Plotting the Course: Designing a Sustainable Lab in a Sea of Complexity

I2SL Annual Conference
October 21, 2025

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Learning Objectives

- **Understand the unique design and operational challenges of high-density chemistry laboratory buildings,** including spatial and energy requirements that influence planning and engineering decisions.
- **Identify strategies for integrating novel design approaches**—such as mass timber structural systems, flat roof configurations, and unconventional process cooling or HVAC solutions—within complex laboratory environments.
- **Examine how to collaborate effectively with established institutional clients** to introduce innovative ideas that exceed traditional performance benchmarks while maintaining trust and project alignment.
- **Evaluate** the role of sustainable design principles in laboratory architecture, and how targeted implementation of key features can deliver measurable environmental and operational benefits.

Program Summary

Chemistry Labs	21,000 SF
Future Quantum Labs	13,300 SF
Office	25,450 SF
Teaching Space	4,850 SF
Collaboration	8,950 SF
Building Support	3,050 SF
TOTAL ASF	77,000 SF
TOTAL GSF	136,700 SF

Construction Budget – $141,200,000 ($1031/SF)

Stakeholders & Standards

Provosts Office

Facilities Management

Operations

Planning

Utility and Energy Services

Design & Construction

College of Arts and Sciences

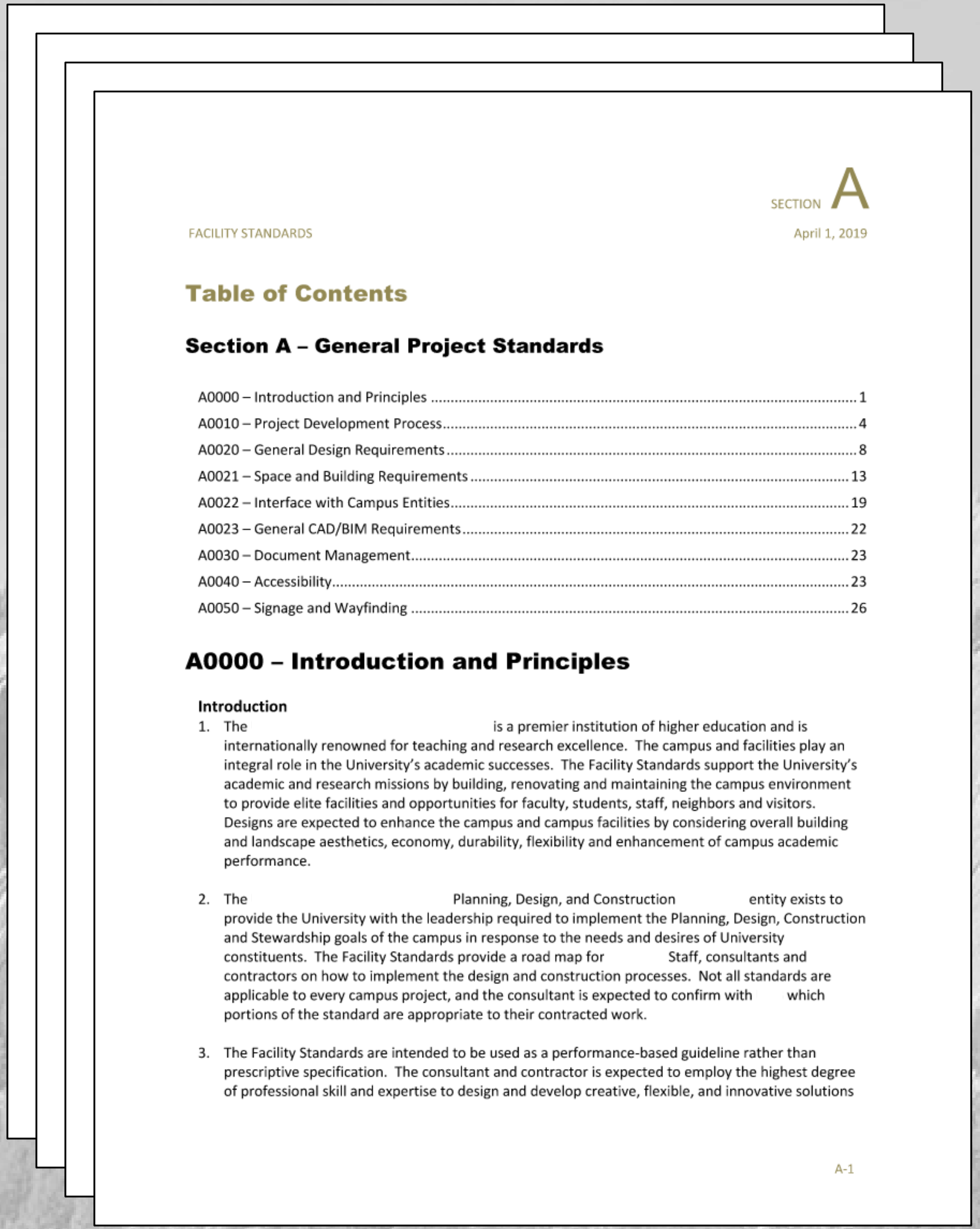
User Leadership

Transportation Services

Engineering Services

Users

Design Review Board



FACILITY STANDARDS

SECTION A

April 1, 2019

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A0000 – Introduction and Principles

Introduction

1. The is a premier institution of higher education and is internationally renowned for teaching and research excellence. The campus and facilities play an integral role in the University's academic successes. The Facility Standards support the University's academic and research missions by building, renovating and maintaining the campus environment to provide elite facilities and opportunities for faculty, students, staff, neighbors and visitors. Designs are expected to enhance the campus and campus facilities by considering overall building and landscape aesthetics, economy, durability, flexibility and enhancement of campus academic performance.

2. The Planning, Design, and Construction entity exists to provide the University with the leadership required to implement the Planning, Design, Construction and Stewardship goals of the campus in response to the needs and desires of University constituents. The Facility Standards provide a road map for Staff, consultants and contractors on how to implement the design and construction processes. Not all standards are applicable to every campus project, and the consultant is expected to confirm with which portions of the standard are appropriate to their contracted work.

3. The Facility Standards are intended to be used as a performance-based guideline rather than prescriptive specification. The consultant and contractor is expected to employ the highest degree of professional skill and expertise to design and develop creative, flexible, and innovative solutions

A-1

750+ Pages

Site Plan

FLOOR PLANS

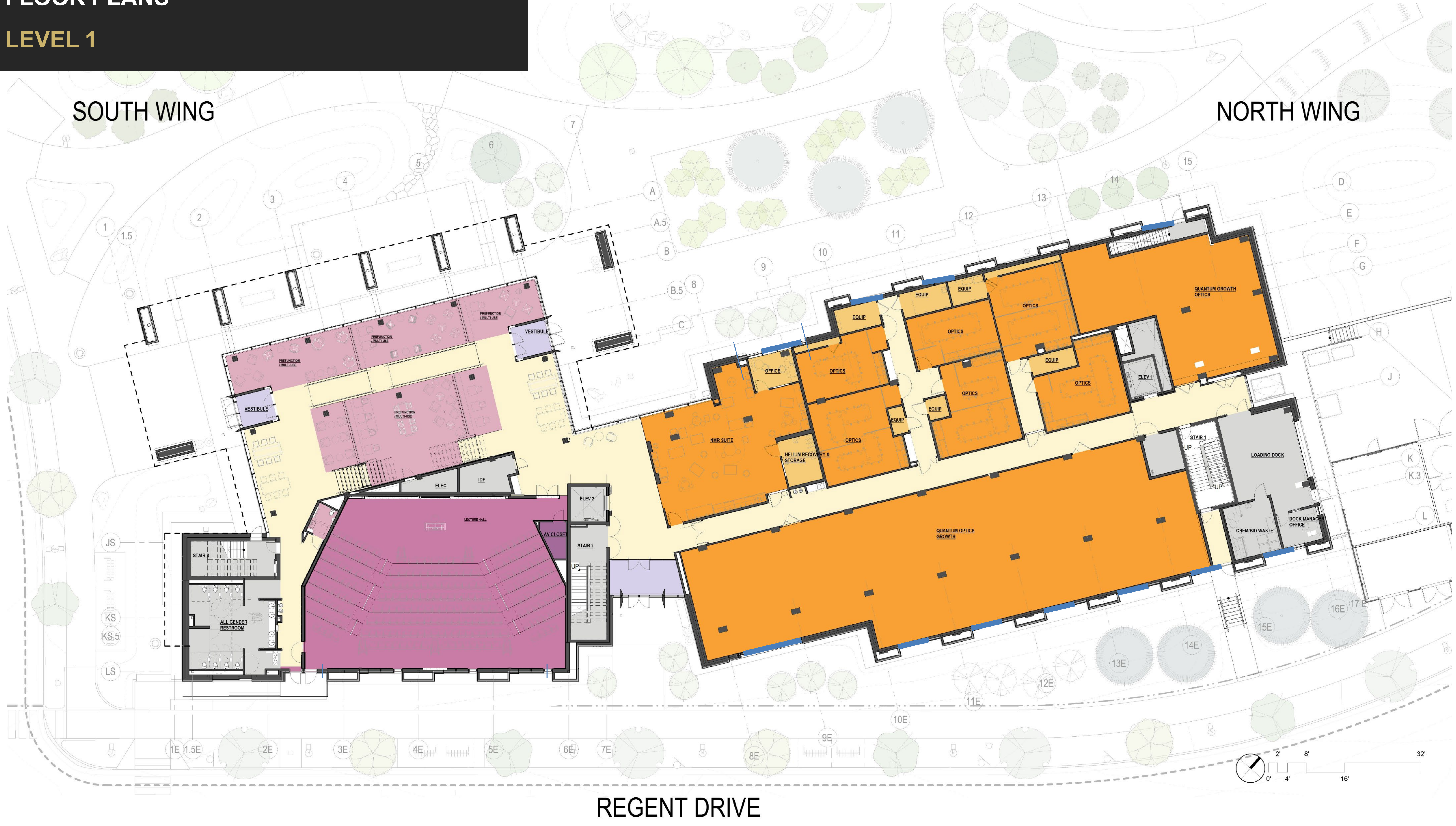
LEVEL BASEMENT

SOUTH WING

NORTH WING

FLOOR PLANS

LEVEL 1



FLOOR PLANS

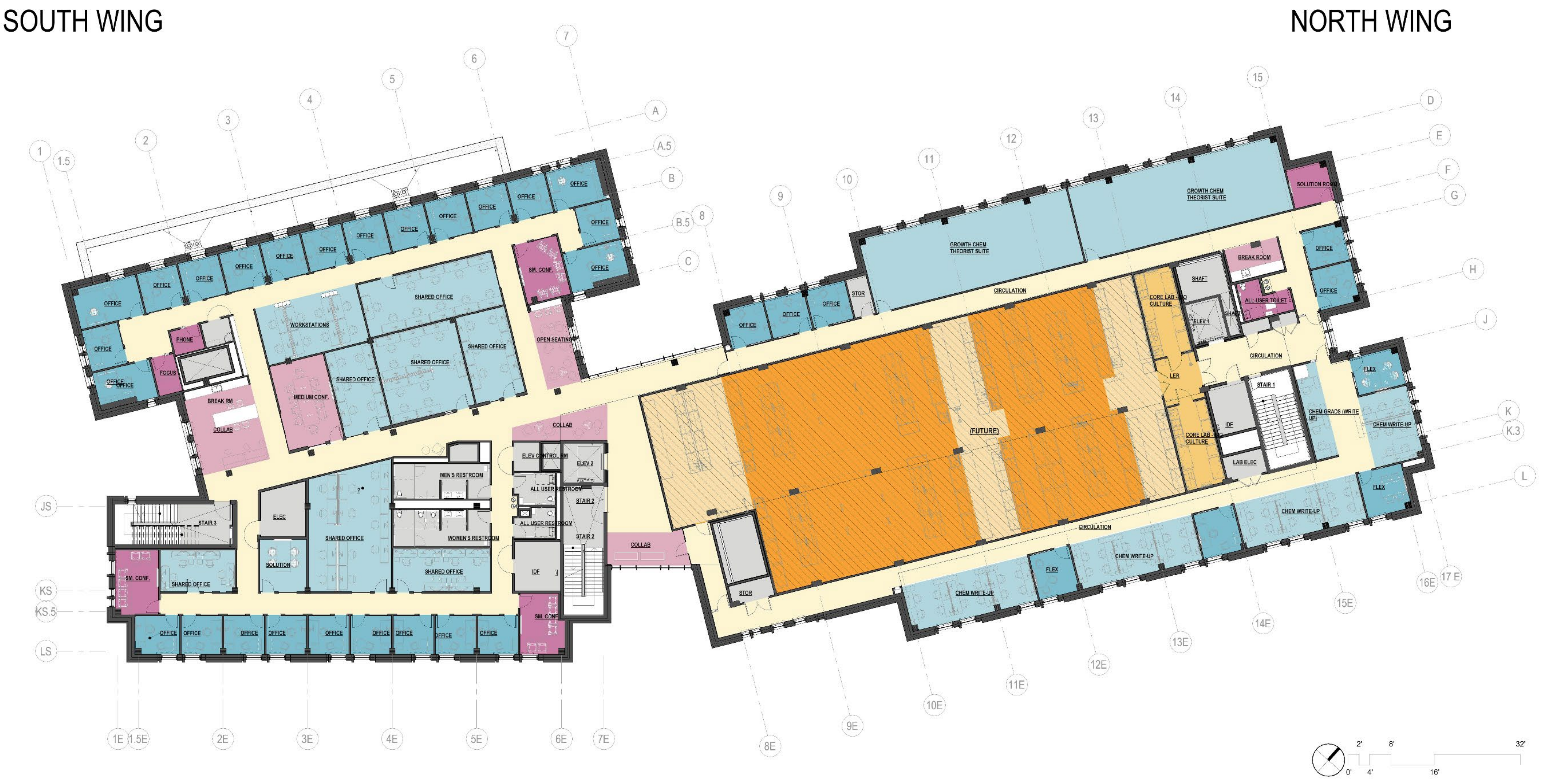
LEVEL 2

SOUTH WING

NORTH WING

FLOOR PLANS

LEVEL 3

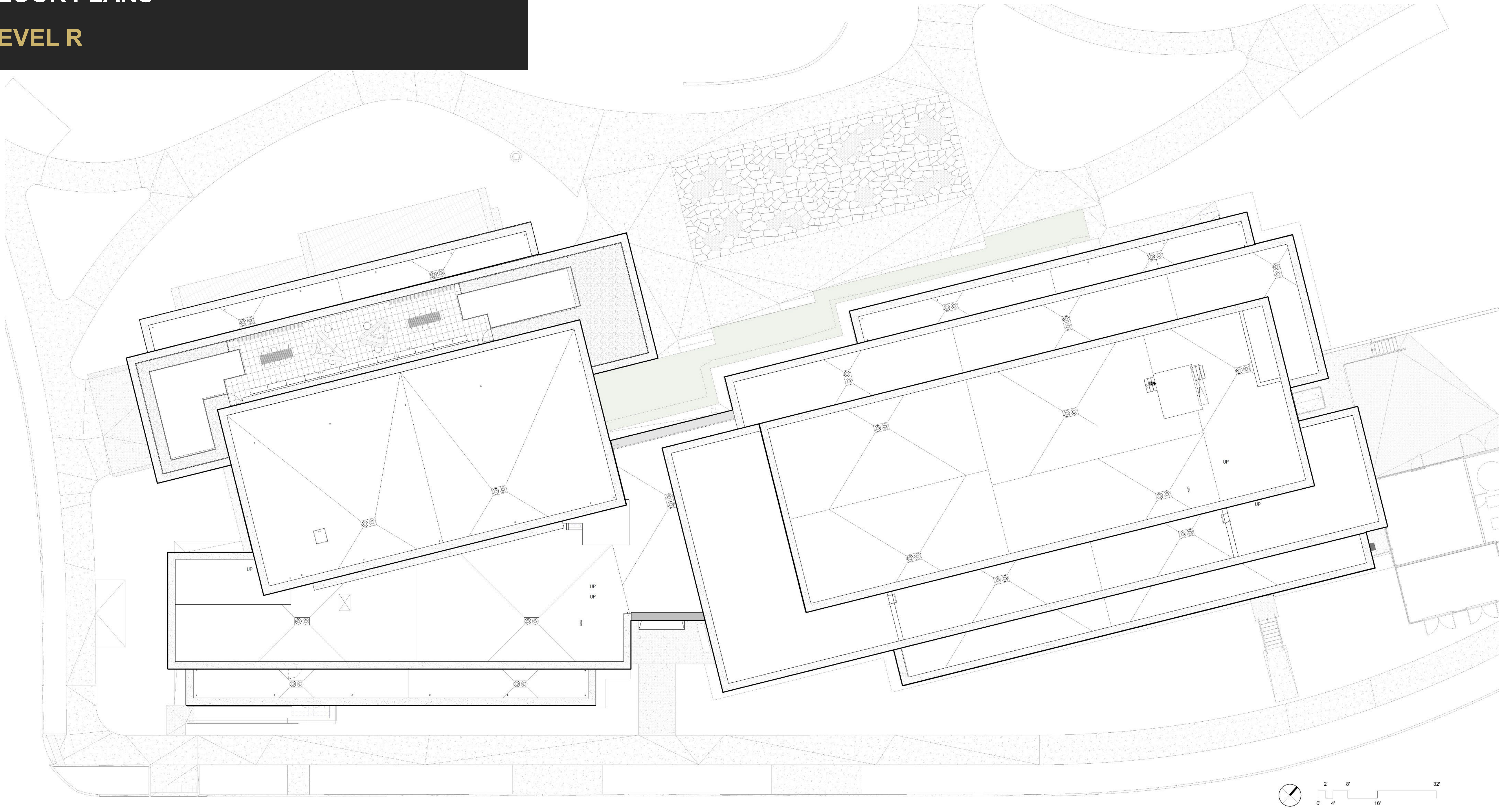


FLOOR PLANS

LEVEL 4

FLOOR PLANS

LEVEL R

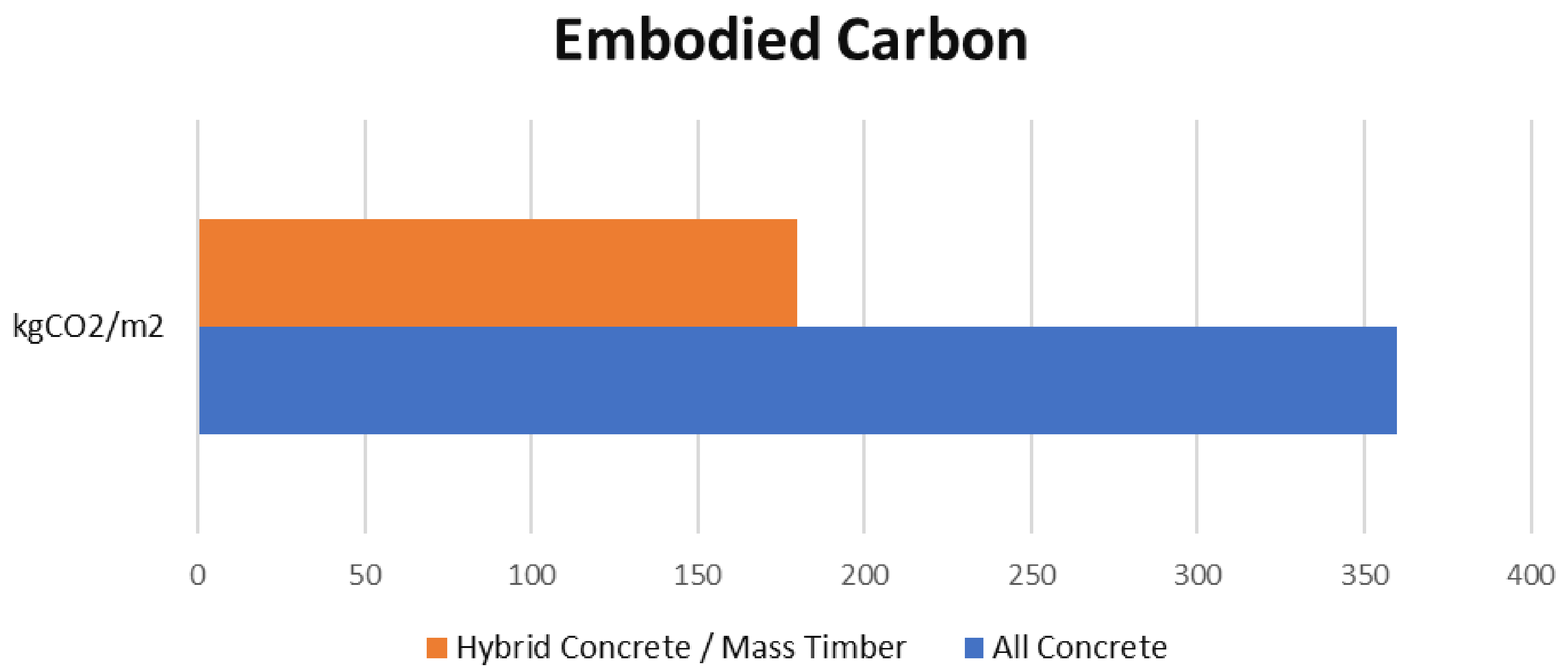


Sustainability
Overview

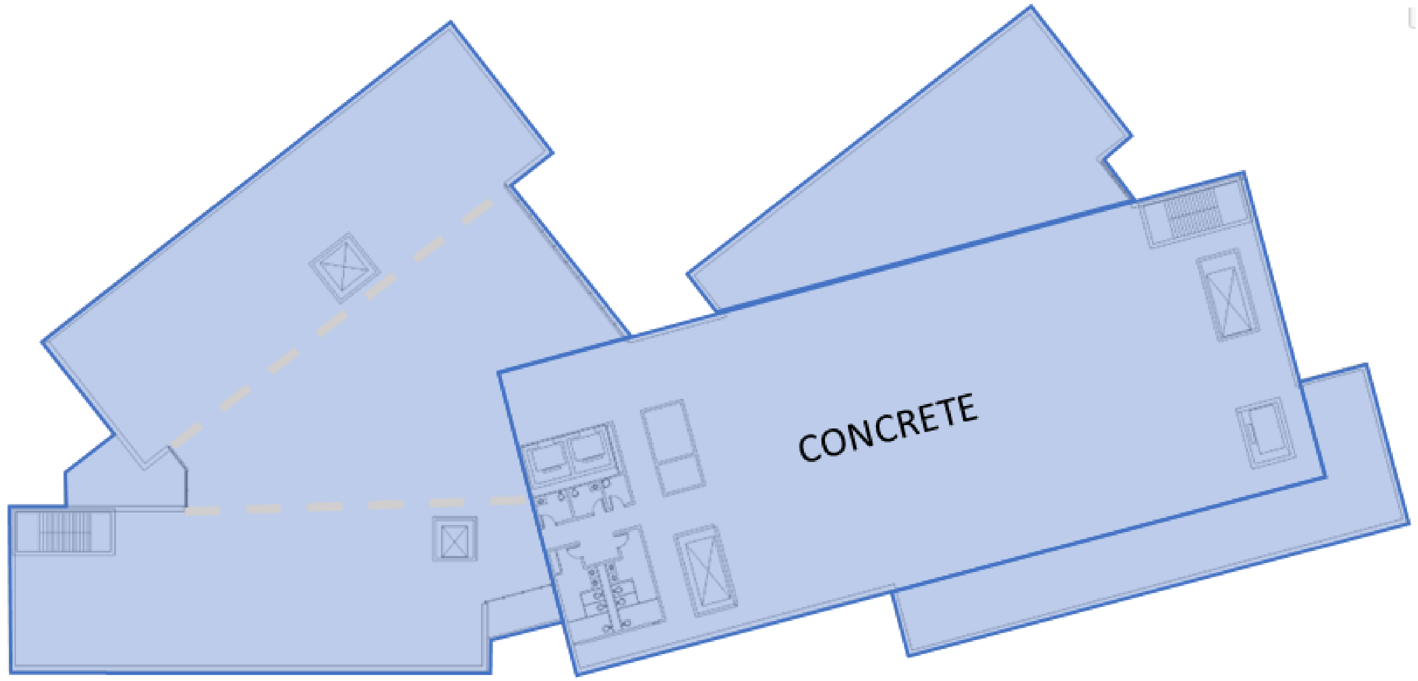
LEED	Indoor Water Use Reduced by	Energy Use Reduced by	pEUI (kBtu/sf/yr)
Gold+	21%+	45.7%	~98

Biophilic Design Implementation

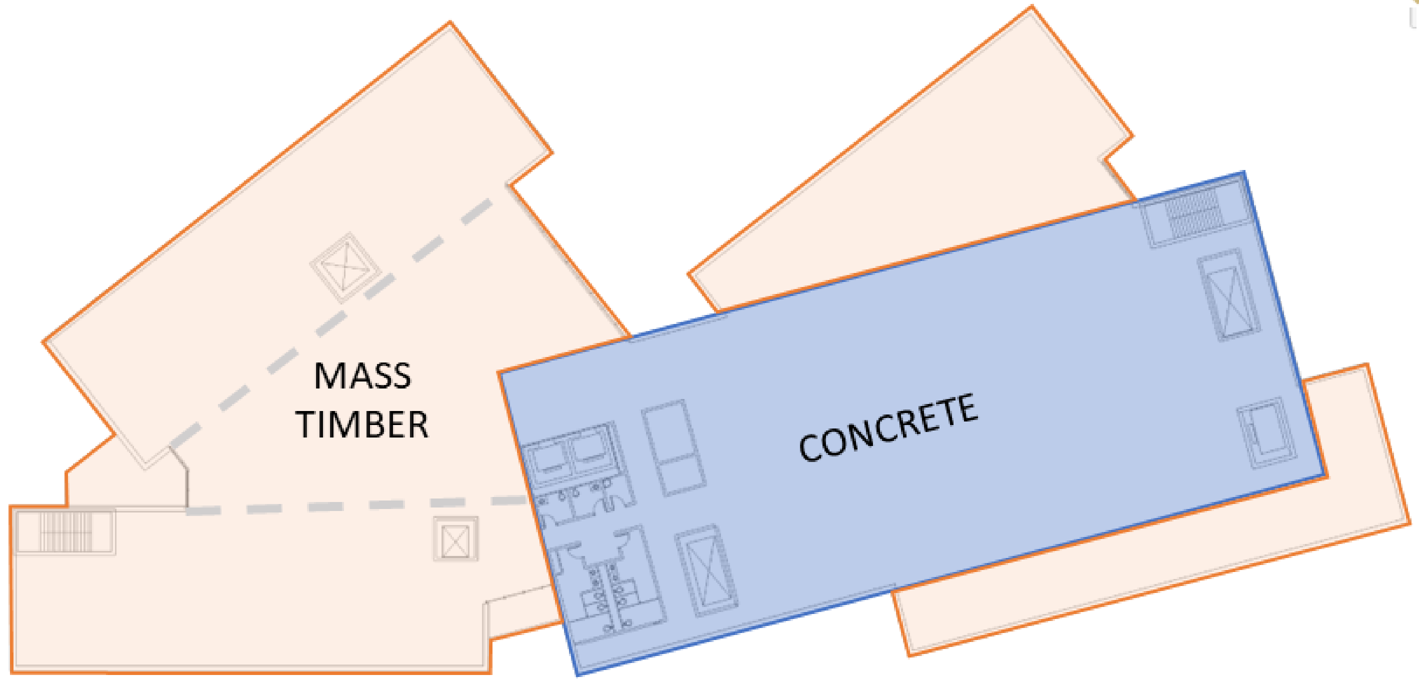
Mass Timber Hybrid Structure



Reduction in carbon is equivalent to the amount of carbon removed by 2,965 acres of forest over one year, or 5 forests the size of the entire campus over one year.



Alternate: All Concrete



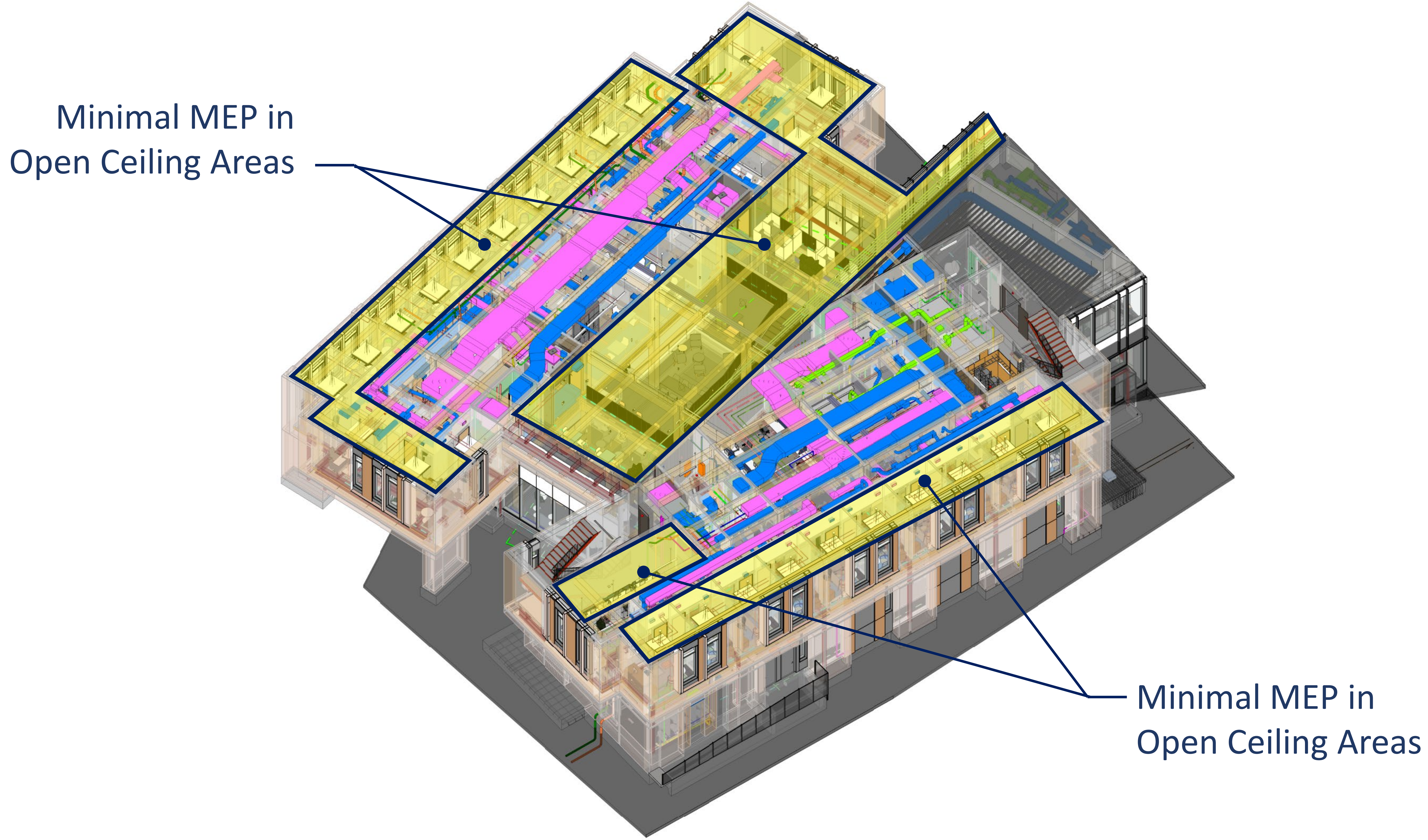
Base Design: Hybrid Concrete / Mass Timber

Mass Timber Coordination

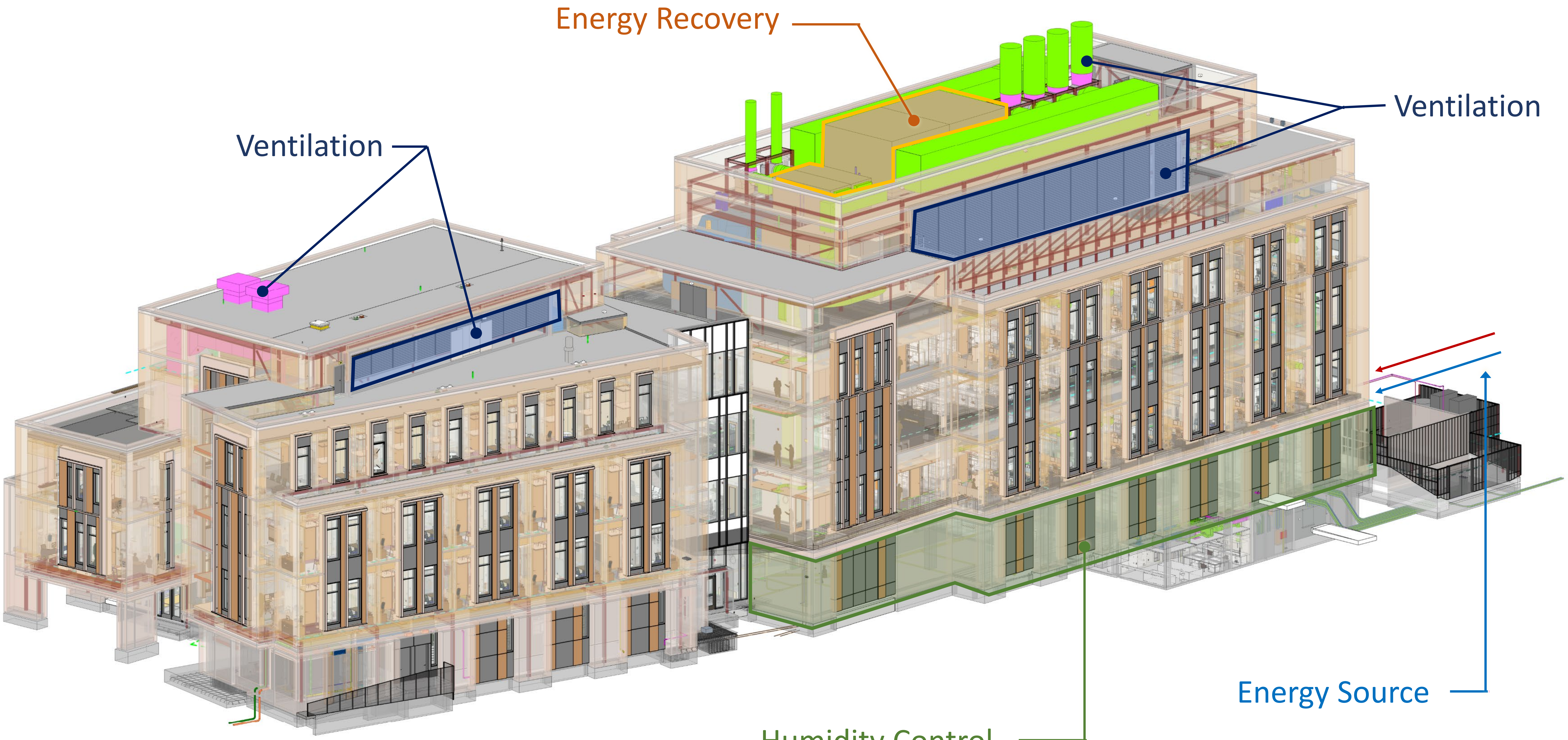
HVAC PLAN, LEVEL 2 SOUTH

SCALE: 1/8" = 1'-0"

Mass Timber Coordination

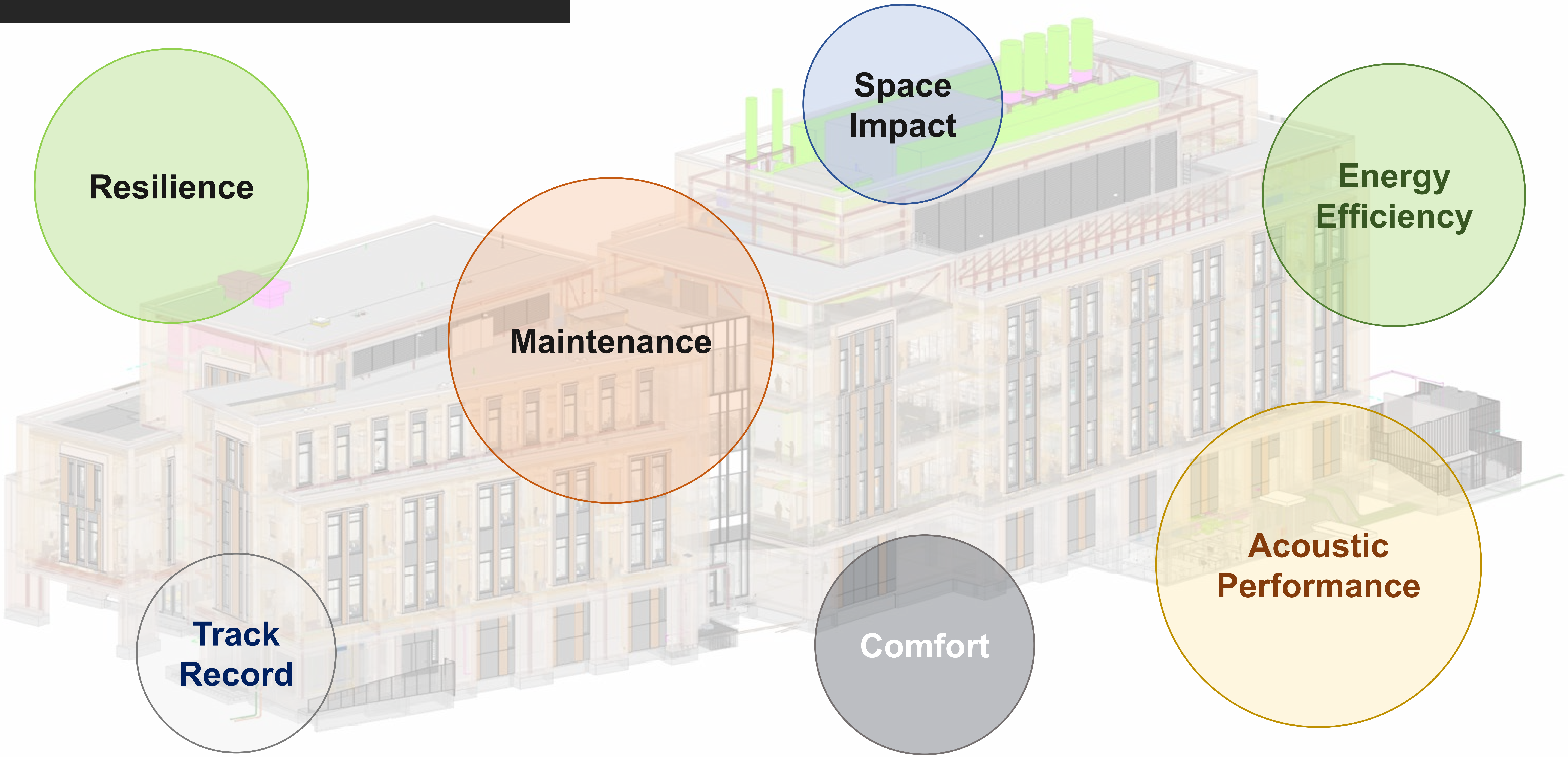


Mechanical System Selection



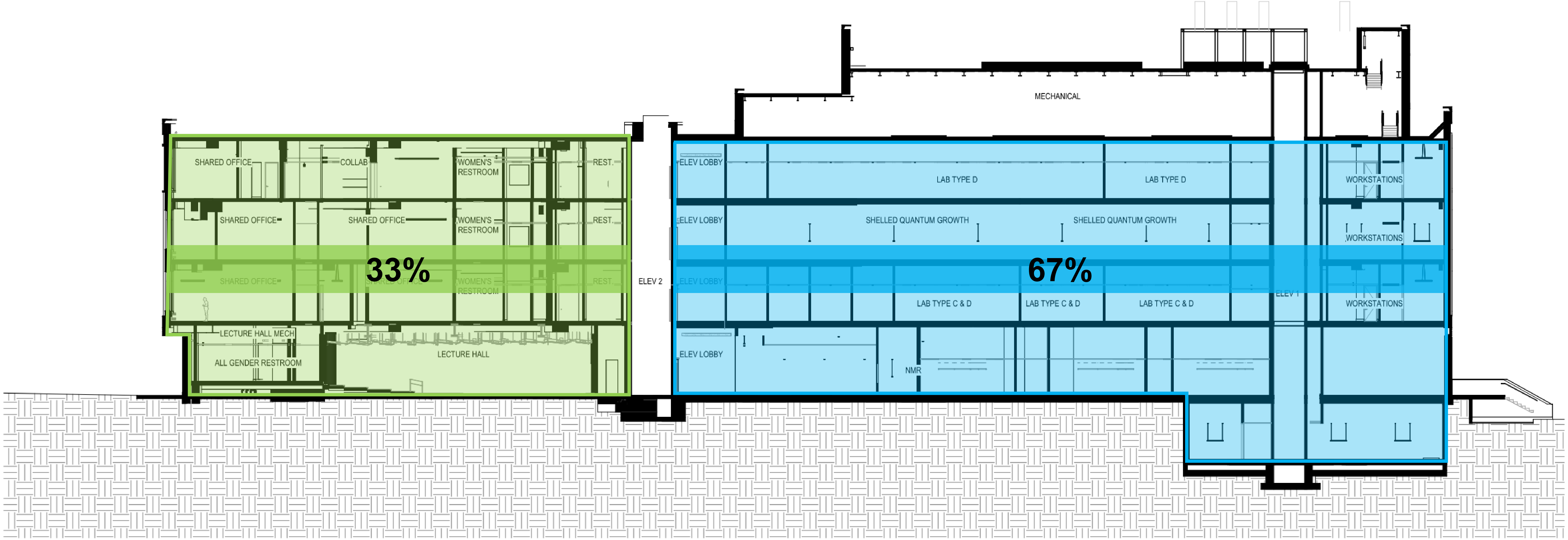
Mechanical System Selection

Decision Criteria



Mechanical System Selection

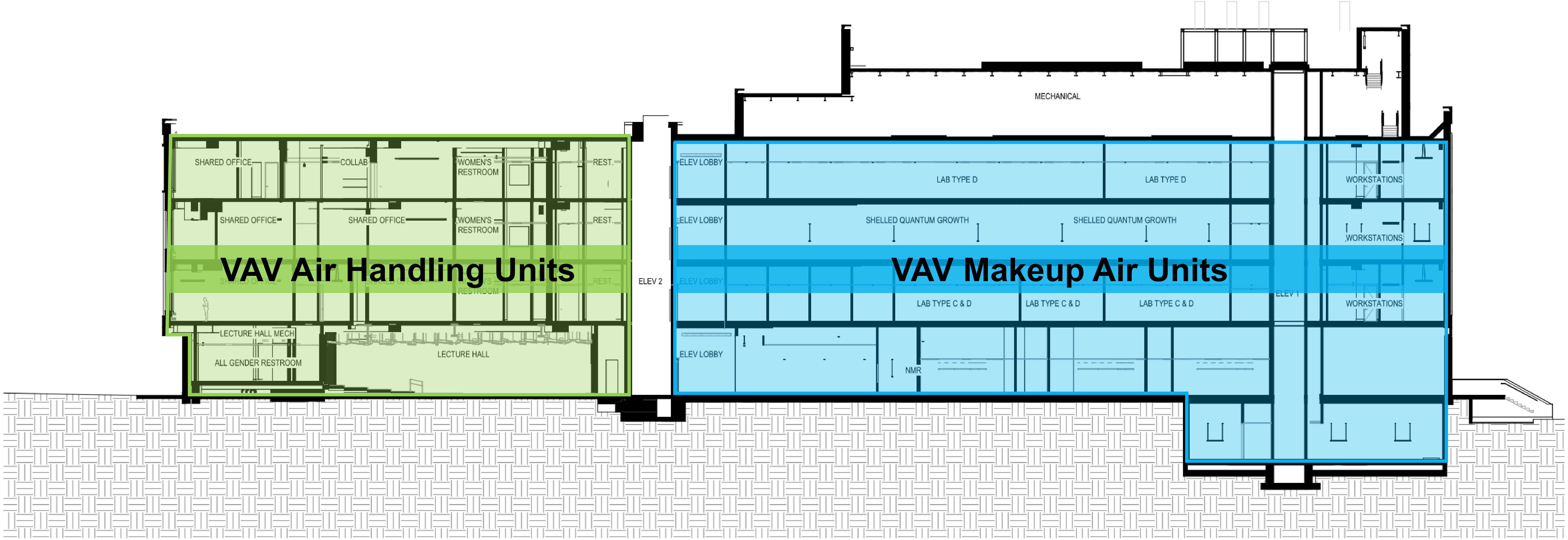
Ventilation



Proportion of Overall HVAC Airflow

Mechanical System Selection

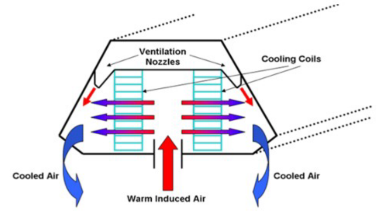
Ventilation



Mechanical System Selection

Ventilation (Non-Labs)

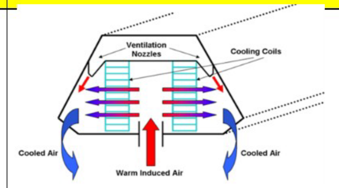
Mechanical Systems Decision Matrix - Ventilation - NON-Laboratories

Order	Option	Description	Maintenance	EUI	Resilience	Space Impact	Acoustic Performance	Performance Track Record in Similar Climate	Comfort	Energy Master Plan Alignment	Cator, Ruma Recommendations	Other Comments	Image
	VAV AHUs	Conventional CU Boulder approach. Use campus steam to generate heating water at 130-140 deg that heats the outside air and reheats at the VAV's. Campus chilled water for the AHU's and point of use cooling FCU's. AHU's to have economizer for energy savings.	Standard maintenance operations with VAV boxes in corridors or above occupied spaces.	Good. Performs good with central plant	Proposing partial redundant AHU's	Fully ducted VAV system requires the most ceiling space and more Penthouse space.	Good - with CU Standards allowing duct liner these systems perform well.	Good. Many installations at CU	Good - main issue is when multiple rooms are served by one VAV therefore the other rooms without a thermostat may suffer.	Good	This is the current preferred option based on comfort, maintenance and acoustics.		
	DOAS + Chilled Beams	Chilled beams reside at the ceiling (like diffusers) with 2-pipe or 4-pipe coils. DOAS ventilation air is ducted to the chilled beams. Could obtain energy recovery within DOAS unit.	Similar to a VAV system, but adds another chilled water system which adds pumps and heat exchangers.	Slightly better that VAV, but a very long pay back is expected. These perform better when the energy is sourced locally to the building where you can leverage efficiencies of condensing boilers and warmer temperature chilled water.	Proposing partial redundant AHU's. The hydronic system for the chilled beams would have redundant pump. Primary air is ventilation only so no ability to increase cooling capacity from AHU's.	DOAS systems allow a reduction in penthouse space and ceiling space for smaller ducts.	Chilled Beams should result in lower sound levels.	Various reports both good and bad. Drip pans now becoming available	Takes a long time to change temperature. CRA currently working with a Hospital that has them and don't like them.	Good	While some chilled beams now come with drip pans, historically you need warmer chilled water and provide sensible cooling only. With classrooms, there is often enough latent load that chilled beams only save about 1/2 of the required ventilation to remove moisture	Use of evaporative cooling is discouraged to avoid condensation potential at the DOAS. Quiet operation since no fans in the chilled beam.	
	DOAS + FCUs	Space saving approach compared to VAV. Energy efficiency comes from conditioning less air, using energy recovery wheel for DOAS AHU's. DOAS also has evaporative cooling.	Similar to a VAV system, but adds distributed fan coil units which have fans, filters and valves that need maintenance.	Slightly better that VAV, but with a maintenance premium.	Proposing partial redundant AHU's. With FCU's, if the main supply air goes down, FCU's can continue to operate.	DOAS systems allow a reduction in penthouse space and ceiling space for smaller ducts. However the FCU's take up additional space in the ceilings than VAV's.	Most difficult accoustically with fans near the occupied zones	Many installations at CU	Good - but often requires dedicated FCU's per space affecting cost	Good	We would not recommend exposed FCU's due to noise concerns. If this approach is pursued, FCU's should be above acoustical ceilings and include lined supply and return ductwork. Additional provisions may be required to mitigate noise.	Could be noisy depending on location of FCU's. Acoustical issues can be addressed, but may add cost and impact ceiling heights.	
	Displacement Ventilation	This could be implemented with a variety of options above. Displacement provides ventilation air down low at a temperature closer to that of the desired room temperature and relies on thermal boyancy of the air heated by humans to rise up to the return plenum.	This would match the VAV maintenance.	Good - similar to VAV. This system also performs better when using a local energy source like condensing boilers.	Proposing partial redundant AHU's.	Fully ducted VAV system requires the most ceiling space and more Penthouse space. Airflow is often increased slightly with this system which would require more space.	Very Good, lower velocity air with a lot of lined supply duct to supply down low.	1 installation at CASE. CRA has several others at K-12 classrooms.	Good - The low floor supply uses natural convection to remove heat off of occupants vertically instead of mixing at the occupant level.	Good	With the heating and cooling coming from the campus plant, energy savings may not be the main reason for chosing this system.	Displacement is better for keeping contaminants away from other individuals as the air from one person travels straight up. Quiet operation since no local fans in this system.	

Mechanical System Selection

Ventilation (Labs)

Mechanical Systems Decision Matrix - Ventilation - Laboratories

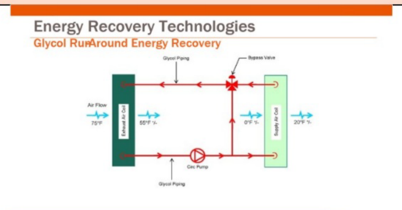
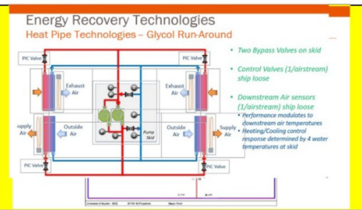
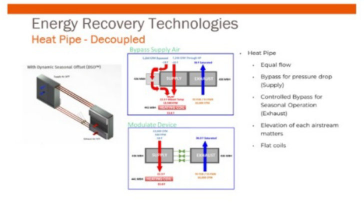
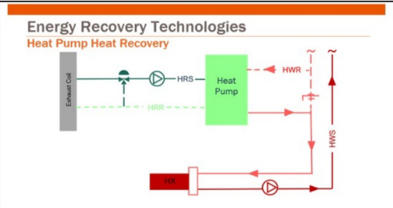
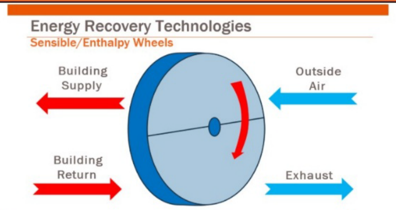
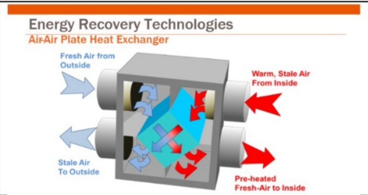
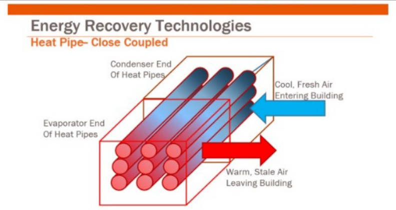
Order	Option	Description	Maintenance	EUI	Resilience	Space Impact	Acoustic Performance	LEED Optimize Energy Performance Points	Performance Track Record in Similar Climate	Reliability & Safety	Comfort	Energy Master Plan Alignment	Path to Electrification	Cator, Ruma Recommendations	Other Comments	Image
	VAV MAUs (Chem)	For Ventilation Driven Laboratories, this is the conventional CU Boulder approach. Use campus steam to generate heating water at 130-140 deg that heats the outside air and reheats at the VAV's. Campus chilled water for the AHU's and point of use cooling FCU's. AHU's to have economizer for energy savings.	Standard maintenance operations with VAV boxes in corridors or above occupied spaces.	Good. Performs good with central plant	Lab ventilation systems will have N+1 redundancy for AHUs.	Fully ducted VAV system requires the most ceiling space and more Penthouse space.	Good - with CU Standards allowing duct liner these systems perform well.		Good. Many installations at CU		Good - main issue is when multiple rooms are served by one VAV therefore the other rooms without a thermostat may suffer.	Good	All systems are fully electric	This is the current preferred option based on comfort, maintenance and acoustics. Our main concern is "FIT" with the low floor-floor heights and larger AHU sizes required.		
	DOAS + Chilled Beams (Chem)	Chilled beams reside at the ceiling (like diffusers) with 2-pipe or 4-pipe coils. DOAS ventilation air is ducted to the chilled beams. Could obtain energy recovery within DOAS unit.	Similar to a VAV system, but adds another chilled water system which adds pumps and heat exchangers.	Sligthly better that VAV, but a very long pay back is expected. These perform better when the energy is sourced locally to the building where you can leverage efficiencies of condensing boilers and warmer temperature chilled water.	Lab ventilation systems will have N+1 redundancy for AHUs. Typically less future flexibility since this system minimizes the amount of air to the spaces.	DOAS systems allow a reduction in penthouse space and ceiling space for smaller ducts.	Chilled Beams should result in lower sound levels.		Various reports both good and bad. Drip pans now becoming available		Takes a long time to change temperature. CRA currently working with a Hospital that has them and don't like them.	Good	All systems are fully electric	While some chilled beams now come with drip pans, historically you need warmer chilled water and provide sensible cooling only. With classrooms, there is often enough latent load that chilled beams only save about 1/2 of the required ventilation to remove moisture	Use of evaporative cooling is discouraged to avoid condensation potential at the DOAS. Quiet operation since no fans in the chilled beam.	
	DOAS + FCUs (Chem)	For load driven Laboratories, this uses the 100% Outside air similar to a DOAS system and FCU's are placed at the highest internal heat gain loads like freezers, etc. The labs would still receive the decided upon air change rates (4 ACH). Space saving approach compared to VAV.	Similar to a VAV system, but adds distributed fan coil units which have fans, filters and valves that need maintenance.	Sligthly better that VAV, but with a maintenance premium.	Lab ventilation systems will have N+1 redundancy for AHUs. Typically less future flexibility since this system minimizes the amount of air to the spaces. However, the FCU's provide additional cooling, but no more air for future fume hoods.	DOAS systems allow a reduction in penthouse space and ceiling space for smaller ducts. However the FCU's take up additional space in the ceilings than VAV's.	Most difficult accoustically with fans near the occupied zones		Many installations at CU		Good - but often requires dedicated FCU's per space affecting cost	Good	All systems are fully electric	Based on the noise concerns and the maintenance issues, we believe this option should be ranked lower than others. We would not recommend exposed FCU's due to noise concerns. If this approach is pursued, FCU's should be above acoustical ceilings and include lined supply and return ductwork. Additional provisions may be required to mitigate noise.	Could be noisy depending on location of FCU's. Acoustical issues can be addressed, but may add cost and impact ceiling heights.	
	VAV MAUs (Optics)	Same as option 1 above for ventilation driven labs. Most of the humidification control would be performed at the main AHU's. Possibly some spot humidification would still be needed.	Similar to VAV, but added maintenance for humidification control	Similar to VAV, but less efficient due to the energy needed for humidification	Lab ventilation systems will have N+1 redundancy for AHUs.	This option takes up more penthouse space, but saves space at the room level	Good - with CU Standards allowing duct liner these systems perform well.		Good. Many installations at CU		More about research temperature control than human comfort.	Good	All systems are fully electric		This may not provide the level of control for each individual optics lab space and should be considered as a VE option over the DOAS with local FCU/Blower Coil units.	
	DOAS + FCUs (Optics)	Same as option 3 above, except the FCU's would be larger - more like "Blower Coils" that are ducted to the optics tables. The DOAS unit would do the base level humidity control and then there would be space level humidity control for each optics lab with the individual/dedicated air streams.	Similar to DOAS/FCU's but added maintenance for humidification	Similar to DOAS/FCU system, but less efficient due to the energy needed for humidification	Lab ventilation systems will have N+1 redundancy for AHUs. Typically less future flexibility since this system minimizes the amount of air to the spaces. However, the FCU's provide additional cooling, but no more air for future fume hoods.	This option takes more space down at the lab level due to the blower coils above ceiling or in adjacent rooms	Most difficult accoustically with fans and humidifiers near the occupied zones		Many installations at CU		More about research temperature control than human comfort.	Good	All systems are fully electric	This approach has been successful in JILA on multiple projects which uses ducted FCU's, but not tight humidity control. We understand the "Jonas Lab" has a similar approach but with tight humidity control and possibly higher airflow rates at the optics tables.	Vibration from equipment over the top of the optics labs needs to be addressed, as well as servicing the equipment.	

Mechanical System Selection

Energy Recovery

- Traditional Glycol
- High-eff. Glycol
- Decoupled Refrig. Coils
- Exhaust Heat Pump
- Energy Rec. Wheel
- Air-Air HX
- Side x Side Refrig. Coils

Energy Recovery Systems Decision Matrix

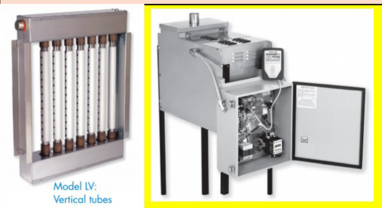
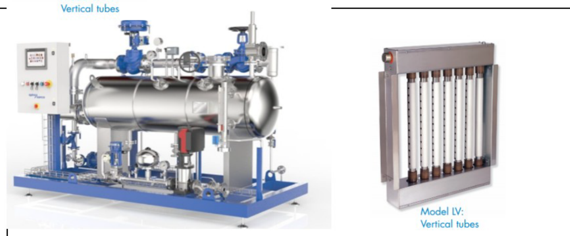
Order	Option	Description	Maintenance	Effectiveness	Resilience (Key Driver)	Space Impact	Acoustic Performance	LEED Optimize Energy Performance Points	Performance Track Record in Similar Climate	Reliability & Safety	Comfort	Energy Master Plan Alignment	Path to Electrification	Image
	Glycol Run-Around	This system uses standard coils in the exhaust air stream and supply air stream and pumps to circulate glycol between the coils.	Simple. Only a pump to maintain	30-40%	Very resiliant. If this fails, the AHU's still have cooling and heating coils.	No savings in AHU length. Minimal space needed for 2 pumps and glycol feeder.	Good. Pumps need to be isolated. Easier since pumps installed by contractor	Good	Lots of systems installed in Colo.		All energy recovery systems perform similar for space level comfort.	All systems will be designed for low temp hot water	System is all electric	
	Konvekta Intelligent High Efficiency Run-Around	This system uses proprietary coils and controls to provide a guaranteed energy recovery performance. This system can be used as a glycol run around simple system or a full 1-coil design where the Konvekta coil does recovery, heating and cooling. This saves AHU length and saves air pressure drop by ommitting 2 coils.	Technically Simple. Only a pump to maintain and a dedicated control panel that is dedicated to their skid. Often the pre-fabricated skid makes access to the pumps challenging. I.T. interface lessons learned, sensor location lessons learned.	70-80%	If the pump skid or controls go down, this system could cause the AHU's to fail in turn. There is a fail safe mode as well as manual manipulation available. Specific provisions required to address lessons learned from SEEL system.	This system can save up to 12 feet of length for AHU's, therefore penthouse size reduction. Large pumping skid required taking up floor space.	Good. Pumps need to be isolated. Often packaged skids don't provide springs.	Best	Approx. 10+ installations in this region. Good track record except some issues at SEEL		All energy recovery systems perform similar for space level comfort.	All systems will be designed for low temp hot water	System is all electric	
	Heat Pipe - Refrigerant energy recovery - Decoupled air streams	This system uses refrigerant piping between supply and exhaust air coils. The refrigerant flows by gravity and natural convection. These coils have a limited separation so unclear if the AHU can reside inside while exhaust outside.	Believed to have very little to no maintenance as it is a gravity refrigerant system.	50-60%	If this fails, the AHU's still have cooling and heating coils.	No AHU length savings, however no pumping skid is needed.	Very good. Nothing to vibrate.	Better	Installed at CSU Terra (National Western)		All energy recovery systems perform similar for space level comfort.	All systems will be designed for low temp hot water	System is all electric	
	Heat Pump system - with glycol exhaust coil.	This system uses an exhaust coil with glycol and pump to circulate water between a Heat Recovery Heat Pump Chiller and the coil. The Heat Pump then heats the heating water system up to 130-140 degrees which aligns perfectly with a low temperature hot water system. This eliminates the supply air heat recovery coil saving air pressure drop.	Increased maintenance since this system has a circulation pump and a Heat Recovery Chiller/Heat Pump with refrigerant compressors and controls	50%-60%	Very resiliant provided the heating system accounts for the heat pump being down.	Approx 3 feet of AHU savings, however a large heat recovery chiller would require significant space.	Most concerning as this has compressors that have a higher frequency noise in addition to the circulation pump	Better	Installed at CSU RIC in 2010		All energy recovery systems perform similar for space level comfort.	All systems will be designed for low temp hot water	System is all electric	
PREVIOUSLY REVIEWED AND REJECTED ENERGY RECOVERY SYSTEMS														
	Energy Recovery Wheel	This system has a wheel between supply and exhaust to recovery energy. While one of the most efficienct systems, this has the highest risk of re-entrainment of hazards. This requires side by side air streams more likely for rooftop units.												
	Air-Air Heat Exchanger	This system uses a brazed plate heat exchanger between supply and exhaust air streams.This requires side by side air streams more likely for rooftop units. This has a mild risk of cross contamination.												
	Heat Pipe Close Coupled Coils	This system uses a refrigerant coil between supply and exhaust air streams.This requires side by side air streams more likely for rooftop units. This has a mild risk of cross contamination.												

Mechanical System Selection

Humidification

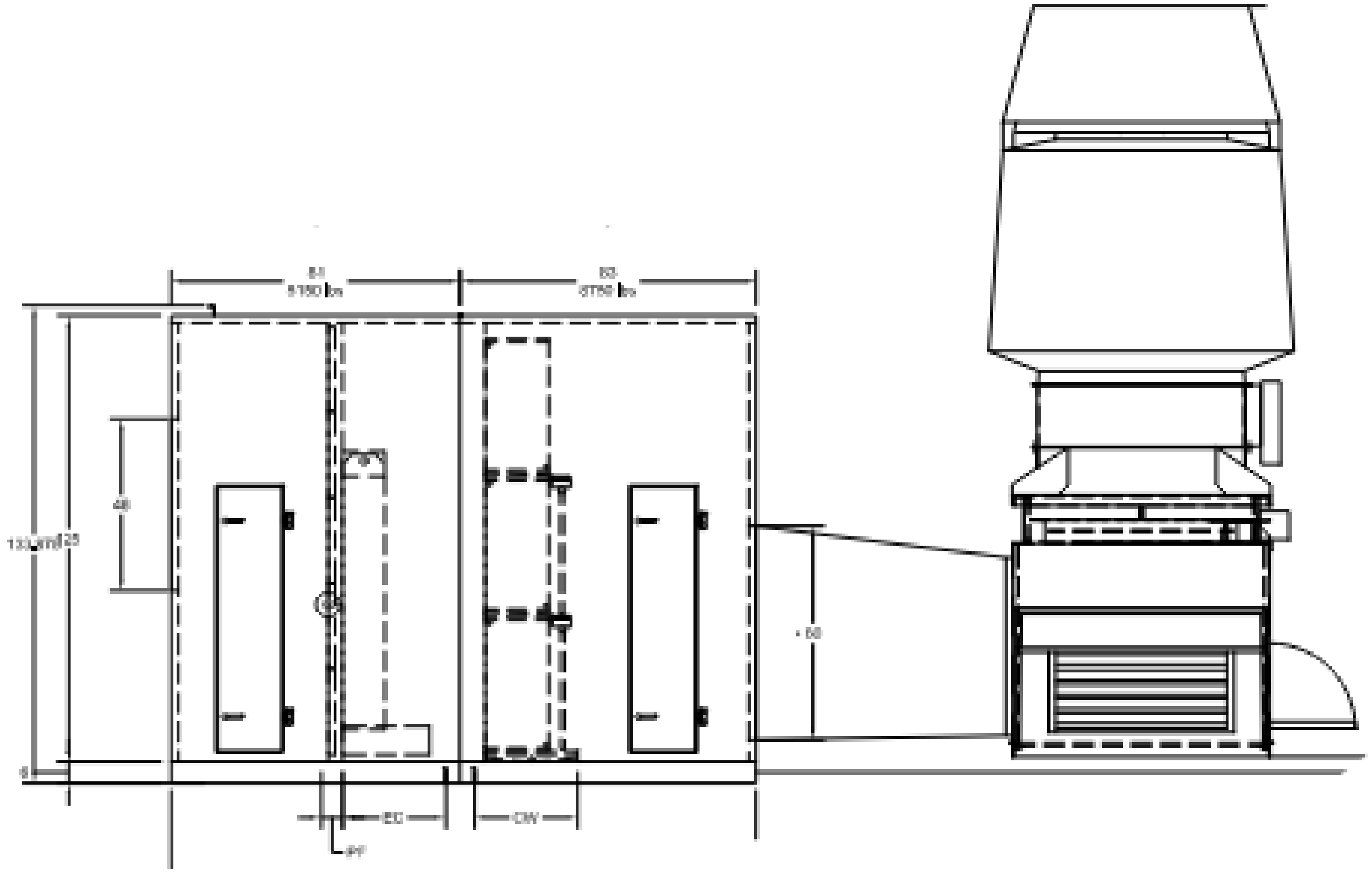
- Packaged Electric (Optics)
- Packaged Gas
- Unfired Steam
- Ultrasonic
- Low-press. Atomizing (Optics)
- High-press. Atomizing (Exhaust)

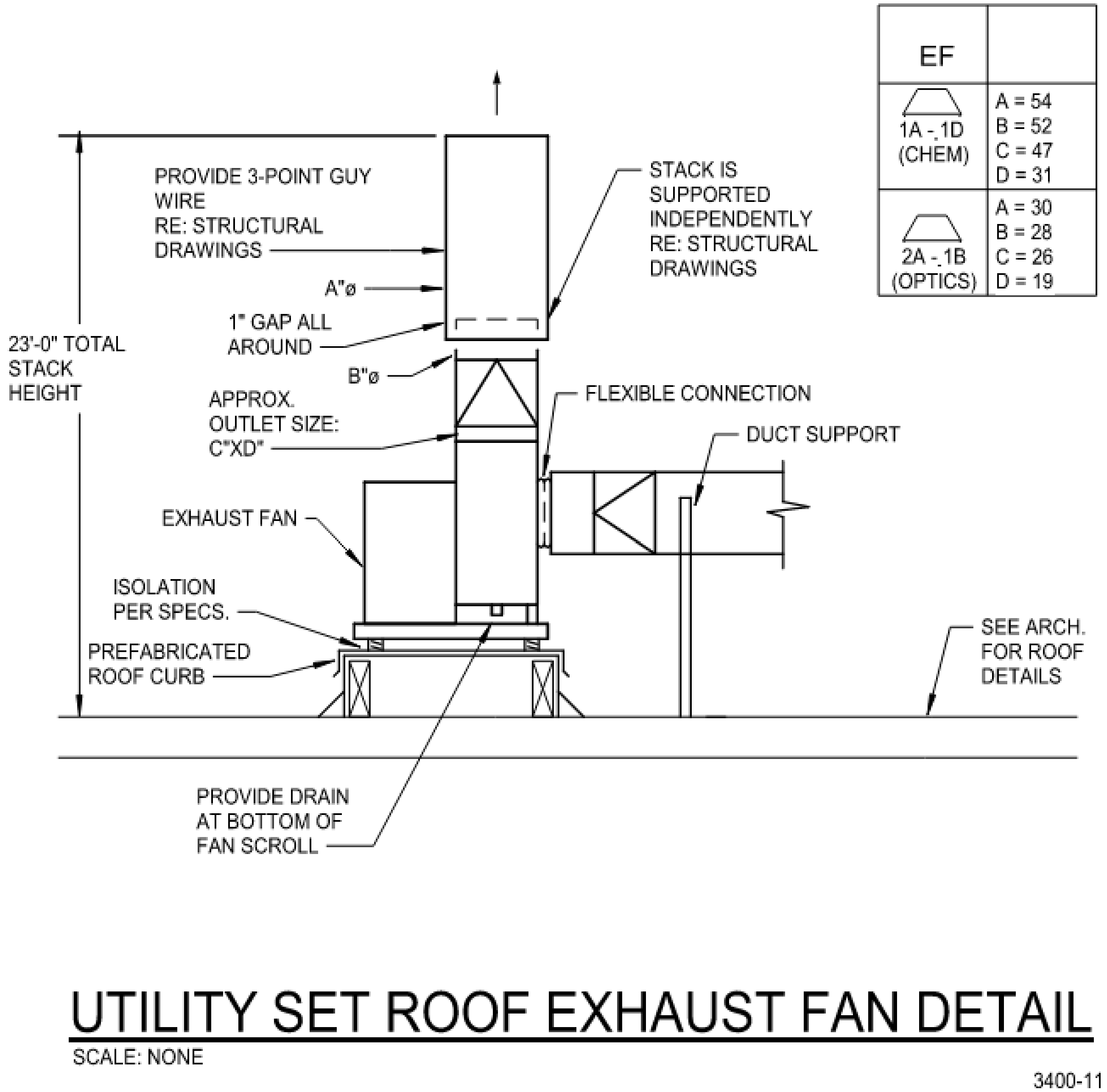
Humidification Systems Decision Matrix

Order	Option	Description	Maintenance	Resilience	Space Impact	Acoustic Performance	LEED Optimize Energy Performance Points	Performance Track Record in Similar Climate	Reliability & Safety	Comfort	Energy Master Plan Alignment	Path to Electrification	Image
●	**Packaged electric steam generator**	Electric resistance heating elements submerged in water generate steam, which is distributed to a dispersion manifold in the airstream.	Evaporating chamber requires seasonal cleanout. RO/DI water feed minimizes maintenance due to less scaling and impurity buildup. Annual PM required. Maintenance of water pretreatment system is critical for reliable operation of any humidification system.	No real redundancy of components. Components subject to failure (rare) are heating elements, which can be replaced. Resilient design may depend on multiple, redundant AHUs.	Steam generating unit could be installed on floor, wall-mounted, or suspended from structure. Approximate footprint is 4' x 6' including maintenance access. Requires 4 - 6' section within AHU or supply duct.	Good, does not generate noise	Low, due to heat requirement	Good, probably most common example	Best reliability due to simplicity	All systems perform similarly	Not impacted by energy master plan	All electric system	
●	**Packaged natural gas steam generator**	Condensing natural-gas burner generates steam, which is distributed to a dispersion manifold in the airstream.	Evaporating chamber requires seasonal cleanout. Pretreated water feed reduces maintenance due to less scaling and impurity buildup. Annual PM required. Maintenance of water pretreatment system is critical for reliable operation of any humidification system.	No real redundancy of components. Components subject to failure (rare) are heating elements, which can be replaced. Resilient design may depend on multiple, redundant AHUs.	Steam generating unit likely needs to be installed on floor. Approximate footprint is 8' x 7' including maintenance access. Combustion air and flue gas vents through roof required. Requires 4 - 6' section within AHU or supply duct.	Good, does not generate noise	Lowest, due to gas combustion efficiency	Good, less common than electric	Gas heat exchangers make this slightly less reliable than option 1	All systems perform similarly	Not impacted by energy master plan	Requires natural gas connection	
●	**Unfired Steam Generator or Process Steam Boiler with steam dispersion manifolds**	Relies on a (relatively) small centralized clean steam generator or electric clean steam boiler. Clean steam is distributed through rigid steam piping to each humidifier/AHU.	Steam distribution systems require more regular maintenance than packaged options. Steam boiler or unfired steam generator requires annual PM at a minimum. Boilers and pressure vessels may require dedicated operator. Maintenance of water pretreatment system is critical for reliable operation of any humidification system.	Resiliency could be built into the steam plant, i.e. redundant central units. Resilient design may also depend on multiple, redundant AHUs.	Larger footprint required for steam generation equipment in a mechanical room. May create the need to distribute steam throughout the building. Requires 4' - 6' section with AHU or supply duct.	Fair, depending on steam generation technology. Higher pressure steam piping may have some noise associated with it.	Good, but depends on central plant	Good, more common on large campuses	Good reliability although steam and condensate system can be more difficult to operate	All systems perform similarly	Lowest, requires steam source	All electric system	
●	**Ultrasonic Humidifier**	Uses electrical transducers to create a cool, fine mist within the airstream where it is absorbed.	Systems include large quantities of small electrical components that are subject to failure after 10,000 hours. Continual monitoring of these components is required to ensure proper capacity is achieved. Replacement of transducers is time consuming and labor intensive. A single system may cost $10 - 15k annually to maintain.	Fairly resilient if designed correctly due to high number of individual transducers and other components.	Requires 4' - 6' section within AHU or supply duct. Air straightener should be used upstream.	Good, does not generate noise	Better because of evaporative cooling effect	Lowest, mostly due to controllability issues	Lowest, mainly due to degradation of performance as transducers fail over time	All systems perform similarly	All electric system	All electric system	
●	**Low Pressure Atomizing System**	Hybrid system that combines evaporative media & atomizing nozzles. Low pressure pumps distribute pre-treated water through nozzle manifold inside the HRU. Ceramic evaporative media "catches" moisture and allows it to evaporate further.	Low pressure pumps require regular maintenance but do not require the more significant rebuilds of a high pressure system. Maintenance of water pretreatment system is critical for reliable operation of any humidification system.	No real redundancy of components. Components subject to failure are pumps, which can be replaced. Resilient design may depend on multiple, redundant AHUs.	Approx. 3'x6' floor-mounted skid, depending on system size. Manufacturer claims reduced length within AHU than other forms of humidification.	Fair. Low-pressure pumps are not as noisy as other atomizing options.	Best due to low energy demand and evaporative cooling effect	Good, recent examples on campus	Good reliability although controls can be more complex	All systems perform similarly	All electric system	All electric system	
●	**High Pressure Atomizing System**	A set of high pressure pumps delivers pre-treated water to a nozzle manifold inside the duct or AHU. The high-pressure water is atomized and absorbed into the airstream.	High pressure pumps require full rebuild on an annual basis. Maintenance of water pretreatment system is critical for reliable operation of any humidification system.	If this fails, the AHU's still have cooling and heating coils.	Approx. 3'x6' floor-mounted skid, depending on system size. For proper absorption, 6 - 8' of duct or AHU distance is recommended.	Poor, likely requires acoustical treatment. High-pressure pumps generate a lot of noise and vibration.	Better because of evaporative cooling effect	Fair, recent examples but can be difficult to control	Good reliability although controls can be more complex	All systems perform similarly	All electric system	All electric system	

Wind Dispersion Modeling

Wind Dispersion Modeling





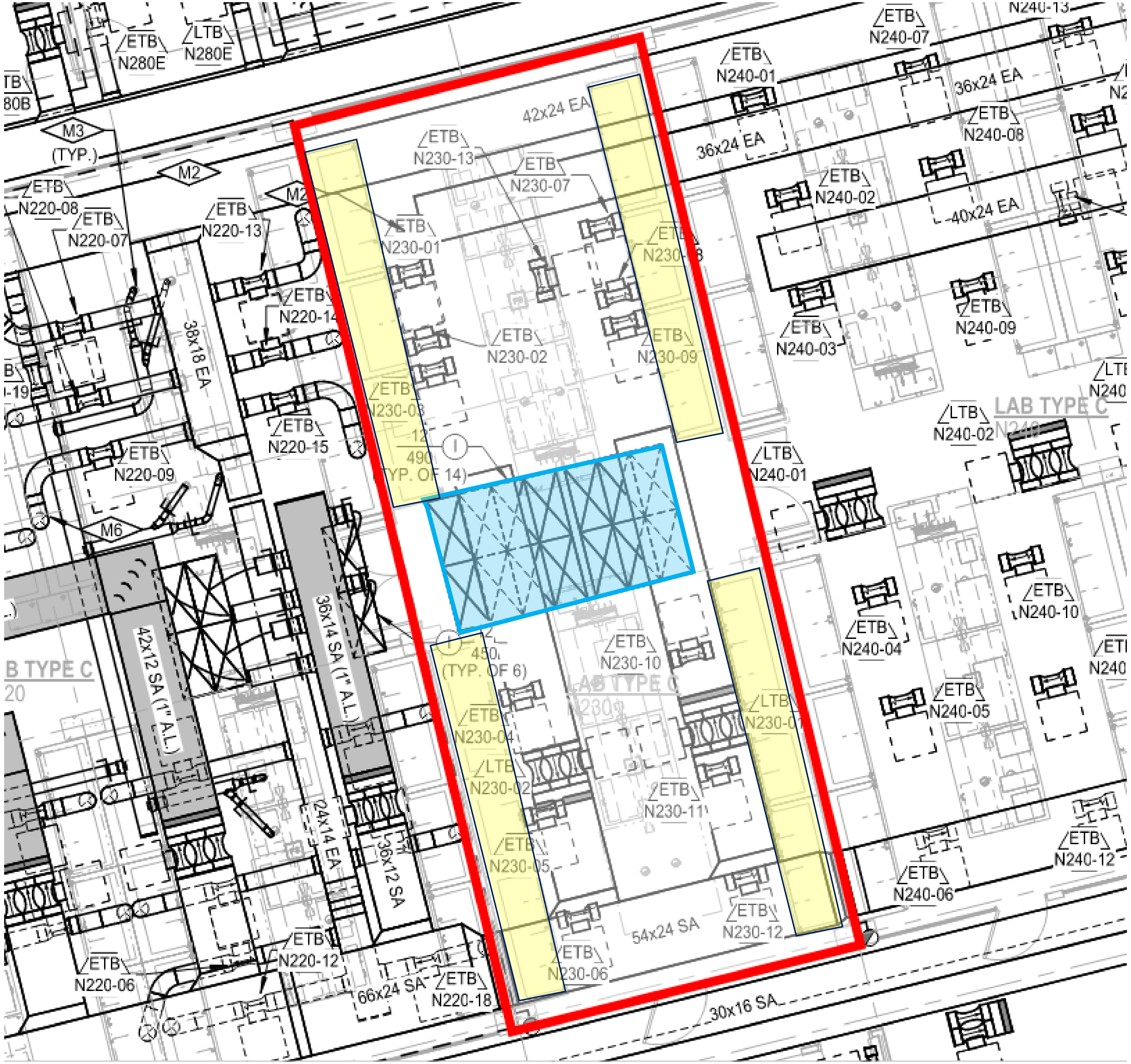
- Compact
- Often higher energy
- Maintenance concerns
- Acoustical impacts

- More space required
- Energy savings opportunities
- Familiar to maintenance staff

Computational Fluid Dynamics

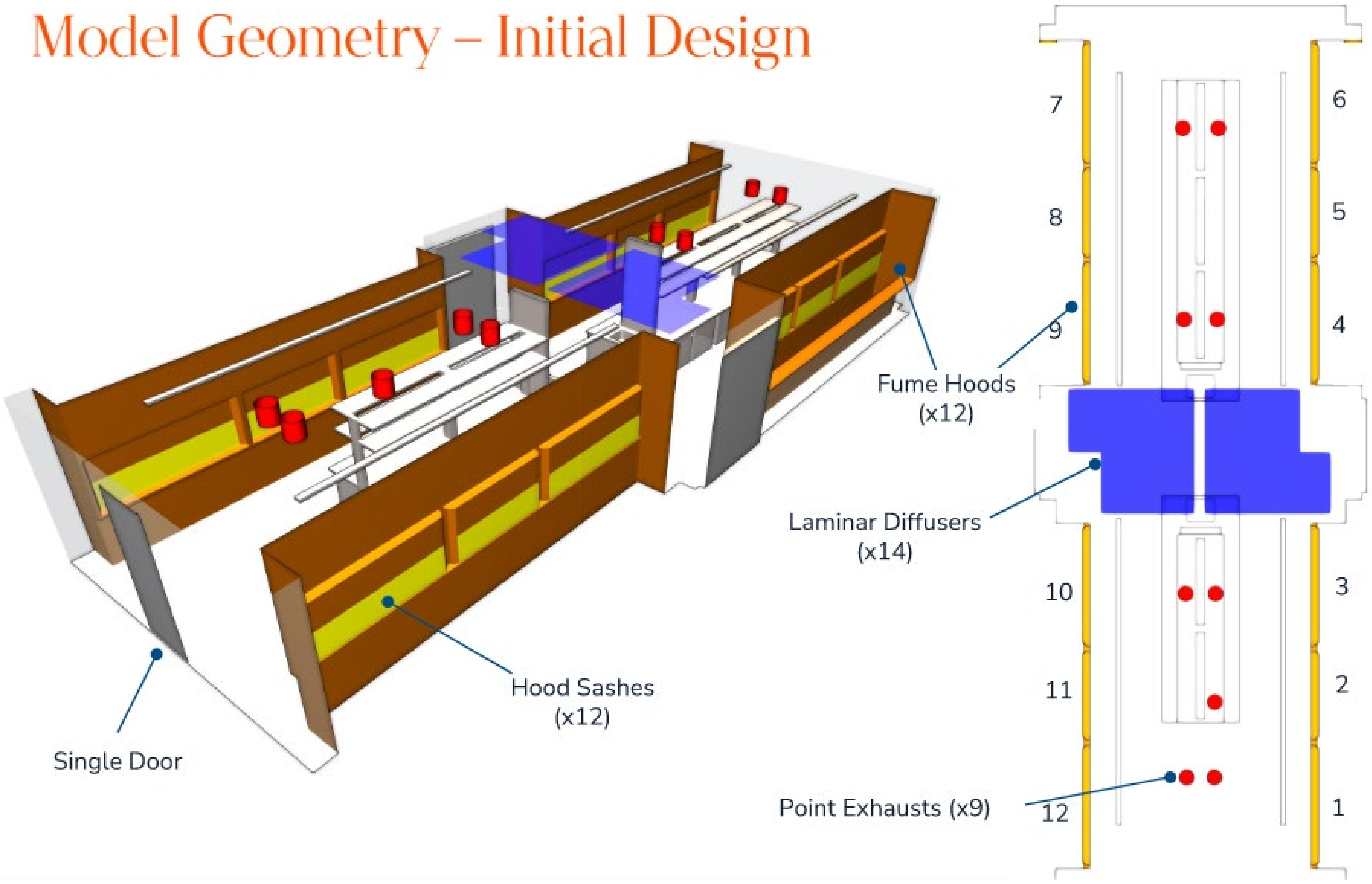
Goals:

- Simulate performance
- Compare options
- Inform design
- Promote effectiveness and conformance with standards



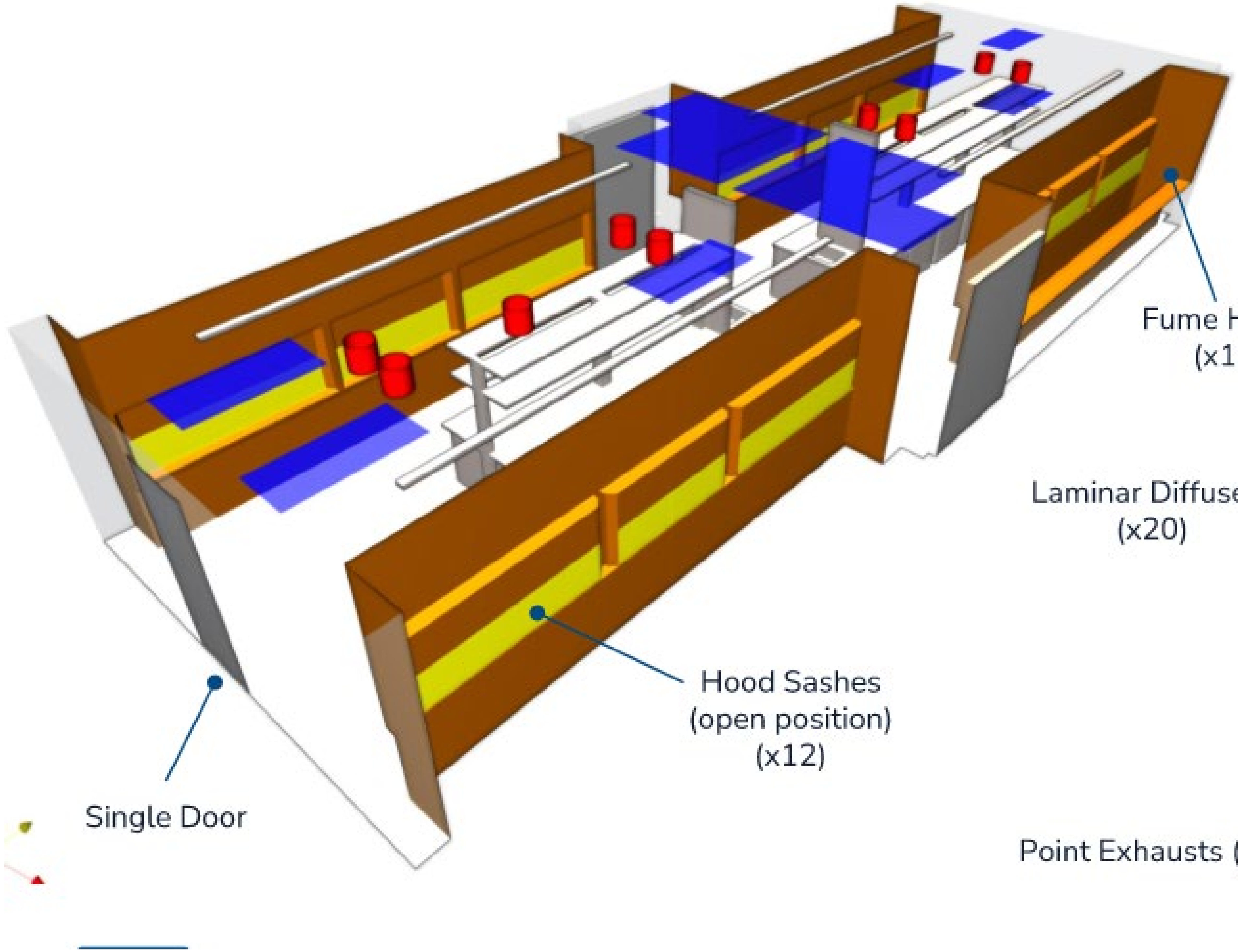
Computational Fluid Dynamics

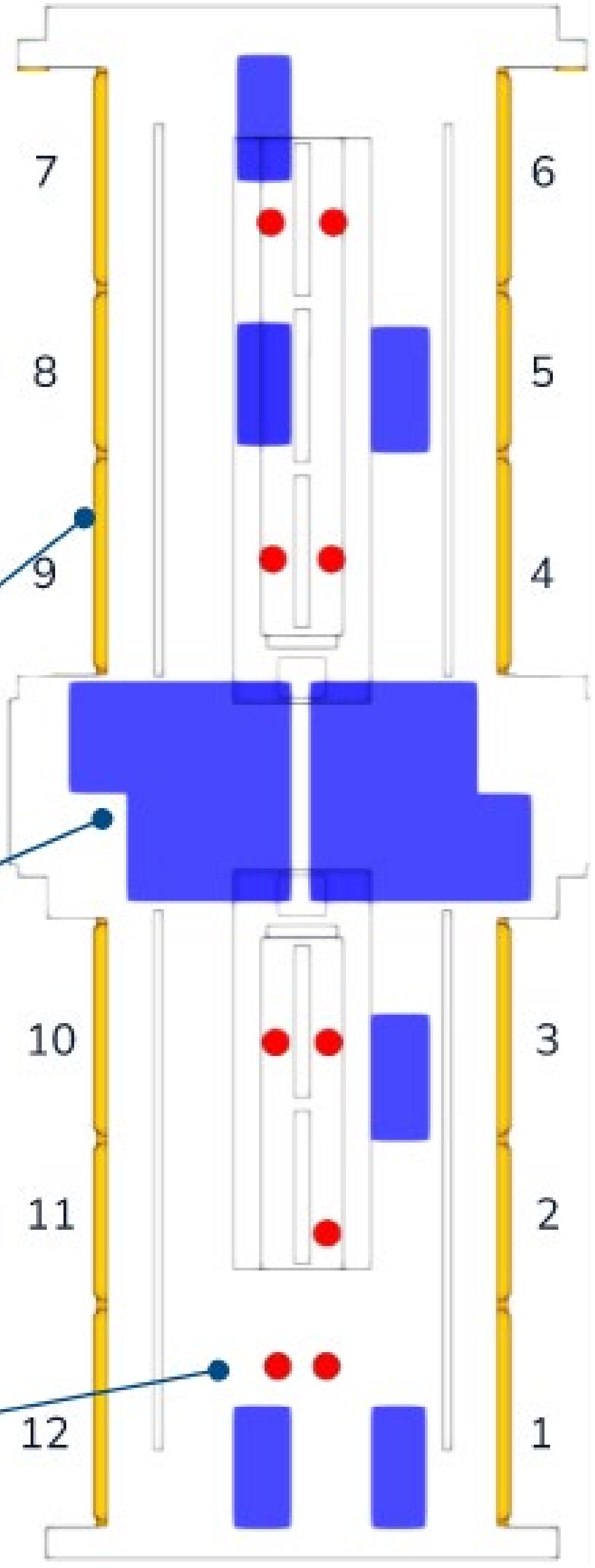
Model Geometry – Initial Design



Computational Fluid Dynamics

Model Geometry – Updated Design

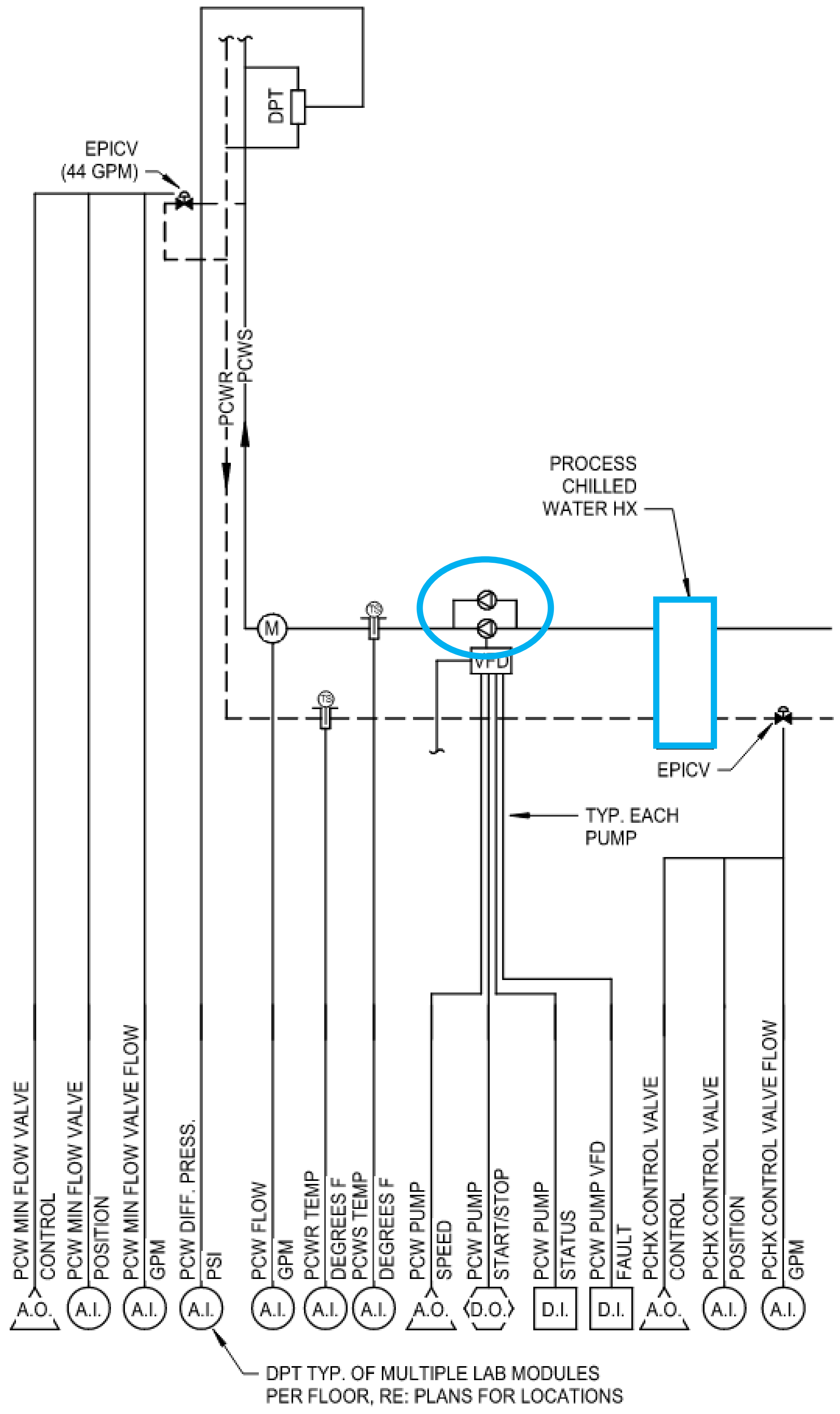




Process Cooling


Pump


Heat Exchanger

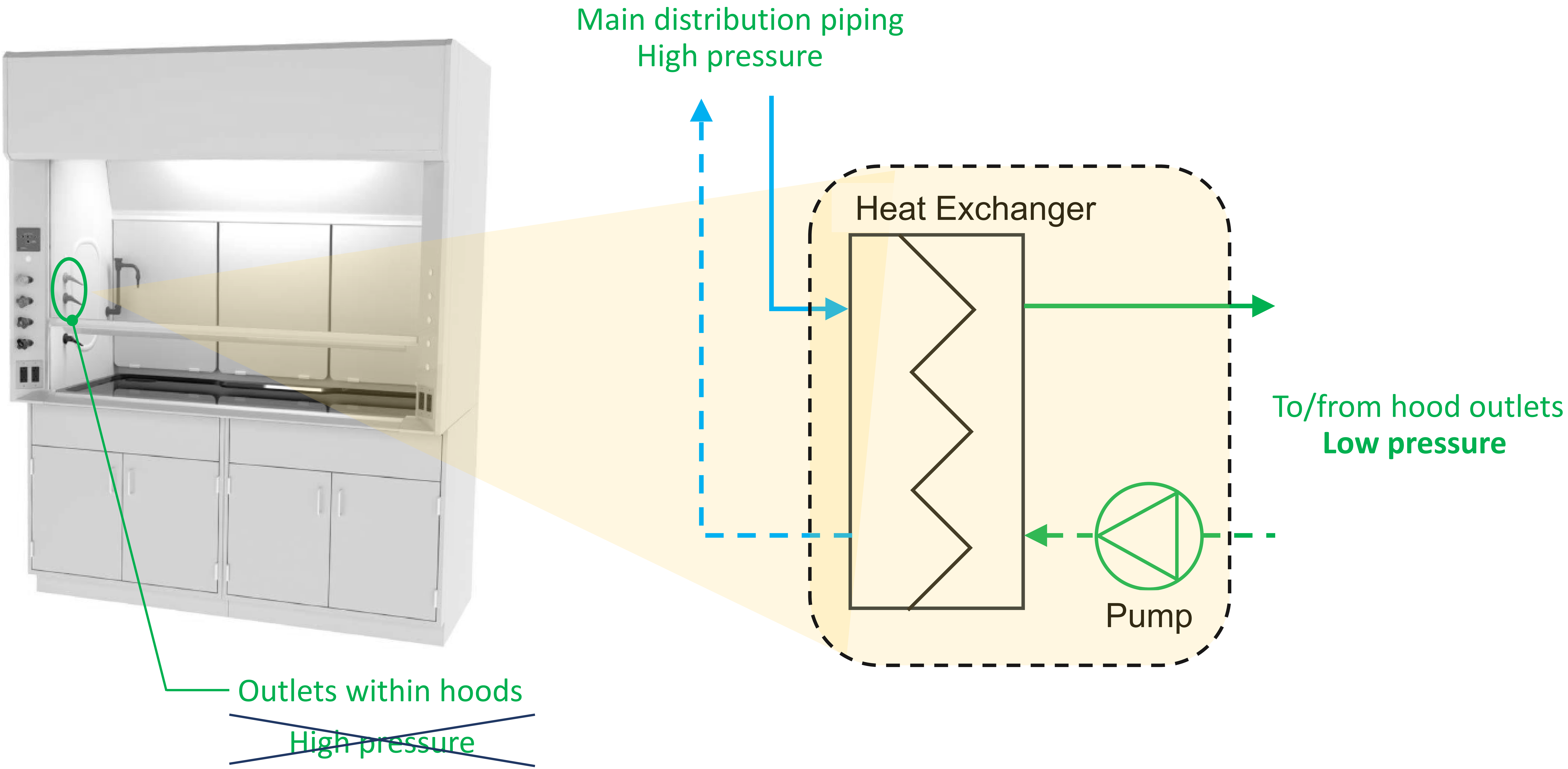


Process Cooling

Main distribution piping

High pressure

Process Cooling



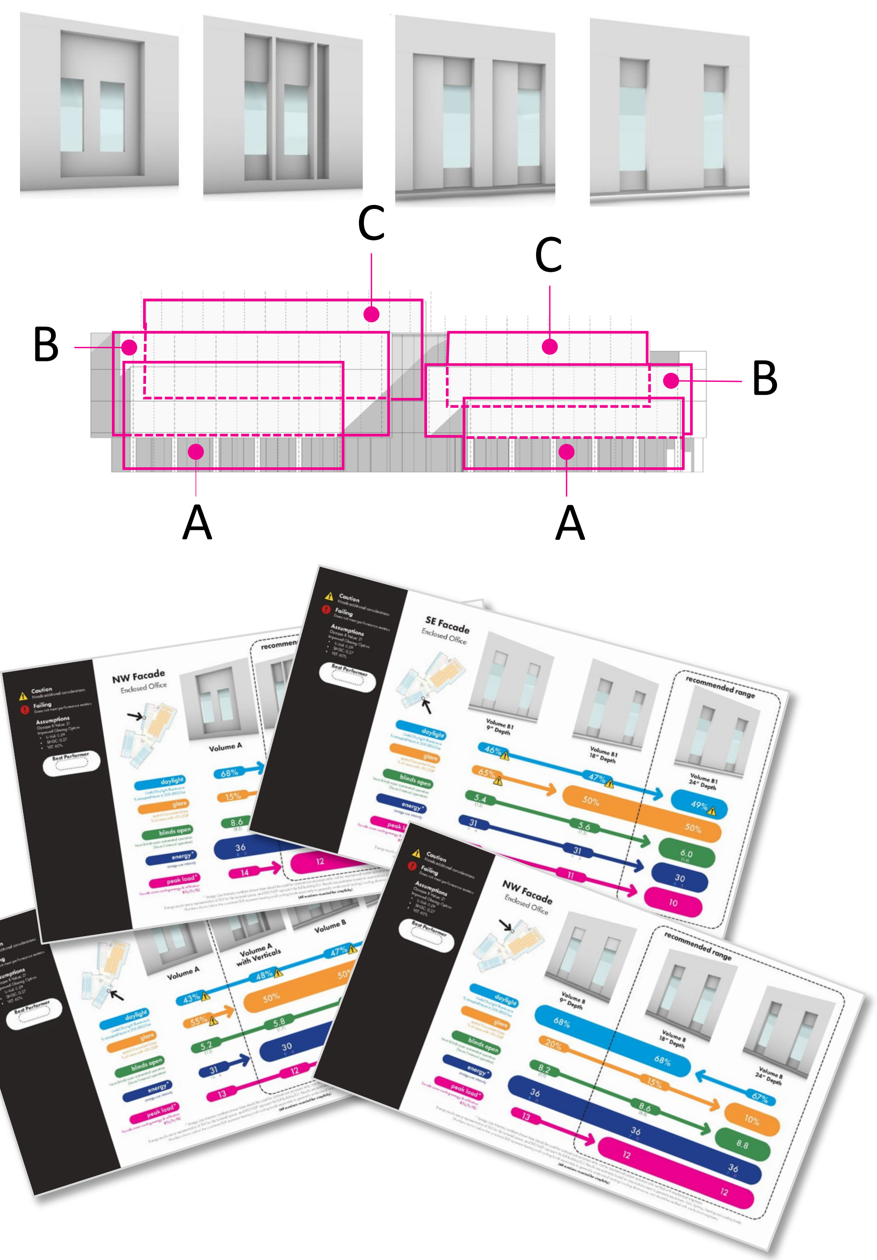
Façade Development

Design Iteration

1 Initial Findings

2 Feedback

3 Façade Adjustment



4 Refine

Façade Development
Performance

daylight
Useful Daylight Illuminance
% occupied hours in 300-3000 lux

A target UDI value in regular occupied spaces is 40%+

Glare
spatial Discomfort Glare
% of views with >5% DGP

Target glare potential is 10% or less.

visibility
hours blinds open automated operation
(hours if manual operation)

Visibility should be 5+ hours of open blinds

peak load*
facade zone cooling energy & infiltration
BTU/hr/ft2

The lower the energy load, the better

thermal comfort
mean radiant temperature

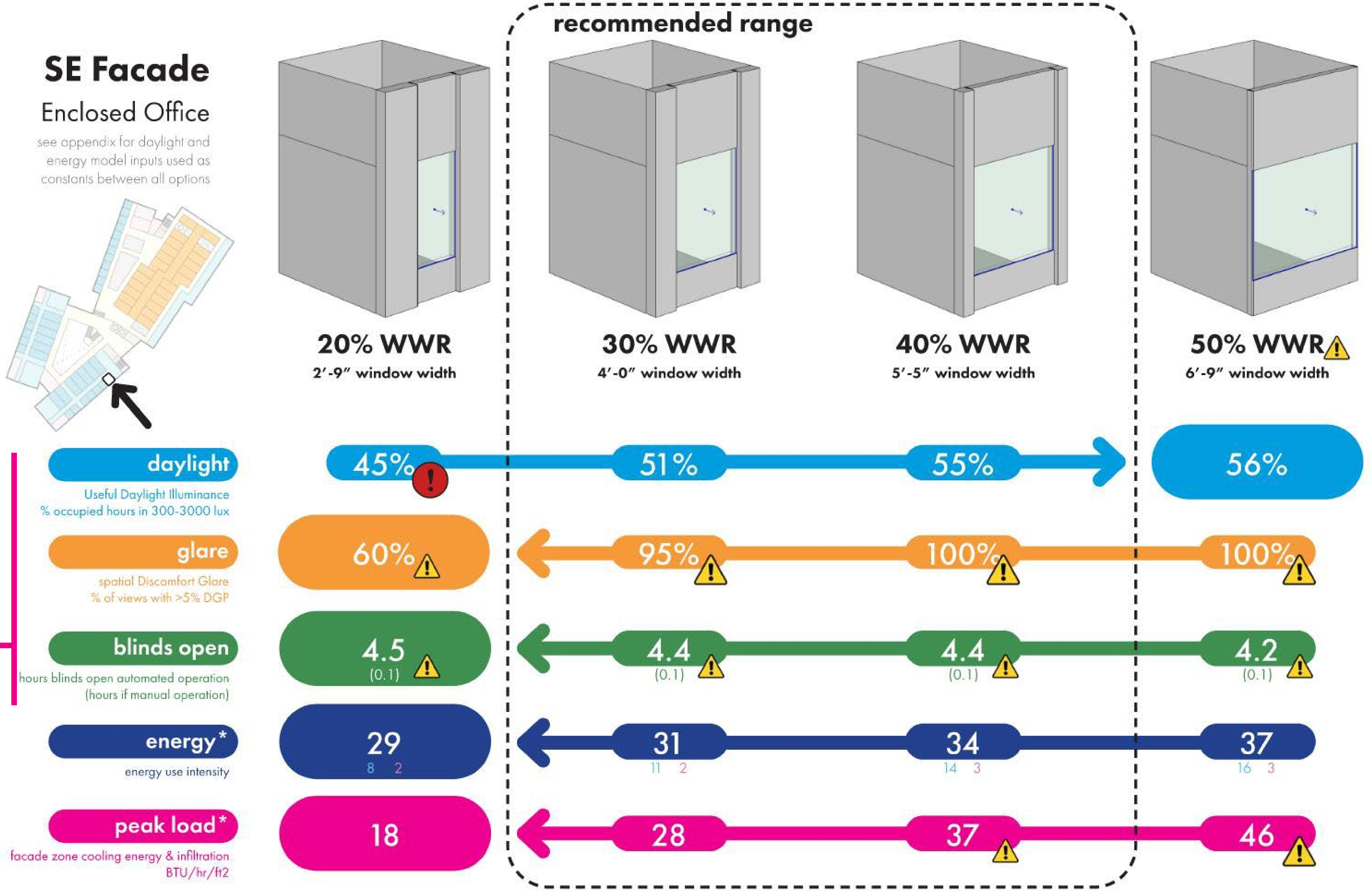
The lower the % dissatisfaction, the better

carbon
exterior shading material quantity

The lower the carbon footprint, the better

Status:
Ongoing

Suggests that glare control strategies will be needed on the SE facades

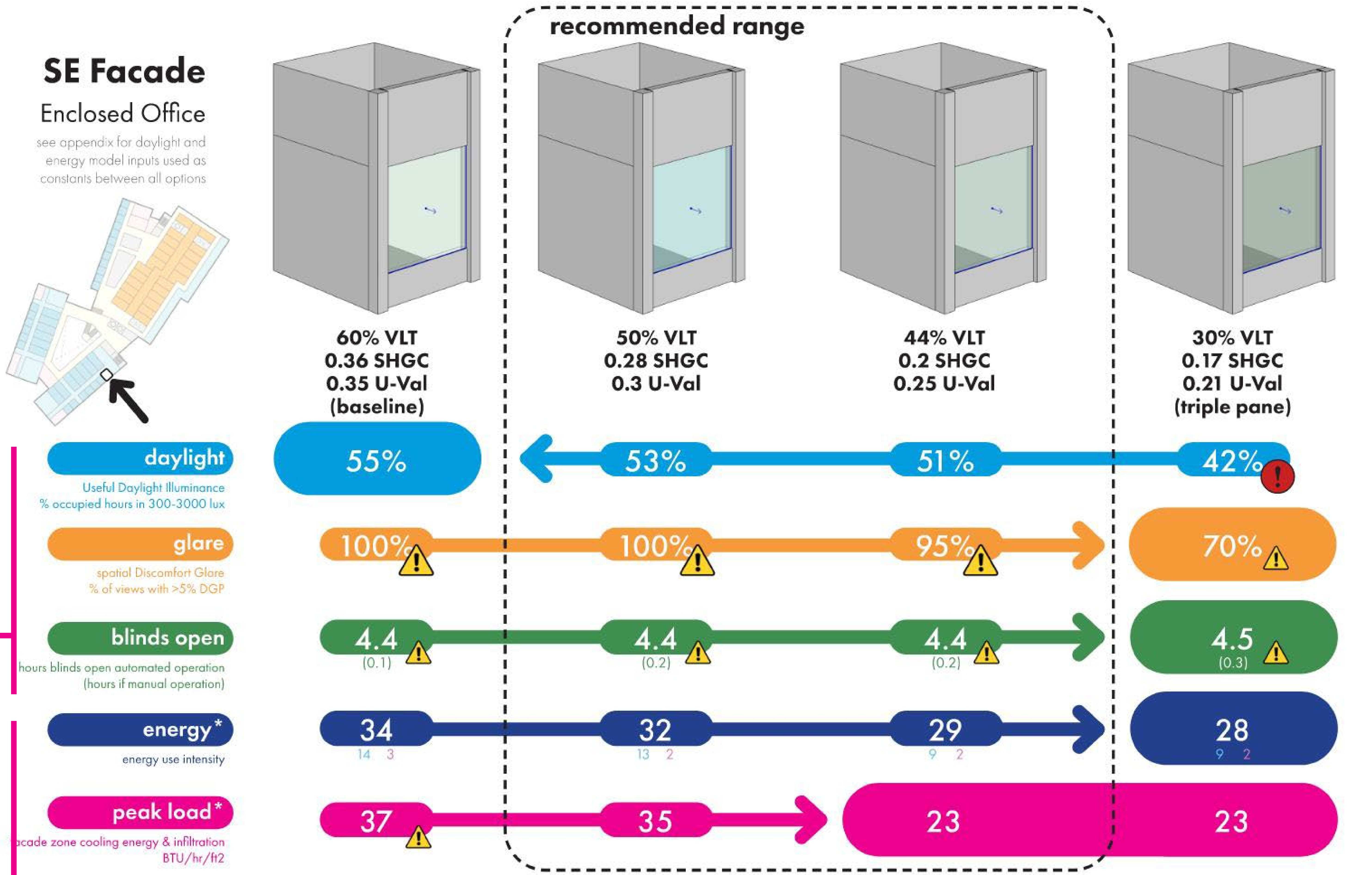


* Energy Use Intensity numbers shown here should be used for comparison purposes only, not for mechanical system selection until verified with mechanical engineers.
Energy results are a representation of EUI for the isolated space, and DO NOT represent the full building EUI. Results are estimates based on assumptions used to generate equipment, fans, lighting, heating and cooling loads.
Numbers shown below the combined EUI represent heating and cooling loads separately to generally understand heating/cooling dominance, and should be verified with mechanical engineers.

(All numbers rounded for simplicity)

Low VLT glass will still require glare control

Low VLT glass does show some energy and load improvement



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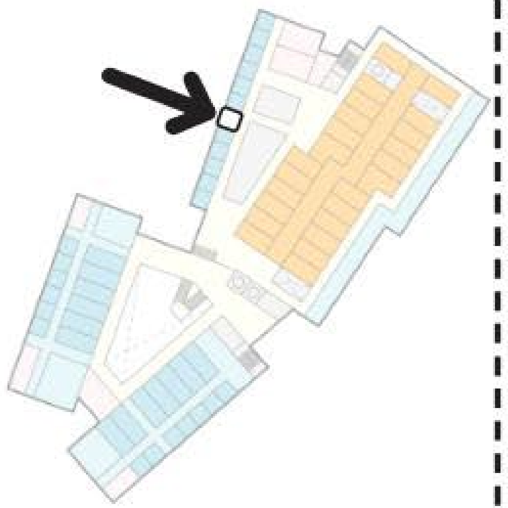
(All numbers rounded for simplicity)

Suggests that glare control strategies may be less critical on NW facing facades

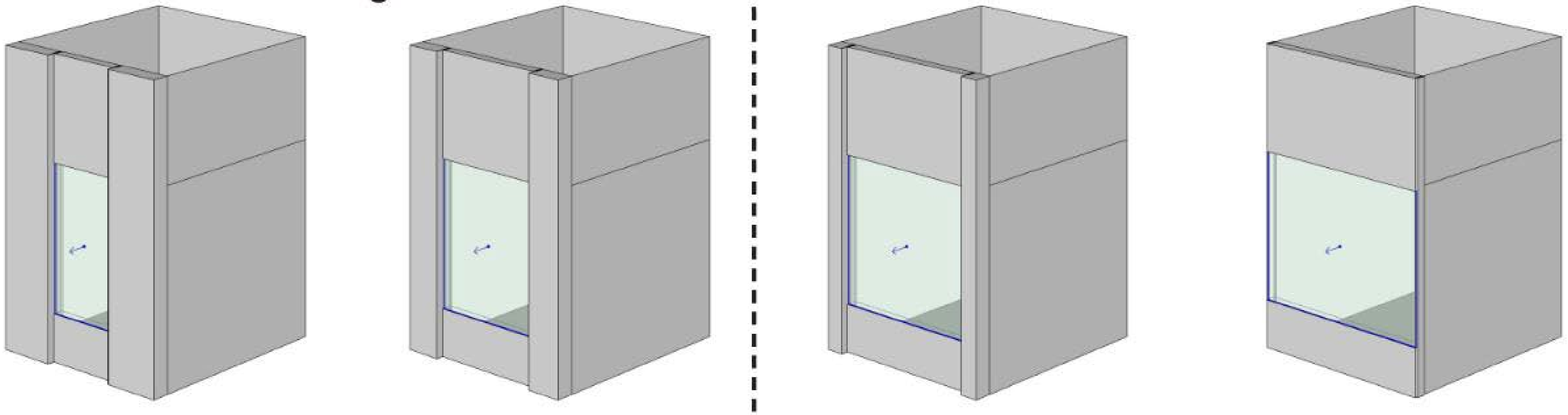
NW Facade

Enclosed Office

see appendix for daylight and energy model inputs used as constants between all options



recommended range (20% WWR and 30% WWR)



	20% WWR 2′-9″ window width	30% WWR 4′-0″ window width	40% WWR 5′-5″ window width	50% WWR ⚠ 6′-9″ window width
				Over lit
daylight Useful Daylight Illuminance % occupied hours in 300-3000 lux	69%	72%	72%	69%
glare spatial Discomfort Glare % of views with >5% DGP	20%	45%	60% ⚠	75% ⚠
blinds open hours blinds open automated operation (hours if manual operation)	7.7 (7.1)	7.6 (7.0)	7.5 (7.0)	7.3 (6.7)
energy* energy use intensity	36 8 11	41 11 13	45 13 14	48 16 15
peak load* facade zone cooling energy & infiltration BTU/hr/ft2	24	36 ⚠	48 ⚠	58 ❗

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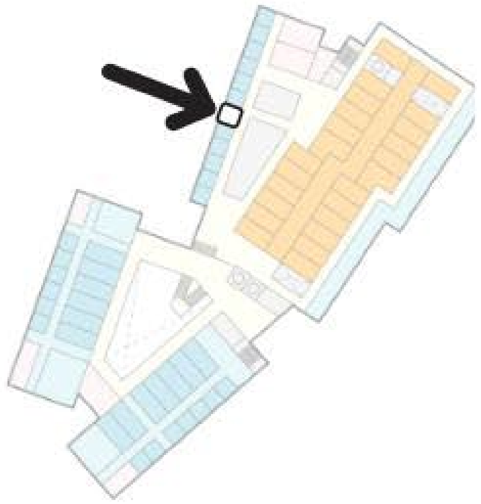
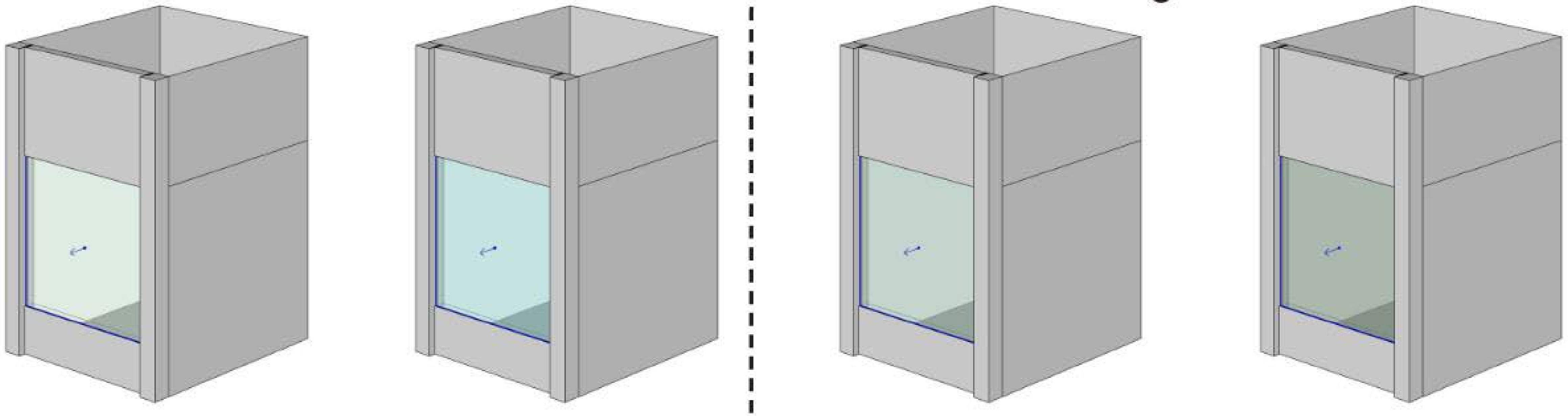
(All numbers rounded for simplicity)

NW Facade

Enclosed Office

see appendix for daylight and energy model inputs used as constants between all options





recommended range (44% VLT and 30% VLT options)

	60% VLT 0.36 SHGC 0.35 U-Val (baseline)	50% VLT 0.28 SHGC 0.3 U-Val	44% VLT 0.2 SHGC 0.25 U-Val	30% VLT 0.17 SHGC 0.21 U-Val (triple pane)
daylight Useful Daylight Illuminance % occupied hours in 300-3000 lux	72%	72%	71%	68%
glare spatial Discomfort Glare % of views with >5% DGP	60% ⚠	55%	45%	30%
blinds open hours blinds open automated operation (hours if manual operation)	7.5 (7.0)	7.6 (7.0)	7.6 (7.0)	7.7 (7.1)
energy* energy use intensity	45 13 14	40 12 11	38 9 11	35 9 9
peak load* facade zone cooling energy & infiltration BTU/hr/ft2	48 ⚠	44 ⚠	26	26

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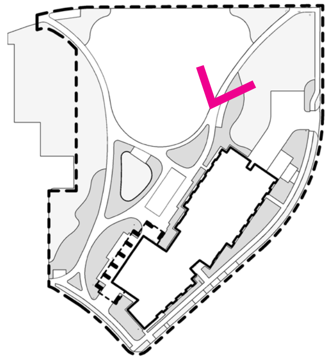
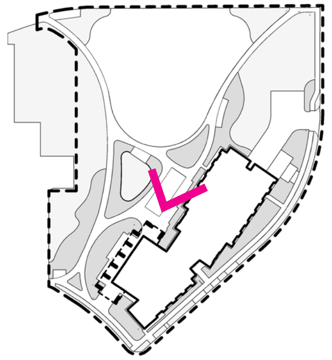
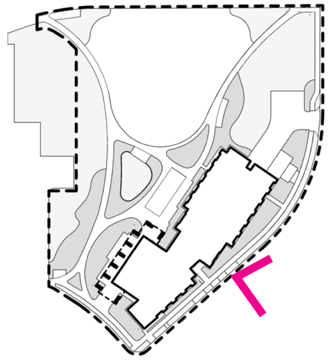


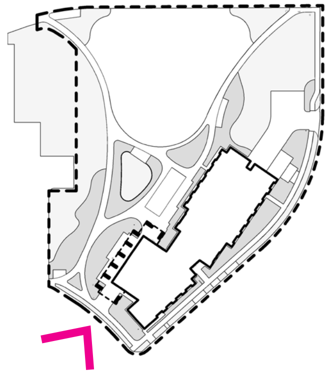
View 01 – Northeast



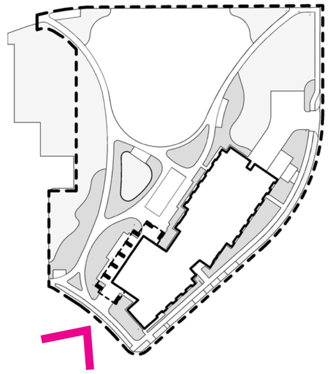
View 02 – Northwest



View 03 – Regent Entry



View 04 – Southwest



View 05 – Southwest Atrium

View 06 – Prefunction

Q&A