

# Passive House + Living Building: Combining Rigorous Building Standards for Maximum Benefit

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# Course Description

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Ashley McGraw Architects and Binghamton University are currently collaborating to design and construct a 2800 square foot research station. The project is located proximate to campus on a 70+ acre nature preserve called Nuthatch Hollow, and is being designed to become certified as a Living Building by the International Living Futures Institute. The project team includes two Passive House Certified Consultants, who chose to overlay the Passive House Standard with the Living Building Challenge as a methodology to achieve rigorous energy use reductions in a high performance building.

As a requirement of the Living Building Challenge, the Nuthatch Hollow project must achieve net positive energy, which means 105% of the project's energy needs must be supplied by on-site renewable energy on a net annual basis, without the use of on-site combustion. Meeting the ambitious Passive House limits on heating and cooling loads, as well as source energy, will allow the Nuthatch project to easily meet the Living Building net positive energy requirements. This approach is more difficult than typical design strategies, but much more valuable in terms of investment and resilience. A PHIUS feasibility study has been initiated and will inform the ongoing design process.

Combining Passive House and Living Building presents some interesting challenges. The strict thermal requirements of Passive House and the material use limitations presented by the LBC "Red List", makes the selection of common building components, like windows, energy recovery ventilators, and insulation materials, into a very rigorous investigative process. The composting toilets used to achieve the water use limitations of LBC must be designed to ventilate through the building envelope in accordance with Passive House thermal and air tightness requirements. On-site energy storage required for LBC must be located strategically in order to eliminate any negative thermal impacts within the Passive House envelope. Reuse of the existing building foundation to meet site disturbance limitations within LBC requires specific attention to envelope details to achieve Passive House.

We are learning many valuable strategies through this challenging process. Collaboration is crucial to understand the building use and schedule in order to reduce loads as much as possible. Binghamton University faculty and students are engaged through integrated course curriculum in the vast amount of materials research required. In the face of all of the challenges, we will keep pushing the limits of what can be accomplished, to reach our climate goals for the future of people and planet.



# Learning Objectives

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At the end of the this course, participants will be able to:

1. Learn how the Passive House standard can facilitate the path to the Living Building Challenge Energy Petal.
2. Understand the compound challenges of meeting two very rigorous building programs: Passive House and Living Building Challenge, and some strategies for overcoming those challenges.
3. Understand documentation and research strategies to overcome the challenges of public bidding an ultra-high performance building.

# AGENDA

- Place
- Project
- Living Building Challenge
- Design
- Combining Standards
- Challenges and Strategies

# Nuthatch Hollow



# Nuthatch Hollow



NUTHATCH  
HOLLOW

Binghamton  
University

Hinman College

Dickinson Community

U Club Binghamton

Texas Roadhouse

IHOP

Fuller Hollow Creek

Fuller Hollow Creek

Fuller Hollow Creek

Susquehanna River

Riverside Dr

Riverside Dr

Crocker Island

Susquehanna River

Vestal Pkwy E

Vestal Pkwy E

434

434

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# Nuthatch Hollow



SYRACUSE

BINGHAMTON

Albany

VERMONT

NEW HAMPSHIRE

MASSACHUSETTS

CONNECTICUT

PENNSYLVANIA

NEW JERSEY

Yonkers

New York

60 km

# Nuthatch Hollow



# Essence of Nuthatch Hollow

Discovery

Diversity

Variety

Layered

Movement

Rhythm

Balance

Resilient

Ancient

Complex

Rejuvenating

Happiness

Oasis

Sanctuary

Water

Nutrients

Changing

Evolving

Energy

Understanding

Intertwined

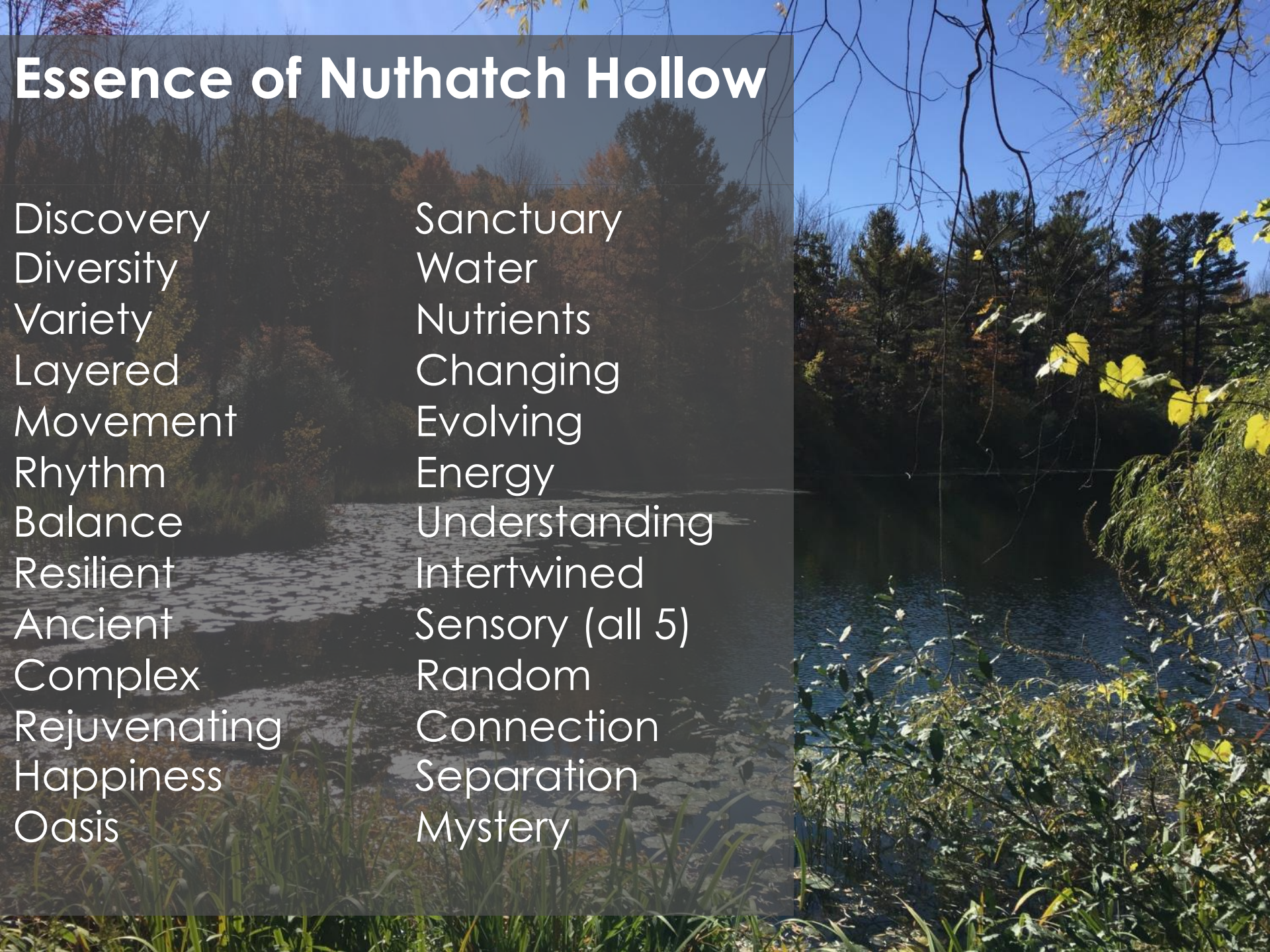
Sensory (all 5)

Random

Connection

Separation

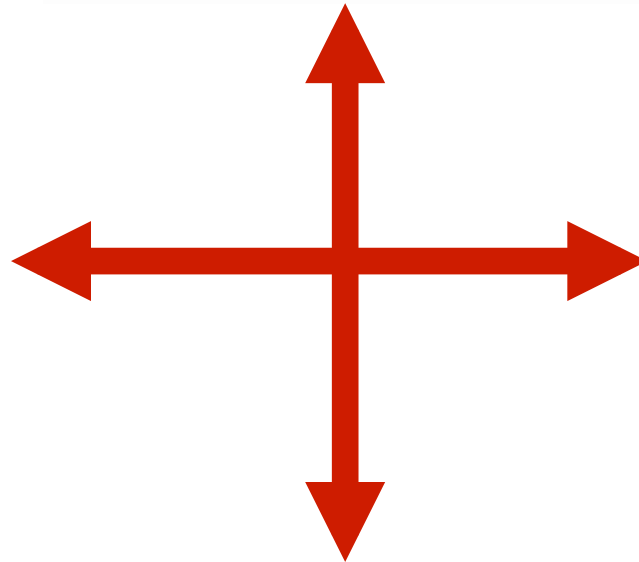
Mystery



# The Living Building at Nuthatch Hollow



ASHLEY MCGRAW



**RYAN BIGGS**  
**CLARK DAVIS**  
ENGINEERING & SURVEYING



**PATHFINDER**  
ENGINEERS & ARCHITECTS LLP

WHO ARE YOU ?



# The Living Building at Nuthatch Hollow

LAB

A scenic view of a pond with reeds and lily pads, surrounded by trees with autumn foliage. A tilted green box with the word 'LAB' is overlaid on the right side of the image.

# The Living Building at Nuthatch Hollow

MULTI-  
PURPOSE

LAB



# The Living Building at Nuthatch Hollow

SUPPORT

MULTI-  
PURPOSE

LAB

SUPPORT



# GOALS



# GOALS

- Place for environmental research



# GOALS

- Place for environmental research
- Hub for interdisciplinary collaboration



# GOALS

- Place for environmental research
- Hub for interdisciplinary collaboration
- Engage a wider audience



# GOALS

- Place for environmental research
- Hub for interdisciplinary collaboration
- Engage a wider audience
- Smart energy technology



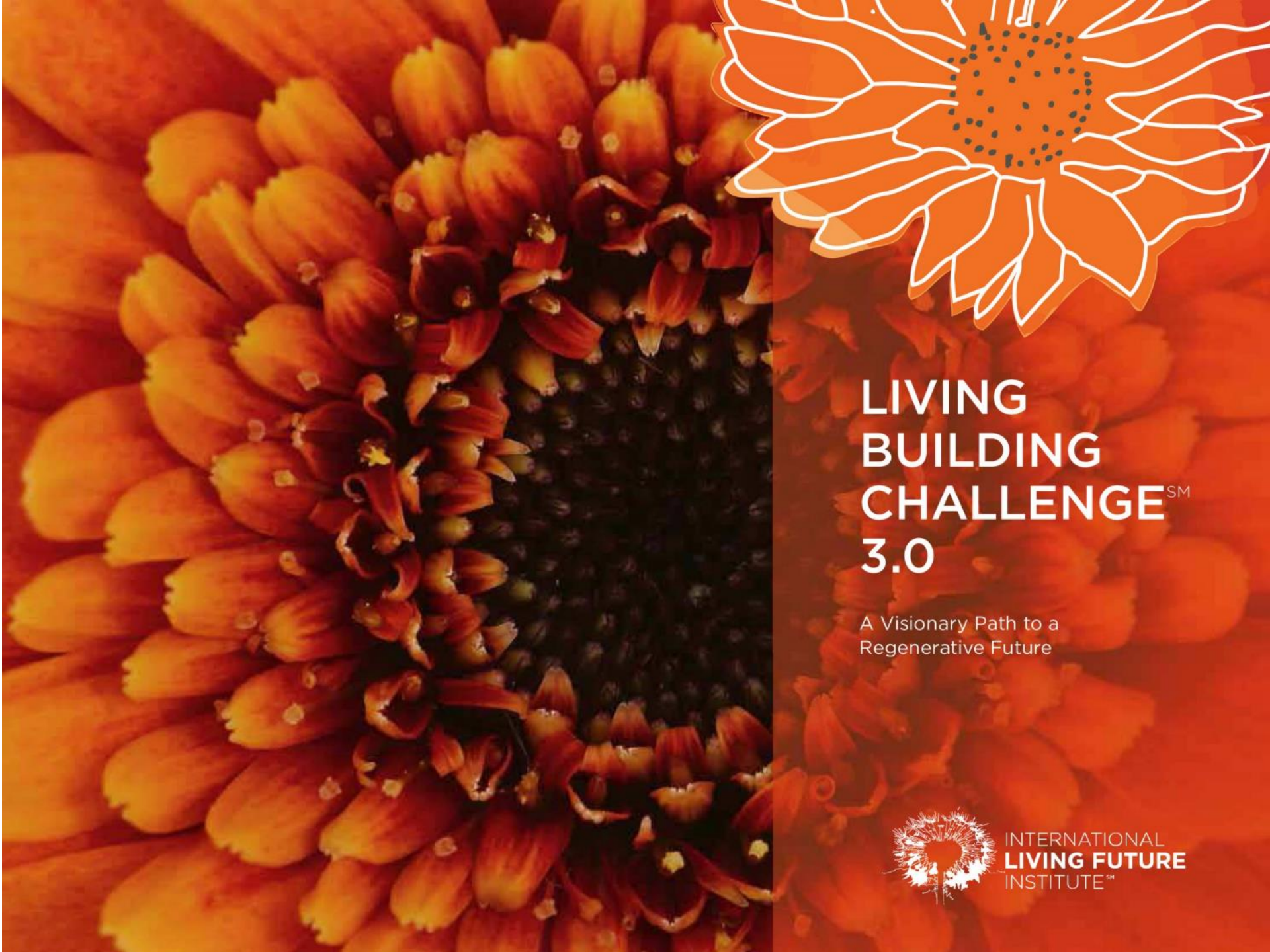
# GOALS

- Place for environmental research
- Hub for interdisciplinary collaboration
- Engage a wider audience
- Smart energy technology
- Replicable



# GOALS

- Place for environmental research
- Hub for interdisciplinary collaboration
- Engage a wider audience
- Smart energy technology
- Replicable
- Living Building Certification



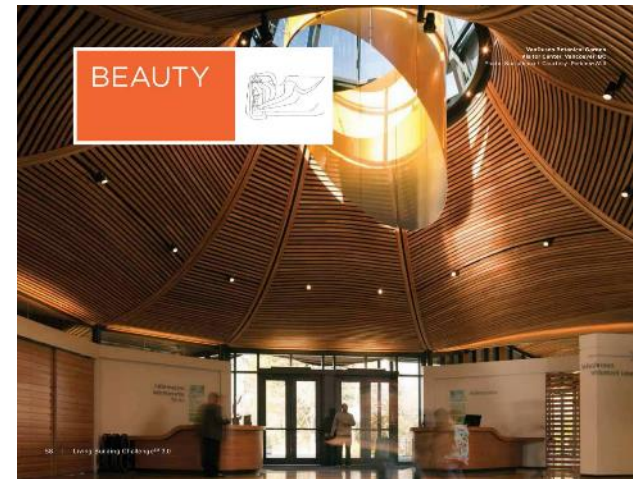
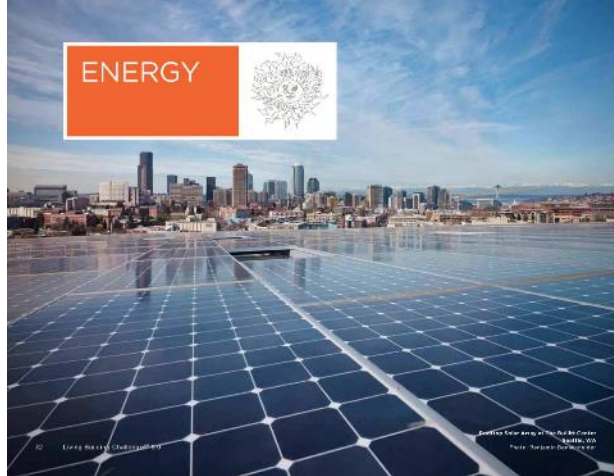
**LIVING  
BUILDING  
CHALLENGE<sup>SM</sup>  
3.0**

A Visionary Path to a  
Regenerative Future



INTERNATIONAL  
**LIVING FUTURE**  
INSTITUTE<sup>SM</sup>





PLACE



WATER



# ENERGY



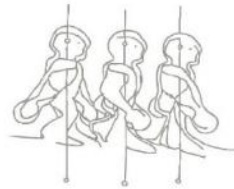
# HEALTH & HAPPINESS



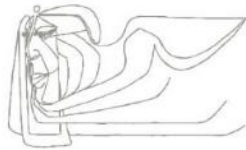
# MATERIALS



# EQUITY



# BEAUTY



VanDusen Botanical Garden  
Visitor Center, Vancouver, BC  
Photo: Nic Lehoux / Courtesy: Perkins+Will





# MATERIALS



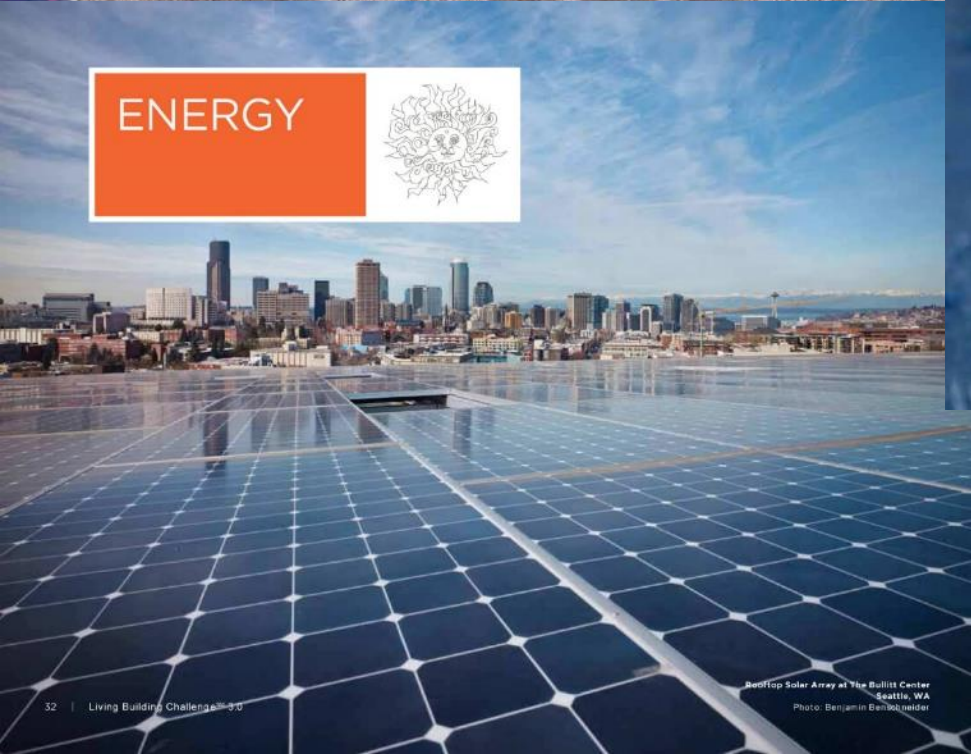
University Childcare Centre

# WATER



28 | Living Building Challenge™ 3.0

# ENERGY



RoofTop Solar Array at The Bullitt Center  
Seattle, WA  
Photo: Benjamin Benbowelder





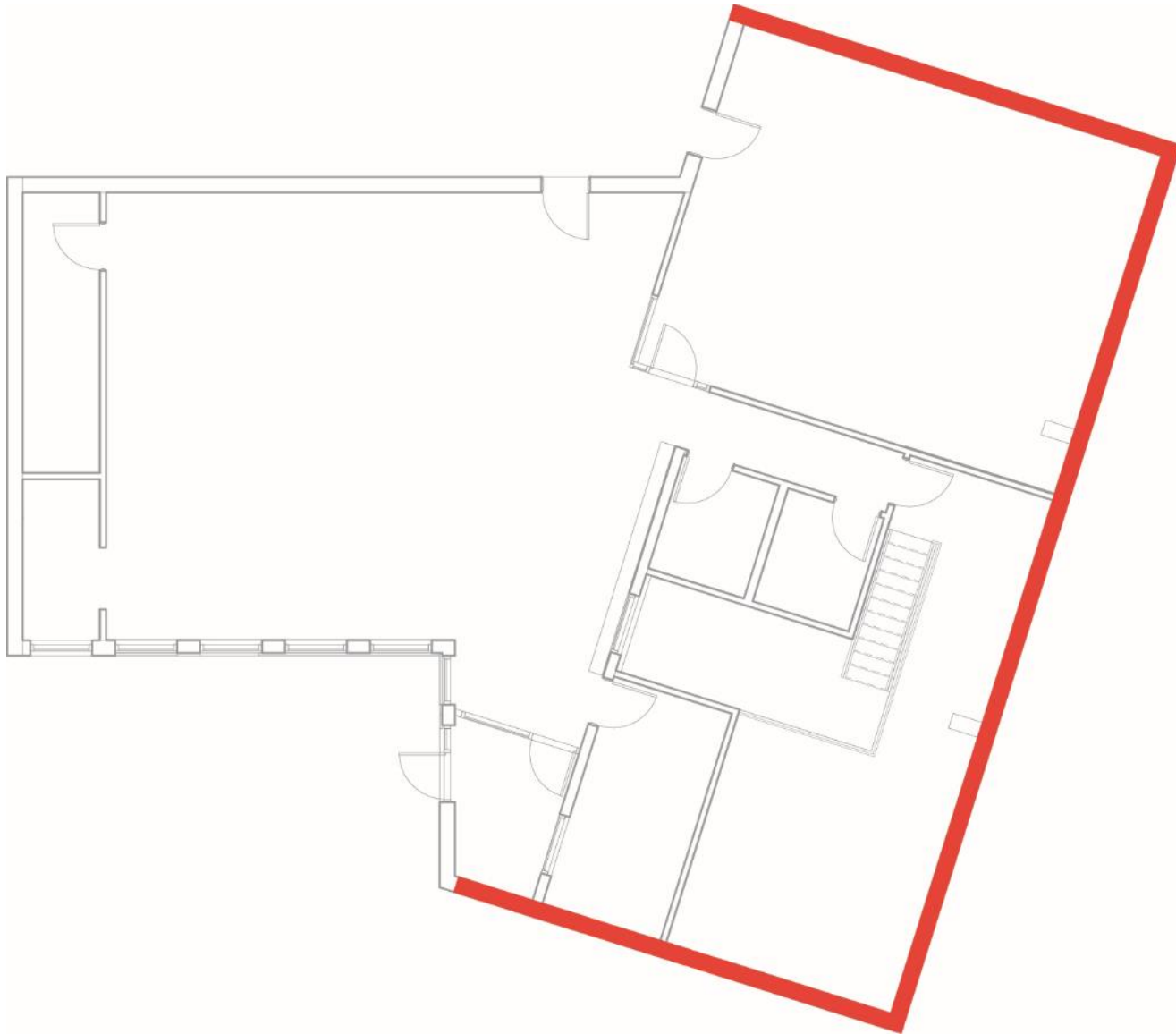






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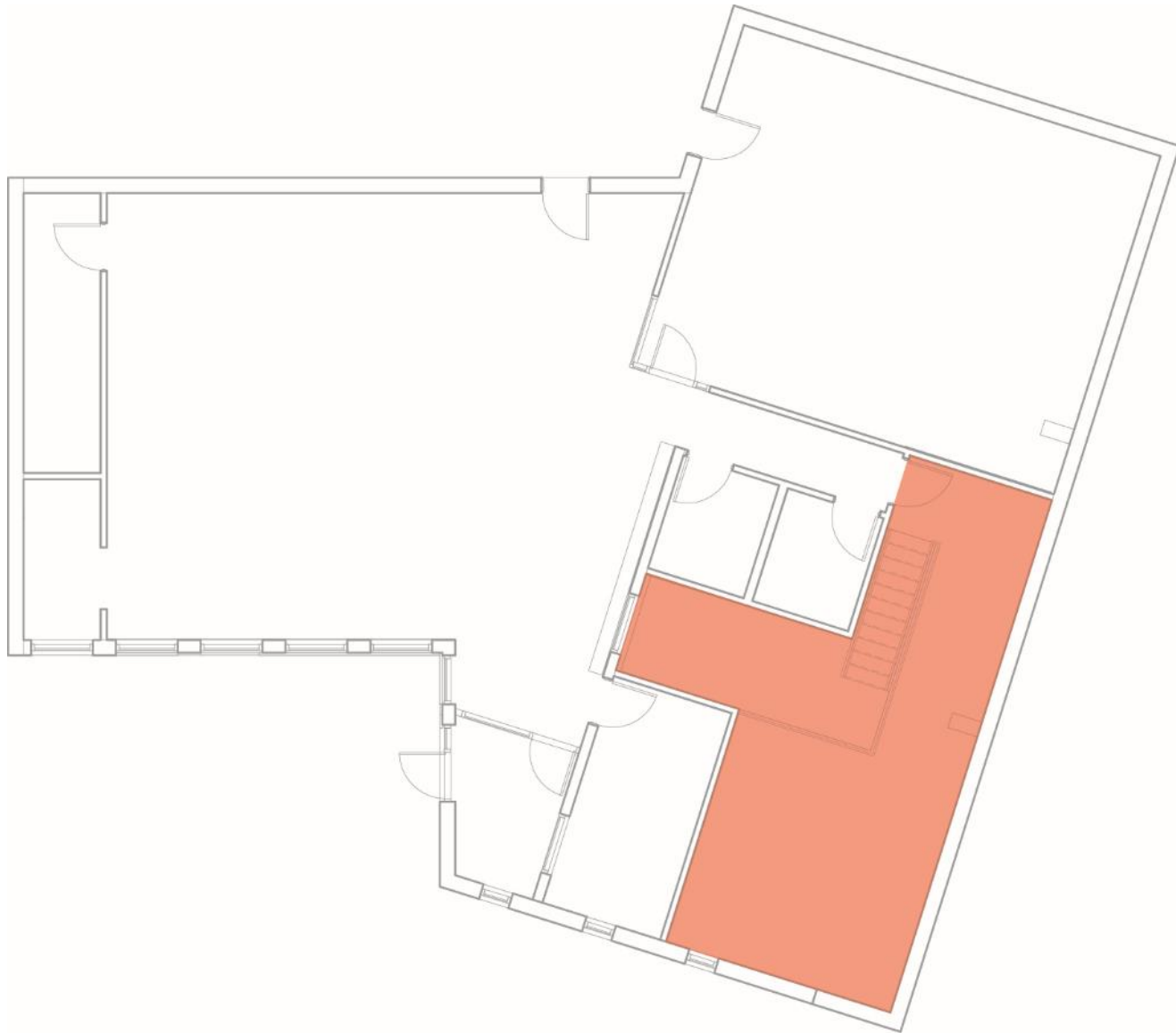
REVEAL



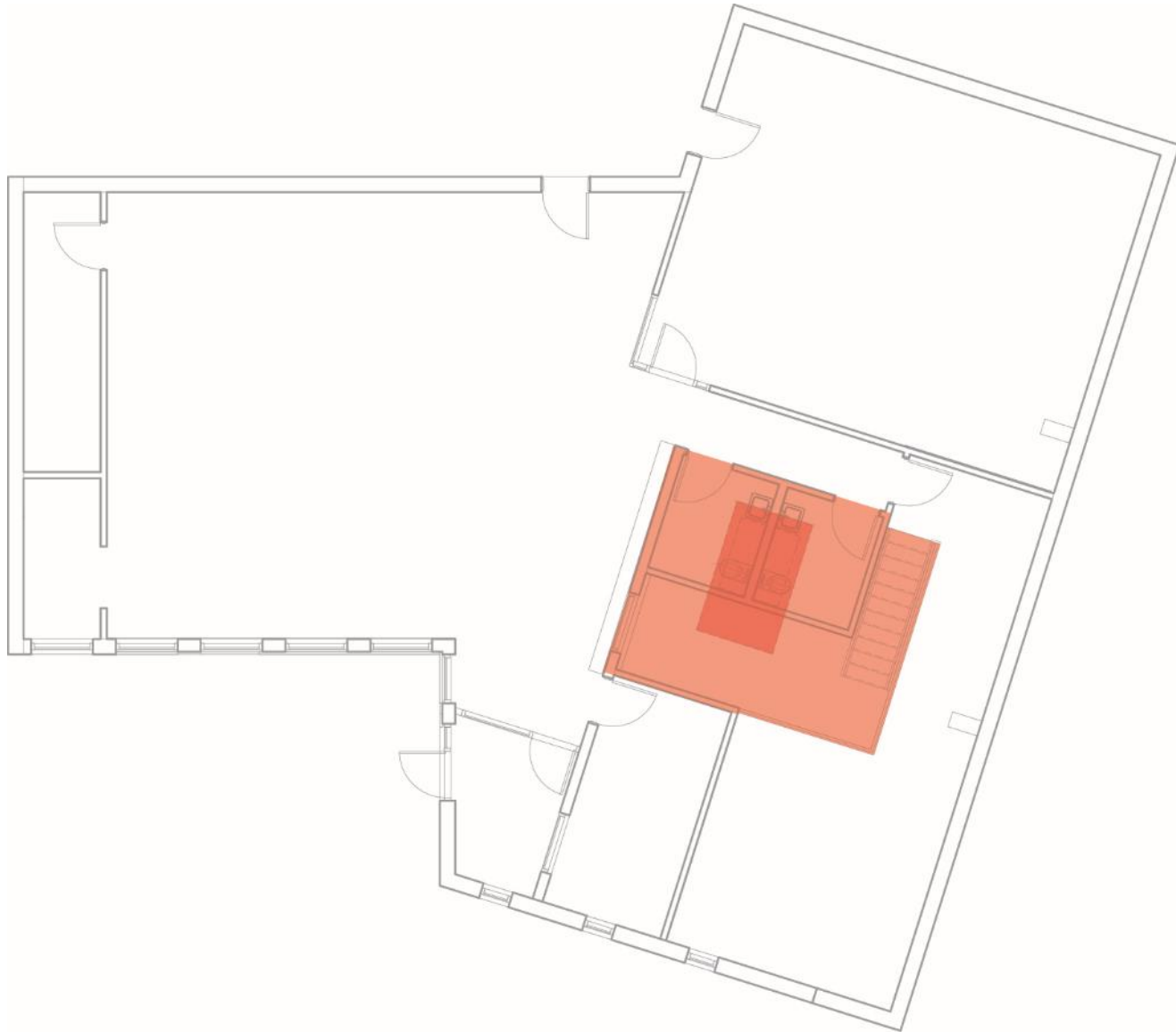
Foundation Walls

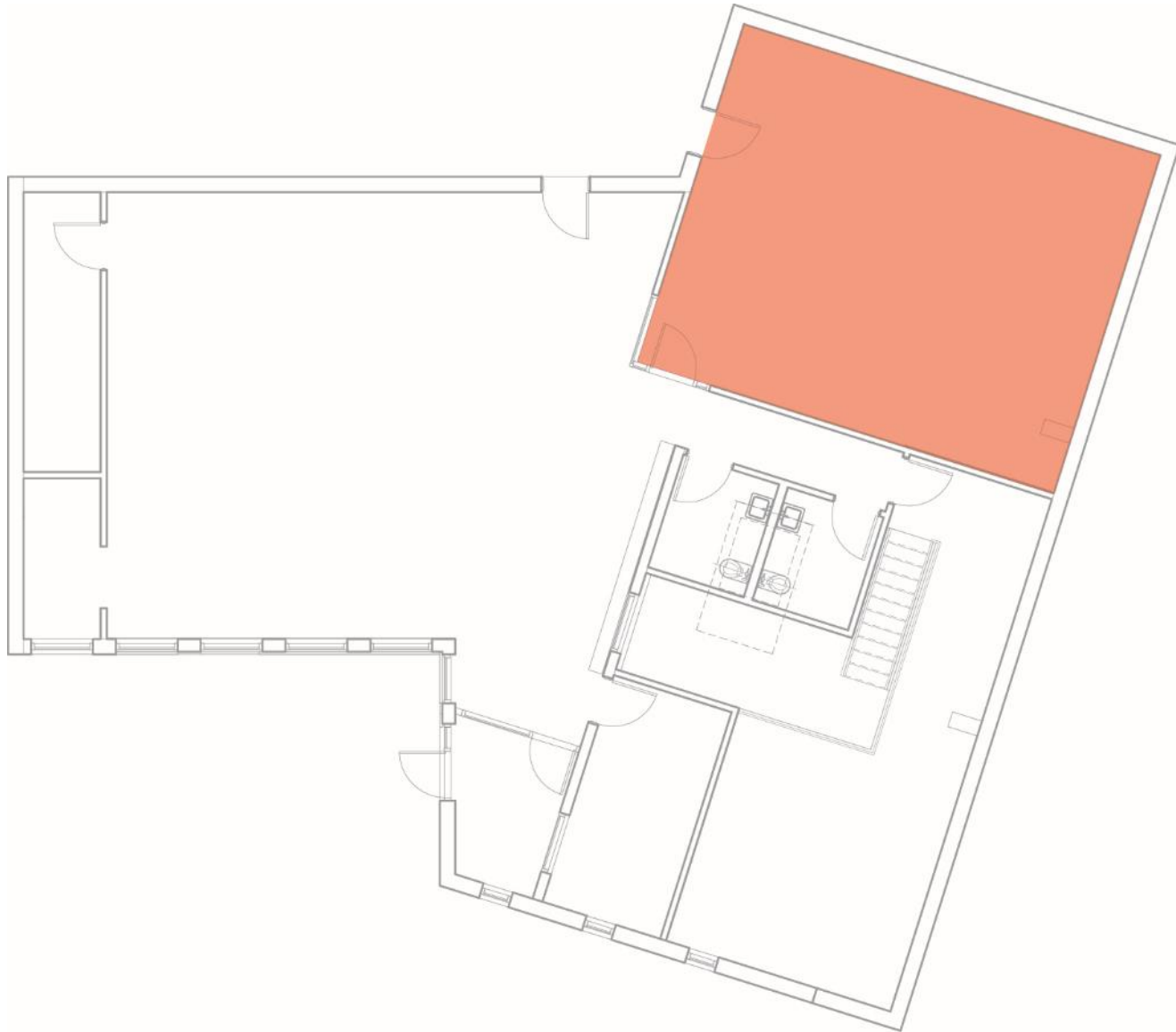






Mechanical Room 

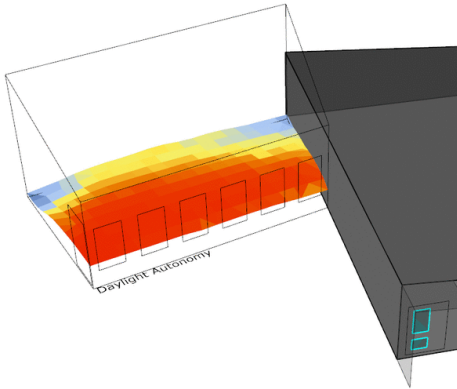
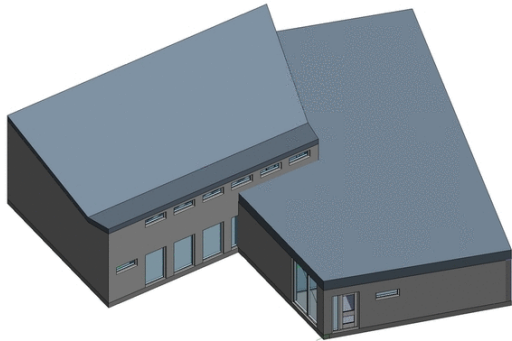







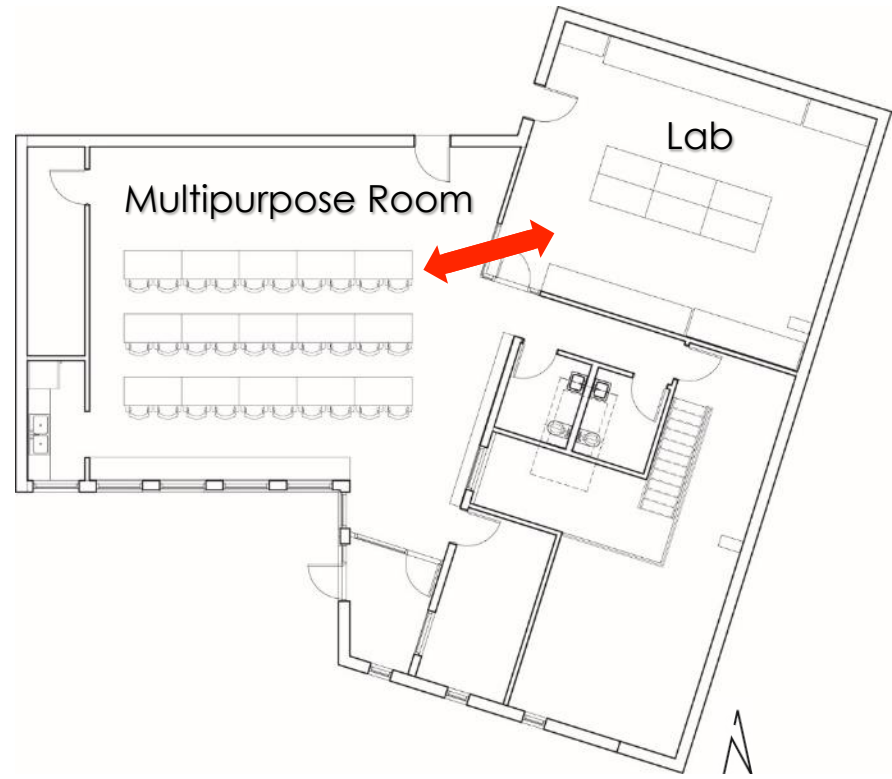
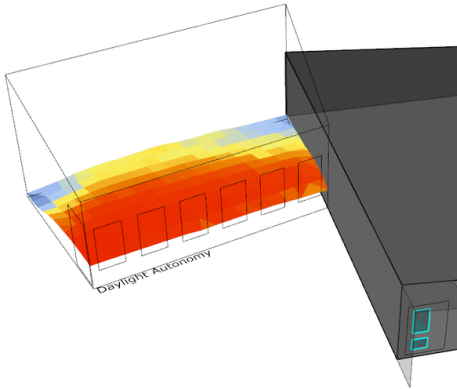
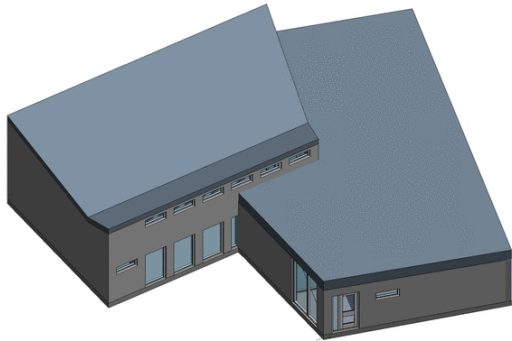
Multipurpose Room 

# 1 PLACEMENT



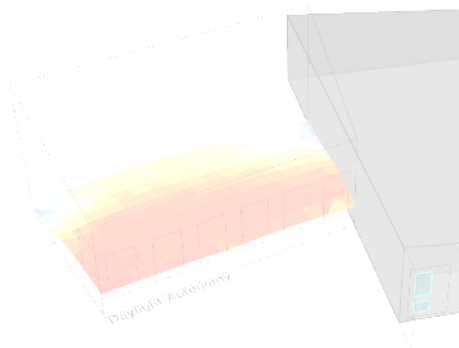
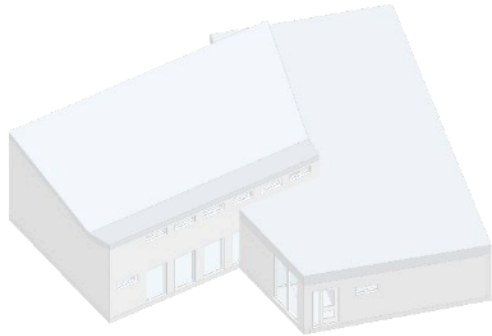
 sDA: 74.86 | Adaptive comfort: 20.46%  
Too hot: 30.45% | Too cold: 49.1%

# 1 PLACEMENT



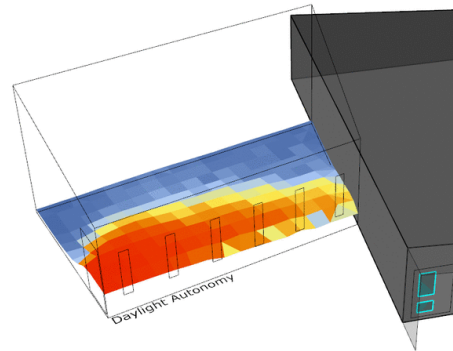
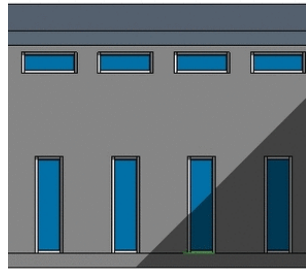
sDA: 74.86 | Adaptive comfort: 20.46%  
Too hot: 30.45% | Too cold: 49.1%

# 1 PLACEMENT



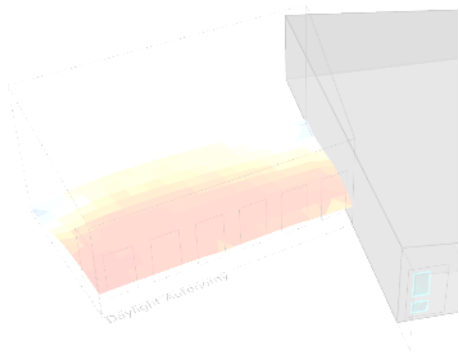
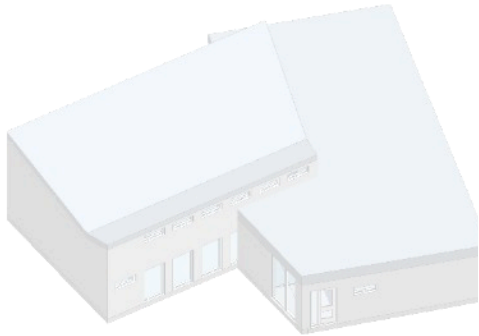
sDA: 75.96 | Adaptive comfort  
Too hot: 32.25% | Too cold: 1.99%

# 2 GLAZING-WALL RATIO



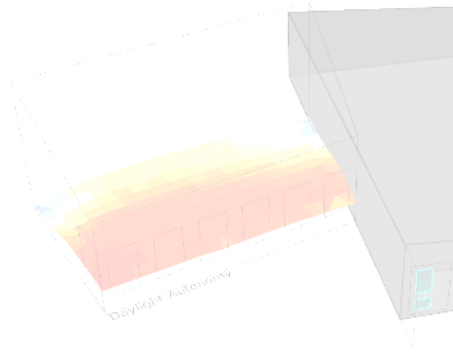
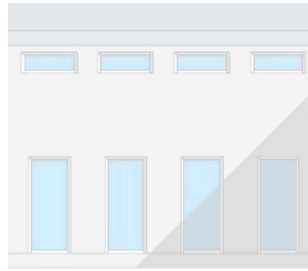
sDA: 37.16 | Adaptive comfort: 21.18%  
Too hot: 25.59% | Too cold: 53.23%

# 1 PLACEMENT



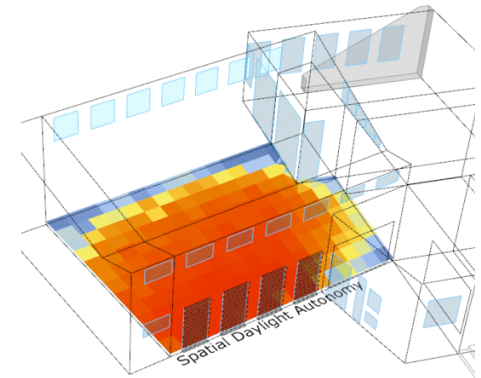
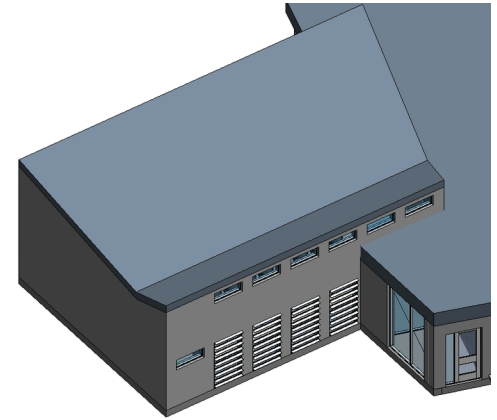
sDA: 75.96 | Adaptive comfort  
Top nat: 32.27% Top sda: 49.03%

# 2 GLAZING-WALL RATIO



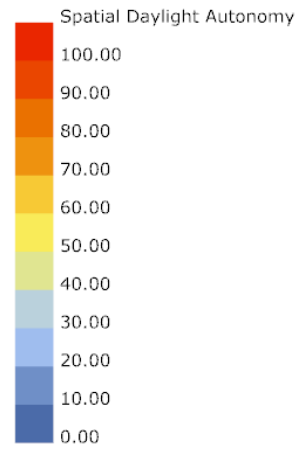
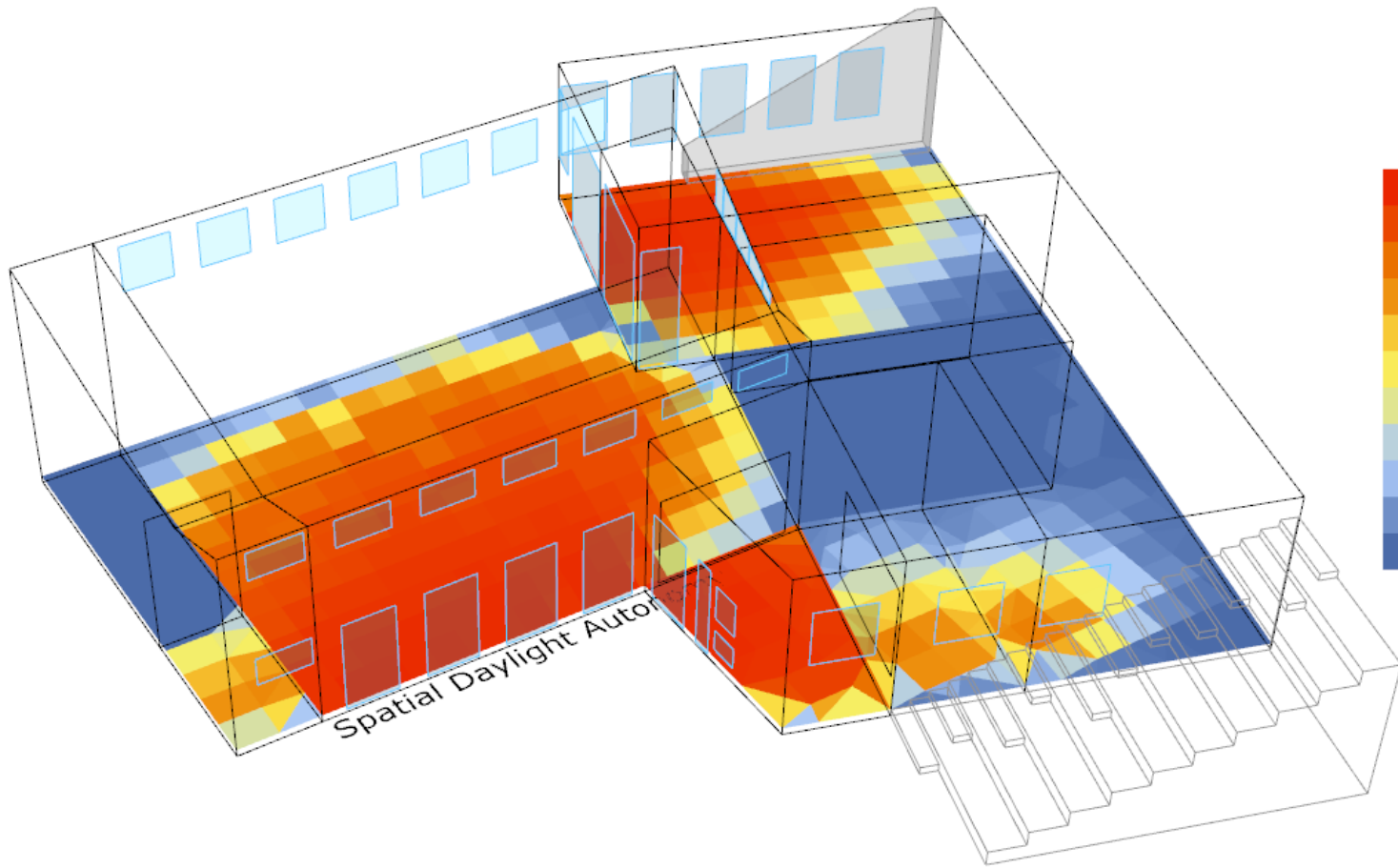
sDA: 75.96 | Adaptive comfort: 20.4%  
Top nat: 32.27% Top sda: 49.03%

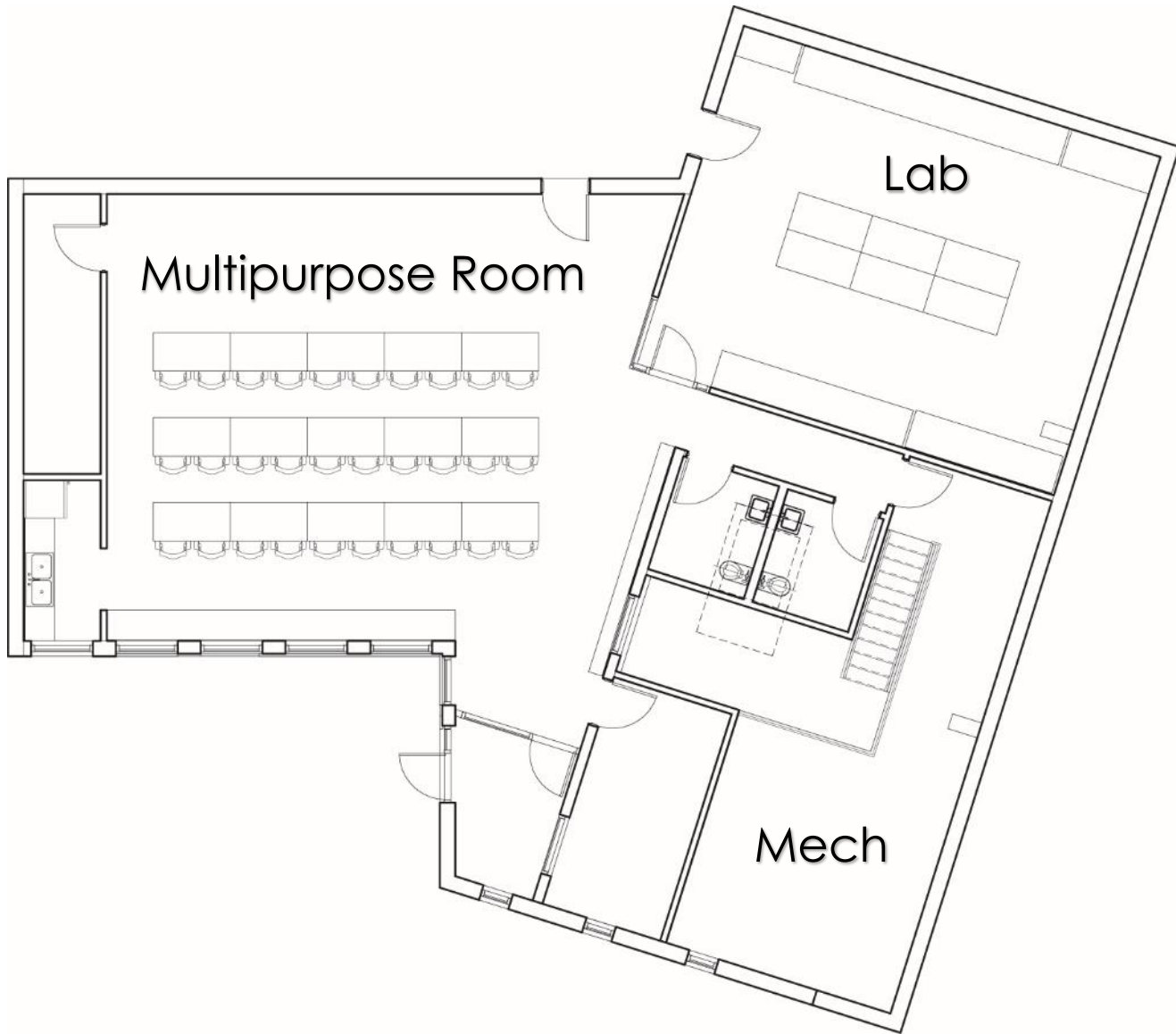
# 3 SHADING DEVICE



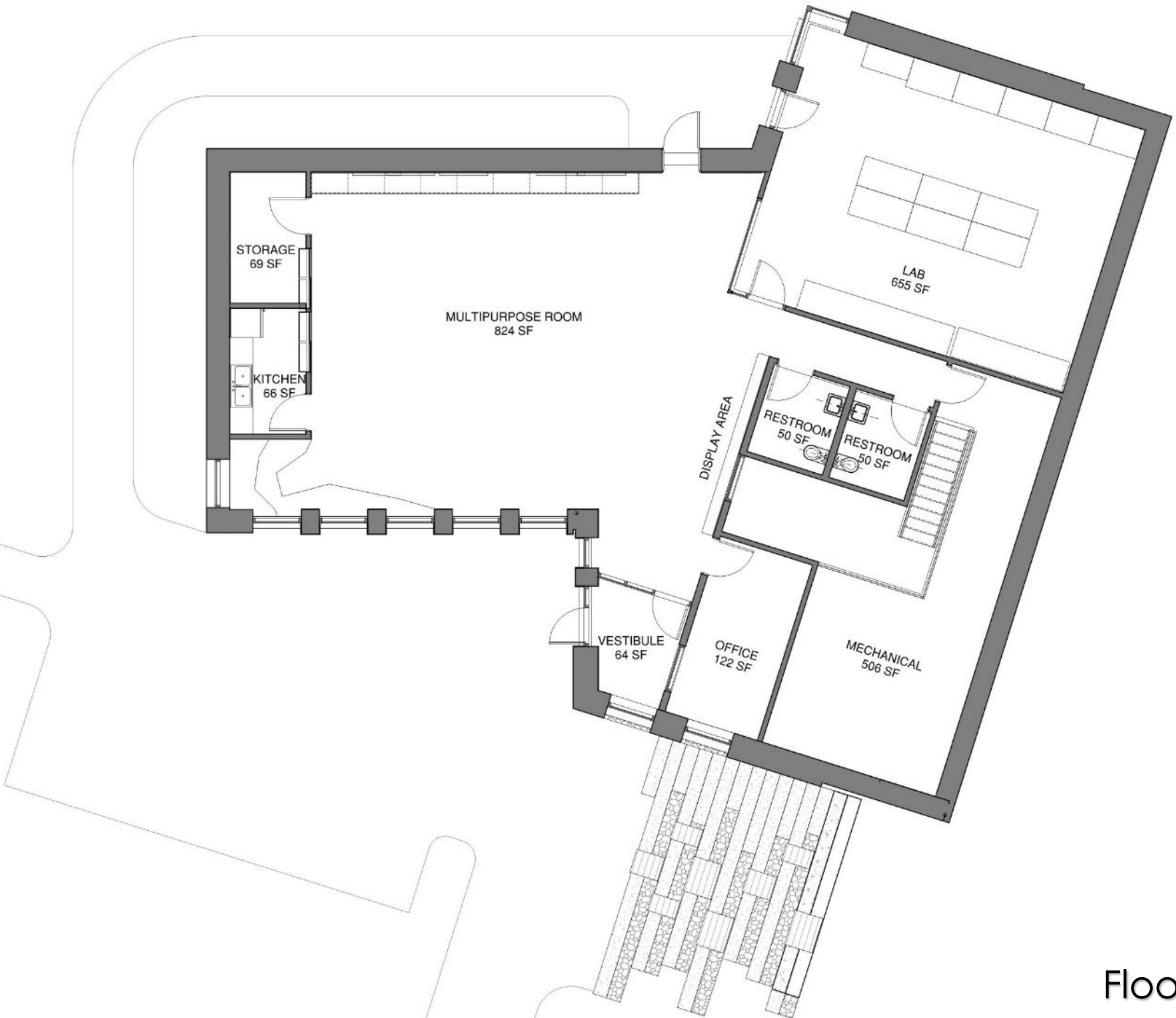
sDA: 75.24%





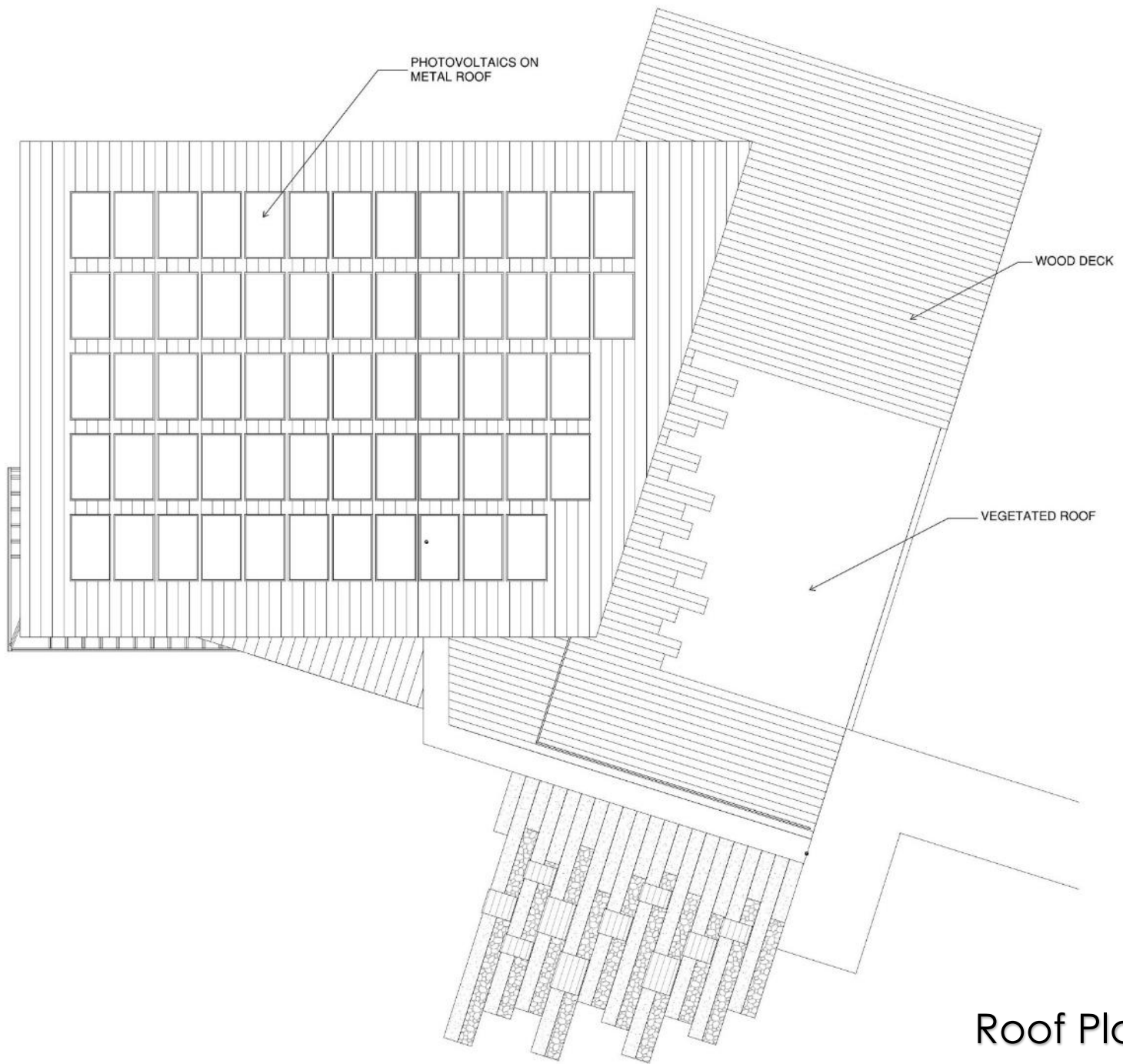


Schematic Floor Plan 



Floor Plan





Roof Plan 



# Current Status



Source Energy:  
**38 KBTU/sf\*yr or 11.1kWh/sf**  
 Site Energy:  
 12.025 KBTU/sf\*yr or  
 3.513kWh/sf\*yr  
 @2909 sf =  
**10,218.32kWh/yr**

WUFI Plus V.3.1.1.0 \\\ZEVE-AMIR1\Projects 5-Z\SUNY Binghamton\16002 SUNY Binghamton Nuthatch Hollow\01-Sustainability\Passive House\PHIUS Feasibility Study\FS-SUNY - AMA-wit...

File Input Options Database Help

Scope: **Passive house verification** English/IP/Outer dimensions/PHIUS+ 2015 Standard Assign data

| Name              | Begin utilization [hr] | End utilization [hr] | Annual utilization days [days/yr] | Illumination level [lux] | Height of utilization level | Relative absence [-] | Part use factor of operating period for lighting [-] |
|-------------------|------------------------|----------------------|-----------------------------------|--------------------------|-----------------------------|----------------------|--|
| Typical Occupancy | 8                      | 17                   | 112                               | 500                      | Level 1: 0 ft               | 0.25                 | 0.9  |
| Summer Rest       | 10                     | 12                   | 60                                | 500                      | Level 1: 0 ft               | .25                  | .9   |
| Once a week       | 8                      | 22                   | 28                                | 500                      | Level 1: 0 ft               | .25                  | .9   |
| Weekend           | 10                     | 14                   | 56                                | 500                      | Level 1: 0 ft               | .25                  | .9   |
| Summer            | 9                      | 16                   | 14                                | 500                      | Level 1: 0 ft               | .25                  | .9   |

Optional data: Typical Occupancy

Average occupancy [#/Person]

Room setpoint temperature [°F]

Heating reduction temperature [°F]

Daily utilization hours [hrs/d]

Annual utilization hours [hrs/yr]

Annual utilization hours during daytime [hrs/yr]

Annual utilization hours during nighttime [hrs/yr]

Daily heating operation hours [hrs/d]

Daily ventilation operation hours [hrs/d]

Number of max water tap openings per day [-]

Data state/results Show warnings

|                 |                  |  |   |
|-----------------|------------------|--|---|
| Heating demand: | 5.47 kBTu/ft²yr  |  | ✓ |
| Cooling demand: | 1.59 kBTu/ft²yr  |  | ✓ |
| Heating load:   | 4.29 Btu/hr ft²  |  | ✓ |
| Cooling load:   | 2.12 Btu/hr ft²  |  | ✓ |
| Source energy:  | 32.53 kBTu/ft²yr |  | ✓ |
| Site energy:    | 10.3 kBTu/ft²yr  |  | ✓ |

Binghamton

State  
 NY

ASHRAE 2013 & Global Solar Radiation  
 Location  
 Edwin A Link Field

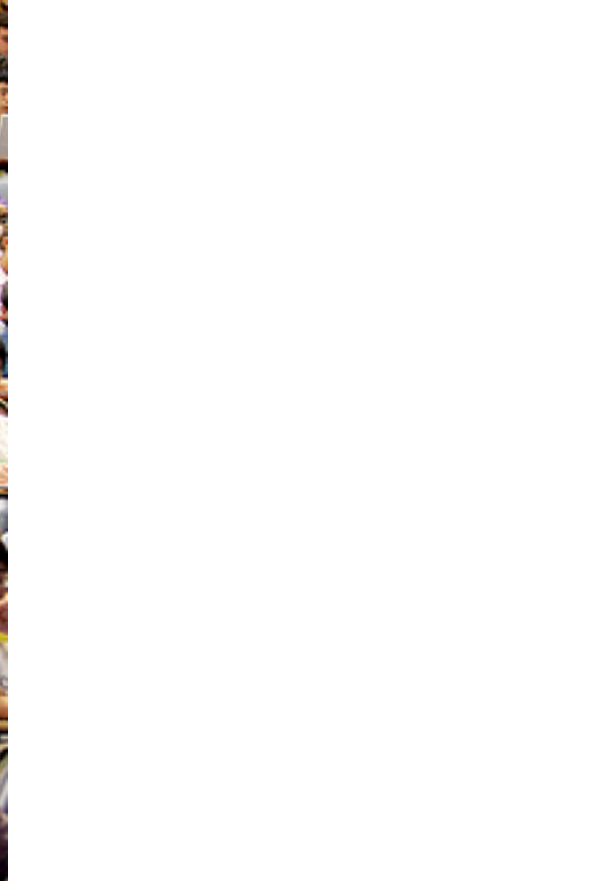
Zone  
 5

Annual heating demand kBTu/sf-iCFA.yr  
 6.4

Annual cooling demand kBTu/sf-iCFA.yr  
 1.6

Peak heating load Btu/sf-iCFA.h  
 4.6

Peak cooling load Btu/sf-iCFA.h  
 3.7



| Name              | Begin utilization [hr] | End utilization [hr] | Annual utilization days [days/yr] | Occupant quantity |
|-------------------|------------------------|----------------------|-----------------------------------|-------------------|
| Typical Occupancy | 8                      | 17                   | 112                               | 45                |
| Summer Typical    | 10                     | 12                   | 60                                | 5                 |
| Once a week       | 8                      | 22                   | 28                                | 60                |
| Weekend           | 10                     | 14                   | 56                                | 5                 |
| Summer Camp       | 9                      | 16                   | 14                                | 45                |



**Roof: R-72**

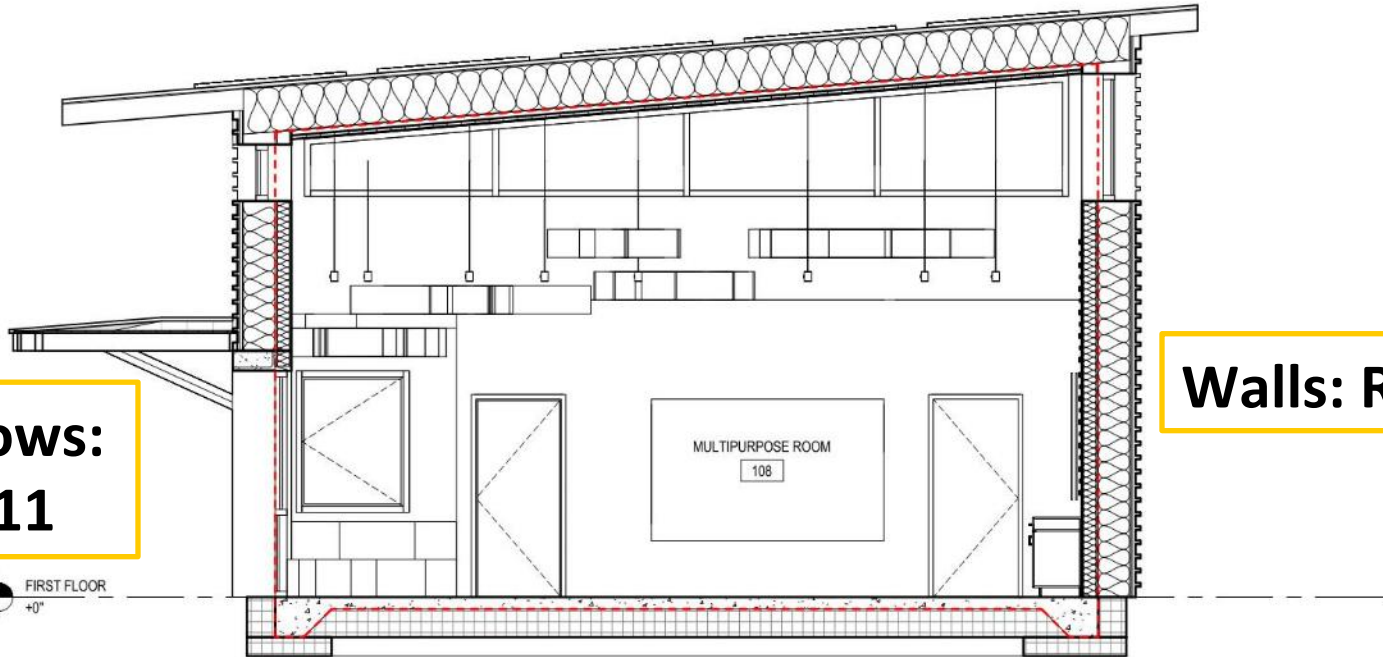
**Windows:  
Uw 0.11**

**Walls: R-61**

FIRST FLOOR  
+0'

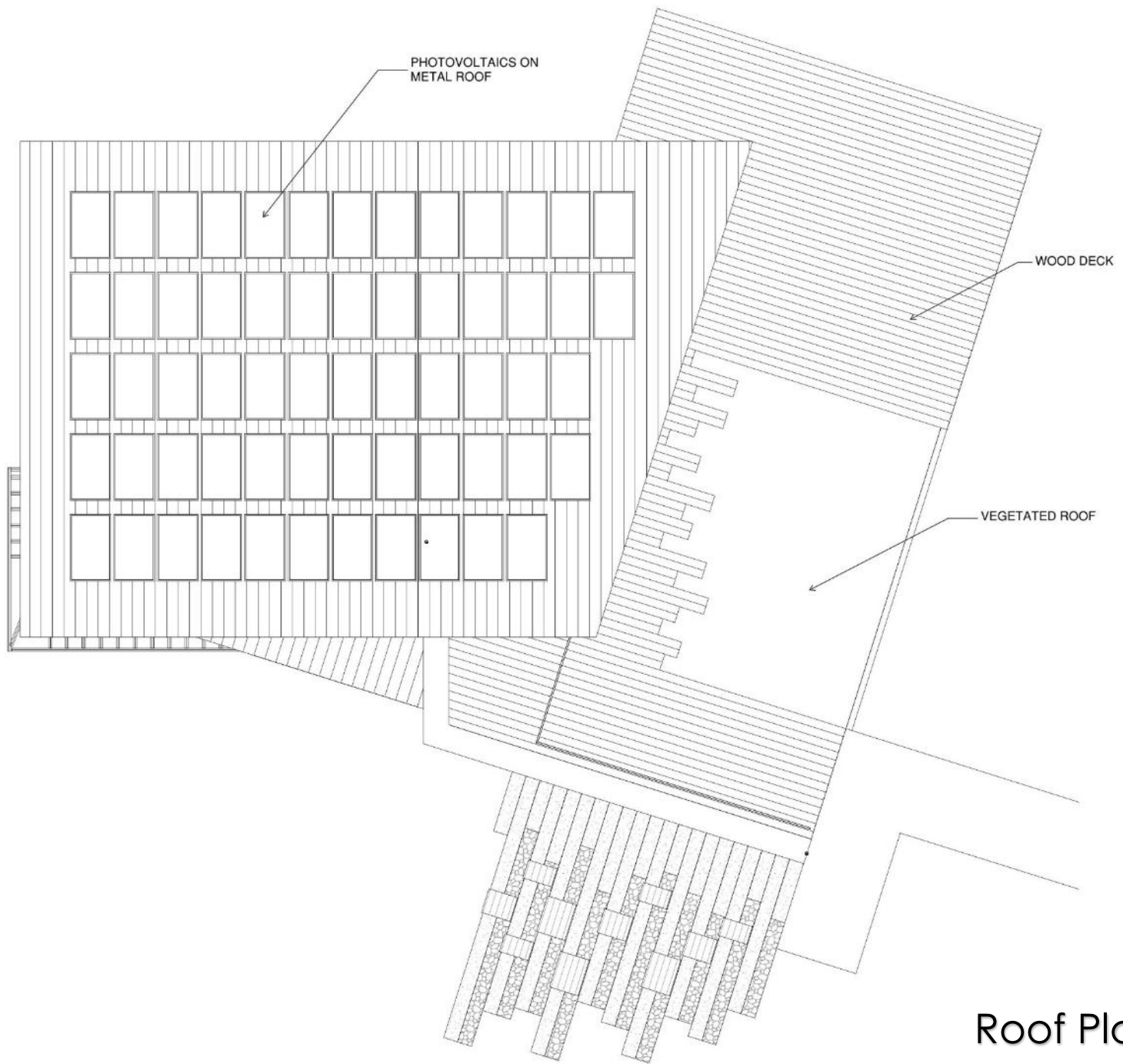
**Slab: R-48**

**Below Grade  
Walls: R-48**









PHOTOVOLTAICS ON METAL ROOF

WOOD DECK

VEGETATED ROOF

Roof Plan



At each hourly time step

if [ $SOC \leq 0$  or  $SOC \geq BC$ ] then

$$B = 0$$

else

$$B = B'$$

end if

$$C_{RE,batt} = \frac{\sum_{hour} \max(0, B_{hour} + \min(LE_{hour}, RE_{hour}))}{\sum_{hour} RE_{hour}}$$

Where  $B$  is the battery state-of-charge,  $BC$  is the battery capacity, and

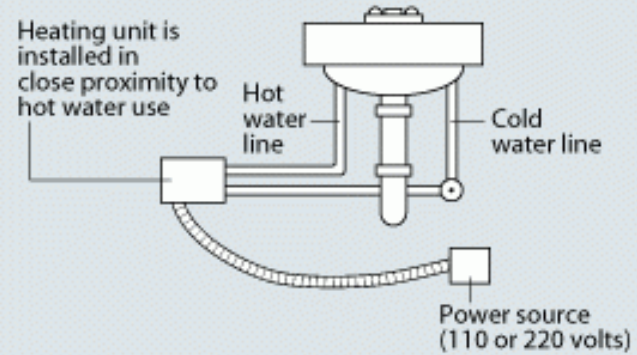
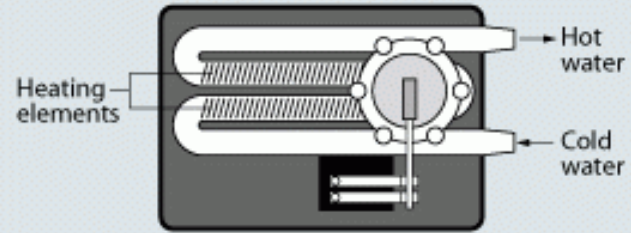
$$B' = LE - RE$$

The battery state of charge at each step is calculated as

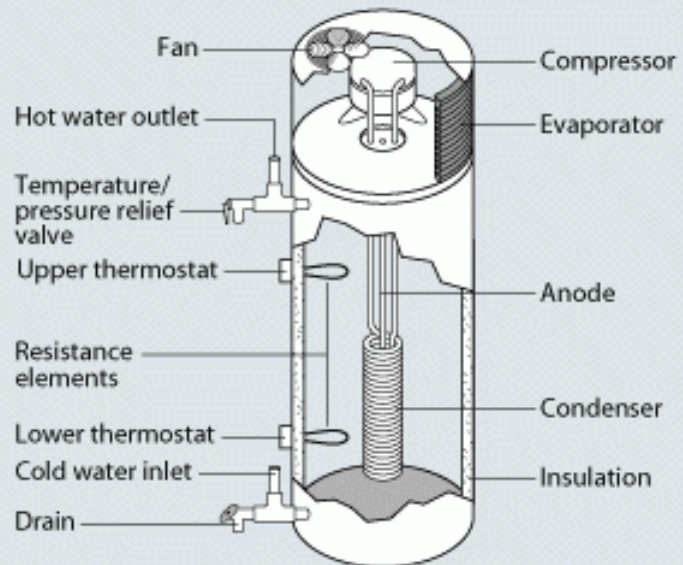
$$SOC_{hour} = \min(BC, \max(0, SOC_{hour-1} - B'_{hour} \cdot (1 + k_{LOSS} \text{sign} B'_{hour})))$$



### Electric Demand Water Heater



### Heat Pump Water Heater



**Carrying Capacity**

Project water needs must be met within the carrying capacity of the site's natural water systems. For example, if the supply is rainwater, there must be sufficient opportunities for evapotranspiration and infiltration; if the supply is groundwater, there must be sufficient opportunities to recharge the aquifer. Where water is returned to the aquifer after use, it must be reintroduced so that it does not compromise natural systems (e.g., appropriately treated and reintroduced at an undamaging temperature, etc.).

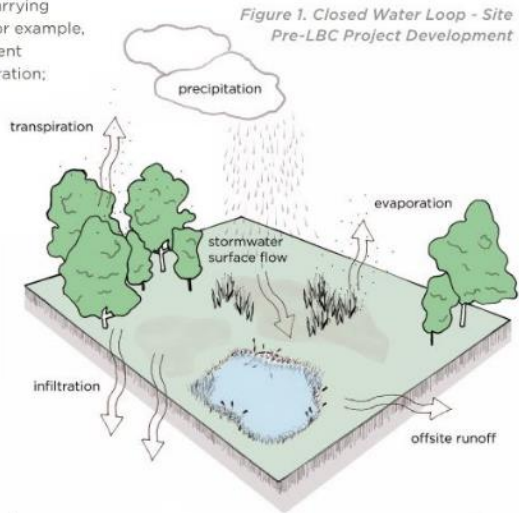


Figure 1. Closed Water Loop - Site Pre-LBC Project Development

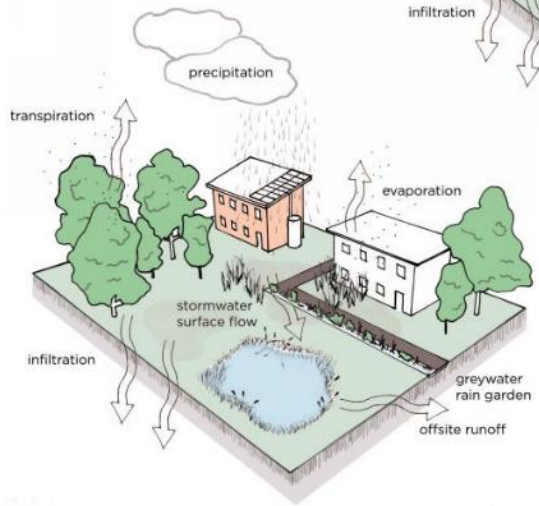


Figure 2. Closed Water Loop - Site Post-LBC Project Development

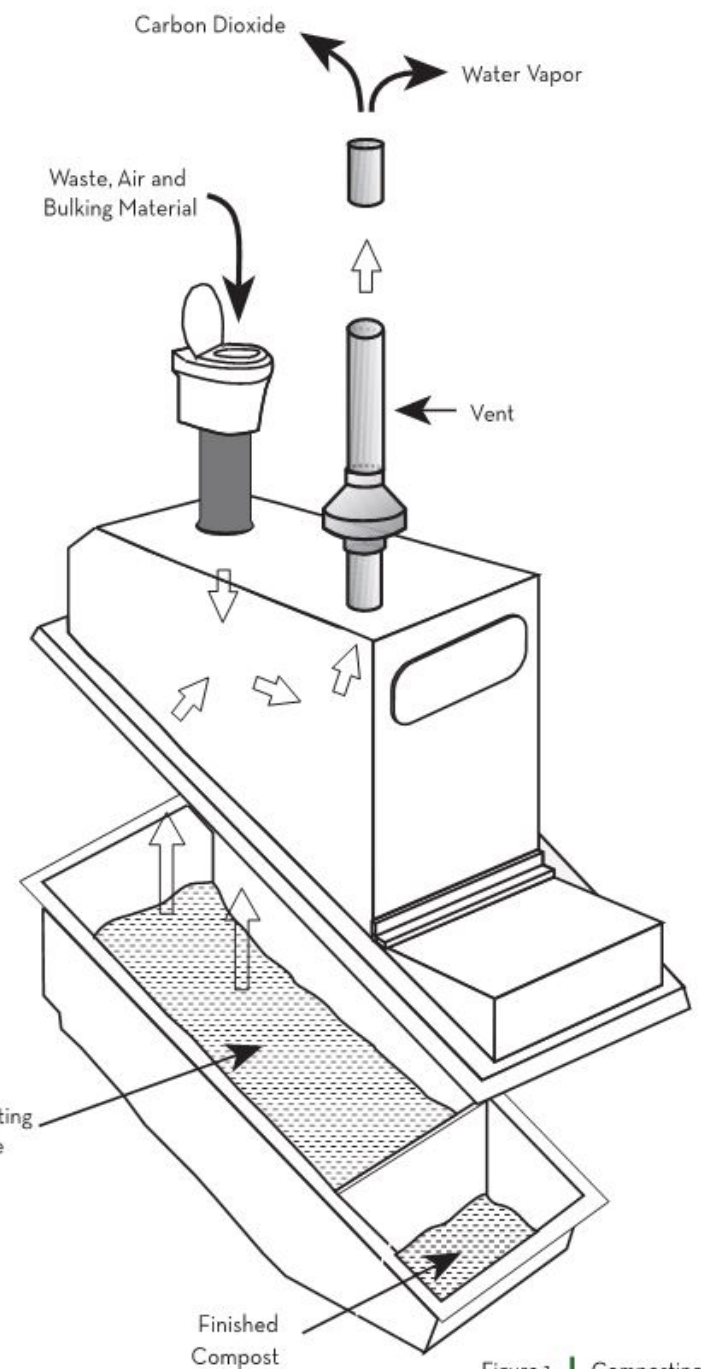


Figure 1. | Composting Process

**Carrying Capacity**

Project water needs must be met within the carrying capacity of the site's natural water systems. For example, if the supply is rainwater, there must be sufficient opportunities for evapotranspiration and infiltration; if the supply is groundwater, there must be sufficient opportunities to recharge the aquifer. Where water is returned to the aquifer after use, it must be reintroduced so that it does not compromise natural systems (e.g., appropriately treated and reintroduced at an undamaging temperature, etc.).

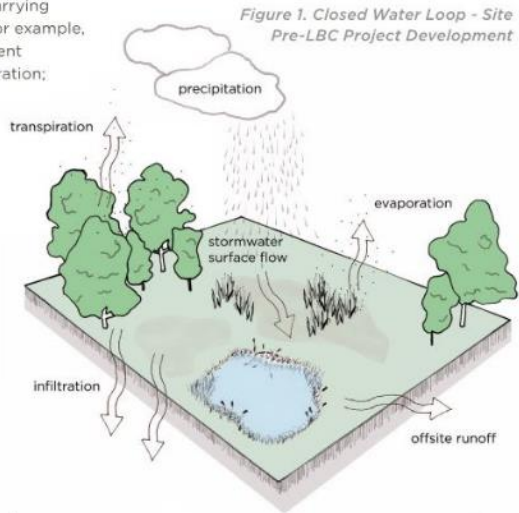


Figure 1. Closed Water Loop - Site Pre-LBC Project Development

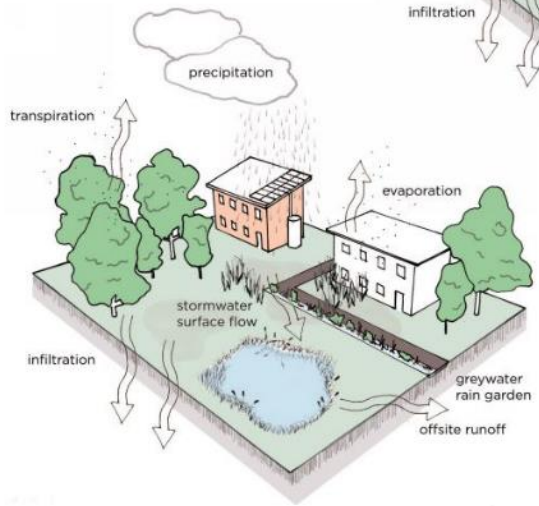


Figure 2. Closed Water Loop - Site Post-LBC Project Development

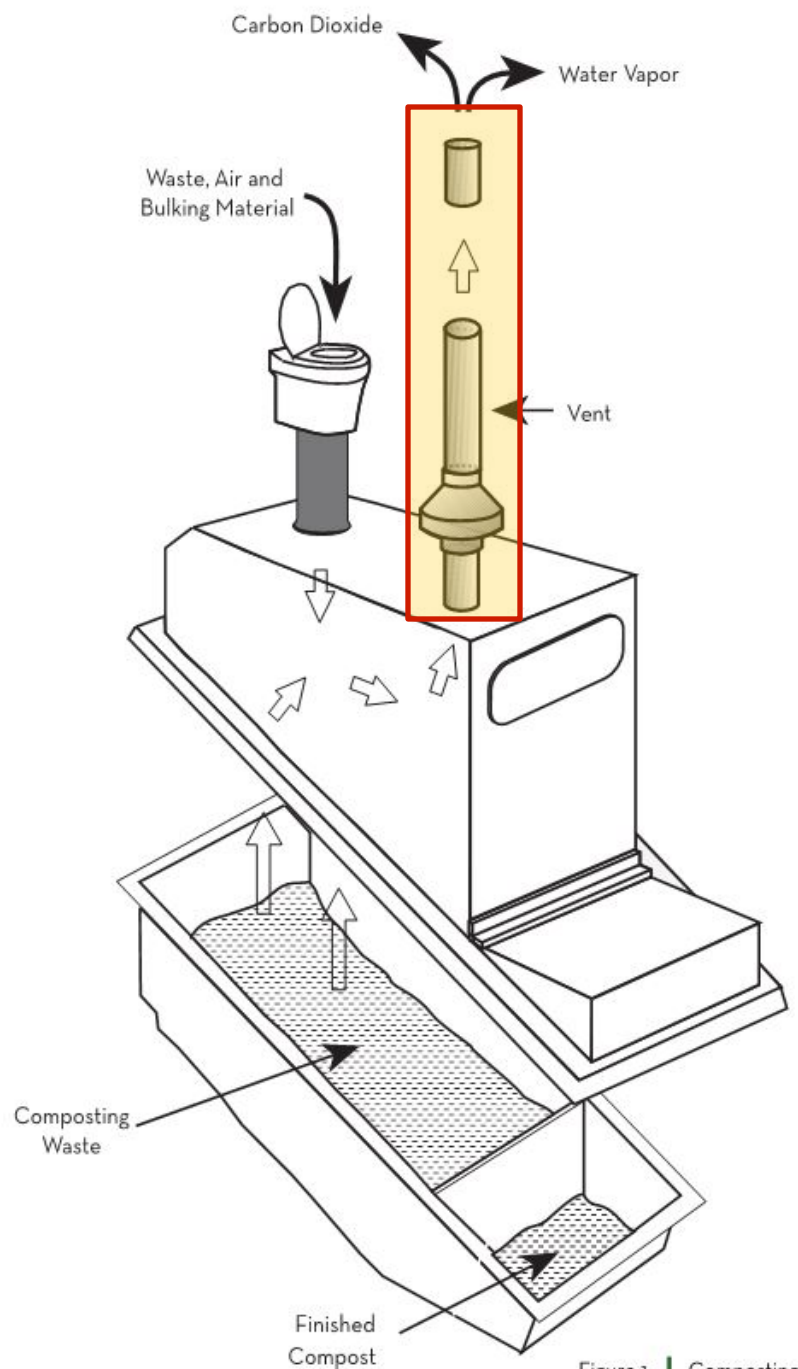
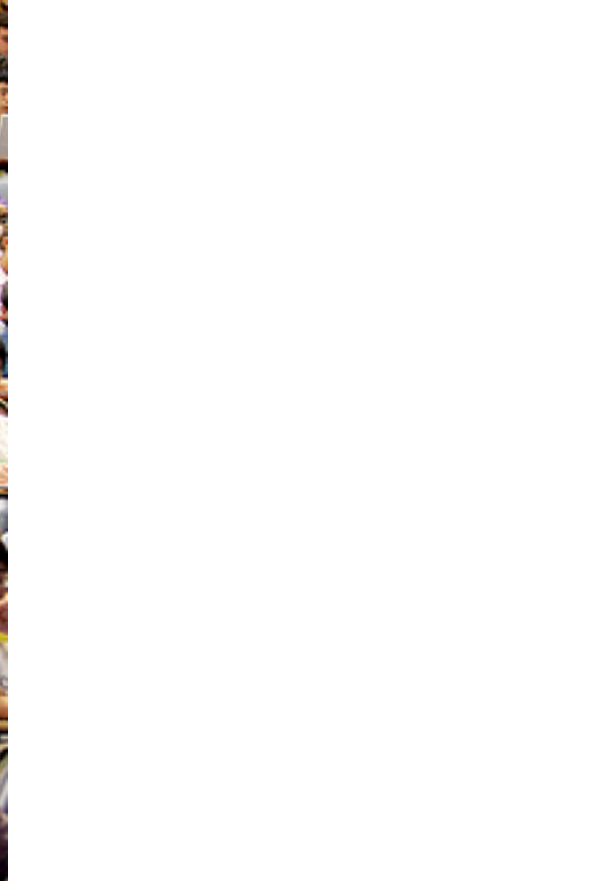


Figure 1. | Composting Process



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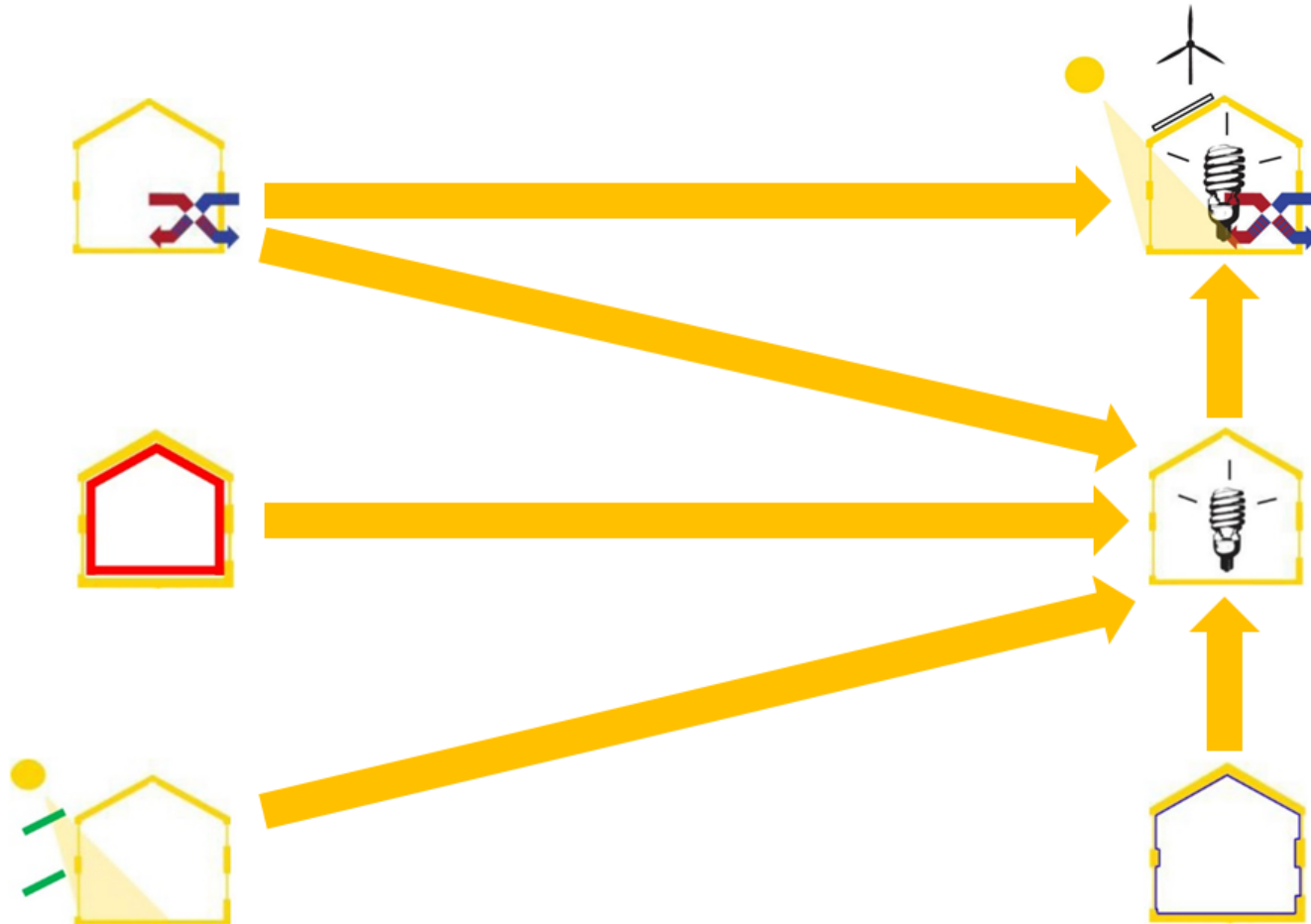


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# Passive House?





**Conclusion**

**Blog: <http://envi.Binghamton.edu>**

A black and white photograph of a classroom. In the foreground, a young boy on the left and a young girl on the right are both raising their hands. The boy is wearing a patterned shirt, and the girl is wearing a light-colored shirt and a headband. In the background, other children are visible, some with their hands raised. A teacher's hand holding a book is visible in the upper center. The word "QUESTIONS ?" is overlaid in the center of the image.

QUESTIONS ?

This concludes The American Institute of Architects  
Continuing Education Systems Course

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