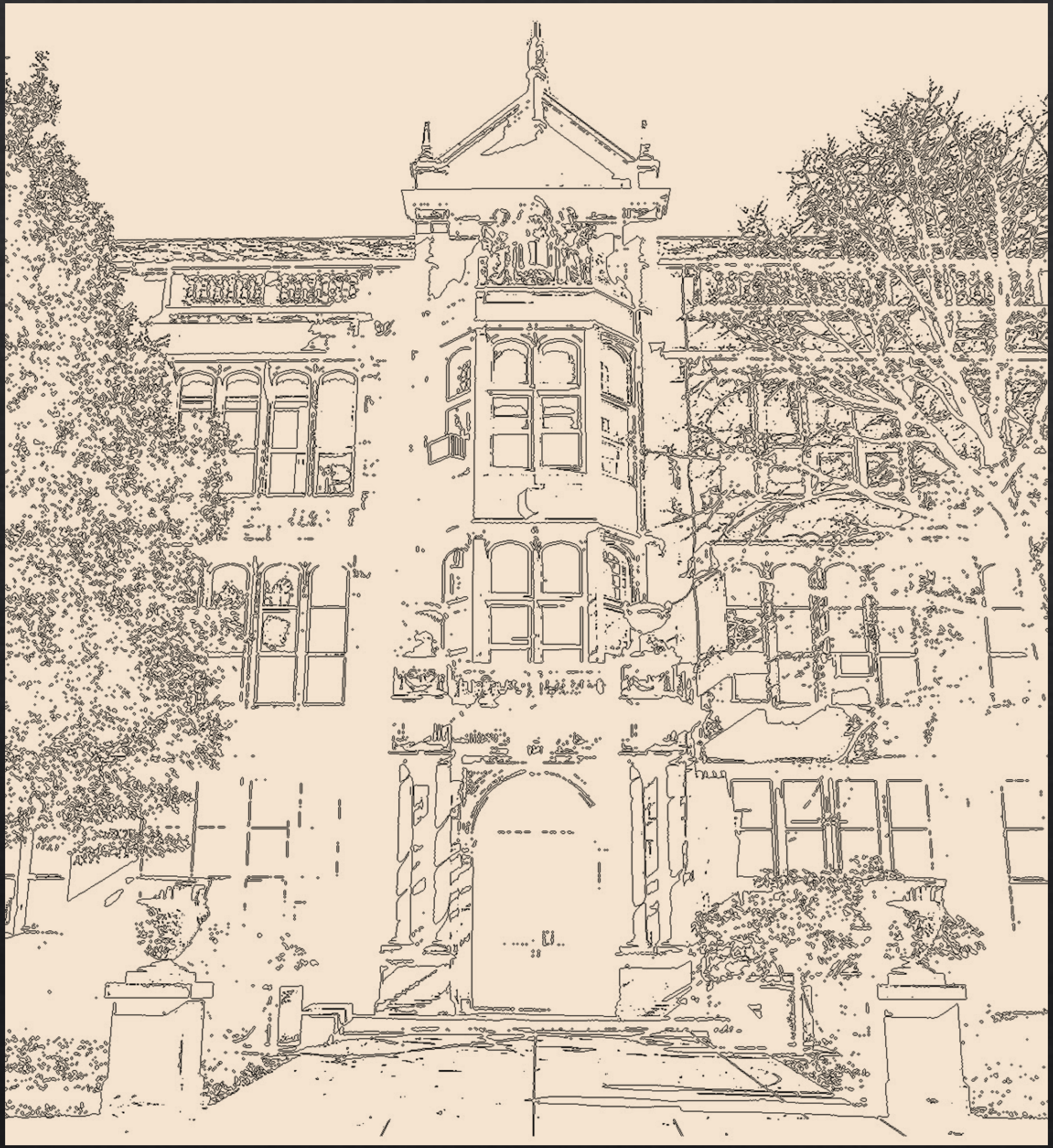


University Laboratory High

Retrofit Design

Origins 1876

Uni High with its rich history of 3 Nobel Laureates and a Pulitzer Prize winner is one of the most unique and beautiful elements on the Illini Campus

- With construction that old, the University has **subpar sustainability standards**
- Having **envisioned** to have a more **full-filled program**, Uni High could be one of the **retrofit designs,** that **preserves the old while introducing the new**

MARK PACI
KANCHAN BHOWMIK INDIAN 88
MATT SPUD SEITZ 88
BONNIE STEPHENS '90
Fleischer
Shannon Flood '88
WILD BOYS
MELINA LARSON '88
PAUL DEBEVEC
KWAK
ASMOOL
THEO '90
WHEELER '90
UCG '99
MARY K MULLALLY
Kathy Szoke '90
$EX
Rebecca
Dolly Banerjee '90
HEATHER GARRETT
Juwan
SAMEER

INSP.I.R. AIM

- Develop the originally proposed east wing with modernized sustainable design
- Reinforce the dual purpose of the building: Education and Education Research

Additional Functions introduced

Gymnasium
Auditorium
Solarium + Cafeteria
Kitchen facilities
Teacher’s Offices

Design Strategy

Architecture

- Merge modern and gothic architectural styles
- Integrative landscape and use of classical proportions

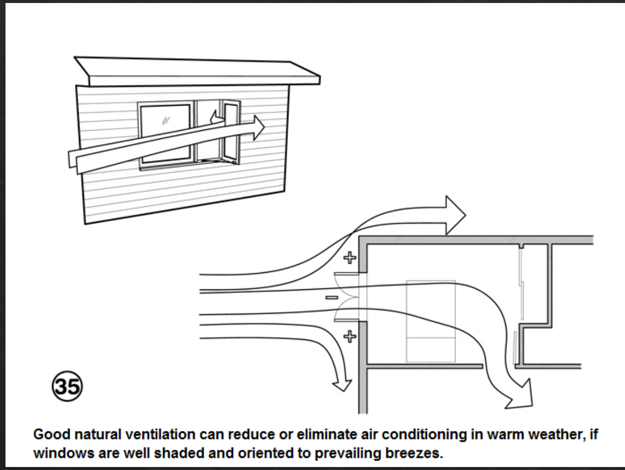
Energy and Sustainability

- Double pane windows
- Solar composite walling system
- CERV and ERV systems
- PV technology

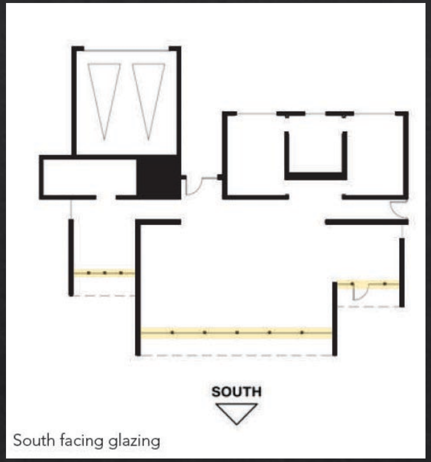
Architecture Façade

Transitioning from the old into the new

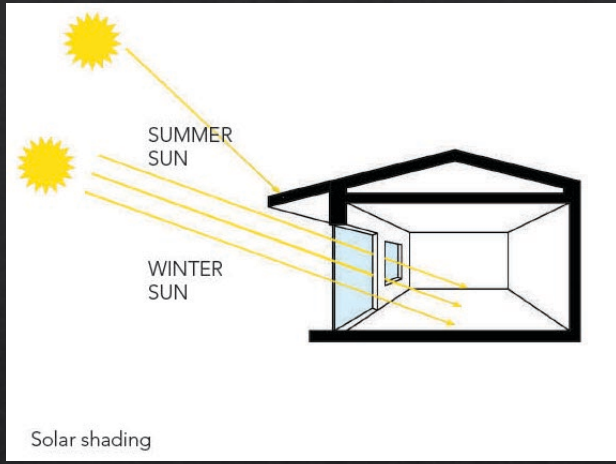
Design Strategies responsive to the climate



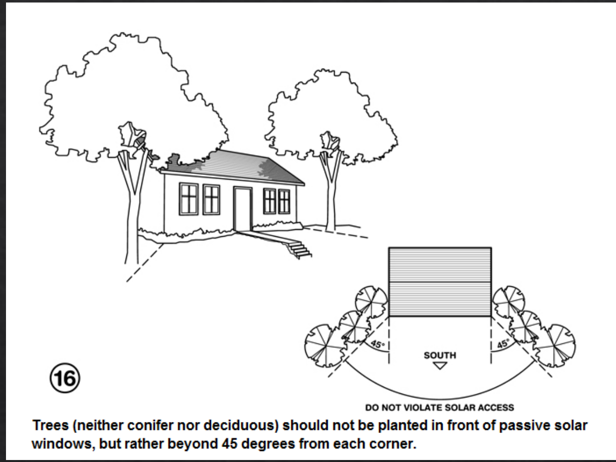
Cross and Stack Ventilation



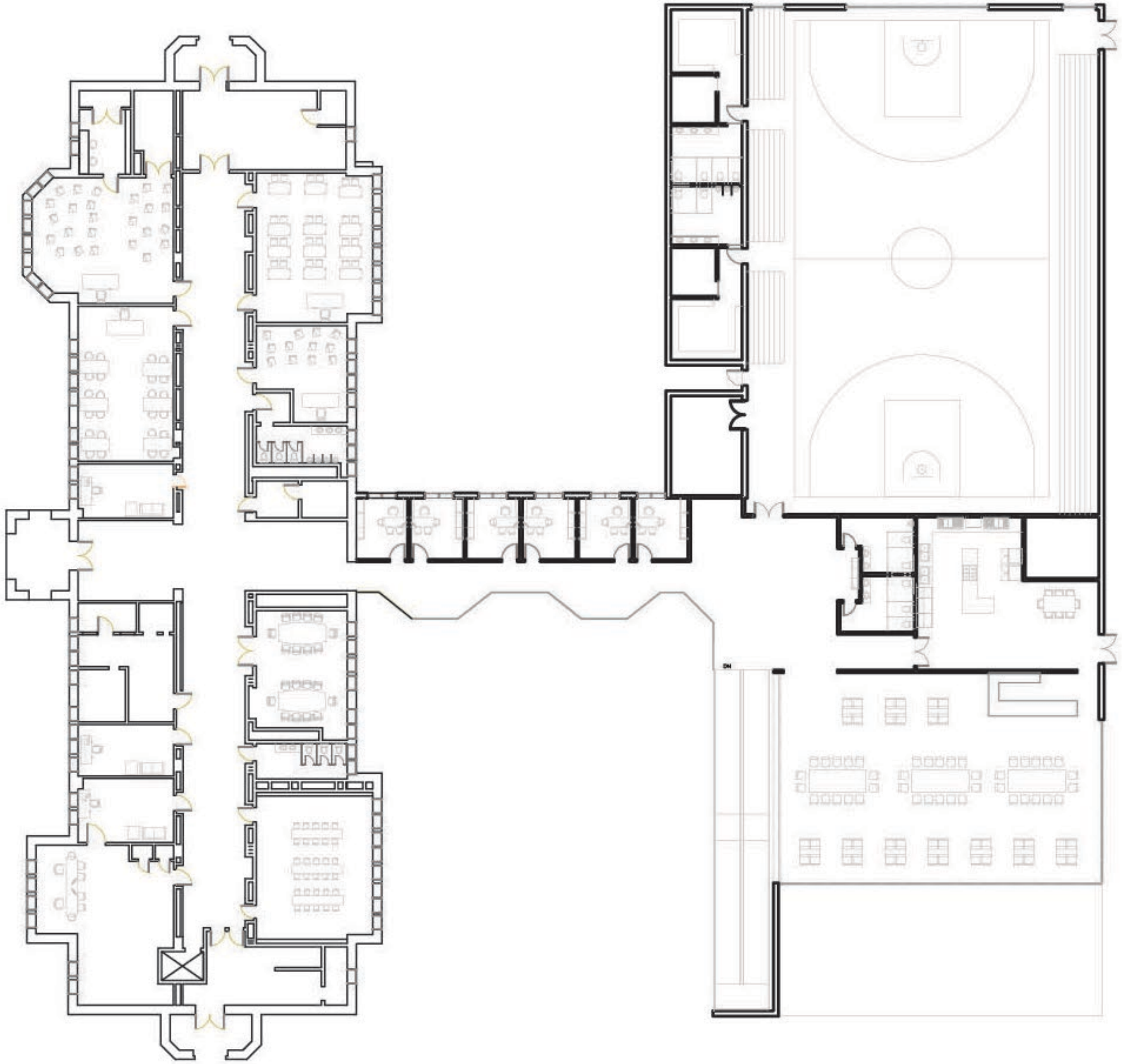
South Façade glazing



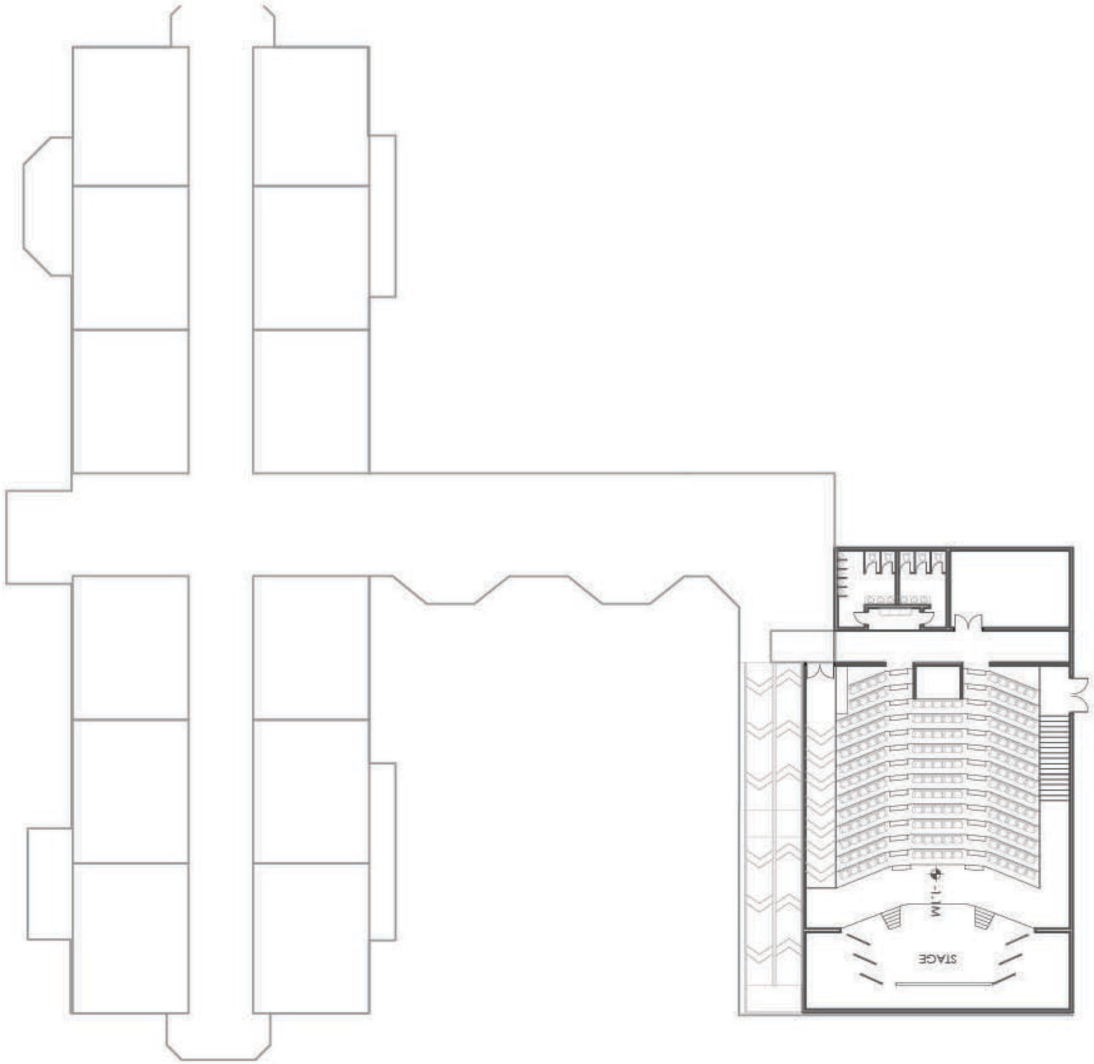
Solar Shading



Tree location and shading



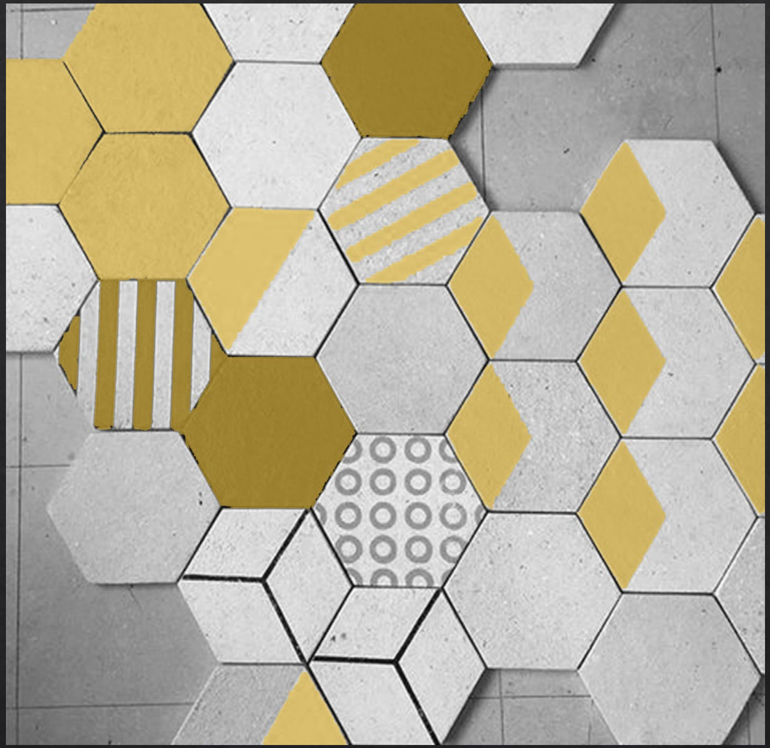
Ground Floor Plan



Basement plan

Interactive Interiors – Interactive connecting corridor

Pavegen



Papertile

Interact and Innovate
Footsteps in energy

Recycle and Design
Personalize patterns

Walling Systems

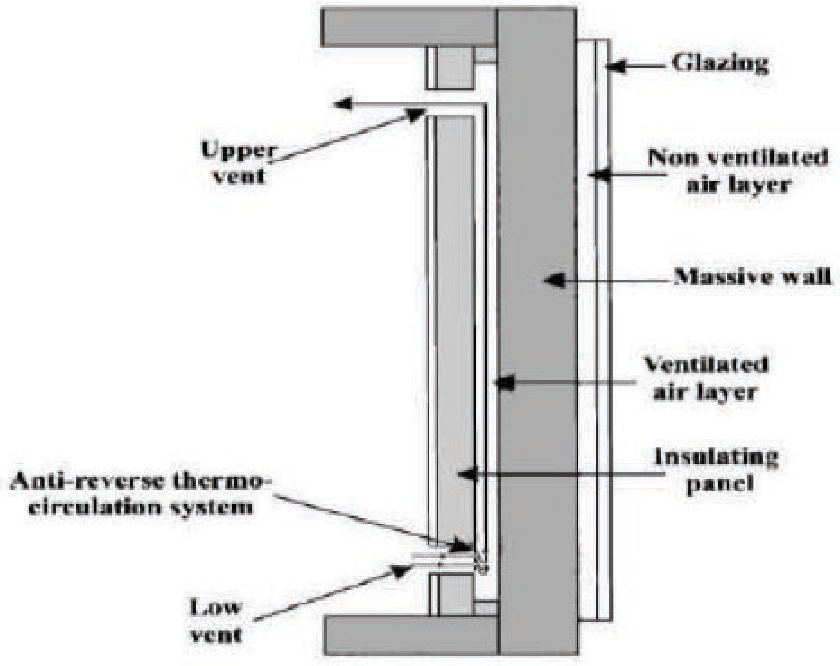
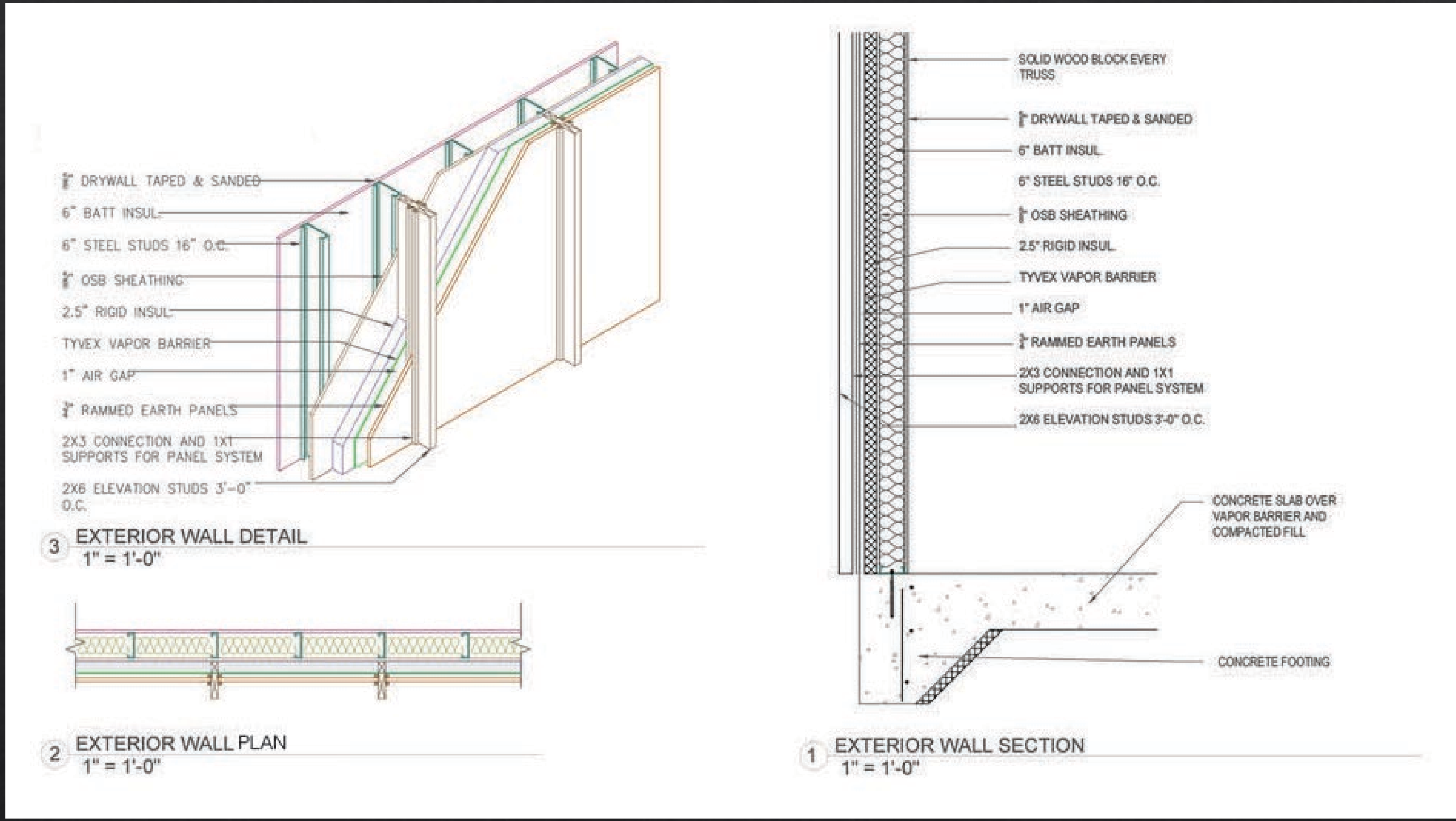


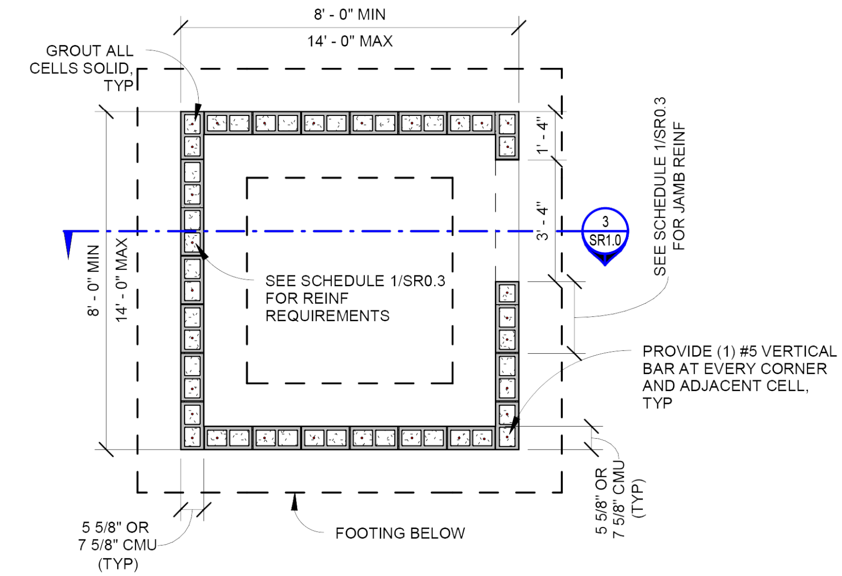
Fig: Solar Composite Wall



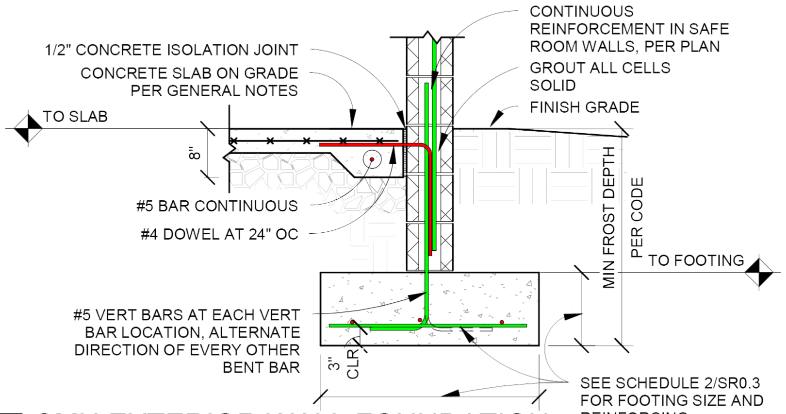
Performance

- Solar Composite Wall (Reverse heat circulation) – Heat retention through green house effect, lesser infiltration of cool air
- Rammed Earth massive wall – Higher U value, works as a better thermal insulator than concrete, sustainable, lesser embodied energy.

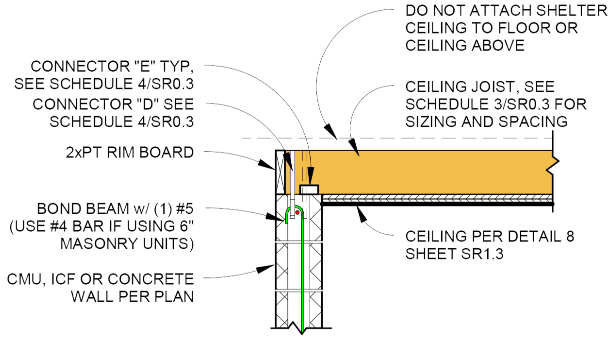
Walling Systems



1 SR1.0 CMU FOUNDATION PLAN
Scale: 1/4" = 1'-0"



4 SR1.0 CMU EXTERIOR WALL FOUNDATION
Scale: 1/2" = 1'-0"

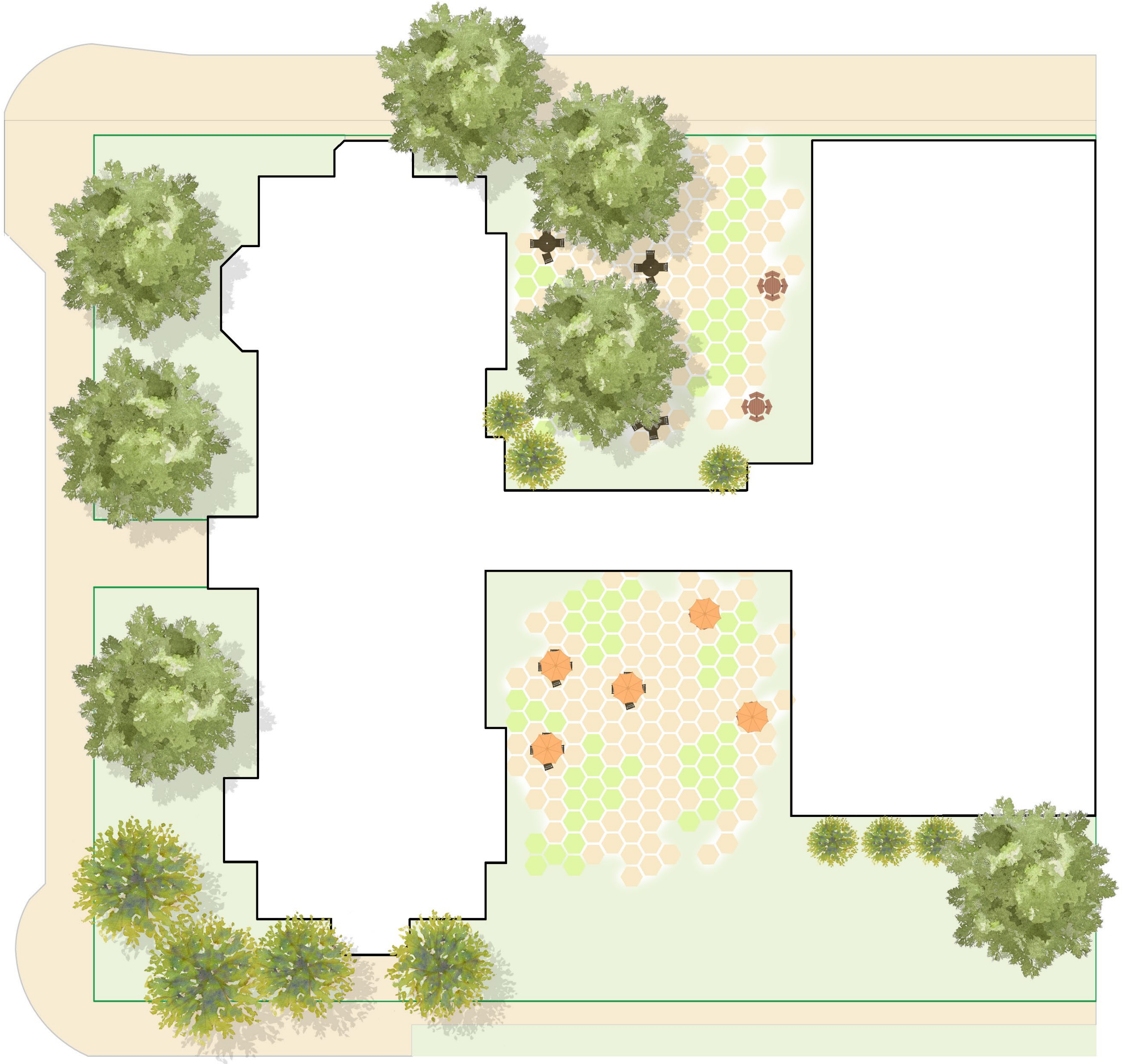


9 SR1.0 ALT WALL/CEILING CONNECTION
Scale: 1/2" = 1'-0"

Resilience

Illinois is prone to tornado weather events, requiring secure and resilient spaces where occupants can wait out the storm. The partial underground theatre space proposed in the east wing will provide space for a full student body and staff with thick concrete walls, free of glass and other shatter prone materials. The ramp entrance provides easy access for disabled or injured persons.

Battery systems are being considered to provide an alternative method to store excess energy produced by the solar arrays for disaster scenarios. This system will be sized to run critical loads for the extent of predicted catastrophes or grid blackout.



Landscape Design

- As an extension of the gym and solarium
- Native shrubs and deciduous trees for shading
- Permeable pavers
- Reduction in stormwater runoff

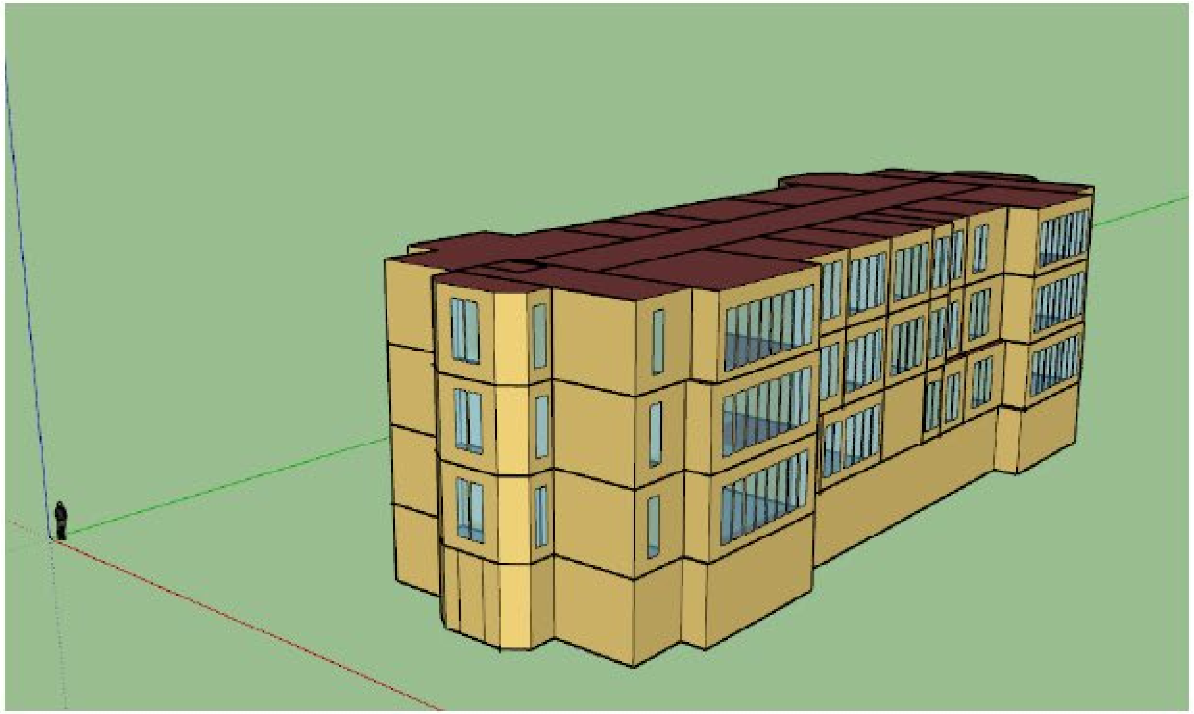
Energy Analysis

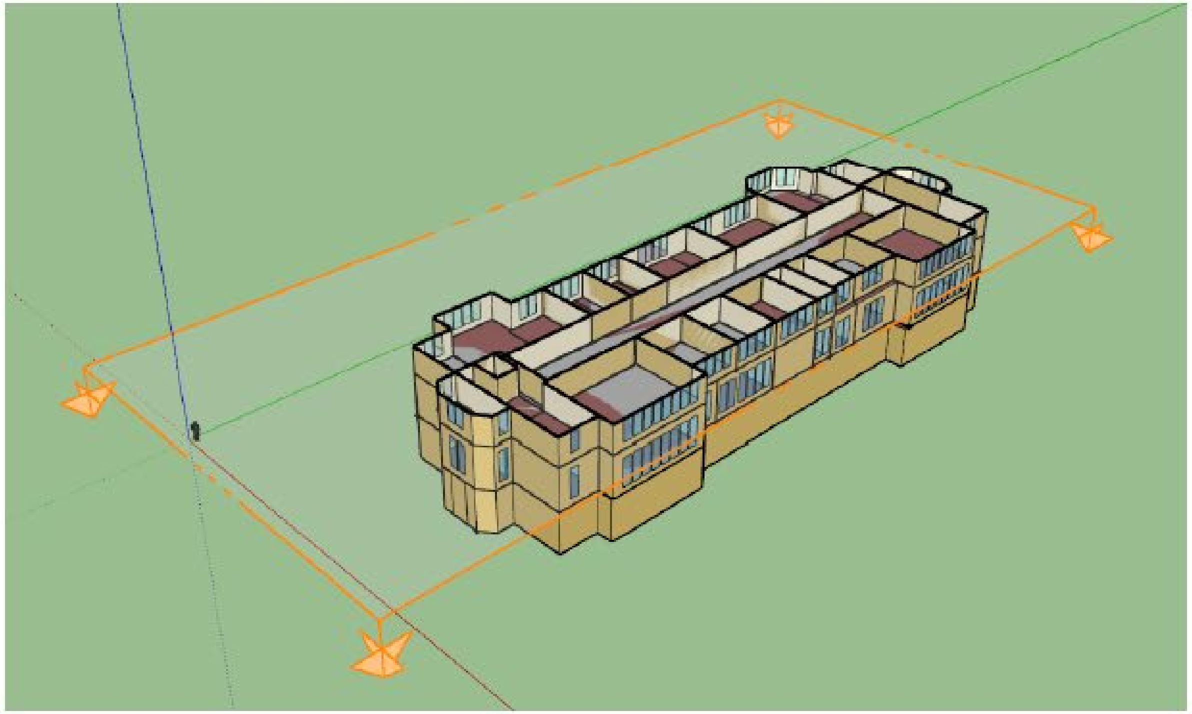
Cases Studied

1. Original building
2. Original building with windows and basement insulation retrofit
3. Insulation with mini-Split heat pumps
4. Original building + Addition (With retrofit insulation)
5. Original Building + Addition with mini-split

Sketch Up + Open Studio

UIUC uses Energy Plus for analysis which is a combination on Open Studio and SketchUp





Assumptions considered for energy simulations

- All rooms except the basement are based on classroom schedules

Heating & Cooling
Humidity
Lights
Activities

- Modern construction standards are used for calculations for building materials

Windows
Walls
Indoor walls
Underground construction walls

Original Building – Current Building Performance

Heating is roughly 10 times more than the simulation

Data (FY2017)

Heating: 6,329,000 kBtu

Cooling: N/A

Electricity: 1,176,000 kBtu

EUI: 141 kBtu/ft^2

Simulation

End Use	Consumption (kBtu)
Heating	615,219
Cooling	315,727
Interior Lighting	899,441
Interior Equipment	638,620

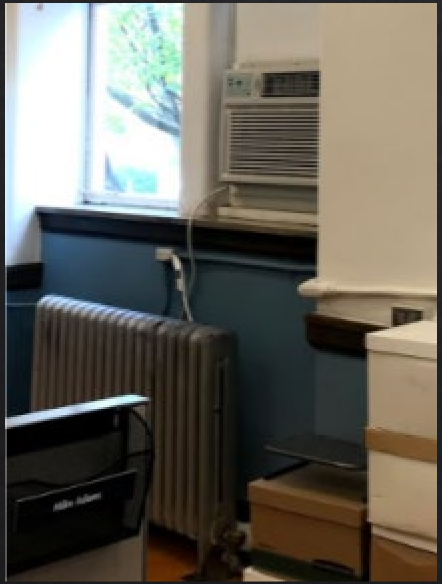
Total Electricity:

1,528,061 kBtu

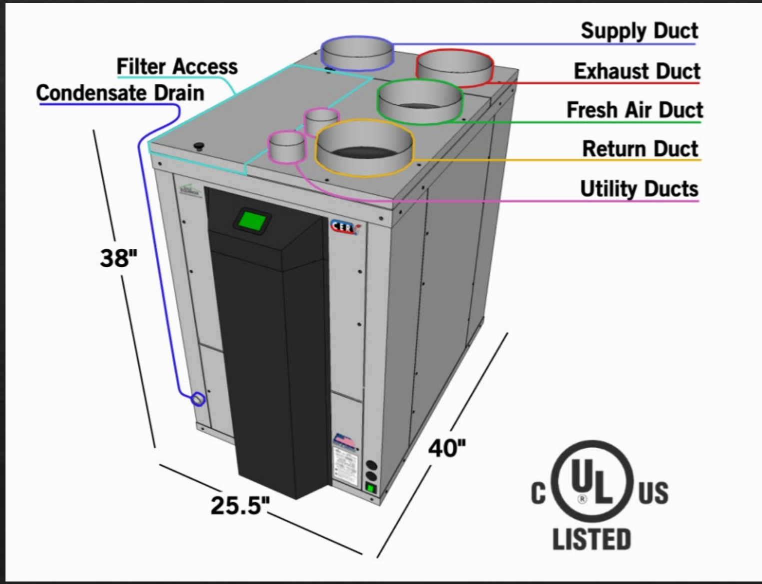
EUI: 51.26 kBtu/ft^2

HVAC

System Components	Existing System	Retrofit Design
Ventilation System	None	The CERV / RenewAire ERV
Heating	Steam Radiators	Ductless Mini Split Heat Pump
Cooling	Window A/C unit	Ductless Mini Split Heat Pump



Existing
Radiator system



CERV
Conditioning Energy Recovery Ventilator

Split AC units

HVAC – Air Quality and Comfort

System Components	Existing System	Retrofit Design
Ventilation System	None	The CERV / RenewAire ERV

System Capabilities	Existing System	Retrofit Design
Flowrate of 35 cfm / student in classrooms	✗	✓
Active monitoring and of CO2 and VOCs	✗	✓

Milton, D. K., Glencross, P. M., and Walters, M. D., (2000) Risk of sick leave associated with outdoor air supply rate, humidification, and occupant complaints. Indoor Air, 10: 212-221.

HVAC – Heating and Energy Consumption

System Components	Existing System	Retrofit Design
Heating	Steam Radiators	Ductless Mini Split Heat Pump
Cooling	Window A/C unit	Ductless Mini Split Heat Pump

System Capabilities	Existing System	Retrofit Design
High heating capabilities for frigid winters	✓	✓
Local control of temperature	✗	✓
Optimal energy usage and reduction of waste energy	✗	✓

PV&E System Overview

- Current electricity consumption of school: **~ 329,000 kWh/year**

- Three separate systems
  - Current Building Roof
  - New Gym Roof
  - Parking Lot

- Two types of panels
  - Standard polycrystalline
  - Bifacial hybrid

PV Module Specs	Standard Panels	Bifacial Panels
Model	Canadian Solar CS3W-395	Sunpreme Maxima GxB 390
Efficiency	17.88%	20.1-24.1%

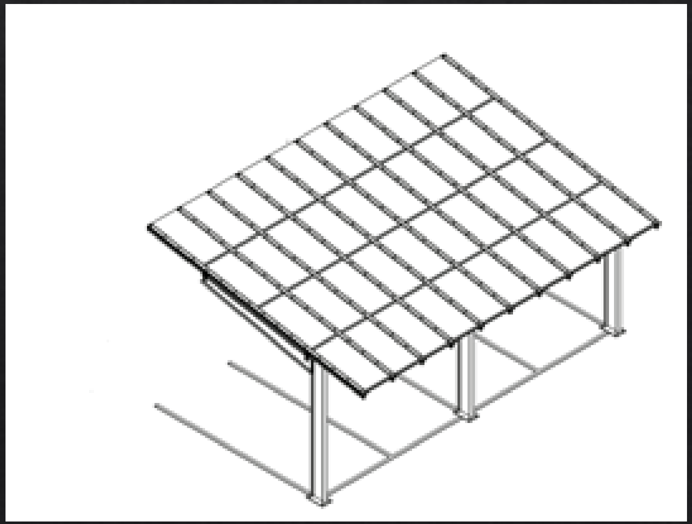
Current Building Roof and New Gym Roof Systems

- Canadian Solar CS3W-395 panels
  - 140 on Current Building
  - 100 on New Gym
- Optimum tilt of 33 degrees
- SunModo SunTurf Roof Mount system
- Yaskawa Solectria 1000 - 65/65 inverter

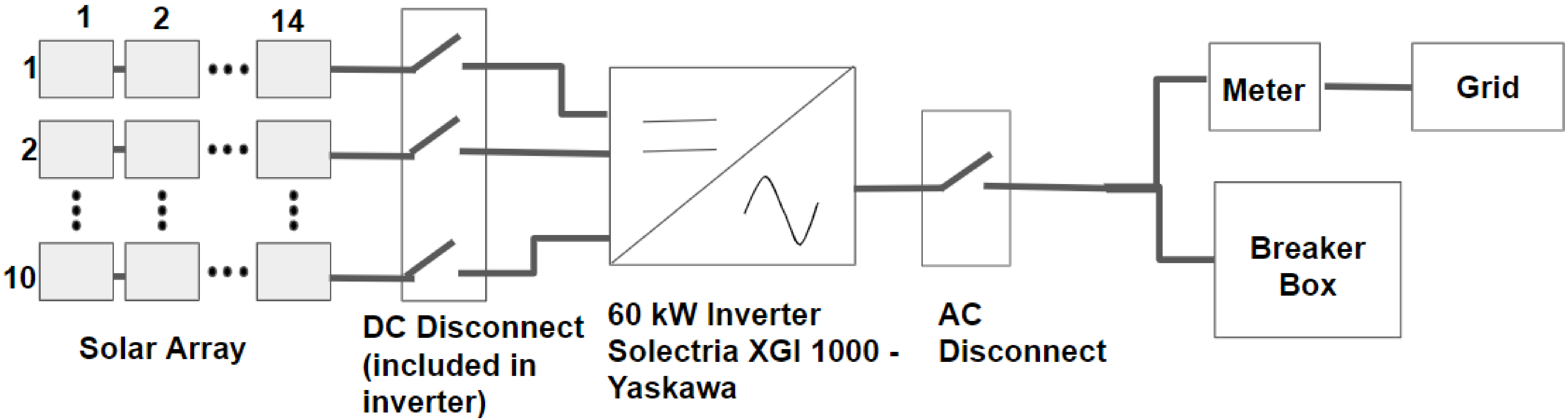


Parking Lot System

- SunPreme Maxima GxB 390 bifacial panels
  - 320 total - groups of 40
  - Tilt of 13 degrees
- SunRail CPR Bifacial Carport
- CPS SC20KTL - DO/US - 480 inverters



Current Building Rooftop Single Line Diagram



Capacity and Generation

- Total installed capacity: ~ **220 kW**
- Total energy generation: ~ **382,000 kWh/year**
- 4.93 $kWh/m^2/day$ for roof mounted panels
- 4.65 $kWh/m^2/day$ for parking lot panels

System	Energy Output
Current Building Roof	99,510.11
New Gym Roof	71,078.65
Parking Lot	211,719.80
Total	382,308.57

Economic Analysis of PV Systems

- Capital Cost: **~$402,000**
  - At installation cost of $1.83/W (NREL)
- Annual Savings: **~$30,000**
  - At utility rate of 7.9 cents per kWh
- Payback period: **13.24 years**

	Current Building Roof	New Building Roof	Parking Lot
Capital Cost ($)	101,199.00	72,285.00	228,384.00
Annual Savings ($/year)	7,901.10	5,643.65	16,810.55
Payback Period (year)	12.81	12.81	13.59

Energy Analysis

Again!

Case 3

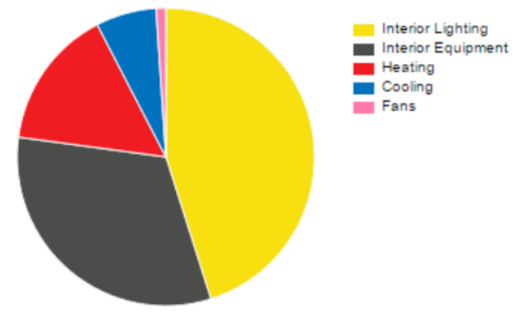
Retrofit
- Mini-split ductless added to all rooms
- No mini-split added in basement

Results
- EUI: **41.40 kBtu/ft^2**
- Heating
  - Additional Savings: **140,997 kBtu**
  - Total reduced : **311,216 kBtu**
  - Total annual saving: **$3,988**
- Cooling
  - Additional Savings: **115,435 kBtu**
  - Total reduced: **184,407 kBtu**
  - Total annual savings: **$4,809**
- Additional fan energy cost: **$543**

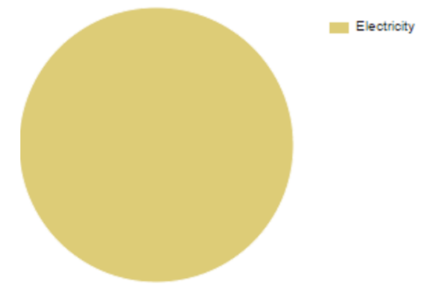
- **78% of HVAC load can be provided by PV**

Average household 129,000 kBtu

End Use	Consumption (kBtu)
Heating	304,003
Cooling	131,320
Interior Lighting	899,441
Interior Equipment	638,620
Fans	20,833

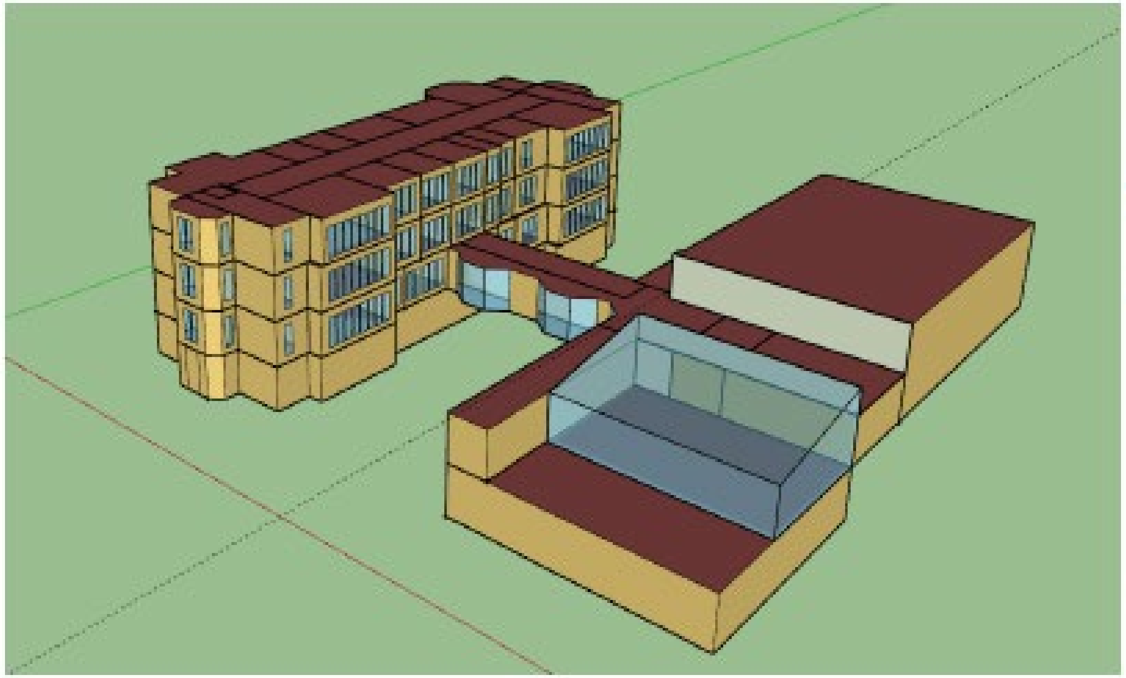


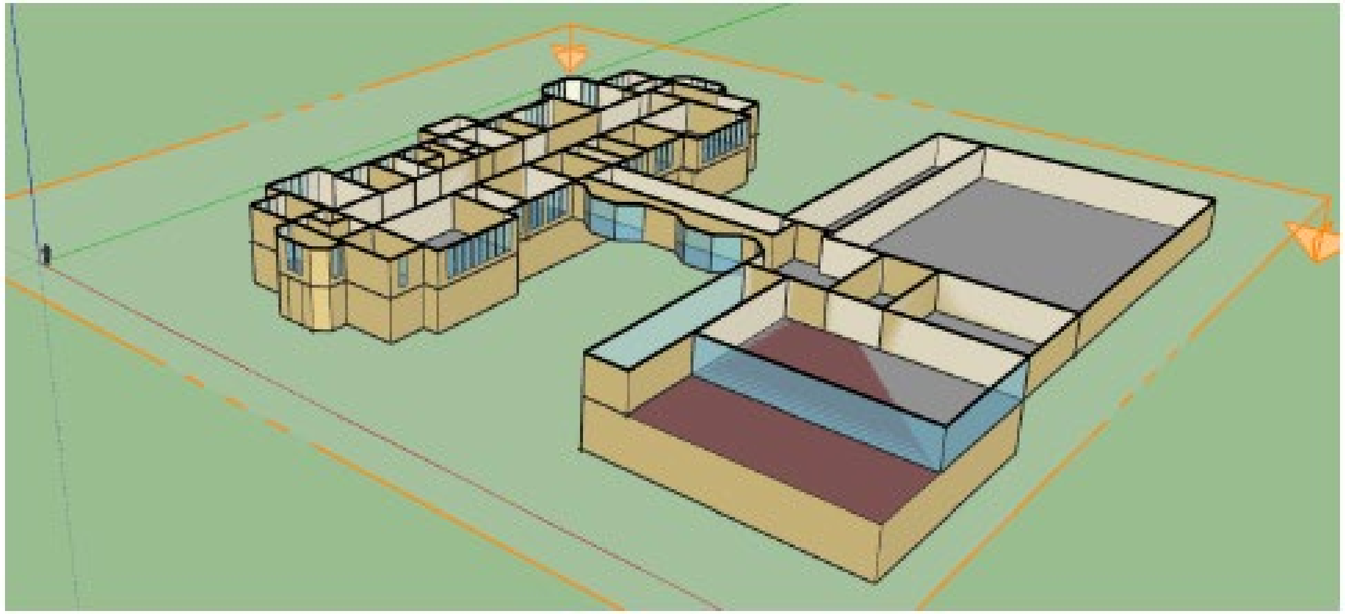
Building End Use pie chart for Case 3



Building Energy End use pie chart for Case 3

Case 5





SketchUp model of original building with extension

Section View of the model

New Parameters include schedules of Gym, Cafeteria, Kitchen, Auditorium, Locker Room, Office

Case 5

Average household 129,000 kBtu

Retrofit:

•Original & Addition (with mini-split)

Results

•EUI: 47.85 kBtu/ft^2

•Total increase by 1,289,000 kBtu

- Compared to case 3

•Total decrease of 729,000 kBtu

- Compared to case 4
- Savings: $6,595

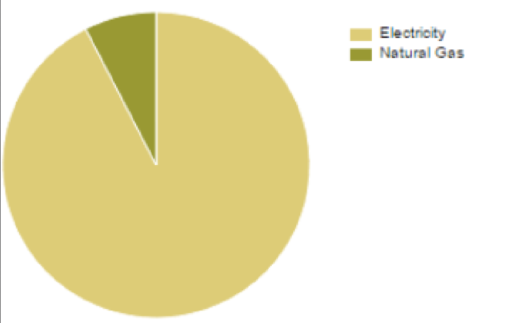
• 63% HVAC load provided by PV (W/O Parking)

•100% HVAC load provided by PV

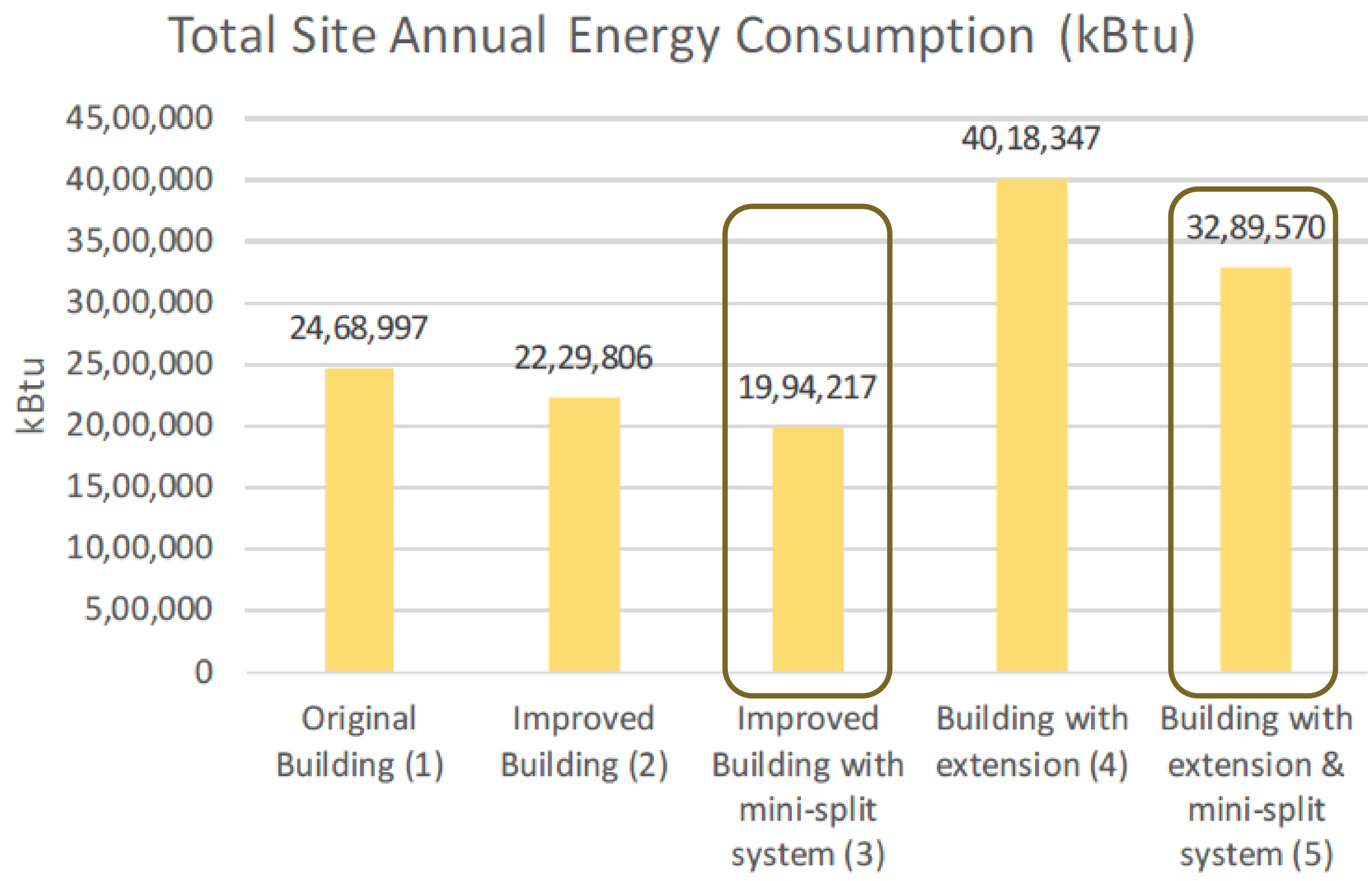
- 88,700 kWh extra (300,000 kBtu)

End Use	Consumption (kBtu)
Heating	649,549
Cooling	272,507
Interior Lighting	1,183,748
Interior Equipment	1,144,688
Fans	39,078

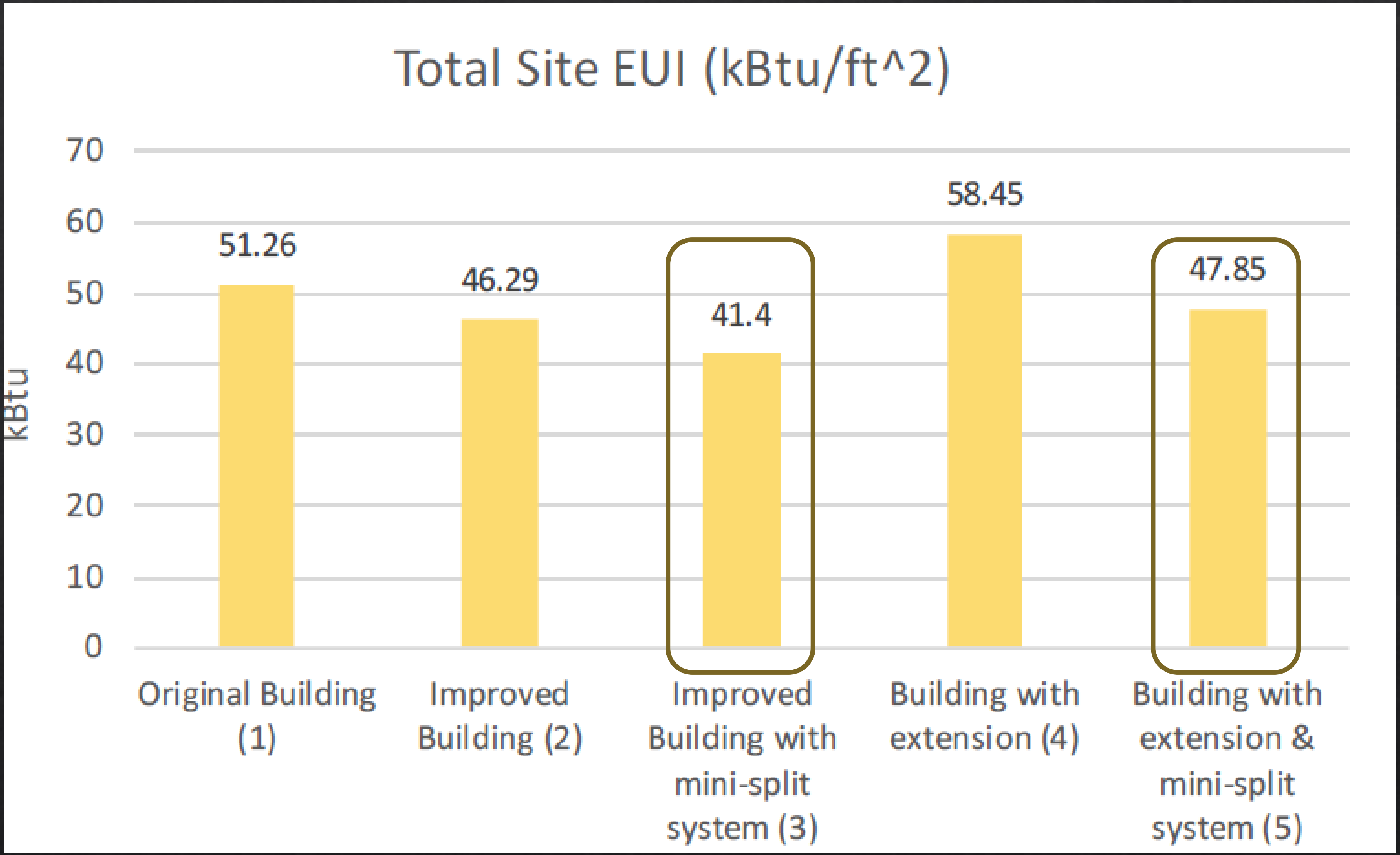
Building End Use summary for Case 5



Building Energy End use pie chart for Case 5



Total site annual energy consumption for each case in bar charts



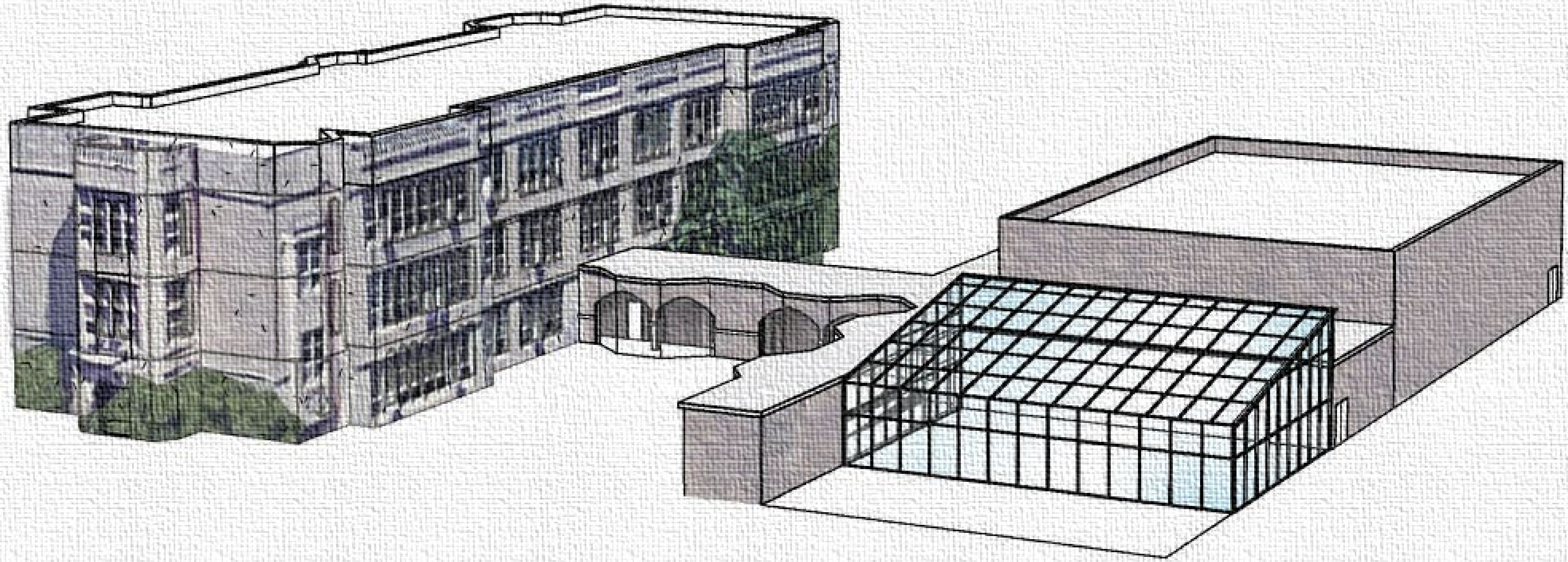
Average K-12 School EUI: 150 kBtu/ft^2

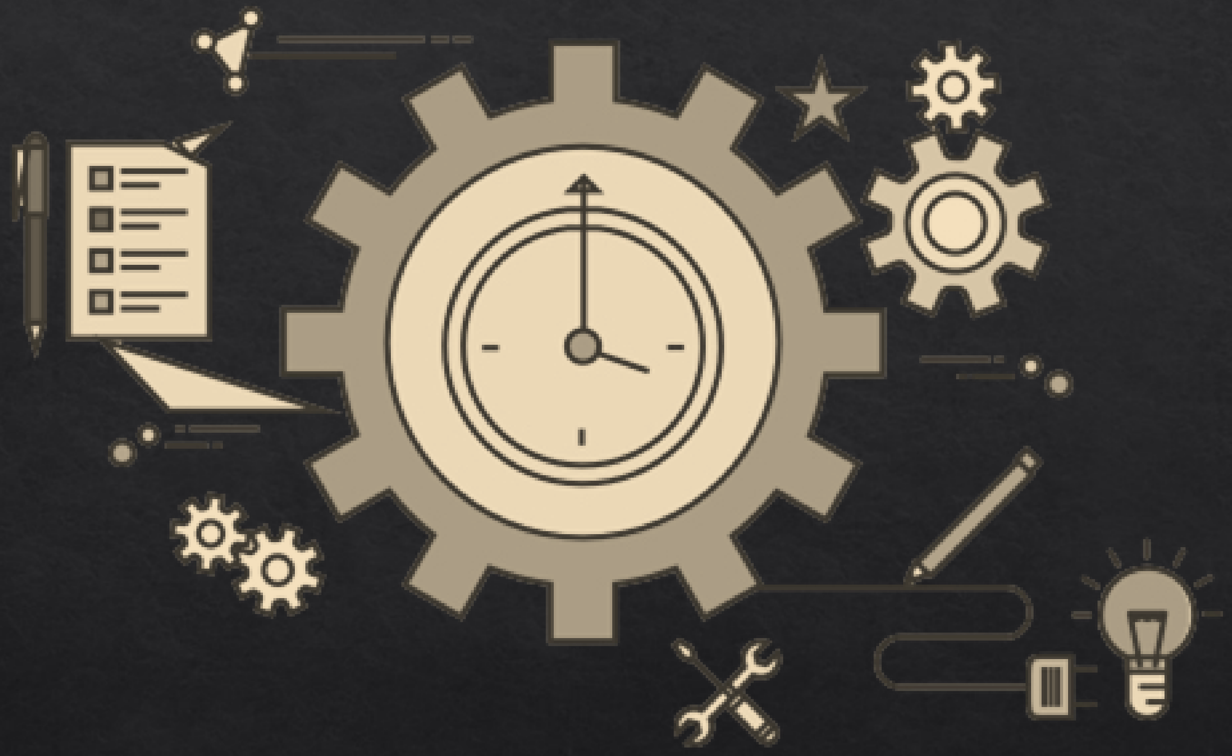
Summary

- Insulation reduces heating and cooling load significantly

- Mini-Split ductless heat-pump further reduces the loads
  - Electricity as main source
  - Electricity energy more expensive per unit
  - Still Yield net positive savings

- Building extension increases energy consumption & EUI
  - Recommend mini-split ductless heat pumps
  - Space and activities
  - Quality of Life





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