WOOD IN ARCHITECTURE

Semana de la Madera—Santiago, Chile—2 September 2016

Brian Court, AIA, LEED AP
The MILLER HULL Partnership
www.millerhull.com

THE MILLER HULL PARTNERSHIP SEATTLE + SAN DIEGO

1977-2016





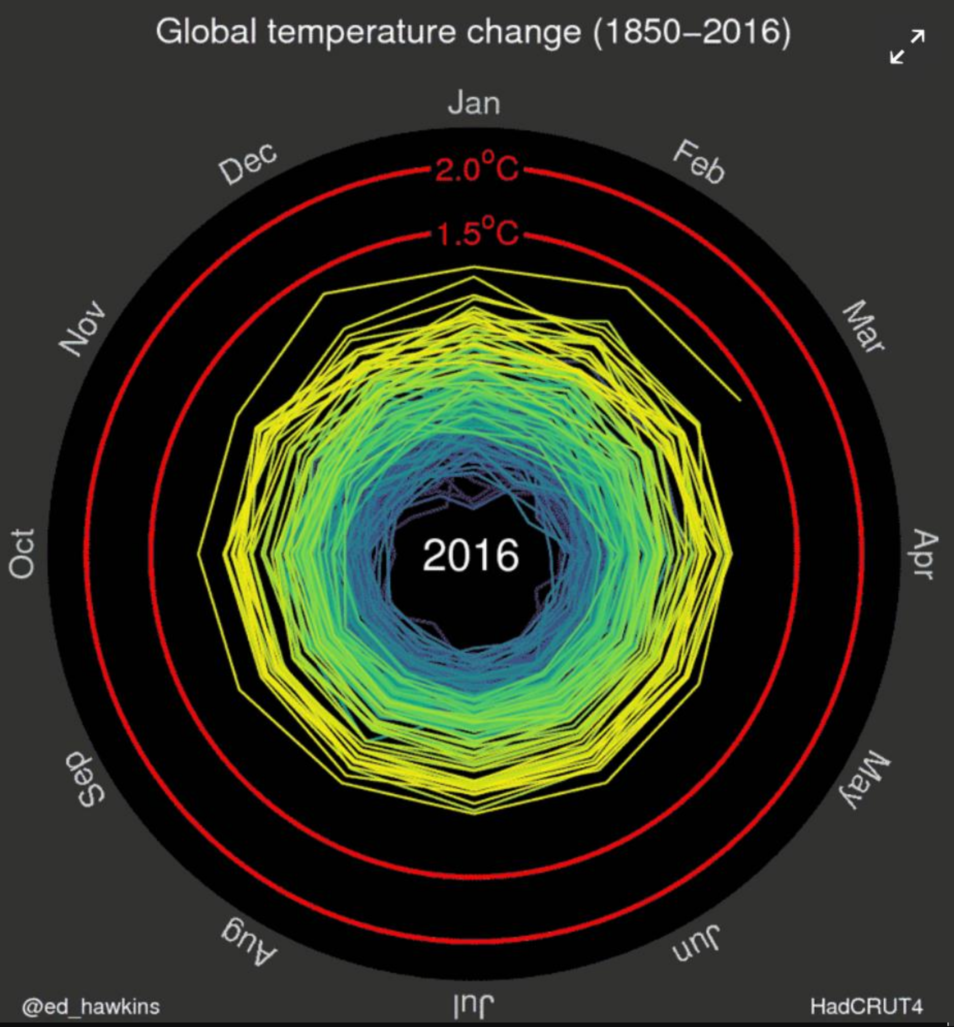
WN 6548 ND

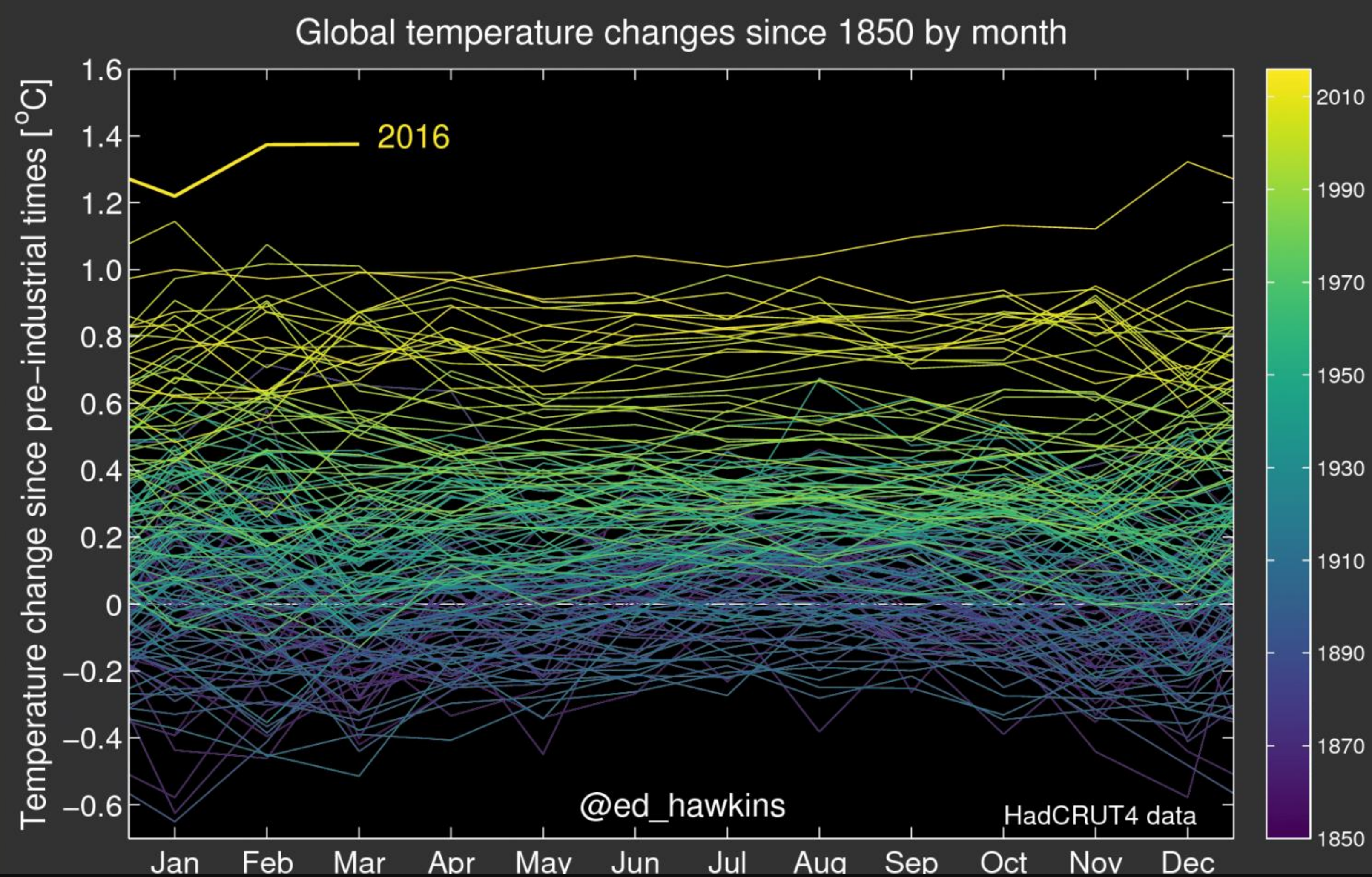

JIMMY'S
FRASER YACHTS

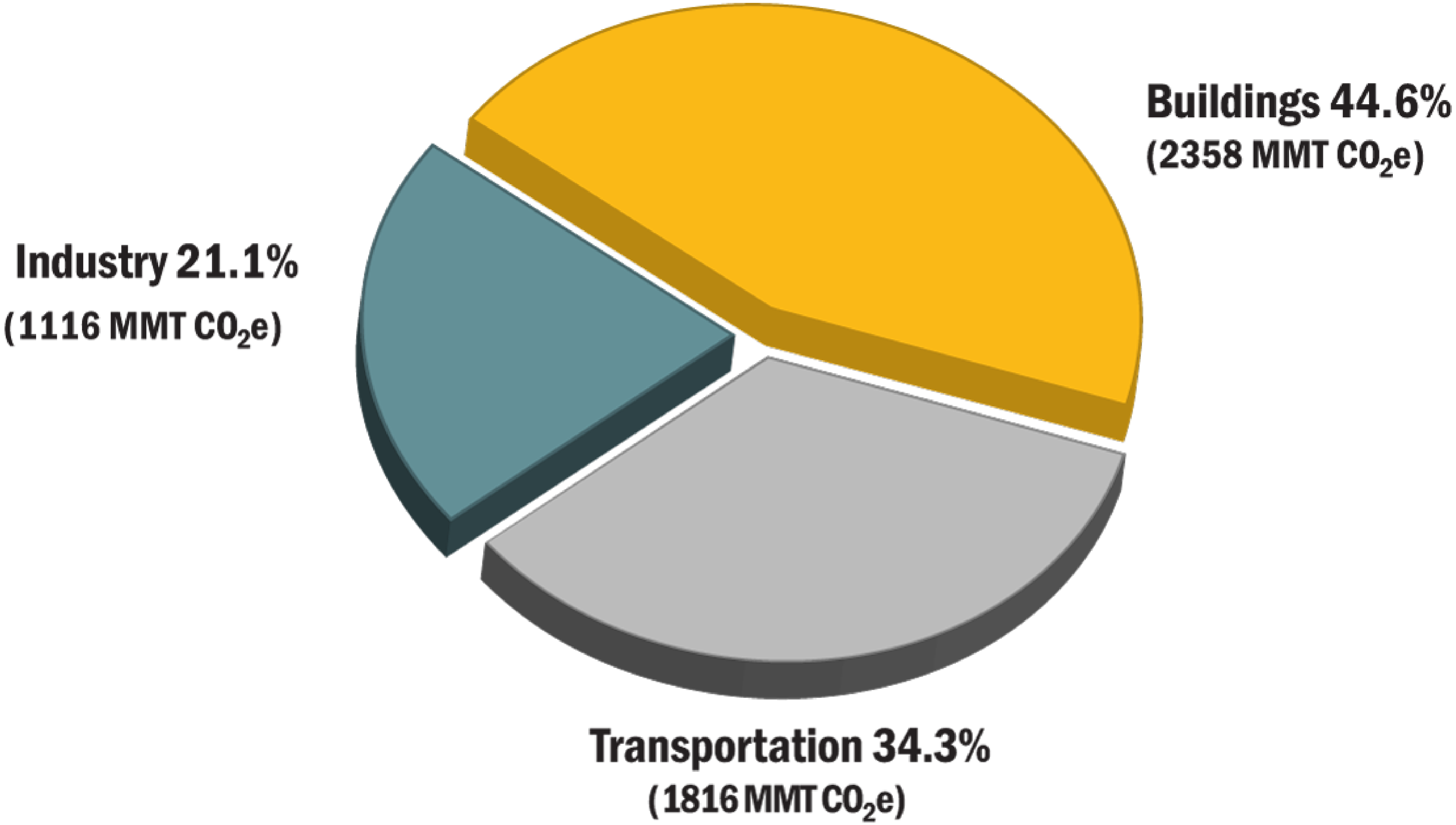



GLOBAL ISSUES

CONFRONTING ARCHITECTURE


Global temperature change (1850–2016)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2.0°C
1.5°C
2016
@ed_hawkins
HadCRUT4


Global temperature changes since 1850 by month
Temperature change since pre–industrial times [°C]
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2016
@ed_hawkins
HadCRUT4 data
2010
1990
1970
1950
1930
1910
1890
1870
1850



U.S. CO_2 Emissions by Sector

Data Source: U.S. Energy Information Administration (2012).

The manufacture of concrete and steel are responsible for nearly 10% of global CO2 emissions.

“The world is facing an imminent, unprecedented, multi-lateral environmental crisis: climate disruption; ocean acidification; an epidemic of extinction; severe shortages of fresh water; loss of topsoil; vulnerable monocultures; a global wave of toxic, carcinogenic, and endocrine-disrupting chemicals; overfishing; clear cutting; and an exploding human population with growing demands for scarce resources

These are not problems for your children. These are our problems.

We need right now is a major leap forward,
and a quantum change in our environment. “

-Denis Hayes, President, Bullitt Foundation

BREEAM

- first environmental assessment standard
- based in Europe since 1990
- points-based spreadsheet system
- predictive not performance based

LEED

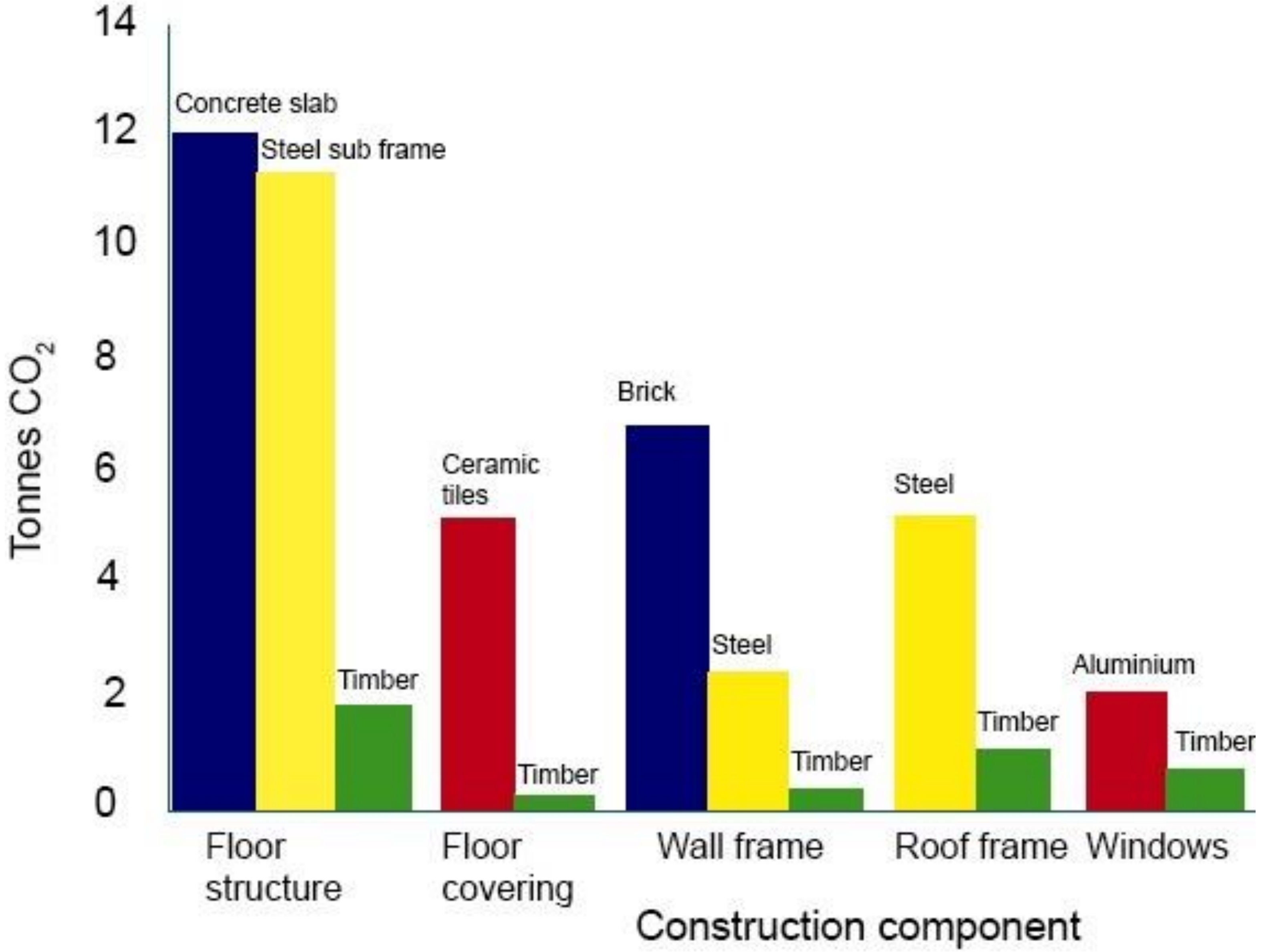
- most common measure of sustainability
- based in US since 1994
- points-based spreadsheet system
- predictive not performance based

LIVING BUILDING CHALLENGE

- most rigorous standard
- net positive ENERGY, WATER + WASTE
- low carbon, regionally sourced, non-toxic MATERIALS
- civilized environments (natural light + ventilation)
- all wood must be FSC

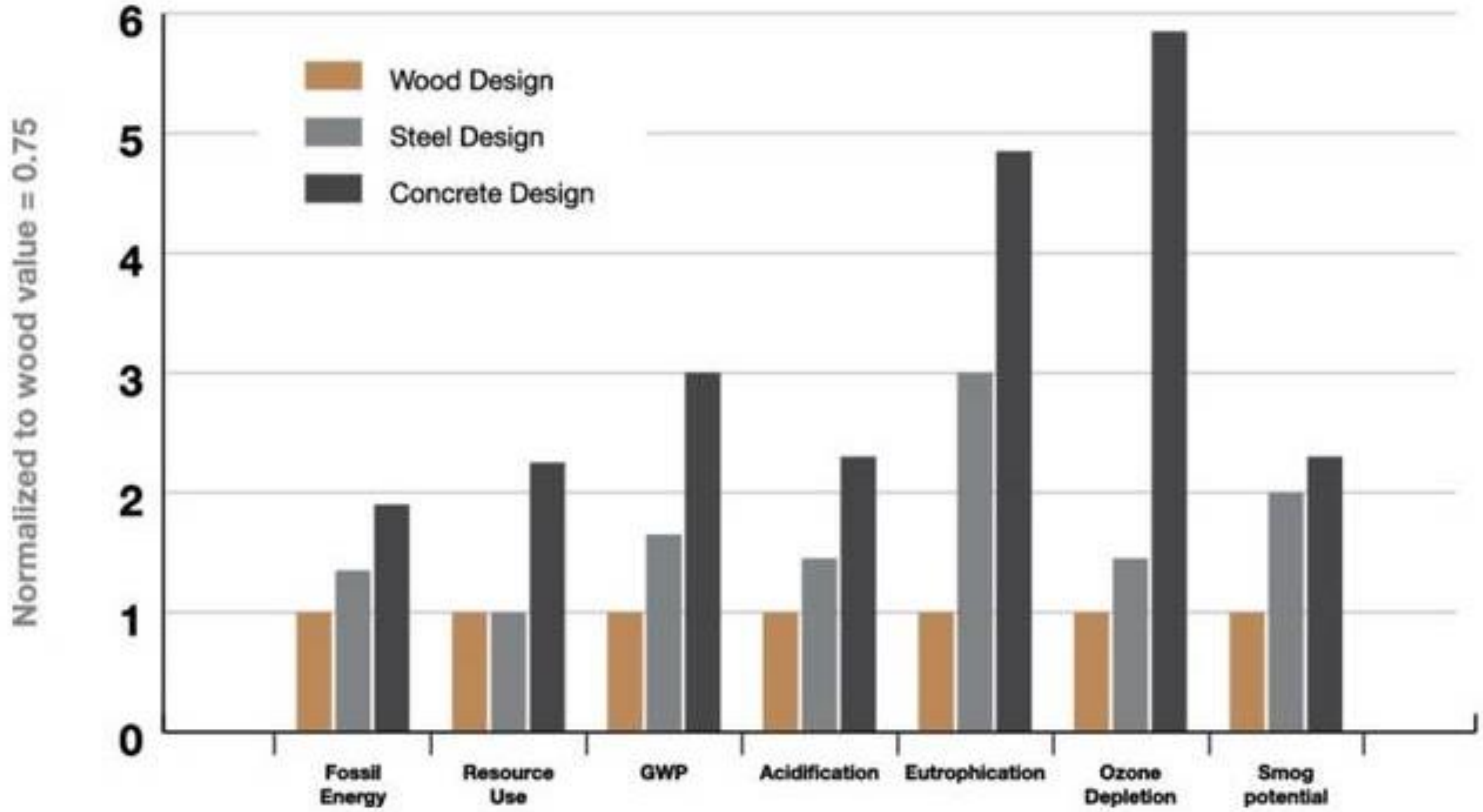

WHY WOOD?

CONSTRUCTION COMPONENTS AND CO2



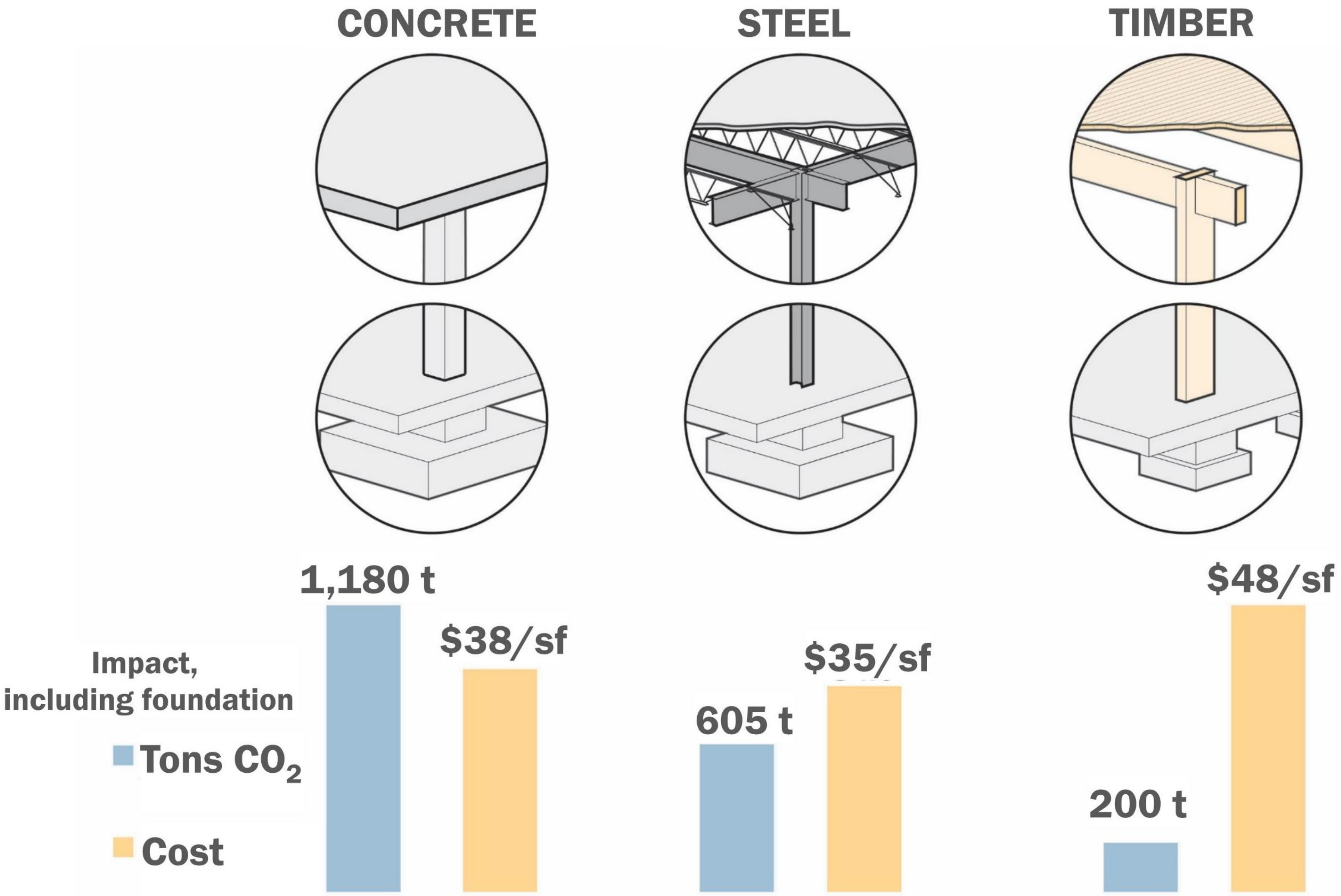
SOURCE: Treehugger

STRUCTURAL SYSTEMS EMBODIED EFFECTS



SOURCE: FPInnovations

STRUCTURAL SYSTEMS
COST & CARBON EMISSIONS IMPACT



SOURCE:
Eskew Dumez Ripple


KOMATSU
FOREST
PROTECTION
NOW


Defend this
FOREST!
EvergladesEarthFirst.org


10:00 AM
1.31.00


RISE UP
and DEFEND
YOUR HOME
tarsandsblockade.org

CLEAR CUT

- destroys ecosystem
- monoculture

SUSTAINABLE FOREST MANAGEMENT

- preserves habitat
- diversity of species and maturity

PROGRAM FOR THE ENDORSEMENT OF FOREST CERTIFICATION SCHEMES (PEFC)

- most common certification standard
- nearly 2/3 of all certified forest land is PEFC

FOREST STEWARDSHIP COUNCIL (FSC)

- second largest forest standard
- the most rigorous
- fastest growing standard

CASE STUDY #1

The Bullitt Center

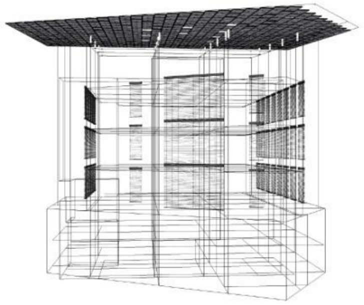

"Our desire is to open a wedge into the future so that we, and others can see what is possible in a contemporary office building. "
Denis Hayes
Bullitt Foundation, President
PHOTO: ANDY SIMONDS


DRINK ORGANIC JUICES
EAT ORGANIC FOODS

BUILDING LIFE CYCLE

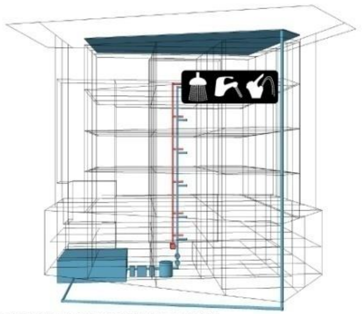
250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL

50 YEAR SKIN
HIGH PERFORMANCE ENVELOPE

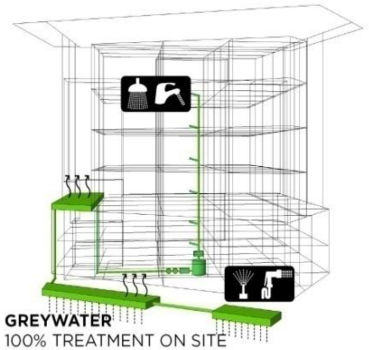


25 YEAR TECHNOLOGY
ACTIVE SOLAR CONTROL
PHOTOVOLTAICS

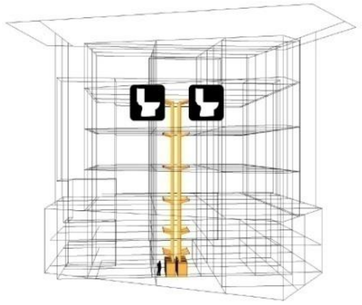
NET ZERO WATER



RAINWATER COLLECTION
100% DEMAND MET ON SITE
50,000 GALLON CISTERN

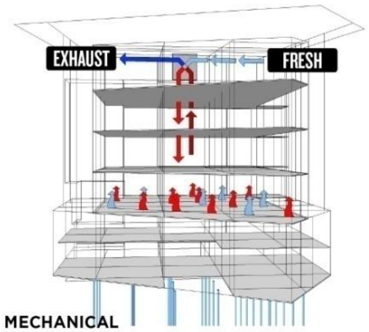


GREYWATER
100% TREATMENT ON SITE
EVAPOTRANSPIRATION & INFILTRATION

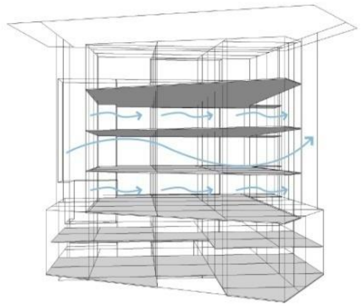


WASTE COMPOST
100% TREATMENT ON SITE

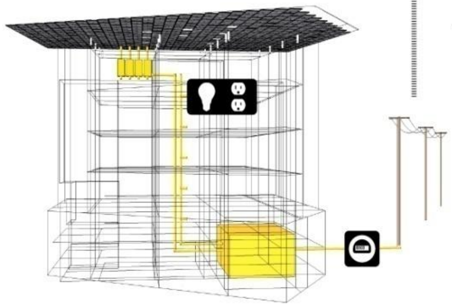
NET ZERO ENERGY



MECHANICAL
GROUND SOURCE HEAT EXCHANGE
RADIANT HEATING/COOLING
HEAT RECOVERY AIR SYSTEM

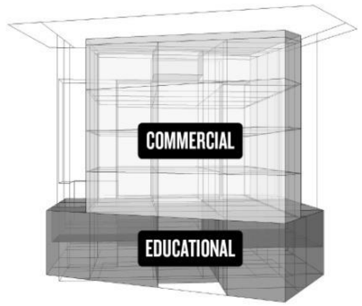


NATURAL VENTILATION
NIGHT FLUSH & OPERABLE WINDOWS

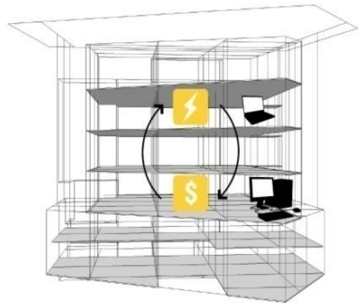


ENERGY
100% RENEWABLE ON SITE
GRID USED AS BATTERY

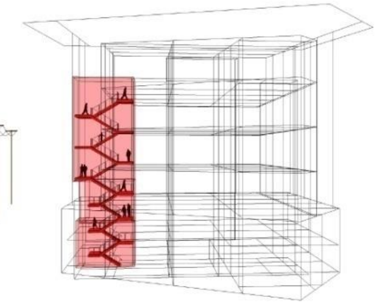
OCCUPANT



PROGRAM
OCCUPANCY
PRIVATE USERS ABOVE, PUBLIC FOCUS USERS AT GRADE

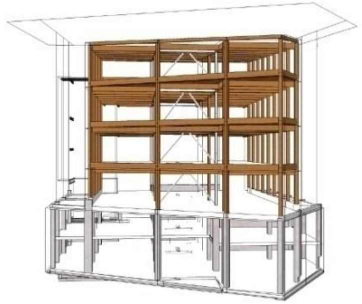


INTERNAL CAP & TRADE
EACH TENANT HAS AN ENERGY BUDGET; UNUSED ENERGY CAN BE TRANSFERRED



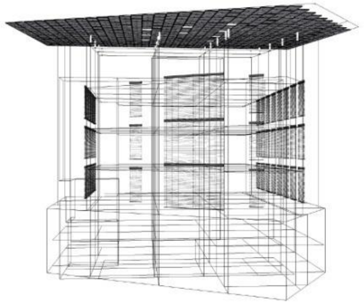
IRRESISTIBLE STAIR
ELEVATOR ALTERNATIVE, HEALTHIER OCCUPANTS, ENGAGEMENT WITH STREET

BUILDING LIFE CYCLE



250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL

50 YEAR SKIN
HIGH PERFORMANCE ENVELOPE



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PHOTOVOLTAICS

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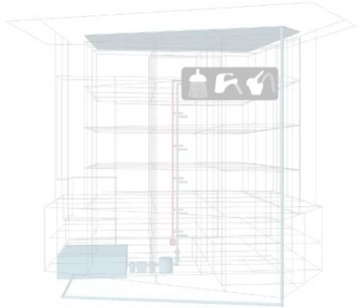
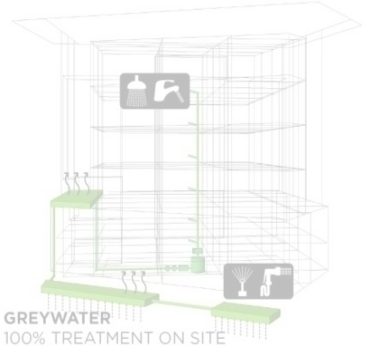


RAINWATER COLLECTION
100% DEMAND MET ON SITE
50,000 GALLON CISTERN



GREYWATER
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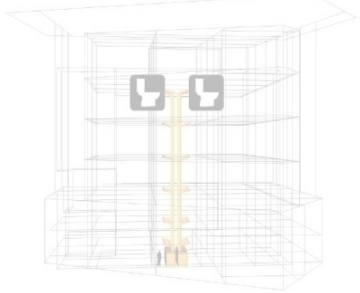
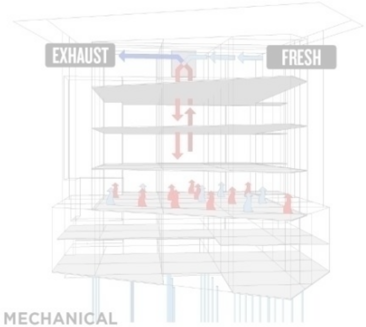
EVAPOTRANSPIRATION & INFILTRATION



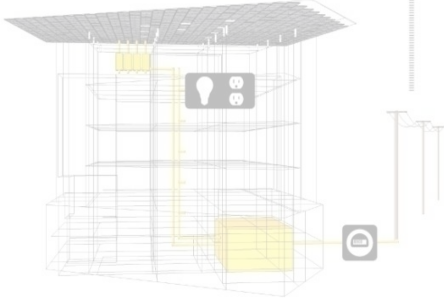
WASTE COMPOST
100% TREATMENT ON SITE

NET ZERO ENERGY



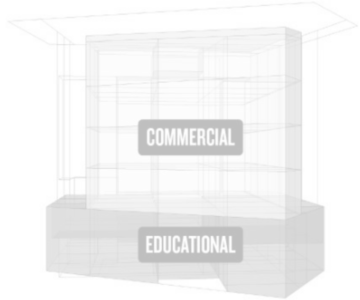
MECHANICAL
GROUND SOURCE HEAT EXCHANGE
RADIANT HEATING/COOLING
HEAT RECOVERY AIR SYSTEM

NATURAL VENTILATION
NIGHT FLUSH & OPERABLE WINDOWS

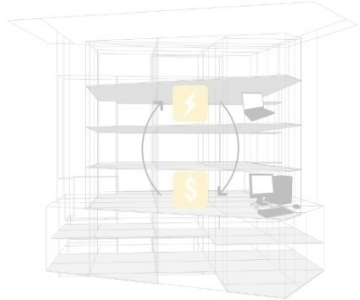


ENERGY
100% RENEWABLE ON SITE
GRID USED AS BATTERY

OCCUPANT



PROGRAM
OCCUPANCY
PRIVATE USERS ABOVE, PUBLIC FOCUS
USERS AT GRADE



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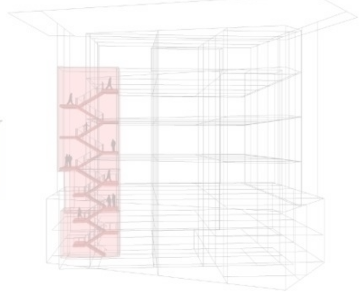


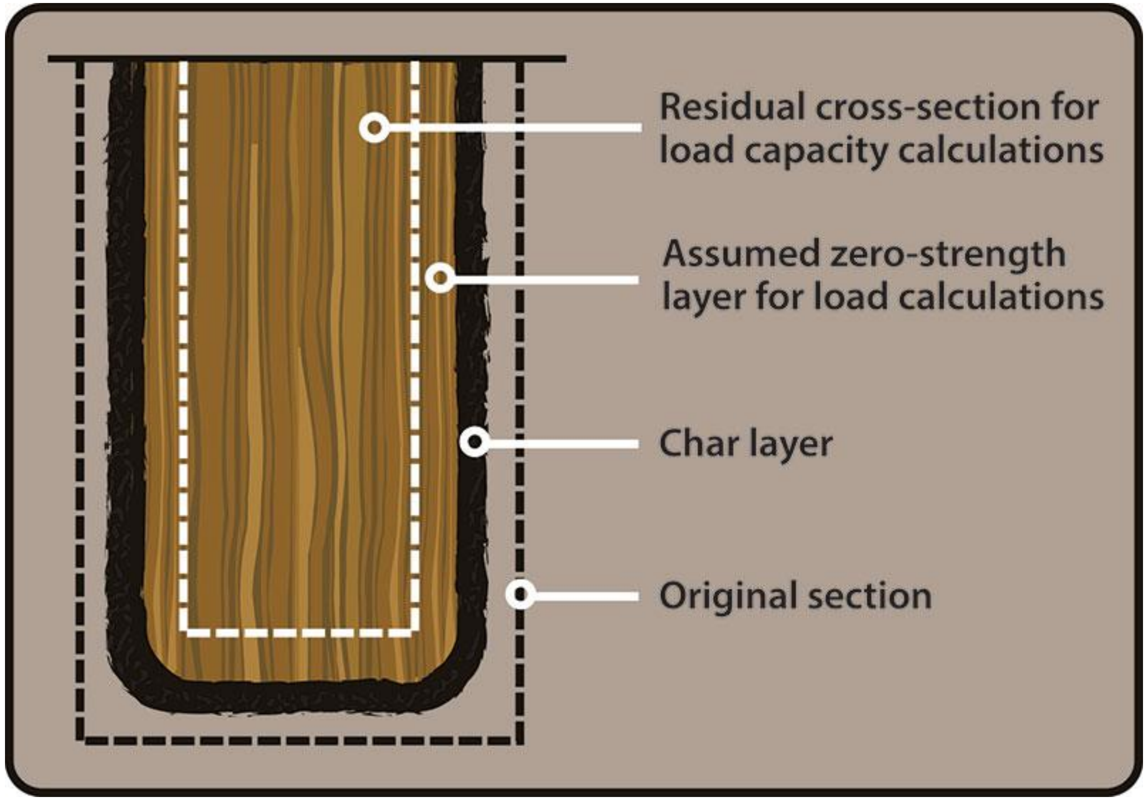
IRRESISTIBLE STAIR
ELEVATOR ALTERNATIVE, HEALTHIER
OCCUPANTS, ENGAGEMENT WITH STREET

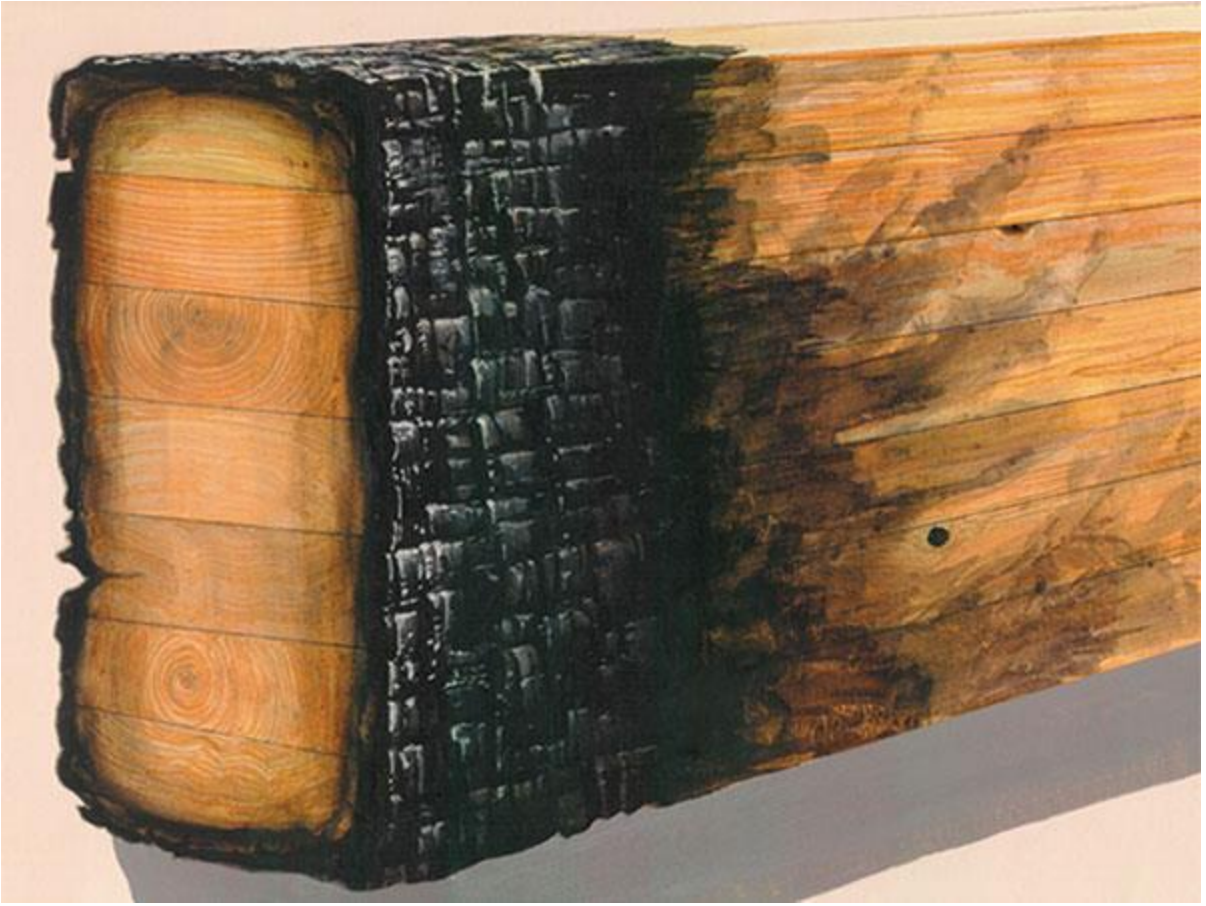

NO PARKING ANY TIME
PEDESTRIANS
SIDEWALK CLOSED


E Pike St
ROAD
CLOSED
SEATTLE ACADEMY OF ARTS AND SCIENCES
1432

The Bullitt Center, The Miller Hull Partnership

GLU-LAMINATED TIMBER



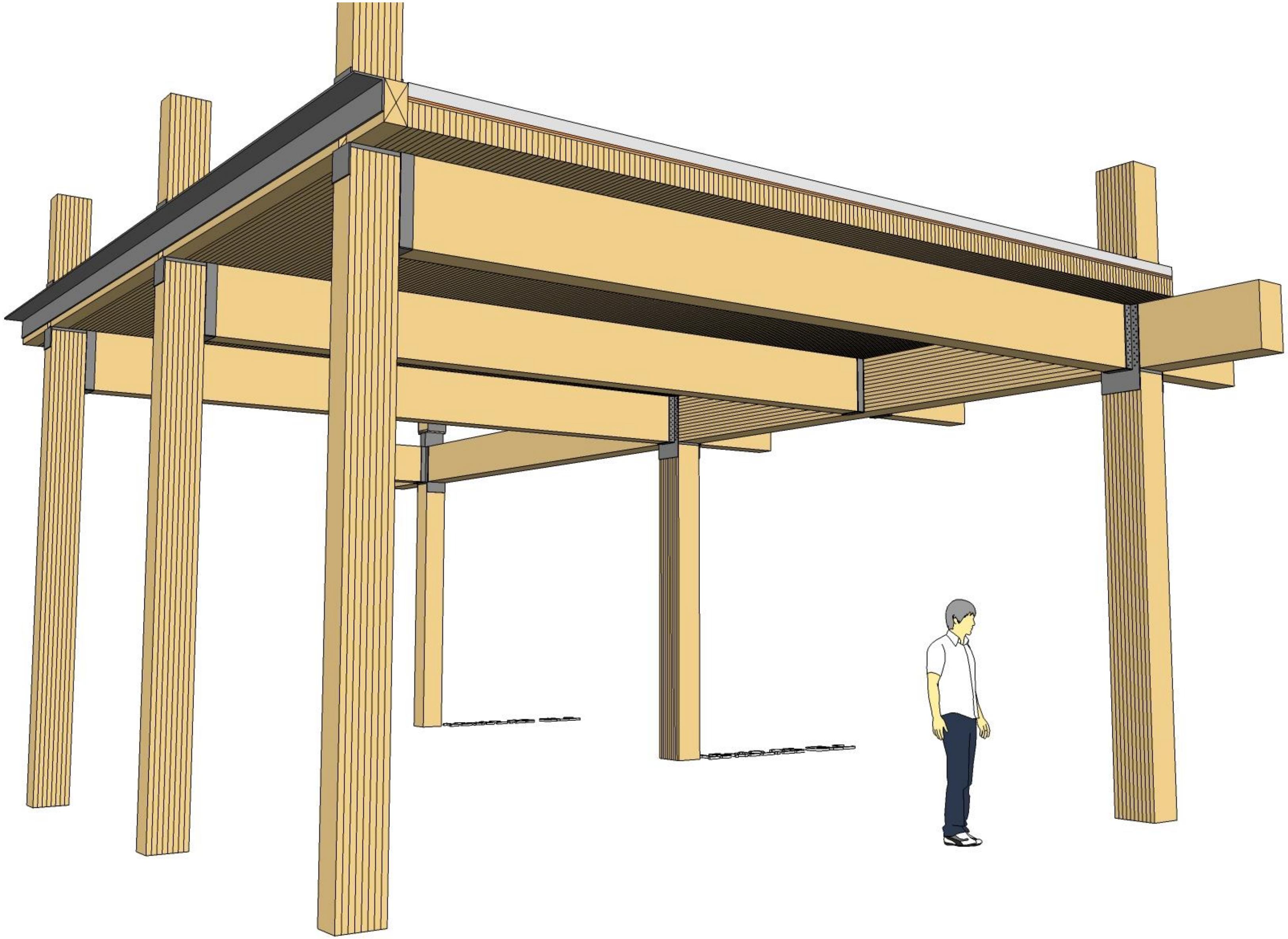


FIRE PROTECTION

Bullitt Center, The Miller Hull Partnership

Wood Innovation Center, Michael Green Associates

CONNECTIONS—CONCEALED OR HIDDEN?



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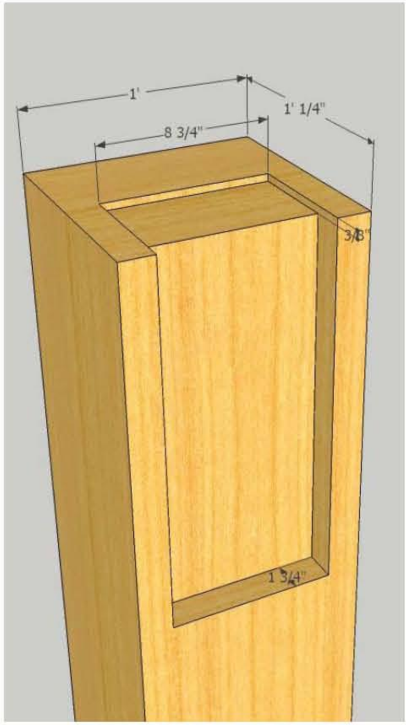
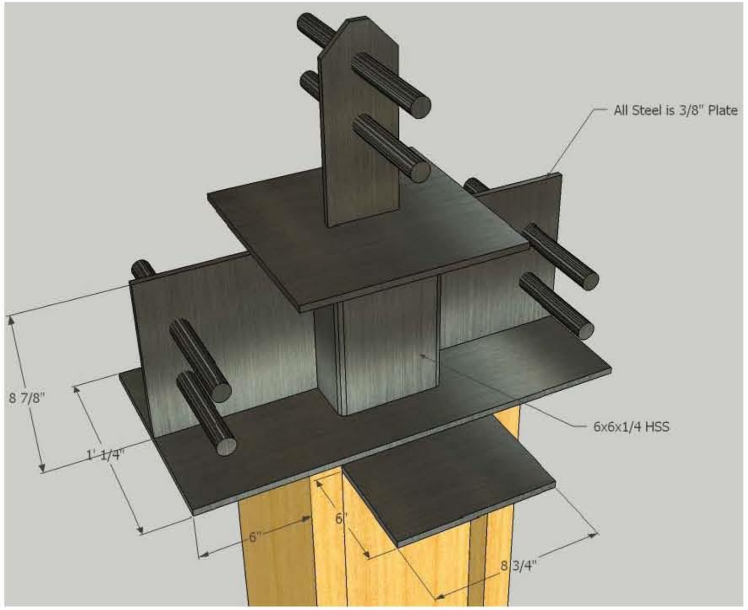
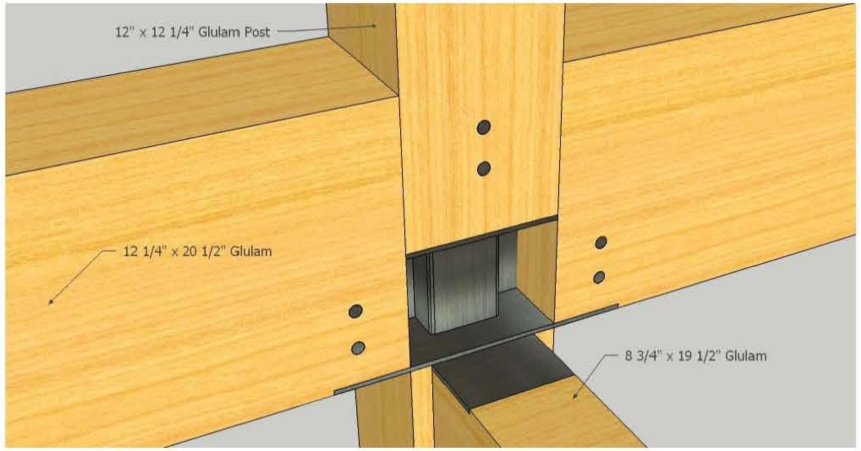




Proposed Joinery Detail:
Post @ Exterior Wall
(Fasteners not Shown)



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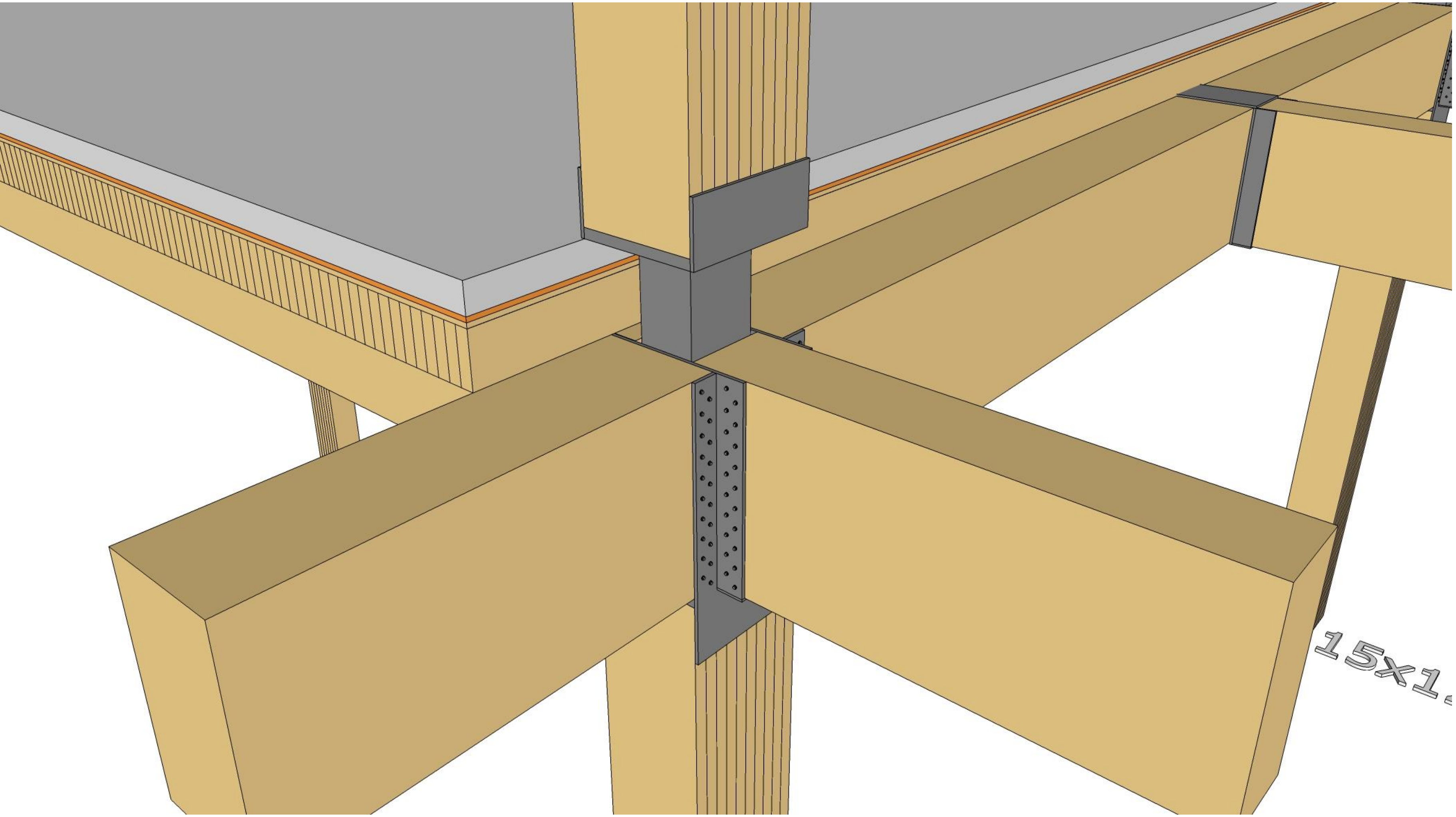

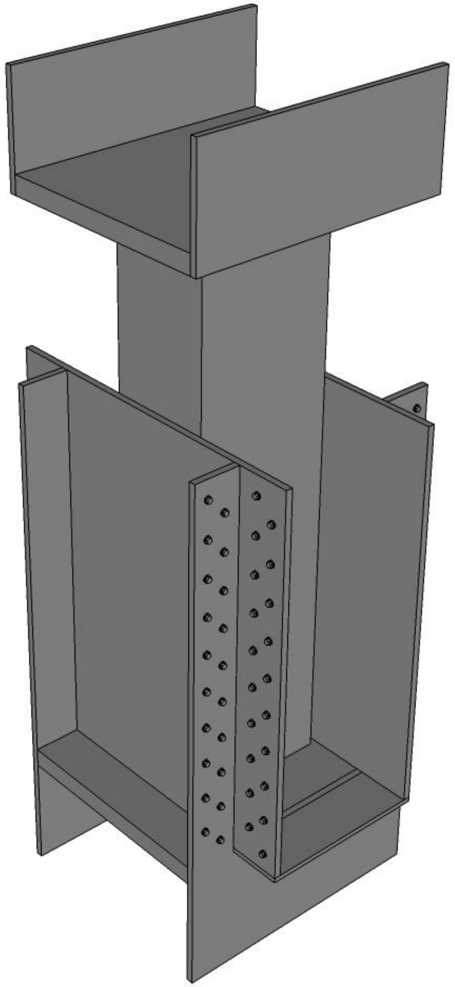

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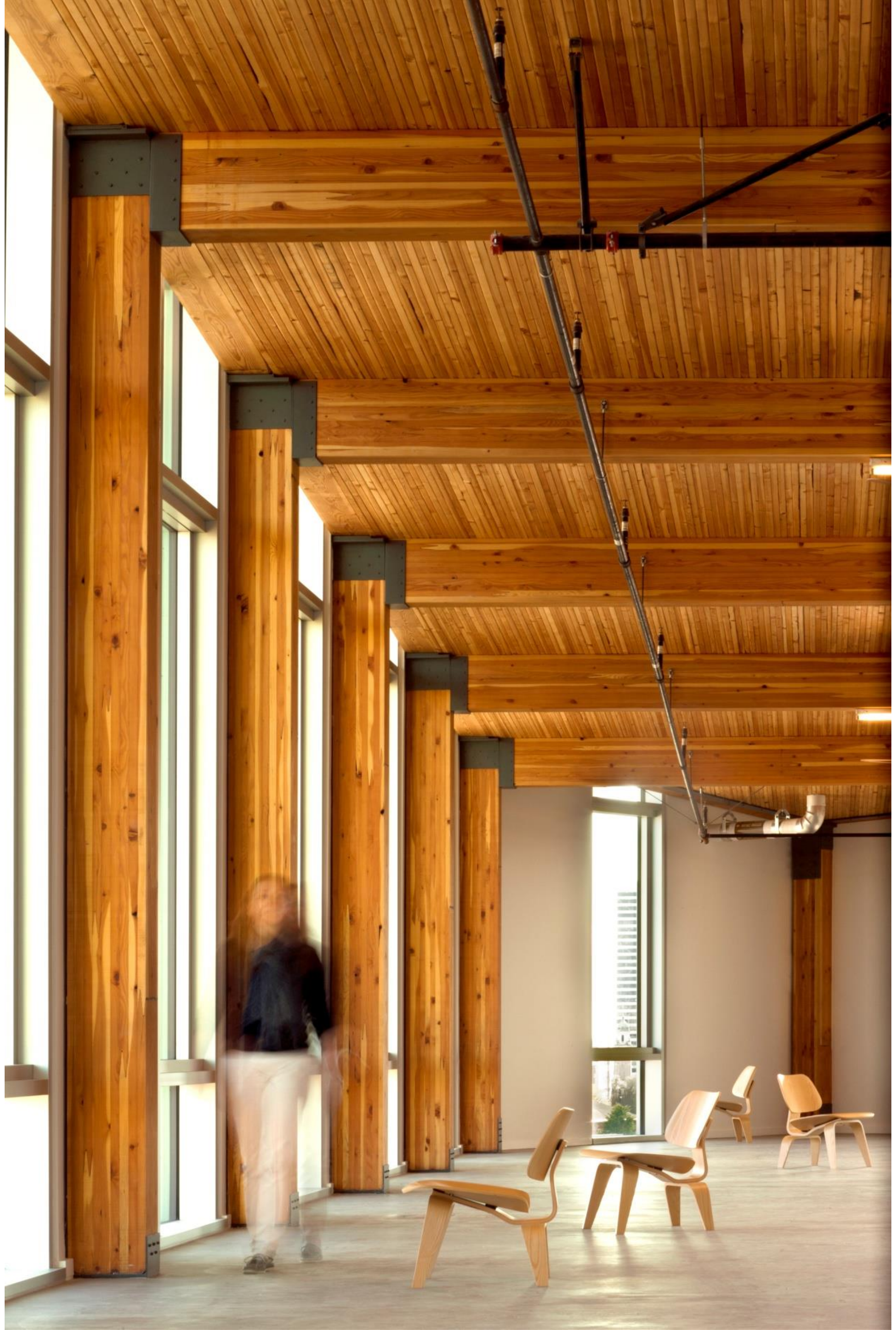
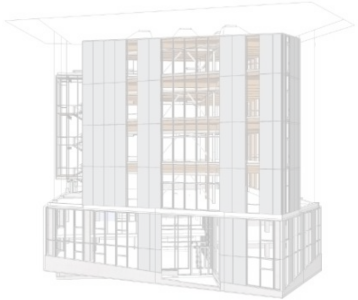



BUILDING LIFE CYCLE

250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL



50 YEAR SKIN
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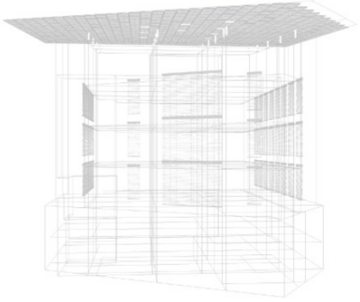
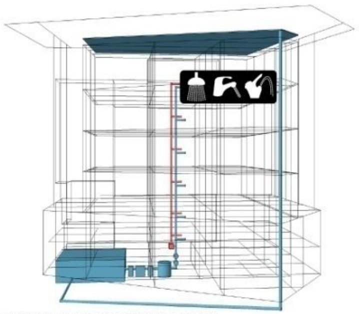


25 YEAR TECHNOLOGY
ACTIVE SOLAR CONTROL
PHOTOVOLTAICS

NET ZERO WATER



RAINWATER COLLECTION
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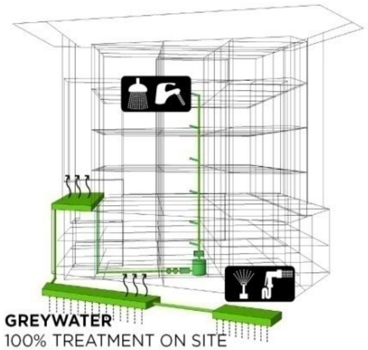

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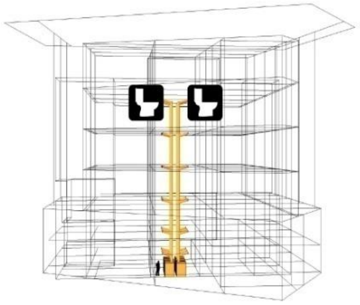

WASTE COMPOST
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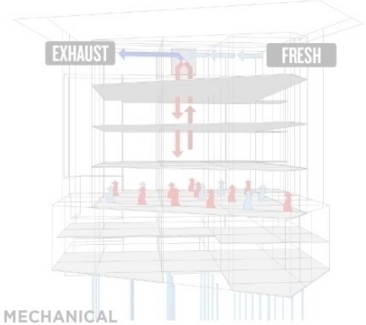

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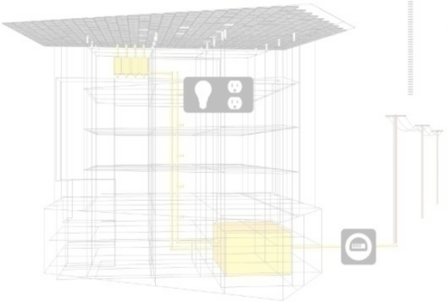

ENERGY
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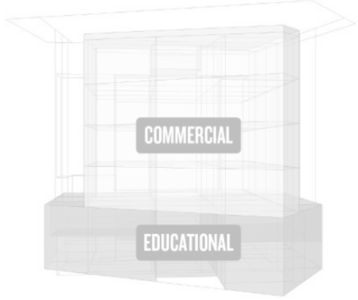

PROGRAM
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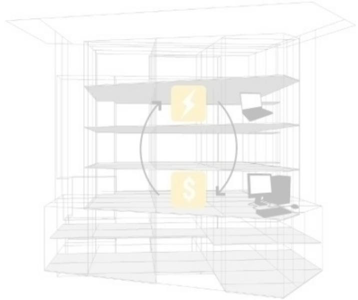

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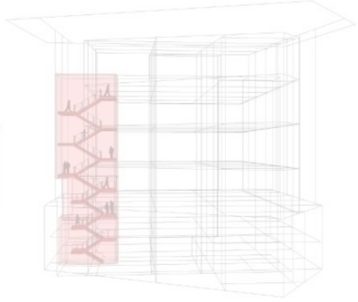
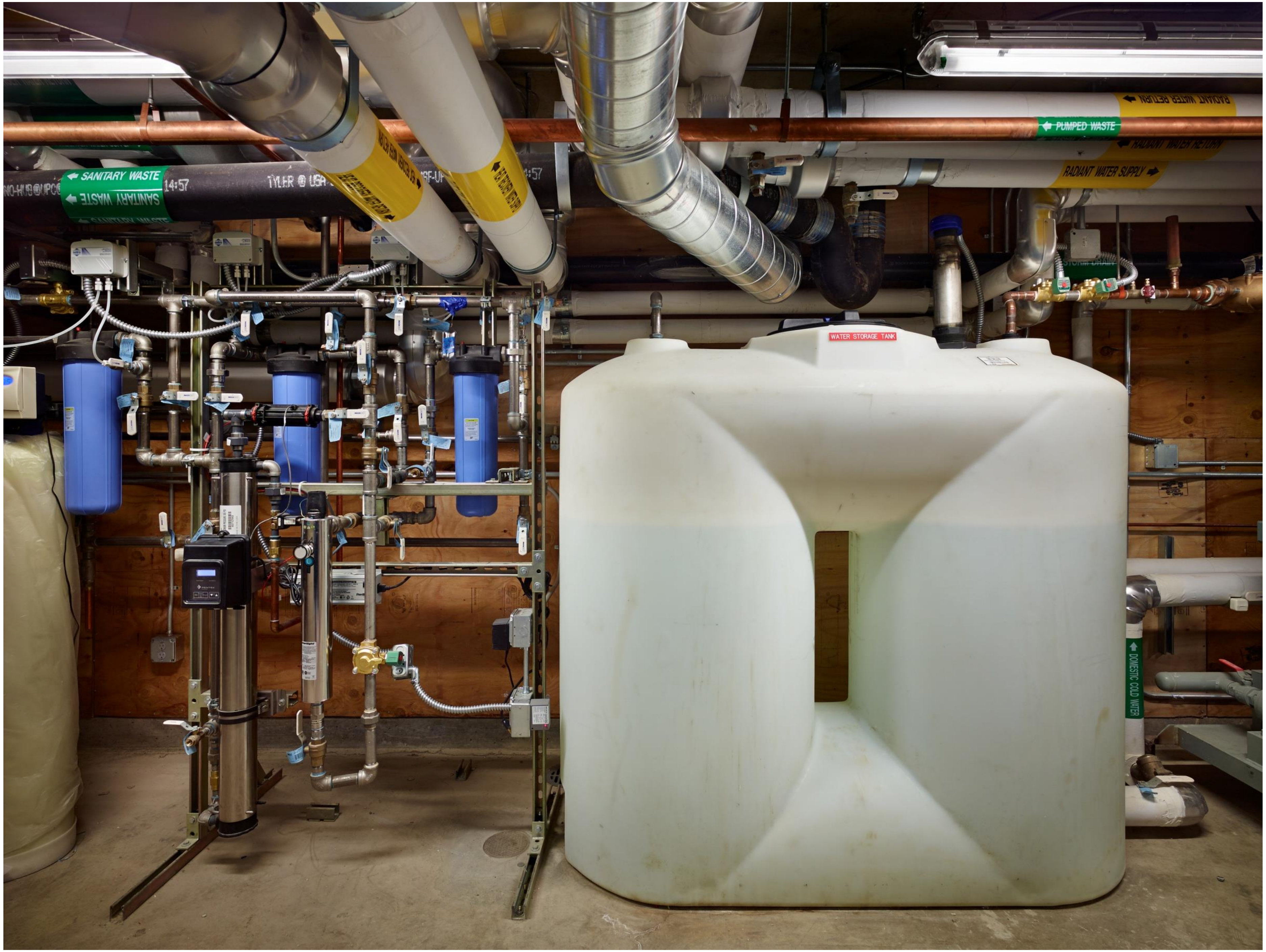
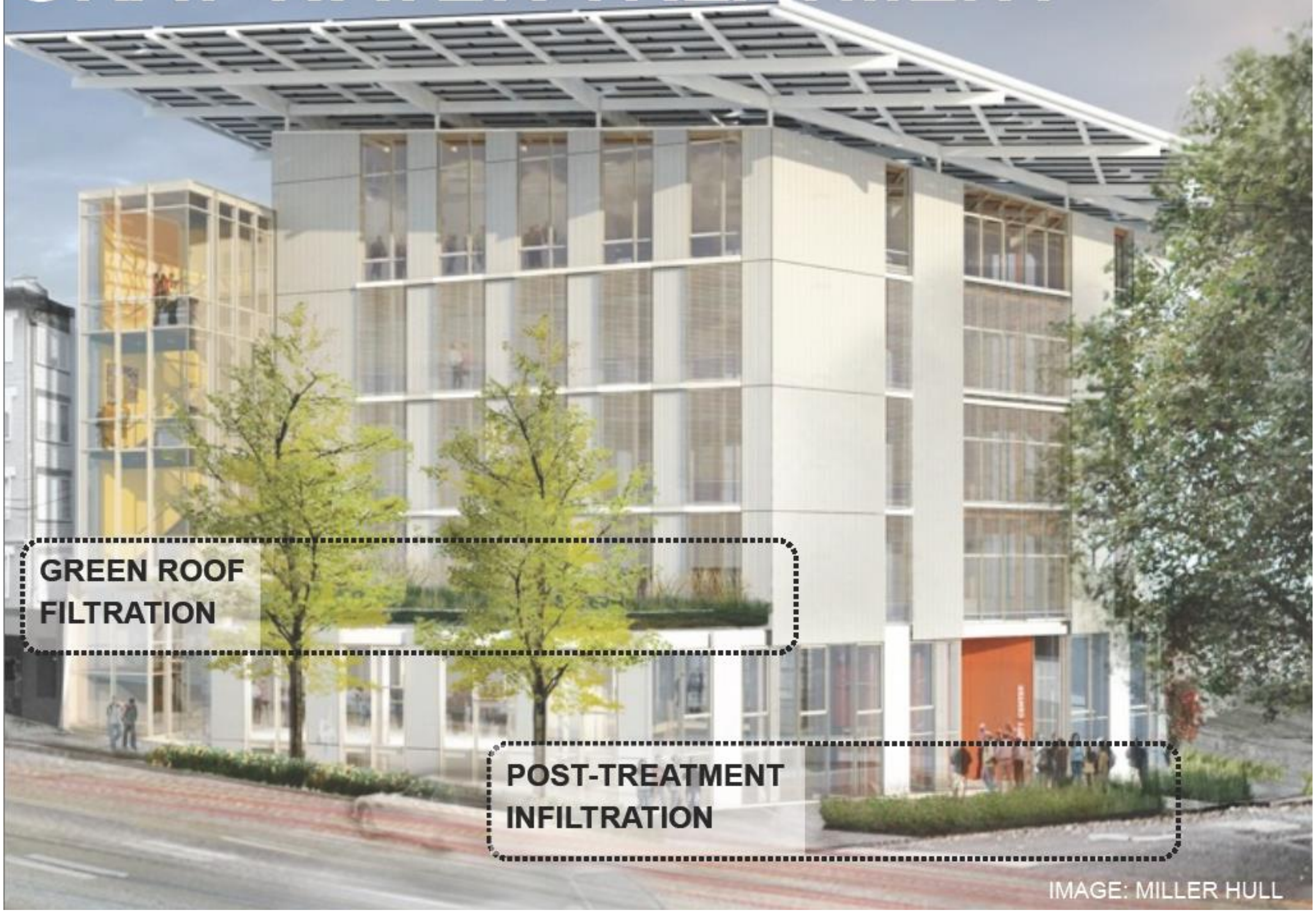


IRRESISTIBLE STAIR
ELEVATOR ALTERNATIVE, HEALTHIER OCCUPANTS, ENGAGEMENT WITH STREET


SANITARY WASTE
SANITARY WASTE
PUMPED WASTE
RADIANT WATER RETURN
RADIANT WATER SUPPLY
WATER STORAGE TANK
DOMESTIC COLD WATER

GRAY WATER TREATMENT




SANITARY WASTE
VENT



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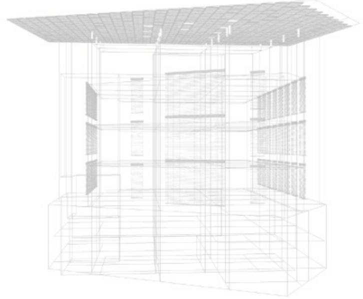

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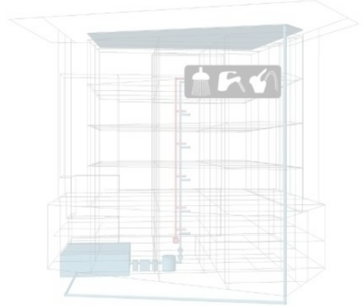

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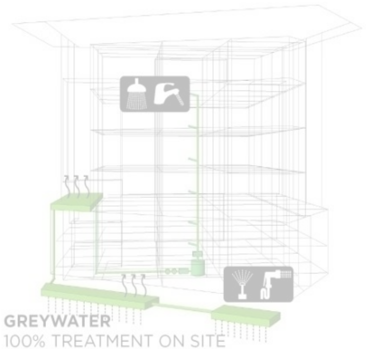

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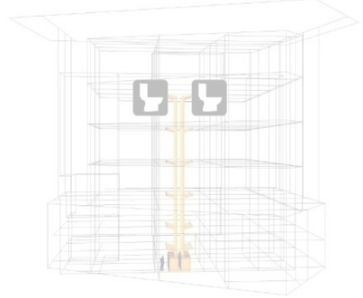

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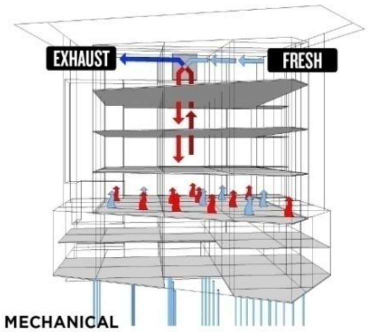

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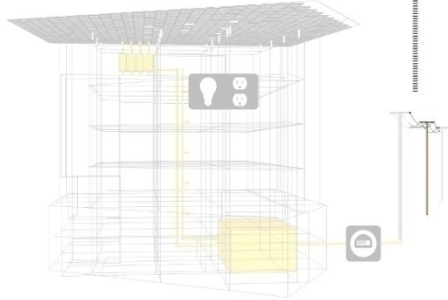

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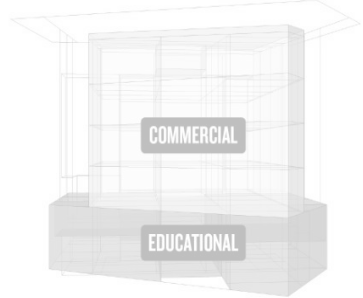
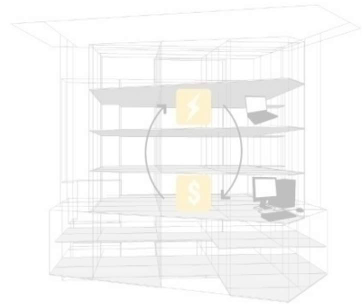
GRID USED AS BATTERY

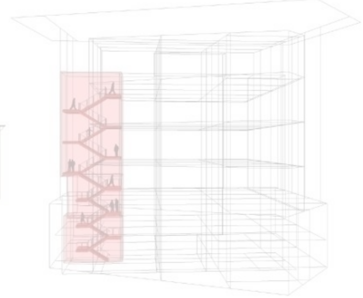
OCCUPANT



PROGRAM
OCCUPANCY
PRIVATE USERS ABOVE, PUBLIC FOCUS
USERS AT GRADE

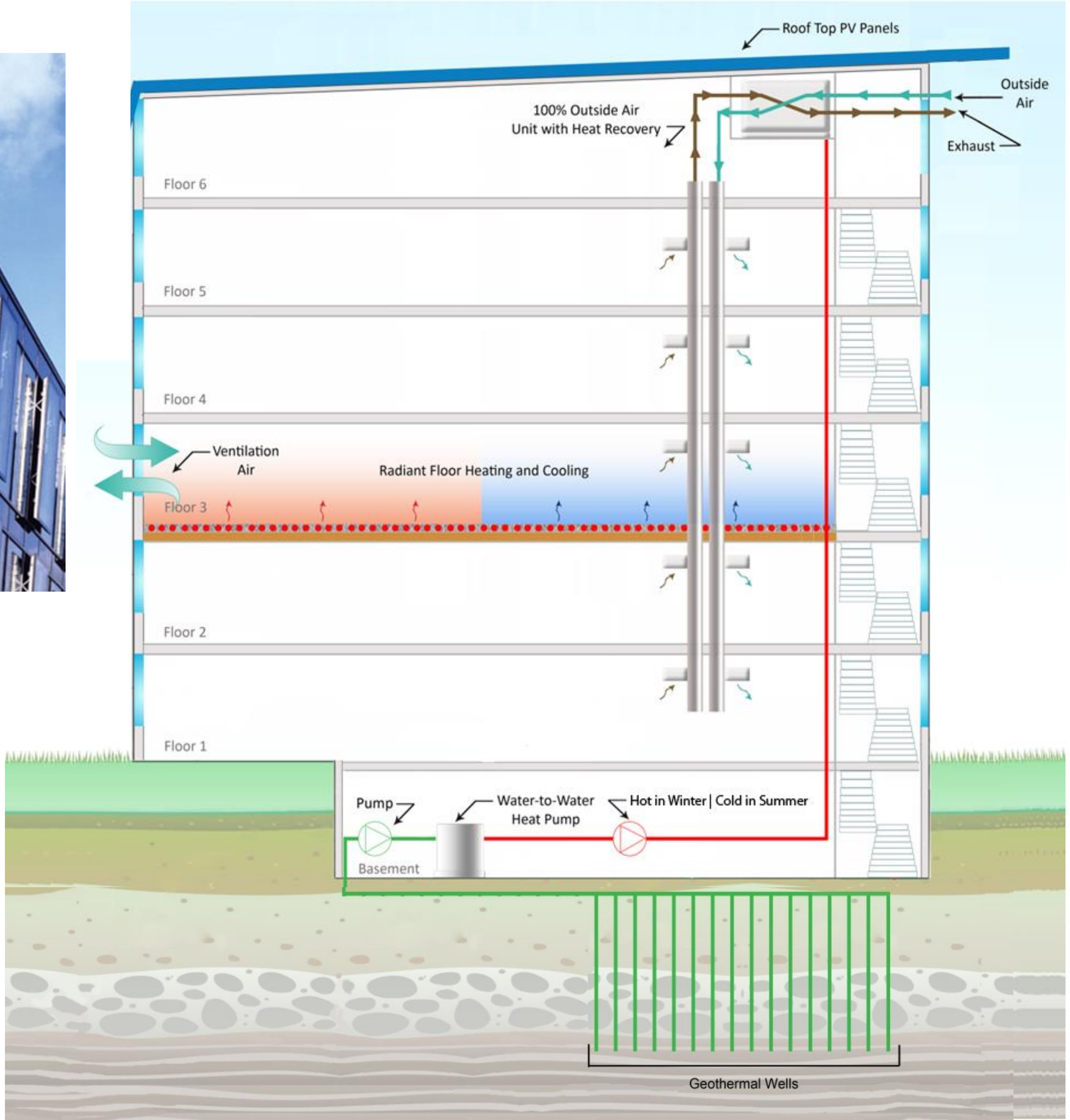


INTERNAL CAP & TRADE
EACH TENANT HAS AN ENERGY BUDGET;
UNUSED ENERGY CAN BE TRANSFERRED



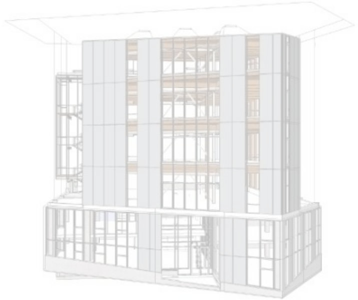
IRRESISTIBLE STAIR
ELEVATOR ALTERNATIVE, HEALTHIER
OCCUPANTS, ENGAGEMENT WITH STREET

HVAC

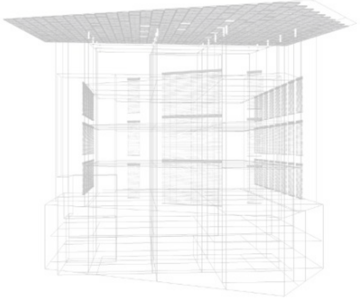

Roof Top PV Panels
Outside
Air
100% Outside Air
Unit with Heat Recovery
Exhaust
Floor 6
Floor 5
Floor 4
Ventilation
Air
Radiant Floor Heating and Cooling
Floor 3
Floor 2
Floor 1
Pump
Water-to-Water
Heat Pump
Hot in Winter | Cold in Summer
Basement
Geothermal Wells

BUILDING LIFE CYCLE

250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL

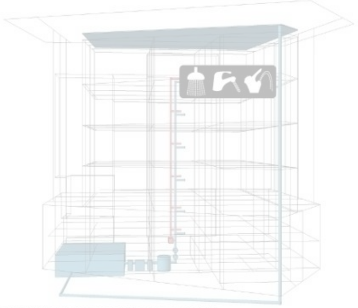


50 YEAR SKIN
HIGH PERFORMANCE ENVELOPE

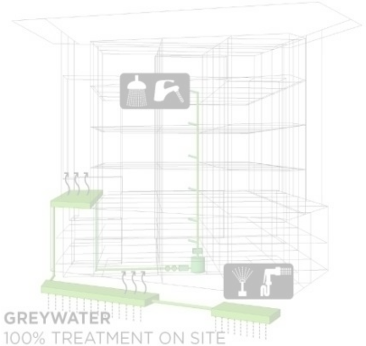


25 YEAR TECHNOLOGY
ACTIVE SOLAR CONTROL
PHOTOVOLTAICS

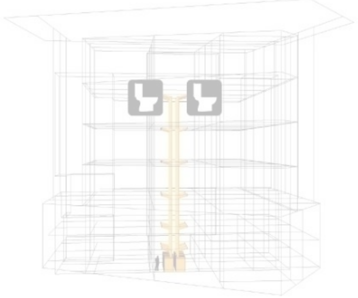
NET ZERO WATER



RAINWATER COLLECTION
100% DEMAND MET ON SITE
50,000 GALLON CISTERN

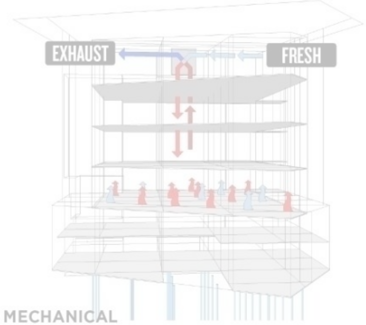


GREYWATER
100% TREATMENT ON SITE
EVAPOTRANSPIRATION & INFILTRATION

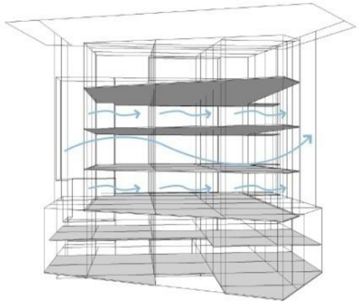


WASTE COMPOST
100% TREATMENT ON SITE

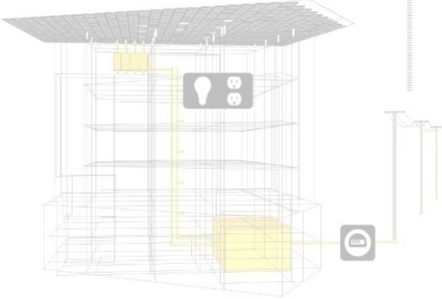
NET ZERO ENERGY



MECHANICAL
GROUND SOURCE HEAT EXCHANGE
RADIANT HEATING/COOLING
HEAT RECOVERY AIR SYSTEM

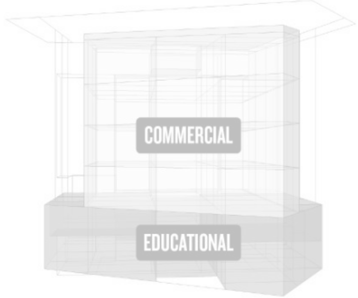


NATURAL VENTILATION
NIGHT FLUSH & OPERABLE WINDOWS

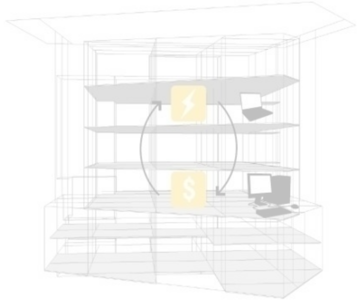


ENERGY
100% RENEWABLE ON SITE
GRID USED AS BATTERY

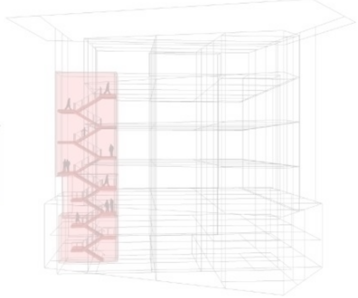
OCCUPANT



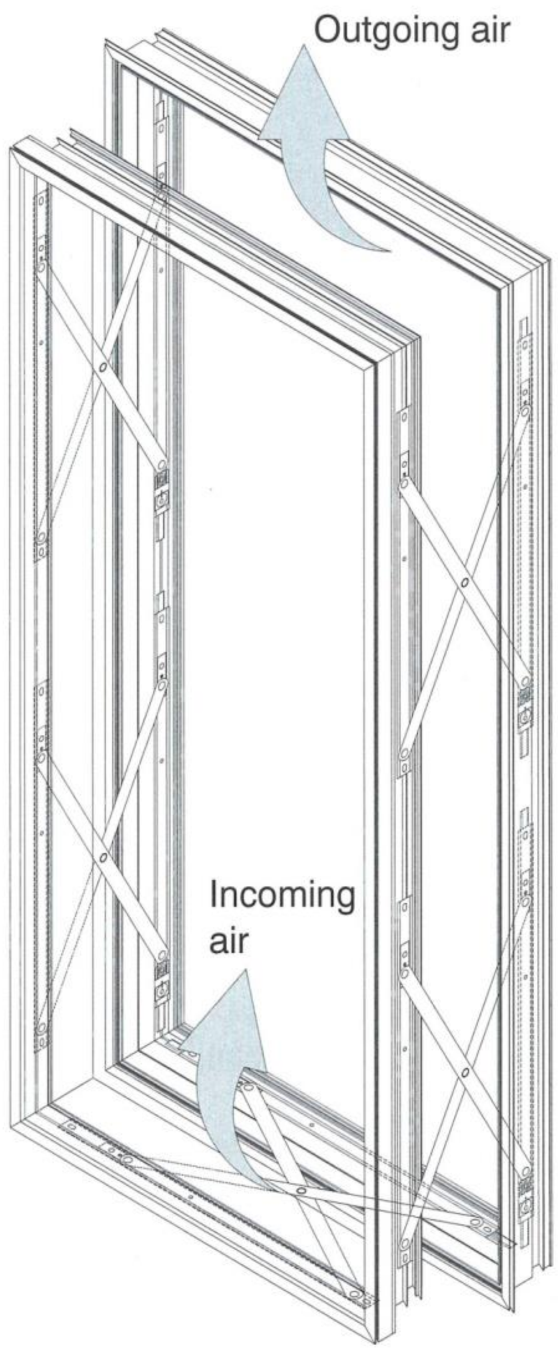
PROGRAM
OCCUPANCY
PRIVATE USERS ABOVE, PUBLIC FOCUS
USERS AT GRADE



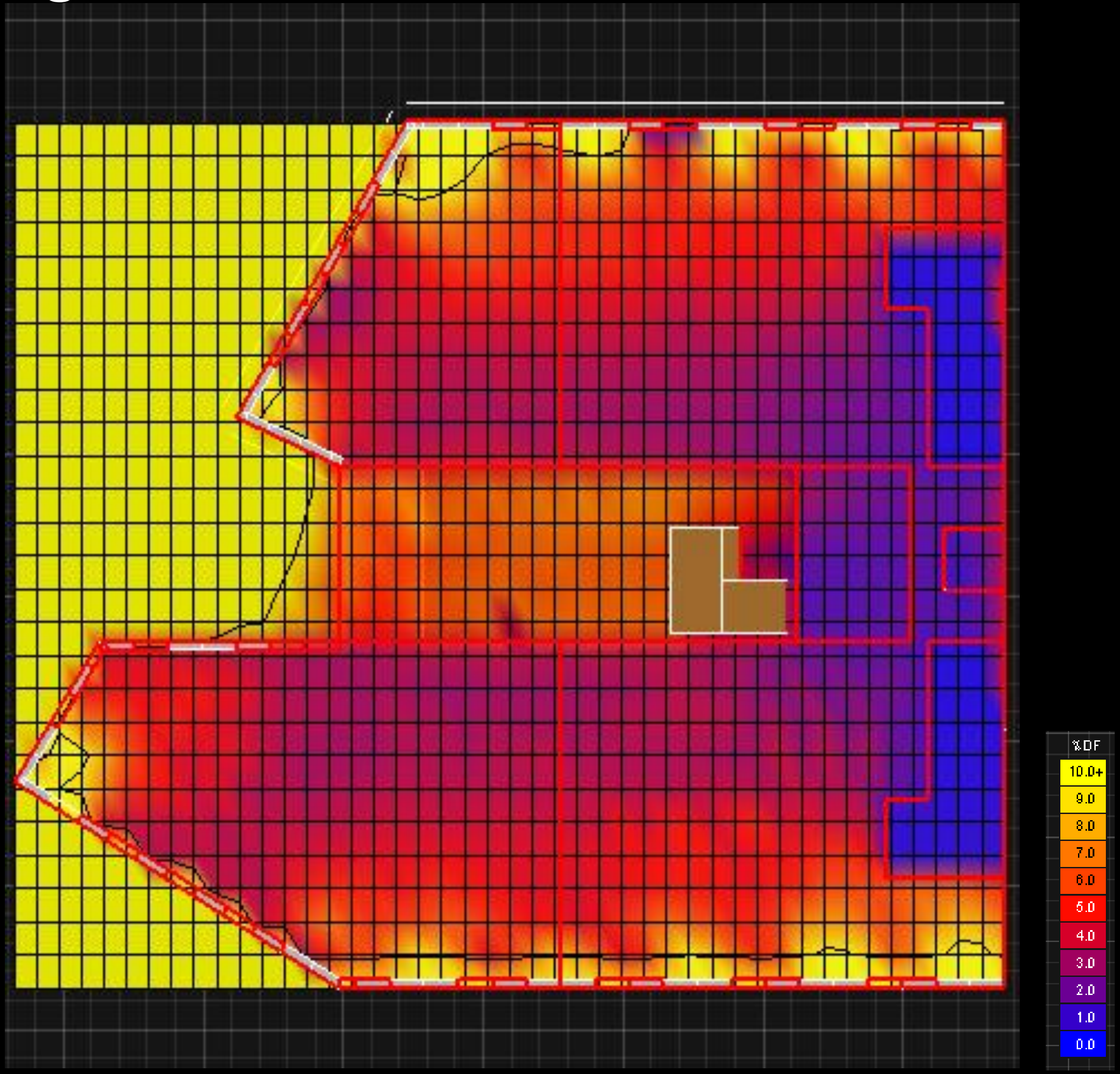
INTERNAL CAP & TRADE
EACH TENANT HAS AN ENERGY BUDGET;
UNUSED ENERGY CAN BE TRANSFERRED



IRRESISTIBLE STAIR
ELEVATOR ALTERNATIVE, HEALTHIER
OCCUPANTS, ENGAGEMENT WITH STREET

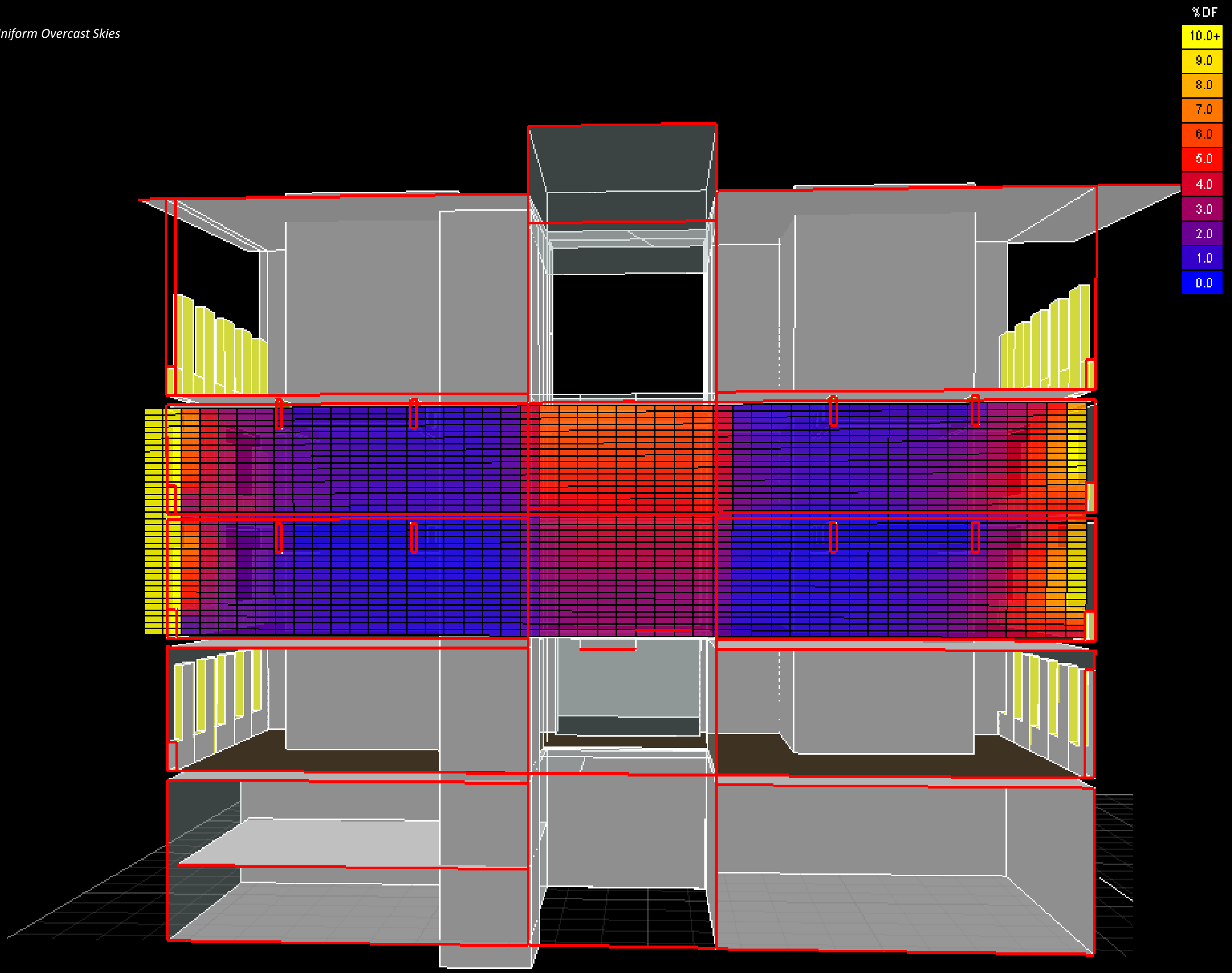

Outgoing air
Incoming air

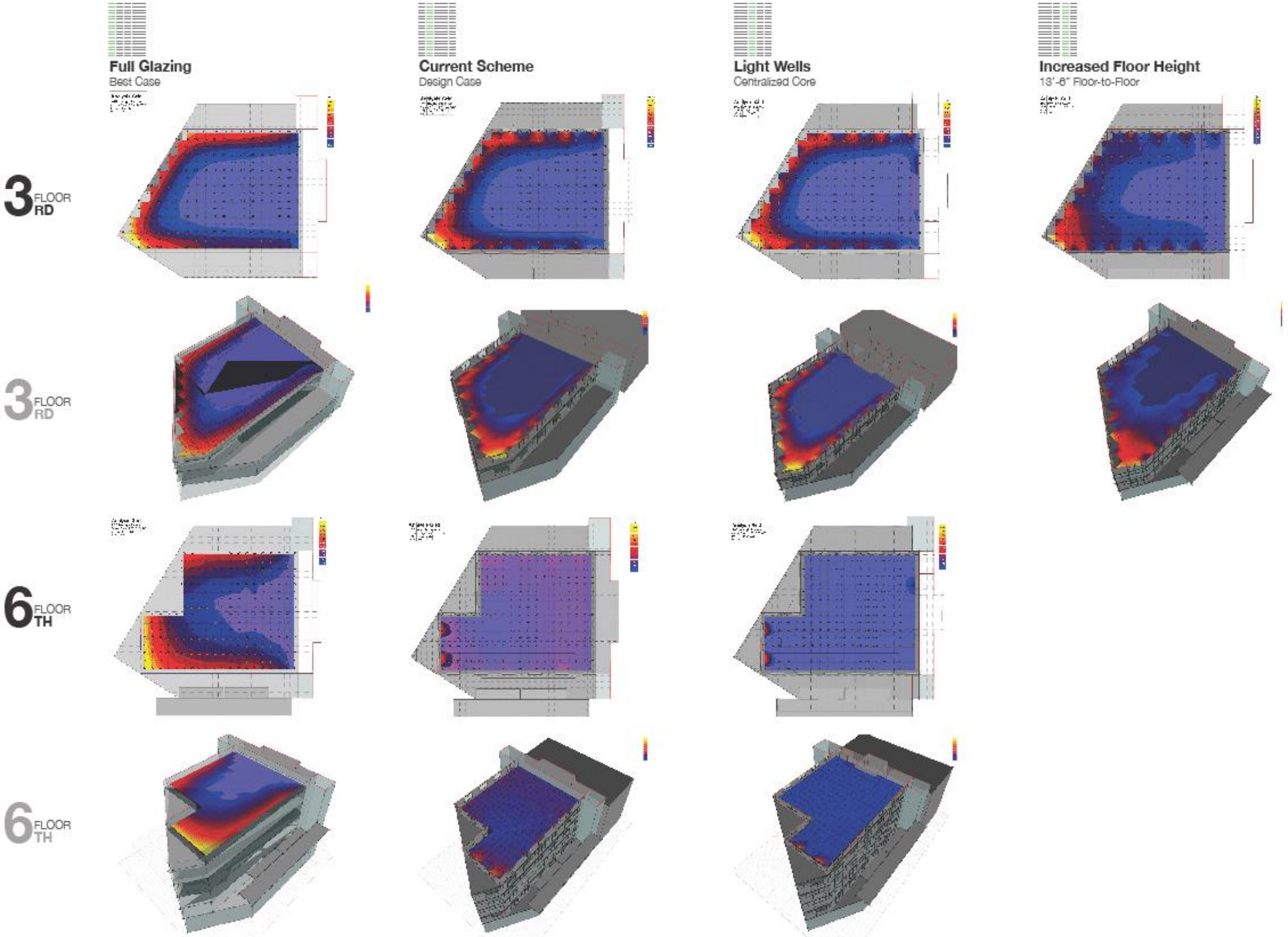
Daylighting Simulation



Daylighting Simulation:

Effect of Atrium – Uniform Overcast Skies



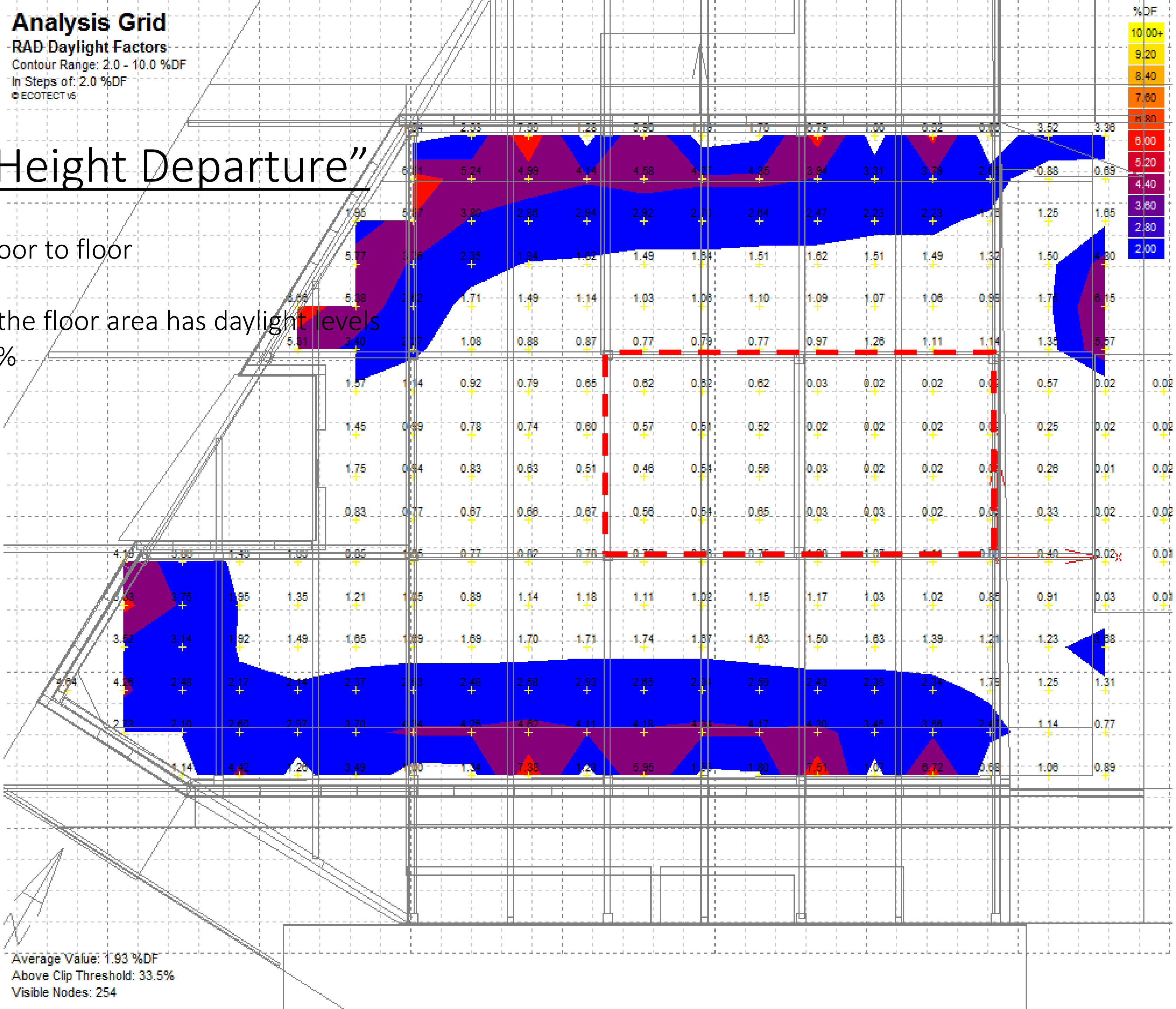


Full Glazing
Best Case
Current Scheme
Design Case
Light Wells
Centralized Core
Increased Floor Height
13'-6" Floor-to-Floor
3 FLOOR RD
3 FLOOR RD
6 FLOOR TH
6 FLOOR TH

No “Height Departure”

11’-6” floor to floor

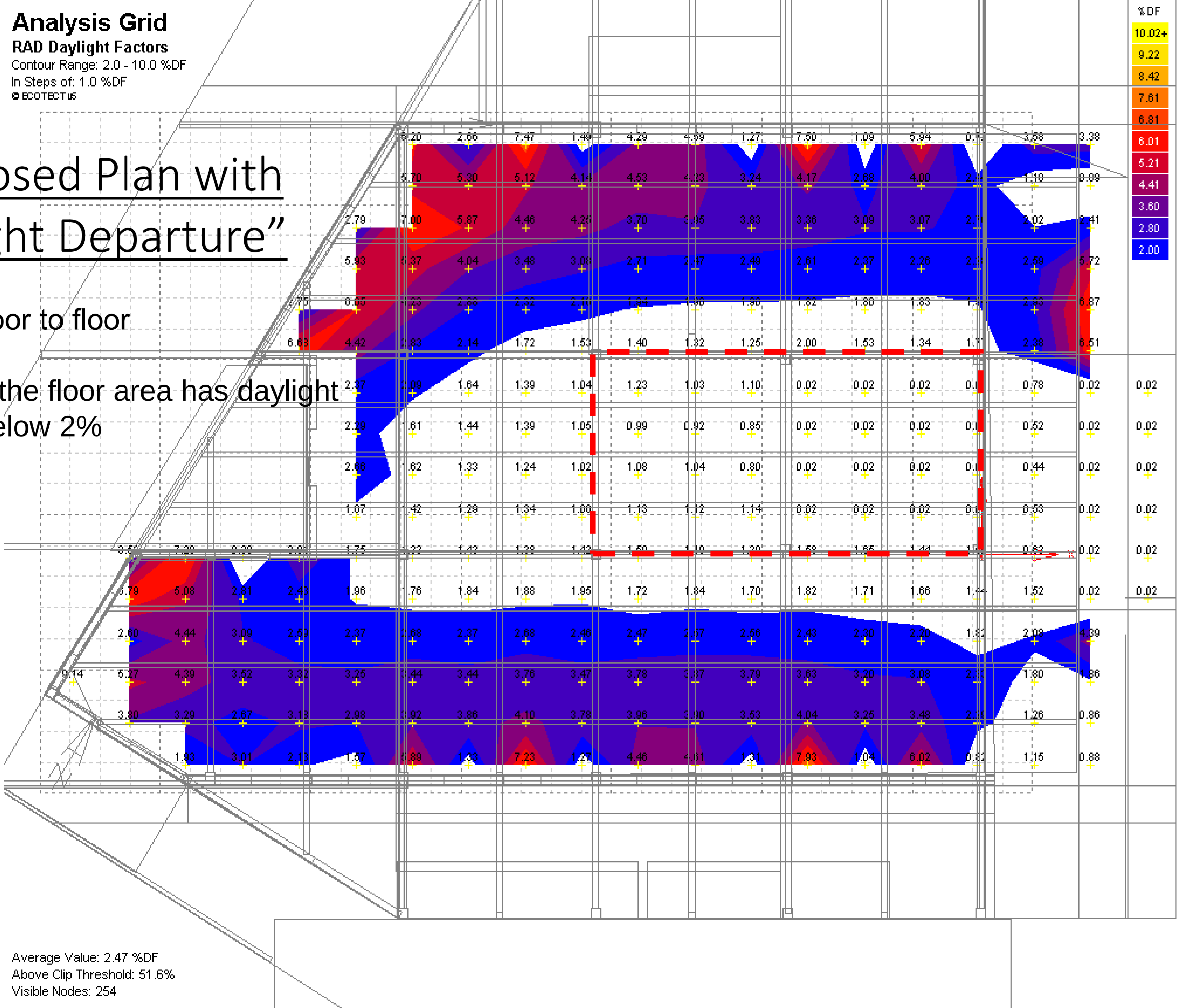
77% of the floor area has daylight levels below 2%



Proposed Plan with “Height Departure”

14’-2” floor to floor

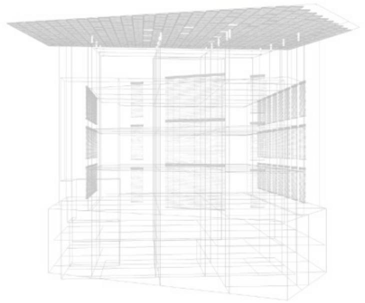
38% of the floor area has daylight levels below 2%



BUILDING LIFE CYCLE

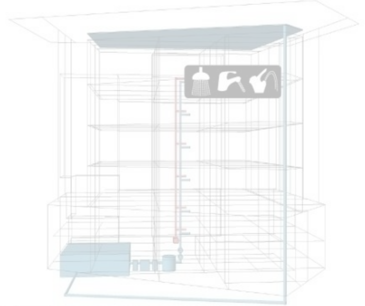
250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL

50 YEAR SKIN
HIGH PERFORMANCE ENVELOPE

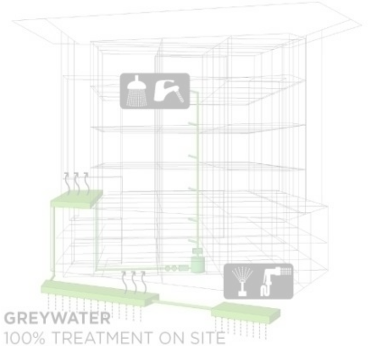


25 YEAR TECHNOLOGY
ACTIVE SOLAR CONTROL
PHOTOVOLTAICS

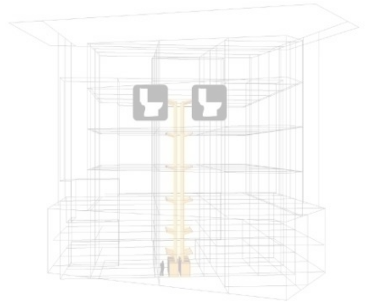
NET ZERO WATER



RAINWATER COLLECTION
100% DEMAND MET ON SITE
50,000 GALLON CISTERN

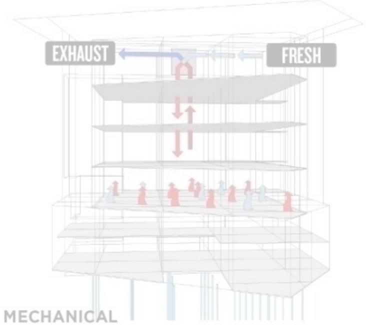


GREYWATER
100% TREATMENT ON SITE
EVAPOTRANSPIRATION & INFILTRATION



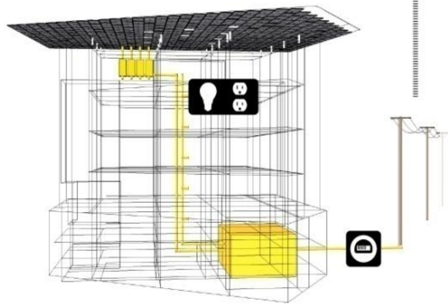
WASTE COMPOST
100% TREATMENT ON SITE

NET ZERO ENERGY



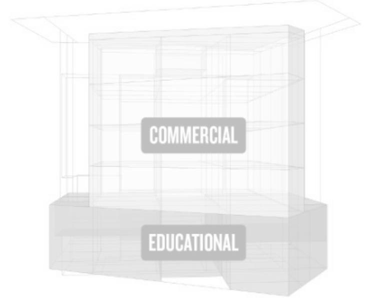
MECHANICAL
GROUND SOURCE HEAT EXCHANGE
RADIANT HEATING/COOLING
HEAT RECOVERY AIR SYSTEM

NATURAL VENTILATION
NIGHT FLUSH & OPERABLE WINDOWS



ENERGY
100% RENEWABLE ON SITE
GRID USED AS BATTERY

OCCUPANT



PROGRAM
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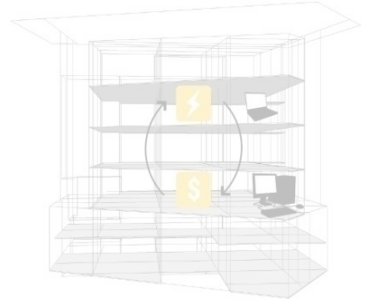
PRIVATE USERS ABOVE, PUBLIC FOCUS
USERS AT GRADE



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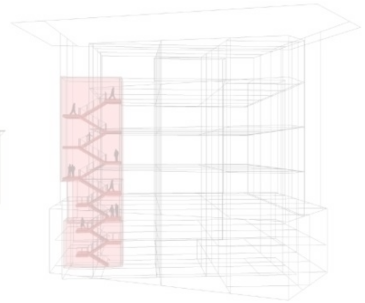

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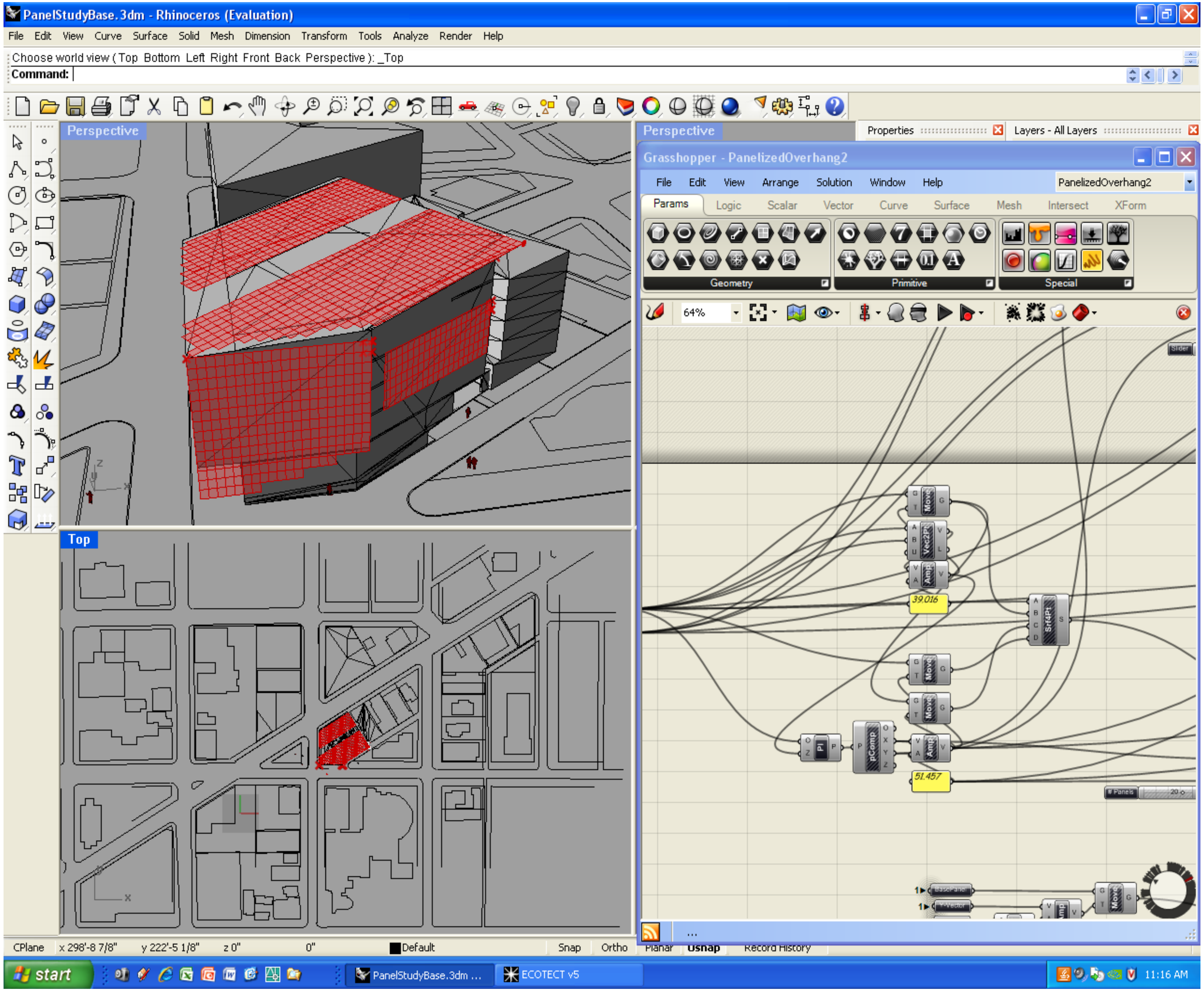
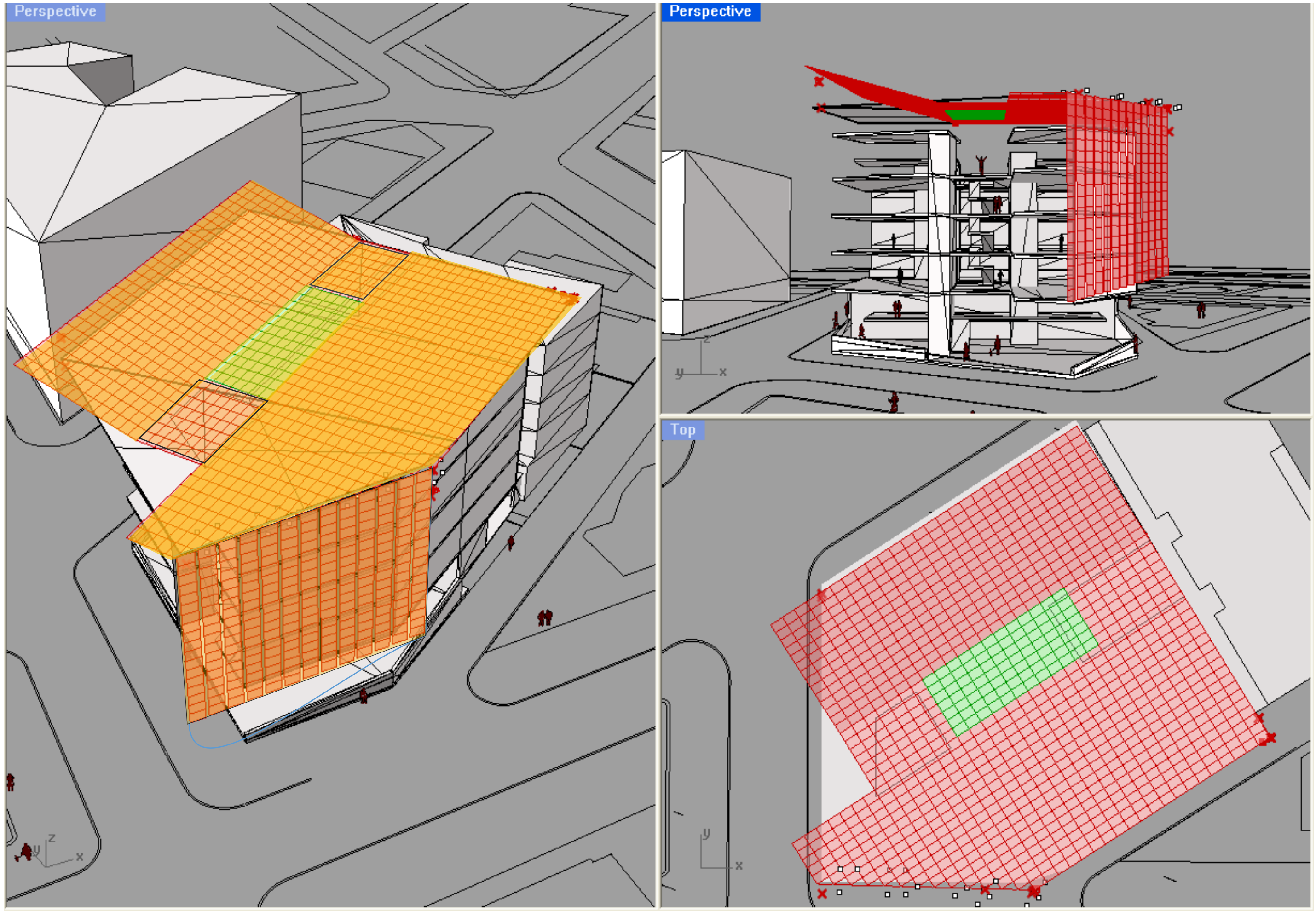

PanelStudyBase.3dm - Rhinoceros (Evaluation)
File Edit View Curve Surface Solid Mesh Dimension Transform Tools Analyze Render Help
Choose world view (Top Bottom Left Right Front Back Perspective): _Top
Command:
Perspective
Top
Perspective
Properties
Layers - All Layers
Grasshopper - PanelizedOverhang2
File Edit View Arrange Solution Window Help
PanelizedOverhang2
Params Logic Scalar Vector Curve Surface Mesh Intersect XForm
Geometry
Primitive
Special
64%
39.016
51.457
CPlane x 298'-8 7/8" y 222'-5 1/8" z 0" 0" Default Snap Ortho Planar Osnap Record History
start
PanelStudyBase.3dm ...
ECOTECT v5
11:16 AM

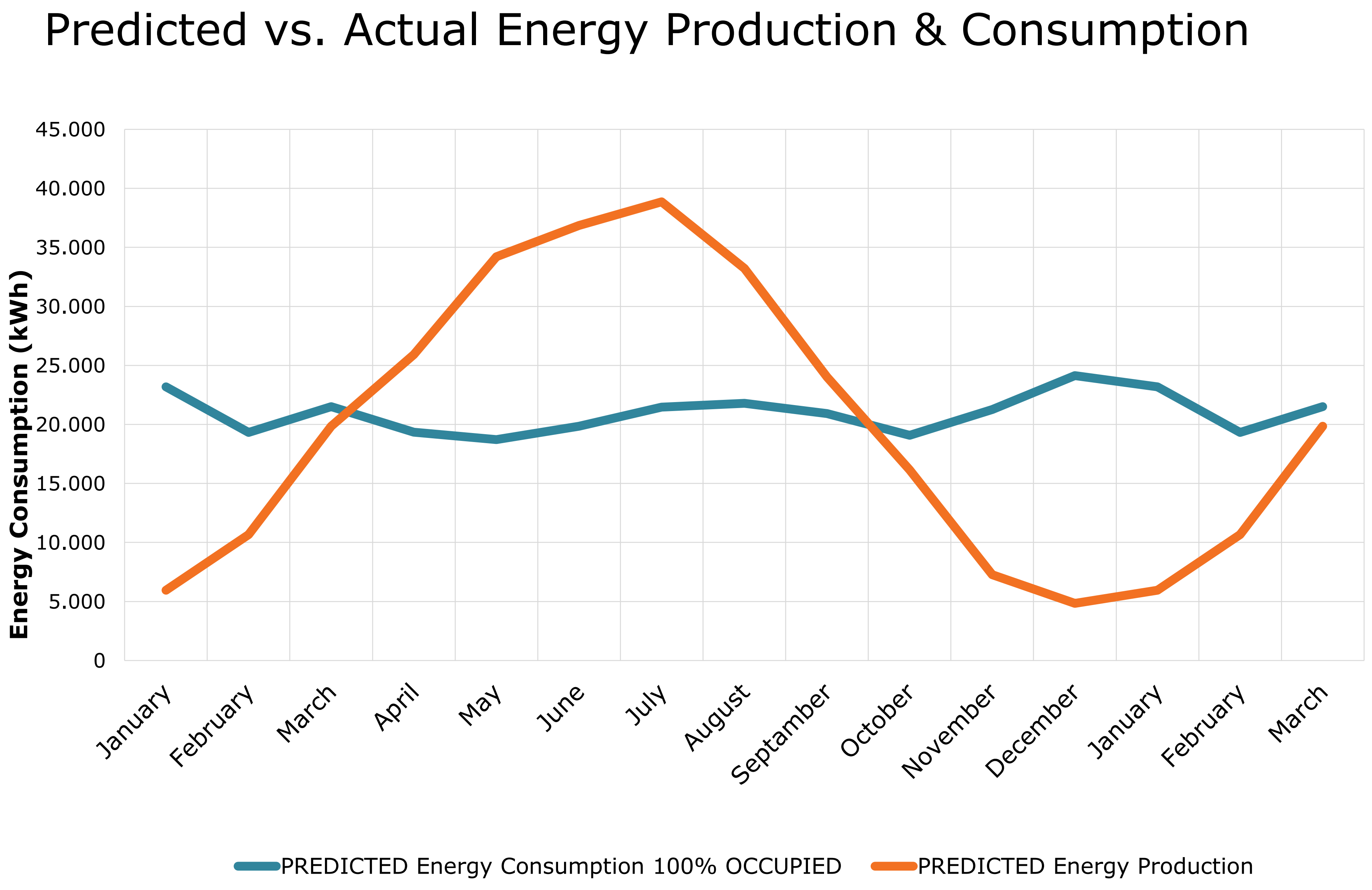
August 12, 2009

Scheme 1a – South Spaced 10.5" (15 deg tilt @ North Roof):

Panel Orientation	Area	Panel #	Sanyo 205	SunPower 315
ROOF SOUTH (5 deg West):	6,272sf =	(503 panels)	101,500 kWh/yr	*(110,500 kWh/yr)*
ROOF MIDDLE (5 deg West):	611sf =	(49 panels)	10,000 kWh/yr	
	524sf * 70% = 367sf =	(42 panels)	7,000 kWh/yr	
(Sliding roof section)	1,048sf * 75% = 785sf =	(84 panels)	12,000 kWh/yr	
ROOF NORTH (5 deg West & 15 deg SE):	4,539sf =	(364 panels)	78,500 kWh/yr	*(85,500 kWh/yr)*
SOUTH WALL:	2,918sf =	(234 panels)	36,000 kWh/yr	
		(1276 panels)	**245,000 kWh/yr**	***(261,000 kWh/yr)***

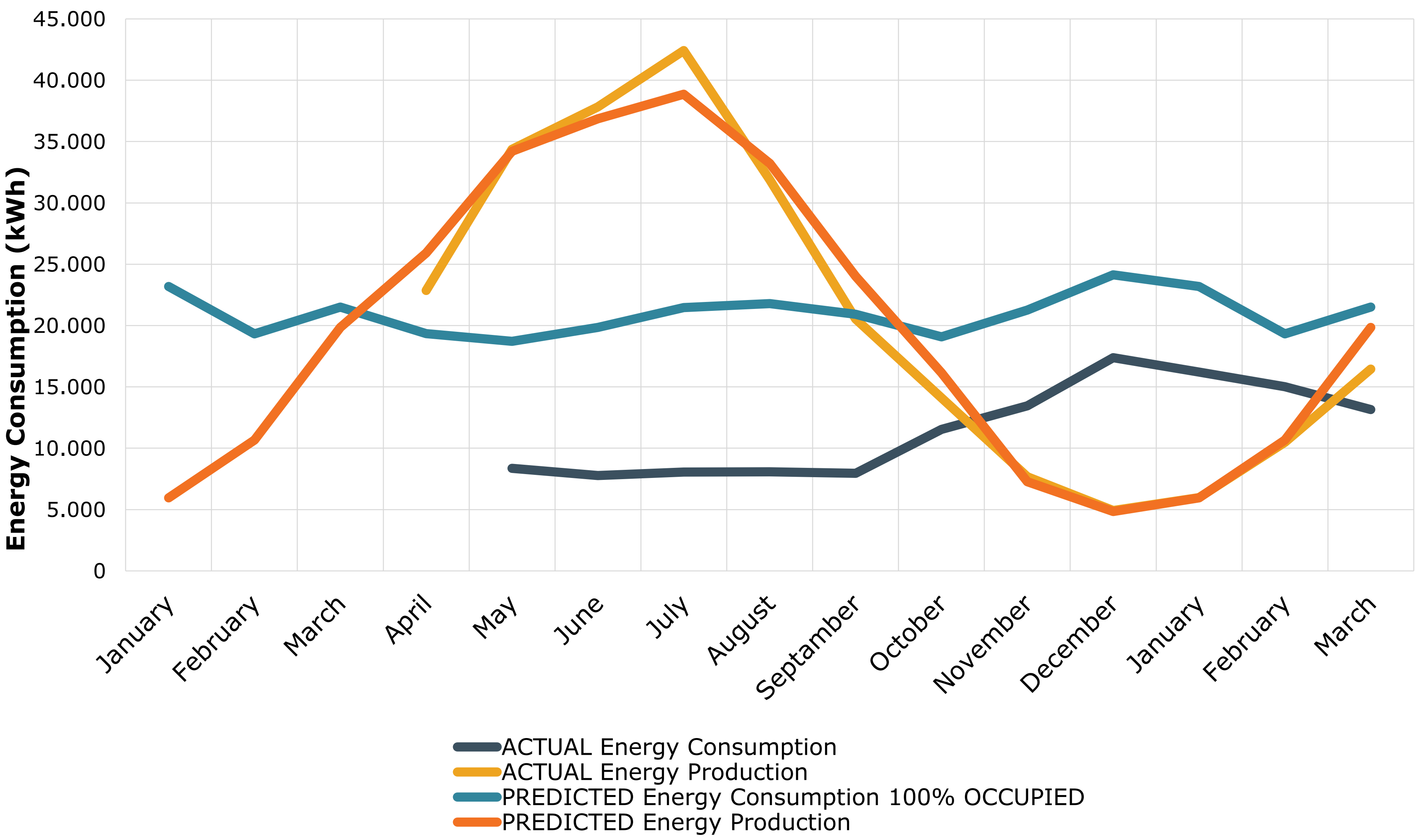


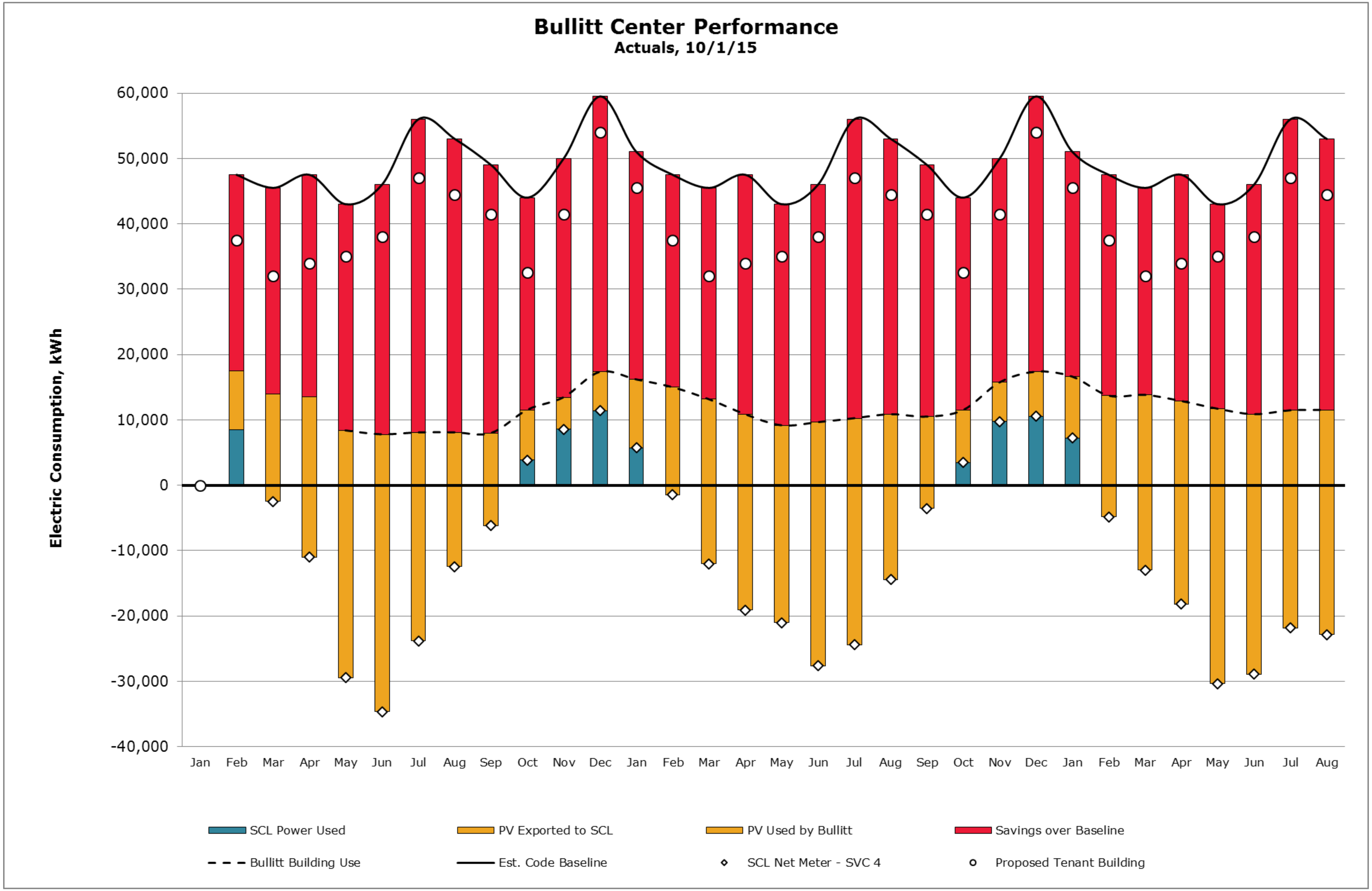
Bullitt Center Energy



Bullitt Center Energy

Predicted vs. Actual Energy Production & Consumption



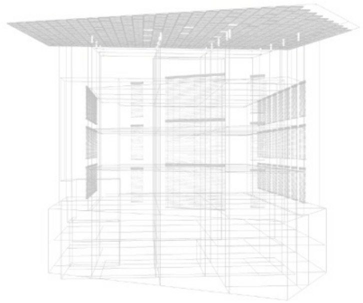


Bullitt Center Performance
Actuals, 10/1/15
Electric Consumption, kWh
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
SCL Power Used
PV Exported to SCL
PV Used by Bullitt
Savings over Baseline
Bullitt Building Use
Est. Code Baseline
SCL Net Meter - SVC 4
Proposed Tenant Building

BUILDING LIFE CYCLE

250 YEAR STRUCTURE
HEAVY TIMBER, CONCRETE & STEEL

50 YEAR SKIN
HIGH PERFORMANCE ENVELOPE



25 YEAR TECHNOLOGY
ACTIVE SOLAR CONTROL
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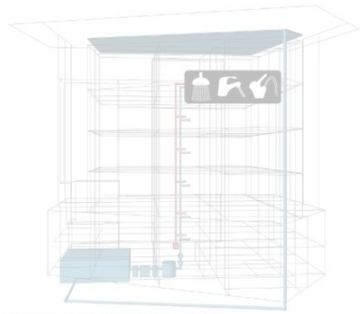
NET ZERO WATER



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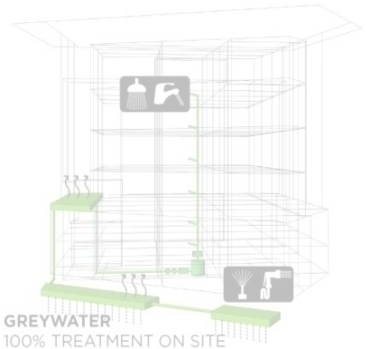

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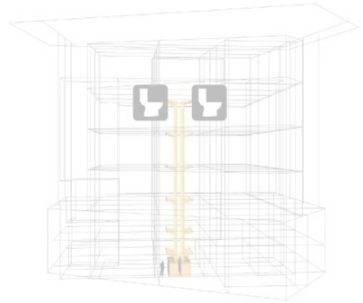
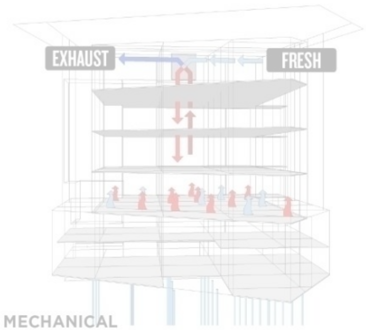


WASTE COMPOST
100% TREATMENT ON SITE

NET ZERO ENERGY



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RADIANT HEATING/COOLING
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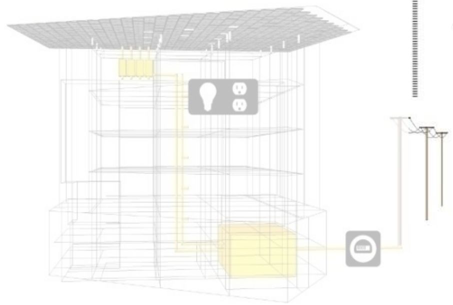
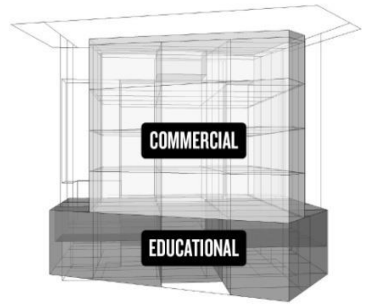
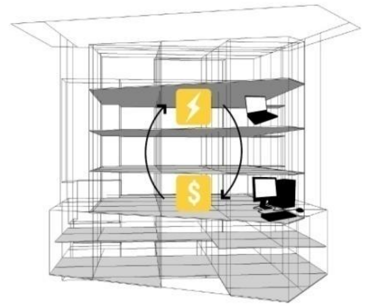


ENERGY
100% RENEWABLE ON SITE
GRID USED AS BATTERY

OCCUPANT



PROGRAM
OCCUPANCY
PRIVATE USERS ABOVE, PUBLIC FOCUS USERS AT GRADE



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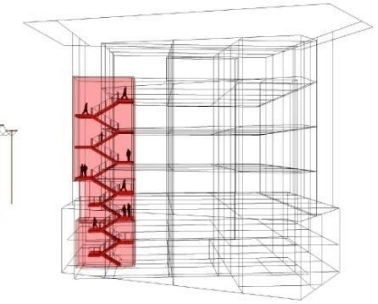
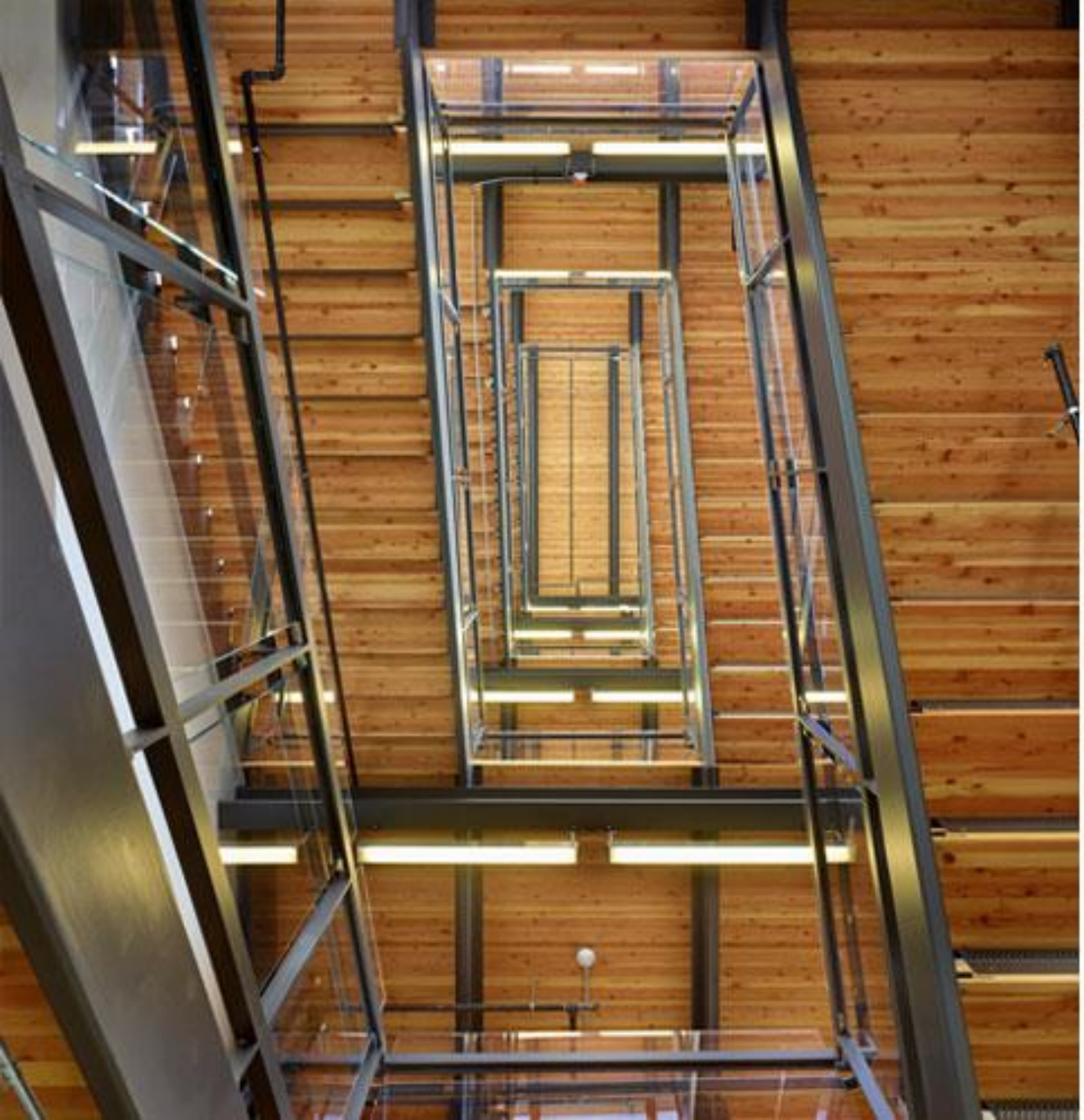
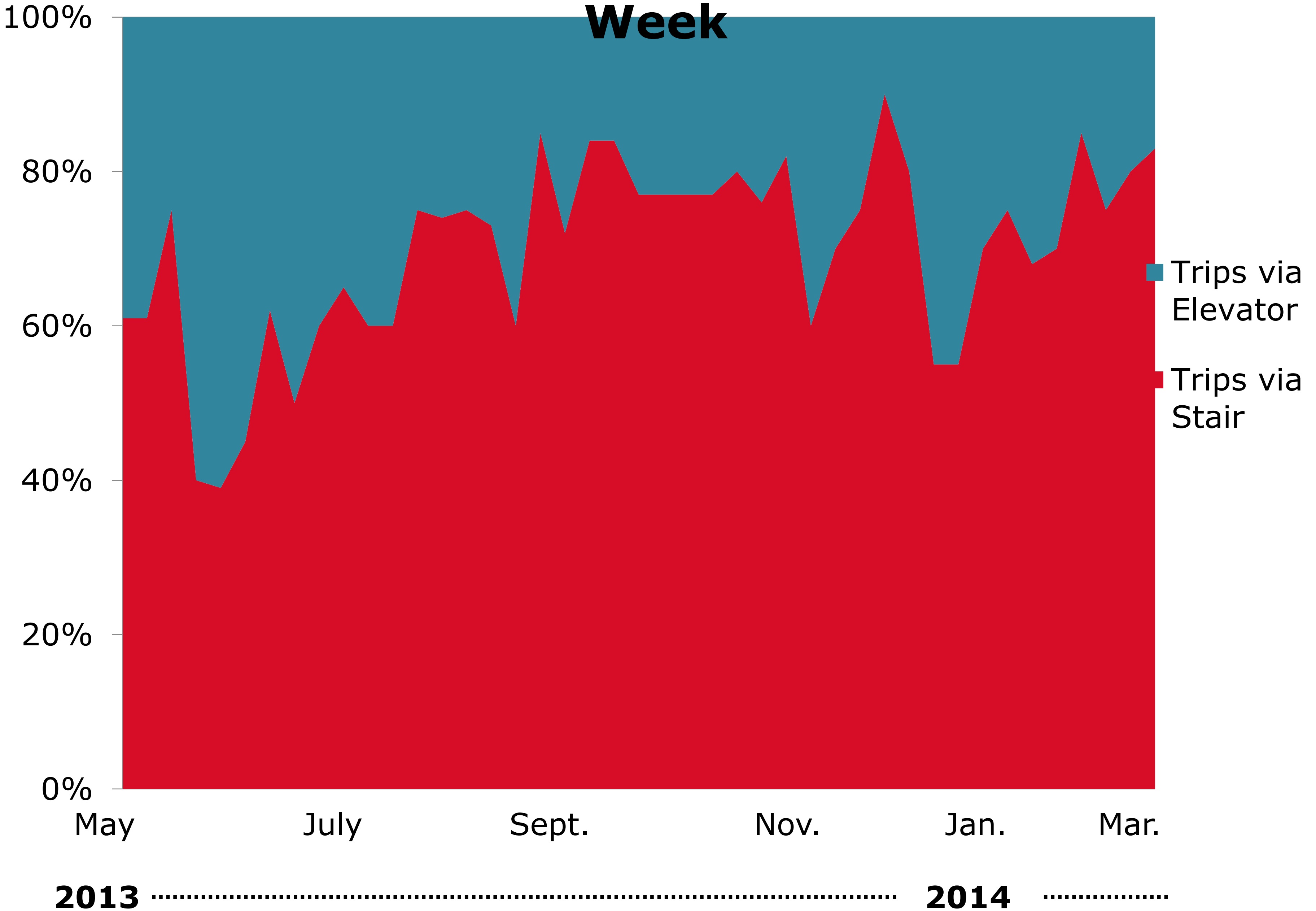


IRRESISTIBLE STAIR
ELEVATOR ALTERNATIVE, HEALTHIER OCCUPANTS, ENGAGEMENT WITH STREET


EAT ORGANIC FOODS




Modes of Arrival to the 6th Floor by Week



Research by: Heather Burpee, University of Washington Integrated Design Lab

Asbestos
Cadmium
Chlorinated Polyethylene
Chlorosulfonated Polyethlene
Chlorofluorocarbons (CFC)
Chloroprene (neoprene)
Formaldehyde
Halogenated Flame Retardants
Hydrochlorofluorcarbons (HCFC)
Lead
Mercury
Petrochemical Fertilizers and Pesticides
Phthalates
Polyvinyl Chloride (PVC)
Creosote, Arsenic Wood treatment

362 CHEMICALS

(1,2-BENZENEDICARBOXYLATO(2-))DIOXOTRILEAD [CAS RN: 69011-06-9]
1,3-BENZENEDIOL, 2,4,6-TRINITRO-, LEAD SALT [CAS RN: 15245-44-0]
CHROMIUM LEAD SILICATE [CAS RN: 11113-70-5]
CYCLO-DI-:-OXO(:-PHTHALATO)TRILEAD [CAS RN: 17976-43-1]
LEAD [CAS RN: 7439-92-1]
LEAD ACETATE [CAS RN: 301-04-2]
LEAD ACETATE, TRIHYDRATE [CAS RN: 6080-56-4]
LEAD ARSENATE [CAS RN: 7784-40-9]
LEAD ARSENITE [CAS RN: 10031-13-7]
LEAD AZIDE [CAS RN: 13424-46-9]
LEAD CARBONATE [CAS RN: 598-63-0]
LEAD CHLORIDE [CAS RN: 7758-95-4]
LEAD CHROMATE [CAS RN: 7758-97-6]
LEAD CHROMATE MOLYBDATE SULFATE RED [CAS RN: 12656-85-8]
LEAD DIOXIDE [CAS RN: 1309-60-0]
LEAD FLUOBORATE [CAS RN: 13814-96-5]
LEAD FLUORIDE [CAS RN: 7783-46-2]
LEAD FLUOROSILICATE [CAS RN: 25808-74-6]
LEAD IODIDE [CAS RN: 10101-63-0]
LEAD NITRATE, CRYSTAL [CAS RN: 10099-74-8]
LEAD OXIDE (LITHARGE) [CAS RN: 1317-36-8]
LEAD OXIDE, RED [CAS RN: 1314-41-6]
LEAD PHOSPHATE [CAS RN: 7446-27-7]
LEAD SILICATE [CAS RN: 11120-22-2]
LEAD STEARATE [CAS RN: 7428-48-0]
LEAD SUB-ACETATE [CAS RN: 1335-32-6]
LEAD SUB-CARBONATE [CAS RN: 1319-46-6]
LEAD SULFIDE [CAS RN: 1314-87-0]
LEAD SULFOCHROMATE YELLOW (C.I. PIGMENT YELLOW 34) [CAS RN: 134
LEAD SULPHATE [CAS RN: 7446-14-2]
LEAD TETRAACETATE [CAS RN: 546-67-8]
LEAD THIOCYANATE [CAS RN: 592-87-0]
LEAD(II) METHANESULPHONATE [CAS RN: 17570-76-2]
LEAD, ISOTOPE OF MASS 214 [CAS RN: 15067-28-4]
LEAD-210 [CAS RN: 14255-04-0]
TETRAETHYL LEAD [CAS RN: 78-00-2]
TETRAMETHYL LEAD [CAS RN: 75-74-1]
1,1,1,2-TETRACHLOR-2,2-DIFLUOROETHANE (CFC-112A) [CAS RN: 76-11-9
1,1,1,2-TETRAFLUORO-2,2-DICHLOROETHANE (CFC-114A) [CAS RN: 374-0
1,1,1,3-Tetrachloro-2,2,3,3-tetrafluoropropane (CFC-214cb) [CAS RN: 2268-46
1,1,2,2-TETRACHLORO-1,2-DIFLUOROETHANE (CFC-112) [CAS RN: 76-12-0
1,1,2-TRICHLOROTRIFLUOROETHANE (CFC-113) [CAS RN: 76-13-1]
1,1,3-Trichloro-1,2,2,3,3-pentafluoropropane (CFC-215) [CAS RN: 1652-81-9
2-Chloro-1,1,1,2,3,3,3-heptafluoropropane (CFC-217ba) [CAS RN: 76-18-6]
BROMOCHLORODIFLUOROMETHANE (CFC-12B1) [CAS RN: 353-59-3]
BROMOTRIFLUOROMETHANE (CFC-13B1) [CAS RN: 75-63-8]
CHLOROHEPTAFLUOROPROPANE (CFC-217) [CAS RN: 422-86-6]
CHLOROPENTAFLUOROETHANE (CFC-115) [CAS RN: 76-15-3]
CHLOROTRIFLUOROMETHANE (CFC-13) [CAS RN: 75-72-9]
DICHLORODIFLUOROMETHANE (CFC-12) [CAS RN: 75-71-8]
DICHLOROHEXAFLUOROPROPANE (CFC-216) [CAS RN: 661-97-2]
DICHLOROTETRAFLUOROETHANE (CFC-114) [CAS RN: 76-14-2]
HEPTACHLOROFLUOROPROPANE (CFC-211) [CAS RN: 422-78-6]
HEXACHLORODIFLUOROPROPANE (CFC-212) [CAS RN: 3182-26-1]
PENTACHLOROFLUOROETHANE (CFC-111) [CAS RN: 354-56-3]
PENTACHLOROFLUOROETHANE (CFC-111) [CAS RN: 354-56-3]
PENTACHLOROTRIFLUOROPROPANE (CFC-213 ISOMER) [CAS RN: 134237-
PENTACHLOROTRIFLUOROPROPANE (CFC-213 ISOMER) [CAS RN: 134237-
PENTACHLOROTRIFLUOROPROPANE (CFC-213) [CAS RN: 2354-06-5]
TETRACHLOROTETRAFLUOROPROPANE (CFC-214) [CAS RN: 29255-31-0]
TRICHLOROFLUOROMETHANE (CFC-11) [CAS RN: 75-69-4]
TRICHLOROPENTAFLUOROPROPANE (CFC-215) [CAS RN: 4259-43-2]
TRICHLOROTRIFLUOROETHANE (CFC-113 ISOMER) [CAS RN: 354-58-5]
4-TOLUENESULFONAMIDE FORMALDEHYDE [CAS RN: 1338-51-8]
AMMONIA-UREA-FORMALDEHYDE [CAS RN: 27967-29-9]
BENZENESULFONIC ACID, 4-HYDROXY-, POLYMER WITH FORMALDEHYDE
BUTYLATED POLYOXYMETHYLENE UREA [CAS RN: 68002-19-7]
CRESOL FORMALDEHYDE [CAS RN: 68003-26-9]
FORMALDEHYDE [CAS RN: 50-00-0]
FORMALDEHYDE CYANOHYDRIN [CAS RN: 107-16-4]
FORMALDEHYDE, COMPD WITH MONOSODIUM SULFITE (1:1) [CAS RN: 87
FORMALDEHYDE, MELAMINE POLYMER, METHYLATED [CAS RN: 68002-20
FORMALDEHYDE, POLYMER WITH 4-(1,1-DIMETHYLETHYL)PHENOL, METH
FORMALDEHYDE, POLYMER WITH PHENOL, POTASSIUM SALT [CAS RN: 12
FORMALDEHYDE, POLYMERS WITH ISOBUTYLENATED PHENOL [CAS RN: (
FORMALDEHYDE, UREA ADDUCT [CAS RN: 68611-64-3]
MELAMINE FORMALDEHYDE [CAS RN: 9003-08-1]
MELAMINE FORMALDEHYDE [CAS RN: 94645-56-4]
MELAMINE-UREA-FORMALDEHYDE (MUF) [CAS RN: 25036-13-9]
NAPHTHALENESULFONIC ACID, FORMALDEHYDE POLYMER, AMMONIUM
NAPHTHALENESULFONIC ACID, FORMALDEHYDE POLYMER, CALCIUM SA
NAPHTHALENESULFONIC ACID, POLYMER WITH FORMALDEHYDE, POTAS
O-CRESOL FORMALDEHYDE EPOXY [CAS RN: 29690-82-2]

PENTACHLOROTRIFLUOROPROPANE (CFC-213 ISOMER) [CAS RN: 134237-
PENTACHLOROTRIFLUOROPROPANE (CFC-213) [CAS RN: 2354-06-5]
TETRACHLOROTETRAFLUOROPROPANE (CFC-214) [CAS RN: 29255-31-0]
TRICHLOROFLUOROMETHANE (CFC-11) [CAS RN: 75-69-4]
TRICHLOROPENTAFLUOROPROPANE (CFC-215) [CAS RN: 4259-43-2]
TRICHLOROTRIFLUOROETHANE (CFC-113 ISOMER) [CAS RN: 354-58-5]
4-TOLUENESULFONAMIDE FORMALDEHYDE [CAS RN: 1338-51-8]
AMMONIA-UREA-FORMALDEHYDE [CAS RN: 27967-29-9]
BENZENESULFONIC ACID, 4-HYDROXY-, POLYMER WITH FORMALDEHYDE
BUTYLATED POLYOXYMETHYLENE UREA [CAS RN: 68002-19-7]
CRESOL FORMALDEHYDE [CAS RN: 68003-26-9]
FORMALDEHYDE [CAS RN: 50-00-0]
FORMALDEHYDE CYANOHYDRIN [CAS RN: 107-16-4]
FORMALDEHYDE, COMPD WITH MONOSODIUM SULFITE (1:1) [CAS RN: 87
FORMALDEHYDE, MELAMINE POLYMER, METHYLATED [CAS RN: 68002-20
FORMALDEHYDE, POLYMER WITH 4-(1,1-DIMETHYLETHYL)PHENOL, METH
FORMALDEHYDE, POLYMER WITH PHENOL, POTASSIUM SALT [CAS RN: 12
FORMALDEHYDE, POLYMERS WITH ISOBUTYLENATED PHENOL [CAS RN: (
FORMALDEHYDE, UREA ADDUCT [CAS RN: 68611-64-3]
MELAMINE FORMALDEHYDE [CAS RN: 9003-08-1]
MELAMINE FORMALDEHYDE [CAS RN: 94645-56-4]
MELAMINE-UREA-FORMALDEHYDE (MUF) [CAS RN: 25036-
NAPHTHAL... FORMALDEHYDE ...
NAPHTH... FORMALDEHYDE ...
NAPHTH... SULFONIC A... POLYMER WITH ... ALDEHYDE, P...
O-CRE... FORMALDEHYDE ... [CAS RN: ...82-2]
P-TERT-BUTYLPHENOL FORM...HYDE [CAS RN: 25085-50-1]
PARAFORMALDEHYDE [CAS ... 525-89-4]
PHENOL FORMALDEHYDE ... 9003-35
PHENOL FORMALDEH... POLYMER HEXAM...
PHENOL-RESORC... FORMALDEHYDE RE...
RESORCINOL FO... [CAS RN: 24...
ROSIN, FORMALDEHYDE, F... ACID PO... POTASSIUM SAL
ROSIN, FORMALDEHYDE, FUM... ACID P... POTASSIUM SALT
SODIUM POLYNAPTHALENESU... [CAS ...9084-06-4]
TOLUENESULFONAMIDE FORM...YDE [C... 25035-71-6]
UREA ...NDED PHENOL-MEL... FORMA... YDE RESIN [CAS R
UREA ...ALDEHYDE [CAS R... 1-05-6]
UREA F... FORMALDEH... 2518...
XYLENE ... 26139-75-3]
CADMIUM ...
CADMIUM 2-ETHYLHEXANOATE [CAS RN: 2420-98-6]
CADMIUM ACETATE [CAS RN: 543-90-8]
CADMIUM ACETATE, DIHYDRATE [CAS RN: 5743-04-4]
CADMIUM BROMIDE [CAS RN: 7789-42-6]
CADMIUM CARBONATE [CAS RN: 513-78-0]
CADMIUM CHLORIDE, 2.5 HYDRATE [CAS RN: 7790-78-5]
CADMIUM CHLORIDE, ANHYDROUS [CAS RN: 10108-64-2]
CADMIUM CYANIDE [CAS RN: 542-83-6]
CADMIUM FLUORIDE [CAS RN: 7790-79-6]
CADMIUM FLUOROSILICATE [CAS RN: 17...-21-8]
CADMIUM IODIDE [CAS RN: 7790-80-9]
CADMIUM NITRATE ... 10022-68-1]
CADMIUM OXIDE [CAS RN: 1306-19-0]
CADMIUM STEARATE [CAS RN: 2223-93-0]
CADMIUM SULFATE, ANHYDROUS [CAS RN: 10124-36-4]
CADMIUM SULFATE, HYDRATE [CAS RN: 7790-84-3]
CADMIUM SULFIDE [CAS RN: 1306-23-6]
ALPHA-HEXABROMOCYCLODODECANE (a-HBCD) [CAS RN: 134237-50-6]
BIS(2-ETHYL-1-HEXYL)TETRABROMOPHTHALATE (TBPH) [CAS RN: 26040-5
BIS(2-HYDROXYETHYL ETHER) (TBBPA) [CAS RN: 4162-45-2]
ETHYLENE BIS(TETRABROMOPHTHALIMIDE) [CAS RN: 32588-76-4]
1,2-BENZENEDICARBOXYLIC ACID, 3,4,5,6-TETRABROMO-, MIXED ESTERS
1,2-BIS(2,4,6-TRIBROMOPHENOXY)ETHANE (BTBPE) [CAS RN: 37853-59-1]
2,2',3,3',4,5',6-HEPTABROMODIPHENYL ETHER (BDE-175) [CAS RN: 446255
2,2',3,4',5',6'-HEPTABROMODIPHENYL ETHER (BDE-183) [CAS RN: 189084-6
2,2',3,4,4',5',6-HEPTABROMODIPHENYL ETHER (OCTABDE BDE-183) [CAS R
2,2',3,4,4'-PENTABROMODIPHENYL ETHER (BDE 85) [CAS RN: 182346-21-0
2,2',4,4',5,5'-HEXABROMODIPHENYL ETHER (BDE-153) [CAS RN: 68631-49-
2,2',4,4',5,6'-HEXABROMODIPHENYL ETHER (BDE-154) [CAS RN: 207122-15
2,2',4,4',5-PENTABROMODIPHENYL ETHER (BDE-99) [CAS RN: 60348-60-9]
2,2',4,4',6-PENTABROMODIPHENYL ETHER (BDE-100) [CAS RN: 189084-64-
2,2',4,4'-TETRABROMODIPHENYL ETHER (BDE-47) [CAS RN: 5436-43-1]
2,2'-[(1-METHYLETHYLIDENE)BIS[(2,6-DIBROMO-4,1-PHENYLENE) [CAS RN
2,3-DIBROMOPROPYL-2,4,6-TRIBROMOPHENYL ETHER (DPTE) [CAS RN: 3
2,3-DIBROMOPROPYL-2,4,6-TRIBROMOPHENYL ETHER (DPTE) [CAS RN: 3
2,4,4'-TRIBROMODIPHENYL ETHER (BDE-28) [CAS RN: 41318-75-6]
2,4,5,2',4',5'-HEXABROMOBIPHENYL [CAS RN: 59080-40-9]
2,4,5,2',4',5'-HEXABROMOBIPHENYL [CAS RN: 59080-40-9]
2,4,6-TRIBROMOPHENOL [CAS RN: 118-79-6]
2,4,6-TRIBROMOPHENYL TERMINATED CARBONATE OLIGOMER [CAS RN:
2-ETHYLHEXYL-2,3,4,5-TETRABROMOBENZOATE (TBB) [CAS RN: 183658-2
2-HYDROXY-PROPYL-2-(2-HYDROXY-ETHOXY)-ETHYL-TBP [CAS RN: 20566
BENZENE, ETHENYL-, HOMOPOLYMER, BROMINATED [CAS RN: 88497-56-
BETA-HEXABROMOCYCLODODECANE (B-HBCD) [CAS RN: 134237-51-7]

DICHLOROPENTAFLUOROPROPANE (HCFC-225CA) [CAS RN: 422-56-0]
DICHLOROPENTAFLUOROPROPANE (HCFC-225CB) [CAS RN: 507-55-1]
DICHLOROTETRAFLUOROPROPANE (HCFC-234) [CAS RN: 425-94-5]
Dichlorotetrafluoropropane (HCFC-234) [CAS RN: 127564-83-4]
DICHLOROTRIFLUOROETHANE (HCFC-123) [CAS RN: 306-83-2]
DICHLOROTRIFLUOROPROPANE (HCFC-243) [CAS RN: 460-69-5]
Dichlorotrifluoropropane (HCFC-243) [CAS RN: 116890-51-8]
HEXACHLOROFLUOROPROPANE (HCFC-221) [CAS RN: 422-26-4]
MONOCHLORODIFLUOROETHANE (HCFC-142B) [CAS RN: 75-68-3]
MONOCHLORODIFLUOROPROPANE (HCFC-262) [CAS RN: 421-02-03]
MONOCHLOROFLUOROMETHANE (HCFC-31) [CAS RN: 593-70-4]
MONOCHLOROFLUOROPROPANE (HCFC-271) [CAS RN: 430-55-7]
MONOCHLOROHEXAFLUOROPROPANE (HCFC-226) [CAS RN: 431-87-8]
MONOCHLOROPENTAFLUOROPROPANE (HCFC-235) [CAS RN: 460-92-4]
MONOCHLOROTETRAFLUOROETHANE (HCFC-124) [CAS RN: 2837-89-0]
MONOCHLOROTETRAFLUOROPROPANE (HCFC-244) [CAS RN: 134190-50-
MONOCHLOROTETRAFLUOROPROPANE (HCFC-251) [CAS RN: 421-41-0]
MONOCHLOROTRIFLUOROETHANE (HCFC-133A) [CAS RN: 75-88-7]
MONOCHLOROTRIFLUOROPROPANE (HCFC-253B) [CAS RN: 460-35-5]
PENTACHLORODIFLUOROPROPANE (HCFC-222) [CAS RN: 422-49-1]
PENTACHLOROFLUOROPROPANE (HCFC-231) [CAS RN: 421-94-3]
TETRACHLORODIFLUOROPROPANE (HCFC-232) [CAS RN: 460-89-9]
TETRACHLO... (HCFC-121) [CAS RN: 354-14-3]
TETRACH... (HCFC-241) [CAS RN: 666-27-3]
Tetrachl... ropane (H... [CAS RN: 134190-49-1]
TETRA... TRIFLUOROP... (HCFC-223) [CAS RN: 422-52-6]
TRICH... DIFLUOROETHANE ...-122) [CAS RN: 354-21-2]
TRICH... DIFLUOROPROPAN... -242) [CAS RN: 460-63-9]
Trichlorodifluoropropane (HCFC... AS RN: 127564-90-3]
TRICHLOROFLUOROETHANE ...131) [CAS RN: 359-28-4]
Trichlorofluoropropane (HCFC... AS RN: 134190-51-5]
TRICHLOROTRIFLUOROPRO... (HCFC-224) [CAS RN: 422-54-8]
TRICHLOROTRIFLUORO... (HCFC-233) [CAS RN: 7125-84-0]
2-METHOXYETHYLM... CHLORIDE [CAS RN: 123-88-6]
DIMERCURY DIC... [CAS RN: 10112-91-1]
DIMERCURY ... OXIDE [CAS RN: 1335-31-5]
DIMETHYL M... [CAS RN: 593-74-8]
ETHYL ME... PHOSPHATE [CAS RN: 2235-25-8]
ETHYL M... [CAS RN: 627-44-1]
FULM... [CAS RN: 628-86-4]
HYD... 1184-57-2]
ME... 7-7]
MERCURIC BROMIDE [CAS RN: 7789-47-1]
MERCURIC CHLORIDE (HGCL2) [CAS RN: 7487-94-7]
MERCURIC CYANIDE [CAS RN: 592-04-1]
MERCURIC IODIDE, RED [CAS RN: 7774-29-0]
MERCURIC NITRATE [CAS RN: 10045-94-0]
MERCURIC OXIDE [CAS RN: 21908-53-2]
MERCURIC SULFATE [CAS RN: 7783-35-9]
MERCURIC SULFIDE [CAS RN: 1344-48-5]
MERCUROUS NITRATE [CAS RN: ...-75-5]
MERCUROUS NITRATE, MONOHYDRATE [CAS RN: 7782-86-7]
MERCUROUS OXIDE [CAS RN: ...-53-5]
MERCURY THIOCYANATE [CAS RN: ...-85-8]
MERCURY, AMMONIATED [CAS RN: 10124-48-8]
MERCURY, ELEMENTAL [CAS RN: ...-97-6]
METHOXYETHYLMERCURIC ACETATE [CAS RN: 151-38-2]
METHYL MERCURY (MEHG) [CAS RN: 22967-92-6]
METHYL MERCURY CHLORIDE [CAS RN: 115-09-3]
METHYLMERCURIC DICYANAMIDE [CAS RN: 502-39-6]
PHENYL MERCURIC PROPIONATE [CAS RN: 103-27-5]
PHENYLMERCURIC ACETATE [CAS RN: 62-38-4]
PHENYLMERCURIC ACETATE [CAS RN: 62-38-4]
PHENYLMERCURIC BORATE [CAS RN: 31224-71-2]
PHENYLMERCURIC BORATE [CAS RN: 31224-71-2]
BUTYL BENZYL PHTHALATE (BBP) [CAS RN: 85-68-7]
DI(2-ETHYLHEXYL)PHTHALATE (DEHP) [CAS RN: 117-81-7]
DI-N-HEXYLPHTHALATE (DNHP) [CAS RN: 84-75-3]
DI-N-OCTYL PHTHALATE (DNOP) [CAS RN: 117-84-0]
DI-N-PENTYL PHTHALATE (DNPP) [CAS RN: 131-18-0]
DIBUTYL PHTHALATE (DBP) [CAS RN: 84-74-2]
DIISOBUTYL PHTHALATE (DIBP) [CAS RN: 84-69-5]
DIISODECYL PHTHALATE (DIDP) [CAS RN: 68515-49-1]
DIISODECYL PHTHALATE (DIDP) [CAS RN: 26761-40-0]
DIISOHEPTYL PHTHALATE [CAS RN: 71888-89-6]
DIISONONYL PHTHALATE (DINP) [CAS RN: 68515-48-0]
DIISONONYL PHTHALATE (DINP) [CAS RN: 28553-12-0]
COKE OVEN EMISSIONS [CAS RN: 8007-45-2]
CREOSOTE [CAS RN: 8001-58-9]
CREOSOTE OIL [CAS RN: 61789-28-4]
CREOSOTE OIL [CAS RN: 70321-79-8]
CREOSOTE OIL, ACENAPHTHENE FRACTION [CAS RN: 90640-84-9]
CREOSOTE OIL, ACENAPHTHENE FRACTION, ACENAPHTHENE-FREE [CAS
CREOSOTE OIL, LOW-BOILING DISTILLATE [CAS RN: 70321-80-1]
EXTRACT RESIDUES (COAL), CREOSOTE OIL ACID [CAS RN: 122384-77-4]
RESIDUES (COAL TAR), CREOSOTE OIL DISTN. [CAS RN: 92061-93-3]

MERCURIC ACETATE [CAS RN: 1600-27-7]
MERCURIC BROMIDE [CAS RN: 7789-47-1]
MERCURIC CHLORIDE (HGCL2) [CAS RN: 7487-94
MERCURIC CYANIDE [CAS RN: 592-04-1]
MERCURIC IODIDE, RED [CAS RN: 7774-29-0]
MERCURIC NITRATE [CAS RN: 10045-94-0]
MERCURIC OXIDE [CAS RN: 21908-53-2]
MERCURIC SULFATE [CAS RN: 7783-35-9]
MERCURIC SULFIDE [CAS RN: 1344-48-5]
MERCUROUS NITRATE [CAS RN: 10415-75-5]
MERCUROUS NITRATE, MONOHYDRATE [CAS RN
MERCUROUS OXIDE [CAS RN: 15829-53-5]
MERCURY THIOCYANATE [CAS RN: 592-85-8]
MERCURY, AMMONIATED [CAS RN: 10124-48-8]
MERCURY, ELEMENTAL [CAS RN: 7439-97-6]
METHOXYETHYLMERCURIC ACETATE [CAS RN: 1
METHYL MERCURY (MEHG) [CAS RN: 22967-92-6
METHYL MERCURY CHLORIDE [CAS RN: 115-09-3
METHYLMERCURIC DICYANAMIDE [CAS RN: 502-
PHENYL MERCURIC PROPIONATE [CAS RN: 103-
PHENYLMERCURIC ACETATE [CAS RN: 62-38-4]
PHENYLMERCURIC ACETATE [CAS RN: 62-38-4]
PHENYLMERCURIC BORATE [CAS RN: 31224-71-
PHENYLMERCURIC BORATE [CAS RN: 31224-71-
BUTYL BENZYL PHTHALATE (BBP) [CAS RN: 85-6
DI(2-ETHYLHEXYL)PHTHALATE (DEHP) [CAS RN: 1
DI-N-HEXYLPHTHALATE (DNHP) [CAS RN: 84-75-3
DI-N-OCTYL PHTHALATE (DNOP) [CAS RN: 117-84
DI-N-PENTYL PHTHALATE (DNPP) [CAS RN: 131-1
DIBUTYL PHTHALATE (DBP) [CAS RN: 84-74-2]
DIISOBUTYL PHTHALATE (DIBP) [CAS RN: 84-69-5
DIISODECYL PHTHALATE (DIDP) [CAS RN: 68515-
DIISODECYL PHTHALATE (DIDP) [CAS RN: 26761-
DIISOHEPTYL PHTHALATE [CAS RN: 71888-89-6]
DIISONONYL PHTHALATE (DINP) [CAS RN: 68515-
DIISONONYL PHTHALATE (DINP) [CAS RN: 28553-
COKE OVEN EMISSIONS [CAS RN: 8007-45-2]
CREOSOTE [CAS RN: 8001-58-9]
CREOSOTE OIL [CAS RN: 61789-28-4]
CREOSOTE OIL [CAS RN: 70321-79-8]
CREOSOTE OIL, ACENAPHTHENE FRACTION [CA
CREOSOTE OIL, ACENAPHTHENE FRACTION, AC
CREOSOTE OIL, LOW-BOILING DISTILLATE [CAS
EXTRACT RESIDUES (COAL), CREOSOTE OIL ACI
RESIDUES (COAL TAR), CREOSOTE OIL DISTN. [C
WOOD CREOSOTE [CAS RN: 8021-39-4]
AMMONIUM COPPER ARSENATE [CAS RN: 10102
ARSENAZO III [CAS RN: 1668-00-4]
ARSENIC [CAS RN: 7740-38-2]
ARSENIC (TRIVALENT) [CAS RN: 22569-72-8]
ARSENIC ACID [CAS RN: 7778-39-4]
ARSENIC DISULFIDE [CAS RN: 1303-32-8]
ARSENIC III [CAS RN: 22541-54-4]
ARSENIC PENTOXIDE [CAS RN: 1303-28-2]
ARSENIC TRICHLORIDE [CAS RN: 7784-34-1]
ARSENIC TRIOXIDE [CAS RN: 1327-53-3]
ARSENIC TRISULFIDE [CAS RN: 1303-33-9]
ARSENIC V [CAS RN: 17428-41-0]
CALCIUM ARSENATE [2ASH3O4.2CA] [CAS RN: 7
CALCIUM ARSENITE [CAS RN: 52740-16-6]
COPPER ARSENATE [CAS RN: 10103-61-4]
CUPRIC ACETOARSENITE [CAS RN: 12002-03-8]
GALLIUM ARSENIDE [CAS RN: 1303-00-0]
IMAZAPYR (ARSENAL) [CAS RN: 81334-34-1]
LEAD ARSENATE [CAS RN: 7784-40-9]
LEAD ARSENITE [CAS RN: 10031-13-7]
MAGNESIUM ARSENATE [CAS RN: 10103-50-1]
POTASSIUM ARSENATE [CAS RN: 7784-41-0]
POTASSIUM ARSENITE (ASH3O3.XK) [CAS RN: 10
SODIUM ARSENATE [CAS RN: 13464-38-5]
SODIUM ARSENATE (ASH3O4.XNA) [CAS RN: 763
SODIUM ARSENITE [CAS RN: 7784-46-5]
TRIETHYL ARSENATE [CAS RN: 15606-95-8]
ARSENIC [7740-38-2]
ASBESTOS [1332-21-4]
CADMIUM [7440-43-9]
CHLORINATED POLYETHYLENE (CPE) [63231-66-3
CHLORINATED POLYETHYLENE (CPE, TYRIN) [64
CHLORINATED POLYVINYL CHLORIDE (CPVC) [68
CHLOROSULFONATED POLYETHYLENE (HYPALO
CREOSOTE [8001-58-9]
FORMALDEHYDE [50-00-0]
LEAD [7439-92-1]
MERCURY, ELEMENTAL [7439-97-6]
NEOPRENE [9010-98-4]

FORMALDEHYDE

formulation. All substances, if present, are at levels well below regulatory limits. See Section 11: Toxicology Information for detailed information.

MATERIAL	IARC	NTP	ACGIH	CAL-65
Vinyl Acetate Monomer	2B	Not Listed	A3	Not Listed
Acetaldehyde	2B	2	A3	Listed
Formaldehyde	1	2	A2	Listed
Crystalline silica	1	1	A2	Listed

IARC - International Agency for Research on Cancer. 1- Carcinogenic to humans; 2A – Probably carcinogenic to humans; 2B – Possibly carcinogenic to humans; 3 - Not classifiable as a carcinogen; 4 – Probably not a carcinogen

NTP – National Toxicology Program (Health and Human Services Dept., Public Health Service, NIH/NIEHS): 1- Known to be carcinogen; 2- Anticipated to be carcinogens

ACGIH – American Conference of Governmental Industrial Hygienists; A1 – Confirmed human carcinogen; A2 – Suspected human carcinogen. A3 – Animal carcinogen; A4 - Not classifiable as a carcinogen; A5 – Not suspected as a human carcinogen

CAL-65 – California Proposition 65 "Chemicals known to the State of California to Cause Cancer"

Respirable crystalline silica: IARC: Group 1 carcinogen, NTP: Known human carcinogen. The weight percent of crystalline silica given represents total quartz and not the respirable fraction. The weight percent of respirable silica has not been measured in this product.

Food and Drug Administration [CFR Title 21, v.3, sec 184.1409] – Ground limestone is Generally Recognized as Safe (GRAS).

POTENTIAL ENVIRONMENTAL EFFECTS: This product has no known adverse effect on ecology. (See Section 12 for more information)

SECTION 3
COMPOSITION, INFORMATION ON INGREDIENTS

MATERIAL	WT%	CAS #
Water	>40	7732-18-5
Limestone	<40	1317-65-3
Expanded Perlite	>5	93763-70-3
Sepiolite	<5	63800-37-3
Attapulgite	<5	12174-11-7
Vinyl Acetate Polymer	<5	9003-20-7
Or Ethylene Vinyl Acetate Polymer		24937-78-8
Crystalline Silica	<2	14808-60-7

All ingredients of this product are included in the U.S. Environmental Protection Agency's Toxic Substances Control Act Chemical Substance Inventory and the Canadian Domestic Substances List (DSL).

The weight percent for silica represents total quartz and not the respirable fraction.

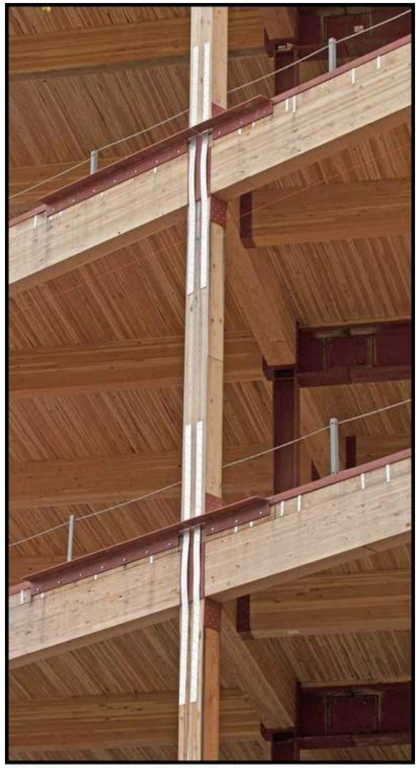
SECTION 4
FIRST AID MEASURES

FIRST AID PROCEDURES

Inhalation	Remove to fresh air. Leave the area of exposure and remain away until coughing and other symptoms subside. Other measures are usually not necessary, however if conditions warrant, contact physician.
Eyes	In case of contact, do not rub or scratch your eyes. To prevent mechanical irritation, flush thoroughly with

2012-8.23_d2244 Metal cladding installation photo: John Stamets

2012-7.28_0274 Connector walks back to building after bolting together the far tip. photo: John Stamets



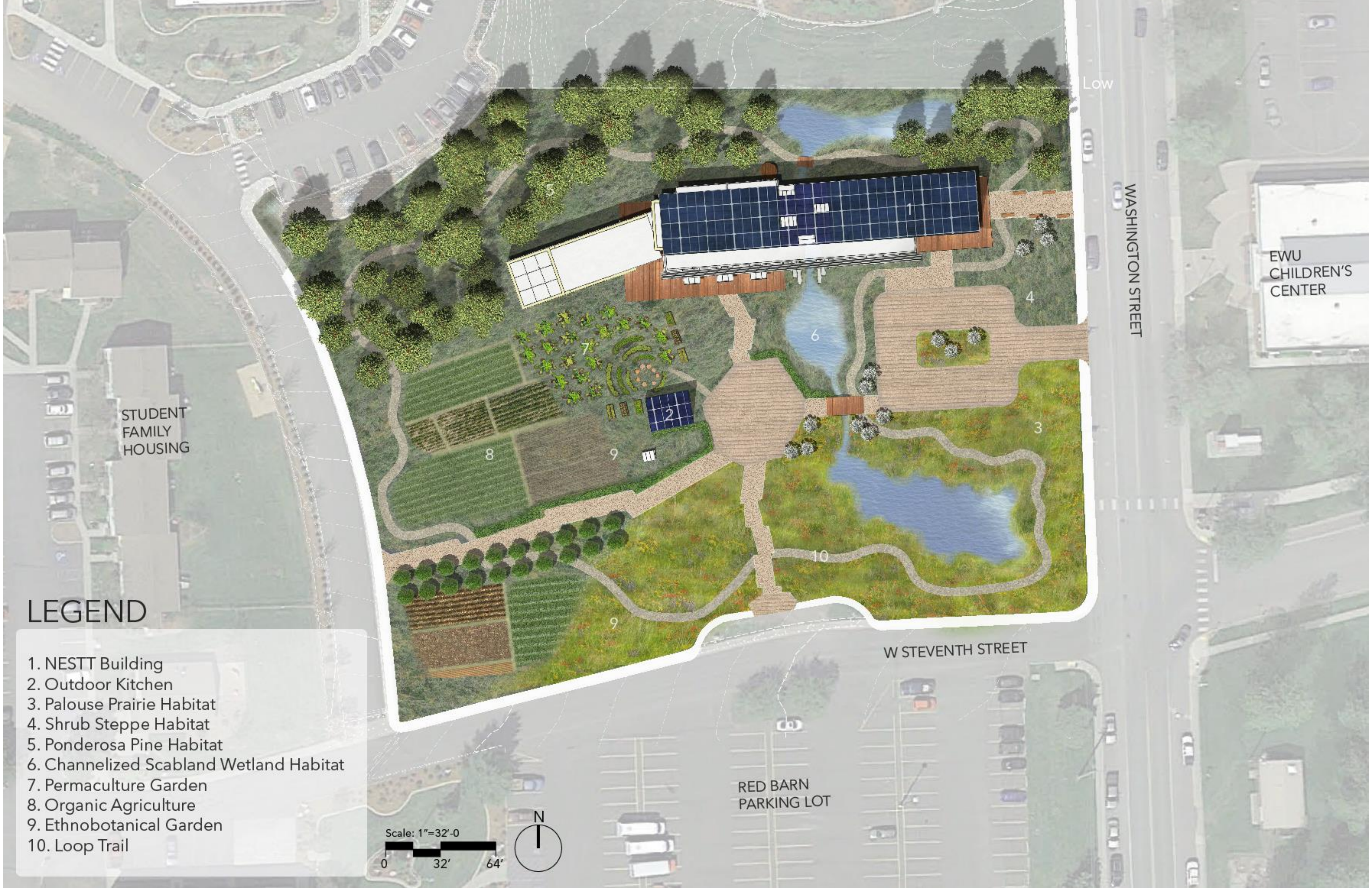
2012-5.8_2520 Vertical tension ties photo: John Stamets

CASE STUDY #2

Eastern Washington University

N.E.S.T.T.

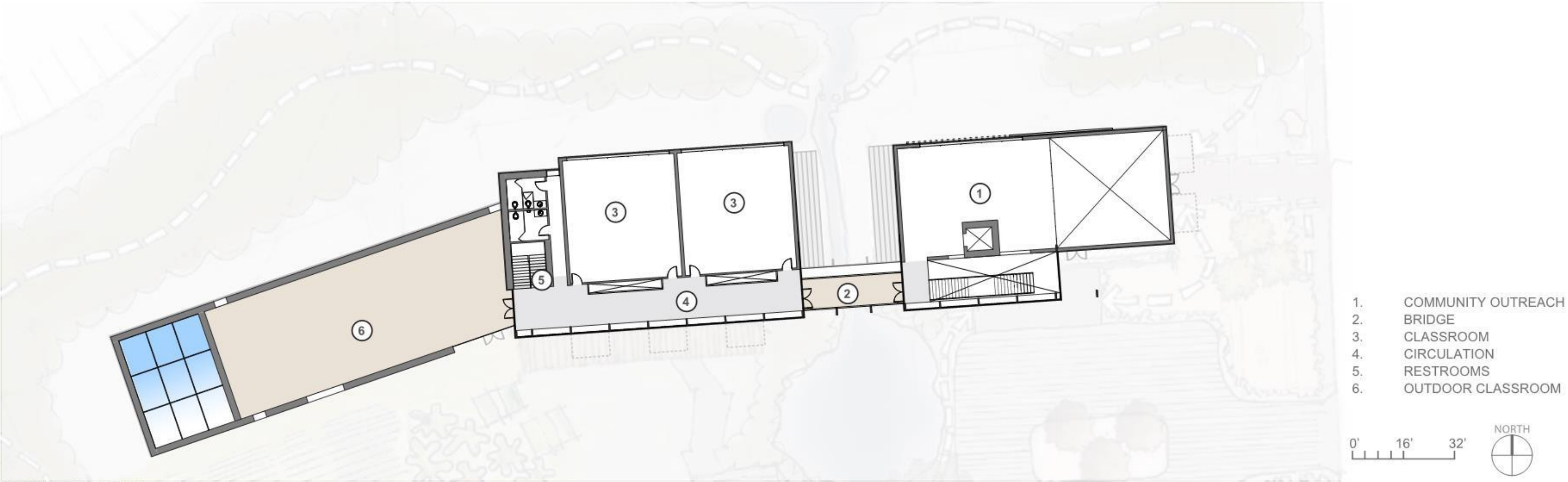
EASTERN WASHINGTON UNIVERSITY
N.E.S.T.T. CENTER


Low
WASHINGTON STREET
EWU CHILDREN'S CENTER
STUDENT FAMILY HOUSING
W STEVENTH STREET
RED BARN PARKING LOT
1
2
3
4
5
6
7
8
9
9
10
LEGEND
1. NESTT Building
2. Outdoor Kitchen
3. Palouse Prairie Habitat
4. Shrub Steppe Habitat
5. Ponderosa Pine Habitat
6. Channelized Scabland Wetland Habitat
7. Permaculture Garden
8. Organic Agriculture
9. Ethnobotanical Garden
10. Loop Trail
Scale: 1"=32'-0
0
32'
64'
N

1. ENTRANCE
2. VEHICULAR DROP-OFF
3. LOBBY
4. CONFERENCE ROOM
5. BRIDGE
6. OUTDOOR CLASSROOM
7. CISTERN
8. LABORATORY
9. OFFICES
10. CIRCULATION
11. RESTROOMS
12. STAFF WORKROOM
13. WATER ROOM
14. ELECTRICAL ROOM
15. MECHANICAL ROOM
16. GREEN HOUSE
17. PORCH
18. ENGINEERING PAD
19. OUTDOOR KITCHEN
20. BUS DROPOFF & PARKING

GROUND FLOOR PLAN

BUILDING CONCEPT



SECOND FLOOR PLAN

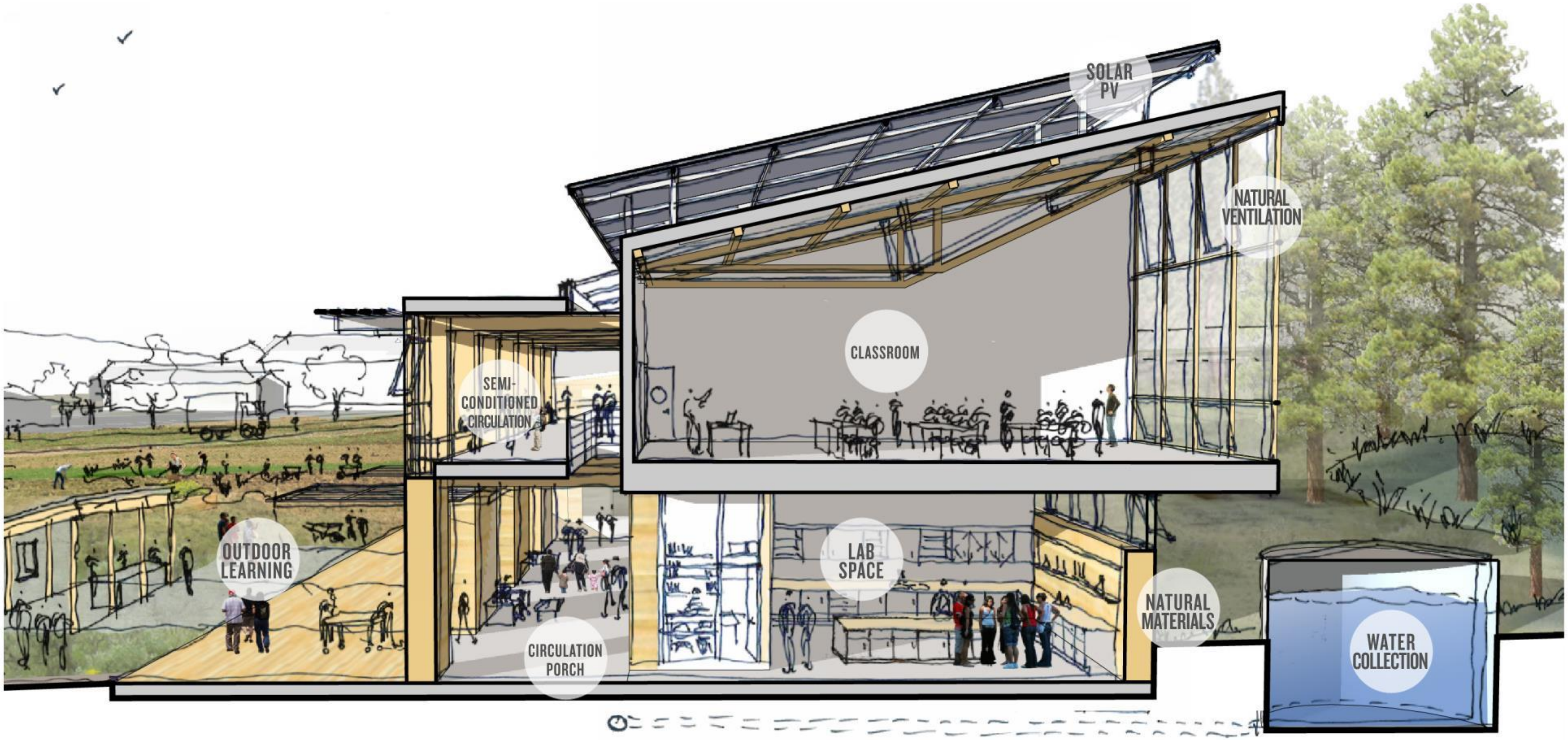
SOUTH ELEVATION

BUILDING CONCEPT

EWU NESTT CENTER

(NATURAL & ENVIRONMENTAL SCIENCE TESTING AND TEACHING)

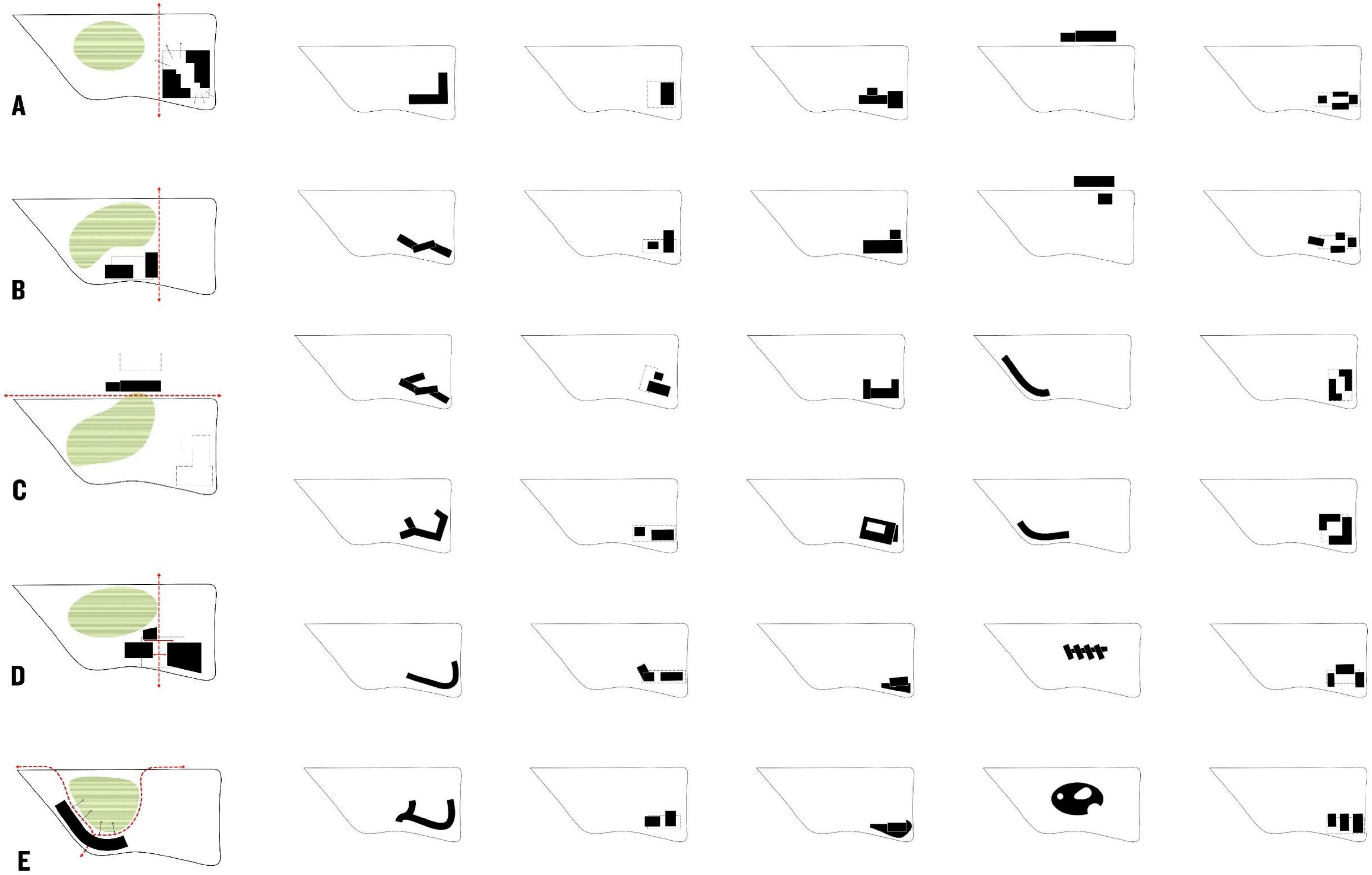
September 2015

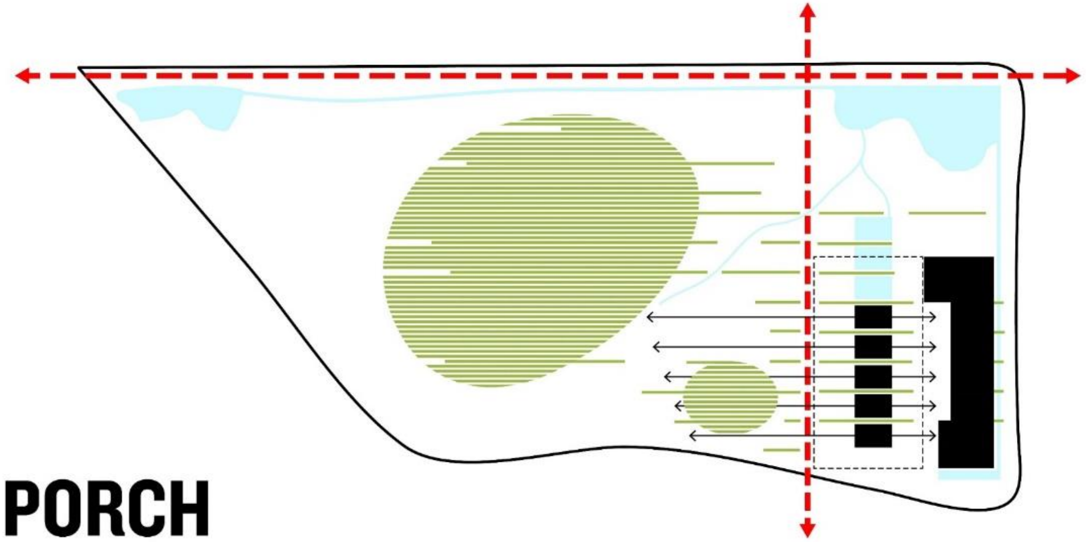


By meeting the Living Building Challenge, the building will be a showcase for sustainable practices, going beyond LEED's highest standard and provide the public with a model of how careful and planned construction can add to the value of the community and be a positive impact on the natural environment.

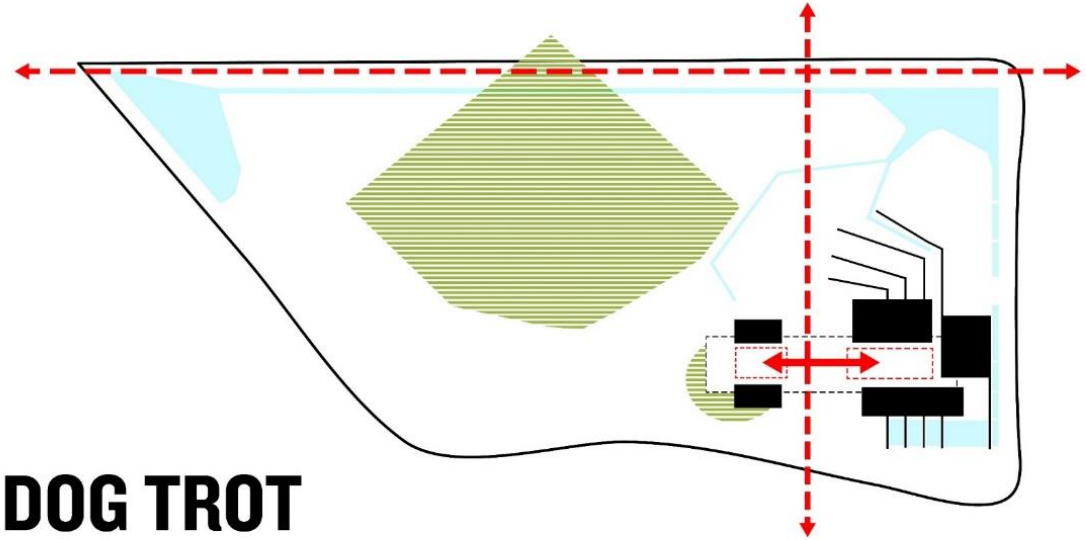
CASE STUDY #3

Georgia Institute of Technology
Living Building

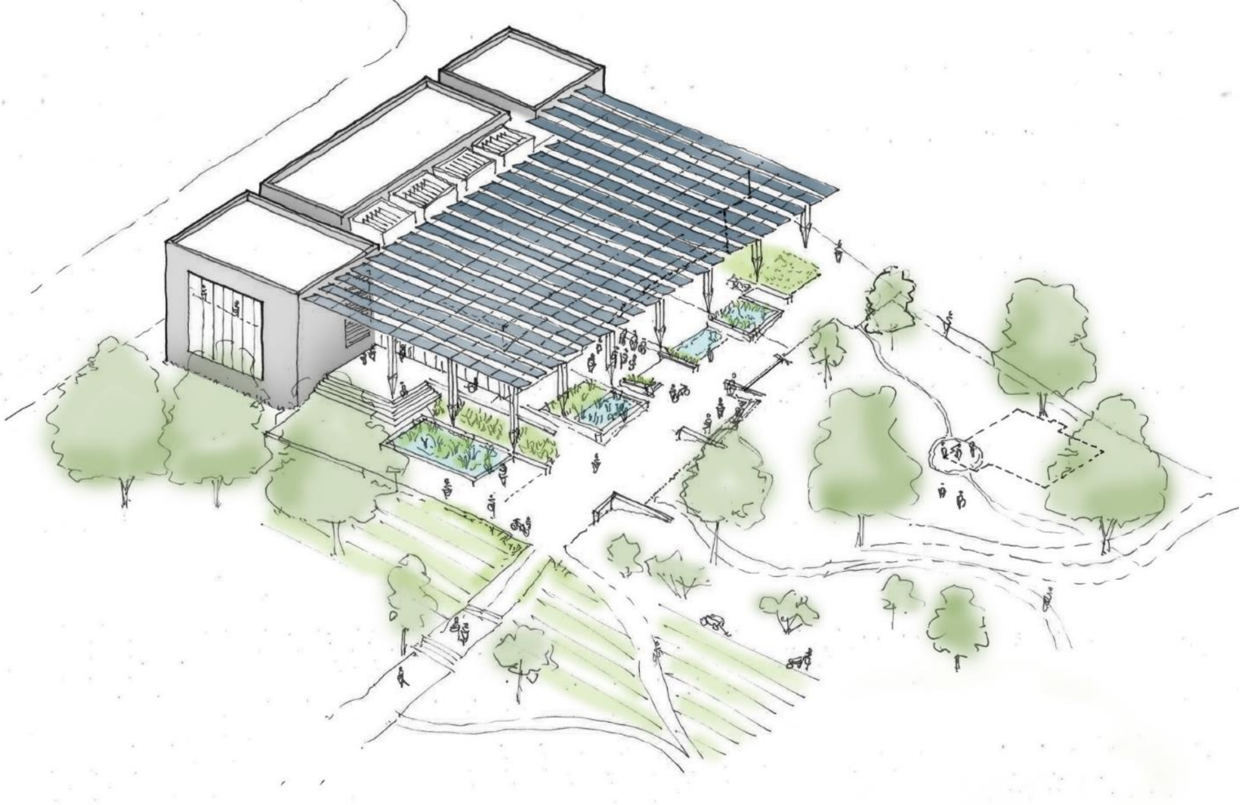


A
B
C
D
E



PORCH



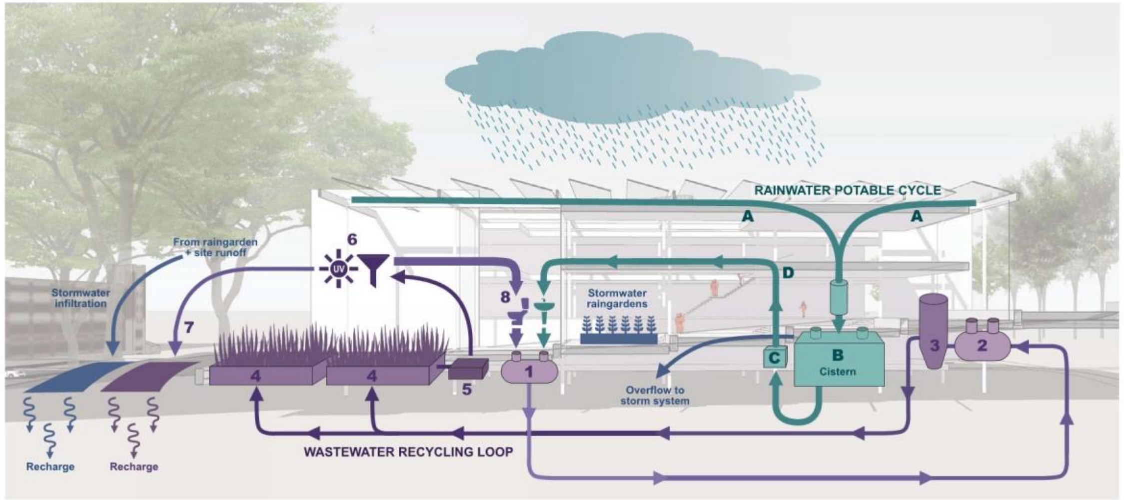
DOG TROT




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)

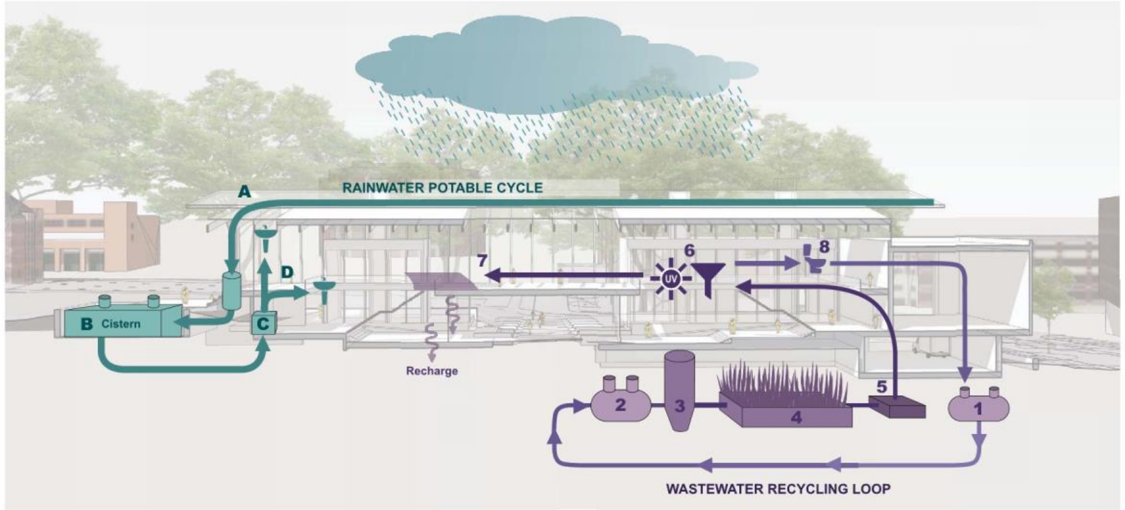
NET POSITIVE WATER CYCLE SYSTEMS



WASTEWATER RECYCLING LOOP

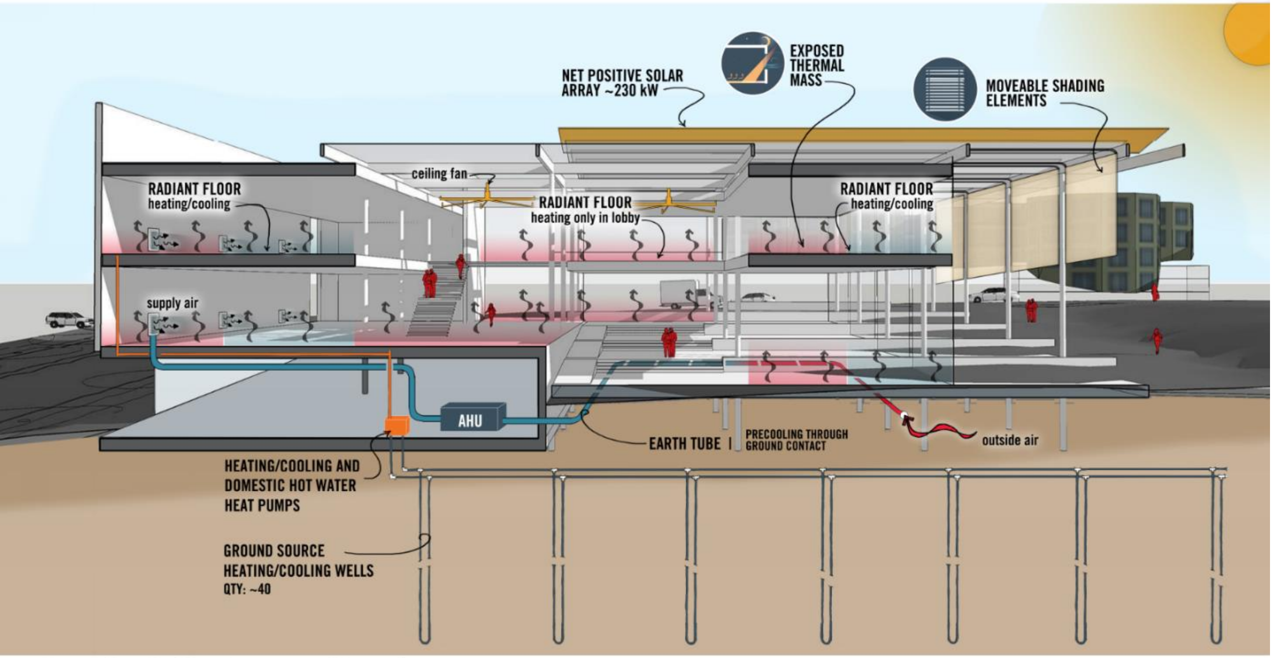
RAINWATER POTABLE CYCLE

NET POSITIVE WATER CYCLE SYSTEMS



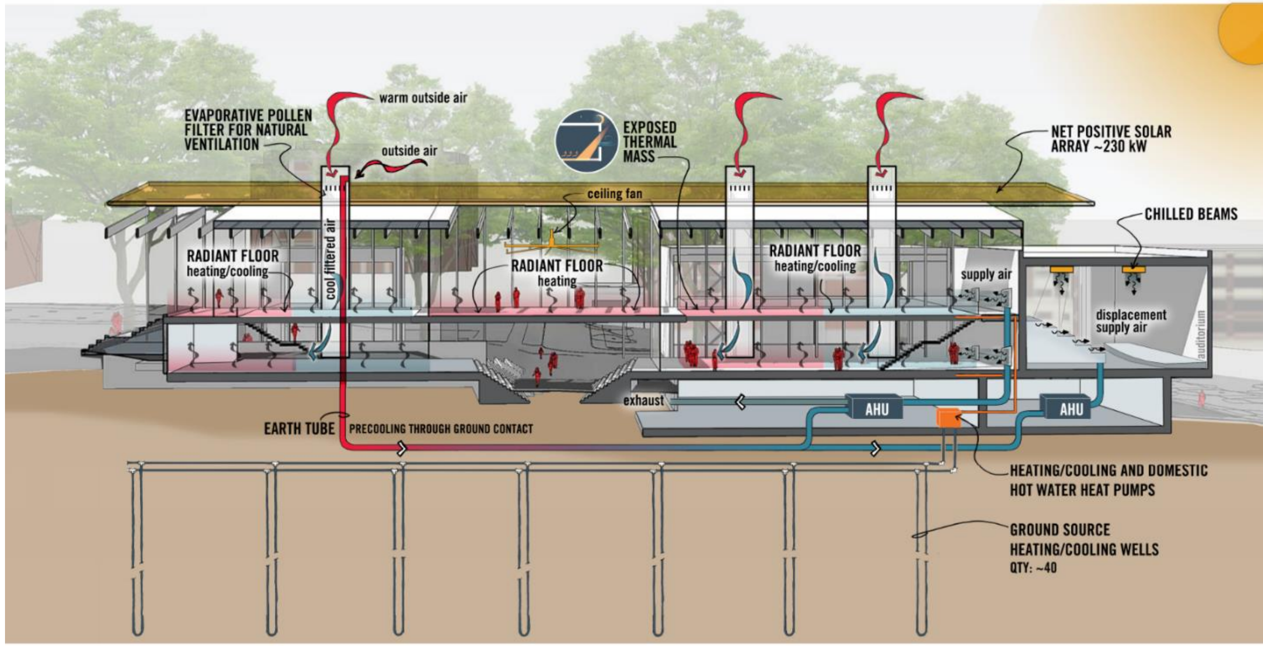
WASTEWATER RECYCLING LOOP

RAINWATER POTABLE CYCLE



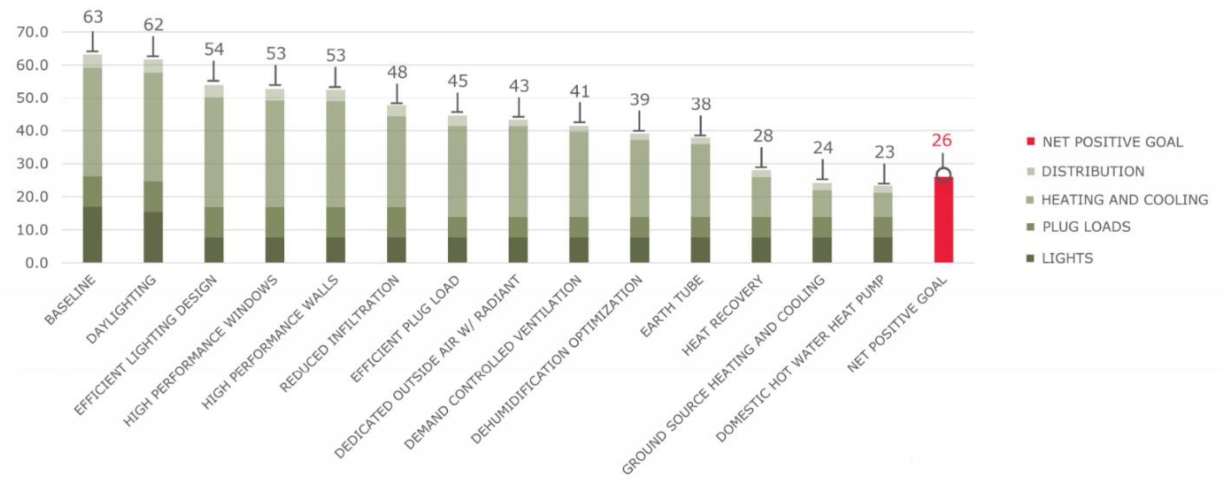
Comfort Systems: Porch - Georgia Tech

March 9, 2016



Comfort Systems: Bridgetrot - Georgia Tech

March 9, 2016

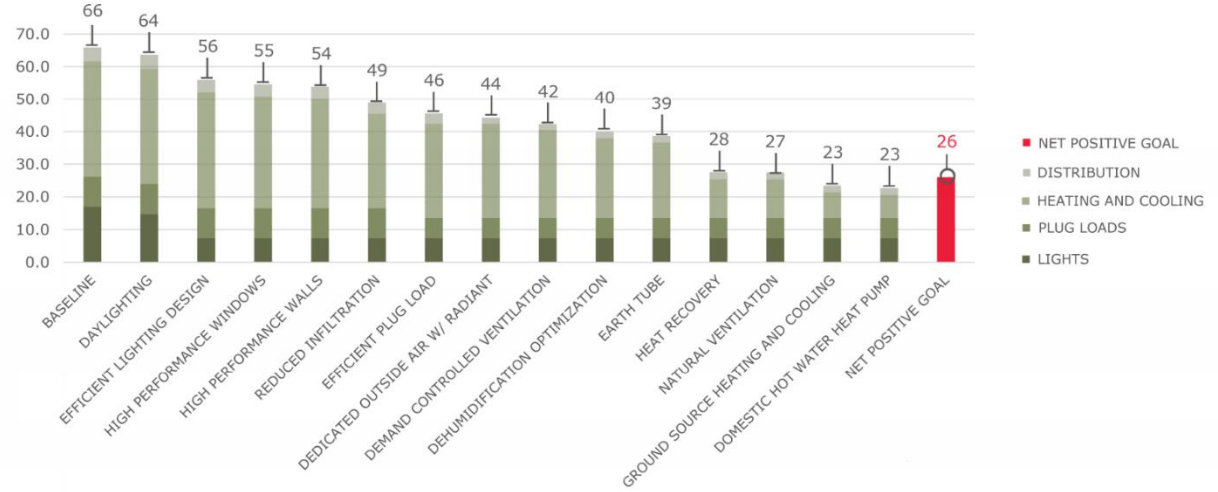


Energy Consumption: Porch - Georgia Tech

March 9, 2016

15-1720.00
inspire interpret integrate

pae-engineers.com
Portland | San Francisco | Seattle



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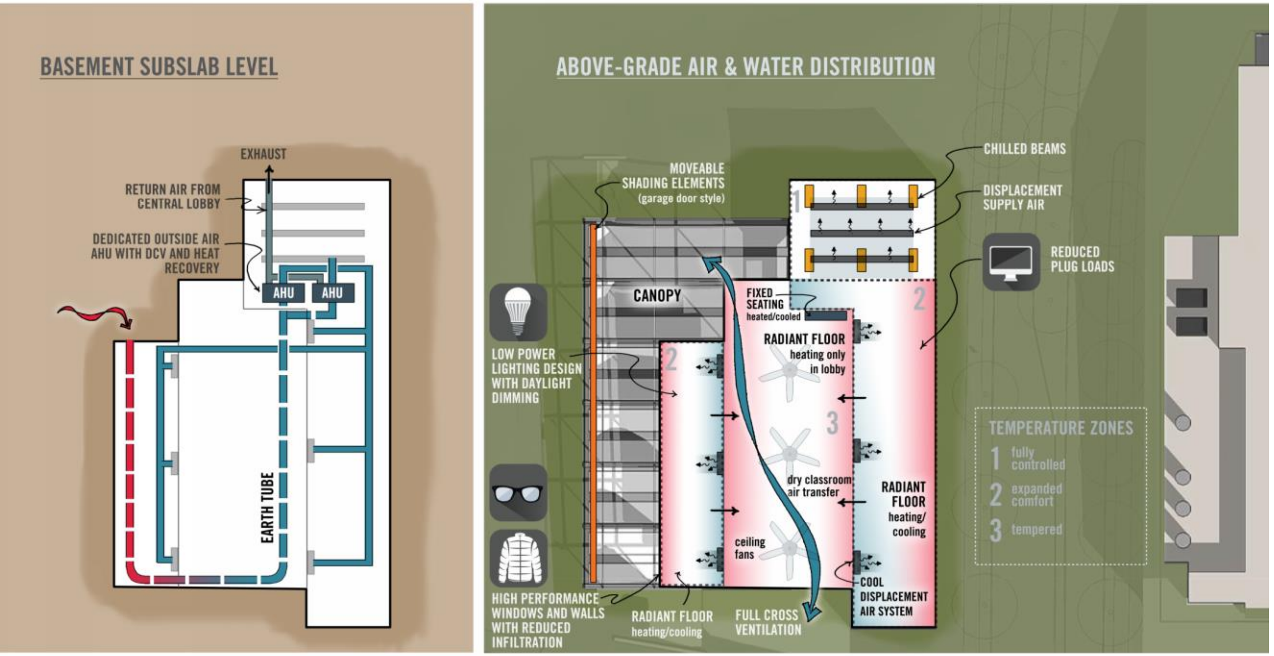

Comfort Systems: Porch - Georgia Tech

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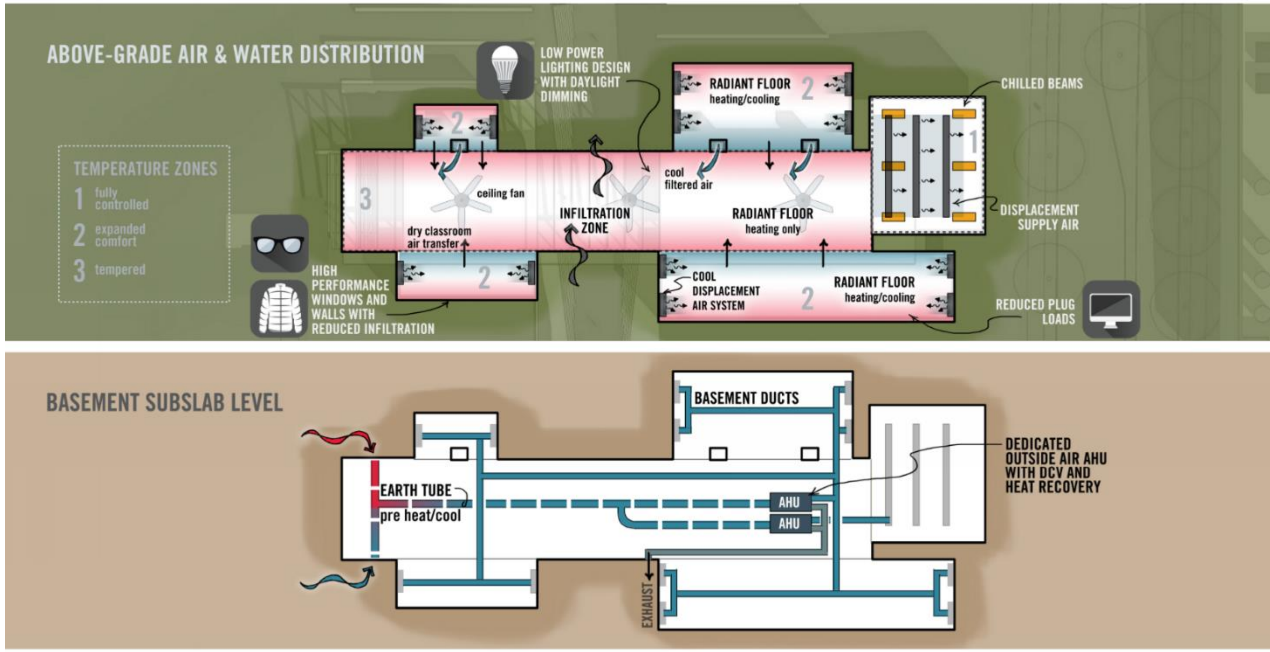

Comfort Systems: Bridgetrot - Georgia Tech

March 9, 2016

15-1720.00
inspire interpret integrate

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PORCH

Pros:

- Compact, efficient shape, lower skin to area ratio
- more completely blocks noise from NanoTech
- demonstration opportunity with active solar controls on east and west (not every building has an ideal alignment)
- north south axis of atrium reinforces connection to Circadian rhythm—solar noon
- engagement of knoll and creation of outdoor room

Cons:

- longer east and west exposures
- less site opportunities for gravity flow stormwater detention and infiltration

DOGTROT

Pros:

- better passive solar orientation and daylighting
- strong connection and engagement with the knoll and eco-commons
- active dynamic space at the Dalney Street cross-axis
- better passive downdraft pollen filter opportunity
- greater opportunity for gravity flow stormwater detention and retention

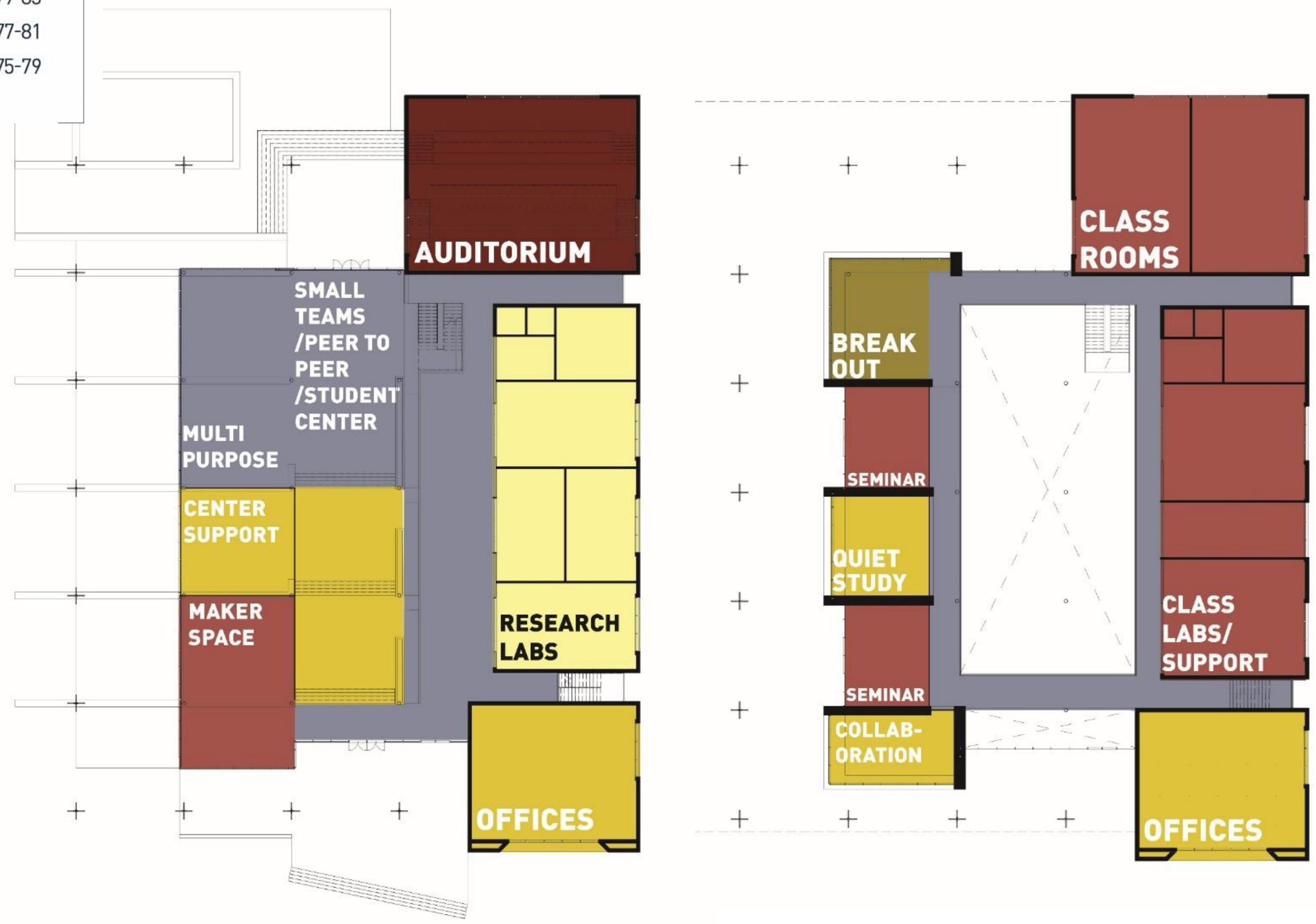
Cons:

- higher skin to area ratio
- requires removal of one significant tree

Building Planning – Temperature Boundary Types

LEGEND

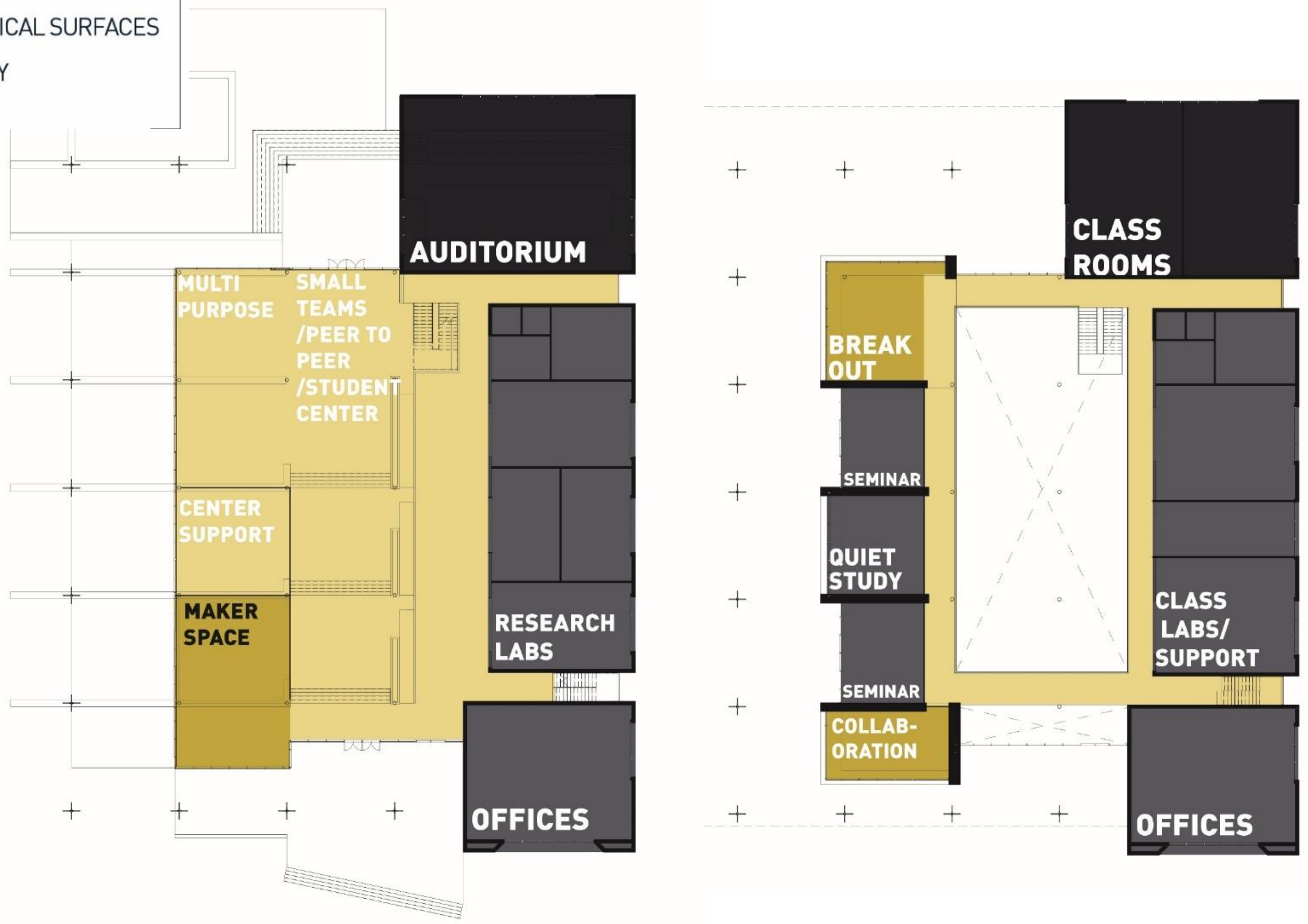
		HEATING	COOLING
A:	FLEXIBLE /TRANSITION SPACES	62-66	79-83
B1:	ACTIVE LEARNING/RESEARCH LABS	61-65	77-81
B2:	ACTIVE LEARNING/STUDENT CENTER	67-71	79-83
B3:	ACTIVE LEARNING/BREAKOUT+ MAKER SPACE	68-72	79-83
C:	CLASSROOMS WITH INSTRUCTOR	67-71	77-81
D:	AUDITORIUM	72-75	75-79



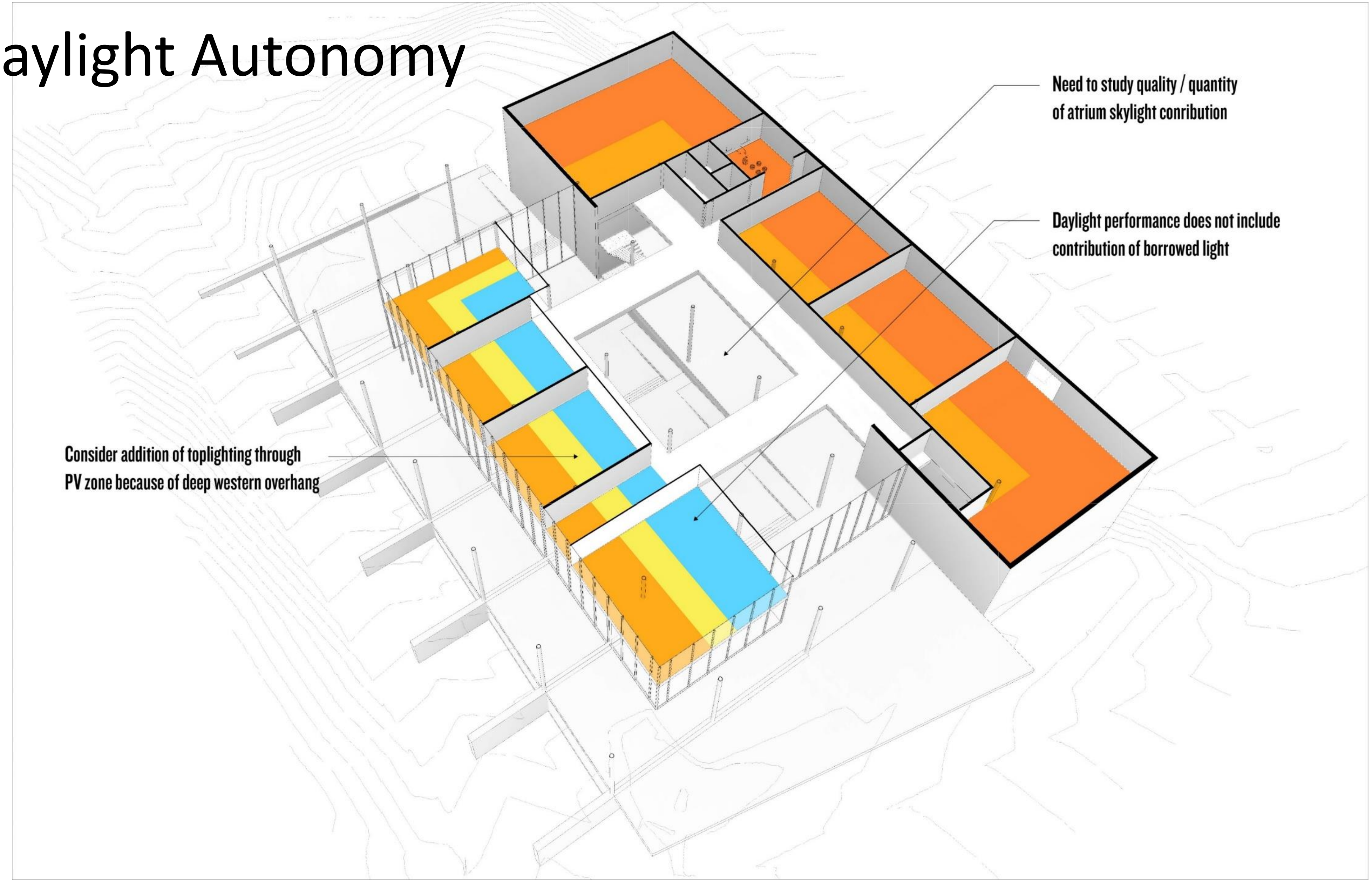
Building Planning – Daylighting Program Types

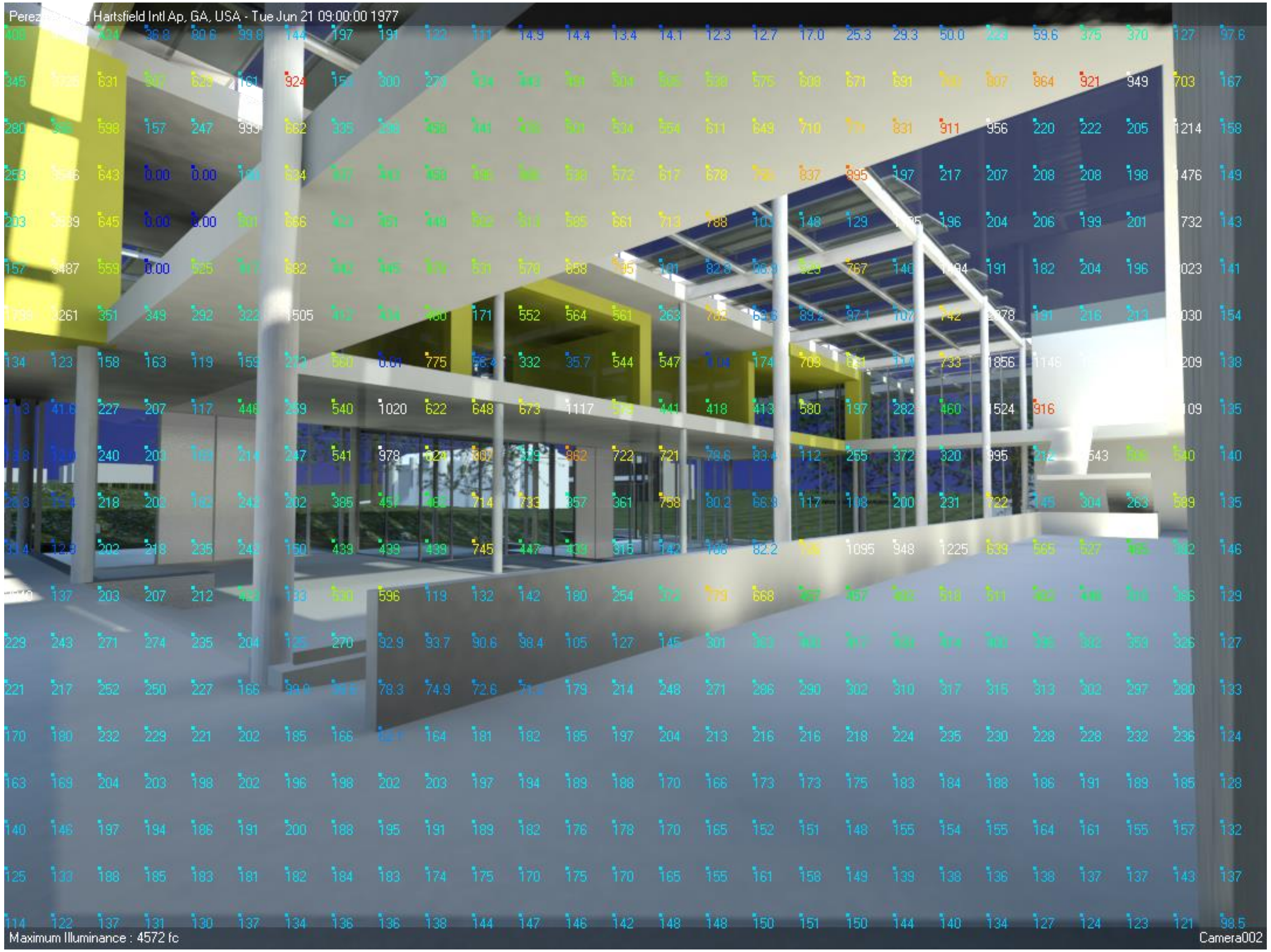
LEGEND

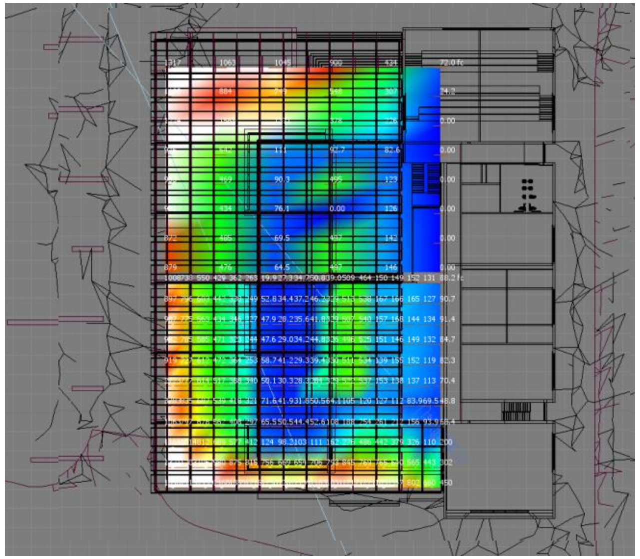
- DIRECT BEAM SUNLIGHT ALLOWED DURING THE DAY
- EARLY AM OR LATE PM SUNLIGHT ALLOWED TO 10' DEPTH
- NO DIRECT BEAM SUNLIGHT ON HORIZONTAL OR VERTICAL SURFACES
- HIGHEST DEGREE OF CONTROL, BLACKOUT CAPABILITY



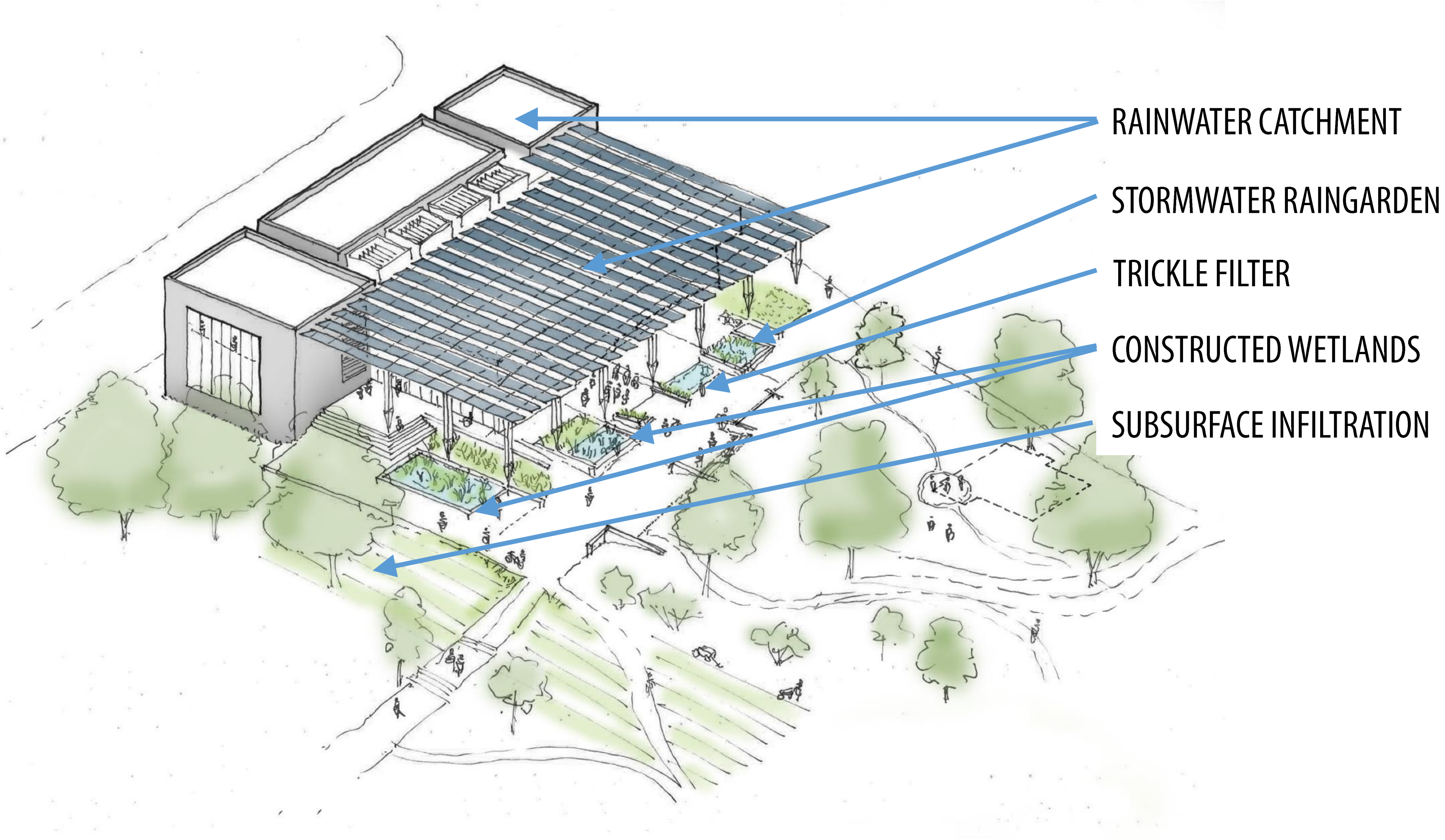
Daylight Autonomy







Porch – June 21 - 9am



PORCH – WATER SYSTEM INTEGRATION

The Living Building @ Georgia Tech

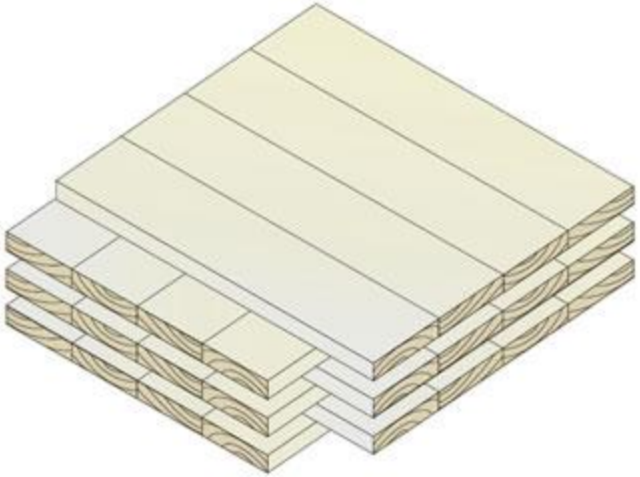
Decision Criteria for Structural Systems

29-Aug-16

Structural System	$/SF	Code Consideration	Embodied Energy Factor	Carbon Estimate	Components within Radius?	Components from GA sources?	Components on Red List?	Thermal comfort	Acoustical comfort	Daylight Impact	Interior Flexibility	PV canopy integration	Biophilia	Innate Beauty***	Notes:
Heavy Timber	$$$½	Allowable	1	BEST	BETTER	BETTER	Yes- Minor	BETTER	BETTER	BETTER	BETTER	ACCEPTABLE	BEST	BEST	Formaldehyde in engineered wood components. Allowable Exceptions under LBC 3.1 Structure becomes the finish- uses less material
CIP Concrete w/PT Slabs	$$$$	Allowable	5	ACCEPTABLE	BETTER	BETTER	Yes- Significant	BEST	Requires greatest level of acoustic treatment	BEST	ACCEPTABLE- Future Floor pentrations limited	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	PVC tendon sheaths. More research on all additive ingredients of concrete required. Formwork will need to be salvage or FSC
CIP Concrete	$$$$$	Allowable	5	ACCEPTABLE	BETTER	BETTER	Yes-extent unknown	BEST	Requires greatest level of acoustic treatment	BETTER	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	ACCEPTABLE	More research on all additive ingredients of concrete required. Formwork will need to be salvage or FSC
Steel	$$$	Allowable	28	HIGH	BEST	BEST	No- but will require coatings and finishing	ACCEPTABLE	ACCEPTABLE	BETTER	BEST	BEST	ACCEPTABLE	BETTER	Research components of finishes to apply to steel. More research on all additive ingredients of concrete topping slabs required.

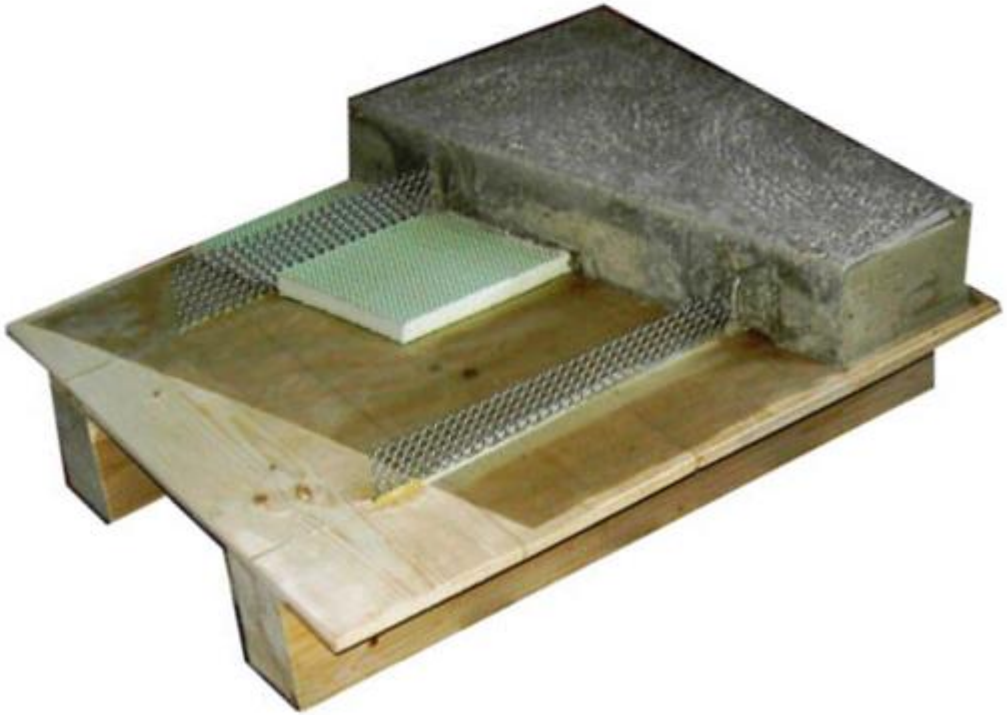
WHAT IS NEXT?

TALL WOOD



London Apartment Building, Andrew Waugh

CROSS-LAMINATED TIMBER (CLT)



CONCRETE+TIMBER HYBRID PANELS, CAST-IN-PLACE (CIP)

LIFE CYCLE TOWER, CREE, AUSTRIA

CONCRETE+TIMBER HYBRID PREFABRICATED PANELS

Bullitt Center, The Miller Hull Partnership

COMPLETE

6 STORIES—SEATTLE

Wood Innovation Center, Michael Green Associates

COMPLETE

7 STORIES—CANADA

Office Building, Michael Green Associates

IN CONSTRUCTION

7 STORIES—MINNEAPOLIS

Apartment Building, Andrew Waugh

COMPLETE

9 STORIES—LONDON

Treet Tower, Artec Architects

IN CONSTRUCTION

14 STORIES—NORWAY

University of British Columbia, Acton Ostry Architects

IN CONSTRUCTION

14 STORIES—VANCOUVER,

WSU Spokane student housing proposal, The Miller Hull Partnership

IN DESIGN

14 STORIES—USDA TALL WOOD COMPETITION

1.2.7 PROGRAMMING: BUILDING ENCLOSURE

METAL FACADE PANELS

A rainscreen system made up of metal panels protects the CLT shear wall panels from the elements and provides a contrast to the warmth of the exposed wood structural systems.

WOOD CURTAIN WALL

In keeping with the natural wood materials used through, the project proposes the use of a wood curtain wall system, where standard aluminum mullions are replaced with sustainable engineered wood.

DAYLIGHTING

The masonry wall at the southwest corner of the existing 2-story building has been carved open revealing heaving timber frame and providing a sunny outdoor connection for new gather functions inside.

SEISMIC UPGRADE

While the load bearing exterior masonry walls of the existing building are maintained, a combination of CLT shear walls and timber brace frames wrap the new data center core providing the required seismic upgrade.

14 STORIES—USDA TALL WOOD COMPETITION

TALL WOOD OPTION 1

- 7000sf floor plate optimized for site and smaller spaces (clinics, offices on-campus; apartments off-campus)
- Distributed shear walls
- 84,000 TOTAL GSF; 71,400 net rentable area

TALL WOOD OPTION 2

- 20,000sf floor plate optimized for open office configuration
- Central core and brace frames at perimeter
- 140,000 TOTAL GSF; 119,000 net rentable area

14 STORIES—USDA TALL WOOD COMPETITION

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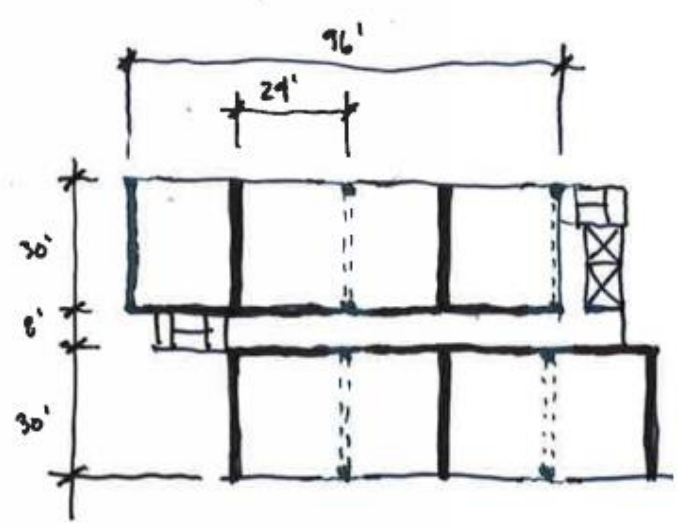

TALL WOOD OPTION 2

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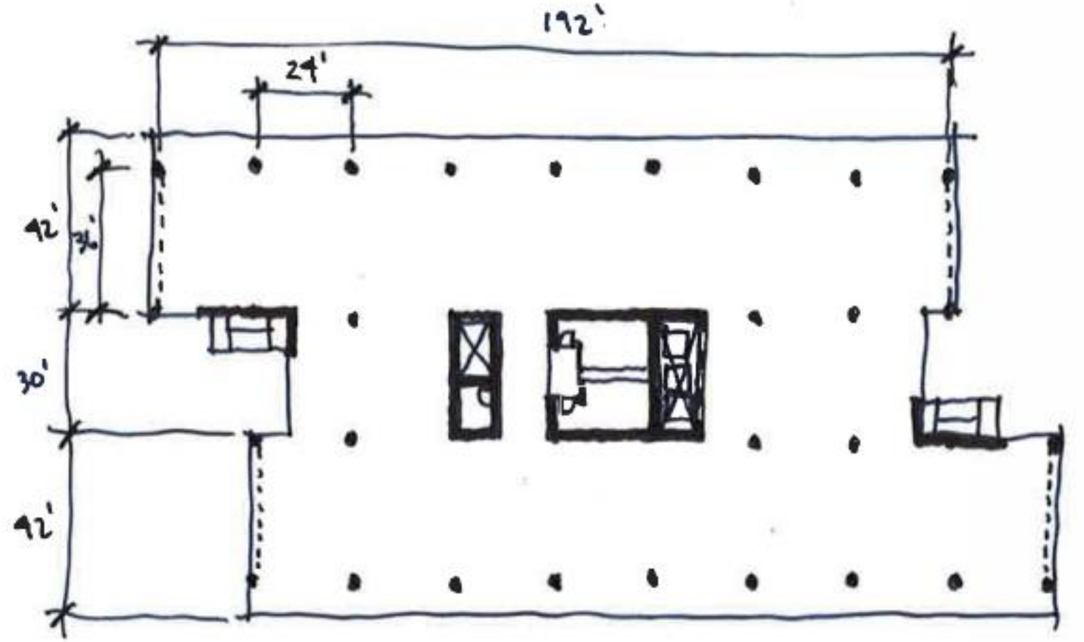
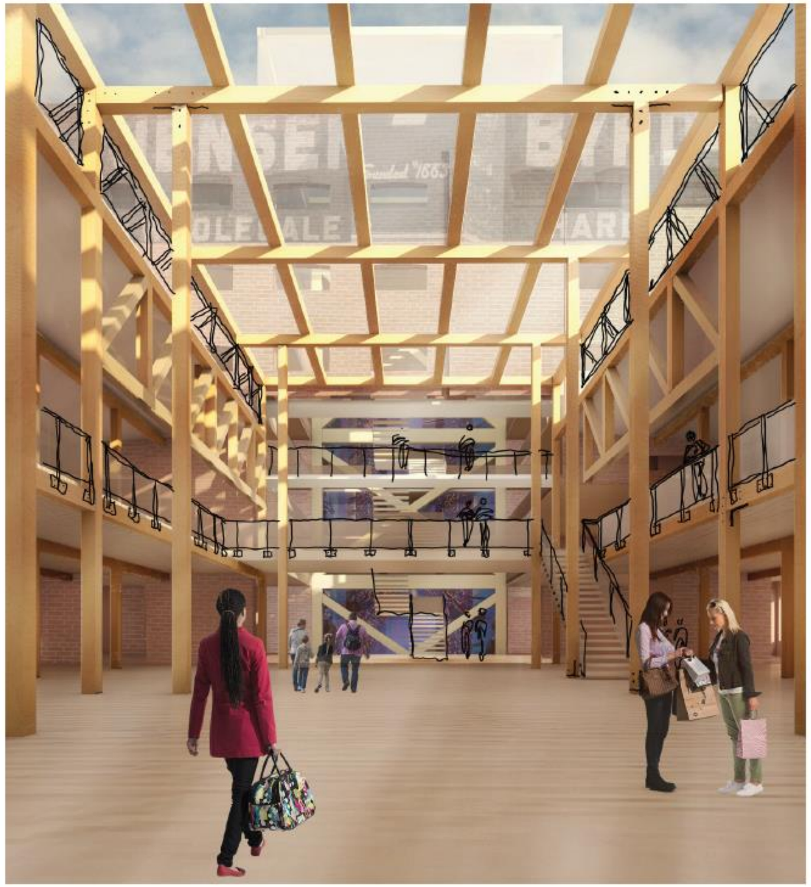
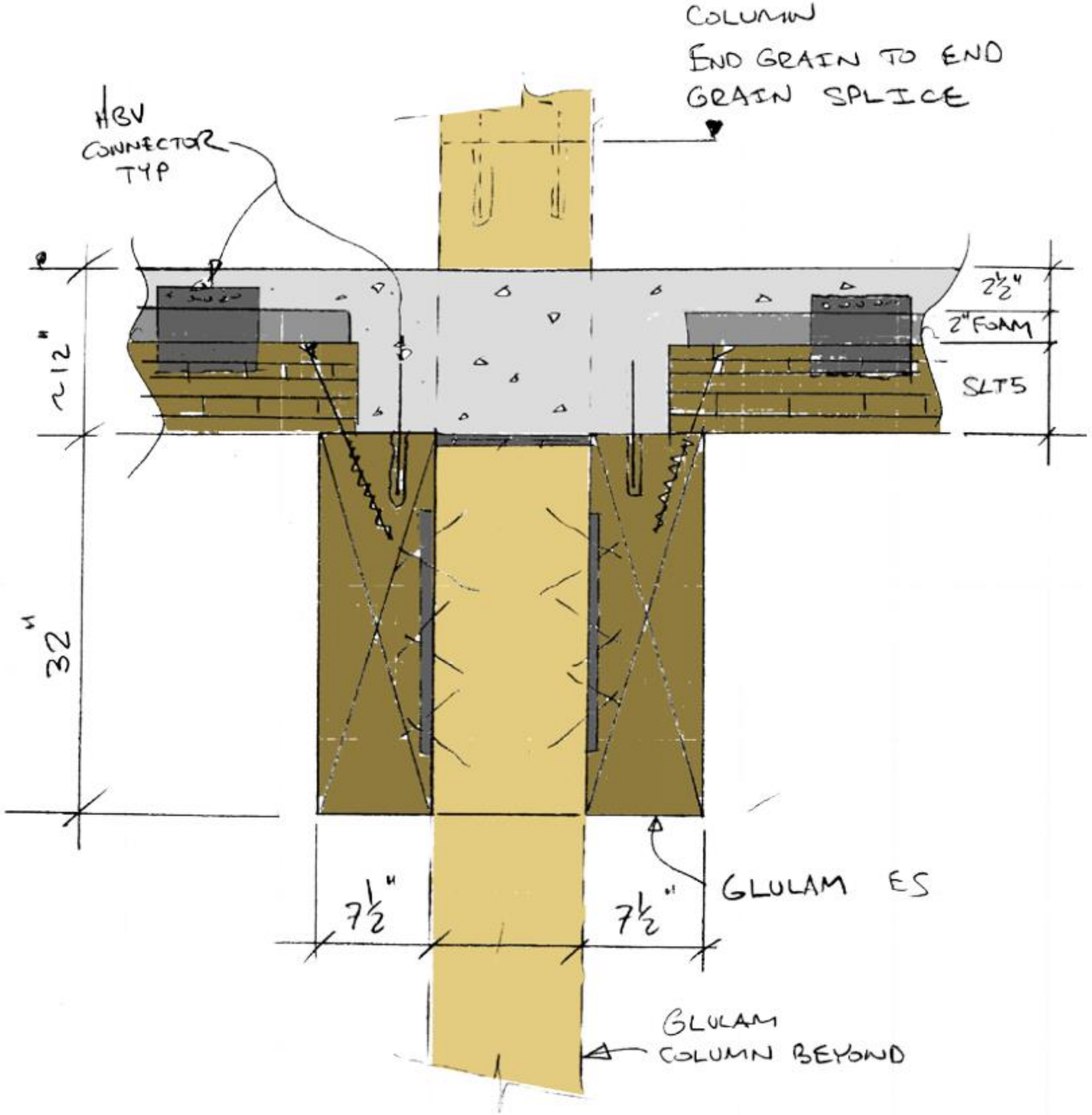


14 STORIES—USDA TALL WOOD COMPETITION



MARKET HALL

While the two story portion of the Jensen-Byrd building was originally constructed with a clerestory roof, the windows had long since been removed and filled in with walls. The clerestory will be restored and continuous second floor removed below it bringing natural light and ventilation to first floor and newly configured second floor mezzanine. This space provide a new home for University bookstore, food service, study areas and other complimentary commercial needs. The connection to the six story portion of the Jensen-Byrd has been enlarged to a two story connection with views through new timber lateral brace frames to the date servers which are on full display providing an iconic counterpoint to the Timber Innovation Center.



14 STORIES—USDA TALL WOOD COMPETITION

Paris Tower proposal, Michael Green Associates

DESIGN PROPOSAL

35 STORIES—PARIS

Timber Tower Research Project, SOM

RESEARCH PROPOSAL

42 STORIES—?

GRACIAS

BRIAN COURT, AIA, LEED AP
briancourt@millerhull.com

The MILLER HULL Partnership
Seattle, Washington

MILLER HULL


PUBLIC
MARKET
CENTER
MEET THE PRODUCER
FARMERS MARKET


PUBLIC MARKET
IMPERIALES
CIGARETTES
PUBLIC
MARKET
ENTRANCE


CORNER MARKE
FARM SEASON is here!
NTRANCE
NIC FRUIT SMOOTHIES!
All ingredients
% ORGANIC FRUIT

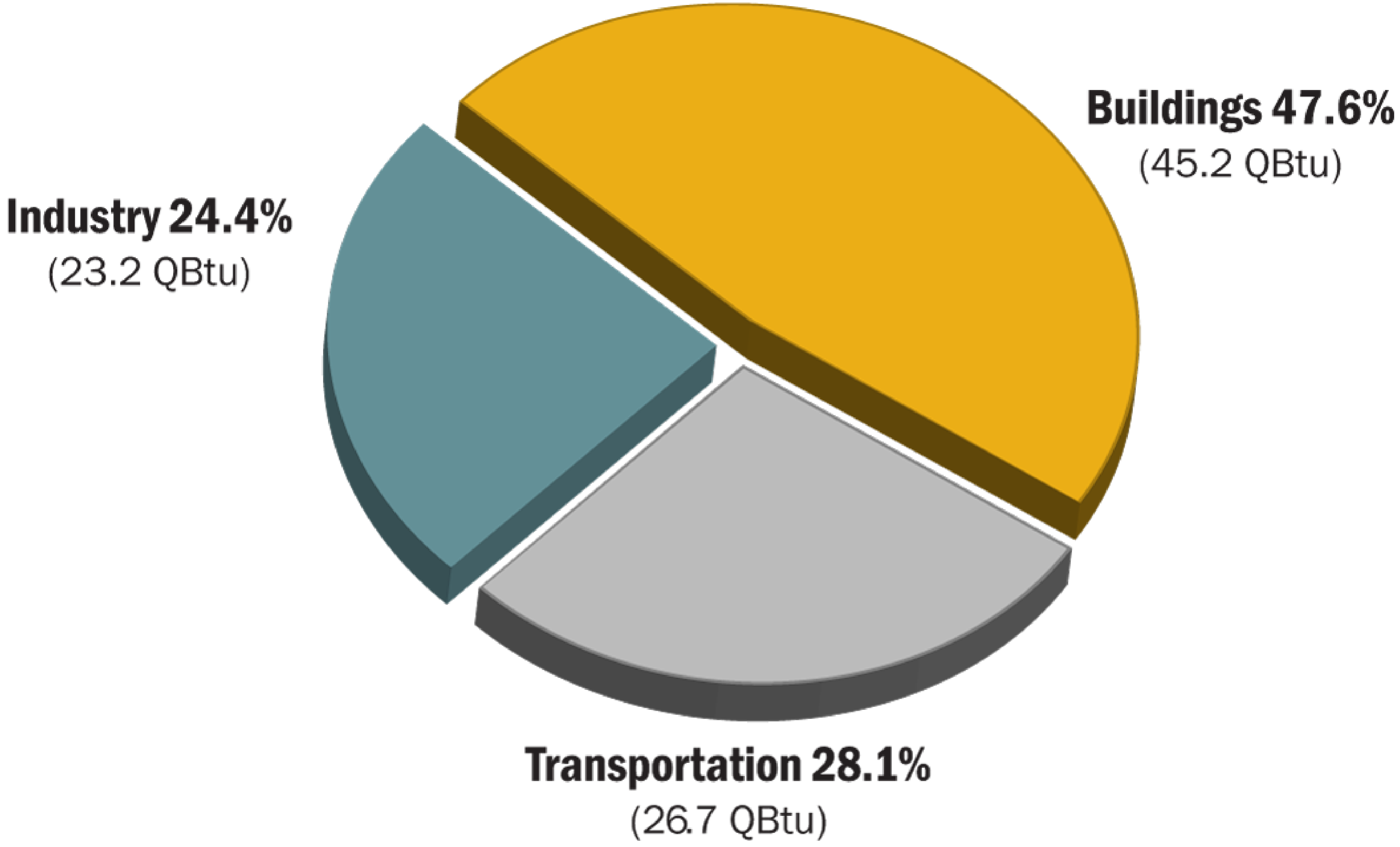

ELLIOTT BAY
Elliott Bay Seawall Project
(Phase 2)
Elliott Bay Seawall Project
(Phase 1: 2013-2016)
Partner Projects
Waterfront Seattle
(Core Project: 2016+
Potential Early Projects:
2012-2015)
SR 99 Tunnel Project
(2011-2015)
WATERFRONT SEATTLE
ELLIOTT BAY SEAWALL PROJECT
SR 99 TUNNEL PROJECT
PARTNER PROJECTS
0'
450'
900'
N
Sources: City of Seattle GIS, Google maps, SDOT 2010 Bike Map, ROMA 2002 Urban Design Assessment
Project construction dates are tentative and subject to change


Pike Place Market
MILLER | HULL


9-14-15

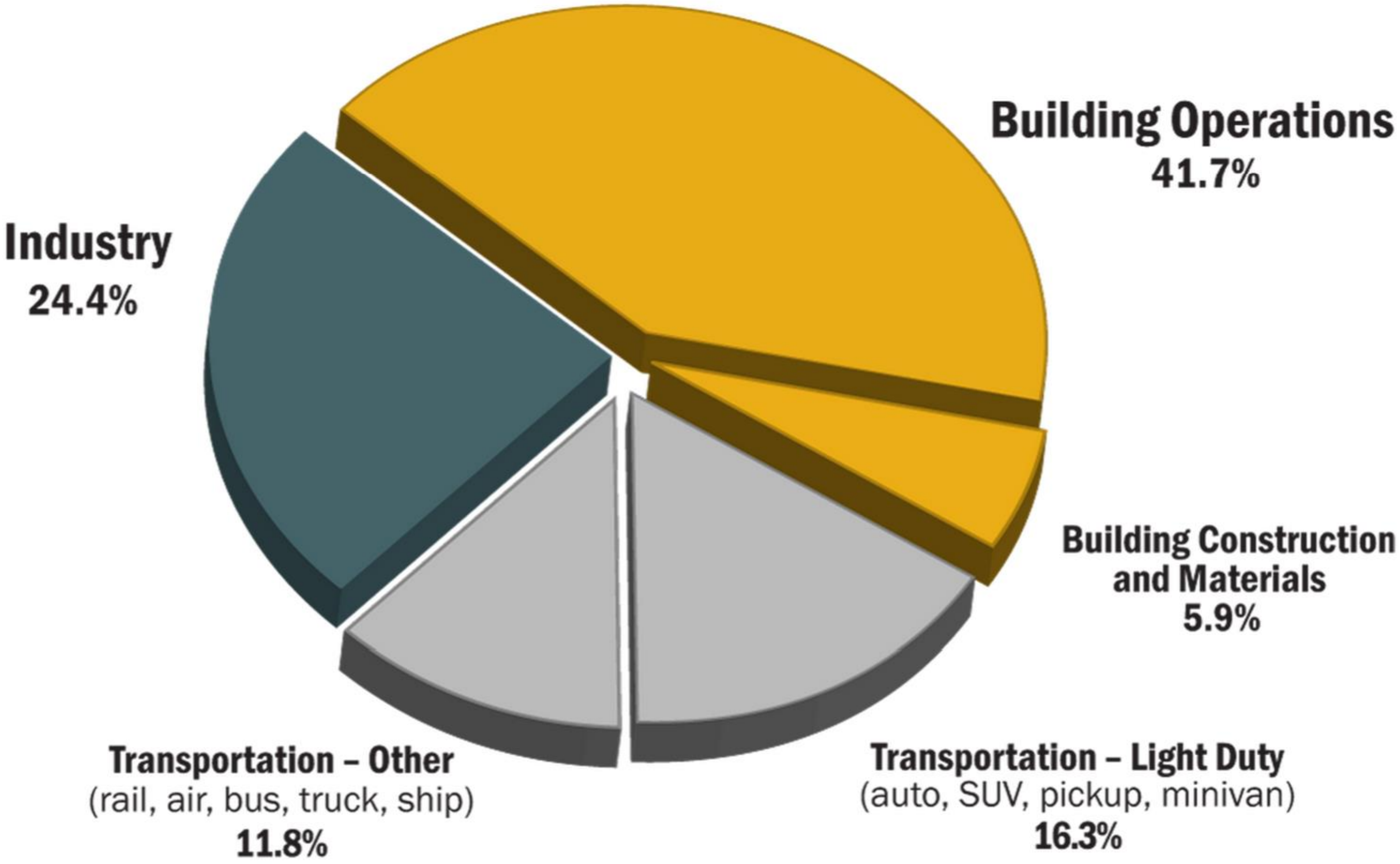

PIKE P
MARK
MILLER HULL


PIKE PLACE
MARKET
MILLER HULL



U.S. Energy Consumption by Sector

Data Source: U.S. Energy Information Administration (2012).

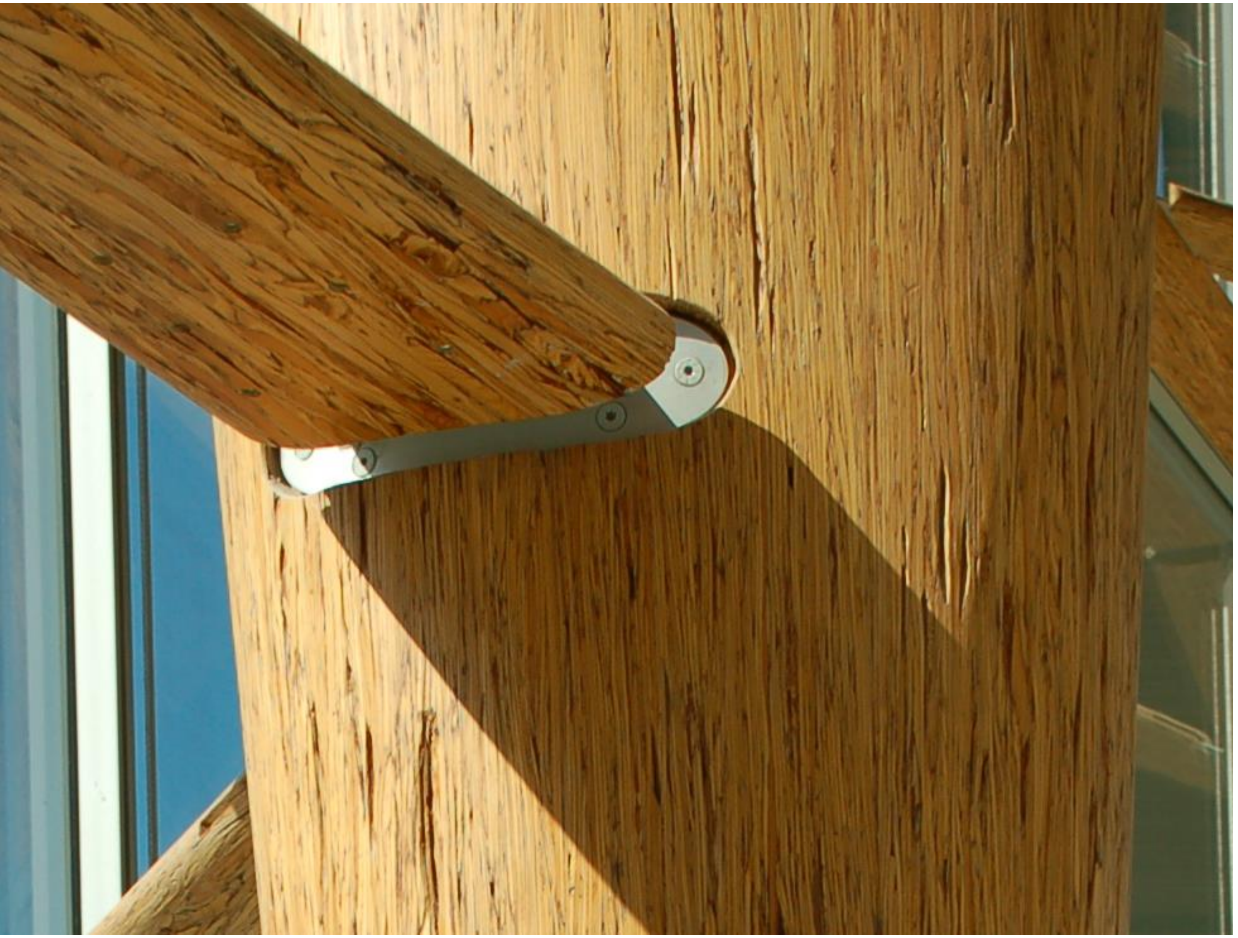


U.S. Energy Consumption by Sector

Data Source: U.S. Energy Information Administration (2012).

LVL courtesy Michael Green Associates

LAMINATED VENEER LUMBER (LVL)



Parallel Strand Lumber (PSL) courtesy Michael Green Associates

Laminated Strand Lumber (LSL) courtesy Michael Green Associates

STAND LUMBER (PSL + LSL)