Cold-Climate Innovation: Sustainable Design at the University at Buffalo

Page Stantec

VANDERWEIL
CELEBRATING 75 YEARS

Introduction

Mo Elsayed

Senior Building Performance and AI Analyst

Page / Stantec

Steven Karl

Principal

Vanderweil Engineers

Mo Elsayed:

As a Senior Building Performance and AI Analyst at Page, Mo works on the integration of emerging technologies into sustainable practices. He specializes in using AI and machine learning to enhance building performance, focusing on energy efficiency, decarbonization, and net-zero strategies.

Steven Karl:

As a Principal at Vanderweil Engineers, Steve’s focus is MEP design and his work integrates energy-efficient technologies, waste reduction strategies, and innovative design principles that reduce the carbon footprint and operational costs of laboratory environments and while providing a healthy, productive space for the researchers.

Learning Objectives

Four learning objectives -

1. Learn how to plan for sustainability from the early stages of the project.
2. Learn how modeling informs the design and impacts system selection.
3. Understand drivers to design a low EUI building in a cold climate.
4. Identify how to implement the ASHRAE hazardous air classification to minimize airflow.

Project Summary -

The University at Buffalo's new Agrusa Hall for the School of Engineering and Applied Sciences features prototyping, fabrication facilities, collaboration spaces, offices, and labs, aligning with the University's award-winning climate action plan and NY State University Construction Fund sustainability directives.

Laboratories consume five times more energy per square foot than office buildings, a challenge that is amplified in cold climates with significant heating demands. In this technical session, our experts will delve into sustainable design and the strategies employed.

Buffalo!

Early Project Intentions

UB's Climate Action Plan

UB's 10 in 10

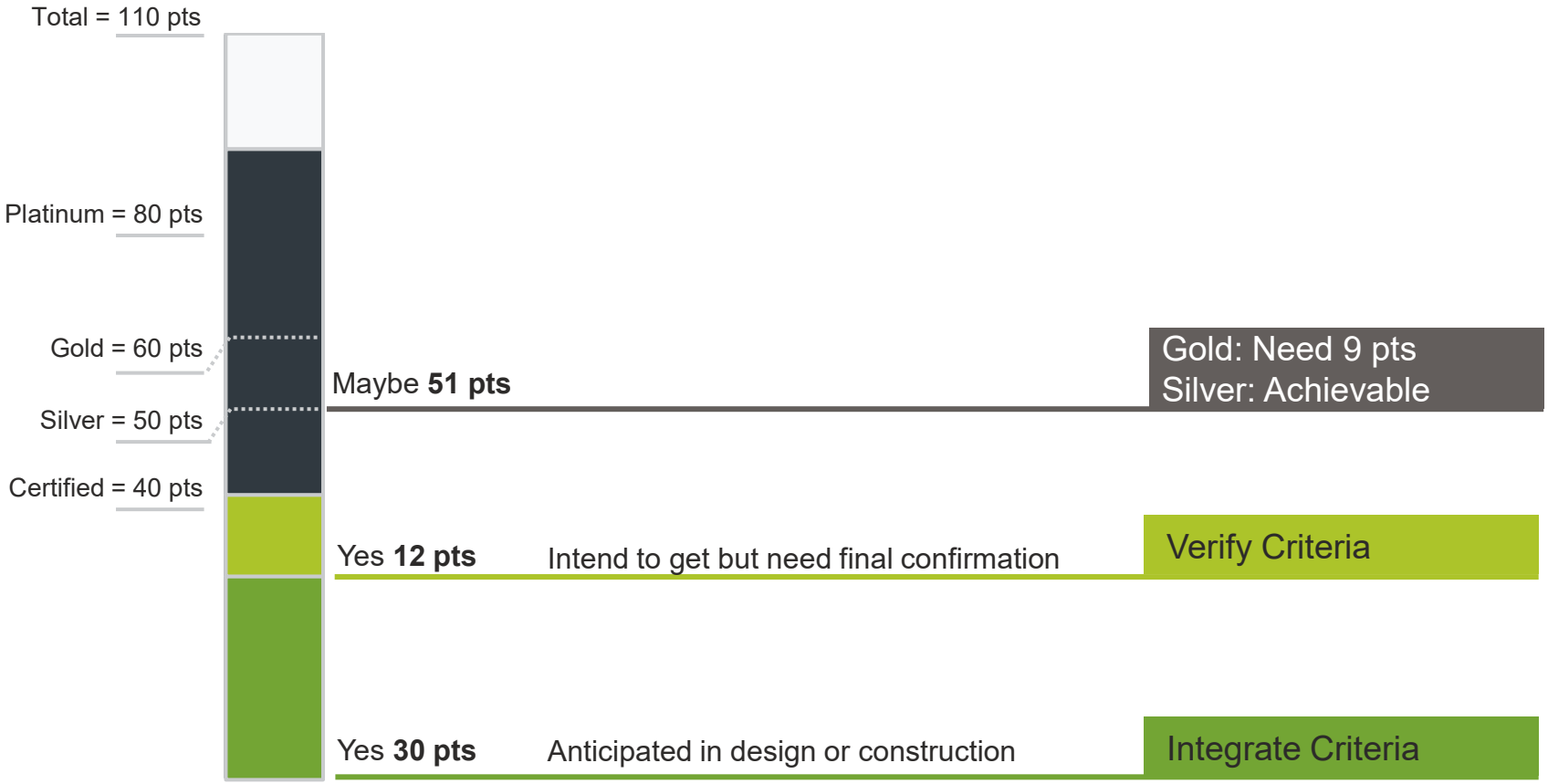
By 2025, UB will directly purchase **100%** of the electricity from **clean energy sources**.

UB will achieve **net zero waste** across all material streams by 2030.

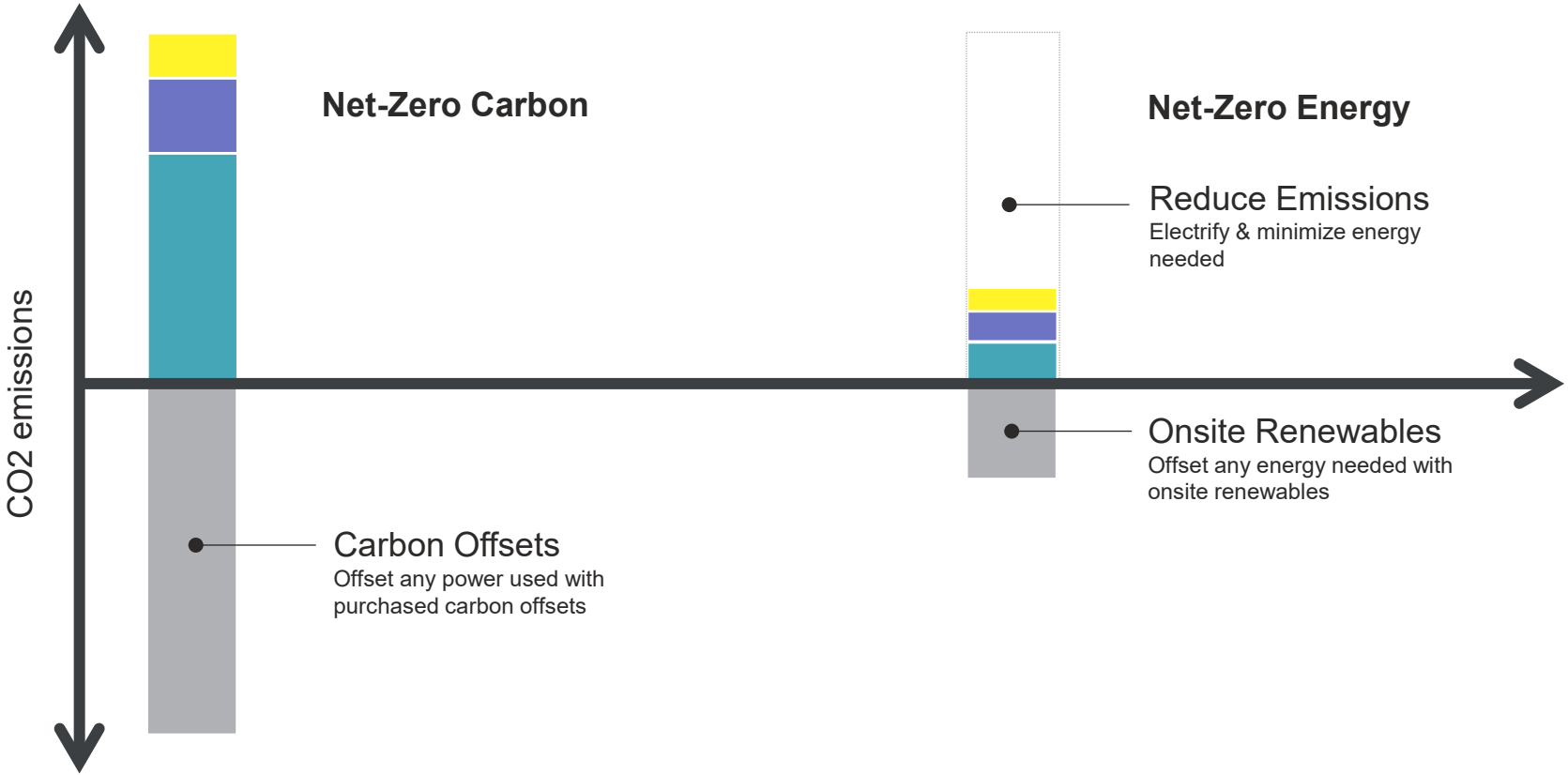
UB will develop **zero carbon commuting** pathways for the campus community.

UB plans to obtain enough **carbon offsets** to fill the gap thus obtaining carbon neutrality by 2030.

Early Project Intentions: LEED Priorities



Early Project Intentions: Define Net-Zero



Early Project Intentions: Target EUIs

EUI Program Directive 1B-2 – Net-Zero Carbon New Buildings and Deep Energy Retrofits (suny.edu)

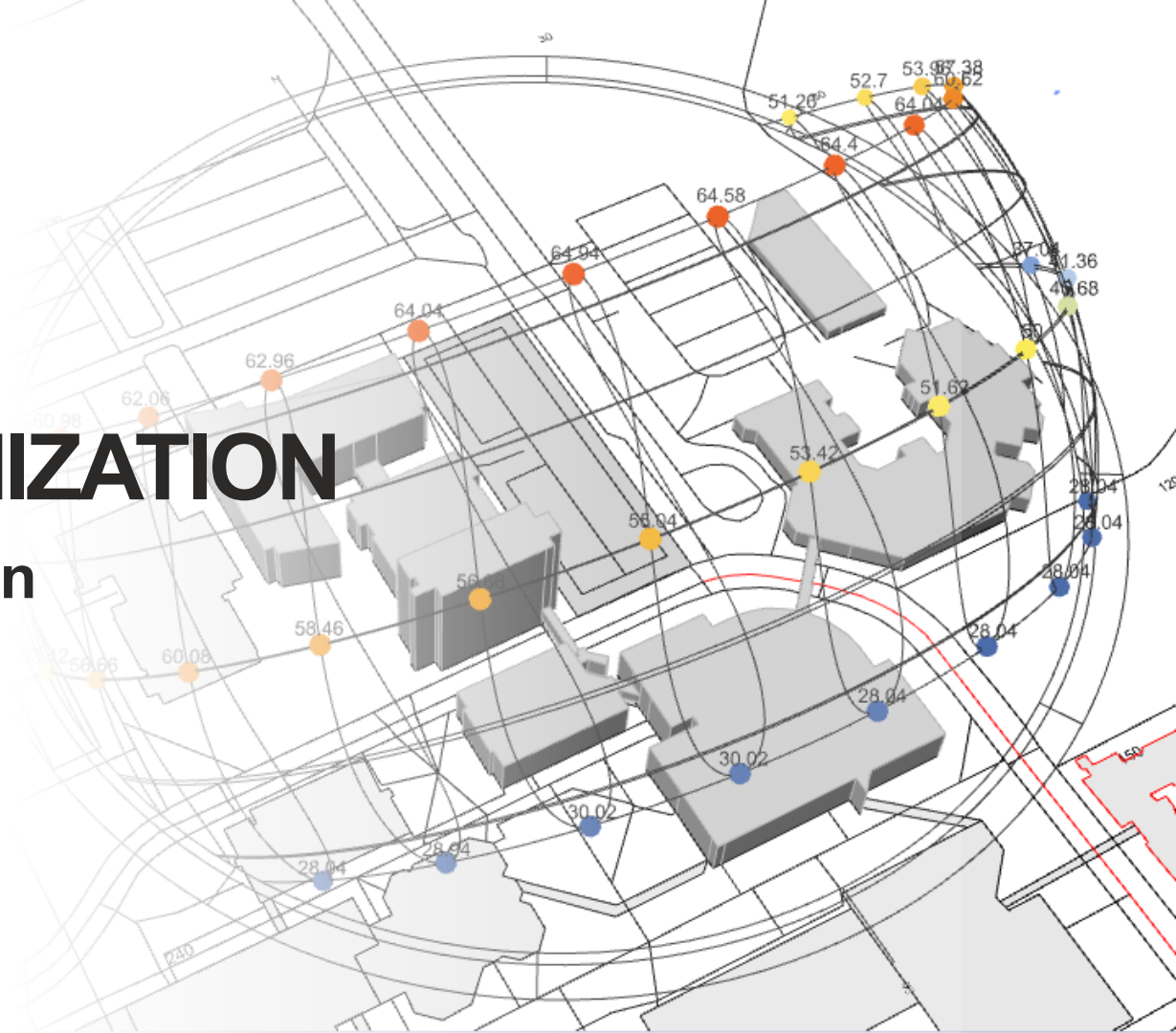
Net Zero Carbon Building Site EUI Targets

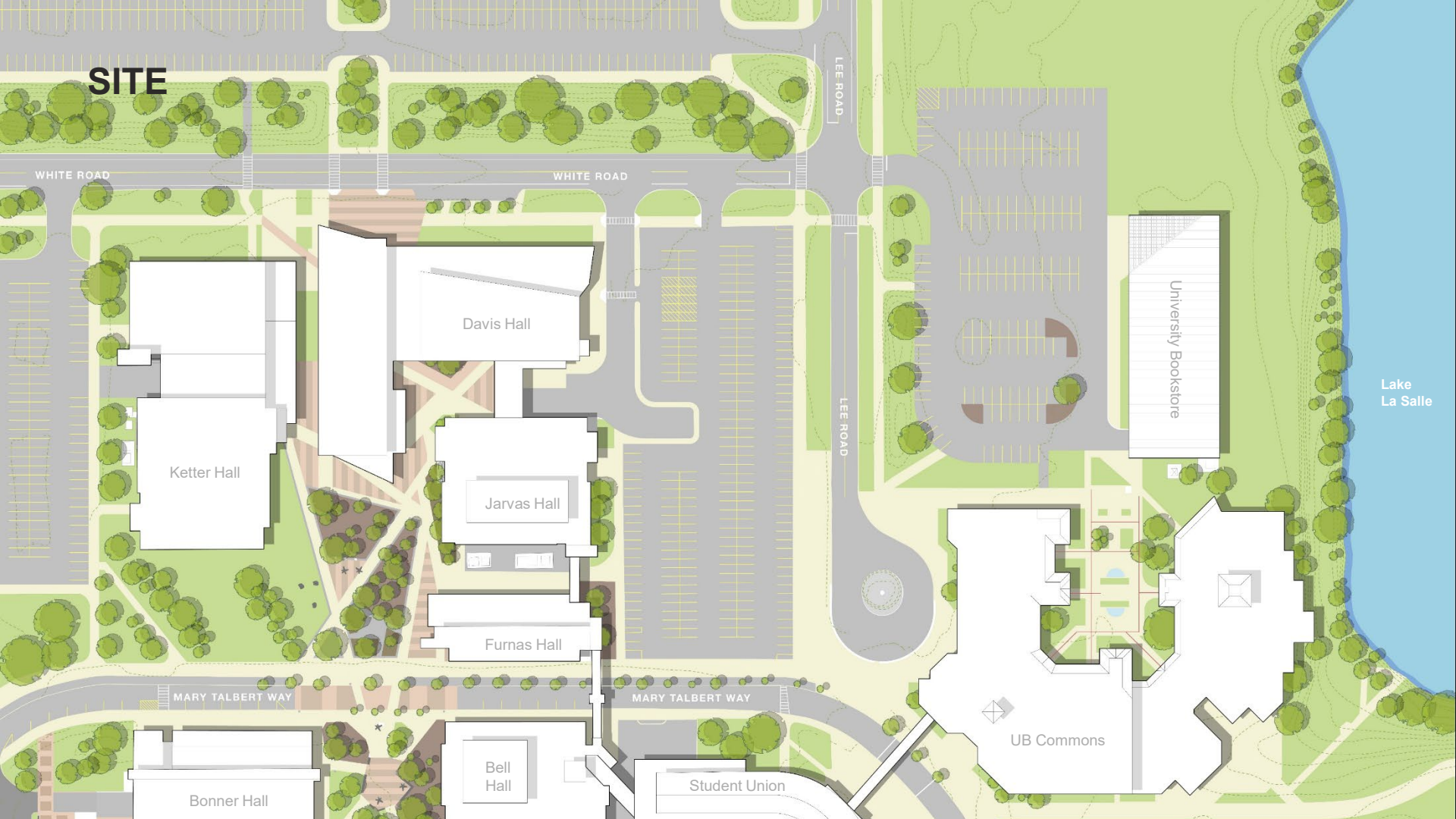
Building/Space Type	EUI
Theater, Performing Arts, Sports Arena	22
Gymnasium, Field House, Fitness Center, Multipurpose/assembly space, Student Activities Center, Broadcasting Studio	26
Ice Rink, Pool	130
Office	29
Classroom	30
Residence Hall	35
Clinic/Outpatient Facility	41
Preschool/daycare	44
Public Safety/ Campus PD, Library	58
Coffee Shop, Cafe	79
Hospital/Inpatient Health	113
Lab: Physics/Geology	128
Kitchen with dining area	144
Lab: Bio/Chem (wet)	160

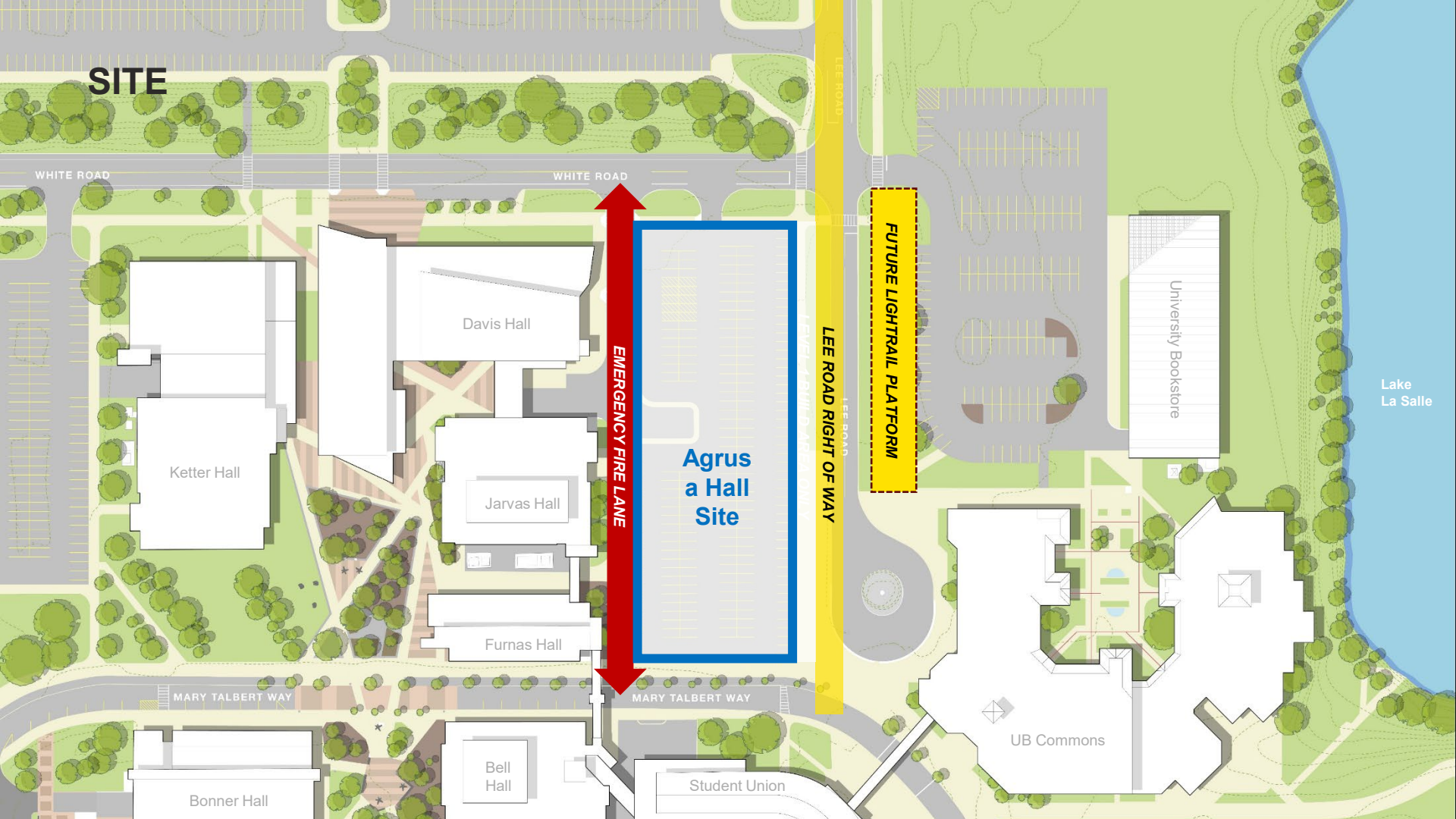
Early Project Intentions: Target EUIs

EARLY OPTIMIZATION

Performance by Design




SITE
WHITE ROAD
WHITE ROAD
LEE ROAD
LEE ROAD
Davis Hall
Ketter Hall
Jarvas Hall
Furnas Hall
University Bookstore
Lake
La Salle
MARY TALBERT WAY
MARY TALBERT WAY
UB Commons
Bell
Hall
Bonner Hall
Student Union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FUTURE LIGHTRAIL PLATFORM
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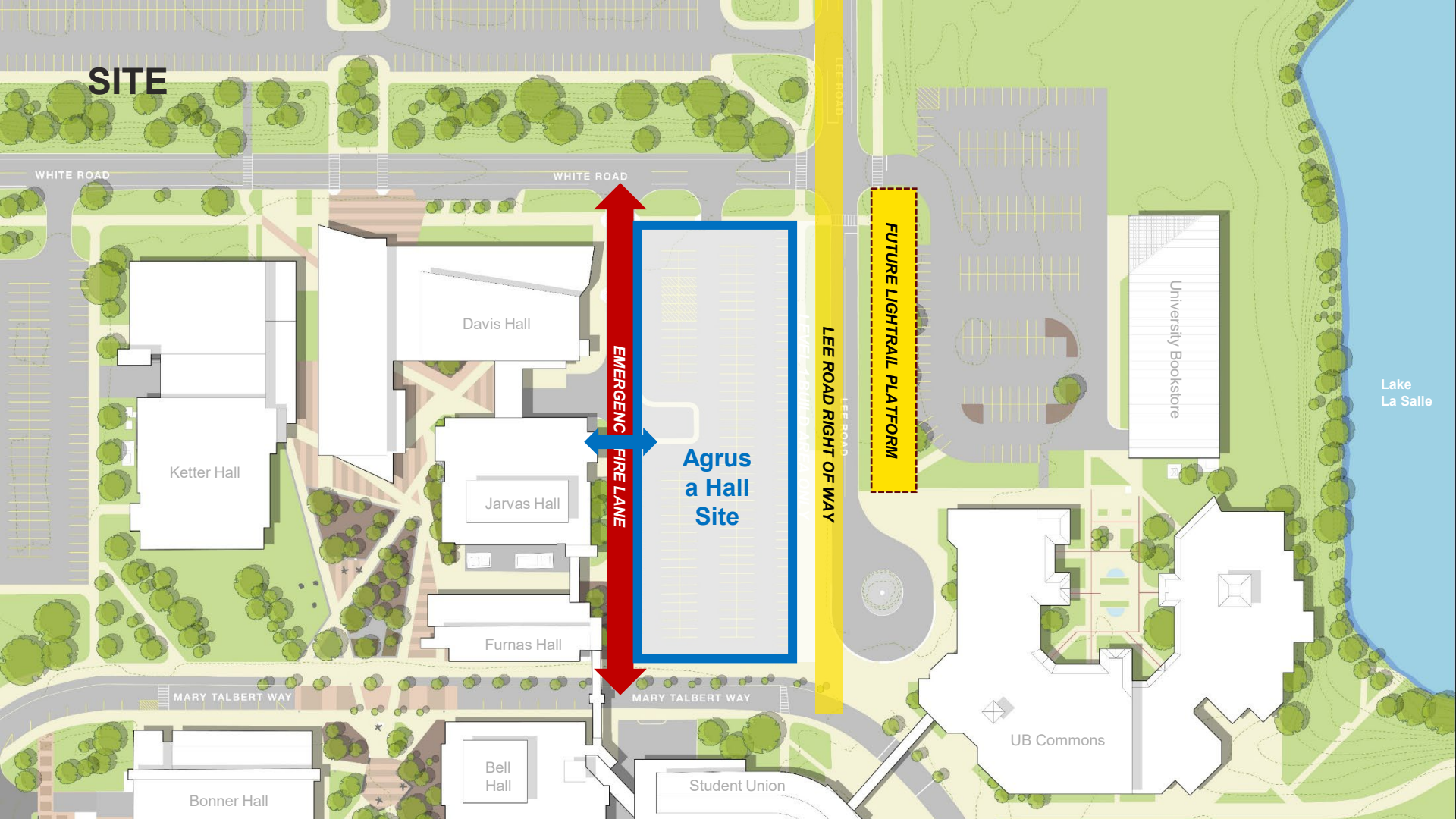
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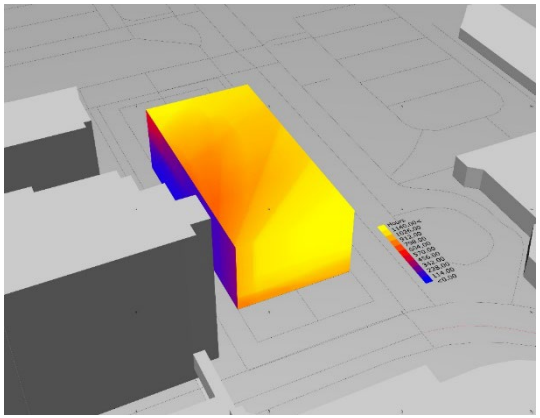
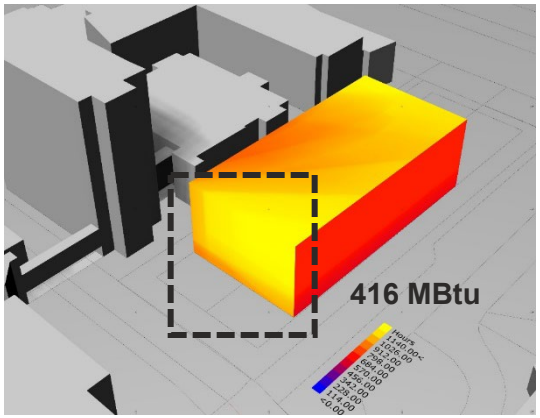
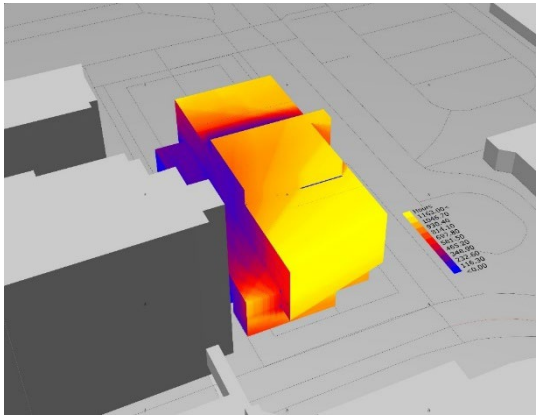
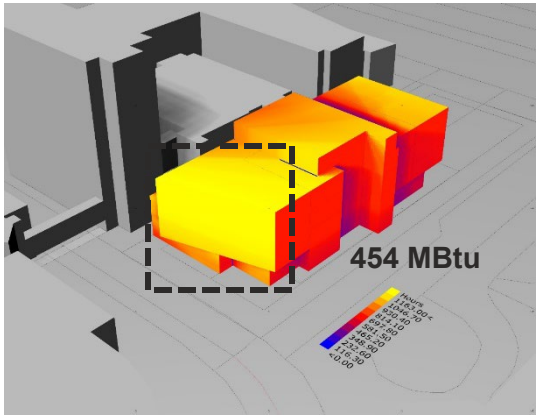
Early Optimization: Passive Solar Harness

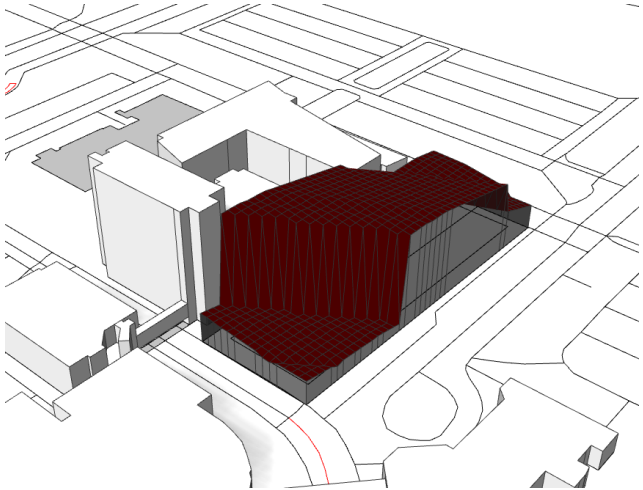






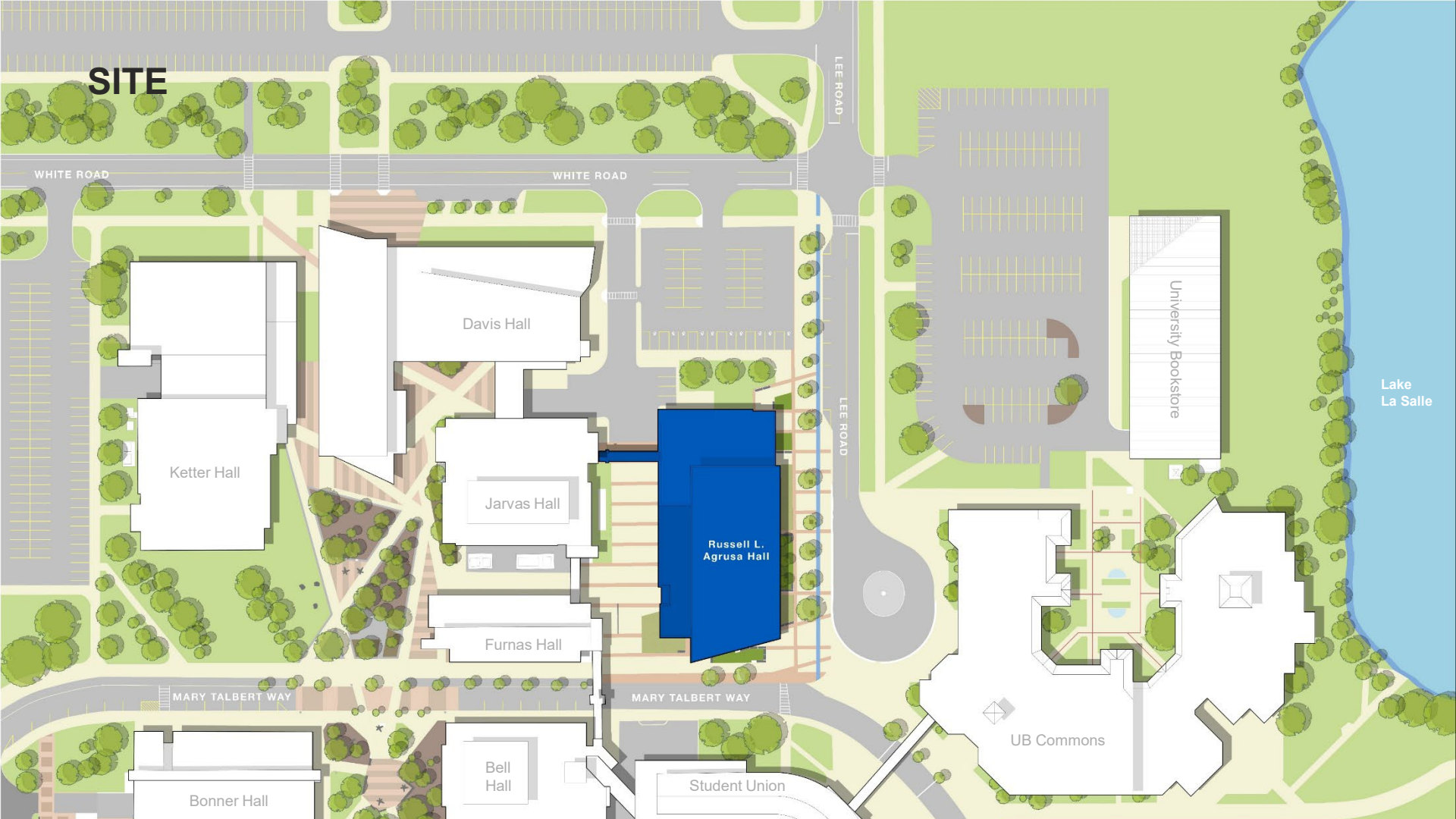


Maximize solar harness in Winter conditions



Bar Scheme | Fully exposed South façade
for optimal BIPV harness and daylight
Tilted South façade **|** 10% added Solar exposure

Early Optimization: Site Analysis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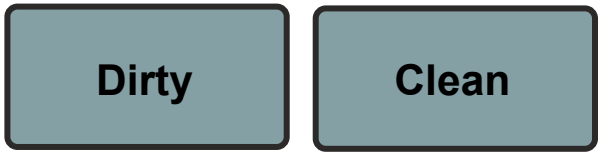
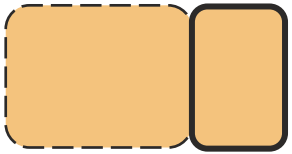
Student Union

Level 1 + 2 Building Blocks

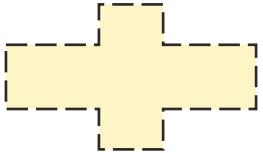


Common Assembly Spaces + Workshops
"Big Blue"

Core / Building Services
(elev, restrooms, loading, etc.)



Atrium + Event Space

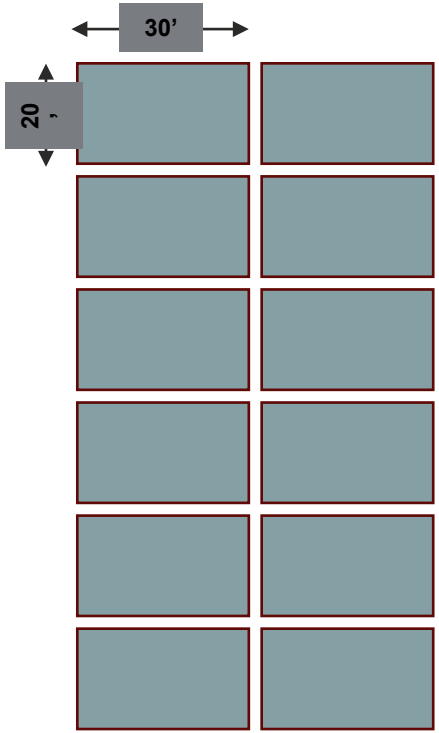


Major Circulation
(including connection to Jarvis)

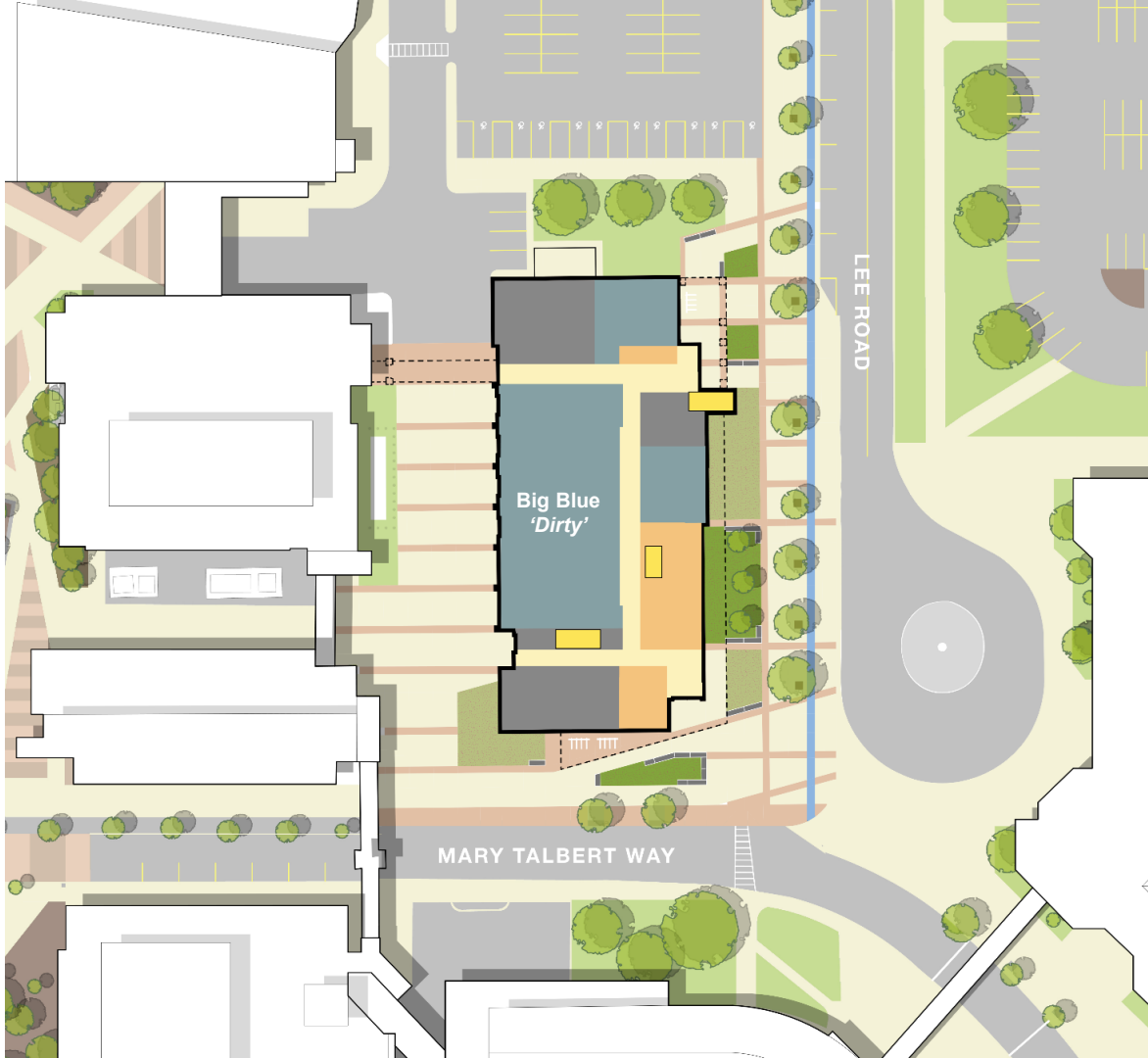
Stairs

‘Big Blue’

Project assembly space for students

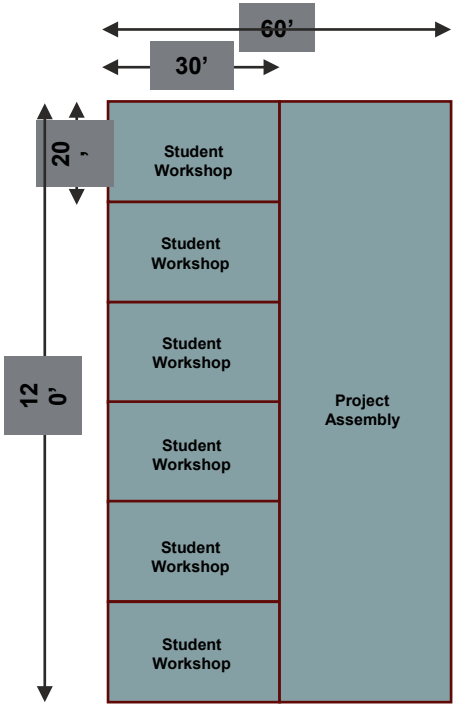


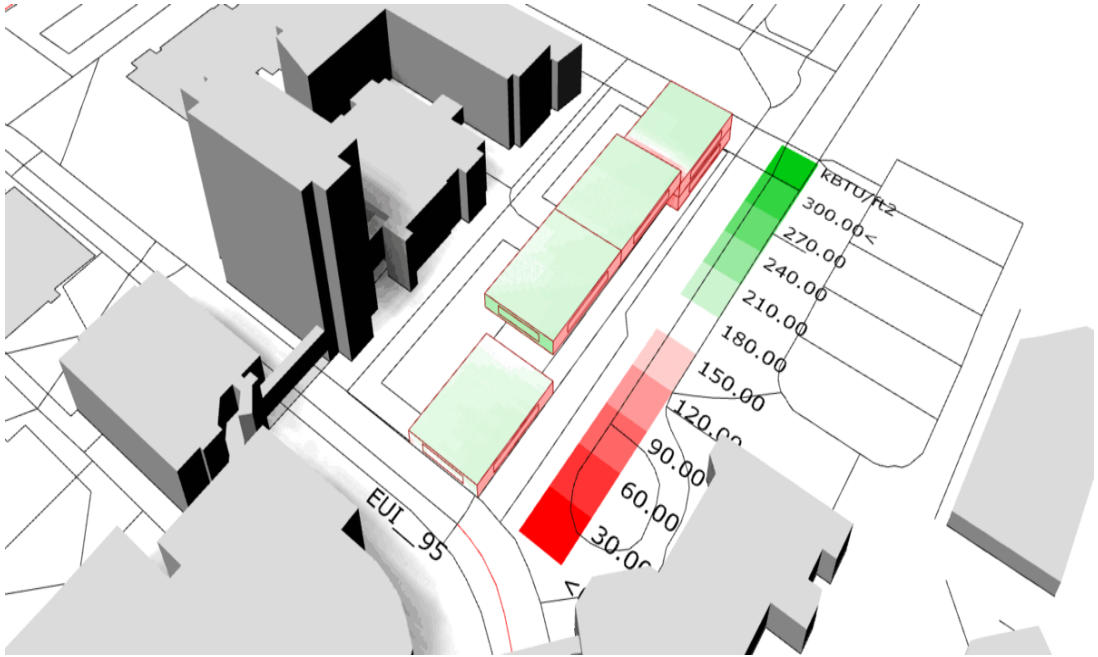
Research Labs
Teaching Labs
Circulation
Stairs
Collaboration
Building Support



‘Big Blue’

Project assembly space for students

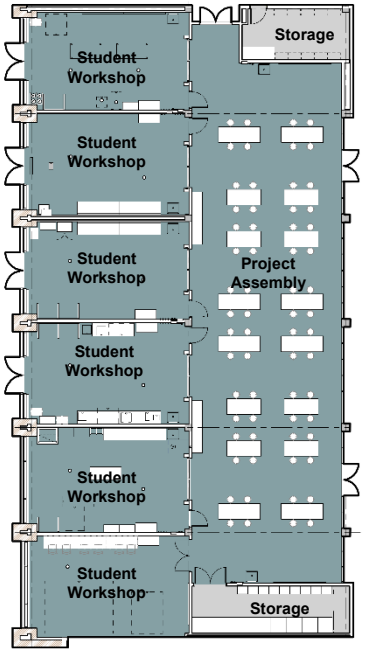




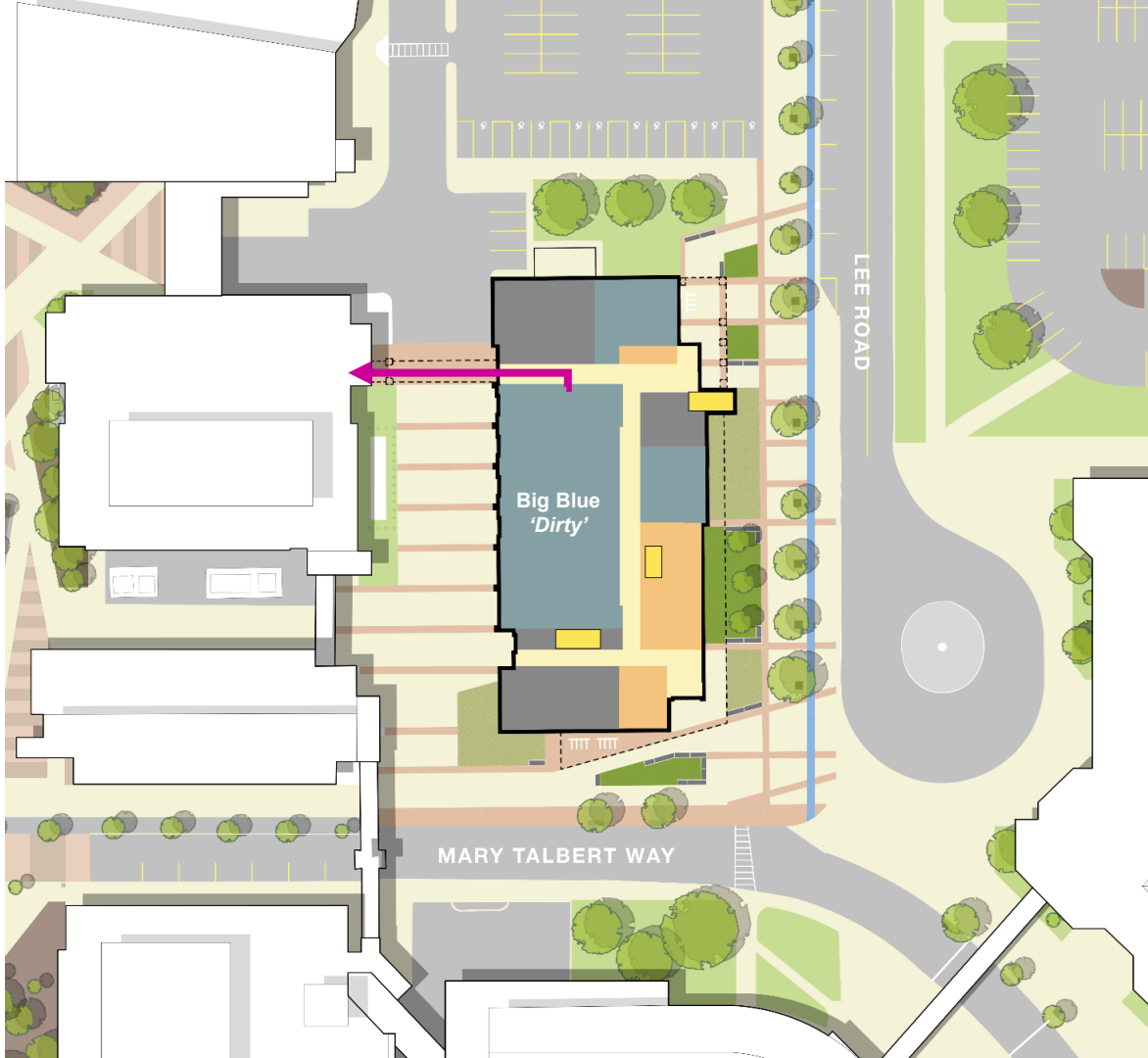
Research Labs
Teaching Labs
Circulation
Stairs
Collaboration
Building Support

‘Big Blue’ – Level 1

Project assembly space for students

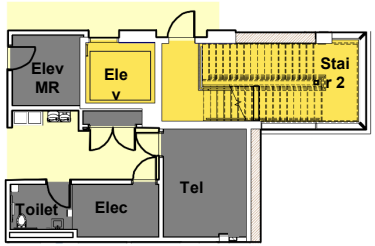


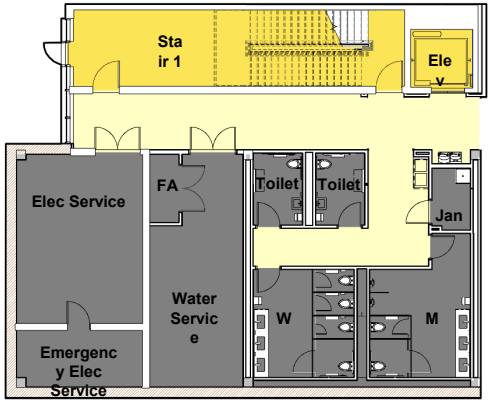
Research Labs
Teaching Labs
Circulation
Stairs
Collaboration
Building Support



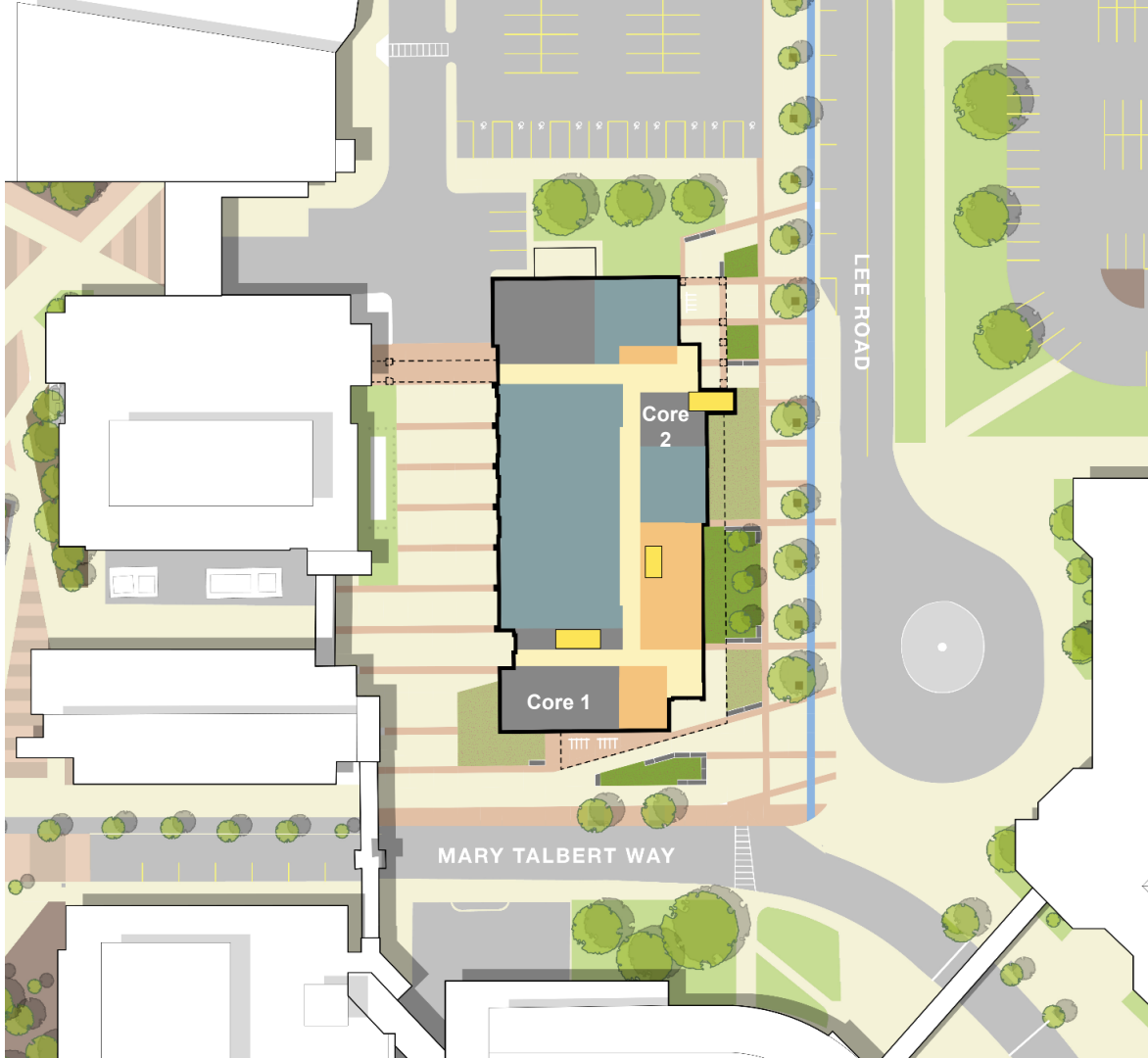
Balancing Exposed vs. Enclosed

Split Core



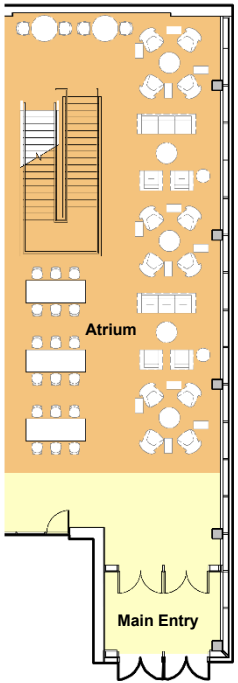


Research Labs
Teaching Labs
Circulation
Stairs / Elevators
Collaboration
Building Support

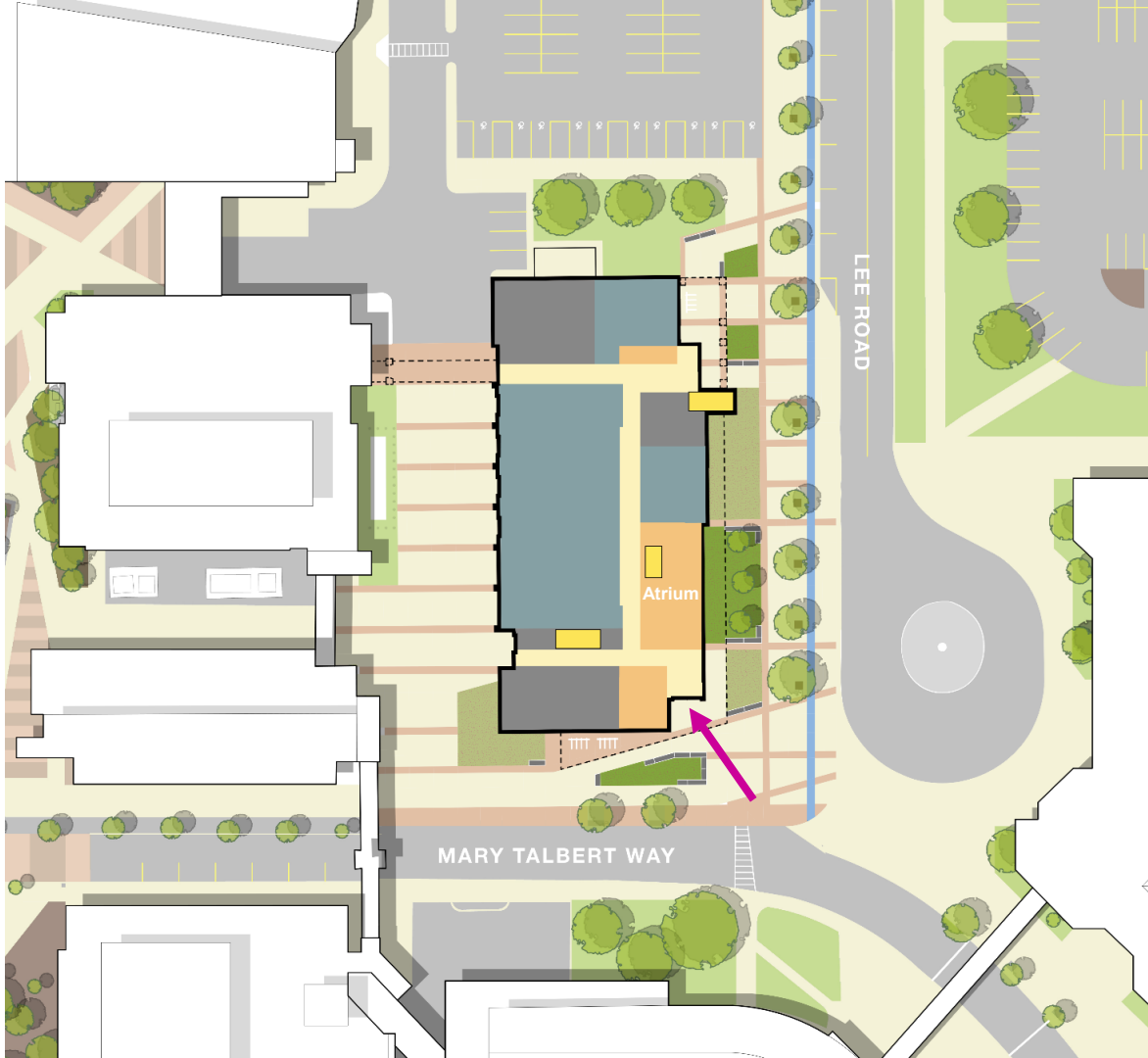


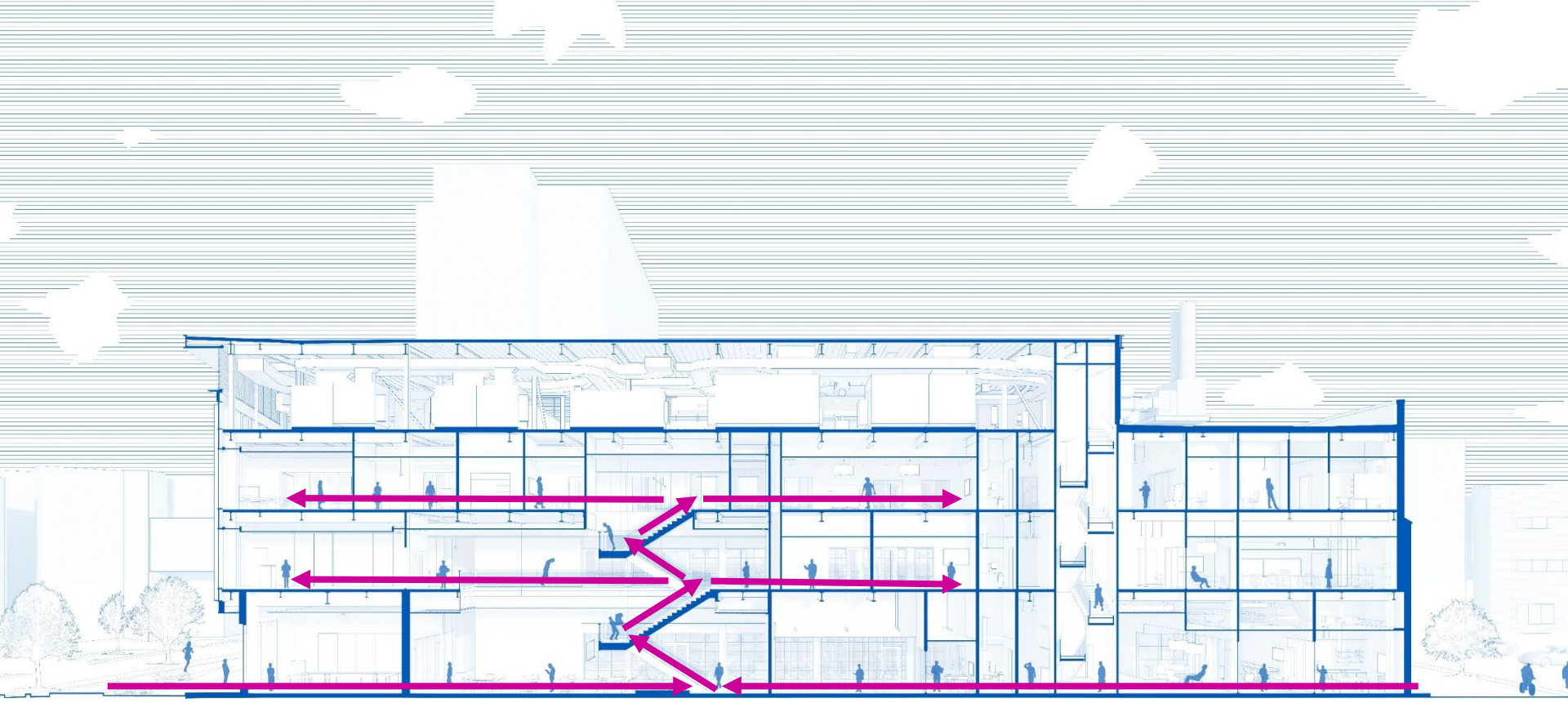
Balancing Exposed vs. Enclosed

Flexible Student Success Atrium



Research Labs
Teaching Labs
Circulation
Stairs
Collaboration
Building Support



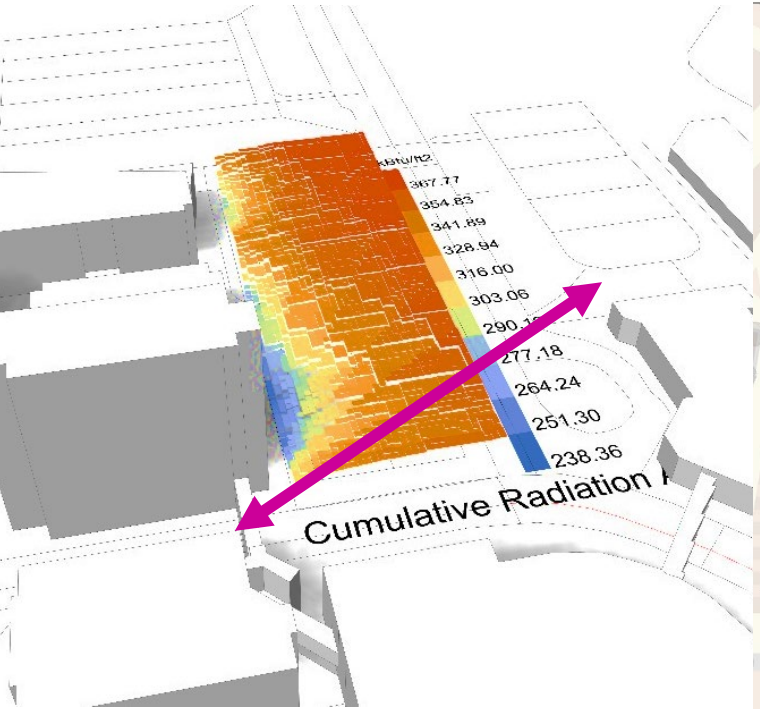


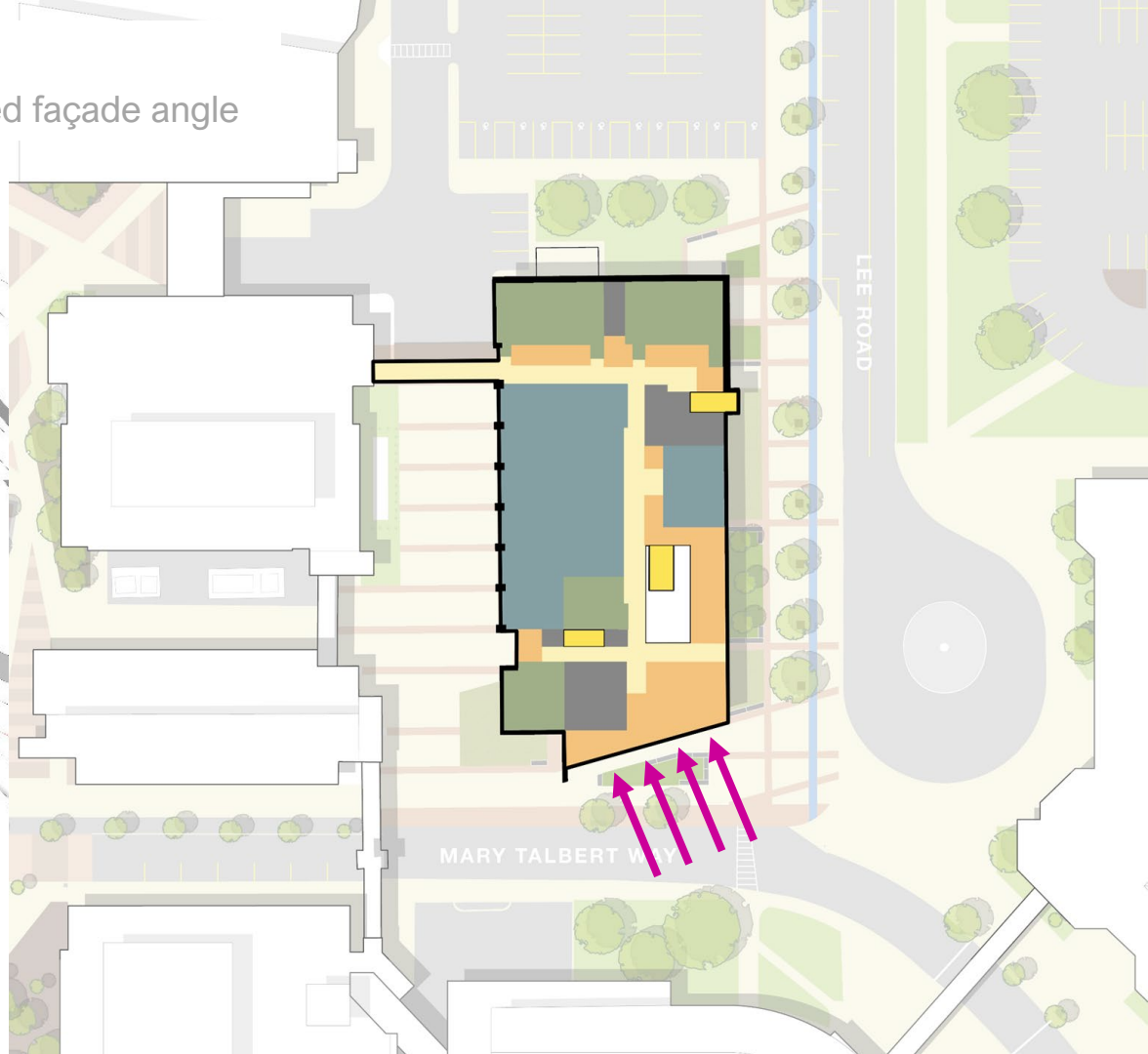
Driving movement and promoting visibility through the heart of the building


University at Buffalo

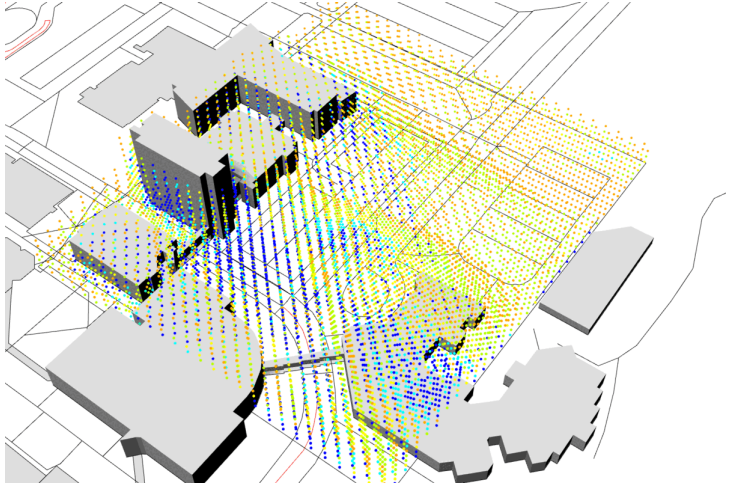
Site Solar Radiation

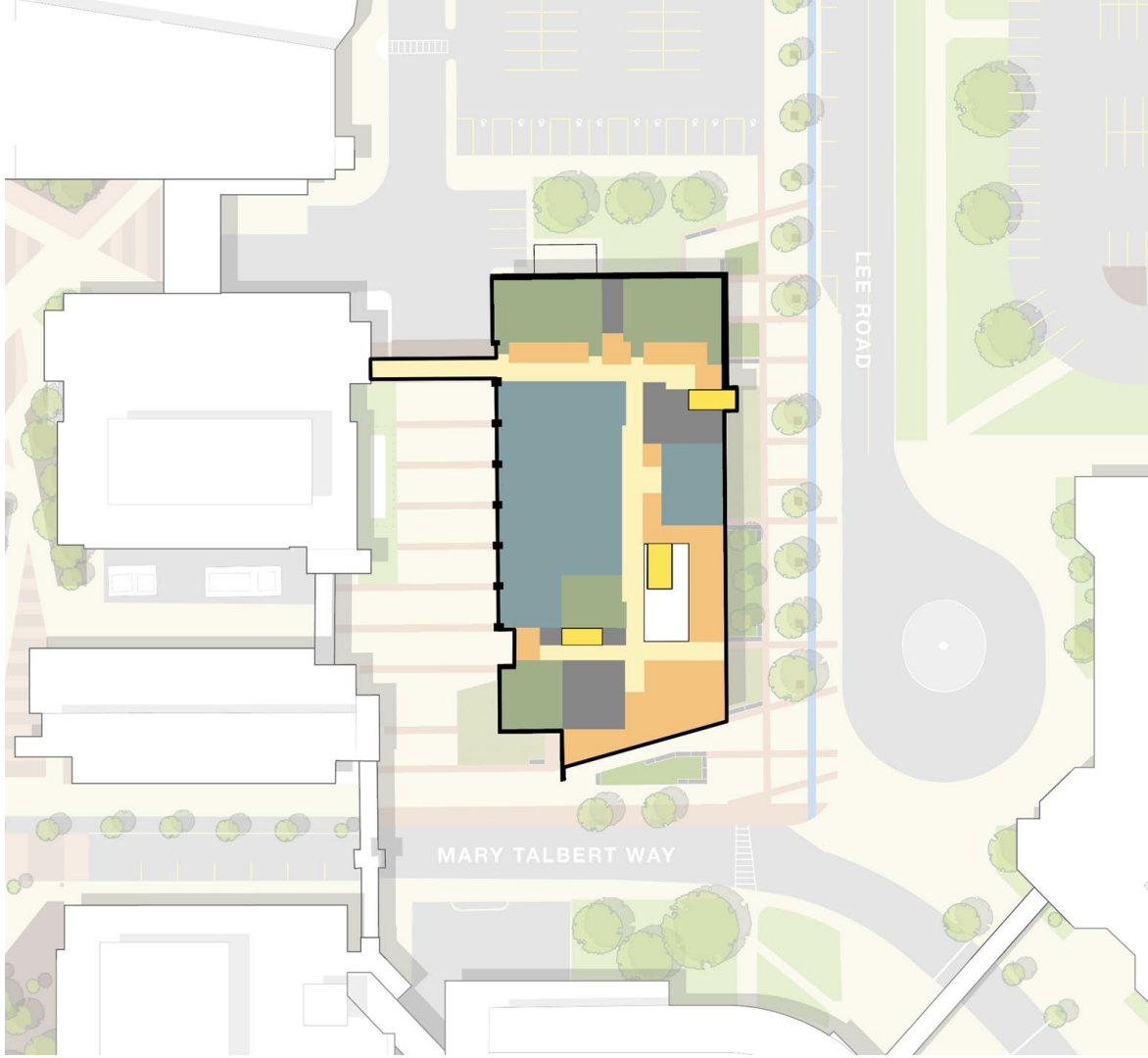
15% increased solar gain through optimized façade angle





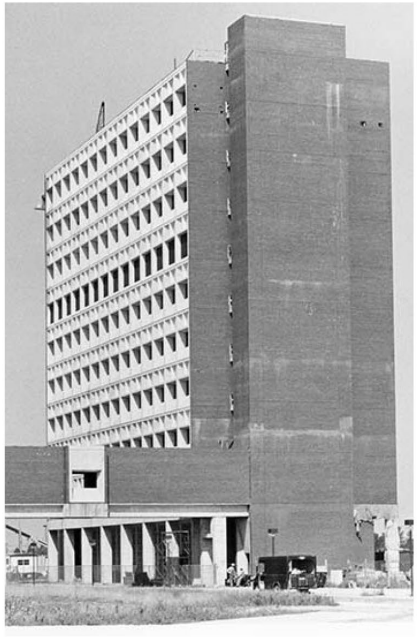
Wind Analysis



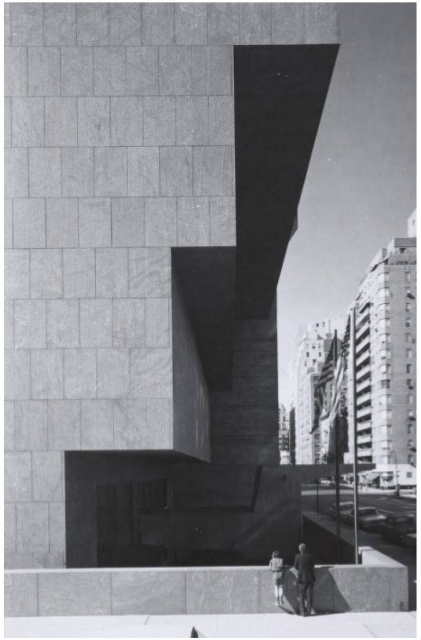


Enclosure Design

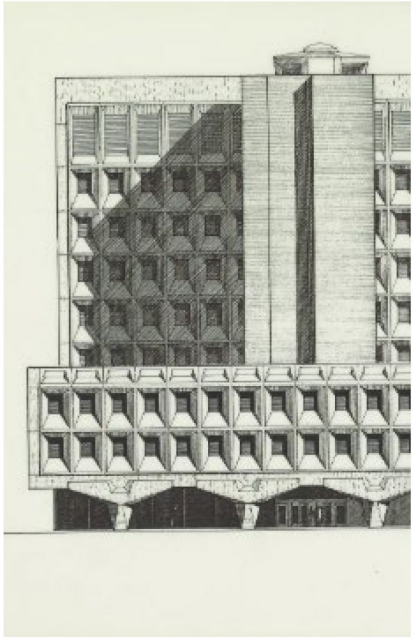
Homage to Marcel Breuer



OPEN V. CLOSED
Furnas Hall, University at Buffalo
1978



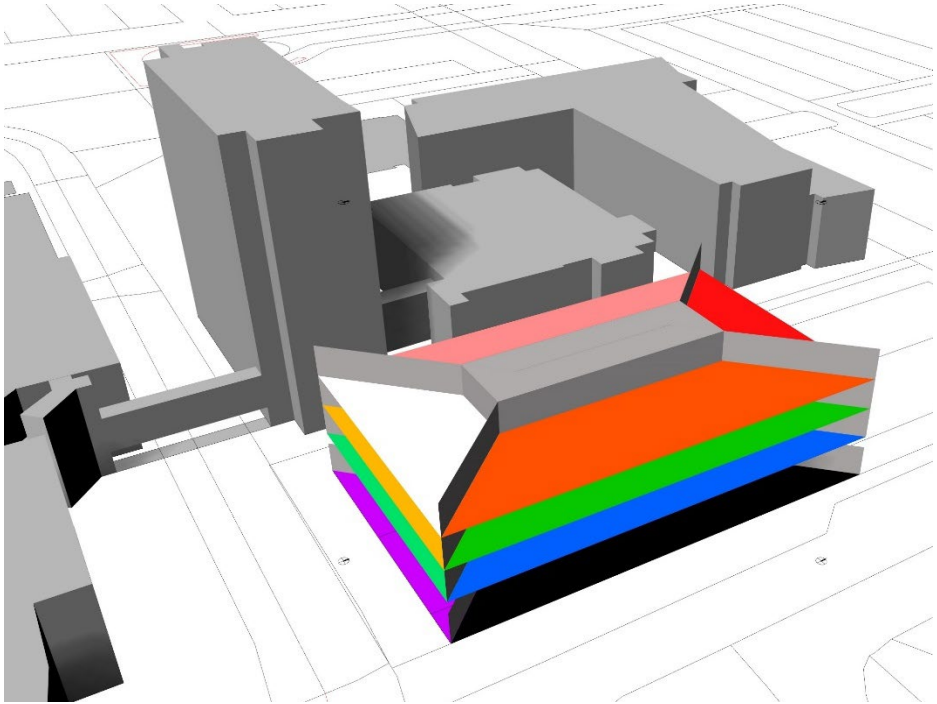
GROUNDED V. PROJECTED
Whitney Museum of American Art,
Manhattan 1966

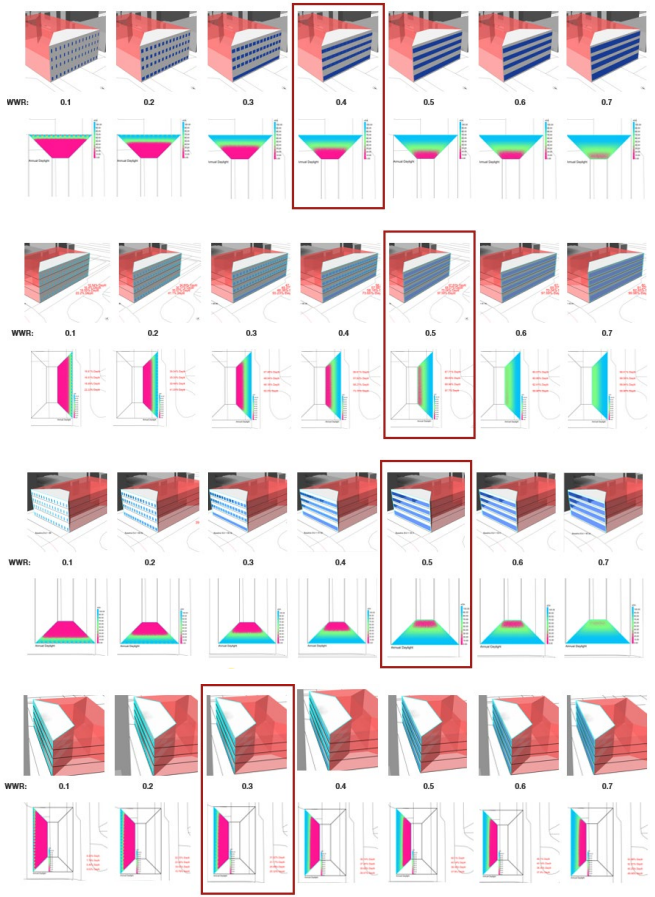


PARALLEL V. PERPENDICULAR
NYU Technology II, Bronx 1956

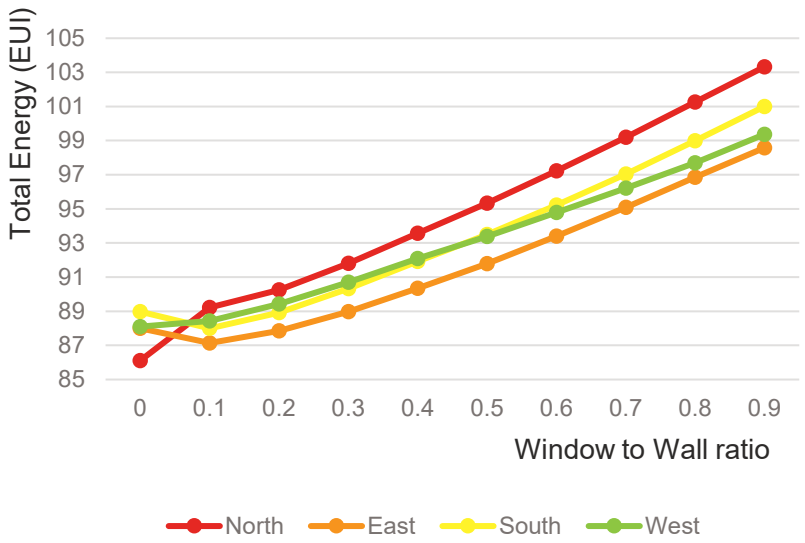
GLAZED V. OPEN
UNESCO Headquarters, Paris 1958

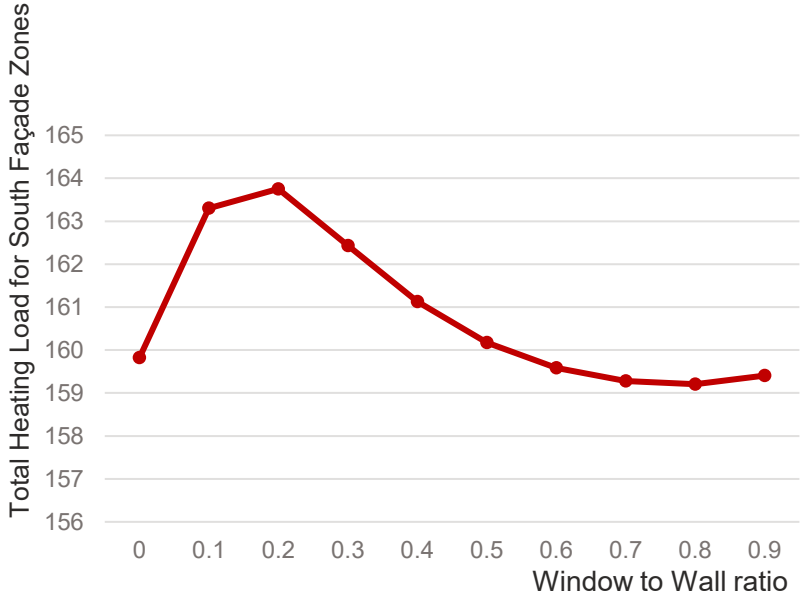
Early Optimization: Window to Wall Ratio Per Facade





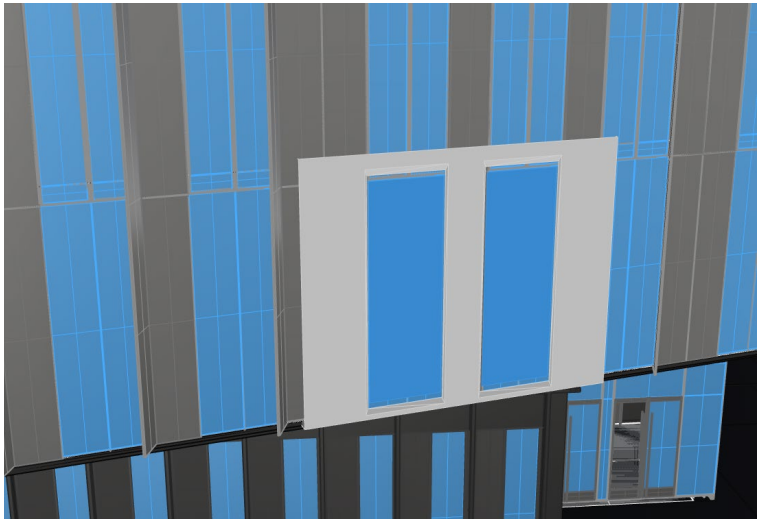
Early Optimization: Window to Wall Ratio Per Facade





IGU (ASHRAE baseline Standard; U-value 0.45; SHGC 0.36): EUI = 75; 2,467,913 kWh annually
Triple LoE Film (77) Clr 3mm/6mm Air; U 0.33; SHGC 0.45: EUI = 72; 2,359,436 kWh annually [4% Reduction]
Triple Glazing Window; U 0.11; SHGC 0.38: EUI = 67; 2,209,277 kWh annually [10.6% Reduction]

Design Optimization: Shading

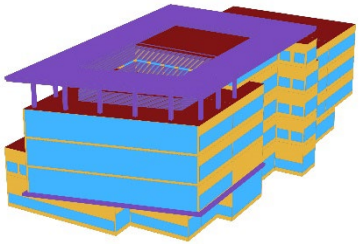


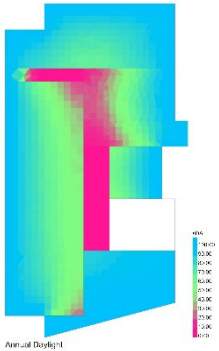
	Daylit [%]	Energy/ Area	Glare [%]
	sDA	**Energy**	**GA**
BASELINE	65.33	55.97	0.23
Current	57.33	55.78	0.17
Vertical Left Shades			
Shade_0.5_1_0_-45	66.67	56.03	0.21
Shade_1_1_0_-45	66	56.12	0.22
Shade_1.5_1_0_-45	65.33	56.16	0.23
Shade_2_1_0_-45	66	56.16	0.22
Shade_0.5_1_0_-30	66	55.95	0.22
Shade_1_1_0_-30	65.33	55.93	0.22
Shade_1.5_1_0_-30	65.33	55.91	0.21
Shade_2_1_0_-30	64.67	55.86	0.21
Shade_0.5_1_0_-15	65.33	55.85	0.22
Shade_1_1_0_-15	64	55.77	0.22
Shade_1.5_1_0_-15	64.67	55.66	0.21
Shade_2_1_0_-15	64.67	55.62	0.19
Shade_0.5_1_0_0	64	55.77	0.21
Shade_1_1_0_0	64	55.62	0.21
Shade_1.5_1_0_0	62.67	55.51	0.19
Shade_2_1_0_0	62	55.42	0.18
Shade_0.5_1_0_15	64	55.78	0.21
Shade_1_1_0_15	63.33	55.57	0.19
Shade_1.5_1_0_15	61.33	55.47	0.18
Shade_2_1_0_15	58.67	55.49	0.17

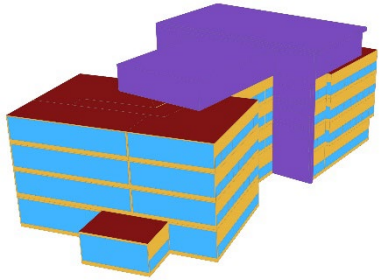
Design Optimization: Shading, Balancing Daylight and Energy

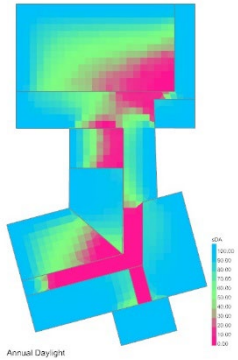
Design Optimization: Shading, Balancing Daylight and Energy

Design Optimization: Energy Model for Design Decisions









Model Assumptions:
5 zones per floor
Proportionally mixed program type
Reduced LPDs with daylight light sensors
Envelope R values, WWR, and shading as set by design team
Basic ASHRAE HVAC templates on auto sized with 11-degree delta

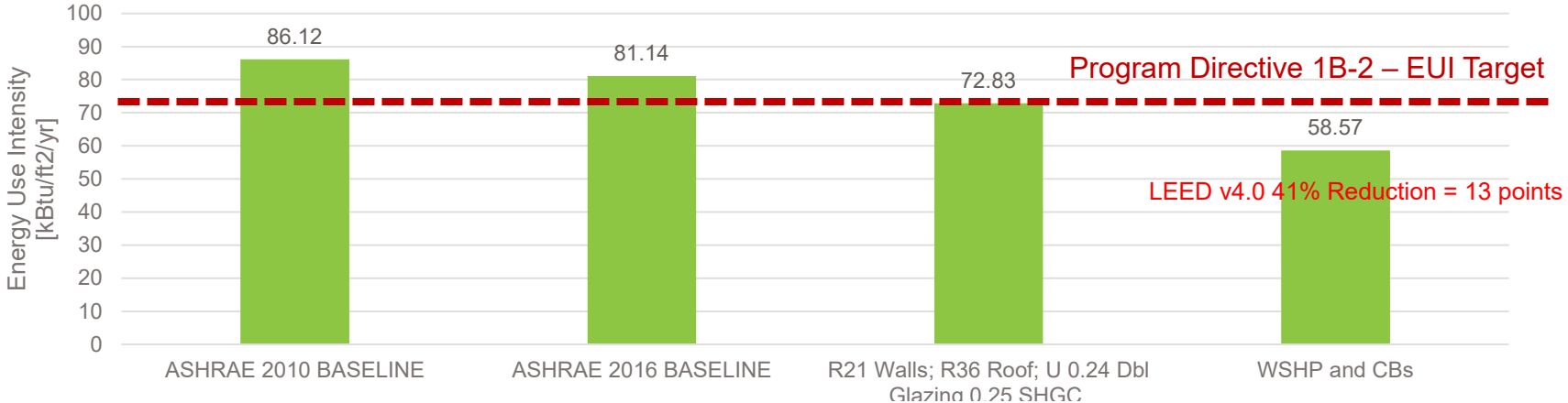
Simulated Energy Consumption

ASHRAE Baseline
2,927 MWh

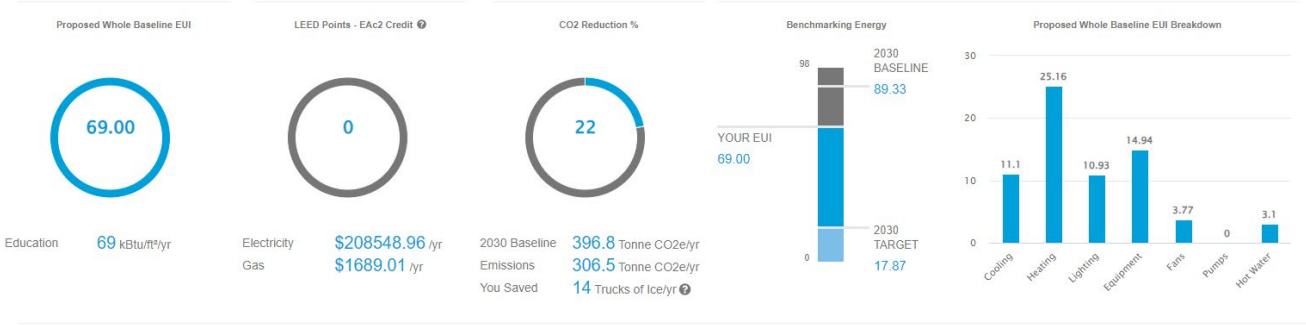
EUI ≈ 60
1,951 MWh

EUI ≈ 40
1,300 MWh

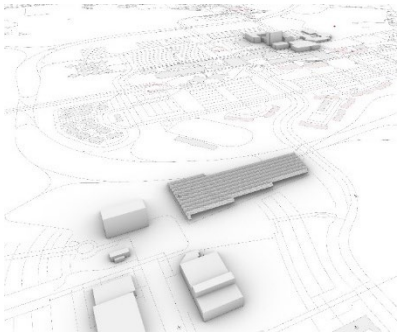
Design Optimization: Energy Model for Optimization Permutations

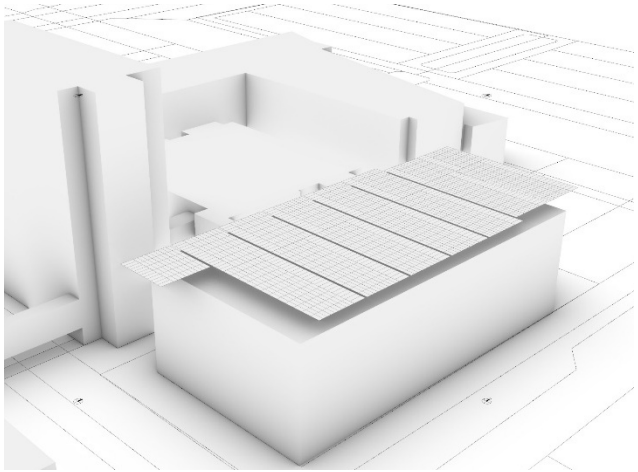


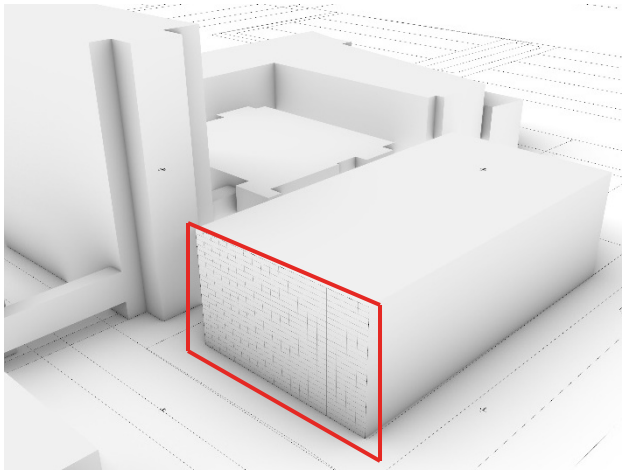
Baseline Energy

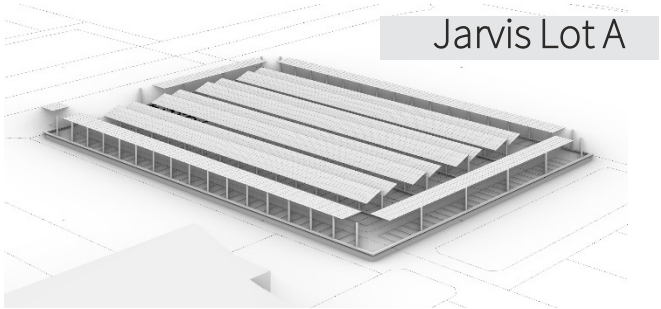


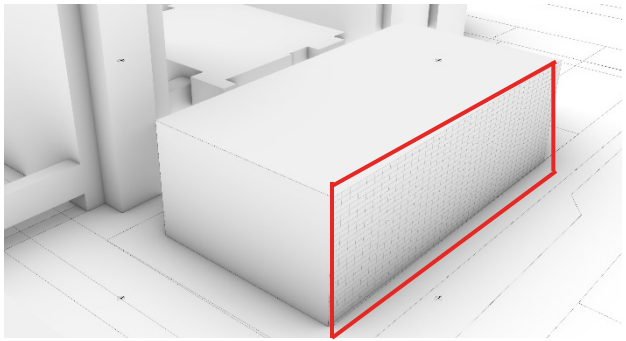
Path to Net Zero



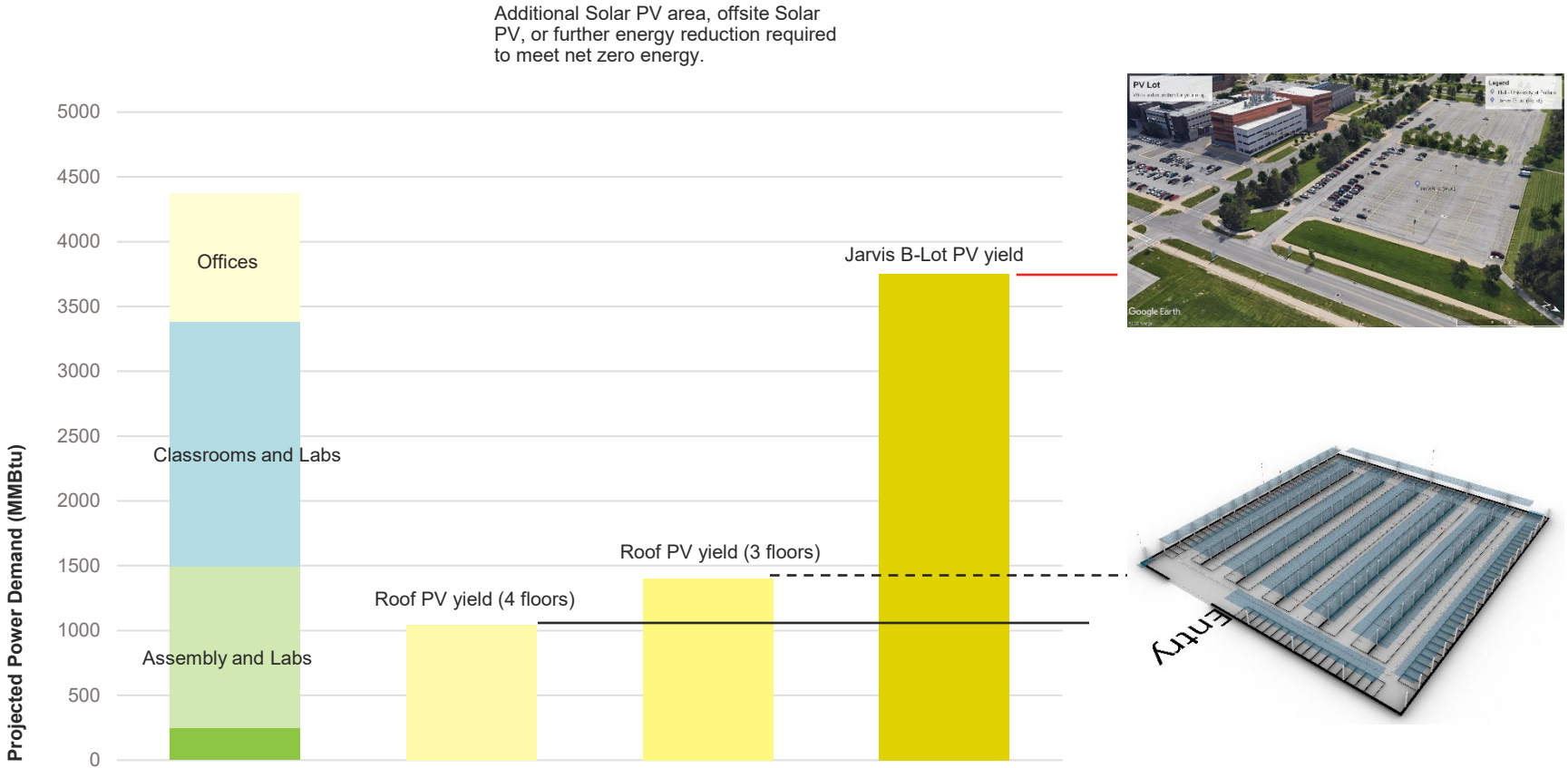






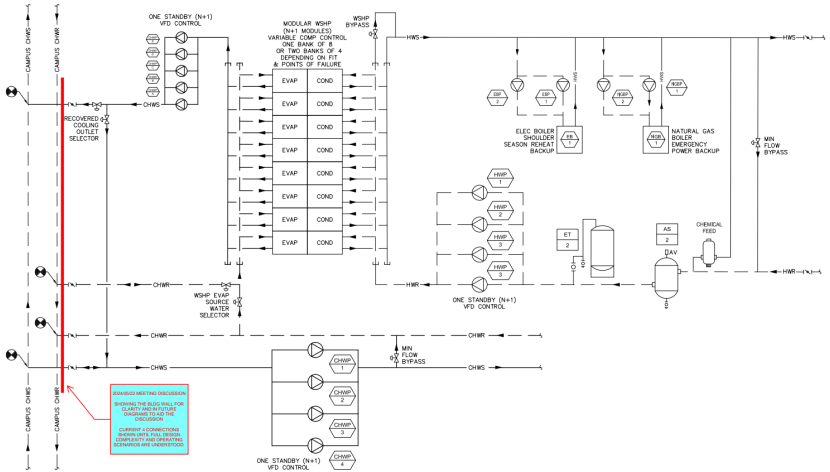


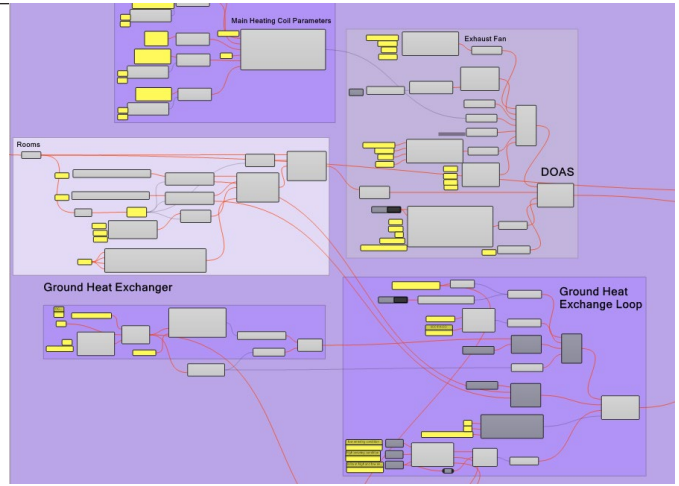
Path to Net Zero

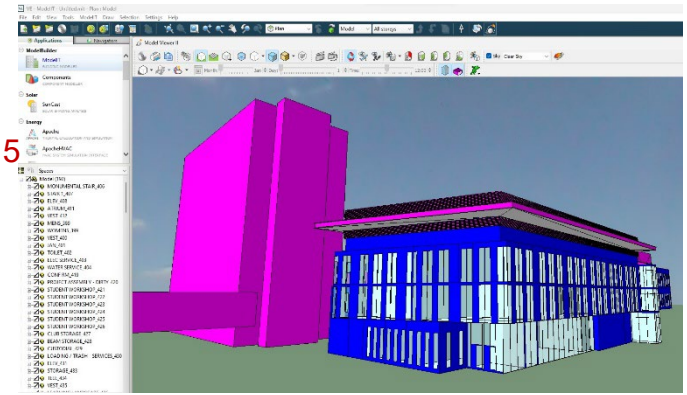



AGRUSA HALL

Parametric Model Export







COMPARITIVE ANALYSIS FOR: (500-ton cooling load defined)

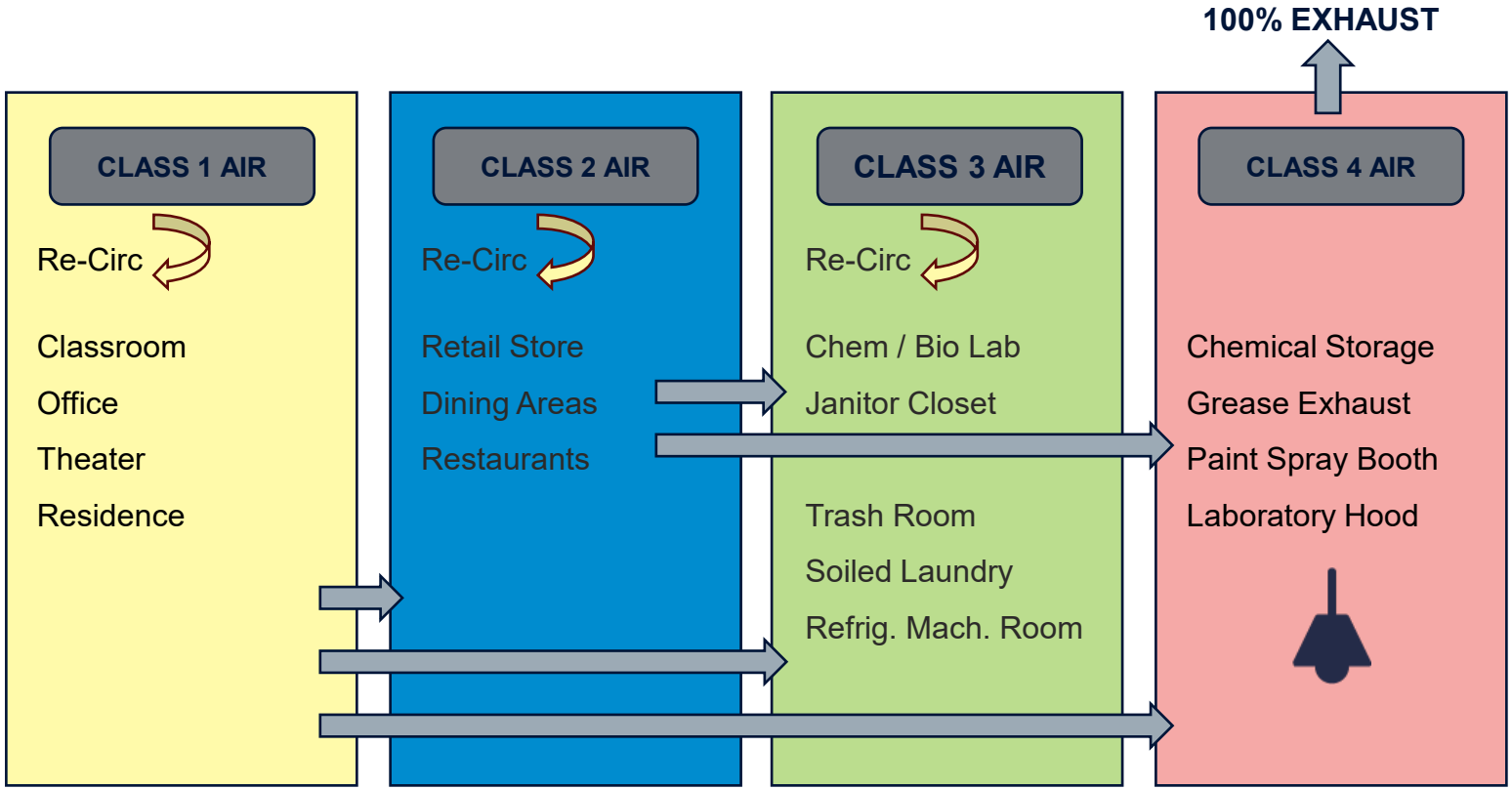
a. BASE BUILDING ASHRAE Packaged VAV with PFP Boxes: EUI = 77.5
b. Bldg with Fan coils, chiller, and electric resistance boiler: EUI = 47.4
c. Bldg with VAV chiller with central air source heat pump: EUI = 45.3
d. Bldg with Water Source heat Pumps with GSHP EUI = 34.98

ASHRAE HAZARD CLASSIFICATION

Reduce & Right-Size Demand

- Reduce demand for outdoor air
- Reuse indoor air
- Reduce need to condition outdoor air
- Reduce mechanical equipment loads
- Safety is the priority!

Classification of Air (ASHRAE 62.1)



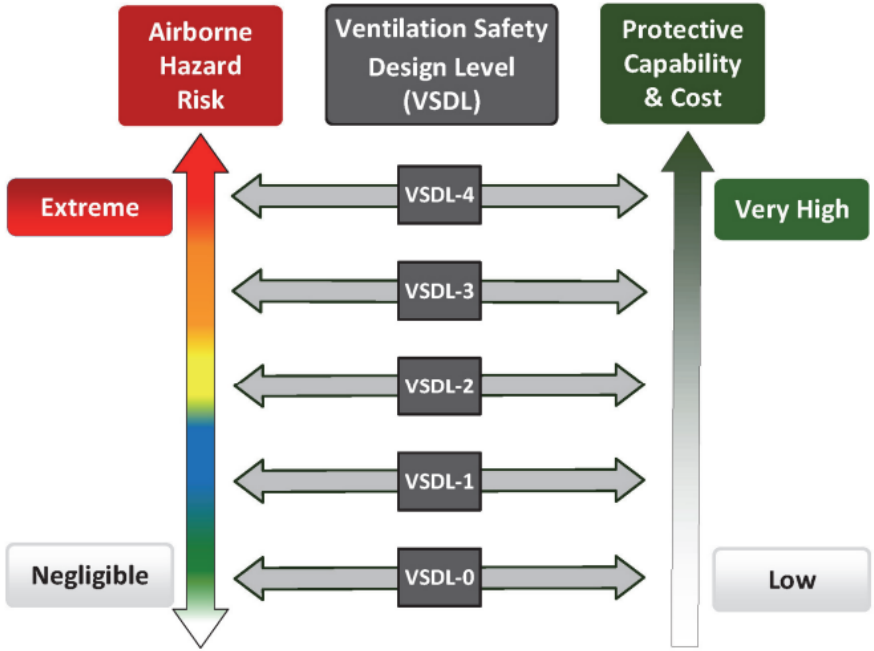
ASHRAE 62.1-2022 Air Classifications

*Recirc only within the same space

ASHRAE Hazard Classification

Risk factor	Examples
0 (Negligible)	• Computer and instrumentation laboratories • Secondary school teaching laboratories • Warm rooms/cold rooms
1 (Low)	• Secondary school teaching laboratories • Shop areas with point sources of hazardous chemicals • Quality control laboratories • Biology laboratories with no volatile hazards beyond disinfectants
2 (Moderate)	• Upper-level undergraduate research laboratories • Biochemistry laboratories focused on aqueous solutions • Academic teaching laboratories
3 (High)	• Inorganic/organic synthesis laboratories • Typical research laboratories
4 (Very high)	• Chemical development laboratories • Polymer synthesis laboratories • Organic/inorganic chemical synthesis laboratories • Special high-hazard research laboratories

*(Source: **ASHRAE**)*



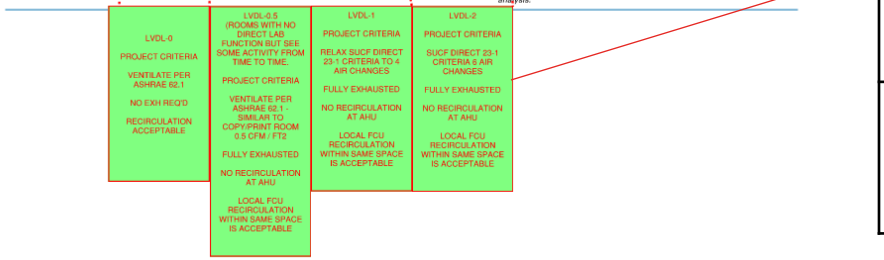
ASHRAE Classification of Laboratory Ventilation Design Levels

ASHRAE Hazard Classification

Classification of Laboratory Ventilation Design Levels

Table 3 LVDL Requirements for Design and Operation *(continued)*

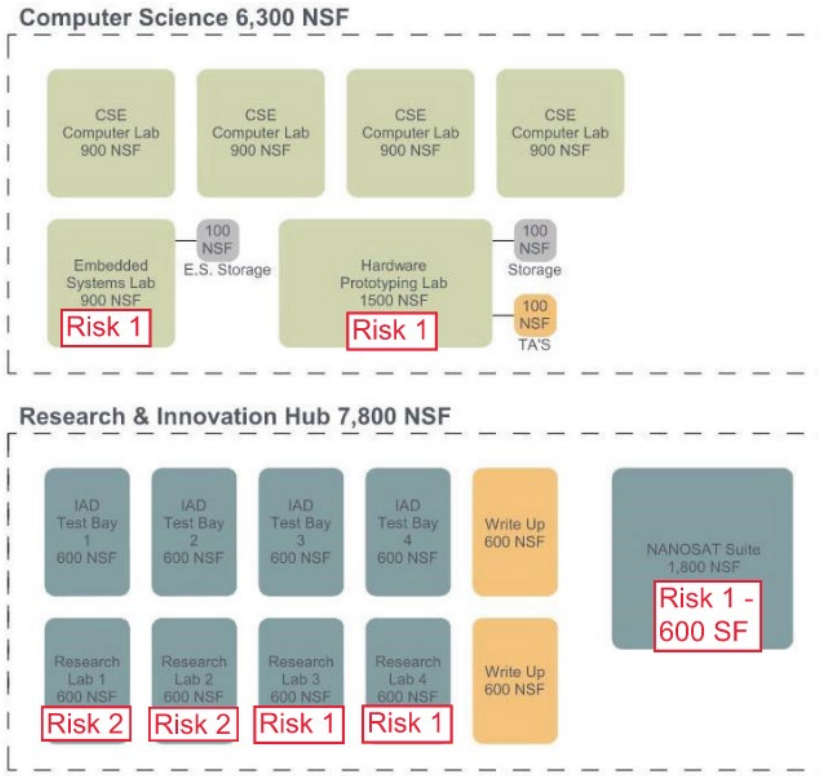
ID	Criterion Description	LVDL-0 Requirement	LVDL-1 Requirement	LVDL-2 Requirement	LVDL-3 Requirement	LVDL-4 Requirement
Supply and Exhaust Airflow Requirements						
4	Occupied minimum exhaust ventilation rate (See the text for the application of minimum ventilation rates, which should not be determined without the supporting risk analysis under any condition.)	Standard 62.1	Standard 62.1	4–6 air changes based on sufficient information for hazard review by an EH&S professional and completion of review. General ventilation rate may be lower if validation of effectiveness of ventilation suggests sufficient dilution and contaminant removal.	If all emission sources of concern are contained by use of local exhaust ventilation, and if inadequate air distribution or mixing from the general ventilation system is not a concern: • Typically 6 ach*, otherwise: • Increase air changes per hour (8 or more*) or investigate and improve ventilation effectiveness. General ventilation rate may be lower if validation of effectiveness of ventilation suggests sufficient dilution and contaminant removal. * Scale minimum air change rates upward based on project-specific analysis. Technologies such as indoor air quality sensing can be used to support the results of this analysis.	If all emission sources of concern are contained by use of local exhaust ventilation, and if inadequate air distribution or mixing from the general ventilation system is not a concern: • Typically 8 ach*, otherwise: • Increase ACH (10 or more*) or investigate and improve ventilation effectiveness. General ventilation rate may be lower if validation of effectiveness of ventilation suggests sufficient dilution and contaminant removal. * Scale minimum air change rates upward based on project-specific analysis. Technologies such as indoor air quality sensing can be used to support the results of this analysis.



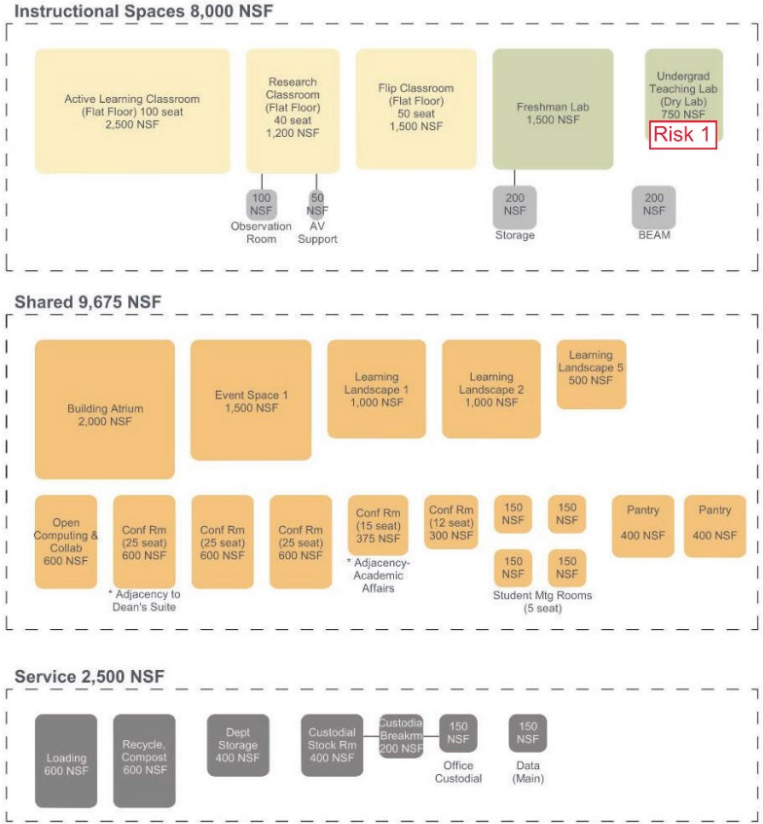
HAZARD LEVEL	PROJECT CRITERIA
LVDL-0	VENTILATE PER ASHRAE 62.1 NO EXHAUST REQUIRED RECIRCULATION ACCEPTABLE
LVDL-0.5*	VENTILATE PER ASHRAE 62.1 - SIMILAR TO COPY/PRINT ROOM 0.5 CFM / FT2 FULLY EXHAUSTED NO RECIRCULATION AT AHU LOCAL FCU RECIRCULATION WITHIN SAME SPACE IS ACCEPTABLE
LVDL-1	RELAX SUCF DIRECT 23-1 CRITERIA TO 4 AIR CHANGES FULLY EXHAUSTED NO RECIRCULATION AT AHU LOCAL FCU RECIRCULATION WITHIN SAME SPACE IS ACCEPTABLE
LVDL-2	SUCF DIRECT 23-1 CRITERIA TO 6 AIR CHANGES FULLY EXHAUSTED NO RECIRCULATION AT AHU LOCAL FCU RECIRCULATION WITHIN SAME SPACE IS ACCEPTABLE
LVDL-3	6 AIR CHANGES FULLY EXHAUSTED NO RECIRCULATION AT AHU LOCAL FCU RECIRCULATION WITHIN SAME SPACE IS ACCEPTABLE

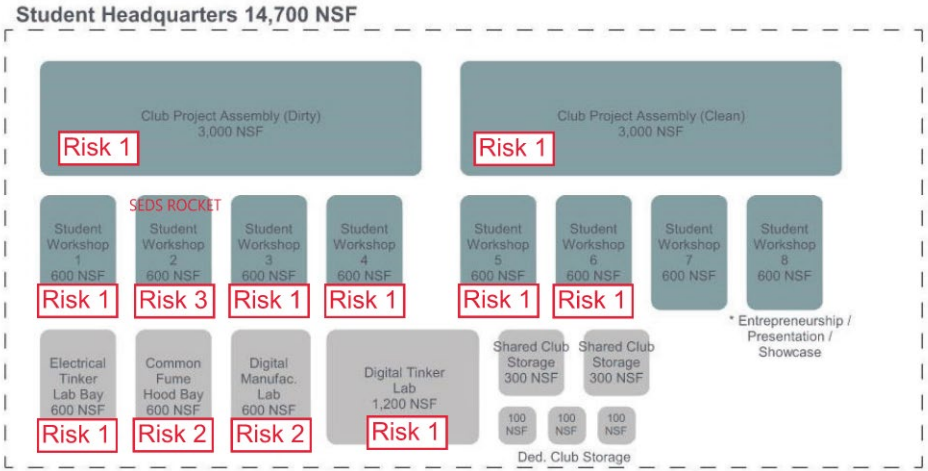
*ROOMS WITH NO DIRECT LAB FUNCTION BUT SEE SOME ACTIVITY FROM TIME TO TIME

Working Session to Classify Spaces



Working Session to Classify Spaces





Final Program

Space ID	Space Name and Type	Number of People	Number of Spaces	NASF Per Space	NASF Total
0.0	Events & Public Spaces				
	Sub-total Events & Public Spaces		15		9,675
1.0	Research & Innovation Hub				
	Sub-total Research & Innovation Hub		11		7,800
2.0	Student Headquarters				
	Sub-total Student Headquarters		21		14,700
3.0	Instructional Spaces				
	Sub-total Instructional Spaces		14		14,300
4.0	Student Excellence & Support				
	Sub-total Student Excellence & Support		136		16,560
5.0	Building Support				
	Sub-total Building Support		18		2,800
			TOTAL BUILDING NASF		65,835
			net to gross multiplier		1.70
			TOTAL BUILDING GSF		111,920

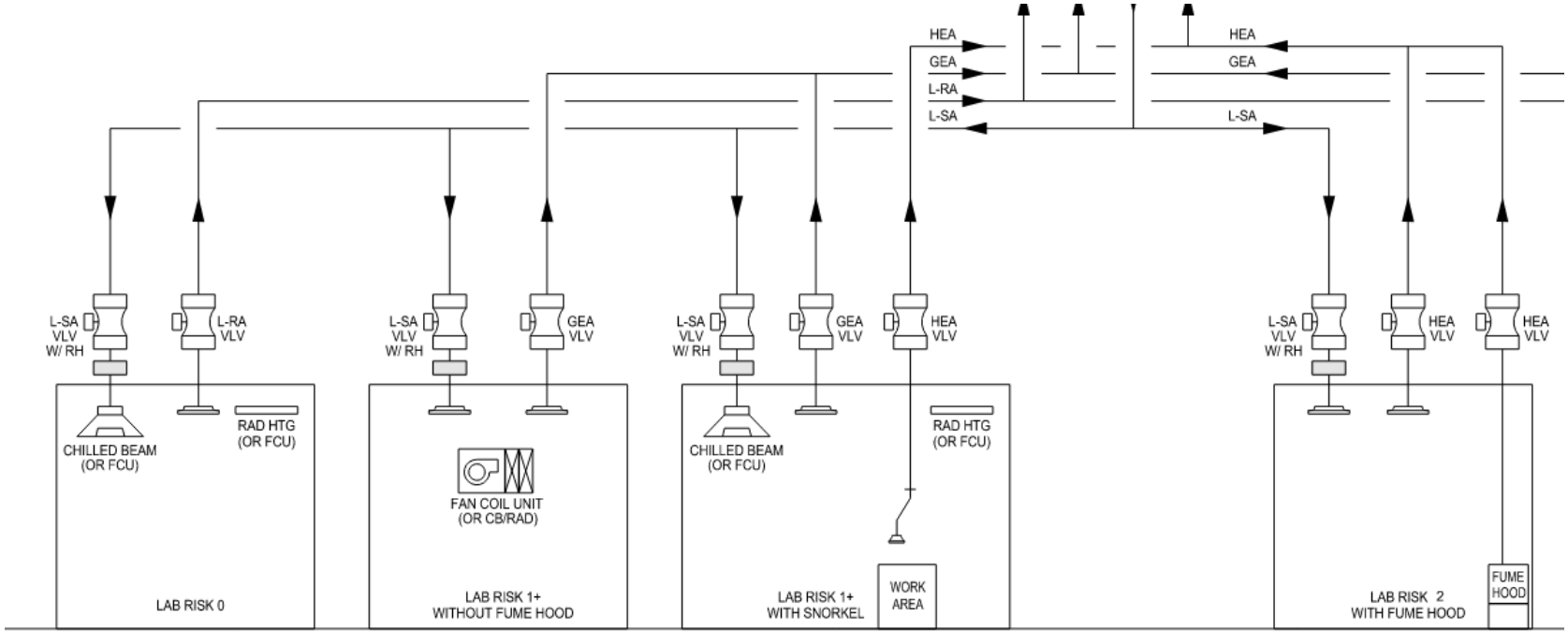
RISK 1 TOTAL SF = 15,750

RISK 2 TOTAL SF = 2,400

RISK 3 TOTAL SF = 600

ALL OTHER SPACES RISK 0

Room Schematics



AHU Riser Diagram

HAZARDOUS EXHAUST

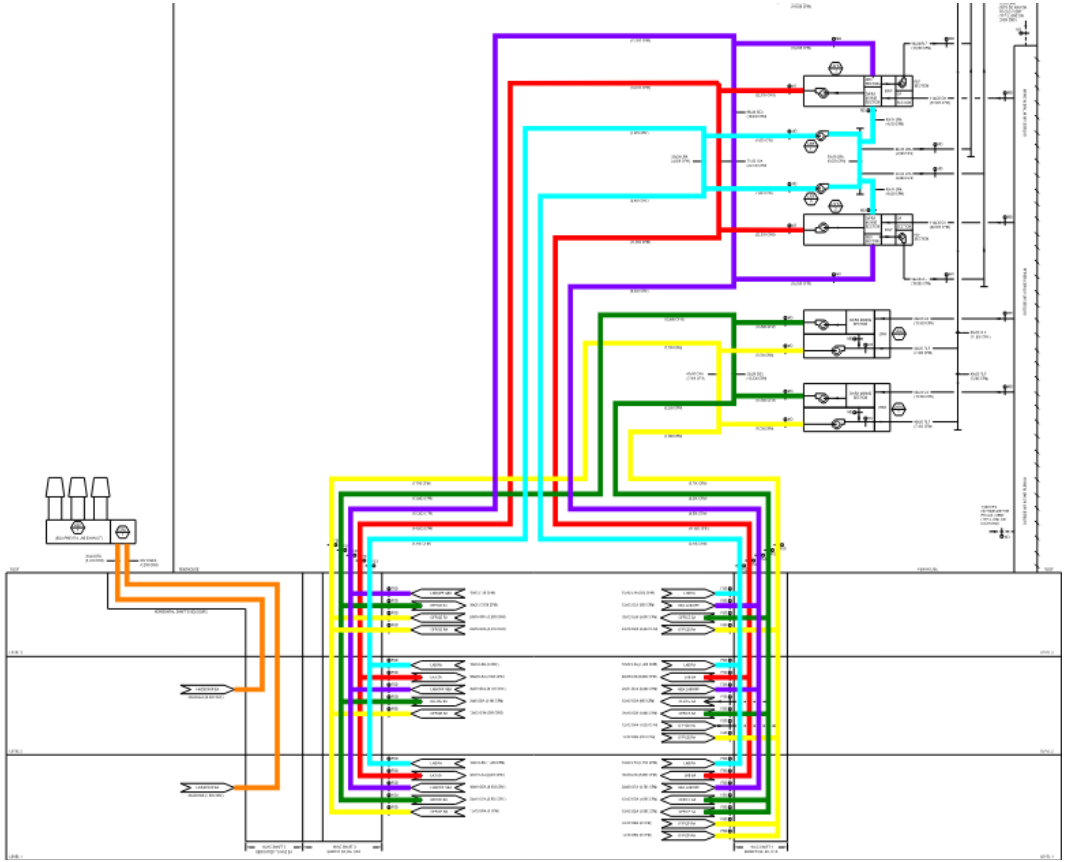
LAB SUPPLY

OFFICE SUPPLY

OFFICE RETURN

LAB RETURN

GENERAL EXHAUST AIR



AHU Schematics

HAZARDOUS EXHAUST

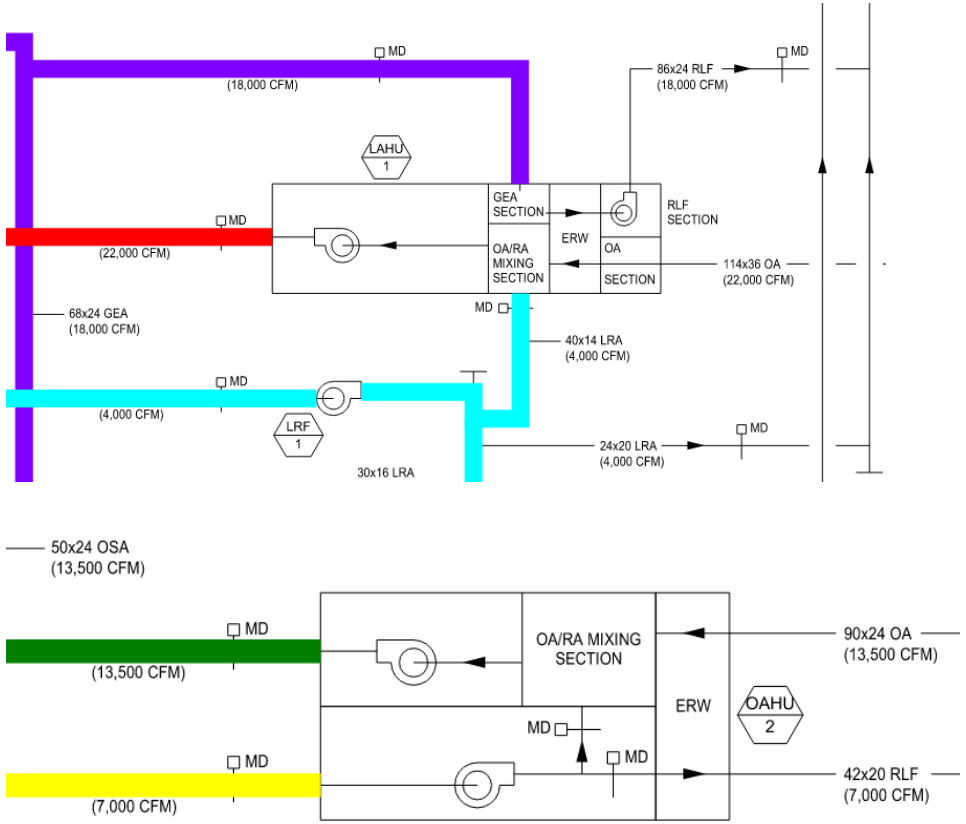
LAB SUPPLY

OFFICE SUPPLY

OFFICE RETURN

LAB RETURN

GENERAL EXHAUST AIR



HVAC Penthouse

HAZARDOUS EXHAUST

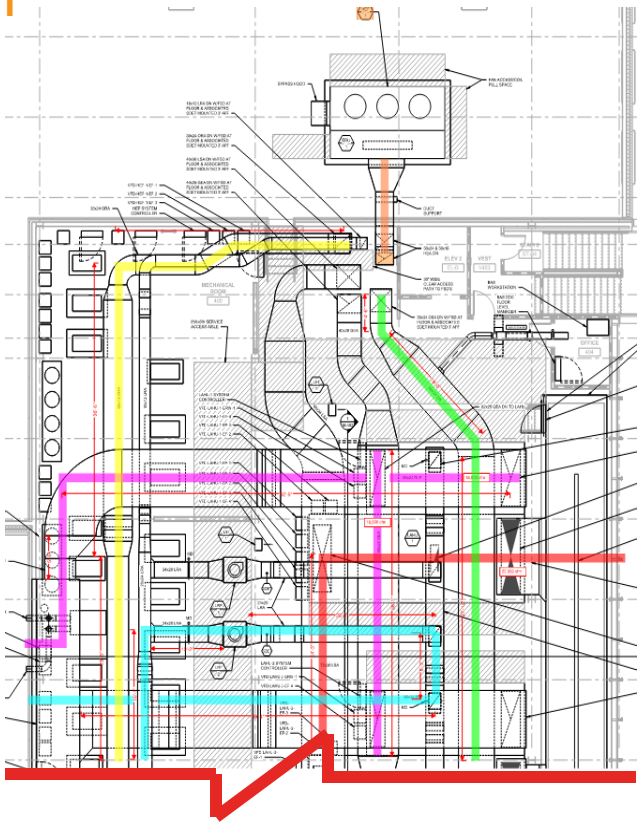
LAB SUPPLY

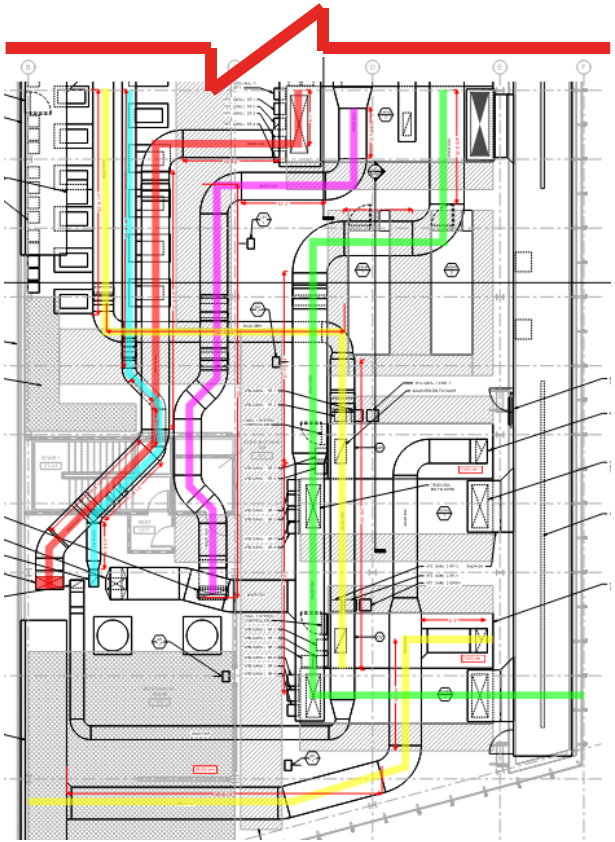
OFFICE SUPPLY

OFFICE RETURN

LAB RETURN

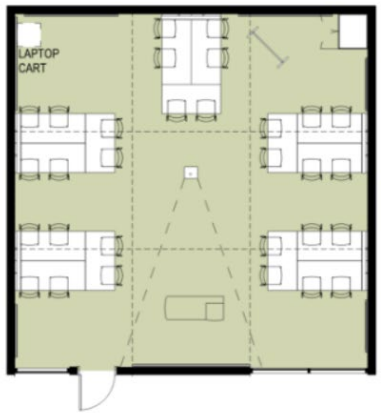
GENERAL EXHAUST

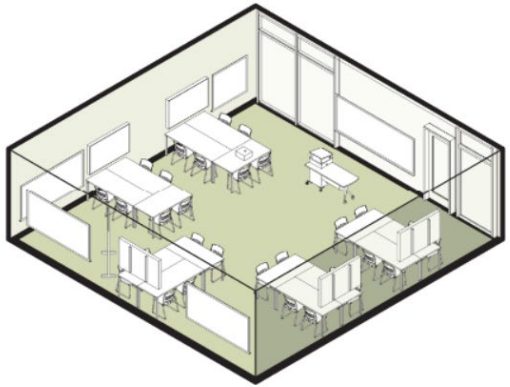




Risk Level 0 Example

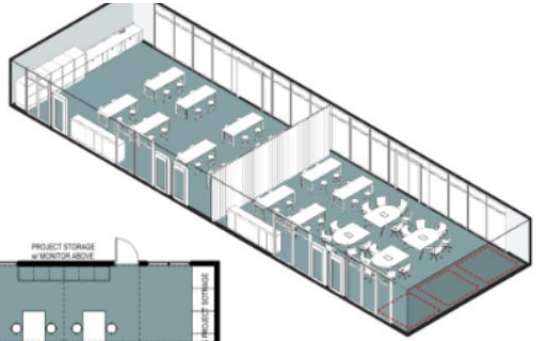
Typical Computer Lab (30 seats) – 900 NSF

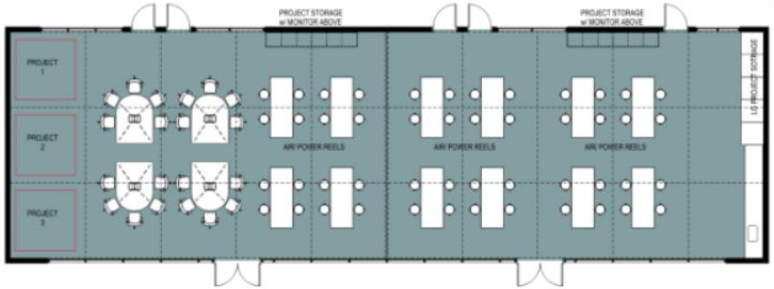




Risk Level 1 Example

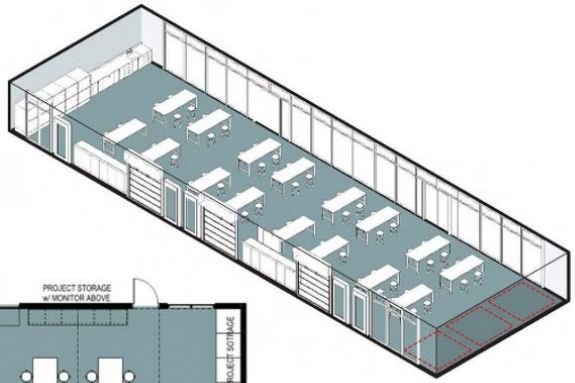
Common Project Assembly
3,000 SF
“Clean”

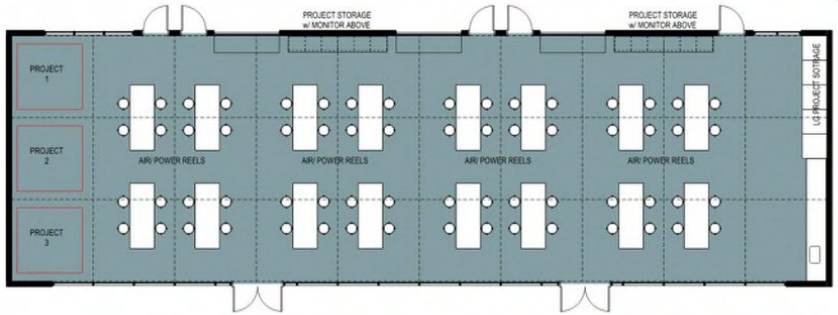




Risk Level 1 Example

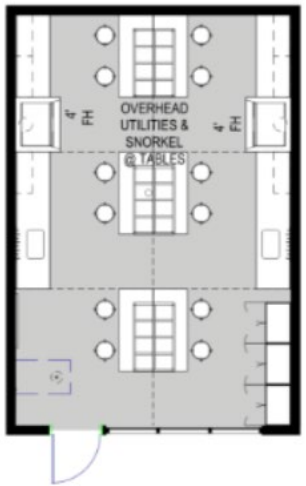
Common Project Assembly
3,000 SF
“Dirty”

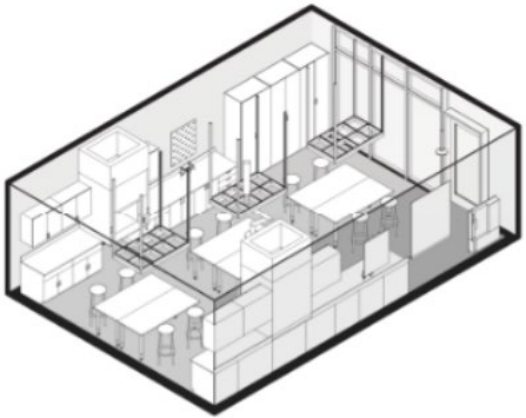




Risk Level 3 Example

Common Fume Hood Bay – 600 SF





Reductions

PRELIMINARY SUPPLY AIRFLOW = 75,000 CFM

PRELIMINARY TONNAGE = 450 TONS

PRELIMINARY HAZARD EXHAUST = 17,000 CFM

Reductions

PRELIMINARY SUPPLY AIRFLOW = 75,000 CFM

FINAL SUPPLY AIRFLOW = 63,000 CFM

PRELIMINARY TONNAGE = 450 TONS

FINAL TONNAGE = 360 TONS

PRELIMINARY HAZARD EXHAUST = 17,000 CFM

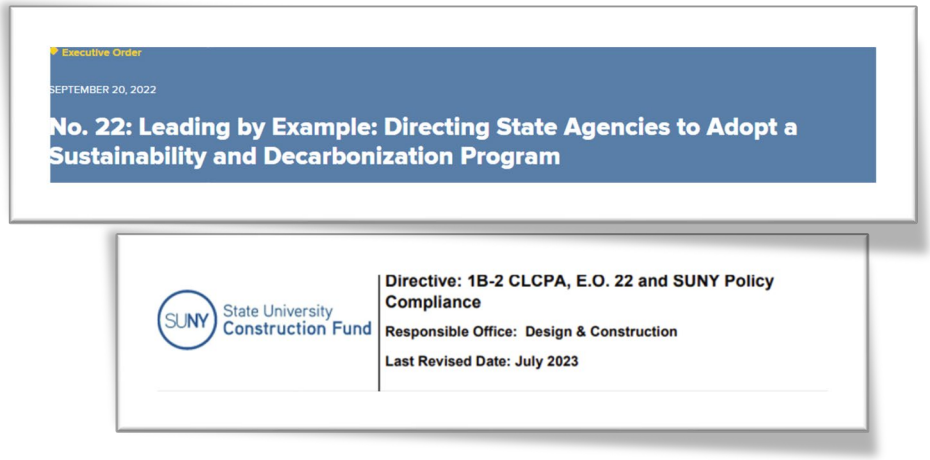
FINAL HAZARDOUS EXHAUST = 15,000 CFM

HEAT PUMP SYSTEM DESIGN

SUNY & State Policies

- **New York State Executive Order 22**

  To the fullest extent feasible, beginning January 1, 2024, all new construction submitted for permitting by Affected Entities shall avoid infrastructure, building systems or equipment that can be used for the combustion of fossil fuels, excluding necessary use for backup emergency generation and process loads, provided that Affected Entities shall avoid the use backup emergency diesel generators where practicable.

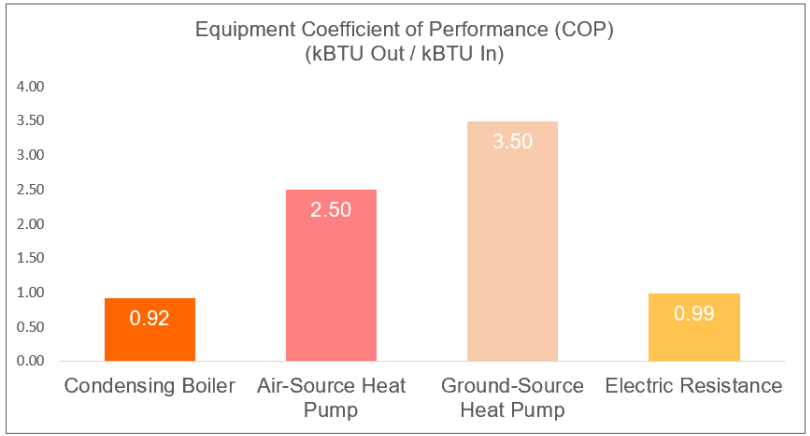


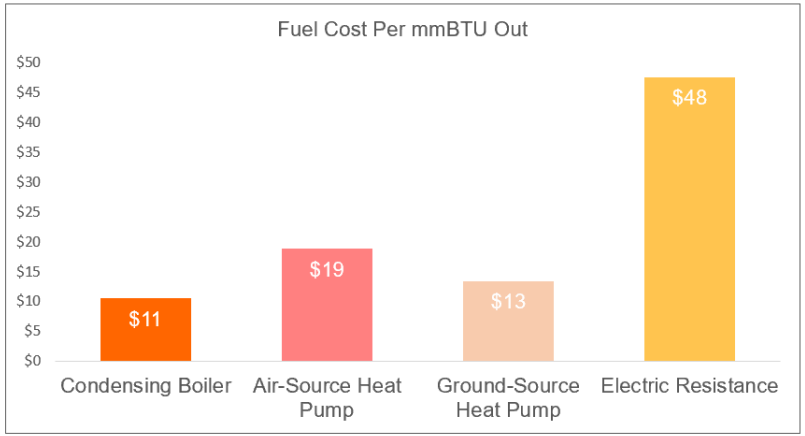
Heating Options – Decisions to be made

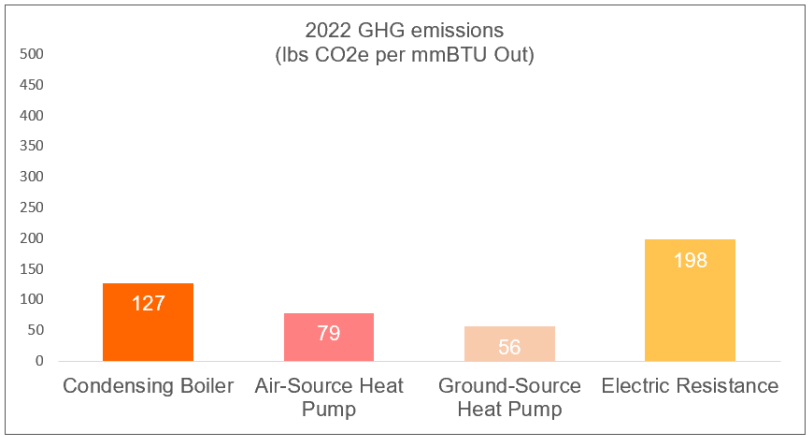
Replacement of heating equipment with **ELECTRIC RESISTANCE HEATING**

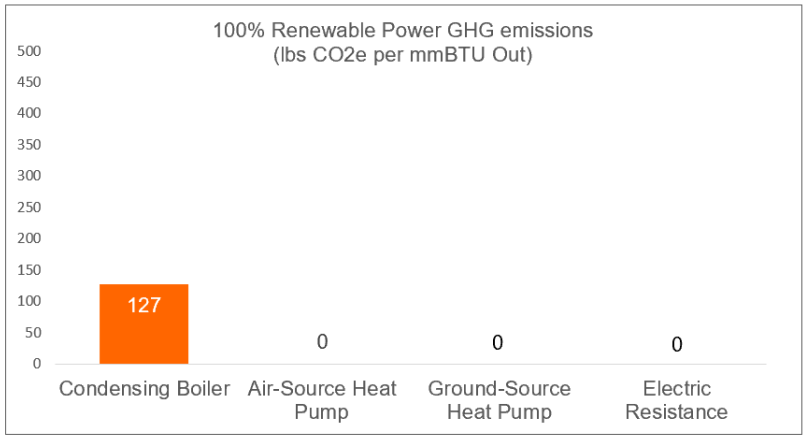
Replacement of heating equipment with **HEAT PUMPS** connected to various thermal energy sources.

Thermal Electrification Comparison

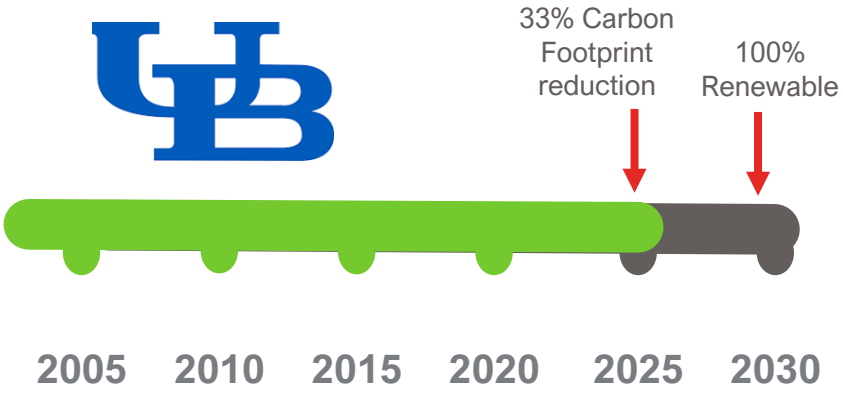


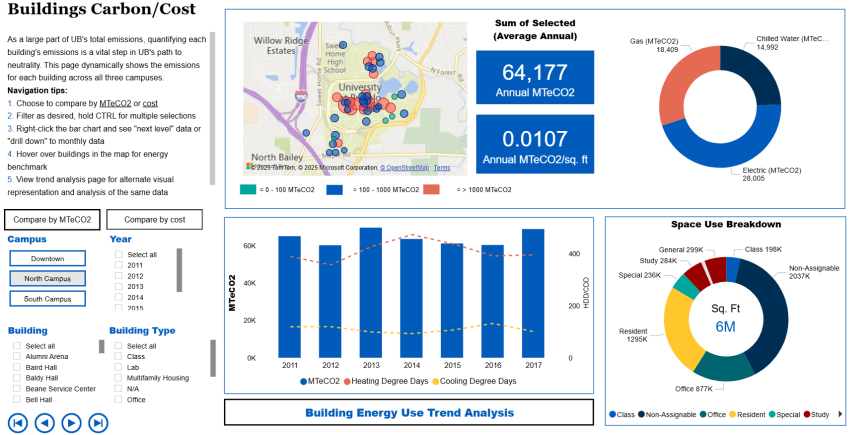






Institutional Carbon Goals





https://www.buffalo.edu/climate-action/how.html

University at Buffalo South Campus – Energy Master Plan

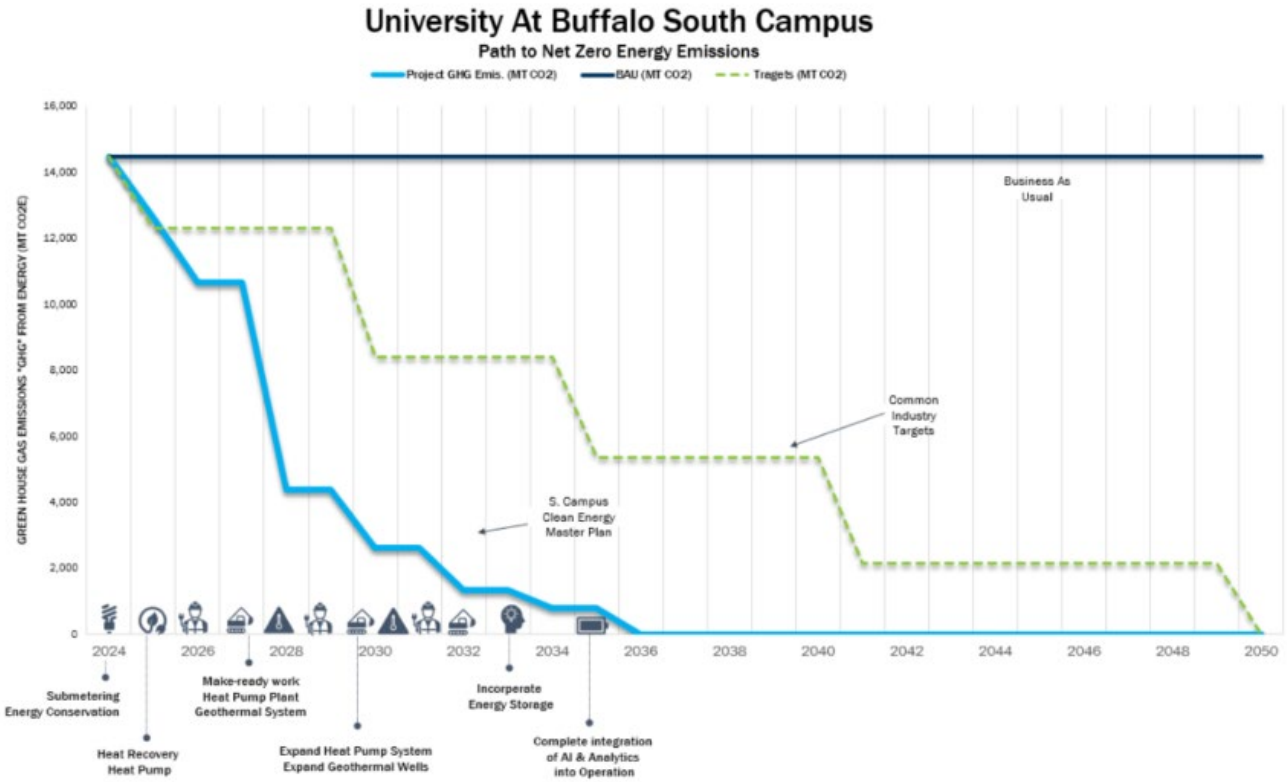


Figure B-2: UB S. Campus path to carbon neutrality

Heating Options – Direction!

~~Replacement of heating equipment with **ELECTRIC RESISTANCE HEATING**~~

Replacement of heating equipment with **HEAT PUMPS** connected to various thermal energy sources.

Plant Options

The following systems were considered for the heating and cooling generation at the Central Utility Plant (CUP)

HEATING SYSTEMS
Heat-shift chillers
Air-source heat pumps
Ground Source heat pump – Geothermal
Campus Steam
Natural Gas Boilers
Electrical Boilers

COOLING SYSTEMS
Heat-shift chillers
Air-source heat pumps
Ground Source heat pump – Geothermal
Water Cooled Chillers
Air Cooled Chillers
Campus Chilled Water

Plant Options

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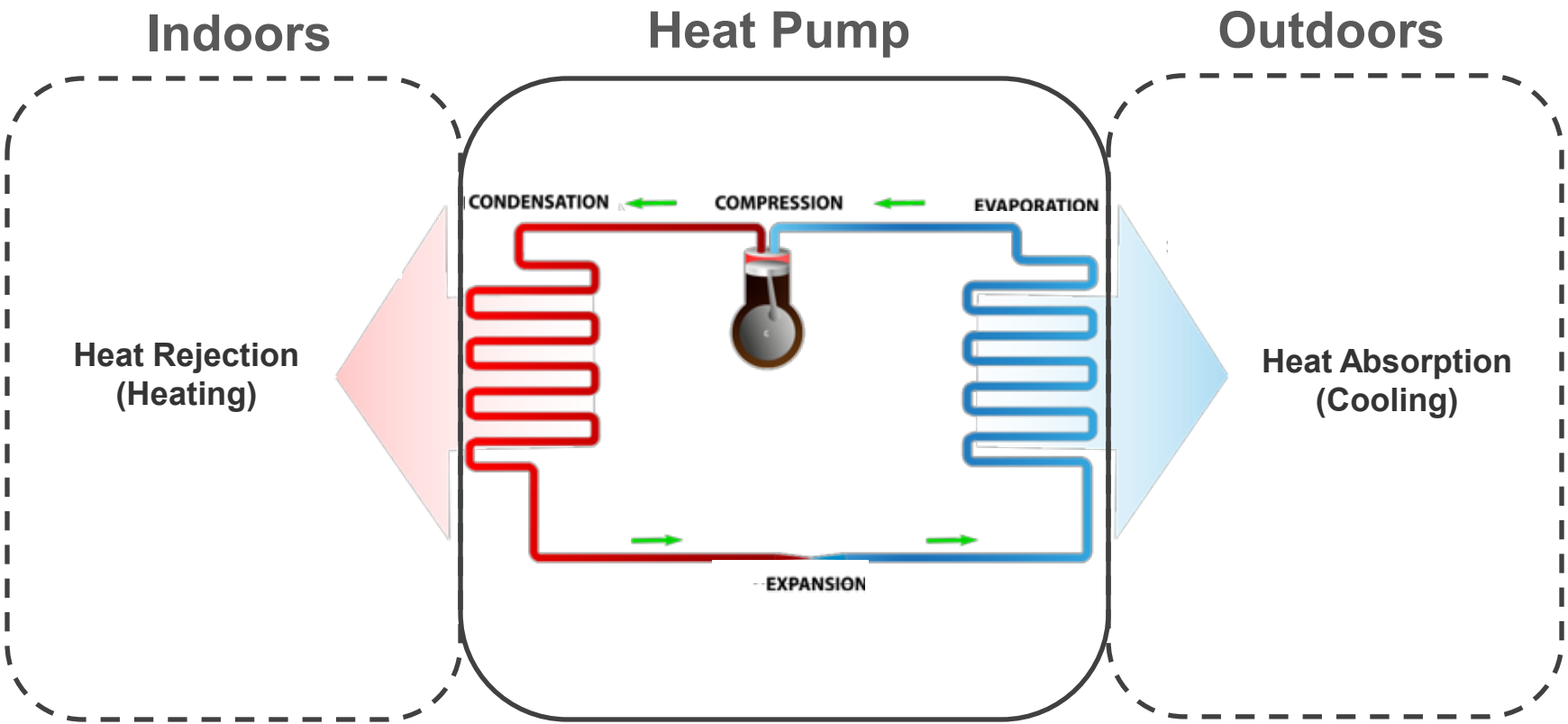
Heat-shift chillers
Air-source heat pumps
Ground Source heat pump – Geothermal
Water Cooled Chillers
Air Cooled Chillers
Campus Chilled Water

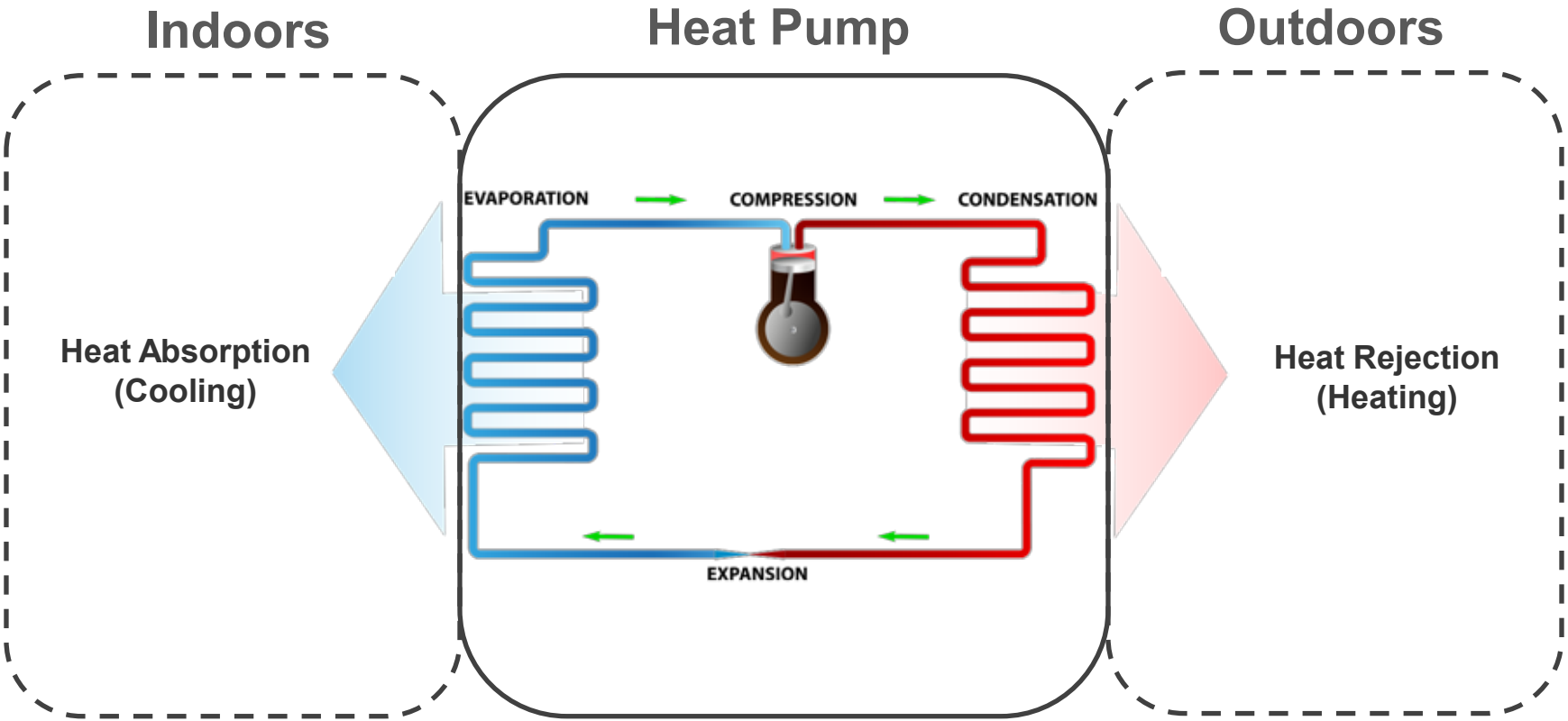
BIG IDEAS!

Campus Chilled Water -> Water Source Heat Pump = Building Heating Water!

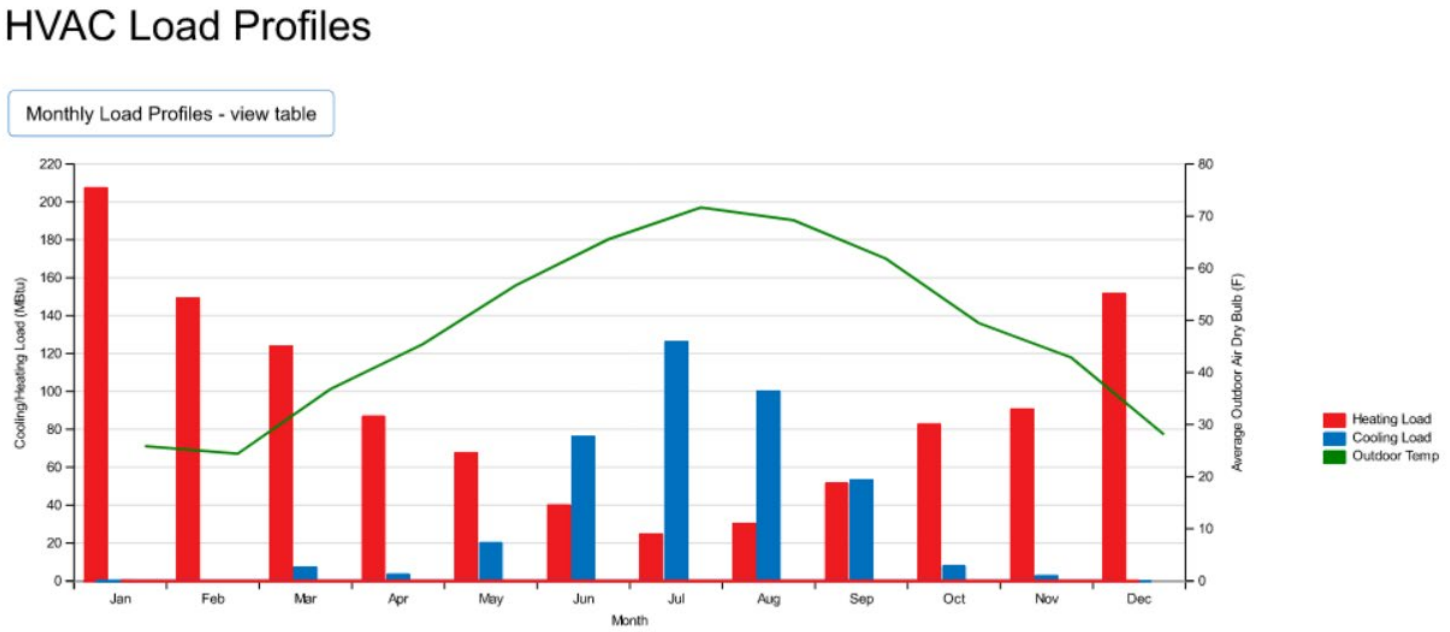
Heat Pumps - Heating



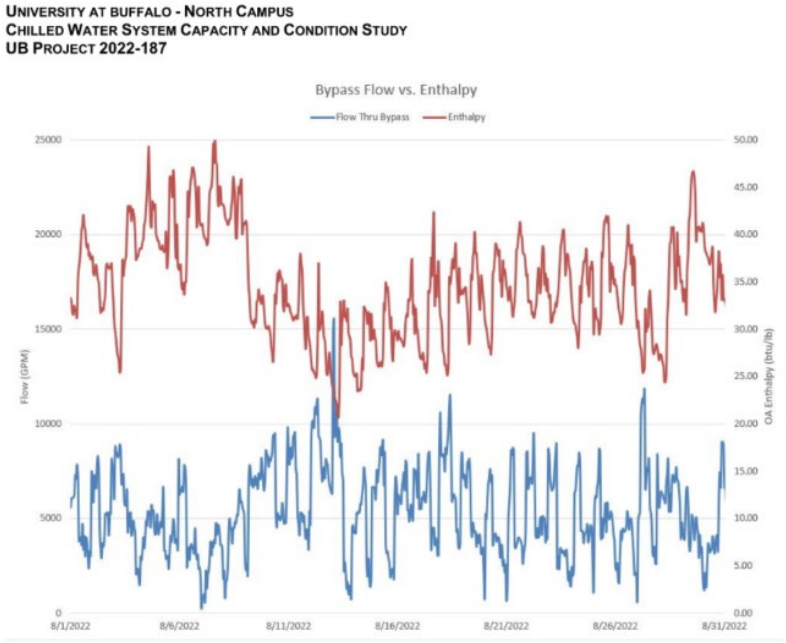
Heat Pumps - Cooling

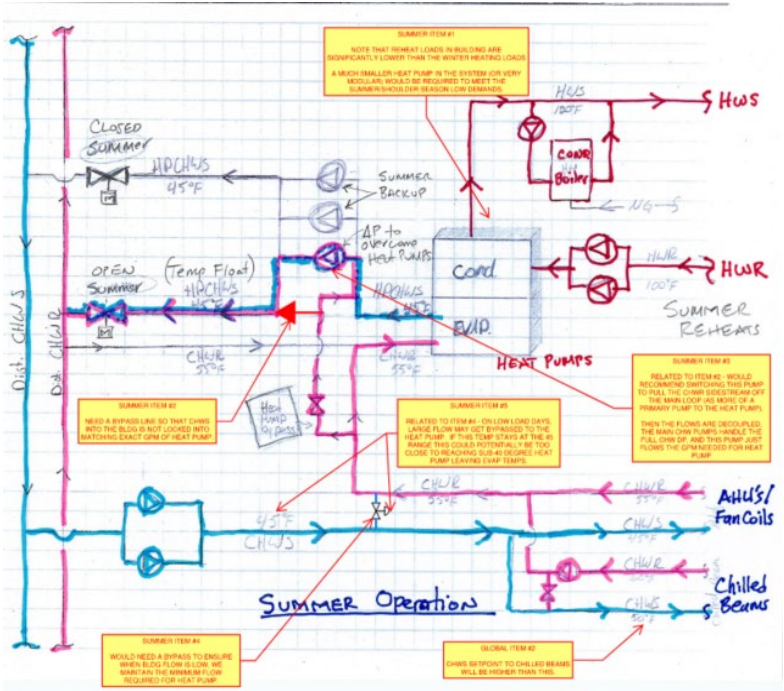


Building Profiles



Meetings with Owner





Meetings with Owner

		Avg Sup Temp Deg F	Avg Ret Temp Deg F	Avg Flow GPM	Total Tonnage Tons	Avg OAT Deg F
JAN	AVG	61.0	60.7	5168.6	0.0	34.1
JAN	MAX	63.9	63.4	5880.6	0.0	48.6
JAN	MIN	58.6	58.3	5109.8	0.0	17.0
FEB	AVG	61.1	60.9	5976.1	1.8	33.6
FEB	MAX	64.4	64.0	7243.9	71.5	61.0
FEB	MIN	57.7	57.7	5581.6	0.0	3.0
MAR	AVG	61.2	60.8	9209.0	0.0	37.0
MAR	MAX	64.2	63.9	14725.5	0.0	58.5
MAR	MIN	60.0	59.6	5920.9	0.0	22.4
APR	AVG	58.5	59.5	10952.4	648.7	50.7
APR	MAX	67.5	67.0	17446.9	5331.4	86.3
APR	MIN	40.7	45.4	8497.7	0.0	26.6
MAY	AVG	49.1	52.0	11734.2	1598.8	60.1
MAY	MAX	63.8	63.4	15355.6	5368.6	95.5
MAY	MIN	39.4	45.1	4714.4	0.0	35.8
JUN	AVG	44.6	50.0	13413.1	3101.2	69.3
JUN	MAX	56.5	57.0	17068.6	6818.6	100.2
JUN	MIN	40.2	46.4	10456.0	0.0	51.4
JUL	AVG	42.3	49.7	13950.6	4396.1	75.2
JUL	MAX	49.8	53.7	16590.2	8209.5	96.2
JUL	MIN	40.1	46.2	11359.9	1061.0	59.8
AUG	AVG	43.3	49.5	13921.7	3644.4	70.7
AUG	MAX	48.4	52.9	16585.6	7077.5	84.8
AUG	MIN	40.1	45.6	11358.3	1098.4	53.0
SEP	AVG	44.4	49.6	13722.7	2959.6	66.3
SEP	MAX	57.5	58.0	17709.0	8064.6	92.2
SEP	MIN	40.2	45.9	10292.7	0.0	47.4
OCT	AVG	51.6	54.3	11811.3	1495.5	56.8
OCT	MAX	64.0	63.7	16347.5	5997.1	86.5
OCT	MIN	40.3	45.7	4710.4	0.0	33.9
NOV	AVG	59.8	59.9	11402.1	164.4	41.7
NOV	MAX	65.0	64.9	16578.7	2571.8	62.1
NOV	MIN	45.4	48.1	9898.7	0.0	24.3
DEC	AVG	62.6	62.4	11196.9	0.0	40.6
DEC	MAX	67.8	67.5	15303.5	0.0	62.6
DEC	MIN	58.8	58.8	9731.9	0.0	25.3

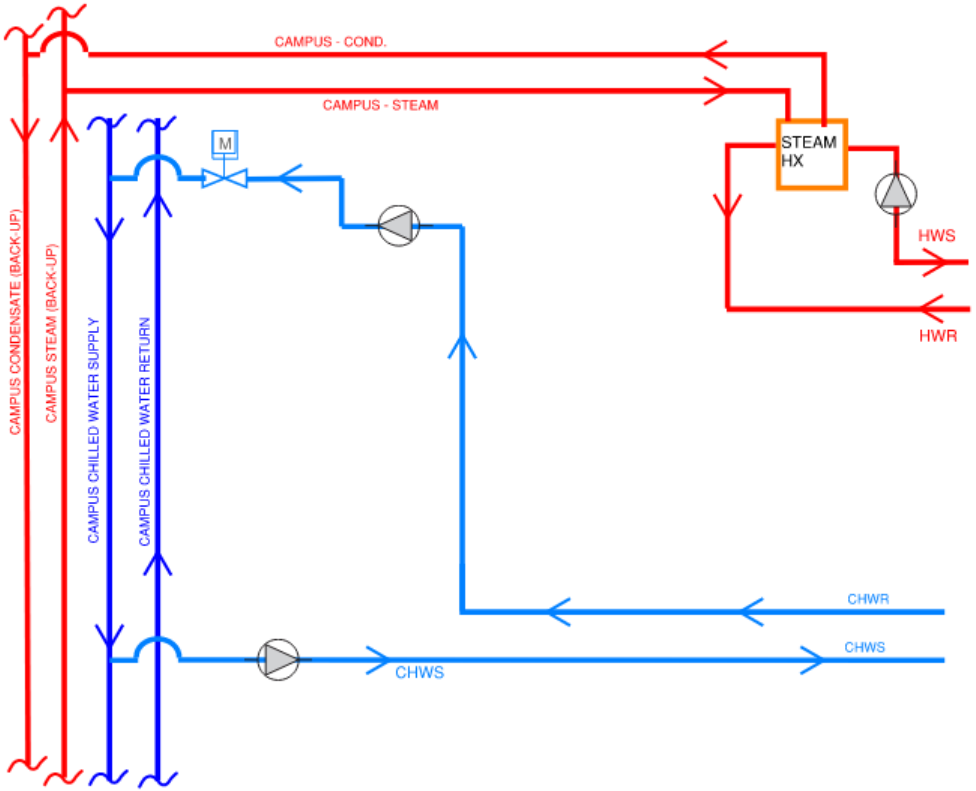
Jan = 61F Average

July = 49F Average

August = 40F Minimum

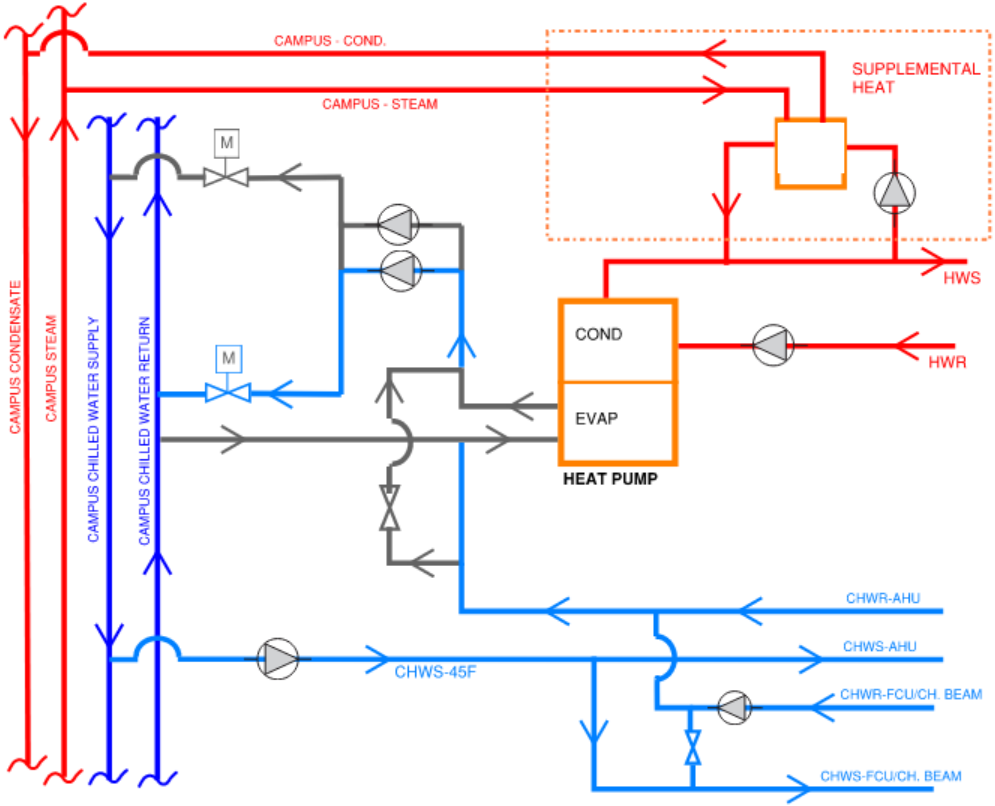
Dec = 68F Max

Existing Campus Arrangement



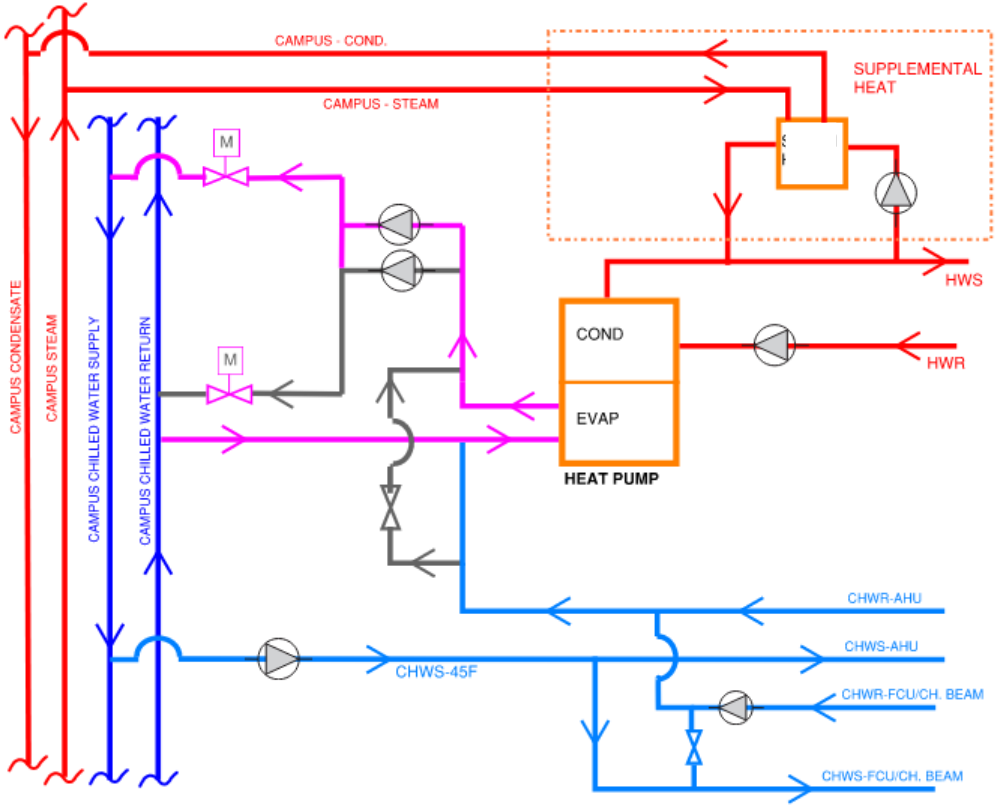
Heat Pump System

- Leverage existing campus infrastructure
- Connect to systems to reduce carbon fuel at Plant



Heat Pump System – Winter Operations

- Utilize Campus Chilled Water in winter for heating (reserve connection to CHW)
- Small Variations = Big Results!



OUTPUTS

% Projected Energy Cost Savings ~32- 39 %

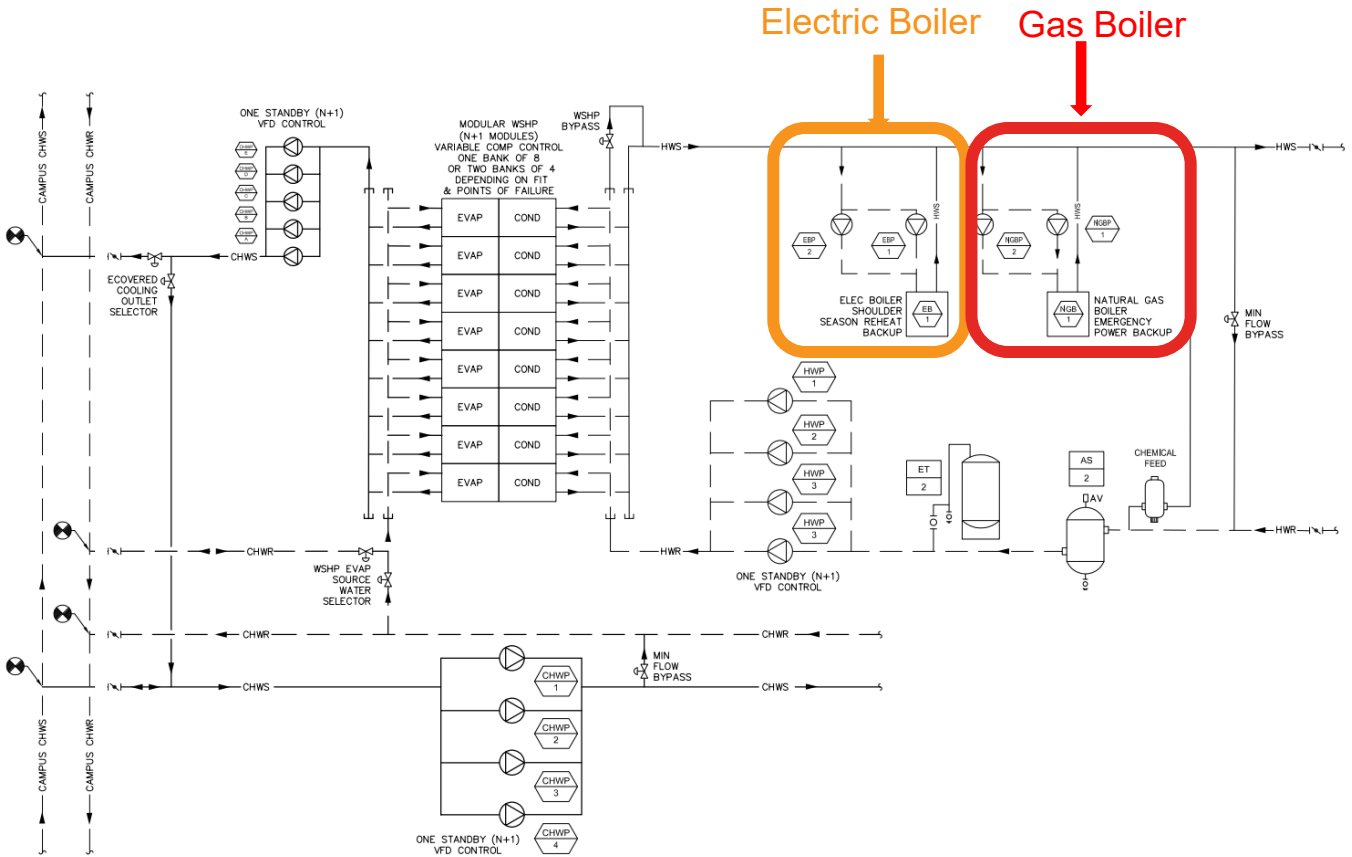
Final Equipment Selections Heat COP

Cooling COP = 3.44

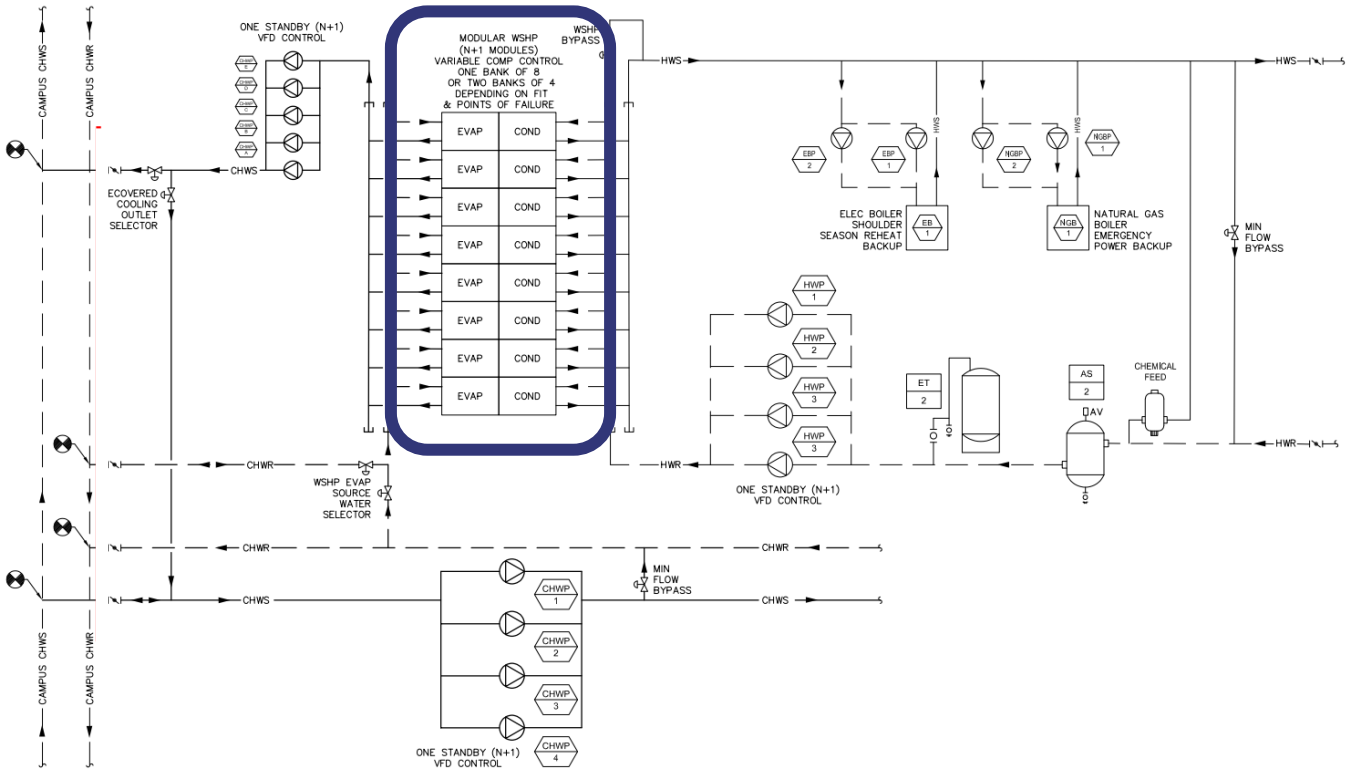
Heating COP = 4.44

Combined = 7.88

Resiliency & Redundancy



Benefit – Molecular Design



Benefits – Reduced Electrical Generator Sizing

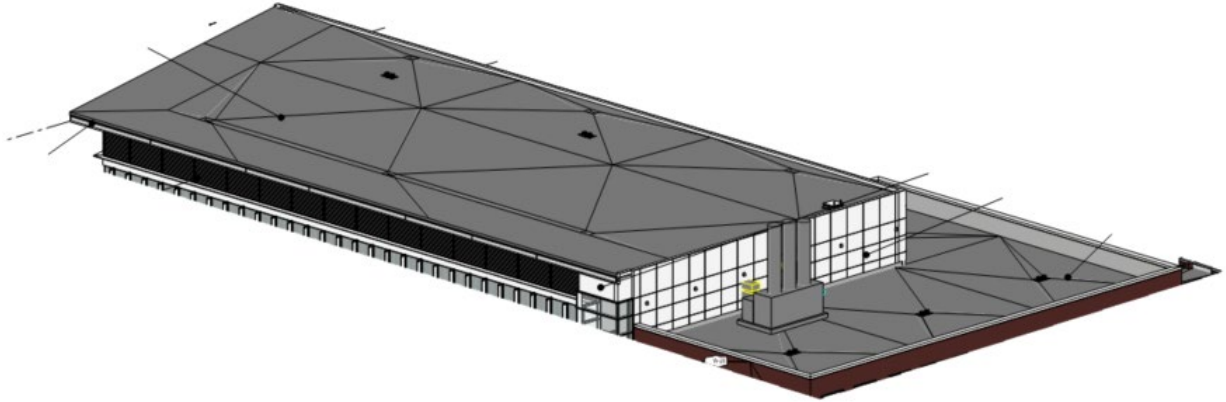
Gas-fired heating:

400 kW

All-electric:

1 MW

Benefits – Limited Roof Top Equipment



QUESTIONS?