BUILDING ENERGY 15

MARCH 3-5, 2015 AT THE SEAPORT WORLD TRADE CENTER

AIA Provider: Northeast Sustainable Energy Association

Provider Number: G338

Design and Energy Modeling for Net Zero Energy

Course Number

John Swift, Jr., PE, LEED, CEM

Course Date

BUROHAPPOLD ENGINEERING

Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

Significantly reducing energy use in commercial buildings is a challenge. Doing so in cold climates even more so. Getting to Net Zero Energy use in these climates, now that's what we call a tough. But with good design and engaged tenants, the near impossible becomes entirely possible, practical, and fun. This panel will describe key strategies for greatly reducing energy consumption in commercial buildings in cold climates with a focus on smart choices for building design, high performance mechanical systems and the tenant's role. Specific strategies and systems will be discussed with pros, cons, and application advice. Several Net Zero Energy commercial buildings in cold climates will be highlighted to show the theory in practice.

Learning Objectives

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

1. Describe relevant characteristics and factors in assessing the potential for a zero net energy building.

2. Describe the process and relationship between design and energy modeling teams during the design process.

3. Describe how to establish energy goals on a project based on the project's critical need.

4. Using several case studies, describe system interactions between different building systems as they contribute to building energy use.

ONE WAY TO ACHIEVE NET ZERO…

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BARRIERS TO ZNE COMMERCIAL BUILDINGS

- **Insufficient technical knowledge & "push"**
- **Perceived higher first cost**
- **Lack of building operator training**
- **Lack of high performance energy standards**
- **No regulatory compliance mechanism**
- **Lack of tenant motivation to save energy**
- **Lack of developer incentives to provide efficient systems**
- **Insufficient sub-metering**
- **"Green" buildings that fall short of ideal**

NREL: FIVE PRIORITIES FOR IMPROVEMENT

- **Thermal Insulation**
  - including air-tight building envelope with high performance glazing
- **Lighting Equipment**
- **Plug and Process Loads**

  http://www.esource.com//system/files/files/2012-01/ESource-CEC-WC-1-12-PlugLoads_0.pdf

  HVAC Components
- **Passive Strategies**
  - **daylighting, natural ventilation, passive solar heating, passive solar avoidance**

Source: Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector, National Renewable Laboratory, December 2007

NREL: FOUR IMPORTANT CHARACTERISTICS

- **Number of stories**
- **Plug and process loads**
- **Use (Principal Building Activity)**
- **Location (Climate Zone)**

Source: Assessment of the Technical Potential for Achieving Net Zero-Energy Buildings in the Commercial Sector, National Renewable Energy Laboratory, December 2007

ENERGY MODELING WORKFLOW PROCESS

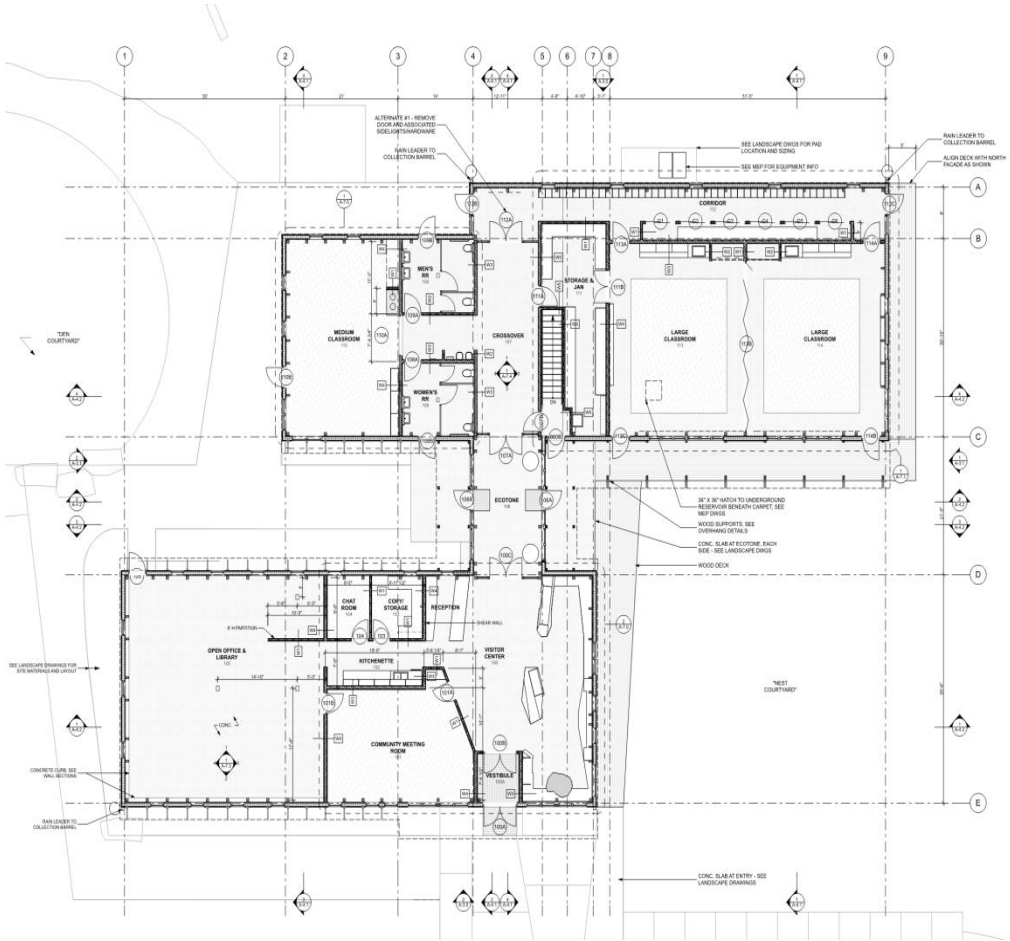
- **Levels of Analysis**
  - **Macro-Conceptual:**
    - Simplified Massing Models
    - Study of Building Massing and Orientation
    - Performance Analysis
    - Daylighting Potential
    - Natural Ventilation Analysis
  - **Micro-Conceptual:**
    - Study of Design Feature
    - Applied to Small Portion of the Building
    - Optimize the Design for Climate, Location
    - Test Options
  - **Detailed Energy Analysis:**
    - Representation of the Building “As Designed”
    - Help Optimize Performance
      Assess Energy Consumption at Each End Use
    - Perform Life Cycle Studies

HITCHCOCK CENTER FOR THE ENVIRONMENT

Image Courtesy of designLAB Architects

PROJECT BRIEF

- Type: Assembly/Educational
- Location: Amherst, MA
- Total Area = 9,100 sf
- Total Stories: 1 Story
- Program:
  - Classrooms
  - Office
  - Meeting Room
  - Exhibition Room



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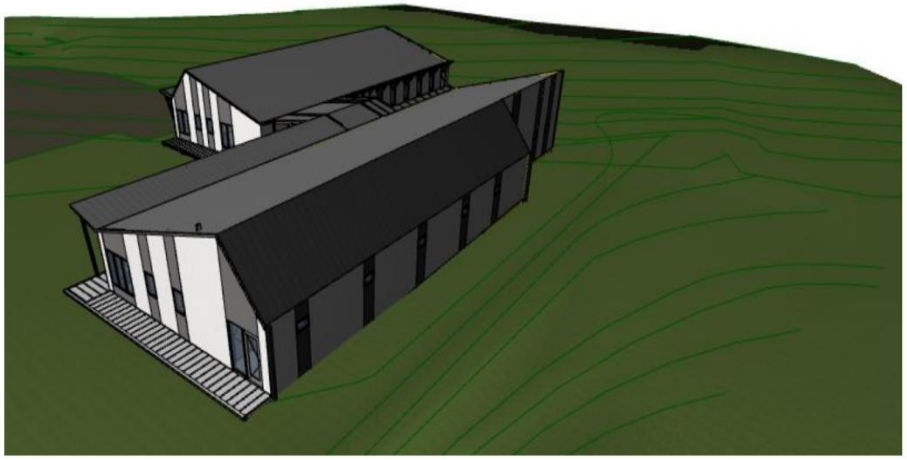
1 View from NW
SCALE: 1/4" = 1'-0"

2 View from SE
SCALE: 1:53.33



3 View from NE
SCALE: 1:38.40

4 View From SW
SCALE: 1/4" = 1'-0"

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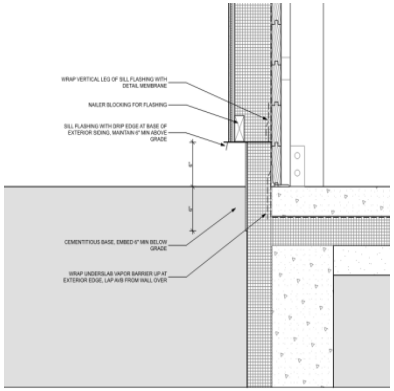
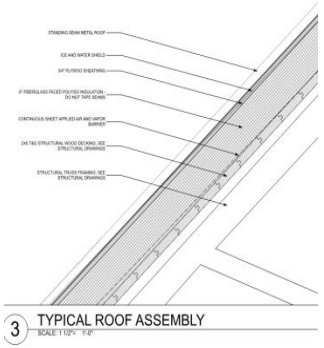
ENERGY CONSERVATION MEASURES SUMMARY

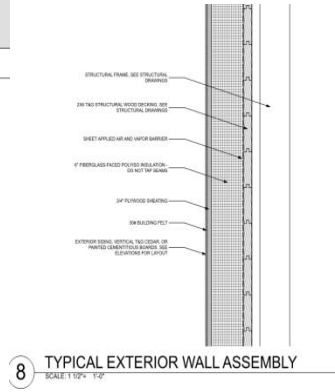
- High-performance Envelope
- External Shading
- High-performance Lighting Fixtures
- Daylight Harvesting
- Natural Ventilation
- Extended Thermal Comfort
- Energy Recovery Units
- High-efficiency, heat recovery VRF units
- Photovoltaic Array

BUILDING ENVELOPE – OPAQUE CONSTRUCTION

Model Input Parameter	Proposed Building Design		
	Description	*Insulation R-value*	*Assembly U-factor/ F-factor / C-factor [BTU/hft²°F]*
Roofs	Insulated (6" Polyiso) Roof	R-39	U-0.022
	Reflectivity	0.30	
Walls - Above Grade	Insulated (6" Polyiso) Wall	R-39	U-0.023
Walls - Below Grade	Insulated Below-grade Wall	R-20	U-0.026
Slab-On-Grade Floors	Fully Insulated (4" XPS)Unheated Slab	R-20	F-0.261







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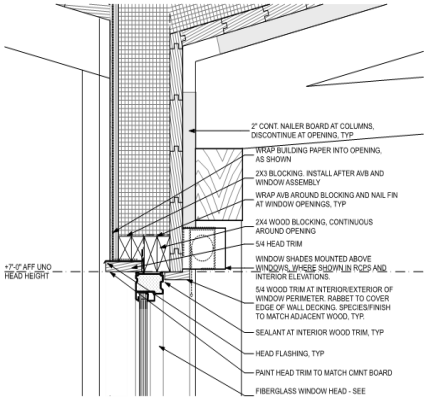
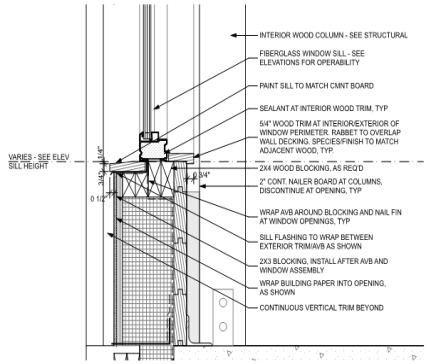
BUILDING ENVELOPE – FENESTRATION

Model Input Parameter	Proposed Building Design[1]				
	Description	*Center-of-Glass U-factor*	*Assembly U-factor [BTU/hft²°F]*	*SHGC*	*VLT*
Vertical Glazing	Alpenglass 5H - Fixed	U-0.14	U-0.16	SHGC-0.43	VLT-0.56
	Alpenglass 5H - Casement	U-0.14	U-0.20	SHGC-0.38	VLT-0.48



1 Window Head, Typ
SCALE: 1 1/2"= 1'-0"



6 Window Sill, Typ
SCALE: 1 1/2"= 1'-0"

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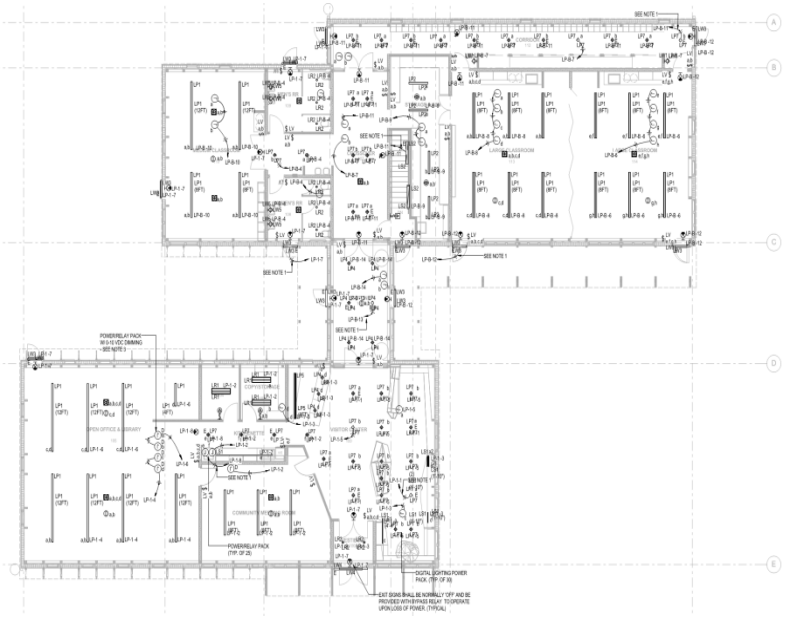
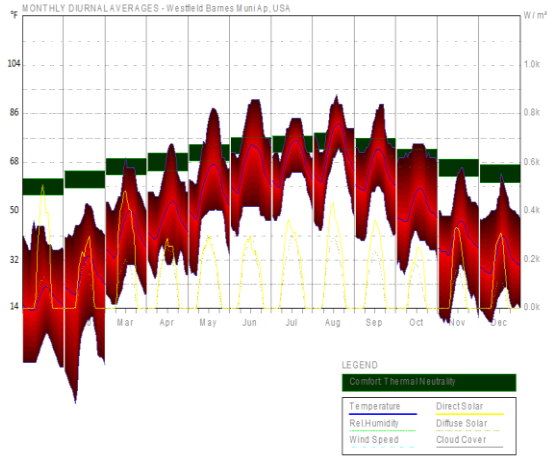
LIGHTING

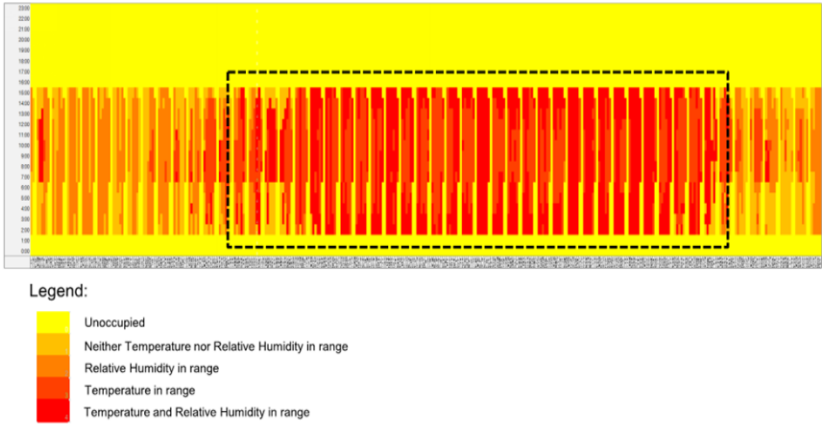
- Average LPD = 0.4 W/sf
- High-efficiency Fixtures
- LED Lighting
- Daylight Harvesting in Classroom and Community Meeting Room



NATURAL VENTILATION

- The building will be in natural ventilation mode when the outside ambient temperature is between 66°F to 78°F and when the outside relative humidity is between 0%-60%.
- HVAC systems will be turned OFF during natural ventilation mode.





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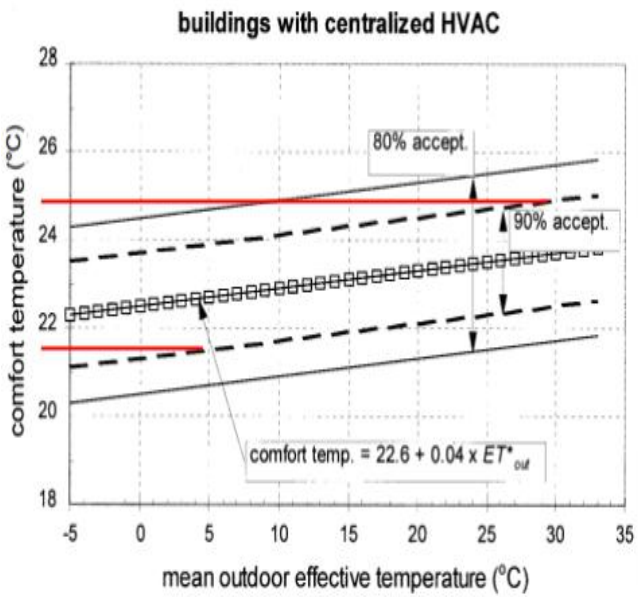
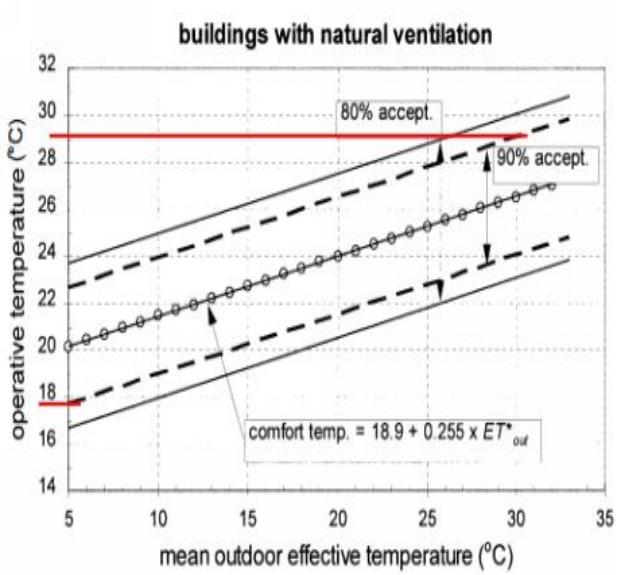
EXTENDED THERMAL COMFORT

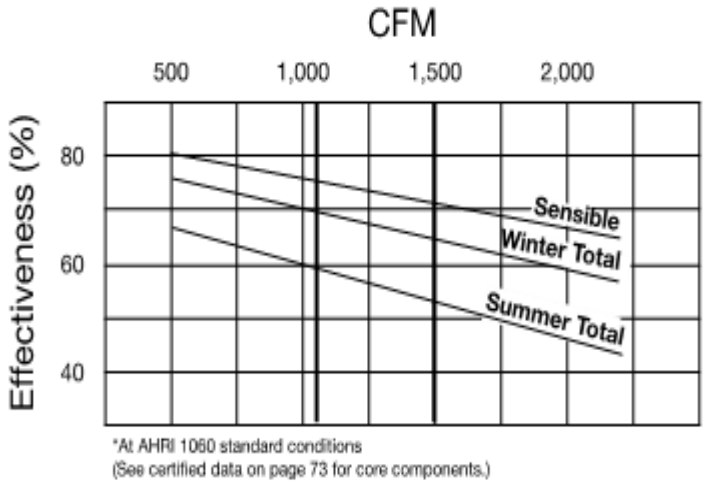
- Indoor Setpoints:
  - Heating: 66°F/61°F
  - Cooling: 78°F/83°F





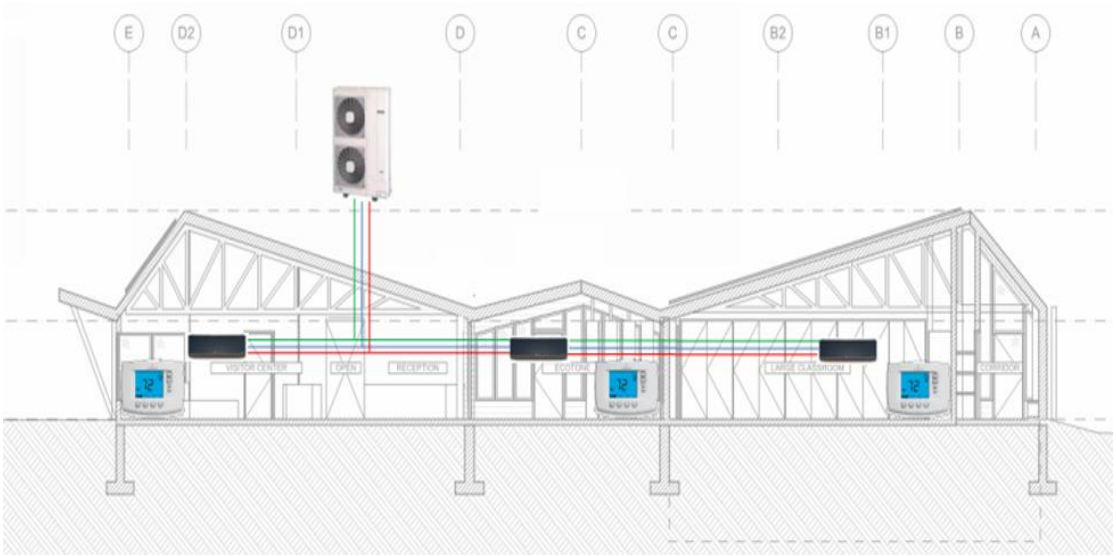
ENERGY RECOVERY UNITS

- Enthalpy Wheel
  - Sensible Efficiency = 75%



VARIABLE REFRIGERANT FLOW UNITS

VRF Model	Capacity (kBtu/h)		Cooling (EER)		Heating (COP)	
	Cooling	Heating	Full-Load	Part-Load	Full-Load	Part-Load
PURY-HP96	92	96	11.4	16.5	3.46	5.10
PURY-HP144	137	144	12.5	16.7	3.47	6.48



VARIABLE REFRIGERANT FLOW UNITS

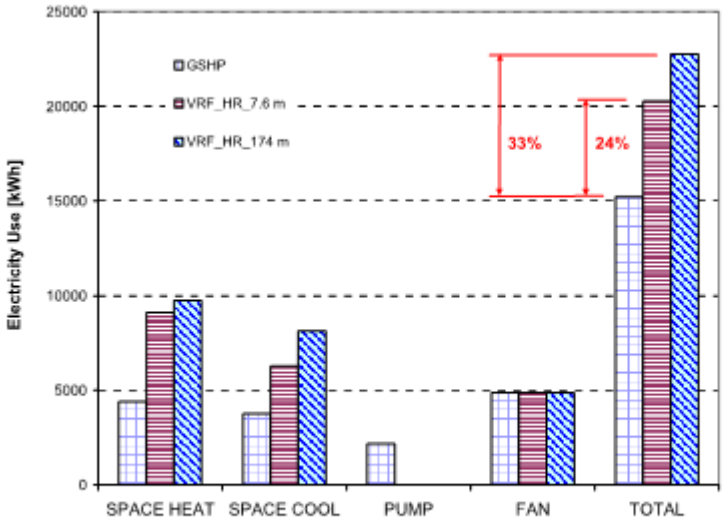
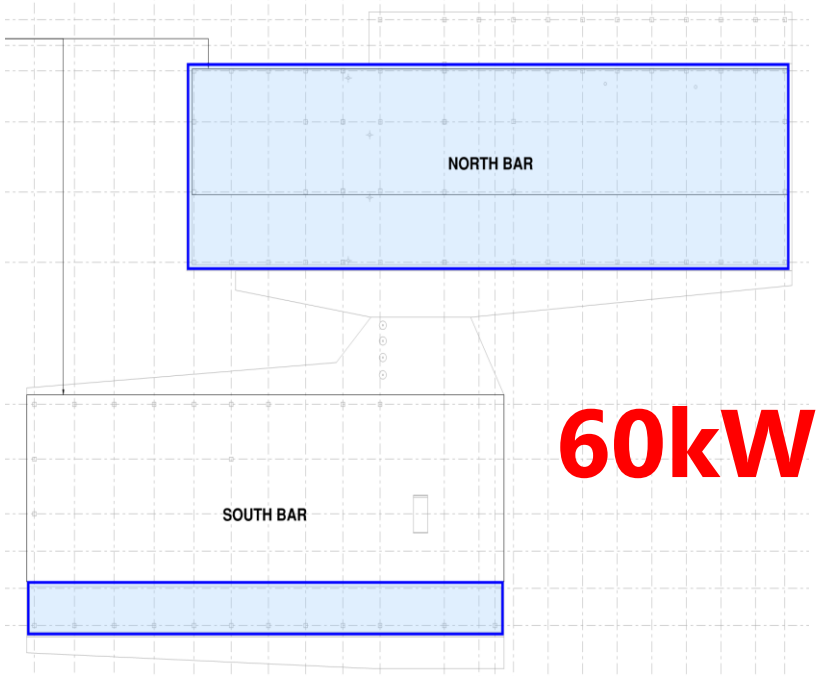


Figure 6 - Annual electricity consumption of the VRF and GSHP systems in Chicago

PHOTOVOLTAICS

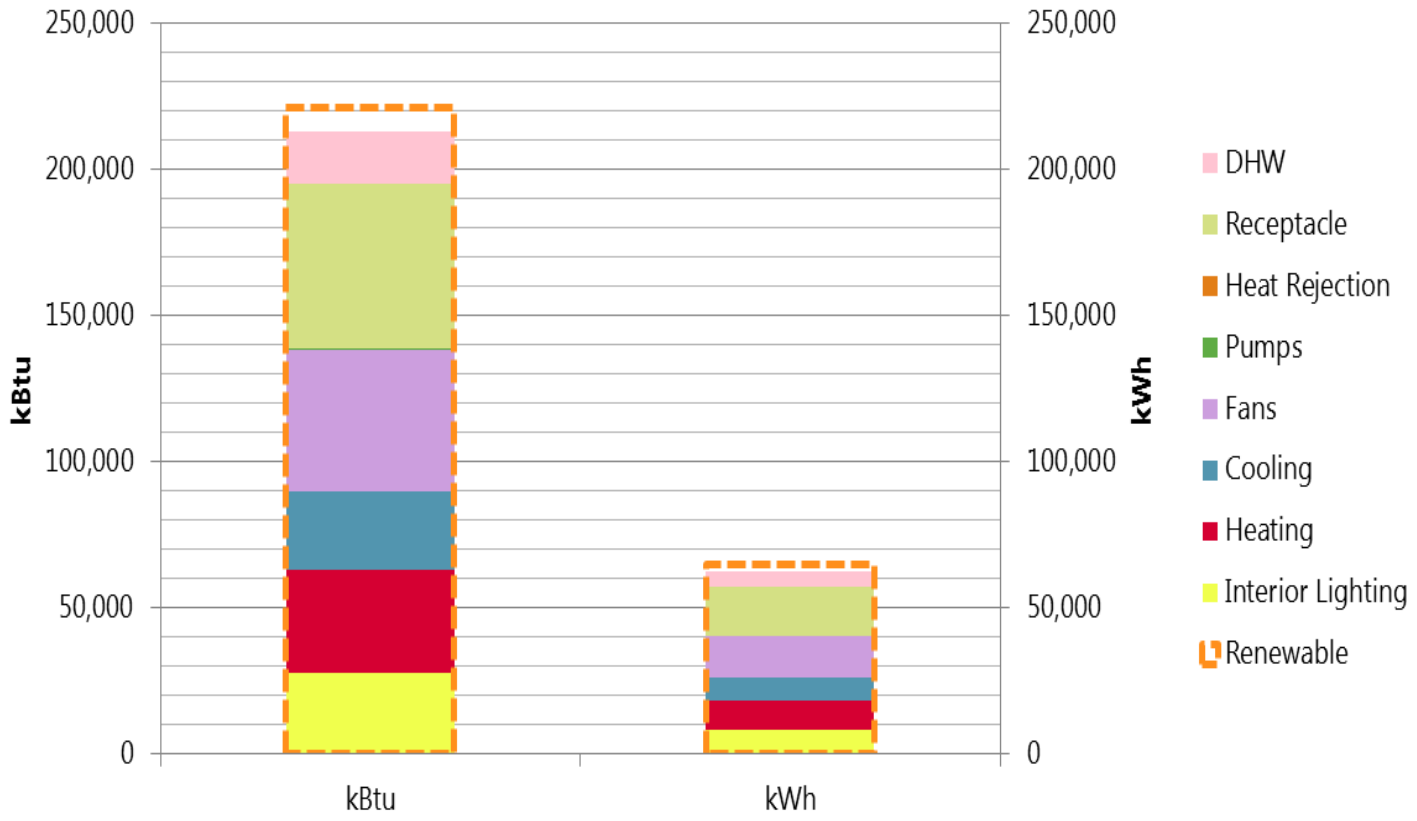
Month	Generated kWh		Total
	3:12 slope	12:12 slope	kWh
Jan	-3,464	-1,232	-4,696
Feb	-2,929	-884	-3,813
Mar	-5,269	-1,447	-6,716
Apr	-4,799	-1,151	-5,950
May	-5,333	-1,202	-6,535
Jun	-5,245	-1,142	-6,387
Jul	-5,883	-1,298	-7,181
Aug	-5,891	-1,393	-7,284
Sep	-4,429	-1,146	-5,575
Oct	-3,035	-856	-3,891
Nov	-2,841	-919	-3,760
Dec	-2,295	-804	-3,099
Total	-51,413	-13,474	-64,887

Note: PV generated electricity based on PV Watts Calculator



Roof-mounted PV Panels

Proposed Building Design - Predicted Annual Energy Consumption



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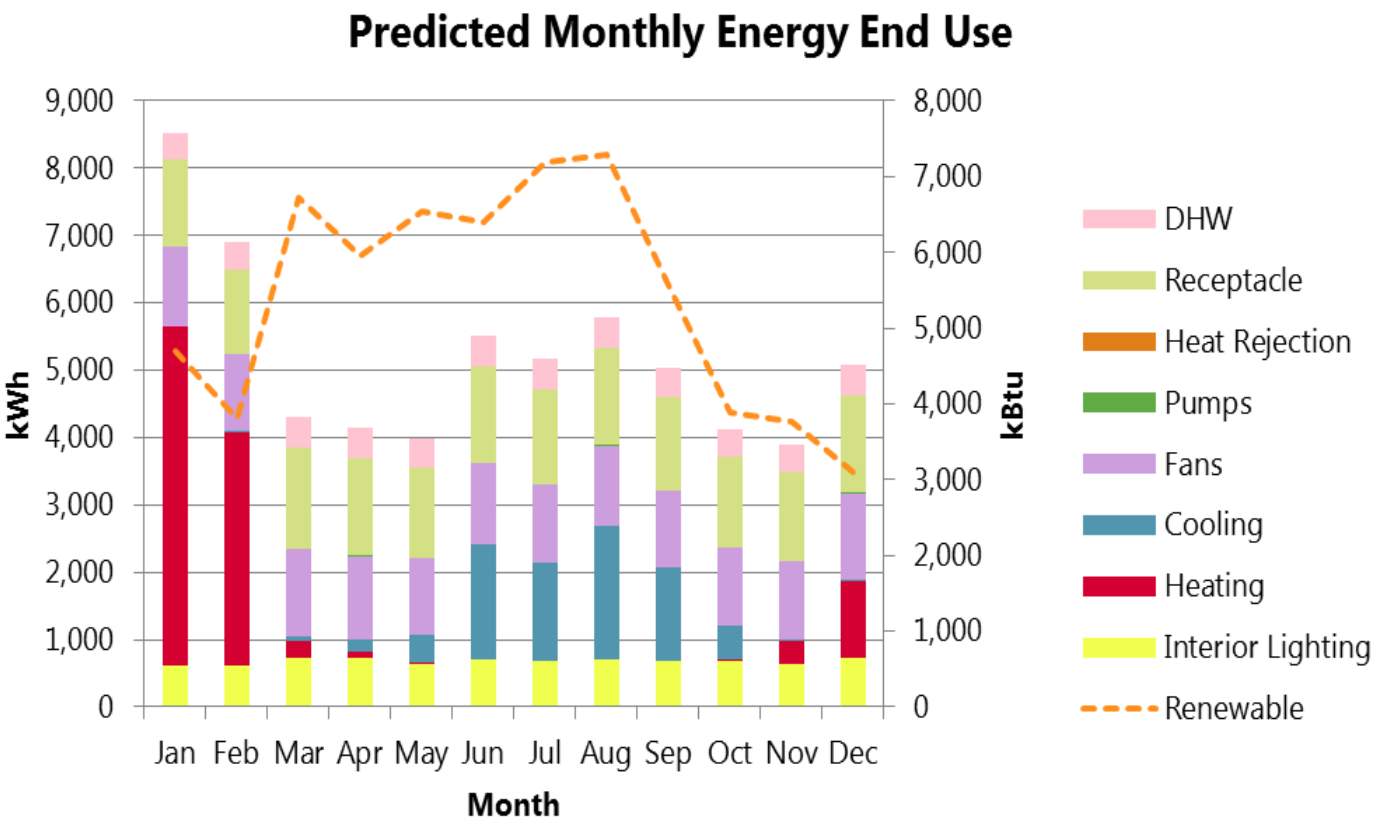
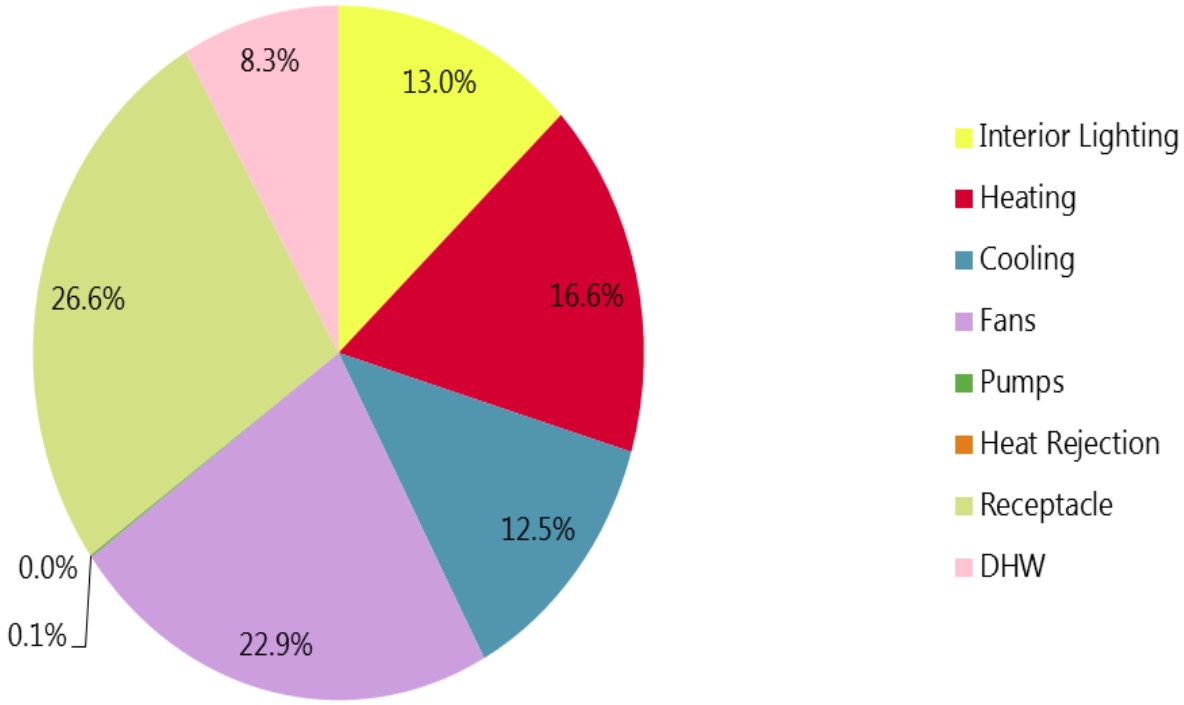
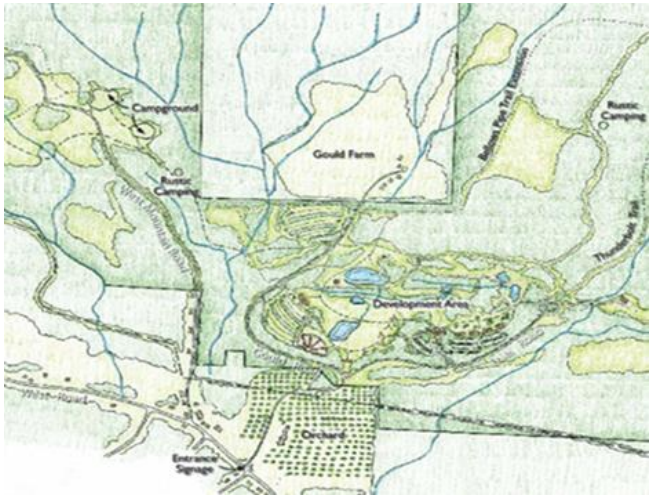


Proposed Building Design - Predicted Site Energy by End Use



GREYLOCK GLEN ENVIRONMENTAL EDUCATION CENTER

- **Project Type**
  - Public/Commercial
    - Hospitality and entertainment
- **Location**
  - Adams, MA, USA
- **General Information**
  - ~117,000 sf
  - Program:
    - Golf course
    - Education/visitor's center
    - Outdoor amphitheater
    - Lodge with dining and meeting facilities (170 rooms)
    - Private overnight cabins
    - Campground
    - Expansion of hiking trails



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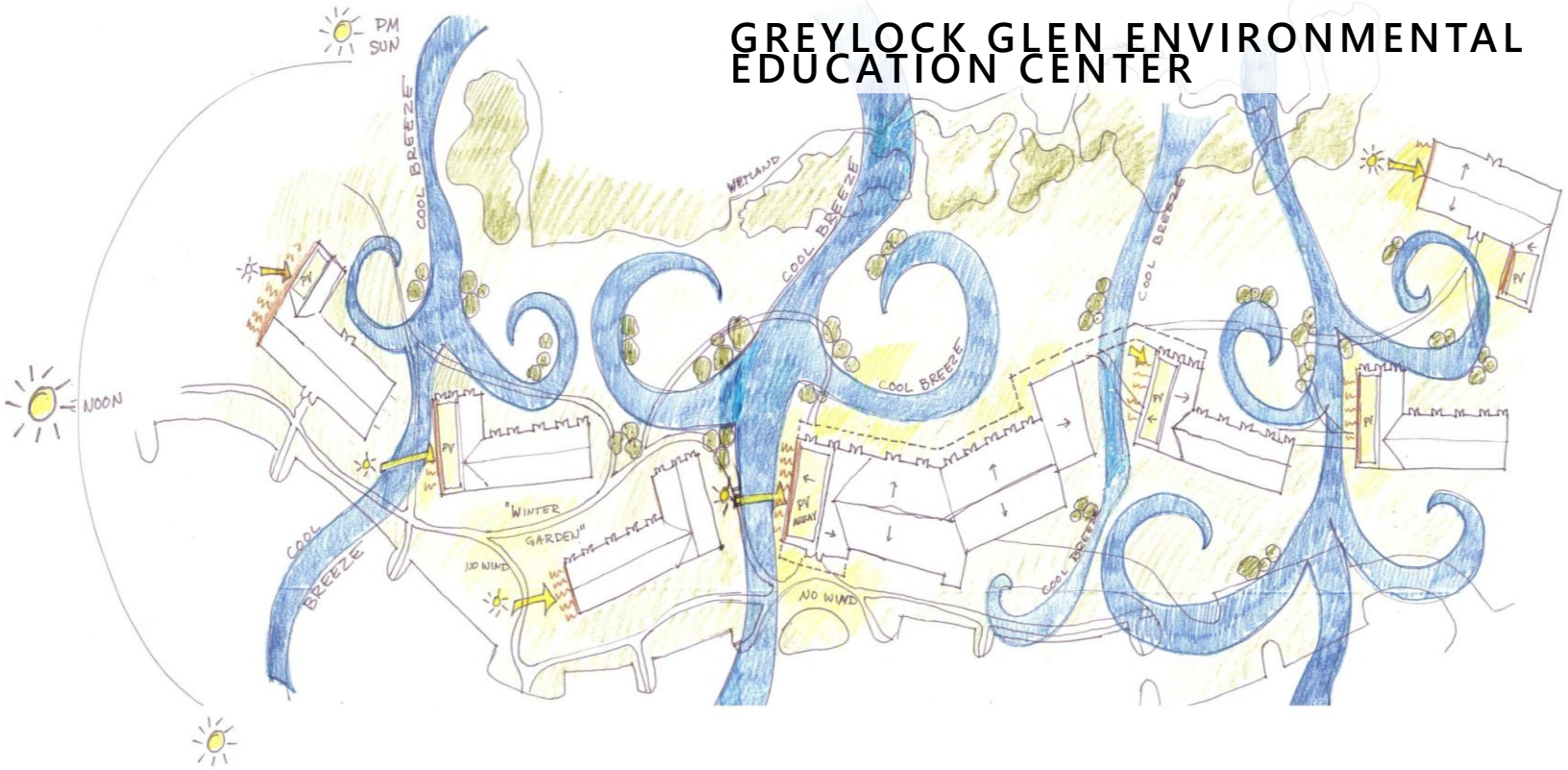
GREYLOCK GLEN ENVIRONMENTAL EDUCATION CENTER



WIND
(COOLING AND VENTILATION)

Buildings are oriented along the North South axis to take advantage of the cooling breezes from the East and West. As breezes move across the wetlands and wooded areas they are cooled. The Courtyards created between the buildings funnel the breezes through the site. Strategically placed trees channel the wind and create a cool microclimate. Outdoor rooms are cooled and shaded for more comfortable summer use.

SUN
(HEATING AND DAYLIGHT)

Buildings are oriented with the public atrium spaces facing +/- 10 degrees of South allowing for solar gain in the winter. South facing facades are shaded by decidious trees and planting during the summer months. Thermal mass stores the heat from the sun and radiates it evenly throughout the day.

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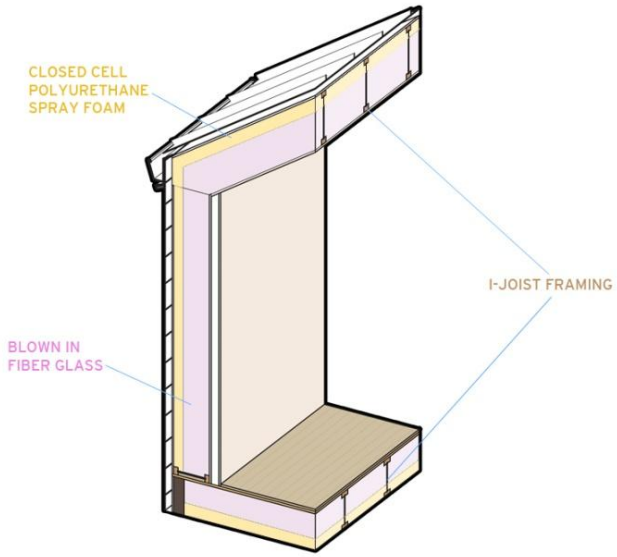
GREYLOCK GLEN: BUILDING ENVELOPE

- **Super Insulated Walls**
  - R-45 Walls, R-70 Roof
- **Triple pane low-e coated glazing with Argon, insulation in the sash and frame**
  - Minimum glazing thickness of 1 inch
  - Warm edge or similar glazing spacer
- **Air barrier with building envelope commissioning**
  - Maximum infiltration of 0.15 air changes per hour
- **Slab and below grade walls/Foundation thermal breaks**
  - R-10



Shading

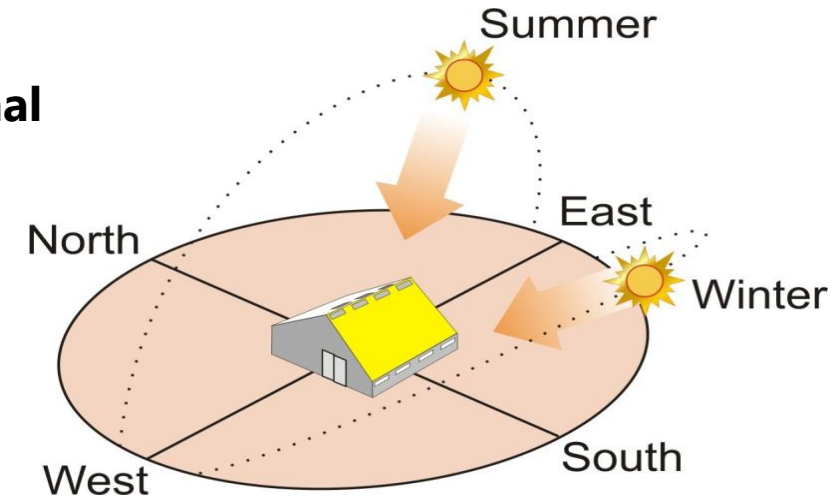
- Consider use of insulating shades, louvers or shutters on windows with large areas during non-daylight hours to prevent heat loss.
  - Operable exterior panels or interior mechanical shades in a track.

- Consider using horizontal louver systems on the south facing windows and vertical louvers on the east and west fenestration

GREYLOCK GLEN: BUILDING ENVELOPE AND ORIENTATION

- **Roof**
  - High albedo or vegetated roofs
    - Refer to LEED v2.2 SS Credit 7.2 Heat Island Effect: Roof for guidelines
  - High solar reflectance index (SRI)
    - Refer to ASTM Standard E1980-01 – Standard Practice for Calculating Solar Reflectance Index

- **Long axis east-west orientation is optimal**

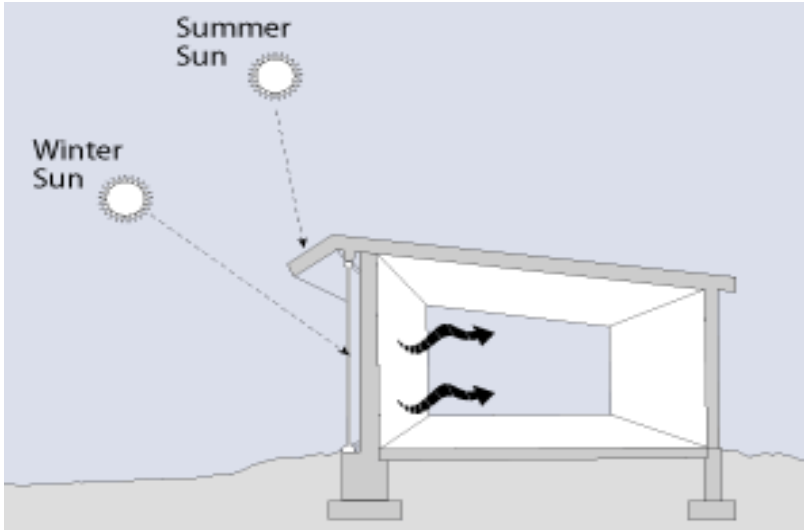


GREYLOCK GLEN: PASSIVE HEATING

- **Utilize thermal mass in the floors and walls to act as solar collectors**
  - Distributes heat throughout the course of the day and night, preventing temperature swings

- **Reduce glazing to the north, east and west**.
  - Area of south facing glazing should be approximately 30% of the floor area being heated by the sun

- **South-facing trombe walls**



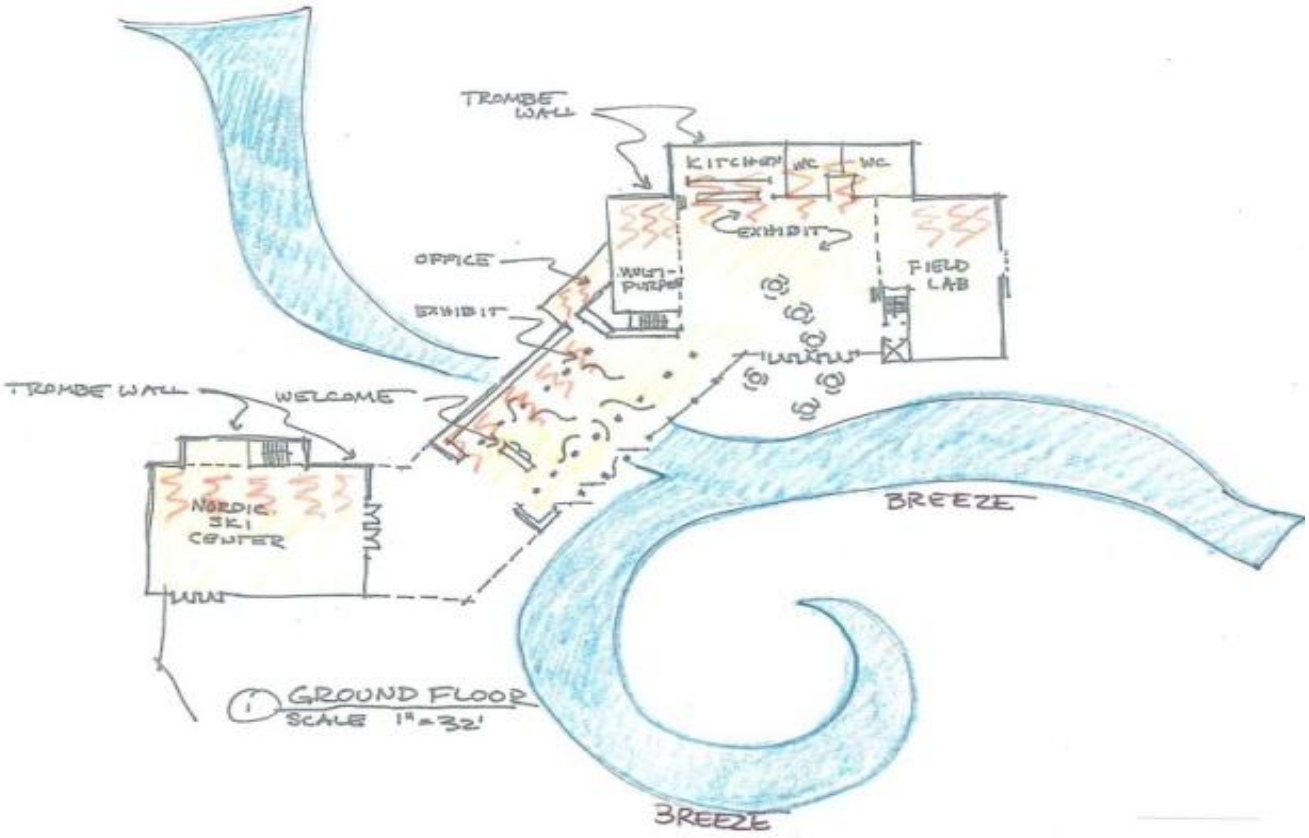
GREYLOCK GLEN: PASSIVE COOLING/NATURAL VENT.

Hybrid Natural Ventilation System:

- **Operable Windows**
- **Building massing arranged to channel breezes across vegetation and into the building**
- **Interior transoms allow cross and stack ventilation to occur across partition walls**
- **Double height spaces exhausted at the top (stack effect)**
- **Exterior Shading, overhangs, or trellis help cool air before it enters building**
- **Bypass the mechanical ventilation with energy recovery system**
  - Bring in outdoor air when it is within comfort range
- **Narrow building footprint will allow to take advantage of cross ventilation**

GREYLOCK GLEN: PASSIVE COOLING/NATURAL VENTILATION

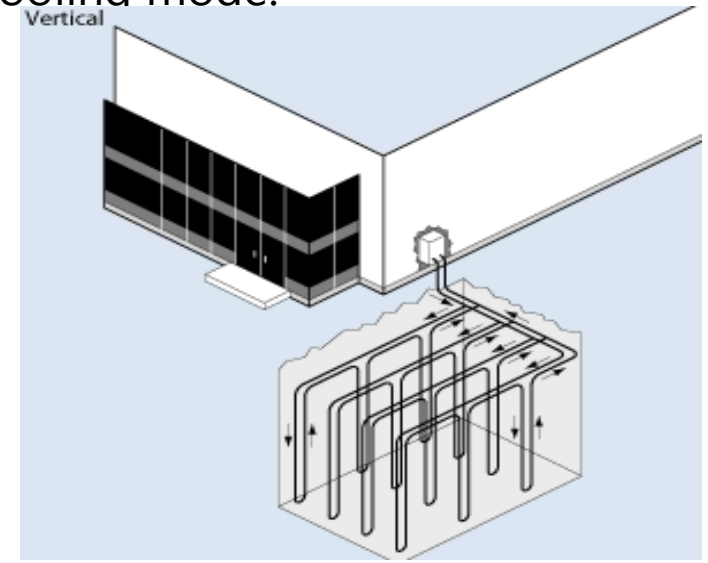
Hybrid Natural Ventilation System:



Heating and Cooling Systems:

Combination of water-to-air and water-to-water GSHPs EER=18, variable speed pumping, premium motors, low pressure drop

- **GSHP wells: 250-400 ft. deep, 15-20 ft. grid, 1.5 wells/ton**
  - Summer Indoor: 75F / 50-55% RH setpoint in cooling mode.
  - Winter Indoor: 70F setpoint in heating mode



GREYLOCK GLEN: HVAC

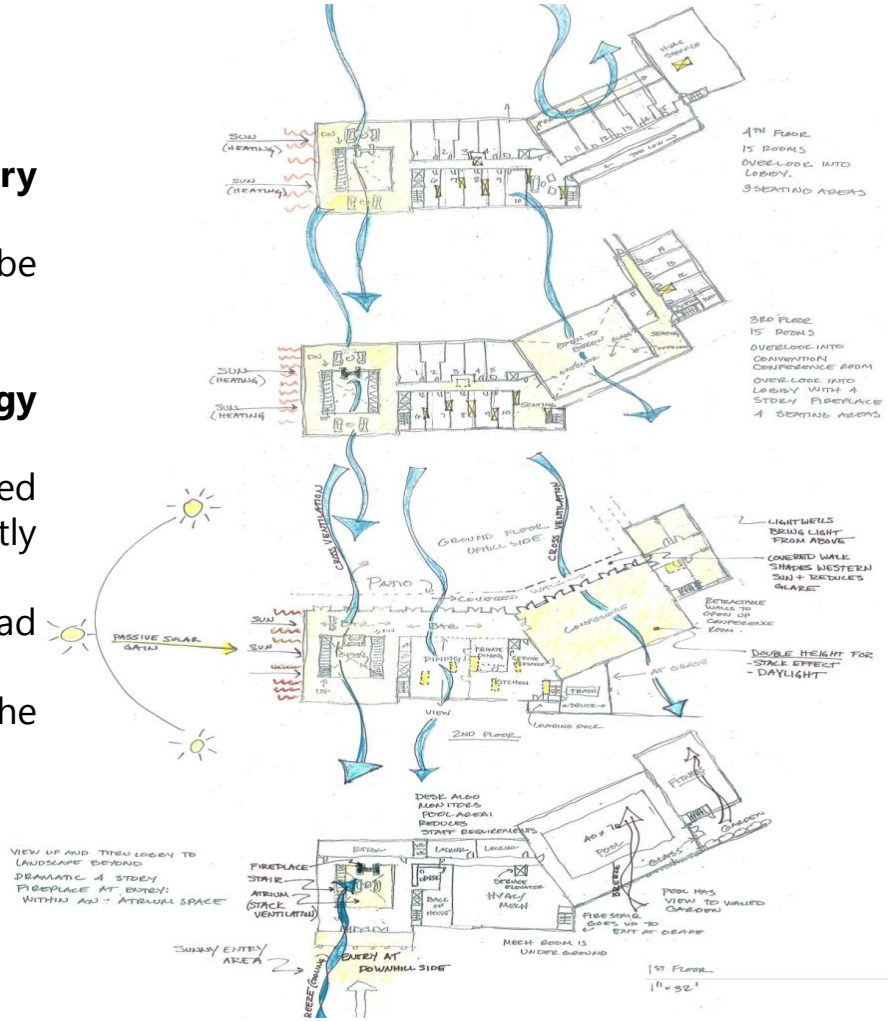
Ventilation:

Preheat the incoming outside air with energy recovery systems

- •Allows most of the heat in the exhausted air to be recaptured and transferred to the incoming air

Mechanical ventilation with a desiccant coated-energy recovery wheel

- •Optimizes indoor air quality by providing the required outdoor air ventilation exchanger while significantly reducing the heating and cooling load
- •Decouples the heating and cooling ventilation load from the building
- •Provides a constant source of ventilation air to the building occupants



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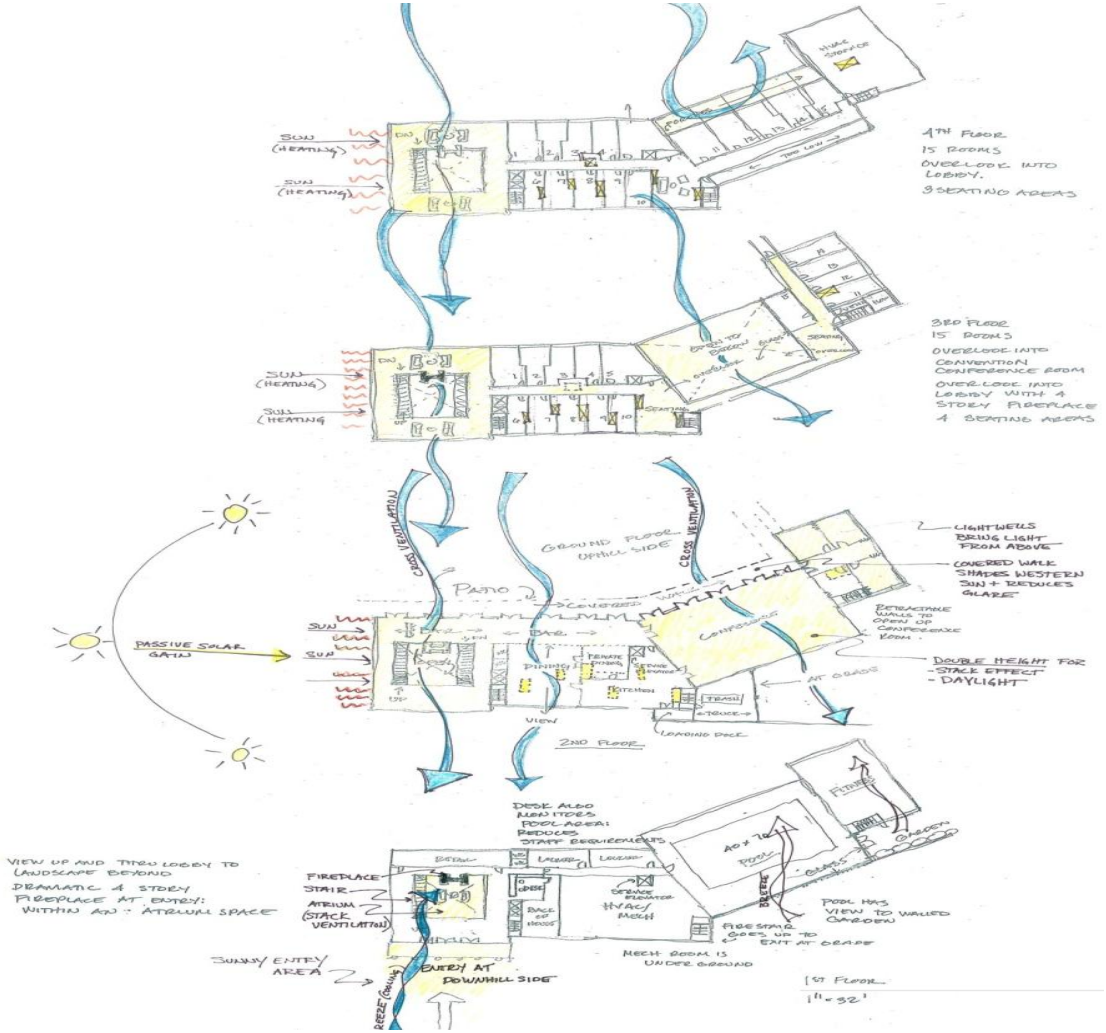
GREYLOCK GLEN: HVAC

Ventilation:



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GREYLOCK GLEN: ELECTRICAL LOADS

Reduced Electrical Lighting Load – Daylighting:

- **Daylight sensors with Daylighting zones oriented parallel to daylight openings on daylight sensors**

- **High clerestory windows with louvers, light shelves or shading**
  - Evenly distribute light and reduce glare

- **Prismatic or light diffusing glazing with high Light Diffusing Power (LDP)**
  - Evenly distribute light and eliminate hot spots
- **Lightwells**

- **Translucent interior folding partition walls**
  - Improve light distribution
  - Allow daylight into interior spaces
  - Allow for room darkening as required by program

GREYLOCK GLEN: RENEWABLE ENERGY

Photovoltaic:

- **Solar thermal systems for heating and domestic HW**
- **Possible satellite energy farm**
  - Replace the tree shaded parking area with a trellised, PV covered parking area
  - Integrate the energy farm into the sculpture garden or other program area
  - Provides more flexibility to the building orientation and footprint while providing an educational, and easily maintained and operated renewable energy area

Wind Turbines:

- **2-3 wind turbines**
- **Wind study/feasibility assessment needs to be done**

GREYLOCK GLEN

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ACADEMY FOR GLOBAL CITIZENSHIP

Project Type

- •Pre K-12 (150 students)

Location

- • Chicago, IL, USA

General Information

- •60,000 sf
- •Program:
  - Learning studios
  - Agricultural plots
  - Orchards
  - Greenhouses
- •Will meet Living Building Challenge Standards
- •Net-positive energy building
- •Carbon-neutral site

BUROHAPPOLD ENGINEERING

a. Limits to Growth

Surrounded by contaminated lands from a history of heavy industry, AGC has the unique opportunity to transform brownfields into fields of green. AGC will select and transform a lifeless and distressed site into a thriving community center containing a harmonious blend of healthy plant, animal, and human habitats.

b. Renewable Energy

Using clean and renewable resources, AGC will harness the power of the sun, the heat of the earth and the strength of the wind to produce more energy than we will need to operate. Renewable energy sources will also serve as demonstration tools for students and community members. These will help to push the project towards its net-positive energy goal and will realize the AGC value of "doing good".

c. Human Scale and Humane Places

LBC requires that the project be designed to create human-scaled rather than automobile-scaled places. The AGC team will work to gage the impacts of the design and development of the site while embracing the humanity of the entire community, working to make decisions that protect and restore the natural environment while also providing a civilized and humane place for all.

d. Urban Architecture

LBC requires that a minimum of 10% (approximately 1 acre) of the developed site be dedicated to food production. AGC intends to incorporate a minimum of 3 acres of urban agriculture, including vegetable gardens, orchards and greenhouses.

e. Educational and Inspirational Services

AGC will function as a community resource and educational environment for all ages – students, families and community members alike. As a learning laboratory, the building will be open to the public for tours and educational discussions.

f. On-site Water Collection

LBC requires that all project water needs be met with on-site water collection and treatment. Water will be collected on-site with roof structures and stored for building use in above ground and in-ground cisterns.

g. Biophilia

The AGC team will help to ensure the transformation of our human-nature relationship, promoting natural features, use of inspiring natural shapes and forms, and celebrating our natural processes and patterns.

h. Embodied Carbon Footprint Offset

The AGC team will help to establish a thorough understanding of how to minimize the carbon footprint during the construction process, and help to reduce the cost of the carbon offset to the owner and account for LBC requirements.

i. Water Cleansing

If ground water contamination is present (after testing), steps will be taken to use an open- loop geothermal system integrated with the aquifer to begin a filtering and cleansing process.

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ACADEMY FOR GLOBAL CITIZENSHIP: BUILDING ENVELOPE

Super Insulated Walls
Roof: R-48

- •Greenroof
- •Skylights (20% of area glazed)
- •Flat

East and West walls: R-36

- •Opaque
- •12″ thick cip concrete
- •No glazing

North and South walls: R-48

- •60% opaque
- •12″ thick cip concrete
- •40% glazing
  - R-3.84

Underslab Insulation

- R-10

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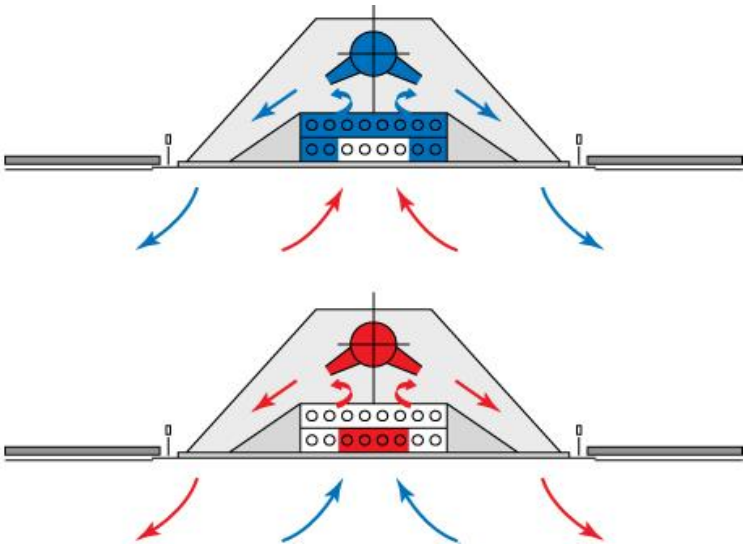
ACADEMY FOR GLOBAL CITIZENSHIP: HVAC

Heating and Cooling Systems:

- **GSHP: Closed loop system**

- **Mechanical System**:
  - DT coils in ERU's
  - Geothermal heat pumps attached to the ERU's
  - Chilled beams

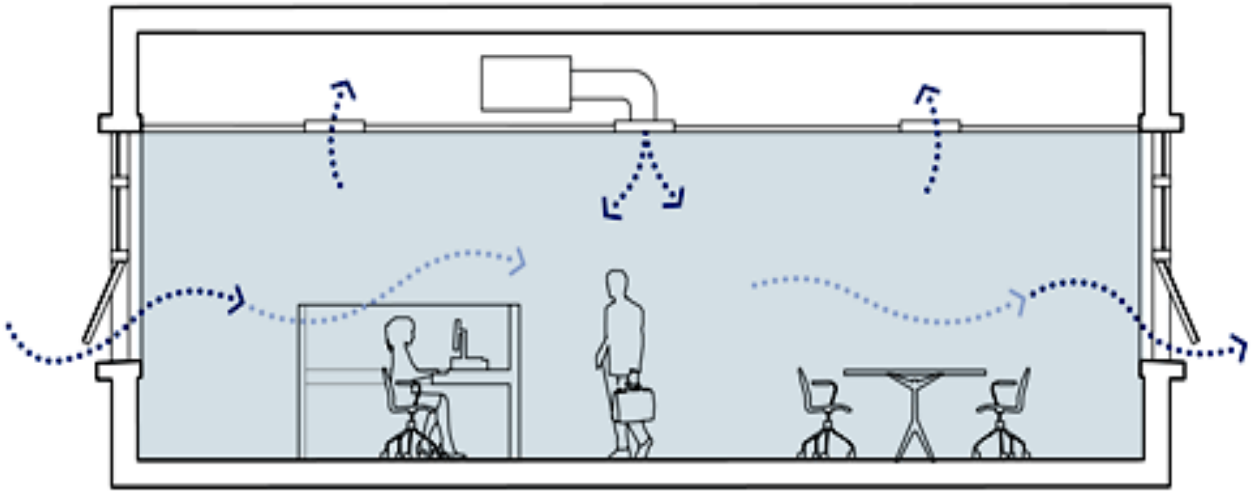


- **Energy Recovery on make-up air systems during non natural ventilation hours**

ACADEMY FOR GLOBAL CITIZENSHIP: HVAC

Ventilation

- **Fan systems – Low pressure, ECM motors (0.00019 kW/CFM), zone distribution**
- **Displacement ventilation**
- **Mixed Mode/Natural Ventilation**



ACADEMY FOR GLOBAL CITIZENSHIP: RENEWABLE ENERGY

Photovoltaic

- **485 kW PV array required to offset the anticipated annual energy consumption**
- **Estimate 48,500-58,200 sf of roof area required**

Wind Turbines

- **4kW wind turbines (4-6)**
  - Assume 4,000 kWh/yr per turbine
  - Total annual energy production ranges between 16,000-24,000 kWh
  - Provide power for low solar months
  - Generate power during dark hours

Solar domestic HW heating

ACADEMY FOR GLOBAL CITIZENSHIP: BEYOND NET ZERO

- **Performance and operation data will be provided to the public to share successful solutions and to motivate others to make changes**
- **Many of the sustainable features are visible and explained to the community and students**
- **School will function as a community resource and an educational environment**
- **Building will be open for public tours and educational discussions at least once per year to further the sustainable building education of the surrounding community**

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ACADEMY FOR GLOBAL CITIZENSHIP: BEYOND NET ZERO

- **Wind turbines will be installed as demonstration to students and community members**
- **Composting**
- **Waste water wetlands**
- **Stormwater management**
  - Rain gardens
  - Porous parking lots

This concludes The American Institute of Architects Continuing Education Systems Course

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