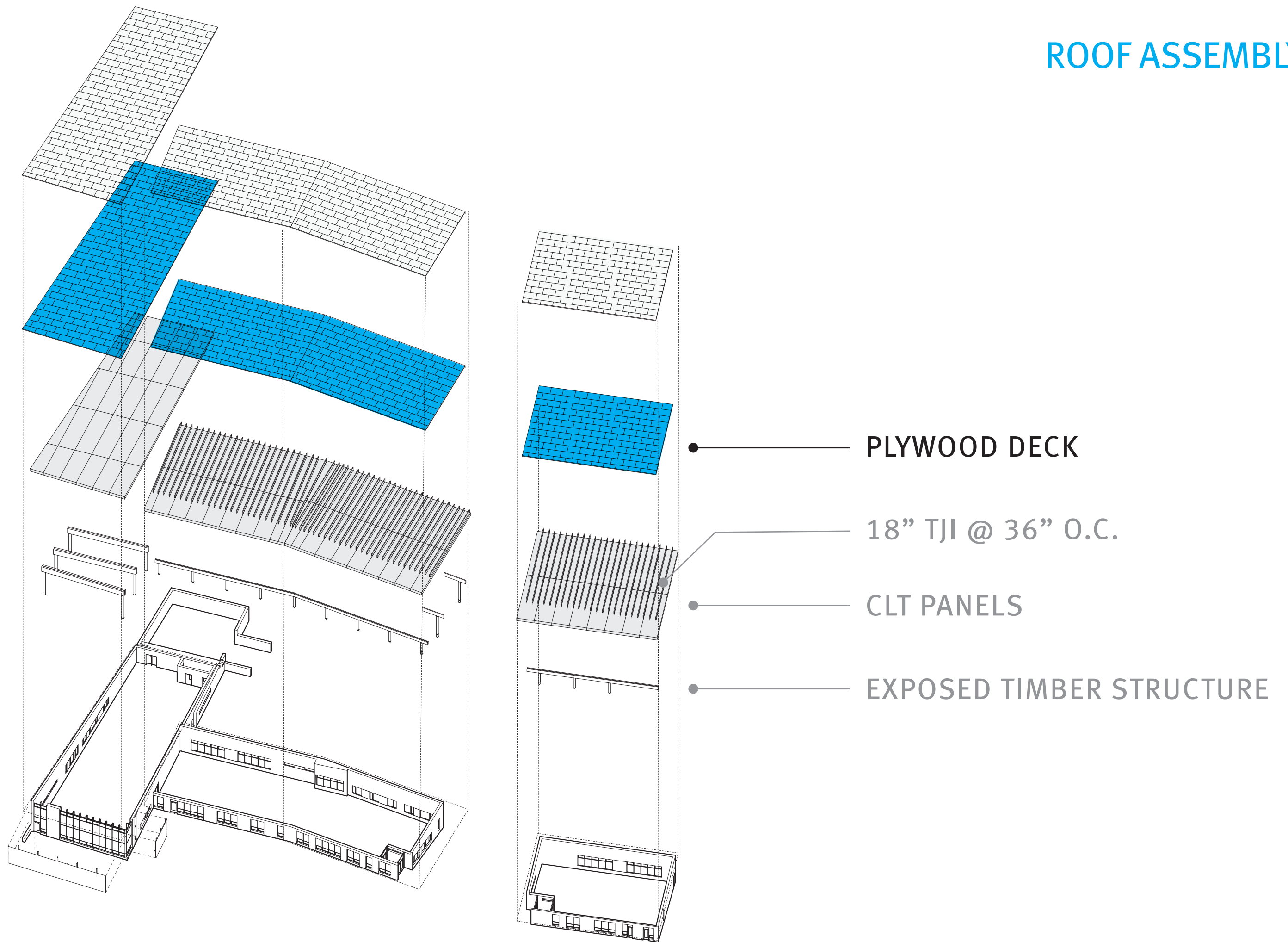
EXPOSED TIMBER STRUCTURE

# ROOF ASSEMBLY

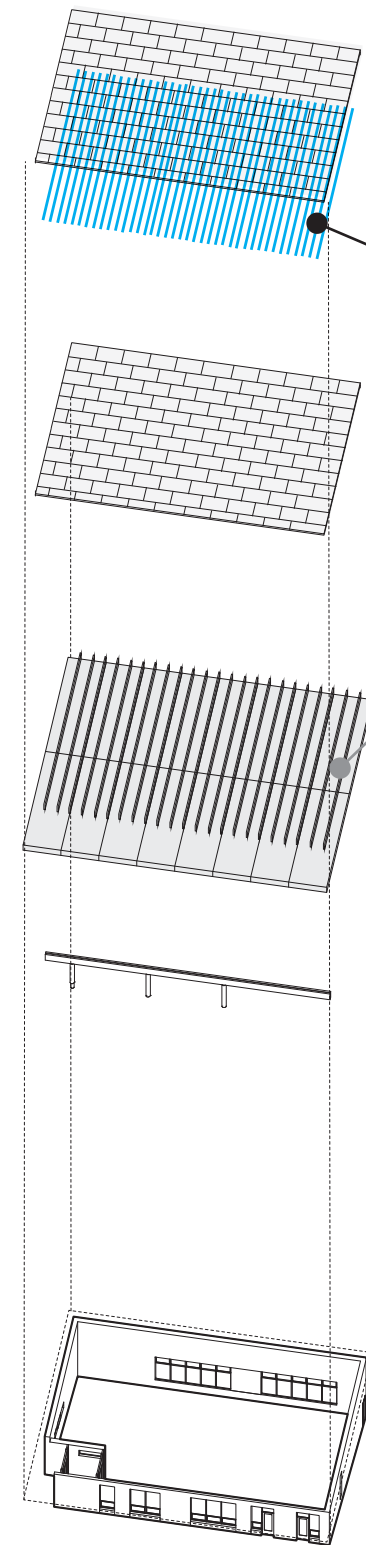
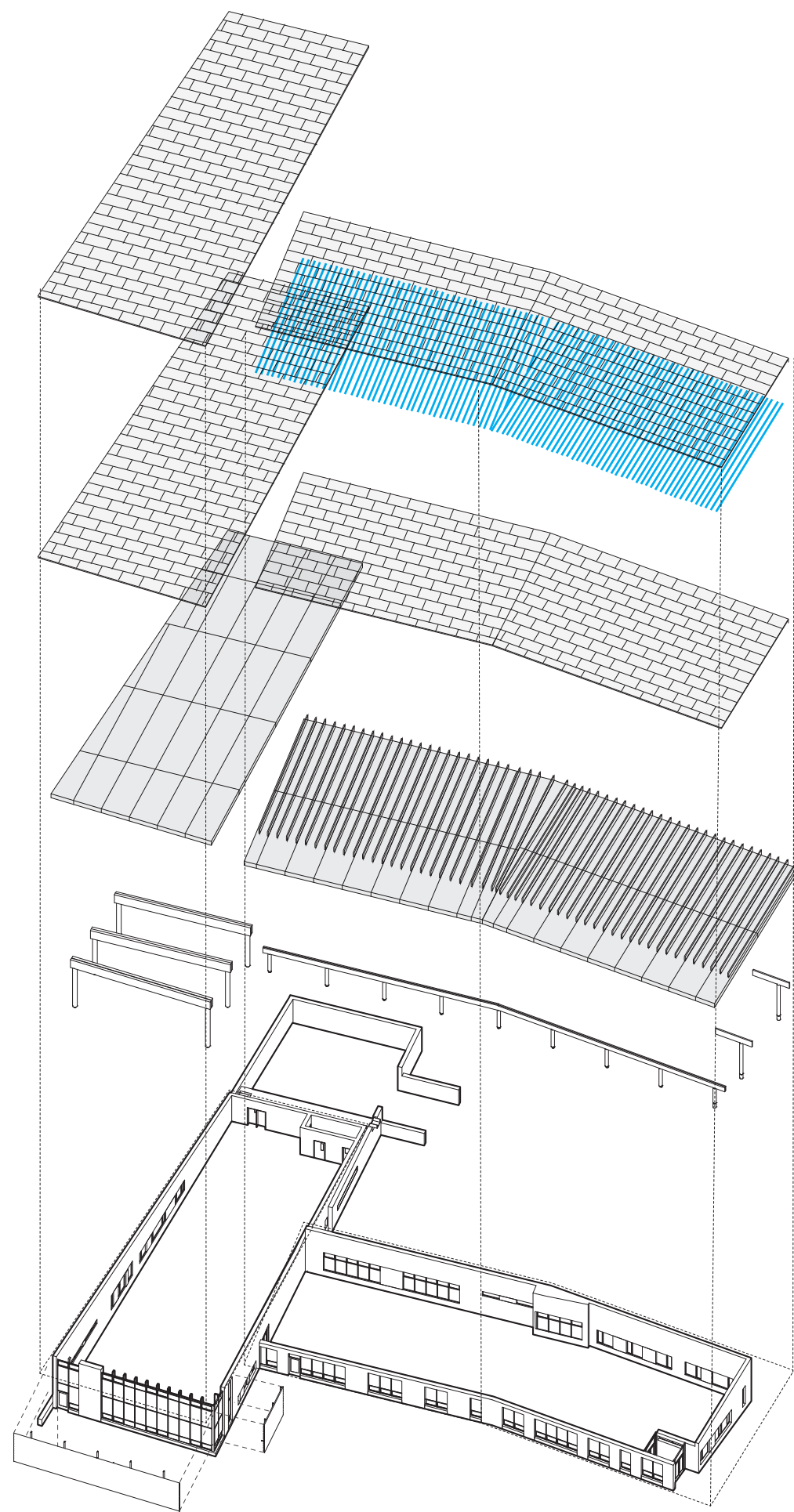




# ROOF ASSEMBLY



# ROOF ASSEMBLY



2X6 BLOCKING FOR VENTILATION CAVITY

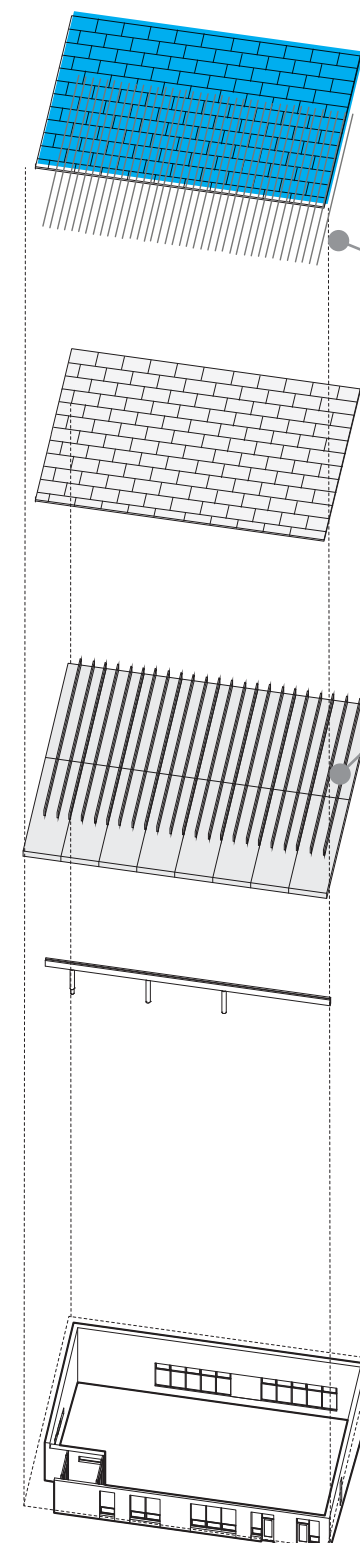
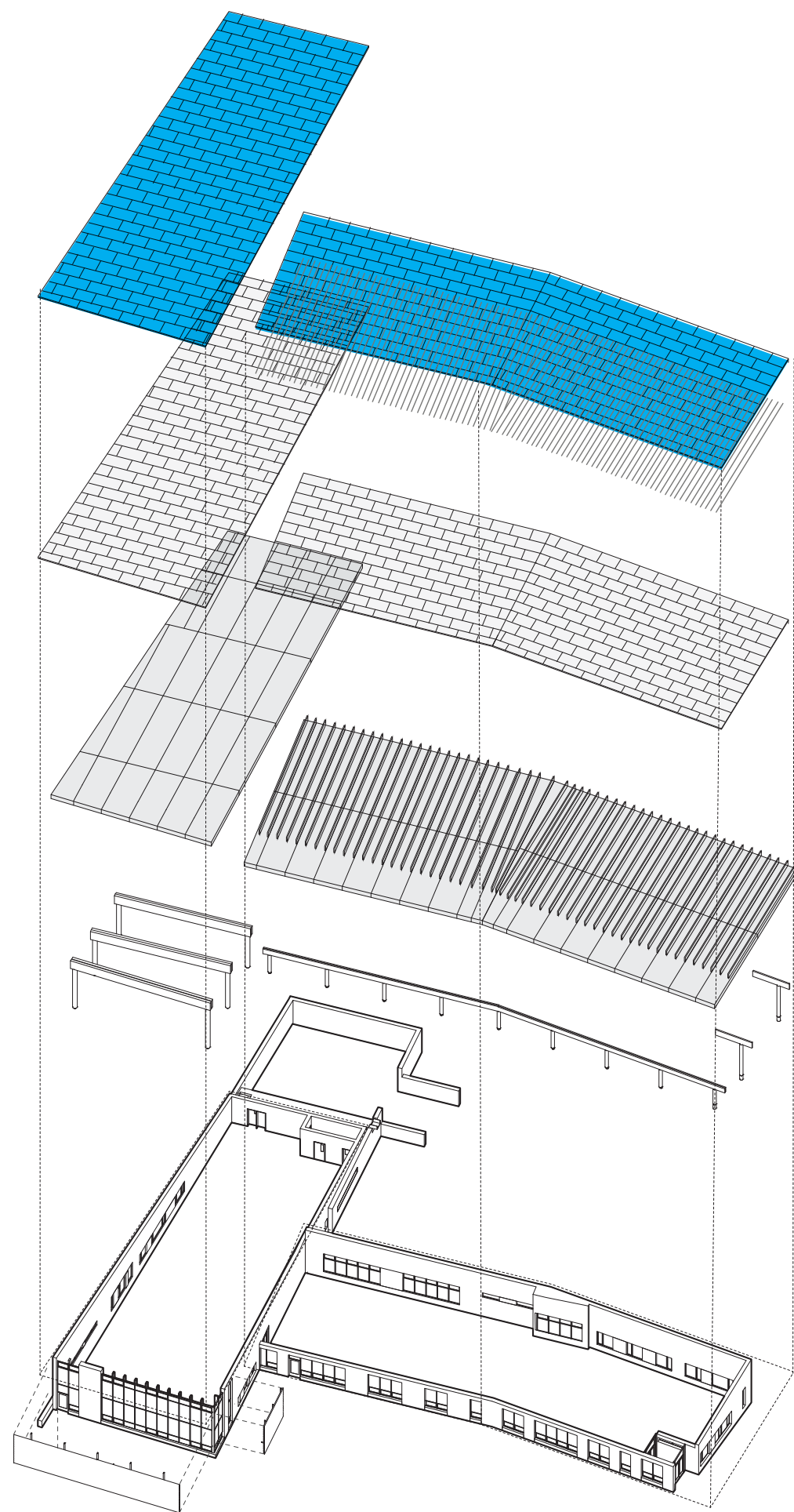
PLYWOOD DECK

18" TJI @ 36" O.C.

CLT PANELS

EXPOSED TIMBER STRUCTURE

# ROOF ASSEMBLY



PLYWOOD DECK

2X6 BLOCKING FOR VENTILATION CAVITY

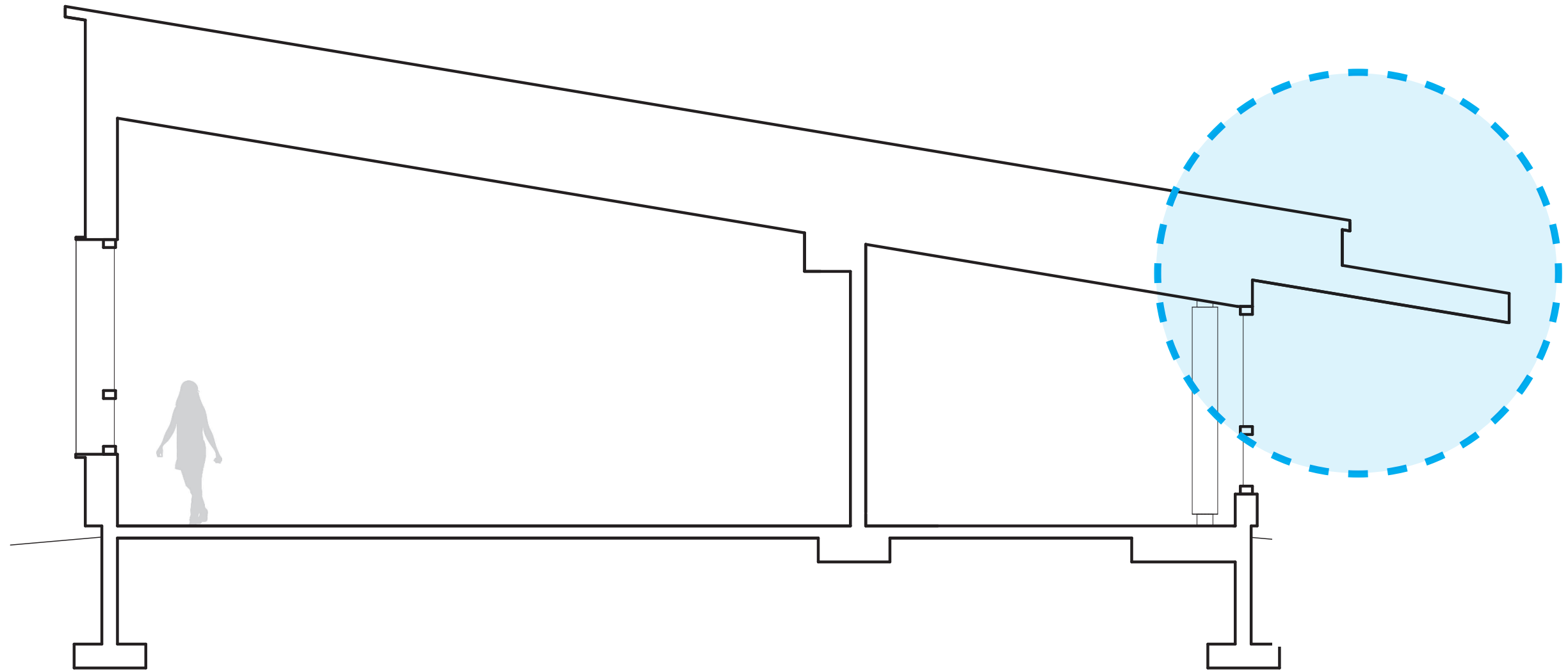
PLYWOOD DECK

18" TJI @ 36" O.C.

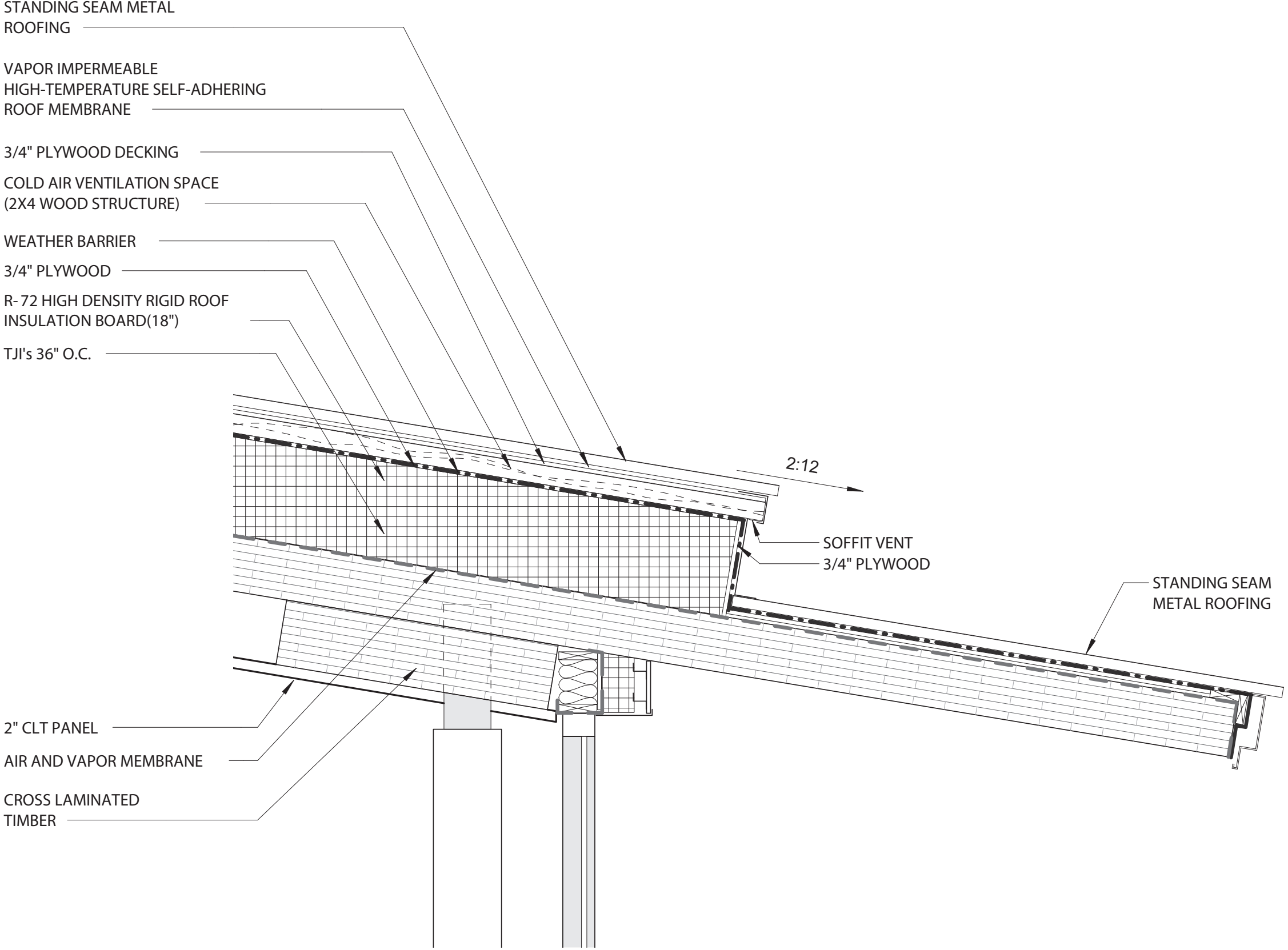
CLT PANELS

EXPOSED TIMBER STRUCTURE

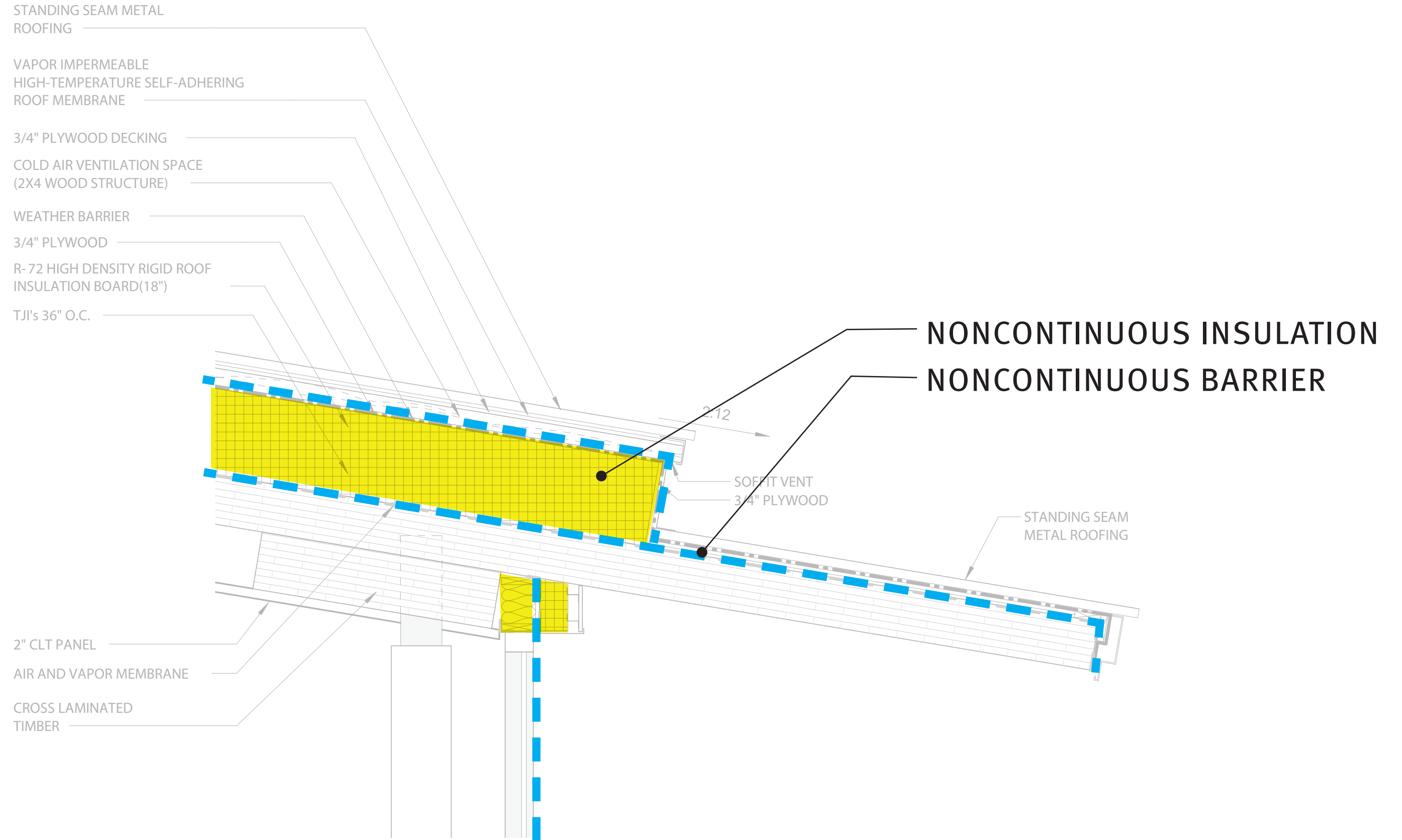


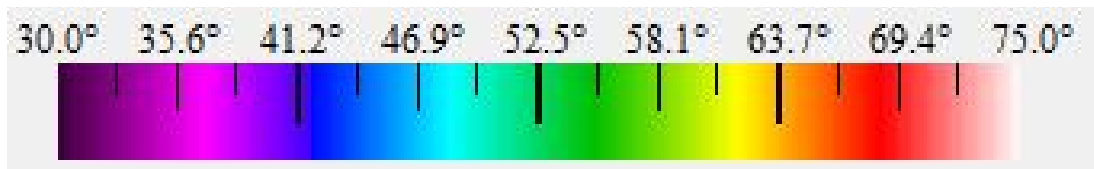
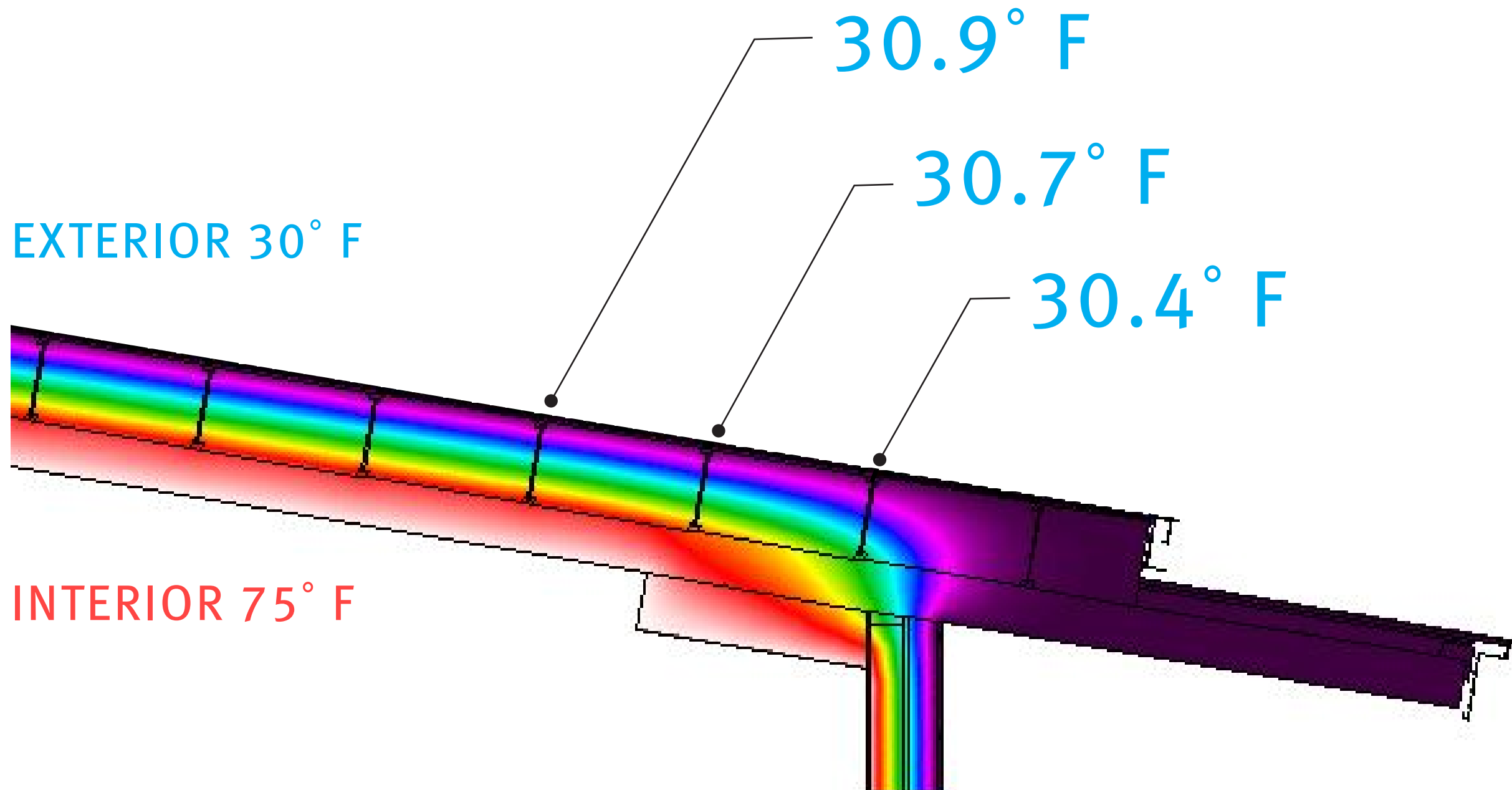


# EAVE DETAIL

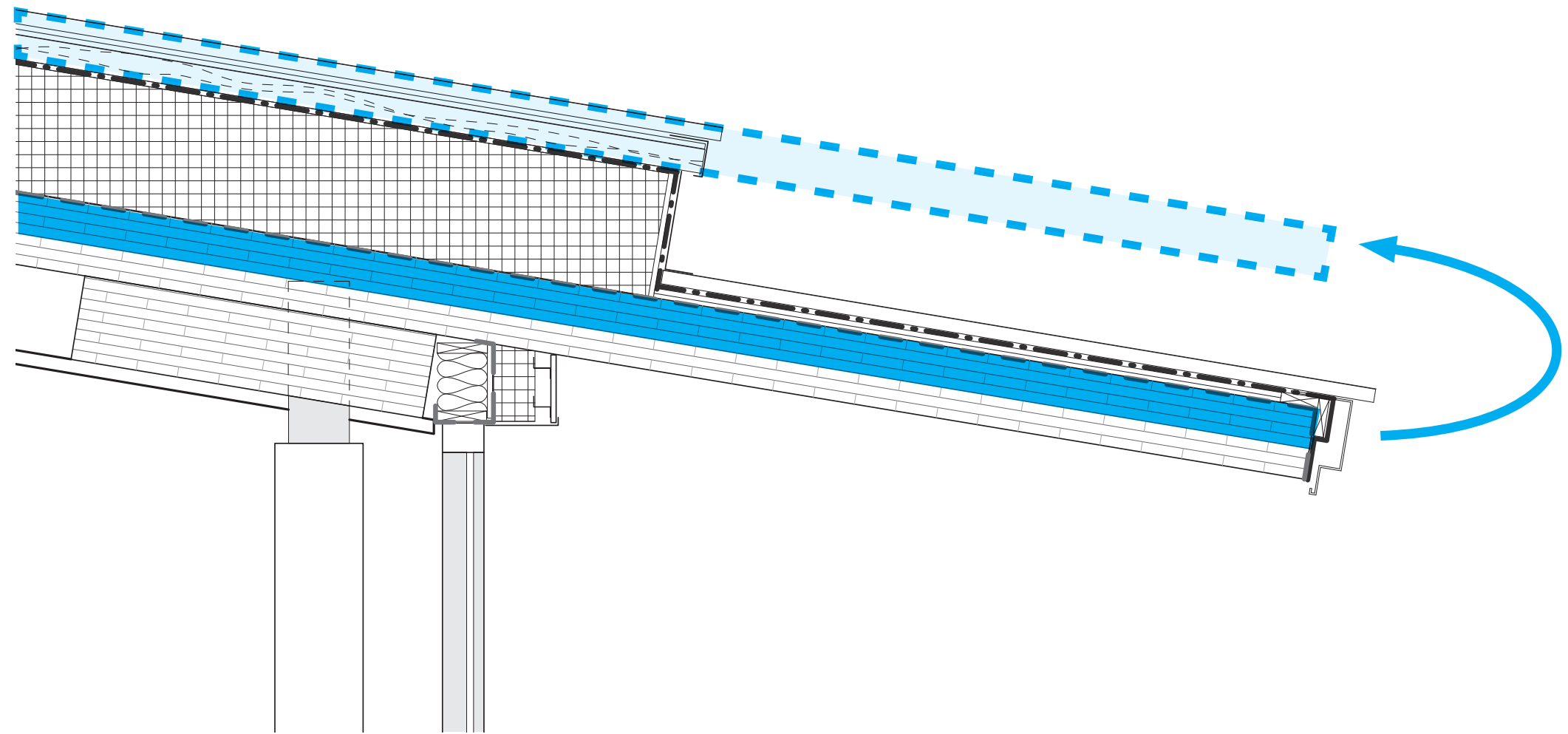


# EAVE DETAIL

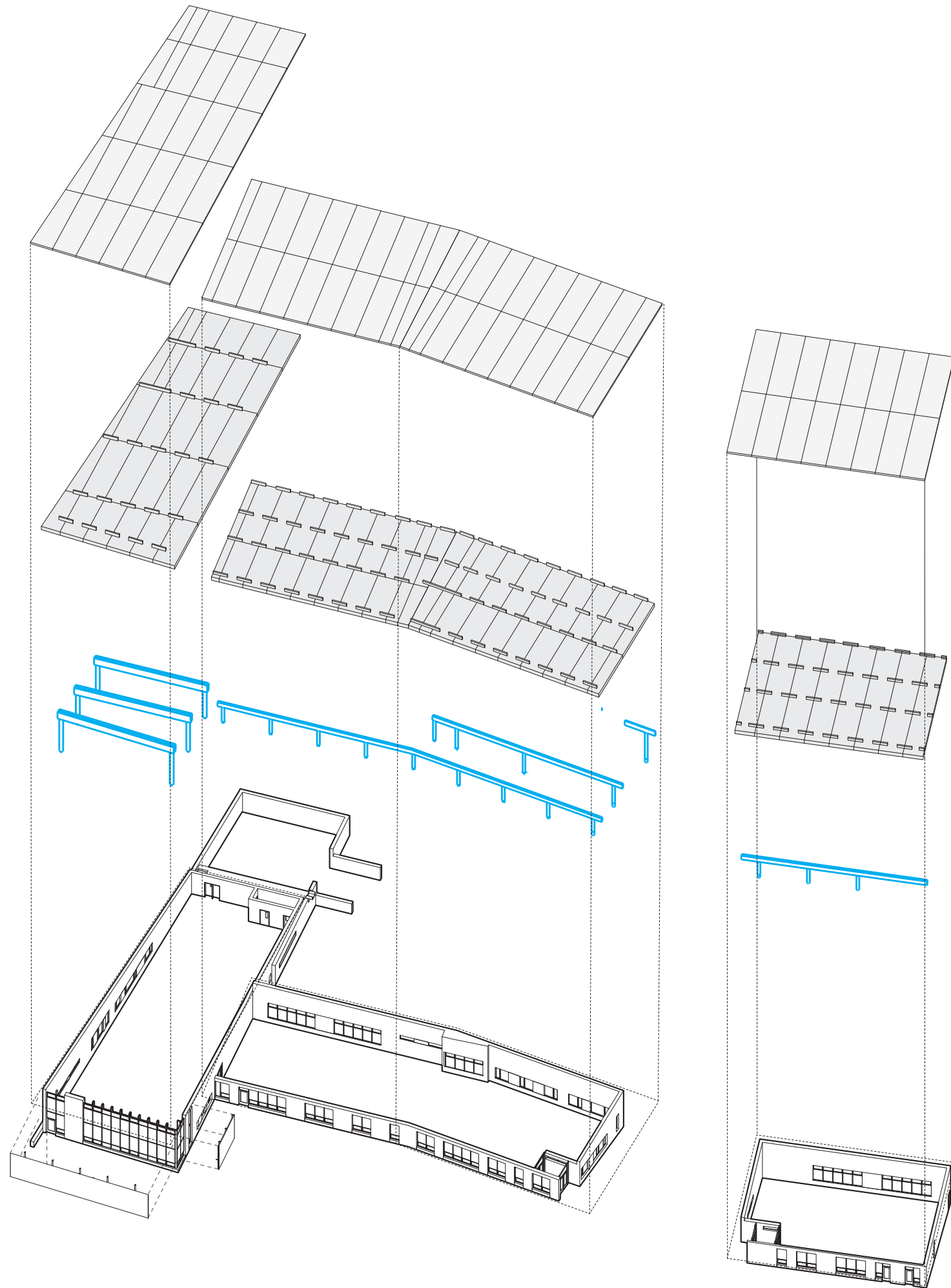








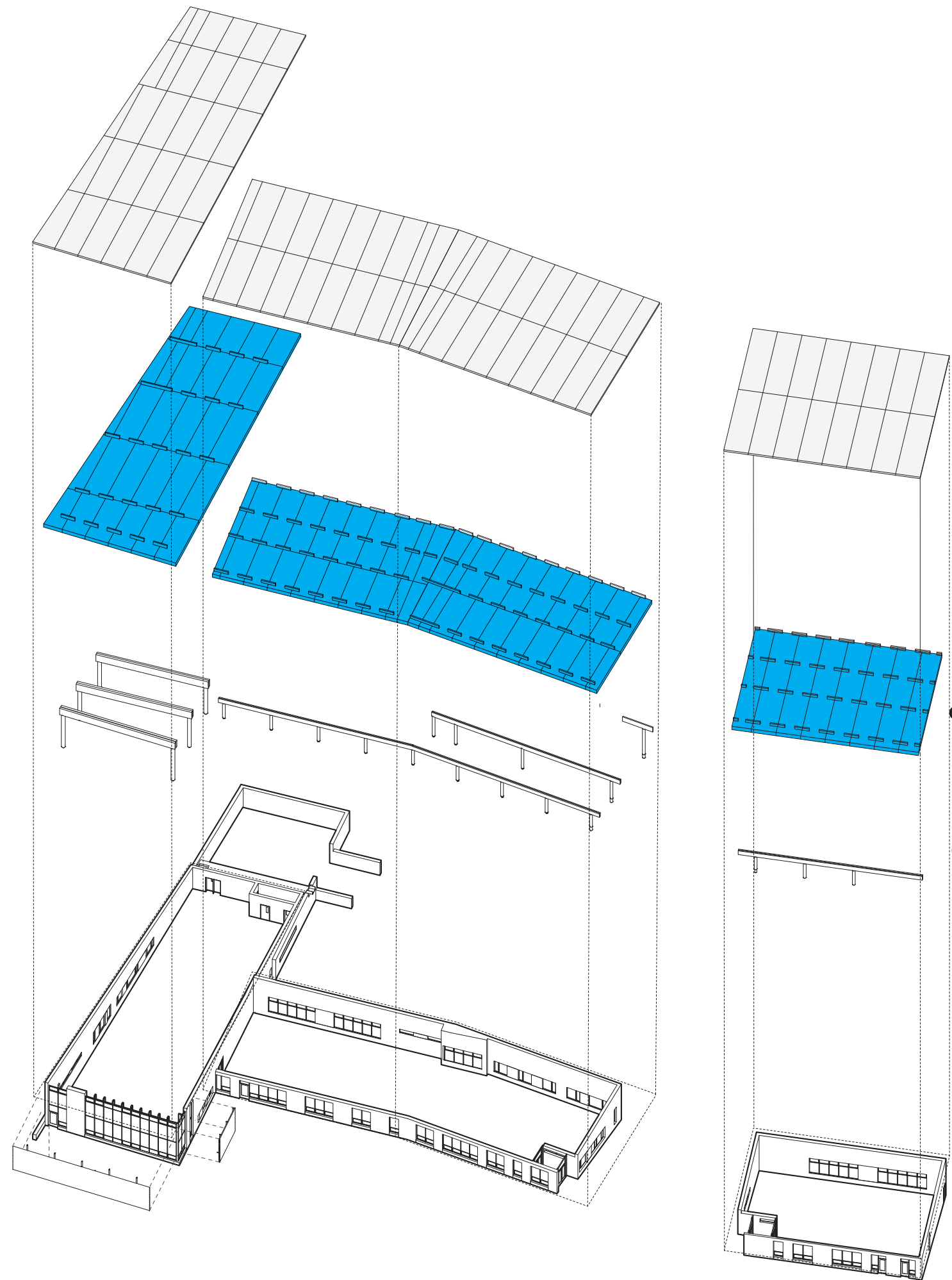
# ROOF ASSEMBLY



EXPOSED TIMBER STRUCTURE



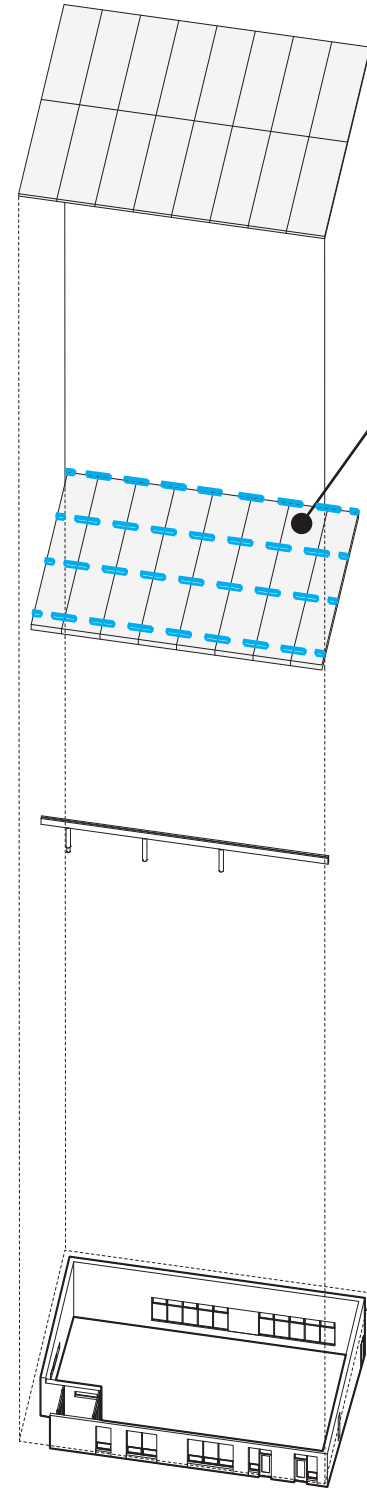
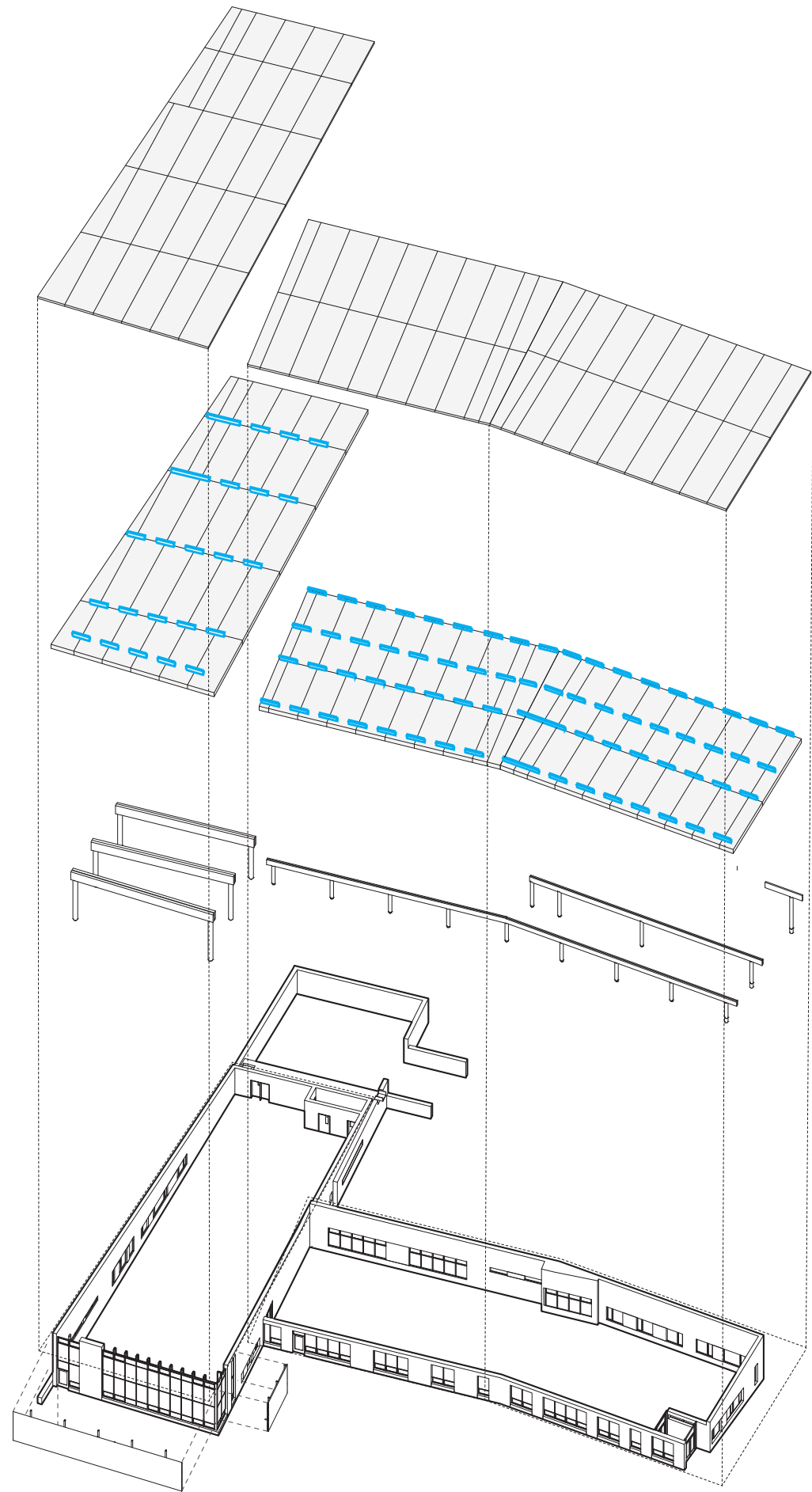
# ROOF ASSEMBLY



● LOWER CLT PANELS

● EXPOSED TIMBER STRUCTURE

# ROOF ASSEMBLY



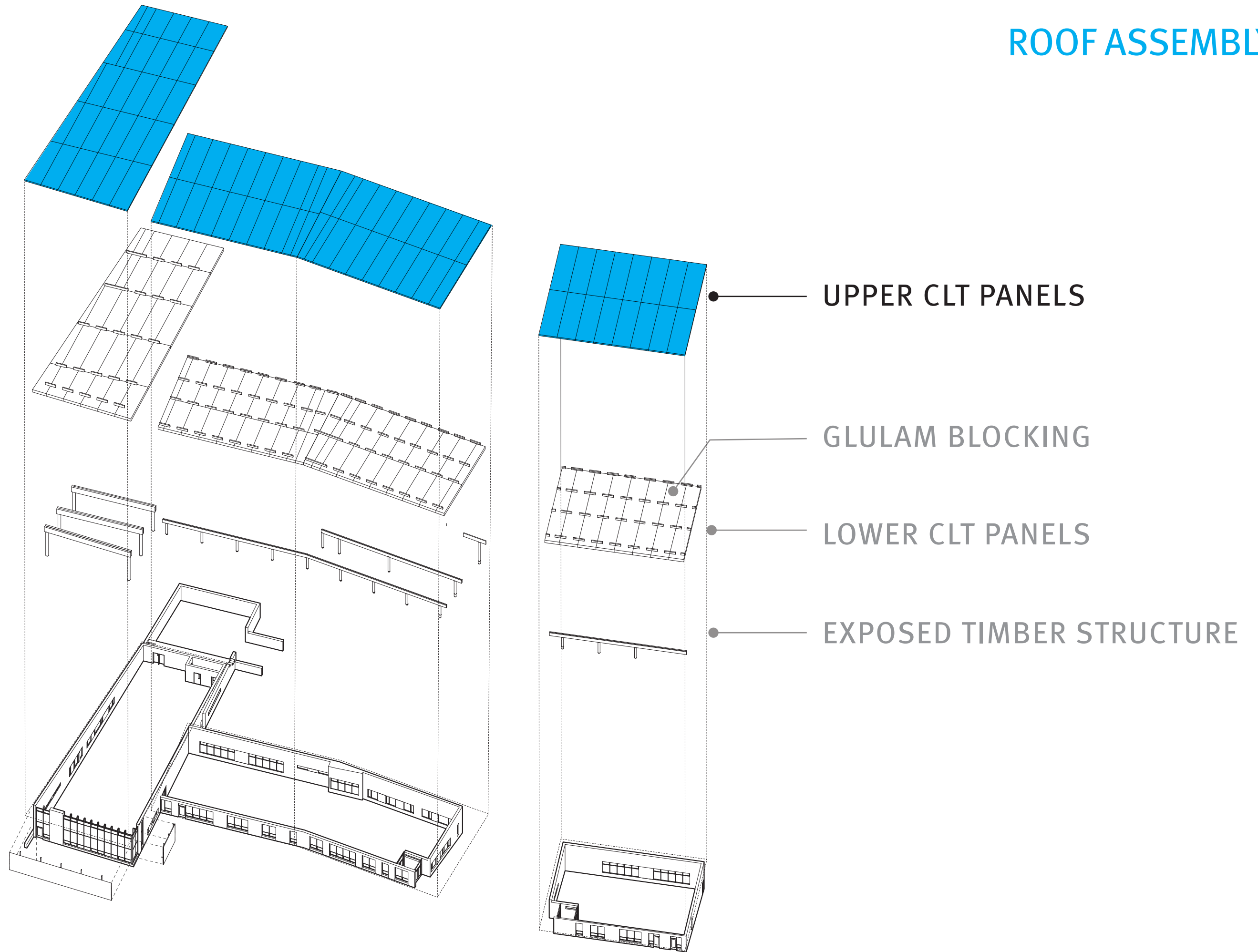
GLULAM BLOCKING

LOWER CLT PANELS

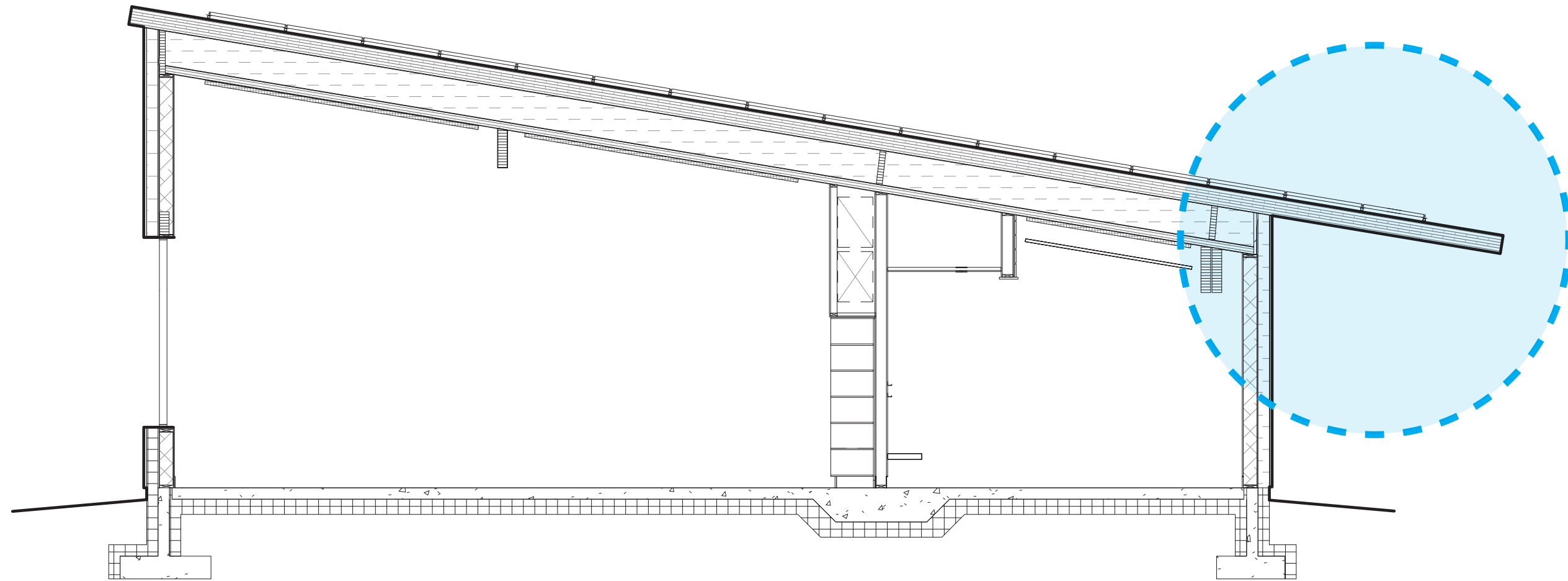
EXPOSED TIMBER STRUCTURE



# ROOF ASSEMBLY

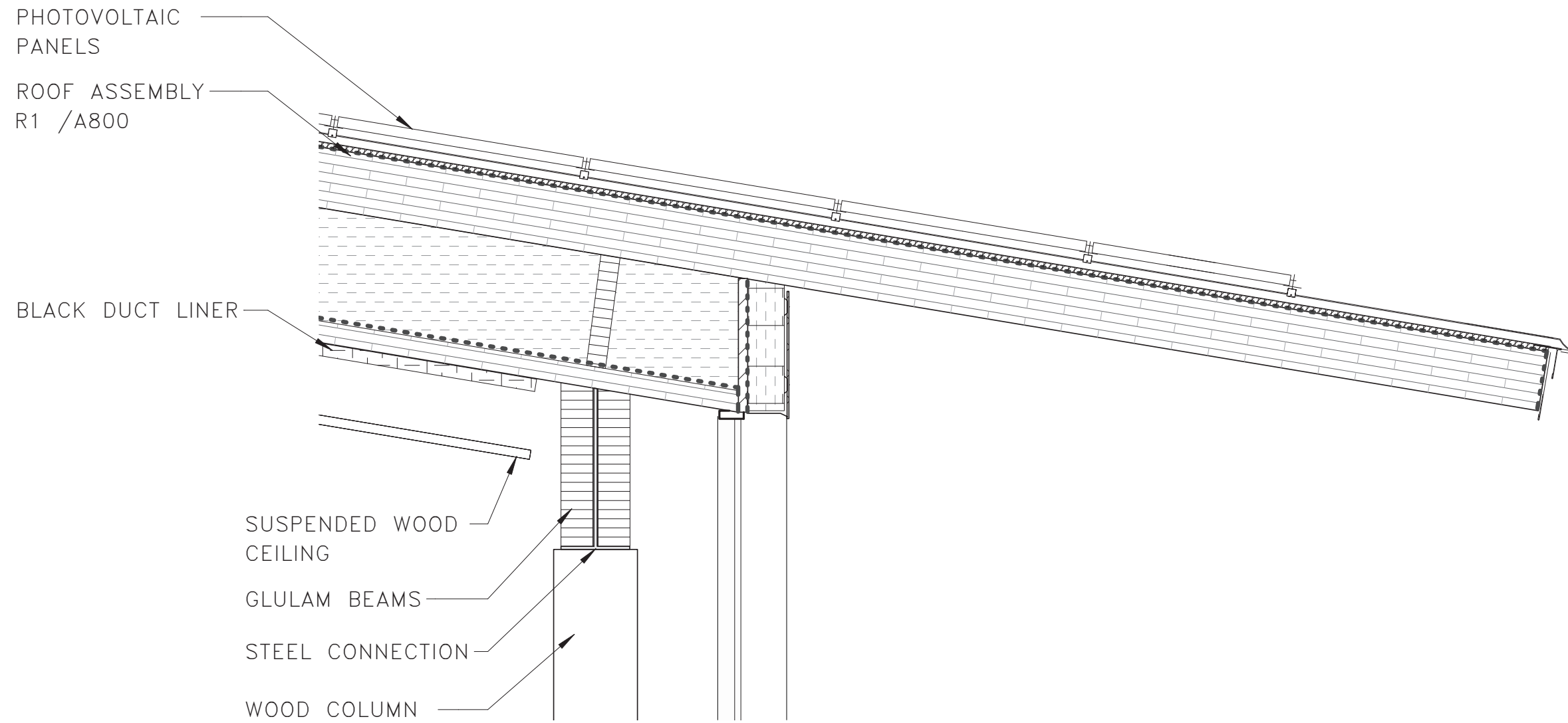


# EAVE DETAIL

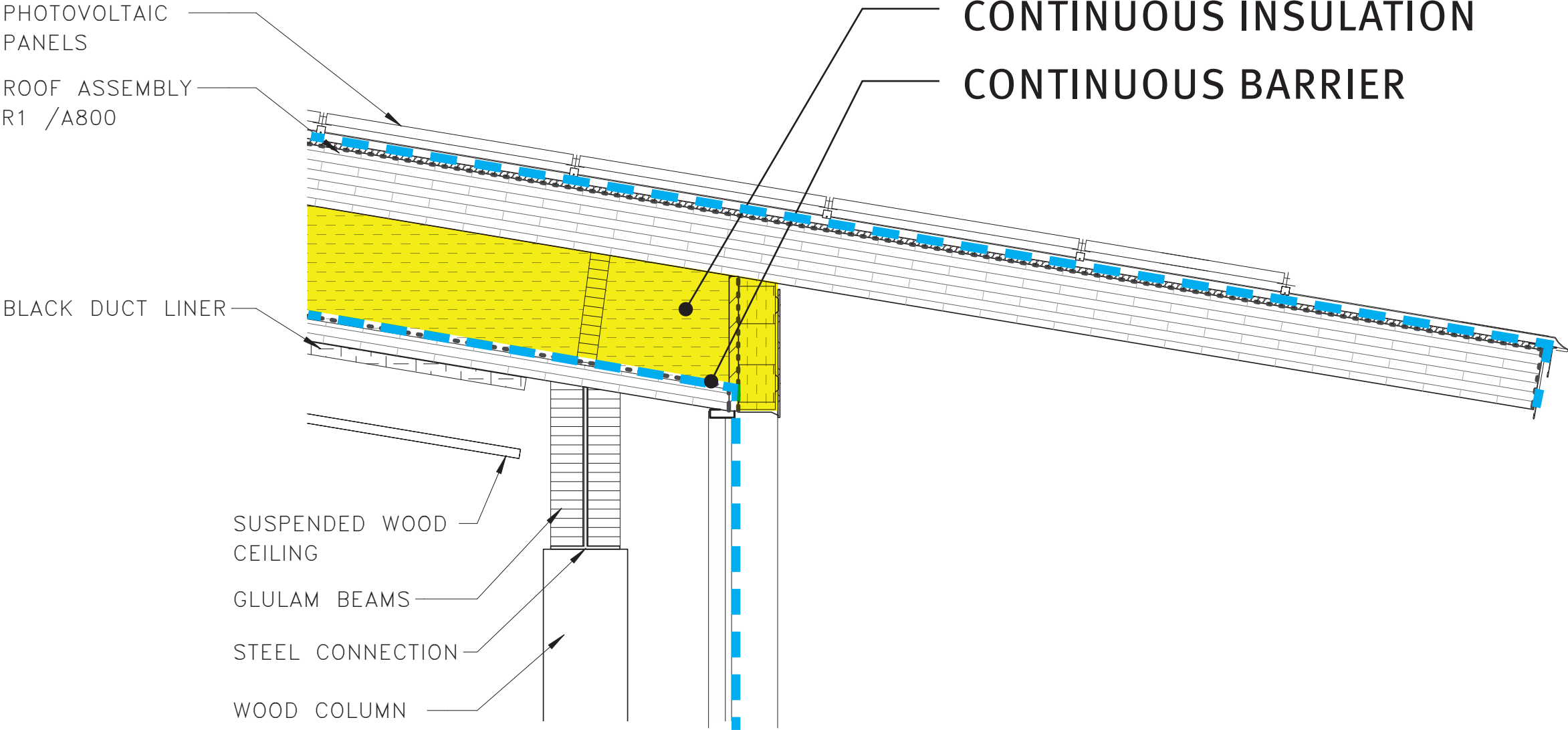




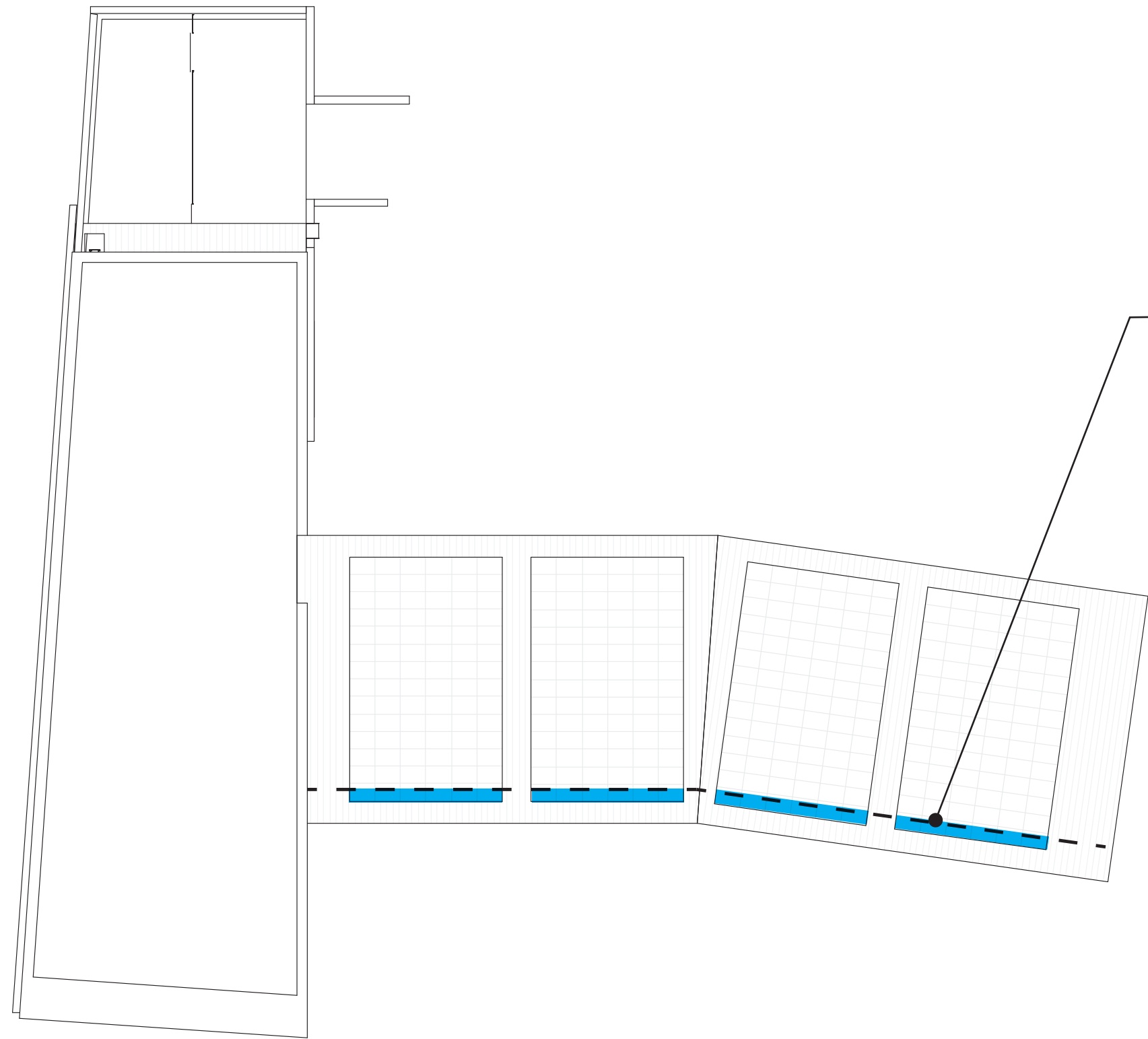
# EAVE DETAIL



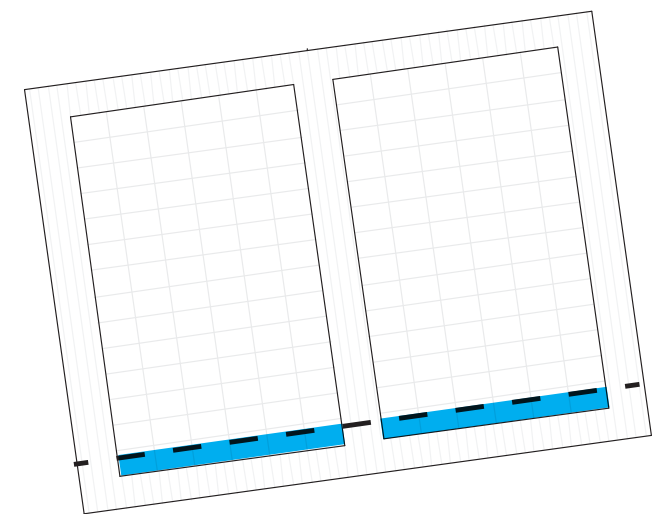
# EAVE DETAIL



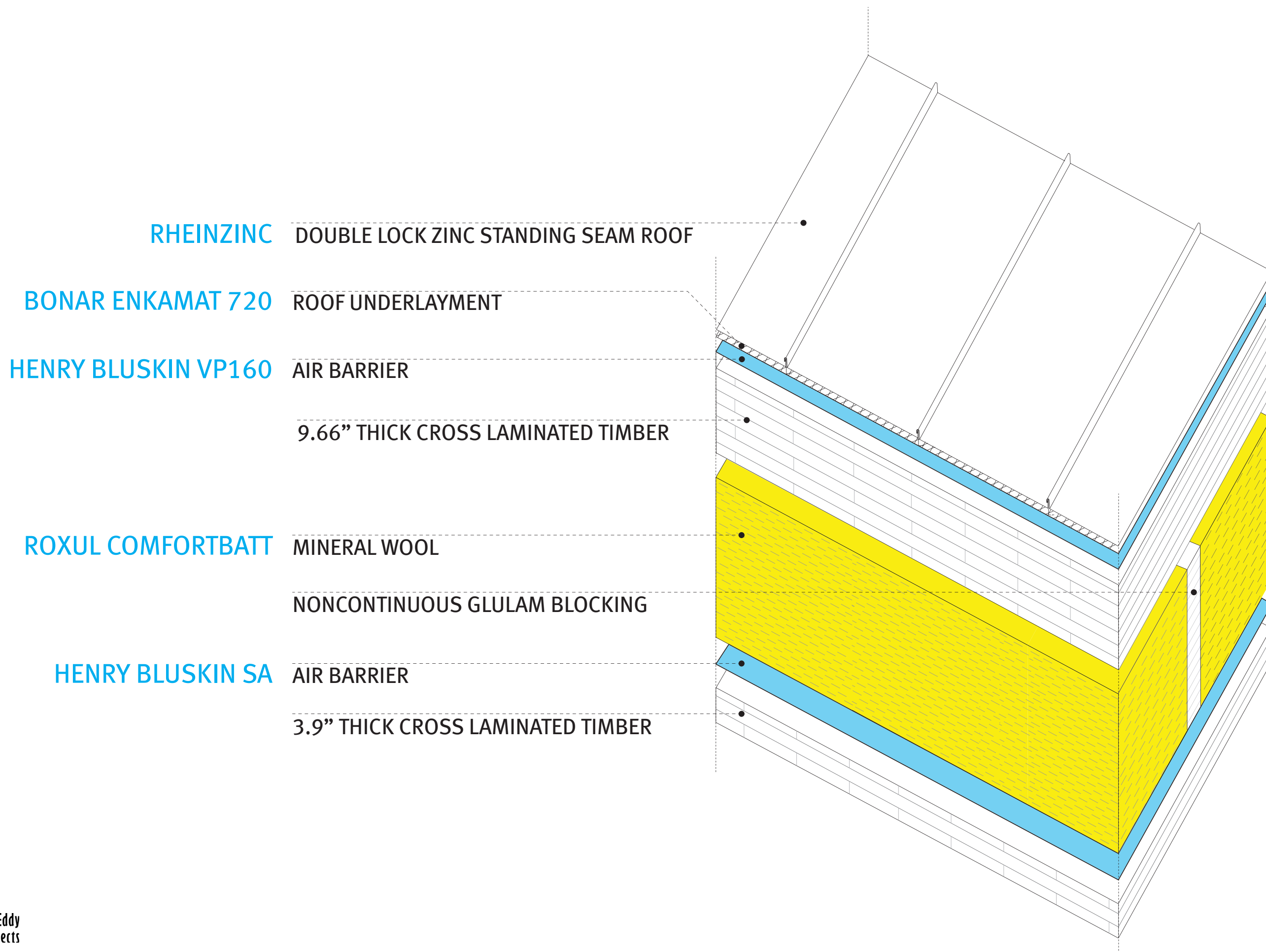




9% INCREASE IN PV AREA



# ROOF AXON





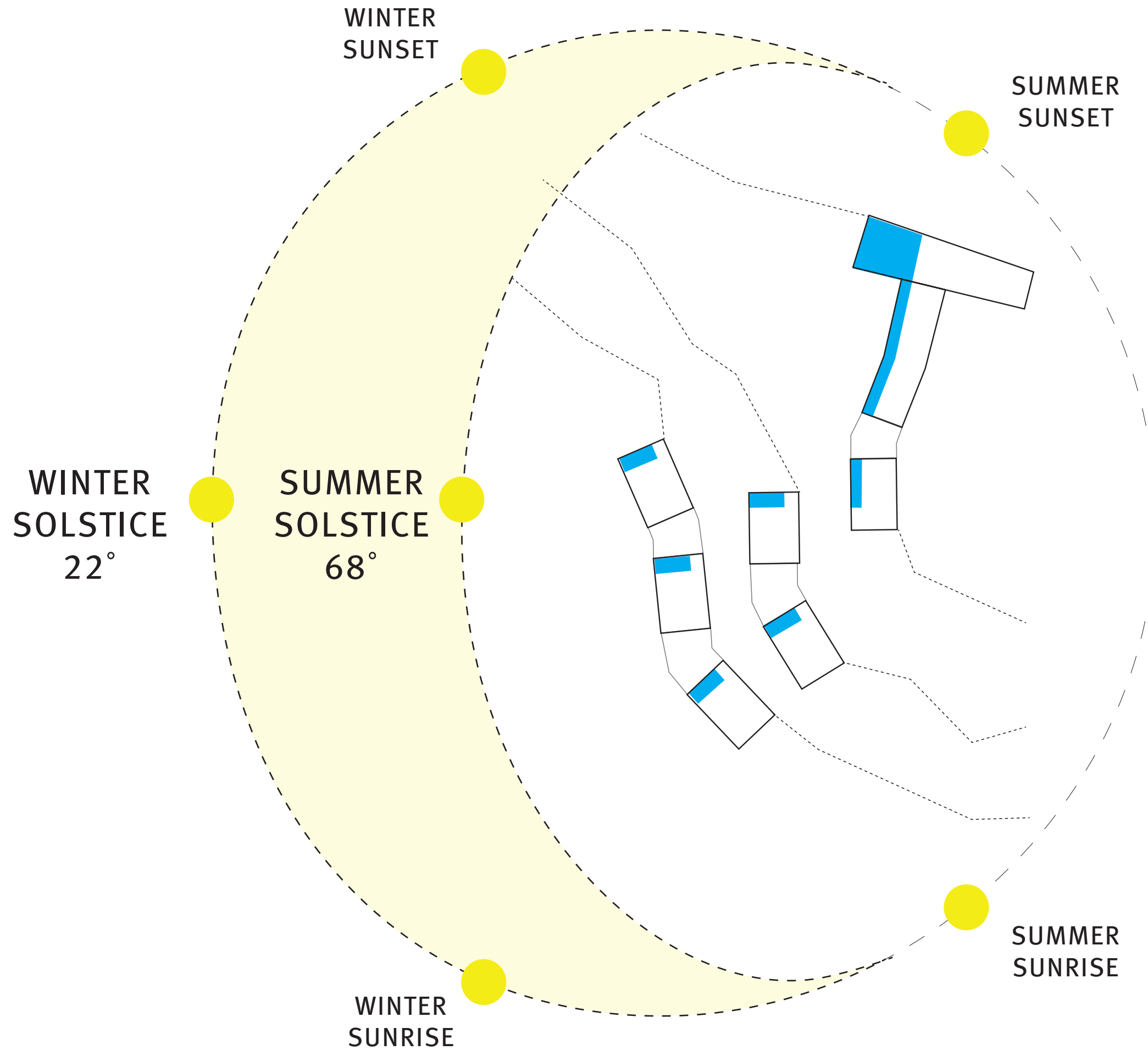
# ENVELOPE DESIGN

# PRIMARY ENVELOPE DESIGN GOALS

- 1 Maximize south facing glazing
- 2 Identify an efficient and cost effective wall assembly
- 3 Minimize the number of envelope products and details

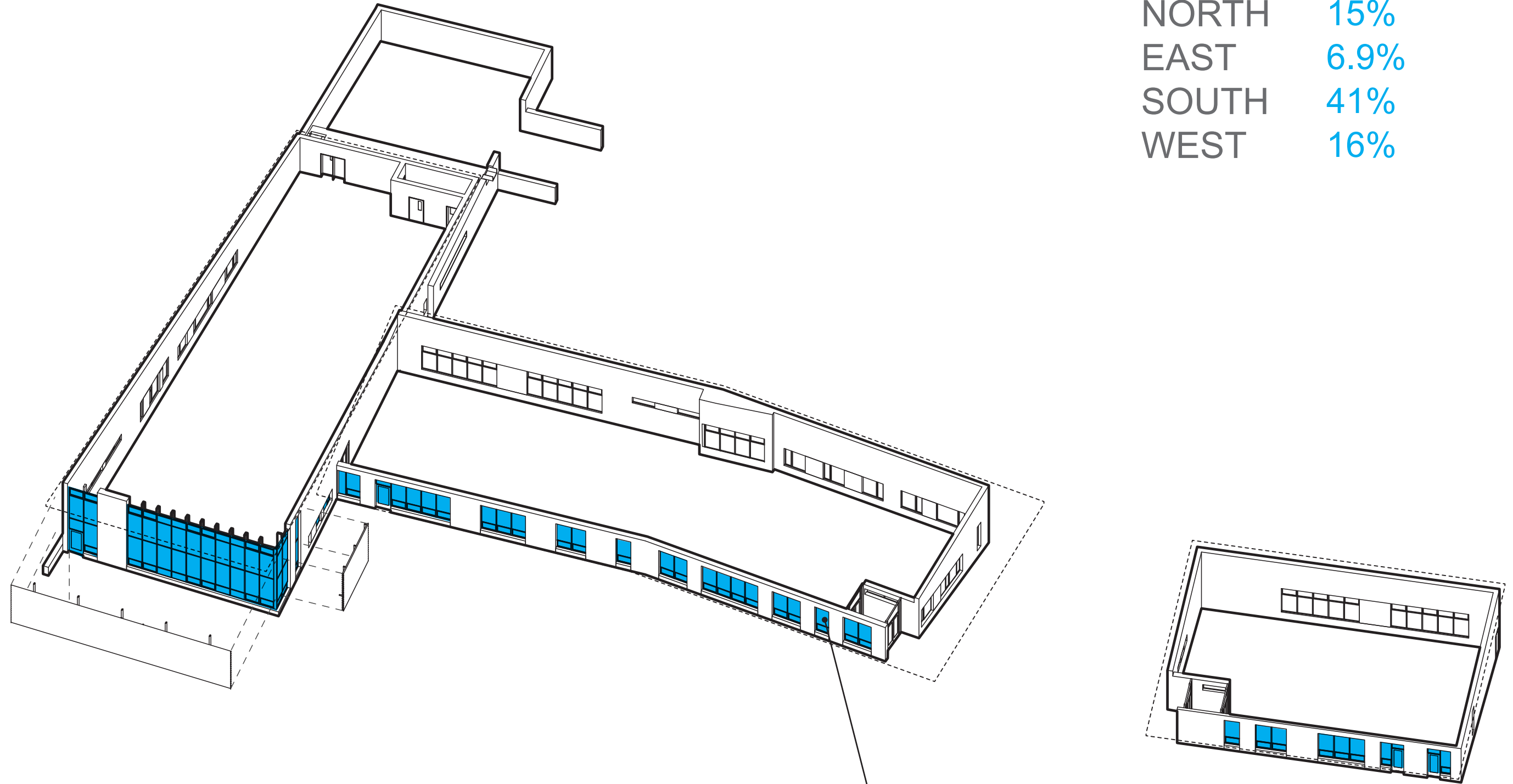


# SUN PATH



# COMMONS WINDOW-TO-WALL RATIO

NORTH	15%
EAST	6.9%
SOUTH	41%
WEST	16%



SOUTH GLAZING



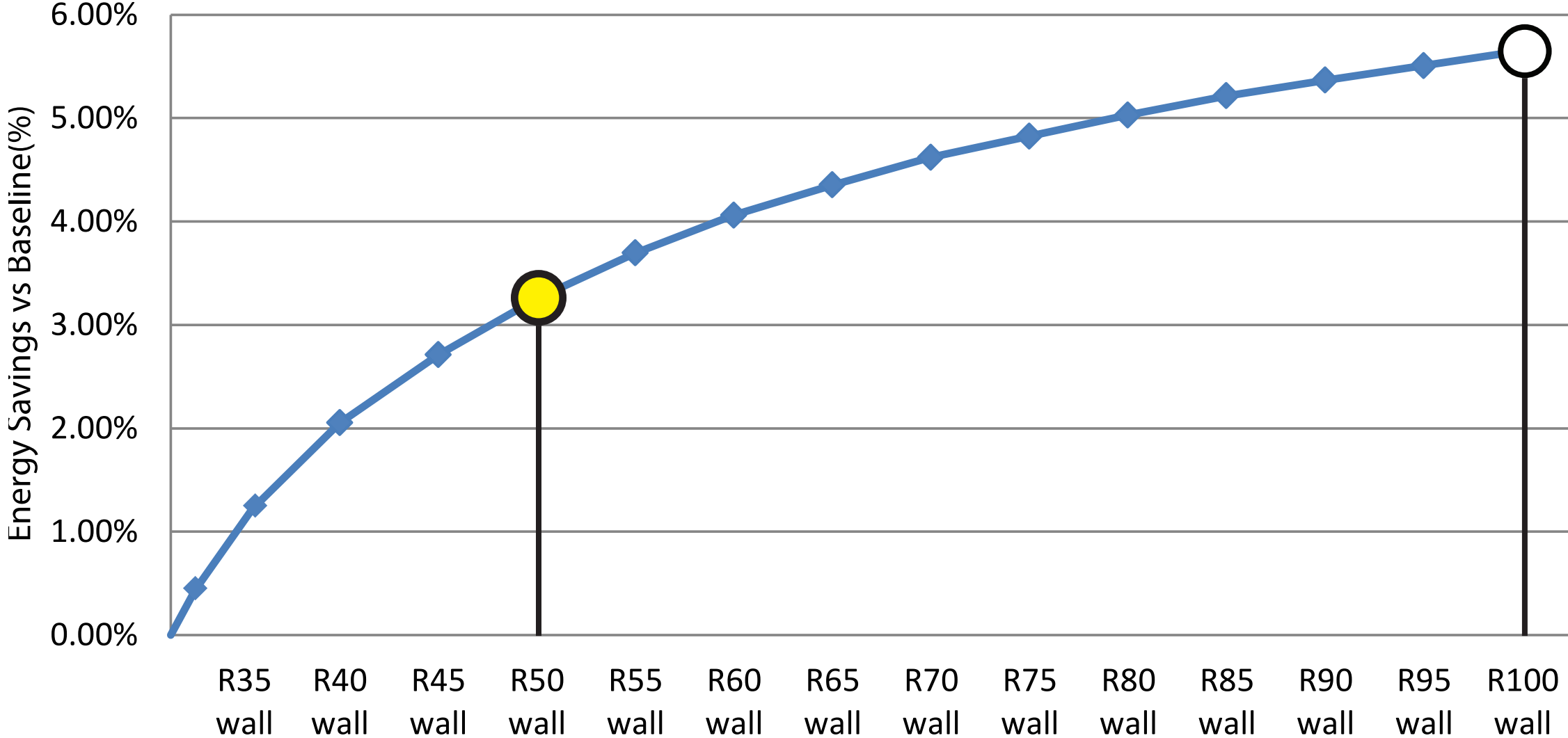
		Low E Coating Combination			Center of Glass Performance		
		#2	#5(or 4)	#6	U-factor	SHGC	VLT
Argon	COG	Passive	Passive	Heatlock	0.148	0.53	0.683
	COG	LowE4	Passive	Heatlock	0.146	0.358	0.619
	COG	SmartSun	Passive	Heatlock	0.144	0.238	0.556
	COG	SmartSun	Passive	-	0.165	0.248	0.569
	<b>UNIT</b>	<b>SmartSun</b>	<b>Passive</b>	-	<b>0.24</b>	<b>0.17</b>	<b>0.38</b>
Air	COG	Passive	Passive	Heatlock	0.184	0.527	0.683
	COG	LowE4	Passive	Heatlock	0.182	0.358	0.619
	COG	SmartSun	Passive	Heatlock	0.18	0.241	0.556
	COG	SmartSun	Passive	-	0.213	0.252	0.569
	<b>UNIT</b>	<b>SmartSun</b>	<b>Passive</b>	-	<b>0.27</b>	<b>0.18</b>	<b>0.38</b>
Kr (95%)	COG	Passive	Passive	Heatlock	0.103	0.534	0.683
	COG	LowE4	Passive	Heatlock	0.1	0.357	0.619
	COG	SmartSun	Passive	Heatlock	0.098	0.235	0.556

# WINDOW UNIT

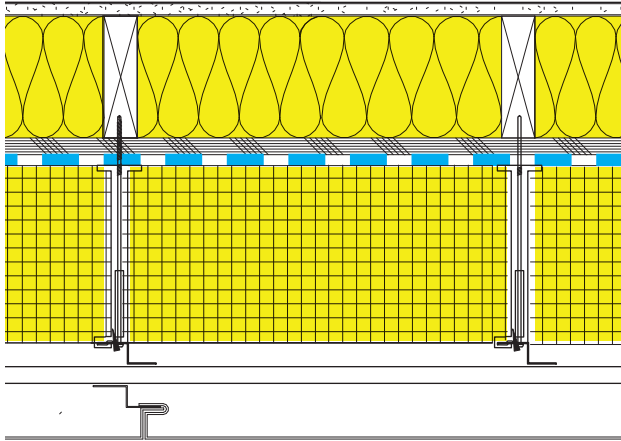
		Low E Coating Combination			Center of Glass Performance		
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	COG	SmartSun	Passive	Heatlock	0.098	0.235	0.556



# WALL ASSEMBLY OPTIMIZATION

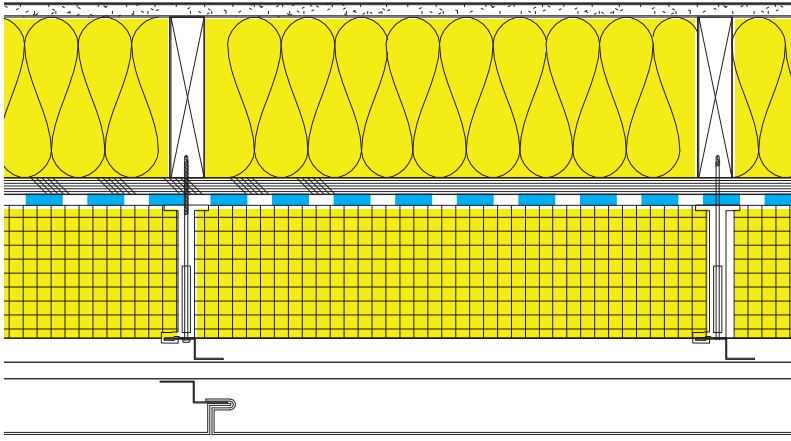


# WALL ASSEMBLY OPTIMIZATION



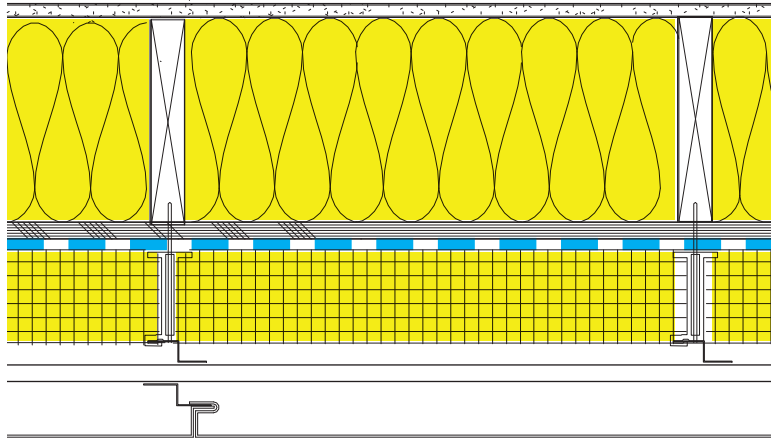
2X6 - 18"o.c.

(5 1/2") R-22 dense-pack cellulose insulation  
(8") semi-rigid exterior insulation



2X8 - 24"o.c.

(7 1/4") R-29 dense-pack cellulose insulation  
(6") semi-rigid exterior insulation

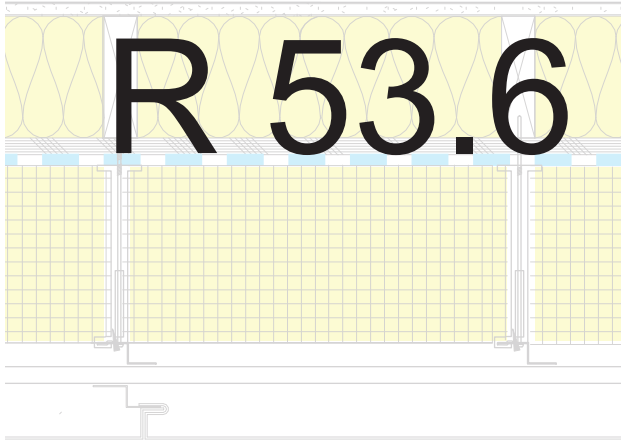


2X10 - 24"o.c.

(9 1/4") R-37 dense-pack cellulose insulation  
(4") semi-rigid exterior insulation

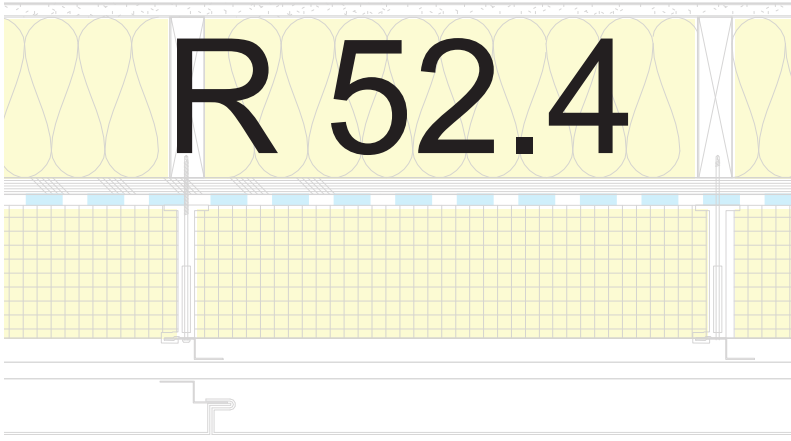


# WALL ASSEMBLY OPTIMIZATION



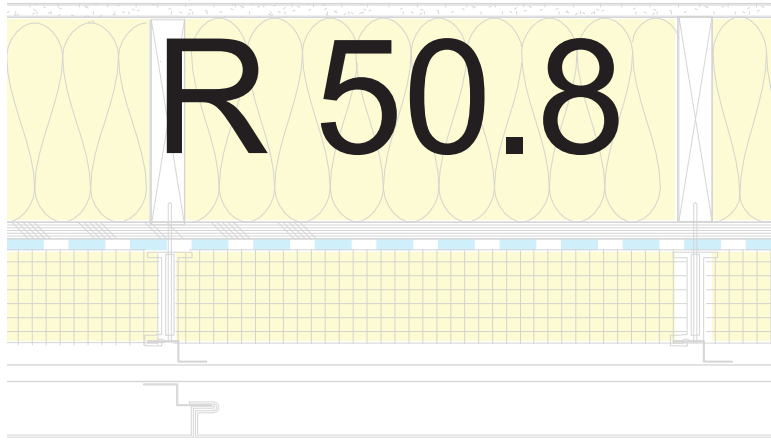
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2X8 - 24"o.c.

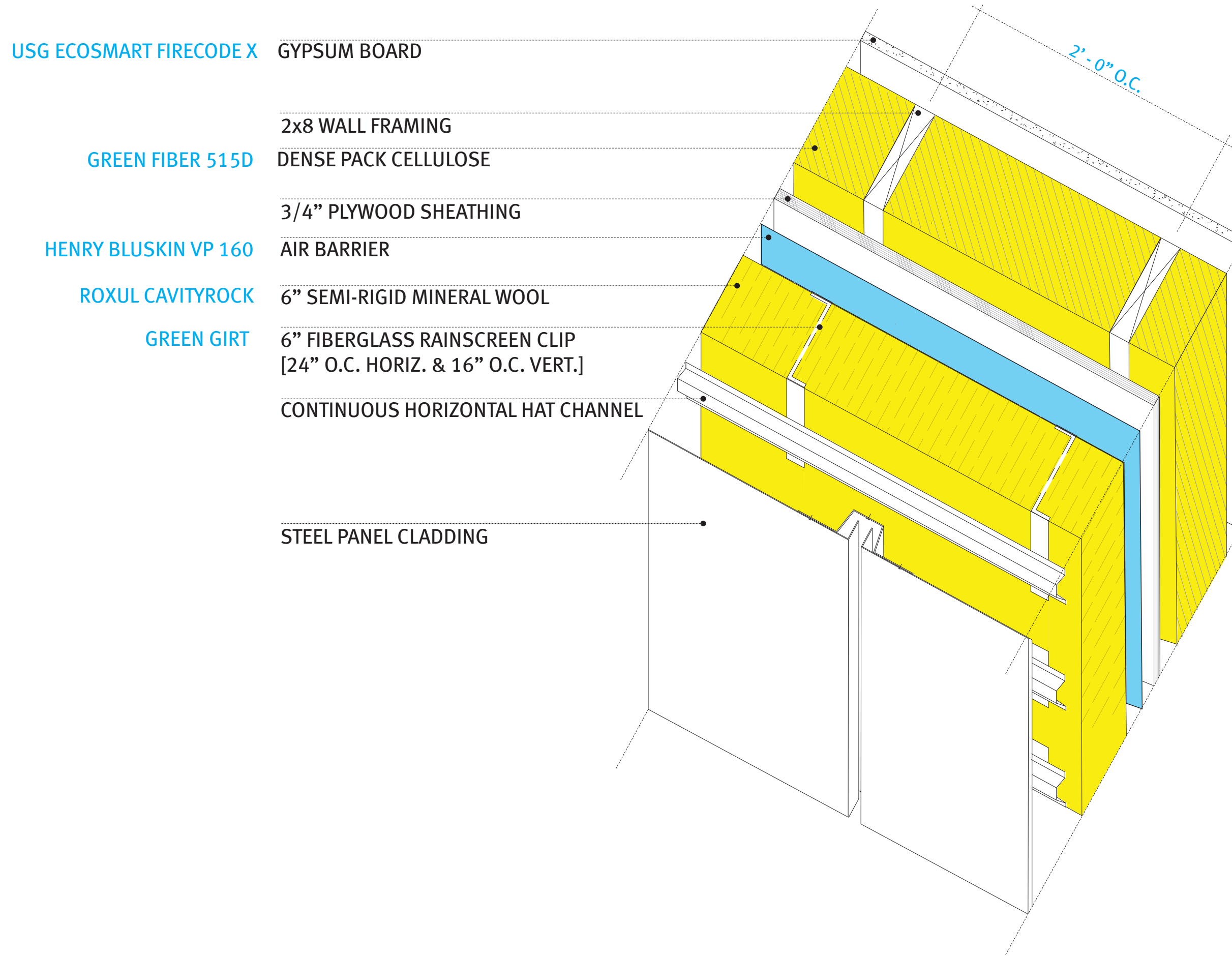
(7 1/4") R-29 dense-pack cellulose insulation  
(6") semi-rigid exterior insulation



2X10 - 24"o.c.

(9 1/4") R-37 dense-pack cellulose insulation  
(4") semi-rigid exterior insulation

# WALL AXON







Alkylphenols

Asbestos

Bisphenol A (BPA)

Cadmium

Chlorinated Polyethylene (CPE) &

Chlorosulfonated Polyethylene (CSPE)

Chlorobenzene

Chlorofluorocarbons (CFCS)

Hydrochlorofluorocarbons (HCFCs)

Chloroprene (neoprene)

Chromium VI

Formaldehyde (added)

Halogenated Fire Retardants (HFRs)

Lead (Added)

Mercury

Polychlorinated Biphenyls (PCBS)

Perfluorinated Compounds (PFCS)

Phthalates

Polyvinyl Chloride (PVC)

Chlorinated Polyvinyl Chloride (CPVC)

Polyvinylidene Chloride (PVDC)

Short Chain Chlorinated Paraffins (SCCPS)

Volatile organic compounds (VOCs) in wet  
applied products

Wood Treatments containing creosote,  
arsenic or pentachlorophenol



Alkylphenols

Asbestos

Bisphenol A (BPA)

Cadmium

Chlorinated Polyethylene (CPE) &

Chlorosulfonated Polyethylene (CSPE)

Chlorobenzene

**CHLOROFLUOROCARBONS (CFCS)**

**HYDROCHLOROFLUOROCARBONS (HCFCS)**

**CHLOROPRENE (NEOPRENE)**

Chromium VI

**FORMALDEHYDE (ADDED)**

**HALOGENATED FIRE RETARDANTS (HFRS)**

Lead (Added)

Mercury

Polychlorinated Biphenyls (PCBS)

Perfluorinated Compounds (PFCS)

**PHTHALATES**

**POLYVINYL CHLORIDE (PVC)**

**CHLORINATED POLYVINYL CHLORIDE (CPVC)**

Polyvinylidene Chloride (PVDC)

Short Chain Chlorinated Paraffins (SCCPS)

**VOLATILE ORGANIC COMPOUNDS (VOCS)**

in wet applied products

Wood Treatments containing creosote,

arsenic or pentachlorophenol

## PRODUCT X

DECLARE LABEL?

..... YES

C2C?

..... YES

HPD?

..... YES

MSDS?

..... YES

PROPRIETARY INGREDIENTS

<1%

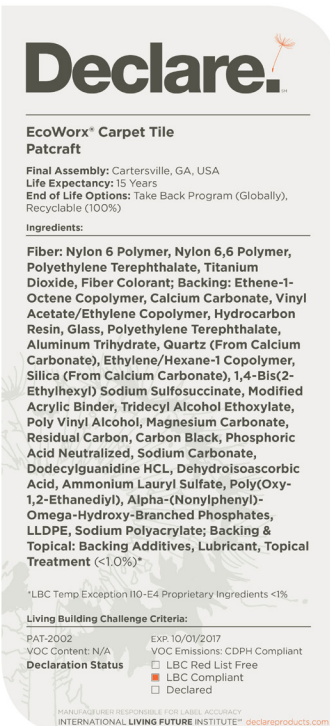
..... YES

>1%

CHECK CASN

?%

ADVOCACY



CASN CHEMICAL OF CONCERN

- 184963-09-5 Chloroprene (Neoprene)
- 126-99-8 Chloroprene (Neoprene)
- 9010-98-4 Neoprene
- 115-28-6 Chlorendic Acid
- 115-96-8 Tris(2-Chloroethyl) Phosphate (Tcep)
- 13560-89-9 Dechlorane Plus (Dp)
- 13674-84-5 Tris(1-Chloro-2-Proryl)Phosphate (Tcpp, Tmcp)
- 13674-87-8 Chlorinated Tris (tdcpp, Tdcp)



# SPACE CONDITIONING & VENTILATION

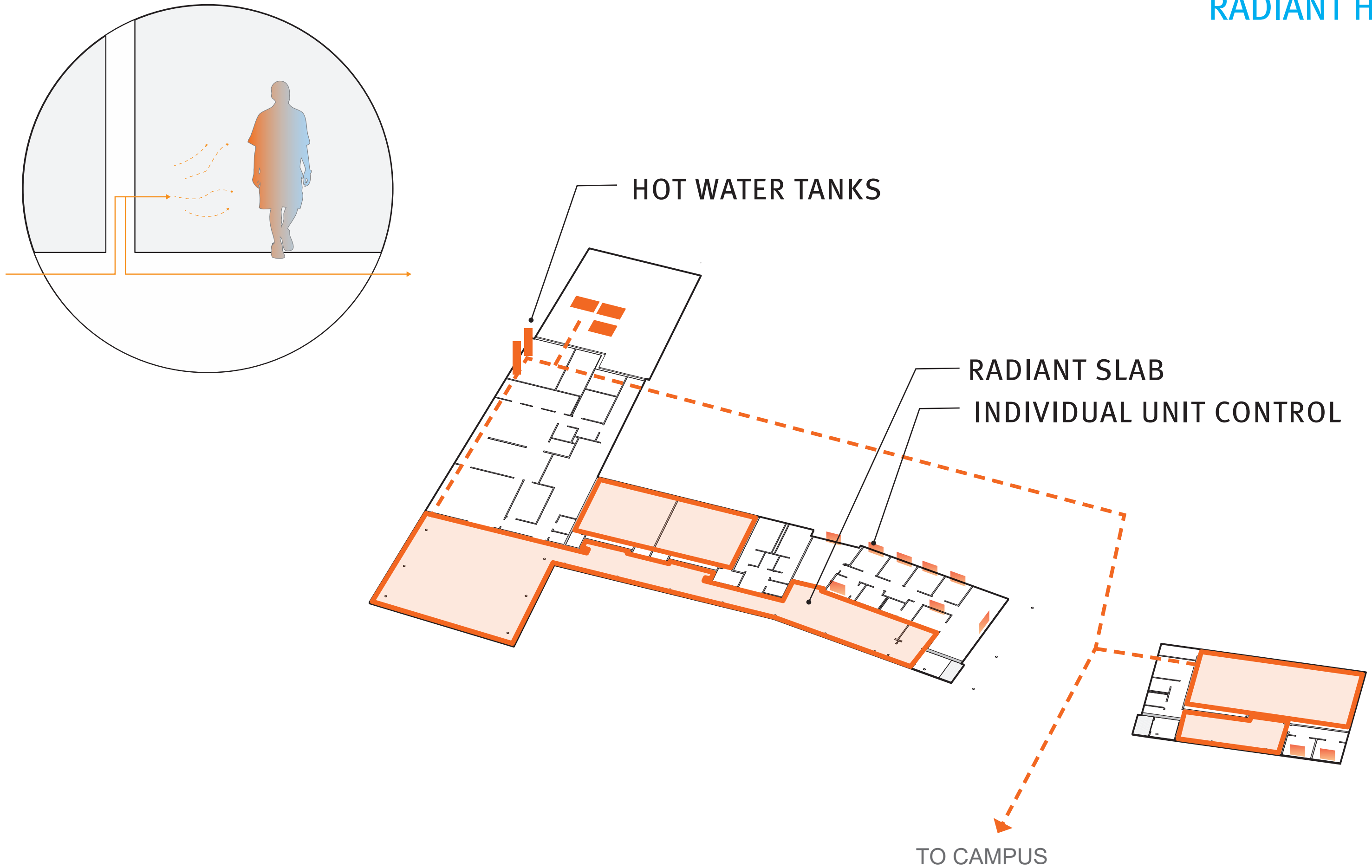
# PRIMARY SPACE CONDITIONING + VENTILATION DESIGN GOALS

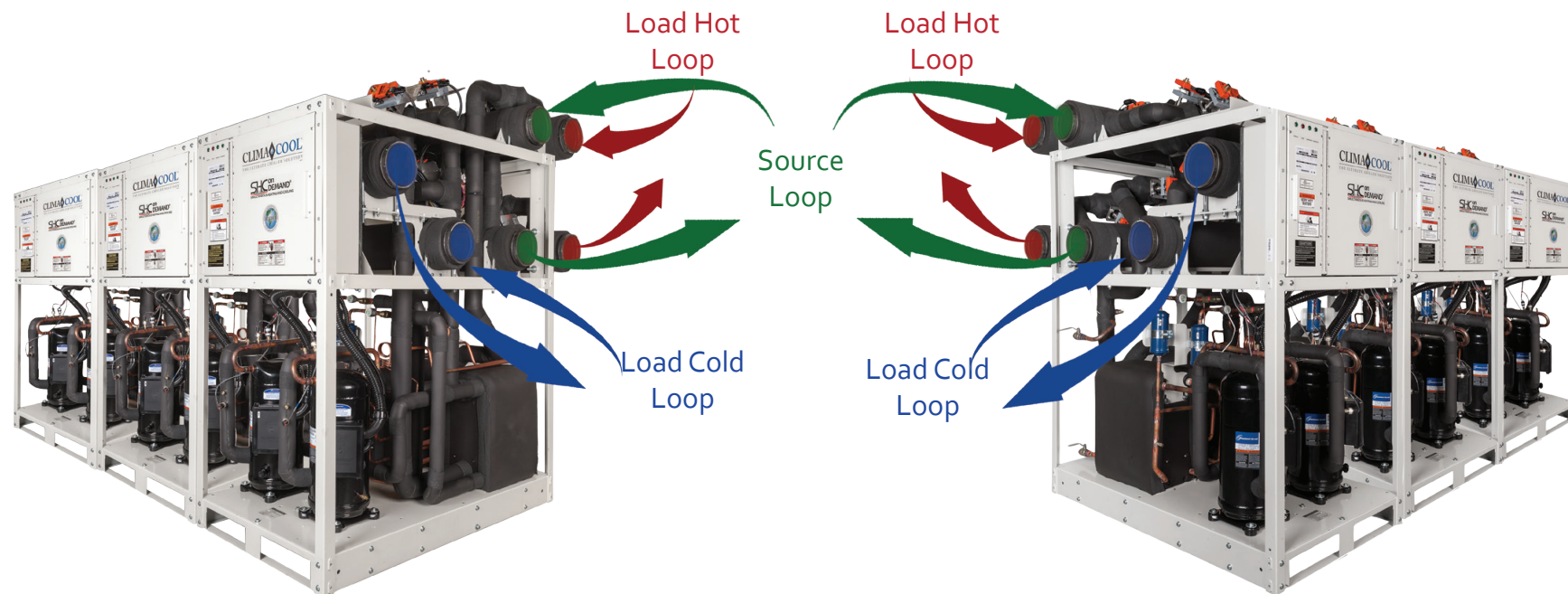
- 1 Create a simple and resilient system
- 2 Maximize ventilation efficiency
- 3 Achieve the energy petal of the Living Building Challenge

<b>ANNUAL HEATING DEMAND</b>	<b>8.1</b> kBTU/ft <sup>2</sup> .yr
<b>ANNUAL COOLING DEMAND</b>	<b>1.0</b> kBTU/ft <sup>2</sup> .yr
<b>PEAK HEATING LOAD</b>	<b>5.7</b> BTU/ft <sup>2</sup> .hr
<b>PEAK COOLING LOAD</b>	<b>3.6</b> BTU/ft <sup>2</sup> .hr



# RADIANT HEAT

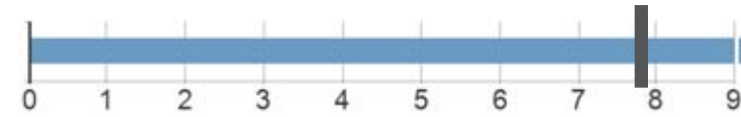




- 75% footprint savings of traditional Boiler/Chiller Systems
- 40% footprint savings over typical simultaneous systems
- Simultaneous heating/cooling in each module
- Connection flexibility for hot, cold and source water loops
- Lowers energy costs by +50% compared to traditional boiler/chiller systems

### Heating demand

specific: **9.6** kBtu/ft<sup>2</sup>yr  
target: **8.1** kBtu/ft<sup>2</sup>yr  
total: 141611.91 kBtu/yr



### Cooling demand

specific: **0.15** kBtu/ft<sup>2</sup>yr  
target: **1** kBtu/ft<sup>2</sup>yr  
total: 2140.9 kBtu/yr  
latent: 0 kBtu/ft<sup>2</sup>yr



### Heating load

specific: **8.72** Btu/hr ft<sup>2</sup>  
target: **5.7** Btu/hr ft<sup>2</sup>  
total: 128702.22 Btu/hr



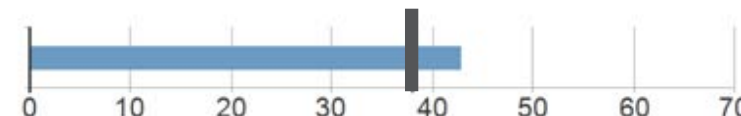
### Cooling load

specific: **0.5** Btu/hr ft<sup>2</sup>  
target: **3.5** Btu/hr ft<sup>2</sup>  
total: 7411.62 Btu/hr



### Primary energy

specific: **42.82** kBtu/ft<sup>2</sup>yr  
target: **38.04** kBtu/ft<sup>2</sup>yr  
total: 631816.18 kBtu/yr



### Site energy

total: -10.29 kBtu/ft<sup>2</sup>yr  
building systems: 100.64 kBtu/yr  
photovoltaic savings: 31.58 kBtu/ft<sup>2</sup>yr



### Air tightness

ACH50: **0.29** 1/hr  
target: **0.48** 1/hr  
CFM50 per envelope area: **0.03** cfm/ft<sup>2</sup>  
target: **0.05** cfm/ft<sup>2</sup>



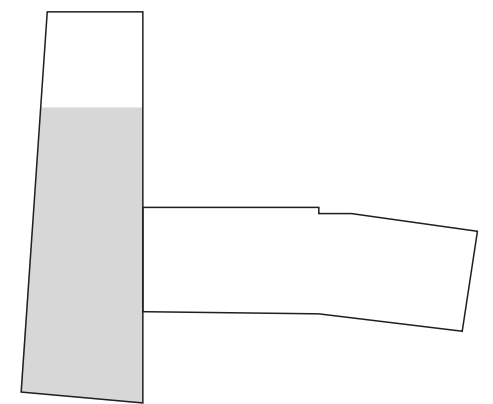
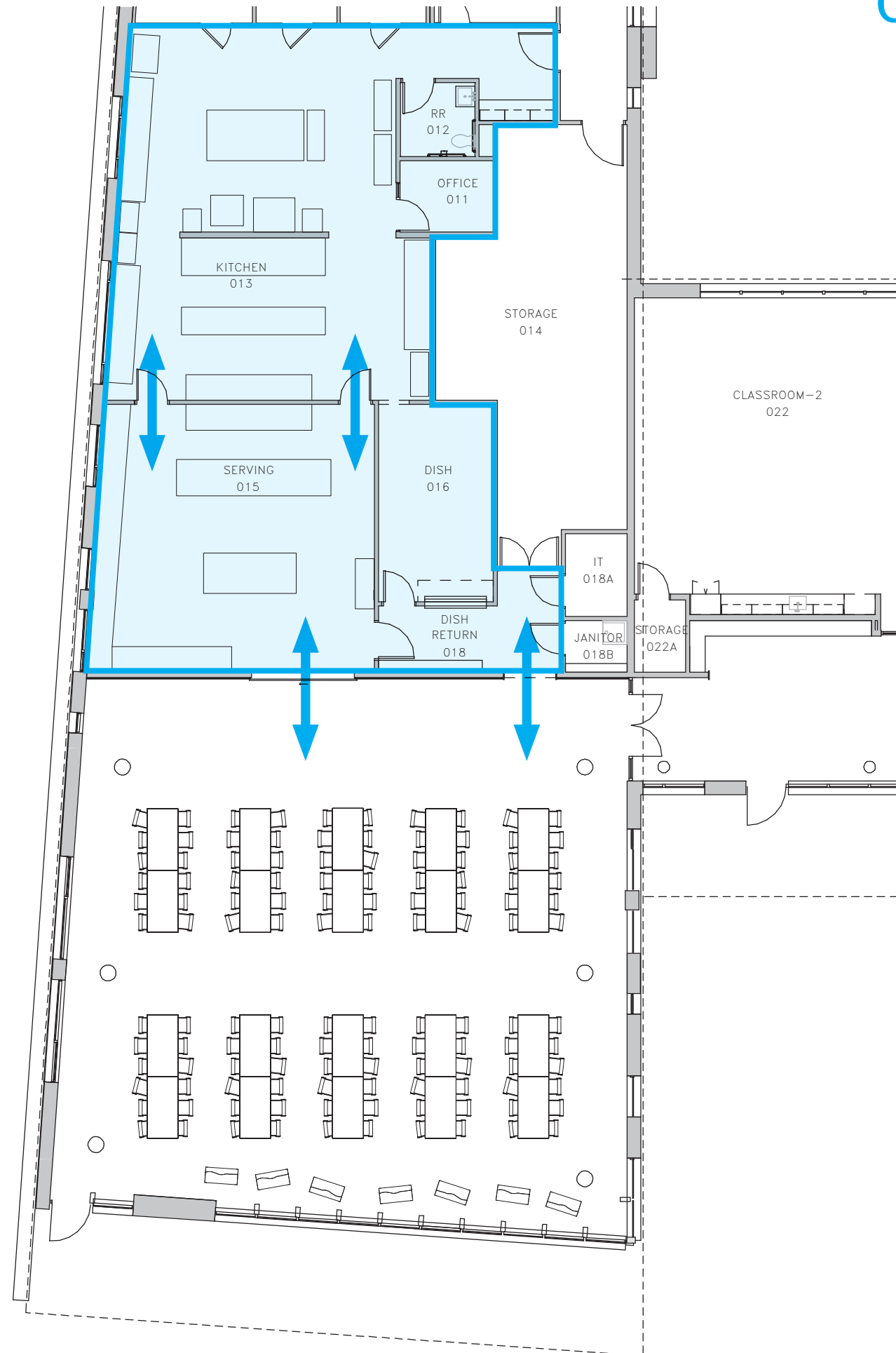


## SWEGON GOLD RX



- Complete air handling unit with direct-driven supply air and extract air fans, supply air and extract air filters and rotary heat exchanger.
- Temperature efficiency, [heat recovery up to 85%](#)
- Air flows up to [<5300 cfm](#)
- [Variable speed regulation](#) of the rotor
- Cooling energy recovery
- [Meets Passive House Certification](#) requirements

# COMMONS KITCHEN + GREAT ROOM



Key Plan

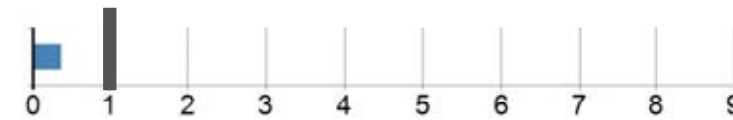
### Heating demand

specific: **1.74** kBtu/ft<sup>2</sup>yr  
target: **8.1** kBtu/ft<sup>2</sup>yr  
total: 25611.07 kBtu/yr



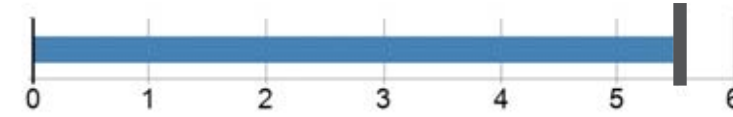
### Cooling demand

specific: **0.38** kBtu/ft<sup>2</sup>yr  
target: **1** kBtu/ft<sup>2</sup>yr  
total: 5649.79 kBtu/yr  
latent: 0 kBtu/ft<sup>2</sup>yr



### Heating load

specific: **5.47** Btu/hr ft<sup>2</sup>  
target: **5.7** Btu/hr ft<sup>2</sup>  
total: 80780.48 Btu/hr



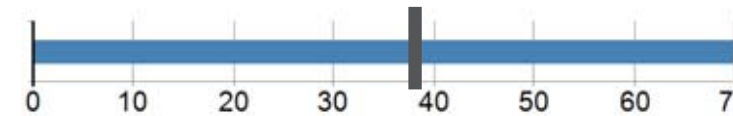
### Cooling load

specific: **1.51** Btu/hr ft<sup>2</sup>  
target: **3.5** Btu/hr ft<sup>2</sup>  
total: 22308.35 Btu/hr



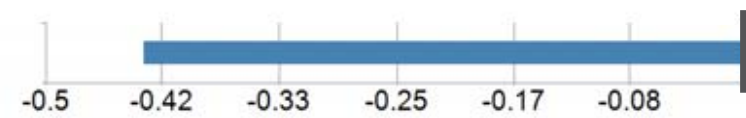
### Primary energy

specific: **73.99** kBtu/ft<sup>2</sup>yr  
target: **38.04** kBtu/ft<sup>2</sup>yr  
total: 1091587.82 kBtu/yr



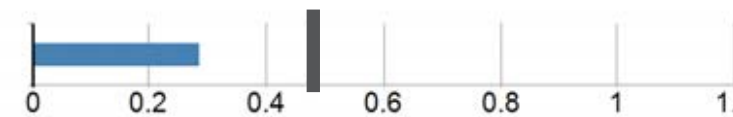
### Site energy

total: -0.43 kBtu/ft<sup>2</sup>yr  
building systems: 206.78 kBtu/yr  
photovoltaic savings: 31.58 kBtu/ft<sup>2</sup>yr



### Air tightness

ACH50: **0.29** 1/hr  
target: **0.48** 1/hr  
CFM50 per envelope area: **0.03** cfm/ft<sup>2</sup>  
target: **0.05** cfm/ft<sup>2</sup>





<b>3. PASSIVE HOUSE CRITERIA</b>		
	<b>Primary Energy / sf w PV</b>	
	<b>kBTU/ft2*yr</b>	<b>kBTU/yr</b>
<b>Criteria</b>	<b>38.04</b>	
Commons	73.99	1,091,754.64
Classroom	12.40	44,888.00
Dormitory #1	20.46	86,054.76
Dormitory #2	21.77	91,564.62
Dormitory #3	21.77	91,564.62
Dormitory #4	21.77	91,564.62
Dormitory #5	21.77	91,564.62
Staff Housing #1	20.46	52,598.00
Staff Housing #2	21.77	38,207.34
<b>Total</b>	<b>34.7</b>	<b>1,679,761</b>

# ENERGY ASSUMPTIONS

Buildings	Building Sq. Ft.	EUI (kWh/SF)	kWh/year	kWh/year (Net Zero + 5%)
Commons	14102	11	155122	162878
Dormitory #1	4009	9.8	39288	41253
Dormitory #2	4009	9.8	39288	41253
Dormitory #3	4009	9.8	39288	41253
Dormitory #4	4009	9.8	39288	41253
Dormitory #5	4009	9.8	39288	41253
Classroom	3404	7.25	24679	25913
Staff Housing #1	5810	9.8	56938	59785
Staff Housing #2	5810	9.8	56938	59785
Gear Storage	1543	1	1543	1620

**TOTAL**

**491,660 kWh/yr**

**542,998 kWh/yr**

# ENERGY MODEL INPUTS - ANNUAL ENERGY CONSUMPTION

IES-VE	Adjusted IES-VE	WUFI	IES-VE	Adjusted IES-VE	WUFI
kBTU/yr	kBTU/yr	kBTU/yr	kWh/yr	kWh/yr	kWh/yr
444,806	322,598	337,604	130,360	94,544	98,942
88,022	49,702	58,101	25,797	14,566	17,028
128,029	105,086	68,305	37,522	30,798	20,018
123,410	105,086	68,305	36,168	30,798	20,018
123,410	105,086	68,305	36,168	30,798	20,018
123,410	105,086	68,305	36,168	30,798	20,018
123,410	105,086	68,305	36,168	30,798	20,018
143,364	66,007	93,534	42,016	19,345	27,412
104,140	77,888	67,943	30,520	22,827	19,912
76,766	-	-	22,498	-	22,498
99,635	-	-	29,200	-	29,200

**TOTAL ANNUAL ENERGY CONSUMPTION**

**462,584 kWh/yr**

**263,386 kWh/yr**



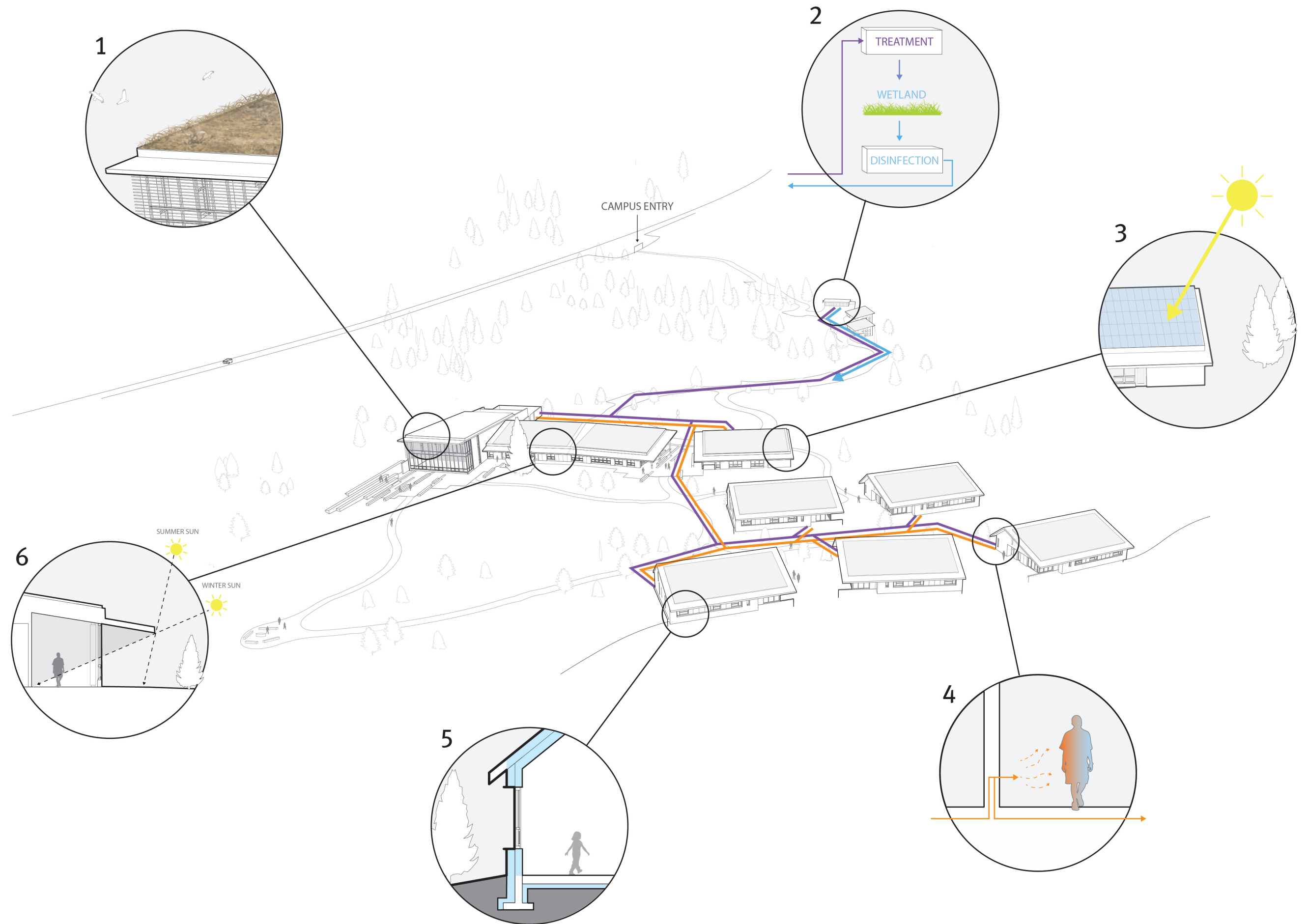
Buildings	kWh/Year Available - Increased Snow Depreciation	kWh/Year Available - Typical System Depreciation
Commons	131,504.90	144,442.00
Dormitory #1	61,104.30	67,406.00
Dormitory #2	60,832.05	67,062.00
Dormitory #3	60,970.45	67,235.00
Dormitory #4	61,151.80	67,473.00
Dormitory #5	60,654.60	66,842.00
Classroom	60,304.50	66,146.00
Staff Housing - 6 Units	37,650.35	41,105.00
Staff Housing - 4 Units	30,429.90	33,253.00
Gear Storage	0.00	0.00
<b>Total Available</b>	<b>564,602.85</b>	<b>620,964.00</b>
<b>Total Campus Difference</b>	<b>127,934.68</b>	<b>184,295.83</b>

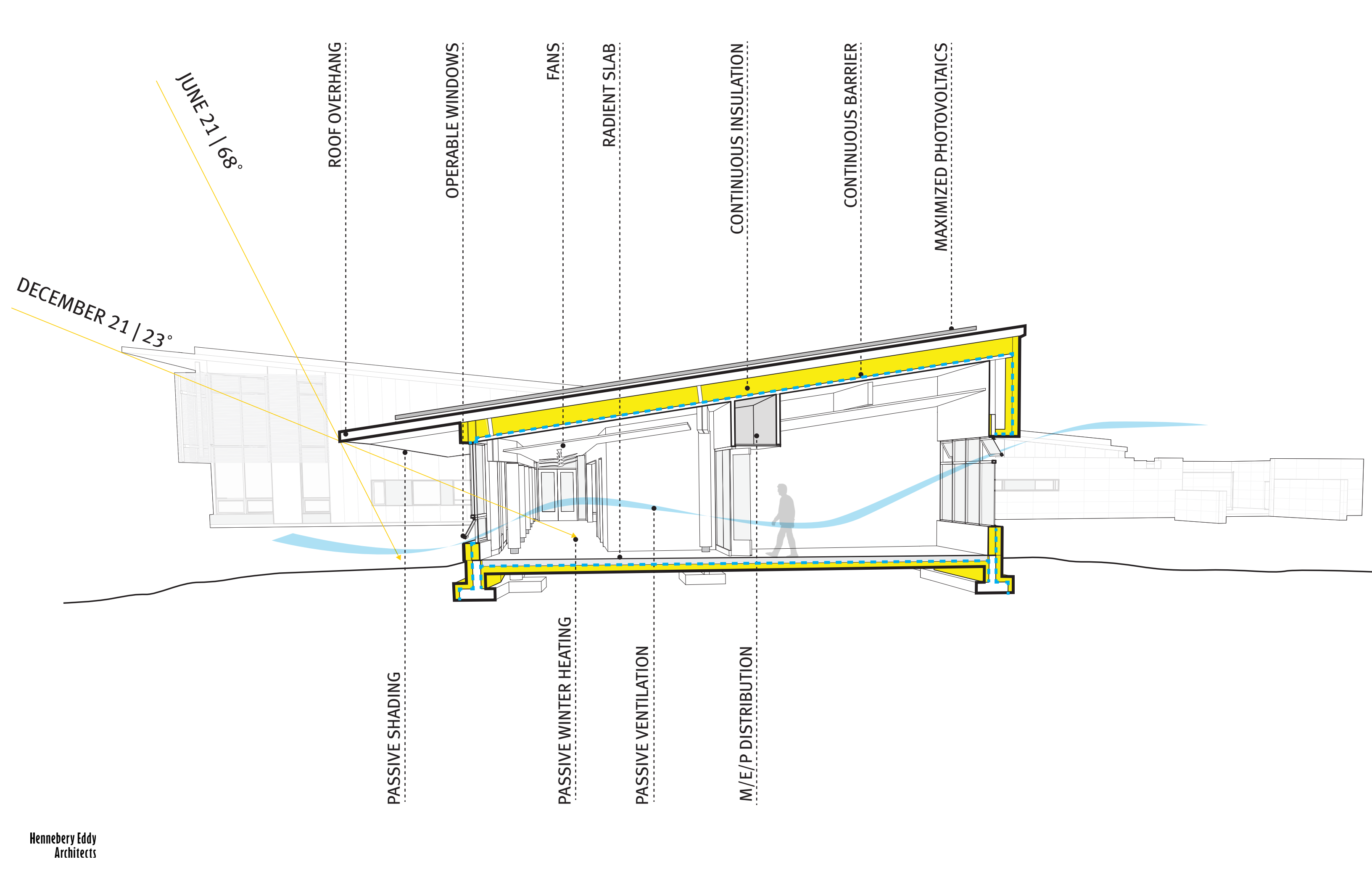
462,584 kWh/yr (IES) = 122% of annual energy demand

263,306 kWh/yr (WUFI) = 214% of annual energy demand

# CAMPUS DESIGN







ROOF OVERHANG

OPERABLE WINDOWS

FANS

RADIANT SLAB

CONTINUOUS INSULATION

CONTINUOUS BARRIER

MAXIMIZED PHOTOVOLTAICS

DECEMBER 21 | 23°

JUNE 21 | 68°

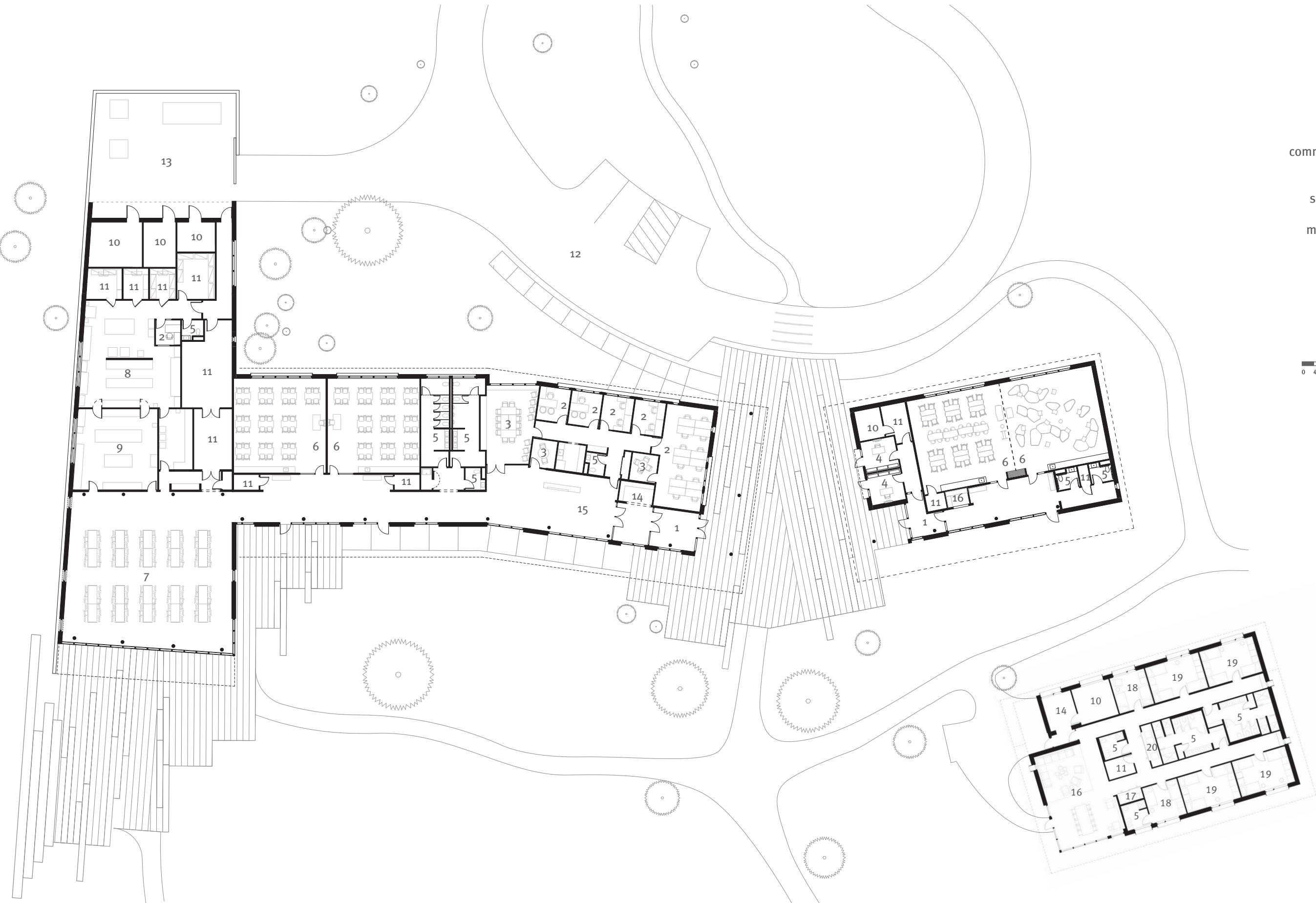
PASSIVE SHADING

PASSIVE WINTER HEATING

PASSIVE VENTILATION

M/E/P DISTRIBUTION

# COMMONS, CLASSROOM + DORM



- entry 1
- office 2
- conference 3
- virtual studio 4
- restroom 5
- classroom 6
- great room 7
- commercial kitchen 8
- servery 9
- mechanical 10
- service/storage 11
- drop off 12
- mechanical yard 13
- mudroom 14
- reception 15
- commons 16
- kitchen 17
- adult dorm 18
- youth dorm 19
- laundry 20



















**YELLOWSTONE FOREVER**

POWER BY DESIGN  
 GLEN CROCKETT PARKS  
 THE INSPIRATION BEHIND THE  
 NATIONAL PARK SERVICE  
 PARKS SERVICE  
 PARKS SERVICE  
 PARKS SERVICE  
 PARKS SERVICE  
 PARKS SERVICE  
 PARKS SERVICE  
 PARKS SERVICE

**NATIONAL PARK SERVICE**

KAREN KREBS  
 NIKKI PARKER  
 LINDSEY ROBERTS  
 TULLY O'ROURKE  
 PAUL YOUNG  
 SAMUELA COOK  
 MONICA HANSEN  
 RYAN JAVIER  
 BOBBI HANSEN

VIVIAN ROSEBERRY  
 BOB FURHAMANN  
 LINDA CHAN  
 MICKI BELLER  
 MARGA HANSEN  
 LARRY TAYLOR  
 JUDY KINTH  
 LINDA YOUNG  
 MIKE PARKER  
 NANCY WARD  
 STEVE FLEETLER  
 LINDSEY ROBERTS  
 LINDSEY ROBERTS  
 KEN VOORHEES  
 JEFF L. BROWN  
 ANNE L. SULLIVAN  
 JEFF HANSEN



A young girl in a striped shirt and dark skirt stands in the foreground on the left, looking towards the interior of the museum.

A woman and a child are sitting on a wooden bench by the window. The woman is reading a book, and the child is looking out the window.

A group of people, including children and adults, are gathered around a digital display in the center of the room, looking at the information presented.

A park ranger in a uniform is pointing at a large wall-mounted map of Yellowstone National Park. A group of people, including a woman with a backpack, are looking at the map.

A wooden service counter is located on the right side of the room, with a person standing behind it.



















