FACADE EFFECTS

Building Zero Carbon from Cascadia to Piedmont

Facade Tectonics FORUM SEATTLE

SPEAKERS

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PAE Engineers

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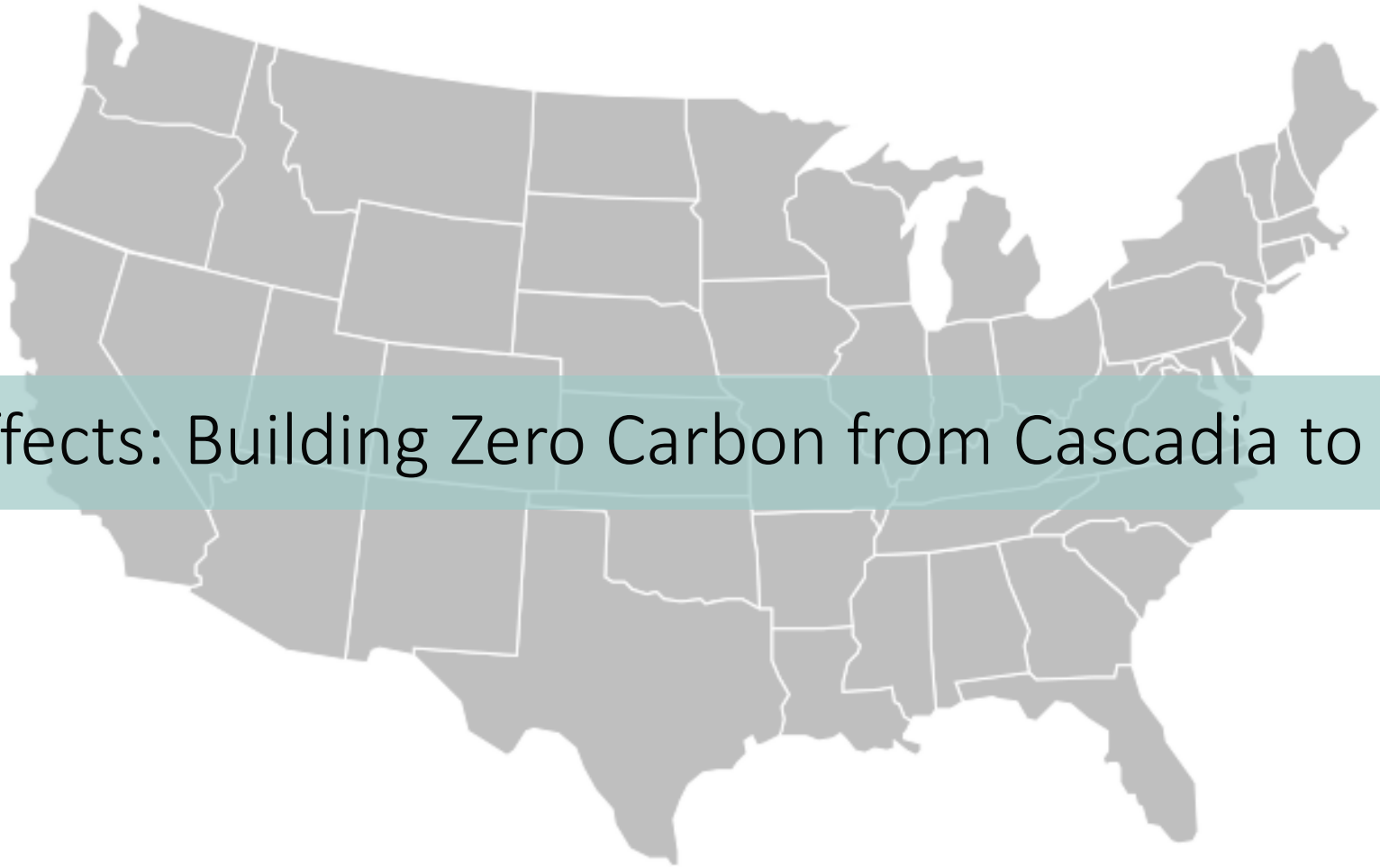
Principal
The Miller Hull Partnership

Margaret Sprug, AIA
Principal
The Miller Hull Partnership

Christopher Meek, AIA, IES
Professor of Architecture
University of Washington

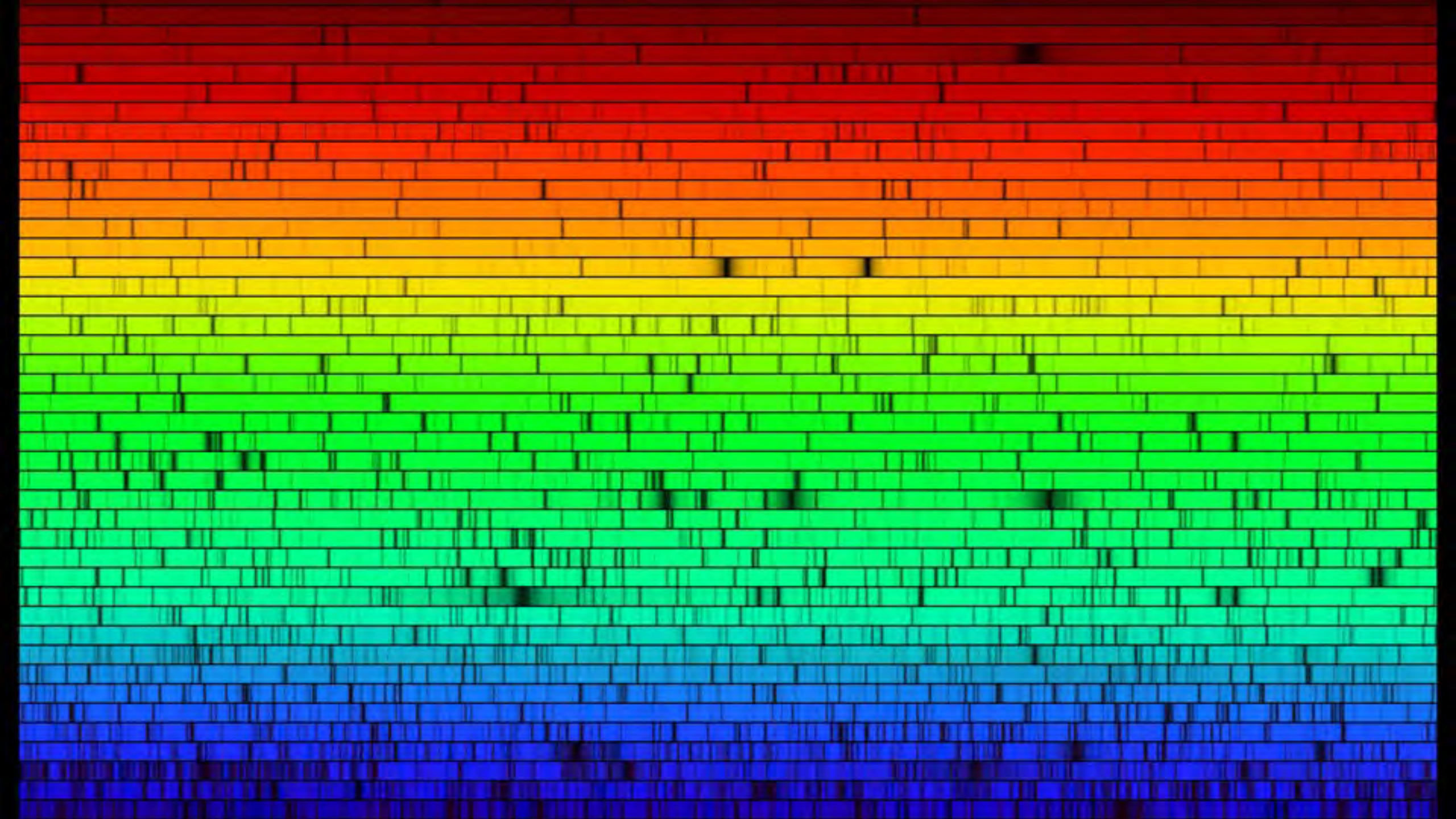


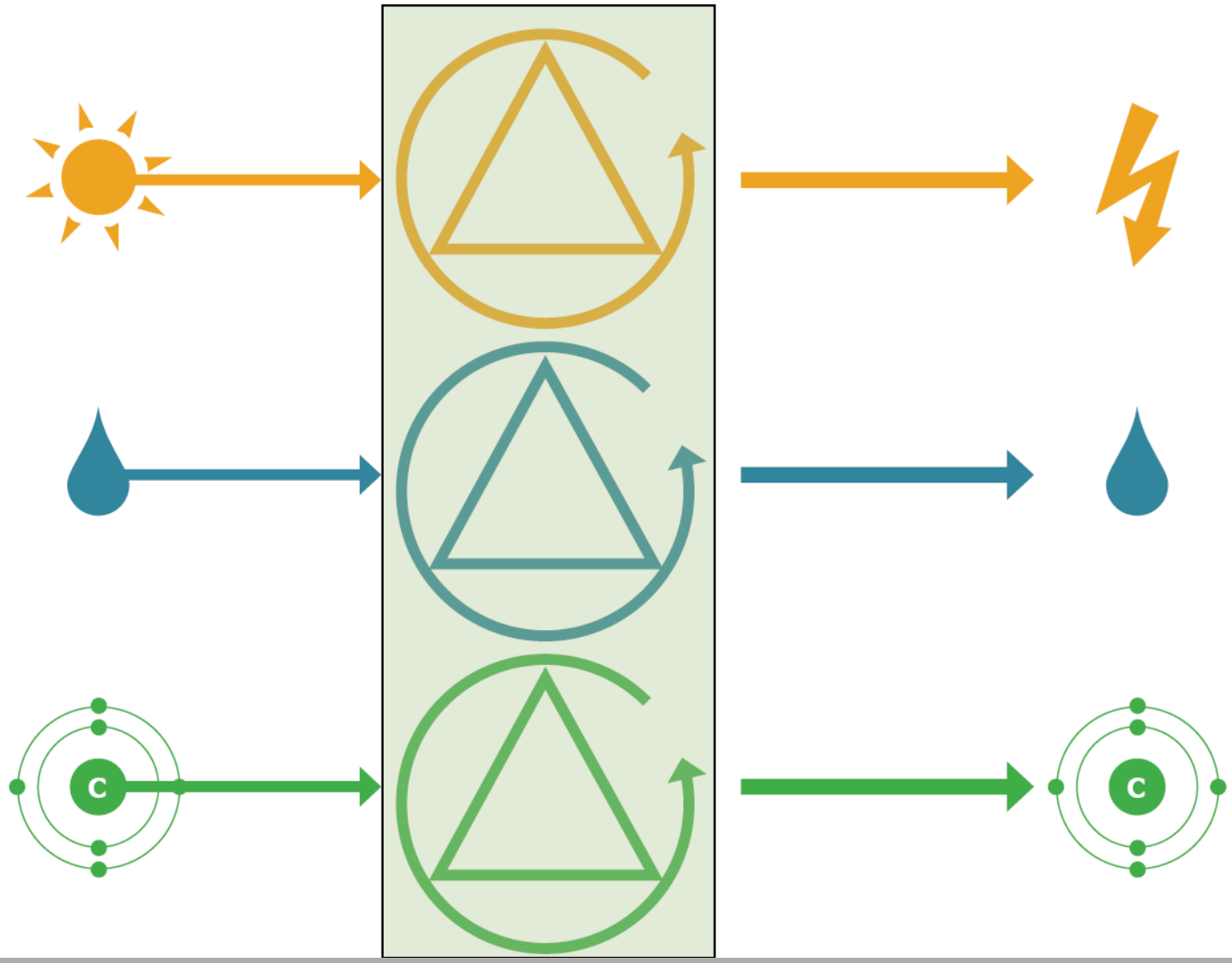
Façade Effects: Building Zero Carbon from Cascadia to Piedmont

A Story from 2040


SKOLSTREJK
FÖR
KLIMATET


NOW LEASING

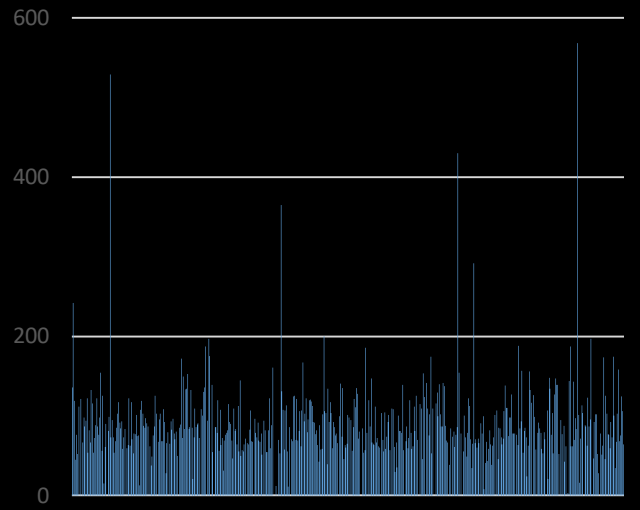



C
C


I
fossil
fuels

Site EUI: 222

Based on Energy and Water Data Disclosure for Local Law 84 (2013)



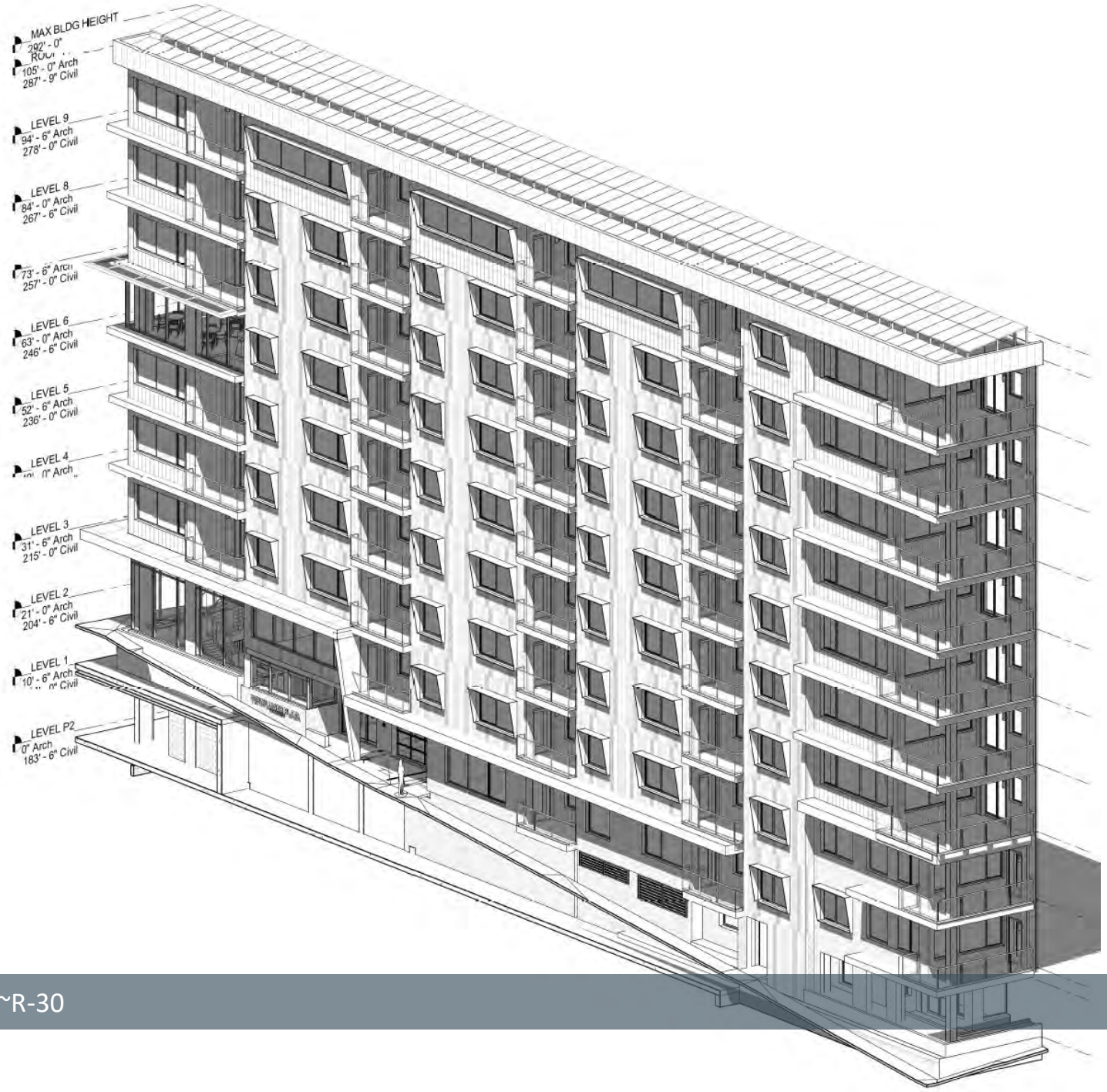

expert
advice
CONNECT
TRAINED
CAREER
PROSPECTS
EDUCATION

Mud Hut ~R-3

Log Cabin ~R-8

Stick Frame ~R-16

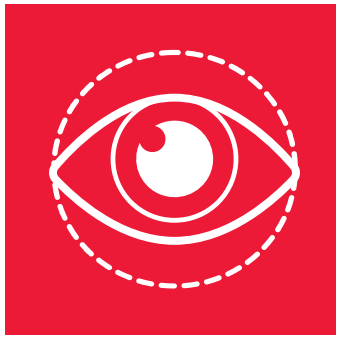
Glass Condo ~R-3



Passive House High Rise ~R-30

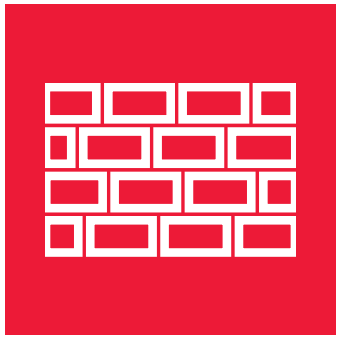
Façade Performance Goal Influencers

Building Program



Aesthetics

Climate

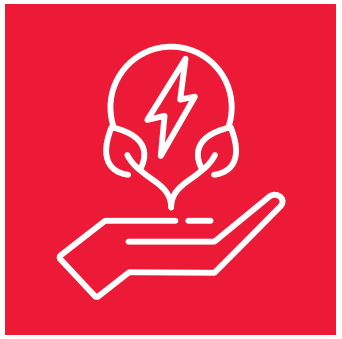


Local Requirements

Long-Term Economics

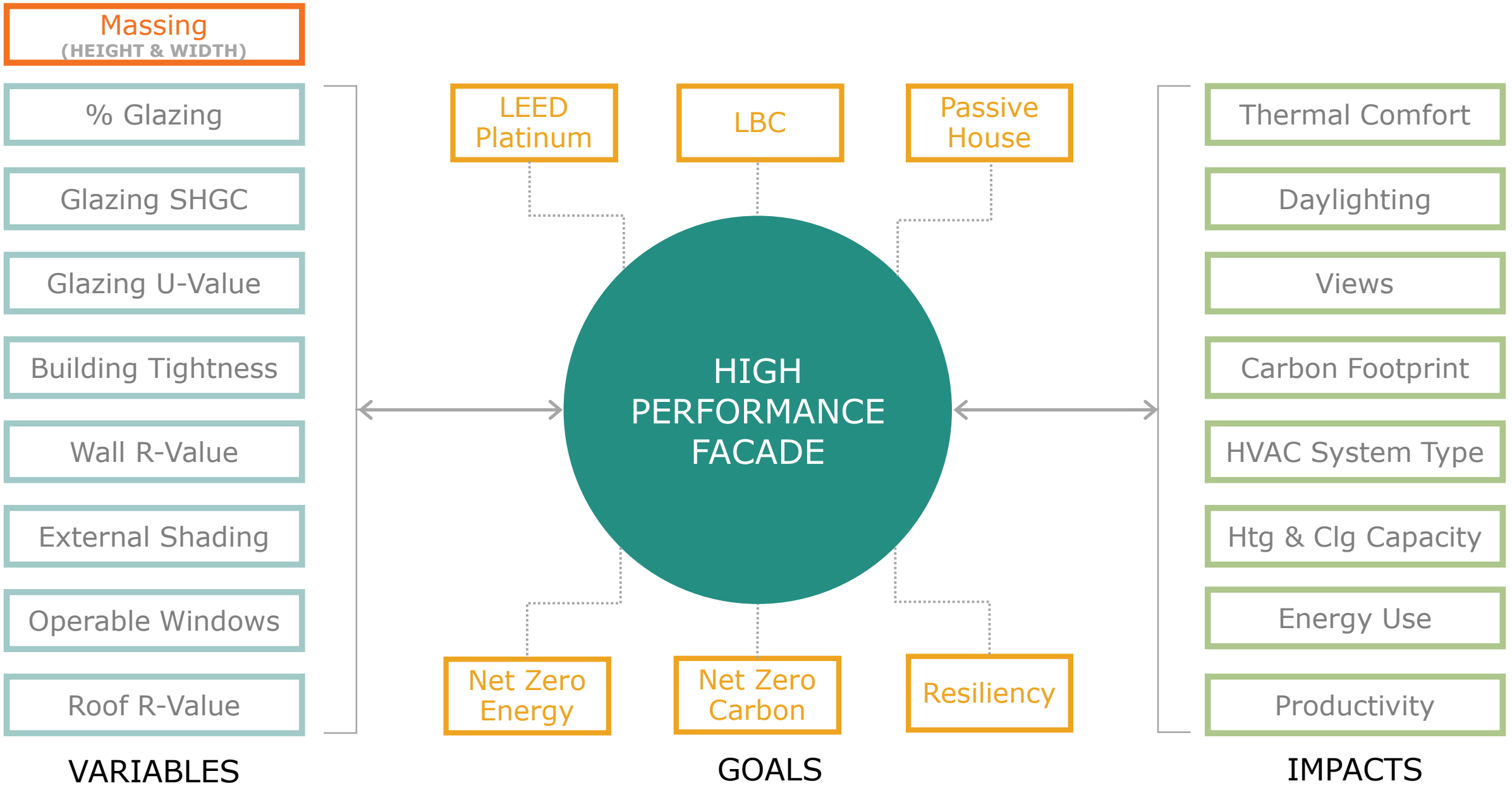
Construction Budget

Building Site



Energy Conservation

Façade Performance



Façade Strategies with the Biggest Impact on Sustainability

- % Glazing
- Glazing performance (U-value and SHGC)
- Building tightness
- Thermal bridging
- External solar shading
- Building mass
- Operable windows (climate dependent)
- Dynamic shading

Current Façade Design Trends

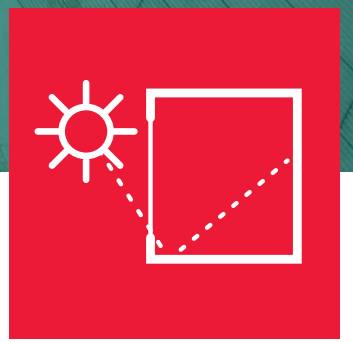
- Focus on Reducing Peak Loads
- Integration with HVAC Systems

Façade Sustainability Myths

Fixed vertical fins on West facades reduce peak cooling loads

Light shelves bring more light into the space

Insulated spandrel performs the same as opaque wall



Glazing below 3’ above finished floor is good for Daylighting

Net Zero What?

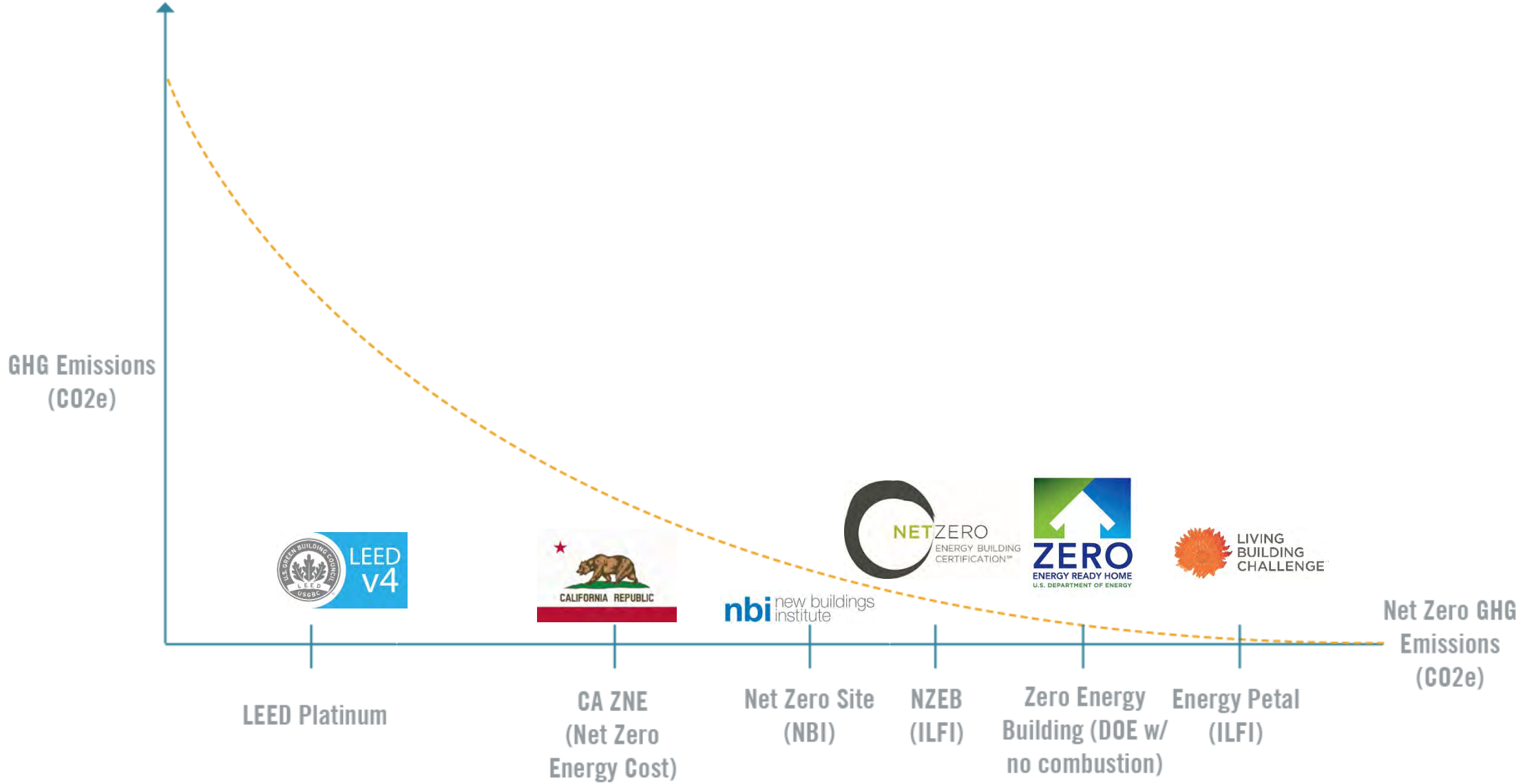
ZERO CARBON CERTIFICATION

ZERO ENERGY CERTIFICATION

LEED ZERO

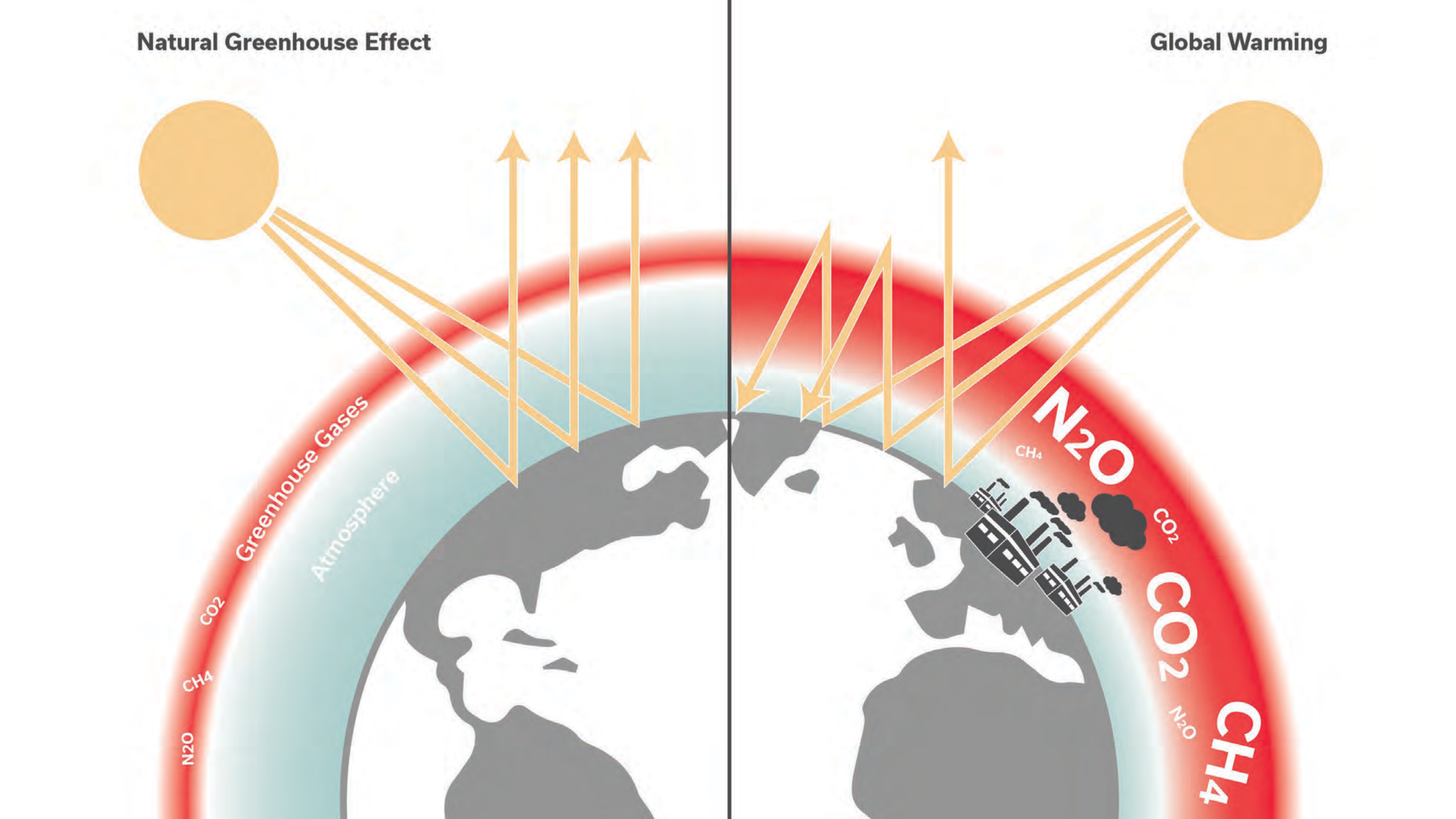
TOTAL = True Impact

Net Zero What?

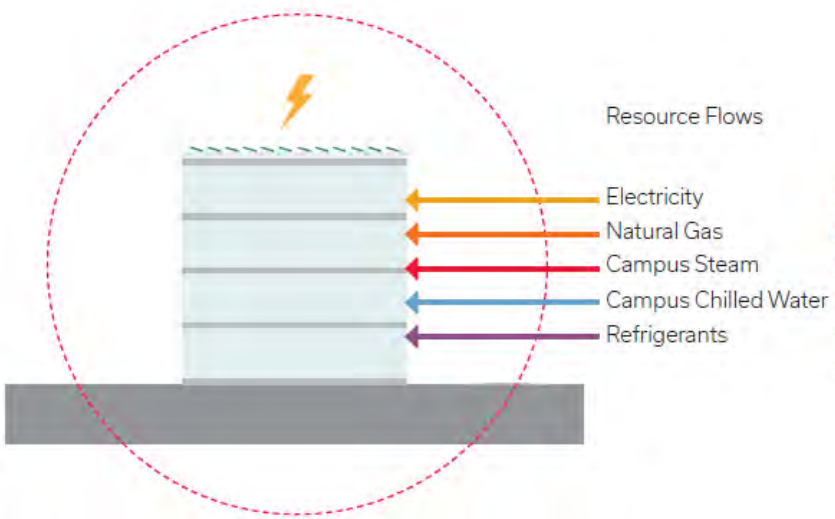



Energy
Energy
Energy


Energy is merely an illusion


Natural Greenhouse Effect
Global Warming
Greenhouse Gases
Atmosphere
CO2
CH4
N2O
N2O
CH4
CO2
CO2
N2O
CH4


CO_2
Carbon Dioxide
H_2O
Water
H_2CO_3
Carbonic Acid



Resource Flows

Electricity

Natural Gas

Campus Steam

Campus Chilled Water

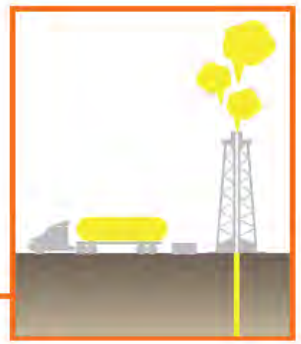
Refrigerants

PSE Power Supply

0.55 lb/kWh

PSE Natural Gas Supply

0.599 lb/kWh



Capitol Campus Steam Plant

PSE Power Supply

0.55 lb/kWh

Capitol Campus Chilled Water Plant

PSE Power Supply

0.55 lb/kWh

HVAC Vendor Supply to Equipment with Compressors

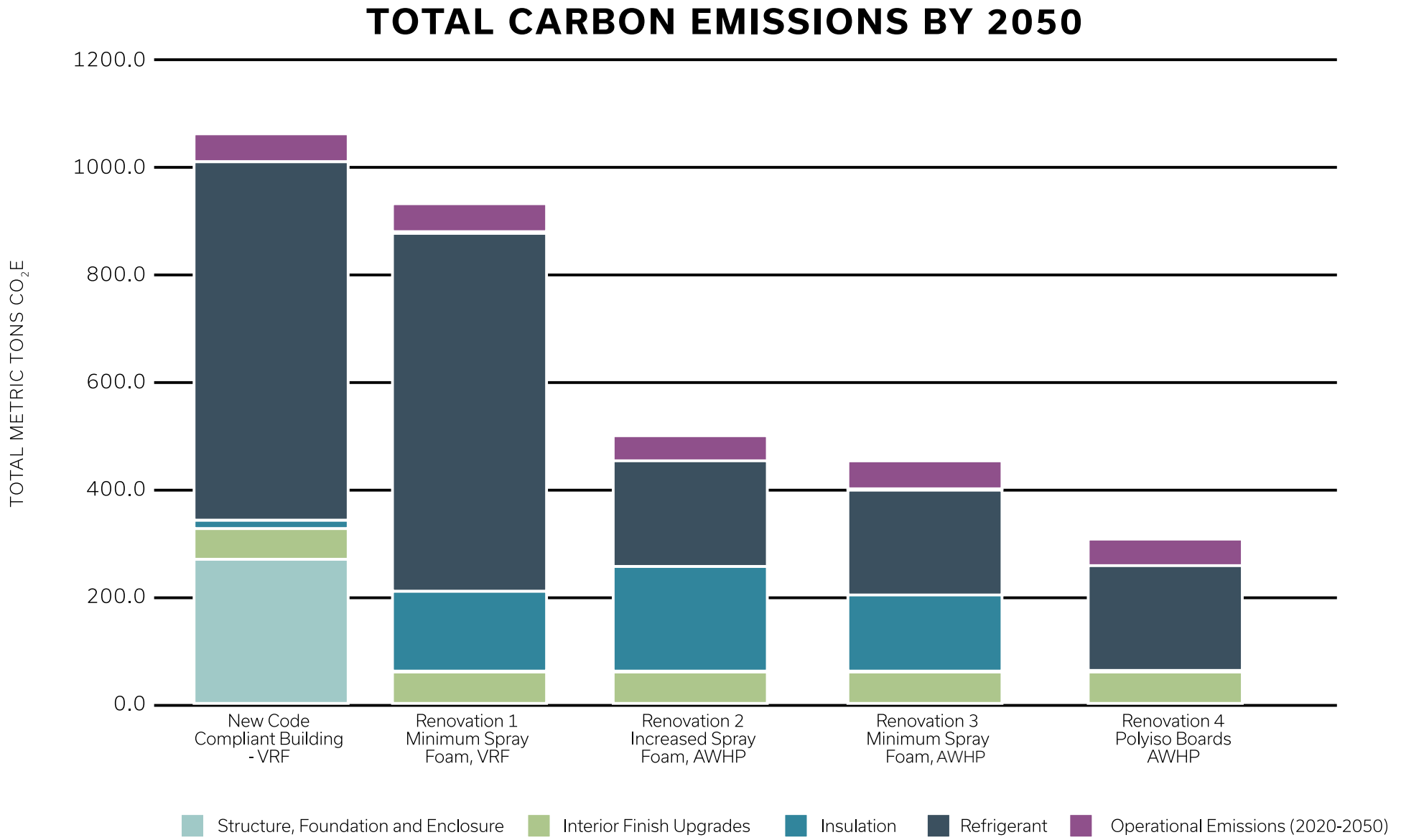
Refrigerant Supply

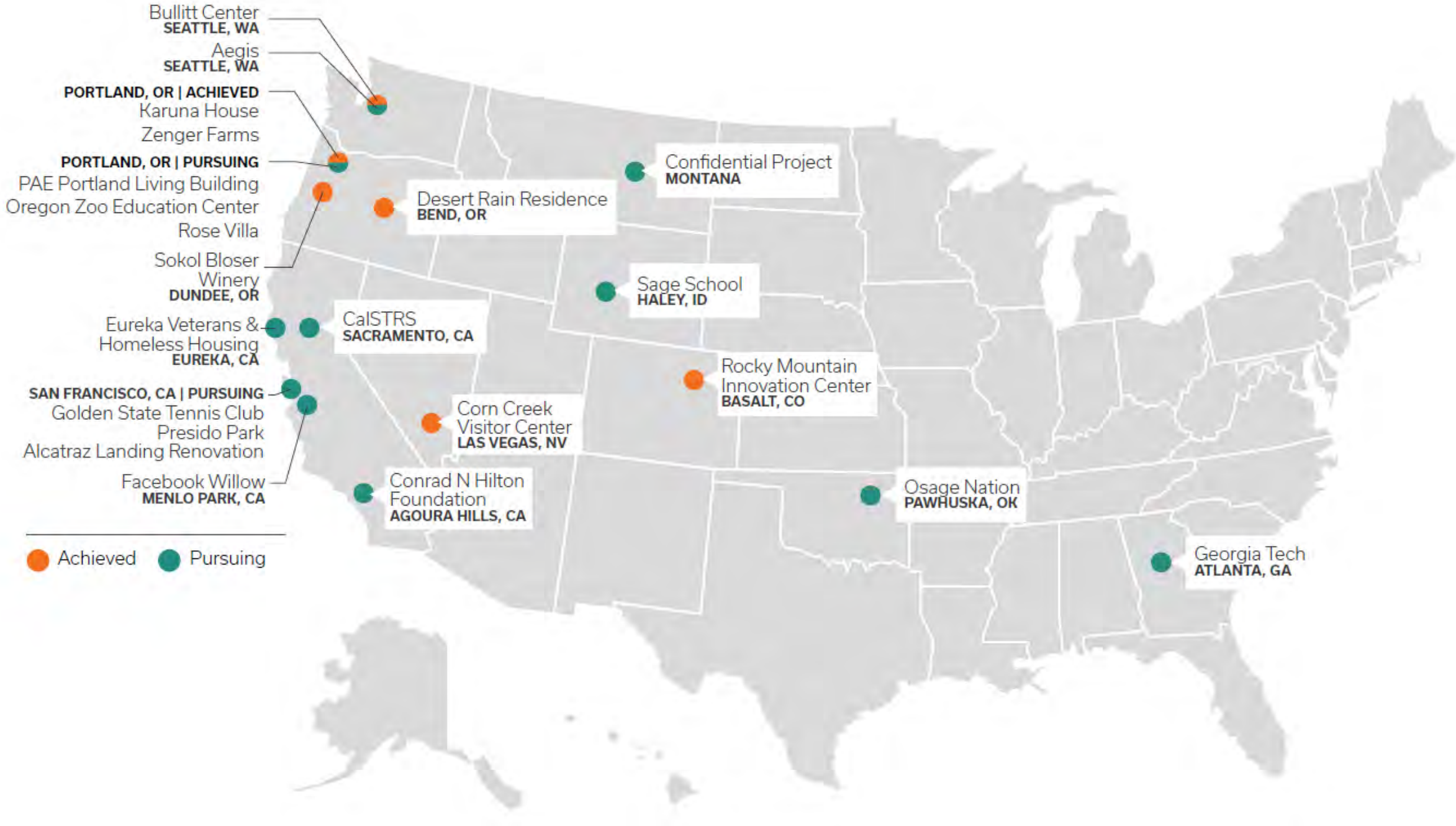
Embodied Energy of Materials

Manufacturing Construction End of Life

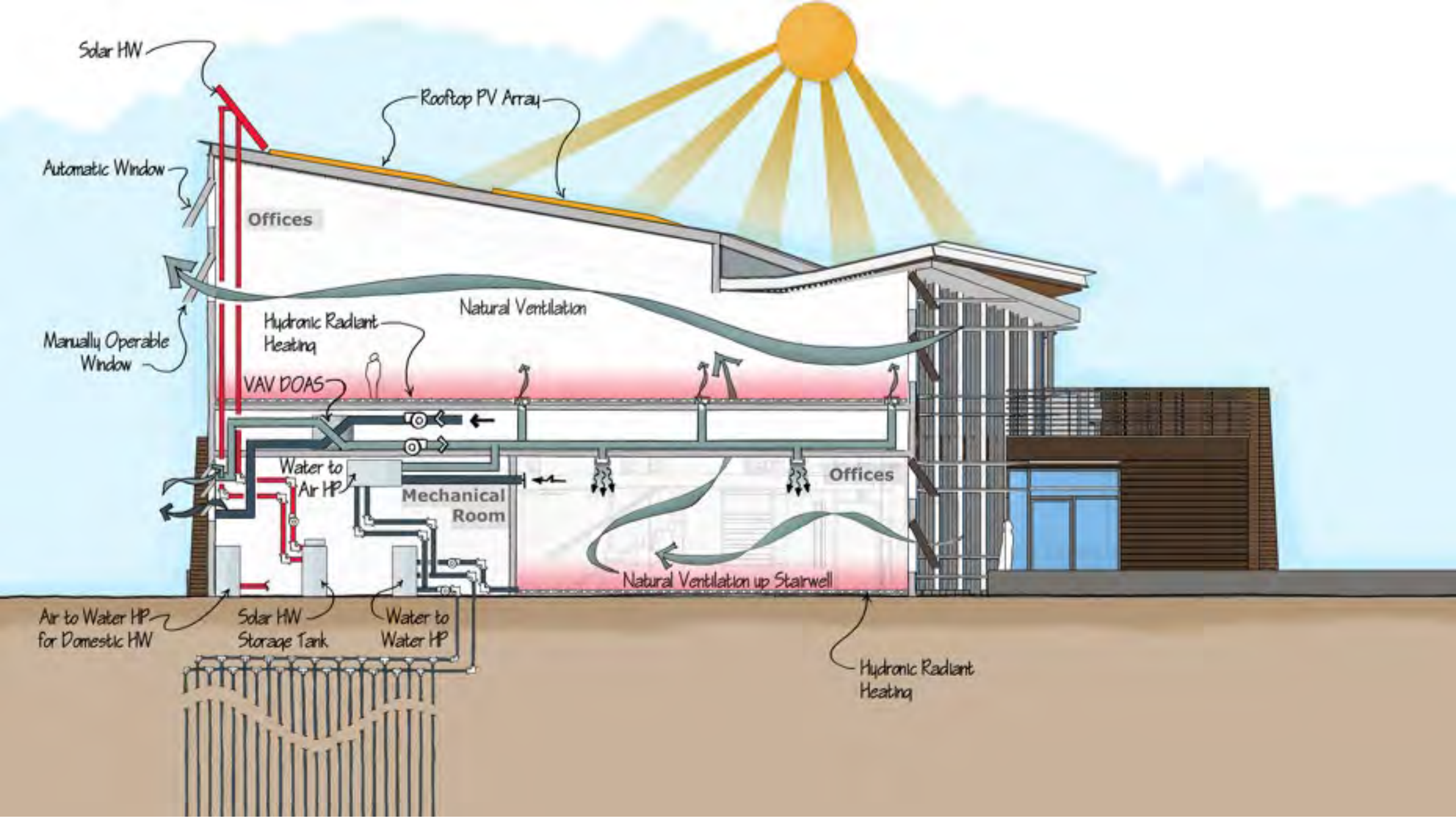
Including wood construction as a carbon sink can support WA State economics.

Greenhouse Gas Emissions



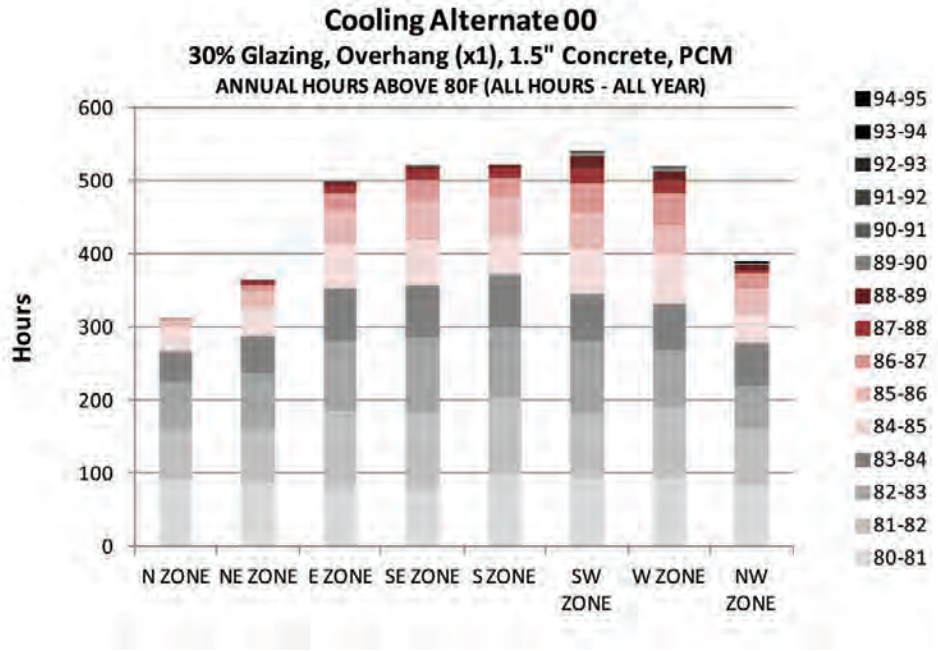

Bullitt Center
SEATTLE, WA
Aegis
SEATTLE, WA
PORTLAND, OR | ACHIEVED
Karuna House
Zenger Farms
PORTLAND, OR | PURSUING
PAE Portland Living Building
Oregon Zoo Education Center
Rose Villa
Sokol Bloser Winery
DUNDEE, OR
Eureka Veterans & Homeless Housing
EUREKA, CA
CalSTRS
SACRAMENTO, CA
SAN FRANCISCO, CA | PURSUING
Golden State Tennis Club
Presido Park
Alcatraz Landing Renovation
Facebook Willow
MENLO PARK, CA
Achieved
Pursuing
Confidential Project
MONTANA
Desert Rain Residence
BEND, OR
Sage School
HALEY, ID
Rocky Mountain Innovation Center
BASALT, CO
Corn Creek Visitor Center
LAS VEGAS, NV
Conrad N Hilton Foundation
AGOURA HILLS, CA
Osage Nation
PAWHUSKA, OK
Georgia Tech
ATLANTA, GA

RMI – Innovation Center

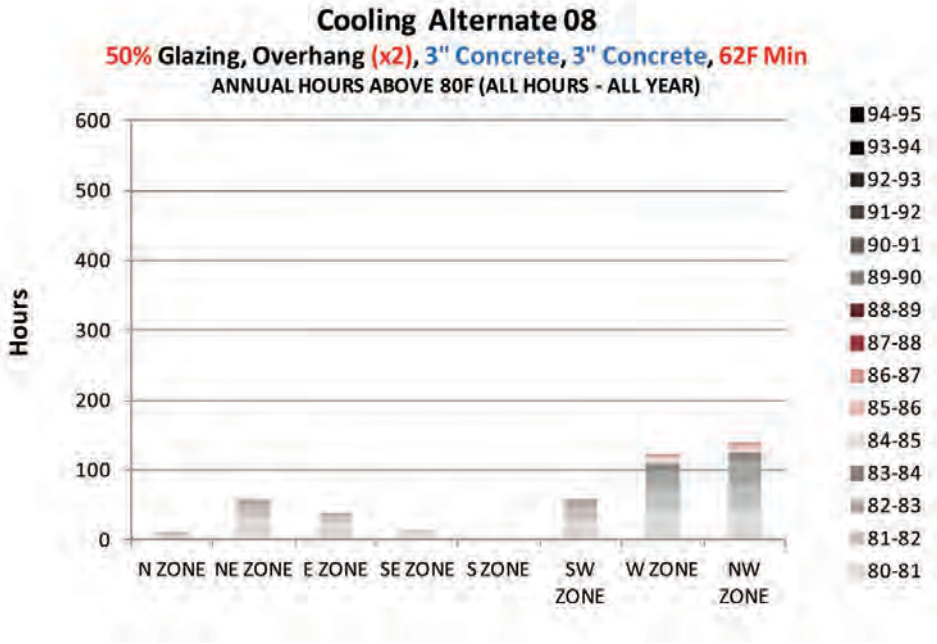

Solar HW
Rooftop PV Array
Automatic Window
Offices
Natural Ventilation
Manually Operable Window
Hydronic Radiant Heating
VAV DOAS
Water to Air HP
Mechanical Room
Offices
Natural Ventilation up Stairwell
Air to Water HP for Domestic HW
Solar HW Storage Tank
Water to Water HP
Hydronic Radiant Heating

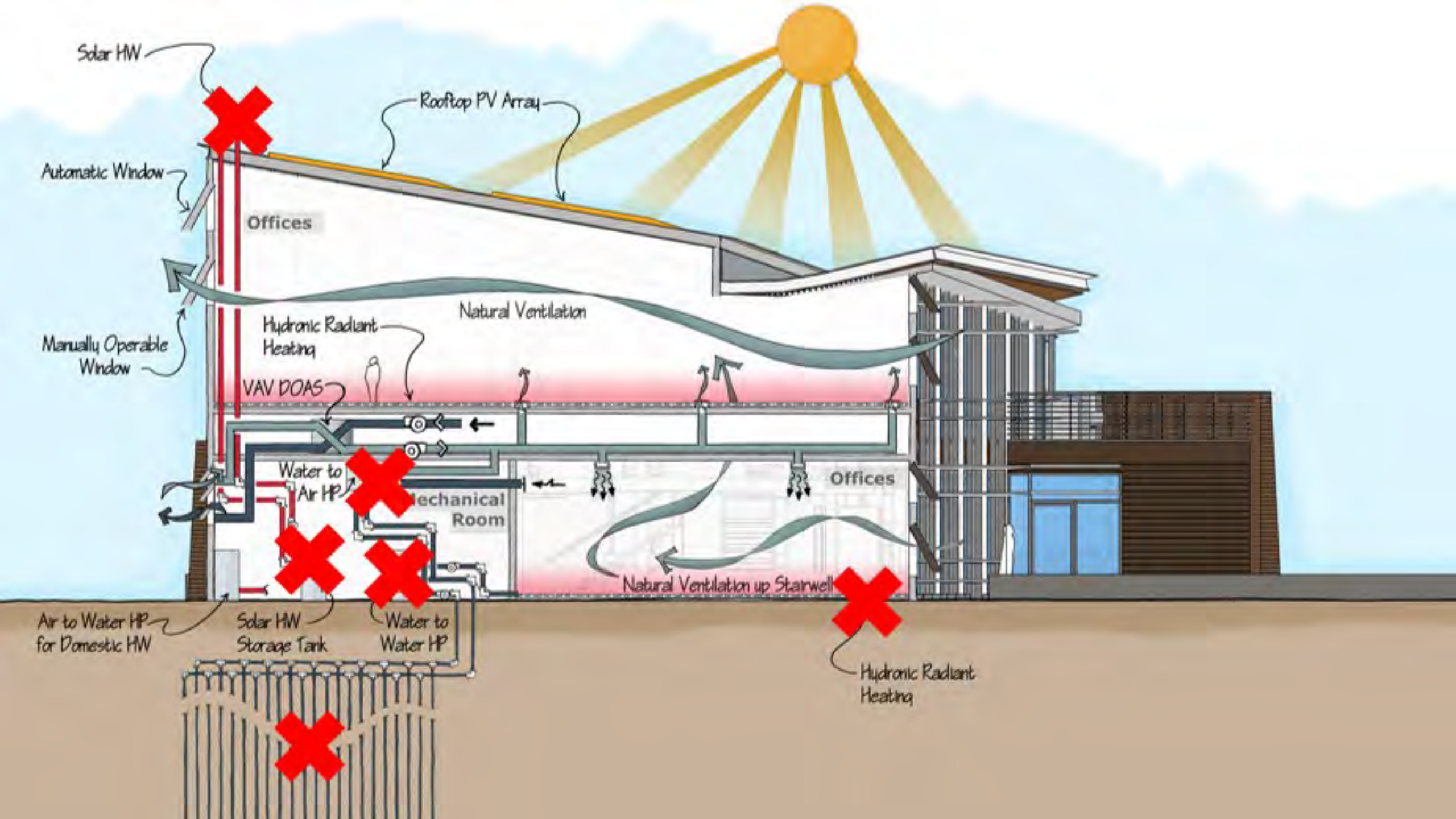
Cooling

Baseline



Optimized Cooling Comfort Alternate




Solar HW
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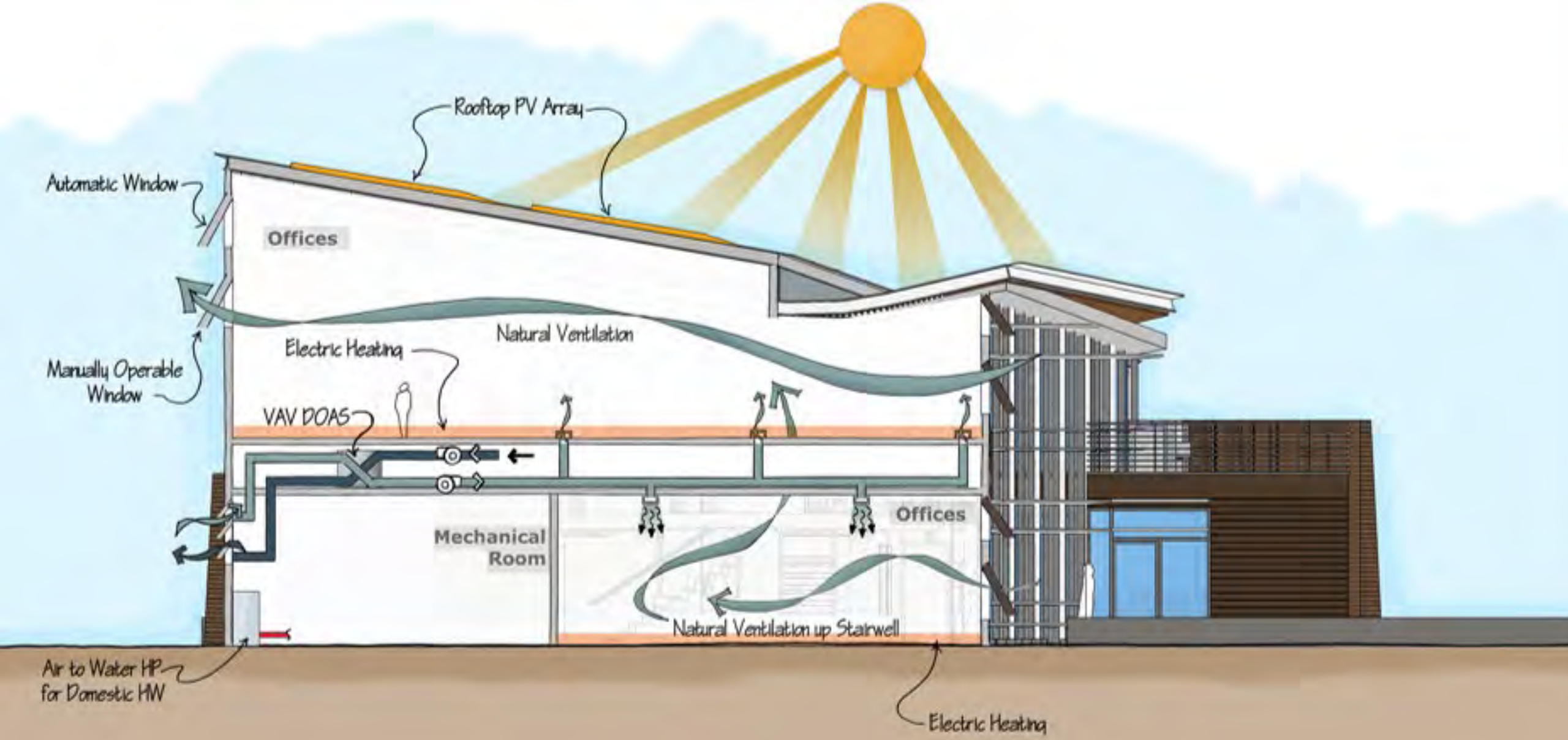
Natural Ventilation up Stairwell
Air to Water HP for Domestic HW
Solar HW Storage Tank
Water to Water HP
Hydronic Radiant Heating


Rooftop PV Array
Automatic Window
Offices
Natural Ventilation
Electric Heating
Manually Operable Window
VAV DOAS
Mechanical Room
Offices
Natural Ventilation up Stairwell
Air to Water HP for Domestic HW
Electric Heating

Key Design Elements – Glazing Design & Performance

RMI Emissions Analysis – 16 years

Operational Emissions

Refrigerants Emissions

Embodied Emissions

1,400 Mt

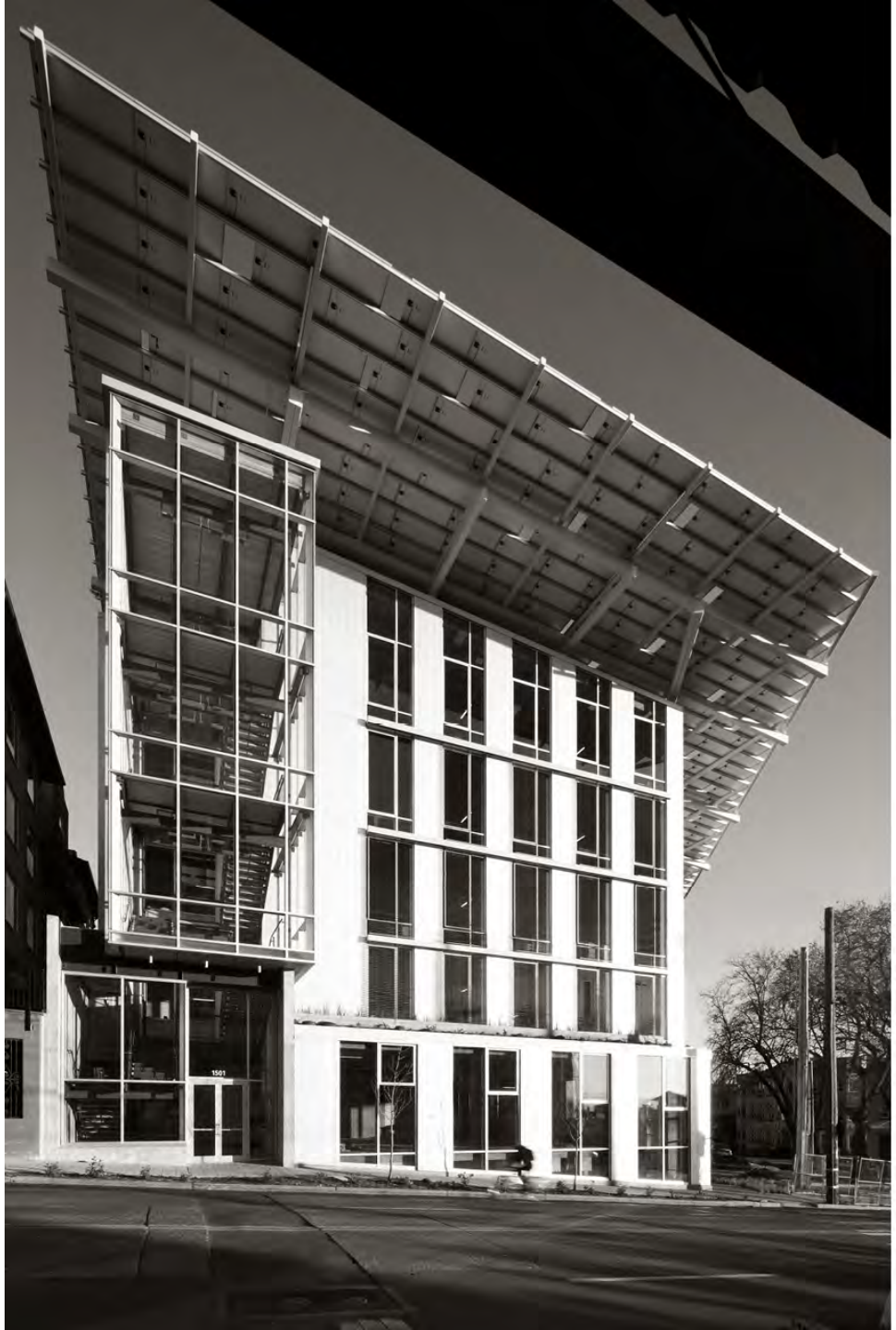
10 Mt

1,130 Mt

THE BULLITT CENTER

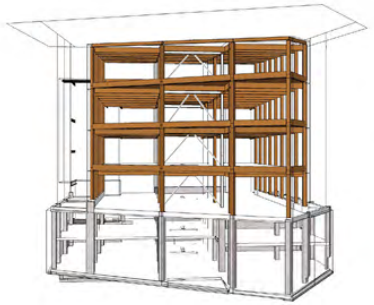
Façade Tectonics, Seattle
07.16.2019

Margaret Sprug, AIA Miller Hull

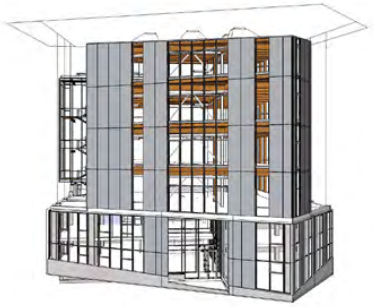


LONG LIFE, LOOSE FIT

250 YEAR STRUCTURE

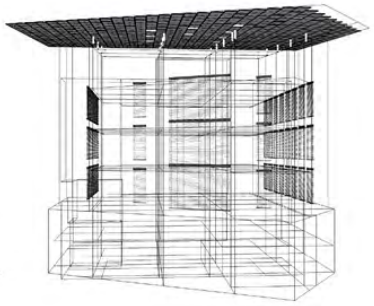


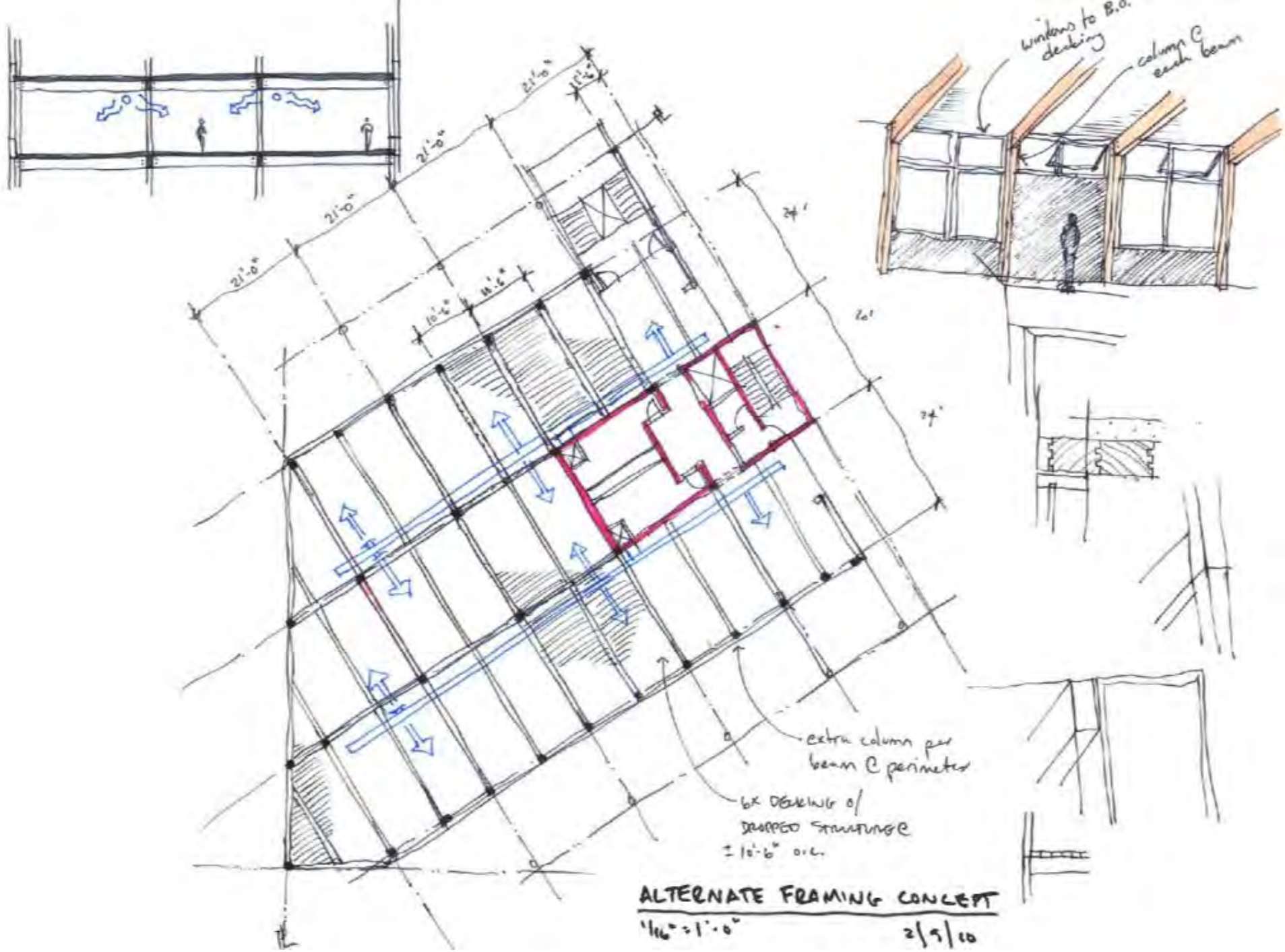
50 YEAR SKIN



35-40 YEAR ACTIVE TECHNOLOGY

ACTIVE SOLAR CONTROL
PHOTOVOLTAICS

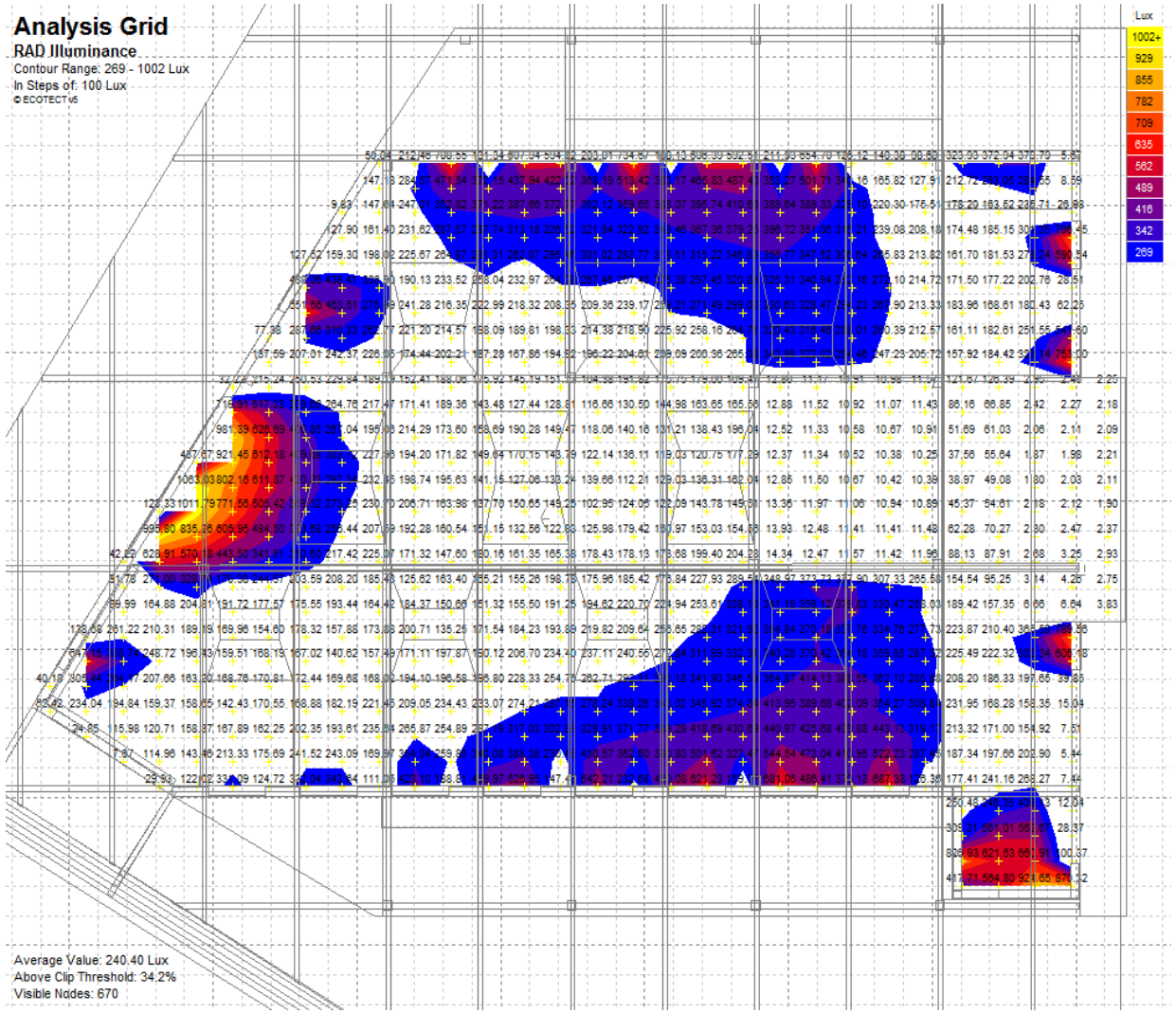




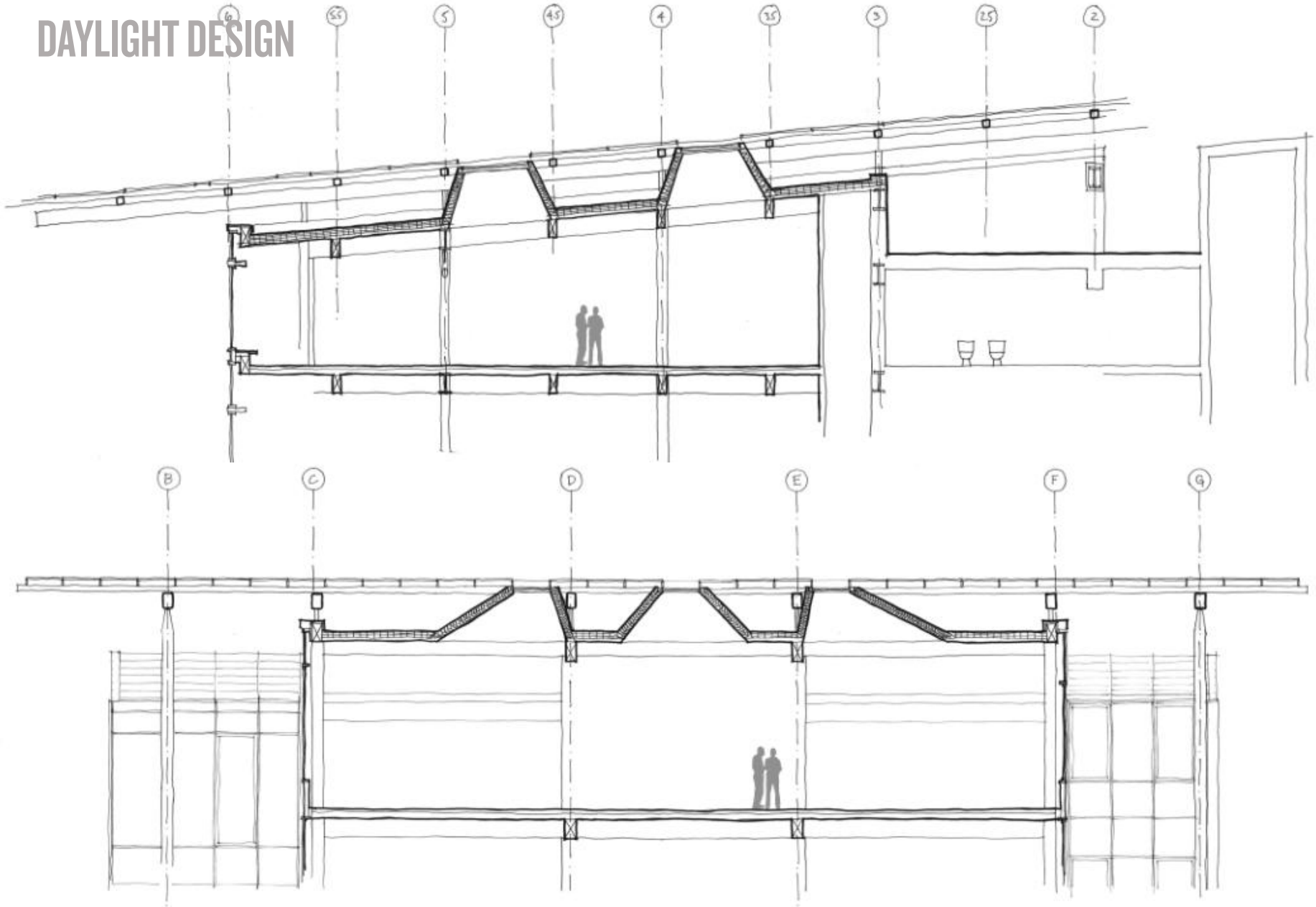
ALTERNATE FRAMING CONCEPT

1/16" = 1'-0" 2/9/10

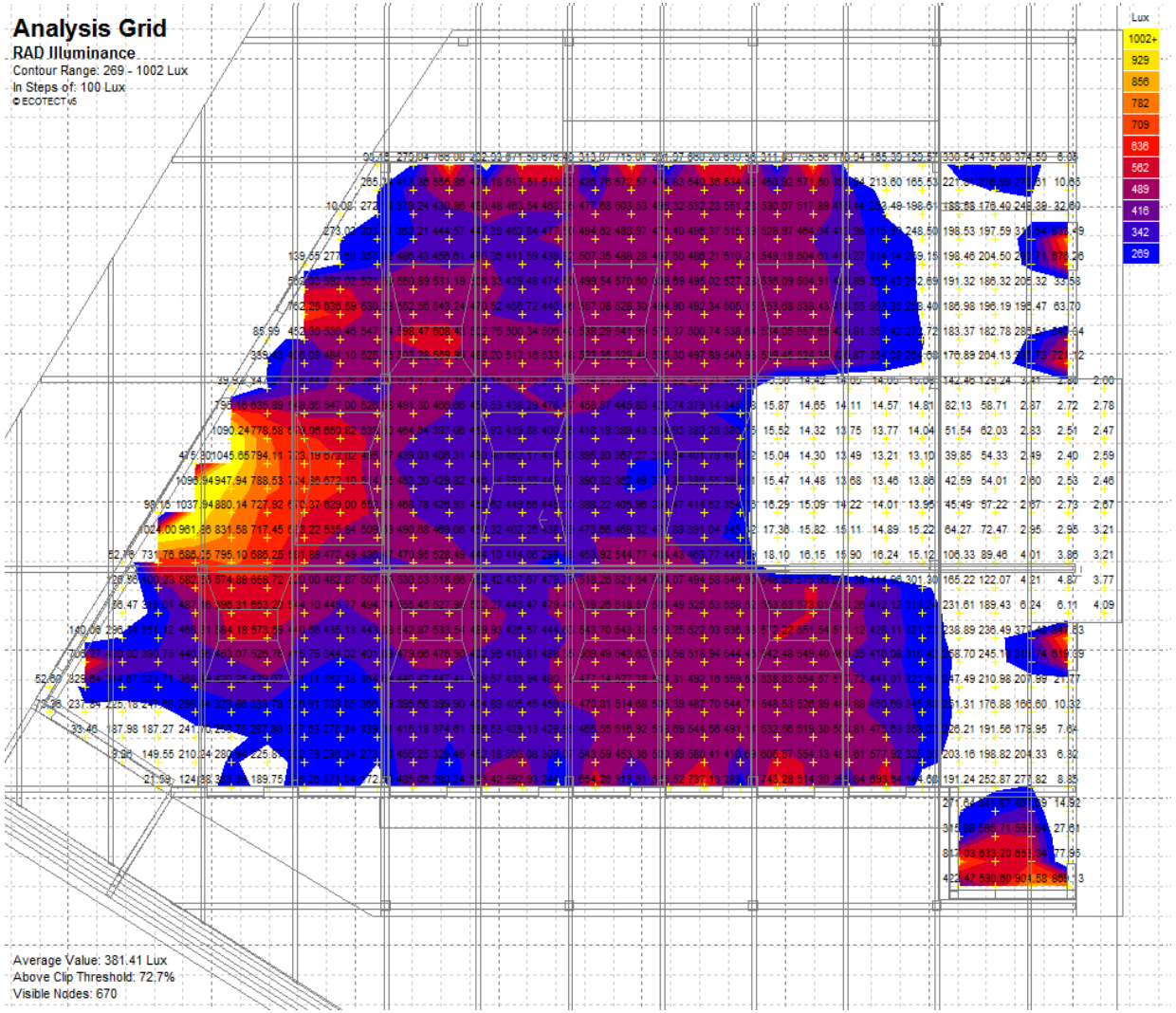
DAYLIGHT DESIGN



DAYLIGHT DESIGN

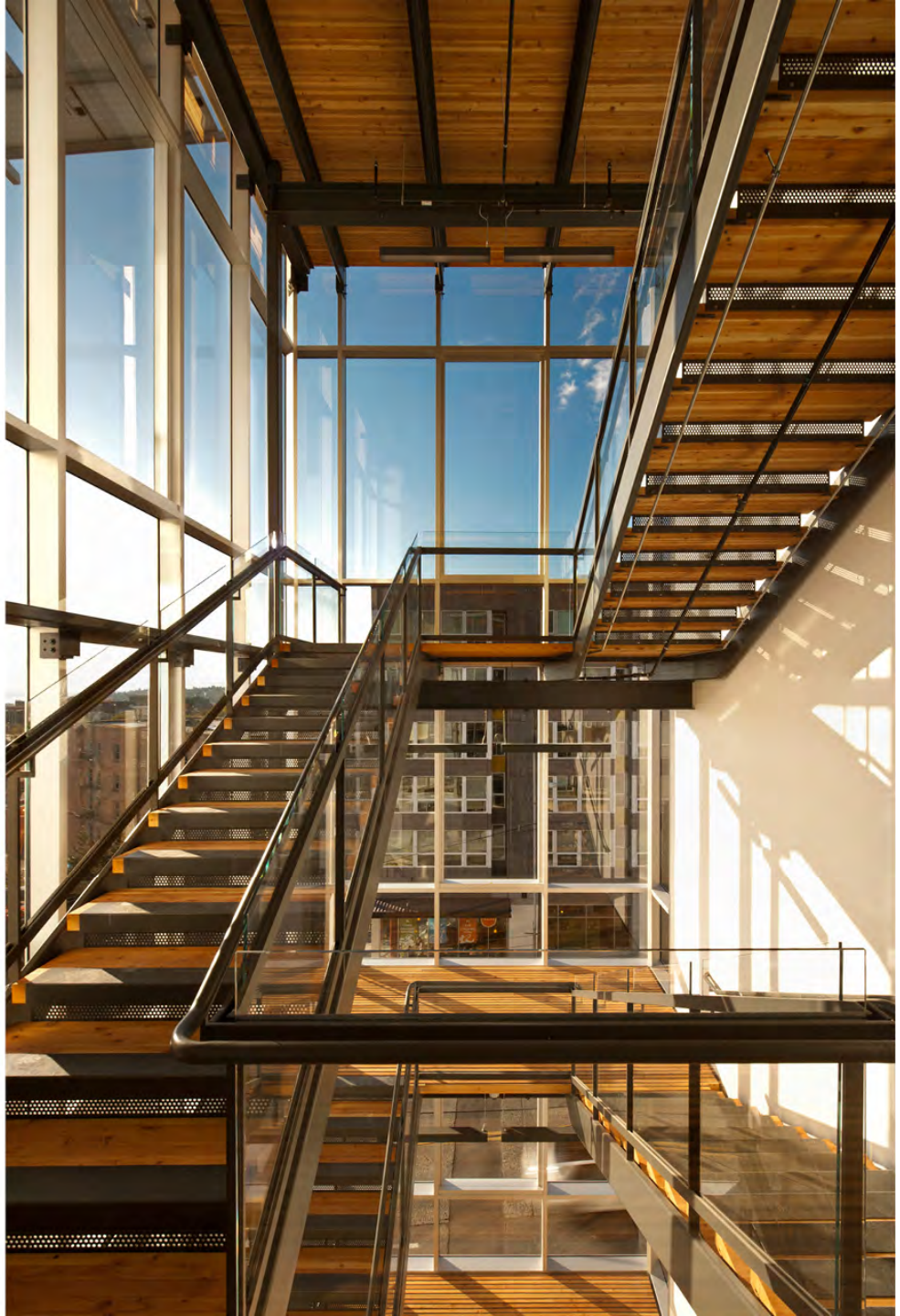


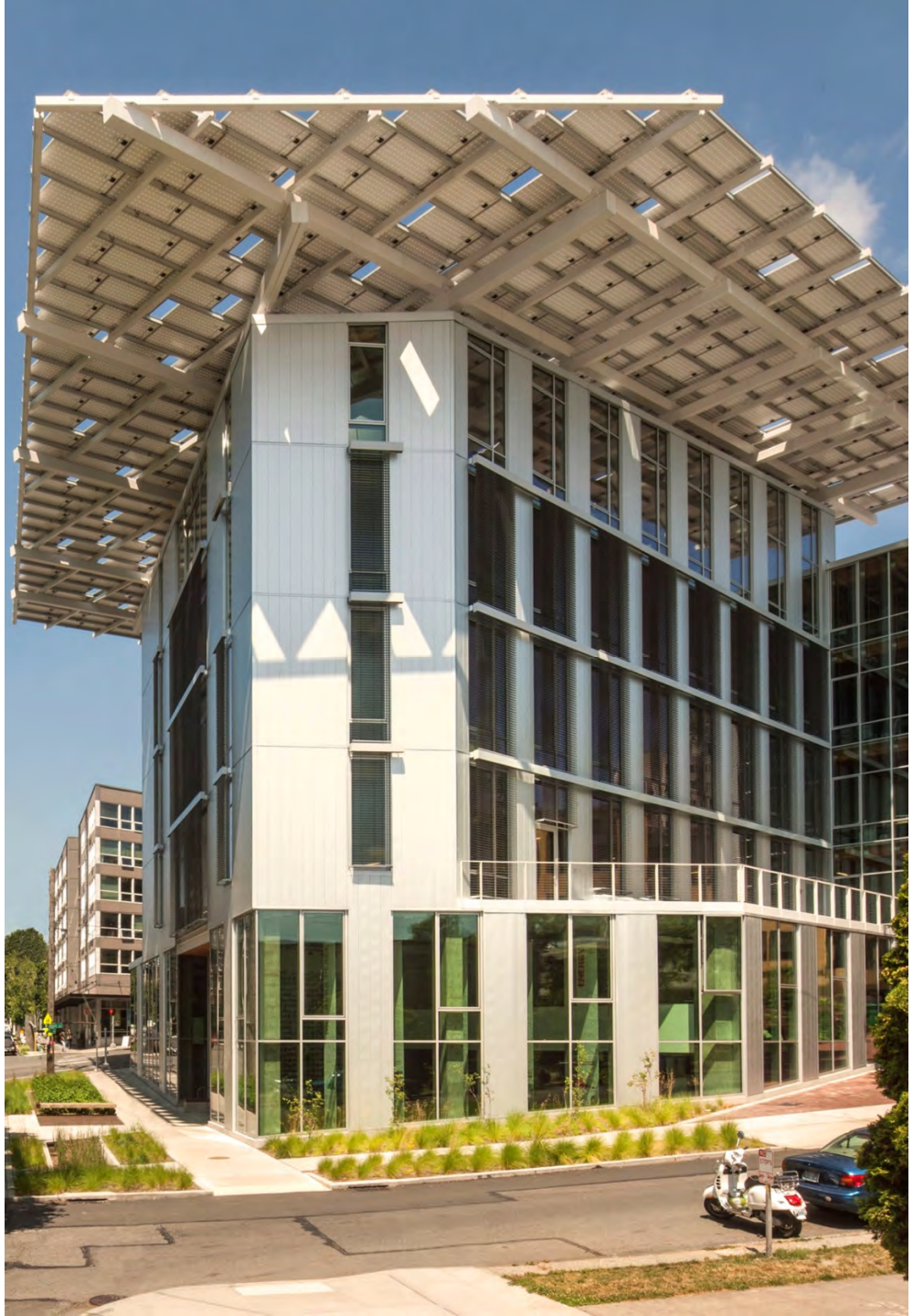
DAYLIGHT DESIGN



MATERIALS & CONSTRUCTION

- V^3 24,526 CF WOOD
- IT TAKES 2 MINUTES TO GROW THIS MUCH WOOD
- C 545 METRIC TONS OF CO2 STORED
- CO_2 1,158 AVOIDED METRIC TONS OF CO2
- TOTAL 1,703 METRIC TONS OF CO2 AVOIDED

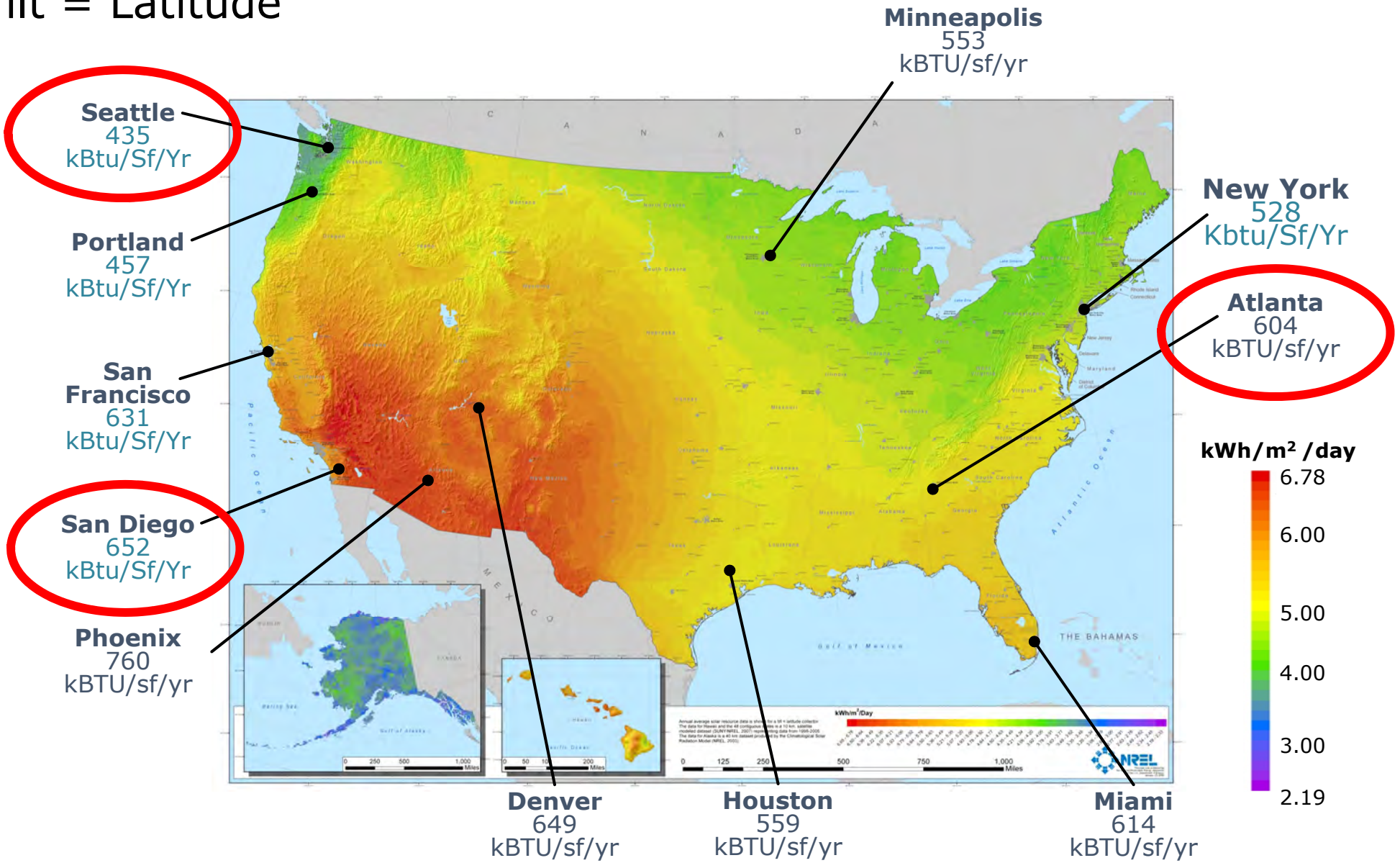




BUILDING SYSTEMS AND PERFORMANCE

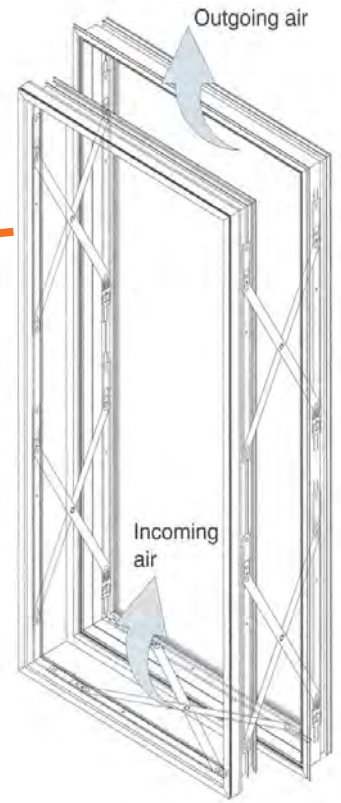
Solar Resource

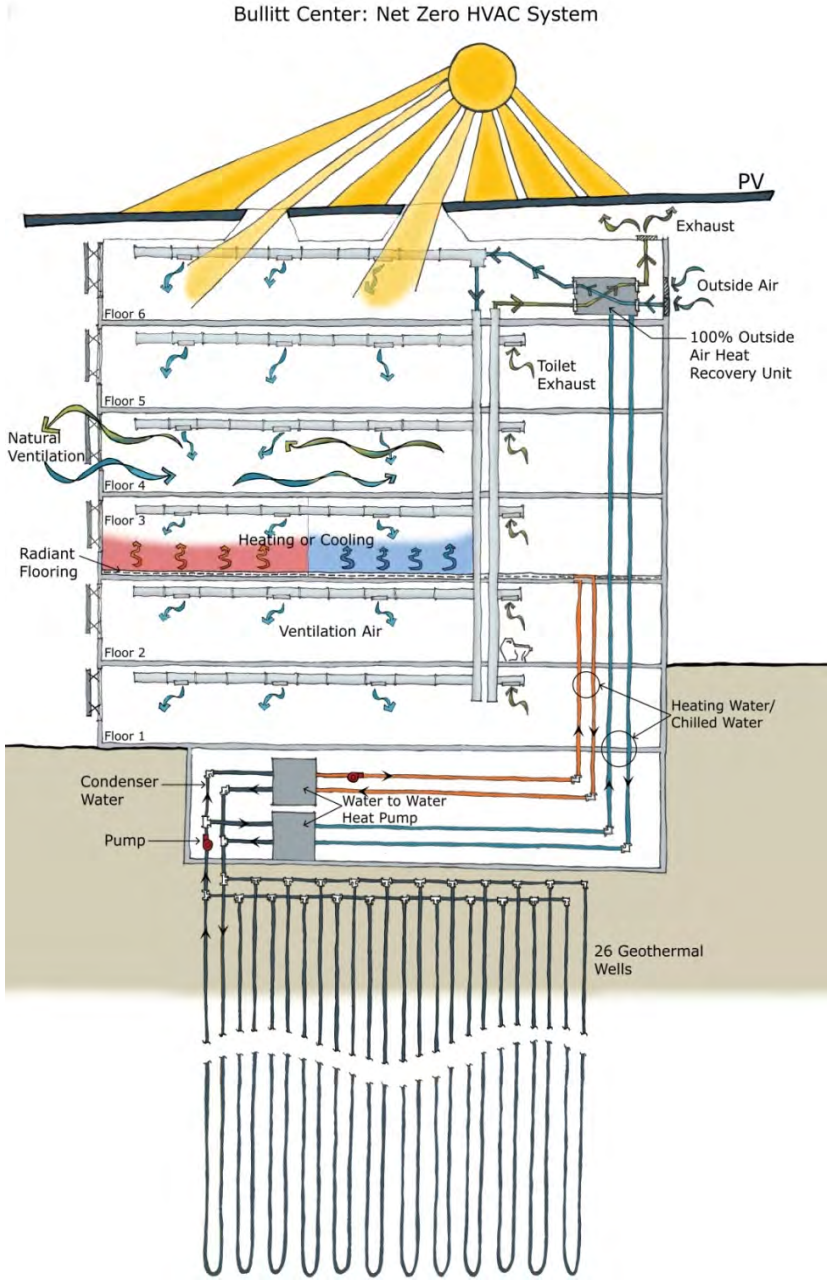
Array Tilt = Latitude

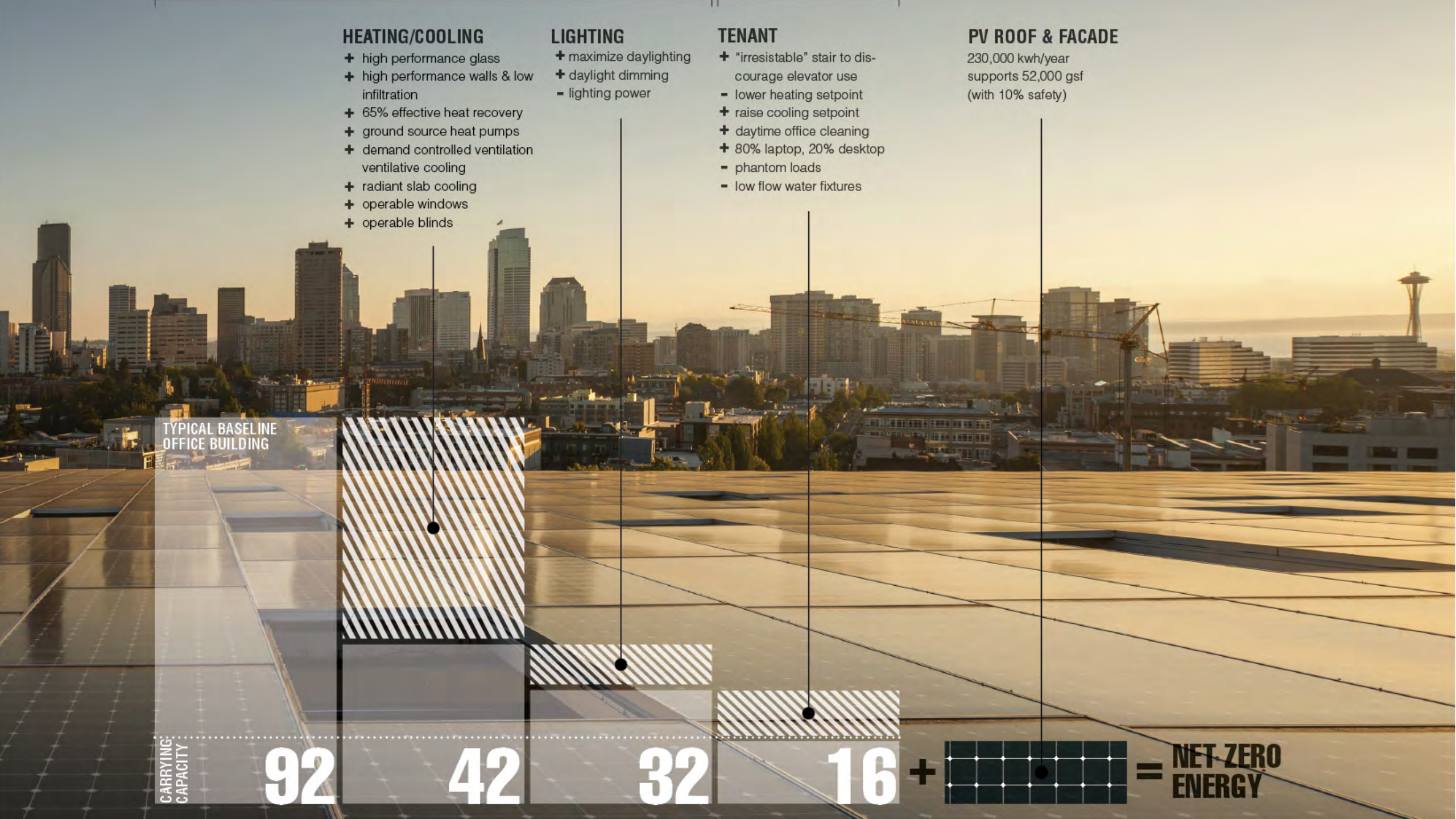


Bullitt Center

HVAC System Overview

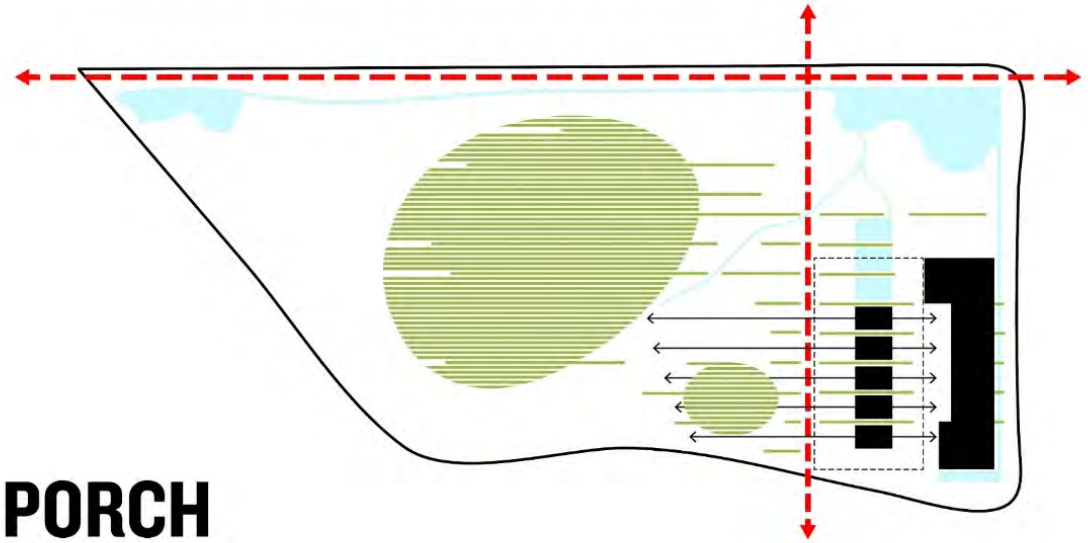




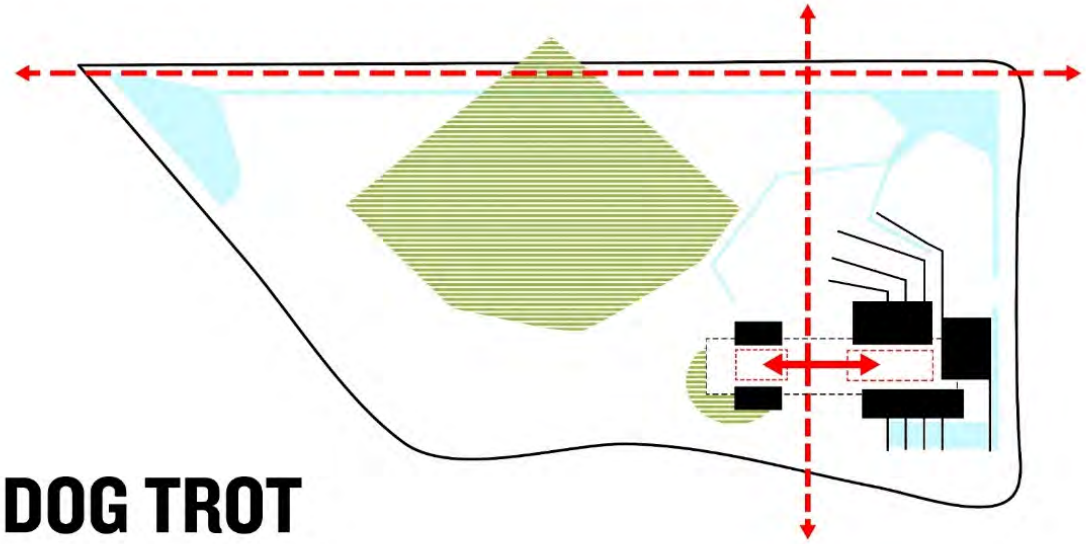

HEATING/COOLING
+ high performance glass
+ high performance walls & low infiltration
+ 65% effective heat recovery
+ ground source heat pumps
+ demand controlled ventilation ventilative cooling
+ radiant slab cooling
+ operable windows
+ operable blinds
LIGHTING
+ maximize daylighting
+ daylight dimming
- lighting power
TENANT
+ "irresistable" stair to discourage elevator use
- lower heating setpoint
+ raise cooling setpoint
+ daytime office cleaning
+ 80% laptop, 20% desktop
- phantom loads
- low flow water fixtures
PV ROOF & FACADE
230,000 kwh/year
supports 52,000 gsf
(with 10% safety)
TYPICAL BASELINE OFFICE BUILDING
CARRYING CAPACITY
92
42
32
16
+
=
NET ZERO ENERGY

THE KENDEDA CENTER FOR INNOVATIVE SUSTAINABLE DESIGN at GEORGIA TECH

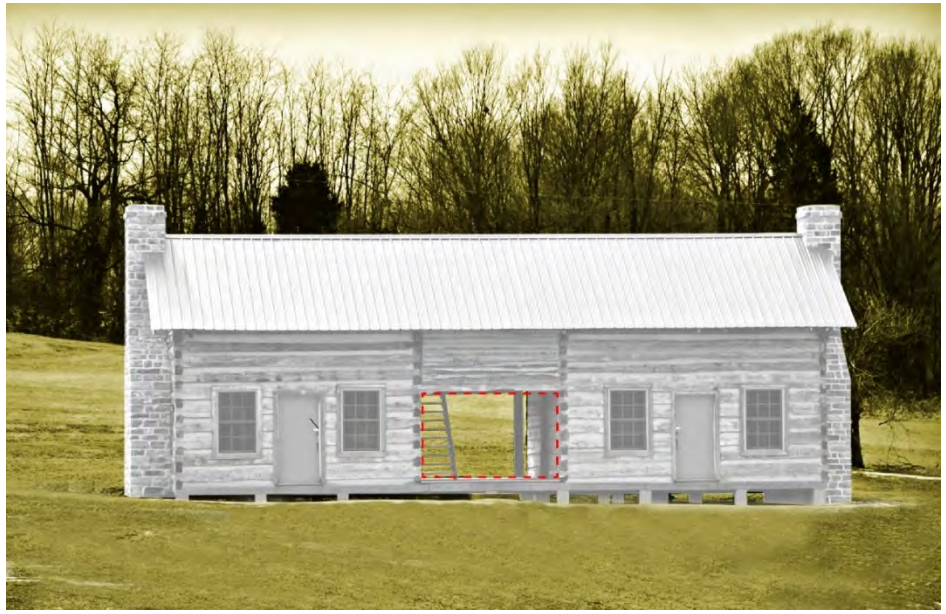
Miller Hull in collaboration with Lord Aeck Sargent



PORCH

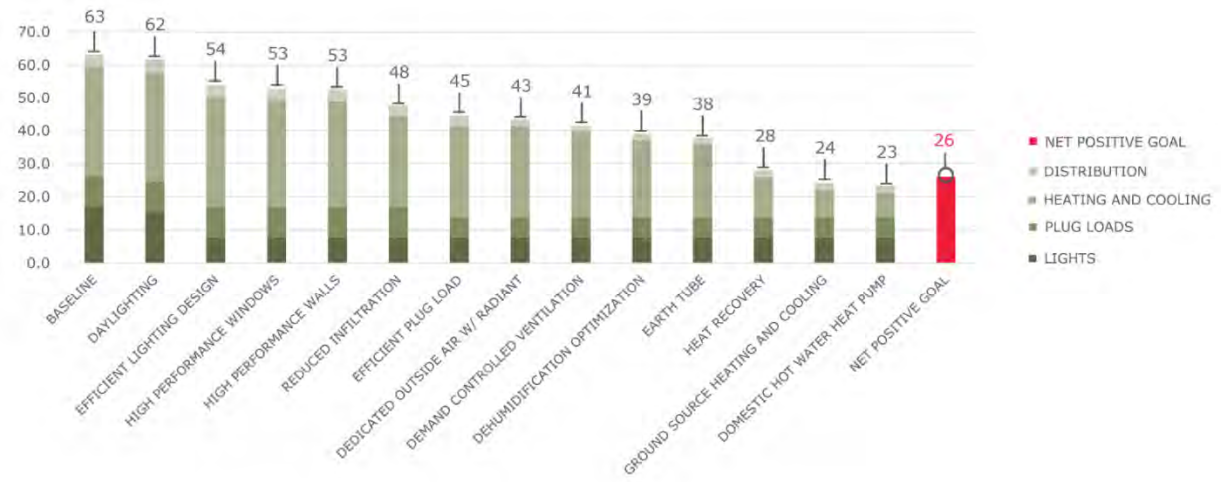


DOG TROT

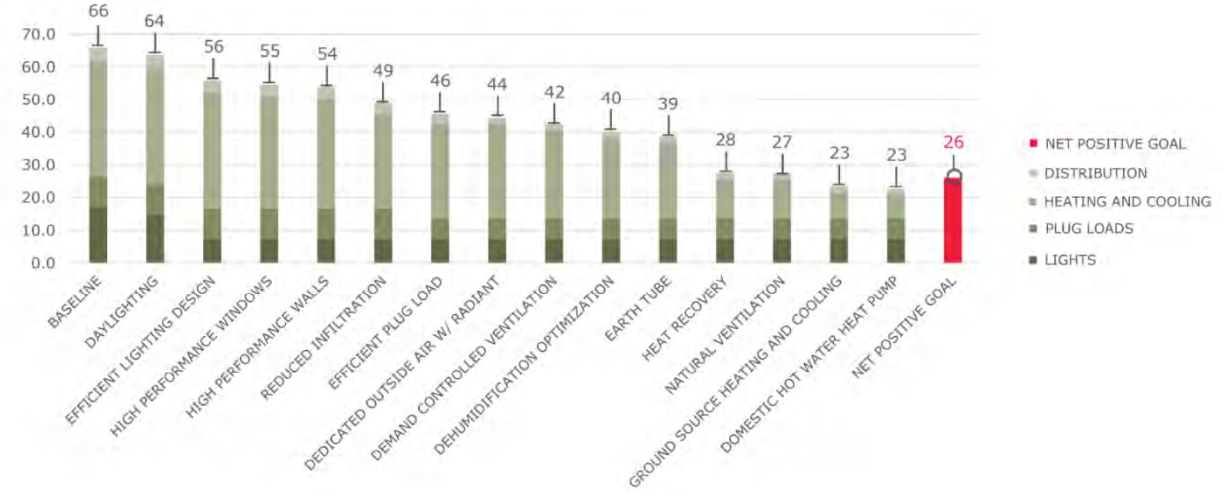



SITE PLAN
LEGEND
1 Constructed Wetland
2 Trickle Filter
3 Overlook
4 Terraces
5 Service Entrance
6 Biofiltration
7 Vegetated Swales
8 Urban Agriculture (+/- 20,000SF)

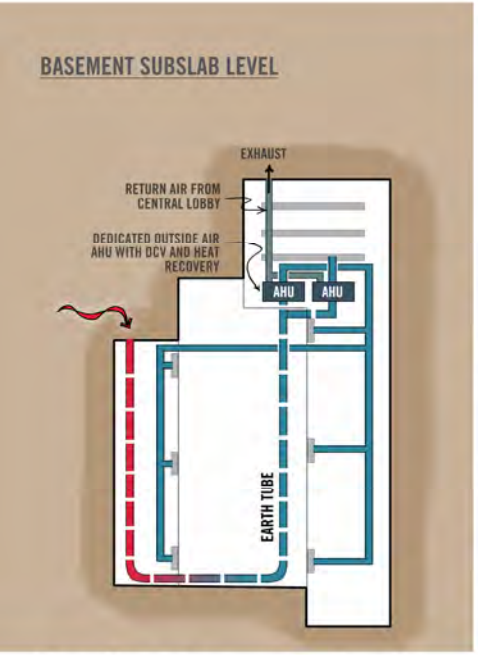

SITE PLAN
LEGEND
1 Constructed Wetland
2 Trickle Filter
3 Overlook + Community Gathering Garden
w/ Urban Agriculture Throughout
4 Terraces
5 Service Entrance
6 Infiltration Gallery
7 Biofiltration
8 Urban Agriculture (+/- 20,000SF)

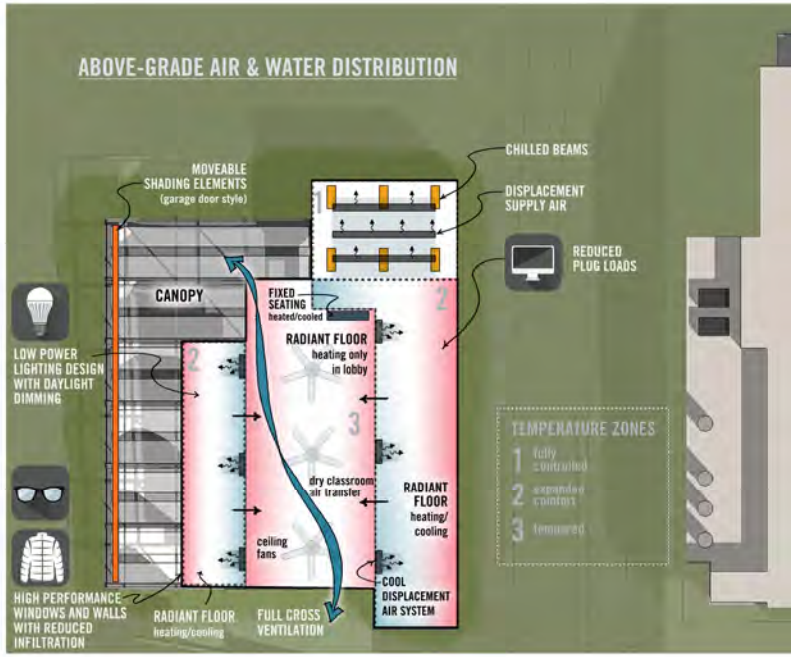


Energy Consumption: Porch - Georgia Tech

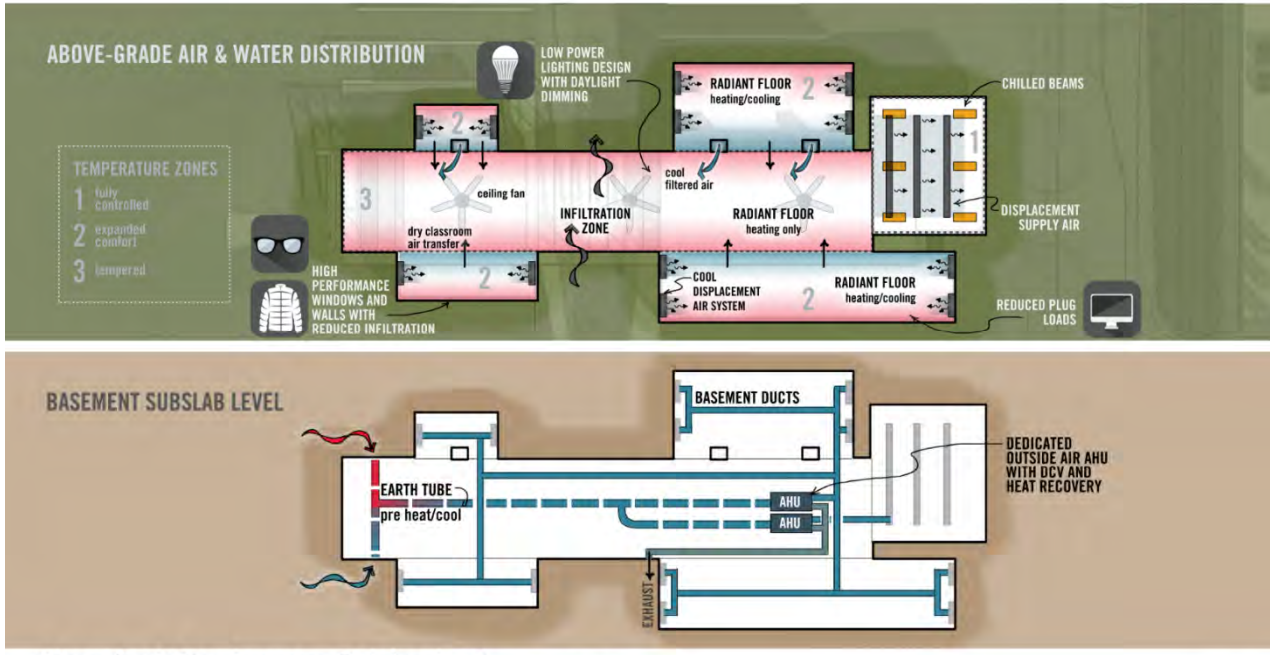


Energy Consumption: Bridgetrot - Georgia Tech

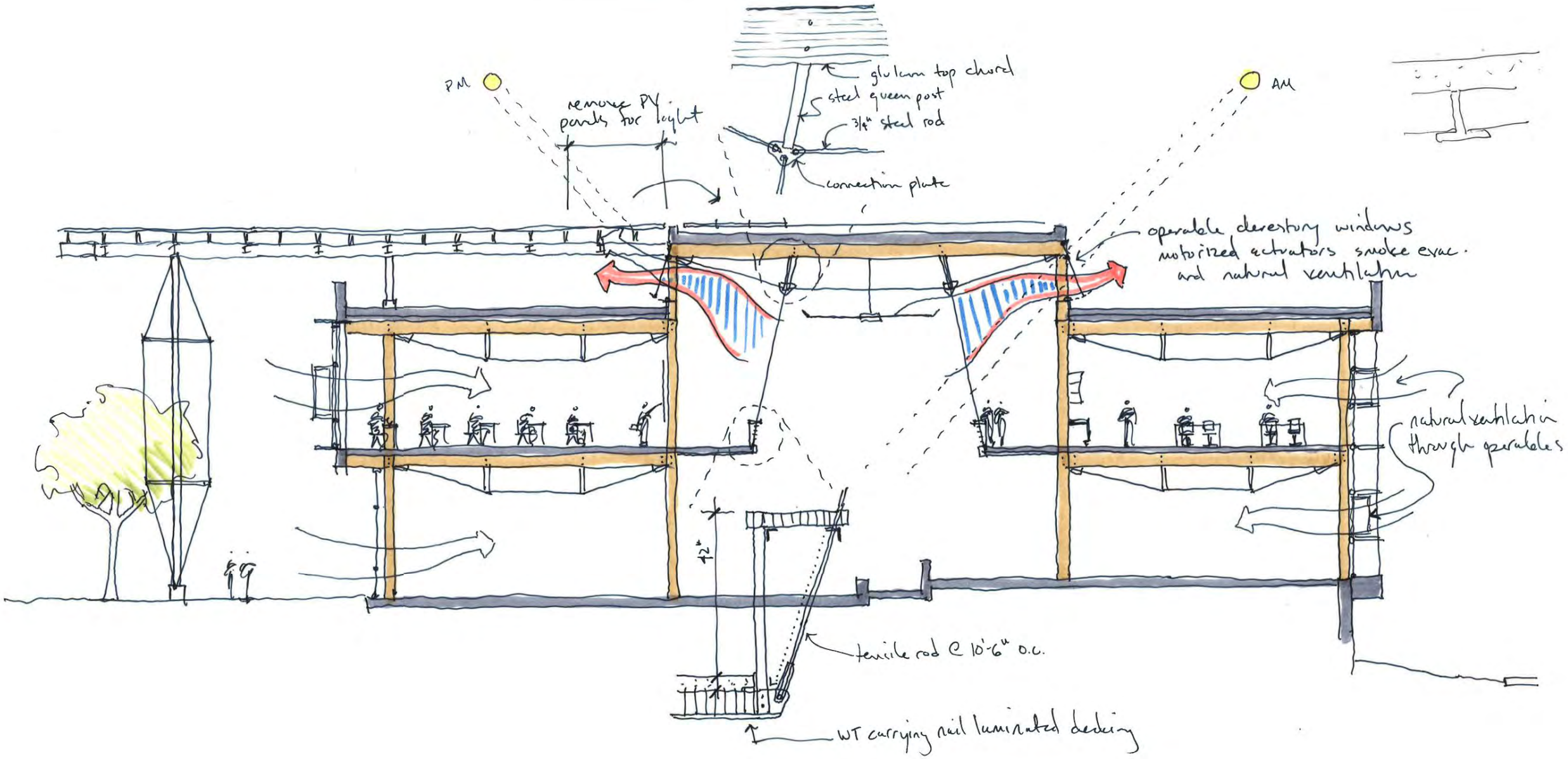




Comfort Systems: Porch - Georgia Tech

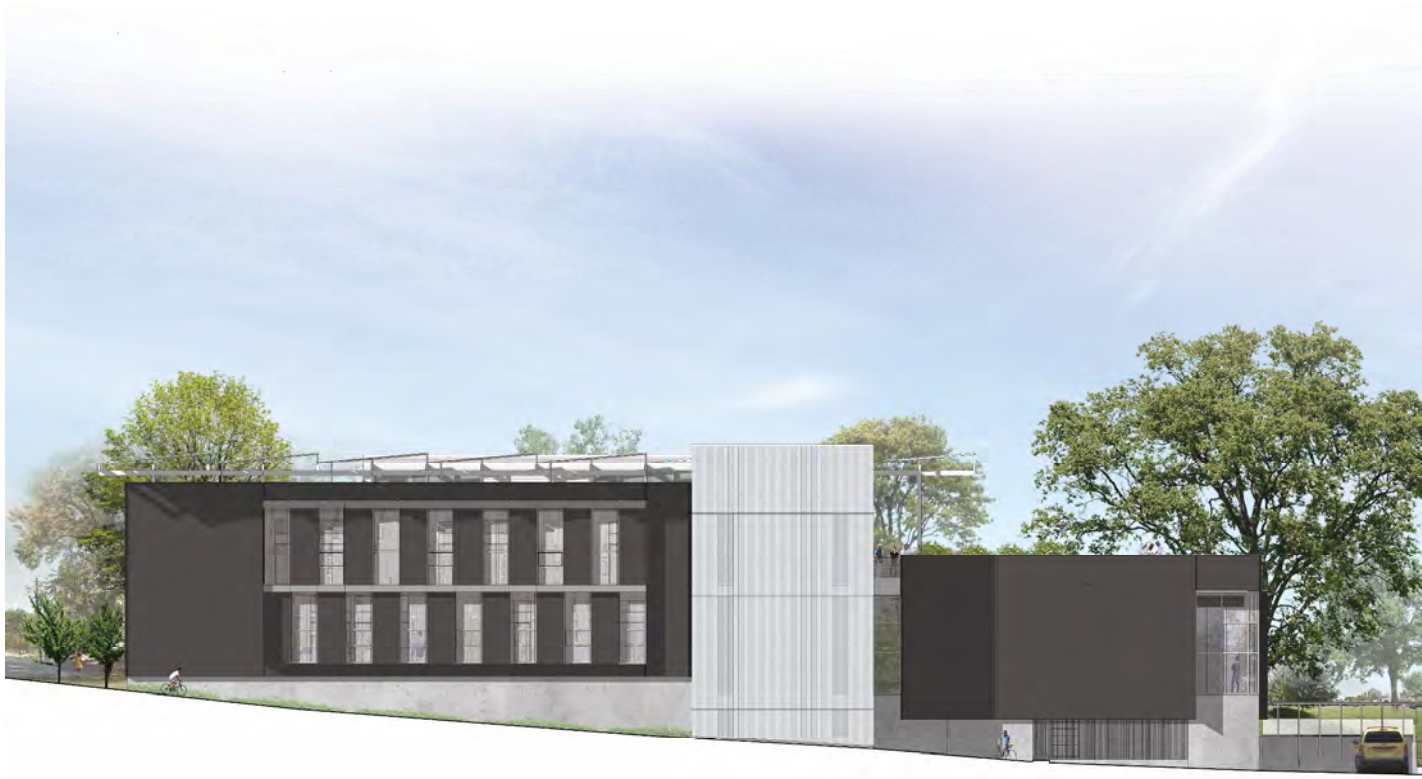


Comfort Systems: Bridgetrot - Georgia Tech

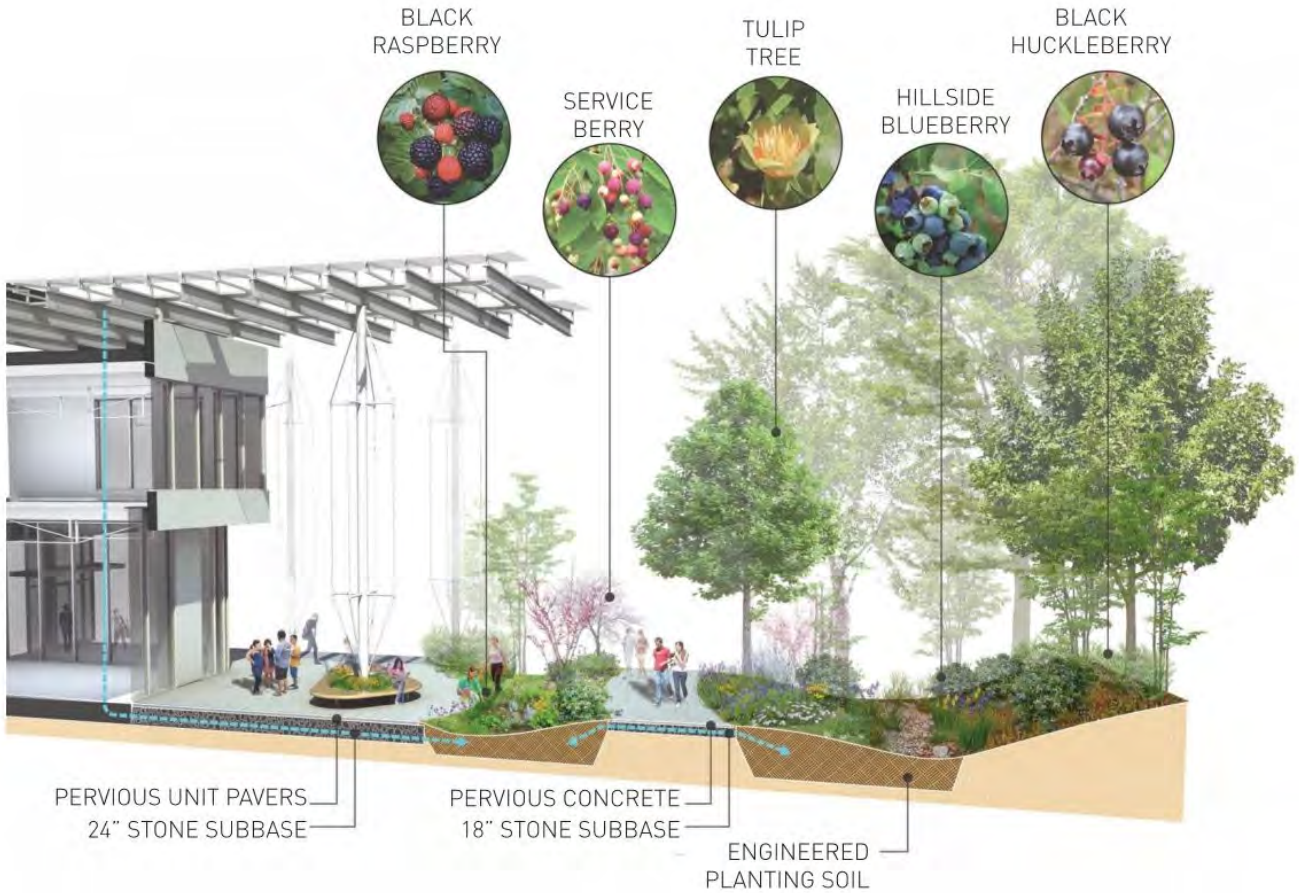

PM
remove PV panels for light
glulam top chord
steel queen post
3/4" steel rod
connection plate
AM
operable clerestory windows motorized actuators smoke evac. and natural ventilation
natural ventilation through operables
tensile rod @ 10'-6" o.c.
WT carrying rail luminated decking

STRUCTURE

THE KENDEDA CENTER FOR INTEGRATED SUSTAINABLE DESIGN

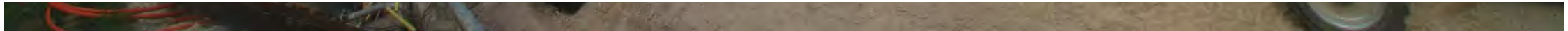



210G
DENNIS TAYLOR

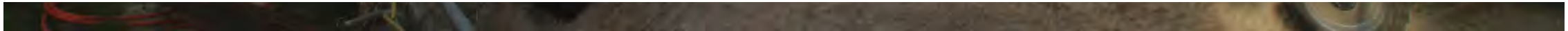

BLACK RASPBERRY
SERVICE BERRY
TULIP TREE
HILLSIDE BLUEBERRY
BLACK HUCKLEBERRY
PERVIOUS UNIT PAVERS
24" STONE SUBBASE
PERVIOUS CONCRETE
18" STONE SUBBASE
ENGINEERED PLANTING SOIL

4pm July 6

5pm July 6

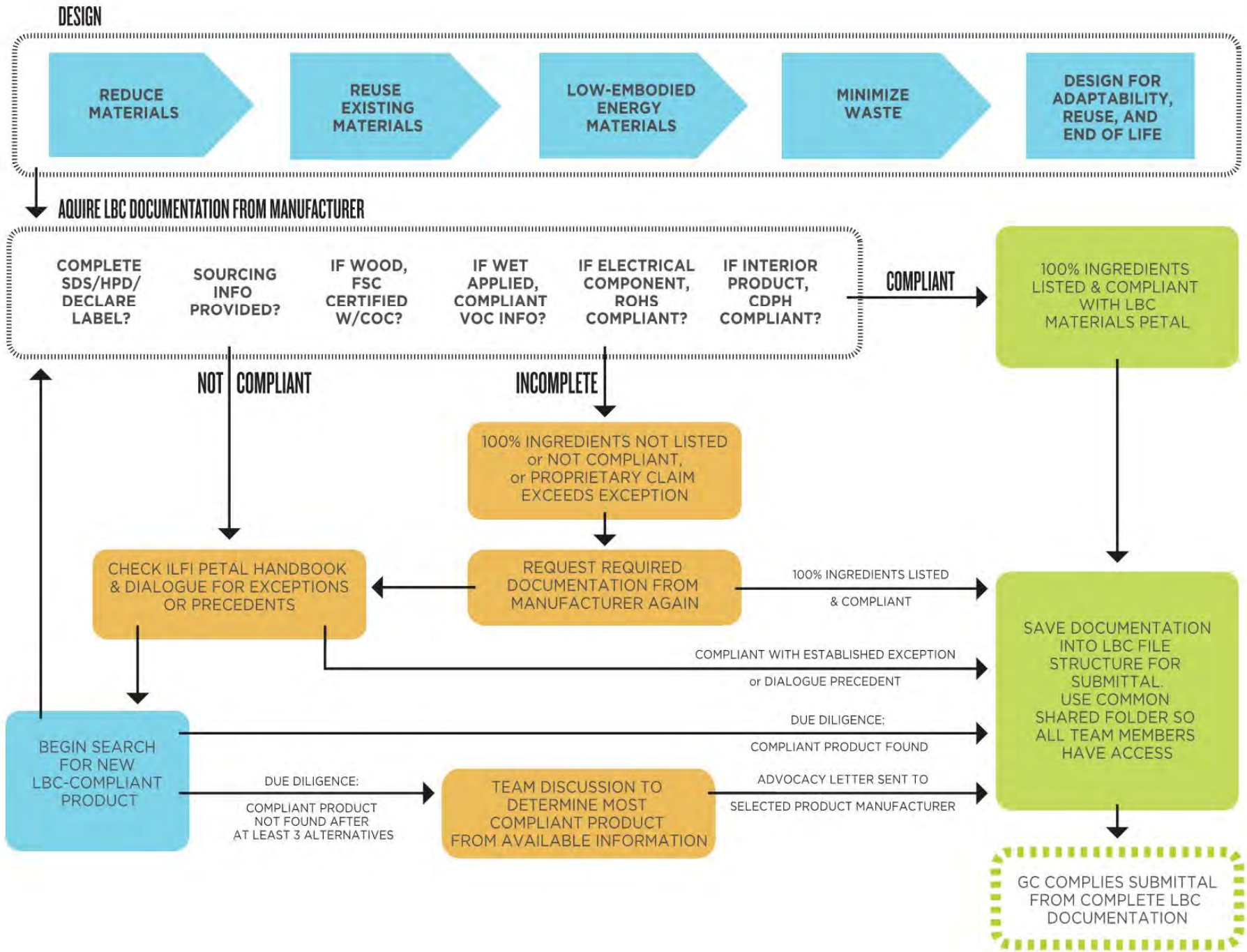


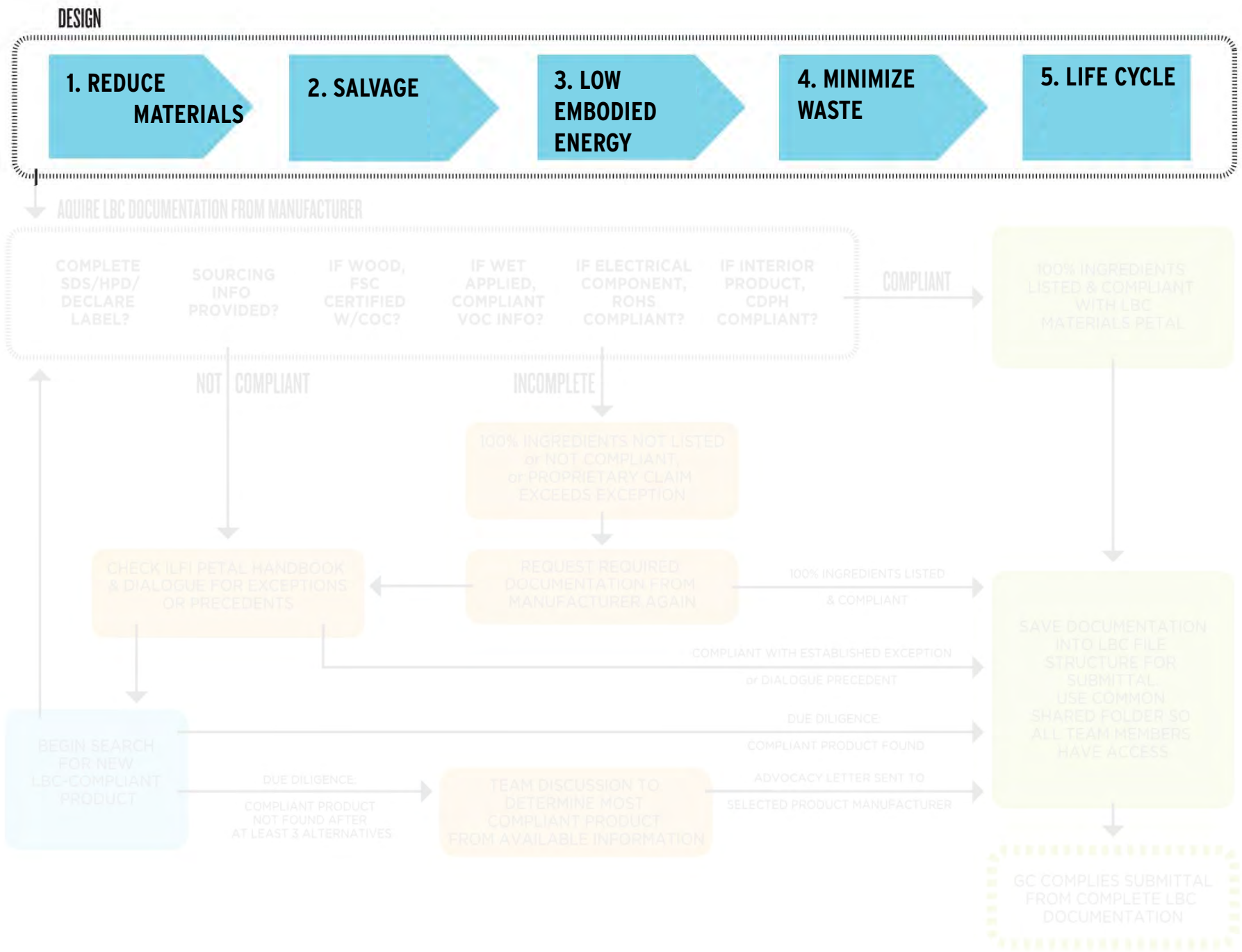
6pm July 6



7pm July 6

8pm July 6


DESIGN
REDUCE MATERIALS
REUSE EXISTING MATERIALS
LOW-EMBODIED ENERGY MATERIALS
MINIMIZE WASTE
DESIGN FOR ADAPTABILITY, REUSE, AND END OF LIFE
AQUIRE LBC DOCUMENTATION FROM MANUFACTURER
COMPLETE SDS/HPD/ DECLARE LABEL?
SOURCING INFO PROVIDED?
IF WOOD, FSC CERTIFIED W/COC?
IF WET APPLIED, COMPLIANT VOC INFO?
IF ELECTRICAL COMPONENT, ROHS COMPLIANT?
IF INTERIOR PRODUCT, CDPH COMPLIANT?
COMPLIANT
100% INGREDIENTS LISTED & COMPLIANT WITH LBC MATERIALS PETAL
NOT COMPLIANT
INCOMPLETE
100% INGREDIENTS NOT LISTED or NOT COMPLIANT, or PROPRIETARY CLAIM EXCEEDS EXCEPTION
CHECK ILFI PETAL HANDBOOK & DIALOGUE FOR EXCEPTIONS OR PRECEDENTS
REQUEST REQUIRED DOCUMENTATION FROM MANUFACTURER AGAIN
100% INGREDIENTS LISTED & COMPLIANT
COMPLIANT WITH ESTABLISHED EXCEPTION or DIALOGUE PRECEDENT
DUE DILIGENCE: COMPLIANT PRODUCT FOUND
SAVE DOCUMENTATION INTO LBC FILE STRUCTURE FOR SUBMITTAL. USE COMMON SHARED FOLDER SO ALL TEAM MEMBERS HAVE ACCESS
BEGIN SEARCH FOR NEW LBC-COMPLIANT PRODUCT
DUE DILIGENCE: COMPLIANT PRODUCT NOT FOUND AFTER AT LEAST 3 ALTERNATIVES
TEAM DISCUSSION TO DETERMINE MOST COMPLIANT PRODUCT FROM AVAILABLE INFORMATION
ADVOCACY LETTER SENT TO SELECTED PRODUCT MANUFACTURER
GC COMPLIES SUBMITTAL FROM COMPLETE LBC DOCUMENTATION


DESIGN
1. REDUCE MATERIALS
2. SALVAGE
3. LOW EMBODIED ENERGY
4. MINIMIZE WASTE
5. LIFE CYCLE
AQUIRE LBC DOCUMENTATION FROM MANUFACTURER
COMPLETE SDS/HPD/ DECLARE LABEL?
SOURCING INFO PROVIDED?
IF WOOD, FSC CERTIFIED W/COC?
IF WET APPLIED, COMPLIANT VOC INFO?
IF ELECTRICAL COMPONENT, ROHS COMPLIANT?
IF INTERIOR PRODUCT, CDPH COMPLIANT?
COMPLIANT
100% INGREDIENTS LISTED & COMPLIANT WITH LBC MATERIALS PETAL
NOT COMPLIANT
INCOMPLETE
100% INGREDIENTS NOT LISTED or NOT COMPLIANT, or PROPRIETARY CLAIM EXCEEDS EXCEPTION
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100% INGREDIENTS LISTED & COMPLIANT
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DUE DILIGENCE: COMPLIANT PRODUCT FOUND
BEGIN SEARCH FOR NEW LBC-COMPLIANT PRODUCT
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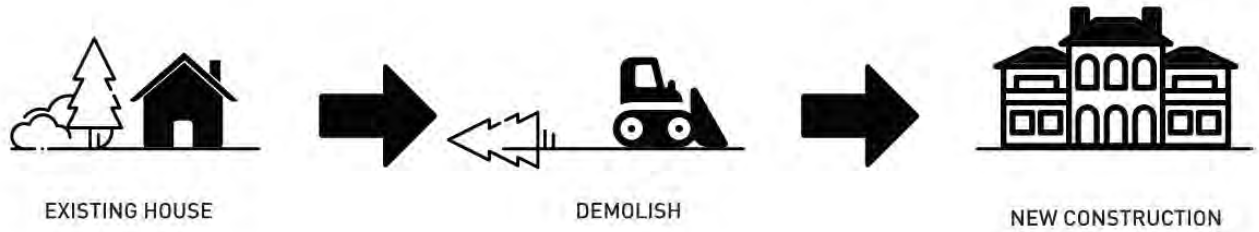
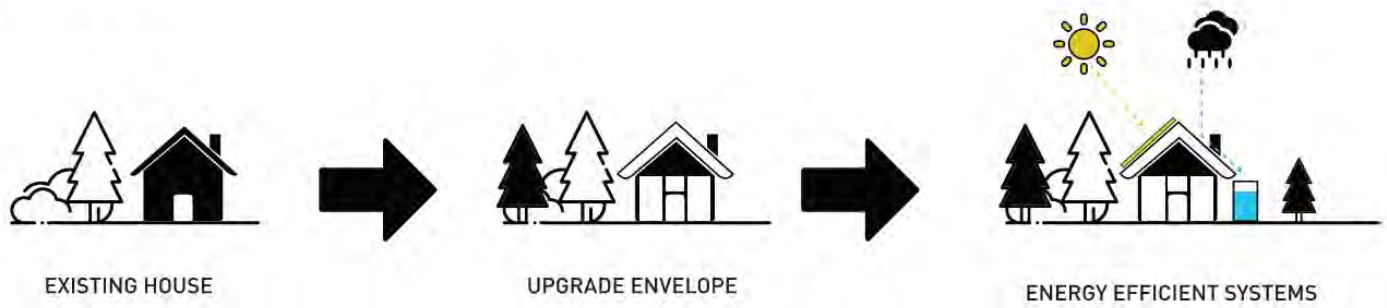
TEAM DISCUSSION TO DETERMINE MOST COMPLIANT PRODUCT FROM AVAILABLE INFORMATION
ADVOCACY LETTER SENT TO SELECTED PRODUCT MANUFACTURER
GC COMPLIES SUBMITTAL FROM COMPLETE LBC DOCUMENTATION

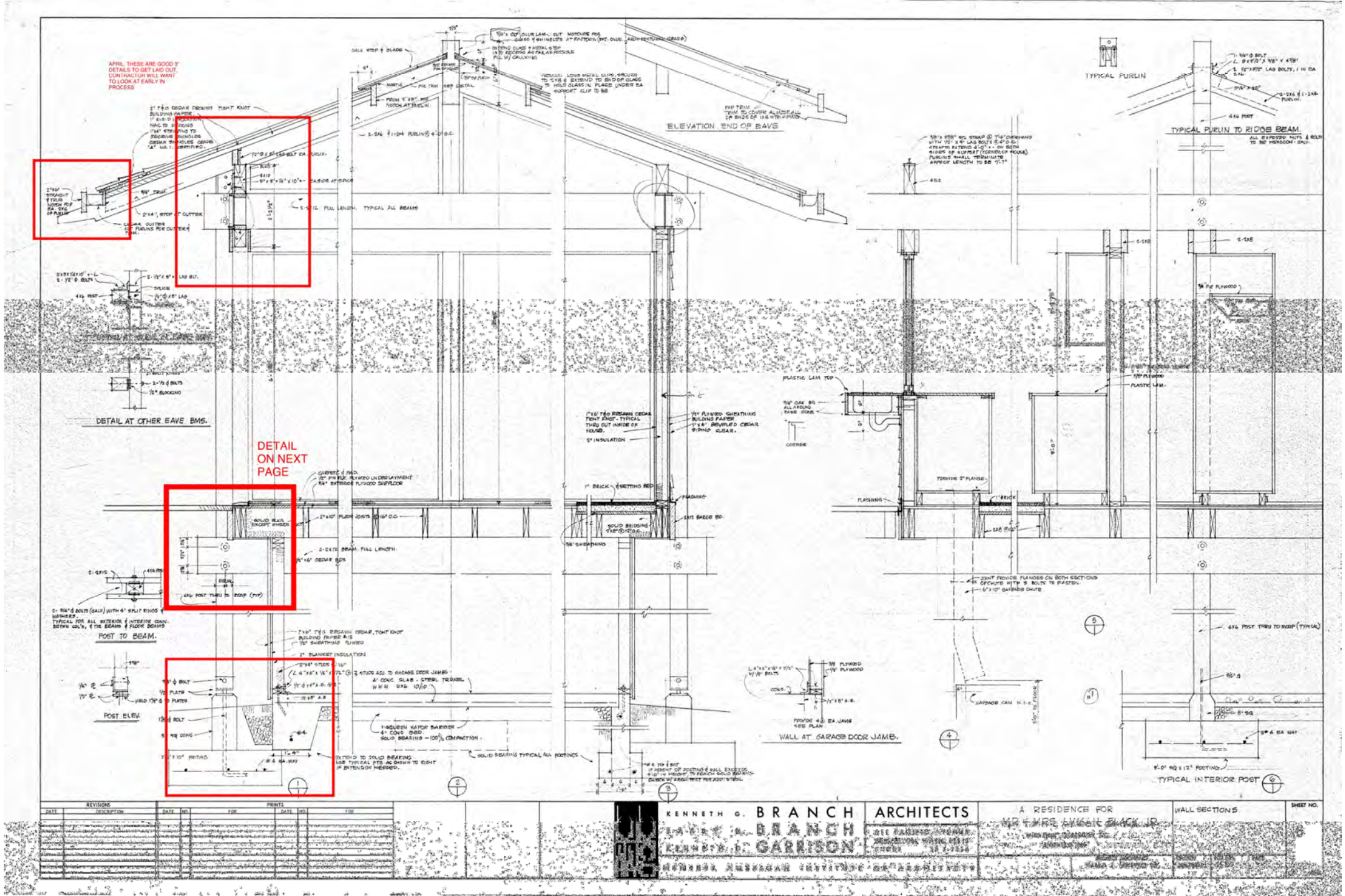
LOOM HOUSE

TYPICAL RESIDENTIAL MODEL:



LOOM HOUSE:




APRIL, THESE ARE GOOD 3' DETAILS TO GET LAID OUT, CONTRACTOR WILL WANT TO LOOK AT EARLY IN PROCESS
ELEVATION END OF EAVE
TYPICAL PURLIN
TYPICAL PURLIN TO RIDGE BEAM.
DETAIL AT OTHER EAVE BMS.
DETAIL ON NEXT PAGE
POST TO BEAM.
POST ELEV.
WALL AT GARAGE DOOR JAMB.
TYPICAL INTERIOR POST
REVISIONS
PRINTS
KENNETH G. BRANCH
ARCHITECTS
A RESIDENCE FOR
WALL SECTIONS
SHEET NO.
6

PV ARRAY

(42) PV MODULES 365W
(42) PV OPTIMIZER
(2) INVERTERS
(2) 9.8 kWh BATTERIES
17,537 kWh/yr

ROOF ASSEMBLY (R-47)

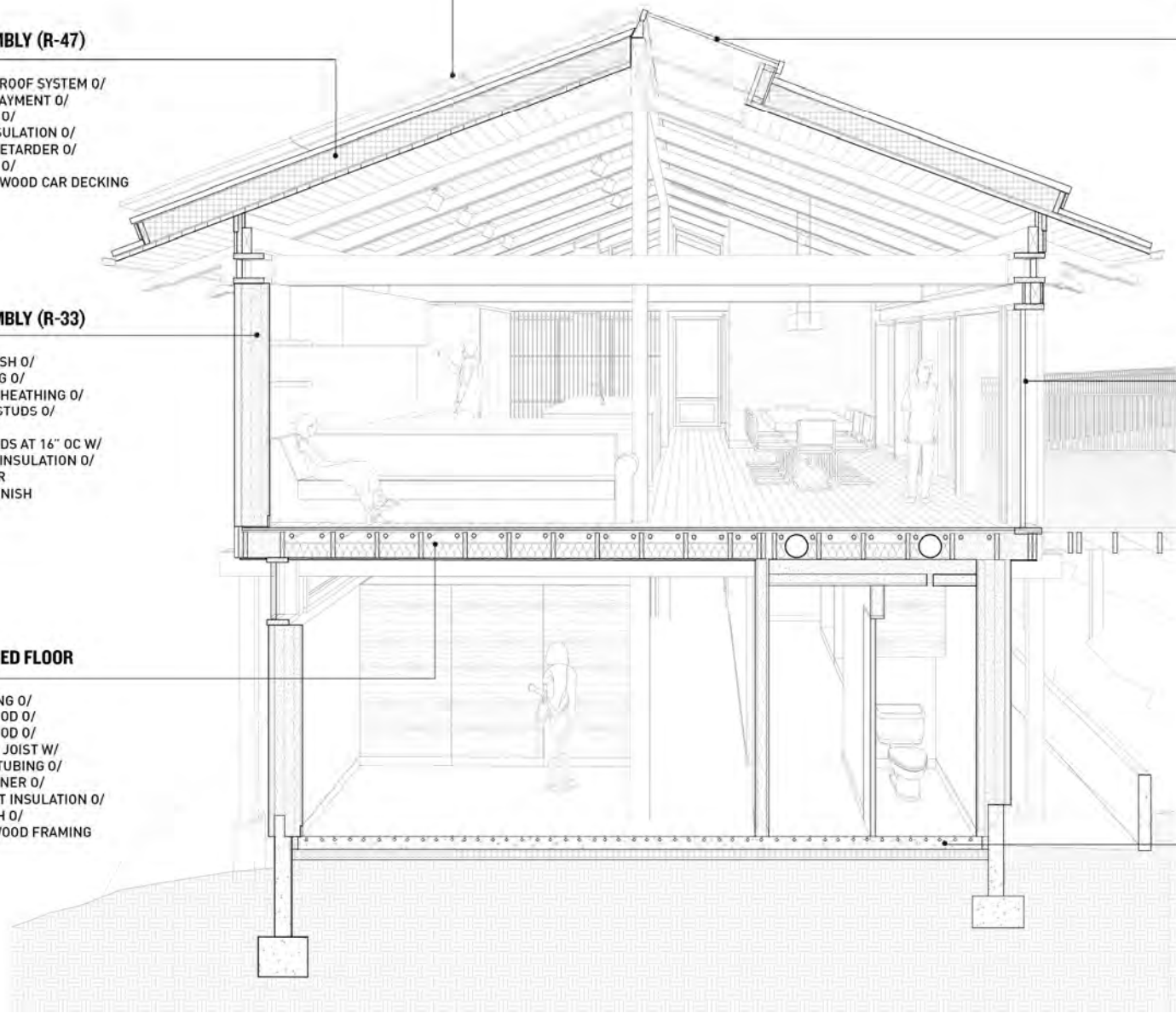
METAL PANEL ROOF SYSTEM O/
ROOF UNDERLAYMENT O/
1/2" PLYWOOD O/
8" POLYISO INSULATION O/
ROOF VAPOR RETARDER O/
1/2" PLYWOOD O/
EXISTING T&G WOOD CAR DECKING

WALL ASSEMBLY (R-33)

EXTERIOR FINISH O/
WOOD FURRING O/
(E) PLYWOOD SHEATHING O/
(E) 2X4 WOOD STUDS O/
3.5" CAVITY O/
2X3 WOOD STUDS AT 16" OC W/
9.5 BLOWN-IN INSULATION O/
VAPOR RARDER
O/ INTERIOR FINISH

WOOD FRAMED FLOOR

WOOD FLOORING O/
(E) 1/2" PLYWOOD O/
(E) 3/4" PLYWOOD O/
(E) 2X10 WOOD JOIST W/
RADIANT PEX TUBING O/
REFLECTIVE LINER O/
ACOUSTIC BATT INSULATION O/
CEILING FINISH O/
(E) EXPOSED WOOD FRAMING



SLOPED GLAZING W/ OPERABLES

TRIPLE GLAZED
U-0.27
SHGC-0.21

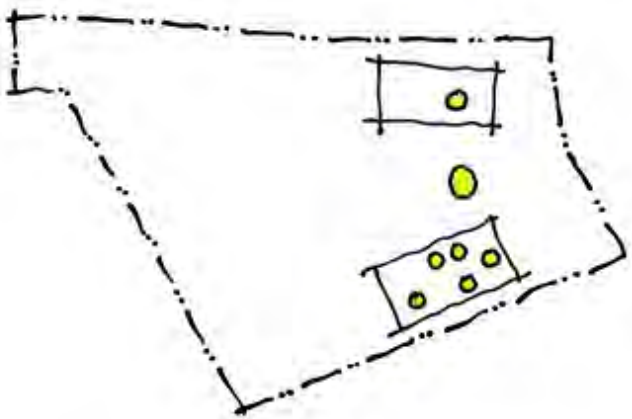
ALUMINUM CLAD CURTAIN WALL

TRIPLE GLAZED
U-0.16
SHGC-0.42

NEW CONCRETE SLAB ON GRADE

POLISHED CONCRETE SLAB-ON-GRADE W/
RADIANT PEX TUBING O/
SLAB VAPOR BARRIER O/
3" XPS RIGID INSULATION O/
CRUSHED ROCK PER STRUCTURAL & GEOTECH


MATURE TREES
GRASS
OFFICE
SPORTS COURT
PUGET SOUND VIEWS
CONFUSING ARRIVAL
DOUBLE ENTRY
PATIO
CHERRY TREE
PROW DECK
STREET
BEACH ACCESS
HIGH WATER USE
ISOLATED ROOMS
DECK
DRIVE
NEIGHBOR



ISOLATED ROOMS

PROSPECT & REFUGE

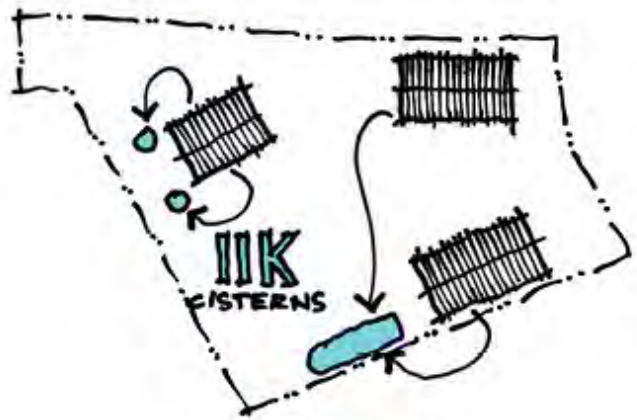
A new indoor/outdoor great room, with an existing central specimen cherry tree, replaces small, cave-like rooms.

GREAT ROOM

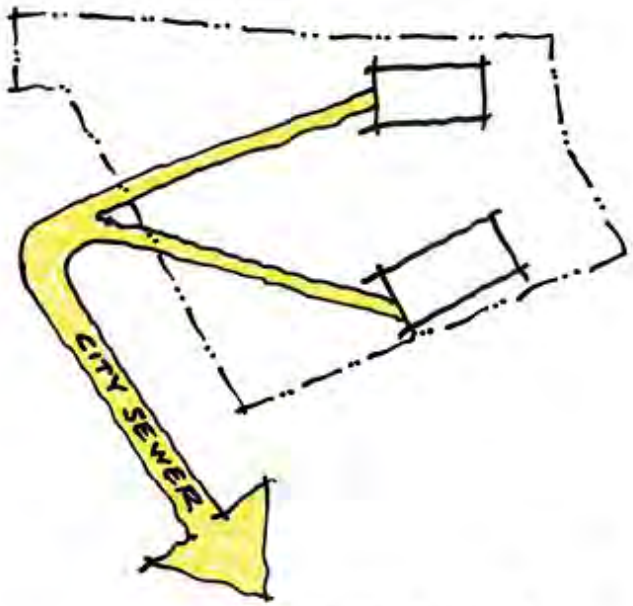
WATER HOG

WATER HARVESTING

Through adaptive water management strategies, all potable water will be harvested and treated on site.



WATER GENERATOR

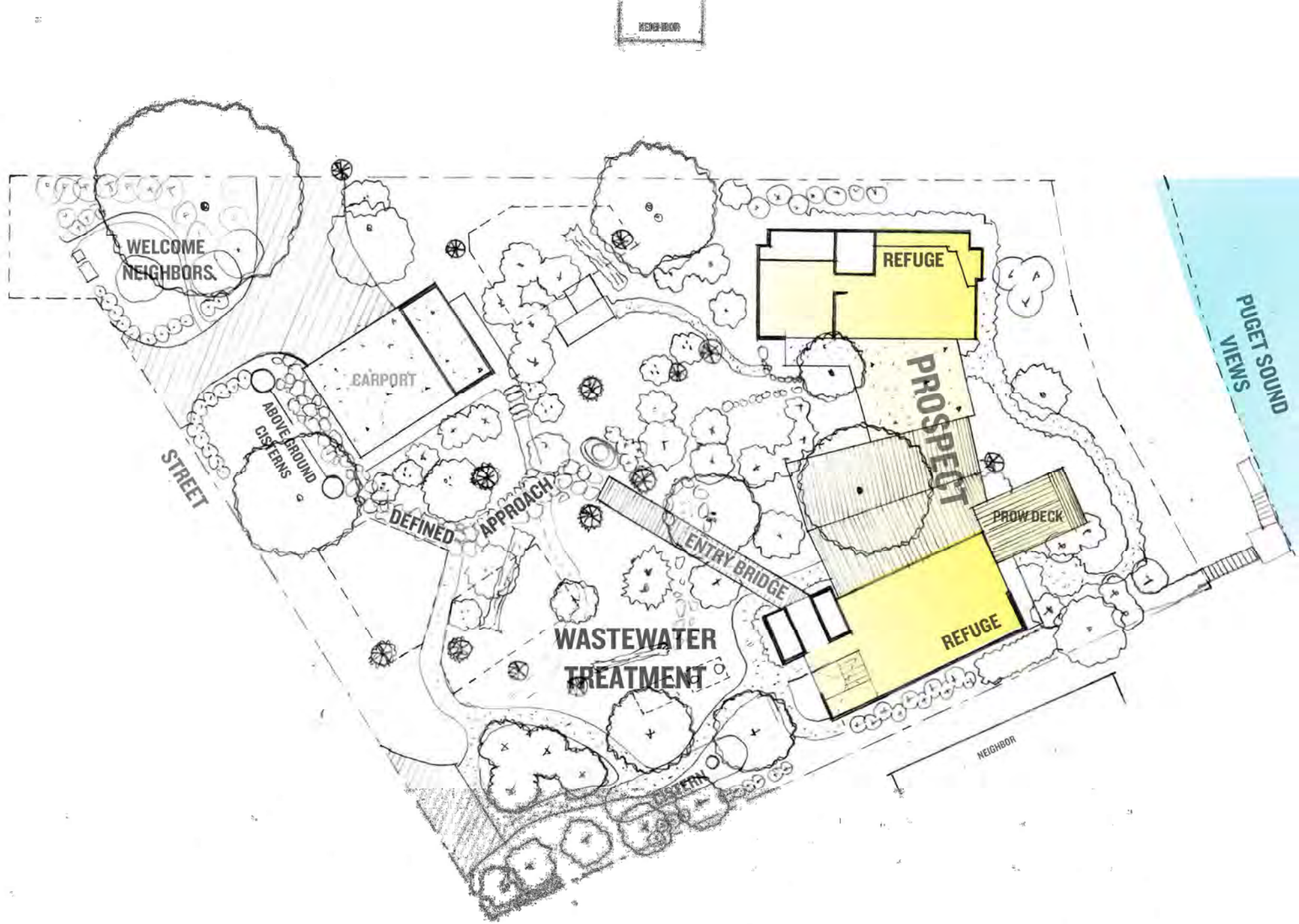


BROKEN CITY SEWER

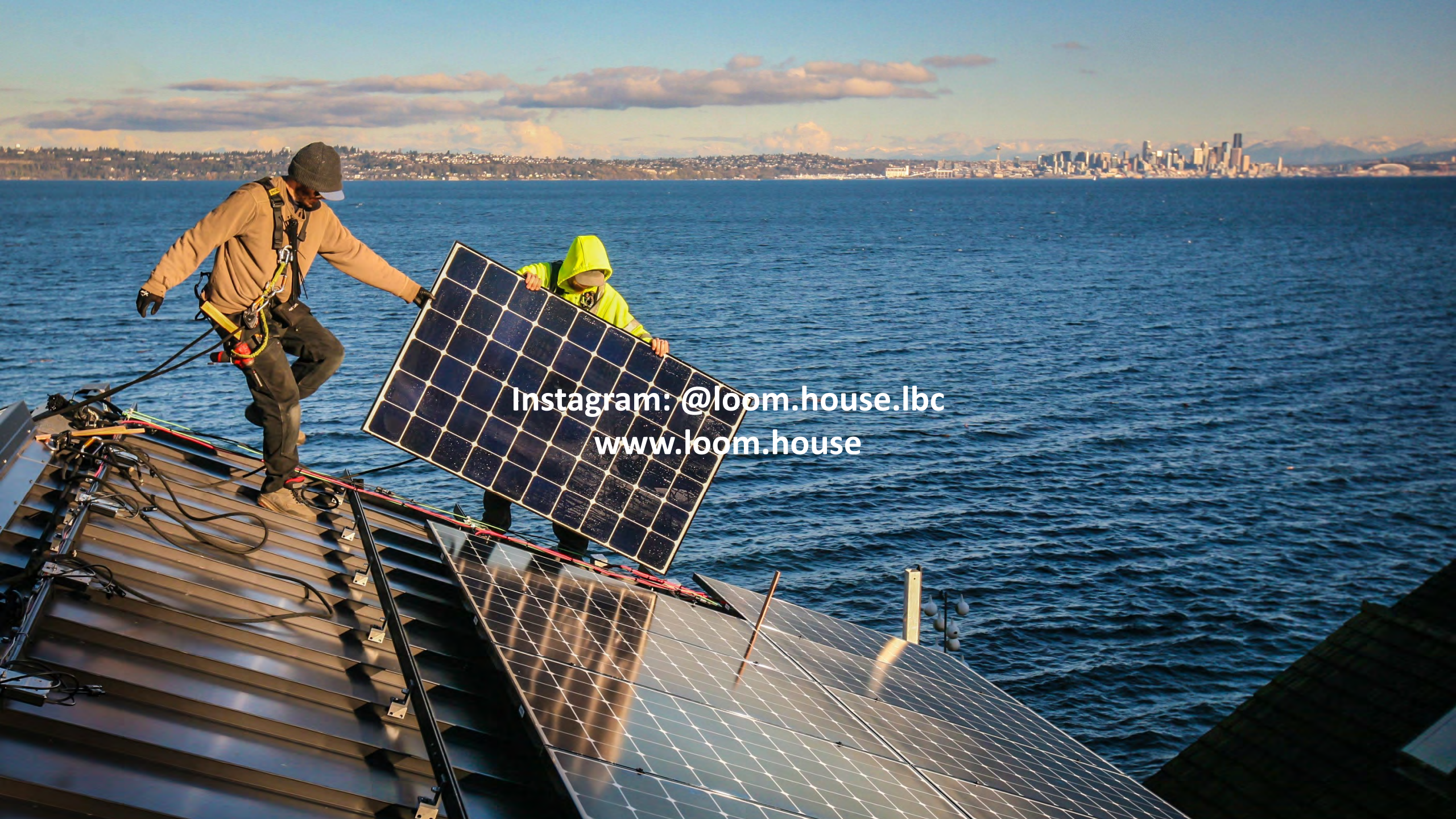
WASTEWATER TREATMENT

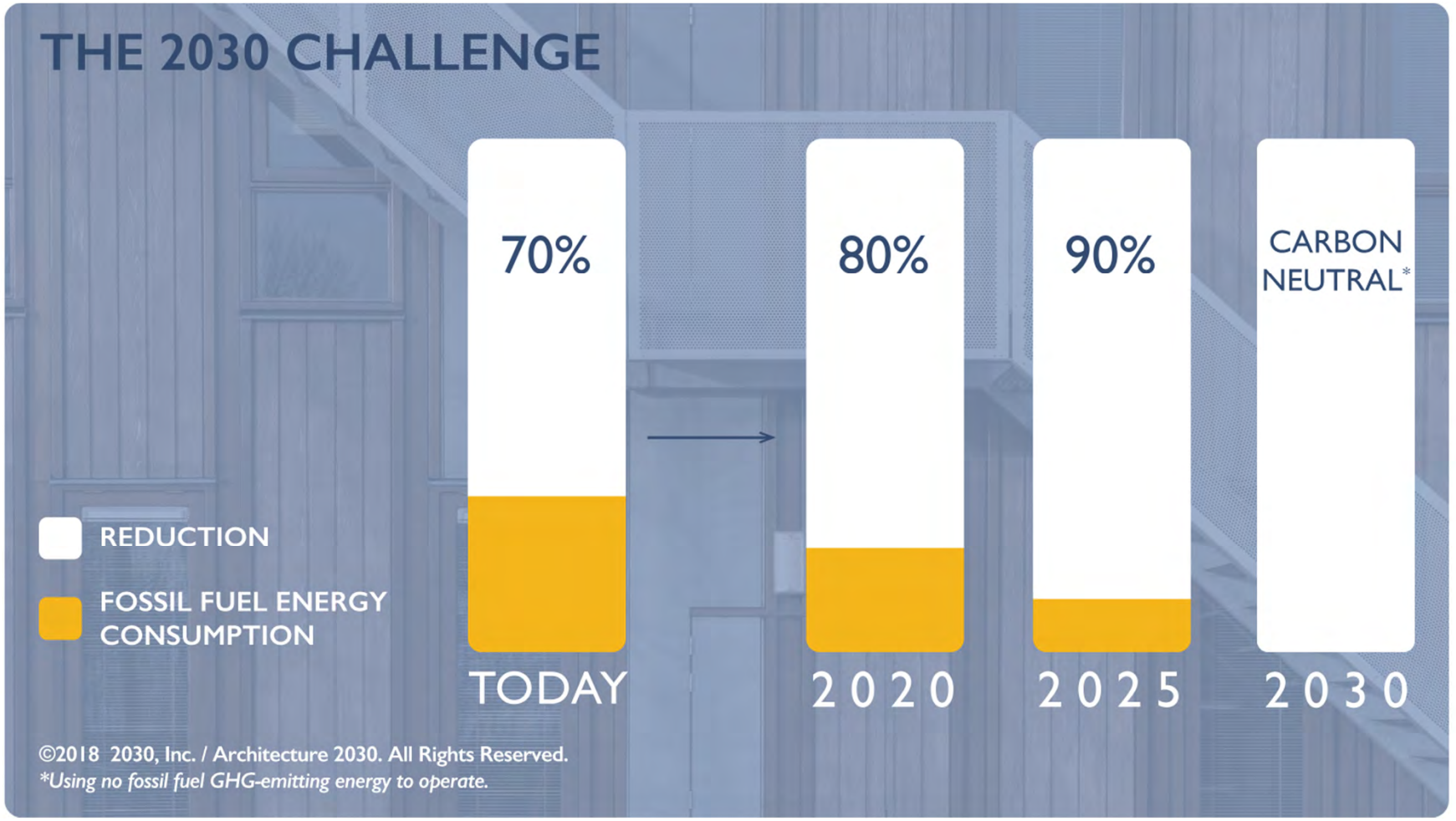
Dated existing city sewer infrastructure means sewage often outflows directly into the Puget Sound.

ON-SITE TREATMENT


WELCOME NEIGHBORS
CARPORT
ABOVE GROUND CISTERNS
STREET
DEFINED APPROACH
ENTRY BRIDGE
WASTEWATER TREATMENT
REFUGE
PROSPECT
PROW DECK
REFUGE
PUGET SOUND VIEWS
NEIGHBOR
CISTERN

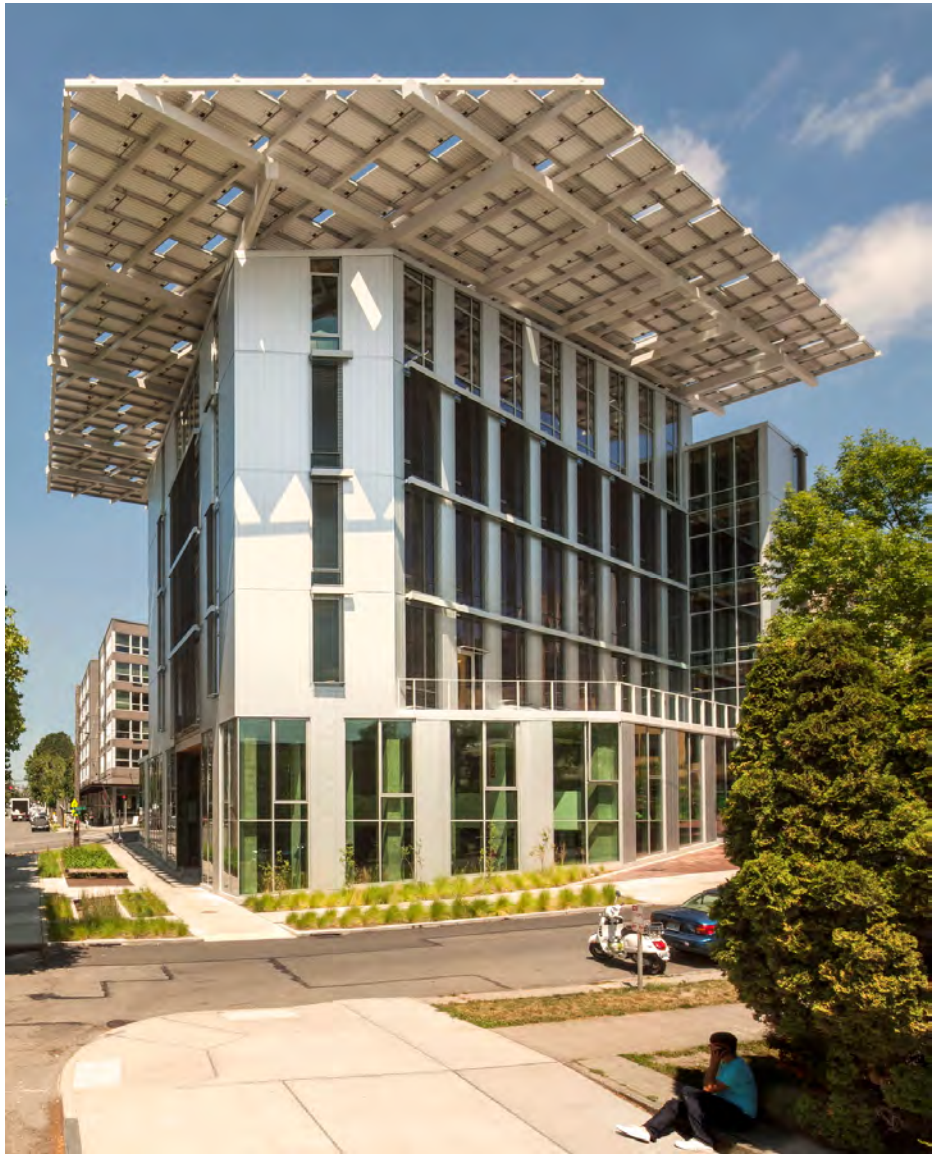

DEWALT


Instagram: @loom.house.lbc
www.loom.house



FACADE PERFORMANCE FOR ZERO CARBON

July 16, 2019



The Bullitt Center

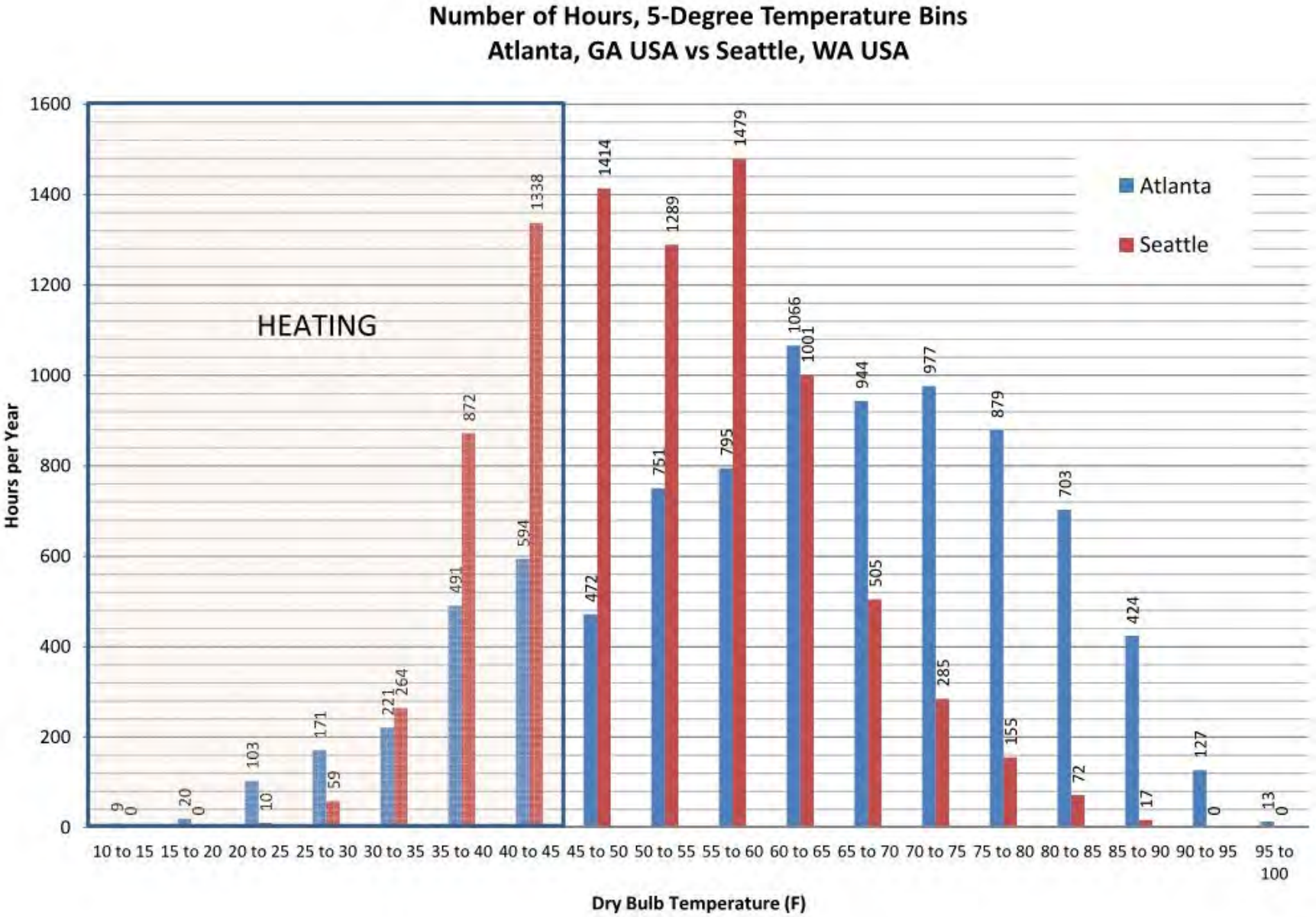
The Kendeda Building (Georgia Tech)

1. make a ***serious*** effort to ***minimize space heating***

2. accommodate the ***mechanical system***
   (keep your engineer happy)

3. make your ***occupants*** happy

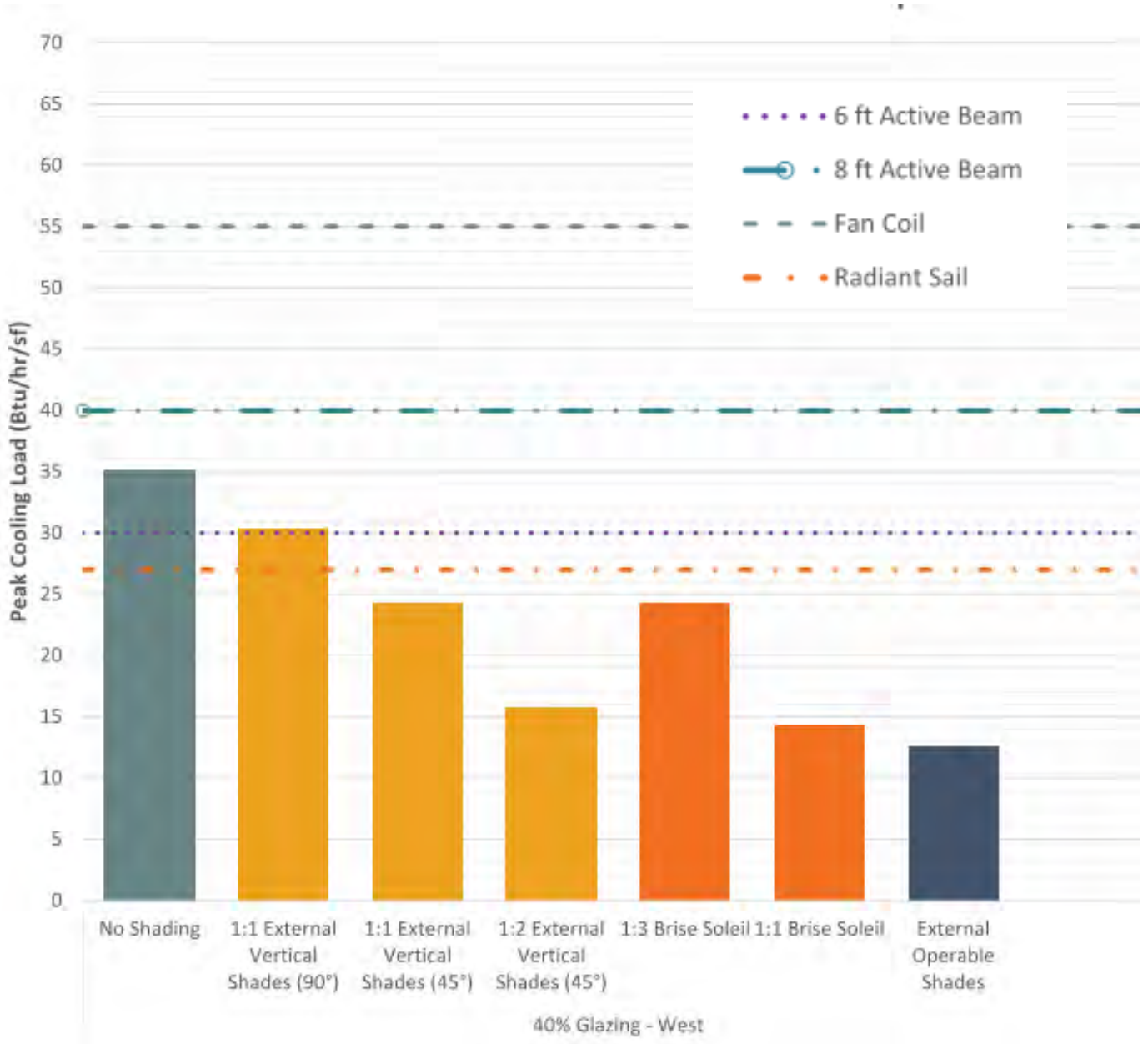
“Rules” for Zero Carbon Facades



Systems and Details

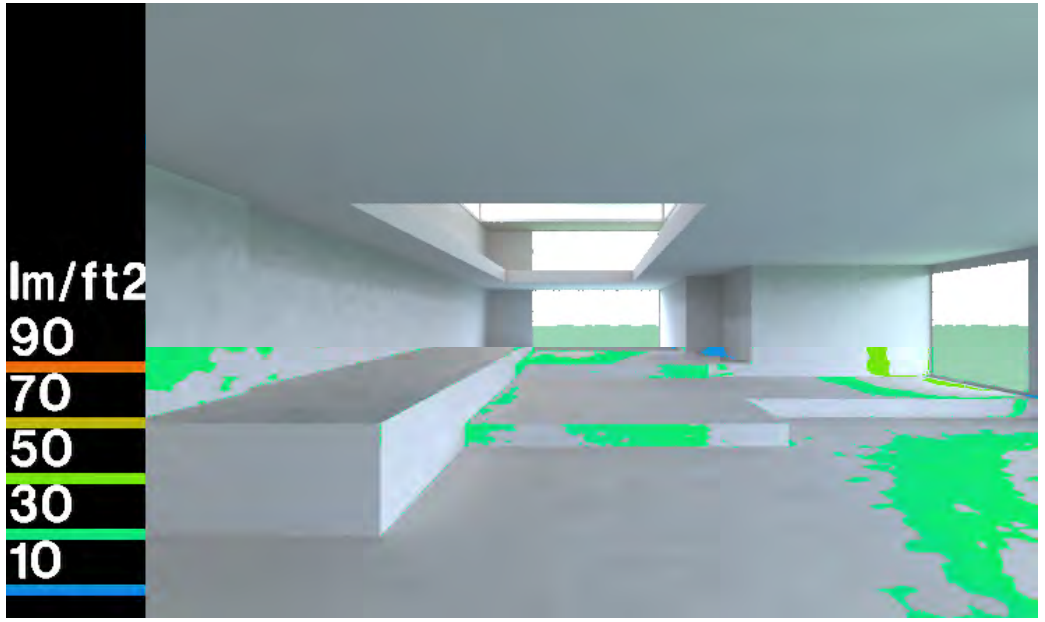
Balance Point Studies

Glazing and Shading

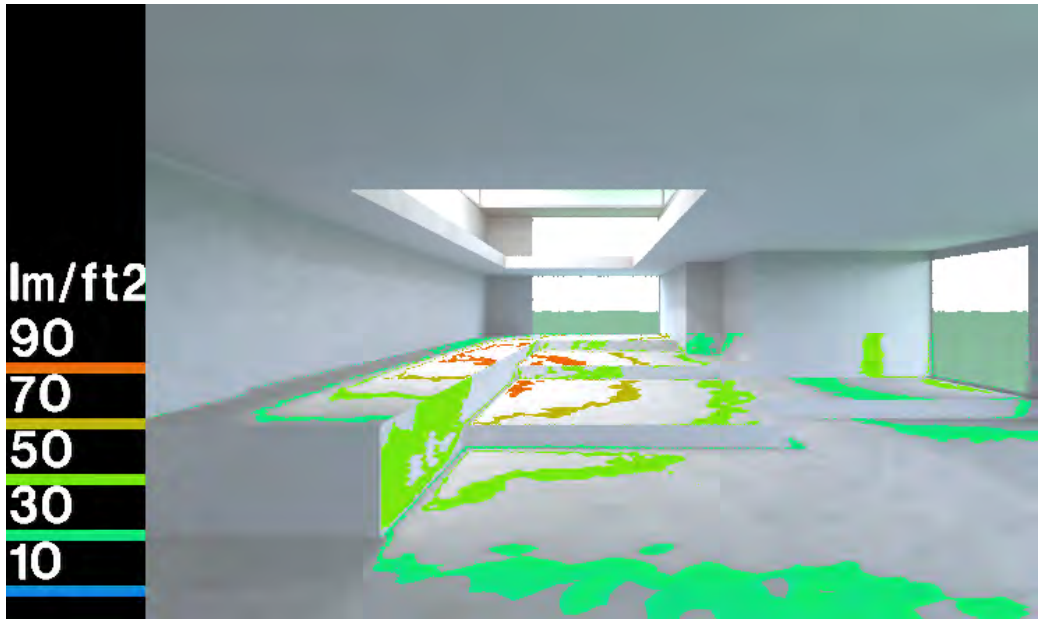


Peak Loads Studies

Biophilia



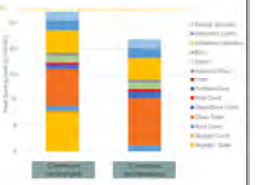
Clerestories,
no skylights



Clerestories
and Skylights

Daylighting Studies (Kendeda Building Atrium)

Façade	Spaces	Space Daylighting performance analysis	Space Solar Gain Performance Analysis
South/ West	Floor 2 classrooms and seminar	Image shows brightness (luminance) of 2nd floor north classroom, no exterior shading condition. Brightness of window plane is balanced by brightness from daylight contribution at atrium wall. Daylight adequacy is good - 23 to 26 fc in center of room. 	Space limit is 20 Btu/hr-SF. Graphic shows loads with no exterior shading except PV overhang. Solar contribution is too high - shading required to bring solar gain within system capacity limit. 

Façade	Spaces	Space Daylighting performance analysis	Space Solar Gain Performance Analysis
South	Atrium	Image shows brightness (luminance) of atrium space using rooftop clerestories, supplemented with unit skylights. Skylights improve illumination from 25fc on floor to ~ 75fc on floor in center of space. 	Space limit is 27 Btu/hr-SF. 20 preferred. With clerestory glazing, space is at 22 Btu/hr-SF with no shading on south-facing glass. 

Floor 2 SW Classroom

Atrium (southern)

1. make a ***serious*** effort to ***minimize space heating***

2. accommodate the ***mechanical system***
   (keep your engineer happy)

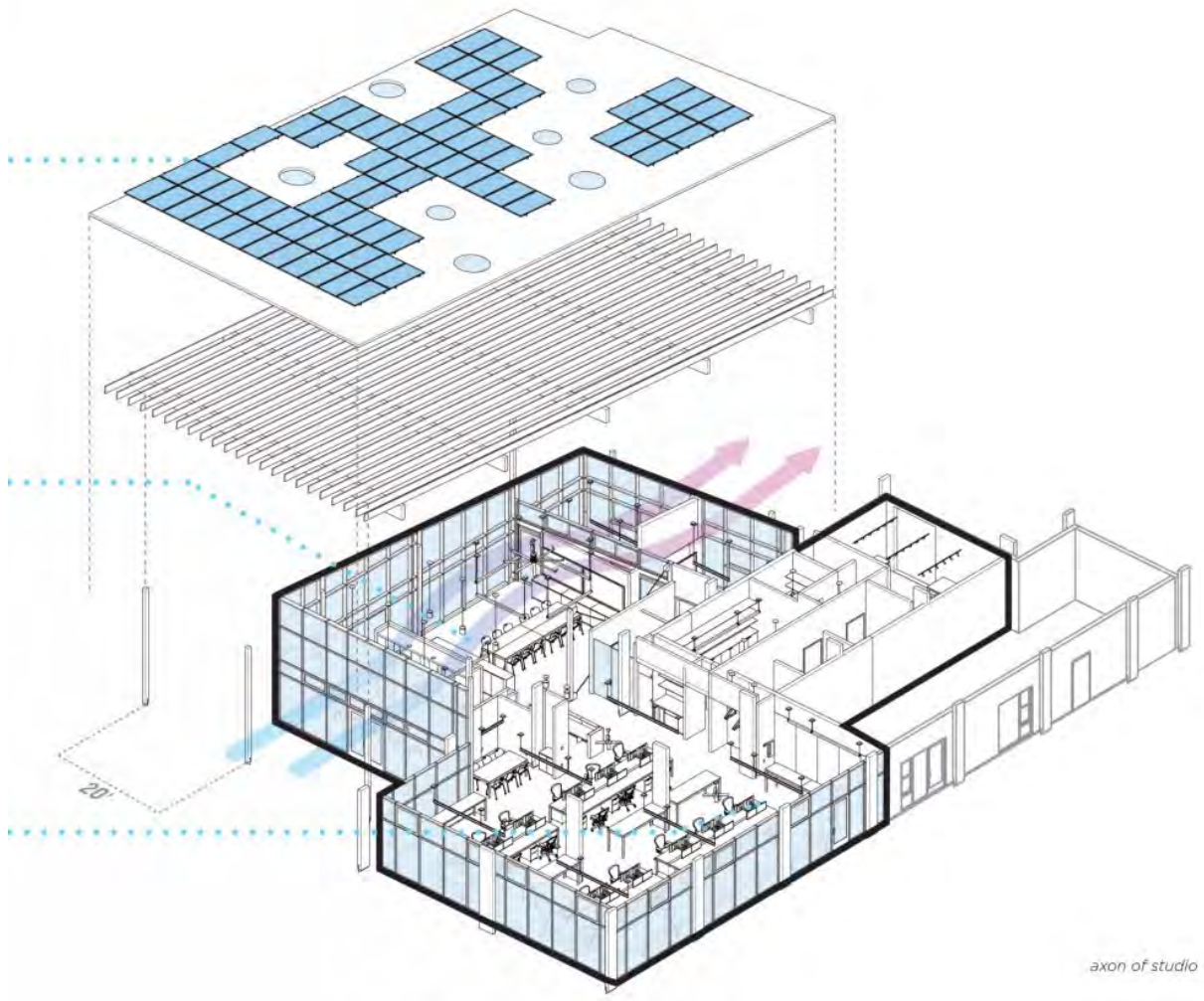
3. make your ***occupants*** happy

“Rules” for Zero Carbon Facades

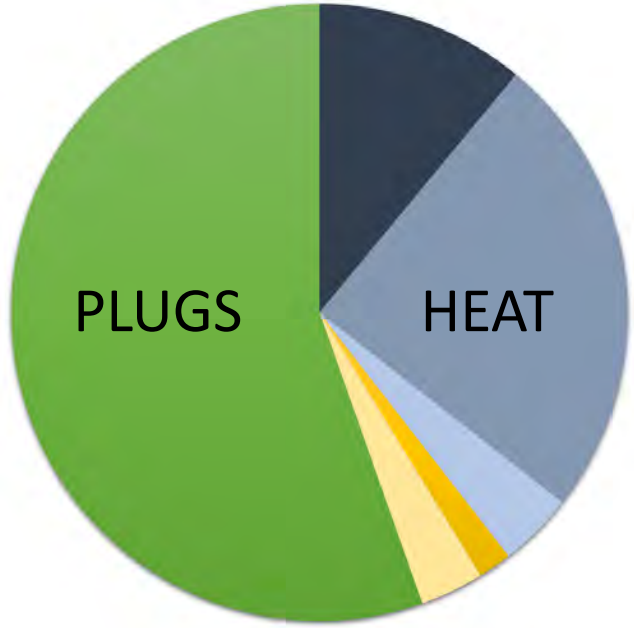
Photovoltaic Panels

Introduce Natural Ventilation

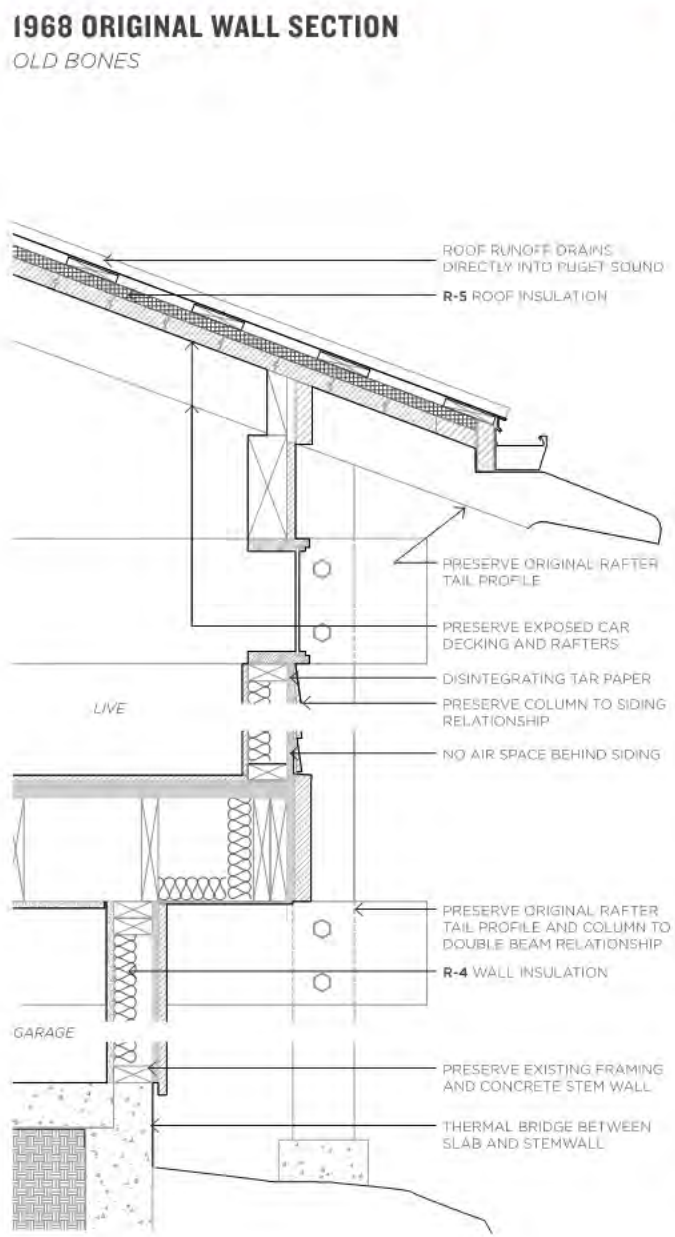
Daylight and Views

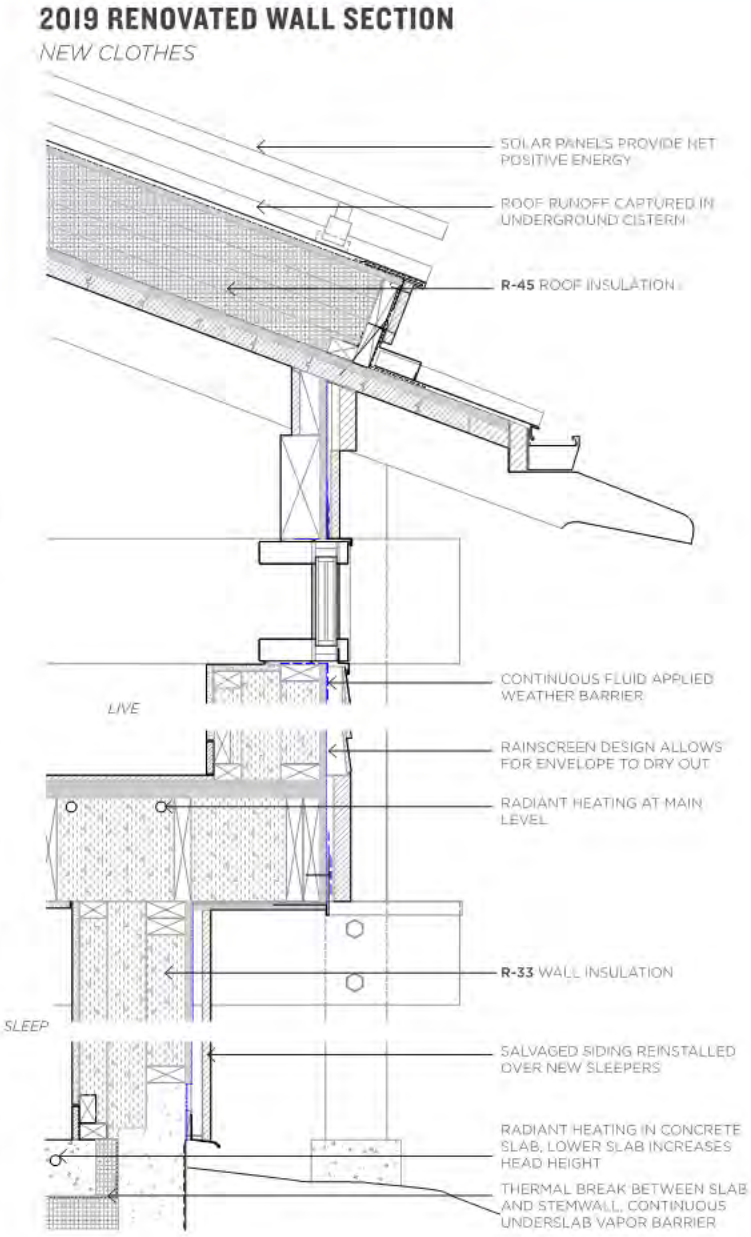


EUI 22

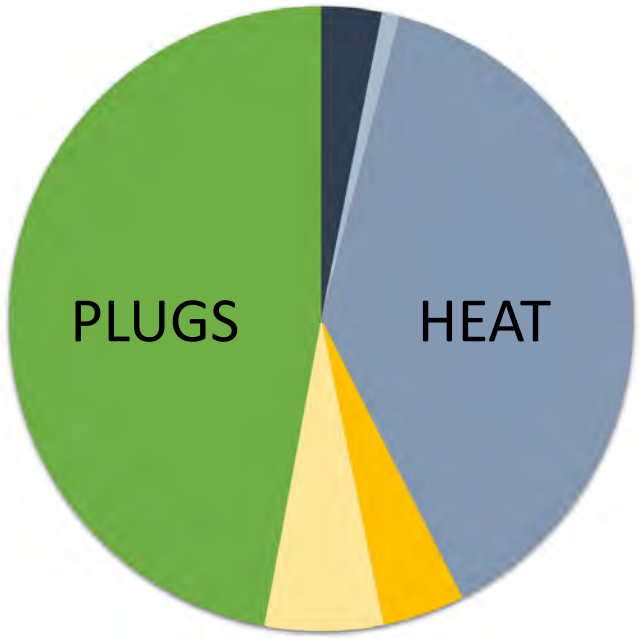


MH San Diego Studio

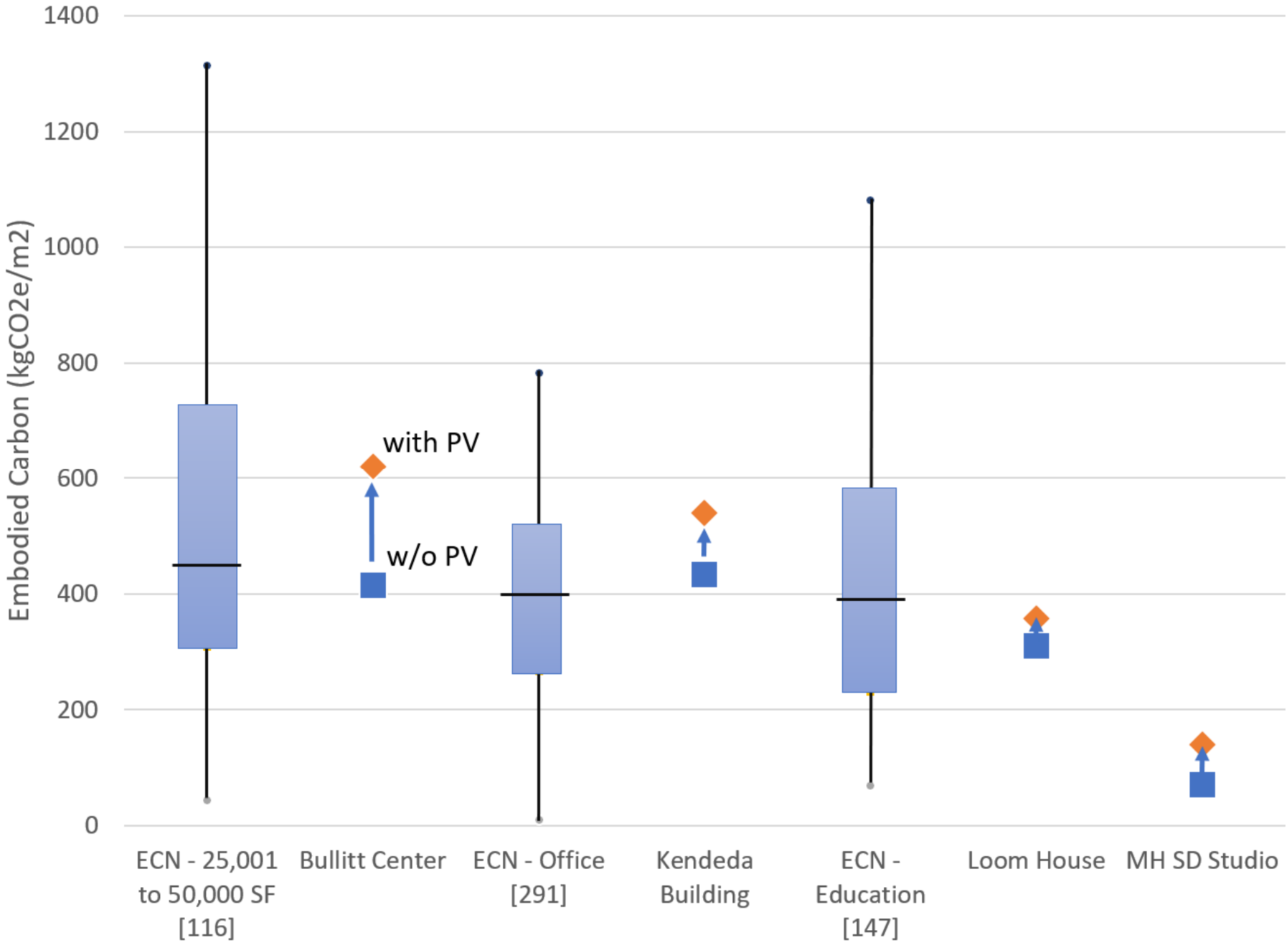




EUI 19

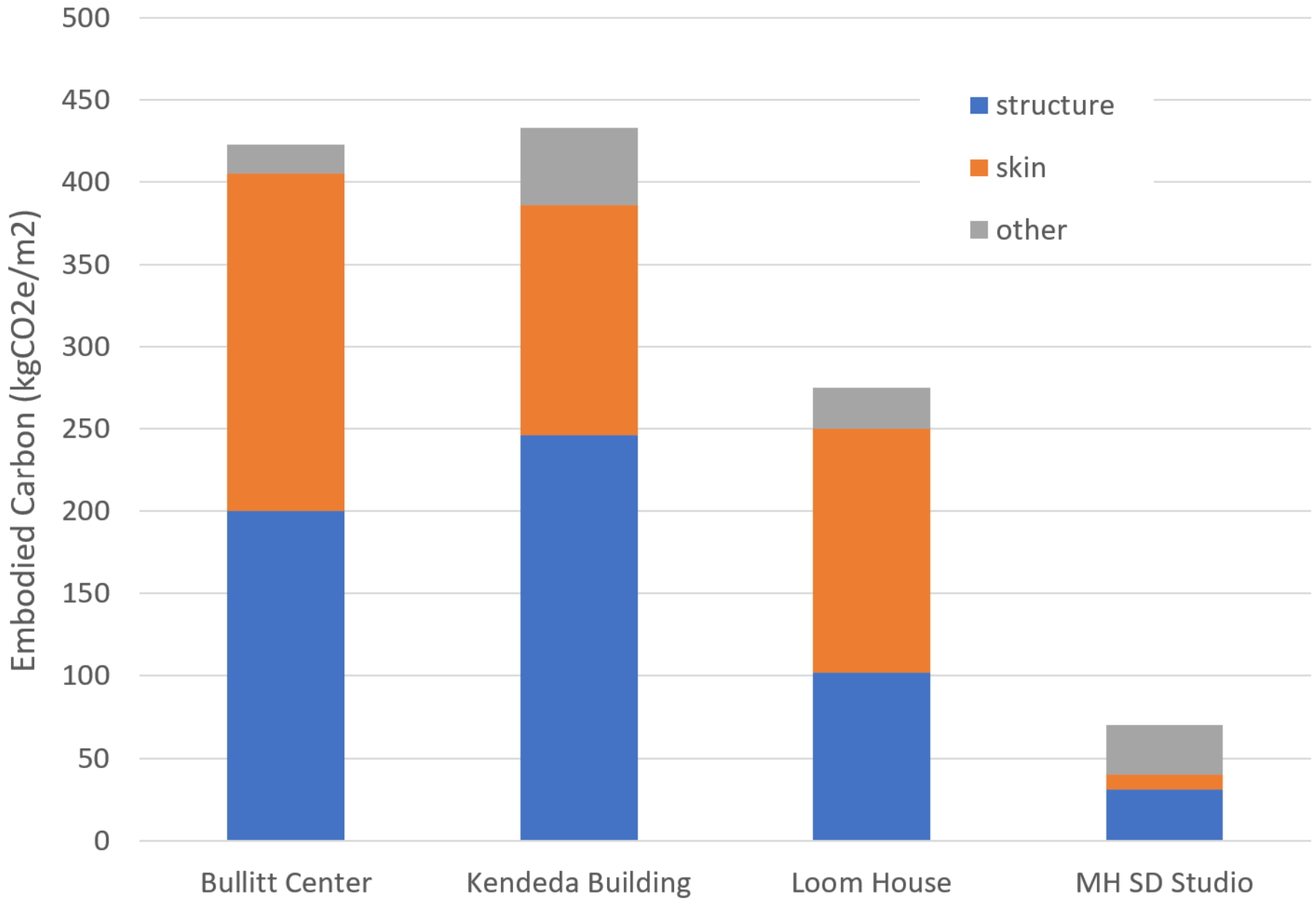


Loom House



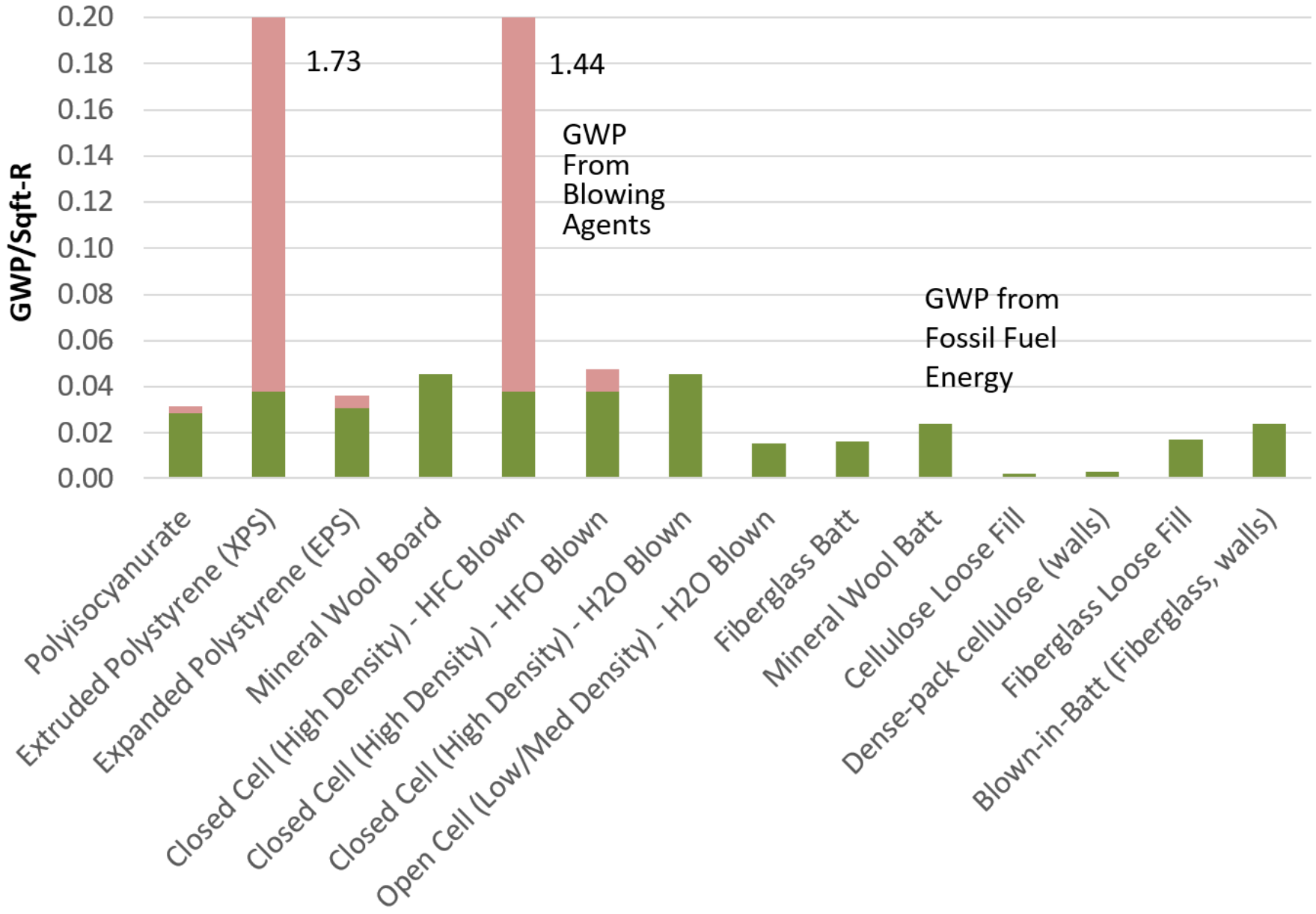
Embodied Carbon Comparison

Selected Projects vs. Samples in Embodied Carbon Network Database [counts]



Embodied Carbon Comparison

Breakdown by Building System



Embodied Carbon Comparison

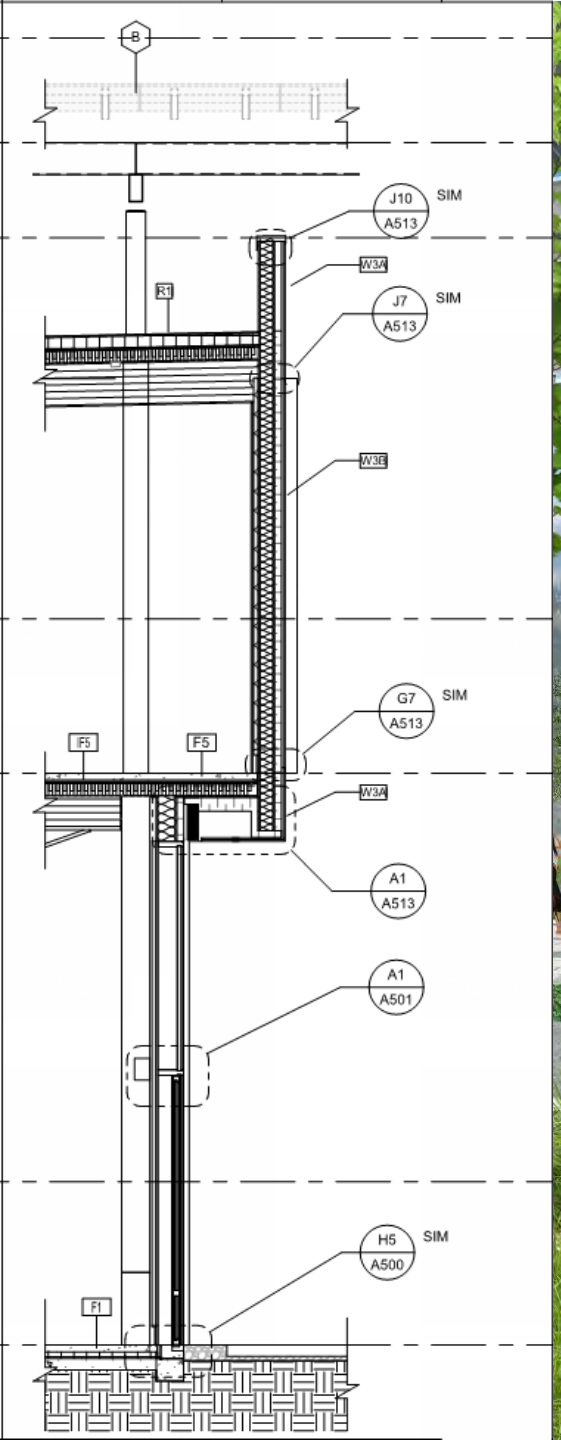
Insulation Types

*We have the capability to deliver **zero carbon buildings** for the same embodied carbon cost*

*There are current **limits to progress on embodied carbon** but we can implement changes we already understand*

***Renovations and TIs** can deliver on net zero performance at much lower embodied carbon investment*

*Working with existing buildings allows designers to **engage with the mass of materials as they exist** in our culture*


B
J10
A513
SIM
W3A
R1
J7
A513
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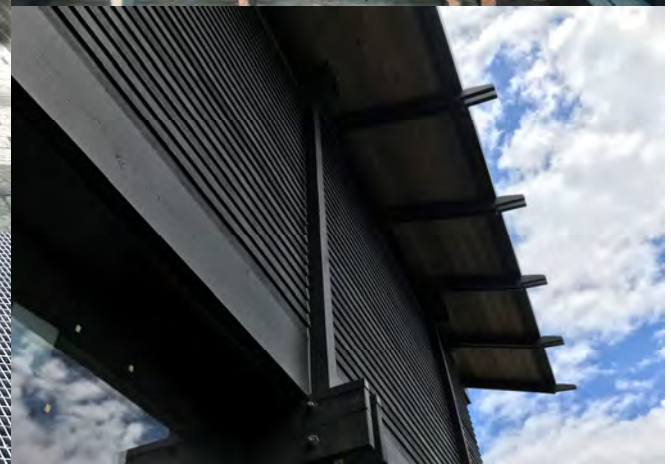

Discussion

FACADE EFFECTS

Building Zero Carbon from Cascadia to Piedmont

Facade Tectonics FORUM SEATTLE

SPEAKERS

David Mead
Senior Associate
PAE Engineers

Jim Hanford, AIA, LEED AP BD+C
Principal
The Miller Hull Partnership

Margaret Sprug, AIA
Principal
The Miller Hull Partnership

Christopher Meek, AIA, IES
Professor of Architecture
University of Washington